ROCKYMARSH RUN
BASELINE ASSESSMENT
2007 – 2008

Rockymarsh Run Targeted Watershed Project

Meeting Regional Goals through Local Benefits (WV) (2007-0082-007)

THE CONSERVATION FUND

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Trout Unlimited
USGS West Virginia Water Science Center
West Virginia University
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18 December 2008

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Watershed Description

Physical Character

Basin Characteristics

Rockymarsh Run watershed straddles the northern boundary between Berkeley and Jefferson counties of West Virginia (*Map A-1*). The watershed is tributary to the Potomac River, which flows into the Chesapeake Bay. The 16.9-square mile surface drainage basin of Rockymarsh Run is long and narrow, about 9 miles long and 2 miles wide, generally following the geologic strike of the area from SSW to NNE. The gradient of the basin is quite low. Over the 16 miles of flowing water in the watershed, the change in elevation is a mere 215 feet. The stream drops about 50 feet in the upper 3 miles of the headwaters, then once it reaches Billmyer Mill Road it drops about 25 feet per mile until it reaches Scrabble. At Billmyer Mill Road the stream drops 12 feet right after it crosses under the road. Once Rockymarsh Run reaches Scrabble it drops 60 feet for the last mile before it discharges into the Potomac River. This steep drop towards the mouth of the watershed results in an aquatic habitat that is much rockier with fast-flowing water as opposed to the slow moving waters with silty bottoms typifying the remainder of the watershed.

Climate

The climate of the area is temperate with an average annual temperature of 54° and a growing season that runs six months from mid-April through mid-October. Average annual precipitation for the area is 39.4 inches and potential annual evapotranspiration is 28.9 inches leaving a surplus for runoff and recharge of 10.5 inches.

Local climate data is recorded continuously at West Virginia University's Kearneysville Agricultural Experiment station and collection of precipitation and soil temperature data was initiated at the Freshwater Institute on Turner Road in the summer of 2008.

Geology

The entire watershed is characterized by karst topography with its attendant sinkholes, springs, closed depressions, disappearing streams, and complex underground drainage systems (*Map A-2*). Karst is a landscape that is a result of the interplay of water with carbonate-based rocks (such as limestone and dolomite) where the rocks are dissolved by water over millions of years. This process results in a very porous landscape distinguished by a predominantly subsurface drainage system where groundwater velocities and volumes approach those of surface streams. Because recharge water enters the ground directly through open fractures, faults, and bedding planes as well as through karst features such as sinkholes and closed depressions, the system is very vulnerable to contamination since this water receives little to no filtration by soil.

Effectively, a large part of the hydrology of the watershed operates underground. The type of karst in Rockymarsh Run is epikarst, or immature karst. Epikarst is characterized by pinnacles of rock formations lying on their sides that may or may not be exposed, covered by both shallow and deep soils. Mature karst is the bare rock left after all the soil covering that rock is worn away. Thus, geology informs the very nature of Rockymarsh Run as the karst aquifer system provides the primary source of water to its streams.

The watershed is completely underlain by three carbonate formations – Conococheague, Stonehenge, and Rockdale Run. The majority of the watershed is comprised of the Conococheague formation in the eastern two-thirds of the watershed with most of the remainder in the Stonehenge formation. The Rockdale Run formation underlies only a small portion of the watershed in the area west of Gosling Marsh Road along Swan Pond Road. These sedimentary carbonate rocks were formed from sediments deposited in the shallow sea that once covered the area over a 200 million year period starting about 540 million years ago. In fact, there is a relict marine species from that era still found in the area – the Madison Cave Isopod, that now lives in the groundwater, having adapted to living in fresh water. The oldest formation is the Conococheague followed by the Stonehenge, with the youngest being the Rockdale Run formation. Prior to the tectonic activity of the Alleghenian Orogeny, these formations lay on top of each other, everywhere you find Conococheague limestone it was once covered by Stonehenge which was once covered by Rockdale Run. The current landscape of the area was formed by erosion of these rocks that were faulted and folded during the last period of tectonic activity – the Alleghenian Orogeny, when Africa collided with North America. Geologically speaking, the watershed lies within the eastern side of the Massanutten Synclinorium within the Great Valley of the Valley and Ridge geomorphic province.

The Alleghenian Orogeny resulted in a complexly fractured landscape of faults and folds, as is found in the watershed. There are three types of faults found in the watershed: normal, strike-slip, and thrust. Thrust faults are the primary driver for the landscape of the watershed as they represent places where geologic formations were thrust upwards. Strike-slip faults are where a formation was shifted from side to side. Normal faults are where the rock slipped downwards. One major strike-slip fault cuts across both forks of Rockymarsh Run, paralleling Winebrenner's Road, and crossing Rt. 45.

There are three thrust fault zones running along the geologic strike of N 20° E, that divide the watershed into four geologic units. The easternmost thrust fault forms the western edge of a belt mostly comprised Conococheague limestone. This thrust fault appears to be the source of the largest springs in the watershed where this fault crosses the stream channel. The next thrust fault to the west forms another zone of mostly Conococheague limestone with some Stonehenge limestone to the east. The westernmost thrust fault forms a boundary between the Rockdale Run formation to the west and an almost pure section of Stonehenge with some outcrops of Conococheague in the southern section.

There are numerous folds in the form of anticlines and synclines as well as overturned anticlines and synclines. The landscape was truly crushed, flipped, folded, and flipped repeatedly. Most of the folds in the watershed occur in the easternmost Conococheague formation. This structurally and hydraulically complex system of steeply dipping rock formations and the convoluted folding and faulting of anticlines and synclines generally running north and south limit groundwater flow to the east and west except where cross-strike faults and fractures occur.

Another geologic feature prominent in the geology of Rockymarsh Run are fracture traces. These are visible traces of past tectonic activity on the landscape that indicate fracture zones underground. There are two types: Strike and Cross-Strike. Strike fracture traces generally follow the geologic strike of the area while Cross-Strike fracture traces are generally perpendicular to geologic strike. Cross-strike fracture traces are particularly influential in regards to groundwater flow as they allow groundwater to flow through bedding planes. Certain areas of the watershed where fracture traces have been noted are also known to be areas of high water tables, and where ground water sometimes flows out of the ground during extreme wet periods. Springs are often found in close proximity to fracture traces as well.

Awareness of geology in karst landscapes helps from an understanding of the complex nature of karst hydrology. Knowing the locations of thrust faults, cross-strike faults, fracture traces, and overturned folds can provide clues to the location of underground conduits and caverns (areas of high groundwater flow). For instance, overturned folds contain numerous structural complexities and fractures that provide avenues for substantial flow of ground water.

Soils

Character

Soils are classified by series and map units. A soil series is a group of soils grouped together because of their similar parent material, soil chemistry, and physical properties. This classification of soils results in series which perform similarly for the purposes of land use. Map units can be complexes of different soil series or just different variations of the same series, often broken down by slope or texture. A map unit is used in a soil survey to indicate the properties of a soil or soil association at a particular location.

Distribution of soil types across a landscape is strongly driven by parent material e.g. limestone and landscape position, e.g. upland and lowland. Almost all of the soils in the watershed are derived from limestone except the Fairplay and Lappans series. Both of these series are derived from marl. Thus, landscape position is the primary driver of soil distribution in the watershed. Soils in the highest landscape positions often contain exposed rock outcrops, and are typically thinner than those lower in the landscape. Rock outcrop complexes cover about 6 square miles of the watershed, about a third of the total watershed area. Drainage typically improves as you move up the landscape from the lowlands.

The most common soil series in the watershed are Hagerstown, Vertrees, Poplimento, Funkstown, Lappans, Toms, Fairplay, and Duffield (*Map A-3*). There are two other fairly common soil series, Ryder and Opequon, that occur in complexes with Poplimento and Hagerstown. The Hagerstown series covers almost half of the watershed, followed by Vertrees and Poplimento, which all together cover 75% of the watershed. These dominant soil types are all found in upland situations. The most common lowland soil types are Lappans, Toms, and Fairplay. All of the upland soils are well drained, except for Funkstown, which is moderately well drained. Of the lowland soils, only Lappans is well drained, however, Lappans has a high water table and tends to have water ponding during the wet season, causing it to receive a hydric rating, as do Lappans, Toms, and Funkstown. Three other soil series that are found in only small areas of the watershed are also hydric: Combs, Dunning, and Holly. Hydric soils are soils formed under conditions of saturation, flooding, or ponding long enough to develop anaerobic conditions in their upper layers.

Limitations

The rocky nature and flat karst topography of the watershed result in soil limitations that primarily relate to groundwater vulnerability. One of the prime soil limitations in the watershed is for the use of soils to dispose of septic system effluent. Septic systems rely on soil for the treatment and drainage of the wastewater that leaves the tank, thus the capability of the soil is very important in terms of maintaining environmental quality and public health. Furthermore, the soil treats all of the wastewater in Rockymarsh Run watershed. As part of the soil survey process all soils are rated according to their potential uses, such as the disposal of wastewater from septic systems. The ratings for septic systems are based on the properties of the soil that affect public health, construction and maintenance of the system, and absorption of the effluent from the septic tank. Almost a third of the area of the watershed is classified as "very limited", and two-thirds as "moderately limited". A soil that is classified as "moderately limited" for septic systems means that the soil has features that are moderately favorable for use septic systems and the limitations of the soil can be overcome or minimized through special planning or design. This limitation also indicates that fair performance and moderate maintenance can be expected. The classification of "very limited" means that the soil has one or more features that render it unfavorable for use as a septic system. The limitations of these soils cannot generally be surmounted without major soil modification, special design, or costly installation procedures. Systems installed in these soils can expect high maintenance and poor performance. The most common severe limitations are slow percolation, depth to bedrock, rock outcrops, high water table, and flooding.

These very same soil limitations also affect how other land uses such as development and agriculture affect the watershed as the soils all provide limited filtration of the pollutants produced by these land uses before they reach surface or ground water. The other significant soil limitation in the watershed is that of hydric soils. Hydric soils in the lowlands of Rockymarsh Run make up 16% of the watershed area. These soils are best suited for their original use as wetlands. Their close proximity to surface and groundwater renders them very susceptible to pollution.

Ecology

The limestone geology of the watershed forms the foundation for its characteristic ecosystems through its affect on the plant and animal communities that form the basis of these ecosystems. This geology generates the soils high in pH, with abundant calcium and fertility, the cold waters rich with marl, and the caverns of the underground world. Many of the plants and animals in Rockymarsh are adapted to these unique conditions.

Aquatic Ecology

The aquatic ecosystem of Rockymarsh Run is characterized by cold water temperatures and marl. The cold water temperatures are a product of the high proportion of groundwater discharged into Rockymarsh Run, primarily from springs. When acidic rainwater dissolves limestone it produces carbon dioxide as one of the byproducts of the process. While underground, the high carbon dioxide levels keep the water acidic and the limestone, or calcium carbonate, dissolved. Once the groundwater is discharged to the surface, most commonly through a spring, various physical and biological processes decrease the amount of carbon dioxide in the water, causing the dissolved calcium carbonate to precipitate back into solid form. Once the calcium carbonate precipitates, it is called marl. It typically takes a mile or so downstream from a spring for the carbon dioxide to reach low enough levels for marl to begin to form. These stretches of stream appear chalky or milky form all of the marl. The stretches upstream from these areas are very clear.

The large amounts of marl covering the stream bottom limits the amount of aquatic life that Rockymarsh Run can maintain. While some fish species that live in warm water live in Rockymarsh run, most of the fish species that live there prefer cold water. The area around springs includes an abundance of plants, such as watercress, that love the calcium rich waters emerging from these springs.

Groundwater Ecology

The karstification of Rockymarsh's limestone bedrock has created flooded underground caverns that are home to unique communities of subterranean animals. These animals, known as stygobites, are dependent on inputs of food from the surface of the land and are sensitive to groundwater pollution. Changes in groundwater recharge patterns caused by land disturbance can also deprive them of their most important need – water (as well as food). Thus, these animals are the local sentinels of groundwater quality. Because of the inherent lack of access to these communities, not much is known about the types and habits of animals that live underground. What is known is that eastern West Virginia is a biodiversity hotspot for these rare and unusual animals. Because subterranean species suffer from the attitude "out of sight, out of mind" they are often neglected in decisions concerning conservation and land management. The extremely limited distribution of these species in the U.S. has caused them to be listed as species in greatest need of conservation in West Virginia. One of these species, the Madison Cave Isopod, is federally listed as threatened. The Madison Cave Isopod is not currently known to live in the watershed, but has been found nearby. Because of limited access to their habitat, it is very difficult to determine the presence or absence of these species. There are seven species of stygobites that have been found in Berkeley and Jefferson counties.

Terrestrial Ecology

Prior to European settlement, the watershed was dominated by upland forest, with alluvial forest and marshes occurring along the waterways. The climax upland forest community for the watershed is the Ridge and Valley Limestone Oak-Hickory Forest. As can be noted from the name, this forest is an assemblage of trees characteristic to the carbonate rock substrates and calcareous soils of the Valley and Ridge province. While there are mature stands of this forest in the watershed, it is unlikely that any virgin stands remain. Few high-quality occurrences of this community exist and most stands have been disturbed by clearing, cutting, and/or grazing. The fertile soils occupied by this forest type are particularly prone to invasion by exotic plants, whose presence degrades the quality of the stand.

The landscape is characterized by a historic disturbance regime of clearing for agriculture and residential development. This disturbance regime has created avenues for invasion by a multitude of exotic plants such as Tree-of-Heaven, Bush Honeysuckles, Autumn Olive, Multiflora Rose, Wineberry, Garlic Mustard, Japanese Stiltgrass, and Japanese Honeysuckle. Early successional forests of cedar, black locust, and box-elder are found as well throughout the watershed in areas that were previously cleared and then abandoned. In certain areas of the watershed there is natural forest regeneration currently occurring in the riparian zone.

Plant Community Types

- Ridge and Valley Limestone Oak-Hickory Forest
- Piedmont/Mountain Alluvial Forest
- Shenandoah Valley Wet Prairie
- Successional Black Locust Woodland
- Successional Box-Elder Woodland
- Eastern Red-Cedar Woodland

Dominant Woody Plants

Large Trees - Various Oak, Maple, Hickory, and Ash species, Sycamore, Hackberry, Tulip Poplar, Black Walnut, Eastern Red-Cedar

Small Trees and Shrubs - Redbud, Smooth Blackhaw, Dogwood, Paw Paw, and Spicebush

Wetland Ecology

The distinct character of the watershed is captured in its very name - "Rockymarsh". The extensive marshes of Rockymarsh, known locally as marl wetlands or classified as Shenandoah Valley Wet Prairies, are distinguished by the presence of marl loam soils and the unique plant communities associated with these soils. It is thought that these wetlands once extended over almost 700 acres along the floodplain. Today, only 92 acres of these wetlands remain. Some of these lost wetlands were mined for marl while most were either filled in, converted to cropland, or used for pasture. Wetlands that have been used for agriculture might still have the potential to revert to a natural wetland. You can spot these former wetlands by the remnant wetland plants that are still growing there.

Marl is a deposit of calcium carbonate mixed with small amounts of clay and organic matter. Marl deposits in the Great Valley are typically found in wetlands or within shallow basins that originally contained wetlands. These wetlands contain a number of rare species uniquely adapted to the calcium-rich soil. There are 12 species of plants in West Virginia found only in

marl wetlands. Berkeley and Jefferson counties contain the only marl wetlands found in West Virginia. While there are some marl deposits in the watershed upstream from Rt. 45 the majority of them are located downstream from Rt. 45.
Plants commonly found in these wetlands are Bulrushes, Sedges, Joe-Pye Weed, and New York Ironweed. All of the rare species in the watershed are found in wetlands or depend on them for part of their life cycle.

Green Infrastructure
A green infrastructure assessment of Jefferson County was performed in 2006. The purpose of the assessment was to identify the natural resource areas required for sustainability, and to connect these areas together into a green infrastructure network. The resulting network is used to inform land use decisions and to identify opportunities for conservation, enhancement, and restoration of natural resources. The assessment identified core forest and riparian areas along with corridors that connect these areas into a cohesive network. Core forests were those at least 100 acres in size, containing at least 10 acres of interior forest and meeting one of the following criteria: contained mature forest; contained rare or threatened species; overlaid a source water protection area; or overlaid a core groundwater recharge area. Core aquatic areas were created by adding a 100-ft buffer to all streams, floodplains, and wetlands. Corridors 600-ft wide were mapped using across non-developed land uses to connect these cores together.

