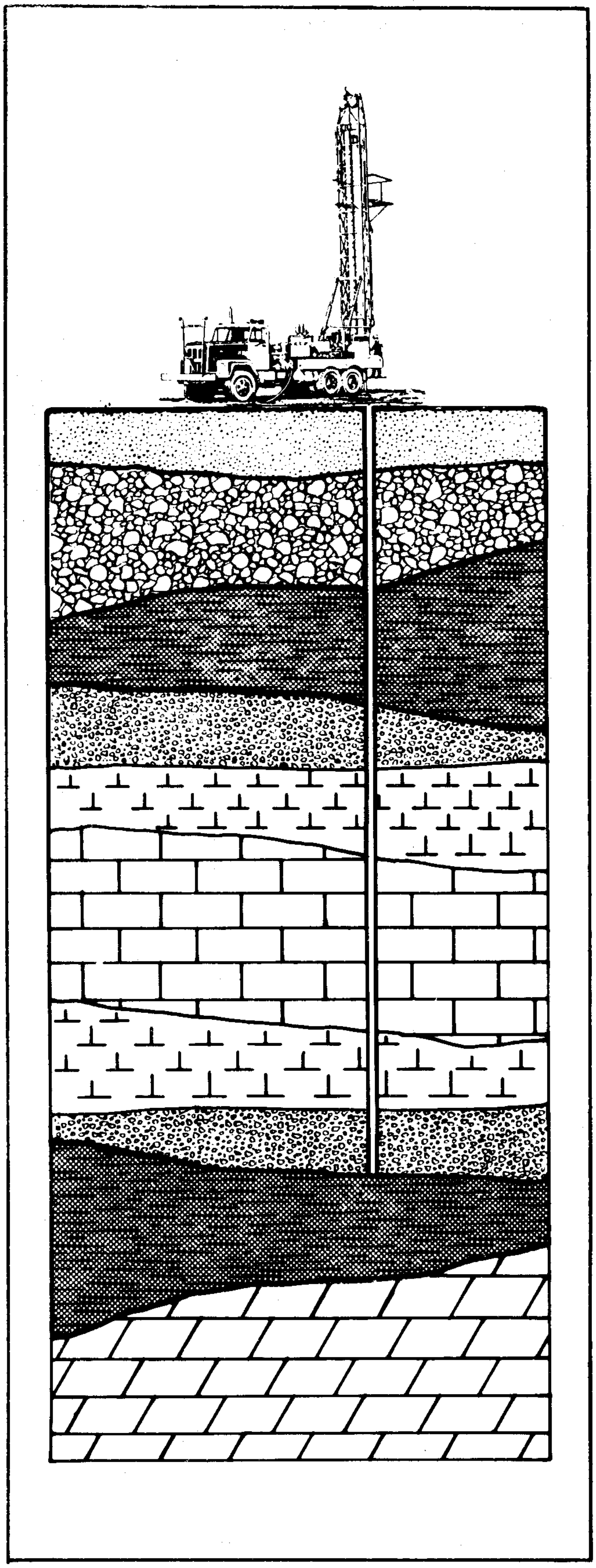

BUCHANAN COUNTY GROUNDWATER

PRESENT CONDITIONS AND PROSPECTS

by
Susan R. Epps

SOUTHWESTERN REGIONAL OFFICE

COMMONWEALTH OF VIRGINIA

STATE WATER CONTROL BOARD

BUREAU OF WATER CONTROL MANAGEMENT

Richmond, Virginia

Planning Bulletin 311

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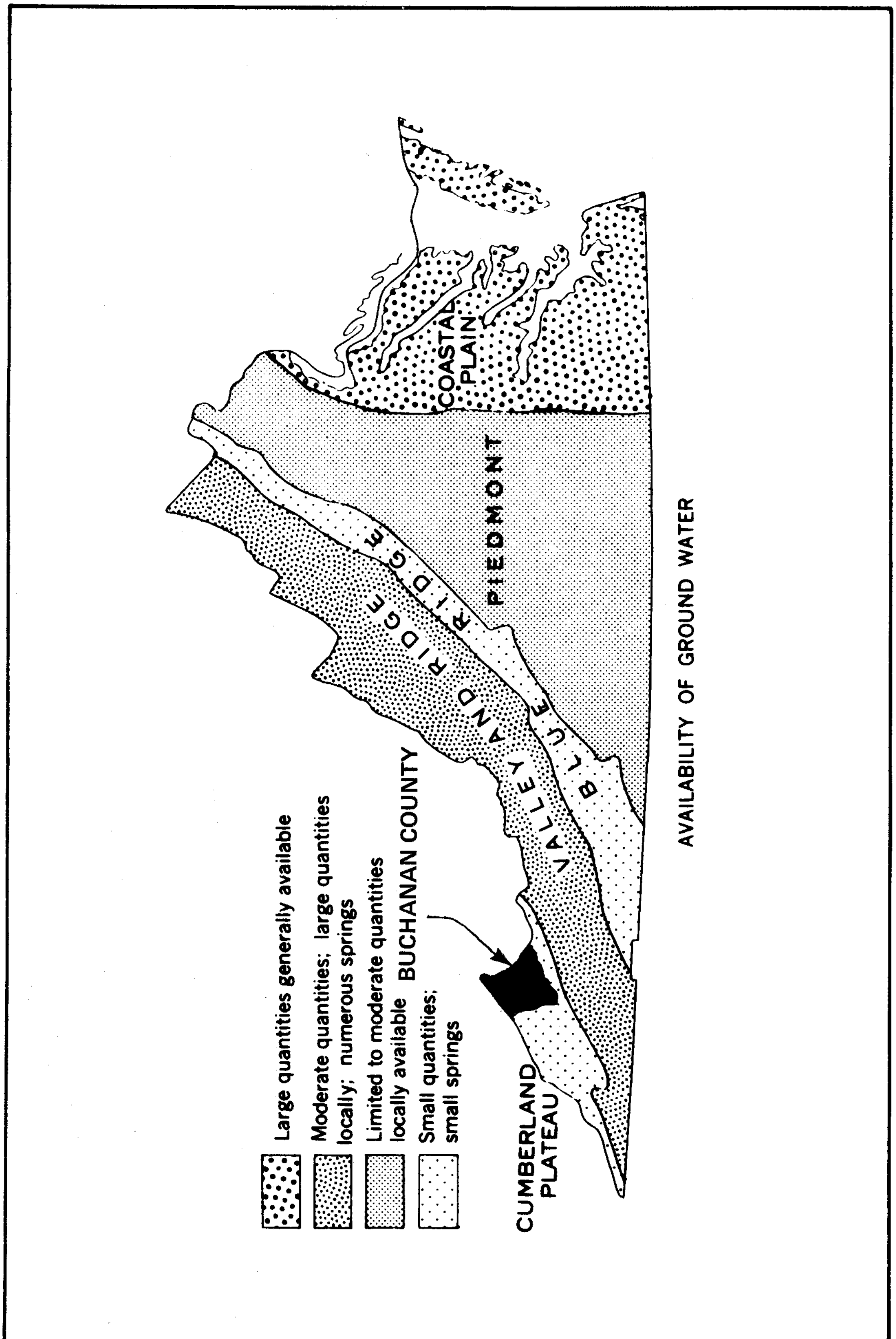


Source: State Water Control Board - BWCM

Frontpiece

EXECUTIVE SUMMARY

BUCHANAN COUNTY GROUNDWATER REPORT

It is the purpose of this report to gather all of the available information on the groundwater of Buchanan County, and to present it in a form in which it can provide governmental agencies, private industry and individual citizens with a concise picture of the existing groundwater conditions in the County, and its future prospects.

Buchanan County lies within the coalfields of Southwest Virginia, and it is the largest producer of bituminous coal in the Commonwealth, with an annual output exceeding 14 million tons. The increased demand for coal as a domestic source of energy will require the expansion of both surface and subsurface mining operations. Population will increase, meeting the demands of an expanding work force. Protection of the existing groundwater resources and its careful utilization in the future will help fill the anticipated increased requirements for water by both industry and population.

The topography of Buchanan County is formed from a raised plateau which has been eroded into a complex group of ridges and narrow, steep-walled, flat-bottomed, V-shaped valleys. The valley bottoms are flood plain deposits of boulders, cobbles, sands and clays which have been transported from the highlands. They are seldom more than 30 feet thick.

Stream flows vary greatly throughout the year, with even the largest streams diminishing to a trickle in dry weather. The steep-sided valleys quickly exit rain water, reducing the volume of recharge into the water table. The denuding of land for strip mining operations hastens runoff even further.

In Buchanan County, nearly all the rocks close to the surface date from the Pennsylvanian Age, which is part of the greatest coal-producing period in the earth's history. They are mostly sandstones, shales and coal beds. Shales usually produce small quantities of water. The voids between the grains of the sandstones are often filled with recemented mineral matter, clay and silt-size particles, and mica flakes, reducing their ability to hold and transmit water. Fractures and fissures in the rocks are often closed at depths below 400 feet due to the weight of the overlying strata. This diminishes both the volume and flow of groundwater. Below 400 feet, the water becomes increasingly salty.

The groundwater in Buchanan County is typically slightly acid, irony, somewhat hard and often contains compounds of sulfur. In the coalfields, the water may contain methane and hydrogen sulfide gases. A typical water well is discussed in the report, along with a recommended technique for venting the well to reduce the danger of accumulating gases. Also discussed are methods for reducing iron, manganese, corrosiveness and bacteria from the groundwater.

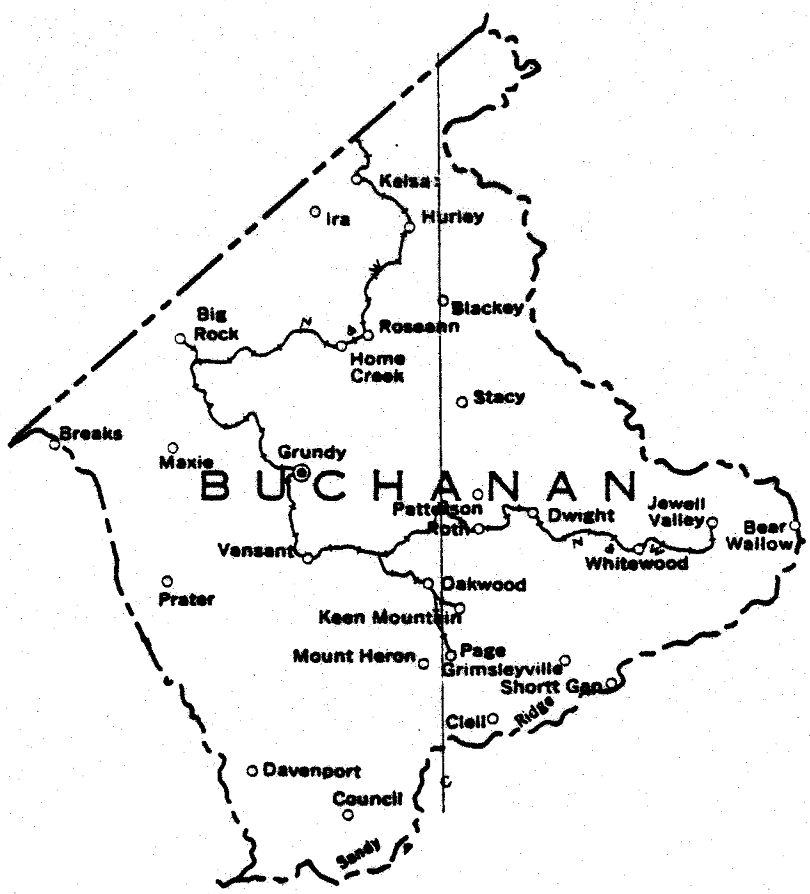
Nearly all of the drinking water in Buchanan County comes from wells, although some is produced by springs, and a few families on ridges use water from cisterns. The largest wells have been developed to serve large shaft mines, coal preparation plants and coke ovens. Several large coal preparation plants have flow rates greater than a million gallons per day, but they recirculate their water so that well, mine or surface water is required only to replace water lost during processing.

The report discusses the methods which would be necessary to develop a large-scale groundwater supply. This would involve placing several wells in a valley fed by a large stream, alternate pumping, proper well depth and using large casing. Also discussed are groundwater problems such as depletion due to overpumping or infiltration into abandoned mines, and quality deterioration caused by mining activities.

The report recommends the adoption of moderate regulations for groundwater use, with priority for human consumption. It concludes by stating if population, industrial usage and mine dewatering continue to grow at recent rates, the total groundwater supply will probably fall short of the County's needs by the year 2000.

BUCHANAN COUNTY GROUNDWATER

Present Conditions and Prospects



By

Susan R. Epps

SOUTHWESTERN REGIONAL OFFICE

VIRGINIA STATE WATER CONTROL BOARD

BUREAU OF WATER CONTROL MANAGEMENT

RICHMOND, VIRGINIA

PLANNING BULLETIN NO. 311

OCTOBER 1978

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ACKNOWLEDGEMENTS

The writer would like to thank many individuals and organizations who provided information and assistance toward this report. The cooperation of dozens of people who allowed access to their wells for sampling is gratefully acknowledged. Several employees of the Island Creek Coal Company supplied information on water conditions in the Company's mines and assisted in sample collection. The Buchanan County School Board and school staffs were helpful in taking water samples from school wells. Special thanks are due to Mr. Don Burke of Keen Drilling Company, and Mr. Noah Horn, water well contractor, for sharing their experience in drilling and groundwater conditions, and for supplying well data. Access to the files and experience of the State Health Department's engineering staff in Abingdon also is greatly appreciated.

FOREWORD

This report is part of a series intended to cover the entire State, and to provide private citizens, groundwater users, developers, investors, well drilling contractors, consultants, professionals, and government officials with as complete a picture as possible of the groundwater situation, including prospects, as it exists in each of the counties of Virginia.

On the basis of this report, prospective groundwater users and anyone else interested in the development and protection of that invaluable resource that is groundwater can call a consulting hydrogeologist to handle their specific groundwater problem, while the State Water Control Board remains at the public's service for general information and governmental action.

BUCHANAN COUNTY GROUNDWATER

PRESENT CONDITIONS AND PROSPECTS

by

Susan R. Epps

ABSTRACT

Buchanan County, part of the coal fields of Southwestern Virginia, is characterized by steep and rocky terrain with no large rivers. Surface streams have such low flows in dry weather that groundwater must supply water for human and most other needs.

The County has shale, sandstone, and coal covered by thick soil in valley bottoms only. Potable groundwater is found mainly in the upper few hundred feet of bedrock. Moderate quantities of groundwater are available in valleys but the ridges have little or no water. The groundwater quality is fair to poor, with acid, iron, sulfur, salinity, and gas being the main problems. Quantity and quality are further reduced as well depth increases. In certain areas, mining activities and over-development of wells have depleted the groundwater resource and degraded its quality. Future consideration must be given to the limitations of the groundwater resource and the interrelation between it and the development of the coal resource.

