Comprehensive Watershed Based Management Plan for Warm Springs Run

A Potomac Direct Drains Watershed

Morgan County, WV

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By

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Cover photo - Warm Springs Run as it passes through Berkeley Springs State Park. (Note well-developed limestone gravel point bar just upstream from the foot bridge.) Credits **-** Robert K. Denton Jr., April 2012

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Preface

The Warm Springs Run is the outfall channel of the largest thermal spring in the Potomac Highlands Region, a unique environmental feature of both historic and natural significance. The reputed therapeutic quality of the spring waters attracted the Native American people to the site. Subsequently, the first spa in the American colonies sprang up around the springs named after the town of Bath, England.

Although the springs were highly valued, and thus conserved and protected from contamination, the Warm Springs Run itself did not merit such regard. Used as an open sewer and waste dump for various historic industries in the Town of Bath, the stream became significantly polluted. Thankfully, in recent decades there has been a concerted effort to reverse the environmental impacts to the Run. The historic industries closed down many years ago. The construction of a sanitary sewer main, installed from 1976 – 1979, extending the length of the stream, now prevents the discharge of waste directly into the channel. However, despite these improvements, the stretch of the Warm Springs Run south of the Town of Bath, upstream from the historic springs, is still utilized by many as little more than a drainage ditch. Currently, this upstream section of the Run still suffers the greatest number of impacts from contemporary development, while the section downstream from the Town of Bath to near the confluence with the Potomac River remains in a relatively undisturbed, natural state.

It is our hope that this management plan will aid the Warm Springs Run Watershed Association, Morgan County, and the State of West Virginia to manage the negative impacts to this important little stream. In doing so, the larger goal of protecting the Chesapeake Bay will be contributed to as well.

Introduction and Description of Warm Springs Run Watershed

The purpose of this document is to provide a Comprehensive Watershed Management Plan for the US Environmental Protection Agency, the Warm Springs Watershed Association, and the stakeholders of the Warm Springs Run (WSR) watershed, to guide future non-point source project proposals for funding through the Clean Water Act Section 319 and other sources.

In 2012 the Warm Springs Watershed Association was awarded a FY11 Chesapeake Bay Regulatory and Accountability grant to be used in the creation of a Comprehensive Watershed Management Plan for the Warm Springs Run (WSR) and its tributaries. This management plan is intended to provide guidance for stream bank restoration and contaminant mitigation activities with the goal of helping West Virginia achieve Total Maximum Daily Load (TMDL) requirements.

The scope of services as outlined in the grant proposal is as follows:

1. Consultant(s) will synthesize information reported in existing reports and documents provided by the client (e.g. Warm Springs Run Watershed Assessment, etc.)

2. Consultant(s) will provide engineering and geological assessment support to analyze soils, geology, hydrology and geomorphology that contribute to non-point and point source pollution in the WSR.

3. Consultant(s) will document the load reductions needed from the WSR watershed to help West Virginia achieve TMDL goals. Consultant(s) will propose a suite of practices to achieve point and non-point source reductions. Also considered will be practices in the non-regulated developed lands section of the Comprehensive Watershed Management Plan (e.g. residential fertilizer and runoff reduction practices).

4. Consultant(s) will:
    a. investigate sources of stream quality impacts relative to their respective negative effect on the Run;
    b. present recommendations on a cost-benefit basis, prioritizing which would which would provide the most benefits from a financial and/or acceptability of implementation basis;
    c. categorize recommendations on the basis of funding source availability (e.g. 319 non-point source reduction; Chesapeake Bay Fund, etc.).
    d. regardless of what recommendations for action that are listed in the management document, the consultant will list next steps to deliver the highest-priority implementation actions. The proposed plans for implementation will include, where possible, education-based as well as engineering-based interventions.

5. Consultant(s) will prepare cost estimates and determine entities to provide technical assistance and remedial activity implementation for all proposed actions.

6. Consultant(s) will deliver a Comprehensive Watershed Based Management Plan to the WSR Watershed Association.

Physical Setting

The WSR watershed is located in north central Morgan County West Virginia, and is the principle surface drainage of the valley formed by Warm Springs Ridge to the west and Horse Ridge, to the east.

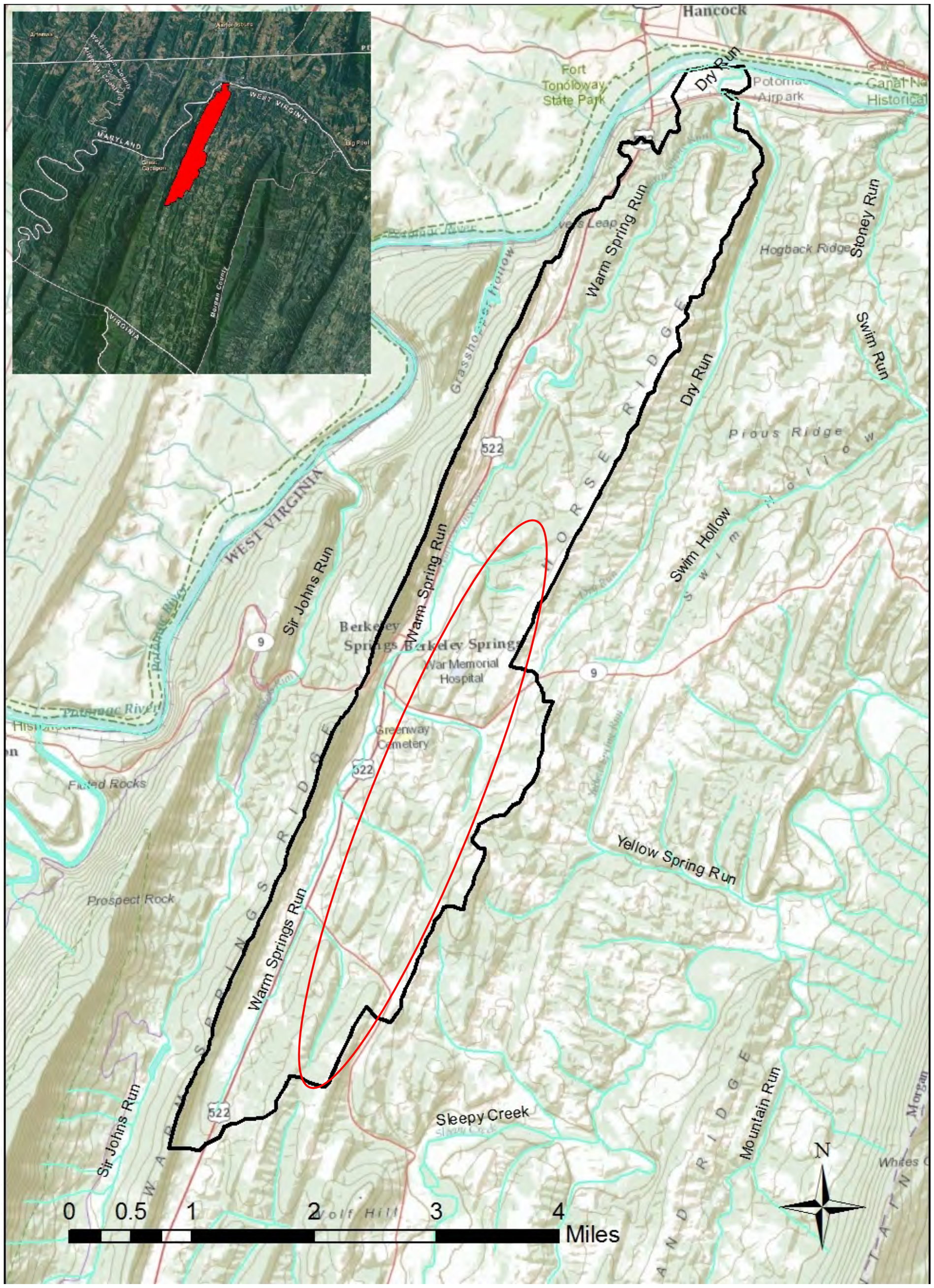


Figure 1. Location of the Warm Springs Run watershed (black outline) in Morgan County, WV. The eastern tributaries are within the red oval.

The WSR is approximately 11.8 miles in total length, and is a non-navigable stream throughout (see Figure 1). The total watershed catchment of the WSR has been estimated at approximately 7,178 acres (not including the Dry Run Watershed to the east); however, the USGS reports the watershed as 7,084 acres (Wiley, et al., 1996). There are five (5) eastern tributaries to the WSR originating in the upland to the east of the main stem's valley, from north to south, respectively: 1) an (unnamed) stream running along Jimstown Road, 2) Yellow Spring Run, 3) an unnamed stream running through Sugar Hollow, 4) Kate's Run, which parallels Winchester Grade Road, and 5) the Dry Run.

Topography and Geology

The topography of the WSR is typical of the drainages located in the eastern Potomac Highlands section of the Ridge and Valley Physiographic Province. The stream's main stem follows along the eastern edge of the Cacapon Mountain Anticlinorium (a broad, generally upward folded area of bedrock), where relatively soft, erosion-prone shale contacts the hard, erosion-resistant Oriskany sandstone forming Warm Springs Ridge. Warm Springs Ridge is the eastern "hogback" of Cacapon Mountain, and extends parallel with the axis of the Cacapon Mountain Anticline (see Figure 2).

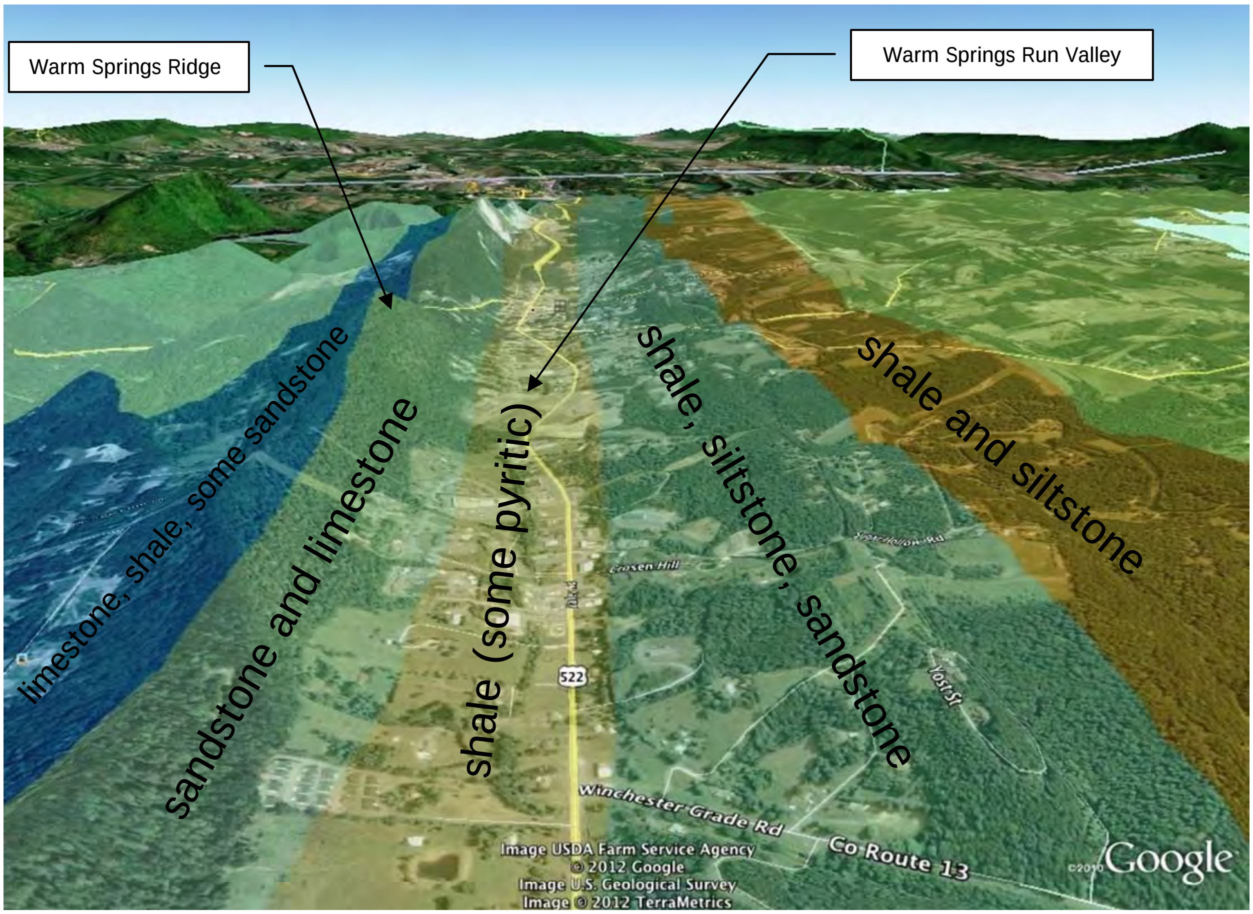


Figure 2. Topographic setting and generalized rock types of the Warm Springs Run Valley.

The WSR valley is underlain entirely by the shale, siltstone and sandstone of the Marcellus, Needmore, and Mahantango Formations, all dating from the Devonian geologic period 415 to 355 mya[1]. The southern (upstream) section flows along the contact of the two units, and is probably controlled by the underlying rocks' lithology and structure. The central section is underlain by the Marcellus and Needmore shales, but the stream wanders back onto the Mahantango in its northern (downstream) reach.

The subordinate, eastern tributaries of the WSR are all underlain by the Brallier and Chemung Formations, composed of clastic rocks (shale, siltstone, and sandstone) also dating to the Devonian geologic period. The plan view of the regional geology is shown on Figure 3, and a cross section is shown on Figure 4.

[1] million years ago

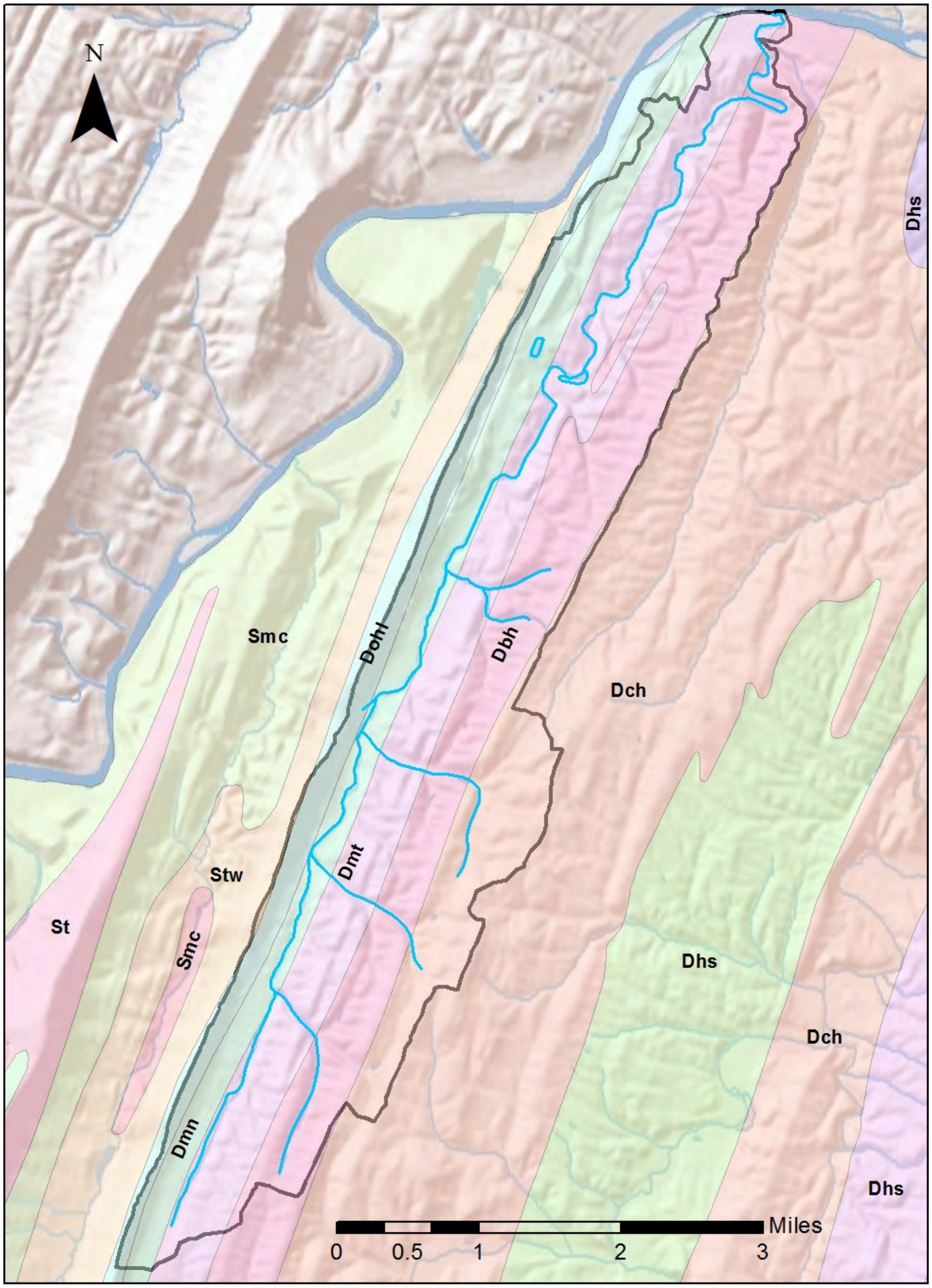


Figure 3. Areal bedrock geology map of the WSR Watershed. (Abbreviations Key: St = Tuscarora Formation; Smc = Mackenzie Group; Stw = Tonoloway and Wills Creek Formations; Dohl = Oriskany Sandstone and Helderberg Limestone; Dmn = Marcellus/Needmore Formations; Dmt = Mahantango Formation; Dbh = Brallier Formation; Dch = Chemung Formation; Dhs = Hampshire Formation)

Key to Geological Codes
(Devonian Period)
Dha – Hampshire Fm.
Dch – Chemung Fm.
Dbh – Brallier Fm.
Dmt – Mahantango Fm.
DMn – Marcellus & Needmore Fms.
Do – Oriskany Group
DS – Early Devonian & Late Silurian Carbonates (includes Helderberg, Tnoloway and Wills Creek Fms.)
(Silurian Period)
Sb – Bloomsburg Fm.
Smc – Mackenzie Group
Srh – Rose Hill Fm.
(Ordovician Period)
Oj – Juniata Fm.
Oo – Oswego Fm.
Om – Martinsburg Fm.
Oc – Conococheague Fm.
Otbr – Trenton & Black River Group Carbonates
Ob – Beekmantown Fm.

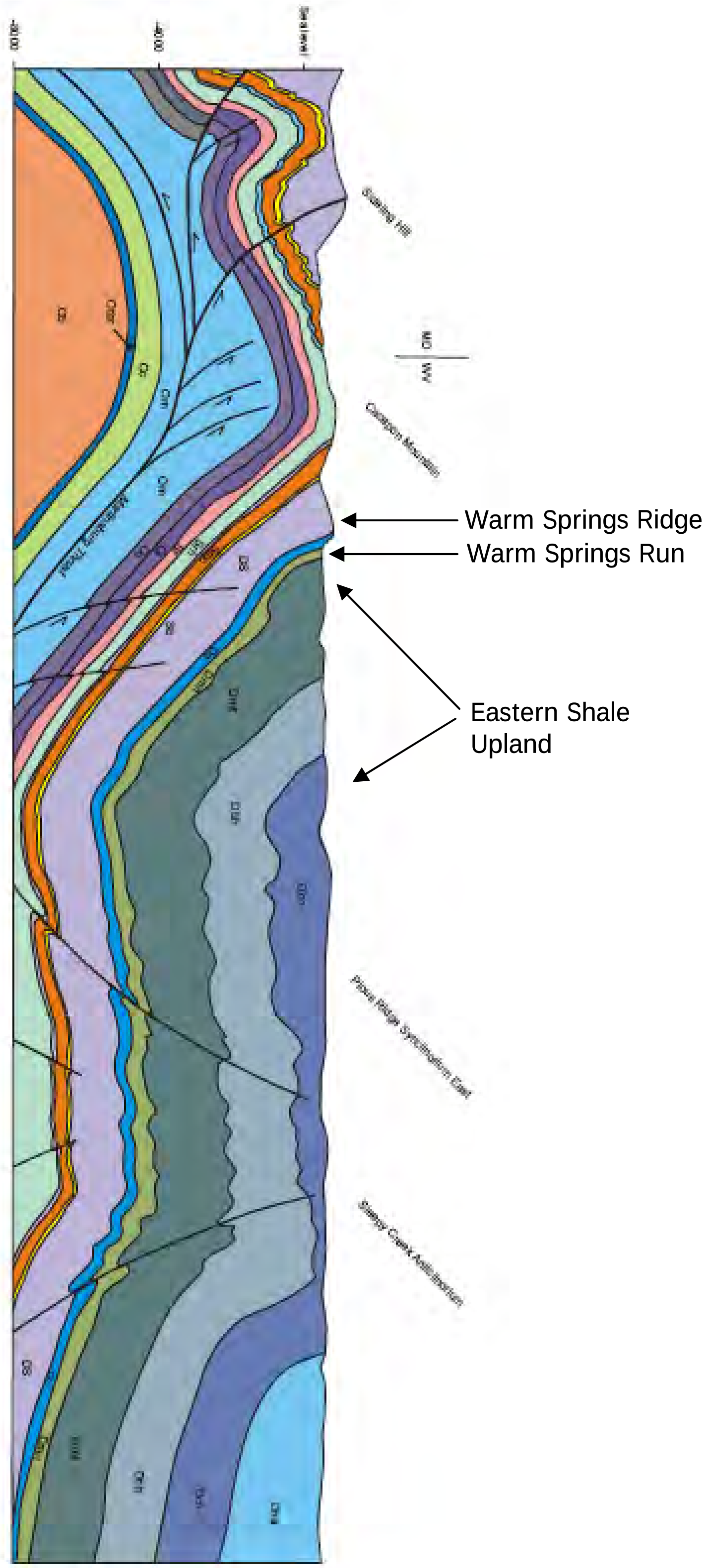


Figure 4. Cross section of the regional geology of the WSR watershed (Donovan et al, 2006).

Mapped Soils

The soils mapped within the WSR Watershed have been discussed in detail in the 2010 WSR Watershed Assessment (WSWA, 2010); however, they can be divided into four (4) broad categories:

1. **Residual soils formed by weathering from shale, siltstone and fine grained sandstone** comprise the majority of the soils in the WSR Valley and the eastern upland area. The predominant soil in the watershed, the Weikert Series, underlies over 65% of the entire area, with lesser amounts of Clearbrook and Cavode soils. These soils are very shallow, averaging only 20 to 40 inches before reaching weathered (paralithic) bedrock, and 36 to 48 inches before reaching hard, lithic bedrock. These soils can have perched water tables, ranging from 10 to 24 inches below the surface. The Weikert series soils have severe erosion potential, while the Clearbrook and Cavode soils have slight to moderate erosion potential. The Weikert Series soils have moderately low to high permeability (0.06 to 6.00 in/hr). They are generally considered very limited for the construction of septic drain fields due to seasonally elevated water tables, shallow bedrock, and high permeability. These soils can have a low pH due to the presence of acid sulfate derived from pyrite present in the parent material (pyritic shale).

2. **Residual soils formed from sandstone on the slopes of Warm Springs Ridge** comprise the second most common soil type in the watershed, dominated by the Shaffenaker and Vanderlip series. These soils are granular, poorly consolidated loamy sands that have severe erosion potential when their vegetative cover has been removed. These soils have been heavily denuded of fines (eluviated), with what little content of fines being transported downhill to the footslope soils. These soils have moderately high to extremely high permeability (0.6 to 19.98 in/hr).

3. **Floodplain soils,** which are composed of transported colluvium and alluvium that have been deposited in the stream valley bottomlands, include the Holly, Melvin, Coombs and Philo series. These soils have been covered or obliterated by development in much of the upstream reach (south of Berkeley Springs) of the WSR watershed. These soils have slight to moderate erosion potential. The floodplain soils have moderately high to high permeability (0.6 to 2.0 in/hr), are frequently flooded, and can have high seasonal water tables. Two of the soils (the Holly silt loam and Melvin silt loam) are considered hydric soils. Hydric soils are characterized by an abundance of moisture and reduced oxygen levels to the extent that the soil supports only water tolerant vegetation. Hydric soils are generally associated with wetland areas.

4. **Footslope soils** are formed by a combination of in-place weathering and the transport of fine soil components from higher elevations, and consist primarily of the Buchanan and Ernest series. These soils are higher in clay content than most of the other soils in the WSR watershed, and often have perched water tables ranging from 16 to 24 inches below the surface. These soils have moderately low to moderately high permeability (0.06 to 0.6 in/hr).

A custom soil report for the WSR watershed was obtained from the USDA-NRCS on May 16, 2012, and is included as Appendix A. A comprehensive comparison of the mapped soils to observed soils was beyond the scope of this management plan; however, during the field work for the plan development all of the observed soils compared favorably with their equivalent mapped units.

Hydrology

The Warm Springs Run is a perennial stream, with a “trellice” pattern typical of the Potomac Direct Drain system of the eastern Potomac Highlands section of the Ridge and Valley Geophysical Province. The stream’s overall course is controlled by the structure of the bedrock over which it flows, as discussed in the previous section on geology. The stream originates at a head spring at an elevation (EL) of approximately 818 feet above mean sea level (AMSL). The stream declines in elevation gradually as it flows northward, and enters the Potomac River at EL 397, just to the east of Hancock, Maryland and approximately 5-miles north of the Town of Bath. There are no sudden drops in elevation, so accordingly there are no significant waterfalls or cascades along the main branch of the WSR. The summit of Warm Springs Ridge to the west of the WSR ranges from 200 to over 400 feet above the valley floor. The highest point of the Ridge is just north of the Town of Bath, at approximately EL 1,060. The shale upland to the east of the mainstem valley ranges from EL 600 to EL 900, with an average elevation of 800 feet AMSL.

Figure 5. Map showing the upstream tributaries and flood control dam locations. The dams are assigned unique identifiers based on the original proposed number of nine (9) dams. Dam #8 was never constructed.

As is typical of the surface streams in the rugged Potomac Highlands, the WSR has a modest perennial base flow[2], but is prone to severe flash flooding after major rainfall events, rapid snowmelt, or a combination of the two. In an effort to control the flash flooding of the main valley nine (9) dams were proposed for the upstream portion of the watershed. Between 1955 and 1961, eight (8) of the nine proposed dams were constructed on various tributary streams throughout the watershed (see Figure 5).

[2] The stream base flow of Morgan County has not been measured as of this report's date.

The dams control runoff from approximately 1,271-acres, and are designed to detain 278 acre-feet (90 million gallons) of water.

The flood control dams managed to mitigate the catastrophic flash flooding that has occurred along the main branch of the WSR since historic times; nevertheless, the WSR is still prone to flooding after major surface flow events. The flood control dams moderate less than 20% of the stream's flow, and rapid runoff as a result of both tropical storms and combined snowmelt/rainfall since that time has continued to cause flooding in Berkeley Springs and the Town of Bath. Storm events greater than 1-inch of rain can cause sheet flow off the steep ridge to the west of town, and the upland to the east; this flow is exacerbated by the fact that these events often occur after the regional soils have been saturated by prior rain or snowmelt. Under such conditions, even permeable soils will shed the water, and the WSR then becomes the primary drain for the valley and its environs.

Stream Channel Modification - Examination of historical topographic maps (Hancock, 1901 – surveyed 1899) suggests that the course of the Warm Springs Run and its tributaries has changed little over the past century. An excerpt of the historic topographic map is included as Figure 6.

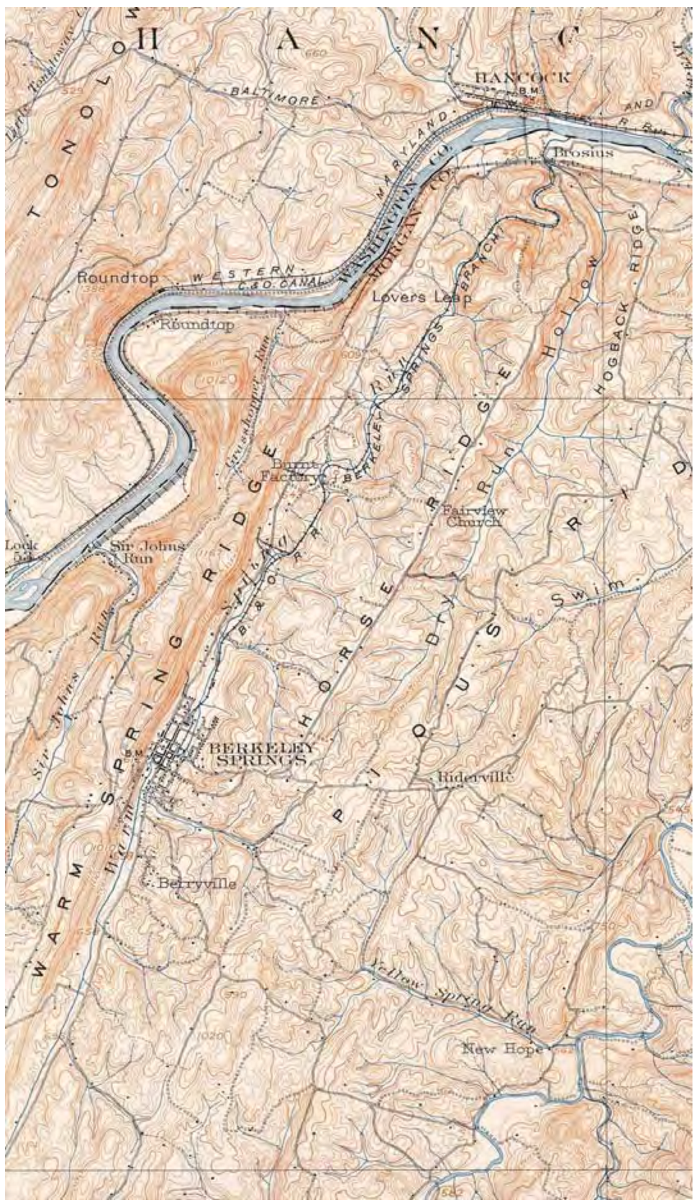


Figure 6. Excerpt of the 1901 Hancock Topographic Quadrangle.

Groundwater - The WSR derives its groundwater base flow from two very different sources, these being: 1) a series of headwaters springs located entirely within the Devonian shale formations, and 2) the Warm Springs themselves, which arise from the Oriskany Sandstone at the east-central base of the Warm Springs Ridge.

The headwater springs are nearly all diffuse rises without a discernable "throat" or discreet opening from the subsurface. Many appear as marshy or swampy wet "areas", and are not readily recognizable as "springs", per se. These springs are recharged by small water-bearing fractures in the bedrock. Water which initially collects in a shallow aquifer that reposes in the soil and weathered rock overburden layer diffuses slowly into the underlying bedrock aquifer through a myriad of tiny cracks and openings. The springs generally rise where there is a contact between different lithologies in the bedrock, often where a less permeable rock type (solid shale, siltstone) contacts a more permeable rock (fractured shale, sandstone, etc.), or where there are small faults or disconformities in the bedrock stratum. It is of note that as it percolates through the strata on its journey to the springs the groundwater picks up various minerals and metals that are present in the bedrock, resulting in the occurrence of "chalybeate" (iron bearing) springs which are often mistaken as sources of contamination due to reddish "slimes" and discoloration coming from the spring rise. These slimes and sheens are due to the presence of naturally occurring iron and sulfur fixing bacteria, which utilize the dissolved iron in their metabolisms. The reddish colors around the spring heads are the result of the iron being oxidized as it comes into contact with the atmosphere.

The eastern tributaries have a low base flow. While this flow has not been measured to date; our field observations did not show any flow greater than 20 to 30 gallons per minute (gpm) during April 2012 in any of the tributaries. The WSWA measured various stream parameters, including flow, during the period of April through June, 2010. Locations of the WSWA monitoring points are shown on Figure 7.

The greatest contributors to the base flow of the WSR are the Warm Springs located in Berkeley Springs State Park. The springs arise from five (5) discreet conduits in the Oriskany Sandstone, at the base of the eastern face of Warm Springs Ridge. The combined flow of the springs is variable, but nominally is reported as averaging 1,000 gpm. The springs were monitored in a groundwater study from November 2005 through March 2006, and the combined flow from the Ladies Spring and Lord Fairfax Spring (two of the five spring rises) varied from a high of 1,930 gpm to a low of 538 gpm (Donovan, et al., 2006). It is interesting to note that the flow at the Warm Springs varied in concert with the flow of Tonoloway Spring (also called the Suburban Bottling Spring), located in the Cold Spring Valley on the western side of Warm Springs Ridge.

Over the years there have been several attempts by hydrologists to locate the recharge area of the Warm Springs; however, the exact location of the recharge area has yet to be established. A study by the USGS in 1994 proposed that 2/3 of the recharge occurred along and on the Warm Spring Ridge, extending at least 11 miles south of the Town of Bath (Lessing and Hobba, 1994). This study also concluded that the temperature of the springs (averaging 74.5^o F) suggests the water circulates to a minimum depth of 1,825-feet below the surface. Tritium isotope analysis of the Warm Springs indicates that the majority of the water is at least 30 years old.

In contrast, the 2006 study (Donovan, et al., 2006) examined the geochemistry of the Warm Springs, as well as the flow rates in a series of springs located west of Warm Springs Ridge. This study established that the water chemistry of the Warm Springs more closely matched springs arising from carbonate (limestone/dolostone) aquifers, in particular the karst Helderberg Limestone and Tonoloway Formation, lying between Warm Springs Ridge and Cacapon Mountain. The Warm Spring differed significantly from the springs originating in regional clastic rock (sandstone, shale, etc.) aquifers. The Warm Springs' flow rate also varied in parallel with the carbonate springs, in particular the aforementioned Tonoloway Spring. These data suggest that the Warm Springs must have a recharge zone that extends beyond the Warm Spring Ridge, and may stretch as far as the eastern slope of Cacapon Mountain (see Figure 4).

Figure 7. Level 1 Stream Survey sampling and observations points being monitored by the Warm Springs Run Watershed Association, with discharge rates measured during the late Spring and Summer of 2010.

Section A - Sources of Impairment in the Warm Springs Run Watershed

Along with all of the other jurisdictions with waters flowing into the Chesapeake Bay, West Virginia has been assigned a Cap Load. The combined Cap Load for all of the jurisdictions represents an overall pollution "diet" that the Chesapeake Bay requires to become healthy again. WV's Cap Load is a "calorie limit" for nitrogen, phosphorus, and sediment limits for WV's portion of the Potomac Basin. For each of these pollutants WV must develop a strategy to reduce the current pollutant load down to the level of the Cap Load as well as derive a strategy on how that Cap Load will be maintained. To do this, we must first know what the current load is, what the future loads will be, and which pollutant sources are responsible for generating those loads (WV-WIP, 2012).

The Chesapeake Bay Program has determined that many of the actions West Virginia is taking to attain the nitrogen and phosphorus Cap Loads will also reduce sediment pollution in West Virginia's rivers and streams sufficiently to achieve the sediment Cap Load for the Bay. Therefore, West Virginia WIP strategies are provided only for nitrogen and phosphorus.

Current and future pollutant load estimates are generated by the Chesapeake Bay Watershed Model (CBWM) and broken down into land uses (sources) and locations. Examples of land use are pasture and developed land. Each of these land uses has a pollution load associated with it (Figure 8). The location part of the equation can best be thought of as a watershed, or all the land area that drains to a particular body of water.

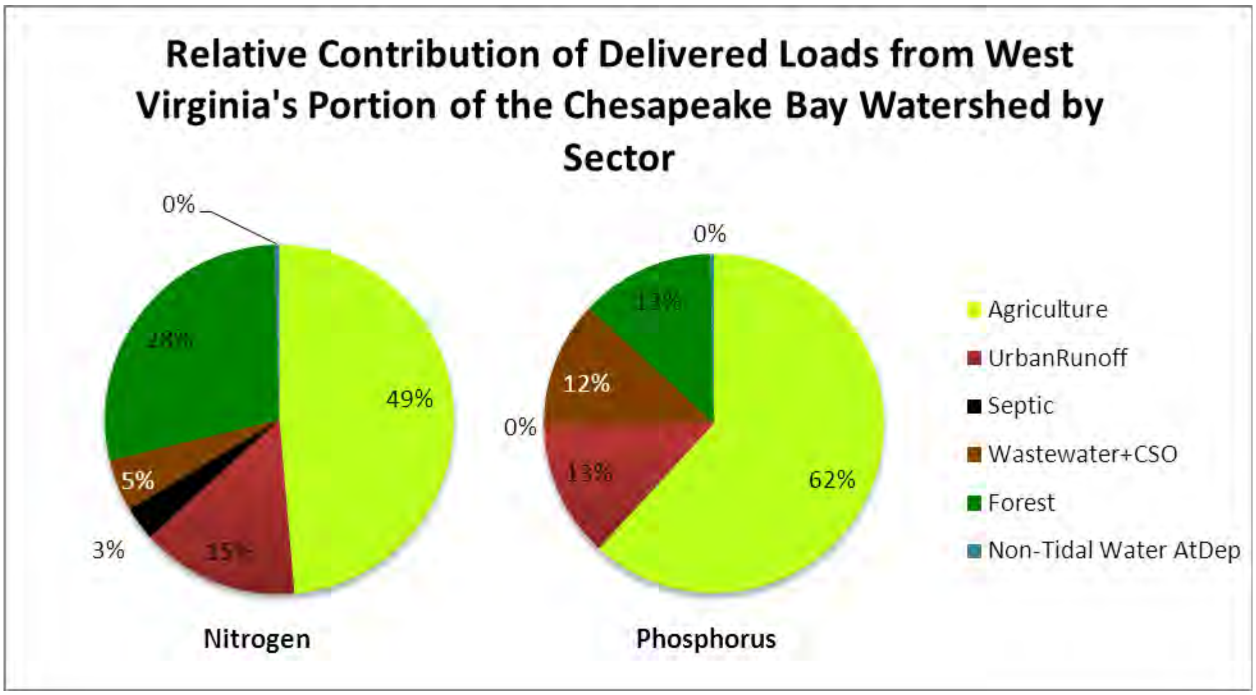


Figure 8. Delivered nitrogen and phosphorus loads from major load sectors in West Virginia. Estimates are generated by the Chesapeake Bay Watershed Model. (WV-WIP, 2012)

The pollutant sources which are responsible for generating loads are grouped into "sectors". The major load sectors in West Virginia are Wastewater, Developed Lands and Industrial (sometimes called "Urban Runoff"), Agriculture, Forest, and Other. Sources within sectors may be regulated or unregulated. Typically, point sources are regulated by National Pollutant Discharge Elimination System (NPDES) permits and non-point sources are unregulated. However, certain functionally similar sources are alternatively classified as point and non-point sources. One example is the subset of animal feeding operations identified as Concentrated Animal Feeding Operations (CAFOs) that require NPDES permits, and the subset of animal feeding operations that do not meet the CAFO size threshold and, therefore, do not require permits. Another example is permitted urban areas that have been designated as municipal separate storm sewer system (MS4) sources based on population density, and non-permitted urban areas that do not meet the population density threshold for MS4 designation. TMDLs must establish “wasteload allocations” for point sources and “load allocations” for non-point sources and background loads. Total nitrogen and phosphorus loadings used in the Chesapeake Bay Model have been calculated for the WSR and Dry Run watersheds as shown in Figures 9 and 10, however, it should be noted that these loadings were based on the land use categories shown on Figure 8, broken down specifically for the WSR Watershed.

The CBWM categorizes loads into “edge-of-stream” and “delivered” loads. An edge-of-stream load, as the term suggests, is the amount of pollutant that enters the stream in the locality of the pollutant source. A delivered load is the proportion of the edge-of-stream load that ultimately reaches the Chesapeake Bay. For nitrogen, the delivered load decreases as you get farther away from the Bay due to in-stream biological processes that convert available nitrogen to gaseous elemental nitrogen. Thus, one pound of edge-of-stream load from Jefferson County, which is closer to Chesapeake Bay, has a much greater impact to downstream tidal waters than a pound of edge-of-stream load from Morgan County, which is further away. The difference between edge-of-stream and delivered loads affects the overall cost and efficiency of implementing pollution reductions.

Based on the CBWM, the load reductions (lbs/acre) of nitrogen, total suspended solids and phosphorus needed to meet the 2025 Chesapeake Bay Initiative goals were estimated by WVDEP for the WSR watershed as shown on Table 1.

Table 1. Projected Load Reductions to meet the 2025 Goals

Total 2010NA Loads	**Total Nitrogen**	**Total Suspended Solids**	**Total Phosphorus**
Crop	19.23	789.94	1.26
Pasture	17.97	790.50	1.77
Residential	18.01	327.05	1.19
2025 Goals	**Total Nitrogen**	**Total Suspended Solids**	**Total Phosphorus**
Crop	15.74	649.53	1.09
Pasture	13.94	512.16	1.28
Residential	17.99	320.51	1.19
Reduction Needed	**Total Nitrogen**	**Total Suspended Solids**	**Total Phosphorus**
Crop	3.50	140.41	0.18
Pasture	4.03	278.35	0.49
Residential	0.03	6.54	0.01
Note – All values in lbs/acre			

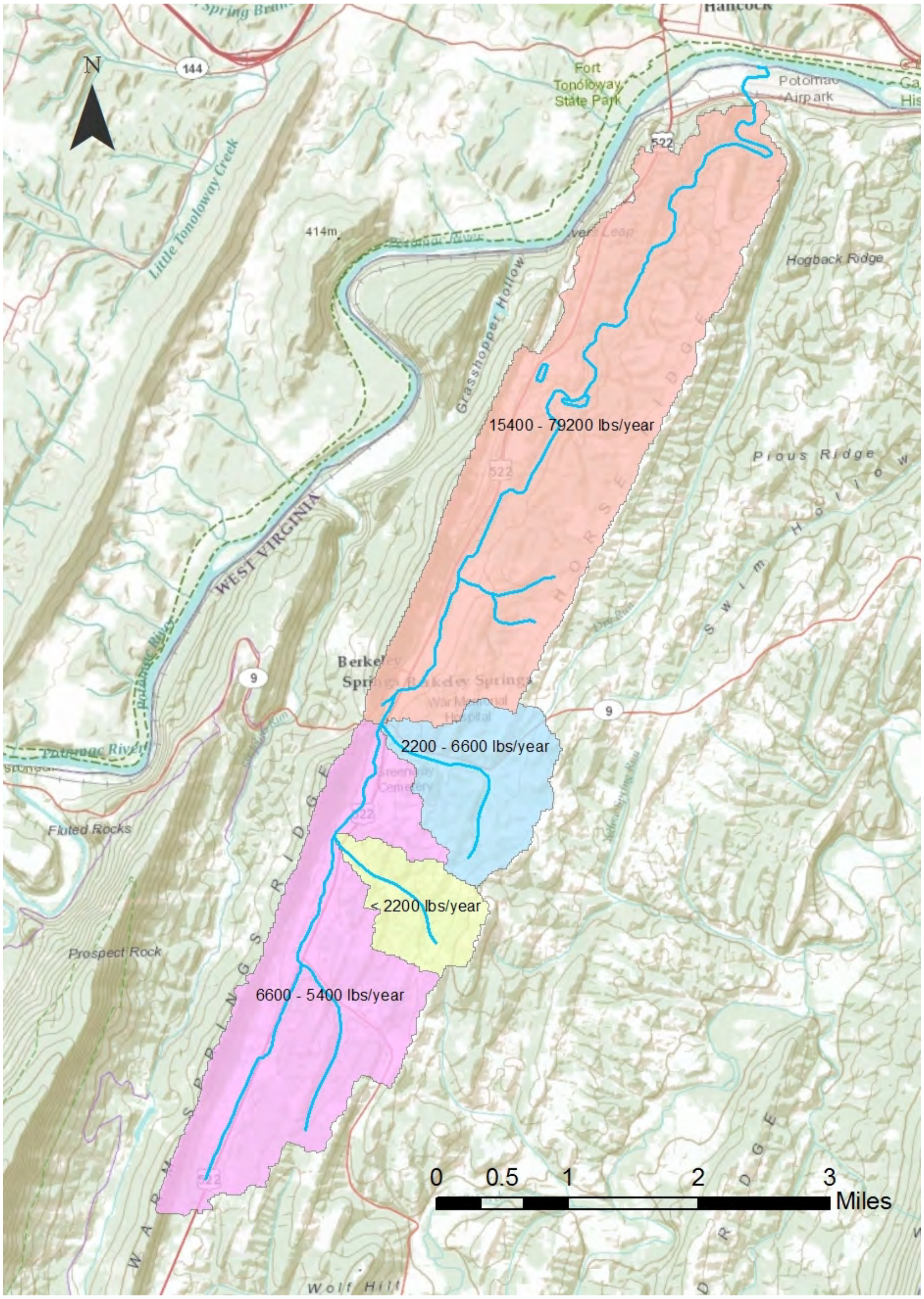


Figure 9. Nitrogen loads (per annum) estimated for the WSR Watershed based on the Chesapeake Bay Model. Individual catchment area load data were derived from the USGS Sparrow Surface Water Quality Model.