Core forest in the watershed covers 1,746 acres or 71% of the forest in the entire watershed. Core aquatic areas cover 1,019 acres while corridors connecting these core forest and aquatic areas cover an additional 1,247 acres creating total green infrastructure area of 4,012 acres.

Rare and Threatened Species
All of the rare species found in the watershed either live in wetlands or are dependent on them at some period in their life cycle. There is one reptile, the Wood Turtle, and six plants: Water Horsetail, Floating Pennywort, Baltic Rush, Water Smartweed, Hard-Stemmed Bulrush, and Marsh Skullcap. All of the plants are found in wetlands. The Wood Turtle winters in streams, breeds in wetlands, and spends the rest of the year in wetland or upland habitat. Other rare species besides these have been found in similar habitats in Jefferson County and may live in the watershed but just haven't been discovered yet. Characteristics of the rare species occurring in the watershed can be found in Appendix B.

While there are currently no known federally listed threatened or endangered species in the watershed, the Madison Cave Isopod, a federally threatened species, has been found nearby in Jefferson County and could live in the watershed, given the nature of potential habitat.

Hydrology

<u>Drainage Network</u>

The porous nature of karst landscapes causes most rainfall to percolate directly into the ground water rather than run off across the surface and into a stream. Thus, the surface drainage network of a karst watershed is quite minimal compared to that of a non-karst watershed;

indeed, the upper third of the watershed has almost no surface drainage features and over half of the watershed rarely has flowing water. There are about 9 miles of perennially flowing reaches and about 7 miles of intermittently flowing reaches. During extremely wet years some intermittent reaches may flow year-round.

The drainage network of Rockymarsh Run is comprised of a mainstem along with two perennially flowing tributaries to the mainstem – the East and West Forks. The West Fork does not have any major tributaries, while the East Fork has two intermittently flowing tributaries flowing in from the east. The mainstem has one perennially flowing tributary flowing in from the east – Dark Hollow Branch. All of the major tributaries to the mainstem and the forks are spring-fed. Just below the confluence of Dark Hollow Branch with the mainstem, in an area known as Springdale, there are a number of small spring-fed tributaries flowing into the mainstem from the east and west. There is one sinking stream separated from the rest of the drainage network located west of Rt. 480 and south of Van Clevesville Rd. and originating in the White Rock Farm subdivision. This stream flows only during very wet periods and assessment of groundwater maps indicates that after re-entering the ground the water may flow towards Opequon Creek to the west.

Flow

Factors that affect the amount of rainfall converted to surface runoff include perviousness, soil moisture, and the structure of underground bedrock. The soils and karst topography of the watershed create a very permeable landscape, such that the only time there is any significant surface runoff is when the soil is very moist.

Stream flows in Rockymarsh Run appear to be dominated by groundwater processes as evidenced by precipitation and streamflow relationships. The U.S. Geological Survey (USGS) installed a stream gage at Scrabble in early 2008. While a stage discharge curve has yet to be established, visual observation of the hydrograph seems to indicate that single-event storms and associated surface runoff have a minor impact relative to longer-term precipitation amounts. The minor contribution of surface runoff to streamflow results in the stream rarely ever exceeding its banks. Once a stage-discharge relationship is established an assessment of runoff-recharge relationships can be established.

The watershed of Rockymarsh Run receives a surplus of about 10.5 inches of rainfall per year. As Kozar (1991) estimates that 9 inches of that rainfall enters the groundwater as recharge, that leaves 1.5 inches for the surface runoff component. Expressed as streamflow, these 10.5 inches of water equal 2.6 billion gallons per year discharged into the Potomac River. Flows change from year to year and season to season in response to annual and seasonal rainfall patterns. A typical water year (October-September) starts with the Run flowing at its lowest level (baseflow) with flows gradually increasing until they reach a peak in mid-Spring. Once the growing season starts, water loss from plants and evaporation cause water levels to begin dropping until they reach low flows in September to start the cycle all over again. The descending limb of the flow curve is generally steeper than the rising limb. During the months of June through August water losses from plant growth exceed the amount of precipitation typically received. In September the losses and gains just about cancel each other out. Peak recharge occurs from November through March.

The majority of the groundwater discharged into Rockymarsh Run emerges through springs. There are five major springs in the watershed with year-round flows greater than 100 gallons per minute (gpm). Three of these have flows greater than 1,000 gpm. These are Rock Spring, Spring Hill Spring, and Southwood Spring. Southwood Spring forms the source of the West Fork while Rock Spring forms the source of perennial flow on the East Fork. There are at least seventeen other springs in the watershed ranging from small year-round flows, seasonal flows, and springs that only flow during extreme wet weather. However, some springs that flow only seasonally can produce flows greater than 1,000 gpm. There are also areas (known as turloughs or estavelles) of the watershed that may discharge large amounts of groundwater in a diffuse manner during wet periods, typically in late winter/early spring. One of the more well known turloughs is along the west side of Gosling Marsh Road, north of Rt. 45. During the spring of 2003 large amounts of water flowed out of this area for several months, often covering the road with several inches of water. Most of the major springs are in close proximity to thrust faults, overturned anticlines/synclines, or cross-strike fracture traces. Two of the largest springs fall along the easternmost thrust fault in the watershed.

Without a comprehensive assessment of groundwater inputs during periods of baseflow it is difficult to say how much groundwater input is lost back underground to seepage once it is discharged to the surface. Based on the USGS seepage assessment in the fall of 2007 it appears that large amounts of groundwater are lost downstream from Rock Spring and in the stretch between Billmyer Mill and the confluence of Rockymarsh Run with Dark Hollow Branch (*Appendix C and Map A-4*). It is also difficult to say how much of the water lost through seepage re-emerges downstream, if at all. Water may be lost from the streambed through seepage in the soil or through cracks in the bedrock. Water that is lost may re-emerge farther downstream through other cracks or via springs or seeps.

While bedrock structure makes it very difficult to determine groundwater paths through the area, it is possible to infer recharge areas using ground-water elevations. Using William Hobba's (U.S. Geological Survey) maps of ground-water elevations in Berkeley and Jefferson counties, the ground-water recharge source area for Rockymarsh Run was delineated. The primary ground-water catchment runs from, south of the surface watershed boundary starting around Shenandoah Junction and the Appalachian Fruit Research Station, to the Potomac River upstream from the mouth of Rockymarsh Run (SSE to NNW). Smaller groundwater catchments flow from the southwest corner of the watershed towards Opequon Creek and from the northeast corner of the watershed to the Potomac River downstream from the mouth of Rockymarsh Run.

History

The earliest settlers of the watershed were the Native Americans; in fact, there is one major archaeological site in the watershed as well as another minor one, pointing to early use of the landscape. The earliest Native Americans were the Mound Builders, or Adena people;

members of the Huron tribe and Iroquois Confederacy were also known to inhabit the area, primarily using it in the warmer months for hunting and fishing grounds.

The first white settlers entered the area in the early 1700's, receiving land grants from Lord Fairfax, who inherited an enormous tract of land encompassing large areas of Virginia and West Virginia. The original name of Rockymarsh Run was VanMeter Marsh Run, named after John VanMeter, who once owned 1,786 acres in the vicinity of Billmyer Mill. Besides agriculture, other early livelihoods included quarries, mills, and even a clothing factory known to have been located somewhere along the Run between Rt. 45 and Billmyer Mill Rd. Three mills (Billmyer Mill, Forman's Mill, and Jones Mill) were known to have been located along the Run at Billmyer Mill Rd. and in Scrabble. At the turn of the 18th century, the Liberty Grove School was built near the intersection of Gosling Marsh Rd. and Swan Pond Rd. Another historic school, Edgewood School, is located right at the edge of the watershed on Edgewood School Rd. There was a watercress farm on the East Fork just upstream from Rt. 45 at one time as well. The water control structure for the operation can still be seen from the road. Still standing are the ruins of an 18th century house and a number of 19th century homes remain inhabited. Additionally, there remain a number of stone spring houses dating from the 18th century in the watershed. There are three officially designated historic districts within the watershed (Swan Pond, Scrabble, and Jones Mill Run) as well as two historic sites, Jones Mill and the power plant at Dam 4.

Land Use

<u>Historical</u>

Prior to European settlement, the watershed was primarily forest with large riparian marshes. Early settlers gravitated to the numerous springs both as a water source for agriculture and as an energy source for mills. By the middle of the 20th century most of the forest had been cleared and the primary land use was agriculture. In the last half of the 20th century, land use began to shift as both residential development and forest acreages increased tenfold. This conversion of agricultural land to residential land use and forest resulted in a loss of about half of the farmland that existed in the middle of the 20th century (*Tables 1&2*). The factors involved in this reversion of agricultural land to forest were worsening profit margins for farmers and the subsequent shift of agricultural production to other areas of the country and overseas.

Table 1. Land Use ca. 1950

Land Use	Acres	Percent
Forest	271.3	2.5%
Residential	179.5	1.7%
Agriculture	10,386.2	95.8%

<u>Contemporary</u>

Unused farmland continues to revert to grassland and forest in various stages of maturity, although some parcels reverting to forest are still in use as pasture. Of the roughly 300 acres of forest found in the watershed back in the 1950's about two-thirds of that still remains. As this represents ecologically important mature forest, it should be a high priority for conservation. While the watershed remains yet relatively rural with almost half the land use comprised of agricultural uses, the incorporated areas of Shepherdstown and Martinsburg are slowly encroaching from the east and west. Other than agricultural uses, 22% of the watershed is developed and 23% is under forest use (*Table 2*, *Map A-5*). In terms of land cover, forest covers 51% of the watershed (*Map A-6*). While "land use" is a description of how people use the land, in other words – how land is used socially and economically; "land cover" is what actually covers the land. Land covers include asphalt, trees, grass, etc.

Table 2. 2007 Land Use

Land Use	Acres	Percent
Open Water/Wetland	119.9	1.1%
Forest	2,527.0	23.6%
Residential, Rural	1,030.4	9.6%
Residential, Low Density	610.5	5.7%
Residential, Medium Density	558.1	5.2%
Residential	**2,199.0**	**20.5%**
Pasture	1,056.1	9.9%
Grassland/Hay	3,132.0	29.2%
Cropland	969.0	9.0%
Orchard	472.5	4.4%
Agriculture	**5,629.6**	**52.5%**
Commercial	8.0	0.1%
Barren	128.0	1.2%
Transportation	225.5	2.1%

Ownership Trends

There are still a substantial number of large tracts of farmland in the watershed, but over time, these tracts are gradually trading hands from a population of aging farmers to developers and speculators. There are currently two conservation easements totaling 147 acres found in the watershed and this number will likely grow over time. Both of these parcels are located along Rockymarsh Run.

Buildout Analysis

All undeveloped parcels both within and contiguous (those that straddle the boundary) to the watershed were identified and potential lot yields calculated based on zoning and subdivision guidelines where appropriate. The undeveloped area of all those parcels is 10,300 acres containing 2,435 potential lots. Within the boundaries of the watershed there are 7,803 undeveloped acres containing 1,563 potential lots. Contiguous to Rockymarsh Run there are 2,692 acres of undeveloped land within the watershed representing 479 potential new homes.

Slightly over 800 acres of land in the watershed is undevelopable floodplain, wetland, or open water. The amount of undeveloped land that has been subdivided and the amount of subdivided land that is in the process of being developed is portrayed in Table 3. The "Subdivided Land" category is a subset of the "Undeveloped Land" category and the "Subdivided Land in Process of Being Developed" category is a subset of the "Subdivided Land" category.

There are currently almost 1,000 homes in the watershed on 2,335 acres, and the total area of the watershed is 10,837 acres. Thus, the average lot size for existing homes is slightly less than 2.5 acres. Lot sizes in the buildout analysis average about 4 acres. This matches the trend in the area towards larger lot subdivisions. When and if all the buildable land in the watershed will be developed is unknown. At historic rates of development (*Figure 1*), the number of homes would double in twenty years. As calculated, there are 413 lots in undeveloped subdivisions in the watershed. At historic rates of development, this pool of available land should be consumed by 2017. The entire pool of undeveloped land could be developed by 2035 at historic rates of development.

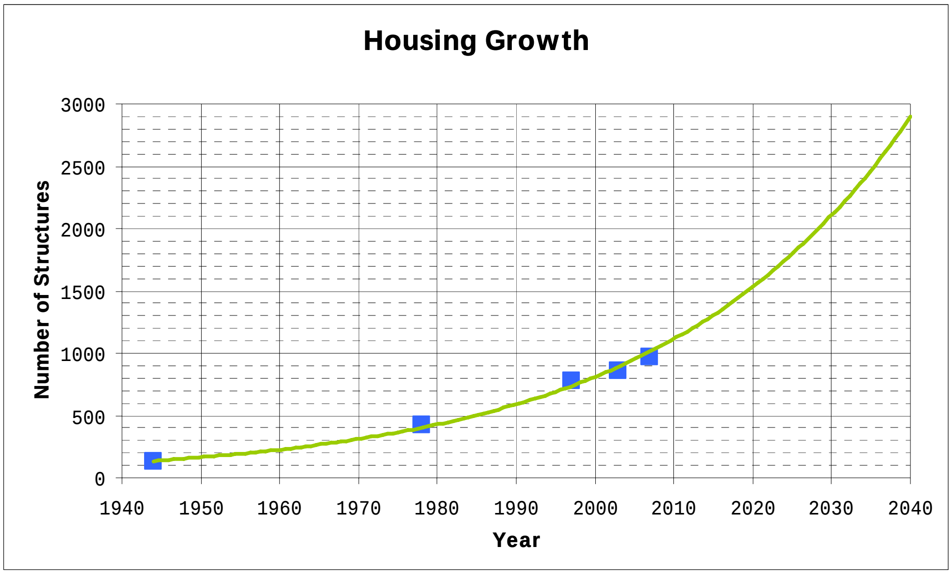
Assumptions Used in Calculation

- The pool of undeveloped parcels was created from all undeveloped parcels larger than 20 acres and undeveloped parcels smaller than 20 acres that have been subdivided. While parcels smaller than 20 acres may be subdivided and developed in the future, the increase in homes would likely be minimal. Most of these smaller parcels already have homes on them.
- In Jefferson County, lot yields were based on standard lot size per zoning designation unless other data was available. Any lots smaller than 10 acres in the Agricultural district were assigned a lot yield of 1. In Berkeley County, which lacks zoning, lot yields were based on the lot yield of one large Berkeley County subdivision in the watershed unless other data was available.
- Undevelopable land was not subtracted from the analysis as there are a number of factors that affect lot yield and because the average lot size resulting from the calculation was significantly higher than the average lot size of existing development.
- A more detailed analysis would include factors such as resource protection areas and open space ratios to develop more exact lot yields. Actual lot yields depend on multiple variables beyond the scope of this analysis.

Table 3. Proportion of Undeveloped Subdivided Land and Status

	Contiguous to Watershed		Within Watershed	
Category	Acres	Lots	Acres	Lots
Undeveloped Land	10,300	2,435	7,803	1,563
Subdivided Land	1,306	816	1,032	413
Subdivided Land in Process of Being Developed	347	77	347	77

Figure 1. Historical and Projected Housing Growth



Demographics

The watershed, located between the growth centers of Shepherdstown and Martinsburg, straddles the border between the West Virginia counties of Berkeley and Jefferson (*Map A-1*). The watershed is located within the Baltimore-Washington Metropolitan Statistical Area as well. Population in the watershed has grown from an agricultural landscape of several hundred people to about 2,500 persons currently. If current growth trends continue, over 5,000 people may live in the watershed by 2030 (based on 2000 census data – persons per household).

There are two unincorporated communities and a number of subdivisions located in the watershed. The communities, Kearneysville (pop. 250) and Scrabble (pop. 49) are located at the south and north ends of the watershed, respectively (*Map A-1*). In historic times, Scrabble was known as Hard Scrabble. There are twenty four subdivisions in the watershed ranging from small to mid-sized (*Map A-7*). Most of these have been fully built out, but a few are still in the process of development. Almost 1,000 acres in the watershed are slated for development in the near future.

