Chapter 2:
Natural Resources

Design and Maps updated June 2016

1.0 Introduction

This section describes both the land and water resources of Shenandoah County. It presents information on the County's topography, geology, soils, and water resources. These resources provide many opportunities, but also pose some severe environmental problems. Development should be guided away from areas with serious limitations, such as steep slopes, shallow depth to bedrock, flood plains, prime agricultural lands, wetlands, and sinkholes. Maps showing general geology, general soils, the hydro-geologic survey of Shenandoah County, and generalized development limitations are included.

2.0 Land Resources

The county's land resources include: topography, geology, forests and agriculture;

2.1 Topography

Shenandoah County lies within the Ridge and Valley physiographic province of Virginia. This province is known for its steep slopes in the mountainous areas with wide valleys lying between. The County's topography is steep to gently rolling, and well drained. Elevations vary from 537 feet above mean sea level in the valley to approximately 2,500 feet along the Massanutten Mountains on the east and over 3,300 feet along the North Mountains on the west. Intersected by narrow valleys in a northeast to southwest direction, these mountains comprise approximately one-half of the County's total land area.
The central portion of the County is the valley proper which is relatively level. Meandering through this area is the North Fork of the Shenandoah River, a major tributary of the Potomac River. Other major watersheds include Cedar Creek, Passage Creek, Stony Creek, and Smith Creek.

Approximately 45 percent of the County contains steep slopes ranging from 15 to 25 percent and, along the eastern and western borders, lands containing slopes of from 25 to 45 percent. The land along the eastern and western sides has severe slope limitations for both farm and non-farm uses.

2.2 Geology

Shenandoah County is underlain by bedrock which geologists have assigned to many different formations and groups which are shown on Figure

2-A on the following page. The formation and group classifications are combined into major geologic belts, and the County lies within three of them. Both the eastern and western sections are made up of Appalachian Sandstones and Shales. The eastern-central part of the County is underlain by the Valley Shale belt and the west-central area is part of the Valley Carbonate belt.

Appalachian Sandstones and Shales are made up of several rock types. The major geologic units found in the belt are the Hampshire, Brallier, Chemung, Tuscarora Formations and the Clinton and Cayuga Groups. Where the bedrock is exposed at the earth's surface, sandstone forms the many high, narrow, linear, northeast-trending ridges characteristic of the area. The Valley Shale belt is made up of a single rock unit, called the Martinsburg Formation. Shale and easily erodible sandstone are the major rock type of this belt.

Valley Carbonates are made up of six major formations or groups. The most common rock types are limestones and dolomites of sedimentary origin. The major geologic units included are the Edinburg Formation, Lincolnshire and New Market Limestones, the Beekmantown Formation, and Conococheaque Limestone.

The bedrock underlying the County influences almost every other feature of the environment and directly or indirectly affects many of man's land use decisions. Each of the major belts shows up in distinct land forms, and each also has an influence on water and its movement above or below the surface. Carbonate rocks (limestone and dolomite) commonly show considerable solution activity and surface collapse features consisting of sinkholes and caves. Such features are direct conduits into the County's groundwater.

One of the direct effects of geology on the use of land is the presence or possibility of rocks and minerals having commercial value. High-calcium limestone is quarried northeast of Strasburg to produce lime. Limestone for roads, concrete and other uses is quarried near Forestville. In the past, limestone and dolomite have been quarried at many other sites. Clay materials near Strasburg and Woodstock were used in the manufacture of brick. Clay near Strasburg was also used to make pottery products and drain tile.

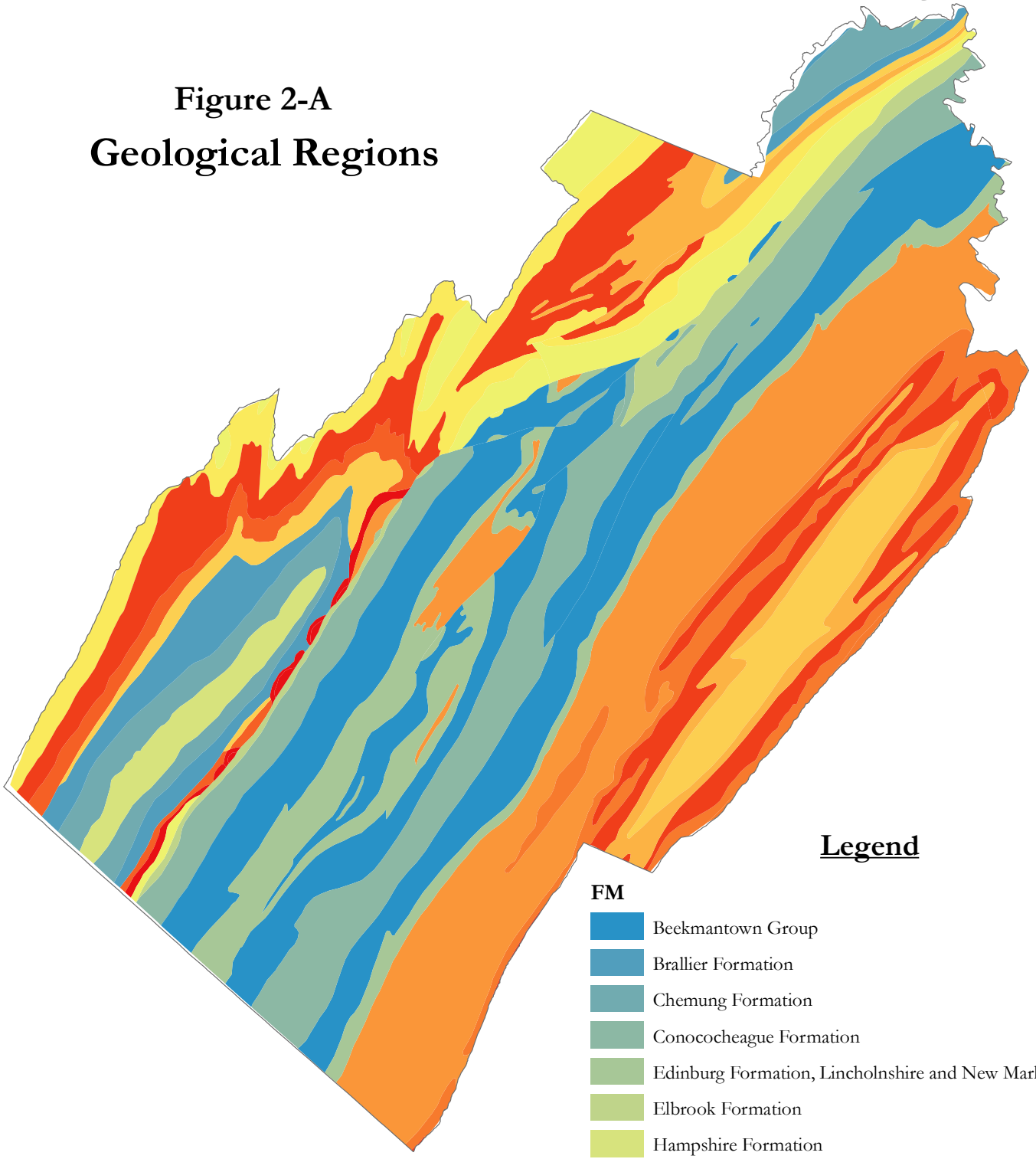
Sand and gravel were produced near Edinburg and Maurertown. Manganese minerals have been mined in the Cedar Creek Valley-Capola Mountain and Massanutten Mountain areas. Iron minerals have been mined in the western part of the County and in the Massanutten Mountain area. A small quantity of zinc ore was mined near Forestville. Samples of shale from selected localities in the County have been tested and found potentially suitable for use in the manufacture of brick, tile, and lightweight aggregate. Sandstone and quartzite at some localities may have potential as sources of high-silica raw materials.