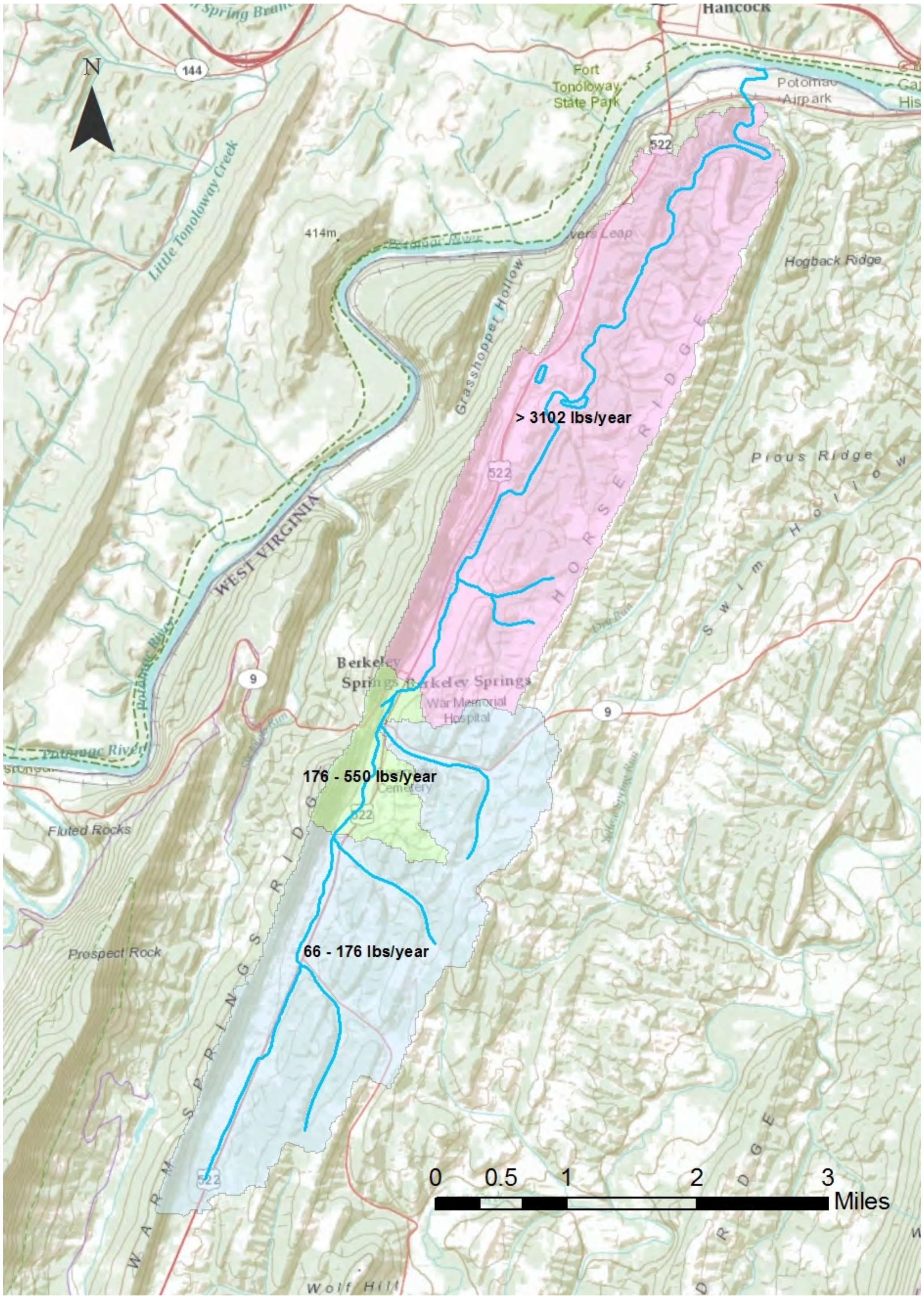


Figure 10. Phosphorus loads (per annum) estimated for the WSR Watershed based on the Chesapeake Bay Model. Individual catchment area load data were derived from the USGS Sparrow Surface Water Quality Model.

Measured Land Use – 2010 WSR Watershed Assessment

A summary of land use categories within the WSR watershed is shown on Figures 11 and 12. The majority (83.4%) of the WSR watershed is comprised of forested land and low to medium density population areas.

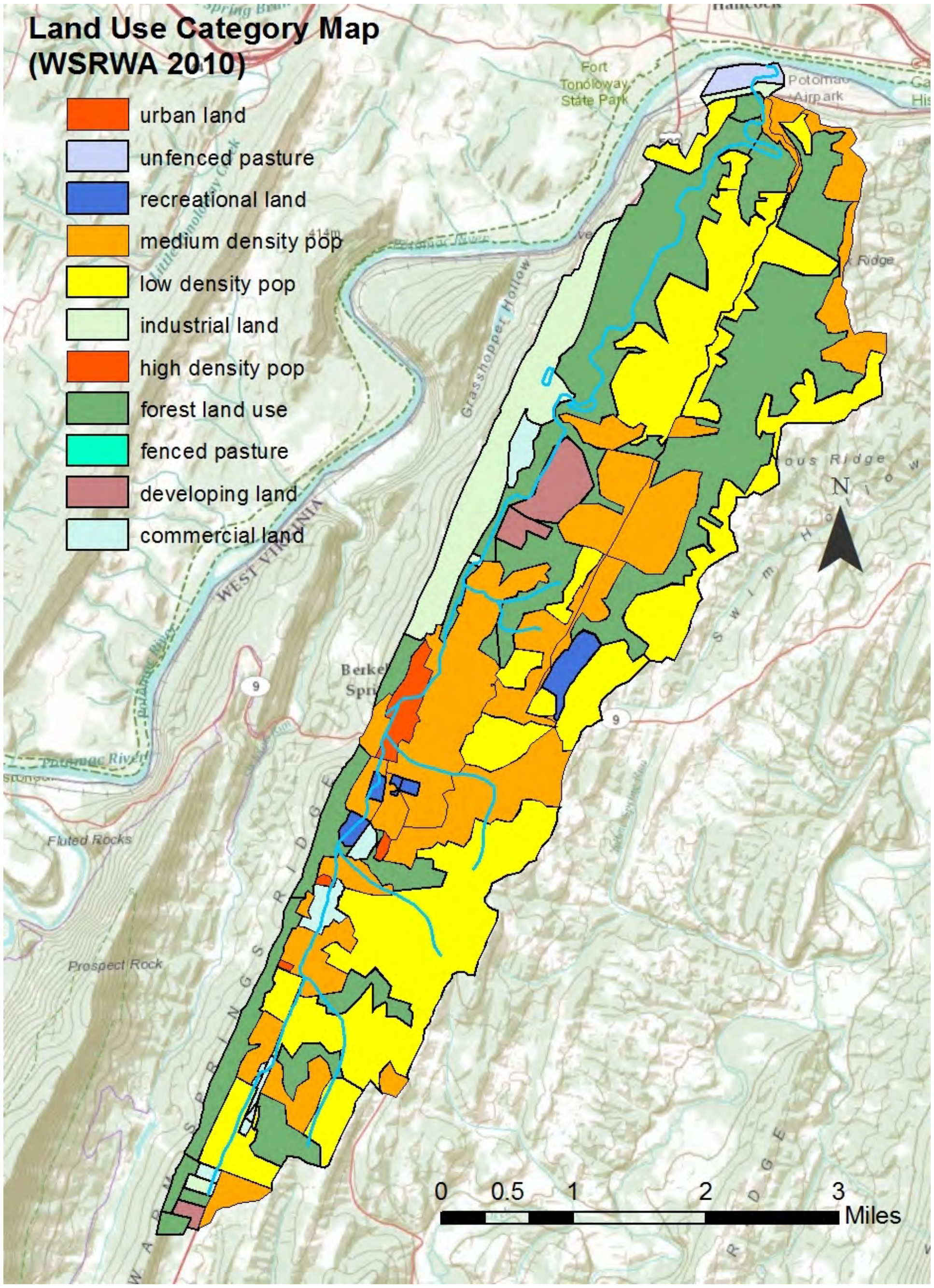


Figure 11. Land use map for the Warm Springs Run and Dry Run watersheds based on categories established in the 2010 Warm Springs Run Watershed Assessment.

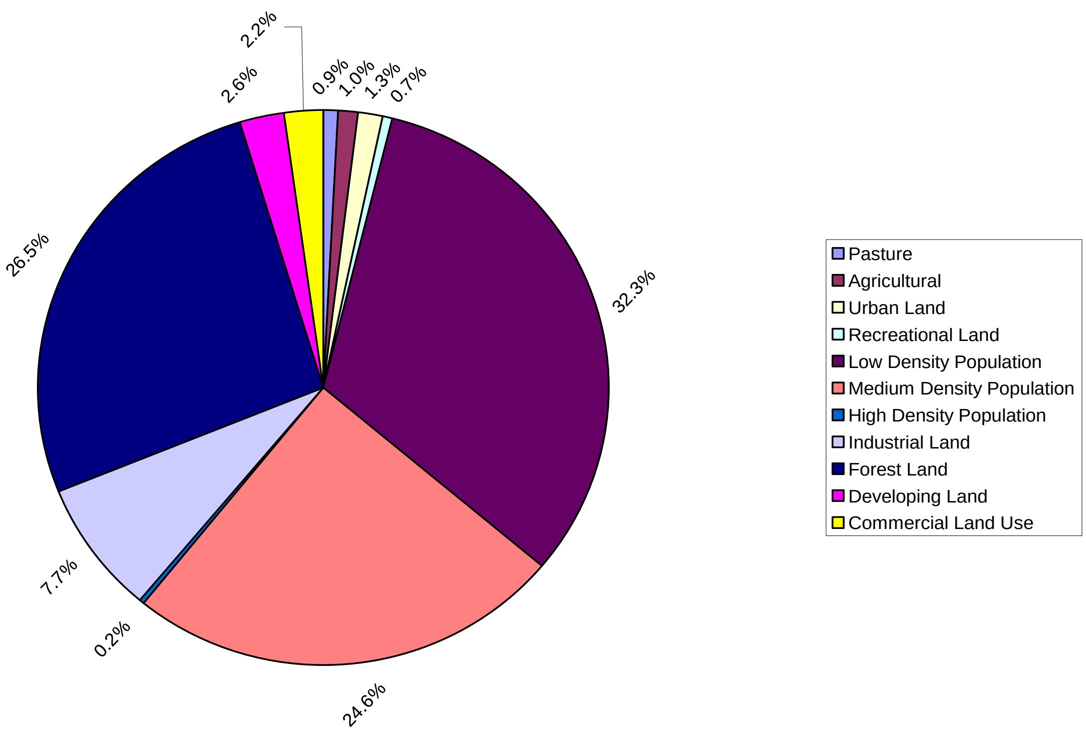


Figure 12. Pie chart showing relative percentages of major land use categories within the WSR Watershed (does not include the Dry Run watershed).

The majority of the industrial land use is occupied by what was formerly known as the US Silica mines and production facility (locally known as the “sand mine”) located north of the Town of Bath. This area comprises approximately 7.7% of the watershed. The remaining land uses (commercial, urban land, etc.) comprise less than 10% of the watershed. Agricultural lands (open pasture, livestock and row crop) comprise only 1.9% of the WSR watershed land use acreage. Thus, the WSR watershed is unique by West Virginia standards, and can be classified more accurately as an “urban/subsurban” watershed, than as one dominated by agricultural land use.

Comparison of the CBWM land use category percentages to the results of the 2010 WSR Assessment shows some significant differences, as shown on Table 2.

Table 2. Land Use Category Comparison

	CBWM (acres)	**2010 WSR WA** (acres)
Background	6,278	3,123
Construction	89	198
Crop	518	59
Extractive	336	584
Pasture	355	85
Residential/Urban	2,254	5,375

Referencing Table 1, the reductions in N, P and TSS loads are based on a significant contribution of crop and pasture to the WSR watershed’s total load; however the land use data collected during the 2010 WSR watershed assessment, and verified during the field investigation stage of this report, suggests that any reduction to loads from these sectors within the WSR watershed would probably be inconsequential in helping West Virginia achieve TMDL goals. Nevertheless, water quality and benthic assessments of the WSR have demonstrated that there are significant sources of impairment that are affecting the stream and its watershed.

Based on the estimates of land use acreage derived from the 2010 WSR Watershed Assessment data, the reductions for total N, P, and TSS were recalculated as shown on Table 3.

Table 3. Recalculated Load Reductions to Meet the 2025 Goals Based on the 2010 WSR WA Land Use Acreage Summary			
Total 2010NA Loads	**Total Nitrogen**	**Total Suspended Solids**	**Total Phosphorus**
Crop	168.85	6,933.06	11.11
Pasture	75.06	3,300.79	7.4
Residential	7.56	137.15	0.5
2025 Goals	**Total Nitrogen**	**Total Suspended Solids**	**Total Phosphorus**
Crop	137.62	5,681.01	9.5
Pasture	56.51	2,075.79	5.18
Residential	7.84	139.7	0.52
Reduction Needed	**Total Nitrogen**	**Total Suspended Solids**	**Total Phosphorus**
Crop	31.23	1,252.05	1.62
Pasture	18.55	1,225.00	2.21
Residential	-0.28	-2.55	-0.01
Note – All values in lbs/acre			

As can be seen by comparison with Table 1, the loads per acre are significantly higher for all three land uses, because of the difference in acreage within the watershed in comparison with the estimated acreage used as an input for the CBWM. Nevertheless, the baseline for individual non-regulated agriculture operations, inclusive of manure transport, is 21% N and 29% P edge-of-stream reduction from 2010NA loadings. The specified reduction rates were determined by the average reduction from 2010 NA prescribed for the agriculture sector exclusive of the CFO land use in the final Phase II WIP 2025 model scenario. Therefore, the actual reduction necessary to comply with the WV WIP 2025 goals will need to be recalculated based on input of the revised land use acreage determined in the 2010 WSR WA.

Impairment of the WSR Watershed

Referencing the West Virginia 2012 Draft Section 303(d) List prepared by the West Virginia Department of Environmental Protection (WVDEP), the Warm Springs Run[3] (identified as WVP-10) is listed as an impaired stream within the Potomac Direct Drains Watershed (HUC# 02070004). Figure 12 shows the sampling points at which impairment parameters were measured by WVDEP.

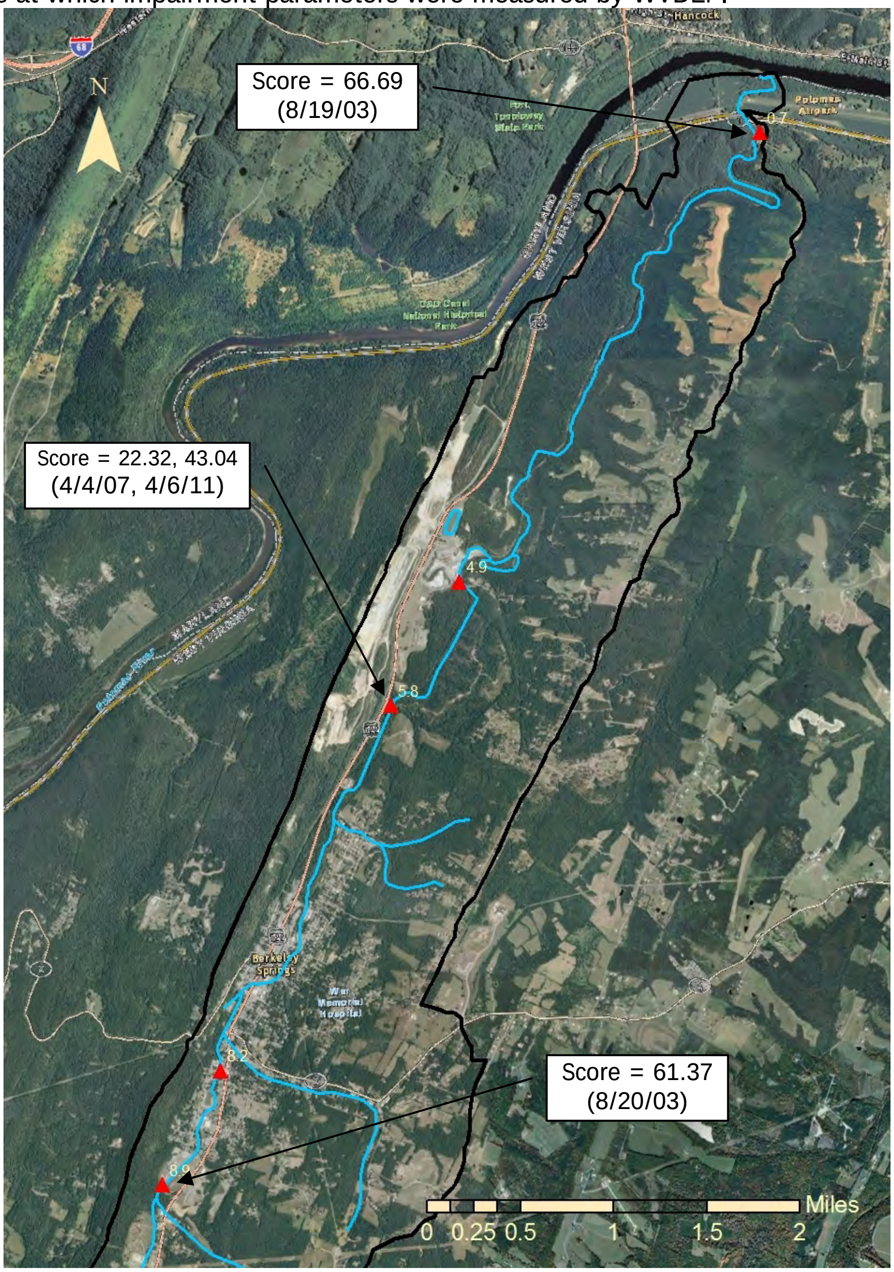


Figure 12. WVDEP Sampling Points along the Warm Springs Run, with benthic evaluation scores and sampling dates when the scores were developed. Any score above 50 is considered indicative of a healthy aquatic benthos. Sampling locations are labeled with their mile points.

The listed impairment parameters are CNA-Biological[4] (aquatic life impairment) and fecal coliform. The impaired reach is listed as encompassing 10.3-miles, reportedly the entire length of the stream[5]. The

[3] It should be noted that in the referenced report, the stream is referred to as the Warm "Spring" Run.

[4] CNA = Conditions Not Acceptable

[5] The WSR Watershed Assessment considers the length of the stream to be 11.8 miles, not 10.3 miles.

WSR was listed as impaired for CNA-Biological on the 2010 Section 303(d) List, but not for fecal coliform, which was added to the 2012 list. Sources of both impairment factors (i.e. CNA-Biological and fecal coliform) are referenced in the 2012 List as "unknown". Total Maximum Daily Load Values for the WSR have not been established yet, and are projected to be developed no later than 2021.

It is of note that the most heavily impaired sampling station measured by WVDEP was located at Mile Point 4.9, approximately 4-miles downstream from the Town of Bath, and approximately 1.3 miles downstream from the Warm Springs Public Service District Water Treatment Plant. Water quality parameters were also measured at the other mile points, but benthic scoring was not performed for any but the sites indicated as scored on Figure 12.

Fecal coliform colony counts were determined at all five sampling points, and selected results or equivalent (comparable) dates are shown on Table 4.

Table 4. Selected Fecal Coliform Results for WVDEP Mile Point Stations

Sample ID	**Mile Point**	**Sampling Date**	**Value** (colonies/100 ml)
33708	**0.7**	**4/3/07**	**500**
34346	0.7	6/26/07	168
34660	**0.7**	**7/24/07**	**420**
35196	**0.7**	**8/16/07**	**2,400**
36137	**0.7**	**9/27/07**	**1,000**
36149	0.7	10/17/07	320
47703	**0.7**	**10/27/09**	**1,100**
33709	**4.9**	**4/3/07**	**500**
34347	**4.9**	**6/26/07**	**600**
34661	4.9	7/24/07	220
35197	**4.9**	**8/16/07**	**2,400**
35425	4.9	9/6/07	350
36138	4.9	9/27/07	172
36150	**4.9**	**10/17/07**	**550**
47708	4.9	10/27/09	60
33710	5.8	4/3/07	300
34348	**5.8**	**6/26/07**	**1,950**
34662	5.8	7/24/07	270
35198	**5.8**	**8/16/07**	**>60,000**
36139	5.8	9/27/07	300
36151	**5.8**	**10/17/07**	**2,700**
47713	5.8	10/27/09	113
33711	8.2	4/3/07	100
34349	**8.2**	**6/27/07**	**4,400**
34663	**8.2**	**7/24/07**	**1,250**
35119	**8.2**	**8/16/07**	**>60,000**
35427	**8.2**	**9/6/07**	**440**
36140	8.2	9/27/07	230
36152	8.2	10/17/07	320
47703	**8.2**	**10/27/09**	**1,100**
Note – Samples in **bold** exceed the West Virginia Water Quality Standard of 400 colonies/100 ml			

As can be seen from the data shown on Table 4, wide variation in values for fecal coliform colonies was observed throughout the sampling period. The data for August 16, 2007 showed a consistent high spike in the coliform data, starting well upstream at Mile Point 8.2, and extending along the entire length of the run. Historical meteorological data records show there was approximately 0.5 inches of rain the day the samples were collected; however, it is unknown whether this may have affected the reported fecal coliform test result.

Similarly, the WVDEP study showed that elevated levels of total N, P, and TSS were observed during the water quality analysis phase of the impairment evaluation, as shown on Table 5.

Table 5. WVDEP WQ Sampling Events - Total N, Total P and TSS					
Sample ID	**Mile Point**	**Sampling Date**	**Total N** (mg/liter)	**Total P** (mg/liter)	**TSS** (mg/liter)
47703	0.7	10/27/09	0.72	0.12	<2
47705	4.9	9/1/09	0.69	NA	<2
47706	4.9	9/8/09	0.84	0.07	NA
47708	4.9	10/27/09	0.83	0.35	<2
47710	5.8	9/1/09	0.86	0.57	3
47718	8.2	10/27/09	0.86	<0.01	<2

The actual load delivered to the Potomac River from the WSR can be inferred from the 10/27/09 data point (Sample ID 47703) shown on Table 4 above. These data were collected when the stream was at normal flow conditions, based on regional climatic records. Discharge rate of the WSR at this sampling point during base flow conditions was measured by the WSR Watershed Association at approximately 14.5 cfs, so the delivered loads of N and P can be calculated as follows:

Total Nitrogen delivered load on 10/27/09 @ mile point 0.7
0.72 mg/l x 14.5 cfs = 292 mg/sec (conversion = 28 liters/cf)
292 mg/sec x 60 = 17.52 g/min
((17.52 x 60) x 24) x 365 = 9,208 kg/year (or) **20,300 lbs/year**

Total Phosphorus delivered load on 10/27/09 @ mile point 0.7
0.12 mg/l x 14.5 cfs = 48.7 mg/sec
48.7 mg/sec x 60 = 2.92 g/min
((2.92 x 60) x 24) x 365) = 1,534 kg/year (or) **3,381 lbs/year**

These loads are much lower than the values which have been inferred for the WSR based on the land use category breakdown in the CBWM. Nevertheless, a significant load of both nitrogen and phosphorus is being delivered annually by the WSR to the Potomac River, and contributes to the TMDL for West Virginia in general. In addition, the WSR has been shown to have significant impairment due to the presence of elevated levels of fecal coliform bacteria, and CNA-biological (due to organic enrichment and sedimentation).

Probable Origin of Measured Impairments

Fecal Coliform – Like many communities in the Potomac Highlands region, only a portion of the residential and commercial properties within the WSR watershed are served by a municipal sewer system. The WSR watershed area is served currently by the Warm Springs Public Service District (WSPSD), and the extent of municipal sewer coverage is shown on Figure 13.

Structures not served by the WSPSD were estimated based on evaluation of recent aerial photography, cross-referenced with the USGS 7.5-minute Topographic Quadrangles (Bath, WV; Hancock, MD-WV). Based on these data, there are approximately 308 structures not currently served by the municipal sewer system. The location of these structures is shown on Figure 13.

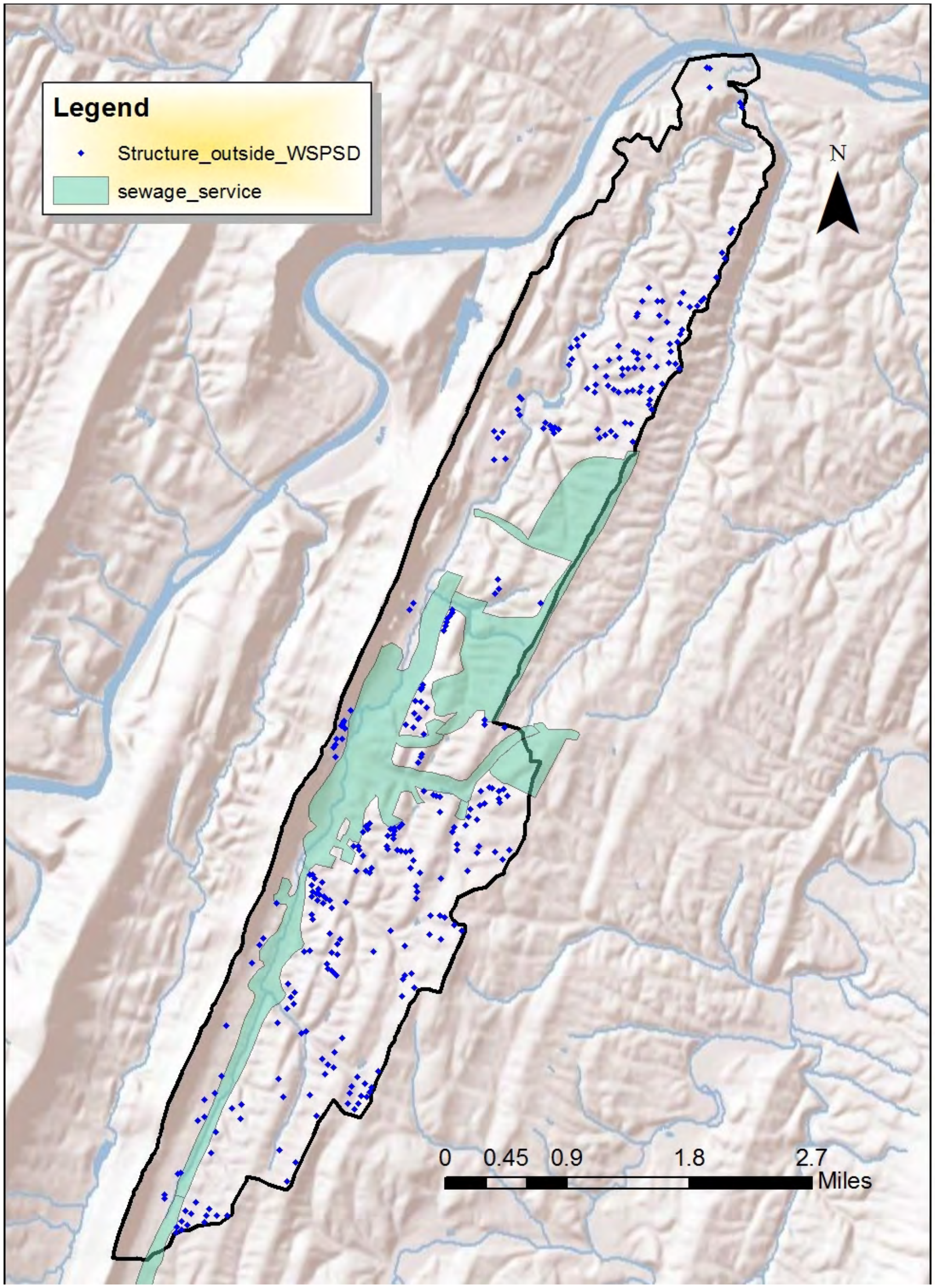


Figure 13. Coverage area of the WSPSD sewer system and locations of structures (blue diamonds) inferred to be served by private sewage disposal systems (i.e. septic drainfields).

It is of note that typically, 1% to 5% of any septic system fail within the first year of operation (USEPA, 1993). Our assessment has revealed that 85% of the septic systems in the WSR watershed are more than 30 years old, which suggests that nominally at least 30% to 50% of these systems (even under ideal conditions) have failed or are failing. In addition, based on USDA-NRCS soil survey data (Appendix A), all of the soils within the WSR watershed are considered of limited suitability due to seasonal high water tables, shallow bedrock, low cation exchange capacity and seepage from the base soil layer.

One of the characteristics of the shale residual soils that dominate the WSR watershed is the occurrence of numerous ephemeral "wet weather" springs. These ephemeral springs become active only after rainfall or snowmelt events, when water that collects just above the lithic (hard) bedrock stratum finds pathways to the surface through high permeability substrata within the residual soils. Rainfall events of 1-inch or less can activate these springs, and if there has been an extended period of higher than normal precipitation with soil saturation even seemingly insignificant rainfall quantities (<0.25 inches) can cause them to begin flowing. The majority of the ephemeral springs are located along the various tributary valleys, and even in "dry" swales that form the trellis of catchments leading to the tributary reaches. It is notable then, that many of the roads in the WSR utilized the tributary valleys and swales as convenient routes to ascend onto the shale uplands to the east of the WSR's main stem. Accordingly, many homes were built along these roads, especially in the tributary valleys and swales south of the Town of Bath. Thus, any sewage effluent which percolates rapidly through the marginal soils would be expected to collect in the weathered bedrock stratum and would be flushed out after rainfall events as the ephemeral springs become active. This may account for the unusually high fecal coliform counts seen in the upper half of the WSR, during the 0.5 inch rainfall event that occurred during the DEP sampling event of 8/16/07 (Table 4). Similarly, relatively high total N values were seen far upstream on the WSR during the 10/27/09 sampling event shown on Table 4. Thus, at least some of the distribution of nutrient loads and pathogens seen in the WSR can probably be attributed to private sewage disposal systems, and the physical and hydrological properties of the soils in which these systems are located.

In summary, even under the best of conditions a fully functional conventional septic system can only be expected to remove 28% total N, 57% total P, and 72% total suspended solids (TSS), respectively (USEPA, 1993). Thus, if a large percentage of the septic systems within the WSR watershed are failing or have failed, or have been installed in unsuitable soils, then their contribution to nutrient loading and fecal coliform counts may be significant. It is not unreasonable to assume that nearly all of the conventional septic systems within the WSR watershed are failing, or have failed, based on the USDA-NRCS soil survey data.

<u>Sediment</u> – Sedimentation of the WSR and its tributaries is probably the major factor contributing to the CNA-Biological impairment observed in the benthic assessment conducted by WVDEP. It is interesting to note that the reduction of sediment load within a watershed also results in accordant reduction in both total N and P loads (WIP, 2012; Simpson and Weammert, 2009). Thus, any strategy to reduce sediment load will help to reduce nutrient loads as well.

Four major sources of sedimentation have been identified in the WSR watershed:

1) Streambank Erosion – The 2007 WSR Stream Corridor Assessment and the subsequent 2010 WSR Watershed Assessment both identified significant areas of stream bank erosion. Many of these areas are located in the reach of the WSR's main stem located upstream from the Town of Bath, and are associated with areas where there is insufficient vegetated buffers and/or direct impact on stream flow by infrastructure objects (e.g. bridges, culverts, manholes, etc.) placed in or adjacent to the stream channel. Removal of stream bank vegetation also contributes significantly to erosion and transport of sediment.

2) Uncontrolled Stormwater Runoff – Urban and developed area runoff increases flow velocity in the stream, by "dumping" stormwater directly into the channel. The Berkeley Springs area does not have a centralized storm sewer system, and all stormwater either drains as sheet flow from impervious surfaces such as paved parking lots, roofs, and roads, or is collected by drop inlets and dumped into the WSR via drain pipes. In many cases, even the so-called "pervious" areas such as gravel parking lots function as impervious surfaces due to compaction of the soil and overlying gravel layers. It is not surprising that there is a close association of impervious surfaces and reaches of the WSR where the stream has become deeply incised or "entrenched" and disconnected from its flood plain (Figures 14 and 15).

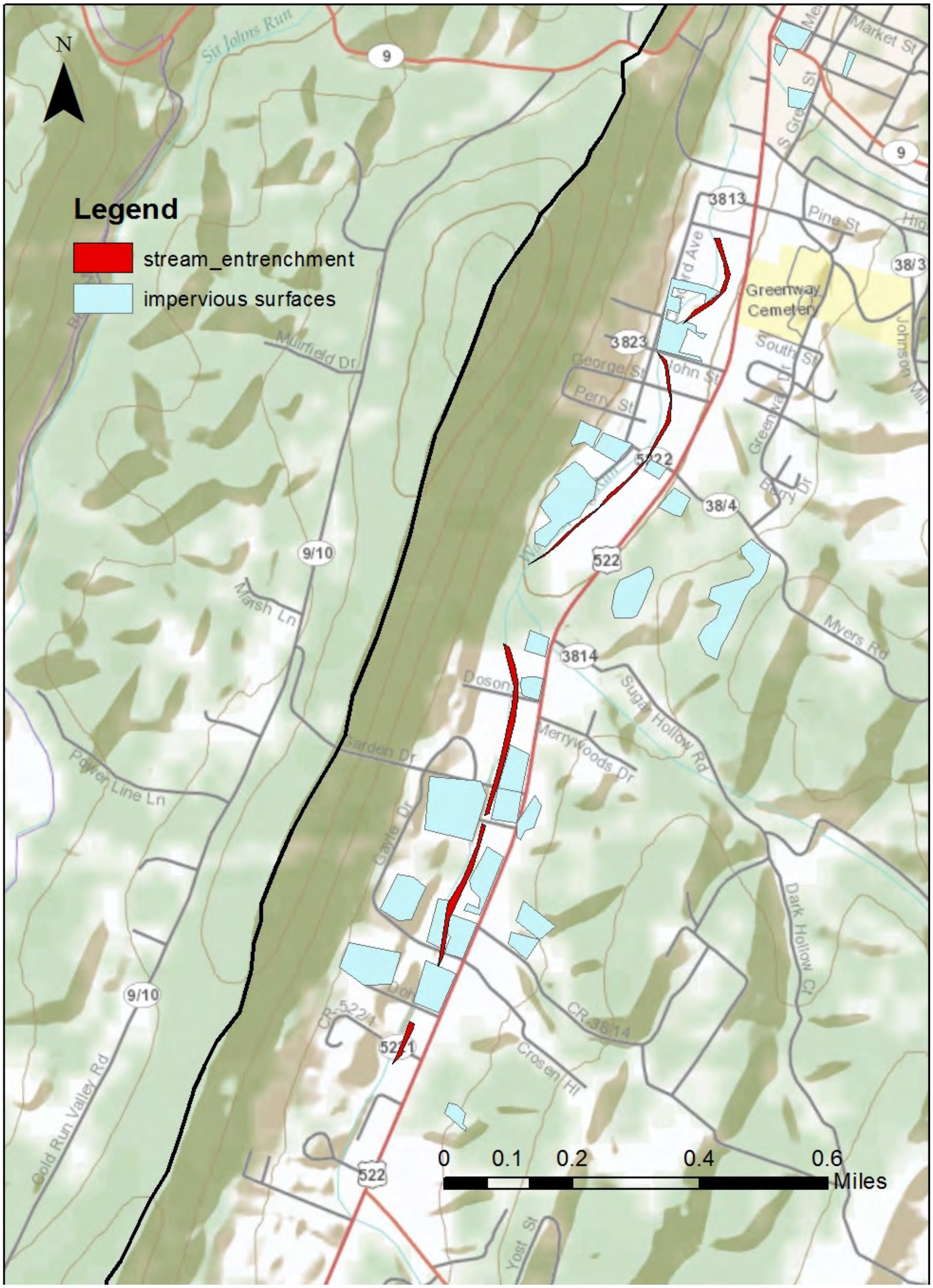


Figure 14. Map showing areas of stream entrenchment (incision) occurring along the WSR channel upstream (south) from the Town of Bath. Relative entrenchment was determined by examination of digital elevation models and verified in the field. Note the association of areas with impervious surfaces and the adjacent stream entrenchment.

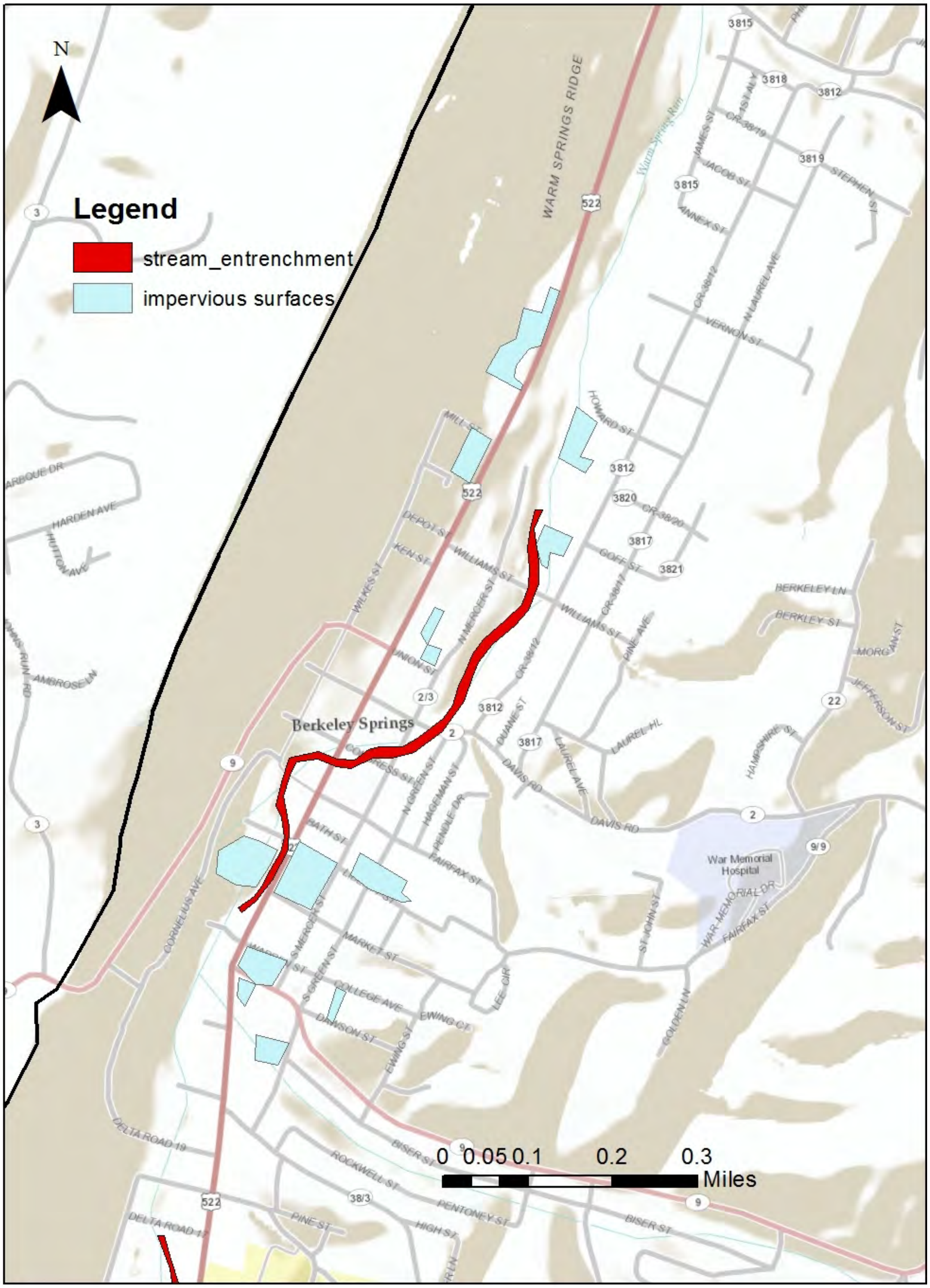


Figure 15. The route of the deeply entrenched WSR as it passes through the central and northern part of the Town of Bath.

It is of note that the WSR north (downstream) from the Town of Bath enters a primarily forested reach, and continues within this forested area nearly to its confluence with the Potomac River. Along this entire stretch there is little evidence of deep entrenchment and/or stream bank erosion, except where infrastructure (mainly roadway bridges) crosses the stream. In many ways, this area probably represents the condition of the entire WSR prior to historical development. It's also of note that although the flood control dams located on the eastern tributaries have helped mitigate the catastrophic flooding the Town of Bath experienced prior to their construction, nevertheless the reduction in flooding has contributed to the stream entrenchment and erosion seen in the WSR's main stem. During flash flood events an undisturbed stream tends to spread out into its floodplain, distributing much of the transported sediment along the floodplain's surface where it enriches the existing soil and nourishes plant life. What sediment is deposited on the stream's bed is usually flushed out and/or incorporated into the streambed's existing structure.

When a catchment area has been modified by both detention structures (such as the flood control dams) and the addition of impervious surfaces and uncontrolled stormwater disposal, the stream channel begins to "detach" itself from its floodplain and becomes entrenched. Thus, the entire sediment load that is disgorged from upstream is carried along the channel, and either is flushed out as suspended solids into the receiving water body (in this case the Potomac River), or settles to the bottom of the channel. This excessive quantity of sediment (which ordinarily would be deposited on the floodplain) results in unnatural conditions on the stream bed, negatively impacting the health of the stream's benthic community. Finally, stormwater that flows into the stream either as sheet flow or from piping, carries with it sediment, chemical contaminants (e.g. oil, grease, salts, etc.), turf grass fertilizer overspread, animal feces, and organic trash that accumulates on the impervious surfaces, further compromising the benthos as it destroys the stream's natural ecological balance and contributes to the nutrient loads.

3) Disturbed Land - Development of land for industrial, commercial, or residential usage includes activities such as clearing and grading of vegetated land. The removal of vegetation and disturbance of soil from development and construction leave soil particles exposed and susceptible to erosion by wind and water. Nitrogen and phosphorus may also be transported from development sites via adsorption to eroded soil particles or dissolution in runoff from exposed areas. Erosion and sediment control practices protect water resources from sediment pollution and increases in runoff associated with land development activities. By retaining soil on-site, sediment and attached nutrients are prevented from leaving disturbed areas and polluting streams.

The relatively steep hillsides fronting onto US Route 522 within the WSR watershed have resulted in significant cut banks being developed to make room for building footprints. In many cases, these cut banks are left denuded of vegetation due to the difficulty in establishing new plant growth. The subsoil that occurs in the residual soils of the watershed is low in fertility. In addition, the presence of pyritic shale in some areas (specifically in soils derived from the Marcellus and Needmore Formations) tends to produce acid sulfate soils in which aluminum is present in a form that is toxic to most plant life. This creates a vicious cycle, where as erosion proceeds, the lighter sediments are transported downgradient, and the weathered shale subsoil continues to erode and oxidize, thus producing more acid sulfate which inhibits plant growth on the already nutrient deficient soil. The sediment thus continues to be transported to downstream water bodies, along with the accompanying nutrients that become bound to the sediment particles.

4) Gravel and Dirt Roads – One of the most poorly understood factors contributing to stream sedimentation is runoff from dirt and gravel roads. Data is unavailable to determine the exact portion of sediment carried off dirt and gravel roads during the beginning or "first flush" of a precipitation event; however, research from other land uses suggests that first flush volumes carry the majority of sediment load in the runoff. First flush is related to factors such as the distribution of intensities during a storm, percent impervious cover, the number of dry days, and watershed area (Klimkos, et al., 2009)..

Gravel and dirt roads, parking lot and paths in the WSR watershed are typically surfaced with unwashed crusher run limestone and/or locally quarried crushed shale and sandstone. Many of these gravel roads and paths act as drainages for water flowing off of the upland areas to the east of the Run. Examination of the channel adjacent to these areas during field work for this plan revealed considerable quantities of limestone gravel and finely divided lime "dust" which had become incorporated into the channel base.

Limestone gravel was also observed as scattered point bars along the course of the Run, especially in the Town of Bath (see cover photograph).

Areas that are surfaced with locally quarried shale and sandstone can yield large amounts of sediment due to the fact that the relatively soft rock fragments are being crushed and powdered by the repeated passage of vehicles over the surface. Shale surfaced roads are the most prone to generation of transportable sediment particles, and water bodies adjacent to the regional dirt roads show high levels of turbidity following storm events as a result. Much of the shale can be reduced to particles that are so small that they become part of the suspended solid load.

Finally, roadside drainage ditches can become "traps" for sediment during light rain events. Once this sediment load is accumulated, and if the ditch is not cleaned out, during heavy rain events (>0.5 inch per hour) these ditches will disgorge their sediment load which is then transported downhill towards the stream channel.

Proposed Reductions of Measured Impairments

As mentioned previously, TMDLs will not be established for the WSR watershed until 2021; therefore, baseline and allocated loads and the reductions needed to comply with the TMDL requirements are currently undetermined. However, using a "worst case" scenario, the maximum daily load delivered to the Potomac River can be extrapolated from the data of the WVDEP benthic assessment as follows:

Table 6. Worst Case Scenario Daily Loads

Stressor	Sample ID	Date	Daily Load Delivered
Fecal Coliform	35196	8/16/10	5.8×10^{12} counts
Sediment (as TSS)	47710	9/1/09	8.0 tons

It should be kept in mind that these values are based on the highest numbers for each stressor observed during the benthic assessment study's water quality data collection events. They are probably not representative of the average daily loads, which will be determined at a future date.