Subdivisions

Leisure Acres
Dark Hollow
Horner
Mecklenburg Heights
The Crofts
Whisper Knoll
Rock Spring Acres
Heatherfield
Springs at Shepherdstown
Deerfield Village

Willow Spring Acres	Muzzey
Persimmon Knoll	Hillcrest
White Rock Farm	Amblers Glen
Shenandoah Farms	Fox Glen
Cozy Retreat	

Watershed Functions

The basic components of a watershed are surface and ground water, wetlands, and uplands. These components interact with one another to create a system of hydrological and ecological functions. The primary driving forces of watershed function in Rockymarsh Run are geology and climate. Rockymarsh Run watershed functions hydrologically by collecting water underground and slowly discharging it through a flat landscape that retains water in marshes and other low lying areas in the riparian zone. The watershed functions ecologically by providing unique wetland, cold-water, and subterranean habitats. To develop a watershed management plan, an understanding of the context of these functions must be determined by assessing the current state of the functions, developing a plan to restore those that are impaired and sustain those that are not.

Hydrological Functions

A watershed functions hydrologically by collecting, storing, and discharging water. Topography, climate, and ambient moisture conditions regulate collection functions. A watershed performs collection by channeling precipitation along the surface until it either percolates into the ground or reaches a stream. Rockymarsh Run is very efficient at collecting water and transmitting it underground. Very little precipitation enters the stream as surface runoff, reflected in the relatively simple surface drainage network of the watershed. A watershed with more surface runoff has many more branches in the "tree" that represents its drainage network. Collection processes are also affected by ambient conditions prior to a precipitation event; during very wet periods, there may be significantly more surface runoff.

The storage function of watershed can best be thought of as how it retains water. It is basically an issue on how long a rain drop takes to reach the mouth of the watershed after it hits the ground. Watershed storage is provided by soil, streams, vegetation, wetlands, and aquifers. In watersheds where surface runoff predominates, there is not as much storage as in watersheds where groundwater recharge dominates, like Rockymarsh Run. The karst topography of the watershed allows large amounts of water to be stored for long periods of time. Some water may stay in the ground for as long as 50 years before it is discharged to the surface. Thus, long retention times are the natural state of the watershed, providing slow and steady flows of cold water. Ambient moisture conditions also affect storage; during very wet periods, the storage system is already full, so more of the precipitation that occurs during that time leaves the watershed as surface runoff.

The final hydrologic function of a watershed is discharge. How much and how fast water gets discharged out of the watershed depends on the collection and storage functions. A watershed that has a collection system that is predominantly on the surface and possessing little aquifer storage tends to have a wider range of flows than one such as Rockymarsh Run. The efficient collection of water and storage in the aquifer cause Rockymarsh Run to have steady year-round flows with little variation. The cold water of Rockymarsh Run is also a manifestation of this slow and steady discharge pattern as the long residence time of the water underground allows it to cool down to a temperature of about 50° F. Streams with more surface runoff are generally warmer that those dominated by groundwater flows.

All three of the hydrologic functions in Rockymarsh are affected by ambient moisture conditions. As the soil becomes more saturated with water and groundwater levels rise collection, storage, and discharge are all affected. Permeability increases in the underground karst of Rockymarsh Run as you get closer to the surface. Thus, during drier periods of the year, groundwater travels relatively slowly. However, as groundwater levels rise up into more permeable zones, it starts to move faster through the more fractured epikarst layer than it does through deeper, less permeable formations. High groundwater levels also make it harder for water to percolate underground, causing water to back up in the system and resulting in localized areas of ponded water.

Ecological Functions

A watershed functions ecologically by providing habitat and pathways for chemical and biological processes, an expression of the interaction between water and life. The aquatic habitat of Rockymarsh is characterized by cold water with an abundance of carbon dioxide with little erosive energy, resulting in a very marshy and silty habitat. Biogeochemical cycling processes occur through the natural weathering of rock and soil, and through plant growth. In a natural undisturbed watershed, nutrients are released and absorbed continuously in a cycle of equilibrium. When humans enter the picture, some of these processes are disturbed through land use practices and confounded by the importation of nutrients into the watershed in the form of human foods and fertilizers. This loss of natural assimilative function and the import of nutrients impair the ability of the ecosystem to process them, as a watershed has a finite capacity for assimilating nutrients. One of the primary tools in watershed management is using ecological processes to mitigate these disturbances or stresses. One such tool is the riparian buffer, a strip of natural vegetation along the stream.

Rockymarsh Run and its associated riparian buffer zone (the strip of land that runs alongside a stream) are part and parcel in terms of ecology. The stream defines the riparian zone and the riparian zone sustains the stream. The riparian zone is a crucial interface between the land and water. The critical habitat of the riparian zone is vital to the health of a variety of plants, animals, and fish. Indeed, riparian zones are often the only habitat suitable for some plants, reptiles (such as the rare Wood Turtle), and amphibians that need moist conditions to live and reproduce. A forested riparian corridor is particularly important for a small stream like Rockymarsh Run; in that it provides everything (except water) the Run needs to maintain a healthy aquatic community.

A healthy riparian zone in this region should be wooded. Trees provide numerous ecological services such as shade that keeps the Run cool; stream habitat in the form of large debris; food for the animals and insects that Brook Trout and other denizens of the Run prey upon; roots to keep the stream banks in place; absorption of nutrients from upland runoff; and absorption of floodwaters. Continuous riparian corridors are also important travel routes for birds and animals.

In its natural, fully functioning state, Rockymarsh Run sustained a thriving cold-water fishery for our native Brook Trout. While there were other contributing factors (such as historical overfishing) that led to the extirpation of Brook Trout, the removal of trees from the riparian corridor has probably been the major cause of the current state of dysfunction. Looking forward, changes in land use may significantly impair the collection and filtration capacity of the watershed as well as its ability to continue producing cold, clear water.

The primary historical changes that affected watershed functions were land clearing for agriculture (vegetation loss) and agriculture production (topsoil/organic matter loss). These changes caused stream temperatures to increase, aquatic productivity to decline, and increased sedimentation.

The watershed and its attendant functions continue to be in flux. Natural regeneration of forests and improved agricultural practices are working for the benefit of Rockymarsh Run while development is creating a landscape less pervious and counteracting natural regeneration of forests. Soil disturbance during the construction and development process, mass grading and topsoil removal in particular, can cause negative impacts on groundwater recharge processes. All told, these changes may exacerbate current warm water temperatures and low stream productivity, as well as reduce cold groundwater inflows by causing a shift to hydrologic functions more dominated by surface runoff.

Critical Functions for Sustaining Designated Uses

Cold Water Aquatic Community
Hydrological Collection
Ecological Habitat

Clean Drinking Water
Hydrological Collection
Ecological Filtration

Maintaining the natural groundwater dominated hydrologic functions of the watershed requires preservation of natural drainage and recharge patterns, while maintaining the natural ecological functions requires restoration and maintenance of riparian forests. Retaining the natural filtration afforded by upland and riparian vegetation as well as maintaining existing groundwater recharge patterns will also serve to sustain our supply of clean drinking water. Maintaining these functions will ensure a continued flow of cold, clean spring water and a healthy productive aquatic community. In summary, the primary stressors to these functions are increases in imperviousness; loss of vegetation, habitat and wetlands; and excess nutrients and sediment.

Watershed Management Context

The federal Clean Water Act Section 303d requires states to develop lists of water bodies that do not meet water quality standards and submit these lists to the U.S. Environmental Protection Agency (USEPA) every two years. Once a water body is listed as impaired, the state must then develop a plan or "Total Maximum Daily Load" (TMDL) for removing that impairment. The TMDL outlines the total maximum daily amount of pollution that can be discharged to a water body and yet still allow it to meet its designated uses. Under Section 305b of the Clean Water Act, states are required to develop an inventory of the water quality of all water bodies and submit a report to the USEPA every two years detailing the status or condition of these water bodies. Every water body in the United States has "designated uses". These are the uses that a water body must be able to provide to users of that water body. One such designation is that a waterbody be "fishable/swimmable". A water body that has been designated as fishable/swimmable must have fish to fish for and be swimmable without swimmers getting ill.

The Clean Water Act also establishes an obligation on upstream water bodies to prevent them from impairing downstream water bodies. In the case of the Chesapeake Bay, the Bay is not meeting its designated uses because of pollution occurring upstream from the Bay. Thus, upstream jurisdictions, including West Virginia, have been encouraged to reduce the nutrients and sediments that are impairing the Chesapeake Bay.

As part of the Chesapeake Bay 2000 Agreement, all of the jurisdictions in the Bay watershed decided on equitable method for allocating load reduction responsibilities among themselves. This process resulted in cap load allocations for each jurisdiction in the Chesapeake Bay watershed. A cap load is the maximum load of nitrogen, phosphorus, and sediment that the Chesapeake Bay can assimilate and still meet its designated uses. To meet its cap load allocation, West Virginia and the other Bay jurisdictions developed Tributary Strategies. As part of West Virginia's strategy, the state developed a watershed priority list that ranks all of the watersheds in the Potomac basin in terms of importance for priority implementation efforts. The 10-digit watershed that contains Rockymarsh Run was ranked fourth on that list.

Hydrologic units are used by state and federal authorities as a nested classification system based on hydrologic order from the smallest catchment measured in acres up to basins covering thousands of square miles. While the definition of a watershed is all of the area upstream from a point that drains to that point, "hydrologic units" do not always meet that criteria, although their boundaries are always based on topographic drainage. Hydrologic units are more of a management unit than a physical phenomenon. Hydrologic units are coded in pairs of numbers, thus there are 2, 4, 6, 8, 10, 12, and 14 digit watersheds. The more digits there are in a hydrologic unit code the smaller the watershed.

The Rockymarsh Run watershed (12-digit Hydrologic Unit (HU) 020700041201) is located in the Eastern Panhandle of West Virginia, within the Rockymarsh Run-Potomac River Hydrologic Unit 0207000412, which is within the Conococheague-Opequon Hydrologic Unit 02070004, which is within the Potomac River watershed Hydrologic Unit 0207, within in the Mid-Atlantic hydrologic region Hydrologic Unit 02. The Potomac River drains into the Chesapeake Bay, an estuary of the Atlantic Ocean.

For management purposes the 12-digit hydrologic unit of Rockymarsh Run has been subdivided further into three 14-digit subwatersheds; Mainstem, West Fork, and East Fork. Each of these subwatersheds has been subdivided further into 16-digit catchments.

Designations used by the West Virginia Department of Environmental Protection

Stream Code WVP-3
Hydrologic Unit 0207004.370
WV Watershed Management Framework Hydrologic Group C

Developed as a coordinated framework for TMDL development and watershed planning, the West Virginia Watershed Management Framework is a five-year cycle that sets the schedule for water quality monitoring, TMDL development, NPDES permit renewals, and watershed prioritization. All of the watersheds in the state are grouped into five hydrologic groups and each of the five hydrologic groups is on a rotating five-year cycle. Listed as impaired in 2006, Rockymarsh Run is slated for development of a TMDL in 2021. Prior to 2021, the WVDEP will perform a detailed assessment of the watershed and then develop a TMDL for the watershed.

Designated Uses and Impairments

Aquatic Life

Trout Water

Rockymarsh Run's designated use as a "Trout Water" was listed as impaired for its entire length in the 2006 WV 303(d) listing. The criterion for listing was "CNA-biological" and the source of the impairment was listed as "unknown". "CNA" stands for "Conditions Not Allowable" and refers to conditions not allowable in state waters; in this instance conditions that adversely alter the biological component of Rockymarsh Run's aquatic ecosystem. The justification for the impairment is the Stream Condition Index (SCI) data collected in Rockymarsh Run in 2003 by the WVDEP. At that time the SCI value was 41.3; all streams with values less than 60.6 are considered impaired. Data collected by the ICPRB in 2006 reflected a SCI that was still below this limit but somewhat higher than in 2003. The SCI is a relative value and requires a reference stream in order to be interpreted correctly. According to Dave Montali (WVDEP, per. comm.) the SCI for Rockymarsh Run may actually be normal for the low gradient karst stream that it is. A low SCI score means that the stream is impaired in its ability to support aquatic life because it lacks a sufficient base for a food chain. Thus, as Rockymarsh is a state listed Trout Water this low SCI score indicates that it cannot support a reproducing trout population.

While Rockymarsh Run may or may not be biologically impaired it certainly is limited in its ability to support a thriving aquatic food chain. Improving that food chain is a goal. Increased riparian tree cover will both filter out nutrients as well provide carbon sources for denitrification.

Human Health

Water (Primary) Contact Recreation
Drinking Water Supply

Although not currently listed as impaired for Human Health uses, recent water quality data collected in Rockymarsh Run indicate the possibility of impairment since the majority of samples collected in 2007 – 2008 exceed the maximum daily fecal coliform limit of 400 colonies per 100 mL. Data collected by the WVDEP in 2003 show fecal coliform levels of 200 colonies/100 mL.

Baseline Condition

Water Quality

Very little historic water quality data exists for Rockymarsh Run, however, extensive water quality monitoring was initiated in 2007 and watershed-wide biological data was collected during the spring of 2008. Known historic samples have been collected by the WVDEP, ICPRB, and USGS (*Appendix D & E*).

Water quality data was collected throughout the watershed in the fall of 2007 and 2008 (*Appendix C*) and has been collected monthly at the USGS stream gage site in Scrabble since May of 2008 (*Map A-4*). Using recharge estimates developed by Kozar (1991), Rockymarsh Run discharges about 2,562,000,000 gallons per year. Using this discharge data and water quality data collected at the stream gage site it is estimated that the average annual pollutant load generated by Rockymarsh Run is 53,150 pounds of nitrogen, 1,853 pounds of phosphorus, and 264 tons of sediment. The actual amount of nutrients and sediment discharged could be quite higher as these numbers do not reflect discharges during storm events when much higher levels of nutrients and sediment may be discharged.

Table 4. Contemporary Water Quality Data Collected at Scrabble (Site 731_126)

Date	Stream Gage Ht. (ft)	Discharge (cfs)	Water Temp. (°C)	Fecal Coliform (col/100 mL)	Total Nitrogen (mg/L as N)	Total Phosphorus (mg/L as P)	Total Suspended Solids (mg/L)
10/31/07	n/d	4.97	8.3	709	2.10	0.13	n/d
05/20/08	1.54	n/a	12.2	1040	2.21	0.18	53
06/24/08	0.90	n/a	14.6	600	2.40	0.06	25
07/30/08	0.87	n/a	16.1	174	2.80	2.56	32
08/26/08	0.81	n/a	15.1	182	2.94	0.04	28
09/23/08	0.79	n/a	14.8	228	2.65	0.08	9
10/29/08	0.76	5.96	7.9	206	2.31	0.03	1
Average	**n/a**	**n/a**	**12.7**	**351**	**2.49**	**0.44**	**24.7**

Temperature

Baseline temperature monitoring was initiated at 10 sites throughout the watershed in September 2007 (*Map A-4*). The threshold for water temperature necessary to sustain Brook Trout populations is 22° C. Although 2008 average air temperatures were higher than normal in June, the months of the year that are normally hottest, July and August, both experienced below normal average air temperatures. In 2008, average water temperatures in the West Fork were well above any other areas in the watershed. A heat wave in early June 2008 caused waters in the West Fork to exceed the temperature threshold for about a week, and later that June the uppermost temperature station logged seven-day daily maximum temperatures above the threshold through July. The other station on the West Fork also logged temperatures above the threshold for short periods several times during this interval and at one point remained continuously above the threshold for a period lasting almost two weeks. Seven-day daily maximum temperatures at all other stations remained below the threshold all summer. At this time, it appears the lower section of Rockymarsh Run from its confluence with Dark Hollow Branch down to Scrabble remains the coldest stretch (*Appendix F*).

Stream Biology

Macroinvertebrates

A watershed-wide assessment of benthic macroinvertebrate assemblages was conducted in spring 2008 at 15 sites (*Appendix G*). Based on the macroinvertebrate taxa identified for each sample, West Virginia Stream Condition Index (WVSCI) scores were calculated for each site. The index ranges from 0-100, with lower scores associated with poorer ecological conditions, as an abundance of macroinvertebrates is necessary to support a diverse and healthy fish population. WVSCI scores for Rockymarsh Run ranged from 19 to 41, with a mean score of 32. The average scores for the East Fork, West Fork, South Mainstem, and North Mainstem were 26.3, 36.7, 34.5, and 28.3, respectively. Any score less than 60.6 is considered by WVDEP to indicate a stream that is impaired in its ability to support aquatic life. Other macroinvertebrate samples collected in 2003 and 2006 resulted in higher scores but were still below the threshold of impairment (*Appendix D*). Both of these previous samples were from only one or two sites and were collected in late summer, rendering comparison difficult.