2.3 Soils

The information in this sub-section was provided by the Soil Conservation Service from the Soil Survey of Shenandoah County. Seven major soil associations are found within the County. They are listed below in Table 2-A, and shown in Figure 2-B, "Soils", on page 2-5.

The soil associations in the survey were grouped into four general kind

Figure 2-A
Geological Regions



Legend

FM

- Beekmantown Group
- Brallier Formation
- Chemung Formation
- Conococheague Formation
- Edinburg Formation, Lincholnshire and New Market Limestones
- Elbrook Formation
- Hampshire Formation
- Juniata, Oswego, Martinsburg, Eggleston Formation
- Keefer Sandstone, Rose Hill and Tuscarora Formations
- Mahantango Formation
- Marcellus Shale and Needmore Formation
- Martinsburg and Orando Formations
- Massanutten Sandstone
- Millboro Shale and Needmore Formation
- Ridgeley Sandstone, Helderber and Cayuga Groups
- landslides with intact stratigraphic units - undivided

1 in = 4 miles

N

0 1.5 3 6 Miles

Figure 2-B
Generalized Soils

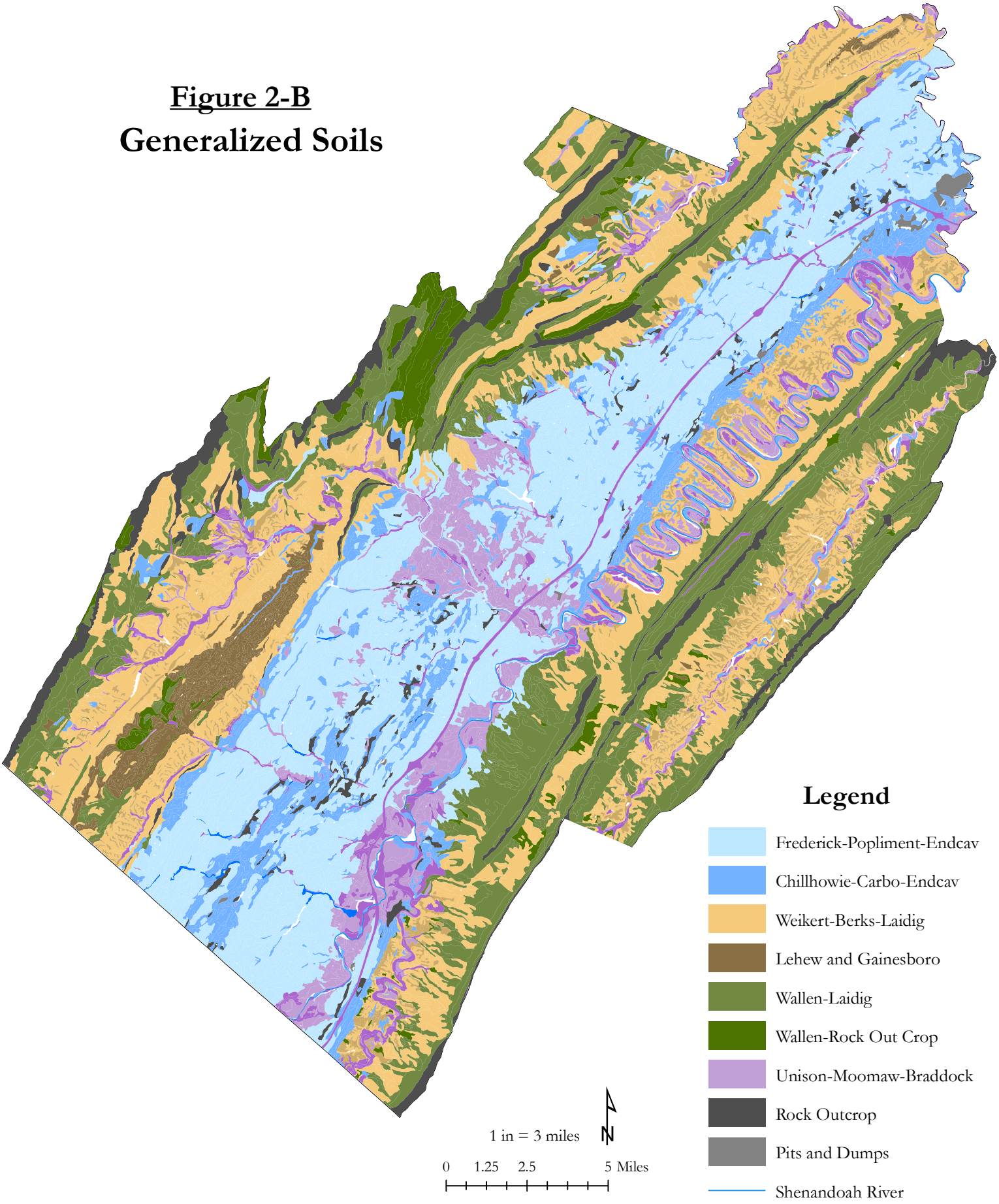


Figure 2-C
Major Soil Association
1. Frederick-Poplimento-Endcav
2. Chilhowie-Carbo-Endcav
3. Weikert-Berks-Laidig
4. Lehew-Gainesboro
5. Wallen-Laidig
6. Wallen-Rock outcrop-Drall
7. Unison-Monongahela-Braddock
Source: Draft Soil Survey of Shenandoah County, Virginia

of landscapes for broad interpretive purposes. Each of the broad groups and the soil associations in each group are described below.

Soils in the Shenandoah Valley Formed in Residuum of Limestone and Interbedded Limestone and Calcareous Shale; on Uplands:

2.3.1. Frederick-Poplimento-Endcav

This association is composed of very deep, well drained soils that have clayey subsoils. Areas of these soils are located on broad uplands whose slope varies from gently sloping to steep; they generally have long smooth slopes. This map unit makes up about 23 percent of the County. It is about 35 percent Frederick soils, 24 percent Poplimento soils, 15 percent Endcav soils and 26 percent soils of minor extent.

The Frederick and Poplimento soils are dominantly gently sloping and sloping. Both soils have a surface texture of silt loam and are gravelly or rocky in some areas. The Endcav soils are dominantly gently sloping and sloping and have silt loam surface textures. Some areas are rocky. Of minor extent in this map unit are well drained Carbo and Timberville soils. Also of minor extent are somewhat poorly drained Toms soils and poorly drained Maurertown soils along small streams and drainage ways and areas of rock outcrop.

The soils in this map unit are used mainly for crops and pastures. The non-rocky soils are used mostly as cultivated cropland and are well suited to this use. The steeper soils and the rocky soils are suited to grasses and trees. The hazard of erosion, rockiness, and steep slopes are the main limitations for farming. The clayey subsoil, rockiness, and steep slopes are the main limitations for community development and most other uses.

2.3.2. Chilhowie-Carbo-Endcav

This association is composed of moderately deep to very deep, well drained soils that have clayey subsoils. Areas of these soils are mainly on gently sloping to moderately steep slopes and broad ridge tops. Rock outcrops and sinkholes are numerous throughout the unit. This map unit makes up about 10 percent of the County. It is about 30 percent Chilhowie soils, 15 percent Carbo soils, 12 percent Endcav soils and 43 percent soils of minor extent.