It is of note that at no time during the benthic assessment sampling was TSS observed near the mouth of the WSR at levels higher than trace (i.e. < 2 mg/l). Thus, the worst case value for TSS was necessarily derived from a sample collected approximately 5.8 miles upstream from the WSR's confluence with the Potomac River. The fecal coliform sample was collected approximately 0.7 miles upstream from the confluence, and is probably more representative of the delivered load (on that date, exclusively). The lack of suspended sediment near the WSR's mouth is somewhat surprising, but implies that much of the sediment is coagulating and settling out prior to arriving at the mouth of the stream. This is not surprising, as the water arriving in the Run from the Warm Spring is highly charged with ionic calcium, which can act as a coagulant for colloidal clay particles that probably make up the bulk of the suspended sediment. It is also symptomatic that the worst benthic scores for the WSR were observed at a station near the center of the Run (mile point 5.8), but not at the 0.7 mile station just upstream from the confluence with the Potomac.

Final load reductions will not be established until 2021; however, based on the reductions called for in the Potomac Direct Drains for which TMDLs have been established (e.g. Opequon Creek, Mill Creek, Sleepy Creek, Elks Run etc.) target reductions can be inferred.

Table 7. Inferred Reductions

Source	Reduction Needed
Fecal Coliform (all sources)	100%
Sediment – (all sources)	30%

Without the benefit of baseline and allocated loads having been determined, the metrics for reduction and the relative success of the management strategies recommended herein will necessarily be derived from periodic stream monitoring. Motoring protocols and schedule are discussed in Section I.

Section B/C - BMPs or “Non-point Source Measures” Proposed to Achieve Load Reductions

The following measures and proposed Best Management Practices (BMPs) are derived from the West Virginia 2012 Watershed Implementation Plan, Phase II; the University of Maryland/Mid Atlantic Water Program Final BMP Report (Simpson and Weimert, 2009); WVDEP Stormwater Guidance Document; the Eastern Panhandle Conservation District and WV Conservation Agency; the USDA-NRCS conservation practice documents; the Chesapeake Stormwater Network Design Specifications and Technical Bulletin No.9; and the West Virginia Water Research Institute.

To Achieve Fecal Coliform Reductions From On-site Waste Treatment (Septic) Systems

Nearly all of the soils types present in the WSR watershed are classified by the USDA-NRCS soils survey as of limited suitability for septic drainfields; therefore, it can be assumed that many, if not all of the existing systems are failing or in the process of failing. Thus, the following management steps are recommended to reduce the quantity of untreated effluent that may be migrating into the shallow aquifer and subsequently to the WSR.

1) Identification and Characterization – An effort should be made to locate all private on-site treatment systems within the WSR watershed by reviewing permit data at the Morgan County Health Department. Once these systems have been located, testing should be conducted to determine if the systems are leaking or functioning properly. Two field screening techniques capable of identifying the locations of failing septic systems are the brightener test and color infrared (CIR) aerial photography. The first uses specific phosphorus-based elements found in many laundry products. Often called brighteners, they indicate the presence of failing on-site wastewater systems (Lalor et al., 1999; TWRI, 1997). The second technique uses color infrared (CIR) aerial photography to characterize septic system performance (Sagona, 1988). This method quickly and cost-effectively assesses the potential effects of failing systems. It uses variations in vegetative growth or stress patterns over septic system field lines to identify potentially malfunctioning systems. A detailed on-site visual and physical inspection will confirm if the system has failed and determine the extent of the repairs needed. County health departments or other authorized personnel may carry out such inspections.

2) Upgrade and Repair – If a system is shown to be leaking, failing or failed, then steps must be taken to repair it. If a drainfield is undersized, it may need to be expanded to a Class II drainfield, which encompasses a larger area for absorption. The services of a licensed septic installer should be engage to evaluate any systems that show signs of failure, and recommend remedial measures that will be necessary.

3) Pumpout and Maintenance – Even properly functioning septic systems can become compromised over time. A septic system management program of scheduled pumpouts and regular maintenance is the best way to reduce the possibility of failure for currently operating systems. A number of local agencies have taken on the responsibility for managing septic systems. We recommend that the local Health Department send residents a 5-year notification for pump-out requirements. The County may contract to have pumpout performed if the owner does not comply with the 5-year requirement and can fine or back-charge the owner for the costs of maintenance.

4) Connection to Sanitary Sewer – The Warm Springs PSD and Health Department should investigate the costs related to connecting residences that are currently served by on-site systems to the municipal sewer system. This may involve the construction of sewerage lift stations, grinders, or other infrastructure to facilitate the transport of sewerage that cannot be gravity fed to the sanitary main.

5) Non-Conventional On-Site Systems – There will inevitably be failing or failed septic systems that either cannot be repaired, or were located in soils that are not amenable to either Class I or II drainfield construction. In these cases, the use of non-conventional systems such as mounds, intermittent or recirculating sand filters, or denitrifying systems may be recommended. In addition, sites that are close together can be "clustered" and may use a centralized wastewater treatment system. Recirculating sand filters systems are recommended for this purpose, as they are ranked as having the highest efficiency in reduction of N, P, TSS and fecal coliform bacteria.

To Achieve Fecal Coliform Reductions from Pasture Sources

There is a single, 6.1-acre fenced cattle pasture located along the west side of Route 522, just south of Weber Lane and approximately 4,300-feet north of the headwater springs of the WSR. The WSR runs through the eastern portion of the cattle pasture, and the animals are allowed to move freely through and into the stream. The cattle are rotated to other sites on a regular basis.

We recommended that a fence be constructed to prevent the cattle from entering the stream. Alternative water sources should be provided to supply the livestock with necessary drinking water. In addition, a vegetated buffer strip should be established between the banks of the Run and the fenced cattle pasture. The combination of fencing and a riparian buffer has the potential to reduce fecal coliform transport to the stream by over 70% (WVCA, 2007).

To Achieve Fecal Coliform Reductions from Cropland Sources

There are two areas of cropland occurring within the WSR watershed: a 59-acre tract of row crop cultivation located just north (downstream) from Airport Lane, on both sides of the WSR; and a 79-acre tract located along the western flank of Horse Ridge on Fairview Lane, approximately 1-mile south of the intersection of Fairview Lane and River Road. Both of the crop areas have sufficient vegetated buffers in place to remove up to 50% of all fecal coliform.

The farm operators should be encouraged to develop nutrient management plans that minimize the use of nutrient sources of fecal coliform (e.g. sewage sludge, manure), while ensuring maximum yield and minimal nutrient loss.

Fecal Coliform Reductions by Wetlands

Due to financial challenges, and/or voluntary non-compliance on the part of septic system owners, it may be impossible to completely mitigate the source of fecal coliform entering the shallow groundwater aquifer supplying the WSR. It is interesting to note that one of the most effective means of reducing fecal coliform and nutrient loads from groundwater is through the protection and maintenance of wetland areas at spring rises, seeps, and tributary channels. Wetlands can reduce N, BOD, and TSS by 90%, 80%, and 80%, respectively; and pathogens by 4 Logs or 99.99% (USEPA, 2003).

Referencing the USFWS National Wetland Inventory, there are 71 jurisdictional wetlands within the WSR watershed encompassing approximately 31-acres. The majority of the wetlands are farm ponds, small impoundments, and pools lying along the WSR and its various tributaries. The flood control dam reservoirs have been sufficiently naturalized to be included as part of the wetland inventory for the watershed. In fact, these reservoir wetlands may serve to significantly reduce both fecal coliform and nutrients loads being discharged with groundwater that emerges from the tributary headsprings.

A putative wetland area that has yet to be delineated and included in the jurisdictional inventory is located at the headwater reach of the WSR's main stem. The following section describes the proposed management plan for this wetland area.

Headwaters Wetland Management Plan

Purpose and Need - The purpose of this wetland management plan is to appropriately characterize and restore to pre-alteration conditions the headwater wetland and intermittent stream system of Warm Springs Run for the purposes of improving water quality downstream. The quality of this wetland area, which is the origin o f the WSR, has an influence on the water quality of the surrounding area, including the Warm Springs Run watershed and the receiving waters of the Potomac River. Therefore, there is a need for a wetland management plan to allocate restoration resources appropriately for the headwater wetland as well as within the watershed.

Topography and Landscape Position - The headwater system of Warm Springs Run is located south of the town of Berkeley Springs, West Virginia. Valley Road (US Route 522) borders this wetland feature to the east. A steeply sloped, forested hillside forms the western border of this depressional feature. This system drains approximately 78 acres, consisting of the surrounding foothills and valley (Figure 16).

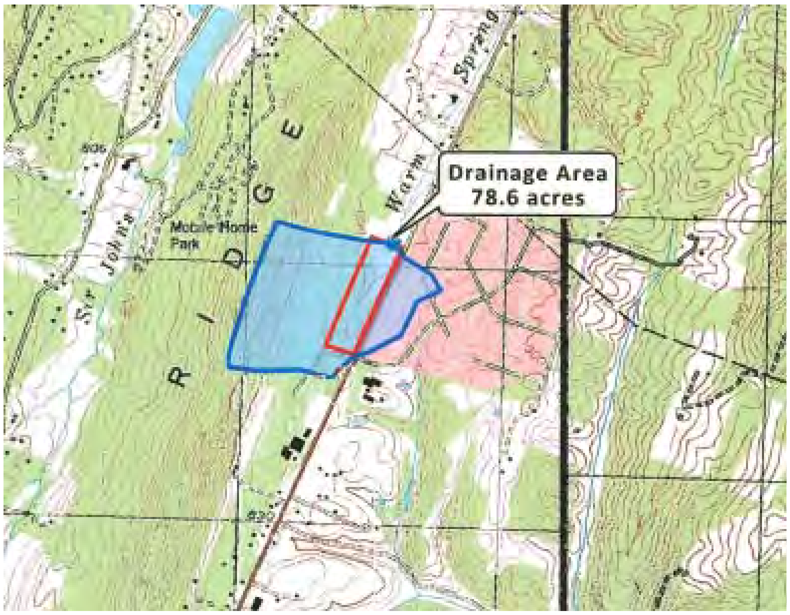


Figure 16. U.S.G.S. Quadrangle-Great Cacapon, WV-MD 2001 depicting the drainage area of the headwater system of Warm Springs Run.

Wetland Condition - Headwater wetland and stream systems perform important ecosystem services and functions and are the piping network for the transportation of pollutants downstream. As the source of streams, these wetlands have a considerable impact on the health and integrity of the downstream reaches. Restoration of this headwater system will improve water quality throughout Warm Springs Run. Table 7 provides the ecosystem services and functions of headwater wetland and stream systems.

Table 8. Ecosystem Services and Functions Provided by Headwater Wetlands
Ecosystem Services and Functions
Source of streams through groundwater discharge
Surface water retention
Stream flow control and maintenance
Nutrient cycling
Carbon sequestration
Habitat for native flora and fauna

Prior to the recent alterations to this feature, the headwater wetland of Warm Springs Run was a palustrine forested (PFO) wetland, as can be seen in the remnant PFO wetland immediately downslope and in the West Virginia Statewide Addressing and Mapping Board (SAMB) Spring 2003 Natural Color Imagery (Figure 16). The present wetland consists of scrub/shrub vegetation and is dominated by invasive species such as broad-leaf cattails (*Typha latifolia)* and Nepal microstegium (*Eulalia viminea)*. This alteration can be seen in the National Agricultural Imagery Program (NAIP) Summer 2011 Natural Color Imagery (Figure 17). A remnant PFO wetland is located immediately downslope of the altered wetland, providing evidence of what the unaltered wetland system may have looked like. Figures 17 and 19 provide a visual description of the wetland conditions on site.

Figure 16. Spring 2003 West Virginia Statewide Addressing and Mapping Board (SAMB) Natural Color Imagery. This aerial image depicts the forested study area that includes the headwater wetland of Warm Springs Run.

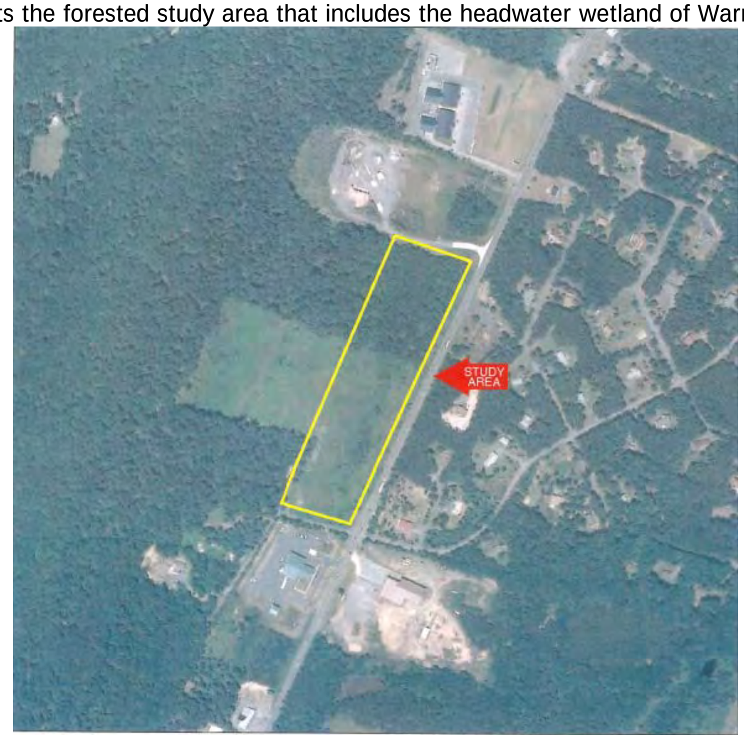


Figure 17. Summer 2011 National Agricultural Imagery Program (NAIP) Natural Color Imagery. This aerial image depicts the altered portion of the headwater wetland of Warm Springs Run. Note that the northern portion of the study area remains a PFO wetland remnant.

Figure 18. Looking south at the altered headwater wetland of Warm Springs Run. The dominant species in this area include broad-leaf cattails, Nepal microstegium, and black willow. Note that this area is dominated by invasive species and noxious weeds.

Figure 19. Looking north-northwest at the remnant PFO wetland located immediately downslope of the altered headwater wetland. This area characterizes what the original site conditions may have looked like.

The sources of hydrology for this wetland include, but are not limited to, surface water runoff, groundwater discharge, and precipitation. Indicators of wetland hydrology include saturation in the upper 12 inches of soil, redoximorphic features present in the soil, and drainage patterns.

Soils in the existing wetland are typically dark gray to gray with soil mottles, a color and condition indicative of hydric soils. The mapped soils for the surrounding area include Clearbrook-Cavode silt loams, Buchanan loam, and Berks-Weikert Channery silt loam. These soils were formed in place from shale, siltstone, and fine-grained sandstone. Although the soils in the surrounding area are not hydric, they are poorly drained and do contain hydric inclusions. This is consistent with what was observed during field work, as groundwater discharge has led to pockets of wetlands in the surrounding area.

The vegetation in this area is predominantly hydrophytic and adapted to wetland environments. A partial list of the plant species documented in the surrounding area at the time of the reconnaissance field work, along with the corresponding wetland indicator status, are listed in Table 9.

Table 9. Partial Plant Species List in Warm Springs Run Headwater System

Plant Species	Wetland Indicator Status
Acer negundo (box elder)	FAC
A. rubrum (red maple)	FAC
Amelanchier canadensis (serviceberry)	FAC
Cornus amomum (silky dogwood)	FACW
Dichanthelium clandestinum (deer-tongue witchgrass)	FAC
Eleocharis obtusa (blunt spikerush)	OBL
Eulalia viminea (Nepal microstegium) *	FAC
Fraxinus pennsylvanica (green ash)	FACW
Impatiens capensis (spotted touch-me-not)	OBL
Juncus effusus (soft rush)	FACW
Lonicera japonica (Japanese honeysuckle) *	FAC
Ludwigia palustris (marsh seedbox)	OBL
Platanus occidentalis (American sycamore)	FACW
Poa palustris (fowl bluegrass)	FACW
Quercus bicolor (swamp white oak)	FACW
Q. palustris (pin oak)	FACW
Rosa multiflora (multiflora rose)	FACU
Rubus argutus (serrate-leaf blackberry)	FACU
Salix nigra (black willow)	FACW
Sambucus canadensis (elderberry)	FACW
Scirpus cyperinus (wool grass)	FACW
Smilax rotundifolia (common greenbrier)	FAC
Typha latifolia (broad-leaf cattail)*	OBL
OBL: Obligate Wetland; plant occurs with an estimated 99% probability in wetlands FACW: Facultative Wetland; estimated 67-99% probability of occurrence in wetlands FAC: Facultative; equally likely to occur in wetlands and non-wetlands FACU: Facultative Upland; 67-99% probability of occurrence in non-wetlands	
*: These species are considered noxious weeds or are non-native invasive species.	

Stream Condition **-** A reconnaissance of the surrounding area found that the remnant PFO wetland contained braided channels and vernal pools, as can be seen in Figure 20.

Figure 20. Looking north-northeast at the shallow stream channels present in the PFO wetland located downslope of the altered wetland.

The stream channels present within this portion of the wetland are shallow, allowing for the overflow of the stream bank and settling of water in the wetland. These channels primarily provide drainage in high-flow situations, and do not become perennial until further downstream. Vernal pools are also present within this system, allowing for surface water detention as well as habitat for wildlife.

Wetland Management Design Concept

Habitat Types - The altered wetland can be restored to a forested condition in order to restore the original habitat in this area. Wetland hydrology and soils are currently present in this wetland; however, the vegetation needs to be enhanced. Scrub-shrub species will be included in the planting plan to encourage a three tiered forest canopy throughout the wetland. Existing upland habitat lacking hydric soils should be preserved and enhanced to create a 100 feet buffer surrounding the headwater wetland of Warm Springs Run.

Approach - It is suggested that planting within the headwater wetland and surrounding riparian area be conducted. However, to increase the success rate of these plantings there needs to be an invasive species management component to the planting process. Prior to planting, a preliminary treatment of invasive species should be conducted, consisting of spot applications to targeted species with a 2% solution of Rodeo, a DOW AgroSciences product with the active ingredient glyphosate. This solution will consist of three gallons of water, eight ounces of herbicide, and two ounces Methylated Seed Oil (MSO) surfactant, which is added to the solution to facilitate absorption of the product into the foliage. The targeted species for this treatment include multiflora rose, broad-leaf cattails, and Nepal microstegium.

Planting should be conducted to restore the existing wetland to a forested state as well as to enhance the existing riparian buffer. One gallon container plants should be planted at a minimum density of 400 stems per acre. Proposed species for planting are listed in Table 10.

Table 10. Proposed Species for Restoration Planting

Plant Species	Growth Habit	Wetland Indicator Status
PALUSTRINE FORESTED WETLAND		
Acer negundo (box elder)	Tree	FAC

Table 10. Proposed Species for Restoration Planting		
Plant Species	**Growth Habit**	**Wetland Indicator Status**
Amelanchier arborea (serviceberry)	Shrub	FAC
Alnus serrulata (brookside alder)	Shrub	OBL
Betula nigra (river birch)	Tree	FACW
Cornus amomum (silky dogwood)	Shrub	FACW
Platanus occidentalis (American sycamore)	Tree	FACW
Quercus palustris (pin oak)	Tree	FACW
Q. phellos (willow oak)	Tree	FAC
Sambucus Canadensis (elderberry)	Shrub	FACW
Salix nigra (black willow)	Shrub	FACW
Viburnum dentatum (southern arrowwood)	Shrub	FAC
FORESTED RIPARIAN BUFFER		
Acer rubrum (red maple)	Tree	FAC
Carya glabra (sweet pignut hickory)	Tree	FACU
C. tomentosa (mockernut hickory)	Tree	NI
Cercis canadensis (eastern redbud)	Shrub	FACU
Cornus florida (flowering dogwood)	Shrub	FACU
Ilex opaca (American holly)	Shrub	FACU
Quercus alba (white oak)	Tree	FACU
Q. prinus (chestnut oak)	Tree	UPL
Q. rubra (red oak)	Tree	FACU
Viburnum prunifolium (black-haw)	Shrub	FACU
OBL: Obligate Wetland; plant occurs with an estimated 99% probability in wetlands FACW: Facultative Wetland; estimated 67-99% probability of occurrence in wetlands FAC: Facultative; equally likely to occur in wetlands and non-wetlands FACU: Facultative Upland; 67-99% probability of occurrence in non-wetlands NI: No Indicator; insufficient information available to determine wetland indicator status		

As previously stated, to reach the goal of a restored forested wetland area, both shrub and tree species will be planted to create a three-tiered forested wetland, similar to the system immediately downslope. In addition, existing upland habitat lacking hydric soils will be preserved and enhanced to create a 100 feet buffer surrounding the headwater wetland of Warm Springs Run. Wetland and riparian seed mixes shall be dispersed in the appropriate areas for immediate ground cover after invasive species removal has taken place.

<u>Regulatory Requirements</u> - As much of this area is included in the jurisdictional waters of the US, consultation with the US Army Corps of Engineers and the West Virginia Department of Environmental Protection should occur prior to any work or replanting taking place. Additionally, the property owner must agree with proposed work as this area appears to be on private property. Furthermore, we recommend that a conservation easement be recorded to protect this system in perpetuity to ensure long term protection of this valuable resource. This will also require the permission of the landowner.

To Achieve Fecal Coliform Reductions from Miscellaneous Sources

Two sources of fecal coliform that can contribute significantly to loads are:

1) Improperly disposed animal fecal waste;
2) Illegal dumping of carcasses.

Animal feces (dogs, cats) can be a significant contributor to fecal coliform and nutrient loads in the urban setting. Fecal material that is left on streets, gutters and sidewalks in the Town of Bath will be washed directly into the WSR via the storm sewers. BMPs for reducing domestic animal waste will be discussed in the subsequent section on sediment reduction from impervious areas.

A second, less recognized source of fecal coliform (and other pathogens) results from the illegal or improper disposal of animal carcasses, primarily the Virginia White Tailed Deer (*Odocoileus virginianus*).

Deer carcasses and "gut bags" (the removed peritoneal sac and organs from a butchered deer) are often disposed of in forested areas, out of sight and at night. One of the places these carcasses are often easily disposed of is areas adjacent to roadways, or forested declivities such as stream bottoms. The remains of several deer carcasses were found in the forested area between the former concrete plant, and the Potomac Edison facility on Route 522, near the headwaters springs of the WSR. In semi-rural areas such as the WSR watershed, a surprisingly large number of deer carcasses are disposed of in this way every autumn, often in the same area.

The best way to reduce this source of fecal coliform is public education and outreach regarding proper disposal methods for animal remains, combined with strict enforcement of local and state codes regarding illegal dumping of carcasses.

To Achieve Sediment Reductions from Stream Erosion Sources

The dimension, pattern, and profile of stream channels adjust in response to changes in the contributing watershed. This can be due to an increase in runoff rates and volumes resulting from an increase in impervious area. Streams also adjust from more direct impacts, such as culverts, bridges, roads, and other infrastructure placed in or adjacent to the channels, or as a result of the removal of streamside vegetation. All of the above have played a role in contributing to the instability of sections of Warm Springs Run.

However, instability of urban stream channels can be corrected to return them to a stable condition. If the primary cause of the degradation is related to an increase in stormwater runoff, steps can be taken to reduce runoff through the provision of enhanced stormwater management (including both traditional stormwater management facilities as well as through the use of Low Impact Development (LID) techniques). Even if it were feasible to provide the necessary level of runoff reduction (which is often very difficult to achieve, especially in large watersheds), some level of stream channel restoration would likely still be required. Thus, the remaining alternative is to restore the stream channel to enable it to withstand the current flow regime and to accommodate the in-stream alterations (culverts, bridges, etc.). Various techniques are available and have been successfully employed in urban streams to return long-term stability. A discussion of these techniques is provided below.

Raising the Stream Invert

In instances where channel incision is the primary source of the instability (either as a result of in-stream impacts, such as the installation of a culvert or other infrastructure that instigates the development of a head-cut, or as a result of an increase in runoff rates or volumes), stability can be restored by raising the stream invert with a reinforced bed material that is sized to accommodate the existing shear stress. This technique, which is most often employed in conjunction with other techniques (discussed below), reconnects the stream to its floodplain. Enabling flood flows to have access to a larger cross-sectional area reduces shear stresses on the channel bed and banks and results in a healthier, more stable riparian habitat.

Figure 21 A/B - Snakeden Branch, Reston, VA. Invert raised to reconnect to the floodplain.

Cross-Vanes, J-Hooks

Cross-vanes, J-hooks, and other in-stream rock/wood structures provide grade control, direct flows away from stream banks, dissipate energy, and improve in-stream habitat. When properly designed and constructed, these structures are very effective in returning long-term stability to the stream channel.

Figure 22A/B - Tributary to Snakeden Branch, Reston, VA. Double-Step Cross-Vane, design and in

Step-Pools

Step-pools are also constructed from large boulders and are typically used to provide transition into and out of culverts in order to dissipate energy and to provide a means for dropping elevation in a controlled and stable manner over a relatively short distance. This is of particular use in conjunction with raising the invert in streams where existing culvert crossings at lower elevations must be maintained.

Figure 23 - Fort Belvoir, VA. Newly constructed step pools.

Imbricated Rock Walls

This practice is very useful in providing permanent stabilization of the bank in areas where the stream channel must remain at a lower elevation and grading of the bank is not feasible. This is often associated with culvert crossings or in instance where infrastructure must be protected. Imbricated rock walls perform better than gabions as these can fail over time. They are also more aesthetically pleasing in a more natural environment.

Figure 24 - The Glade, Reston VA. Newly constructed imbricated rock wall to protect trail.

Grading to Provide a Bankfull Bench

In instances when channel instability is due to increased flow rates (i.e. a larger channel cross-section is needed), this can be provided through grading of the banks. If the channel is currently incised and raising the invert is not feasible, a bankfull bench can be graded at the lower elevation in order to provide the necessary cross-sectional area. This can require a significant amount of disturbance depending on the existing conditions and required channel size, and thus can be problematic in forested areas or when utilities or other infrastructure is located adjacent to the channel.

Figure 25 - Snakeden Branch, Reston VA. Newly constructed bankfull bench at lower elevation.

Heavy Planting Densities

Regardless of the selected restoration technique, the planting of heavy densities of native trees, shrubs, and herbaceous materials is an essential element to achieving long term stability. This is often overlooked or the quantity of plants is reduced in order to save money – often at the expense of a failed project.

Figure 26 A/B - The Glade, Reston, VA. Planting of newly restored channel and 1 year later.

To Achieve Sediment Reductions from Gravel and Dirt Roads

Practices are under development by the University of Maryland (UMD) Center for Dirt and Gravel Road Studies to help reduce the amount of sediment runoff from dirt and gravel roads. These techniques, termed environmentally sensitive road maintenance practices (ESMPs) are:

1. Driving Surface Aggregate(DSA): durable and erosion resistant road surface;
2. Raising the Profile: raising road elevation to restore natural drainage patterns;
3. Grade Breaks: elongated humps in the road surface designed to shed water;
4. Additional Drainage Outlets: creating new outlets in ditchline to reduce channelized flow; and
5. Berm Removal: Removing unnecessary berm and ditch on downhill side of road to encourage sheet flow.

Effectiveness of these ESMPs to reduce TSS is shown on Table 11 as follows:

Tabel 11. ESMP Efficacy at TSS Reduction

Technique	**TSS Effectiveness Estimate**
Driving Surface Aggregate - Limestone	50%
Driving Surface Aggregate - Sandstone	55%
Raising the Road Profile	45%
Grade Breaks	30%
Additional Drainage Outlets	15%
Berm Removal	35%
Note – Reduction estimates based on total ESMP efficacy adjusted by first-flush factor (UMD, 2009)	

Description/Definition of BMP and Effectiveness Estimate:

Driving Surface Aggregate (Preferred Method)

DSA is a specific gradation of crushed stone developed by the Center for Dirt and Gravel Road Studies specifically for use as a surface wearing course for unpaved roads. DSA achieves sediment reductions by decreasing erosion and transport of fine material from the road surface. Due its relatively high efficacy in reducing TSS, we recommend this method for controlling sediment runoff from the dirt and grave roads within the WSR Watershed. We are recommending that an initial 1-mile of road be used as a demonstration project to evaluate the efficacy of this method in reducing sediment loss. Based on the results of this project, decisions can be made regarding moving forward aggressively on a gravel and dirt road DSA resurfacing effort county-wide.

Raising the Road Profile

Raising the road profile involves importing material to raise the elevation of an unpaved road. It is typically practiced on roads that have become entrenched (lower than surrounding terrain). Raising the elevation of the road is designed to restore natural drainage patterns by eliminating the down-slope ditch and providing cover for pipes to drain the up-slope ditch. Removing the down-slope ditch will eliminate concentrated flow conveyed in the ditch and will create sheet flow. Raising the Road Profile achieves sediment reduction by controlling and reducing the volume of road runoff. Raising the road profile involves importing fill material to raise the elevation of the roadway up to the elevation of the surrounding terrain. The road is filled to a sufficient depth as to eliminate the ditch on the down-slope side of the road and encourage sheet flow. Shale and gravel are the most common fill materials for roads. Other potential recycled fill materials include ground glass, waste sand, automobile tires, clean concrete rubble, etc.

Grade Breaks

Grade breaks are an intentional increase in road elevation on a downhill grade which causes water to flow off of the road surface. It is designed to reduce erosion on the road surface by forcing water into the ditches or surrounding terrain. Erosion of the road surface is reduced by forcing runoff laterally off the road. In some cases, grade breaks are used to force water off the road entirely, serving as an additional drainage outlet. Sites where water is not forced off the road entirely convey the water into a roadside ditch. The Center's report forced water into the roadside ditch.

Additional Drainage Outlets

Drainage outlets are designed to capture water flowing in the roadside ditch and force it to leave the road area. There are two major types of drainage outlets. Turnouts (also called bleeders or cutouts) outlet water from the down-slope road ditch. They usually consist of relatively simple cuts in the down-slope road bank to funnel road drainage away from the road. Drainage that is carried by the up-slope road ditch is usually outletted under the roadway by the use of a crosspipe (also called culvert, sluice pipe, or tile drain). Installing additional drainage outlets reduces concentrated flow, peak flow discharges and sediment transport and delivery from unpaved roads and ditches into streams, and can increase infiltration. It does not affect sediment generation from the road surface or deliver in the up-slope ditch, thus all data on sediment reductions in the report is only for down-slope ditch unless otherwise noted. Drainage outlets are to be placed in locations that have the least likelihood of reaching streams. If a newly added outlet conveys sediment to the stream, little, if any, sediment reductions will be obtained.

Berm Removal

A berm is a mound of earthen material that runs parallel to the road on the downslope side. Berms can be formed by maintenance practices and road erosion that lowers the road elevation over time. In many cases, the berm is unnecessary and creates a ditch on the downslope side of the road. This berm can be removed to encourage sheet flow into surrounding land instead of concentrated flow in an unnecessary ditch. Restoring sheet flow results in decreased runoff and sediment transport along the roadway, increase infiltration, and reduced maintenance associated with the road drainage system.

Nutrient Removal **-** Total Nitrogen (TN) and Total Phosphorous (TP) removal is minimal with dirt and gravel road erosion and sediment control. One reason is that dirt and gravel roads are not fertilized. The other is that the environmental benefit association with dirt roads is such that nitrogen (N) and phosphorus (P) reductions are not anticipated; nutrient reductions are not a component of the average function of dirt and gravel roads. If N and P reductions are associated with dirt and gravel roads they should track sediment reductions.

One situation where nutrient reductions could be associated with dirt and gravel roads is on farm lanes where the road was used as a conduit to the stream. If projects remove that mechanism so water is dispersed out onto the field, then the nutrient removal is proportional to the amount of water reduced from discharging directly to the stream.

To Achieve Sediment Reductions from Disturbed Areas

There are many areas of exposed weathered shale in the landscape and in road side ditches within the Warm Springs Run watershed. Exposed and weathered shale is a source of sediment and runoff to the watershed. Therefore, there is a need for a weathered shale management plan that will appropriately characterize and provide potential restoration techniques for these areas.

Areas of exposed weathered shale are located throughout the Warm Springs Run watershed in locations of previous development activities as shown in Figures 27 - 29.

Figure 27. Exposed weathered shale along roadside with minimal vegetative growth after many years.

Figure 28. Exposed weathered shale behind shopping center. Slope devoid of vegetation.

Figure 29. Weathered shale adjacent to commercial development. Minimal vegetative growth after several years.

These exposed weathered shale areas in their current condition increase runoff and sediment supply into the channels and streams within the Warm Springs watershed. Additionally, these areas have the potential to negatively affect water chemistry if these shales have sulfides in them and are acid-forming. Restoration of these areas will improve water quality throughout Warm Springs Run.

Management Strategy

As these areas are potential acid sulfate soils, the following protocol should be used in determining the reclamation of these areas, as recommended by Professor W. Lee Daniels, PhD, Department of Crop and Soil Environmental Sciences, Virginia Tech (http://www.landrehab.org/content.aspx?ContentID=1384):

1. Field investigate area, including the collection of soil and drainage samples.

2. Laboratory analyses including pH, Potential Peroxide Acidity test, and other relevant characterization tests are completed.

3. A reclamation prescription can then be developed based on the laboratory results and the site specific conditions. The prescription shall include a lime recommendation, emphasizing that the lime must be thoroughly incorporated into the top 6 inches of soil. Fertilization needs shall also addressed, and incorporation of organic amendments or topsoil covers are typically recommended but not always essential for reclamation success. After incorporating these amendments, seeding should be completed only during established planting dates in the fall or spring.

We recommend seeding and planting be conducted to restore the areas to a vegetated state. In all areas we recommend a temporary erosion and sediment control cover crop (annual ryegrass and foxtail millet) coupled with a native seed mix including herbs, grasses, and woody species. In areas other than roadside ditches we recommend one gallon container plants trees and shrubs should be planted at a minimum density of 400 stems per acre. Proposed species for planting are listed in Table 12.

Table 12. Partial Plant Species List for Reforestation of Weathered Shale reas	
Plant Species	**Wetland Indicator Status**
Juniperus virginiana (eastern red cedar)	FACU
Cercis canadensis (eastern redbud)	FACU-
Viburnum prunifolium (black haw)	FACU
Cornus florida (flowering dogwood)	FACU-
Acer rubrum (red maple)	FAC
Quercus rubra (red oak)	FACU-
Quercus phellos (willow oak)	FAC+
Quercus alba (white oak)	FACU-
Hamamelis virginiana (witch hazel)	FAC-
Nyssa sylvatica (black gum)	FAC
Ulmus rubra (slippery elm)	FAC
Ilex opaca (American holly)	FACU+
Diospyros virginiana (persimmon)	FAC-
OBL: Obligate Wetland; plant occurs with an estimated 99% probability in wetlands FACW: Facultative Wetland; estimated 67-99% probability of occurrence in wetlands FAC: Facultative; equally likely to occur in wetlands and non-wetlands FACU: Facultative Upland; 67-99% probability of occurrence in non-wetlands	

In conclusion, restoration of the weathered shale areas of Warm Springs Run will benefit water quality downstream and the entire watershed by decreasing runoff, reducing sediment deposition, and potentially reduce acid sulfides from entering the streams. In order to return the area from its currently altered state, some laboratory analyses must be conducted prior to restoration of the area, as each area may require a different method to restore the area. We recommend that a 1-acre plot of disturbed land be chosen as a demonstration project to evaluate the efficacy of the above described management practice for revegetation and stabilization.

To Achieve Sediment Reductions from Uncontrolled Stormwater Runoff

The WSR watershed area has three primary sources for uncontrolled stormwater runoff:

1) Paved streets and roads, in particular in the Town of Bath, Route 522, and along the eastern tributaries;

2) Roof drains, which channel water directly into the stream via downspouts that empty into disposal pipes;

3) Sheet flow from impervious areas (e.g. parking lots).

We propose the following methods to manage and reduce sediment load from these targeted areas:

Street Sweeping

Streets, roads, highways and parking lots accumulate significant amounts of pollutants that contribute to stormwater pollutant runoff to surface waters. Pollutants, including sediment, debris, trash, road salt, and trace metals can be minimized by street sweeping. Street sweeping can also improve the aesthetics of municipal roadways, control dust and decrease the accumulation of pollutants in catch basins. An effective municipal street sweeping program can meet regulatory requirements, assess street sweeping effectiveness, and minimize pollutants in roadways.

Street sweeping is practiced in most urban areas, often as an aesthetic practice to remove trash, sediment buildup, and large debris from curb gutters. Effective street sweeping programs can remove several tons of debris a year from city streets minimizing pollutants in stormwater runoff. In colder climates, street sweeping can be used during the spring snowmelt to reduce pollutants in stormwater runoff from road salt, sand and grit.

Municipalities can choose between the three different types of street sweepers (mechanical, regenerative air and vacuum filter) keeping in mind the targeted pollutants, pollutant type (large debris to particles less than 10 microns in diameter (PM10)), types of surfaces, travel distances, noise ordnances, and costs. Municipals often find it useful to have a compliment of each type of street sweeper in their fleet (CASQA, 2003).

Each type of street sweeper has it advantages and disadvantages concerning pollutant removal effectiveness, traveling speed, and noise generated by the street sweeper. With the different types of modern street sweepers capable of removing PM10 particles, price and personal preference are the primary selection criteria for most users. No definitive independent studies have yet been staged to determine "the best" sweeping system. Anecdotal data has also been inconclusive.

Implementation - An effective municipal street sweeping program should address at a minimum the following components:

Street Sweeping Schedule: Designing and maintaining a street sweeping schedule can increase the efficiency of a program. A successful program will need to be flexible to accommodate climate conditions and areas of concern. Areas of concern should be based on traffic volume, land use, field observations of sediment and trash accumulation and proximity to surface waters (CASQA, 2003). Street sweeping in these areas may need to be increased and the schedule amended. It is recommended that schedules include minimum street sweeping frequencies of at least once a year. In cold climates prone to snowfall the Connecticut Department of Environmental Protection recommends that municipalities conduct street sweeping as soon as possible after the snow melts (McCarthy, 2005). Removal of the accumulated sand, grit, and debris from roads after the snow melts reduces the amount of pollutants entering surface waters.

To evaluate the effectiveness of a street sweeping program, municipalities should maintain accurate logs of the number of curb-miles swept and the amount of waste collected (CASQA, 2003). Monthly or yearly intakes (per ton) can be measured per district, road, season, or mile. This information can be used to develop a written plan, schedule, and periodic re-evaluation for street sweeping that would target the following:

- those roadways with contributing land uses (high level of imperviousness, high level of industrial activity) that would be expected to show high pollutant concentrations and
- those roadways that have consistently accumulated proportionately greater amounts of materials (pounds per mile swept) between currently scheduled sweeps (Curtis, 2002).

Gross intake amounts can be presented to regulatory agencies and to finance directors to measure performance. The City of Dana Point, California reported that when sweeping was conducted twice a month, the monthly debris intake was 23 tons. Dana Point then increased street sweeping frequency to a weekly basis and the monthly total increased to 46 tons of debris (City of Dana Point, 2003).

Street Sweepings Storage and Disposal: Street sweeping material often includes sand, salt, leaves, and debris removed from roads. Often the collected sweepings contain pollutants and must be tested prior to disposal to determine if the material is hazardous. Municipals should adhere to all federal and state regulations that apply to the disposal and reuse of sweepings.

Municipalities are encouraged to develop comprehensive management plans for the handling of sweepings. A critical aspect of a management plan is selecting a location for storing and processing street sweepings (McCarthy, 2005). Storage locations should be equipped with secondary containment and possibly overhead coverage to prevent stormwater runoff from contacting the piles of sweepings. It is also recommended to cover the piles of sweepings with tarps to prevent the generation of excessive dust. Storage locations should be sized accordingly to completely contain the volume of the disposed sweepings. To estimate the size of the storage location, estimate the volume of sweepings either on a ton-per-street mile or on pounds-per-capita basis (McCarthy, 2005). An average figure for urban areas is 20.25 tons-per street-mile (McCarthy, 2005).

Street Sweepings Reuse Practices: Although sweepings may contain pollutants, federal and state regulations may allow the reuse of sweepings for general fill, parks, road shoulders and other applications as long as the material is not a threat to surface waters. Prior to reuse, trash, leaves, and other debris from sweepings should be removed by screening or other methods (MPCA, 1997). Trash and debris removed should be disposed of by recycling or sent to a landfill (MPCA, 1997).

Parking Policy: Established parking policies increases the effectiveness of a street sweeping program. Parking policies can be established as city ordinance and incorporate the following:

1) Institute a parking policy to restrict parking in problematic areas during periods of street sweeping.
2) Post permanent street sweeping signs in problematic areas; use temporary signs if installation of permanent signs is not possible.
3) Develop and distribute flyers notifying residents of street sweeping schedules (CASQA, 2003).

Operation and Maintenance Program: A municipality should dedicate time for daily and weekly equipment maintenance. Regular maintenance and daily start up inspections insures that street sweepers are kept in good working condition (City of Greeley, 1998). It is vital for municipals to inventory and properly stock parts to prevent downtime and decrease productivity. Old sweepers should be replaced with new technologically-advanced sweepers, preferably modern sweepers that maximize pollutant removal (CASQA, 2003).

Manufactured Products for Stormwater Inlets

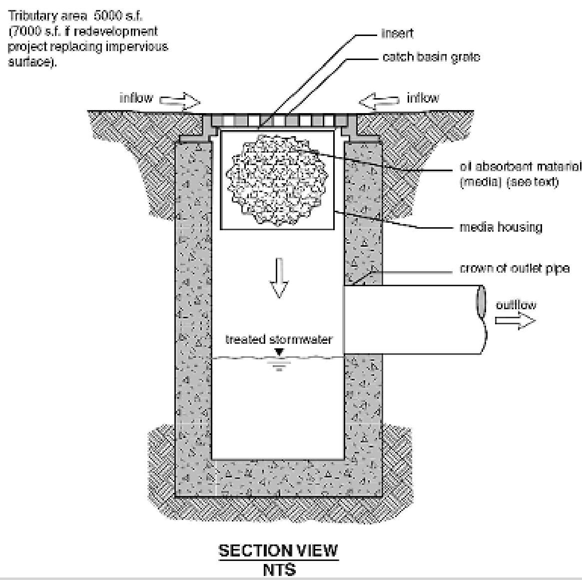
A variety of products called swirl separators or hydrodynamic structures have been widely applied to stormwater inlets in recent years. Swirl separators are modifications of traditional oil-grit separators. They contain an internal component that creates a swirling motion as stormwater flows through a cylindrical chamber. The concept behind these designs is that sediments settle out as stormwater moves in this swirling path, and additional compartments or chambers are sometimes present to trap oil and other floatables (see Figure 30). There are several different types of proprietary separators, each incorporating slightly different design variations, such as off-line application.

Swirl separators are best installed on highly impervious sites. Because little data are available on their performance (independently conducted studies suggest marginal pollutant removal), swirl separators should not be used as a stand-alone practice for new development. The best application for these products is as pretreatment to another stormwater device or, when space is limited, as a retrofit.

Siting and Design - The design of swirl concentrators is specified in the manufacturer's product literature. For the most part, swirl concentrators are rate-based designs. That is, their size is based on the peak flow of a specific storm event. This design contrasts with most other stormwater management practices, which are sized based on the capture, storage or treatment of a specific volume. Sizing based on flow rate allows the practice to provide treatment within a much smaller area than other stormwater management practices.

Maintenance - Swirl concentrators require frequent, typically quarterly, maintenance. Maintenance is performed using a vacuum truck, as is used for catch basins (see Catch Basin). In some regions, it may be difficult to find environmentally acceptable disposal methods. Due to hazardous waste, pretreatment, or groundwater regulations, sediments may sometimes be barred from landfills, from land applications, and from introduction into sanitary sewer systems.

Efficacy - While manufacturers' literature typically reports removal rates for swirl separators, there is little independent data to evaluate the effectiveness of these products. Two studies investigated one of these products. Both studies reported moderate pollutant removal, but while the product outperforms oil/grit separators, which have virtually no pollutant removal (Schueler, 1997), the removal rates are not substantially different from the standard catch basin. One long-term advantage of these products over catch basins is that if they incorporate an off-line design, trapped sediment will not become resuspended. Data from the two studies are presented below. Both studies are summarized in a Claytor (1999).