Given the lack of an adequate reference stream, (another low-gradient, karst stream known to be of high quality) it is difficult to determine with certainty whether the low SCI scores are an indication of impairment or just what should be expected for a stream of this type. However, it is believed that the macroinvertebrate assemblages are natural and are not indicative of either poor habitat or water quality. Further analyses of habitat and water quality will be conducted before reaching a definitive conclusion.

Fish assemblages

Fish species found in Rockymarsh Run include sculpins, darters, dace, suckers, shiners, sunfish, largemouth bass, and common carp among others (*Appendix H*). The West Virginia Division of Natural Resources regularly stocks the stream with non-native Rainbow Trout. Brook Trout were historically native to the watershed but were extirpated in the second half of the 20th century through a combination of overfishing and poor environmental quality.

Habitat

Instream conditions vary according to groundwater (spring) inputs. Stream stretches dominated by groundwater inputs with their high levels of carbon dioxide are clear and possess good stream bottom quality. Other stretches have cloudy water caused by the precipitation of calcium carbonate and this precipitate coats the stream bottom. Thus, instream habitat quality is partly dependent on the level of carbon dioxide in the water. As spring discharges are high in carbon dioxide, the sections of Rockymarsh Run downstream from these discharges are characterized by clear water and open pebbly/rocky substrate. As carbon dioxide diffuses out of the water, calcium carbonate (found in high levels in karst ground waters) begins to precipitate, cloud the water, and settle on the bottom. Materials on the bottom such as pebbles, rocks, and organic debris become coated with this silt and sometimes a hard impenetrable layer of marl, rendering much of the habitat inaccessible to foraging and spawning (for those fish that require that type of habitat).

Stressors

Stressors are the causes of impairments to Rockymarsh Run. Stressors are phenomena that "stress" the natural system, impairing its ability to perform its natural functions and provide services to both animals and humans. The sources of these stresses will be discussed in the next section and a summary table of stressor/source relationships is included at the end of the "Sources" section.

Stressors in Rockymarsh Run Watershed

Stressor	Description
Nutrients	The primary nutrients of concern are nitrogen and phosphorus. While not a major stressor to Rockymarsh they are a major source of impairment to the Chesapeake Bay, to which it is tributary.
Temperature	High stream temperatures are a stressor to the designated use of Rockymarsh Run as a cold-water fishery.
Habitat Alteration	Habitat alteration in the form of tree removal in the riparian zone causes stream temperatures to rise, impairing the cold-water fishery. Riparian forests are also an important base to the aquatic food chain.
Pathogens	Pathogens from pastures and septic tanks impair the "Human Health" designated use of Rockymarsh Run for contact recreation and as a drinking water source for livestock and wildlife.
Flow Alteration	The karst hydrogeologic system of Rockymarsh Run evolved over millennia to the point where it is today. Maintaining this system of groundwater recharge and discharge patterns is important for the maintenance of stream flows and the cold groundwater inputs that are required to sustain a cold-water fishery and drinking water uses. Altering these recharge/discharge patterns will result in flows that are warmer and more variable, thus disrupting the natural hydrology of the watershed. Removal of natural vegetation, soil compaction, and increased impervious surfaces also disrupt natural recharge processes.
Siltation	Rockymarsh Run is characterized by stretches of stream with large groundwater inputs followed by marl-based stretches. Instream precipitation of calcium carbonate (marl) is a natural source of siltation within these marl-based stretches. Spawning habitat and forage are covered by marl making it difficult for aquatic animals to find food and reproduce. Stretches with high groundwater inputs represent the best habitat and should be of highest priority for riparian restoration. The issue is exacerbated in non-shaded stretches where warmer temperatures decrease carbon dioxide solubility, increasing marl precipitation. Siltation from surface erosion is a minor, temporary stressor, primarily arising from site disturbance during residential construction.

Sources

Sources are the physical causes of stressors to Rockymarsh Run that require management in order to meet the goals of the watershed management plan.

<u>Point Sources</u>

The only point source in the watershed is The Conservation Fund's Freshwater Institute. This facility discharges about 0.9 mgd of aquaculture effluent into Dark Hollow Branch, a tributary to Rockymarsh Run. The stressors from this source are nutrients and thermal modification.

Agriculture

Agriculture in the watershed consists of dairy farms, cattle operations, orchards, crops, and horse farms. Stressors associated with agriculture are nutrients, siltation, pathogens, and habitat alteration.

Currently, there are 5,630 acres of agricultural land in the watershed. Over half of this is grassland or hay, almost 19% pasture, and 17% cropland with the remainder in orchards.

Best Management Practices

- Riparian Forest Buffers
- Riparian Grass Buffers
- Wetland Restoration
- Tree Planting
- Stream Restoration
- Nutrient Management
- Enhanced Nutrient Management
- Cover Crops
- Conservation Tillage
- Land Retirement
- Conservation Plans
- Off-Stream Watering w/ Fencing & Rotational Grazing
- Off-Stream Water with Fencing
- Streambank Fencing
- Animal Waste Management
- Horse Paddock Management

Construction

Construction is a temporary source, thus its impact varies from year to year. Stressors associated with construction are siltation, flow alteration, and temperature.

Best Management Practices

- Erosion & Sediment Control
- Low Impact Development

Developed Lands

Urban runoff in Rockymarsh Run comes from residential and commercial lands. Stressors associated with developed lands are nutrients, pathogens, siltation, and temperature.

Currently, there are 2,199 acres of developed land in the watershed, almost half of it is rural residential with 25% in medium density residential and 28% in low density residential. Impervious surfaces cover 1.7% of the watershed (*Map A-8*)

Best Management Practices

Riparian Forest Buffers
Riparian Grass Buffers
Wetland Restoration
Tree Planting
Stream Restoration
Nutrient Management
Stormwater Management

<u>Septic Systems</u>

All of the domestic wastewater in the watershed is treated by septic systems. The stressors associated with septic systems are nutrients and pathogens.

Currently, there are estimated to be 923 septic systems in the watershed.

Best Management Practices

Septic System Pumping
Advanced Treatment Systems
Connection to Centralized Wastewater Treatment

<u>Hydromodification (Upstream Impoundment)</u>

Impoundments are ponds or lakes located directly in the floodway of Rockymarsh Run or adjacent to it. Some of these impoundments are abandoned marl pits. Slow flowing water and lack of shade increase heat absorption and raise stream temperatures.

There are 11 impoundments along Rockymarsh Run, totaling 19.7 acres in surface area.

<u>Habitat Modification</u>

Habitat modification, in this case removal of trees from the riparian corridor results in multiple stressors – temperature, nutrients, and siltation.

Trees have been removed from 65% of the 100-ft wide riparian corridor of Rockymarsh Run.

Best Management Practices

Riparian Forest Buffers

<u>Natural Sources</u>

Natural sources are sources of stressors that are not produced by humans. In this case the primary natural sources are wildlife and groundwater discharges. Wildlife are natural sources of pathogens in the watershed. Groundwater in the form of spring flow is a natural source of silt in the form of precipitated calcium carbonate (marl). Groundwater is both a positive and negative source of stream health. Positive in the form of providing the cold water necessary to sustain native brook trout populations, and negative in the manner that marl precipitation limits the biological capacity of stretches not afforded the beneficial inputs of large quantities of groundwater. Thus, two types of habitat characterize the watershed – groundwater-based and marl-based.

Stressors and Sources

Stressor	Sources
Nutrients	Point Sources, Agriculture, Developed Lands, Septic Systems
Temperature	Point Sources, Habitat Modification, Developed Lands
Habitat Alteration	Habitat Modification
Pathogens	Septic Systems, Agriculture, Natural Sources
Flow Alteration	Developed Lands
Siltation	Agriculture, Construction, Developed Lands, Natural Sources

Management Plan

Introduction

Current Condition

As a karst watershed, Rockymarsh Run is very vulnerable because it possesses unique traits that affect how it responds to changes in land use. While surface drainage processes dominate most watersheds, the higher porosity of a karst watershed creates a predominantly underground drainage system. This karst drainage system functions to promptly absorb water across the landscape, slowly transport it underground where it can cool off, and then release it through cold-water springs. As surface and subsurface karst hydrologic processes are interrelated, changes in surface drainage can affect subsurface drainage and vice versa. Thus, modifying a karst landscape through development may cause changes in the underground drainage system by affecting either the surface drainage patterns or how much water flows into a certain area or both. These changes could subsequently express themselves in the formation of new sinkholes, ponding of runoff, or changes in spring flow.

The main differences between karst and non-karst watersheds are runoff and stream flow characteristics, groundwater vulnerability, and water temperature. The flat and porous karst nature of the watershed absorbs water readily, resulting in very little runoff and fluctuation in stream flow. In contrast, a non-karst watershed has substantially more runoff and wide variations in streamflow, resulting in periodic flooding. The absorptive capacity of karst releases water slowly and consequently, a karst watershed rarely floods along the stream channel and has little variation in depth throughout the year. However, rainfall in a karst watershed does tend to back up on the landscape during very wet periods, causing localized ponding at sites away from the stream.

The porous nature of the underground plumbing of karst and high seasonal water tables render the groundwater very vulnerable because percolating rainwater is not afforded the benefit of extensive soil filtration, as it is in non-karst watersheds. Whereas typical surface drainage processes transport water quickly across the landscape and into receiving streams, karst processes typically absorb water rapidly underground, but the rate at which they can do so depends on seasonal groundwater levels. During wet periods when groundwater levels are high, runoff water tends to back up as the karst system can only handle so much water at a time. The best analogy is that of a partially plugged bathtub drain – when groundwater levels rise high, only so much water can drain at a time, thus, as more water falls as rain, this causes groundwater levels to rise higher and higher, to the point where they pond on the surface in some areas. This causes the groundwater to become very vulnerable to contamination, particularly from septic systems, whose drainfields may be submerged by groundwater during these periods.

Cold-water streams are characterized by a large proportion of their flow being derived from groundwater. Rockymarsh Run maintains these cold-water inputs by efficiently collecting water and transmitting it underground where it re-emerges as cold spring flow. As surface runoff processes begin to increase in dominance as the land is developed, this causes stream temperatures to increase via increased inflows of warm surface runoff and decreased inputs of cold groundwater into the stream.

In terms of current watershed condition, the watershed is rated in excellent condition in regards to watershed-wide impervious cover (1.7%) and forest cover (51%). However, as most of that forest is located away from the stream the watershed is rated as poor in terms of riparian forest cover. Currently, only 34% of the riparian zone is covered by forest, the watershed needs over twice the current amount to receive a good rating – to be rated as excellent would require 77% riparian forest cover. Another factor affecting the condition of the watershed is bacterial contamination from septic tanks and livestock pastures. While not in pristine condition, Rockymarsh Run does function relatively well as a cold-water ecosystem, and with a little restoration could re-attain its ability to sustain Brook Trout. The crucial task is to maintain the natural functions of the watershed in the face of landscape change. Thus, the current state of the watershed is one on the cusp, where we go from here all depends on our stewardship of the watershed.

<u>Threats</u>

The distinctive karst hydrology and aquatic ecosystem of Rockymarsh Run are threatened by increased development and its associated increase in impervious surfaces. Impervious surfaces (roofs, roads, and sidewalks) prevent water from infiltrating into the ground where it normally would, reducing groundwater recharge and disrupting the natural drainage patterns of the watershed. The slow infiltration of rainfall in Rockymarsh Run during wet seasons expresses itself as the ponding of water in certain low-lying areas of the watershed, resulting in hazards to farmers and homeowners. Increasing the impervious cover in the watershed will only worsen the problem. Filling of sinkholes and closed depressions during development exacerbates this problem even further, as the water has no stream network to flow into once the "drain" of the plumbing is closed. Furthermore, changing runoff patterns through mass grading and addition of imperviousness may cause water to infiltrate into the ground in new areas or in greater quantities, causing shifts in underground flow patterns that may result in the development of new sinkholes and changes in spring flow. Finally, development may affect stream ecology by increasing water temperatures and disrupting habitat through higher peak flows. Thus, changes in the landscape will disturb the hydrology, geology, and ecology of the watershed.

The potential consequences of these threats are increased stream temperatures, contaminated groundwater, and increased loads of pollutants. Impervious surfaces cause stream water temperatures to rise via increased surface runoff of warmer water and decreased summertime stream flows. A decrease in summertime stream flow will cause the water to heat up even more. Thus, these changes in hydrology caused by decreases in perviousness exacerbate each other as the increase in runoff of warmer water is intensified by instream warming. Furthermore, increases in peak storm flows in Rockymarsh Run will cause changes in the stream channel, widening it and cutting down the banks. This will increase sediment loads to the Chesapeake Bay and smother aquatic habitat in the stream, impairing the ability of our native brook trout to survive. Finally, population increases will also result in more nutrient pollution from lawn fertilizers and wastewater.

<u>Solutions</u>

The functions we are in danger of losing are the ability to collect slowly rainwater and transform it into cold spring water, slowly discharged – essential for the survival of Brook Trout. The challenge is to retain these functions in the face of a changing landscape. This will require more intense management of the resource as well as restoration to ensure no net loss of watershed function. Sustaining these functions will require higher standards for managing and mitigating human impacts on the watershed.

Management Goals

The Rockymarsh Run Watershed Management Plan seeks to promote and facilitate coordinated, collaborative action to reduce pollutant loads sufficient to meet regional Chesapeake Bay restoration responsibilities while providing local benefits in the form of the restoration of a reproducing population of Brook Trout and allowing for the designated uses of the watershed for recreation and drinking water. Rockymarsh Run is a watershed on the cusp, requiring restorative efforts to meet current water quality goals, and maintenance efforts to maintain these targets in the face of landscape change produced by residential development. This management plan seeks to provide mitigation of multiple stressors through the implementation of practices that provide multiple benefits. Adaptive management will be utilized to focus initial efforts on areas designated as critical, assess progress, and adapt management strategies as necessary.

The primary goal for watershed management in Rockymarsh Run is the reduction of nutrient and sediment loads to meet Chesapeake Bay commitments. Meeting this goal will also serve to achieve the secondary goals of Brook Trout restoration and drinking water protection.

Objectives

Reduce nutrient and sediment loads via increase in riparian forest cover
- Indicator – Percent forest cover in 100-ft riparian zone
  - Current Condition = 34%
  - Target Condition = 50%
- Implementation Goal – Plant 48 acres of riparian forest
  - Nitrogen Load Reduction = dependent on initial land use
  - Phosphorus Load Reduction = dependent on initial land use
  - Sediment Load Reduction = dependent on initial land use

Reduce nutrient loads via pumping of septic tanks
- Indicator – Number of septic tanks pumped on an annual basis
  - Current Condition = 0
  - Target Condition = 375
- Implementation Goal – Pump 375 septic tanks per year
  - Nitrogen Load Reduction = 222 pounds

Prioritization

Riparian Forest Restoration

Priority sites for riparian restoration were chosen based on existing riparian forest cover, landowner willingness, perennial streamflow, and stream temperature data (*Map A-9*).

Septic Tank Pumping

To determine the most effective areas (in terms of water quality improvement) for the implementation of septic system BMP's and index of septic system risk was developed. The index was calculated using building density weighted by building age, soil suitability, proximity to flowing water, and presence of floodplain (*Map A-10*).