Carbo and Endcav soils are dominantly gently sloping to strongly sloping and have silty clay loam surface textures. The Carbo soils are moderately deep and

the Endcav soils are very deep. The Chilhowie soils are on ridge tops and short, steep side slopes. Chilhowie soils are moderately deep and have a surface texture of silty clay loam. Rock outcrops and sinkholes are numerous throughout this map unit. Of minor extent in this unit are shallow, well drained Opequon soils, deep well drained Edom and Timberville soils and pits and dumps.

This unit is mainly used for crops and pasture. Most of the steep and rocky areas are in pasture and woodland. The hazards of erosion, rockiness and slope are the main limitations for farming. The clayey subsoil, depth to bedrock, and steep slopes are the main limitations for community development and most other uses.

2.3.3 Soils formed in Residual or Colluvial material from shale and sandstone on uplands and mountain foot slopes.

Weikert-Berks-Laidig

This association comprises shallow to very deep, well drained soils that have loamy subsoils.

Areas of these soils are on hills and ridges, lower side slopes and foothills, and are generally gently sloping to very steep. This map unit makes up about 38 percent of the county. It is about 21 percent Weikert soils, 20 percent Berks soils, 12 percent Laidig soils and 47 percent soils of minor extent.

The Weikert and Berks soils are predominantly in moderately steep to very steep areas. Both have silt loam surfaces and are closely intermingled on the landscape. Weikert soils are shallow and Berks soils are moderately deep. They are on hills and ridges in the Valley and lower mountains side slopes. Some areas are very stony.

The Laidig soils are very deep and well drained. Most areas are stony or very stony. It is on lower side slopes and narrow ridge tops and side slopes of the foothills. Of minor extent in this map unit are well drained, Gilpin, Sequoia and Wheeling soils, somewhat poorly drained Toms and Guyan soils, and poorly drained Maurertown and Purdy soils.

This unit is mostly in woodland. A few areas are in cultivated crops and pasture. These areas are mostly along small streams and the North Fork of the Shenandoah River. Slope and depth to bedrock are the main limitations for community development and most other uses.

Lehew-Gainesboro

This association has moderately deep, well drained soils that have loamy subsoils. Areas of these soils are on hills and ridges. They generally have short smooth slopes and are highly dissected. They map unit makes up about 30 percent of the county. It is about 40 percent Lehew soils, 20 percent Gainesboro soils and 40 percent soils of minor extent.

The Lehew and Gainesboro soils are dominantly on steep side slopes. They are moderately deep and well drained. Of minor extent in this unit are the moderately deep, well drained Berks, Gilpin and Wallen soils and shallow, well drained Weikert soils. This unit is mostly wooded. A few small areas along the ridge tops are in pasture. Slope and depth to bedrock are the main limitations for

community development and most other uses.

Soils in the Appalachian Mountains; Massanutten Mountains, and mountain food slopes that formed in residual or colluvium material weathered from sandstone.

Wallen-Laidig

Soils in this association are moderately deep and very deep, somewhat excessively drained and well drained and have loamy subsoils. Areas of these soils are gently sloping to very steep, on the tops and side slopes of the Appalachian Mountains. Most of this unit is in the George Washington National Forest. This unit makes up about 11 percent of the county. It is 38 percent Wallen soils, 35 percent Laidig soils and 27 percent soils of minor extent.

The Wallen soils are somewhat excessively drained and have very stony and extremely stony surfaces. They are on side slopes and tops of the mountains and are droughty in the summer. The Laidig soils are well drained and have very stony surfaces. They are on the lower side slopes and foot slopes. Of minor extent in the map units are well drained Zepp, Lehew and Gilpin soils, excessively drained Drall soils and Rock outcrops. All areas in this map unit are wooded. Slope and stones on the surface are the main limitations of this unit for community development and most other uses.

Wallen-Rock outcrop-Drall

This association contains moderately deep and very deep, somewhat excessively and excessively drained soils that have a loamy or sandy subsoil and areas of Rock outcrop. Areas of these soils are gently sloping to very steep, on the tops and upper side slopes of the Massanutten Mountains. Most of this unit is in the George Washington National Forest. This unit makes up about 9 percent of the county. It is 40 percent Wallen soils, 18 percent Rock outcrop, 8 percent Drall soils, and 34 percent soils of minor extent.

The Wallen soils are somewhat excessively drained and have very stony and extremely stony surfaces. They are on upper side slopes and tops of the mountains. The Rock outcrops which consist of sandstone are mainly 30 feet apart and are on the upper side slopes and tops of the mountains. The Drall soils are excessively drained and have extremely stony surfaces. They are on tops and upper side slopes of the mountains. Of minor extent in this map unit are well drained Massanutten and Laidig and Weikert soils.

All areas of this map unit are wooded. Slope, rock outcrops and surface stones are the main limitations of this map unit for community development and most other uses.

2.3.4 Soils on river terraces that formed in alluvial materials.

Unison-Monongahela-Braddock

These soils are very deep, well drained soils that have a loamy or clayey subsoil. They are located in areas that are nearly level to moderately steep, on terraces along the North Fork of the Shenandoah River and Stony Creek. This map unit makes up 6 percent of the county. It is 26 percent Unison soils, 15

percent Monongahela soils, 11 percent Braddock soils and 48 percent soils of minor extent.

The Unison and Braddock soils are well drained and are at slightly higher elevations that the Monongahela soils. In some areas these soils are gravelly or cobbly. The Monongahela soils are moderately well drained and are usually adjacent to the flood plain. This soil has a seasonal high water table. Some areas of this soil are cobbly. Of minor extent in this map unit are well drained Allegheny, Chavies and Nolin soils, and moderately well drained Cotaco soils.
This unit is used mostly for crops and pastures. A small acreage is wooded. The seasonal high water table in the Monongahela soils and the permeability of the Unison and Braddock soils are the main limitations of this unit for community development and most other uses. Flooding is a hazard on some of the minor soils.

The Soil Survey of Shenandoah County includes an interpretation of the soil data and detailed mapping of soil types overlaid on aerial photography. In addition, through the use of the geographic information system that was developed at the Natural Resource Conservation Service's Culpeper office, generalized maps of soil limitations for various uses and maps of prime agricultural soils are available. These resources should be incorporated as appropriate into proposed development plans.

3.0 Forests and Agriculture

The forests of Shenandoah County are one of its most precious resources. These woodlands add to the economic vitality of the County, its natural beauty, and to the quality of life for its residents. The County's woodlands are used for recreation, watershed and wildlife management, and for a variety of forest products.

Shenandoah County's woodlands are dominated by the Upland Hardwood – Southern Pine forest type. The most common tree species in this forest type include: white oak, black oak, chestnut oak, scarlet oak, northern red oak, pignut hickory, bitternut hickory, mockernut hickory, red maple, white ash, tulip tree, Virginia pine, shortleaf pine, pitch pine, table mountain pine, white pine, eastern hemlock and black gum. The forests are dominated by saw-timber-size trees which are16 inches in diameter or greater in size. Major forest pests affecting the health of these trees include the gypsy moth, southern pine bark beetle and hemlock wooly adelgid.