CHAPTER I

INTRODUCTION

General

Buchanan County lies in the coal fields of Southwest Virginia, and is part of the Appalachian Plateau Province. It is bounded on the northwest by Pike County, Kentucky; on the northeast by McDowell County, West Virginia; on the southwest by Dickenson County, Virginia; and on the southeast by Russell and Tazewell Counties, Virginia. Its largest town is Grundy, the county seat, which is centrally located. Several communities have grown up in the vicinity of large coal mines. South of Grundy are Vansant, Deel, Oakwood and Keen Mountain, which form an almost continuous chain of development in the Levisa Fork valley along U. S. 460. A built-up strip extends north from Grundy along the Levisa Fork and U. S. 460 to Big Rock, which is near the Kentucky line. Hurley community is in the northern corner of the County.

The 1970 census indicated that 32,071 people lived in Buchanan County, and 2,050 people were in the town of Grundy. Nearly all live in the narrow valleys and hollows. The economy is dependent on coal mining, which employed almost half the work force in 1970. Buchanan County had Virginia's heaviest coal production, 14,814,524 tons, in 1970. Other products from natural resources include natural gas, coke and lumber. Manufacturing and farming are small contributors to the County's economy.

Methods of Investigation and Data Assembly

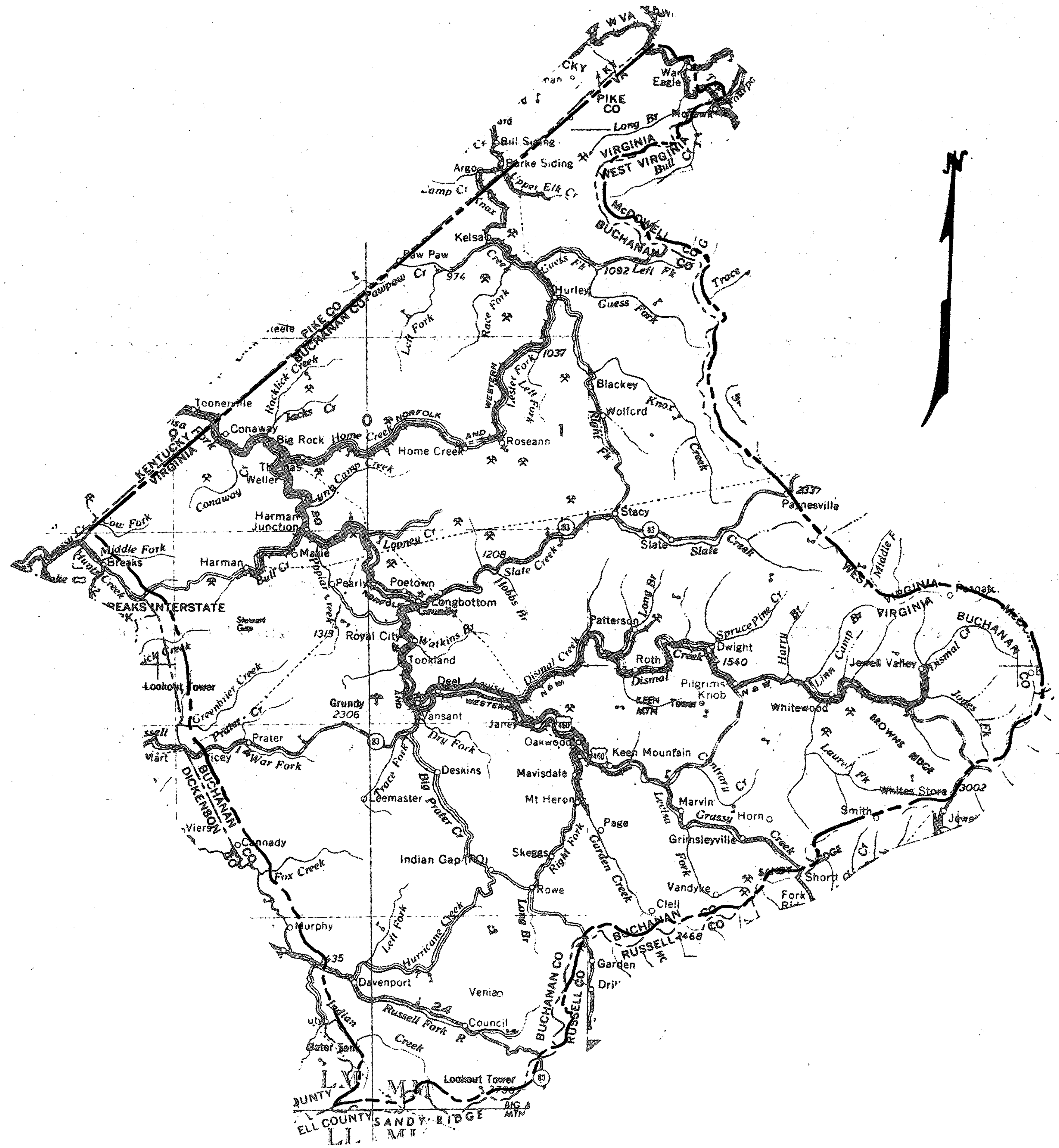
Most of the data in this report have come from continuing effort projects by the State Water Control Board. No attempt was made to do geologic mapping, as information of this type is obtainable from the Virginia Division of Mineral Resources. Water samples for analysis are spigot samples, and the analyses were performed by the Water Control Board's laboratory in Abingdon, and by the State Consolidated Laboratory. Field data taken for wells include coordinate locations, geologic formation, environment and any information the owners can supply, such as depth or yield. More complete information on well construction and yields was obtained from well drillers in the form of Water Well Completion Reports.

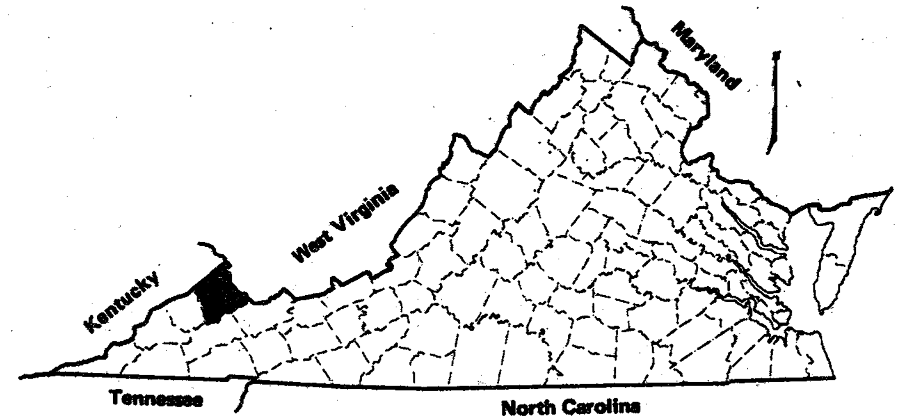
All well information, completion reports and records of chemical analyses used in this report are in the files of the State Water Control Board in Richmond, and the Southwest Regional Office in Abingdon. These data have been computerized for storage and retrieval, and were used to compile Tables 3 and 4.

Water Well Numbering System

Each water well on file with the State Water Control Board has been assigned a number. Well numbers are assigned consecutively as information is received, giving each well in a county a unique number. In this report, wells are identified throughout the text and plates by their numbers, which are listed with other well information in Table 3.

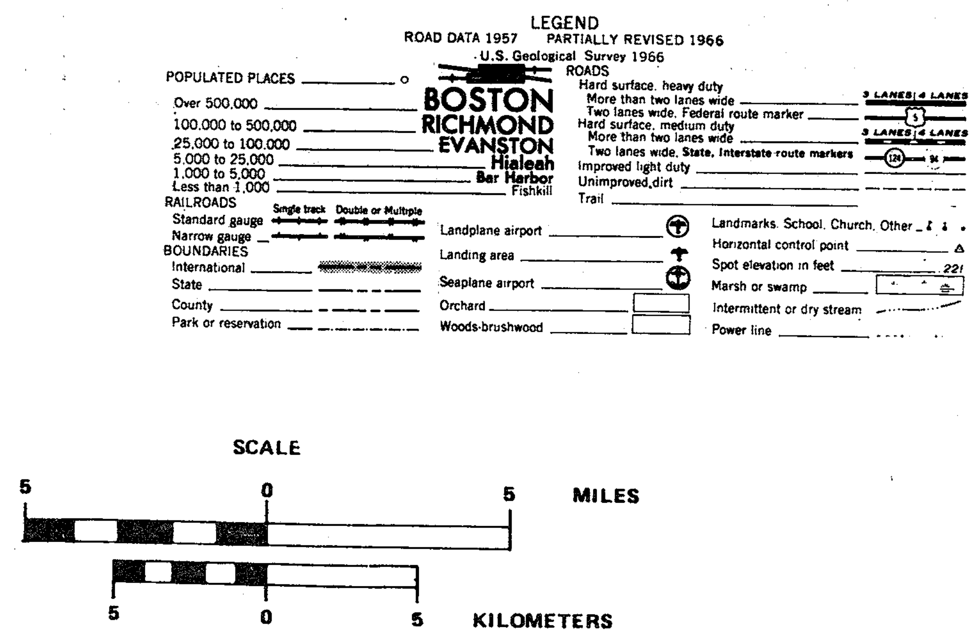
INDEX MAP OF BUCHANAN COUNTY





County Area: 508 Square Miles

County Population: 32,071 (1970)



Source: Virginia State Water Control Board—SWRO

PLATE NO. 1

CHAPTER II

PHYSICAL SETTING

Physical Characteristics

Buchanan County, part of the coal fields of Southwest Virginia, could be characterized as a jumble of irregular mountains cut by narrow, steep-sided valleys. Altitude ranges from 845 feet above sea level where the Levisa Fork enters Kentucky to 3,735 feet on Big A Mountain at the Russell County boundary. Buchanan County has an area of 508 square miles about 87 percent of which is forested.

The most prominent ridge is Big A Mountain which forms the southeast boundary of the County. Other ridges attain a maximum of 2,300 to 2,600 feet above sea level. They have no preferred orientation though all have steep sides with slopes that frequently reach 50 percent or more. The valley of the Levisa Fork roughly bisects the County, passing southeast to northwest and through Grundy. It is intersected by the valleys of Dismal Creek and Slate Creek from the east. The bottoms of these larger valleys are seldom more than 500 feet wide. Nearly all but headwater streams have developed a flood plain or flat bottom in their valleys though most of these valleys are very narrow. The Buchanan County land form is typically either steep mountainside or flat flood plain with little area of gentle slope.

Buchanan County's topography has been altered by man. Strip mines have cut into many ridges and follow the same level along the mountain. The larger ones may be 100 feet wide, have vertical cuts

80 feet high and are a mile long. Refuse piles of waste rock and coal have accumulated near coal mines and preparation plants. These wastes are usually piled in a hollow or valley and may completely fill in these spaces. The same material is frequently used for fill in valley bottoms.

Hydrology

Buchanan County is part of the Big Sandy River Basin which drains in a northwestward direction to the Mississippi River and ultimately to the Gulf of Mexico. The County lies in the headwaters of the tributaries of the Big Sandy River. The Levisa Fork drains the central portion of the County, Russell Fork drains the southwest side, and Tug Fork and its tributary, Knox Creek, drain the northeastern side of the County. Streams in Buchanan County have steep profiles and rocky beds.

Severe variations in stream flow result from the County's steep terrain. Utilization of surface water is hampered because even the largest streams diminish to a trickle in dry weather, and construction of reservoirs would flood scarce level land displacing people and their livelihood in the valleys. Quick runoff makes streams prone to flash floods, and several times a year some stream overflows its banks. Records from a gaging station on the Levisa Fork at Grundy illustrate the unreliability of surface streams. Average flow over 28 years is 272 cubic feet per second (cfs), the minimum flow is 0.2 cfs and the maximum flow was 33,200 cfs. Average runoff for the County is 1.13 cfs per square mile.

Climate

The climate of Buchanan County, determined by latitude, elevation, topography and the prevailing winds, is classed as central temperate. The County receives precipitation from winter storms, humid tropical air masses and thunderstorms. Precipitation is about 37 to 44 inches per year; an average of about 21 inches of snow falls in a year. The heaviest precipitation results from late winter rains and summer thunderstorms. Weather records for Grundy show the highest monthly average precipitation in March and July at 4.10 and 4.15 inches, respectively. The dryest part of the year begins in September with a low rainfall of 2.00 inches in October.

The average annual temperature reported at Grundy in nine years of record is about 57° F. The average temperature for January is 34.4°, and for July is 76.6°. This station has recorded extremes of -12° and 100°.

Soils and Vegetation

Soils are sandy, stony and thin over most of the County. They are derived from the weathering of bedrock; the sandstones break down into sand and the shales weather to clay. Soil on the ridges is generally no more than a foot thick, of low fertility, and water holding capacity is moderate to poor. Thicker soils are found in the valleys. Colluvial soils slide and wash down slopes forming piles at the bases of ridges. Soils in valley flats consist of silt, sand, gravel and boulders that have been deposited by streams. These terrace deposits may reach a maximum depth of about 20 feet.

About 87 percent of Buchanan County is forested. Oak, hickory and maple predominate, and the greater part of the forested area consists of sapling and pole-size timber. About eight percent of the County is farmed chiefly for tobacco and grazing. Strip mines and refuse piles have created areas nearly bare of vegetation, but legislation provides that recent strip mines, spoil and refuse must be revegetated.

CHAPTER III

HYDROGEOLOGY

Geologic Setting and History

Buchanan County is part of the Appalachian Plateau Province which is characterized by layered sedimentary rocks with little folding and breaking. The Province includes the coal mining areas of Virginia, West Virginia, Kentucky and Tennessee, where the surface rocks are mostly shale, siltstone, sandstone and coal. Buchanan County lies next to the folded rocks of the Appalachian Valley and Ridge Province, where long, broad valleys have formed in limestones and the higher ridges are capped by sandstone.

The rocks discussed in this report originated as sediments deposited in ancient seas and coasts. Almost all of the hard rock formations at or near the surface in Buchanan County date from the Pennsylvanian Age, which existed roughly 280 to 320 million years ago. The environment then probably resembled that of the present-day Middle Atlantic Coast. Rivers flowed westward from the area of the present Appalachian Mountains to an inland sea which sometimes covered parts of Buchanan County. Sand and pebbles were deposited along rivers and beaches; silt, mud and clay settled out in marshes, lagoons and on the sea floor. Where the land was low and swampy, thick fern-like vegetation grew and formed peat beds. Thousands of feet of sediments accumulated with time and the weight of upper layers compressed the lower layers into rock. Sand and pebble beds became sandstone, and conglomerate, mud and silt became shale and siltstone; plant remains became coal.