The typical design of a catch basin insert is a set of filters that are specifically chosen to address the pollutants expected at that site (Source: King County, Washington, 2000)

Figure 30. Example Hydrodynamic Structure

Table 13. Effectiveness of Manufactured Products for Stormwater Inlets		
Study	Greb et al., 1998	Labatiuk et al., 1997
Notes	Investigated 45 precipitation events over a 9-month period. Percent removal rates reflect overall efficiency, accounting for pollutants in bypassed flows.	Data represent the mean percent removal rate for four storm events.
TSS[a]	21	51.5
TDS[a]	-21	-
TP[a]	17	-
DP[a]	17	-
Pb[a]	24	51.2
Zn[a]	17	39.1
Cu[a]	-	21.5
PAH[a]	32	-
NO_2+NO_3[a]	5	-

[a] TSS=total suspended solids; TDS=total dissolved solids; TP=total phosphorus; DP=dissolved phosphorus; Pb=lead; Zn=zinc; Cu=copper; PAH=polynuclear aromatic hydrocarbons; NO_2+NO_3=nitrite+nitrate-nitrogen

Low Impact Development (LID) Retrofit Practices

Urban development significantly alters the natural features and hydrology of a landscape. Development and redevelopment usually creates impervious surfaces like concrete sidewalks and asphalt roadways, commercial and residential buildings, and earth compacted by construction activities. Prevented from soaking into the ground, rainwater runs across parking lots and streets, collecting used motor oil, pesticides, fertilizers, and other pollutants.

In most cities, a complex system of piping usually feeds contaminated stormwater flows directly into streams and coastal waters. More recently, stormwater control structures like dry extended detention ponds or wet retention ponds have been installed, most in new development, to intercept stormwater on its way to surface waters.

Historically, the goal of stormwater planning has been to prevent localized flooding by moving large amounts of water offsite as quickly as possible. However, experience has shown that traditional stormwater management has many limitations.

Expensive, ever-expanding storm sewer systems strain municipal budgets. Fast moving stormwater discharges cause downstream flooding, erode stream banks, and contribute to water quality violations. Bacteria and other pathogens carried in stormwater contaminate coastal waters, often requiring beach closures. Rainwater diverted or otherwise unable to soak into the soil cannot recharge aquifers. This reduces stream base flows, which can cause streams to dry-up for extended periods of time. Stormwater that collects in detention basins or flows over impervious surfaces is often much warmer than the streams into which it flows. This is a problem because a temperature increase of just one or two degrees can stress fish and other aquatic organisms.

Management Techniques - Like other alternative development strategies, LID seeks to control stormwater at its source. Rather than moving stormwater offsite though a conveyance system, the goal of LID is to restore the natural, pre-developed ability of an urban site to absorb stormwater.

LID retrofitting integrates small-scale measures scattered throughout the development site. Constructed green spaces, native landscaping, and a variety of innovative bioretention and infiltration techniques capture and manage stormwater on-site. LID reduces peak runoff by allowing rainwater to soak into the ground, evaporate into the air, or collect in storage receptacles for irrigation and other beneficial uses. In areas with slow drainage or infiltration, LID captures the first flush before excess stormwater is diverted into traditional storm conveyance systems. The result is development that more closely maintains pre-development hydrology. Furthermore, LID has been shown to be cost effective, and in some cases, cheaper than using traditional stormwater management techniques.

The following are the techniques for LID retrofits that are feasible for the WSR watershed, in particular the Town of Bath and developed areas with impervious surfaces:

- **Bioretention Cells** – Commonly known as rain gardens, bioretention cells are relatively small-scale, landscaped depressions containing plants and a soil mixture that absorbs and filters runoff.
- **Cisterns and Rain Barrels** – Used to harvest and store rainwater collected from roofs. By storing and diverting runoff, these devices help reduce the flooding and erosion caused by stormwater runoff. And because they contain no salts or sediment, they can provide "soft" chemical-free water for garden or lawn irrigation, reducing water bills and conserving municipal water supplies.
- **Green Roofs** – These are roofs partially or completely covered with plants. Used for decades in Europe, green roofs help mitigate the urban "heat island" effect and reduce peak stormwater flows. The vegetated cover also protects and insulates the roof, extending its life and reducing energy costs.
- **Permeable and Porous Pavements** – These BMPs reduce stormwater runoff by allowing water to soak through the paved surface into the ground beneath. Permeable pavement encompasses a variety of mediums, from porous concrete and asphalt, to plastic grid systems and interlocking paving bricks suitable for driveways and pedestrian malls. Permeable pavement helps reduce runoff volumes at a considerably smaller cost than traditional storm drain systems.
- **Vegetated Filter Strips** – Vegetated filter strips (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter

strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. One challenge associated with filter strips, however, is that it is difficult to maintain sheet flow, so the practice may be "short circuited" by concentrated flows, receiving little or no treatment.

- **Grass Swales** – These are broad, open channels sown with erosion resistant and flood tolerant grasses. Used alongside roadways for years primarily as stormwater conveyances, swales can slow stormwater runoff, filter it, and allow it to soak into the ground. Swales and other biofiltration devices like vegetated filter-strips improve water quality and reduce in-stream erosion by slowing the velocity of stormwater runoff before it enters the stream. They also cost less to install than curbs, storm drain inlets, and piping systems.

<u>Efficacy of LID Retrofits to Reduce Loads</u> – Various studies have been conducted to document the efficiency of the aforementioned LID methods to reduce contaminant loads. These data are summarized on Table 14 as follows:

Table 14. LID Load Reductions (Yu et al., 1992)

	Bio-Retention*	Porous Pavement	Grass Swales	75' Filter** Strip	150' Filter Strip
Total N	49%	35% - 75%	38%	-27	40%
Total P	65% - 87%	42% - 65%	29%	-25	20%
TSS	85%	71% - 99%	81%	54%	64%

*includes rain gardens, rain barrels, and green roofs

** To date, only one study (Yu et al., 1992) has investigated the effectiveness of a grassed filter strip to treat runoff from a large parking lot. The study found that the pollutant removal varied depending on the length of flow in the filter strip. The narrower (75-foot) filter strip had moderate removal for some pollutants and actually appeared to export lead, phosphorus, and nutrients.

In summary, LID retrofits can help reduce flow rates delivered to the receiving water body, as well as TSS and sedimentation in general. The reduction of nutrient loads varies, however, by the method being employed. Nevertheless, the reduction in stormwater quantity delivered to the WSR will inevitably assist in reducing streambank erosion that is related to uncontrolled stormwater runoff from impervious areas.

To Achieve Load Reductions by Conservation of the Lower Run

As was stated previously, the results of the WVDEP Benthic Assessment and Water Quality sampling have demonstrated that some of the best overall benthic scores were observed at mile station 0.7, just upstream from the WSR's confluence with the Potomac River. Similarly, the result for fecal coliform at this mile station was an order of magnitude lower than the upstream stations during the monitoring event of August 16, 2007, at which time unusually high levels of fecal coliform were observed along the entire length of the Run. Although there have been variations in the values throughout the water quality monitoring events, the overall high benthic scores reflect the general positive effect on the WSR's condition as it passes through the downstream reach.

There are few sources of impairment to the WSR north (downstream) from the Town of Bath, the most significant being the Warm Springs Public Service District water treatment plant, and the discharges from the (former) U.S. Silica facility north of the Town of Bath. It is our understanding that both of these facilities are in compliance with their discharge requirements. The WSPSD plant typically discharges 500,000 gallons of treated water to the Run daily (0.77 cfs), and 1,550,000 gallons per day after a 1-inch rain. This increase is attributed to sump pumps and/or residential drain systems that are channeled into the municipal sanitary sewer system. Based on their NPDES permit information, the sand mine operates five outlets that collectively discharge an average of 2.2 million gallons per day (3.4 cfs) to the Run.

It is of note that nearly the entire lower 4-mile reach of the WSR passes through a forested area, with little residential development of any kind. The few agricultural areas are buffered by vegetated strips as described in the previous sections on load reductions from cropland and pasture sources. Thus, this section has the benefit of a significant (greater than 150-feet) forested riparian buffer through nearly its entire reach. There are no sections of the stream throughout the lower 4-miles where there is significant erosion or stream channel incision, with the exception of a small area just downstream from the CSX yard located along River Road. We suspect that the uncontrolled discharged of stormwater from the CSX yard may have accelerated erosion and incision along this section, as the yard's stormwater flows downhill towards Airport Lane, and from there directly into the Run.

We recommend that Morgan County and the Eastern Panhandle Conservation District enter into discussion with the owners of this section of the Run to possibly create a conservation easement along the stream. Ideally, this easement would allow for the protection of a 150-foot wide forested riparian buffer along the stream (at the minimum) and ideally as wide as is feasible. Within this easement, the forest should be managed and protected from timbering and/or residential or commercial development. This would also allow the County to develop the area as public space, with considerable resources for outdoor recreation (i.e. hiking, bicycling, and fishing) and conservation education and interpretation.

To Reduce Flooding in the Town of Bath

The BMPs described in the prior sections of this report will help achieve reductions in both nutrient and sediment loads delivered to the Potomac River, and ultimately to the Chesapeake Bay; but there is a side benefit to encouraging onsite absorption in the upstream section of the WSR south of the Town of Bath, and that is helping to control catastrophic flooding.

It is of note that when the flood control dams were constructed along the eastern tributaries and the drainage swales feeding into them, the historic flash flooding seen in the Town of Bath was reduced considerably. There were several reasons for this.

1) It should be understood that in their undisturbed natural state, streams in mountainous regions on steep grades collect water that sheets off the hillsides. The unrestricted flow of water downhill carries along with it rocks, brush, leaves, and other debris that collects at "pinch points" in the channel. The water becomes dammed up temporarily behind these "dams", which then break suddenly, releasing a torrent which collects more debris, and the process repeats itself at the next pinch point. By the time the water reaches the main stem it is moving with destructive depth and velocity, carrying with it logs, rocks, and enormous quantities of sediment. The effects of this type of flash flooding on developed areas can be devastating. The 1985 flood along forks of the South Branch of the Potomac River in Pendleton County WV bears testament to the destructive power of these types of flash flooding events. Thus, the flood control dams helped to mitigate the contribution of the eastern tributries to the catastrophic flooding events seen in the Town of Bath by mitigating the type of stream behavior during flooding described above.

2) When the flood control dams were constructed, there was little commercial development along the reach (the main stem) of the WSR that parallels US Route 522 south of the Town of Bath. Thus, much of the water sheeting off the east slope of Warm Springs Ridge was absorbed by the relatively permeable soils along the pediment of the ridge and in the floodplain of the main stem. This upstream absorption, combined with the mitigating effects of the flood control dams was able to bring about a significant reduction in the catastrophic historic flooding seen in the Town of Bath since the 18th Century.

It is interesting then, that severe flooding in the Town of Bath has been on the increase in recent decades. Particularly notable was the flooding that occurred in January 1996, caused by the rapid snowmelt of over 30-inches of snow, combined with six inches of rain and unseasonably warm weather. Hurricane Fran in September of that same year dropped 5-inches of rain on the Potomac Highlands and caused further severe flooding. These severe flooding events are now occurring on a regular basis, most frequently caused by tropical systems or unusually heavy late winter/spring storms. We propose that these flooding events are being exacerbated by the loss of upstream absorption areas along the main stem of the WSR due to rapid commercial development and the resulting introduction of extensive areas of impervious surfaces, much of which has occurred within the last three decades. Removal of the forest cover along large stretches of the WSR upstream from the Town of Bath has also added to the problem. It is of note that the US Forest Service (USDA-USFS) has estimated that a forest canopy of one acre can collect as much as 4-inches of rain from a storm, reducing the contribution to the receiving water body by over 100,000 gallons per acre.

In summary, reducing runoff volume using green infrastructure has benefits beyond just removing pollutants. It also recharges groundwater, provides better protection of sensitive aquatic resources, and reduces the size and cost of hard infrastructure that would otherwise need to be constructed to prevent serious flooding. Therefore, in addition to the upstream absorption practices described in the previous sections of this plan, we would encourage Morgan County to pursue an aggressive policy of reforestation and urban tree planting wherever feasible along the WSR. The planting of trees in the commercial downtown section of the Town of Bath is strongly recommended as well.

(Note – One challenge with this approach has been how to account for the runoff reduction provided by green infrastructure in rainfall/runoff models commonly used by engineers. A runoff reduction calculation guideline has been developed by the USFS, and is included as Appendix C to this report.)

Section D – Technical and Financial Assistance Needed

The following section describes costs and financial assistance needed to implement the proposed management measures described in Section B/C. These costs are based on existing management plans for the Potomac Direct Drains, regional pricing structures for standard practices such as wetland and streambank restoration, and data derived from the USDA-NRCS, Chesapeake Stormwater Network, and USEPA menus of stormwater BMPs. Actual costs may vary depending on a number of site specific factors.

Table 15. Estimated Costs of Implementing Management Measures in the WSR Watershed

Onsite Treatment Systems (Septic Systems)

Practice	Planned Units	Cost per Unit	Total Cost
Field Assessment of Failed Systems	300	$750	$225,000
Repair & Upgrade of Failed Systems*	255	$6,500	$1,657,500
De-nitrification System Installs**	42	$12,000	$504,000
Subtotal			**$2,386,500**
*assuming an 85% failure rate **assuming 85% failure rate of priority systems located adjacent to tributary streams			

Fenced Pasture

Practice	Planned Units	Cost per Unit	Total Cost
Stream Fencing	1,336 feet	$2.50/foot	$3,340
Watering Station	1	$17,000/station	$17,000
Stream Crossing	2	$3,400	$6,800
Grass Buffer (agricultural)	1 acre	$230/acre	$230
Nutrient Management Plan	72 man hours	$85/hour	$6,120
Subtotal			**$33,490**

Cropland

Practice	Planned Units	Cost per Unit	Total Cost
Nutrient Management Plan	72 man hours	$85/hour	$6,120
Subtotal			**$6,120**

Misc. Fecal Coliform Reduction

Practice	Planned Units	Cost per Unit	Total Cost
Wetland Restoration	7.8 acres	$5,000/acre	$39,000
Pet Waste Reduction Campaign	1	$25,000	$25,000
Carcass Dumping Education Campaign	1	$25,000	$25,000
Subtotal			**$89,000**

Stream Erosion and Exposed Soil Repair

Practice	Planned Units	Cost per Unit	Total Cost
Design, oversight and construction	7,487 linear feet	$250/foot	$1,871,750
Road BMPs and Culvert Improvements	20	$10,000	$200,000
Exposed Soil Repair	1 acre	$13,500	$13,500
Subtotal			**$1,887,250**

(Table 15, continued)

Stormwater BMPs and Sediment Control

Practice	**Planned Units**	**Cost per Unit**	**Total Cost**
Rain Garden Installation	25	$500	$10,000
Green Roof Installation	$20/SF	225,000SF	$4,500,000
Vegetated Buffers at Impervious Sites	11.25 acres	$20,000	$225,000
Rain Barrel Workshops (15 barrels ea.)	5	$1,200	$6,000
Rain Garden Demonstrations	3	$20,000	$60,000
Street Sweeping (O&M Only)	12 miles-weekly	$30/mile	$18,720
Manufactured Sediment Traps	8	$20,000 ea.	$160,000
DSA Resurfacing Demonstration Project*	1 mile	$105,000	$105,000
Shale Bank Demonstration Project**	1 acre	$7,500	$13,000
Subtotal			**$5,097,720**
*Includes design, grading, equipment and materials, and testing **includes testing, liming and compost, native species planting, plus oversight			

Stream Sampling

Practice	**Planned Units**	**Cost per Unit**	**Total Cost**
Preparation of Sampling QAPP	1	$4,000	$4,000
ToN/ToP	35 per year*	$44	$1,540
Dissolved Nitrate plus nitrite as N	35 per year*	$20	$700
Dissolved Ammonia as N	35 per year*	$20	$700
Total Suspended Solids	35 per year*	$10	$350
Dissolved Ortho-phosphorus as P	35 per year*	$10	$350
Total Suspended Sediment	35 per year*	$20	$700
Fecal Coliform	35 per year*	$20	$700
Sand-fine split	3 per year	N/A	N/A
Subtotal			**$9,040**
*one (1) normal flow sample per 5 stations on a quarterly basis, and 3 "peak flow" samples per station per year			

Grand Total			**$9,509,120**

Specific sources of funding will be explored by establishing partnerships with various regional, state and private organizations and entities. Among which are the entities shown on the following list. (Organizations the WSWA has worked with in the past are shown in **bold**).

Morgan County

Morgan County Arts Council
Morgan County Board of Education
Morgan County Commission
Morgan County Department of Health
Morgan County Economic Development Authority
Morgan County Planning Commission
Morgan County Solid Waste Authority
Morgan County Extension Office, including the Morgan County Master Gardeners
Morgan County Chamber of Commerce

Town of Bath

Town of Bath
Town of Bath Tree Board
Warm Springs Public Service District

State and Federal Agencies

Berkeley Springs State Park
WV Department of Highways
WV Department of Environmental Protection
WV Division of Natural Resources
WV Division of Forestry
Chesapeake Bay Watershed Forester
WV Division of Fish and Wildlife
The Eastern Panhandle Regional Planning and Development Council
US EPA District 9

Private Entities

Streetscape Committee
The Museum of Berkeley Springs
Travel Berkeley Springs
Morgan County Rotary Club
Morgan County Lions Club

Section E – Information/Education Campaign

The Roles of the Warm Springs Run Watershed Association and its Partners (provided by Kate Lehman, President WSWA)

The Warm Springs Watershed Association (WSWA) was founded in 2008 and is currently is the process of becoming a 501(c)(3) organization. The mission of the WSWA is to restore, protect and preserve the Warm Springs Run and its watershed through education and the establishment of partnerships with concerned citizens, civic organizations, and governmental agencies.

From its inception the WSWA has engaged in various projects designed to restore, protect and preserve the Run. We have:

- completed corridor and watershed assessments;
- cleaned trash and debris from the Run on a regular basis;
- planted riparian buffers in various locations;
- trained volunteers to monitor the Run and test for fecal coliforms;
- monitored 10 sites for water chemistry, benthic organisms and fecal coliforms;
- engaged in efforts to control invasive species including purple loosestrife, mile-a-minute plant and Japanese knotweed.

We have done extensive work to educate the community about the existence of the Run, issues resulting in its impairment, and the role of individuals and organizations to help restore, protect and preserve the Run. Over the past three years we have made Power Point presentations to nearly every civic or governmental agency in the watershed. So, too, we have mailed brochures to every household in the watershed and published articles in the *Morgan Messenger,* the local paper, about our efforts and accomplishments. Each year at the Morgan County Fair we sponsor an interactive display designed to educate participants about the presence and significance of benthic macroinvertebrates in the Run.

Our efforts to establish partnerships with various organizations were recognized by the West Virginia Watershed Network in 2009 and 2011. The following is a partial list of some of the organizations with whom we've formed partnerships:

- Town of Bath Council;
- Morgan County Commission;
- Morgan County Planning Commission;
- Morgan County Department of Health;
- Morgan County Economic Development Authority;
- Morgan County Board of Education;
- Eastern Panhandle Conservation District;
- WV Extension Office;
- Morgan County Master Gardeners;
- Berkeley Springs State Park;
- The Museum of the Berkeley Springs;
- Potomac Valley Audubon Society watershed education program;
- WV DEP;
- US Division of Fish and Wildlife;
- WV DNR.

Members of the Warm Springs Watershed Association are proud of what we have accomplished over the past four years. Our efforts have been recognized by other organizations, including the WV Watershed Network, which named us an outstanding new watershed association in 2010.

Despite our many successes, at the Strategic Planning Session held in February 2011, we recognized that such piecemeal projects are not sufficient in and of themselves to bring water quality closer to the proposed TMDLs for the Phase 2 Plan for the Chesapeake Bay Initiative. Thus it is that we applied for and were awarded a grant to establish a Comprehensive Watershed Management Plan. We believe that the experience gained through the aforementioned projects and the partnerships formed with concerned citizens, civic organizations, and governmental agencies put the WSWA in an excellent position to implement this plan.

Morgan County Arts Council

The Morgan County Arts Council owns the Ice House, which is located at the corners of Independence and Mercer Streets in the Town of Bath. In the 19^{th} century the building now known as the Ice House was a tannery which dumped waste from the tanning process directly into the nearby Warm Springs Run.

The WSWA plans to work with the MAC, the **Morgan County Historic Society** and the **Museum of the Berkeley Springs** to develop an exhibit on the historic industrial base of the Town of Bath and the subsequent degradation of Warm Springs Run as well as the long-term implication of some of the processes involved in, for example, tanning leather.

The WSWA and the MAC will provide public education programs to highlight how the current placement of the Ice House continues to impact upon the Run, specifically in terms of storm water management issues. Grants will be sought to implement best management practices to reduce the amount of stormwater runoff into the Run, including the installation of blue or green roofs, rain barrels and raised rain gardens adjacent to the Ice House and a rain garden at the edge of the Ice House Parking lot, which abuts the Run

Morgan County Board of Education

Berkeley Springs High School is built in the floodplain of the Warm Springs Run. Flooding, always an issue has become worse in recent years due to increased sediment depositions. During flooding, sediment deposits in the floodplain have become so deep as to bury gutter down spouts.

Fieldwork done as part of the Comprehensive Watershed Management Plan revealed two sources of increased sedimentation and thus flooding. The area upstream, especially around Morgan Square, has a very high percentage of impervious surfaces, which increases the volume and quantity of runoff into the Run. The result is incised or entrenched stream beds in the portion of the Run flowing past Widmyer Elementary School, which accounts for the increased sediment load deposited downstream at the High School. Interestingly, the installation of the raised sewer manholes in the bed of the stream exacerbated the sedimentation problem significantly, based on comments from school officials.

Members of the WSWA have already met with the Superintendent of Schools, the Treasurer/CSBO, and Superintendent of Maintenance to explore a partnership to seek funding from the **WV Conservation Agency** for natural stream bank restoration in front of Widmyer Elementary School. There was also discussion of working together to secure funds to implement non-engineering stormwater management practices at Widmyer and the High School, including green or blue roofs, rain barrels, and rain gardens so as to reduce the quantity and volume of stormwater entering the Run.

A workshop would be held for parents to encourage them to use these BMPs where applicable at their homes.

Merchants in Morgan Square

The WSWA will hold education programs for the merchants upstream from Widmyer as to non-engineering BMPs for reducing stormwater runoff in this area, which has a very high percentage of impervious surfaces. The WSWA will seek grants to assist merchants in purchasing and installing such devises.

Dollar General / Reed's Pharmacy

During recent construction on the area across from Widmyer Elementary School, a significant portion of a shale hill was denuded, which also increases runoff into WSR. The WSWA will partner with the merchants who own this property to do a demonstration shale bank reclamation and replanting project.

Morgan County Commission

The WSWA and the Eastern Panhandle Conservation District have already gained permission from the County Commission to install a rain garden in the area between the county employee parking lot and the Run. At this point we are waiting to determine what portion of that area will be used to access the intake valve where water is taken from the Run to use in the geo-thermal heating/cooling system for the Courthouse.

The WSWA will also explore non-engineering BMPs for the County Courthouse and Sheriff's headquarters.

The WSWA will also meet with appropriate parties, including the County Commission to discuss regularly scheduled street sweeping, including cost and implementation.

Morgan County Department of Health

The WSWA will form a partnership with the Morgan County Department of Health to determine the location and age of on-site sewage treatment systems in the watershed.

The WSWA will partner with WVDEP Non-Point Source team to secure a grant to be used to reach out to homeowners with on-site sewage treatment systems, including a first class mailing as well as newspaper articles and public meetings. Homeowners will be given information on how to recognize problems with an on-site sewage treatment system as well as information about available financial assistance to pump out functioning systems and replace failing systems. Finally, we will educate homeowners as to the proper ongoing care and maintenance of on-site sewage treatment systems.

Morgan County Planning Commission

On June 26 and WSWA and Matthew Pennington, Region 9, are making an hour-long presentation to the Planning Commission on the basic principles of stormwater management.

The Planning Commission is in the process of upgrading (not sure that's the right word) the County's existing stormwater management ordinances. The WSWA will work with the PC to insure encourage the adoption of practices that will help to reduce stormwater runoff into Warm Springs Run. The WSWA will also partner with the PC and the Chamber of Commerce to hold a workshop for local merchants on what non-engineering BMPs can be used, as well as seek grant money to help merchants improve their stormwater practices.

The WSWA, the County Commission and the Planning Commission will work together to seek landowner permission to delineate the wetland at the headwaters of the WSR, and submit delineation to the US Army Corps of Engineers for designation as a jurisdictional wetland.

Once that designation has taken place, these three organizations will form a partnership to restore the headwaters wetland.

Morgan County Extension Office, including the Morgan County Master Gardeners

The WSWA and Extension Office will hold a workshop of ways that homeowners can reduce runoff, including soil amendment, raised beds, rain barrels and rain gardens.

Town of Bath

The WSWA will meet with the Town of Bath Council to discuss the benefits of regularly scheduled street sweeping in the town, including cost and implementation.

WSWA, and Town of Bath, and Streetscapes will partner to seek grants for the installation of manufactured sediment traps in the Town of Bath to reduce stormwater runoff into the Run.

Town of Bath Tree Board

The WSWA will continue to partner with the Town of Bath Tree Board as well as the **Lions Club** to plant more trees in town, and where possible, to improve the riparian buffer of the Run as it flows through the town.

Warm Springs Public Service District

The WSWA will work with the WSPSD to explore the benefits of installing engineered structures to direct flow away from the raised manholes in the Run, thus reducing scouring around these surfaces. The WSPSD should be invited to be a partner in seeking funding for manufactured sediment traps so as to reduce the volume of stormwater that ends up in the Run. In addition, the WSWA should work with WSPSD to explore the possibility of sealing the raised manholes to prevent possible infiltration of water into the sanitary sewer main during flooding events.

Eastern Panhandle Conservation District

The WSWA and EPCD will work with the farmer in the watershed whose livestock has direct access to the run. We will seeks grants to help pay for fencing to keep the cattle out of the Run, as well as the installation of an alternative source of water for the herd.

Section F, G, & H – Schedule for Implementing Non-point Source (NPS) Management Measures, Description of Milestones, and Measurable Goals

- Submit WSR Comprehensive Watershed Management Plan to U.S. Environmental Protection Agency and WVDEP.
- Develop and submit proposal for funding assistance for baseline load sampling to be performed by WSWA.
- Hold meeting with Morgan County Commission and Public Works Department to discuss street sweeping schedule, costs and implementation.
- Hold public meeting(s) with owners of individual treatment (septic) systems regarding low-interest loan program, proper septic maintenance and methods for evaluating failing or failed septic systems.
- Identify and list specific on-site treatment systems throughout the WSR watershed using publicly available data (health department records, building permits, etc.)
- Field verify septic system records, and perform on-site inspections for evidence of failed or failing systems.
- Upgrade, pump and/or account for the failing or failed septic systems throughout the watershed.
- Hold three (3) Rain Barrel workshops (15 barrels each).
- Hold Rain Garden workshops, including the installation of two (2) to three (3) demonstration rain gardens at specific sites in the Town of Bath.
- Hold two (2) workshops with stakeholders regarding non-engineering stormwater BMPs for on-site bioretention and treatment of stormwater, and grant funding available for such efforts.
- Hold workshop with regional stakeholders regarding the use of washed crushed limestone (vs. crusher run) to reduce sediment loads to the WSR.
- Outreach to regional farmers regarding nutrient management and sediment control. Discuss fencing and alternate water supply options for cattle pasture area(s).
- Commence Natural Stream Design streambank erosion mitigation and prevention projects.
- Obtain permission from landowner to delineate the wetland at the headwaters of the WSR, and submit delineation to U.S. Army Corps of Engineers for designation as a jurisdictional wetland.
- Commence restoration of the headwaters wetlands.
- Determine appropriate 1-acre demonstration plot for shale bank reclamation and replanting.
- Commence shale bank demonstration project. Evaluate success after 1-year
- Determine appropriate 1-mile stretch of dirt/gravel road for DSA demonstration project.
- Commence DSA demonstration project. Evaluate results after 1-year.

- Submit annual reports to WVDEP and USEPA summarizing water quality and benthic quarterly monitoring.

- Prepare revised WSR Comprehensive Watershed Management Plan upon establishment of TMDLs for the WSR in 2021.

Section I – Monitoring Program

Sampling by WSWA - In order to determine the efficacy of the NPS management actions, specific parameters will need to be measured and tracked. We recommend that sampling should include the State TMDL variables (i.e. total nitrogen, total phosphorus and total suspended solids). In addition, the majority of the Potomac Direct Drains for which TMDLs have been established are tracking fecal coliform and (in some cases) sediment loads. The Draft 2012 Impaired Stream List for WV describes the WSR as being impaired by fecal coliform and CNA-biological (due to sedimentation). Thus, the proposed WSR monitoring program should also track these two parameters as well.

We recommend that volunteers from the WSR Watershed Association be trained in the proper methods for collecting grab samples, recording the chain of custody, and delivering the samples to the selected laboratory within the appropriate hold time.

Sampling Protocol – Recommended tests are based on the Chesapeake Bay Water-Quality Monitoring Program, Potomac River Nontidal Nutrient and Sediment Sampling Quality Assurance Project Plan, Section B.4 – Analytical Methods (WVDEP, 2005).

Samples should be collected at locations identical to the mile points at which the WVDEP is conducting benthic and water quality assessments, namely at mile points 0.7, 4.9, 5.8, 8.2 and 8.9 respectively. The samples should be analyzed for the following parameters:

1. Total Nitrogen
2. Total Phosphorus
3. Total Suspended Solids
4. Fecal coliform
5. Dissolved Nitrate + Nitrite as N
6. Dissolved Ammonia as N
7. Dissolved Ortho-Phosphate as P
8. Total Suspended Sediment

The selected laboratory should be certified by the State of West Virginia for the analysis of the target parameters.

Samples should be collected quarterly, during times of normal flow. Normal flow will be defined as any period in which there has not been a significant (>0.25-inch) rainfall or snowmelt water equivalent within 7 days of the sampling event. In addition, samples should be collected during or within 24 hours of a significant precipitation event (as defined above) above to monitor peak flow effects on the measured parameters. The number of samples collected during peak flow events may be up to (but not exceeding) four per year.

It is our understanding that the WSWA has the capability to monitor the following parameters in the field:

- Dissolved Oxygen
- Temperature
- pH
- nitrate
- discharge rate

Storm samples should also be tested for sand equivalent value (also known as sand/fine split). This test is performed in the field, and requires only a standard sieve screen. WSWA volunteers will be trained to run the test.

These data should be collected concurrent with the sample collection at each sampling event.

Certificates of analyses along with chain of custody documentation should be retained and kept in a secure repository by the WSWA for the duration of the testing. Annual data summaries should be shared with WVDEP and EPA Region 9.

A quality assurance project plan (QAPP) should be prepared prior to the commencement of any testing. We recommend using the West Virginia Potomac River Nontidal Monitoring Program QAPP document (Appendix B) as a model for the WSR sampling QAPP. The QAPP should be submitted to WVDEP and USEPA District 9 for approval prior to the commencement of testing.

Sampling by WVDEP – It is assumed that WVDEP will continue its ongoing 5-year cycle sampling in the Potomac Direct Drains watershed. These data will then be used to augment and act as a comparison to data collected by the WSWA for the same mile point stations. Collectively, these data will be used to establish the TMDL base load allocations and reductions necessary within the WSR watershed to meet state and watershed specific reduction goals.

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Appendix A: USDA-NRCS Soil Report

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Morgan County, West Virginia

WSR Watershed

May 16, 2012

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://soils.usda.gov/sqi/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://soils.usda.gov/contact/state_offices/).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

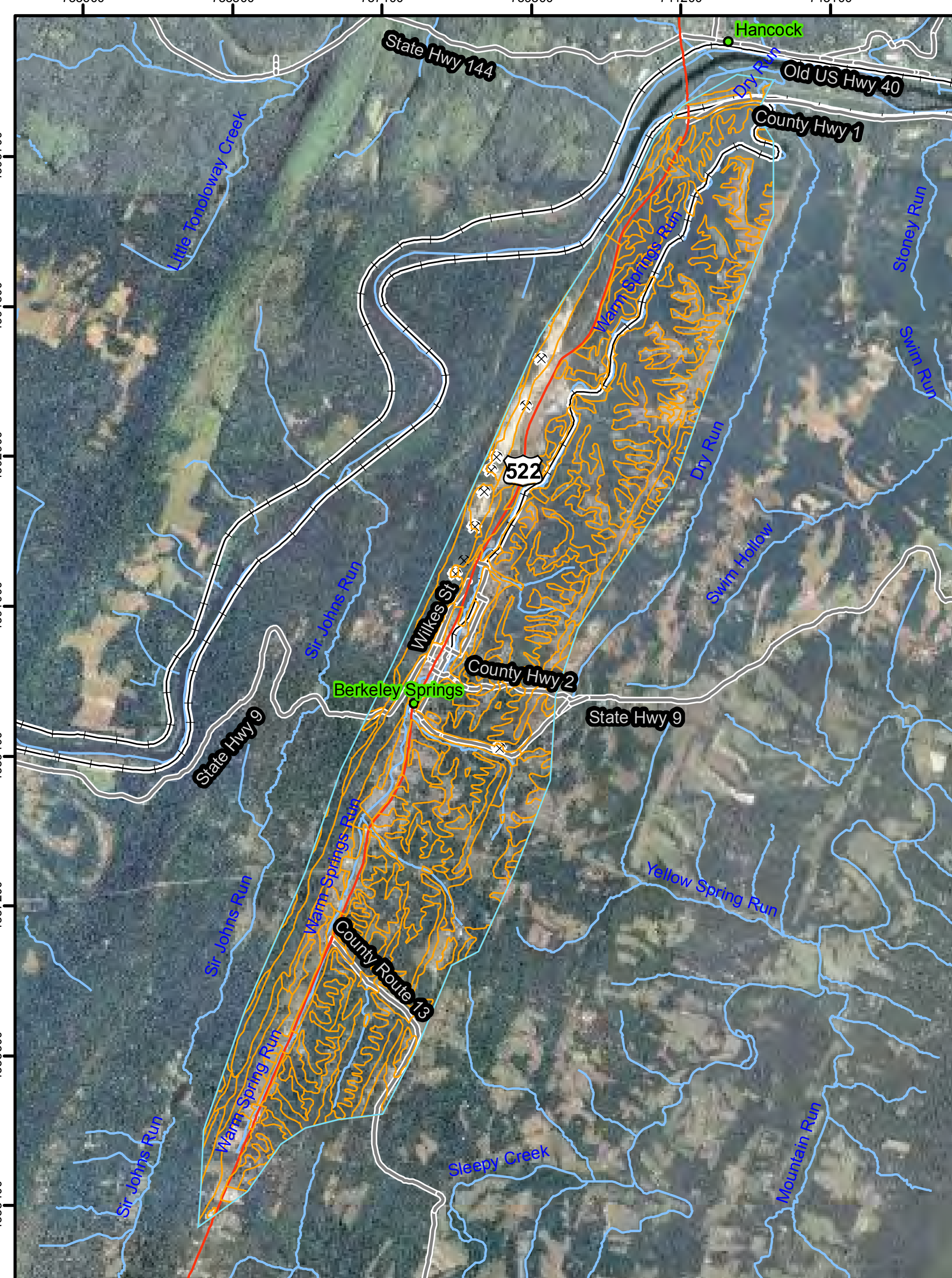
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:76,800 if printed on A size (8.5" x 11") sheet.

N

Meters: 0, 500, 1,000, 2,000, 3,000

Feet: 0, 2,500, 5,000, 10,000, 15,000

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features
- Gully
- Short Steep Slope
- Other

Political Features
- Cities

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads

MAP INFORMATION

Map Scale: 1:76,800 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 17N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Morgan County, West Virginia
Survey Area Data: Version 8, Apr 2, 2009

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Morgan County, West Virginia (WV065)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
BeC	Berks-Clearbrook channery silt loams, 8 to 15 percent slopes	224.4	2.9%
BkB	Berks-Weikert channery silt loams, 3 to 8 percent slopes	72.2	0.9%
BqF	Blackthorn very gravelly sandy loam, 35 to 55 percent slopes, rubbly	19.8	0.3%
BuB	Buchanan gravelly loam, 3 to 8 percent slopes	7.0	0.1%
BuC	Buchanan gravelly loam, 8 to 15 percent slopes	34.2	0.4%
BxC	Buchanan loam, 3 to 15 percent slopes, extremely stony	100.6	1.3%
BxE	Buchanan loam, 15 to 35 percent slopes, extremely stony	43.3	0.6%
ClD	Caneyville silt loam, 15 to 25 percent slopes	3.8	0.0%
CrC	Clarksburg gravelly silt loam, 8 to 15 percent slopes	2.7	0.0%
CvB	Clearbrook-Cavode silt loams, 0 to 8 percent slopes	88.8	1.2%
Cz	Combs fine sandy loam	16.8	0.2%
ErB	Ernest silt loam, 3 to 8 percent slopes	10.2	0.1%
ErC	Ernest silt loam, 8 to 15 percent slopes	12.4	0.2%
Ho	Holly silt loam	138.4	1.8%
Ln	Lindside silt loam	72.8	0.9%
Me	Melvin silt loam	0.2	0.0%
MrC	Murrill gravelly loam, 8 to 15 percent slopes	17.7	0.2%
MsE	Murrill loam, 15 to 35 percent slopes, extremely stony	171.4	2.2%
Pg	Philo gravelly loam	42.6	0.6%
Ph	Philo silt loam	10.7	0.1%
Qm	Quarry, limestone	1.2	0.0%
Qo	Quarry, sandstone	162.1	2.1%
ShC	Schaffenaker loamy sand, 3 to 15 percent slopes, very bouldery	23.6	0.3%
SkF	Schaffenaker-Rock outcrop complex, 35 to 65 percent slopes, rubbly	161.1	2.1%
SnE	Schaffenaker-Vanderlip loamy sands, 15 to 35 percent slopes, very bouldery	34.9	0.5%
SnF	Schaffenaker-Vanderlip loamy sands, 35 to 65 percent slopes, very bouldery	295.4	3.9%
SxE	Sideling gravelly loam, 15 to 35 percent slopes, extremely stony	39.7	0.5%

Morgan County, West Virginia (WV065)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Ua	Udorthents, smoothed	391.1	5.1%
Uu	Urban land-Udorthents complex, 0 to 25 percent slopes	288.5	3.8%
W	Water	13.1	0.2%
WaB	Weikert channery silt loam, 3 to 8 percent slopes	21.1	0.3%
WaC	Weikert channery silt loam, 8 to 15 percent slopes	340.0	4.4%
WbC	Weikert-Berks channery silt loams, 8 to 15 percent slopes	802.6	10.5%
WbD	Weikert-Berks channery silt loams, 15 to 25 percent slopes	1,709.5	22.3%
WkF	Weikert-Berks very channery silt loams, 25 to 70 percent slope	2,294.1	29.9%
Totals for Area of Interest		**7,667.9**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Morgan County, West Virginia

BeC—Berks-Clearbrook channery silt loams, 8 to 15 percent slopes

Map Unit Setting

Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Berks and similar soils: 55 percent
Clearbrook and similar soils: 40 percent
Minor components: 5 percent

Description of Berks

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 2.0 inches)

Interpretive groups

Land capability (nonirrigated): 3e
Other vegetative classification: Dry Uplands (DU2)

Typical profile

0 to 7 inches: Channery silt loam
7 to 21 inches: Very channery silt loam
21 to 25 inches: Extremely channery silt loam
25 to 29 inches: Bedrock

Description of Clearbrook

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 12 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 2.1 inches)

Interpretive groups

Land capability (nonirrigated): 3e
Other vegetative classification: Dry Uplands (DU2)

Typical profile

0 to 8 inches: Channery silt loam
8 to 19 inches: Very channery silty clay loam
19 to 22 inches: Extremely channery silty clay
22 to 26 inches: Bedrock

Minor Components

Cavode

Percent of map unit: 5 percent

BkB—Berks-Weikert channery silt loams, 3 to 8 percent slopes

Map Unit Setting

Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Berks and similar soils: 45 percent
Weikert and similar soils: 40 percent
Minor components: 15 percent

Description of Berks

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope, summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 2.0 inches)

Interpretive groups

Land capability (nonirrigated): 3e
Other vegetative classification: Dry Uplands (DU2)

Typical profile

0 to 7 inches: Channery silt loam
7 to 21 inches: Very channery silt loam
21 to 25 inches: Extremely channery silt loam
25 to 29 inches: Bedrock

Description of Weikert

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.6 inches)

Interpretive groups

Land capability (nonirrigated): 3e
Other vegetative classification: Droughty Shales (SD2)

Typical profile

0 to 6 inches: Channery silt loam
6 to 14 inches: Very channery silt loam
14 to 18 inches: Extremely channery silt loam
18 to 22 inches: Bedrock

Minor Components

Clearbrook

Percent of map unit: 10 percent

Cavode

Percent of map unit: 5 percent

BqF—Blackthorn very gravelly sandy loam, 35 to 55 percent slopes, rubbly

Map Unit Setting

Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Blackthorn and similar soils: 80 percent
Minor components: 20 percent

Description of Blackthorn

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Gravelly colluvium derived from sandstone over clayey residuum weathered from limestone

Properties and qualities

Slope: 35 to 55 percent
Surface area covered with cobbles, stones or boulders: 35.0 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Moderate (about 7.1 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Other vegetative classification: Not Suited (NS)

Typical profile

0 to 1 inches: Slightly decomposed plant material
1 to 2 inches: Very bouldery highly decomposed plant material
2 to 7 inches: Very gravelly sandy loam
7 to 47 inches: Very gravelly sandy loam
47 to 65 inches: Silty clay

Minor Components

Caneyville

Percent of map unit: 10 percent

Dekalb

Percent of map unit: 5 percent

Schaffenaker

Percent of map unit: 5 percent

BuB—Buchanan gravelly loam, 3 to 8 percent slopes

Map Unit Setting

Elevation: 370 to 2,210 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 48 to 55 degrees F
Frost-free period: 120 to 180 days

Map Unit Composition

Buchanan and similar soils: 85 percent
Minor components: 15 percent

Description of Buchanan

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Loamy colluvium derived from sandstone and shale

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 36 inches to fragipan
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 16 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.8 inches)

Interpretive groups

Land capability (nonirrigated): 2e
Other vegetative classification: Acid Loams (AL2)

Typical profile

0 to 8 inches: Gravelly loam
8 to 33 inches: Gravelly loam

33 to 65 inches: Gravelly loam

Minor Components

Andover

Percent of map unit: 5 percent
Landform: Drainageways

Cavode

Percent of map unit: 5 percent

Calvin

Percent of map unit: 5 percent

BuC—Buchanan gravelly loam, 8 to 15 percent slopes

Map Unit Setting

Elevation: 370 to 2,210 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 48 to 55 degrees F
Frost-free period: 120 to 180 days

Map Unit Composition

Buchanan and similar soils: 85 percent
Minor components: 15 percent

Description of Buchanan

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Loamy colluvium derived from sandstone and shale

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 36 inches to fragipan
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 16 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.8 inches)

Interpretive groups

Land capability (nonirrigated): 3e
Other vegetative classification: Acid Loams (AL2)

Typical profile

0 to 8 inches: Gravelly loam
8 to 33 inches: Gravelly loam
33 to 65 inches: Gravelly loam

Minor Components

Berks

Percent of map unit: 5 percent

Calvin

Percent of map unit: 5 percent

Andover

Percent of map unit: 4 percent
Landform: Drainageways

Litz

Percent of map unit: 1 percent

BxC—Buchanan loam, 3 to 15 percent slopes, extremely stony

Map Unit Setting

Elevation: 370 to 2,210 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 48 to 55 degrees F
Frost-free period: 120 to 180 days

Map Unit Composition

Buchanan and similar soils: 85 percent
Minor components: 15 percent

Description of Buchanan

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Loamy colluvium derived from sandstone and shale

Properties and qualities

Slope: 3 to 15 percent
Surface area covered with cobbles, stones or boulders: 9.0 percent
Depth to restrictive feature: 20 to 36 inches to fragipan
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 16 to 30 inches
Frequency of flooding: None

Frequency of ponding: None
Available water capacity: Low (about 3.1 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Other vegetative classification: Very Rocky, Acid Soils (RA2)

Typical profile

0 to 3 inches: Slightly decomposed plant material
3 to 4 inches: Moderately decomposed plant material
4 to 5 inches: Loam
5 to 33 inches: Gravelly loam
33 to 65 inches: Gravelly loam

Minor Components

Andover

Percent of map unit: 10 percent
Landform: Drainageways

Rubble land

Percent of map unit: 3 percent

Cavode

Percent of map unit: 1 percent

Udifluvents

Percent of map unit: 1 percent

BxE—Buchanan loam, 15 to 35 percent slopes, extremely stony

Map Unit Setting

Elevation: 370 to 2,210 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Buchanan and similar soils: 85 percent
Minor components: 15 percent

Description of Buchanan

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Loamy colluvium derived from sandstone and shale

Properties and qualities

Slope: 15 to 35 percent

Surface area covered with cobbles, stones or boulders: 9.0 percent
Depth to restrictive feature: 20 to 36 inches to fragipan
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 16 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.4 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Other vegetative classification: Very Rocky, Acid Soils (RA2)

Typical profile

0 to 2 inches: Slightly decomposed plant material
2 to 4 inches: Loam
4 to 30 inches: Gravelly loam
30 to 65 inches: Gravelly loam