APPENDICES

Appendix A – Maps

Appendix B – Rare Species

Appendix C – Annual Water Quality Data

Appendix D – Historical Water Quality Data

Appendix E – Historical Biological Data

Appendix F – Stream Temperature Data

Appendix G – Benthic Assessment

Appendix H – Fish Species

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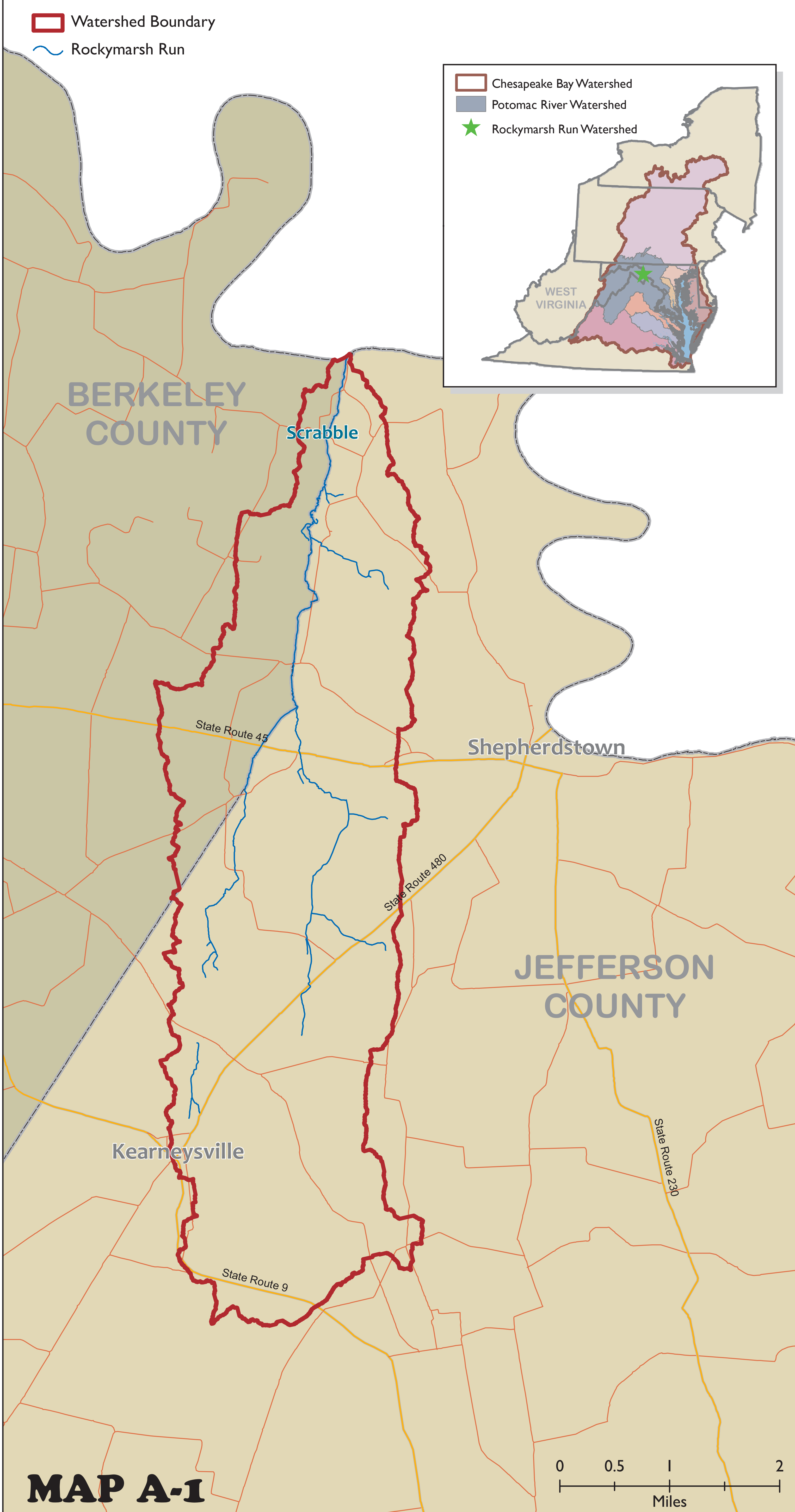
Appendix A – Maps