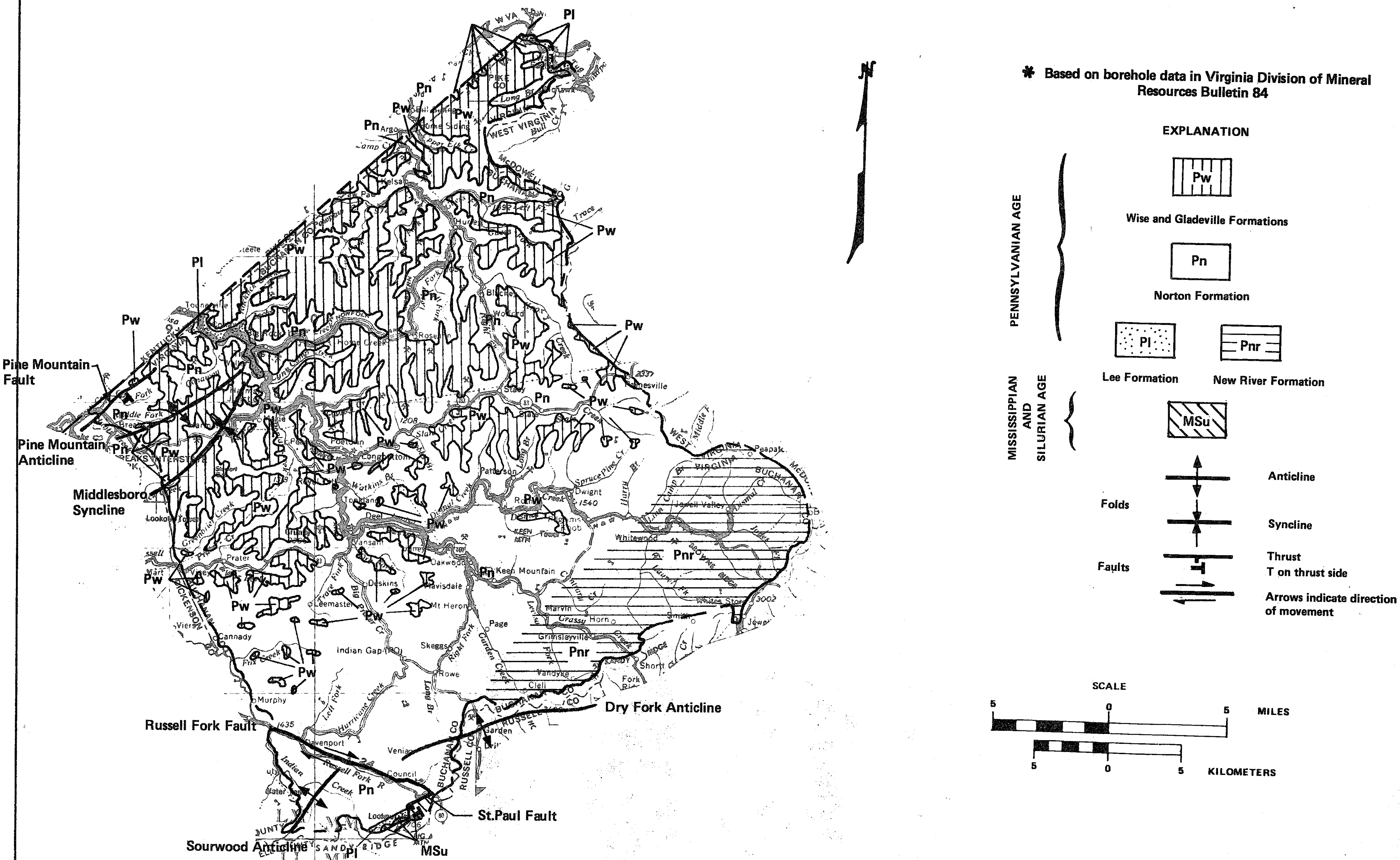
During the time of Appalachian Mountain building, the Buchanan County area was subjected to lesser amounts of the same forces that created the mountains to the east. First, the area rose well above sea level, which stopped deposition of sediments and began erosion. Then, rock layers buckled under pressure into slight folds; and last, the rocks broke forming several long faults.

Meanwhile, streams continued to flow in a general northwestward direction across the County. When the land was raised, the streams began cutting valleys and erosion started removing the upper layers of rock. Erosion by weather and streams continues today, although down-cutting of valleys has slowed, permitting streams to deposit sand, silt and boulders in valley bottoms. The stream deposits are considered to be of Quaternary Age, as they are still being made and shaped.

Structure

In general, the rocks in the County are almost level. Slight folding has occurred, causing rock layers to dip or slant down only 70 to 80 feet per mile, on the average, toward the northwest. There are three anticlines where rock layers have been slightly arched upward, which are shown on Plate 2. The largest arch, the Dry Fork anticline, runs near the southeast boundary of Buchanan County and into Tazewell County. It has raised and tilted the rocks in an area several miles wide along the southeast border, but dips are still only a few degrees. In the western corner of the County is a small

GENERALIZED GEOLOGIC MAP OF BUCHANAN COUNTY, VIRGINIA *



Source: Virginia State Water Control Board—SWRO

arch called the Pine Mountain anticline, with a slight downwarp, the Middlesboro syncline, beside it. Small local folds are visible in many places as undulations in the nearly flat rock layers. In general, the same rock will be found at about the same elevation within a distance of a few hundred feet.

Three major faults have broken the bedrock near the edges of the County. The St. Paul fault has thrusted older rocks upward and northwestward over the coal field rocks, forming roughly a square mile of Big A Mountain in Buchanan County. The Russell Fork fault runs along the stream of that name. The south side of this fault has moved approximately four miles westward relative to the north side of the fault, according to Miller (1974). The Pine Mountain fault is parallel to the Kentucky border and lies within a mile of it. Rocks on the southeast side of the fault have thrusted northwestward and over the northwest side of the fault. In addition to these are many small faults, most of which show only a few inches of vertical movement and a very small break in the rock.

Formations

In order to identify and describe rock strata, they are divided into formations which have recognizable characteristics over an area. Formations are usually discussed from oldest to youngest in the order that they were formed. The sedimentary rocks of Buchanan County have had younger layers placed upon older layers, so the formations will be discussed from deepest to highest. Only the formations that are exploited for groundwater or involved in mining activities will be considered. Except for Big A Mountain, all of the hard rock

TABLE 1

GEOLOGIC FORMATIONS, AQUIFER SYSTEMS AND THEIR HYDROLOGIC PROPERTIES

Age	Formation & Symbol	Lithology (Rock Type)	Thickness in Feet	Hydrologic Properties
Quaternary 0-2 Million Years	Unconsolidated Deposits Qu	Soil, sand, gravel, silt, clay and boulders.	0-20	Unreliable due to shallowness.
Pennsylvanian 280-320 Million Years	Wise Formation Gladeville Sandstone Pw	Sandstone, shale, siltstone and coal beds.	≤ 800	Little or no water because of elevation.
	Norton Formation - New River Formation Pn	Chiefly gray shale and siltstone; also, medium to fine grained sandstone and coal beds.	500-1200	Yields fair to good in first 300 feet below stream level.
	Lee Formation - New River Formation Pl, Pnr	Sandstone, shale, siltstone, conglomerate and coal beds. The coarsest sandstone and conglomerate	100-1300	Yields fair to good in first 300 feet below stream level; mostly dry at greater depths.

TABLE 1 (Cont'd)

(Cont'd)	(Cont'd)	are concentrated in one to three sandstone masses in the Lee Formation. Where all three sandstone masses are absent and the formation is mostly siltstone and shale, it is referred to as the New River Formation.		
	Pocahontas Ppo	Sandstone, siltstone, shale and coal beds.	0-600	Dry because of depth.
Mississippian 320-345 Silurian 395-430	Mississippian and Silurian Formations MSu	Sandstone, conglomerate and shale.	--	Little or no water due to elevation; dry at depth.

Source: Virginia Division of Mineral Resources, Bulletin 84.

formations discussed belong to the Pennsylvanian Age, a part of the Carboniferous Period or great coal forming time of the earth's history. The unconsolidated deposits along streams are considered to be of Quaternary Age.

Formations of Mississippian and Silurian Age. A portion of Big A Mountain that lies within Buchanan County is formed by a number of formations, each having a small outcrop area. For this report, these rocks are grouped together as Mississippian and Siluraian Age formations because of their small area and insignificance as a groundwater source. These formations consist largely of sandstones which are made up of purer sand with less mica and fine material than the coal field sandstones. The sandstones and a conglomerate show red, brown and white colors, and some of the sandstones break into blocky chunks as they weather. Red, brown and green shales, and limy shales make up the remainder of this group of rock.

Pocahontas Formation. The Pocahontas Formation in Buchanan County lies deep underground and is one of the important coal bearing formations. The top of the formation is about 800 to 1,000 feet above sea level in the vicinity of Grundy. It probably has a small outcrop strip near Big A Mountain, but elsewhere it is reached only by deep shaft mines. The formation consists of sandstone, siltstone, shale and coal. The sandstones are mostly gray, have mica flakes, are medium to fine grained and poorly sorted. The siltstones and shales are also gray, and the shales have many coal plant fossils. The Pocahontas No. 1 to No. 7 coal beds are included in this formation. The Pocahontas Formation is thickest, more than 600 feet, on the southeast boundary of Buchanan County. The upper surface of the formation is an unconformity, an irregular surface created when part or all of the formation was removed by erosion. Because more rock is missing toward the northwest, the Pocahontas Formation becomes progressively thinner in that direction and disappears entirely before reaching the Kentucky border.

Lee and New River Formations. The Lee Formation appears at the ground surface in a narrow strip near Big A Mountain and in the lowest elevations in western Buchanan County. In the eastern part of the County, the Lee Formation and some of the overlying Norton Formation merge into the New River Formation. The New River Formation is exposed at the surface in the eastern corner of the County. Its equivalent, the Lee Formation, lies at increasing depths westward. Near Keen Mountain, the top of the formation is drawn about 300 feet above sea level. It lies about 600 feet above sea level at Grundy, and about 930 feet above sea level near Big Rock.

The Lee Formation varies considerably with area. Where it is thickest along the northwest border, the top, center and bottom of the formation are marked by sandstones which are 100 feet thick or more. The sandstones are nearly all quartz, the bottoms of which are coarsest and frequently have quartz pebble conglomerates. Between the sandstones are two main intervals of dark gray shales, siltstones, coals and a few thin sandstones with mica flakes. The Lee Formation includes the Pocahontas No. 8 and No. 9, War Creek and Horsepen coals in the lower shale, and the Tiller, Jawbone, Raven and Aily coal beds are in the upper shale unit. Maximum thickness of the Lee Formation along the Kentucky border is approximately 1,300 feet. The formation becomes thinner toward the southeast, as it loses first the upper and then the middle sandstone. Several miles east of Keen Mountain, the bottom sandstone disappears and the rocks are referred to as the New River Formation. Where the New River Formation is at the surface in eastern Buchanan County, it consists of sandstone, shale, siltstone and coal. The sandstones are usually gray, have a great deal of mica and silt, and are thin bedded except for a massive gray sandstone. The shales and siltstones are darker gray with thin bedding, coal beds and fragments of coal.

Norton Formation. The Norton Formation has the largest exposure in the County. It includes most rocks at the surface in the southern half of the County and west of the outcrop area of the New River Formation, and in lower elevations in the northwestern half of the County. Because of the northwestward dip, the top of the formation slants downward toward the Kentucky border. In the western and central portions of the County, the lower beds of the Norton Formation merge westward into the upper Lee Formation and eastward into the New River Formation. The Norton Formation is made up of shale, siltstone and coal, with smaller amounts of sandstone. The shales and siltstones are gray, thin bedded and frequently have coal plant fossils. The sandstones are lighter gray, medium to fine grained, and usually have mica, clay and silt. The

Norton Formation includes the Norton, Hagy, Splash Dam, Banner and Kennedy coals. As the underlying Lee Formation becomes thinner eastward, the Norton Formation acquires its upper and middle shales and coals. The Norton Formation ranges from about 550 feet thick in northwest Buchanan County to about 1,200 feet thick in the center of Grundy.

Gladeville and Wise Formations. The Gladeville Sandstone and the overlying Wise Formation occur at high elevations in the central and northwestern areas of the County. Near the Kentucky border, the bottom of this group lies about 1,300 to 1,500 feet above sea level. As the formations are traced southeastward and up-dip, they occur at increasing elevations until they disappear altogether. The Gladeville is a gray, coarse, mica-bearing sandstone that weathers with pronounced iron stains while the Wise Formation has dark gray shale and siltstone, sandstone and coal. The top of the Wise Formation has been eroded, and the total thickness is not measurable in Buchanan County.

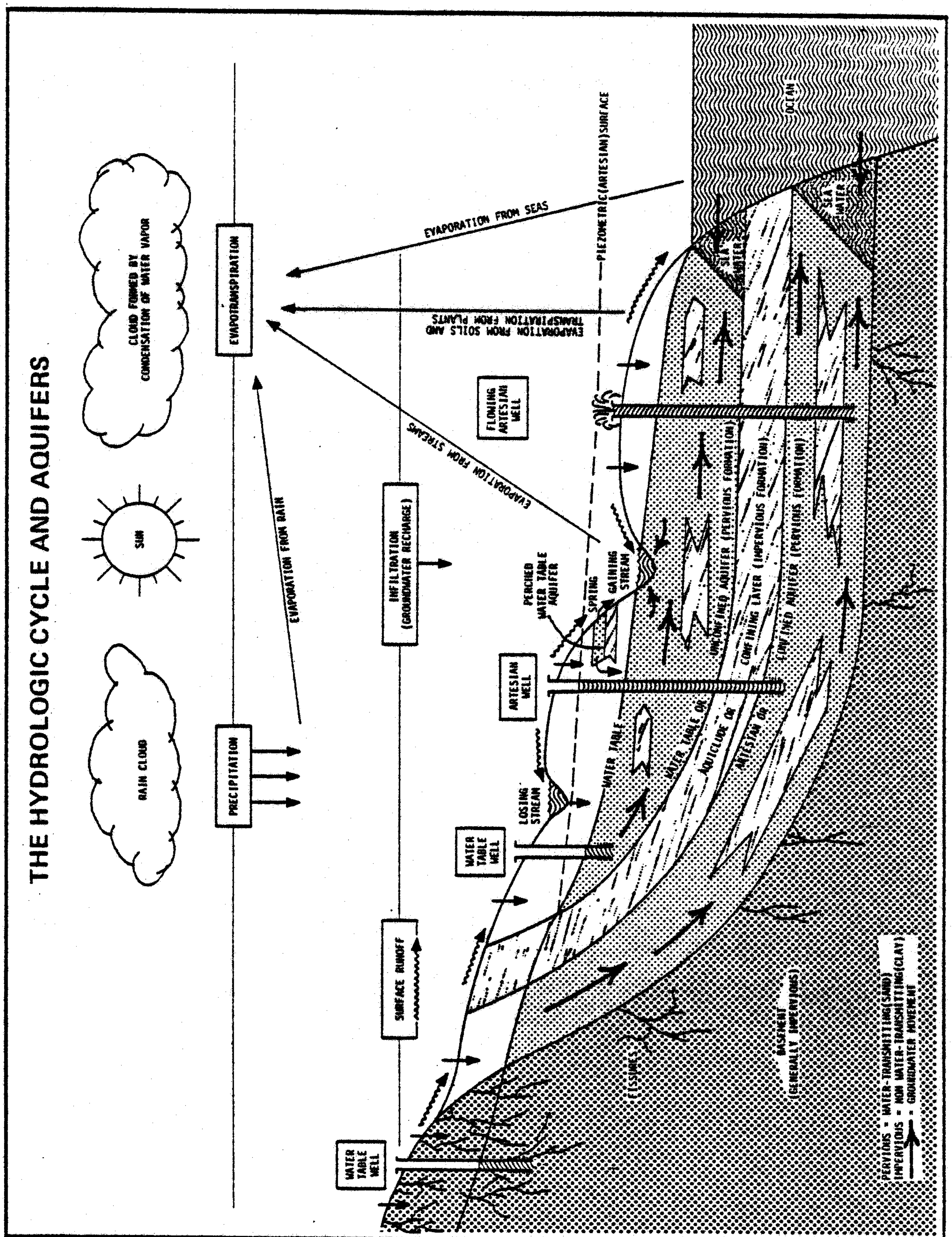
Unconsolidated Deposits. Valley bottoms, filled with terrace and flood plain deposits, have created the flattened bottoms along all major streams and many small ones in all parts of the County. Terrace and flood plain deposits consist of silt, sand, gravel, clay and boulders. The different sizes of material can be mixed together in any fashion, but the base of the deposits and former stream beds are frequently marked by beds of boulders. The thickness of terrace and flood plain deposits is usually less than 20 feet.