There are 184, 400 acres of forest land in Shenandoah County. The majority of these acres belong to private landowners, both residents of the County and also absentee owners. There are also federal landholdings (George Washington – Jefferson National Forest), state lands (Devil's Backbone State Forest) and county lands (County parks) located within the boundaries of Shenandoah County. Following is a table displaying the data for each of these ownership classes:

Shenandoah County's economy is very dependent upon its forest resources. At least 1,031 workers are dependent upon the forest products industry. Shenandoah County's forest products economy ranks 61st in the state, but is the leader among all of the counties in the Lord Fairfax Planning District. Following

Figure 2-B

Farm and Forested Land

Figure 2-E Forest Ownership in Shenandoah County		
Ownership	Acres	% of Total Forest Land
Private	116,500	63%
County & Local Government	300	.2%
State	400	.2%
Federal	67,200	36%
Source:Virginia Department of Forestry		

Figre 2-F Shenandoah County Forest Economic Information	
Direct Economic Impact (primary and secondary industries)	$54,493,794
Indirect Economic Impact (services to industry: trucking, supplies, maintenance etc).	$8,652,295
Induced Economic (employee spending)	$18,678,811
Total Annual Forest Economic Impact	$81,824,900

is a table showing the forest economic information for the county:

The commercial quality and value of these trees vary greatly depending upon the soil types which underlay these woodlands. There are many acres of forests growing upon shale-derived soils that are of very low quality and value. Conversely, trees growing on limestone soils, or river bottom alluvial soils, are of very high quality and value. It is these better quality soils that make Shenandoah County a leader in the world market of fine hardwood products.

From 1986 through 1992, cumulative harvest revenues for Shenandoah County landowner averaged approximately $380,000. Beginning in 1993, and through the end of 2001, these same annual harvest revenues have significantly increased to $1,380,000. The reasons for this one million dollar increase in annual revenues can be attributed to an improved global hardwood market, an increased demand for hardwood products, a decrease in timber harvested from National Forests and the recognition of the superior quality of Shenandoah Valley hardwoods. For every $1.00 landowners receive for their timber, an additional $35.39 of "value added dollars" is generated for Virginia's economy.

Shenandoah County relies upon its rural landscapes to support its population and, in part, its economy. Yet trends for the county show increasing fragmentation and parcelization of once manageable forested acreage. The loss of productive forest land equates to a possible decline in the economic viability of the county due in part from the decreased revenues generated by traditional forest products. The county should seek a balance between managed growth and the retention of productive forest land.

Approximately 41 percent of the land in Shenandoah County (133,032 acres) is classified as "land in farms" according to the 2002 Census of Agriculture. Agricultural land includes crop land and pasture land, orchards, and confined

feeding operations.

There were 989 farms in Shenandoah County as of 2002, which represented an increase of about 19 percent in the number of farms since 1987. During that period, the average size of a farm also decreased by about 19 percent from 167 acres to 135 acres. The recent trend in farming in Shenandoah County is toward less land-intensive uses, including the development of additional confined feeding operations (predominantly poultry).

Almost one-third (30 percent, or 98,506 acres) of the County is regarded as having prime agricultural soils. This is the highest percent and acreage of all the counties in the Northern Shenandoah Valley Region. The largest area of prime farm land is in the central part of the County. Every effort should be made to reserve prime agricultural land for agricultural uses.

4.0 Hydrology

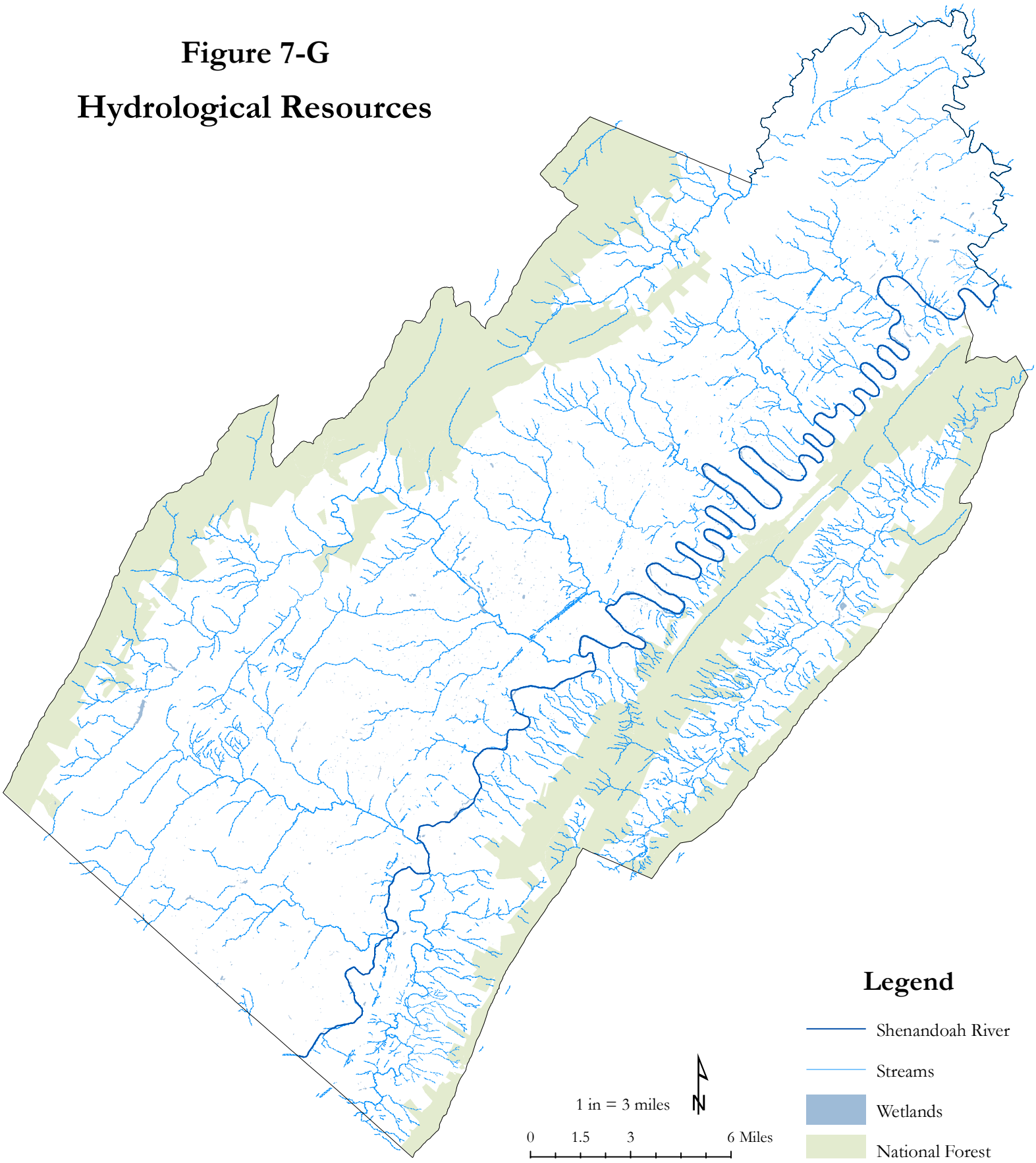
The hyrdology section of this chapter includes sub sections on water sources; water quality; water quantity; water and land use; surface water pollution and protection; ground water pollution and protection; water conservation; drought management; and storm water management. The section concludes with several recommendations to conserve and protect the county's water resources.