Minor Components

Rubble land

Percent of map unit: 10 percent

Hazleton

Percent of map unit: 2 percent

Berks

Percent of map unit: 1 percent

Calvin

Percent of map unit: 1 percent

Dekalb

Percent of map unit: 1 percent

ClD—Caneyville silt loam, 15 to 25 percent slopes

Map Unit Setting

Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Caneyville and similar soils: 85 percent
Minor components: 15 percent

Description of Caneyville

Setting

Landform: Hillslopes

Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Clayey residuum weathered from limestone

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability (nonirrigated): 6e
Other vegetative classification: Limy Uplands (LU2)

Typical profile

0 to 4 inches: Silt loam
4 to 12 inches: Gravelly silt loam
12 to 24 inches: Silty clay
24 to 28 inches: Bedrock

Minor Components

Opequon

Percent of map unit: 5 percent

Murrill

Percent of map unit: 5 percent

Blackthorn

Percent of map unit: 3 percent

Litz

Percent of map unit: 2 percent

Caneyville

Percent of map unit:
Other vegetative classification: Limy Uplands (LU1)

CrC—Clarksburg gravelly silt loam, 8 to 15 percent slopes

Map Unit Setting

Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Clarksburg and similar soils: 80 percent
Minor components: 20 percent

Description of Clarksburg

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Mixed loamy colluvium derived from limestone, sandstone, and shale

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 36 inches to fragipan
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.57 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.2 inches)

Interpretive groups

Land capability (nonirrigated): 3e
Other vegetative classification: Fertile Loams (FL2)

Typical profile

0 to 12 inches: Gravelly silt loam
12 to 29 inches: Silty clay loam
29 to 60 inches: Clay loam

Minor Components

Sideling

Percent of map unit: 8 percent

Murrill

Percent of map unit: 8 percent

Litz

Percent of map unit: 4 percent

CvB—Clearbrook-Cavode silt loams, 0 to 8 percent slopes

Map Unit Setting

Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches

Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Clearbrook and similar soils: 50 percent
Cavode and similar soils: 35 percent
Minor components: 15 percent

Description of Clearbrook

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 2.6 inches)

Interpretive groups

Land capability (nonirrigated): 3w
Other vegetative classification: Dry Uplands (DU2)

Typical profile

0 to 8 inches: Silt loam
8 to 19 inches: Very channery silty clay loam
19 to 22 inches: Extremely channery silty clay
22 to 26 inches: Bedrock

Description of Cavode

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Clayey residuum weathered from shale

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 40 to 72 inches to paralithic bedrock
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None

Frequency of ponding: None
Available water capacity: Moderate (about 8.0 inches)

Interpretive groups

Land capability (nonirrigated): 3w
Other vegetative classification: Acid Loams (AL2)

Typical profile

0 to 12 inches: Silt loam
12 to 51 inches: Silty clay loam
51 to 62 inches: Very channery silty clay loam
62 to 66 inches: Bedrock

Minor Components

Berks

Percent of map unit: 5 percent

Buchanan

Percent of map unit: 5 percent

Dunning

Percent of map unit: 5 percent
Landform: Flood plains

Cz—Combs fine sandy loam

Map Unit Setting

Elevation: 370 to 700 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Combs and similar soils: 85 percent
Minor components: 15 percent

Description of Combs

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Recent coarse-loamy alluvium derived from limestone, sandstone, and shale

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)
Depth to water table: About 42 to 72 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water capacity: High (about 9.6 inches)

Interpretive groups
Land capability (nonirrigated): 2w
Other vegetative classification: Moist Loams (ML2)

Typical profile
0 to 20 inches: Fine sandy loam
20 to 53 inches: Fine sandy loam
53 to 65 inches: Fine sandy loam

Minor Components

Lindside
Percent of map unit: 10 percent

Typic udipsamments
Percent of map unit: 4 percent

Melvin
Percent of map unit: 1 percent
Landform: Flood plains

ErB—Ernest silt loam, 3 to 8 percent slopes

Map Unit Setting
Elevation: 300 to 3,000 feet
Mean annual precipitation: 34 to 55 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 214 days

Map Unit Composition
Ernest and similar soils: 85 percent
Minor components: 15 percent

Description of Ernest

Setting
Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Loamy colluvium derived from sandstone and shale

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 36 inches to fragipan
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 12 to 32 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.1 inches)

Interpretive groups

Land capability (nonirrigated): 2e
Other vegetative classification: Acid Loams (AL2)

Typical profile

0 to 7 inches: Silt loam
7 to 27 inches: Channery silty clay loam
27 to 43 inches: Channery silty clay loam
43 to 65 inches: Channery silt loam

Minor Components

Berks

Percent of map unit: 5 percent

Brinkerton

Percent of map unit: 5 percent
Landform: Depressions

Clearbrook

Percent of map unit: 3 percent

Holly

Percent of map unit: 1 percent
Landform: Flood plains

Philo

Percent of map unit: 1 percent

ErC—Ernest silt loam, 8 to 15 percent slopes

Map Unit Setting

Elevation: 300 to 1,300 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 46 to 55 degrees F
Frost-free period: 120 to 214 days

Map Unit Composition

Ernest and similar soils: 80 percent
Minor components: 20 percent

Description of Ernest

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Loamy colluvium derived from sandstone and shale

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 36 inches to fragipan
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 12 to 32 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.0 inches)

Interpretive groups

Land capability (nonirrigated): 3e
Other vegetative classification: Acid Loams (AL2)

Typical profile

0 to 6 inches: Silt loam
6 to 26 inches: Channery silty clay loam
26 to 42 inches: Channery silty clay loam
42 to 65 inches: Channery silt loam

Minor Components

Berks

Percent of map unit: 7 percent

Clearbrook

Percent of map unit: 6 percent

Brinkerton

Percent of map unit: 4 percent
Landform: Depressions

Rushtown

Percent of map unit: 3 percent

Ho—Holly silt loam

Map Unit Setting

Elevation: 370 to 700 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F

Frost-free period: 131 to 170 days

Map Unit Composition

Holly and similar soils: 80 percent
Minor components: 20 percent

Description of Holly

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Recent loamy alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Frequent
Frequency of ponding: Occasional
Available water capacity: High (about 9.6 inches)

Interpretive groups

Land capability (nonirrigated): 3w
Other vegetative classification: Wetlands (W2)

Typical profile

0 to 3 inches: Silt loam
3 to 24 inches: Silt loam
24 to 39 inches: Loam
39 to 65 inches: Gravelly sandy loam

Minor Components

Philo

Percent of map unit: 10 percent

Tygart

Percent of map unit: 7 percent

Brinkerton

Percent of map unit: 2 percent
Landform: Coves

Ernest

Percent of map unit: 1 percent

Ln—Lindside silt loam

Map Unit Setting

Elevation: 370 to 700 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Lindside and similar soils: 80 percent
Minor components: 20 percent

Description of Lindside

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Recent fine-silty alluvium derived from limestone

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water capacity: High (about 11.6 inches)

Interpretive groups

Land capability (nonirrigated): 2w
Other vegetative classification: Moist Loams (ML2)

Typical profile

0 to 7 inches: Silt loam
7 to 48 inches: Silty clay loam
48 to 60 inches: Stratified gravelly sandy loam to silt loam to silty clay loam

Minor Components

Tioga

Percent of map unit: 10 percent

Melvin

Percent of map unit: 5 percent
Landform: Flood plains

Dunning

Percent of map unit: 5 percent
Landform: Flood plains

Me—Melvin silt loam

Map Unit Setting

Elevation: 370 to 700 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Melvin and similar soils: 90 percent
Minor components: 10 percent

Description of Melvin

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Recent fine-silty alluvium derived from limestone, sandstone, and shale

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Frequent
Frequency of ponding: Occasional
Available water capacity: Very high (about 12.3 inches)

Interpretive groups

Land capability (nonirrigated): 3w
Other vegetative classification: Wetlands (W2)

Typical profile

0 to 10 inches: Silt loam
10 to 36 inches: Silty clay loam
36 to 68 inches: Sandy loam
68 to 72 inches: Silt loam

Minor Components

Lindside

Percent of map unit: 7 percent

Ernest

Percent of map unit: 3 percent

MrC—Murrill gravelly loam, 8 to 15 percent slopes

Map Unit Setting

Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Murrill and similar soils: 90 percent
Minor components: 10 percent

Description of Murrill

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Loamy colluvium derived from sandstone over residuum weathered from limestone

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups

Land capability (nonirrigated): 3e
Other vegetative classification: Fertile Loams (FL2)

Typical profile

0 to 9 inches: Gravelly loam
9 to 55 inches: Gravelly clay loam
55 to 72 inches: Silty clay loam

Minor Components

Clarksburg

Percent of map unit: 5 percent

Buchanan

Percent of map unit: 2 percent

Caneyville

Percent of map unit: 2 percent

Litz

Percent of map unit: 1 percent

MsE—Murrill loam, 15 to 35 percent slopes, extremely stony

Map Unit Setting

Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Murrill and similar soils: 85 percent
Minor components: 15 percent

Description of Murrill

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Loamy colluvium derived from sandstone over residuum weathered from limestone

Properties and qualities

Slope: 15 to 35 percent
Surface area covered with cobbles, stones or boulders: 9.0 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Moderate (about 7.0 inches)

Interpretive groups

Land capability (nonirrigated): 7s

Other vegetative classification: Very Rocky, Limy Soils (RL2)

Typical profile

0 to 9 inches: Loam
9 to 43 inches: Gravelly loam
43 to 60 inches: Silty clay

Minor Components

Buchanan

Percent of map unit: 10 percent

Caneyville

Percent of map unit: 3 percent

Litz

Percent of map unit: 2 percent

Pg—Philo gravelly loam

Map Unit Setting

Elevation: 370 to 700 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Philo and similar soils: 75 percent
Minor components: 25 percent

Description of Philo

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Recent coarse-loamy alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water capacity: Moderate (about 8.4 inches)

Interpretive groups

Land capability (nonirrigated): 2w
Other vegetative classification: Acid Loams (AL2)

Typical profile

0 to 9 inches: Gravelly loam
9 to 48 inches: Gravelly loam
48 to 65 inches: Stratified sand to gravelly loam

Minor Components

Pope

Percent of map unit: 10 percent

Melvin

Percent of map unit: 5 percent
Landform: Flood plains

Holly

Percent of map unit: 5 percent
Landform: Flood plains

Ernest

Percent of map unit: 3 percent

Tygart

Percent of map unit: 2 percent

Ph—Philo silt loam

Map Unit Setting

Elevation: 370 to 700 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Philo and similar soils: 75 percent
Minor components: 25 percent

Description of Philo

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Recent coarse-loamy alluvium derived from sandstone and shale

Properties and qualities

Slope: 0 to 3 percent

Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water capacity: Moderate (about 8.7 inches)

Interpretive groups

Land capability (nonirrigated): 2w
Other vegetative classification: Acid Loams (AL2)

Typical profile

0 to 10 inches: Silt loam
10 to 53 inches: Silt loam
53 to 65 inches: Stratified sand to very gravelly sandy loam

Minor Components

Pope

Percent of map unit: 10 percent

Melvin

Percent of map unit: 5 percent
Landform: Flood plains

Holly

Percent of map unit: 5 percent
Landform: Flood plains

Ernest

Percent of map unit: 3 percent

Tygart

Percent of map unit: 2 percent

Qm—Quarry, limestone

Map Unit Setting

Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Quarry, limestone: 97 percent
Minor components: 3 percent

Description of Quarry, Limestone

Properties and qualities

Slope: 0 to 200 percent

Depth to restrictive feature: 0 inches to lithic bedrock
Capacity of the most limiting layer to transmit water (Ksat): High to very high (1.98 to 19.98 in/hr)
Available water capacity: Very low (about 0.0 inches)

Interpretive groups
Other vegetative classification: Not Suited (NS)

Typical profile
0 to 60 inches: Bedrock

Minor Components

Caneyville
Percent of map unit: 1 percent

Murrill
Percent of map unit: 1 percent

Opequon
Percent of map unit: 1 percent

Qo—Quarry, sandstone

Map Unit Setting
Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition
Quarry, sandstone: 95 percent
Minor components: 5 percent

Description of Quarry, Sandstone

Properties and qualities
Slope: 0 to 200 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Available water capacity: Very low (about 0.0 inches)

Interpretive groups
Other vegetative classification: Not Suited (NS)

Typical profile
0 to 60 inches: Bedrock

Minor Components

Schaffenaker
Percent of map unit: 2 percent

Vanderlip

Percent of map unit: 2 percent

Dekalb

Percent of map unit: 1 percent

ShC—Schaffenaker loamy sand, 3 to 15 percent slopes, very bouldery

Map Unit Setting

Elevation: 800 to 1,200 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Schaffenaker and similar soils: 80 percent
Minor components: 20 percent

Description of Schaffenaker

Setting

Landform: Ridges
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Sandy residuum weathered from sandstone

Properties and qualities

Slope: 3 to 15 percent
Surface area covered with cobbles, stones or boulders: 2.1 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.6 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Other vegetative classification: Very Rocky, Acid Soils (RA2)

Typical profile

0 to 0 inches: Slightly decomposed plant material
0 to 1 inches: Moderately decomposed plant material
1 to 4 inches: Loamy sand
4 to 18 inches: Gravelly loamy sand
18 to 24 inches: Gravelly loamy sand
24 to 28 inches: Bedrock

Minor Components

Lithic quartzipsamments
Percent of map unit: 7 percent

Vanderlip
Percent of map unit: 5 percent

Dekalb
Percent of map unit: 5 percent

Aquic quartzipsamments
Percent of map unit: 2 percent

Rock outcrop
Percent of map unit: 1 percent

SkF—Schaffenaker-Rock outcrop complex, 35 to 65 percent slopes, rubbly

Map Unit Setting
Elevation: 800 to 1,200 feet
Mean annual precipitation: 27 to 44 inches
Mean annual air temperature: 36 to 56 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition
Schaffenaker and similar soils: 45 percent
Rock outcrop: 40 percent
Minor components: 15 percent

Description of Schaffenaker

Setting
Landform: Ridges
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Sandy residuum weathered from sandstone

Properties and qualities
Slope: 35 to 65 percent
Surface area covered with cobbles, stones or boulders: 40.0 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Available water capacity: Very low (about 1.6 inches)

Interpretive groups

Land capability (nonirrigated): 8s
Other vegetative classification: Not Suited (NS)

Typical profile

0 to 0 inches: Slightly decomposed plant material
0 to 1 inches: Moderately decomposed plant material
1 to 4 inches: Loamy sand
4 to 18 inches: Gravelly loamy sand
18 to 24 inches: Gravelly loamy sand
24 to 28 inches: Bedrock

Description of Rock Outcrop

Properties and qualities

Slope: 100 to 200 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)

Interpretive groups

Land capability (nonirrigated): 8s

Typical profile

0 to 60 inches: Bedrock

Minor Components

Lithic quartzipsamments

Percent of map unit: 8 percent

Vanderlip

Percent of map unit: 5 percent

Dekalb

Percent of map unit: 2 percent

Schaffenaker

Percent of map unit:
Other vegetative classification: Not Suited (NS)

SnE—Schaffenaker-Vanderlip loamy sands, 15 to 35 percent slopes, very bouldery

Map Unit Setting

Elevation: 800 to 1,200 feet
Mean annual precipitation: 27 to 44 inches
Mean annual air temperature: 36 to 56 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Schaffenaker and similar soils: 45 percent
Vanderlip and similar soils: 40 percent
Minor components: 15 percent

Description of Schaffenaker

Setting

Landform: Ridges
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Sandy residuum weathered from sandstone

Properties and qualities

Slope: 15 to 35 percent
Surface area covered with cobbles, stones or boulders: 2.1 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.6 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Other vegetative classification: Very Rocky, Acid Soils (RA2)

Typical profile

0 to 0 inches: Slightly decomposed plant material
0 to 1 inches: Moderately decomposed plant material
1 to 4 inches: Loamy sand
4 to 18 inches: Gravelly loamy sand
18 to 24 inches: Gravelly loamy sand
24 to 28 inches: Bedrock

Description of Vanderlip

Setting

Landform: Ridges
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Sandy residuum weathered from sandstone

Properties and qualities

Slope: 15 to 35 percent
Surface area covered with cobbles, stones or boulders: 2.1 percent
Depth to restrictive feature: 96 to 120 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 5.8 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Other vegetative classification: Very Rocky, Acid Soils (RA2)

Typical profile

0 to 2 inches: Slightly decomposed plant material
2 to 6 inches: Loamy sand
6 to 26 inches: Very cobbly loamy sand
26 to 50 inches: Sand
50 to 65 inches: Very bouldery sand

Minor Components

Dekalb

Percent of map unit: 5 percent

Hazleton

Percent of map unit: 5 percent

Lithic quartizpsamments

Percent of map unit: 2 percent

Sideling

Percent of map unit: 2 percent

Rock outcrop

Percent of map unit: 1 percent

Vanderlip

Percent of map unit:
Other vegetative classification: Very Rocky, Acid Soils (RA1)

Schaffenaker

Percent of map unit:
Other vegetative classification: Very Rocky, Acid Soils (RA1)

SnF—Schaffenaker-Vanderlip loamy sands, 35 to 65 percent slopes, very bouldery

Map Unit Setting

Elevation: 800 to 1,200 feet
Mean annual precipitation: 27 to 44 inches
Mean annual air temperature: 36 to 56 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Schaffenaker and similar soils: 40 percent

Vanderlip and similar soils: 40 percent
Minor components: 20 percent

Description of Vanderlip

Setting

Landform: Ridges
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Sandy residuum weathered from sandstone

Properties and qualities

Slope: 35 to 65 percent
Surface area covered with cobbles, stones or boulders: 2.1 percent
Depth to restrictive feature: 96 to 120 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 5.8 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Other vegetative classification: Not Suited (NS)

Typical profile

0 to 2 inches: Slightly decomposed plant material
2 to 6 inches: Loamy sand
6 to 26 inches: Very cobbly loamy sand
26 to 50 inches: Sand
50 to 65 inches: Very bouldery sand

Description of Schaffenaker

Setting

Landform: Ridges
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Sandy residuum weathered from sandstone

Properties and qualities

Slope: 35 to 65 percent
Surface area covered with cobbles, stones or boulders: 2.1 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.6 inches)

Interpretive groups
Land capability (nonirrigated): 7s
Other vegetative classification: Not Suited (NS)

Typical profile
0 to 0 inches: Slightly decomposed plant material
0 to 1 inches: Moderately decomposed plant material
1 to 4 inches: Loamy sand
4 to 18 inches: Gravelly loamy sand
18 to 24 inches: Gravelly loamy sand
24 to 28 inches: Bedrock

Minor Components

Dekalb
Percent of map unit: 5 percent

Hazleton
Percent of map unit: 5 percent

Sideling
Percent of map unit: 5 percent

Lithic quartzipsamments
Percent of map unit: 4 percent

Rock outcrop
Percent of map unit: 1 percent

Vanderlip
Percent of map unit:
Other vegetative classification: Very Rocky, Acid Soils (RA1)

Schaffenaker
Percent of map unit:
Other vegetative classification: Not Suited (NS)

SxE—Sideling gravelly loam, 15 to 35 percent slopes, extremely stony

Map Unit Setting
Elevation: 370 to 2,500 feet
Mean annual precipitation: 34 to 55 inches
Mean annual air temperature: 46 to 55 degrees F
Frost-free period: 110 to 180 days

Map Unit Composition
Sideling and similar soils: 80 percent
Minor components: 20 percent

Description of Sideling

Setting

Landform: Mountain slopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Loamy colluvium derived from sandstone and siltstone; loamy colluvium derived from shale and siltstone

Properties and qualities

Slope: 15 to 35 percent
Surface area covered with cobbles, stones or boulders: 9.0 percent
Depth to restrictive feature: 60 to 96 inches to paralithic bedrock
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 30 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Moderate (about 7.1 inches)

Interpretive groups

Land capability (nonirrigated): 7s
Other vegetative classification: Very Rocky, Acid Soils (RA2)

Typical profile

0 to 1 inches: Slightly decomposed plant material
1 to 3 inches: Moderately decomposed plant material
3 to 5 inches: Gravelly loam
5 to 35 inches: Gravelly loam
35 to 50 inches: Channery clay
50 to 62 inches: Very flaggy clay loam

Minor Components

Hazleton

Percent of map unit: 10 percent

Buchanan

Percent of map unit: 5 percent

Berks

Percent of map unit: 2 percent

Calvin

Percent of map unit: 2 percent

Andover

Percent of map unit: 1 percent
Landform: Drainageways

Ua—Udorthents, smoothed

Map Unit Setting

Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Udorthents and similar soils: 95 percent
Minor components: 5 percent

Description of Udorthents

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Interpretive groups

Other vegetative classification: Not Suited (NS)

Minor Components

Berks

Percent of map unit: 1 percent

Weikert

Percent of map unit: 1 percent

Urban land

Percent of map unit: 1 percent

Ernest

Percent of map unit: 1 percent

Clearbrook

Percent of map unit: 1 percent

Uu—Urban land-Udorthents complex, 0 to 25 percent slopes

Map Unit Setting

Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches

Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition
Urban land: 45 percent
Udorthents and similar soils: 45 percent
Minor components: 10 percent

Description of Udorthents

Properties and qualities
Slope: 0 to 25 percent
Depth to restrictive feature: More than 80 inches
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 0.0 inches)

Interpretive groups
Other vegetative classification: Not Suited (NS)

Typical profile
0 to 6 inches: Variable

Description of Urban Land

Properties and qualities
Slope: 0 to 25 percent
Depth to restrictive feature: 10 inches to
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)

Interpretive groups
Other vegetative classification: Not Suited (NS)

Typical profile
0 to Variable

Minor Components

Berks
Percent of map unit: 2 percent

Philo
Percent of map unit: 2 percent

Weikert
Percent of map unit: 2 percent

Buchanan
Percent of map unit: 1 percent

Ernest
Percent of map unit: 1 percent

Clearbrook
Percent of map unit: 1 percent

Vanderlip
Percent of map unit: 1 percent

W—Water

Map Unit Setting

Elevation: 370 to 2,210 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition

Water: 100 percent

WaB—Weikert channery silt loam, 3 to 8 percent slopes

Map Unit Setting

Elevation: 370 to 1,600 feet
Mean annual precipitation: 27 to 50 inches
Mean annual air temperature: 36 to 57 degrees F
Frost-free period: 120 to 200 days

Map Unit Composition

Weikert and similar soils: 85 percent
Minor components: 15 percent

Description of Weikert

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope, summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.3 inches)

Interpretive groups

Land capability (nonirrigated): 3e
Other vegetative classification: Droughty Shales (SD2)

Typical profile

0 to 6 inches: Channery silt loam
6 to 11 inches: Very channery silt loam
11 to 14 inches: Extremely channery silt loam
14 to 18 inches: Bedrock

Minor Components

Rough

Percent of map unit: 9 percent

Clearbrook

Percent of map unit: 5 percent

Rock outcrop

Percent of map unit: 1 percent

WaC—Weikert channery silt loam, 8 to 15 percent slopes

Map Unit Setting

Elevation: 370 to 1,600 feet
Mean annual precipitation: 27 to 50 inches
Mean annual air temperature: 36 to 57 degrees F
Frost-free period: 120 to 200 days

Map Unit Composition

Weikert and similar soils: 85 percent
Minor components: 15 percent

Description of Weikert

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Available water capacity: Very low (about 1.2 inches)

Interpretive groups
Land capability (nonirrigated): 4e
Other vegetative classification: Droughty Shales (SD2)

Typical profile
0 to 5 inches: Channery silt loam
5 to 10 inches: Very channery silt loam
10 to 13 inches: Extremely channery silt loam
13 to 17 inches: Bedrock

Minor Components

Rough
Percent of map unit: 9 percent

Clearbrook
Percent of map unit: 5 percent

Rock outcrop
Percent of map unit: 1 percent

WbC—Weikert-Berks channery silt loams, 8 to 15 percent slopes

Map Unit Setting
Elevation: 370 to 1,200 feet
Mean annual precipitation: 34 to 44 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 131 to 170 days

Map Unit Composition
Weikert and similar soils: 45 percent
Berks and similar soils: 40 percent
Minor components: 15 percent

Description of Weikert

Setting
Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities
Slope: 8 to 15 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.6 inches)

Interpretive groups
Land capability (nonirrigated): 4e
Other vegetative classification: Droughty Shales (SD2)

Typical profile
0 to 6 inches: Channery silt loam
6 to 14 inches: Very channery silt loam
14 to 18 inches: Extremely channery silt loam
18 to 22 inches: Bedrock

Description of Berks

Setting
Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities
Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 2.0 inches)

Interpretive groups
Land capability (nonirrigated): 4e
Other vegetative classification: Dry Uplands (DU2)

Typical profile
0 to 7 inches: Channery silt loam
7 to 12 inches: Channery silt loam
12 to 21 inches: Very channery silt loam
21 to 25 inches: Extremely channery silt loam
25 to 29 inches: Bedrock

Minor Components

Clearbrook
Percent of map unit: 9 percent

Ernest
Percent of map unit: 3 percent

Cavode
Percent of map unit: 2 percent

Rushtown

Percent of map unit: 1 percent

WbD—Weikert-Berks channery silt loams, 15 to 25 percent slopes

Map Unit Setting

Elevation: 300 to 1,600 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 217 days

Map Unit Composition

Weikert and similar soils: 50 percent
Berks and similar soils: 35 percent
Minor components: 15 percent

Description of Weikert

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.4 inches)

Interpretive groups

Land capability (nonirrigated): 6e
Other vegetative classification: Shale Hills (SH2)

Typical profile

0 to 4 inches: Channery silt loam
4 to 12 inches: Very channery silt loam
12 to 16 inches: Extremely channery silt loam
16 to 20 inches: Bedrock

Description of Berks

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.8 inches)

Interpretive groups

Land capability (nonirrigated): 6e
Other vegetative classification: Dry Uplands (DU2)

Typical profile

0 to 5 inches: Channery silt loam
5 to 10 inches: Channery silt loam
10 to 19 inches: Very channery silt loam
19 to 23 inches: Extremely channery loam
23 to 27 inches: Bedrock

Minor Components

Ernest

Percent of map unit: 5 percent

Rough

Percent of map unit: 4 percent

Philo

Percent of map unit: 2 percent

Cavode

Percent of map unit: 1 percent

Rock outcrop

Percent of map unit: 1 percent

Clearbrook

Percent of map unit: 1 percent

Rushtown

Percent of map unit: 1 percent

Berks

Percent of map unit:
Other vegetative classification: Dry Uplands (DU1)

Weikert

Percent of map unit:
Other vegetative classification: Shale Hills (SH1)

WkF—Weikert-Berks very channery silt loams, 25 to 70 percent slope

Map Unit Setting

Elevation: 300 to 1,600 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 217 days

Map Unit Composition

Weikert and similar soils: 50 percent
Berks and similar soils: 35 percent
Minor components: 15 percent

Description of Weikert

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities

Slope: 25 to 70 percent
Depth to restrictive feature: 10 to 20 inches to paralithic bedrock
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 1.5 inches)

Interpretive groups

Land capability (nonirrigated): 7e
Other vegetative classification: Not Suited (NS)

Typical profile

0 to 1 inches: Slightly decomposed plant material
1 to 3 inches: Very channery silt loam
3 to 14 inches: Very channery silt loam
14 to 18 inches: Bedrock

Description of Berks

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Gravelly residuum weathered from sandstone and shale

Properties and qualities

Slope: 25 to 70 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 2.4 inches)

Interpretive groups

Land capability (nonirrigated): 7e
Other vegetative classification: Not Suited (NS)

Typical profile

0 to 1 inches: Slightly decomposed plant material
1 to 3 inches: Very channery silt loam
3 to 13 inches: Very channery loam
13 to 25 inches: Very channery silt loam
25 to 29 inches: Bedrock

Minor Components

Ernest

Percent of map unit: 6 percent

Rough

Percent of map unit: 4 percent

Philo

Percent of map unit: 2 percent

Rock outcrop

Percent of map unit: 1 percent

Pope

Percent of map unit: 1 percent

Rushtown

Percent of map unit: 1 percent

Berks

Percent of map unit:
Other vegetative classification: Dry Uplands (DU1)

Weikert

Percent of map unit:
Other vegetative classification: Shale Hills (SH1)

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

Building Site Development

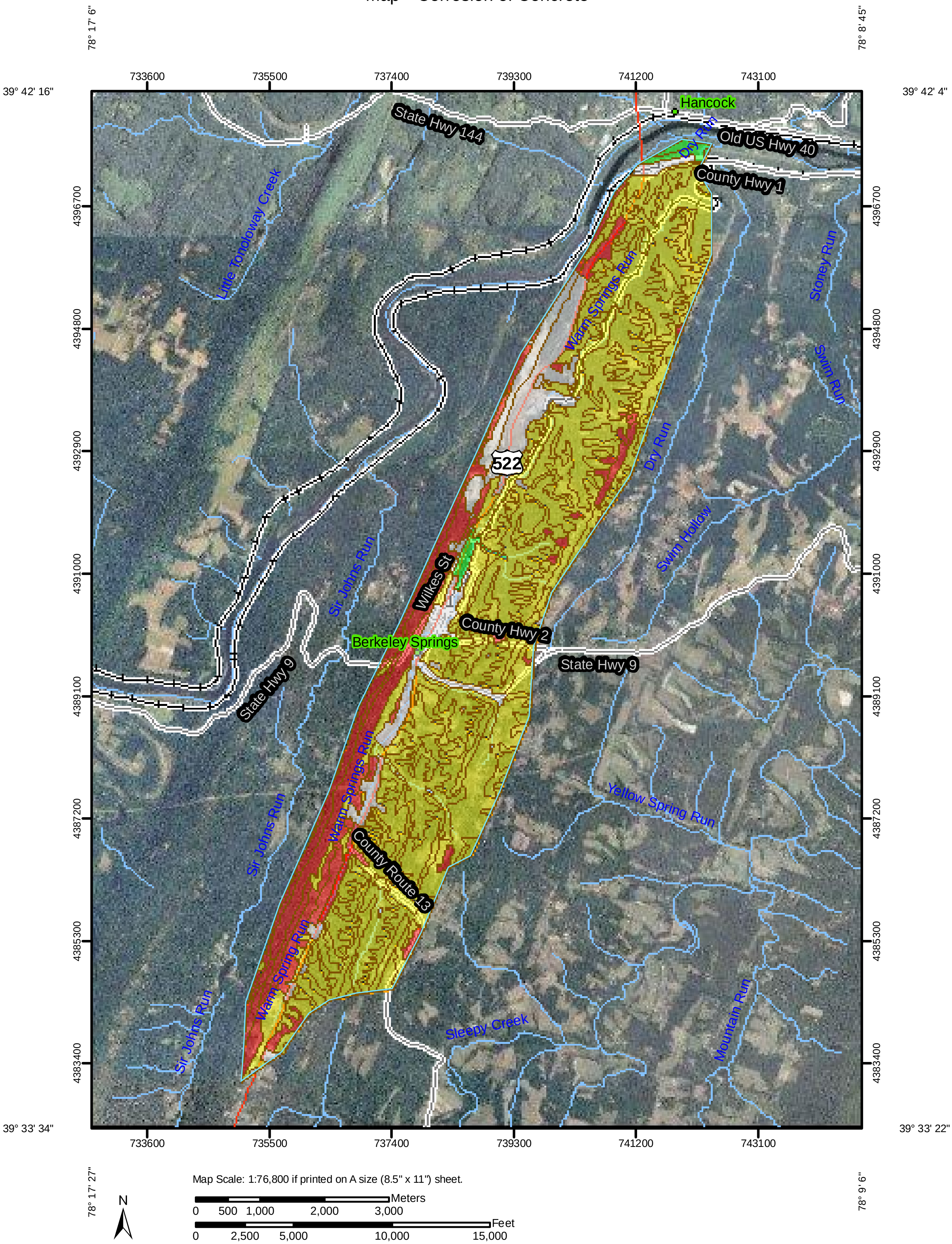
Building site development interpretations are designed to be used as tools for evaluating soil suitability and identifying soil limitations for various construction purposes. As part of the interpretation process, the rating applies to each soil in its described condition and does not consider present land use. Example interpretations can include corrosion of concrete and steel, shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping.

Corrosion of Concrete

"Risk of corrosion" pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens concrete. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the concrete in installations that are entirely within one kind of soil or within one soil layer.

The risk of corrosion is expressed as "low," "moderate," or "high."

Map—Corrosion of Concrete



Map Scale: 1:76,800 if printed on A size (8.5" x 11") sheet.

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Soil Ratings

High

Moderate

Low

Not rated or not available

Political Features

Cities

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

MAP INFORMATION

Map Scale: 1:76,800 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 17N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Morgan County, West Virginia
Survey Area Data: Version 8, Apr 2, 2009

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Corrosion of Concrete

Corrosion of Concrete— Summary by Map Unit — Morgan County, West Virginia (WV065)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
BeC	Berks-Clearbrook channery silt loams, 8 to 15 percent slopes	High	224.4	2.9%
BkB	Berks-Weikert channery silt loams, 3 to 8 percent slopes	High	72.2	0.9%
BqF	Blackthorn very gravelly sandy loam, 35 to 55 percent slopes, rubbly	High	19.8	0.3%
BuB	Buchanan gravelly loam, 3 to 8 percent slopes	High	7.0	0.1%
BuC	Buchanan gravelly loam, 8 to 15 percent slopes	High	34.2	0.4%
BxC	Buchanan loam, 3 to 15 percent slopes, extremely stony	High	100.6	1.3%
BxE	Buchanan loam, 15 to 35 percent slopes, extremely stony	High	43.3	0.6%
ClD	Caneyville silt loam, 15 to 25 percent slopes	Moderate	3.8	0.0%
CrC	Clarksburg gravelly silt loam, 8 to 15 percent slopes	Moderate	2.7	0.0%
CvB	Clearbrook-Cavode silt loams, 0 to 8 percent slopes	Moderate	88.8	1.2%
Cz	Combs fine sandy loam	Low	16.8	0.2%
ErB	Ernest silt loam, 3 to 8 percent slopes	Moderate	10.2	0.1%
ErC	Ernest silt loam, 8 to 15 percent slopes	Moderate	12.4	0.2%
Ho	Holly silt loam	Moderate	138.4	1.8%
Ln	Lindside silt loam	Low	72.8	0.9%
Me	Melvin silt loam	Low	0.2	0.0%
MrC	Murrill gravelly loam, 8 to 15 percent slopes	High	17.7	0.2%
MsE	Murrill loam, 15 to 35 percent slopes, extremely stony	High	171.4	2.2%
Pg	Philo gravelly loam	High	42.6	0.6%
Ph	Philo silt loam	High	10.7	0.1%
Qm	Quarry, limestone		1.2	0.0%
Qo	Quarry, sandstone		162.1	2.1%
ShC	Schaffenaker loamy sand, 3 to 15 percent slopes, very bouldery	High	23.6	0.3%
SkF	Schaffenaker-Rock outcrop complex, 35 to 65 percent slopes, rubbly	High	161.1	2.1%
SnE	Schaffenaker-Vanderlip loamy sands, 15 to 35 percent slopes, very bouldery	High	34.9	0.5%

Corrosion of Concrete— Summary by Map Unit — Morgan County, West Virginia (WV065)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
SnF	Schaffenaker-Vanderlip loamy sands, 35 to 65 percent slopes, very bouldery	High	295.4	3.9%
SxE	Sideling gravelly loam, 15 to 35 percent slopes, extremely stony	Moderate	39.7	0.5%
Ua	Udorthents, smoothed		391.1	5.1%
Uu	Urban land-Udorthents complex, 0 to 25 percent slopes		288.5	3.8%
W	Water		13.1	0.2%
WaB	Weikert channery silt loam, 3 to 8 percent slopes	Moderate	21.1	0.3%
WaC	Weikert channery silt loam, 8 to 15 percent slopes	Moderate	340.0	4.4%
WbC	Weikert-Berks channery silt loams, 8 to 15 percent slopes	Moderate	802.6	10.5%
WbD	Weikert-Berks channery silt loams, 15 to 25 percent slopes	Moderate	1,709.5	22.3%
WkF	Weikert-Berks very channery silt loams, 25 to 70 percent slope	Moderate	2,294.1	29.9%
Totals for Area of Interest			**7,667.9**	**100.0%**

Rating Options—Corrosion of Concrete

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

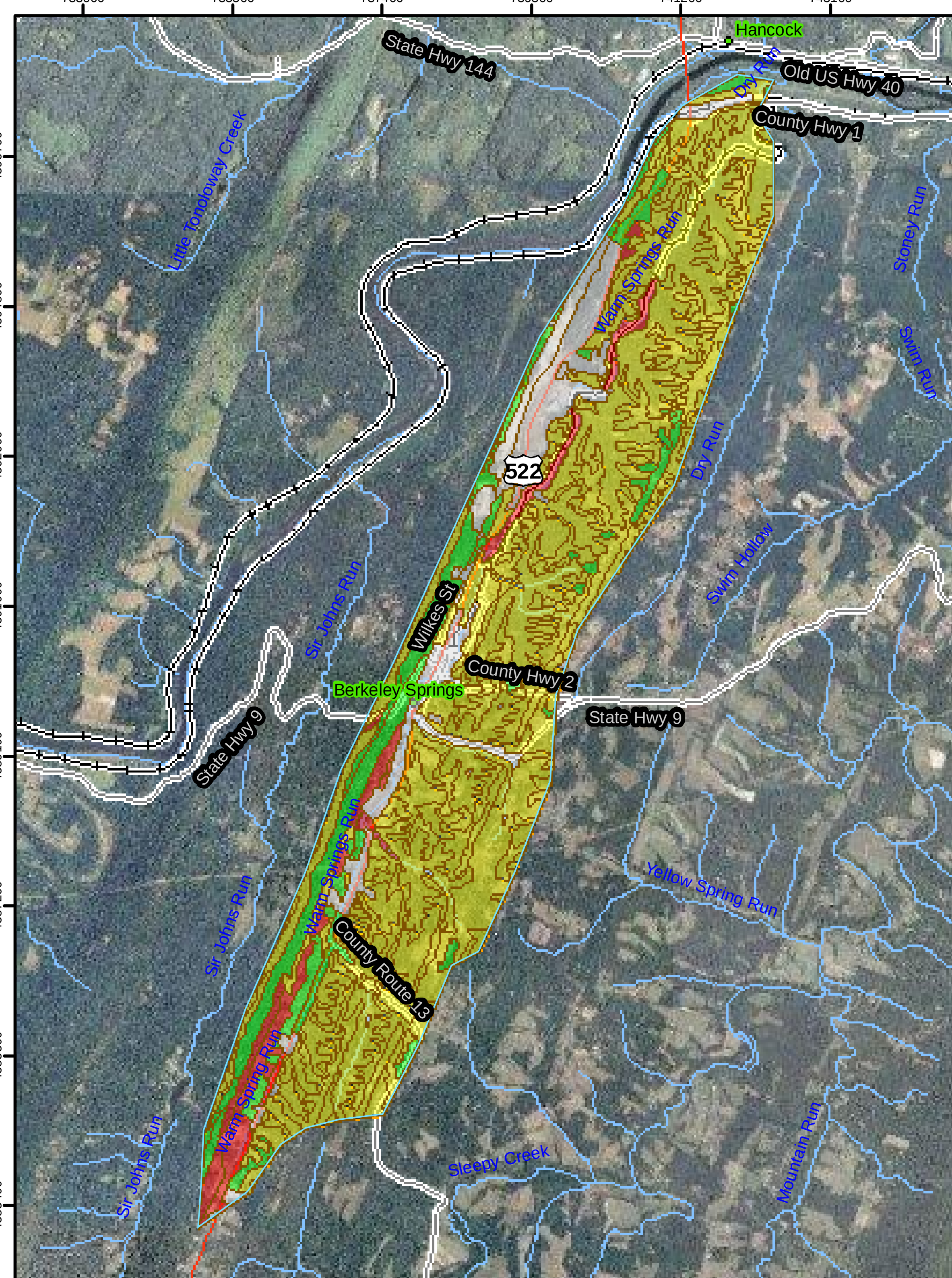
Tie-break Rule: Higher

Corrosion of Steel

"Risk of corrosion" pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel in installations that are entirely within one kind of soil or within one soil layer.

The risk of corrosion is expressed as "low," "moderate," or "high."

Map—Corrosion of Steel



78° 17' 27"
78° 9' 6"

Map Scale: 1:76,800 if printed on A size (8.5" x 11") sheet.

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Soil Ratings

High

Moderate

Low

Not rated or not available

Political Features

Cities

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

MAP INFORMATION

Map Scale: 1:76,800 if printed on A size (8.5" × 11") sheet.

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Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 17N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Morgan County, West Virginia
Survey Area Data: Version 8, Apr 2, 2009

Date(s) aerial images were photographed: Data not available.

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Table—Corrosion of Steel

Corrosion of Steel— Summary by Map Unit — Morgan County, West Virginia (WV065)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BeC	Berks-Clearbrook channery silt loams, 8 to 15 percent slopes	Low	224.4	2.9%
BkB	Berks-Weikert channery silt loams, 3 to 8 percent slopes	Low	72.2	0.9%
BqF	Blackthorn very gravelly sandy loam, 35 to 55 percent slopes, rubbly	Moderate	19.8	0.3%
BuB	Buchanan gravelly loam, 3 to 8 percent slopes	High	7.0	0.1%
BuC	Buchanan gravelly loam, 8 to 15 percent slopes	High	34.2	0.4%
BxC	Buchanan loam, 3 to 15 percent slopes, extremely stony	High	100.6	1.3%
BxE	Buchanan loam, 15 to 35 percent slopes, extremely stony	High	43.3	0.6%
ClD	Caneyville silt loam, 15 to 25 percent slopes	High	3.8	0.0%
CrC	Clarksburg gravelly silt loam, 8 to 15 percent slopes	Moderate	2.7	0.0%
CvB	Clearbrook-Cavode silt loams, 0 to 8 percent slopes	High	88.8	1.2%
Cz	Combs fine sandy loam	Low	16.8	0.2%
ErB	Ernest silt loam, 3 to 8 percent slopes	Moderate	10.2	0.1%
ErC	Ernest silt loam, 8 to 15 percent slopes	Moderate	12.4	0.2%
Ho	Holly silt loam	High	138.4	1.8%
Ln	Lindside silt loam	Moderate	72.8	0.9%
Me	Melvin silt loam	High	0.2	0.0%
MrC	Murrill gravelly loam, 8 to 15 percent slopes	Moderate	17.7	0.2%
MsE	Murrill loam, 15 to 35 percent slopes, extremely stony	Moderate	171.4	2.2%
Pg	Philo gravelly loam	Low	42.6	0.6%
Ph	Philo silt loam	Low	10.7	0.1%
Qm	Quarry, limestone		1.2	0.0%
Qo	Quarry, sandstone		162.1	2.1%
ShC	Schaffenaker loamy sand, 3 to 15 percent slopes, very bouldery	Low	23.6	0.3%
SkF	Schaffenaker-Rock outcrop complex, 35 to 65 percent slopes, rubbly	Low	161.1	2.1%
SnE	Schaffenaker-Vanderlip loamy sands, 15 to 35 percent slopes, very bouldery	Low	34.9	0.5%

Corrosion of Steel— Summary by Map Unit — Morgan County, West Virginia (WV065)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
SnF	Schaffenaker-Vanderlip loamy sands, 35 to 65 percent slopes, very bouldery	Low	295.4	3.9%
SxE	Sideling gravelly loam, 15 to 35 percent slopes, extremely stony	High	39.7	0.5%
Ua	Udorthents, smoothed		391.1	5.1%
Uu	Urban land-Udorthents complex, 0 to 25 percent slopes		288.5	3.8%
W	Water		13.1	0.2%
WaB	Weikert channery silt loam, 3 to 8 percent slopes	Moderate	21.1	0.3%
WaC	Weikert channery silt loam, 8 to 15 percent slopes	Moderate	340.0	4.4%
WbC	Weikert-Berks channery silt loams, 8 to 15 percent slopes	Moderate	802.6	10.5%
WbD	Weikert-Berks channery silt loams, 15 to 25 percent slopes	Moderate	1,709.5	22.3%
WkF	Weikert-Berks very channery silt loams, 25 to 70 percent slope	Moderate	2,294.1	29.9%
Totals for Area of Interest			**7,667.9**	**100.0%**

Rating Options—Corrosion of Steel

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Land Management

Land management interpretations are tools designed to guide the user in evaluating existing conditions in planning and predicting the soil response to various land management practices, for a variety of land uses, including cropland, forestland, hayland, pastureland, horticulture, and rangeland. Example interpretations include suitability for a variety of irrigation practices, log landings, haul roads and major skid trails, equipment operability, site preparation, suitability for hand and mechanical planting, potential erosion hazard associated with various practices, and ratings for fencing and waterline installation.

Erosion Hazard (Road, Trail)

The ratings in this interpretation indicate the hazard of soil loss from unsurfaced roads and trails. The ratings are based on soil erosion factor K, slope, and content of rock fragments.