Groundwater Origin and Movement

Fresh groundwater originates as precipitation, primarily as rain and snow-melt which soak into the earth, and moves according to gravity. The groundwater system receives all water reaching the earth's surface that does not flow off, evaporate, or is not taken up by plants. Precipitation that has formed surface streams may indirectly supply groundwater when the stream is higher than the water table and sinks into its bed. More water can enter the ground where soils are thick and porous, as in valleys and on gentle slopes. After entering the ground, water is still under the influence of gravity and flows from higher to lower areas. It also tries to follow a path of least resistance. It enters and follows cracks in the bedrock and the more permeable rock layers. If all the water cannot find a way down into rock, it flows along the top of bedrock in the soil layer, frequently emerging as a spring.

The depth to which groundwater can penetrate is limited to the depth of rock openings and permeable beds. Evidence from deep mines and gas wells indicate that little water penetrates beyond 400 feet below local valley level though there are some reports of deep, saline water under artesian pressure in the County and in the adjacent states.

Groundwater flows toward low areas where it discharges naturally as springs and seepage into streams. Groundwater seepage, though usually unnoticeable in stream beds, sustains the flow of streams between rains. Groundwater also discharges through wells, ditches and mine drainage.



Source: State Water Control Board - BWCM **PLATE NO. 3**

Location of Groundwater

Groundwater occurrence in Buchanan County depends on local conditions of rock and topography more than on formations. Consequently, it is not possible to delineate specific water-bearing formations or aquifers. Following is a list of geologic and other factors which determine the availability of groundwater in the County:

Rock Characteristics. The permeability of a rock depends on interconnected openings such as pores between grains through which water can pass. Shales and siltstones are not porous or the pores are too small. A sandstone or conglomerate may have spaces between grains that allow water to flow through, but most of the sandstones and conglomerates of the coal fields are clogged with clay, silt and mica between sand grains, or the grains have grown together. Some massive unbroken sandstones are poor aquifers, but have less matter that will mineralize the water.

Bedding Planes and Contacts. Bedding planes between layers of rock are open cracks that may contain groundwater. Cracks along the contact between two different types of rock are more pronounced and serve as passages for water. Because of the frequent changes in rock type and the common bedding planes, almost any drilled well encounters some cracks in the rock regardless of formation.

Fractures and Faults. Nearly vertical breaks resulting from fracturing and faulting of bedrock can serve as channels for water to move vertically. Except for a few of the larger faults that are mapped, these breaks occur unpredictably and are scattered throughout the County.

Depth. The weight of overlying rock is great enough at some depth to squeeze shut the water-bearing cracks in rock. As water has to go further to a well, its chance of being blocked and the length of time it requires to travel increases. This sets a rough limit of about 300 to 400 feet below local stream level within which useful quantities of groundwater are normally found. In the central portion of the County, and probably in most of the remainder, this limit in water circulation is also an upper limit to deeper, highly mineralized, stagnant water. The Pocahontas Formation and lower Lee Formation, which are penetrated by coal mines in the eastern half of the County and by gas wells throughout the County, are nearly dry.

Topography. Topography is the major control of precipitation runoff, so it controls the infiltration of water into the ground. The largest and most reliable sources of groundwater have been found in valleys and on lower slopes. The few wells drilled on tops of ridges usually are dry holes or go dry. This effectively eliminates the Gladeville sandstone and Wise Formation, and parts of the New River and Norton formations that are high above valley levels as important sources of groundwater.

Streams. Streams are a source of groundwater recharge and mark the upper surface of the water table. Rocks below stream level will be saturated with water, and a well drilled close to a stream and extending below it may draw water from the stream.

Terrace and Flood Plain Deposits. The loose rock, sand and silt in valley bottoms are probably the most permeable formation in the County. Unfortunately, they are thin and the water table is usually near the bottom of these deposits, especially in dry weather. They are not likely to be reliable producers of groundwater unless they extend deeper than stream level, and most Buchanan County streams are flowing on bedrock.

Depth to Water

The level at which water stands in a well and below which all rock openings are filled with water is called the water table. The water table in Buchanan County generally imitates the land surface in subdued form at a lower level. Water levels will have the highest altitude in ridges, but because groundwater drains down from ridges, the levels will be deeper below the top of a ridge than elsewhere. Under valleys the water table is close to stream level. Wells drilled at the base of a slope occasionally overflow at the surface because of the head of water in the slope.

Heavy pumpage, as from wells or mines, lowers the water table. Wells located together sometimes interfere with each other, and large numbers of wells in built-up areas cause a general lowering of the water table. This is happening around Vansant and probably other areas, too, where wells are thick, water levels are dropping, and the shallower wells are going dry. Pumping and draining of underground mines are necessary to prevent groundwater from flooding them, but it also lowers water levels above the mine, sometimes to mine level. Jewell Ridge, on the southeast boundary of Buchanan

County, is one of several areas of the Virginia coal fields that have been dewatered by mining. The most severe lowering of the water table is on mined-out ridges, and reports of dewatering have been scattered throughout the County. Sometimes a new water supply has been discovered by drilling below the mine.

Key Water Wells

The State Water Control Board maintains a network of Groundwater Research Stations across Virginia. Activities under this program in Buchanan County have been the monitoring of groundwater levels and quality. Observation Well No. 51 was operated in Buchanan County from March 1972 to February 1974 (Well No. 24 on Table 3). It is located on Slate Creek in Grundy, is 288 feet deep and taps the Norton Formation. Water levels measured in this well reflected seasonal variations in precipitation. Table 2 shows monthly average measurements from a continuous water level recorder on Observation Well No. 51. Detailed records for this well are available from the Bureau of Surveillance and Field Studies at the State Water Control Board office in Richmond.

Monitoring wells are regularly sampled for possible changes in groundwater quality. The following two wells in Buchanan County have been used in the quality monitoring program: Well No. 68, which is located at the Island Creek Coal Company's central shop near Oakwood, and Well No. 89, which is at the sanitary landfill near Grundy. The discharge from an abandoned coal mine directly under the landfill is also being monitored. The groundwater quality monitoring program has been active in Buchanan County since August

Table 2

OBSERVATION WELL NO. 51 (GRUNDY)

Water Level Measurement

Owner:	Town of Grundy	Aquifer:	Norton Formation
County:	Buchanan County	Elevation:	1,115 Ft. M.S.L.
Period of Record:	March 1972 - February 1974	Total Depth:	288 Ft.
Location:	364,500 N x 955,480 E (Virginia Plane Coordinates)	Diameter:	10 In.

Monthly Average Low Point Measurements
Feet Below Land Surface Datum

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year Avg.
1972	--	--	106.35	105.80	105.70	105.72	106.29	113.93	115.15	114.40	113.81	114.04	110.12
1973	114.48	114.90	--	--	--	--	--	--	--	--	--	--	--
1974	112.94	113.94	--	--	--	--	--	--	--	--	--	--	--

Source: Virginia State Water Control Board - SWRO

1975. Updated analyses will be available as they are made from the State Water Control Board's regional office in Abingdon, or from the Bureau of Surveillance and Field Studies at the Agency office in Richmond.

CHAPTER IV

GROUNDWATER QUALITY

All groundwater contains some mineral matter dissolved from rocks. The amount and chemical composition of dissolved matter depends on the type of rock and length of contact. Human activities may add more chemicals to the water or may aggravate natural effects on groundwater quality. Groundwater in and near coal seams is usually more mineralized than groundwater from other types of rock. Water quality worsens as depth increases, and 300 to 400 feet below stream level seems to be the lower limit to drinkable water in Buchanan County. Very shallow groundwater occurring in soil on top of bedrock is prone to contamination. The poorest quality water comes from wells in the Keen Mountain to Grundy area.

Buchanan County's groundwater is characteristically acid to slightly alkaline, irony, somewhat hard and may have a sulfurous odor. Total solids range from low to high, and bacterial contamination seems to be a minor problem except in shallow water. Groundwater from depths of less than 300 feet below valleys is generally fresh. Residents complain most commonly about taste, odor, staining, corrosion and gas. Occasional complaints include gas explosions of wells, digestive system upsets, turbidity, scums, hardness and deposits. A listing of chemical analyses is given in Table 4, page C-3. More complete information is on file at the State Water Control Board offices in Abingdon and Richmond.

Gas and Odor

The presence of gasses in water is manifested by odor, bubbles, gas collecting in water systems, and sometimes, in severe cases, by fires. The most common complaints are for odor. The most dangerous situations involve a sufficient quantity of gas to cause fire or explosion.

The chief cause of odor seems to be sulfur compounds, especially hydrogen sulfide (H_2S) gas. Hydrogen sulfide is a gas with an odor like rotten eggs, and is described by some residents as a "swampy smell." It is flammable and poisonous in high concentrations and seems to aggravate corrosion. The minimum concentration that can be detected by taste in drinking water is 0.05 milligrams per liter[1], and concentrations of a few tenths of a milligram per liter cause odor[2]. Hydrogen sulfide in groundwater may have come from the anaerobic decomposition of plant matter during coal formation, or may result from a reaction between sulfur minerals and groundwater. The odor problem is worst in the Keen Mountain to Vansant area, but wells having a hydrogen sulfide odor are scattered across the rest of the County. Being a gas, hydrogen sulfide will leave water upon standing and can be removed by aeration.

Some water wells produce sufficient quantities of gas to cause fires or explosions. In these cases, methane is believed to be the

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[1]California State Water Resources Control Board, Water Quality Criteria (1963), p. 200.

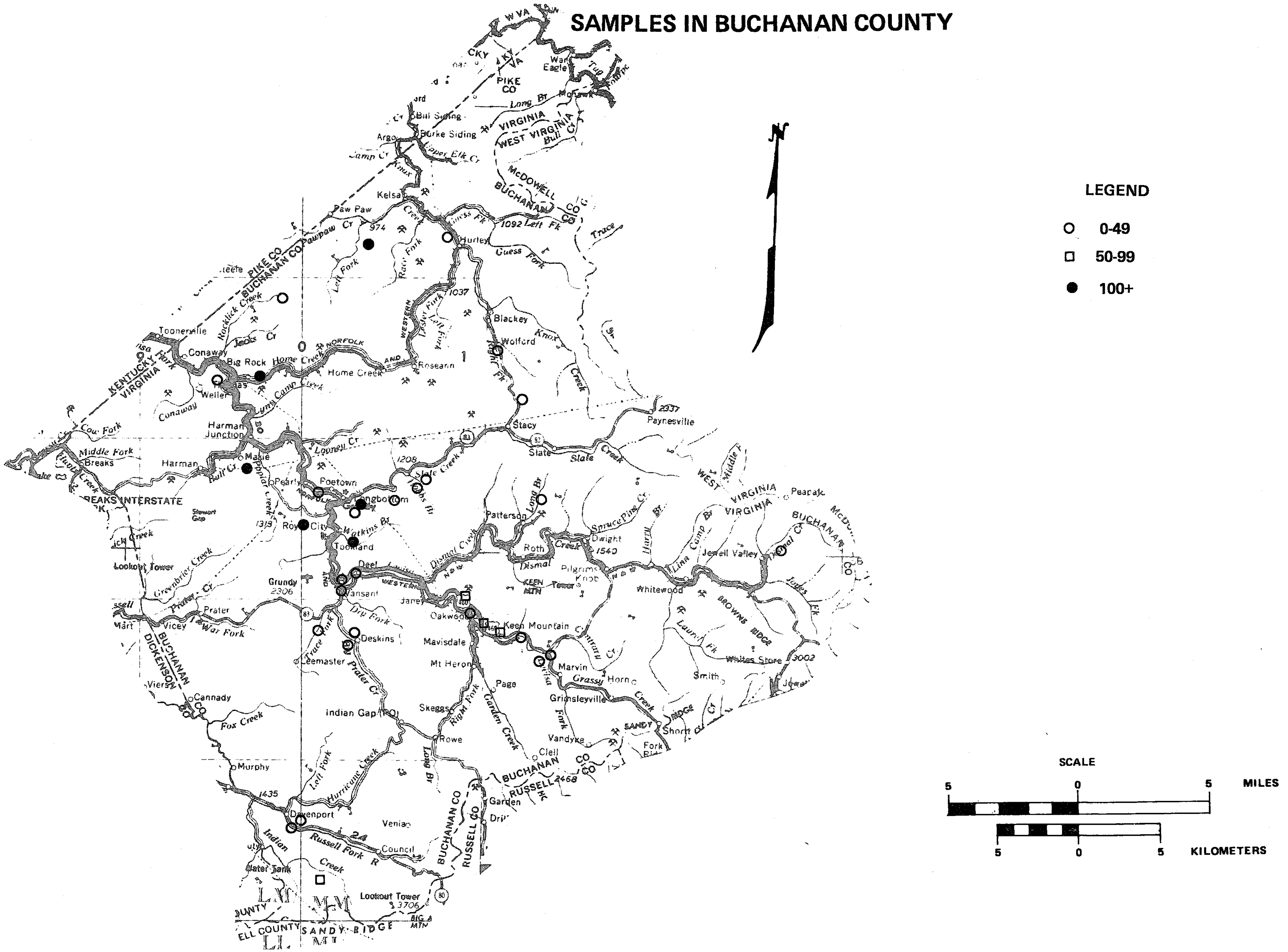
[2]APHA, AWWA and WPCF, Standard Methods (1971), p. 551.

chief offender, usually accompanied by hydrogen sulfide, and possibly natural gas or sulfur dioxide gas. Methane alone is odorless, tasteless and highly flammable. It is noticed by its flammability and by forming bubbles in water. Methane is produced by decomposition of organic matter underground and is associated with coal seams. It is a major hazard in coal mines and is most common in water wells of the Oakwood and Vansant areas. Fire precautions should be taken for gas in wells just as for natural gas. Well and pump houses, filters, water tanks and hot water heaters are likely places for gas to collect. Fires have been started by electrical sparks and by people entering well houses with lighted cigarettes. For an example, well No. 6 at the Oakwood Highway Shop exploded, blowing the roof off the well house and destroying the pump and pressure tank. The gas was believed to have been ignited by an electrical spark. The danger of flammable gas can be partly avoided by placing the well some distance from a house or other structure and by venting the well, which was not done on the Highway Shop well before the explosion. Plate 10 shows a typical water well with a gas vent.