4.1 Water Sources

On average, approximately 36 inches of precipitation per year fall onto Shenandoah County land. Approximately 26" of this water returns to the atmosphere through evaporation, 6" enters the county's streams as surface runoff, and 4" infiltrates the soil and eventually recharges the groundwater supply.
Surface runoff (water which does not infiltrate the soil) becomes part of approximately 1150 miles of permanent and intermittent county streams. All of these streams or tributaries, whether or not they originate in Shenandoah County, eventually enter the North Fork of the Shenandoah River, which has averaged over the period 1925-2000 some 375 million gallons per day as it passes the USGS gage at Strasburg. Approximately two miles further downstream the North Fork leaves the county, entering, in order, the Shenandoah River, the Potomac River, and the Chesapeake Bay. Shenandoah County land represents 49% of the total North Fork watershed, and 7% of the total Potomac River watershed.

Water that infiltrates and percolates into bedrock (the earth's crust below the soil) enters one of four hydrogeological regions (Figure 2-C, page 2-14). Water may remain here, depending on local hydrogeological conditions, for days, years, decades, or longer. At some point, however, much of this water returns to the surface by one of three routes: 1) through one of the numerous springs in the county; 2) through one of the thousands of wells, both private and public; or 3) through subsurface connections between groundwater and stream channels. During periods of base flow, when no surface runoff is occurring, all of a stream's flow comes from groundwater inputs.

Figure 7-G
Hydrological Resources



Surface water may also enter the groundwater system. This may occur through subsurface connections, or by way of surface depressions or sinkholes which occur especially in areas underlain by carbonates (limestone and dolomite). Groundwater Under the Influence of Surface Water (GWUISW) is the term applied to this phenomenon.

Approximately 30% of county land, concentrated in the central valley area, overlies carbonate rock, primarily limestone. This bedrock material is characterized by numerous caves and caverns, sinkholes, underground solution channels, and fractionated layers. When these conditions are present the term karst is applied. Groundwater in karst terrain is noted for easy entry from surface water sources, quite rapid lateral movement, and hence susceptibility to contamination which can spread rapidly over large underground areas.

4.2 Water Quality

Water quality in general refers to the suitability of water for its intended or desired uses. Both aesthetic characteristics and safety influence water's suitability for a particular use. Water suitable for one use may not be suitable for another. For example, the water in a high quality trout stream is still not safe to drink without treatment.

Drinking water supplies for the people who live and work in Shenandoah County come from the following sources: 1) water for the towns of Strasburg and Woodstock is drawn from the North Fork and is treated at treatment plants for the two towns respectively; 2) water for the towns of New Market, Mt. Jackson, Edinburg, and the county's two sanitary districts (Stoney Creek Sanitary District, serving the Bryce Mountain area, and Toms Brook/Maurertown Sanitary District) is drawn from drilled wells and treated in treatment plants before reaching the consumer; 3) approximately 60 other public water systems (serving 25 or more people on a year-round basis) obtain their drinking water from drilled wells and treat it as necessary; 4) the rest of the rural population of the county (the majority of county residents) obtains drinking water from private wells, with only rare treatment of the water before it reaches the tap; and 5) a relatively few rural residents who obtain their drinking water from cisterns or from water haulers.

Surface water quality in Virginia is evaluated by the Virginia Department of Environmental Quality (DEQ) as to its suitability, not only for fishing and swimming, but also for the maintenance of aquatic life and in-stream usage. In its most recent report, DEQ listed segments of the following streams in Shenandoah County as "impaired" meaning unfit for swimming or fishing: Holmans Creek, Smith Creek, Mill Creek, Toms Brook, and portions of the North Fork. Fecal coliform and high nitrate levels are the most common sources of impairment. It should be evident that the quality of river water at the intakes for the public water systems of Woodstock and Strasburg, and hence the amount of treatment necessary to make the water potable, is directly affected by the impaired nature of the upstream tributaries.

Besides water for human uses, habitat for many aquatic species is provided by county streams and riparian areas. The North Fork, Passage Creek, Cedar Creek, and Little Stony Creek are examples of many of the streams in the county

with valuable ecological features to accompany their value for traditional off stream uses.

4.3 Water Quantity

In 2001 a Regional Water Supply Committee study (Northern Shenandoah Valley Regional Partnership) forecast that by 2025 the maximum daily demand for water from the North Fork would exceed the low mean flow of record supply of water. In the absence of augmentation, i.e., impoundments of water upstream in the watershed, or reduced demand (for example, rerouting Frederick County and Winchester water supply to the main stem of the Shenandoah River), the demand for water from the North Fork will continue to out pace the low mean flow of record by an ever widening margin. Nine dams temporarily impound the flows of seven county streams resulting in a potential maximum storage of approximately 1800 million gallons.

These dams, however, were constructed for other purposes such as flood control, hydroelectricity, and recreation, and none are connected with existing treatment plants or distribution systems. Looking to the long term, therefore, the availability of water from the North Fork for human consumption is clearly in jeopardy during periods of drought conditions. The issue of adequate flow in the North Fork was addressed by a Minimum Instream Flow (MIF) study conducted jointly by the United States Geological Survey (USGS) and Virginia Tech and completed in 2004. This study established the minimum instream flow requirements to support drinking water supplies, aquatic habitats and recreational uses of the river.

As for groundwater supplies, the very complex nature of the bedrock geology underlying Shenandoah County makes it virtually impossible to know with any degree of certainty how much groundwater is stored beneath the county. Individual wells vary greatly as to depth and yield, suggesting that there are an infinite number of small aquifers of varying capacity but no main aquifer or underground river. During periods of drought such as the summer of 1999 there were reports of a number of springs and wells which ceased to function, indicating that the water table in those areas had receded significantly.

It is clear that the county does not have an unlimited supply of groundwater. Over time the demand for groundwater has increased and will continue to do so as the population grows and as per capita consumption rates remain much higher than they were 50 or 100 years ago. Groundwater is also the main source of water for much of the county's livestock as well as for a number of industries located here. For example, the poultry processing plant at Columbia Furnace consumes over one million gallons of water per day, drawn from company wells.

4.4 Water and Land Use

Water quality and quantity on the one hand and land use activity on the other are inextricably intertwined. As growth development continues to expand westward from the greater Washington area, counties located in the path are faced with the challenge of preserving their agricultural heritage, their rural culture,

and open spaces. Shenandoah County is no exception. One of the major goals stated in the 1991 Comprehensive Plan was "to guide, and direct growth into and around the towns served by the road network and other public facilities [meaning water and sewer primarily], while preserving the rural and open space character of those areas outside the public service areas."

Unfortunately there is a disconnect between that stated goal and reality. Between 1990 and 2000 there was an increase of 1,549 total dwelling units, and 795 of them (51.3%) were located in the towns; 754 (48.7%) were located in the rural areas of the County. Each new home in rural areas requires its own well and septic system, both of which put added strain on the fragile groundwater environment.

4.5 Surface Water Pollution and Protection

Under the federal Clean Water Act (1972), point source discharges (sewage treatment plants, industrial facilities, etc.) are regulated through the National Pollutant Discharge Elimination System, a nationwide permitting program. In Virginia this permitting authority is under the State Water Control Board which issues and renews hundreds of Virginia Pollutant Discharge Elimination System (VPDES) permits annually through the DEQ. These permits authorize individuals, municipalities, and industrial facilities to discharge directly to surface waters provided they meet certain specified discharge requirements

Nonpoint source (NPS) pollution is a very complex issue. Unlike pollution from a discharge pipe, which is point source and readily identified, NPS pollution comes from many diffuse sources and is not always easy to identify. NPS pollution can come from agricultural land, parking lots, construction sites, lawns, driveways, etc. As rainwater or snowmelt moves over these areas it picks up numerous contaminants and carries them to nearby streams and rivers. NPS pollution also can affect groundwater, especially in the Shenandoah Valley with its karst geology where surface water and groundwater are so easily interchanged.