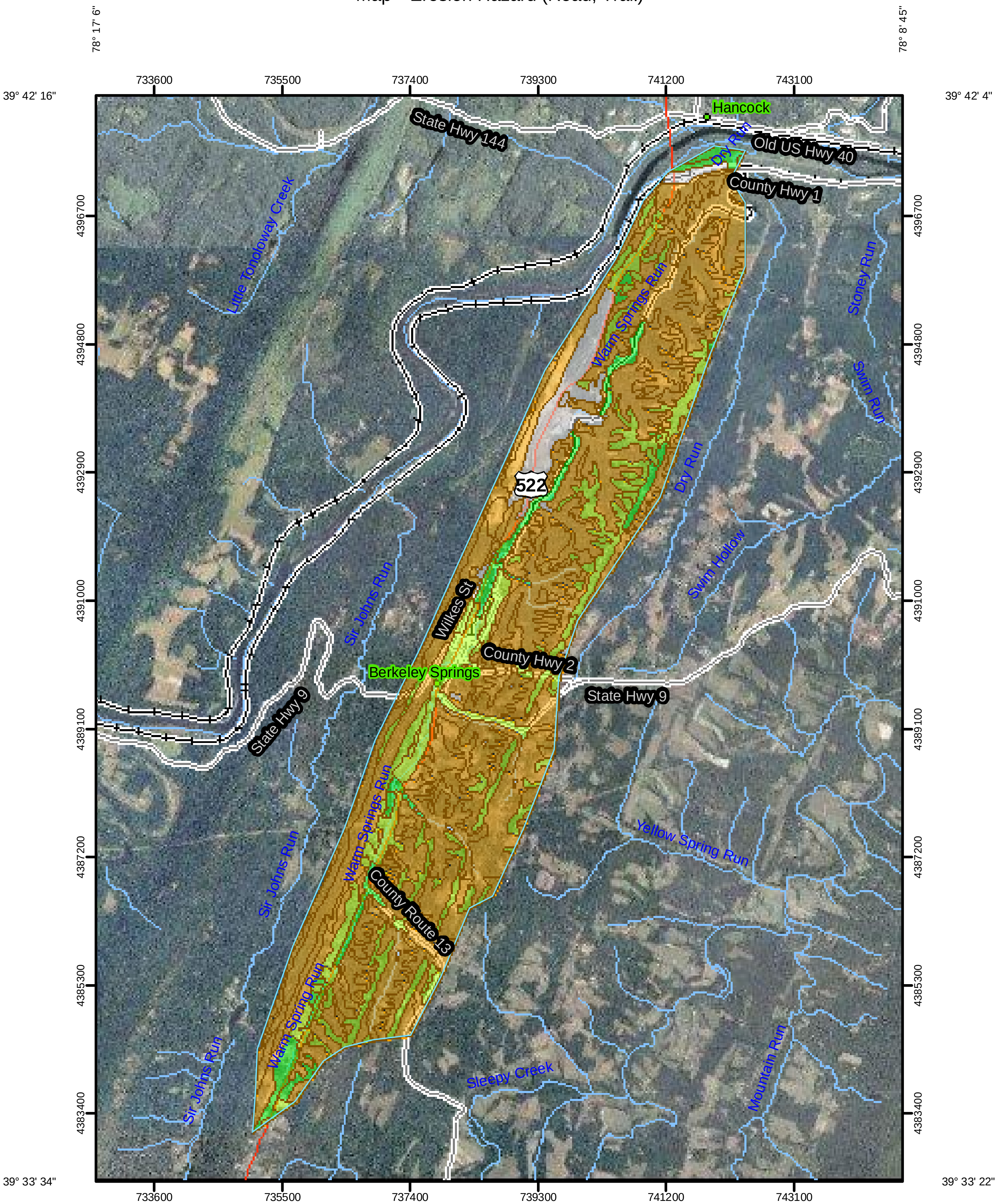
The ratings are both verbal and numerical. The hazard is described as "slight," "moderate," or "severe." A rating of "slight" indicates that little or no erosion is likely; "moderate" indicates that some erosion is likely, that the roads or trails may require occasional maintenance, and that simple erosion-control measures are needed; and "severe" indicates that significant erosion is expected, that the roads or trails require frequent maintenance, and that costly erosion-control measures are needed.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

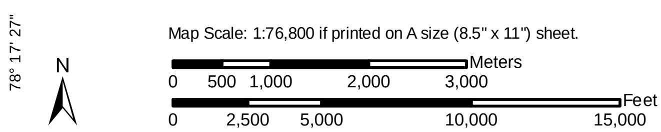
The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Map—Erosion Hazard (Road, Trail)



Map Scale: 1:76,800 if printed on A size (8.5" x 11") sheet.



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Soil Ratings

Very severe

Severe

Moderate

Slight

Not rated or not available

Political Features

Cities

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

MAP INFORMATION

Map Scale: 1:76,800 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

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Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 17N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Morgan County, West Virginia
Survey Area Data: Version 8, Apr 2, 2009

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—Erosion Hazard (Road, Trail)

Erosion Hazard (Road, Trail)— Summary by Map Unit — Morgan County, West Virginia (WV065)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
BeC	Berks-Clearbrook channery silt loams, 8 to 15 percent slopes	Moderate	Berks (55%)	Slope/erodibility (0.50)	224.4	2.9%
			Clearbrook (40%)	Slope/erodibility (0.50)		
BkB	Berks-Weikert channery silt loams, 3 to 8 percent slopes	Slight	Berks (45%)		72.2	0.9%
BqF	Blackthorn very gravelly sandy loam, 35 to 55 percent slopes, rubbly	Severe	Blackthorn (80%)	Slope/erodibility (0.95)	19.8	0.3%
BuB	Buchanan gravelly loam, 3 to 8 percent slopes	Moderate	Buchanan (85%)	Slope/erodibility (0.50)	7.0	0.1%
BuC	Buchanan gravelly loam, 8 to 15 percent slopes	Severe	Buchanan (85%)	Slope/erodibility (0.95)	34.2	0.4%
BxC	Buchanan loam, 3 to 15 percent slopes, extremely stony	Severe	Buchanan (85%)	Slope/erodibility (0.95)	100.6	1.3%
BxE	Buchanan loam, 15 to 35 percent slopes, extremely stony	Severe	Buchanan (85%)	Slope/erodibility (0.95)	43.3	0.6%
ClD	Caneyville silt loam, 15 to 25 percent slopes	Severe	Caneyville (85%)	Slope/erodibility (0.95)	3.8	0.0%
CrC	Clarksburg gravelly silt loam, 8 to 15 percent slopes	Severe	Clarksburg (80%)	Slope/erodibility (0.95)	2.7	0.0%
CvB	Clearbrook-Cavode silt loams, 0 to 8 percent slopes	Slight	Clearbrook (50%)		88.8	1.2%
Cz	Combs fine sandy loam	Slight	Combs (85%)		16.8	0.2%
ErB	Ernest silt loam, 3 to 8 percent slopes	Moderate	Ernest (85%)	Slope/erodibility (0.50)	10.2	0.1%
			Brinkerton (5%)	Slope/erodibility (0.50)		
ErC	Ernest silt loam, 8 to 15 percent slopes	Severe	Ernest (80%)	Slope/erodibility (0.95)	12.4	0.2%
			Brinkerton (4%)	Slope/erodibility (0.95)		
Ho	Holly silt loam	Slight	Holly (80%)		138.4	1.8%
Ln	Lindside silt loam	Slight	Lindside (80%)		72.8	0.9%
Me	Melvin silt loam	Slight	Melvin (90%)		0.2	0.0%
			Lindside (7%)			
MrC	Murrill gravelly loam, 8 to 15 percent slopes	Severe	Murrill (90%)	Slope/erodibility (0.95)	17.7	0.2%

Erosion Hazard (Road, Trail)— Summary by Map Unit — Morgan County, West Virginia (WV065)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
MsE	Murrill loam, 15 to 35 percent slopes, extremely stony	Severe	Murrill (85%)	Slope/erodibility (0.95)	171.4	2.2%
Pg	Philo gravelly loam	Slight	Philo (75%)		42.6	0.6%
Ph	Philo silt loam	Slight	Philo (75%)		10.7	0.1%
Qm	Quarry, limestone	Severe	Quarry, limestone (97%)	Slope/erodibility (0.95)	1.2	0.0%
				Slope/erodibility (0.95)		
Qo	Quarry, sandstone	Severe	Quarry, sandstone (95%)	Slope/erodibility (0.95)	162.1	2.1%
				Slope/erodibility (0.95)		
ShC	Schaffenaker loamy sand, 3 to 15 percent slopes, very bouldery	Moderate	Schaffenaker (80%)	Slope/erodibility (0.50)	23.6	0.3%
SkF	Schaffenaker-Rock outcrop complex, 35 to 65 percent slopes, rubbly	Severe	Schaffenaker (45%)	Slope/erodibility (0.95)	161.1	2.1%
			Rock outcrop (40%)	Slope/erodibility (0.95)		
				Slope/erodibility (0.95)		
SnE	Schaffenaker-Vanderlip loamy sands, 15 to 35 percent slopes, very bouldery	Severe	Schaffenaker (45%)	Slope/erodibility (0.95)	34.9	0.5%
			Vanderlip (40%)	Slope/erodibility (0.95)		
SnF	Schaffenaker-Vanderlip loamy sands, 35 to 65 percent slopes, very bouldery	Severe	Vanderlip (40%)	Slope/erodibility (0.95)	295.4	3.9%
			Schaffenaker (40%)	Slope/erodibility (0.95)		
SxE	Sideling gravelly loam, 15 to 35 percent slopes, extremely stony	Moderate	Sideling (80%)	Slope/erodibility (0.50)	39.7	0.5%
			Hazleton (10%)	Slope/erodibility (0.50)		
Ua	Udorthents, smoothed	Not rated	Udorthents (95%)		391.1	5.1%
			Weikert (1%)			
			Urban land (1%)			
			Ernest (1%)			
			Clearbrook (1%)			
			Berks (1%)			
Uu	Urban land-Udorthents complex, 0 to 25 percent slopes	Moderate	Udorthents (45%)	Slope/erodibility (0.50)	288.5	3.8%
				Slope/erodibility (0.50)		
			Urban land (45%)	Slope/erodibility (0.50)		
				Slope/erodibility (0.50)		
W	Water	Not rated	Water (100%)		13.1	0.2%
WaB	Weikert channery silt loam, 3 to 8 percent slopes	Moderate	Weikert (85%)	Slope/erodibility (0.50)	21.1	0.3%
			Rough (9%)	Slope/erodibility (0.50)		
			Clearbrook (5%)	Slope/erodibility (0.50)		

Erosion Hazard (Road, Trail)— Summary by Map Unit — Morgan County, West Virginia (WV065)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
WaC	Weikert channery silt loam, 8 to 15 percent slopes	Severe	Weikert (85%)	Slope/erodibility (0.95)	340.0	4.4%
WbC	Weikert-Berks channery silt loams, 8 to 15 percent slopes	Moderate	Weikert (45%)	Slope/erodibility (0.50)	802.6	10.5%
			Berks (40%)	Slope/erodibility (0.50)		
WbD	Weikert-Berks channery silt loams, 15 to 25 percent slopes	Severe	Weikert (50%)	Slope/erodibility (0.95)	1,709.5	22.3%
WkF	Weikert-Berks very channery silt loams, 25 to 70 percent slope	Severe	Weikert (50%)	Slope/erodibility (0.95)	2,294.1	29.9%
			Berks (35%)	Slope/erodibility (0.95)		
Totals for Area of Interest					**7,667.9**	**100.0%**

Erosion Hazard (Road, Trail)— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Severe	5,404.2	70.5%
Moderate	1,417.0	18.5%
Slight	442.6	5.8%
Null or Not Rated	404.2	5.3%
Totals for Area of Interest	**7,667.9**	**100.0%**

Rating Options—Erosion Hazard (Road, Trail)

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Sanitary Facilities

Sanitary Facilities interpretations are tools designed to guide the user in site selection for the safe disposal of sewage and solid waste. Example interpretations include septic tank absorption fields, sewage lagoons, and sanitary landfills.

Septic Tank Absorption Fields

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 60 inches is evaluated. The ratings are based on the soil properties that affect absorption of the effluent, construction and maintenance of the system, and public health. Saturated hydraulic conductivity (Ksat), depth to a water table, ponding, depth to bedrock or a cemented pan, and flooding affect absorption of the effluent. Stones and boulders, ice, and bedrock or a cemented pan interfere with installation. Subsidence interferes with installation and maintenance. Excessive slope may cause lateral seepage and surfacing of the effluent in downslope areas.

Some soils are underlain by loose sand and gravel or fractured bedrock at a depth of less than 4 feet below the distribution lines. In these soils the absorption field may not adequately filter the effluent, particularly when the system is new. As a result, the ground water may become contaminated.

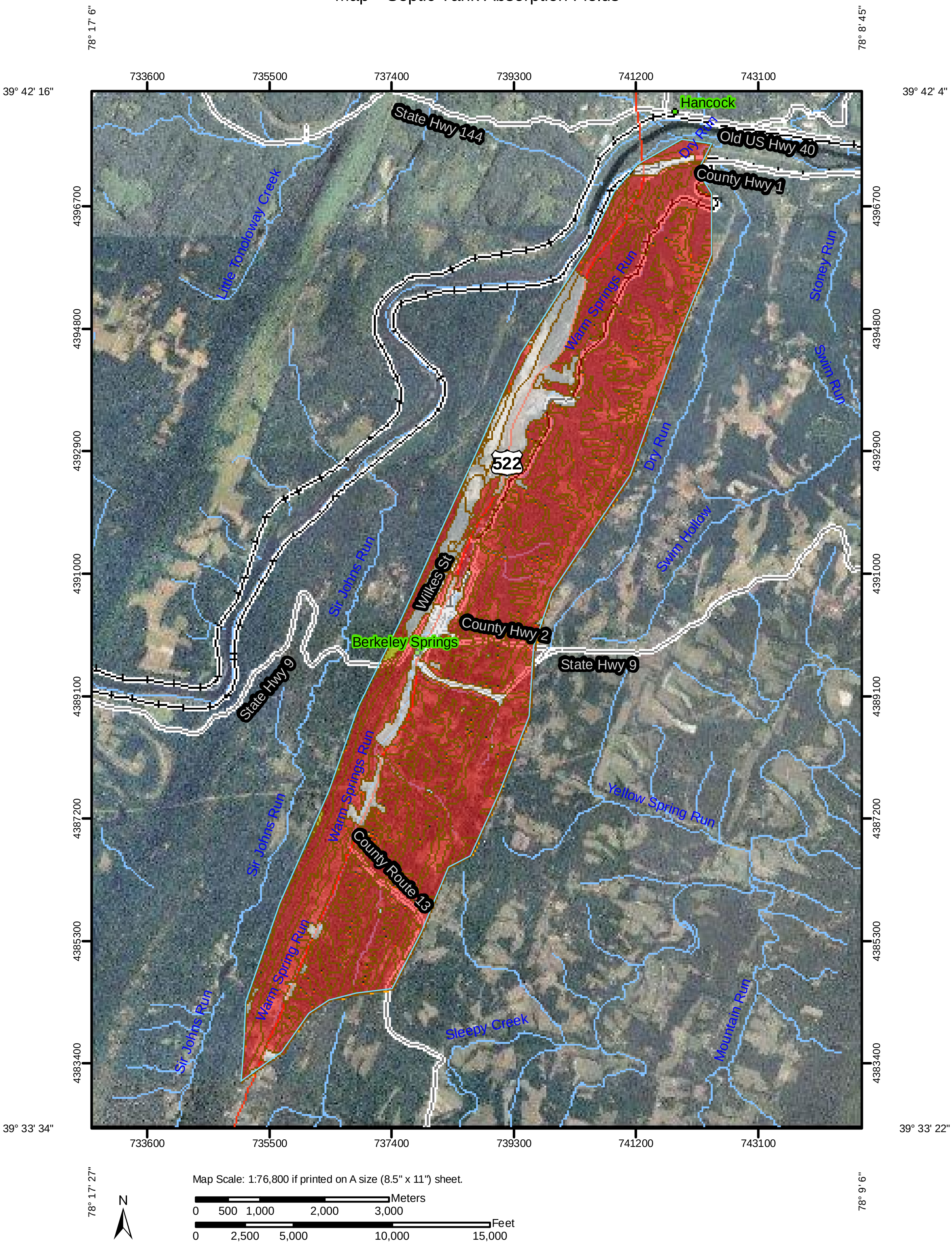
The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Custom Soil Resource Report
Map—Septic Tank Absorption Fields



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Political Features

- Cities

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads

MAP INFORMATION

Map Scale: 1:76,800 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 17N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Morgan County, West Virginia
Survey Area Data: Version 8, Apr 2, 2009

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—Septic Tank Absorption Fields

Septic Tank Absorption Fields— Summary by Map Unit — Morgan County, West Virginia (WV065)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
BeC	Berks-Clearbrook channery silt loams, 8 to 15 percent slopes	Very limited	Berks (55%)	Seepage, bottom layer (1.00)	224.4	2.9%
				Depth to bedrock (1.00)		
				Slope (0.63)		
			Clearbrook (40%)	Depth to saturated zone (1.00)		
				Depth to bedrock (1.00)		
				Slope (0.63)		
				Large stones (0.00)		
BkB	Berks-Weikert channery silt loams, 3 to 8 percent slopes	Very limited	Berks (45%)	Seepage, bottom layer (1.00)	72.2	0.9%
				Depth to bedrock (1.00)		
			Weikert (40%)	Depth to bedrock (1.00)		
				Seepage, bottom layer (1.00)		
BqF	Blackthorn very gravelly sandy loam, 35 to 55 percent slopes, rubbly	Very limited	Blackthorn (80%)	Too steep (1.00)	19.8	0.3%
				Slow water movement (0.72)		
BuB	Buchanan gravelly loam, 3 to 8 percent slopes	Very limited	Buchanan (85%)	Slow water movement (1.00)	7.0	0.1%
				Depth to saturated zone (1.00)		
			Andover (5%)	Slow water movement (1.00)		
				Depth to saturated zone (1.00)		

Septic Tank Absorption Fields— Summary by Map Unit — Morgan County, West Virginia (WV065)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
BuC	Buchanan gravelly loam, 8 to 15 percent slopes	Very limited	Buchanan (85%)	Slow water movement (1.00)	34.2	0.4%
				Depth to saturated zone (1.00)		
				Slope (0.63)		
			Andover (4%)	Slow water movement (1.00)		
				Depth to saturated zone (1.00)		
BxC	Buchanan loam, 3 to 15 percent slopes, extremely stony	Very limited	Buchanan (85%)	Slow water movement (1.00)	100.6	1.3%
				Depth to saturated zone (1.00)		
				Slope (0.04)		
			Andover (10%)	Slow water movement (1.00)		
				Depth to saturated zone (1.00)		
BxE	Buchanan loam, 15 to 35 percent slopes, extremely stony	Very limited	Buchanan (85%)	Slow water movement (1.00)	43.3	0.6%
				Depth to saturated zone (1.00)		
				Too steep (1.00)		
ClD	Caneyville silt loam, 15 to 25 percent slopes	Very limited	Caneyville (85%)	Too steep (1.00)	3.8	0.0%
				Slow water movement (1.00)		
				Depth to bedrock (1.00)		
CrC	Clarksburg gravelly silt loam, 8 to 15 percent slopes	Very limited	Clarksburg (80%)	Depth to saturated zone (1.00)	2.7	0.0%
				Slow water movement (1.00)		
				Slope (0.63)		

Septic Tank Absorption Fields— Summary by Map Unit — Morgan County, West Virginia (WV065)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
CvB	Clearbrook-Cavode silt loams, 0 to 8 percent slopes	Very limited	Clearbrook (50%)	Depth to saturated zone (1.00)	88.8	1.2%
				Depth to bedrock (1.00)		
			Cavode (35%)	Slow water movement (1.00)		
				Depth to saturated zone (1.00)		
				Depth to bedrock (0.18)		
Cz	Combs fine sandy loam	Very limited	Combs (85%)	Flooding (1.00)	16.8	0.2%
				Seepage, bottom layer (1.00)		
				Depth to saturated zone (0.84)		
ErB	Ernest silt loam, 3 to 8 percent slopes	Very limited	Ernest (85%)	Depth to saturated zone (1.00)	10.2	0.1%
				Slow water movement (1.00)		
			Brinkerton (5%)	Slow water movement (1.00)		
				Depth to saturated zone (1.00)		
			Philo (1%)	Flooding (1.00)		
				Depth to saturated zone (1.00)		
				Depth to bedrock (1.00)		
				Slow water movement (0.46)		

Septic Tank Absorption Fields— Summary by Map Unit — Morgan County, West Virginia (WV065)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
ErC	Ernest silt loam, 8 to 15 percent slopes	Very limited	Ernest (80%)	Depth to saturated zone (1.00)	12.4	0.2%
				Slow water movement (1.00)		
				Slope (0.63)		
			Brinkerton (4%)	Slow water movement (1.00)		
				Depth to saturated zone (1.00)		
				Slope (0.63)		
Ho	Holly silt loam	Very limited	Holly (80%)	Flooding (1.00)	138.4	1.8%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Seepage, bottom layer (1.00)		
				Slow water movement (0.72)		
Ln	Lindside silt loam	Very limited	Lindside (80%)	Flooding (1.00)	72.8	0.9%
				Depth to saturated zone (1.00)		
				Seepage, bottom layer (1.00)		
				Slow water movement (0.72)		

Septic Tank Absorption Fields— Summary by Map Unit — Morgan County, West Virginia (WV065)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
Me	Melvin silt loam	Very limited	Melvin (90%)	Flooding (1.00)	0.2	0.0%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Slow water movement (0.46)		
			Lindside (7%)	Flooding (1.00)		
				Depth to saturated zone (1.00)		
				Seepage, bottom layer (1.00)		
				Slow water movement (0.72)		
MrC	Murrill gravelly loam, 8 to 15 percent slopes	Somewhat limited	Murrill (90%)	Slow water movement (0.72)	17.7	0.2%
				Slope (0.63)		
MsE	Murrill loam, 15 to 35 percent slopes, extremely stony	Very limited	Murrill (85%)	Too steep (1.00)	171.4	2.2%
				Slow water movement (0.72)		
Pg	Philo gravelly loam	Very limited	Philo (75%)	Flooding (1.00)	42.6	0.6%
				Depth to saturated zone (1.00)		
				Seepage, bottom layer (1.00)		
				Slow water movement (0.50)		
Ph	Philo silt loam	Very limited	Philo (75%)	Flooding (1.00)	10.7	0.1%
				Depth to saturated zone (1.00)		
				Seepage, bottom layer (1.00)		
				Slow water movement (0.46)		
Qm	Quarry, limestone	Not rated	Quarry, limestone (97%)		1.2	0.0%
			Caneyville (1%)			
			Murrill (1%)			
			Opequon (1%)			

Septic Tank Absorption Fields— Summary by Map Unit — Morgan County, West Virginia (WV065)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
Qo	Quarry, sandstone	Not rated	Quarry, sandstone (95%)		162.1	2.1%
			Schaffenaker (2%)			
			Vanderlip (2%)			
			Dekalb (1%)			
ShC	Schaffenaker loamy sand, 3 to 15 percent slopes, very bouldery	Very limited	Schaffenaker (80%)	Seepage, bottom layer (1.00)	23.6	0.3%
				Depth to bedrock (1.00)		
				Filtering capacity (1.00)		
				Slope (0.04)		
SkF	Schaffenaker-Rock outcrop complex, 35 to 65 percent slopes, rubbly	Not rated	Rock outcrop (40%)		161.1	2.1%
			Lithic Quartzipsamments (8%)			
			Vanderlip (5%)			
			Dekalb (2%)			
SnE	Schaffenaker-Vanderlip loamy sands, 15 to 35 percent slopes, very bouldery	Very limited	Schaffenaker (45%)	Too steep (1.00)	34.9	0.5%
				Seepage, bottom layer (1.00)		
				Depth to bedrock (1.00)		
				Filtering capacity (1.00)		
			Vanderlip (40%)	Filtering capacity (1.00)		
				Too steep (1.00)		
				Seepage, bottom layer (1.00)		
				Large stones (0.07)		
SnF	Schaffenaker-Vanderlip loamy sands, 35 to 65 percent slopes, very bouldery	Very limited	Vanderlip (40%)	Filtering capacity (1.00)	295.4	3.9%
				Too steep (1.00)		
				Seepage, bottom layer (1.00)		
				Large stones (0.07)		
			Schaffenaker (40%)	Too steep (1.00)		
				Seepage, bottom layer (1.00)		
				Depth to bedrock (1.00)		
				Filtering capacity (1.00)		

Septic Tank Absorption Fields— Summary by Map Unit — Morgan County, West Virginia (WV065)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
SxE	Sideling gravelly loam, 15 to 35 percent slopes, extremely stony	Very limited	Sideling (80%)	Slow water movement (1.00)	39.7	0.5%
				Depth to saturated zone (1.00)		
				Too steep (1.00)		
			Hazleton (10%)	Too steep (1.00)		
				Seepage, bottom layer (1.00)		
				Depth to bedrock (1.00)		
				Large stones (0.18)		
			Andover (1%)	Slow water movement (1.00)		
				Depth to saturated zone (1.00)		
Ua	Udorthents, smoothed	Not rated	Udorthents (95%)		391.1	5.1%
			Weikert (1%)			
			Urban land (1%)			
			Ernest (1%)			
			Clearbrook (1%)			
			Berks (1%)			
Uu	Urban land-Udorthents complex, 0 to 25 percent slopes	Not rated	Urban land (45%)		288.5	3.8%
			Berks (2%)			
			Philo (2%)			
			Weikert (2%)			
			Vanderlip (1%)			
			Clearbrook (1%)			
			Buchanan (1%)			
			Ernest (1%)			
W	Water	Not rated	Water (100%)		13.1	0.2%

Septic Tank Absorption Fields— Summary by Map Unit — Morgan County, West Virginia (WV065)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
WaB	Weikert channery silt loam, 3 to 8 percent slopes	Very limited	Weikert (85%)	Depth to bedrock (1.00)	21.1	0.3%
				Seepage, bottom layer (1.00)		
			Rough (9%)	Depth to bedrock (1.00)		
				Seepage, bottom layer (1.00)		
			Clearbrook (5%)	Slow water movement (1.00)		
				Depth to saturated zone (1.00)		
				Depth to bedrock (1.00)		
WaC	Weikert channery silt loam, 8 to 15 percent slopes	Very limited	Weikert (85%)	Depth to bedrock (1.00)	340.0	4.4%
				Seepage, bottom layer (1.00)		
				Slope (0.63)		
			Rough (9%)	Depth to bedrock (1.00)		
				Seepage, bottom layer (1.00)		
				Slope (0.50)		
			Clearbrook (5%)	Depth to saturated zone (1.00)		
				Depth to bedrock (1.00)		
				Slope (0.50)		
				Large stones (0.02)		
WbC	Weikert-Berks channery silt loams, 8 to 15 percent slopes	Very limited	Weikert (45%)	Depth to bedrock (1.00)	802.6	10.5%
				Seepage, bottom layer (1.00)		
				Slope (0.63)		
			Berks (40%)	Seepage, bottom layer (1.00)		
				Depth to bedrock (1.00)		
				Slope (0.63)		

Septic Tank Absorption Fields— Summary by Map Unit — Morgan County, West Virginia (WV065)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
WbD	Weikert-Berks channery silt loams, 15 to 25 percent slopes	Very limited	Weikert (50%)	Depth to bedrock (1.00)	1,709.5	22.3%
				Too steep (1.00)		
				Seepage, bottom layer (1.00)		
			Berks (35%)	Too steep (1.00)		
				Seepage, bottom layer (1.00)		
				Depth to bedrock (1.00)		
WkF	Weikert-Berks very channery silt loams, 25 to 70 percent slope	Very limited	Weikert (50%)	Depth to bedrock (1.00)	2,294.1	29.9%
				Too steep (1.00)		
				Seepage, bottom layer (1.00)		
			Berks (35%)	Too steep (1.00)		
				Depth to bedrock (1.00)		
				Seepage, bottom layer (1.00)		
Totals for Area of Interest					**7,667.9**	**100.0%**

Septic Tank Absorption Fields— Summary by Rating Value		
Rating	Acres in AOI	Percent of AOI
Very limited	6,633.1	86.5%
Somewhat limited	17.7	0.2%
Null or Not Rated	1,017.1	13.3%
Totals for Area of Interest	**7,667.9**	**100.0%**

Rating Options—Septic Tank Absorption Fields

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Erosion Factors

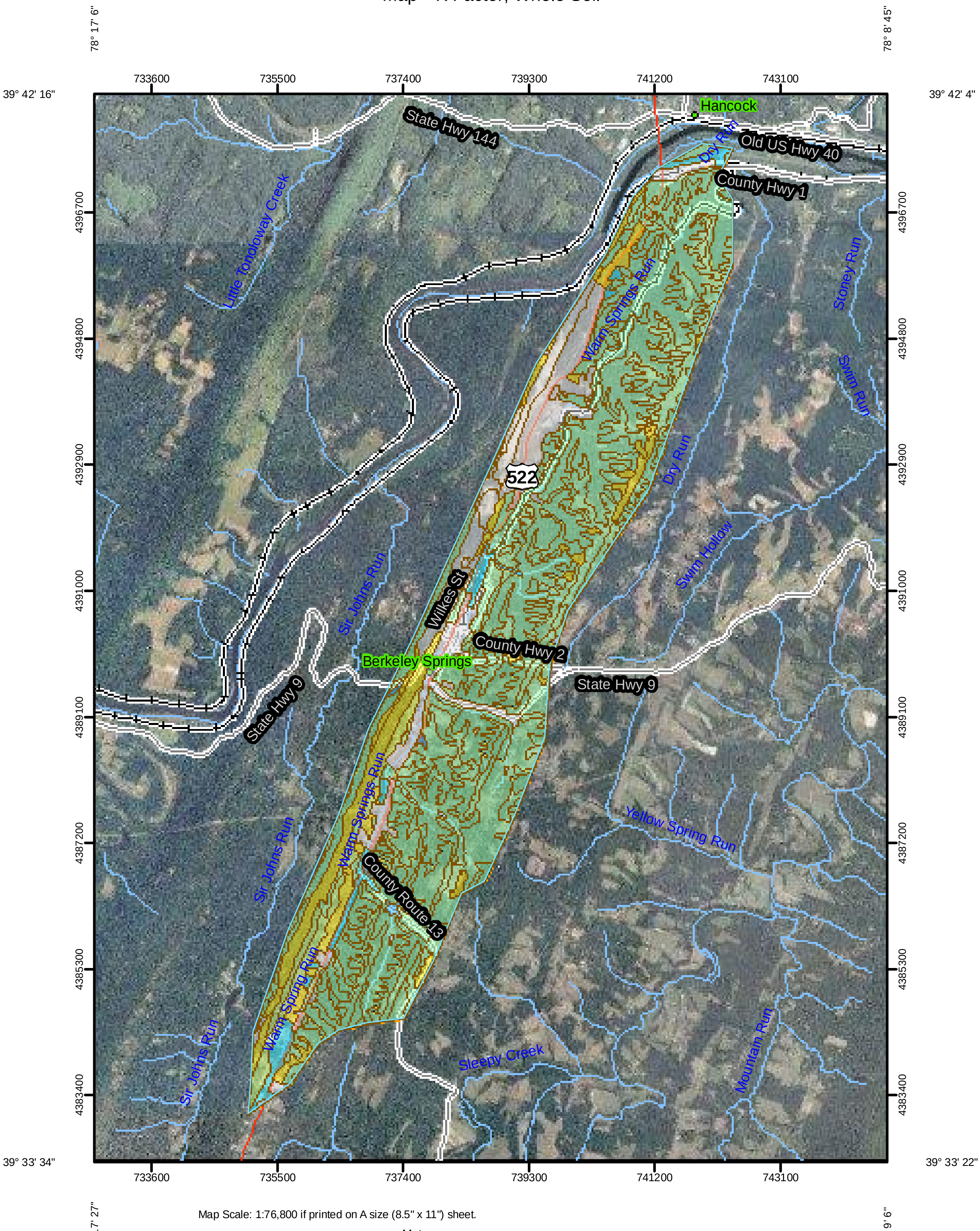
Soil Erosion Factors are soil properties and interpretations used in evaluating the soil for potential erosion. Example soil erosion factors can include K factor for the whole soil or on a rock free basis, T factor, wind erodibility group and wind erodibility index.

K Factor, Whole Soil

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Custom Soil Resource Report
Map—K Factor, Whole Soil



Map Scale: 1:76,800 if printed on A size (8.5" x 11") sheet.

Meters
0 500 1,000 2,000 3,000

Feet
0 2,500 5,000 10,000 15,000

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Political Features

- Cities

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads

MAP INFORMATION

Map Scale: 1:76,800 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 17N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Morgan County, West Virginia
Survey Area Data: Version 8, Apr 2, 2009

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—K Factor, Whole Soil

K Factor, Whole Soil— Summary by Map Unit — Morgan County, West Virginia (WV065)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
BeC	Berks-Clearbrook channery silt loams, 8 to 15 percent slopes	.17	224.4	2.9%
BkB	Berks-Weikert channery silt loams, 3 to 8 percent slopes	.17	72.2	0.9%
BqF	Blackthorn very gravelly sandy loam, 35 to 55 percent slopes, rubbly	.28	19.8	0.3%
BuB	Buchanan gravelly loam, 3 to 8 percent slopes	.24	7.0	0.1%
BuC	Buchanan gravelly loam, 8 to 15 percent slopes	.24	34.2	0.4%
BxC	Buchanan loam, 3 to 15 percent slopes, extremely stony	.24	100.6	1.3%
BxE	Buchanan loam, 15 to 35 percent slopes, extremely stony	.24	43.3	0.6%
ClD	Caneyville silt loam, 15 to 25 percent slopes	.43	3.8	0.0%
CrC	Clarksburg gravelly silt loam, 8 to 15 percent slopes	.28	2.7	0.0%
CvB	Clearbrook-Cavode silt loams, 0 to 8 percent slopes	.37	88.8	1.2%
Cz	Combs fine sandy loam	.28	16.8	0.2%
ErB	Ernest silt loam, 3 to 8 percent slopes	.43	10.2	0.1%
ErC	Ernest silt loam, 8 to 15 percent slopes	.43	12.4	0.2%
Ho	Holly silt loam	.28	138.4	1.8%
Ln	Lindside silt loam	.37	72.8	0.9%
Me	Melvin silt loam	.43	0.2	0.0%
MrC	Murrill gravelly loam, 8 to 15 percent slopes	.28	17.7	0.2%
MsE	Murrill loam, 15 to 35 percent slopes, extremely stony	.28	171.4	2.2%
Pg	Philo gravelly loam	.37	42.6	0.6%
Ph	Philo silt loam	.37	10.7	0.1%
Qm	Quarry, limestone		1.2	0.0%
Qo	Quarry, sandstone		162.1	2.1%
ShC	Schaffenaker loamy sand, 3 to 15 percent slopes, very bouldery	.17	23.6	0.3%
SkF	Schaffenaker-Rock outcrop complex, 35 to 65 percent slopes, rubbly		161.1	2.1%
SnE	Schaffenaker-Vanderlip loamy sands, 15 to 35 percent slopes, very bouldery	.17	34.9	0.5%
SnF	Schaffenaker-Vanderlip loamy sands, 35 to 65 percent slopes, very bouldery	.17	295.4	3.9%

K Factor, Whole Soil— Summary by Map Unit — Morgan County, West Virginia (WV065)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
SxE	Sideling gravelly loam, 15 to 35 percent slopes, extremely stony	.20	39.7	0.5%
Ua	Udorthents, smoothed		391.1	5.1%
Uu	Urban land-Udorthents complex, 0 to 25 percent slopes		288.5	3.8%
W	Water		13.1	0.2%
WaB	Weikert channery silt loam, 3 to 8 percent slopes	.28	21.1	0.3%
WaC	Weikert channery silt loam, 8 to 15 percent slopes	.28	340.0	4.4%
WbC	Weikert-Berks channery silt loams, 8 to 15 percent slopes	.28	802.6	10.5%
WbD	Weikert-Berks channery silt loams, 15 to 25 percent slopes	.28	1,709.5	22.3%
WkF	Weikert-Berks very channery silt loams, 25 to 70 percent slope	.28	2,294.1	29.9%
Totals for Area of Interest			**7,667.9**	**100.0%**

Rating Options—K Factor, Whole Soil

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

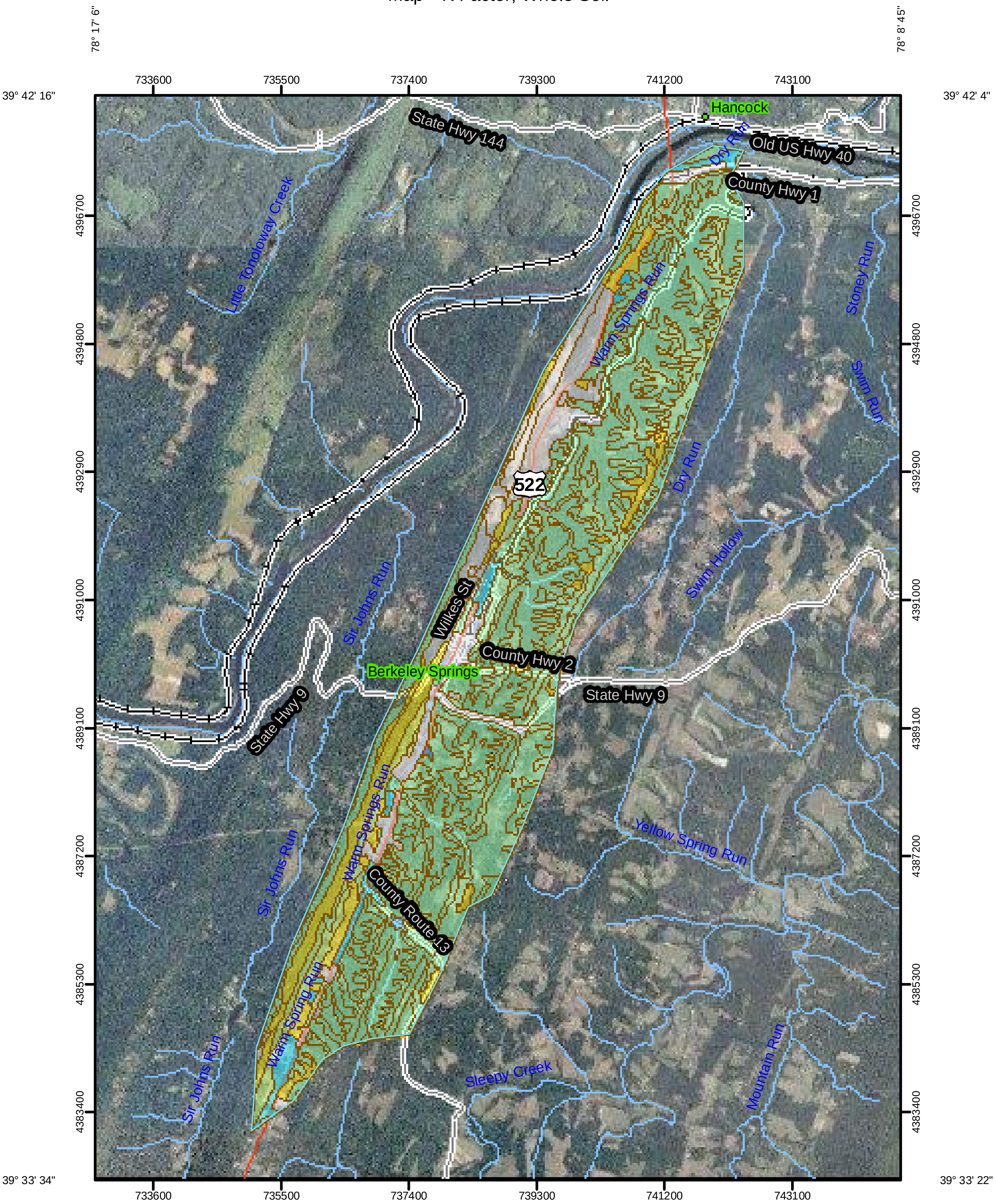
Layer Options: All Layers

K Factor, Whole Soil

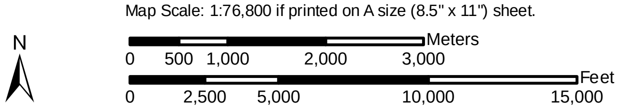
Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Map—K Factor, Whole Soil



Map Scale: 1:76,800 if printed on A size (8.5" x 11") sheet.



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Soil Ratings
- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Political Features
- Cities

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads

MAP INFORMATION

Map Scale: 1:76,800 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 17N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Morgan County, West Virginia
Survey Area Data: Version 8, Apr 2, 2009

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—K Factor, Whole Soil

K Factor, Whole Soil— Summary by Map Unit — Morgan County, West Virginia (WV065)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
BeC	Berks-Clearbrook channery silt loams, 8 to 15 percent slopes	.17	224.4	2.9%
BkB	Berks-Weikert channery silt loams, 3 to 8 percent slopes	.17	72.2	0.9%
BqF	Blackthorn very gravelly sandy loam, 35 to 55 percent slopes, rubbly	.28	19.8	0.3%
BuB	Buchanan gravelly loam, 3 to 8 percent slopes	.24	7.0	0.1%
BuC	Buchanan gravelly loam, 8 to 15 percent slopes	.24	34.2	0.4%
BxC	Buchanan loam, 3 to 15 percent slopes, extremely stony	.24	100.6	1.3%
BxE	Buchanan loam, 15 to 35 percent slopes, extremely stony	.24	43.3	0.6%
ClD	Caneyville silt loam, 15 to 25 percent slopes	.43	3.8	0.0%
CrC	Clarksburg gravelly silt loam, 8 to 15 percent slopes	.28	2.7	0.0%
CvB	Clearbrook-Cavode silt loams, 0 to 8 percent slopes	.37	88.8	1.2%
Cz	Combs fine sandy loam	.28	16.8	0.2%
ErB	Ernest silt loam, 3 to 8 percent slopes	.43	10.2	0.1%
ErC	Ernest silt loam, 8 to 15 percent slopes	.43	12.4	0.2%
Ho	Holly silt loam	.28	138.4	1.8%
Ln	Lindside silt loam	.37	72.8	0.9%
Me	Melvin silt loam	.43	0.2	0.0%
MrC	Murrill gravelly loam, 8 to 15 percent slopes	.28	17.7	0.2%
MsE	Murrill loam, 15 to 35 percent slopes, extremely stony	.28	171.4	2.2%
Pg	Philo gravelly loam	.37	42.6	0.6%
Ph	Philo silt loam	.37	10.7	0.1%
Qm	Quarry, limestone		1.2	0.0%
Qo	Quarry, sandstone		162.1	2.1%
ShC	Schaffenaker loamy sand, 3 to 15 percent slopes, very bouldery	.17	23.6	0.3%
SkF	Schaffenaker-Rock outcrop complex, 35 to 65 percent slopes, rubbly		161.1	2.1%
SnE	Schaffenaker-Vanderlip loamy sands, 15 to 35 percent slopes, very bouldery	.17	34.9	0.5%
SnF	Schaffenaker-Vanderlip loamy sands, 35 to 65 percent slopes, very bouldery	.17	295.4	3.9%

K Factor, Whole Soil— Summary by Map Unit — Morgan County, West Virginia (WV065)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
SxE	Sideling gravelly loam, 15 to 35 percent slopes, extremely stony	.20	39.7	0.5%
Ua	Udorthents, smoothed		391.1	5.1%
Uu	Urban land-Udorthents complex, 0 to 25 percent slopes		288.5	3.8%
W	Water		13.1	0.2%
WaB	Weikert channery silt loam, 3 to 8 percent slopes	.28	21.1	0.3%
WaC	Weikert channery silt loam, 8 to 15 percent slopes	.28	340.0	4.4%
WbC	Weikert-Berks channery silt loams, 8 to 15 percent slopes	.28	802.6	10.5%
WbD	Weikert-Berks channery silt loams, 15 to 25 percent slopes	.28	1,709.5	22.3%
WkF	Weikert-Berks very channery silt loams, 25 to 70 percent slope	.28	2,294.1	29.9%
Totals for Area of Interest			**7,667.9**	**100.0%**

Rating Options—K Factor, Whole Soil

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Layer Options: All Layers

Water Features

Water Features include ponding frequency, flooding frequency, and depth to water table.

Flooding Frequency Class

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent.

"None" means that flooding is not probable. The chance of flooding is nearly 0 percent in any year. Flooding occurs less than once in 500 years.

"Very rare" means that flooding is very unlikely but possible under extremely unusual weather conditions. The chance of flooding is less than 1 percent in any year.