Sulfates

Sulfates seem to be the compounds most likely to render groundwater undrinkable in Buchanan County. Sulfates cause very unpleasant tastes and a sulfurous odor, and there have been complaints of slight diarrhea and nausea from highly sulfurous water. The Virginia State Department of Health and U. S. Public Health Service give a recommended limit of 250 milligrams per liter on sulfates, but taste and

SULFATE IN MG/L FROM WELL SAMPLES IN BUCHANAN COUNTY



Source: Virginia State Water Control Board-SWRO

PLATE NO. 4

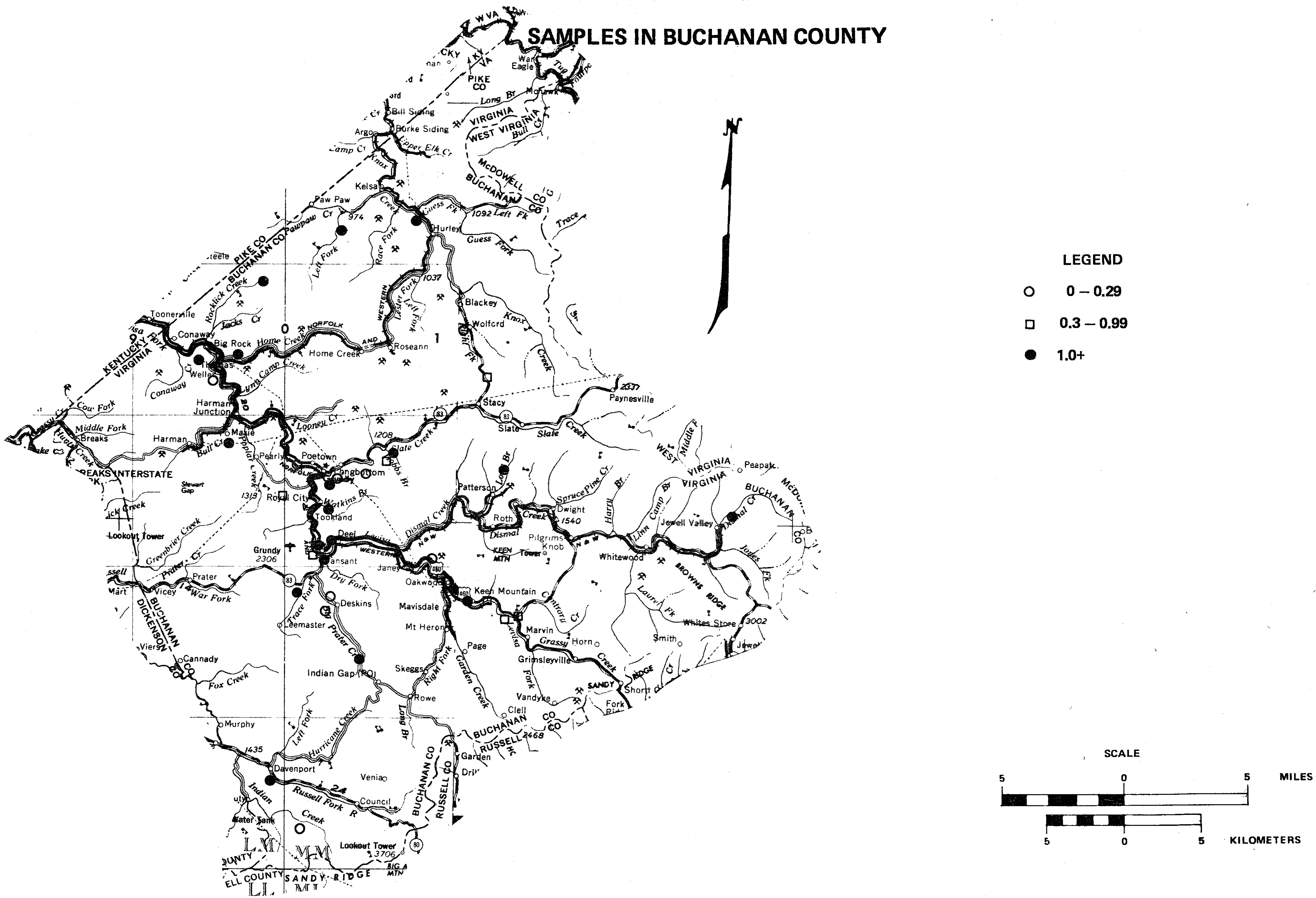
effects on digestive systems appear at lower concentrations when hydrogen sulfide and high total dissolved solids are also present. The sulfates in groundwater are most likely to be sodium sulfate, calcium sulfate (gypsum), magnesium sulfate (Epsom salt), potassium sulfate and ferrous sulfate. Sulfur appears to take hydrogen sulfide and sulfates as alternative forms; usually, when hydrogen sulfide is strong, analysis will show sulfate to be low.

Natural sulfates in groundwater are produced by leaching and oxidation of sulfur minerals such as pyrite in coal seams. Mapping the incidence of sulfates on Plate 4 reveals no geographic pattern. Sulfur minerals occur in coal and are worse in some coal beds than others. Mine discharges that were analyzed had up to 800 milligrams per liter of sulfates, and well No. 90, which is known to have penetrated a coal mine, had 426 milligrams per liter of sulfates. Casing off coal seams during well construction has been known to reduce the sulfurous content, probably hydrogen sulfide as well as sulfate, in water. Filters for removal of sulfur compounds have been effective for many wells but ordinary water softeners do not help.

Iron

Iron is the usual cause of red and brown stains on clothes and porcelain. In heavy concentrations, it causes water to turn reddish or makes an iron floc which settles to the bottom in a reddish, rusty-looking mass. Locally, it is sometimes called "rusty water" and "red sulfur." Iron problems are worse with acidic water, which aggravates the problem by corroding iron from pipes which then enters the water supply as flecks of rust or as dissolved iron.

IRON IN MG/L FROM WELL SAMPLES IN BUCHANAN COUNTY



Source: Virginia State Water Control Board – SWRO

PLATE NO. 5

Iron in groundwater occurs as compounds such as ferrous sulfate, ferrous oxide or ferrous chloride. Ferrous oxide, upon contact with air in pressure tanks and on the surface, forms ferric oxide or rust, which explains the red color and rust that often appear in well water after it stands awhile. The Virginia State Department of Health has set a recommended limit of 0.3 milligrams per liter on iron, which is the concentration above which staining begins. Iron may begin to give water a slight astringent taste at 0.1 milligrams per liter.[3]

Iron is a common element in the earth's crust and is found in all types of rock in Buchanan County. Iron minerals break down and enter groundwater fastest where they are exposed to weathering. Red or brown iron stains on rock and rusty deposits in mine drainage are evidence of iron, and a well drilled in the same rock would be expected to have irony water. No area of the County is known to be immune to iron problems (see Plate 5). Well drillers report that the coal beds and upper weathering zone of rock are frequently irony and recommend casing off these layers. The use of plastic piping eliminates corrosion of iron from pipes by acidic water. Iron filters are popular in both domestic and public water supplies, but usually do not solve the problem completely. A high manganese content interferes with iron filters. Irony water is also treated by spraying or trickling to aerate it; this converts most of the iron to ferric oxide which is then filtered out by sand.

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[3] Water Quality Criteria (1963), p.202.

Manganese

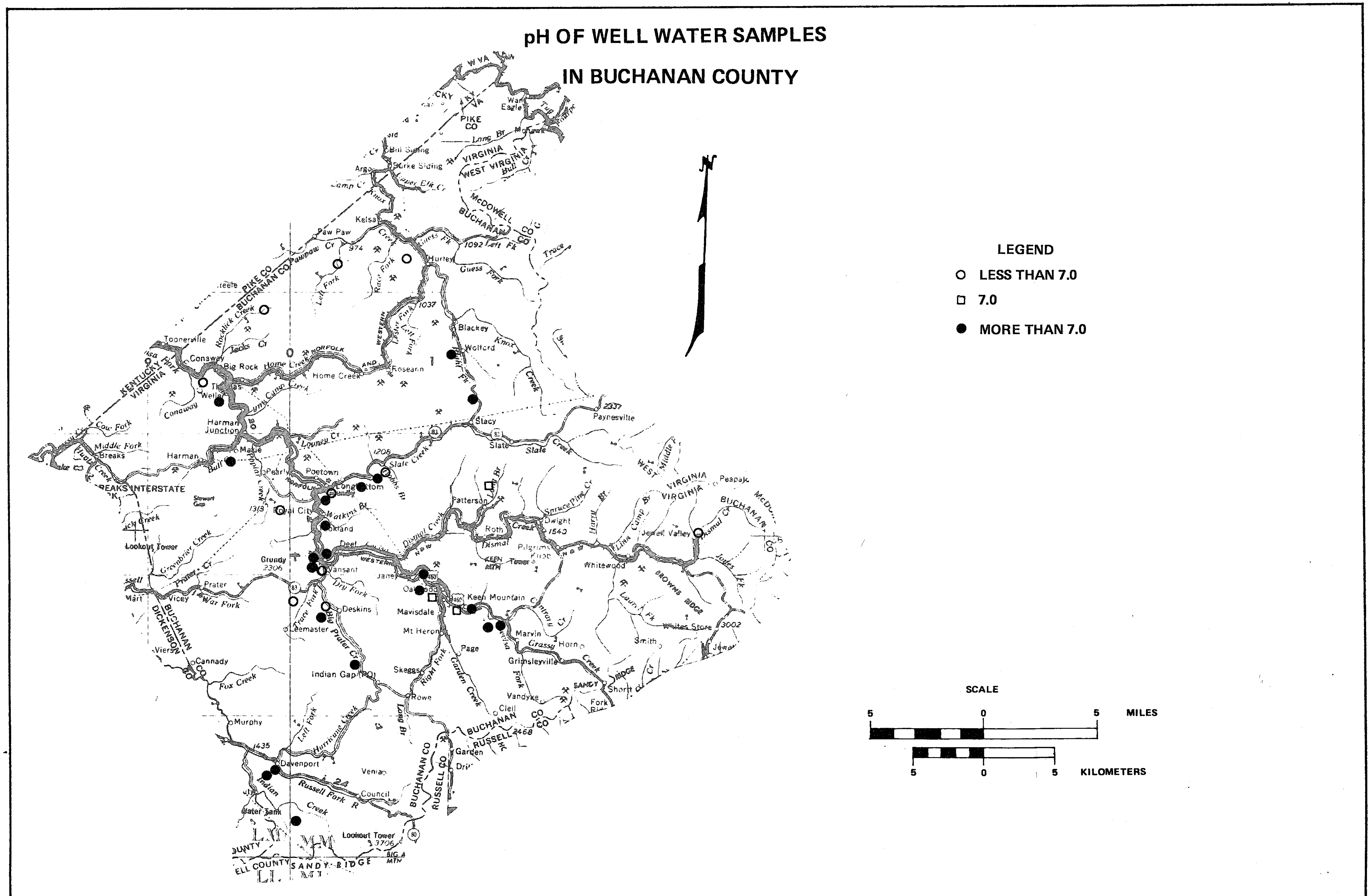
Manganese frequently occurs with iron in groundwater and has similar characteristics. It is noted for causing a metallic taste, discolored laundry, black stains on fixtures and colored water. Concentrations as low as 0.1 milligram per liter may cause staining, and even less can affect some industrial processes.[4] An exceptionally high manganese content of 3.15 milligrams per liter was probably responsible for the blackish water and heavy black deposits on porcelain at the Quillen and Garden Schools (well No. 76). Manganese impairs the efficiency of iron filters. The State Health Department has a recommended limit of 0.05 milligrams per liter for manganese.

Manganese is dissolved by groundwater from manganese-bearing minerals and from concentrations of manganese in soils. The same precautions in well construction that help to avoid iron also seem to reduce manganese. Ion exchange filters for manganese or for manganese and iron are being used successfully. Aeration and chemical precipitation are some possible treatment methods.

pH, Alkalinity and Corrosion

The pH of a water is a measure of the degree to which it is acid or alkaline. A pH of 7.0 is neutral, pH values above 7.0 up to a maximum of 14.0 are increasingly alkaline, and from 7.0 down to a minimum of 1.0 are increasingly acid. The alkalinity is a measure of the water's ability to neutralize acids. As a general

[4] Ibid., p. 214.



Source: Virginia State Water Control Board — SWRO

PLATE NO. 6

statement, waters having a pH less than 7.0 act like weak acids and are corrosive to water systems. Waters having a higher pH than 7.0 are slightly alkaline and tend to deposit matter in pipes. Most boiler feed waters need a pH in a range from 8.0 to 10.0, but excessive alkalinities contribute to boiler scale. Well water samples from Buchanan County had pH values from 6.3 to 8.2, and the worst corrosion was noticed with the most acid or saline water. In several wells having hydrogen sulfide, a drop in pH was observed as the water stood and the pipes showed corrosion, even with pH's up to 7.3.

The pH of groundwater depends on what substances the water has dissolved from both natural and man-made sources. Rain becomes slightly acid by absorbing carbon dioxide from the air, and it acquires organic acids from plant remains and soil when it enters the ground. As it resides in soil or rock, groundwater takes on the pH of the most easily dissolved minerals around it. Shale, sandstone and coal are acid to mildly alkaline rocks, and have acid or alkaline water, depending on the composition of the water-bearing rock. In the coal fields, pyrite creates acid water in mines or wells by producing sulfuric acid. Pyrite decomposes most rapidly where mining and mine refuse piles have exposed it to air and moisture. Mine water may have a pH as low as 3.5, and the lowest pH on a well sample was 6.3 for a well that passed through a mine. There seems to be a tendency toward more acid water in the western part of the County. Many water treatment plants raise the pH and alkalinity of a water supply by adding soda ash or lime to control corrosion. The use of plastic pipes, glass-lined tanks and bronze fittings minimizes the effects of corrosion in private water systems.

Chloride

The "saltiness" or salinity of groundwater is caused by sodium chloride (salt) and by lesser amounts of other chloride compounds. A salty taste may be caused by chloride concentrations down to 100 milligrams per liter.[5] Chlorides are notorious for corroding iron and steel. The Virginia State Department of Health recommends that chlorides not exceed 250 milligrams per liter, mostly because of taste.

Minute amounts of chlorides occur in almost any rock. The large chloride concentrations in Buchanan County probably are residues from when the sediments that formed the rocks were in contact with the sea. Percolation of fresh rainwater into the rocks has removed the chlorides in the upper layers of rock. In the central part of the County, wells extending 300 to 400 feet below stream level produced 40 to 805 milligrams per liter of chlorides. The same relationship of depth to salinity is believed to hold for all but possibly the southeastern part of the County. Gas wells and test holes several thousand feet deep have reported only saltwater below the first few hundred feet. Heavy pumping has caused at least one case of salt-water intrusion. Well No. 17, serving Grundy, has gone from 15.5 to more than 600 milligrams per liter of chloride after days of heavy pumping in dry weather.