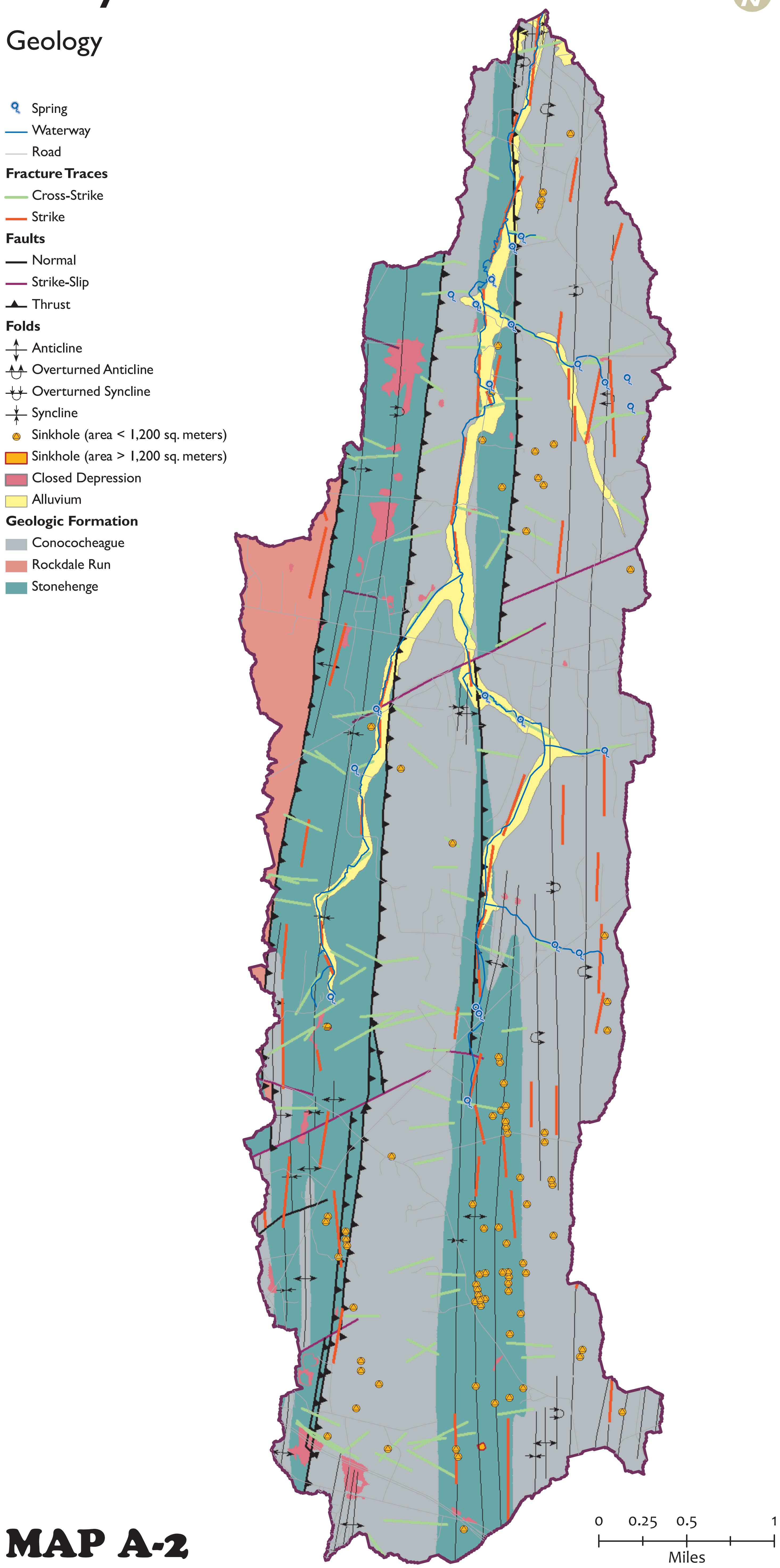
Rockymarsh Run Watershed



MAP A-1

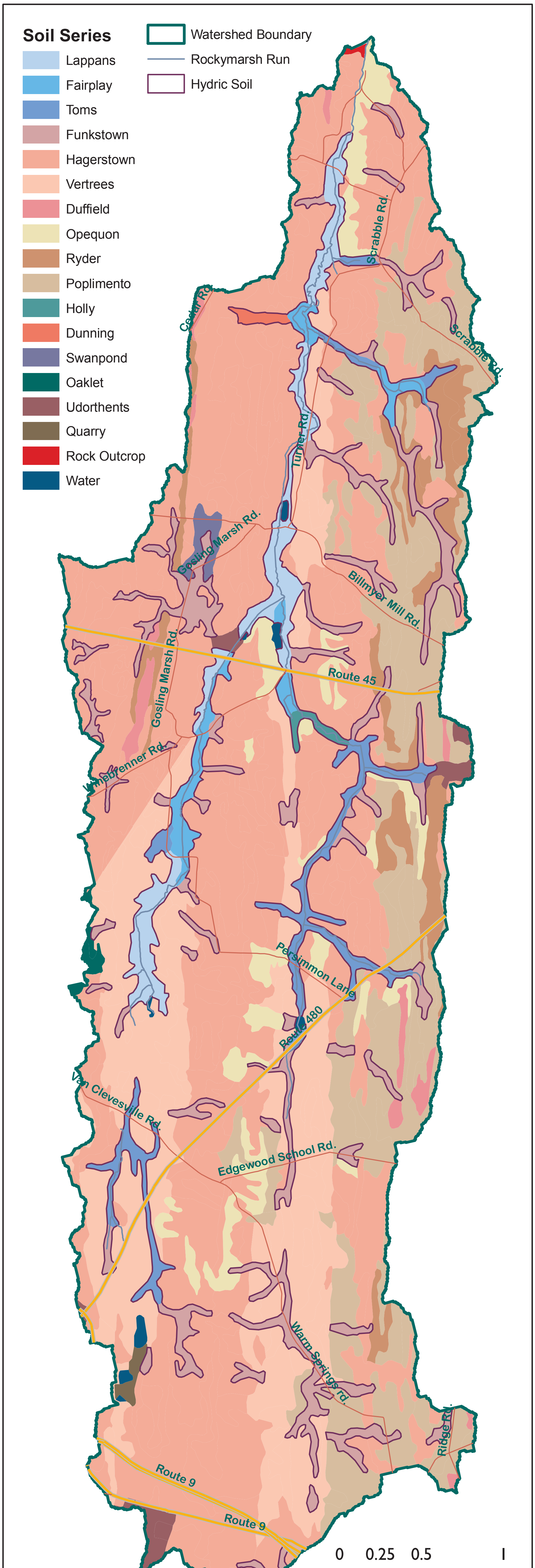
Rockymarsh Run Watershed

Geology

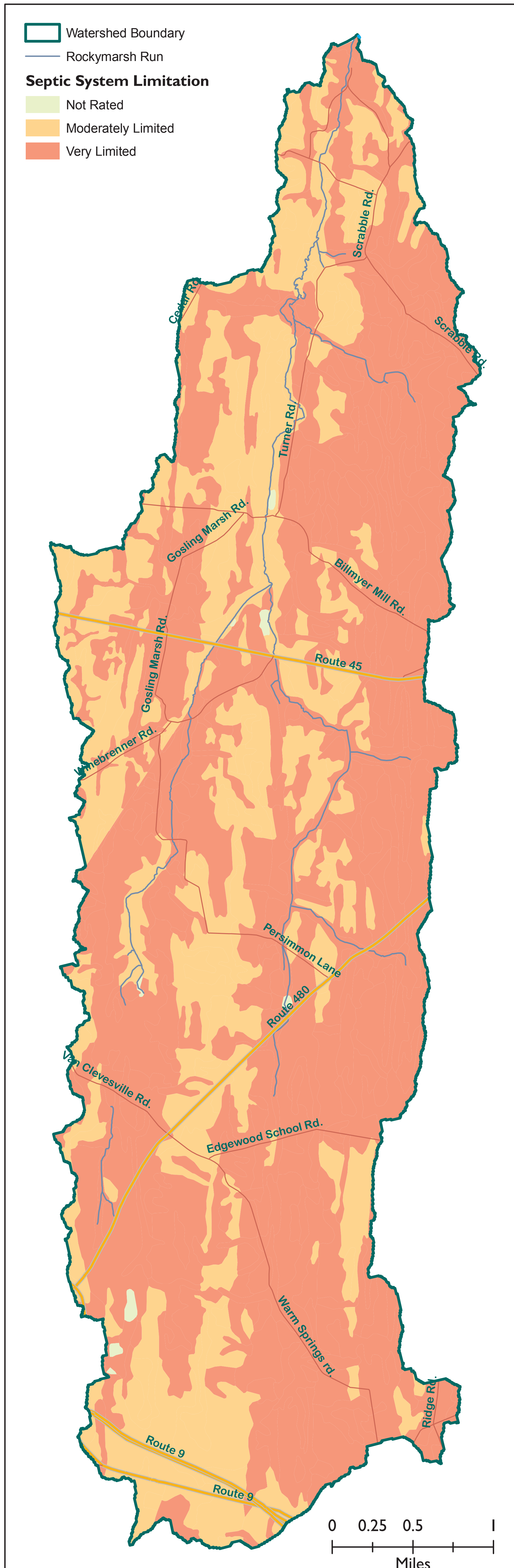


MAP A-2

Soils of Rockymarsh Run Watershed

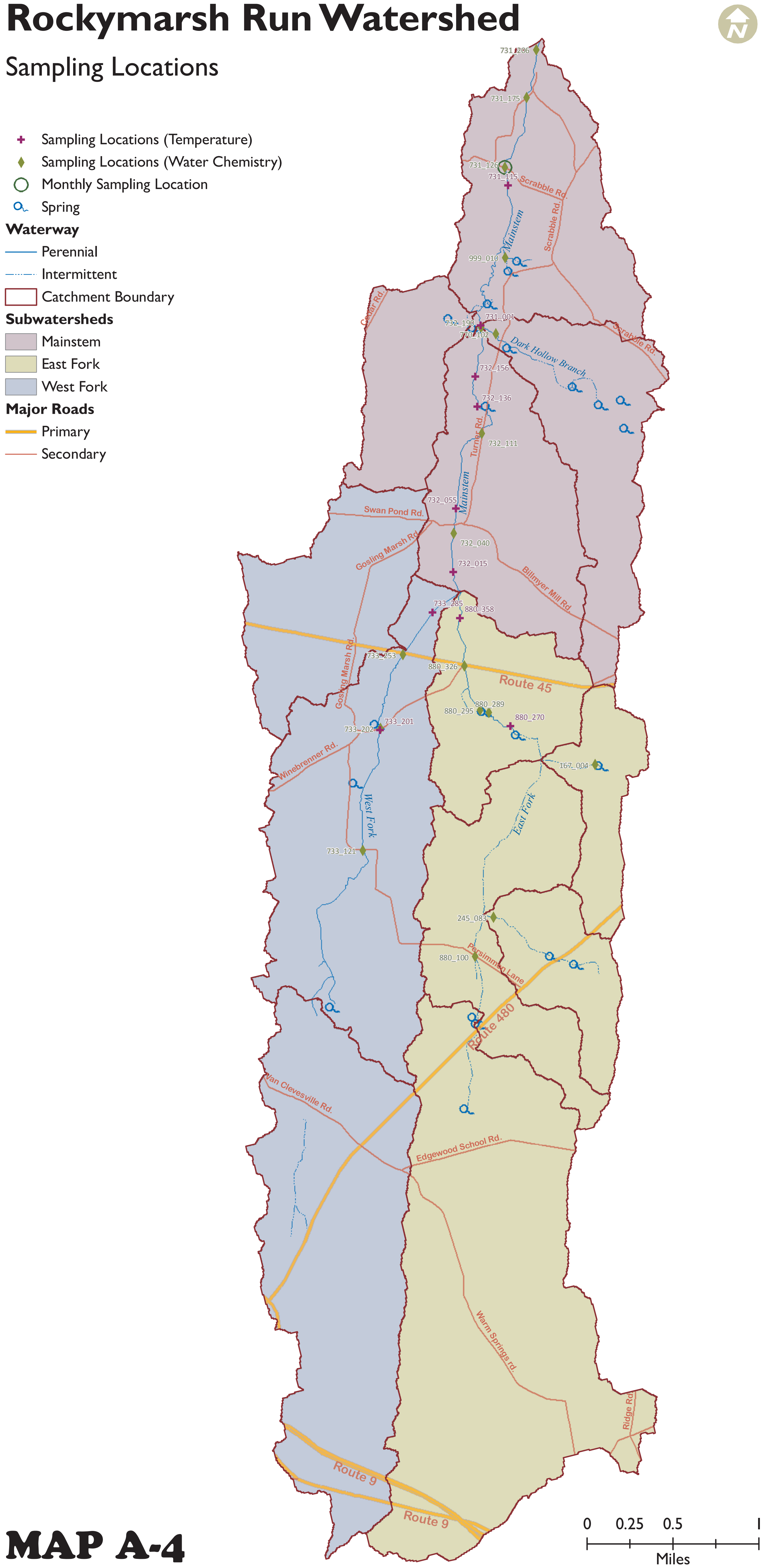


MAP A-3



Rockymarsh Run Watershed

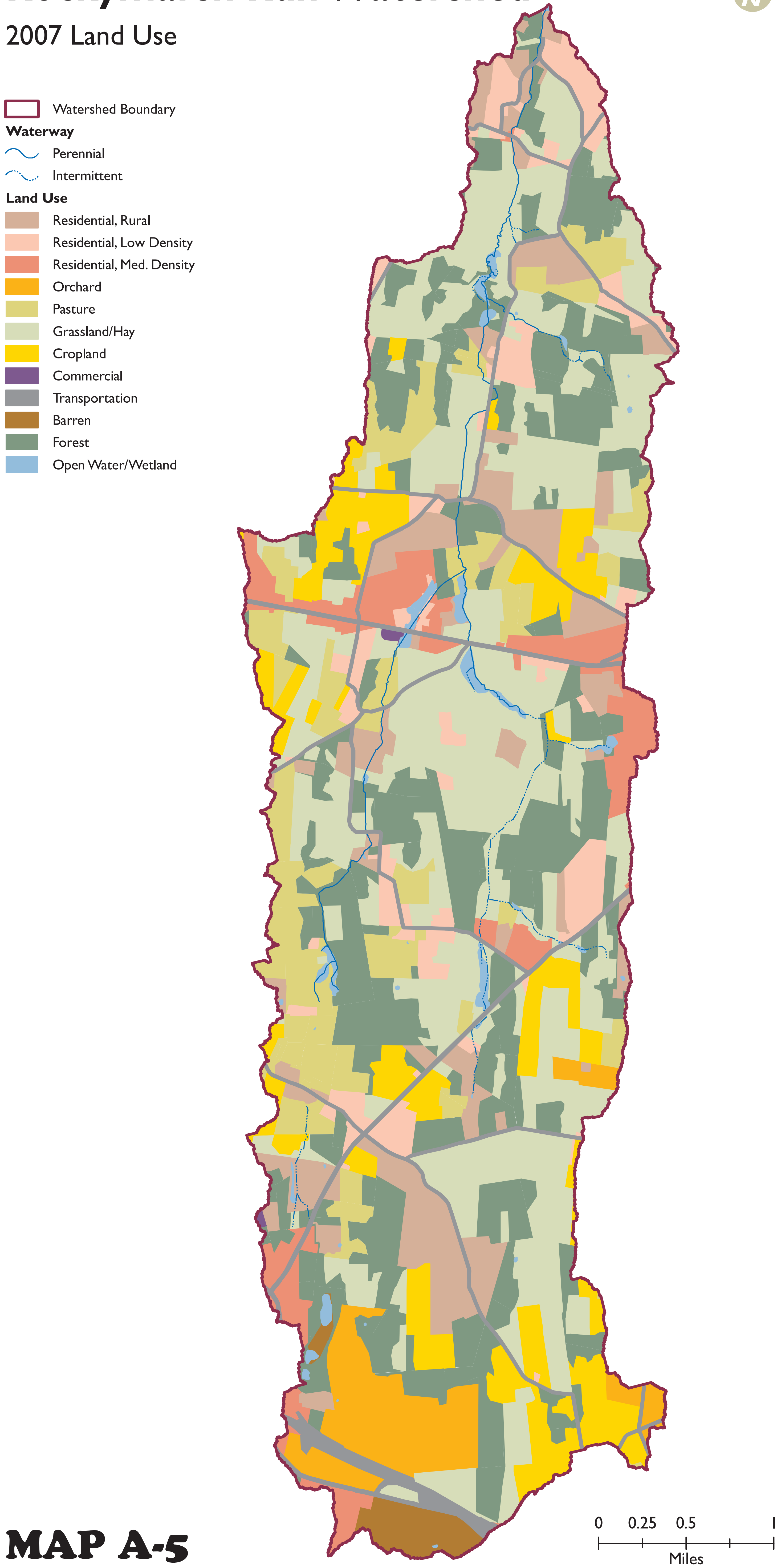
Sampling Locations



MAP A-4

Rockymarsh Run Watershed

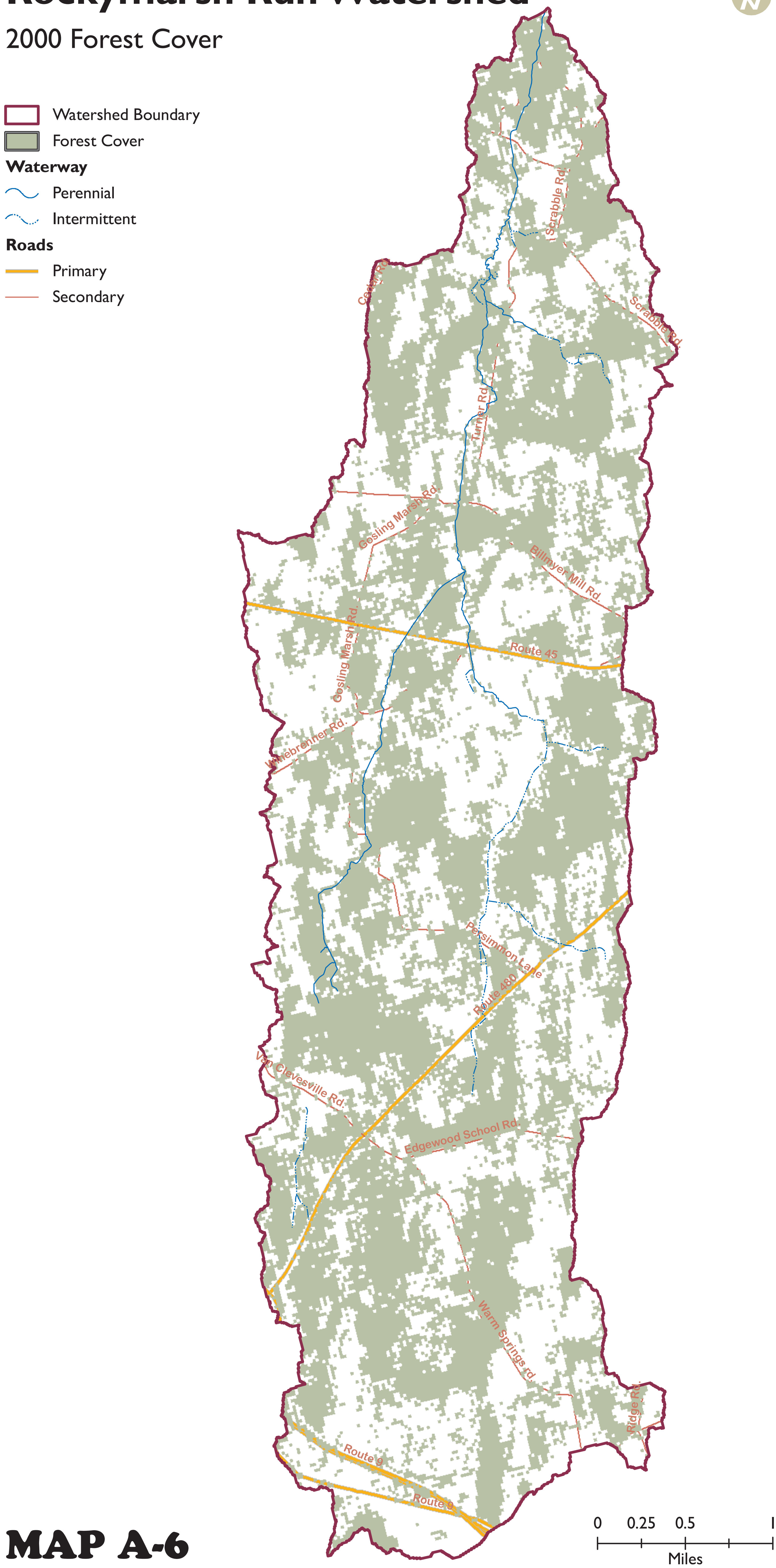
2007 Land Use



MAP A-5

Rockymarsh Run Watershed

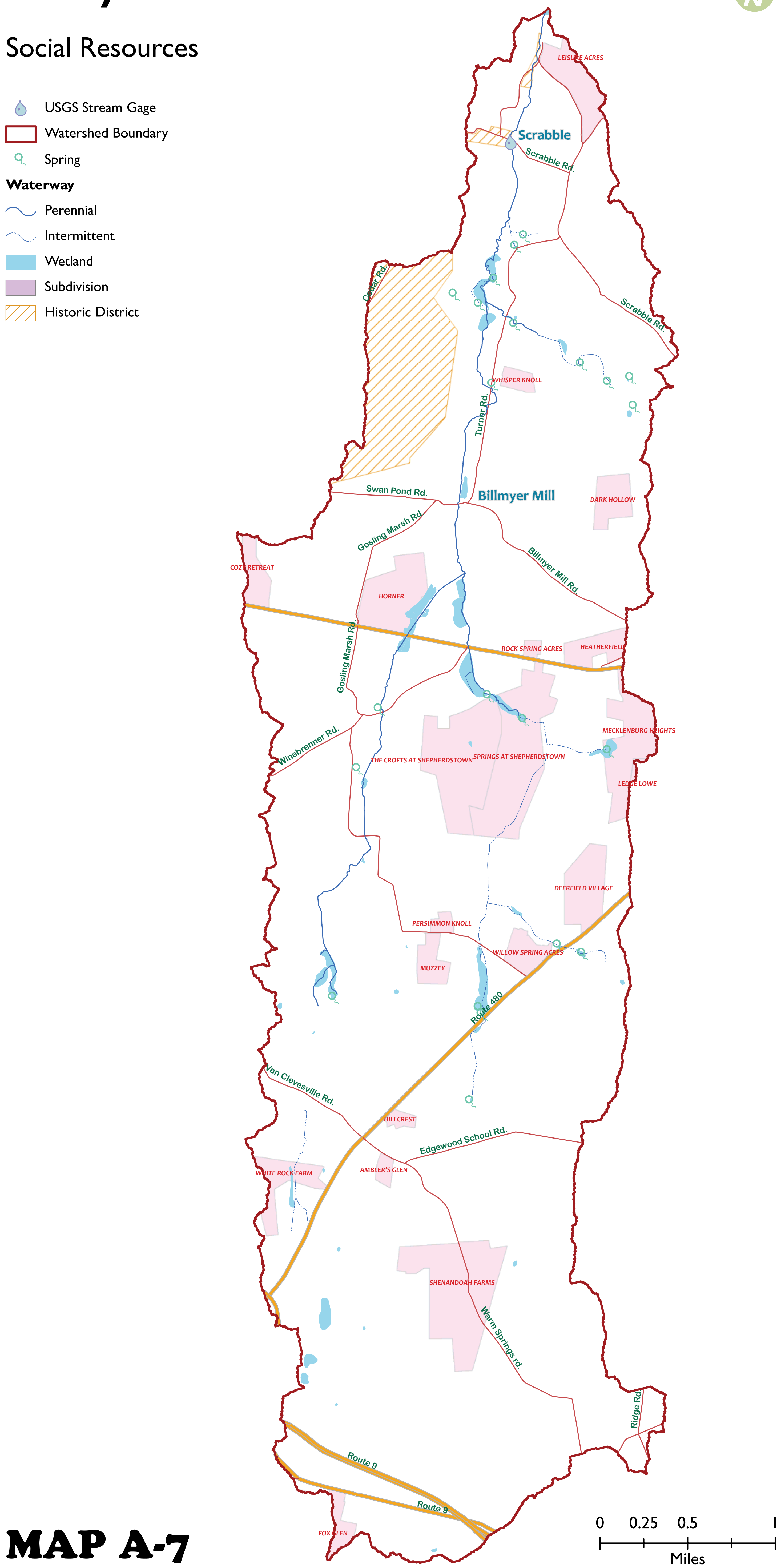
2000 Forest Cover



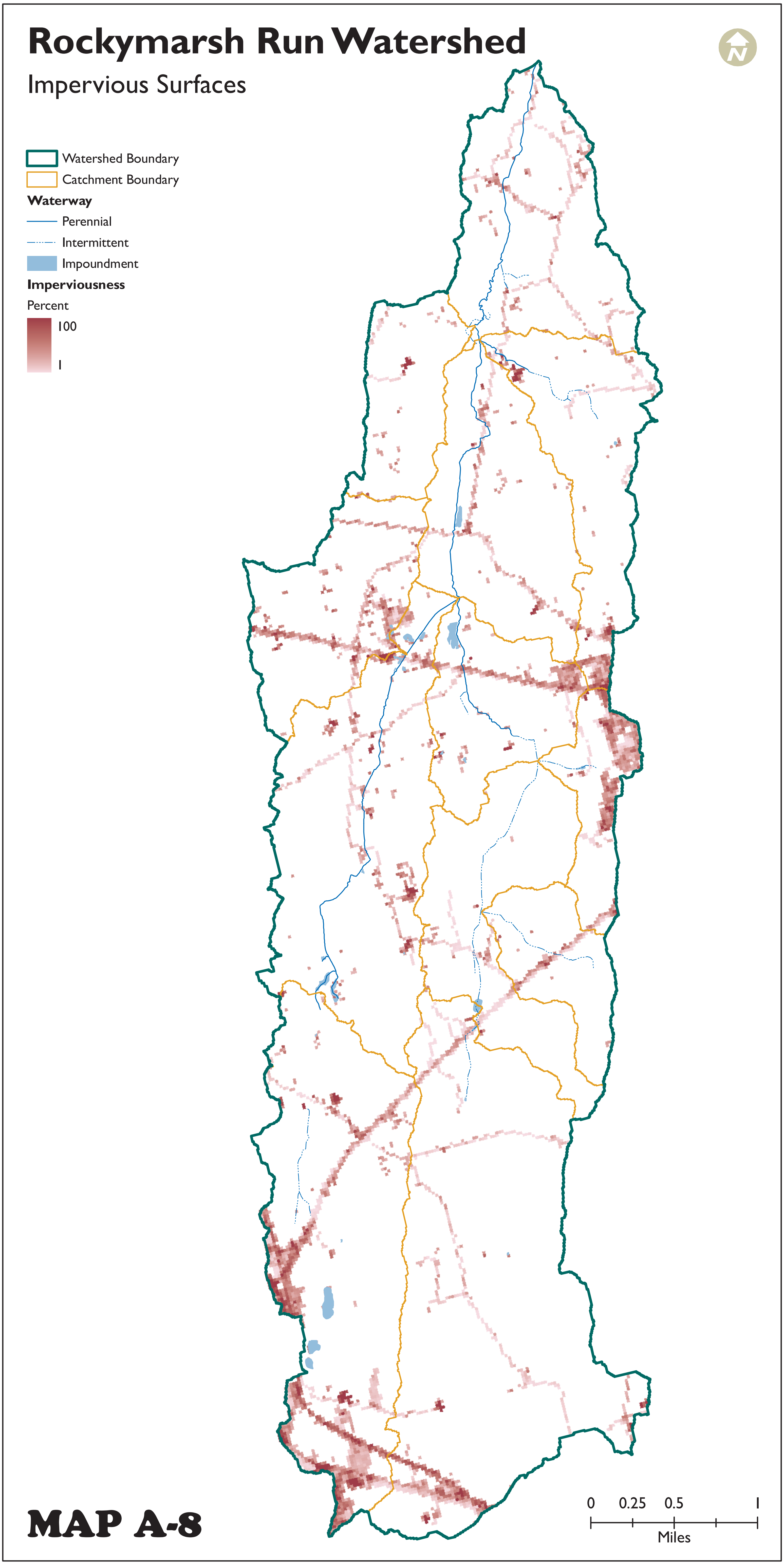
MAP A-6

Rockymarsh Run Watershed

Social Resources



MAP A-7


Rockymarsh Run Watershed
Impervious Surfaces
Watershed Boundary
Catchment Boundary
Waterway
Perennial
Intermittent
Impoundment
Imperviousness
Percent
100
1
N
0
0.25
0.5
1
Miles

MAP A-8

Rockymarsh Run Watershed

Riparian Forest Condition

Watershed Boundary

Waterway

Perennial

Intermittent

Priority Buffer Restoration Areas

Percent Riparian Forest (100-ft Buffer)