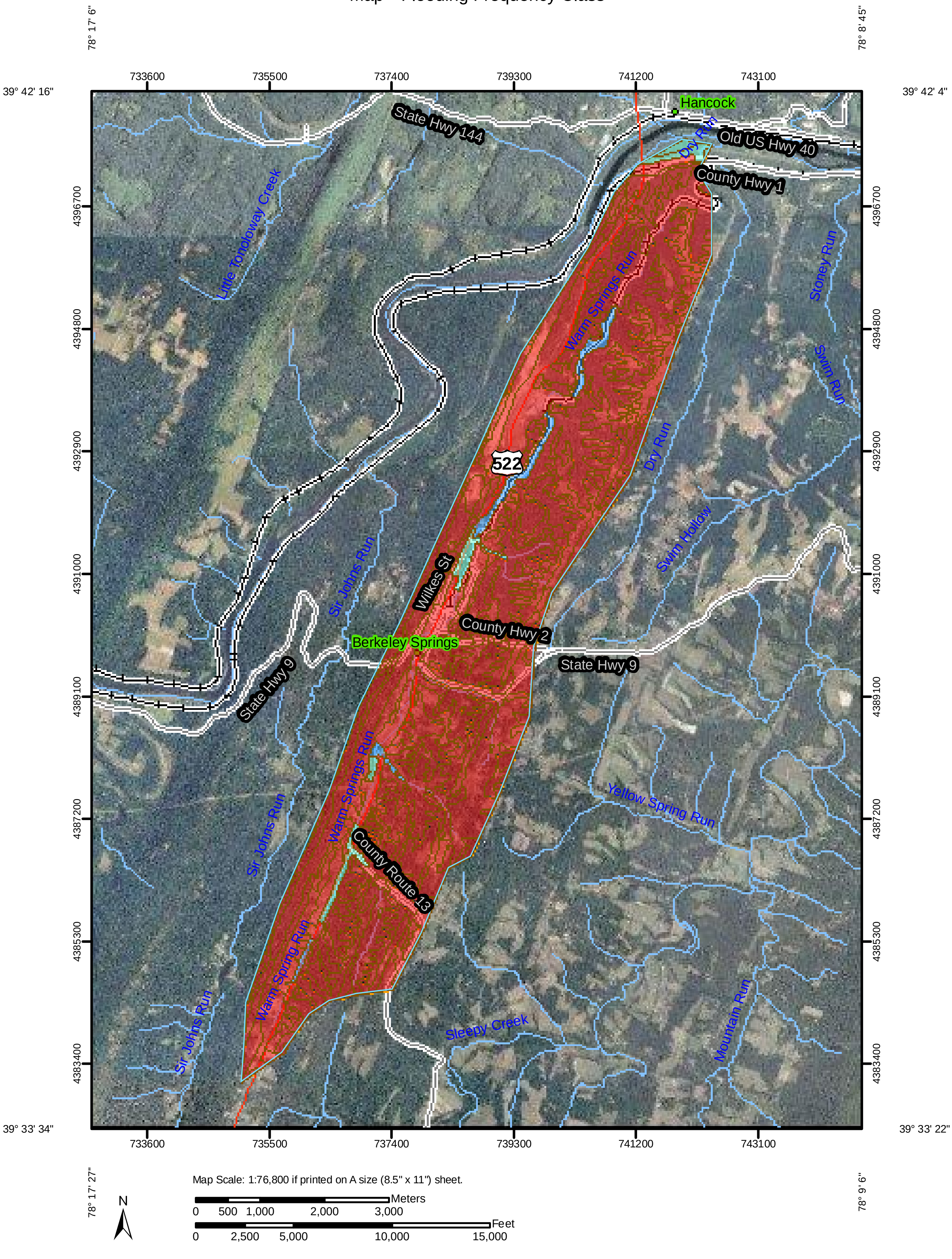
"Rare" means that flooding is unlikely but possible under unusual weather conditions. The chance of flooding is 1 to 5 percent in any year.

"Occasional" means that flooding occurs infrequently under normal weather conditions. The chance of flooding is 5 to 50 percent in any year.

"Frequent" means that flooding is likely to occur often under normal weather conditions. The chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year.

"Very frequent" means that flooding is likely to occur very often under normal weather conditions. The chance of flooding is more than 50 percent in all months of any year.

Custom Soil Resource Report
Map—Flooding Frequency Class



Map Scale: 1:76,800 if printed on A size (8.5" x 11") sheet.

Meters: 0, 500, 1,000, 2,000, 3,000

Feet: 0, 2,500, 5,000, 10,000, 15,000

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- None
- Very Rare
- Rare
- Occasional
- Frequent
- Very Frequent

Political Features

- Cities

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads

MAP INFORMATION

Map Scale: 1:76,800 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

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Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 17N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Morgan County, West Virginia
Survey Area Data: Version 8, Apr 2, 2009

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Flooding Frequency Class

Flooding Frequency Class— Summary by Map Unit — Morgan County, West Virginia (WV065)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BeC	Berks-Clearbrook channery silt loams, 8 to 15 percent slopes	None	224.4	2.9%
BkB	Berks-Weikert channery silt loams, 3 to 8 percent slopes	None	72.2	0.9%
BqF	Blackthorn very gravelly sandy loam, 35 to 55 percent slopes, rubbly	None	19.8	0.3%
BuB	Buchanan gravelly loam, 3 to 8 percent slopes	None	7.0	0.1%
BuC	Buchanan gravelly loam, 8 to 15 percent slopes	None	34.2	0.4%
BxC	Buchanan loam, 3 to 15 percent slopes, extremely stony	None	100.6	1.3%
BxE	Buchanan loam, 15 to 35 percent slopes, extremely stony	None	43.3	0.6%
ClD	Caneyville silt loam, 15 to 25 percent slopes	None	3.8	0.0%
CrC	Clarksburg gravelly silt loam, 8 to 15 percent slopes	None	2.7	0.0%
CvB	Clearbrook-Cavode silt loams, 0 to 8 percent slopes	None	88.8	1.2%
Cz	Combs fine sandy loam	Occasional	16.8	0.2%
ErB	Ernest silt loam, 3 to 8 percent slopes	None	10.2	0.1%
ErC	Ernest silt loam, 8 to 15 percent slopes	None	12.4	0.2%
Ho	Holly silt loam	Frequent	138.4	1.8%
Ln	Lindside silt loam	Occasional	72.8	0.9%
Me	Melvin silt loam	Frequent	0.2	0.0%
MrC	Murrill gravelly loam, 8 to 15 percent slopes	None	17.7	0.2%
MsE	Murrill loam, 15 to 35 percent slopes, extremely stony	None	171.4	2.2%
Pg	Philo gravelly loam	Occasional	42.6	0.6%
Ph	Philo silt loam	Occasional	10.7	0.1%
Qm	Quarry, limestone	None	1.2	0.0%
Qo	Quarry, sandstone	None	162.1	2.1%
ShC	Schaffenaker loamy sand, 3 to 15 percent slopes, very bouldery	None	23.6	0.3%
SkF	Schaffenaker-Rock outcrop complex, 35 to 65 percent slopes, rubbly	None	161.1	2.1%
SnE	Schaffenaker-Vanderlip loamy sands, 15 to 35 percent slopes, very bouldery	None	34.9	0.5%

Flooding Frequency Class— Summary by Map Unit — Morgan County, West Virginia (WV065)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
SnF	Schaffenaker-Vanderlip loamy sands, 35 to 65 percent slopes, very bouldery	None	295.4	3.9%
SxE	Sideling gravelly loam, 15 to 35 percent slopes, extremely stony	None	39.7	0.5%
Ua	Udorthents, smoothed	None	391.1	5.1%
Uu	Urban land-Udorthents complex, 0 to 25 percent slopes	None	288.5	3.8%
W	Water	None	13.1	0.2%
WaB	Weikert channery silt loam, 3 to 8 percent slopes	None	21.1	0.3%
WaC	Weikert channery silt loam, 8 to 15 percent slopes	None	340.0	4.4%
WbC	Weikert-Berks channery silt loams, 8 to 15 percent slopes	None	802.6	10.5%
WbD	Weikert-Berks channery silt loams, 15 to 25 percent slopes	None	1,709.5	22.3%
WkF	Weikert-Berks very channery silt loams, 25 to 70 percent slope	None	2,294.1	29.9%
Totals for Area of Interest			**7,667.9**	**100.0%**

Rating Options—Flooding Frequency Class

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: More Frequent

Beginning Month: January

Ending Month: December

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Appendix B: Example Quality Assurance Project Plan (QAPP)

CHESAPEAKE BAY WATER-QUALITY MONITORING PROGRAM

POTOMAC RIVER NONTIDAL NUTRIENT AND SEDIMENT SAMPLING

QUALITY ASSURANCE PROJECT PLAN

JUNE 1, 2005 to MAY 31, 2006

WEST VIRGINIA DEPARTMENT OF ENVIRONMENTAL PROTECTION, DIVISION OF WATER AND WASTE MANAGEMENT

IN COOPERATION WITH THE
U.S. GEOLOGICAL SURVEY

Created April 2005

QUALITY ASSURANCE PROJECT PLAN

for the

West Virginia Potomac River Nontidal Monitoring Program
NUTRIENT AND SEDIMENT SAMPLING

Prepared by

Douglas B. Chambers
U.S. Geological Survey, Water Resources Discipline
West Virginia Water Science Center
11 Dunbar Street
Charleston, West Virginia 25301

for

West Virginia Department of Environmental Protection
Division of Water and Waste Management
601 57th Street
Charleston, WV 25304

for the period of

June 1, 2005 to May 31, 2006

Approvals:

Douglas B. Chambers, Project Chief, USGS | Date

John Wirts, Project Coordinator, WVDEP | Date

Matthew Monroe, Environmental Coordinator, WVDAg | Date

Richard Batiuk, Quality Assurance Officer, EPA Chesapeake Bay Program Office | Date

CONTENTS

Tables

A. Project Management

A.1 Introduction
This Quality-Assurance Project Plan (QAPP) describes quality-assurance goals and measures for the Potomac River Nontidal monitoring program designed to support Chesapeake Bay restoration programs.

The project, the *Potomac River Nontidal Monitoring Program*, includes the monitoring of nutrient and suspended-sediment concentrations and streamflow in selected West Virginia tributaries of the Potomac River. This project is supported through West Virginia Department of Environmental Protection (WVDEP) and U.S. Geological Survey (USGS) cooperative funds. The objectives of this project are to:

- characterize nutrient and sediment concentrations in terms of flow and load for four (4) major West Virginia tributaries to the Potomac River;
- provide nutrient and sediment data for calibration of the Chesapeake Bay Watershed model (WSM) and loading inputs to the Chesapeake Bay Water-Quality (WQ) model; and
- integrate the information collected in this program with other elements of the monitoring program to gain a better understanding of the processes affecting the water quality of the Chesapeake Bay.

The WVDEP and the USGS conduct this project cooperatively. Sampling events, goals, and objectives for this project are overseen by the USGS Project Chief, Douglas B. Chambers.

A.2 Distribution List
This QAPP will be distributed to the following project participants:

Douglas B. Chambers, USGS West Virginia Water Science Center, Project Chief/Water-Quality Specialist, (304) 347-5130 ext 231

Ronald D. Evaldi, USGS West Virginia Water Science Center, Supervisory Hydrologist, (304) 347-5130 ext. 239

John Wirts, WVDEP, Watershed Assessment Section, Project Coordinator, (304) 926-0495

Matthew Monroe, WVDAg, Environmental Coordinator, (304) 260-8627

A.3 Project/Task Organization
Douglas B. Chambers, USGS, is the Project Chief for the Potomac River Nontidal Monitoring Program and is responsible for the technical design, operation, and execution of the program as outlined in the annual scope of work to WVDEP. He is also responsible for the evaluating and describing of collected data, quality assurance and quality control for the program, and producing USGS reports. Doug is also the Water-Quality Specialist for the USGS West Virginia Water Science Center.

John Wirts, WVDEP, DWWM, Watershed Assessment Section, serves as the Project Coordinator for the Potomac River Nontidal Monitoring Program. He is tasked with assuring that all project commitments, the project timetable, and deliverables are completed.

A.4 Problem Definition/Background
The decline in water quality of the Chesapeake Bay within the last decade has, in large part, been attributed to excessive nutrients entering the estuary from its surrounding tributaries. In an effort to improve the water quality of the Bay, Federal, State, and local governments have initiated point and non-point source nutrient-reduction programs within the tributary basins discharging to the Bay. Monitoring at

key sites can help to quantify improvements in water quality and verify the effectiveness of nutrient-control measures implemented in the watersheds.

In addition, the quality of the river discharge, and the timing and magnitude of the pollutant concentrations and loads delivered to the estuary are important data needed to enhance knowledge of or need to strengthen other components of the Chesapeake Bay water-quality monitoring program. The integration of all of these components will lead to a better understanding of the factors influencing water quality that can then be translated into better water-quality management for the Bay and its tributaries.

With these general goals in mind, the West Virginia Department of Environmental Protection'(WVDEP), in cooperation with the USGS, initiated the Potomac River Nontidal Monitoring Program as part of the Chesapeake Bay Water-Quality Monitoring Program.

The Chesapeake Bay Nontidal Water Quality Monitoring Work Group and the State of West Virginia selected four Potomac River tributaries – Patterson Creek, the South Branch of the Potomac River, The Cacapon River, and Opequon Creek –for monitoring. Combined, these streams contribute over 30 percent of the flow to the Potomac River above Point of Rocks, Maryland and they contribute nutrients and sediments from a wide range of land-use, geologic, and hydrologic conditions. A monitoring site will be established near the most downstream stream flow gaging station in each stream to monitor nutrient and sediment concentrations and streamflow to help calculate transport of these nutrient and sediment loads to the Potomac River and, ultimately, to the Bay.

A.5 Project/Task Description

Water-quality samples that are representative of the entire river cross section are collected and later analyzed to determine concentrations of selected nutrient species and suspended sediment in the river. These samples are collected during different seasons across different flow regimes. When combined with the continuous, 15-minute flow record from the USGS gage at each station, it is possible to estimate nutrient and sediment loads on a monthly and annual basis with a known level of confidence. Additionally, water-quality field measurements are made for dissolved oxygen, pH, alkalinity, specific conductance, water temperature and air temperature.

The USGS's National Field Manual for the Collection of Water-Quality Data (Wilde and others, 1998, http://water.usgs.gov/public/owq/FieldManual/index.html) describes the sampling process in detail. Data-collection quality will be monitored by the assessment of field blanks and replicates and by annually conducting and documenting the results of random field audits.

Sampling will be performed during each season. Field data will be entered and quality-assured monthly. Streamflow, nutrient, and suspended-sediment concentration data sets from each monitoring station will be forwarded to John Wirts at WVDEP by September 30 of each year. Quarterly reports describing field activities, quality-control results, and data-management issues will be submitted with the data to John Wirts. Additionally, data interpretation of nutrient trends and trend explanation will be performed by project hydrologists and incorporated into various USGS and/or WVDEP reports.

A.6 Data-Quality Objectives and Criteria for Measurement Data

This study provides West Virginia resource managers with information that can help to quantify changes in water quality, quantify nutrient loads critical for evaluating progress towards reducing controllable nutrients to the Chesapeake Bay, and verify the effectiveness of nutrient-control measures taken in the watersheds. These data can be also be used to calibrate or validate models used to calculate watershed capload allocations. A calibrated model was developed that can simulate constituent relationships, seasonal variation, and changes in trends. As a result, water-quality samples need to be collected monthly throughout the year under different streamflow conditions to determine loads within a known confidence interval. Once completed, this information is then given to researchers and Bay resource managers.

For laboratory precision and accuracy, approximately 10% of samples are analyzed in duplicate. Detailed quality assurance procedures are described for NWQL in Pritt and Raese (1995), and for the USGS Kentucky Sediment Laboratory in Sholar and Shreve (1998).

A.7 Special Training Certification

Field sampling teams will be led by UISGS personnel trained in water-quality sampling operations, record management, quality-assurance procedures, vehicle operations and maintenance, and troubleshooting. Laboratory personnel must be trained in analytical methods, quality-control procedures, record management, maintenance and troubleshooting.

A.8 Documentation and Records

Water-quality field measurements of temperature, dissolved oxygen, pH, alkalinity, and specific conductance are recorded at each site. Additionally, water-quality samples are collected and submitted for analysis to the USGS National Water-Quality Laboratory in Denver, Colorado. Samples are evaluated for total nitrogen (ammonium plus organic nitrogen), dissolved nitrite, dissolved nitrate plus nitrite, dissolved ammonia, total phosphorus, dissolved orthophosphate, and total suspended solids. Suspended sediments, including a sand/fines split for storm samples, are analyzed at the USGS Sediment Laboratory in Louisville, Kentucky.

All data will be recorded using standardized data sheets for the specific projects (Attachment A). These data will be keyed into the USGS data management systems by technicians who collect the data. These data will be provided to WVDEP in hard copy in the form of tables and data summaries. Electronic data will be submitted with the final deliverables in ASCII text files and spreadsheets via CD-ROM or by email.

B. Measurement/Data Acquisition

B.1 Experimental Design

This document provides a detailed description of the monitoring and analysis components of a study conducted by the WVDEP, in cooperation with the USGS, to quantify nutrient and suspended-sediment contributions of 4 West Virginia tributaries to the Potomac River.

The number of events to be sampled and the number of samples per event is based on the requirements of the Chesapeake Bay Nontidal Water-Quality Monitoring Network. Water-quality samples need to be collected monthly during base flow and under various stormflow conditions. “Continuous” flow measurements also need to be collected.

Station Description
Monitoring stations were selected from a list of Chesapeake Bay Program priority monitoring sites. The location of the monitoring sites and drainage area information are presented in table 1.

Table 1. Location of Potomac River Non-Tidal Monitoring sites.

Station Name	USGS Station Identification	Latitude	Longitude	Drainage (sq. mi.)
Patterson Creek near Headsville, WV	01604500	39° 26' 35"	78° 49' 20"	211
South Branch Potomac River near Springfield, WV	01608500	39° 26' 49"	78° 39' 16"	1,486
Cacapon River near Great Cacapon, WV	01611500	39° 34' 56"	78° 18' 36"	675
Opequon Creek near Martinsburg, WV	01616500	39° 25' 25"	77° 56' 20"	273

B.2 Sampling Method

USGS personnel, with assistance from WVDEP and WVDAg personnel, collect all water-quality samples at each of the four Potomac River Non-tidal Monitoring stations in accordance with the USGS National Field Manual for the Collection of Water Quality Data (Wilde and others, 1998).

Base-flow samples are collected at monthly and stormflow samples are collected seasonally, with an average coverage of two storms per season. An experienced USGS Hydrologic Technician, assisted by an individual from either WVDEP or WVDAg, will collect routine monthly, baseflow samples. The monitoring program emphasizes the collection of water-quality samples during periods of high flow (storm-event sampling), because most of the river-borne nutrient and suspended-sediment load is associated with storm events. Teams of two USGS Hydrologic Technicians will collect samples during high-flow events predicted through weather forecasts and by remote monitoring of river stage from the USGS offices. Discrete samples are collected during storm events, and can be collected during the rise, peak, or fall of the hydrograph. Sediment samples collected during storm events will also be analyzed for sand/fine percentage. No more than one sample per day will be collected at each site, although storm samples may be collected on succesive days during the same event. Water-discharge data are also collected for each of the streams throughout the period.

Water-quality samples are collected using the appropriate isokinetic sampler. These samplers hold either a 1- or 3 liter polyethylene bottle. The samplers are either mounted on a wading rod for use in wadeable conditions or lowered to the water using bridge crane for sampling higher flows. The general approach is to collect depth-integrated water samples using the Equal-Width Increment (EWI) sampling method, with minor variations to conform to site conditions. If velocities at a site fall below 1.5 ft/s, below which a true isokinetic sample cannot be collected, a weighted-bottle sample will be collected.

Patterson Creek
USGS personnel collect water samples from Patterson Creek at the Headsville streamflow gaging station. Base-flow and stormflow samples are collected using the equal-width increment (EWI) method. This method involves the collection of water-quality samples at the centroids of equal width increments along the river cross section. Under wadeable conditions, a gage height < 4.5, corresponding to a discharge of 465 cfs, samples will be collected using a USGS DH-81 sampler. At stages higher than 4.5, samples will be collected using a D-95 sampler suspended from the WV Route 46 bridge near Champwood, WV, downstream from the gaging station.

South Branch Potomac River
USGS personnel collect samples from the South Branch Potomac River near Springfield using the EWI method. Under wadeable conditions, a gage height $\leq$ 3.00 corresponding to a discharge of 1,365 cfs, samples will be collected using a USGS DH-81 sampler. At stages higher than 3.0', samples will be collected using a D-95 sampler suspended from the W. Va. Secondary Route 3 bridge downstream from the gaging station.

Cacapon River
USGS personnel collect Cacapon River water samples at the USGS gaging station near Great Cacapon. Under wadeable conditions, a gage height <2.5' corresponding to a discharge of 535 cfs, samples will be collected by wading, using a USGS DH-81 sampler. At stages above 2.5' samples will be collected using a D-95 sampler suspended from the W. Va. Secondary Route 7 low-water bridge up to a stage of 4' and discharge of 1,480 cfs, when the low-water bridge becomes too dangerous to sample from. At stages exceding 4' samples will be collected from the WV route 9 bridge using a D-95 sampler suspended from a bridge crane.

Opequon Creek
USGS personnel collect Opequon Creek water samples at the stream flow gaging station near Martinsburg. Under wadeable conditions, a gage height $\leq$ 3.5' corresponding to a discharge of 375 cfs, samples will be collected at a cross section about 40 feet upstream from the bridge using a USGS DH-81 sampler. At stages higher than 3.5', samples will be collected using a D-95 sampler suspended from the bridge on County Road 19.

Constituents Monitored
The monitoring program focuses on quantifying the water quality and loads of major nutrient species and suspended sediment from Patterson Creek, Cacapon River, South Branch of the Potomac River, and Opequon Creek. Chemical parameters monitored for the program include:

TN	total nitrogen
NO_2	dissolved nitrite
NH_4	dissolved ammonia as N
NO_{23}	dissolved nitrate plus nitrite as N
TP	total phosphorus
o-PO_4	dissolved orthophosphorus as P
TSS	total suspended solids
SSC	total suspended sediment
S/F	sand-fine split (storm samples only)

Analytical methods for these constituents are shown in table 2.

B.3 Sample Handling and Custody

Sample Treatment and Preservation
Water-quality samples collected by the USGS (Wilde and others, 1998) are split using a polypropylene churn splitter. The composite sample is introduced into a pre-cleaned plastic churn splitter and sub-samples for whole-water analysis are drawn while churning at a rate of 1.0 ft/second. The remaining samples are filtered on site for dissolved analysis using a 0.45-micrometer (average pore size, polycarbonate) capsule filter (Wilde and others, 1998). After acid is added to the appropriate samples for preservation, the nutrient samples are placed immediately on ice and chilled to a temperature of 4 degrees Celsius. Samples are shipped to the USGS NWQL in Denver, CO according to USGS technical

memorandum 02.04 (W.D. Lanier, 2002). This document can be found at (http://nwql.usgs.gov/Public/tech_memos/nwql.02-04.html). Suspended-sediment samples, collected concurrently with the water-quality samples from the churn splitter or collected separately, are shipped to the USGS Sediment Laboratory in Louisville, Kentucky, for analysis. Chain-of-custody procedures follow recommended USGS National Water-Quality Laboratory procedures.

Table 2. Potomac River Nontidal Monitoring sampling parameters.

Lab Code	Parameter Code	Parameter/ Methodology	Reference	Reporting Level
		Total Nitrogen		
LC 2756	P62855	*Alkaline persulfate digestion* I-4650-03	Patton and Kryskalla (2003)	0.06 mg/L
		Nitrogen, Nitrite as N		
LC 1973	P00613	*Colorimetry, ASF* I-2540-90	Fishman (1993)	0.008 mg/L
		Dissolved Nitrite & Nitrate as NO_{2+3}		
LC 1975	P00631	*Colorimetry, Cd-reduction*	Fishman (1993)	0.05 mg/L
		Dissolved Ammonia (NH_3)		
LC 1976	P00608	*Colorimetry, Auto* i-2522-78	Fishman (1993)	0.02 mg/L
		Total Phosporous		
LC 2333	P00665	*Colorimetry, Auto* USEPA 365.1		0.004 mg/L
		Dissolved Orthophosphate (DIP or o-PO_4)		
LC 1978	P00671	*Colorimetry, Auto* I-2601-81	Fishman (1993)	0.01 mg/L
		Total Suspended Sediment (SSC)		
n/a	P80154	*Hydroscopic glass-fiber filtration* ASTM method D3977-97 Methods A or B	Sholar and Shreve (1998)	0.5 mg/L
		Sand Fine Split (S/F)		
n/a	P70331	Wet-seiving filtration ASTM method D3977-97 Method C	Sholar and Shreve (1998)	
		Total Suspended Solids (TSS)		
LC 169	P00530	*Gravimetric* I-3765-89	Fishman and Friedman (1989)	10 mg/L

B.4 Analytical Methods

Analytical Methods employed Analytical methods for these constituents are documented in table 2 and described in the USGS National Water-Quality Laboratory documents.

Laboratory Analysis

Water-quality samples collected by the USGS for the River Input Monitoring Program are analyzed by the USGS National Water-Quality Laboratory (NWQL) in Denver, CO. Analytical techniques employed by the laboratory are documented in table 2. Sediment samples are analyzed by the USGS Sediment Laboratory in Louisville, Kentucky (Sholar and Shreve, 1998).

B.5 Quality Assurance/Quality Control

Quality assurance and quality control are a significant component of the monitoring program. The quality-assurance effort includes documentation of concentration variability within the cross section, sediment-transport analysis, quality assurance of sample-collection techniques and field personnel, and accounting for variability within and among the analyzing laboratories. Quality-assurance results can be obtained from: USGS West Virginia Water Science Center, at 11 Dunbar Street, Charleston, WV, 25301.

Laboratory quality-control methods are documented in the USGS National Water-Quality Laboratory (NWQL) Quality Control manual (Pritt and Raese, 1995); also available at http://wwwnwql.cr.usgs.gov/Public/pubs/QC_Fact/text.html).

Field quality control is checked during random field audits. The Quality Assurance officer assures that samples were collected, labeled, and preserved according to standard operating procedures. A field checklist will be prepared, and a summary report will be submitted.

B.6 Instrument/Equipment Testing, Inspection, and Maintenance

Instrument probes are cleaned and thoroughly inspected between sampling events. If any probe is not functioning correctly, it is determined whether it is necessary to perform maintenance and/or replace (retire) the instrument.

Physical sampling gear is inspected before each use to assure that all parts are intact. Any gear that shows operational deficiency is not used until repairs can be made.

B.7 Instrument Calibration and Frequency

The meters used to determine field parameters are calibrated daily. Specific instructions for calibration are found in the operating manuals provided with the instrument. Fresh standards are available for calibration prior to each sampling period. The field technician is responsible for providing directions for appropriate calibration, including the appropriate potassium chloride concentration to use for salinity calibrations. Dissolved oxygen (DO) is measured with an amperometric meter. The DO meter is calibrated using the saturated air method.

A calibration record is maintained for each unit in a logbook. This log serves as documentation for pre- and post-calibration information for each parameter recorded. The log is useful in determining drift in a probe, which indicates that maintenance is necessary for maintenance. The field technician remains aware of questionable performance of any instruments, and determines when it is necessary to perform maintenance and/or replace an instrument.

B.8 Inspection Acceptance Requirements for Supplies and Consumables

The field technician routinely inspects equipment and supplies. The field technician is responsible for determining when supplies and consumables should be discarded. Special attention should be paid to the condition of any filtration supplies (pads, bottles, etc.) and ultra-clean gear to assure that they are uncontaminated. If contamination is suspected, the supplies should be discarded. Any supplies that have exceeded their expiration date are disposed of.

B.9 Data Acquisition

USGS streamflow data is used in the River Input project but not directly collected as part of the project. Streamflow data is a necessary data input in the load estimation model. Site summaries of historic streamflow conditions are shown in Table 3. Period of record indicates the period for which there are published discharge values for the USGS station. The annual mean for the period of record is the arithmetic mean of the individual daily-mean discharges for the designated period of record. The highest and lowest daily means are the maximum daily-mean discharge and minimum daily-mean discharge, respectively, for the designated period of record.

Daily-mean discharges are computed by applying the daily mean stages (gage heights) to the stage-discharge curves (James and others, 2003). The USGS provides stage and discharge data for gaging stations on the world wide web (WWW). These data may be accessed at http://water.usgs.gov.

Table 3. Potomac River Nontidal Monitoring site drainage area and historic streamflow conditions. [mi^2, square miles; ft^3/s, cubic feet per second]

Period of Record	**Drainage (sq. mi.)**	**Period of Record Annual Mean discharge (ft^3/s)**	**Highest Daily Mean discharge (ft^3/s)**	**Lowest Daily Mean discharge (ft^3/s)**
Patterson Creek near Headsville, WV (01604500)				
August 1938 to Present Year	211	170.1	11,100	0.48
South Branch Potomac River near Springfield, WV (01608500)				
August 1928 to Present Year	1,486	1,332	145,000	52
Cacapon River near Great Cacapon, WV (01611500)				
December 1922 to September 1995, October 1996 to Present Year	675	581.6	67,900	26
Opequon Creek near Martinsburg, WV (01616500)				
July 1947 to Present Year	273	239.7	15,000 (estimated)	26

B.10 Data Management

All data will be collected using standardized data sheets (see Attachment A) for the specific projects. Data sheets will be coded with a site code (sample area and station number, date, collection time, and collector's initials). These data will be keyed into the USGS's data management systems by technicians who collect the data. All data files will be documented in metadata files. Data files will be maintained on the USGS computer network and backed up by diskette and raw datasheets. The USGS WV Water Science Center in Charleston will house the archived copies. Copies of the original data sets will be provided to WVDEP and maintained by the project coordinator. Electronic files with appropriate metadata will be forwarded to the appropriate analysts. The project data manager will maintain field data sheets, which will be kept at the same location as the electronic files.

Field data are entered into the USGS computers using standard USGS data entry procedures. Summary statistics are calculated to identify anomalies in the data. All data anomalies are verified against the raw data and corrected if necessary. Several times during the year, some provisional data files will be transferred from USGS to WVDEP via CD-ROM or via the Internet. These intermediate data transfers include flow data from each station for the previous calendar year, raw nutrient and suspended-sediment data and quality-control results from the previous calendar year. Metadata files created by the data manager and linked to the data files also will be transferred to WVDEP.

C. Assessment/Oversight

C.1 Assessment and Response Actions

The USGS quality-assurance officer will conduct random field and office audits to ensure that data collection and data manipulation follow guidelines set forth in the to the quality-assurance plan. A minimum of one field audit will be conducted each year. The field audit will consist of examining all aspects of the field collection for accuracy and adherence to sampling procedures. The field audit will be representative of all sites, but will not necessarily require a visit to each site. A summary report documenting the field activities will be provided. Office audits will be conducted to ensure that all logs are completed and up-to-date, and that proper data management and manipulation is being conducted. The principal investigator will be immediately notified of any deficiencies and take immediate corrective actions.

The project coordinator will continually monitor the logs and records associated with the project to assure that project schedules are being met. The project coordinator will immediately take any corrective action necessary if project schedules and procedures are being violated. The quality-assurance officer will perform and report on technical system audits and data-quality audits. Data-quality assessments will be conducted to determine whether the assumptions were met.

A USGS Water Science Center Water-Quality Review is held every three years by the USGS Regional Water-Quality Specialist and Regional Staff. Field methods are observed for consistency with USGS procedures and the District water-quality database (QWDATA) and the national database (STORET) are in agreement.

C.2 Reports to Management

Quarterly progress reports will be submitted from the USGS to WVDEP to describe quarterly project activities (Attachment B). Any deviations from scheduled project activities will be noted and the effect of these deviations on the final project outcome will be described. Corrective measures will also be suggested. The Project Chief (USGS) will be responsible for producing and distributing progress reports.

D. Data Validation and Usability

D.1 Data Review, Validation, and Verification

Data will be verified using a previously developed data quality-control system. After being scrutinized during the data-entry phase, data are analyzed and plotted to examine any outliers or anomalies. These are then examined, verified, and corrected if necessary. Field audits are performed to assure that all data are collected according to standard operating procedures, and that the collection effort is consistent and equal. The USGS Project Chief is responsible for performing quality control, or assuring that quality control is performed by appropriate staff.

All field logs and information are thoroughly reviewed prior to data analysis to assure that all data were collected uniformly. Any data that are not collected according to standard operating procedures are examined to determine whether they are representative. All quality-assurance reports are examined prior to data analysis to verify that data were properly and consistently collected. Any deviations in data collection are taken into account during data analysis. All calibration logs are examined to determine how well the measurement instruments performed. If there appears to be significant drift in instrument performance, the data are adjusted accordingly. All raw data are kept in paper files. Data are entered twice and compared for keying errors. These errors will be corrected. Original (raw) data are retained by the data manager.

D.2 Validation and Verification Methods

The field technician or senior field staff person will verify all data entered in the field. This person will examine all data sheets to ensure that they are accurately and legibly completed. They will then sign and record the date and time on the data sheets when verified. All field validation must occur prior to leaving the site before samples are discarded. Any recording errors are to be marked through and initialed. The true value is to be recorded next to the error, and all errors are to be explained in the remarks column of the data sheet. These data sheets will be placed in a notebook and logged on a daily log sheet. These notebooks will be forwarded to the data manager on request. The data manager will forward the data sheets to the data entry staff. The final verified computerized data set is forwarded to the data analysts.
A substantial effort is incorporated into the monitoring program to document and ensure quality assurance (QA) and quality control (QC). The quality-assurance effort includes documentation of observed concentration variability within the cross section, sediment transport analysis, quality assurance of sample-collection techniques and field personnel, and the variability within and among the analyzing laboratories. Field quality control is verified during random field audits. The QA officer assures that samples are collected, labeled and preserved in accordance with standard operating procedures. Field blanks and trip blanks are submitted to evaluate the potential for contamination of samples during their collection, processing, and transport.

Laboratory validation and verification procedures follow NWQL protocol found on the web at:

http://nwql.usgs.gov/Public/pubs/QC_Fact/text.html.

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Attachment A: Example of Field Data Sheet

Version 6: 11/2004 FIELD ID ____________

U. S. GEOLOGICAL SURVEY SURFACE-WATER QUALITY NOTES

NWIS RECORD NO ____________

STATION NO. ____________ STATION NAME ____________

SAMPLE DATE ________ MEAN SAMPLE TIME (WATCH) ________ TIME DATUM ______ (eg. EST, EDT, UTC) END DATE ________ END TIME ________

SAMPLE MEDIUM ____ SAMPLE TYPE ____ SAMPLE PURPOSE (71999) _____ PURPOSE OF SITE VISIT (50280) _____

PROJECT NO. ____________ PROJ NAME____________ PROJECT NO. ____________ PROJ NAME____________

SAMPLING TEAM ____________ TEAM LEAD SIGNATURE ____________ DATE ________

START TIME ________ GAGE HT ______ TIME ________ GHT _____ TIME ________ GHT _____ TIME ________ GHT _____ END TIME ________ GHT _____

Sample Set ID _____ **LABORATORY INFORMATION**

SAMPLES COLLECTED: NUTRIENTS ___ MAJOR IONS ___ TRACE ELEMENTS: FILTERED ___ UNFILTERED ___ MERCURY: FILTERED ___ UNFILTERED ___ VOC ___

RADON ___ (Radon samp coll time:________) TPC ___ (VOL FILTERED_______mL) PIC ___ (VOL FILTERED_______mL) TPC(QC) ___ (VOL FILTERED_______mL)

DOC ___ ORGANICS: FILTERED ___ UNFILTERED ___ RADIOCHEMICALS: FILTERED ___ UNFILTERED ___ ISOTOPES ___ MICROBIOLOGY ___

CHLOROPHYLL ___ BOD ___ COD ___ ALGAE ___ INVERTEBRATES ___ FISH ___ BED SED. ___ SUSP. SED. ___ CONC. S/F SIZE

WASTEWATER _____ OTHER ____________ OTHER ____________ OTHER ____________ OTHER ____________

LABORATORY SCHEDULES: ________ ________ ________ ________ ________ ________

LAB CODES: ________ ADD/DELETE ________ ADD/DELETE ________ ADD/DELETE ________ ADD/DELETE ________ ADD/DELETE ________ ADD/DELETE

COMMENTS: ____________ DATE SHIPPED ____________

****Notify the NWQL in advance of shipment of potentially hazardous samples—phone 1-866-ASK-NWQL or email LabLogin@usgs.gov**

FIELD MEASUREMENTS

TEMP, WATER (00010) ________ °C Q, INST. (00061) ____________ cfs MEAS. RATING EST ANC ( ) ____________ mg/L

pH (00400) ____________ UNITS GAGE HT (00065) ____________ ft ALKALINITY ( ) ____________ mg/L

COND (00095) ____________ µS/cm@25 °C TEMP, AIR (00020) ____________ °C CARBONATE (00452) ____________ mg/L

DIS. OXYGEN (00300) ________mg/L TURBIDITY ( ) _____ —-_____ METHOD CODE _____ BICARBONATE (00453) ____________ mg/L

UNITS: FNU NTRU FNMU FBU

DO SAT. (00301) ____________ % OTHER: ________ ____________ HYDROXIDE (71834) ____________ mg/L

BAROMETRIC PRES. (00025) ________ mm Hg OTHER: ________ ____________ eH (00090) ____________ mvolts

SAMPLING INFORMATION

Sampler Type (84164) _______ Sampler ID ________ Sample Compositor/Splitter: PLASTIC TEFLON CHURN (4L 8L 14L) CONE OTHER _______ ID_______

Sampler Bottle/Bag Material: PLASTIC TEFLON OTHER ________ Nozzle Material: PLASTIC TEFLON OTHER ________ Nozzle Size: 3/16" 1/4" 5/16"

Stream Width: _______ ft mi Left Bank _____ Right Bank _____ Mean Depth: ______ft Ice Cover ______% Ave. Ice Thickness ______ in.

Sampling Points: _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____

Sampling Location: WADING CABLEWAY BOAT BRIDGE UPSTREAM DOWNSTREAM SIDE OF BRIDGE _______ ft mi above below gage _______

Sampling Site: POOL RIFFLE OPEN CHANNEL BRAIDED BACKWATER Bottom: BEDROCK ROCK COBBLE GRAVEL SAND SILT CONCRETE OTHER ______

Stream Color: BROWN GREEN BLUE GRAY CLEAR OTHER ________ Stream Mixing: WELL-MIXED STRATIFIED POORLY-MIXED UNKNOWN OTHER____

Weather: ***SKY***- CLEAR PARTLY CLOUDY CLOUDY ***PRECIPITATION***- NONE LIGHT MEDIUM HEAVY SNOW SLEET RAIN MIST ________

WIND- CALM LIGHT BREEZE GUSTY WINDY EST. WIND SPEED______ MPH ***TEMPERATURE***- VERY COLD COOL WARM HOT ________

Sampling Method (82398): EWI [10] EDI [20] SINGLE VERTICAL [30] MULT VERTICAL [40] OTHER ____________ Stream Velocity (81904) ______ ft/sec

Transit Rate, minimum (50014) ________ft/sec Transit Rate (50015) ________ ft/sec Transit Rate, maximum (50016) ________ ft/sec

Hydro.Condition: Not determined [A]; Stable, low stage [4]; Falling stage [5]; Stable, high stage [6]; Peak stage [7]; Rising stage [8]; Stable, normal stage [9]

No. Days Since Last Significant Rainfall ________

OBSERVATIONS: ____________

COMPILED BY: ____________ **DATE** ______ **CHECKED BY:** ____________ **DATE:** _______ **LOGGED INTO NWIS BY:** ____________ **DATE** ______

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METER CALIBRATIONS/FIELD MEASUREMENTS

STN NO____________________________

Calibrated by:______________________________ Location:____________________________

Date:_________________ Time:_____________

TEMPERATURE Meter MAKE/MODEL __________________ S/N _______________ Thermister S/N ______________ Thermometer ID ______________

Lab Tested against NIST Thermometer/Thermister? N Y Date: ____________________ ±___________ °C

Measurement Location: SINGLE POINT AT _______ ft DEEP STREAMSIDE _______ FT FROM LEFT RIGHT BANK VERTICAL AVG/MEDIAN OF ________ POINTS

Field Readings # 1 ________ # 2 ________ # 3 ________ # 4 _________ # 5 _________ **MEDIAN:**__________ **°C** Remark ___ ___ Qualifier ___ ___

pH Meter MAKE/MODEL _____________________ S/N _________________ Electrode No. _______________ Type: GEL LIQUID OTHER ____________

Sample: FILTERED UNFILTERED CONE SPLITTER CHURN SPLITTER SINGLE POINT AT _______ FT DEEP VERTICAL AVG. OF _____ POINTS

pH BUFFER	BUFFER TEMP	THEO-RETICAL pH FROM TABLE	pH BEFORE ADJ.	pH AFTER ADJ.	SLOPE	MILLI-VOLTS
pH 7						
pH 7						
pH 7						
pH ___						
pH ___						
pH ___						
CHECK pH ___						

TEMPERATURE CORRECTION FACTORS FOR BUFFERS APPLIED? Y N

BUFFER LOT NUMBERS :

pH 7: ____________________________

pH ____: ____________________________

CHECK pH ____: ____________________________

BUFFER EXPIRATION DATES:

pH 7: ____________________________

pH ____ : ____________________________

CHECK pH ____: ____________________________

Calibration Criteria: ± 0.2 pH units

Field Readings # 1________ # 2_______ # 3_______ # 4_______ # 5 _______ **MEDIAN:** ________ **Units** Remark ___ ___ Qualifier ___ ___

SPECIFIC CONDUCTANCE Meter MAKE/MODEL ______________________ S/N _________________ Sensor Type: DIP FLOW-THRU OTHER____________

Sample: CONE SPLITTER CHURN SPLITTER SINGLE POINT AT _______ ft DEEP VERTICAL AVG. OF _______ POINTS

STD VALUE	STD TEMP	SC BEFORE ADJ.	SC AFTER ADJ.	STD LOT NO	STD EXPIR-ATION DATE	COMMENTS

AUTO TEMP COMPENSATED METER ___

MANUAL TEMP COMPENSATED METER ___

CORRECTION FACTOR APPLIED? Y N

CORRECTION FACTOR= ____________

Calibration Criteria: the greater of 5 µS/cm or 3% of measured value

Field readings # 1________ # 2_______ # 3_______ # 4_______ # 5 _______ **MEDIAN:** ________ **µS/cm**

DISSOLVED OXYGEN Meter MAKE/MODEL _____________________________ S/N ____________________ Probe No. ________________________

Air Calibration Chamber in Water Air-Saturated Water Air Calibration Chamber in Air Winkler Titration Other__________________________

Sample: SINGLE POINT AT _______ ft DEEP VERTICAL AVG. OF _____ POINTS BOD BOTTLE OTHER_____________ Stirrer Used? Y N

WATER TEMP °C	BAROMETRIC PRESSURE mm Hg	DO TABLE READING mg/L	SALINITY CORR. FACTOR	DO BEFORE ADJ.	DO AFTER ADJ.