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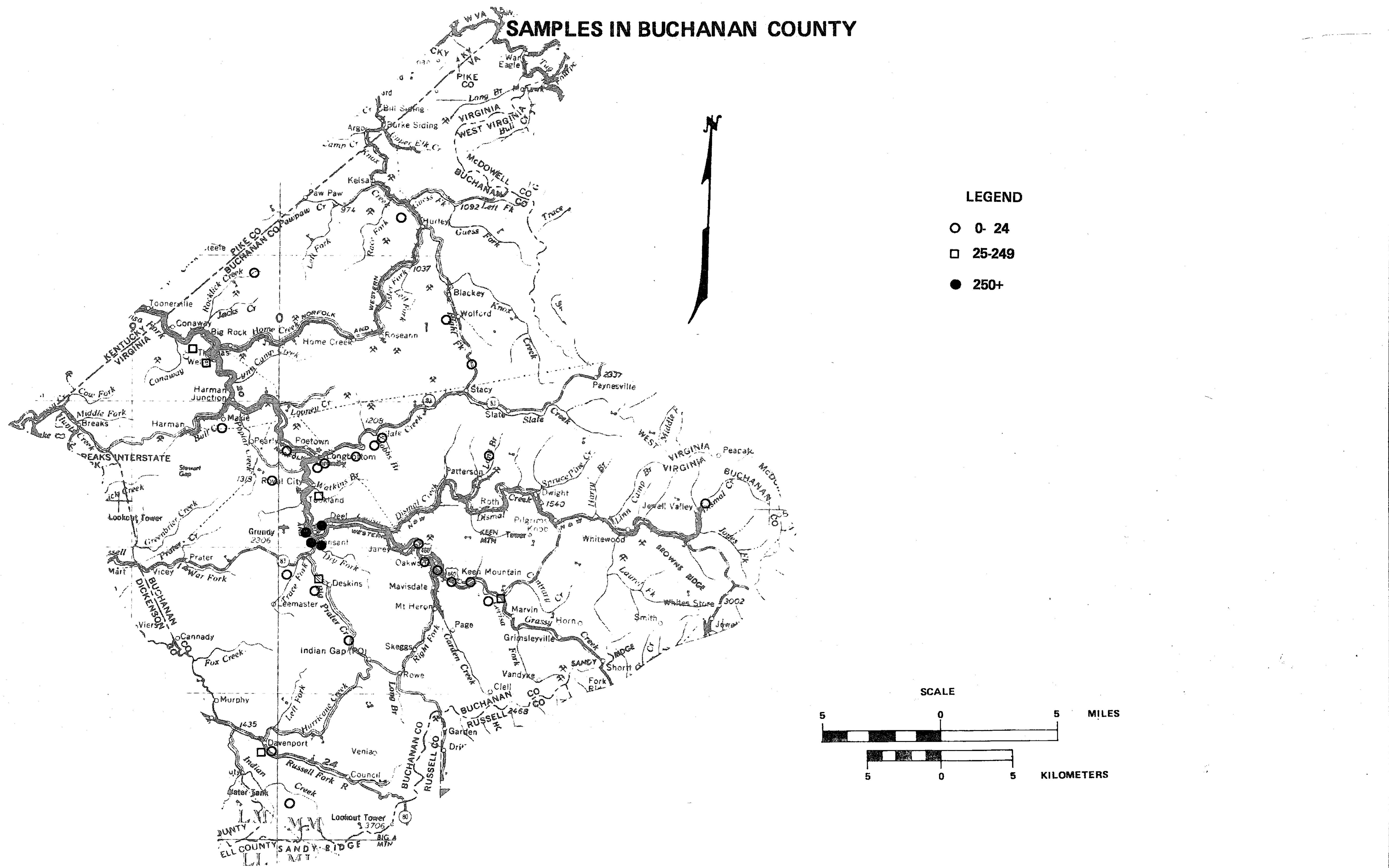
[5]Ibid., p. 160.

CHLORIDES IN MG/L FROM WELL SAMPLES IN BUCHANAN COUNTY



Source: Virginia State Water Control Board—SWRO

PLATE NO. 7

Hardness

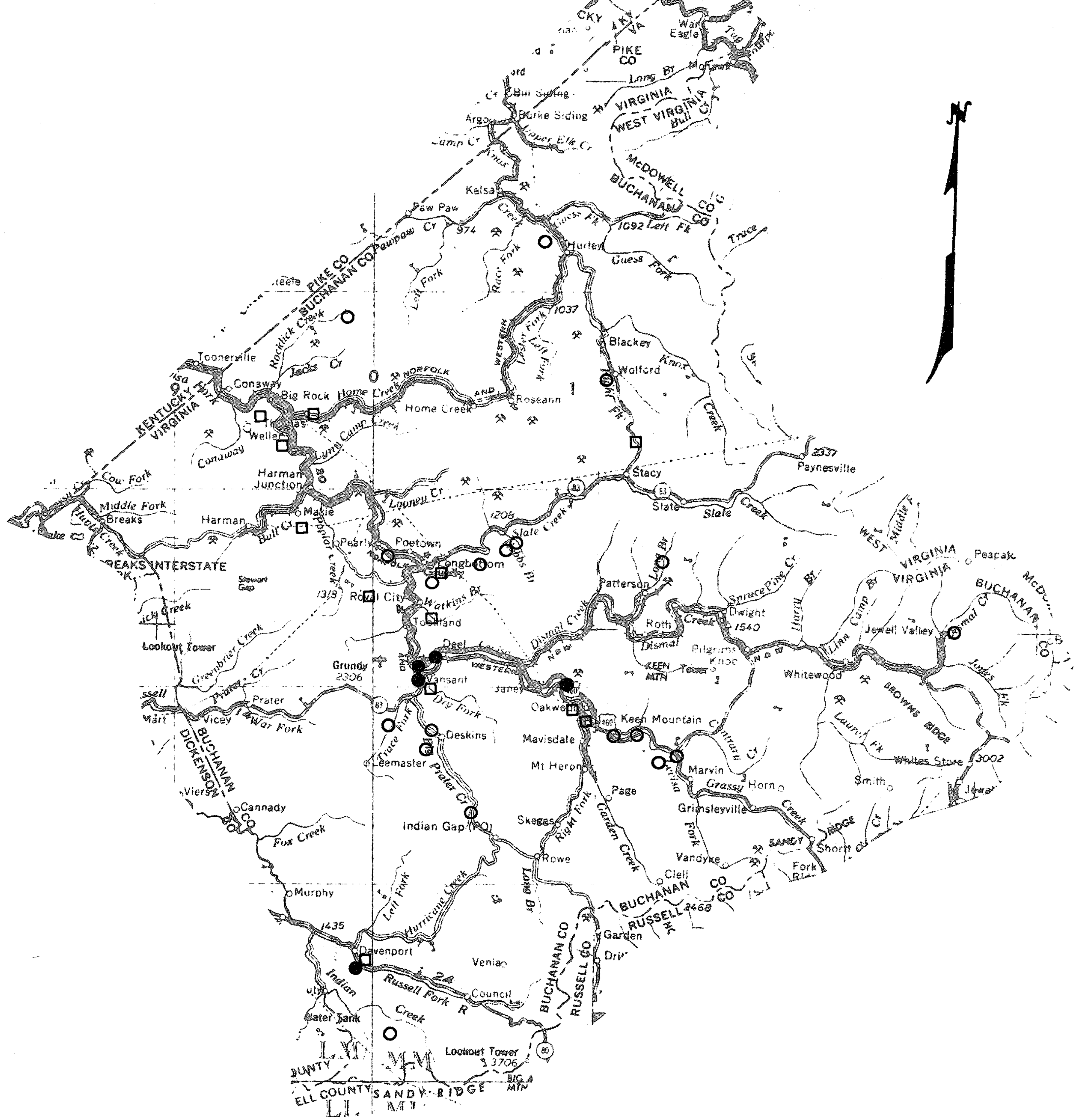
Hardness is caused by metals dissolved in water, especially calcium and magnesium in limestone areas, and also by iron, chlorides and other substances. It interferes with soaps and detergents, forms a curd or scum during washing, and makes scale in boilers and water systems. Samples in Buchanan County ranged from 31 to 310 milligrams per liter of hardness. Water having less than 60 milligrams per liter of hardness is considered soft, and above 120 milligrams per liter is considered hard.

The amount of hardness in groundwater varies with the type of rock the water occurs in. Water from limestone is characteristically hard, shales usually produce hard water and sandstones have softer water. Groundwater that is high in chlorides or sulfates is likely to be hard. Many water softeners on the market are designed to remove calcium and magnesium hardness from limestone waters. This type of softener has not been effective for sulfurous, irony and acid water in Buchanan County. An analysis would be necessary to determine the cause of hardness, and then filters or treatment could be selected to remove the offending substance.

Total Dissolved Solids

Total dissolved solids is the sum of all matter dissolved in water from mineral, organic, pollutant or other sources. The effects of the total dissolved solids are determined by the individual compounds, but as a general statement, a large solids content makes the water less palatable and makes it undesirable for industrial or human use. The Virginia Department of Health recommends

TOTAL DISSOLVED SOLIDS IN MG/L
FROM WELL SAMPLES IN BUCHANAN COUNTY



LEGEND

- O 0-249
- □ 250-499
- ● 500+

SCALE

5 0 5 MILES

5 0 5 KILOMETERS

Source: Virginia State Water Control Board—SWRO

PLATE NO. 8

a limit of 500 milligrams per liter of total dissolved solids. Deeper groundwater usually is more mineralized because it has had longer contact with rock and soil than shallow water.

Nitrates

Nitrates are almost nonexistent in rocks, and the nitrates in groundwater usually originate on the surface from organic matter, fertilizer, detergents and sewage. The U. S. Public Health Service recommends a limit of 10 milligrams per liter of nitrate as nitrogen.

Turbidity and Color

The turbidity of water is caused by particles such as mud, coal fines and rock powder, which can be settled or filtered out. The color of water is caused by dissolved matter such as iron, manganese and some organic compounds. Turbidity has been known to occur in wells having cracks around the casing that allow surface water to enter and in wells that penetrated or were disturbed by mines. Iron causes a reddish color and manganese can cause blackish water. Turbidity is often a warning of surface contamination in a well. Casing and grouting are used to prevent turbidity, and bacteria tests by the County Health Department are recommended to determine if the water is safe for drinking. Color is treated by removing the offending substance.

Bacteria

Bacteria harmful to humans result from pollution of groundwater. Typical sources are septic tank systems, privies, dumps, leaking sewers and surface water entering close to or at wells. Iron and sulfur bacteria form slimes or clumps in water systems and wells, which are a nuisance and contribute to taste and odor. The most common diseases transmitted by polluted groundwater are dysentery and gastroenteritis, which cause diarrhea, abdominal pains and nausea, especially in persons not accustomed to the water. Anyone who wishes to know about the safety of a water source for human consumption should contact the local health department office to have the water tested. Most problems of well contamination can be avoided by casing and grouting the well into bedrock to seal off surface water, by a sanitary well seal, and by locating the well away from and not downhill of septic tanks, drainfields and privies. Plate 10 gives an example of a well constructed to exclude surface water. Some persons use home chlorinators with a large tank to increase contact time and thereby control bacteria. The Health Department should be contacted for advice on well and septic tank system locations, well construction and safety of drinking water.

CHAPTER V

GROUNDWATER DEVELOPMENT AND POTENTIAL

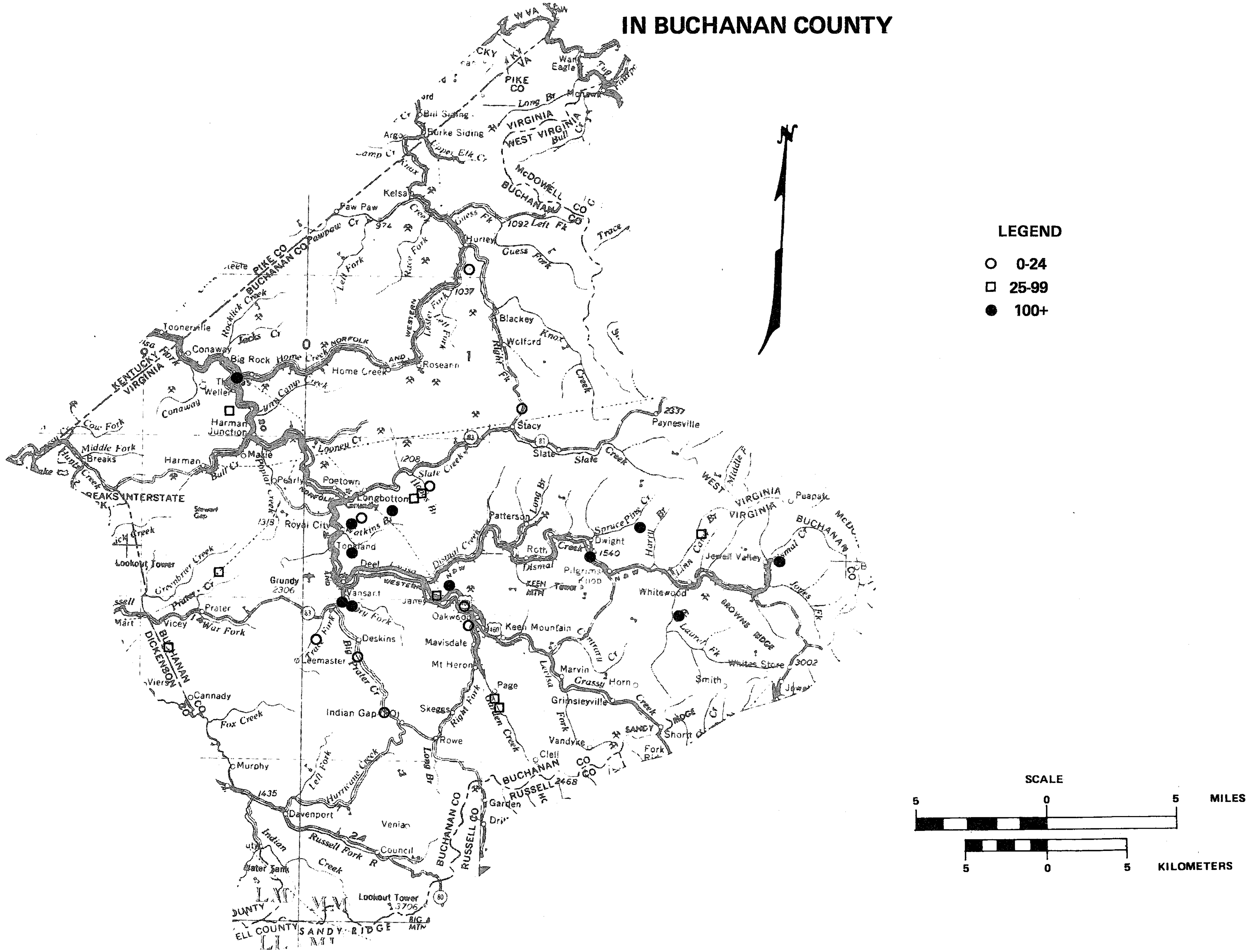
Present Development

At the time this report was written, nearly all drinking water in Buchanan County came from groundwater. Most of it was produced from wells, a few homes used springs, a water supply at Oakwood drew water from an abandoned mine, and several families on ridges used water from cisterns.

The largest volume of groundwater for a public water supply is used by the town of Grundy, which pumped an average of about 400,000 gallons per day in 1975. Small privately-owned supplies using wells serve groups of residences in Hurley and Jewell Valley. The largest wells have been developed to serve large shaft mines, coal preparation plants and coke ovens. Several of the larger coal preparation plants have water flow rates of more than a million gallons per day, but these plants recycle their water, so that well, mine or surface water is only required to replace water lost during processing. The most numerous wells are those that serve homes. Nearly all schools and numerous small businesses and shops outside of public supply areas have their own wells.