The contaminants commonly found may include the following:

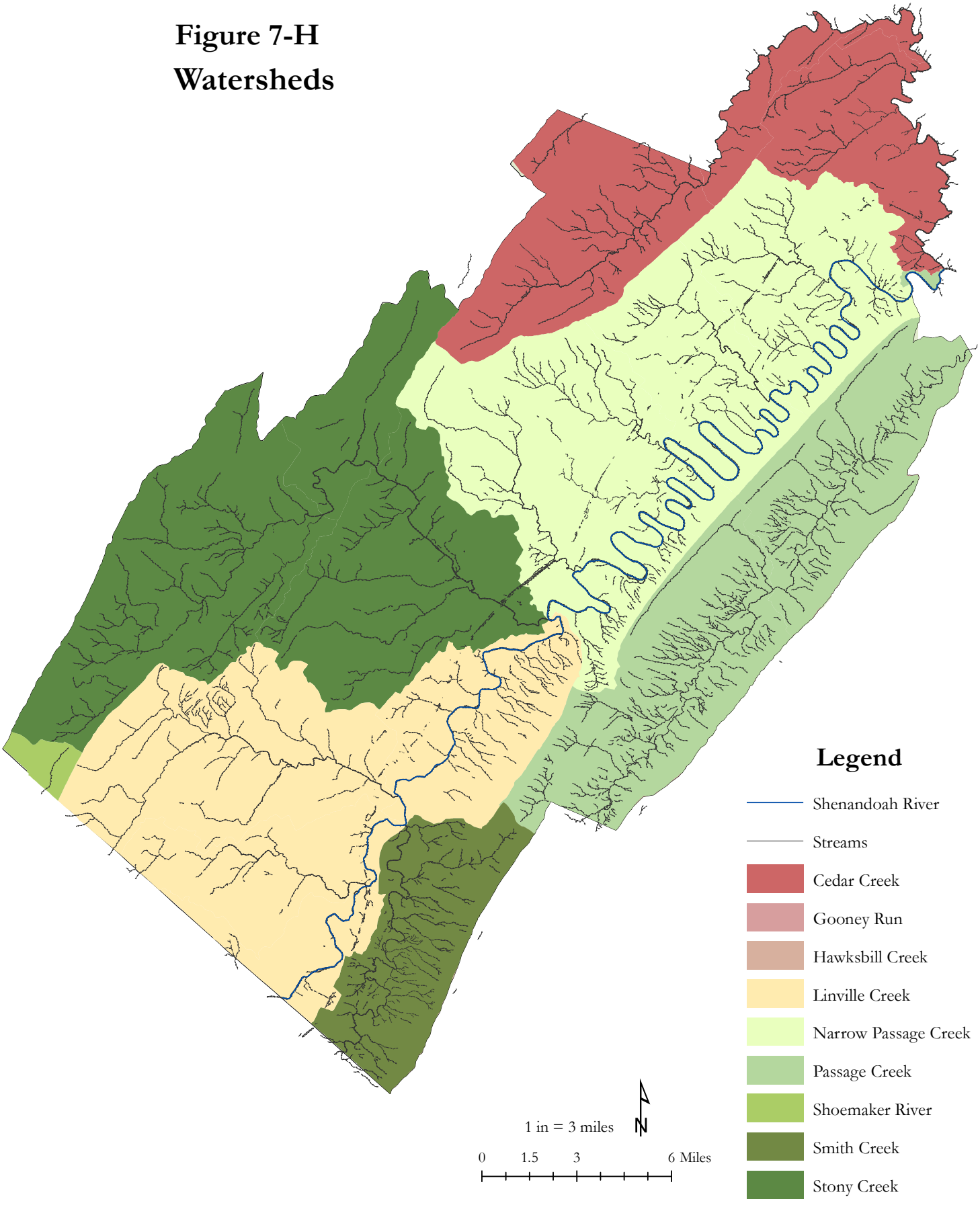
- Oil, grease, and toxic chemicals from urban runoff
- Excess fertilizers or pesticides from agricultural and residential areas
- Sediment from improperly managed construction sites or cropland
- Bacteria and nutrients from livestock and faulty septic systems

Best Management Practices (BMPs) are among the best means of controlling gricultural NPS pollution. The Virginia Water Quality Improvement Act provides financial incentives to landowners for the installation of BMPs which minimize the movement of agricultural pollutants such as sediment, nutrients, and pesticides to water resources. Riparian fencing, vegetative filter strips, controlled manure storage, and alternative watering systems are a few examples of BMPs.

Riparian areas are very important to the ecological health of stream systems. Protection of riparian areas is needed to help maintain the ecological, aesthetic, and recreational qualities of streams, especially coldwater streams. Some coldwater (trout) streams have been affected by acid precipitation and are vulnerable to further acidification.

The number of alternative wastewater treatment systems designed

Figure 7-H
Watersheds



for surface discharge has increased substantially. Improperly constructed or maintained systems potentially threaten stream water quality. The number and location of these systems need to be monitored to ensure that they do not adversely affect streams.

Under the Clean Water Act there is provision for addressing and restoring those streams that have been designated as "impaired" by DEQ and EPA (see section above on Water Quality). The terminology used is Total Maximum Daily Load (TMDL) which is the pollution threshold below which a stream must be restored to make it safe for swimming and fishing. The program is complex, controversial, and costly, and will take at least a decade to complete. It requires establishing for each impaired stream, based on modeling of that stream's watershed, the TMDL of specific pollutants such as fecal coliform, sediments, nutrients, aquatic or benthic, metals, organics, pH, etc.. It also requires identifying point and non-point sources of these pollutants as well as remedial action to bring them into compliance. Public participation by interested property owners is both encouraged and essential.

4.6 Groundwater Pollution and Protection

Groundwater located in karst terrain, which is the case for much of Shenandoah County, is particularly vulnerable to pollution from surface sources. Among the main threats are underground storage tanks, sinkholes, uncapped abandoned wells, improperly managed animal waste, excessive use of fertilizers and pesticides, and poorly maintained septic systems.

In 2000-2001 the county sponsored a Source Water Assessment and Protection Plan (SWAPP) study for the five major public water systems that obtain their drinking water from groundwater sources: New Market, Mt. Jackson, Edinburg, and the Stoney Creek and Toms Brook/Maurertown Sanitary Districts. Using the science of hydrogeology the recharge areas for all of the wells in these five systems were delineated for the first time, and potential sources of contamination within each recharge area were identified and characterized as to risk. It was discovered that the recharge areas are quite large (on the order of four square miles per well) and quite irregular in shape. It should be noted that each of these five systems treats the groundwater before it passes on to the consumer. This is also true of the approximately 60 smaller "public systems" in the county that are regulated by the health department.

The number of individual property owners who treat their drinking water or have it tested on a regular basis is unknown, but is believed to be very small. Since 1994 there has been a county-wide long-term Citizen Groundwater Monitoring Program under the auspices of the Friends of the North Fork with funding support from the county. Currently 36 wells are tested on a semi-annual basis for fecal coliform, nitrates, metals, chemicals, herbicides, and the like. During the mid-90s there were frequent positive samples of fecal coliform, nitrates, manganese, lead, and the herbicides atrazine, and metholachlor.