0.0 - 10.0

10.1 - 30.0

30.1 - 50.0

50.1 - 70.0

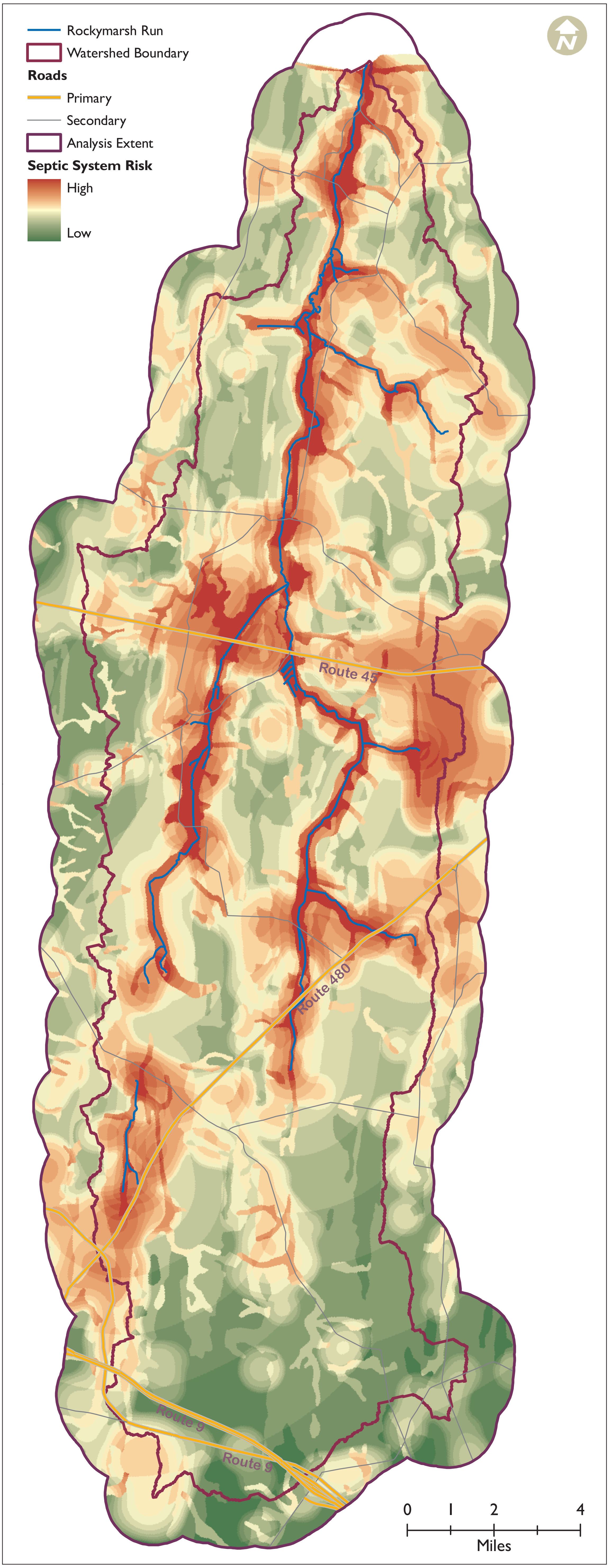
70.1 - 100.0

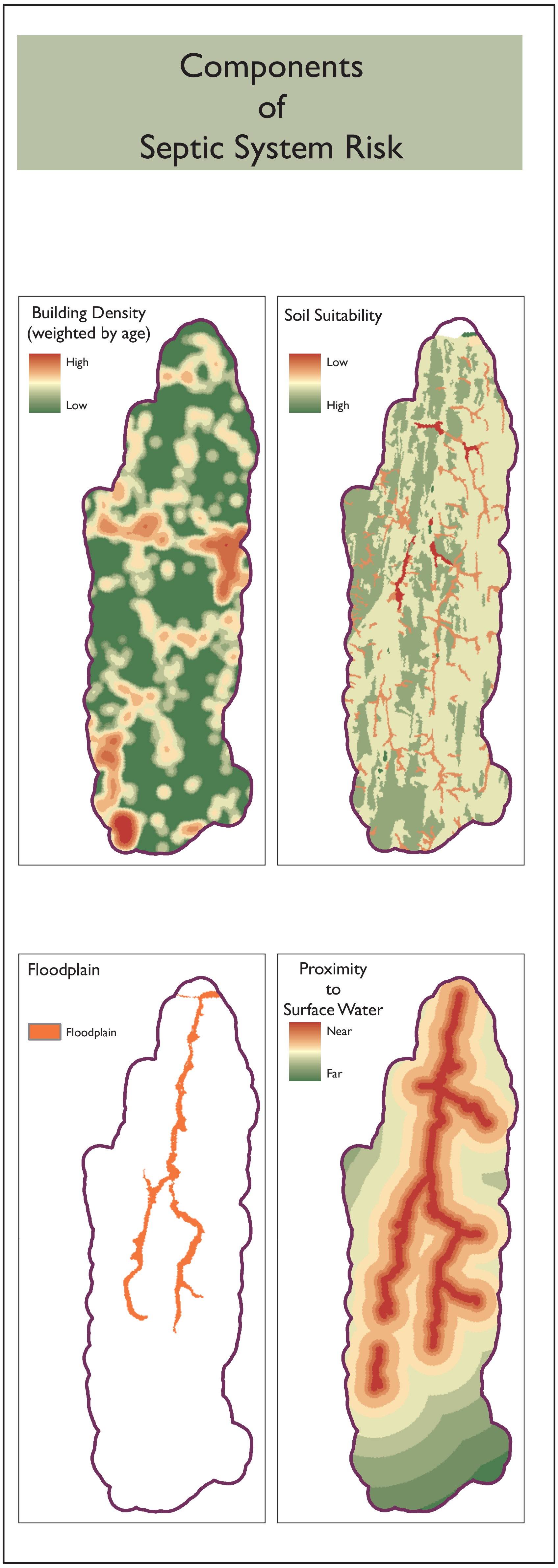
0 0.25 0.5 1

Miles

MAP A-9

Septic System Risk in Rockymarsh Run Watershed





MAP A-10

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Appendix B - Rare Species

Group	Common Name	Scientific Name	State Rank	Global Rank
Reptile	Wood Turtle	*Glyptemys Insculpta*	S2	G4
Plant	Water Horsetail	*Equisetum Fluviatile*	S2	G5
Plant	Floating Pennywort	*Hydrocotyle Ranunculoides*	S2	G5
Plant	Baltic Rush	*Juncus Balticus Var Littoralis*	S1	G5
Plant	Water Smartweed	*Polygonum Amphibium Var Emersum*	S2	G5
Plant	Hard-Stemmed Bulrush	*Schoenoplectus Acutus Var Acutus*	S2	G5
Plant	Hooded Skullcap	*Scutellaria Galericulata*	S1	G5

STATE RANK

- S1 Five or fewer documented occurrences, or very few remaining individuals within the
- state. Extremely rare and critically imperiled.
- S2 Six to 20 documented occurrences, or few remaining individuals within the state. Very rare and imperiled.
- S3 Twenty-one to 100 documented occurrences.

GLOBAL RANK

- G1 Five or fewer documented occurrences, or very few remaining individuals globally. Extremely rare and critically imperiled.
- G2 Six to 20 documented occurrences, or few remaining individuals globally. Very rare and imperiled.
- G3 Twenty-one to 100 documented occurrences. Either very rare and local throughout its range or found locally in a restricted range.
- G4 Common and apparently secure globally, though it may be rare in parts of its range, especially at the periphery.
- G5 Very common and demonstrably secure, though it may be rare in parts of its range, especially at the periphery.

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Appendix C - Rockymarsh Run
Watershed-Wide Sampling
Fall 2007

Site No.	Reach	Date	Discharge (cfs)	Water Temp. (°C)	pH (units)	Dissolved Oxygen (mg/L)	Specific Conductivity (µS/cm @ 25°C)	Total Alkalinity (mg/L as $CaCO_3$)	Carbon Dioxide (mg/L)	Turbidity (NTU)	Total Coliform (col/100 mL)	Fecal Coliform (col/100 mL)	E. coli (col/100 mL)	Nitrate (mg/L as N)	Total Nitrogen (mg/L as N)	Total Phosphorus (mg/L as P)
731_206	Mainstem_North	10/31/07	4.447	7.2	8.3	11.94	525	255	2.7	3	1733	818	292	2.08	2.33	0.05
731_175	Mainstem_North	10/31/07	4.654	7.4	8.3	11.91	531	254	2.9	2	2420	982	579	2.14	2.40	0.05
731_126	Mainstem_North	10/31/07	4.968	8.3	8.2	11.82	533	253	3.0	3	2420	709	344	1.72	2.10	0.13
770_102	Dark Hollow Branch	10/31/07	2.049	12.4	7.7	10.83	544	261	10.9	3	2420	90	2	2.22	2.77	0.14
732_190	Mainstem_South	10/31/07	2.974	9.3	8.2	11.47	532	254	3.4	3	1986	530	211	2.60	2.84	0.05
732_111	Mainstem_South	10/31/07	2.744	9.1	8.1	11.45	539	262	4.3	1	2420	390	1203	2.26	2.73	0.05
732_040	Mainstem_South	10/31/07	3.13	10.0	7.9	10.83	542	258	6.2	2	>2420	2100	344	2.94	3.30	0.05
733_253	West Fork	11/01/07	0.847	9.8	8.0	10.17	562	270	5.4	10	>2420	530	548	1.54	1.90	0.05
733_202	West Fork	11/01/07	0.687	9.6	8.0	10.69	562	252	5.4	8	2420	570	461	2.36	2.60	0.05
733_121	West Fork	11/01/07	0.419	10.2	8.0	10.81	596	268	5.4	7	>2420	591	488	2.34	2.58	0.05
880_326	East Fork	11/01/07	3.188	11.5	7.2	7.28	556	257	29.6	7	816	164	326	2.60	2.84	0.05
880_289	East Fork	11/01/07	0.059	11.7	7.5	5.78	592	295	19.1	53	>2420	330	365	1.64	2.58	0.08

Appendix C - Rockymarsh Run
Watershed-Wide Sampling
Fall 2008

Site No.	Reach	Date	Discharge (cfs)	Water Temp. (°C)	pH (units)	Dissolved Oxygen (mg/L)	Specific Conductivity (µS/cm @ 25°C)	Total Alkalinity (mg/L as $CaCO_3$)	Carbon Dioxide (mg/L)	Turbidity (NTU)	Total Coliform (col/100 mL)	Fecal Coliform (col/100 mL)	E. coli (col/100 mL)	Nitrate (mg/L as N)	Total Nitrogen (mg/L as N)	Total Phosphorus (mg/L as P)
731_206	Mainstem_North	10/29/08	7.46	7.3	8.0	11.65	551	246	2.5	3.4	2600	180	360	1.73	2.12	0.09
731_175	Mainstem_North	10/29/08	6.12	6.8	7.6	11.92	560	248	1.3	1.6	1600	172	378	2.46	2.93	0.05
731_126	Mainstem_North	10/29/08	5.96	7.9	8.1	11.59	570	264	1.8	3.1	900	206	328	1.73	2.31	0.05
770_102	Dark Hollow Branch	10/29/08	2.59	12.6	7.9	12.17	580	254	6.8	4.6	2000	244	394	2.40	3.14	0.09
732_190	Mainstem_South	10/29/08	5.25	7.4	8.1	11.68	570	255	2.3	1.4	1800	188	208	2.46	2.91	0.05
732_111	Mainstem_South	10/29/08	3.47	8.6	8.0	11.57	579	274	4.8	1.9	1200	194	254	2.46	3.08	0.05
732_040	Mainstem_South	10/30/08	3.50	7.9	7.8	10.33	588	264	9.8	2.4	1600	170	210	2.46	2.80	0.05
733_253	West Fork	10/30/08	1.06	6.1	7.9	11.67	597	261	6.5	4.5	1600	440	590	1.82	2.27	0.05
733_202	West Fork	10/30/08	0.67	5.7	8.1	12.55	595	249	2.5	n/m	2500	510	640	2.64	3.09	0.31
733_121	West Fork	10/30/08	1.05	6.5	8.0	12.16	633	273	5.0	2.5	700	260	290	2.76	3.21	0.05
880_326	East Fork	10/30/08	3.72	10.9	7.3	8.56	593	270	30.0	6.3	1400	100	220	2.64	2.86	0.05
880_289	East Fork	10/30/08	0.16	10.6	7.5	9.00	601	271	18.5	6.4	900	90	200	2.04	2.60	0.06

Appendix D - Historical Water Quality Data

Source (Contact): Mark Kozar (USGS)

Source (Document): Geohydrology, Water Availability, and Water Quality of Jefferson County, West Virginia, with Emphasis on the Carbonate Area WRIR 90-4118

Site	Site ID	Date	Nitrite + Nitrate (mg/L as N)	Diss. Ortho-P (mg/L as P)	Temperature	Latitude	Longitude
Dark Hollow Branch	148	8/2/1988	3.22	0.02	14	39 28 04	-77 50 12
W Fork @ Winebrenners Rd.	145	8/2/1988	n/d	n/d	26	39 26 09	-77 51 35

Appendix E - Historical Stream Biology Data

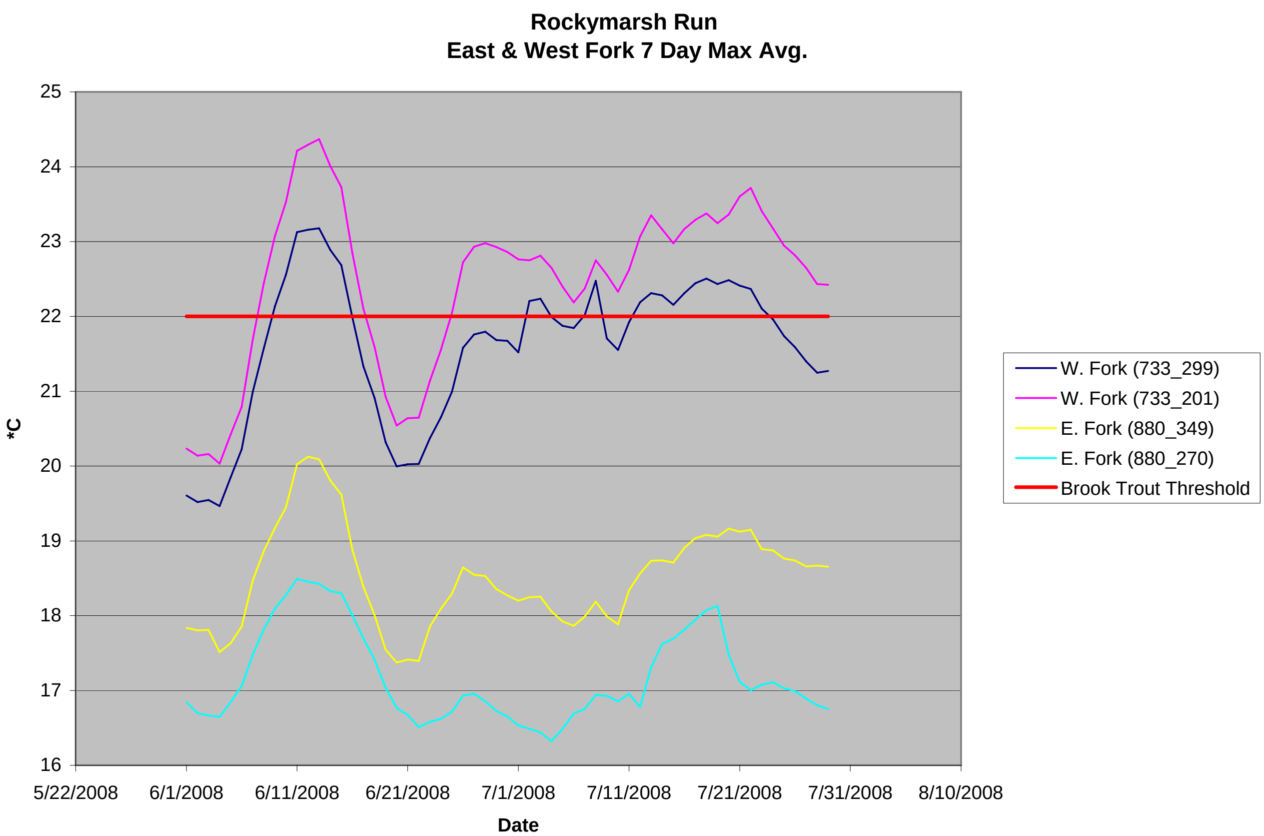
Source (Contact): John Wirts (WVDEP)
Source (Document): Schwartz_fr Wirts 090804.xls