Plate 11 gives locations of water wells that are on record with the State Water Control Board, and Plate 9 shows locations of recorded well yields. There are records for only a small fraction of the total number of wells in the County (see Table 3), although a higher proportion of public and industrial wells are represented.

WELL YIELDS IN GALLONS PER MINUTE IN BUCHANAN COUNTY



Source: Virginia State Water Control Board-SWRO

The picture of yields is also biased. Well drillers seldom report private wells or abandoned holes, which biases the data toward successful wells and wells developed for high yields. For example, for the town of Grundy, two yields were recorded at 350 and 200 gallons per minute, the yield of a well abandoned after some years of use was recently tested at 150 gallons per minute, and three abandoned wells are said to have had insufficient yields, but only the first two wells have drillers' records. Many wells have not been tested for yield, especially wells for homes and small businesses. As a rule, an adequate home well produces at least three gallons per minute, and few residents complain of shortages outside of heavily developed areas. Many of these wells probably could yield more or were drilled only as deep as necessary for a small water supply.

The only definite pattern in the location of reported high yield wells is that all are located in valleys along sizeable streams. Fewer big yields are recorded northwest of Grundy, probably due to the location of demand for larger quantities of water rather than a change in the water-bearing properties of rocks.

Development of Large Supplies

Any attempt to develop a large-scale groundwater supply should consider the following factors. First, areas most likely to have the best supplies of groundwater should be identified. Man-made conditions, such as the amount of existing groundwater development and dewatering by mines, should be considered along with natural conditions.

Second, several promising well sites should be reserved. Many towns, communities and subdivisions have eliminated all their convenient well sites by building on them. When expansion of the water supply becomes necessary, they are forced to purchase water from an outside source or to construct water lines and wells at a considerable distance outside their boundaries.

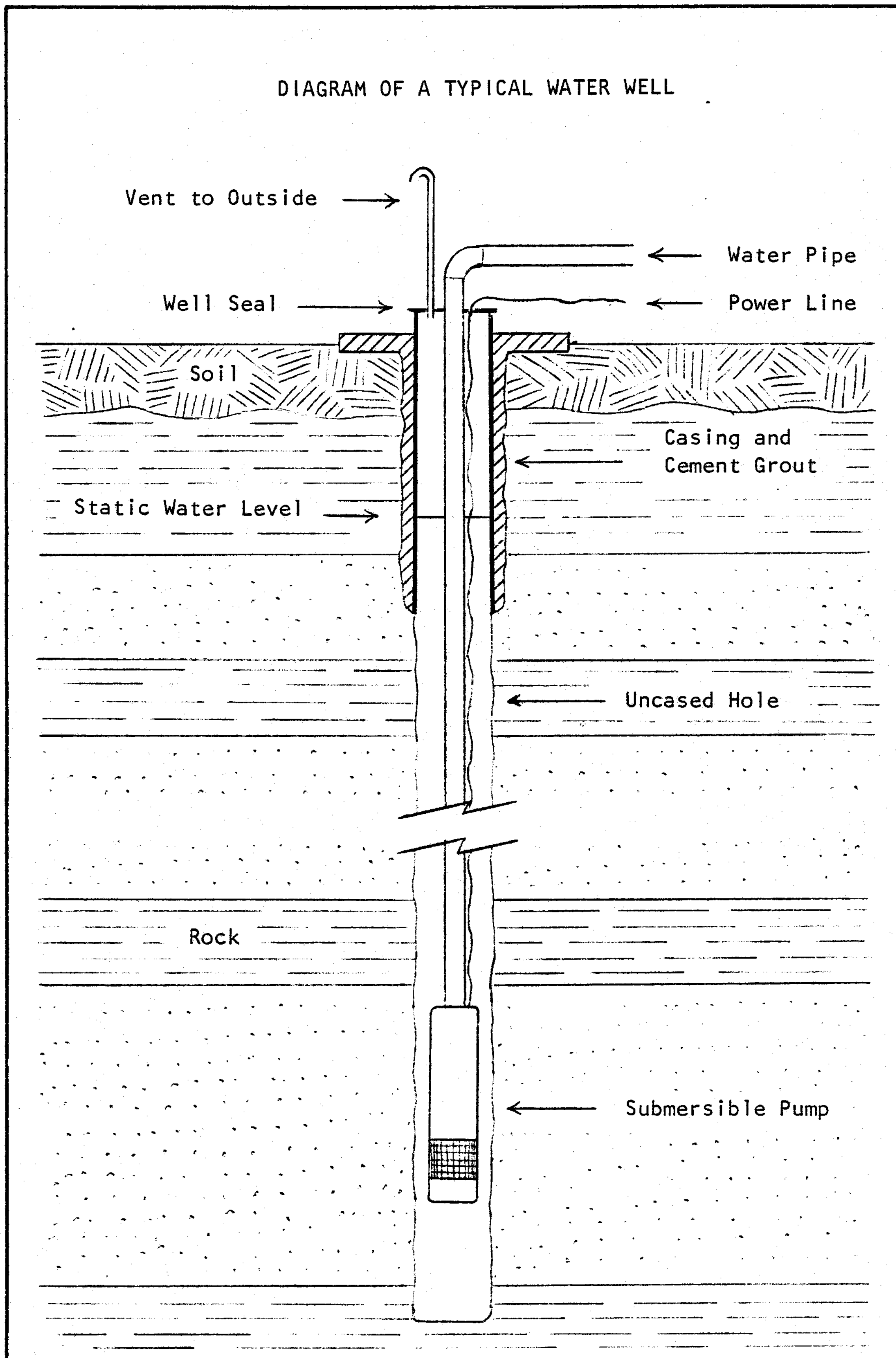
Third, it is never certain that a particular site will have the desired yield. The number of sites reserved should allow for drilling more than one hole to get an expected yield. Some arrangement, such as purchasing an option, should be made to allow the well site to be bought, depending on the success of the well.

Fourth, the sites that are chosen need to be spaced apart as much as possible to avoid interference between wells.

The most promising site for a well is on a flat valley bottom close to a large stream. The location of a well to be used for a public water supply is governed by sanitation in addition to yield, and the well site must be approved by the State Department of Health. A series of wells for large production should be spaced to avoid interference between wells. A well producing 100 gallons per minute must draw that water from a far larger area than a five gallon per minute home well. It would be wise to place wells as far apart as feasible to minimize the chances of interference, and also, to avoid drilling near shallower private wells that might be dewatered. Some large wells in the coal fields are located between 200 and 500 feet apart and are not reported to have trouble. On the other end of the scale, one of Grundy's wells dewatered several shallower wells up to a quarter mile away, and two of the Town's wells (Nos. 15 and 17) are reported to influence each other even though they are two miles apart.

Most wells in the County designed for high production are 200 to 300 feet deep. This allows for penetration of most of the upper 300 or 400 feet of rock that is most productive. It also gives sufficient depth below the water table for drawdown, the lowering of the water level in the well during pumping. All of the high yield wells have an 8- or 10-inch casing diameter and usually an 8-inch hole diameter, which allows insertion of a larger capacity pump than does a 6-inch well.

A pumping test is usually made to determine the production of the well. The water level in the well before pumping should be recorded. During the test, the output of the well and the active or pumping water level are recorded at intervals and at the end of the test. A good pump test should be at least eight hours long, and tests of two or three days have been conducted on wells that may be pumped continuously. Sometimes, the well is only pump tested until the pumping water level stabilizes. The yield and pumping water level at the end of the test indicate the maximum sustained yield and how deep the pump must be set. The rise of the water level in the well after the pump is shut off is sometimes noted to determine how fast the well recovers between pumpings.



Source: Virginia State Water Control Board - SWRO

PLATE NO. 10

Domestic and Other Small Wells

The majority of wells in Buchanan County were drilled to provide three to ten gallons per minute for dwellings and businesses. They are generally between 50 and 250 feet deep, and have a 6-inch diameter hole and casing. Nearly all wells are located in valleys where there is normally enough groundwater to supply small wells. Exceptions have been reported in areas above coal mines close to a few heavily pumped deep wells. The main considerations in choosing the site of a domestic well are drilling in valleys and lower slopes, and avoiding sources of contamination. A well should be located as far as practical from septic tanks and drain fields, privies, dumps, and areas where animals are confined, and should not be downhill from any of these. The County Health Department can offer advice on the safe location of a well.

Potential

It is impossible to make any estimates of the potential groundwater production for all of Buchanan County. Groundwater production potential is the known or probable volume of water that can be withdrawn from an aquifer at a specific point or over a specified area. In order to estimate potential, there has to be an aquifer, a reliable water producing formation which extends over some area. The occurrence of groundwater in the County is determined by local conditions of terrain, recharge, depth and rock type rather than by formation; the same rock layer that produces generously next to a large stream in a valley will be dry beneath a ridge.

It is possible to make some estimates of the groundwater available under certain conditions based on reported yields. The best production of 50 to 300 gallons per minute have been obtained by wells in valleys which are spaced 200 to more than 1,000 feet apart. Based on these figures, a large capacity well field could be constructed down the center of one of the larger valleys in an area that has not suffered dewatering or heavy groundwater development. Such a well field might have 300- to 400-foot deep wells spaced approximately 500 feet apart in a line. These wells could be expected to have an average yield of 200 gallons a minute. Wells in a well field are usually alternated in pumping or resting to keep water levels from declining too much in a particular well, to prolong pump life and to allow maintenance. If a field of five such wells were pumped for an average of a little over eight hours each, the total production would be about 0.5 million gallons per day. This would provide roughly 120 million gallons per year on the basis of pumping about eight hours per day on working days.

CHAPTER VI

GROUNDWATER PROBLEMS

General

Buchanan County's groundwater is inadequate in some places to meet demands for both volume and quality. Water levels and individual well production have dropped in areas of concentrated groundwater use and above some coal mines. On the other hand, the presence of large quantities of water underground is detrimental to mining activities. Poor groundwater quality plagues the majority of County residents. All of these problems are rooted in natural conditions but are being aggravated by human activities.

Groundwater Depletion

Heavy use of groundwater in Buchanan County coincides with the location of people and industry. Since people and industries are concentrated in certain valleys, as in the Grundy and Vansant areas, these places are the most likely to deplete their groundwater supply. Overpumping by several large wells or by many small wells occurs when water is drawn from the ground faster than precipitation and streams can recharge it. The geohydrology and topography of Buchanan County effectively prevent migration of groundwater through ridges so each valley is limited to its own groundwater recharge; one valley could be running out of groundwater while the next is not affected.

Groundwater depletion has followed two patterns in the County: a cone of drawdown around a pumping center, and a general lowering of the water table over a large area of many wells. A cone of drawdown has formed around the town of Grundy's "swimming pool" well. A large volume well like this must draw water from hundreds of yards away. It lowers the water table and well yields within its zone of influence, with the lowest water levels right at the well. It may completely dry up shallower wells within a few hundred feet, and has diminishing effects on water levels and yields at increasing distance from the large well.

A general lowering of the water table can occur over a larger area where there are numerous wells. These may be small domestic wells but, when they are close together, the cumulative effect is to pump more groundwater than the immediate area can supply. Problems will first appear after a dry spell with the shallowest wells going dry and pumps having to be set deeper. Because water levels usually stabilize at greater depths, at least for a few years, a resident who has had a shallow well dried up can usually get water by drilling as deep as some of the deeper wells in his neighborhood.

Wells that are going dry usually give some warning signs. If the water level in the well is monitored, a gradual drop will be noted. Pumps frequently burn out when the water level drops below the pump intake. Well water may become muddy, and air is taken into the water system as pumping water levels drop close to the intake. In some parts of Buchanan County, gas and changes in quality or taste occur before a well goes dry. A well owner who notices these symptoms may warn himself against inconvenience and repairs by measuring the water level with a weighted line. It should be remembered that the water will drop to its lowest level during pumping.

Dewatering

The loss of groundwater due to mining threatens to become Buchanan County's most serious problem. The loss of groundwater into deep mines is a common problem throughout the world. Buchanan County has been better off so far in this respect than some mining regions.

Dewatering occurs because mines act as underground drains. In order to work the mine, groundwater that enters it must be pumped or drained out. From the viewpoint of groundwater effects, there are differences between the two main types of underground coal mines used in the County. Drift mines are driven horizontally into ridges and lie above valley bottoms. These drain water from the rock above them but, although they might diminish recharge to wells below, drift mines are not reported to affect wells in valleys. Jewell Ridge, on the southeastern boundary, and probably Sandy Ridge, on the southern end of the County, have been dewatered but groundwater is produced in the valleys below the mines. One well that was drilled into a mined-out ridge encountered no water until it penetrated the mine and passed into water-bearing rock beneath it.

Shaft mines lie below the level of valley bottoms and therefore could drain groundwater from both valleys and ridges. The largest shaft mines in the County are about 1,200 to 1,300 feet below the main valleys. Most of the groundwater is shallower than about 400 feet and the rock becomes increasingly impermeable as depth increases. The mining levels are therefore several hundred feet below the main water-bearing rock. The shaft mines are said to have little or no water entering, and there are numerous water wells above them which continue to produce.

The shaft mines can affect well production if a vertical connection exists between the aquifer and the mine. This may be a natural joint or fault, or a shaft, bore hole, or cave-in. In practice, mine shafts are sealed against groundwater although some leakage may continue, and some bore holes have been plugged.

The collapse of mine roofs sends fractures upward and slightly outward through the rock beds. When the fractures reach water-bearing rock they drain groundwater into the mine. The typical pattern of dewatering above mines is that wells in a limited area suddenly go dry but wells a mile away are unaffected.

Mine Water

Groundwater entering coal mines is an expensive nuisance, even a hazard, to the miner. It can flood the mine, create unpleasant working conditions, short unprotected electrical systems, and is sometimes blamed for cave-ins by lubricating cracks in the roof rock. Some mines above stream level can drain by gravity but the others are forced to pump, which is most expensive for the shaft mines.

The most common method of dealing with water in deep mines is by pumping it to the surface and discharging it to streams.

However, several mines in Buchanan County utilize mine water for spraying to control dust in the mine and for process water in coal preparation plants. At this writing, much of the galleries of the largest shaft mines are reported to be nearly dry because of their depth. Where groundwater does enter deep mines, it is a problem that the operators would prevent if feasible. The elaborate engineering that has been undertaken to prevent groundwater from entering mines is far beyond the scope of this report, so only a brief mention of some of the methods can be made.

The infiltration of water into a mine tends to concentrate at a fracture or a small area. Mine water, like a high yield well, requires broken or permeable rock, and a source of recharge, such as precipitation or a stream. Most efforts to prevent mine water attack the source or the conduit of the water. A stream crossing over a mine can be run through a watertight culvert or flume, in one of the cheapest and easiest methods. This technique has improved the infiltration problem in the gypsum mine at Plasterco, Virginia. Tracers such as dye may help identify the water's source. Wells are useful for dewatering limited areas, which is done around some mine shafts in Buchanan County. Mine water can sometimes be stopped by injecting grout through bore holes to form an impermeable barrier, but this is a difficult and expensive technique used in limited areas.

These methods of controlling mine water are not of much help to the problem of groundwater supplies. A watertight conduit for streams and wells for the purpose of dewatering mines also diminishes the groundwater supply. Grouting entire roofs of coal mines is not feasible because of the expense and size of the area involved.