With the exception of those who live in the towns and sanitary districts where sewer service is provided, the majority (approximately 60%) of the county's residents rely on septic systems. The fact that most of these are located

in karst terrain poses an exceptionally serious potential threat to groundwater quality. Aside from meeting the initial installation requirements set by the health department, there is no regulation of a septic system thereafter. In the absence of any required inspections or pump-outs it is a virtual certainty that many septic systems in the county are failing to perform their intended function. The Virginia Cooperative Extension Service reports that: "Malfunctioning septic systems are currently the leading cause of groundwater pollution in Virginia." To the extent that this occurs in karst terrain the problem can be particularly pervasive.

4.7 Water Conservation

The fragile nature of the quantitative water supply in Shenandoah County is addressed in the earlier section on Water Quantity. The situation with respect to groundwater is of particular interest because the quantity of groundwater available is essentially unknown and unknowable and because upwards of 80% of the population obtains its drinking water and household water from wells or springs and both the agricultural and industrial sectors are similarly dependent on groundwater.

During the droughts of the summer of 1999 and again in 2002, the county issued a drought advisory with guidelines for voluntary water conservation. The guidelines included such measures as: discontinuing watering of lawns, washing cars only at commercial car washes, discontinuing irrigation of crops during daily periods of high evaporation, use of soaker hoses to water trees, shrubs, and vegetable gardens, and a host of steps to reduce water consumption in individual households.

As population increases and periodic droughts occur, developing an ethic of water conservation as a permanent way of life in the Valley should be a serious consideration. In the event of extreme drought conditions, some form of mandatory conservation measures may be necessary, although action by the Governor would be required to put such measures in effect.

Public education is the key to creating an ethic of water conservation. Citizens and businesses need to understand that water quantity is critical in the Valley and they need to learn what they can do to reduce their own water demands. Simple things like low volume flush toilets and shower heads can in the aggregate cut a household's water demands by a substantial percentage.

4.8 Drought Management

During the drought of 1999 the county formed an emergency committee to deal with drought issues, particularly the plight of farmers with dwindling supplies of water for livestock and poultry. Out of this effort grew some very positive measures, both short and long term, for drought management. Among the short-term measures were development of a list of commercial water haulers, a list of locations where individual farmers with portable water storage capability could load them, advice regarding procurement of suitable water bladders for hauling and/or storing water, advice on proper well management, conservation techniques, and in the extreme, delivery of water by volunteer fire departments.

Long-term measures focused on monitoring the status of streams and individual wells and springs; permanent on-farm water storage, including ponds; water metering systems for livestock; and financial incentives for farmers through agencies such as FSA, NRCS, and the Soil and Water Conservation District. The Virginia Cooperative Extension Service agent took the responsibility of disseminating all of this information to the farm community.

4.9 Stormwater Management

Inadequate management of accelerated runoff of stormwater resulting from development throughout the North Fork watershed increases flood flows and velocities, contributes to erosion and sedimentation, overtaxes the carrying capacity of streams and storm sewers, infiltrates municipal sewer systems, increases the cost of public facilities to carry and control stormwater, undermines flood plain management and flood control efforts in downstream communities, reduces groundwater recharge, and threatens public health by way of pollutants washed from the surface into drinking water supplies (automobile oil and grease, sediment from construction sites, bacteria from animal waste, excess lawn care and farm fertilizers and pesticides, as well as deposits of airborne pollutants).

Historically, managing storm flows focused on simple routing of stormwater through gutters and storm sewers with the objective of removing the stormwater as quickly as possible. A more effective approach to stormwater management is to maintain as nearly as possible the natural runoff flow characteristics. This can be accomplished either by augmenting the infiltration process or by temporarily storing stormwater for release at controlled rates of discharge. Actual stormwater management techniques can be structural (detention ponds, pipes, etc.) or non-structural (land use planning to effectively preserve existing vegetation, drainage swales, perviousness, etc.). Both techniques should be used as complementary elements of a management plan. The effectiveness of a stormwater management program is a function of comprehensive planning and sound engineering design.

A comprehensive program of stormwater management, including reasonable regulation of development and activities causing accelerated runoff, is fundamental to the county's and the towns' health, safety, and welfare, their resources, and the environment. The Virginia Stormwater Management Program (1990) gives the counties and the towns the option of establishing local stormwater management programs to regulate activities on private property within their jurisdictions.

5.0 Water Resources Recommendations

Five general objectives of good water resource management are proposed to achieve the major goals of this plan relating to preserving and enhancing the environmental quality of the County and providing for the economical delivery of necessary public services. These objectives are: Efficiency in the use of existing water supplies and wastewater facilities; appropriate development of needed new water supplies, water facilities, and wastewater facilities; protection of surface and groundwater resources from depletion, pollution, and ecological degradation;

acquisition and maintenance of necessary data and information; involvement of local officials and citizens in water resource decisions. Recommendations to help accomplish these objectives are presented below:

5.1 Efficiency in use of existing supplies and facilities

- Develop a county-wide water conservation plan with emphasis on public education and the nurturing of an ethic which promotes the voluntary conservation of water resources as a way of life in Shenandoah County.
- Reduce the percentages of unaccounted-for water from municipal systems.
- Follow the Drought Management Plan for the county when appropriate, and ensure that it is updated annually. The plan should provide for both voluntary and mandatory (in the case of extreme drought) water conservation and allocation.

5.2 Appropriate development of new supplies or facilities

- Maintain and improve as necessary existing public water supplies and wastewater facilities
- Develop a plan for utilizing the assets of the North Fork Wastewater Treatment Plant to best advantage. Process all septage at this plant in place of the current Toms Brook facility.
- Reexamine existing land use codes with a view toward guiding future growth into areas with existing water and sewer and minimizing new development requiring individual wells and septic systems
- As a member of the Regional Water Resources Policy Committee, support planning for augmenting the flow of the North Fork by 2015. Impoundment of a significant amount of water for release as needed during periods of extreme drought is indicated.
- Along the Route 11 corridor, extend the water line north from Woodstock to join the Toms Brook/Maurertown system at its southern terminus. This stretch currently has sewer service but no water service.

5.3 Protection of Water Resources

- Address nonpoint source pollution by promotion of agricultural, urban, forestry, and other BMPs; cooperation with the Natural Resources Conservation Service and Cooperative Extension Service to implement BMPs; promotion of techniques to reduce agricultural and household chemical use; and appropriate enforcement of the Erosion and Sediment Control Law.
- Adopt, as appropriate, the recommendations of the SWAPP project pertaining to the five major public water systems that depend on groundwater supplies.
- Additions to the Code of Virginia in 1998 and 1990 gave local governments the authority to "protect surface and groundwater." The County Code should be amended to specifically provide for this protection in all planning and zoning land use actions.
- Use available local tools to protect groundwater from contamination by underground storage tanks, animal wastes, biosolids, excessive fertilizer and pesticide use (both agricultural and residential), or other threats as identified.
- Institute a program for periodic inspections of septic systems and, if

warranted, pump-outs. Encourage citizens to have their septic tanks pumped out every five years.