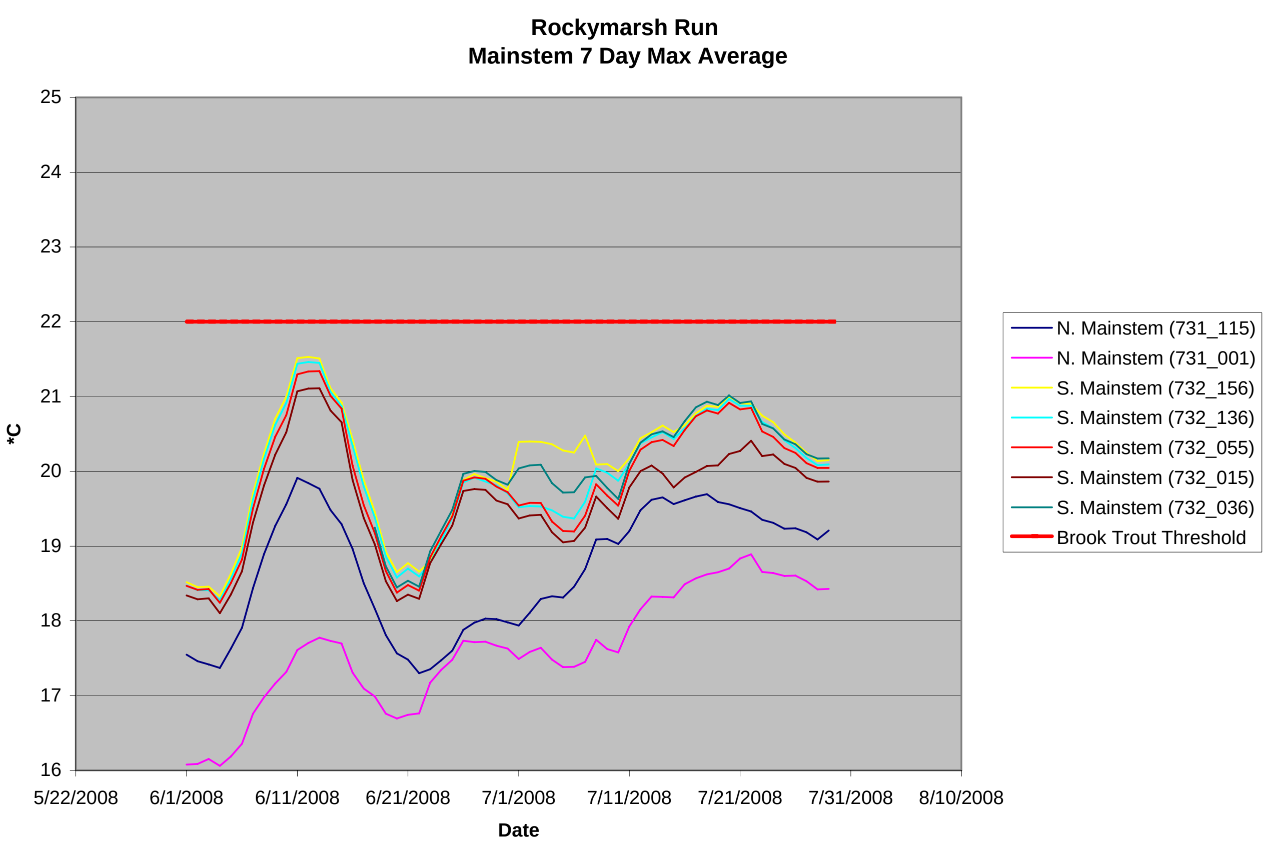
	Station_ID	Date	WVSCI Score	Fecal coliforms (col./100 mL)	Temp. (deg. C)	Turbidity	UTM East	UTM North
Rockymarsh @ Dam 4 Rd.	P-00013-0.4	8/20/03	41.25	200	18.2	clear	772803.5	4375609

Source (Contact): Jim Cummins (ICPRB)
Source (Document): ICPRBWVSCI Calculation Database for Contractors and Consultants v2.1.mdb

	Date	WVSCI Score	WVSCI Ranking	Total Habitat Score	Habitat Ranking (ICPRB)	Latitude	Longitude
Rockymarsh Mouth	9/18/2006	59	Slightly Impaired	160	Sub-Optimal	39.4917	-77.8259
Rockymarsh @ Rt. 45	9/27/2006	44	Moderately Impaired	185	Sub-Optimal	39.43937	-77.8484

Appendix F – Water Temperature





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Appendix G

June 2008 Benthic Macroinvertebrate Assessment

Mariya Schilz and Todd Petty
West Virginia University
October 30, 2009

In June 2008 we collected benthic macroinvertebrate samples from 15 sites (0,21,24,25,26,27,28,30,31,33,34,35,36,37,38) in Rocky Marsh watershed (Figure 1).

At each site, we sampled four widely separated riffle habitats (to the extent that riffle habitats were present) using a modified kick net with 500µm mesh and dimensions of 335 x 508 mm. A ¼-m square region of stream bottom was scoured in front of the kick net at each of the four sampled riffles. The four kick samples of each site were combined into a single composite sample. Samples were preserved in 95% ethanol. At sites with a large amount of macroinvertebrates and/or vegetation, samples were split into two bottles for better preservation. These samples have been processed in the lab and identified to the lowest practical taxonomic level.

Based on the taxa identified for each sample, West Virginia Stream Condition Index (WVSCI) scores were calculated for each site (Table 1). The WVSCI is currently the accepted index used in the state, and is modeled after the US EPA's Rapid bioassessment protocols. The index ranges from 0 to 100, with lower scores associated with poorer ecological conditions.

Site	Date	WVSCI	Tot Num	% EPT	EPT	% Tol	% E	MHI	% Dom	Frich	% Acid Tol	% Al Tol
0	Jun-08	39	212	23	1	34	0	6	30	7	0	19
21	Jun-08	23	521	0	0	77	0	7	60	7	0	0
24	Jun-08	26	2421	0	0	23	0	7	73	5	0	0
25	Jun-08	30	565	0	0	38	0	7	32	6	0	0
26	Jun-08	37	369	2	2	11	2	7	82	6	0	0
27	Jun-08	39	688	0	1	6	0	7	74	8	0	0
28	Jun-08	34	100	0	0	16	0	7	42	7	0	0
30	Jun-08	31	403	8	1	22	0	6	66	6	0	8
31	Jun-08	41	431	6	2	10	2	6	82	7	0	4
33	Jun-08	27	319	0	0	27	0	7	52	6	0	0
34	Jun-08	36	15695	0	1	1	0	7	92	6	0	0
35	Jun-08	30	1480	0	0	32	0	6	41	7	0	0
36	Jun-08	36	640	16	2	50	13	7	43	10	0	4
37	Jun-08	28	73	0	0	22	0	6	60	6	0	0
38	Jun-08	19	279	0	0	75	0	8	69	4	0	0

Table 1. Macroinvertebrate community metrics from the collected sample, including 1) WVSCI score, 2) total number of individuals, 3) % Mayfly (Ephemeroptera)-Caddisfly (Trichoptera)-Stonefly (Plecoptera) (EPT) abundance, 4) EPT family taxa richness, 5) % individuals generally tolerant of pollution, 6) % Mayflies, 7) the Modified Hilsenhoff Biotic Index, 8) % dominant individuals, 9) family taxa richness, 10) % individuals generally tolerant of acid, and 11) % individuals generally tolerant of aluminum flock.

Over 24,000 individuals were identified in the 15 samples, and we observed extremely high levels of variation in the total number of invertebrates among the sites (Table 1, Appendix 1).

Overall, WVSCI scores were poor ranging from 19 to 41, with a mean WVSCI score of 32. Normally this would be of concern and be indicative of poor stream health. This conclusion is difficult to draw at this time however. The scores are low because overall diversity of invertebrates in the system is low. This is particularly true of the EPT taxa (Table 1). However, it is not clear whether this is the result of impaired habitat or if the assemblage is natural given high alkalinities and low gradient structure of the system.

Our initial feeling is that the assemblages are natural and are not indicative of poor habitat and water quality conditions. We will need to conduct further analysis of habitat and water quality data before making a final conclusion as to the health of this stream. We intend to finalize these analyses next spring when we add habitat data to the overall dataset.

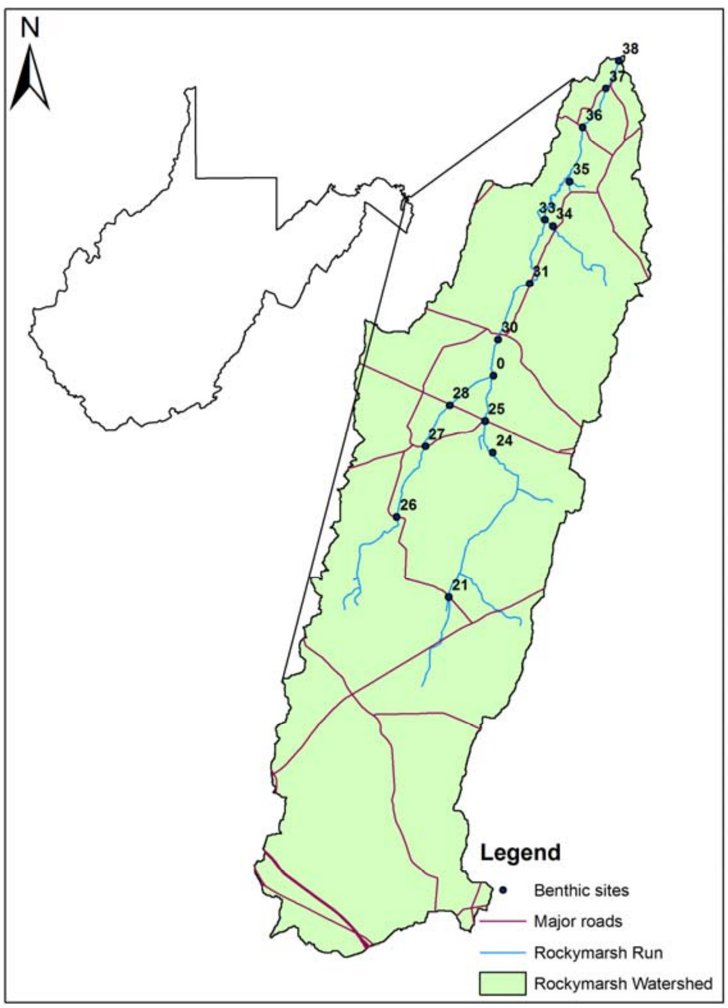

Figure 1. Map of benthic macroinvertebrate sample sites.

Appendix 1: Benthic macroinvertebrate data.

								Sites							
Taxa	0	21	24	25	26	27	28	30	31	33	34	35	36	37	38
Turbellaria															
Oligochaeta		48		16				1	4		88	40			17
Aeolosomatidae															
Nematoda															
Nemertea															
Hirudinidae															
Corbiculidae															
Sphaeriidae															
Clams	1					16	10			14		239	8	1	
Planorbidae															
Physidae															
Lymnaeidae															
Snails	56	35	10	179		16	3			1	2	604	16	2	
Cambaridae						1	1		1				1		
Gammaridae	33		84	24		64	19	265	354	50	1091	33	143	44	66
Talitridae															
Crangonyctidae															
Asellidae			1768	146	304	510	42	16	8	167	14505	124	34	8	
Baetidae					8				8				80		
Caenidae															
Heptageniidae															
Isonychiidae															
Leptophlebiidae															
Ephemerellidae															
Siphlonuridae															
Tricorythidae															
Ephemeridae															
Ameletidae															
Neoephemeridae															
Oligoneuriidae															
Unknown Mayfly															
Hydropsychidae	40				1	1		33	16		1		24		
Philopotamidae															
Rhyacophilidae															
Polycentropodidae															
Lepidostomatidae															
Limnephilidae															
Leptoceridae															
Odontoceridae															
Hydroptilidae															

Glossosomatidae															
Brachycentridae															
Helicopsychidae															
Psychomyiidae															
Unkown Caddisfly	8														
Chloroperlidae															
Capniidae/Leuctridae															
								Sites							
Taxa	0	21	24	25	26	27	28	30	31	33	34	35	36	37	38
Perlidae															
Pteronarcyidae															
Perlodidae															
Peltoperlidae															
Nemouridae															
Unknown Stonefly															
Gomphidae							1								
Cordulegastridae															
Aeshnidae															
Calopterygidae															
Libellulidae															
Coenagrionidae															
Unkown Dragonfly							8								
Elmidae					16	40					8				
Psephenidae															
Chrysomelidae															
Ptilodactylidae															
Curculionidae															
Dytiscidae		30													
Staphylinidae															
Haliplidae															
Carabidae															
Hydrophilidae															
Georyssidae															
Dryopidae															
Gyrinidae															
Tenebrionidae															
Helophoridae															
Corydalidae															
Sialidae															
Pyralidae															
Cossidae															
Corixidae															
Gerridae															
Saldidae															
Veliidae															
Chironomidae	64	312	8	176	32	40	16	72	40	86		432	278	16	193

Tipulidae	2	8											16	2	3
Tabanidae															
Dolichopodidae															
Simuliidae	8	40	551	24				16					40		
Athericidae															
Empididae															
Ceratopogonidae					8										
Blephariceridae															
Sciomyzidae															
Dixidae															
Stratiomyidae															
Tanyderidae										1					
Unknown Diptera															
								Sites							
Taxa	0	21	24	25	26	27	28	30	31	33	34	35	36	37	38
Uenoidae															
Molannidae															
Phryganeidae															
Hydracarina															
Muscidae															
Aphididae															
Noctuidae															
Halipidae															
Ephydridae															
Sminthuridae															
Thaumaleidae															
Lestidae															
Baetiscidae															
Isotomidae		48										8			
Cyclopoida															
Unionidae															
Taeniopterygidae															
Poduridae															
Tortricidae															
Psychodidae															
Sum	212	521	2421	565	369	688	100	403	431	319	15695	1480	640	73	279

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Appendix H – Fish Species

Potential Fish Species in Rockymarsh Run Watershed (HU_02070004370)
Sources: West Virginia GAP Analysis, NatureServe

ANGUILLIDAE
American Eel, *Anguilla rostrata*

CATOSTOMIDAE
Quillback, *Carpiodes cyprinus*
White Sucker, *Catostomus commersoni*
Creek Chubsucker, *Erimyzon oblongus*
Northern Hog Sucker, *Hypentelium nigricians*
Golden Redhorse, *Moxostoma erythrurum*
Shorthead Redhorse, *Moxostoma macrolepidotum*

CENTRARCHIDAE
Rock Bass, *Ambloplites rupestris*
Redbreast Sunfish, *Lepomis auritus*
Green Sunfish, *Lepomis cyanellus*
Pumpkinseed, *Lepomis gibbosus*
Bluegill, *Lepomis macrochirus*
Longear Sunfish, *Lepomis megalotis*
Smallmouth Bass, *Micropterus dolomieu*
Largemouth Bass, *Micropterus salmoides*

COTTIDAE
Blue Ridge Sculpin, *Cottus caeruleomentum*
Slimy Sculpin, *Cottus cognatus*
Potomac Sculpin, *Cottus girardi*

CYPRINIDAE
Rosyside Dace, *Clinostomus funduloides*
Spotfin Shiner, *Cyprinella spiloptera*
Common Carp, *Cyprinus carpio*
Common Shiner, *Luxilus cornutus*
Pearl Dace*, *Margariscus margarita*
River Chub, *Nocomis micropogon*
Golden Shiner, *Notemigonus crysoleucas*
Silverjaw Minnow, *Notropis buccata*
Spottail Shiner, *Notropis hudsonius*
Rosyface Shiner, *Notropis rubellus*
Bluntnose Minnow, *Pimephales notatus*
Blacknose Dace, *Rhinichthys atratulus*
Longnose Dace, *Rhinichthys cataractae*
Creek Chub, *Semotilus atromaculatus*
Fallfish, *Semotilus corporalis*

FUNDULIDAE
Banded Killifish*, *Fundulus diaphanus*

PERCIDAE
Greenside Darter, *Etheostoma blennioides*
Fantail Darter, *Etheostoma flabellare*
Tesselated Darter, *Etheostoma olmstedi*

*Rare