Calibration Criteria: ± 0.3 mg/L

Zero DO Check __________mg/L Adj. to __________ mg/L Date: _______________

Zero DO Solution Date___________ Thermister Check? Y N Date__________

Membrane Changed? N Y Date: ________________ Time: ________

Barometer Calibrated? N Y Date: __________________ Time: ________

Battery Check: REDLINE _____ RANGE ______________

Field readings # 1________ # 2_______ # 3_______ # 4_______ # 5 _______ **MEDIAN:** ________ **mg/L** Remark ___ ___ Qualifier ___ ___

STN NO____________________________

TURBIDITY CALIBRATION

Meter: MAKE/MODEL ______________________ S/N ____________________ Type: TURBIDIMETER SUBMERSIBLE SPECTROPHOTOMETER

Sample: COLLECTION TIME: ________ MEASUREMENT TIME: ________

MEASUREMENT: IN-SITU/ON-SITE VEHICLE DISTRICT LAB NWQL OTHER ___________________

SAMPLE DILUTED? Y N VOL. OF DILUTION WATER _________ mL SAMPLE VOLUME ________ mL

TURBIDITY VALUE = A x (B+C) / C

A= TURBIDITY VALUE IN DILUTED SAMPLE
B= VOLUME OF DILUTION WATER, mL
C= SAMPLE VOLUME, mL

COMMENTS:

Calibration Criteria: ± 0.5 TU or ± 5%	Lot Number or Date Prepared	Expiration Date	Concentration ______ (units)	Temperature °C	Initial instrument reading	Reading after adjustment
Stock Turbidity Standard						
Zero Standard *(DIW)*						
Standard 1						
Standard 2						
Standard 3						

Field Readings #1 __________ #2 __________ #3 __________ #4 __________ #5 __________

MEDIAN __________ **Parameter Code** ________ FNU NTRU FNMU FBU **METHOD CODE** ___ **Remark Codes(s)** ___ ___ **Qualifier(s)** ___ ___

CROSS SECTION NOTES BAROMETRIC PRESSURE = ________ MM HG

STATION	ft FROM LEFT BANK (00009) OR ft FROM RIGHT BANK (72103)	TIME	GAGE HT ft (00065)	DISCHARGE (INST) cfs (00061)	DEPTH ft (81903)	TEMP °C (00010)	SC µS/cm (00095)	DO mg/L (00300)	DO SAT % (00301)	pH units (00400)	TURBIDITY ______ (______) ______ (METHOD	NWIS RECORD NO.
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												

NOTES:

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STN NO___________________________

ALKALINITY/ANC CALCULATIONS

BEGINNING H_2O TEMP. _________ °C

pH	ΔpH	VOL ACID DC OR mL	ΔVOL ACID DC OR mL	ΔpH / ΔVOL ACID

End H_2O temp. _________ °C

BEGINNING H_2O TEMP. _________ °C

pH	ΔpH	VOL ACID DC OR mL	ΔVOL ACID DC OR mL	ΔpH / ΔVOL ACID

End H_2O temp. _________ °C

FIRST TITRATION RESULTS

DATE _____________ INITIALS ______________

BEGIN TINE___________ END TIME___________

ALKALINITY/ANC _____________ meq/L

ALKALINITY/ANC _____________ mg/L AS $CaCO_3$

BICARBONATE ______mg/L ______meq/L AS HCO_3^-

CARBONATE _______mg/L ______ meq /L AS CO_3^{2-}

ACID: 1.6N 0.16N 0.01639N

OTHER:______________________________

ACID LOT NO. ________________________

ACID EXPIRATION DATE __________________

SAMPLE VOLUME: ______________mL

FILTERED UNFILTERED CHURN CONE

METHOD: INFLECTION POINT GRAN

FIXED ENDPOINT

STIRRING METHOD: MAGNETIC MANUAL

SECOND TITRATION RESULTS

DATE _____________ INITIALS ______________

BEGIN TINE___________ END TIME___________

ALKALINITY/ANC _____________ meq/L

ALKALINITY/ANC _____________ mg/L AS $CaCO_3$

BICARBONATE ______mg/L ______meq/L AS HCO_3^-

CARBONATE _______mg/L ______ meq /L AS CO_3^{2-}

ACID: 1.6N 0.16N 0.01639N

OTHER:______________________________

ACID LOT NO. ________________________

ACID EXPIRATION DATE __________________

SAMPLE VOLUME: ______________mL

FILTERED UNFILTERED CHURN CONE

METHOD: INFLECTION POINT GRAN

FIXED ENDPOINT

STIRRING METHOD: MAGNETIC MANUAL

CALCULATIONS

ALKALINITY OR ANC (meq/L) = 1000 (B) (C_a) (CF) / V_s

ALKALINITY (mg/L AS $CaCO_3$) = 50044 (B) (C_a) (CF) / V_s

where:

B = volume of acid titrant added from the initial pH to the bicarbonate equivalence point (near pH 4.5), in milliliters. To convert from digital counts to milliliters, divide by 800 (1.00 mL = 800 counts)

C_a = concentration of acid titrant, in milliequivalents per milliliter (same as equivalents per liter, or *N*)

CF = correction factor (obtain from OWQRL for Hach acid cartridges of certain lot numbers — default value is 1.00)

V_s = volume of sample, in milliliters

For samples with pH $\leq$ 9.2:

BICARBONATE (meq/L) = 1000 (B-2A) (C_a) (CF) / V_s

BICARBONATE (mg/L) = 61017 (B-2A) (C_a) (CF) / V_s

CARBONATE (meq/L) = 2000 (A) (C_a) (CF) / V_s

CARBONATE (mg/L) = 60009 (A) (C_a) (CF) / V_s

where:

A = volume of acid titrant added from the initial pH to the carbonate equivalence point (near pH 8.3), in milliliters. To convert from digital counts to milliliters, divide by 800 (1.00 mL = 800 counts)

NOTE: For samples with pH > 9.2, these equations for bicarbonate and carbonate will fail to give accurate results. Use the Alkalinity Calculator at http://oregon.usgs.gov/alk or PCFF.

HACH CARTRIDGE CORRECTION FACTOR __________

[SEE OWQ WAQI NOTES FOR INFO]

pH meter calibration	Meter make/model:		S/N	
Electrode No.		Type: gel liquid other	Slope	Milli-volts
pH buffer	**Buffer temp**	**Theoretical pH from table**	**pH before adj.**	**pH After adj.**
pH 7				
pH __				
Check pH ___				

Comments/Calculations:

4 SW form ver. 6.0

STN NO________________________

QUALITY-CONTROL INFORMATION

LOT NUMBERS

PRESERVATIVE LOT NUMBERS

PLACE LABELS FROM VIALS ON SAMPLE BOTTLES

7.5N HNO_3 __________ (METALS&CATIONS)   6N HCl __________ (Hg)   4.5N H_2SO_4 __________ (NUTRIENTS&DOC)   Conc. H_2SO_4 __________ (COD, PHENOL, O&G)   NaOH __________ (CYANIDE)

OTHER __________   1:1 HCl __________ (voc)   Number of drops of HCL added to lower pH to ≤ 2 ______ (**NOTE:** Maximum number of drops = 6)

BLANK WATER LOT NUMBERS

Inorganic (99200) __________   2nd Inorganic (99201) __________   Spike vials (99104) __________

Pesticide (99202) __________   2nd Pesticide (99203) __________   Surrogate vials __________

VOC/Pesticide (99204) __________   2nd VOC/Pesticide (99205) __________

FILTER LOT NUMBERS

capsule__________ pore size __________ type __________

disc__________ pore size __________ type __________

plate __________ pore size __________ type __________

organic carbon __________ pore size __________ type __________

other __________ pore size __________ type __________

QC SAMPLES

WERE QC SAMPLE COLLECTED? **YES** **NO**

Starting date for set of samples (99109) (YMMDD) __________

Ending date for set of samples (99110) (YMMDD) __________

Sample Type	NWIS Record No.	Sample Type	NWIS Record No.	Sample Type	NWIS Record No.
Equip Blank ____	________	Sequential ____	________	Trip Blank ____	________
Field Blank ____	________	Spike ____	________	Other ____	________
Split ____	________	Concurrent ____	________	Other ____	________

NWQL Schedules/lab codes (QC Samples) ________ ________ ________ ________ ________ ________

________ ________ ________ ________ ________ ________ ________ ________ ________

COMMENTS____

(Circle appropriate selections)

99100 Blank-solution type
- 10 Inorganic grade (distilled/deionized)
- 40 Pesticide grade (OK for organic carbon)
- 50 Volatile-organic grade (OK for inorganic, organic, and organic carbon)
- 80 Universal blank water
- 200 Other

99101 Source of blank water
- 10 NWQL
- 40 NIST
- 55 Wisconsin District Mercury Lab
- 200 Other

99105 Replicate-sample type
- 10 Concurrent
- 20 Sequential
- 30 Split
- 40 Split-Concurrent
- 50 Split-Sequential
- 200 Other

99102 Blank-sample type
- 1 Source Solution
- 30 Trip
- 40 Sampler
- 50 Splitter
- 60 Filter
- 70 Preservation
- 80 Equipment (done in non-field environment)
- 90 Ambient
- 100 Field
- 200 Other

99111 QC sample associated with this environmental sample
- 1 No associated QA data
- 10 Blank
- 30 Replicate Sample
- 40 Spike sample
- 100 More than one type of QA sample
- 200 Other

99106 Spike-sample type
- 10 Field

99107 Spike-solution source
- 10 NWQL

99108 Spike-solution volume, mL __________

99112 Purpose, Topical QC data
- 1 Routine QC (non-topical)
- 10 Topical for high bias (contamination)
- 20 Topical for low bias (recovery)
- 100 Topical for variability (field equip)
- 110 Topical for variability (field collection)
- 120 Topical for variability (field personnel)
- 130 Topical for variability (field processing)
- 140 Topical for variability (shipping&handling)
- 200 Topical for variability (lab)
- 900 Other topical QC purpose

REFERENCE LIST FOR CODES USED ON THIS FORM

A COMPLETE SET OF FIXED-VALUE CODES CAN BE FOUND ON-LINE AT: http://wwwnwis.er.usgs.gov/currentdocs/index.html

Sample Medium Codes
- 9 Surface water
- R Quality-control sample (associated environmental sample –9 (SW))
- Q Artificial

Value Qualifiers
- e see field comment
- f sampleield preparation problem
- k counts outside the acceptable range

Null-value Qualifiers
- e required equipment not functional or available
- f sample discarded; improper filter used
- o insufficient amount of water

71999 SAMPLE PURPOSE

10	Routine
15	NAWQA
20	NASQAN
30	Benchmark
40	SW Network
60	Lowflow Network
70	Highflow Network
110	Seepage Study
180	Cross-Section Variation

84164 SAMPLER TYPE

100	Van Dorn Sampler
110	Sewage Sampler
125	Kemmerer Bottle
3044	US DH-81
3045	US DH-81 With Teflon Cap And Nozzle
3047	Sampler, Frame-Type, Plastic Bottle W/Reynolds Oven Bag
3048	Sampler, Frame-Type, Teflon Bottle
3049	Sampler, Frame-Type, Plastic Bottle
3050	Sampler, Frame-Type, Plastic Bottle W/Teflon Collapsible Bag
3051	US DH-95 Teflon Bottle
3052	US DH-95 Plastic Bottle
3053	US D-95 Teflon Bottle
3054	US D-95 Plastic Bottle
3055	US D-96 Bag Sampler
3057	US D-99 Bag Sampler
3058	US DH-2 Bag Sampler
3060	Weighted-Bottle Sampler
3061	US WBH-96 Weighted-Bottle Sampler
3070	Grab Sample
3071	Open-Mouth Bottle
3080	VOC Hand Sampler
4010	Thief Sampler
4115	Sampler, point, automatic
8000	None
8010	Other

Sample Type Code

9	Regular
7	Replicate
2	Blank
1	Spike
4	Blind
5	Duplicate
6	Reference material
8	Spike solution
A	Not determined
B	Other QA
H	Composite

ALKALINITY/ANC PARAMETER CODES

- 39086 Alkalinity, water, filtered, incremental titration, mg/L
- 00418 Alkalinity, water, filtered, fixed endpoint, mg/L
- 29802 Alkalinity, water, filtered, Gran titration, mg/L
- 00419 ANC, water, unfiltered, incremental titration
- 00410 ANC, water, unfiltered, fixed endpoint, mg/L
- 29813 ANC, water, unfiltered, Gran titration, mg/L
- 29804 Bicarbonate, water, filtered, fixed endpoint, mg/L
- 63786 Bicarbonate, water, filtered, Gran, mg/L
- 00453 Bicarbonate, water, filtered, incremental, mg/L
- 00440 Bicarbonate, water, unfiltered, fixed endpoint, mg/L
- 00450 Bicarbonate, water, unfiltered, incremental, mg/L
- 29807 Carbonate, water, filtered, fixed endpoint, mg/L
- 63788 Carbonate, water, filtered, Gran, mg/L
- 00452 Carbonate, water, filtered, incremental, mg/L
- 00445 Carbonate, water, unfiltered, fixed endpoint, mg/L
- 00447 Carbonate, water, unfiltered, incremental, mg/L
- 29810 Hydroxide, water, filtered, fixed endpoint, mg/L
- 71834 Hydroxide, water, filtered, incremental, mg/L
- 71830 Hydroxide, water, unfiltered, fixed endpoint, mg/L
- 71832Hydroxide, water, unfiltered, incremental, mg/L

Time Datum Codes

Time Zone	Std Time Code	UTC Offset (hours)	Daylight Time Code	UTC Offset (hours)
Hawaii-Aleutian	HST	-10	HDT	-9
Alaska	AKST	-9	AKDT	-8
Pacific	PST	-8	PDT	-7
Mountain	MST	-7	MDT	-6
Central	CST	-6	CDT	-5
Eastern	EST	-5	EDT	-4
Atlantic	AST	-4	ADT	-3

82398 SAMPLING METHOD

10	Equal Width Increment (EWI)
20	Equal Discharge Increment (EDI)
25	Timed Sampling Interval
30	Single Vertical
40	Multiple Verticals
50	Point Sample
55	Composite, multi-point samples
70	Grab Sample (Dip)
80	Discharge Integrated, Equal Transit Rate (ETR)
90	Discharge Integrated, Centroid
120	Velocity Integrated
8010	Other
8030	Grab Sample At Water-Supply Tap

50280 PURPOSE OF SITE VISIT

1001	Fixed frequency, surface-water
1002	Storm hydrograph, surface-water
1003	Extreme high flow, surface-water
1004	Extreme low flow, surface-water
1005	Diurnal, surface-water
1006	Synoptic, surface-water
1098	NAWQA surface-water quality control
1099	Other, surface-water
3001	Occurrence Survey, bed sediment or tissue
3002	Spatial Distribution Survey, bed sediment or tissue
3003	Synoptic Study, bed sediment or tissue
3098	Bed-sediment or tissue quality control
3099	Other, bed sediment or tissue

Attachment B: Example of Quarterly Report to West Virginia Department of Environmental Protection

SAMPLE

Potomac River Nontidal Monitoring Program : *Quarterly Progress Report*

Monitoring Sites:

- (01578310) Patterson Creek near Headsville, WV
- (01646580) South Branch of the Potomac River near Springfield, WV
- (01594440) Cacapon River at Great Cacapon, WV
- (01491000) Opequon Creek near Martinsburg, WV

Report Period: January 1, 2003 – March 31, 2003

Funding: West Virginia Department of Environmental Protection (WVDEP) and U.S. Geological Survey (USGS)
Start Date: June 2005
Completion Date: continuous

Project Personnel: USGS Chief: Doug Chambers; USGS Lead Technician: Jeremy White and additional assistance from various other USGS and WVDEP personnel.

Project Objectives:

Determine the ambient concentration of nutrient and suspended sediment water-quality samples collected over a range in flow conditions in four major West Virginia tributaries to the Potomac River: Patterson Creek, the South Branch of the Potomac River, The Cacapon River, and Opequon Creek.

This Quarter's Sampling Events:

	Sample Type		
	Routine	**Storm**	**QA/QC**
Patterson Creek Nr Headsville	3	5	2
So. Br. Potomac @ Springfield	3	3	1
Cacapon River @ Great Cacapon	3	4	1
Opequon Cr. Nr Martinsburg	3	3	1

SAMPLE

Appendix C: Accounting for Trees in Stormwater Modeling and Calculations

Accounting for Trees in Stormwater Models and Calculators

Trees and forests have a natural ability to reduce stormwater runoff. As more and more communities encourage or even require the use of natural vegetative systems as part of their stormwater management programs, municipal planners and engineers require technical tools that allow them to quantify the stormwater benefits of this "green infrastructure" in a way that works seamlessly with existing models and methods.

This fact sheet summarizes methods and tools to account for the ability of green infrastructure to reduce runoff and remove pollutants. It is organized into two categories:

1. Methods for incorporating green infrastructure into runoff models
2. Models and calculators for estimating the functions, benefits, and economics of green infrastructure

1. Methods for Incorporating Green Infrastructure into Runoff Models

Historically, stormwater management has focused on peak runoff rate control, which requires a site designer to generate a post-development runoff hydrograph and a pre-development runoff hydrograph and manage the difference between the two.

More recently, site designers have been introduced to water quality control criteria that are intended to manage the "capture and treat" (e.g. water quality) volume.

Most recently, communities have developed stormwater ***runoff reduction*** criteria that specify a runoff volume that must be "captured and reduced" (e.g., reused, evaporated, utilized by plants, infiltrated or otherwise retained on site). Green infrastructure practices, such as conservation of forests, rain gardens and green rooftops, can be used to meet the runoff reduction criteria. A particular challenge is providing credit for these runoff reduction volumes within rainfall/runoff models.

In principle, when runoff reduction practices are used to capture and retain or infiltrate runoff, downstream stormwater management practices should not be required to detain, retain or otherwise treat the volume that is removed. In other words, ***runoff reduction should be accounted for in stormwater runoff computations***.

While it is not easy to predict the absolute hydrograph modification provided by reducing stormwater runoff volumes, it is clear that reducing runoff volumes will have an impact on the runoff hydrograph of a development site. The challenge facing stormwater managers and site designers is developing a hydrograph generating technique that provides adequate credit for stormwater runoff volumes that are reduced on site.

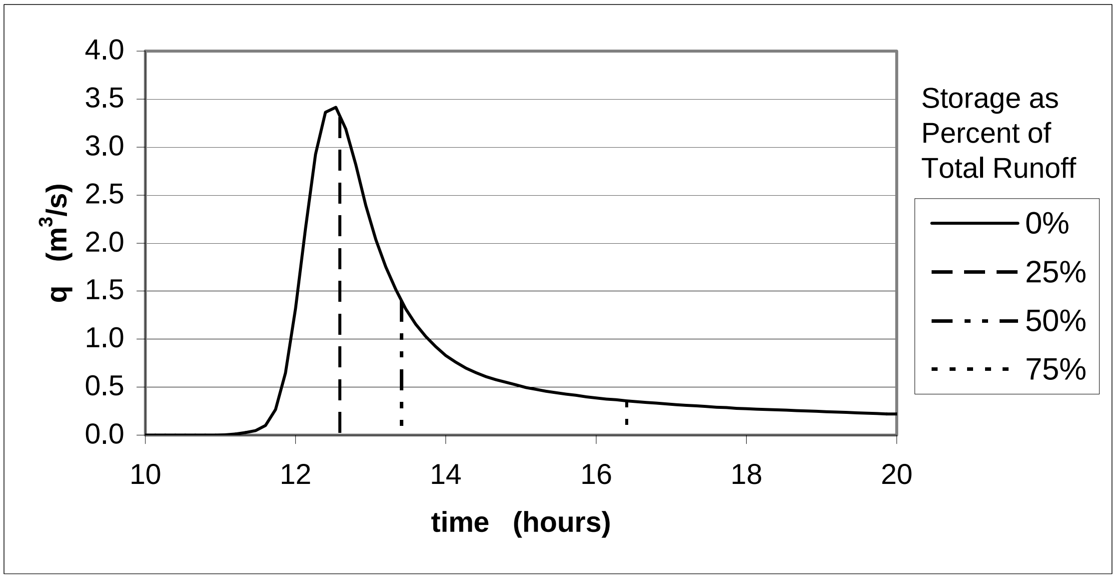
There are a variety of approaches that can be used to adjust the runoff hydrograph to account for the effect of runoff reduction practices in a site drainage area. In most cases, the "credit" received is likely dependent on the storm event and development intensity. In order to be useful to stormwater managers and site designers, the method developed and used must meet a number of objectives:

1. Field performance – solves real problems (e.g., water quality, channel protection, long term maintenance/performance)
2. Greater efficiency – does not lead to the overbuilding of stormwater best management practices (BMPs) (e.g., size or number of practices)
3. Incentivizes runoff reduction and environmental site design – leads to meaningful results if the designer applies ample effort to use runoff reduction practices
4. Simple – easy to understand & use, fits into spreadsheets and common models (e.g., TR-55)
5. Allows for a range of practices – broadens the suite of BMPs to use at a site – basins are not "automatic"
6. Accountability for the local public works staff – provides some assurance that today's plan approvals will not equal tomorrow's drainage complaints
7. Defensible – makes sense with the site hydrology; engineers believe it is realistic and plausible
8. Accurate – reflects actual site hydrology
9. Adaptable to different pollutants -- Addresses pollutants of concern for different applications
10. Relevant at the subwatershed scale – Can be tied to stormwater benchmarks for the subwatershed, such as flow, volume, and pollutant load reduction

The following section describes five approaches, all of which use the USDA Natural Resources Conservation Service (NRCS) (formerly known as the Soil Conservation Service) unit hydrograph method (USDA SCS, 1986) as a baseline. For some methods, a post-development hydrograph without runoff reduction practices is generated for the site, and is then adjusted. Other methods initially adjust the runoff depth that results from a site with runoff reduction practices, and then generates a post-development site hydrograph. Each approach is discussed below.

1. Truncated Hydrograph (Volume Diversion)

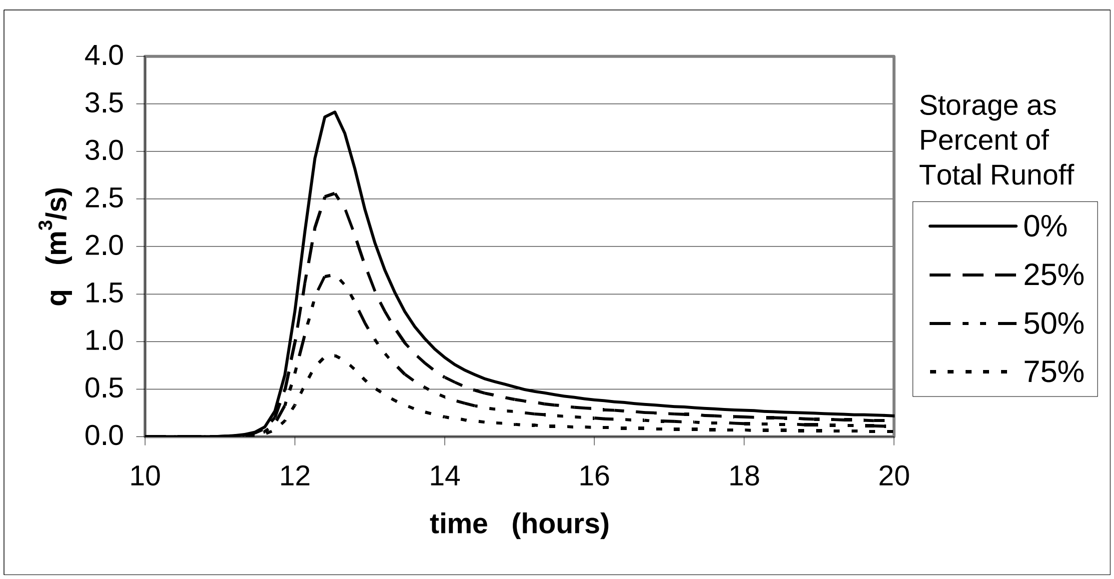
The truncated hydrograph approach applies runoff reduction in-line at the outlet of a drainage area. The philosophy behind this approach is that runoff reduction practices will accept and retain a portion of the initial runoff during a given rain event, which will modify the ultimate volume of runoff from the site, as well as the shape of the ultimate runoff hydrograph. For this particular option, a post-development runoff hydrograph for the original site prior to implementing runoff reduction practices is generated. The volume of runoff reduced by runoff reduction practices is then subtracted from the rising limb, or front portion, of the hydrograph. If the amount of runoff reduced is less than the volume up to the hydrograph peak, then no reduction in the peak flow or time to peak is reflected. As a result, this approach often results in conservative design estimates of the resulting peak flow, and ultimately gives less credit for runoff reduction practices.



Graphic source: Paul Koch

<u>*2. Hydrograph Scalar Multiplication*</u>

Similar to the previous approach, the hydrograph scalar approach begins by generating a post-development hydrograph for the original site prior to implementing runoff reduction practices. In this particular approach, the hydrograph is then multiplied by a scalar, which adjusts the magnitude of the original site hydrograph. The scalar is simply the ratio of runoff generated from the site with runoff reduction practices to the runoff generated from the original site (with no runoff reduction practices). The effect of runoff reduction practices is applied over the entire hydrograph rather than at the beginning. As a result, the degree to which the peak flow rate would be reduced is decreased, resulting in a conservative peak flow rate estimate, and giving less credit for runoff reduction practices. Also, no delay in the time to peak is reflected using this approach.



Graphic source: Paul Koch

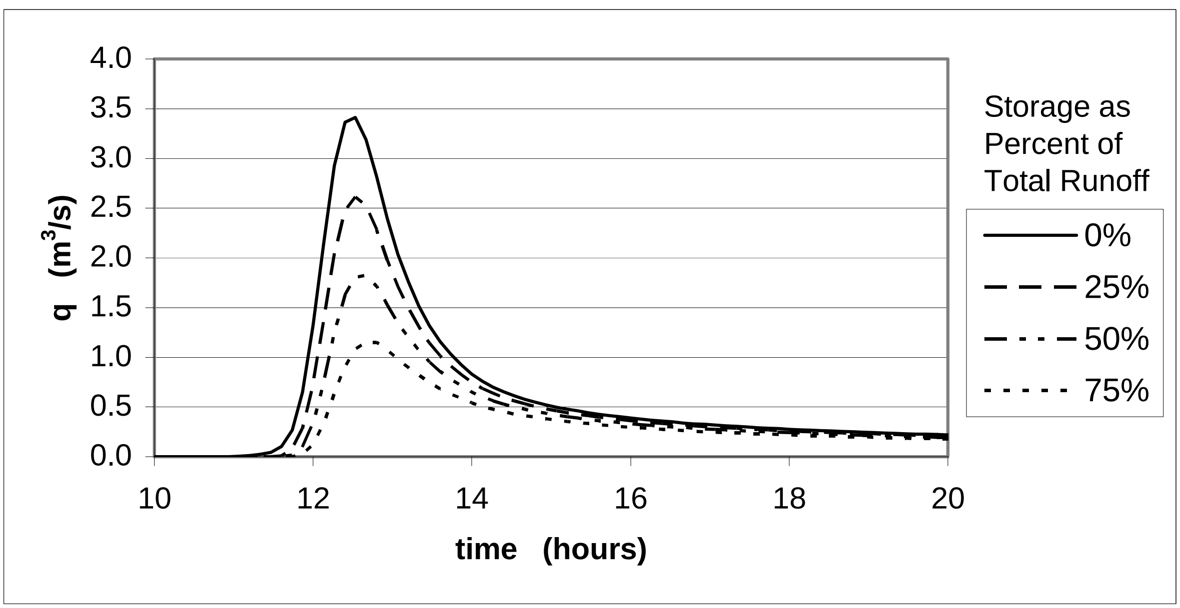
3. Precipitation Adjustment- Subtract Retention from Rainfall

This approach adjusts the NRCS runoff depth formula (USDA SCS, 1986) prior to generating a hydrograph, eliminating the need to develop an original post-development site hydrograph. For this approach, the amount of runoff reduced is subtracted from the rainfall depth (Equation 1), and hydrograph calculations are subsequently performed.

$$Q = \frac{\left((P-R)-I_a\right)^2}{\left((P-R)-I_a\right)+S} \qquad (1)$$

where
P=rainfall depth (in),
R = Reduced Runoff (in),
Q= Runoff (in),
I_a *= initial abstraction,*
S = potential maximum retention after runoff begins

The problem with this approach is that the volume of runoff reduced is never fully accounted for, as the change in runoff volume generated will always be less than the amount of runoff reduced. Further, adjusting the rainfall is not truly representative of what actually occurs over the site, and no delay in the time to peak is reflected using this approach.



Graphic source: Paul Koch

4. Adjusted CN

The Adjusted CN approach adjusts the NRCS runoff depth formula (USDA SCS, 1986) by changing the curve number (CN) for the portion of the site draining to runoff reduction practices. Site runoff is calculated using Equations 2-4. The CN can be adjusted to an improved site condition; for example, to a meadow in good condition.

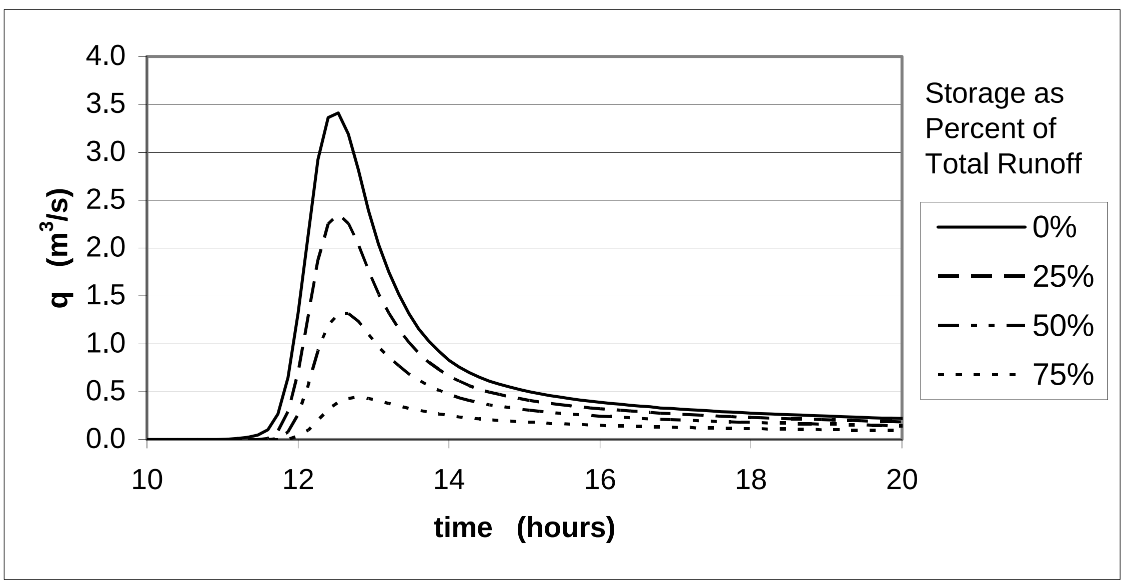
$$S = \frac{1000}{CN} - 10 \qquad (2)$$

$$I_a = 0.2S \qquad (3)$$

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad (4)$$

where
P=rainfall depth (in),
Q= Runoff (in),
I_a = initial abstraction,
S = potential maximum retention after runoff begins
CN = curve number

This approach reduces the runoff generated from the site and the runoff peak flow rate; however, no delay in the time to peak is reflected. Further, the effect of runoff reduction is distributed over the entire course of the storm, as opposed to occurring at the beginning. As a result, the degree to which the peak flow rate would be reduced is decreased, resulting in a conservative peak flow rate estimate, and less credit for runoff reduction practices. This method is a plausible way to reduce volumes and peak rates, and fits into the models that are understood by design consultants and plan reviewers.



Graphic source: Paul Koch

<u>*5. Runoff Adjustment - Subtract Retention from Runoff*</u>

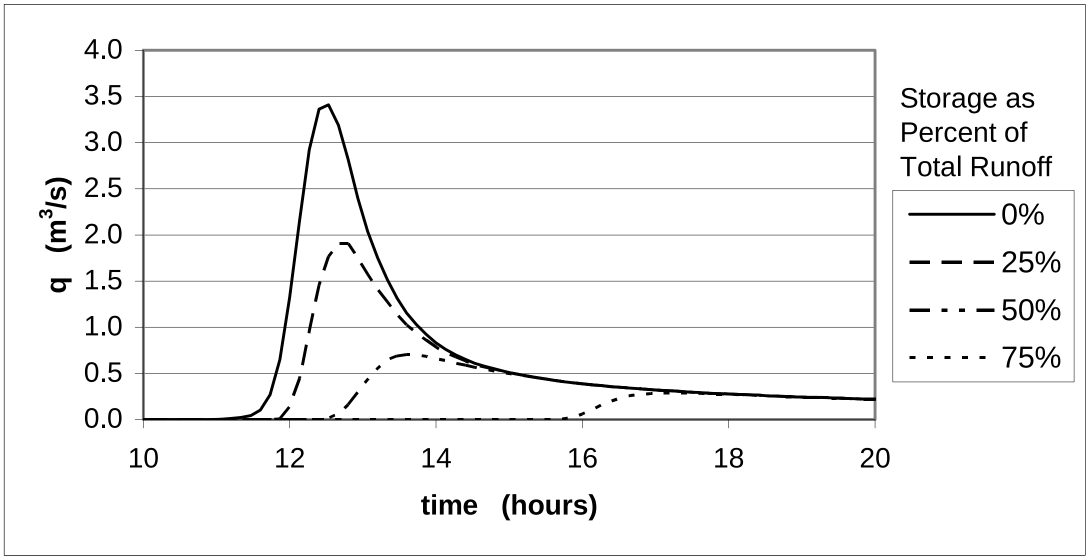
The philosophy behind this approach is that runoff reduction practices will accept and retain a portion of the initial runoff during a given rain event, which will modify the volume of runoff from the site, as well as the shape of the resulting runoff hydrograph. The runoff adjustment approach was developed by Koch (2005), and adjusts the NRCS runoff depth formula (USDA SCS, 1986) prior to generating a hydrograph. The amount of runoff reduced is subtracted from the calculated site runoff (Equation 5).

In order to generate a site hydrograph for an entire storm event, the storm is divided into discreet time periods. For each time period, an excess runoff rate is determined based upon watershed characteristics and the amount of rainfall during that time period. This excess runoff rate is then translated into a hydrograph. The site hydrograph for the entire storm event is created by summing each of these hydrographs over the duration of the storm. Instead of making a subtraction from the site hydrograph, the runoff adjustment approach subtracts each individual time period hydrograph, until the volume of runoff reduction has been reached.

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} - R \qquad (5)$$

where
P=rainfall depth (in),
R = Reduced Runoff (in),
Q= Runoff (in),
I_a *= initial abstraction,*
S = potential maximum retention after runoff begins

The runoff adjustment approach not only subtracts the runoff reduction volume at the beginning of the hydrograph, but also tends to reduce the peak flow and extend the time to peak of the site hydrograph, all of which are expected effects of utilizing runoff reduction practices. This approach appears to model the actual hydrology of runoff reduction practices most closely, but it is difficult and time-consuming because subtraction of time period hydrographs requires that the time period hydrographs be individually calculated throughout a storm event cannot be used to generate the resulting hydrograph. Existing hydrology programs, such as TR-55 and TR-20, do not have the capability to subtract individual hydrographs from the site hydrograph and account for runoff reduction practices in this manner.



Graphic source: Paul Koch

2. Models and Calculators for Estimating the Functions, Benefits, and Economics of Green Infrastructure

This section describes sixteen models and calculators that are available to account for the functions, benefits, and economics of green infrastructure. It includes a range of hydrologic and hydraulic (H&H) models, water quality models, build-out models, and cost-benefit calculators and tools. Web links are provided for additional information.

"Green Build-Out" Model

Casey Trees and LimnoTech developed a model (based on the STRATUM model) to predict the stormwater benefits of trees and green roofs for different coverage scenarios in Washington, DC. The model was applied to an "intensive greening" scenario and a "moderate greening" scenario, both of which demonstrated that trees and green roofs can be used to achieve substantial reductions in stormwater runoff and sewage discharges to local rivers. Specific outputs from the model include city-wide runoff volume reduction, reduction in CSO frequency and discharge, and the cost savings associated with these environmental benefits.
http://www.caseytrees.org/programs/planning-design/gbo.html

Green Roof Life Cycle Cost-Benefit Calculator

Green Roofs for Healthy Cities developed this calculator to help evaluate various roofing related investment scenarios. The Tool focuses on long timeframes, real monetary costs and savings, and financial returns attributed to employing conventional and green (vegetative) roofs. It also provides some guidance to the users about how to factor in financial information from benefits that may be overlooked in the analysis. To access the calculator, a free user account must be created.
http://www.greenroofs.org/index.php?option=com_content&task=view&id=626&Itemid=116

"Green Values" Stormwater Calculator

A calculator developed by the Center for Neighborhood Technology that can be used to estimate the financial and hydrologic impacts that various green infrastructure technologies can have on a development site. Specific outputs of the calculator include reduction in peak discharge, average annual groundwater recharge increase, reduction in total detention required and costs associated with green infrastructure versus conventional practices. http://greenvalues.cnt.org/calculator

Hydrological Simulation Program – FORTRAN (HSPF)

EPA's FORTRAN (HSPF) is a comprehensive package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants. This model can simulate the hydrologic, and associated water quality, processes on pervious and impervious land surfaces and in streams and well-mixed impoundments. It is the only comprehensive model of watershed hydrology and water quality that allows the integrated simulation of land and soil contaminant runoff processes with in-stream hydraulic and sediment-chemical interactions. The result of this simulation is a time history of the runoff flow rate, sediment load, and nutrient and pesticide concentrations, along with a time history of water quantity and quality at any point in a watershed. HSPF simulates three sediment types (sand, silt and clay) in addition to a single organic chemical and transformation products of that chemical. Analysis of stormwater treatment using HSPF can be cumbersome. http://www.epa.gov/ceampubl/swater/hspf/

Long-Term Hydrologic Impact Assessment Model (L-THIA)

The Local Government Environmental Assistance Network's Long-Term Hydrologic Impact Assessment (L-THIA) model was developed as an accessible online tool to assess the water quality impacts of land use change. Based on community-specific climate data, L-THIA estimates changes in recharge, runoff, and nonpoint source pollution resulting from past or proposed development. Inputs include land use/cover, soils, and runoff event mean concentrations. The model allows the user to modify inputs of impervious cover, forest and open space to reflect the use of green infrastructure practices. As a quick and easy-to-use approach, L-THIA's results can be used to generate community awareness of potential long-term problems and to support planning aimed at minimizing disturbance of critical areas.
http://www.ecn.purdue.edu/runoff/lthianew/

Low Impact Development Rapid Assessment (LIDRA) of Cost-Effectiveness for CSO Control

This paper presents a simple model for assessing the cost-effectiveness of investments in green infrastructure (GI) techniques, including green roofs, porous pavement and stormwater wetlands, for reducing combined sewer overflows (CSOs) in urban watersheds. The LIDRA model can be used as a policy-planning tool to compare GI introduced alone or in conjunction with traditional stormwater management techniques, to conventional approaches focusing wholly on centralized infrastructure. The potential reduction in CSOs resulting from various levels of GI adoption is simulated using a modified Rational Method. A life-cycle cost analysis is used to compare GI with other alternatives. The model assesses GI effectiveness in terms of estimated change in annual CSO hours (an hour during which a CSO event occurs) resulting from GI installation.
http://www.nyc.gov/html/planyc2030/downloads/pdf/water_quality_bmp_study.pdf

Pollutant Load and Reduction Model
Comprehensive Environmental Inc. has developed a Pollutant Load and Reduction Model that can be helpful to a variety of users including watershed groups, municipal land use decision-makers, and engineers. The simple spreadsheet model allows the user to determine how different types of green infrastructure (GI) techniques, including stormwater wetlands, ponds, infiltration facilities, rain gardens and swales, can reduce the pollutant loads in a given watershed. Model inputs include land use, annual rainfall, road sanding information and BMP information. Impervious cover inputs are based on land use type but can be changed manually to account for GI practices that reduce impervious cover or conserve natural areas, if desired. Outputs include annual loads of TSS, TP and TN and the amount reduced by using GI techniques.
http://www.nsrwa.org/programs/low_impact_development.asp

Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds (P8)
P8 is a model for predicting the generation and transport of stormwater pollutants in urban watersheds. Continuous water balance and mass balance calculations are performed on a user-defined system consisting of watersheds (divided into pervious and impervious areas), devices (buffer strips, swales, ponds, infiltration basins, pipes, flow splitters and aquifers), particle classes, and water quality components. Simulations are driven by continuous hourly rainfall and daily air temperature time series data. The model simulates pollutant transport and removal in a variety of devices, some of which are green infrastructure practices. Water quality components include total suspended solids, total phosphorus, total Kjeldahl nitrogen, copper, lead, zinc, and hydrocarbons. Outputs for each device include such factors as removal efficiency, flow, loads and concentrations, water and mass balance, and sediment accumulation rates.
http://www.epa.gov/ORD/NRMRL/pubs/600r05149/600r05149p8ucm.pdf

RECARGA
The University of Wisconsin developed RECARGA as a design tool for evaluating the performance of bioretention facilities, raingardens, and infiltrations basins. Individual BMPs, with up to 3 distinct soil layers and optional underdrains, can be modeled under user-specified precipitation and evaporation conditions. The results of this model can be used to properly size BMPs to meet specific performance objectives, such as reducing runoff volume or increasing groundwater recharge, and for analyzing the potential impacts of varying the design parameters.
http://dnr.wi.gov/runoff/stormwater/technote.htm

Site Evaluation Tool (SET)
SET was developed by the Upper Neuse River Basin Association and Tetra Tech Inc. to help assess the environmental impacts and costs of a site's stormwater management design. The SET is designed primarily for local government site review planners, professional developers, and stormwater engineers, but it is useful for anyone with an interest in reducing stormwater runoff impacts. The model predicts total annual stormwater volume and total annual TSS, TP and TN, as well as costs associated with each scenario. Although the model was developed for the Upper Neuse River Basin, it is applicable to the entire Piedmont region. The model includes a wide range of green infrastructure practices, such as green roofs, permeable pavement, ponds, wetlands, rain barrels/cisterns, bioretention, and forest buffers.
http://www.unrba.org/set/index.shtml

Stormwater Management Model (SWMM)
EPA's SWMM is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. SWMM was first developed in 1971, and has since undergone several major upgrades since then. It continues to be widely used throughout the world for planning, analysis and design related to stormwater runoff, combined sewers, sanitary sewers, and other drainage systems in urban areas, with many applications in non-urban areas as well. http://www.epa.gov/ednnrmrl/models/swmm/index.htm

Source Loading and Management Model (SLAMM)
SLAMM was originally developed by USGS to better understand the relationships between sources of urban runoff pollutants and runoff quality. It has been continually expanded since the late 1970s and now includes a wide variety of green infrastructure practices and other pollution controls (infiltration practices, wet detention ponds, porous pavement, street cleaning, catchbasin cleaning, and grass swales). SLAMM is strongly based on actual field observations, with minimal reliance on theoretical processes that have not been adequately documented or confirmed in the field. SLAMM incorporates unique process descriptions to more accurately predict the sources of runoff pollutants and flows for the storms of most interest in stormwater quality analyses. SLAMM calculates mass balances for both particulate and dissolved pollutants and runoff flow volumes for different development characteristics and rainfalls. Its primary capabilities include predicting flow and pollutant discharges that reflect a broad variety of development conditions and the use of many combinations of common urban runoff control practices. http://wi.water.usgs.gov/slamm/

Street Tree Management Tool for Urban forest Managers (STRATUM)
STRATUM is a street tree management and analysis tool developed by the Center for Urban Forest Research for urban forest managers that uses tree inventory data to quantify the dollar value of annual environmental and aesthetic benefits: energy conservation, air quality improvement, CO_2 reduction, stormwater control, and property value increase. STRATUM quantifies the stormwater volume reduction benefits of trees based on canopy interception. It is an easy-to-use, computer-based program that allows any community to conduct and analyze a street tree inventory. Baseline data can be used to effectively manage the resource, develop policy and set priorities. Using a sample or an existing inventory of street trees, this software allows managers to evaluate current benefits, costs, and management needs.
http://www.itreetools.org/street_trees/introduction_step1.shtm

Urban Forest Effects Model (UFORE)
The Urban Forest Effects Model (UFORE) is a computer model that calculates the structure, environmental effects and values of urban forests. The UFORE model was developed by researchers at the USDA Forest Service, Northeastern Research Station in Syracuse, NY. The current version was designed only to incorporate data on urban forest structure and carbon storage, and sequestration. This programs aids in urban forest assessments and sampling, including assessments for exotic pest infestations and urban forest effects on carbon dioxide, the dominant greenhouse gas." One component of the model still under development, UFORE-Hydro, is designed to evaluate at the watershed scale, how changes in impervious surface and tree canopy (and some additional variables) affect 1) the total volume of runoff, 2) the peak

storm event volume and duration of peak, 3) stream baseflow, 4) the total annual pollutant loading and 5) the mean event pollution load. These factors are determined based on the canopy interception, infiltration and evapotranspiration provided by individual trees and forest patches. http://www.ufore.org

Water Balance Model (WBM)

The Water Balance Model (WBM) powered by QUALHYMO is a public domain, on-line decision support and scenario modeling tool for promoting rainwater management and stream health protection through implementation of "green" development practices. The appeal and the strength of the tool is that it is evolving to meet the "needs and wants" of participating agencies. The British Columbia Inter-Governmental Partnership developed the WBM in 2003.
Initially, the WBM was a planning tool that had a site focus. It enabled users to evaluate the effectiveness of source controls --- such as absorbent landscaping, infiltration facilities, green roofs, and rainwater harvesting --- in achieving performance targets for rainwater volume capture and runoff rate control under various combinations of land use, soil and climate conditions.
The WBM has since been integrated with QUALHYMO, a rainfall-runoff simulation tool, to provide drainage engineers with a suite of analytical capabilities, from site to watershed. The over-arching goal in integrating these tools is to help local governments achieve desired urban stream health and environmental protection outcomes at a watershed scale.
http://www.waterbalance.ca/

Watershed Treatment Model (WTM)

Developed by the Center for Watershed Protection, the Watershed Treatment Model (WTM) is a simple spreadsheet model that tracks pollutant sources and the effectiveness of various watershed treatment options in urban and urbanizing watersheds. A wide range of treatment options, including green infrastructure practices, are contained in the WTM (e.g., impervious cover disconnection, riparian buffers, ponds, wetlands, swales and filters). The WTM can be used to develop TMDLs for nutrients or sediment; direct bacteria detective work in urbanized watersheds; determine the effectiveness of watershed education programs; and target the future program in a Phase II community. Specific outputs of the WTM include total loads of sediment, nutrients and bacteria from a given watershed. The WTM is currently being revised to provide estimates of runoff reduction associated with various watershed treatment options.
www.cwp.org

References

Koch, P.R. 2005. A Milwaukee Model for LID Hydrologic Analysis. In *Managing Watersheds for Human and Natural Impacts Part of Engineering, Ecological, and Economic Challenges,* Watershed 2005, Glenn E. Moglen, Editor, July 19–22, 2005 , Williamsburg, Virginia. American Society of Civil Engineers. Reston, VA.

U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS). (1986). *Technical Release 55: Urban Hydrology for Small Watersheds*. *Second Edition.* USDA SCS, Washington, DC.

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