- Locate sinkholes and sinkhole dumps, and implement sinkhole protection with a sinkhole ordinance
- Continue improvement to municipal sewer facilities, particularly with respect to stormwater infiltration. Encourage cooperation among towns and other water and sewer service providers and outlying areas to provide services as needed.
- Monitor all discharge from alternative systems.
- Support the efforts of the U.S. Forest Service and the Virginia Department of Game and Inland Fisheries to mitigate the acidification of coldwater streams.
- Support implementation of the Minimum Instream Flow Study for the North Fork recommendations.
- Encourage riparian landowners to maintain streambank vegetation and minimize disturbances in riparian areas in order to protect stream habitat and water quality. Encourage landowners to apply to have riparian land placed in the Conservation Reserve Program or conservation easements.
- Develop site plan review criteria for the definition and protection of wetlands.
- Stress the role that individual landowners must play in the protection of groundwater by proper on-site wastewater system maintenance (items 5 and 8 above), limited use of fertilizers and pesticides, control of animal wastes, wellhead maintenance, proper use and disposal of household chemicals and waste oil, and the like.
- In coordination with the towns, develop a county-wide stormwater management plan (Virginia Stormwater Management Program, 1990)

5.4 Acquire and maintain data

- The county's Geographical Information System (GIS) is the central repository for water and other geographical data for the county. The GIS Coordinator is responsible for entering appropriate and accurate data into the system and for ensuring that it is kept up- to- date. The GIS should continue to be supported as a matter of priority.
- The SWAPP project provides a specific database on potential sources of contamination located within the groundwater recharge areas of five major public water systems. Changes will inevitably occur within these recharge areas so this data base needs to be kept current
- Numerous federal and state agencies maintain extensive data bases that are accessible through the internet. USGS, EPA, DCR, DEQ, and the Virginia Department of Health are especially pertinent. County and town planners should access these as a matter of course.
- The Friends of the North Fork and the Friends of the Shenandoah have each engaged in monitoring and recording surface water quality on selected streams in the county. The Friends of the North Fork in cooperation with the Board of Supervisors have sponsored the Citizen Groundwater Monitoring (testing of 36 individual wells) program. These efforts should continue to be supported, and expanded. Furthermore, systematic trend analysis should be performed so as to better exploit the value of the data being compiled.

- In the event that a Groundwater Monitoring Network is established by the State Water Commission, the county should be prepared to participate in a major way. Few if any counties stand to benefit more from filling in the unknowns about our groundwater supply.

5.5 Local Involvement

- In June 1999 the county Board of Supervisors created the Water Resources Advisory Committee (WRAC) to advise the Board on matters of water quality and quantity and to help provide both the leadership and the public participation needed to continue the process of water resource management. The SWAPP project, which was funded by the county, is an example of how this committee can contribute to public awareness of the importance of protecting the sources of groundwater to the major public water systems in the county. The WRAC should continue to be supported by the county.
- Public education is an essential factor. The county and town governments, the schools, the libraries, the media, and local service groups are all conduits for public awareness and education. In 2000 the WRAC published and distributed a 16-page "Primer on Water in Shenandoah County," written in layman's language for all citizens of the county. It is important that this document be kept current and reprinted at yearly intervals.

6.0 Natural Resource Limitations

Approximately 56% of the county's total land area has severe limitations for on-site septic systems and almost 40% has severe excavation limitations. These limitations include slow permeability, a seasonally high water table, flooding, rock fragments, shallow depth to bedrock, steep slopes, danger of well contamination, surface rock outcroppings, and other factors.

Land with severe limitations for on-lot sewerage systems is located along the eastern and western portions of the county and in the extreme center. Generally this area corresponds to the Appalachian Mountain section (including the Massanuttens) and the land underlain by the Martinsburg Formation.

The best general areas for constructing septic tank and drain field systems are those underlain by limestone and terrace gravel, which generally occupy the valley lowlands in the center of the county. However, these areas also have the greatest potential for groundwater pollution and the danger of well contamination from septic systems because of the underground stream network and solution channels associated with the limestone formations.

In summary, the land area of Shenandoah County is not well suited for excavations and conventional septic tanks and drain fields. Public policy should be toward limiting growth in those areas where public sewer systems are not available now nor economically feasible in the future.

7.0 Air Quality

As development continues and perhaps accelerates, as traffic on I-81 continues to grow, and as federal and state air quality standards become more

stringent, the subject of air quality in the Shenandoah Valley will likely become a hot environmental issue. As of 2004, several locales in the region, and the Shenandoah National Park, were in non-compliance with the EPA air quality standards for ozone.

Early that year the Shenandoah Valley Air Quality Project (SHENAIR) was initiated under the auspices of the Northern Shenandoah Valley Regional Commission. The mission of SHENAIR, which was spawned in the Frederick County/Winchester area, is to study and improve air quality in the northern Valley. In order to gather data throughout the region, additional air quality monitoring stations will be required. Currently monitoring stations are located in Frederick County, Winchester, Front Royal, Luray, Harrisonburg, and the Shenandoah National Park.

Federal legislation in the form of the Clean Air Act requires EPA to establish National Ambient Air Quality Standards (NAAQS) and reevaluate those standards every five years. Virginia has an Air Pollution Control Law and supporting regulations to supplement the federal statute. In addition to ozone, other pollutants such as particulate matter, carbon monoxide, lead, nitrogen dioxide, and sulfur dioxide are governed by these statutes. Emission sources include power generating stations and large industrial facilities (some of which are located hundreds of miles upwind in Ohio, West Virginia, and western Pennsylvania), gasoline marketing and distribution centers, solvent-based paint processes, on-road vehicles, and off-road mobile sources such as farm and construction equipment and lawn and garden equipment.

One tool in the process of coping with air quality threats and maintaining ambient air quality within the prescribed standards is air quality modeling. Modeling can be used to simulate air quality events and concentrations, recreate air pollution episodes, determine causes and contributing factors, predict future conditions, test control strategies, and demonstrate success.

At this point in time, the subject of protecting air quality in the northern Shenandoah Valley is still in its infancy. While there is little that any one county can do on its own to stop pollution, a regional approach, such as the SHENAIR initiative, offers substantial promise of success. As a member of the Northern Shenandoah Valley Regional Commission, Shenandoah County should support the SHENAIR project.

8.0 Summary

The natural resources of Shenandoah County provide many opportunities, but also pose some severe environmental problems. Development should be guided away from areas with serious limitations, such as steep slopes, shallow depth to bedrock, flood plains, prime agricultural lands, wetlands, and sinkholes.

Forest areas and agriculture should be preserved as major natural and economic assets. Floodplains along the North Fork of the Shenandoah River and its tributaries must be protected, and riparian lands kept in their natural state. The water resources of the County must be protected, both surface water and groundwater. Because of the rock and soil conditions and the hydrogeological cycle, the water resources are directly inter-connected.

A first step was the development of the Shenandoah County Water Resources Assessment as part of the 1991 plan. Now the recommendations of that assessment need to be carried out by the Planning Commission and Board of Supervisors. Specific recommendations for water resource protection are included on pages 2-20 through 2-23 of this section.

The following points summarize the major efforts that are needed to implement those recommendations and to mount a comprehensive water resources management effort:

- Develop a comprehensive Shenandoah County Water Resources Plan which deals with both surface and ground water issues, and delineates and protects wells, wetlands, and sinkholes.
- Work with the other counties in the region to develop a Shenandoah Valley Regional Water Supply Plan.
- Look for long-term solutions for storm water management and non-point source pollution abatement.
- Monitor the progress of the Health Department and Department of Environmental Quality in their permitting and monitoring of individual alternative treatment systems.
- Consider special County ordinances which may require higher standards than the State for wells and septic systems.
- Explore a county-wide mechanism for the monitoring and maintenance of alternative and septic treatment systems.
- Participate in a regional approach to improving air quality by supporting the SHENAIR project.