Quality Deterioration

Human activities in Buchanan County have aggravated natural groundwater quality problems and created new ones. The deterioration of chemical quality by disturbing natural conditions is traceable to mining, deep drilling, and over-pumping of groundwater. Bacterial contamination of groundwater is a common result of sewage entering the ground or of poor well construction.

Vertical openings such as core drill holes, gas wells, and mine shafts may act as pathways for upward migration of the more mineralized water that lies below the potable water layer. According to observations in the Virginia coal fields, reports from a gas well driller, and a study in Kentucky, deep groundwater is saline, sulfurous, gassy, and sometimes under an artesian head. Several of the worst water samples and complaints about quality were from wells that were close to coal test holes and mine shafts. Some well owners have stated that after a test hole or gas well was drilled within a few hundred feet of their well, the quality of the water worsened and often gas appeared in the water.

Mines and piles of spoil and refuse add to the mineralization of water by exposing more rock surface area to weathering and leaching. When water that collects in underground mines or leaches through strip mine spoil and coal preparation plant refuse enters the groundwater regime, it can degrade groundwater with acid, sulfur and iron compounds, turbidity, and total solids. Some mines have waters that equal the quality of the groundwater in the area, while others could pollute ground or surface water, or both.

Biological contamination of groundwater is most common around housing concentrations. Bacteria enter the ground in the largest numbers where septic tank drain fields, privies, leaking sewers, and trash are concentrated. Pollution of wells by bacteria does not seem to be as much of a problem in Buchanan County as in the limestone valleys east of it. This is because the shale and sandstone in Buchanan County are more reliable for filtering out disease-causing organisms than cavernous limestone. Probably the majority of cases of bacteria contamination in wells result from open dug wells, bad well construction, or sources of pollution very close to the well. There is a danger of general groundwater pollution in heavily populated areas.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

The quantity of groundwater available in Buchanan County, overall, is sufficient to meet demands for domestic water in the near future. Since groundwater is dispersed throughout the County, and demand is highly concentrated, the groundwater resource is inconvenient and will probably not be fully utilized. Localized shortages of groundwater have already developed. At this writing, the John Flannagan Water Authority has been created to study the feasibility of bringing surface water from the Flannagan Reservoir in adjacent Dickenson County to serve Grundy and built-up parts of Buchanan County.

A few predictions can be made concerning Buchanan County's groundwater supply. Groundwater shortages in high use areas will become more severe unless new areas with underdeveloped groundwater supplies are tapped. Considering the difficult terrain and the economics involved, it is probable that people in built-up sections will continue to suffer seasonal shortages which gradually will become year-round shortages while the next valley a mile away has groundwater to spare.

The expansion of underground mining will cause an expansion of dewatering above and near the mines. There is a limit to how much area can be supported by the massive sandstone that forms the roofs of the deepest shaft mines. If it were to be undermined too extensively without supports being left, this rock layer would collapse, probably causing surface subsidence, fracturing up to the aquifers, extensive dewatering and a massive inflow of water into the mine. This is not likely to occur while the mine is active because the operators would avoid a condition which could amount to a mining disaster.

Quality problems will continue to bother groundwater users and will probably be a factor in any decision to use a surface water source. Areas of bad groundwater seem to spread, and it appears that the Grundy area is beginning to experience salt water intrusion into potable water aquifers. Contamination of groundwater by sewage in heavily populated areas is expected to increase.

There are now three possible alternatives for the future of the groundwater resource. One of these is the common law doctrine which allows one individual or group to abuse or exploit their groundwater rights to the detriment of others. This attitude is becoming increasingly intolerable in an age of vast population and a limited resource. A second alternative is a policy of strict nondegradation and nondepletion of groundwater. This is unrealistic in Buchanan County where it would prohibit all deep mining in a region where coal mining supports, directly or indirectly, the majority of residents, and such a policy would cripple a vital energy source as well. Strict nondegradation would also prohibit waste disposal by landfills and septic tanks.

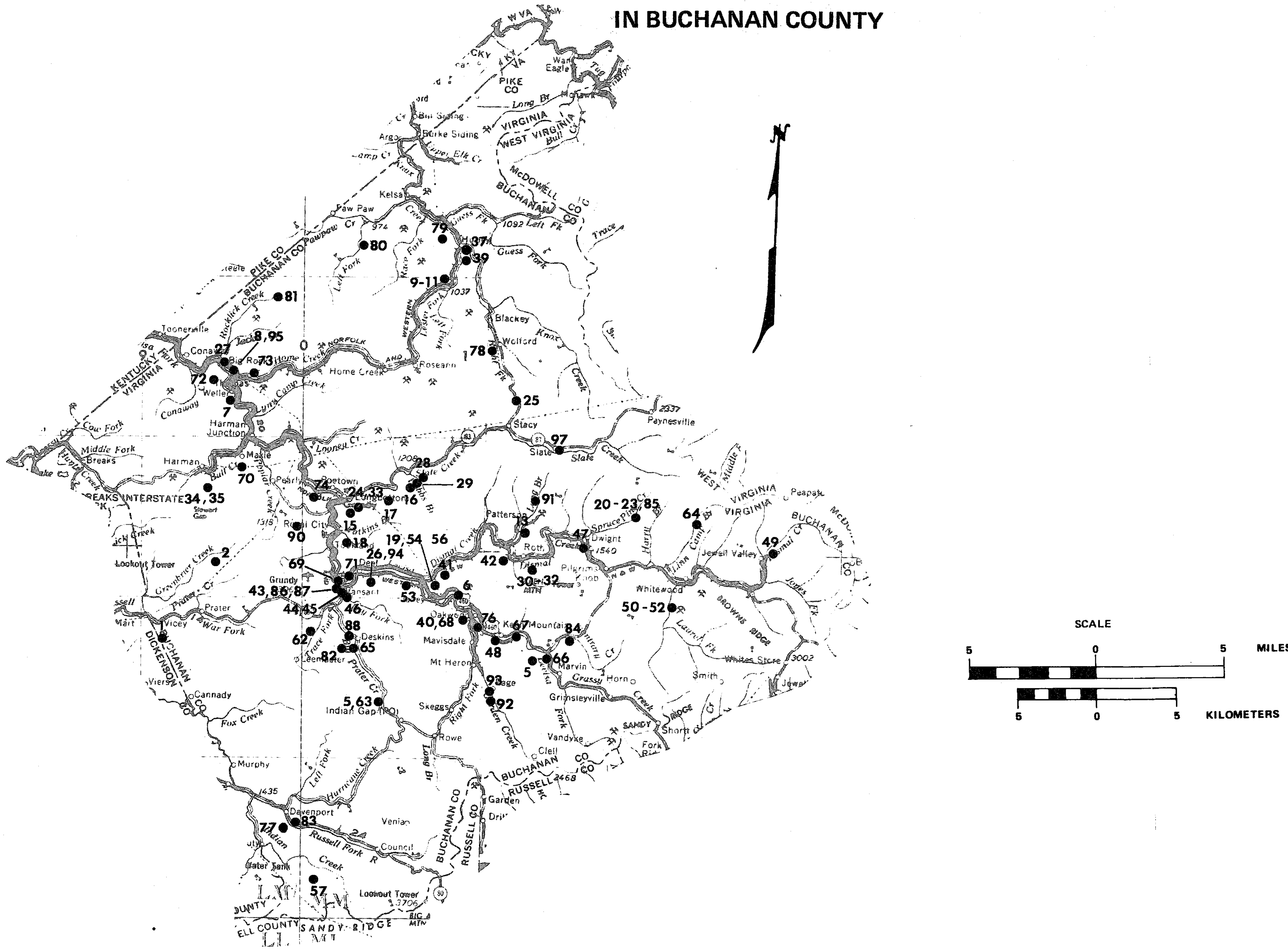
The alternative recommended by this report is moderate regulation to ensure that water will be available from some source, with priority for human consumption. Groundwater must be recognized as a valuable mineral resource which travels under property lines and can be removed or damaged by the utilization of other mineral resources. Once it is destroyed or polluted, it does not return to its original state for decades, sometimes never. A fair approach to the problem of dewatering or contamination of one person's groundwater by the acts of another would require the guilty party to supply the victim with water or to pay the cost of an alternate supply. Assuming population, industrial usage and mine dewatering continue to grow at recent rates, the total groundwater supply will fall short of the County's needs, probably by the year 2000.

APPENDIX A

KEY WATER WELLS IN BUCHANAN COUNTY

The following Buchanan County map shows approximately 80 wells which are included in Appendix B. The numbers appearing next to each well may be cross-referenced with the information contained in Appendices B and C.

WELL LOCATION MAP IN BUCHANAN COUNTY



Source: Virginia State Water Control Board-SWRO

PLATE NO. 11

APPENDIX B

SUMMARY OF WATER WELL DATA FOR BUCHANAN COUNTY

The following pages have been compiled from computer printout sheets for the Buchanan County area. This printout is updated frequently to include information from new Water Well Completion Reports submitted by water well drilling contractors. The locations for many of the wells may be found in Appendix A.

TABLE 3

VIRGINIA STATE WATER CONTROL BOARD
BUREAU OF WATER CONTROL MANAGEMENT

SUMMARY OF WATER WELL DATA FOR BUCHANAN COUNTY

THE FOLLOWING LIST OF WELL DATA SUMMARIZES BASIC DATA OBTAINED FROM WATER WELL COMPLETION REPORTS WHICH ARE ON PERMANENT FILE IN THE OFFICES OF THE VIRGINIA STATE WATER CONTROL BOARD. ADDITIONAL INFORMATION FOR MANY OF THE WELLS IS AVAILABLE AND CAN BE OBTAINED BY CONTACTING THE APPROPRIATE REGIONAL OFFICE OR THE BUREAU OF WATER CONTROL MANAGEMENT AT THE AGENCY HEADQUARTERS IN RICHMOND.

EXPLANATION OF PARAMETERS

SWCB NO.: STATE WATER CONTROL BOARD NUMBER - A SEQUENTIAL NUMBERING SYSTEM USED WITHIN A COUNTY; WHEN REFERRING TO A SPECIFIC WELL USE THIS NUMBER

OWNER AND/OR PLACE: IDENTIFIES ORIGINAL OR CURRENT WELL OWNER AND/OR LOCATION OF WELL

YEAR COMP.: YEAR IN WHICH WELL CONSTRUCTION WAS COMPLETED

LOG: TYPE OF LOG ON FILE FOR WELL: D = DRILLERS, E = ELECTRIC, G = GEOLOGIC

ELEV.: ELEVATION - MEASURED IN FEET ABOVE MEAN SEA LEVEL

TOTAL DEPTH: TOTAL DEPTH DRILLED, IN FEET, WITH RESPECT TO LAND SURFACE

CASING: MAXIMUM AND MINIMUM DIAMETER OF CASING, IN INCHES, USED IN WELL

STATIC LEVEL (SWL): DEPTH, IN FEET, TO WATER WITH RESPECT TO LAND SURFACE; MEASUREMENTS TAKEN WHEN WELL IS NOT PUMPED AND ARE GENERALLY THOSE RECORDED ON COMPLETION DATE

YIELD: REPORTED OR MEASURED PRODUCTION, IN GALLONS PER MINUTE

DRAWDOWN: DIFFERENCE, IN FEET, BETWEEN STATIC LEVEL AND PUMPING LEVEL, I.E., REPORTED OR MEASURED DROP, IN FEET, IN WATER LEVEL DUE TO PUMPING

USE: USE OF WATER OR WELL UNDER CONSIDERATION: DOM = DOMESTIC, PUB = PUBLIC, GOV = GOVERNMENT, IND = INDUSTRIAL, COM = COMMERCIAL, INS = INSTITUTIONAL, ABD = ABANDONED, DST = DESTROYED, IRR = IRRIGATION, RCH = ARTIFICIAL RECHARGE, OBS = OBSERVATION WELL

VIRGINIA STATE WATER CONTROL BOARD
BUREAU OF WATER CONTROL MANAGEMENT

SUMMARY OF WATER WELL DATA FOR BUCHANAN COUNTY

SWCB NO.	NAME AND LOCATION	Z	VIRGINIA PLANE COORD. NORTH	EAST	DATE MO.	YR.	SWL LSD	TD (FT.)	ELEV.	CAS. DIA.	PUMP YIELD	TEST DRDN.	LOG	USE
1	CLINCHFIELD COAL CO.				6	70	25	125		06	50	20	D	IND
2	CLINCHFIELD COAL CO.				6	70	55	185		08	50	30	D	IND
3	CLINCHFIELD COAL CO.				6	70	35	125		06	30	20	D	IND
4	JEWELL RIDGE COAL CO., LAUREL FK. MINE 12-A				6	70	70	205		08	150	20		IND
5	CORRECTIONAL UNIT NO. 29	2	324894	959823	5	68	100	203	1550	06	13		D	INS
6	VA. DEPT. HIGHWAYS, OAKWOOD SHOP	2	344337	975693	1	69		305	1280	08 06				GOV
7	N & W RAILROAD						30	83		10				IND
8	BUCHANAN CO. COAL CORP.										60			IND
9	SOUTHWESTERN VA. COAL					63	130	200		08		30		IND
10	SOUTHWESTERN VA. COAL					63	120	190		08		40		IND
11	SOUTHWESTERN VA. COAL					63	130	205		08		50		IND
12	ISLAND CREEK COAL CO. VA. POC. MINE NO. 1				6	65				10	100			ABD
13	PATTERSON COAL CO.						40	97		06				IND
14	APPALACHIAN VENEERING							200						ABD
15	TOWN OF GRUNDY, SLATE CREEK WELL	2	363684	953769				308	1020	10	100			PUB
16	EASTERN ISLES CORP.				5	65	17	202		08	50	30		IND
17	GRUNDY SWIMMING POOL	2	366260	963248	8	65	28	309	1140	08	200		D	PUB
18	TOWN OF GRUNDY	2	356601	953741	7	65	80	325	1260	08	80		D	ABD
19	JEWELL SMOKELESS COAL				3	72	40	160		06	50	25		IND
20	JEWELL RIDGE COAL CO., SPRUCE PINE MINE 18				3	72	60	200		08	160	10		IND
21	JEWELL RIDGE COAL CO., SPRUCE PINE MINE 18				4	72	35	245		08	150	40		ABD

SUMMARY OF WATER WELL DATA FOR BUCHANAN COUNTY (Cont'd)

SWCB NO.	NAME AND LOCATION	Z	VIRGINIA PLANE COORD. NORTH	EAST	DATE MO.	YR.	SWL LSD	TD (FT.)	ELEV.	CAS. DIA.	PUMP YIELD	TEST DRDN.	LOG	USE
22	JEWELL RIDGE COAL CO., SPRUCE PINE MINE 18				5	72	55	205		08	55	50		IND
23	JEWELL RIDGE COAL CO., SPRUCE PINE MINE 18				10	72	60	245		08	300			IND
24	OBSERVATION WELL NO. 51, TOWN OF GRUNDY							288	1115	10				OBS
25	JAN NICHOLS	2	384632	988914					1920					DOM
26	ANCHORAGE SHOP. CEN.					72		85	1130					IND
27	CO. COAL CORP., BIG RK.							70		08				PUB
28	CO. VOCATIONAL SCHOOL					72	18	102		06	11	66	D	ABD
29	BUCHANAN CO. SCHOOLS, VOCATIONAL SCHOOL	2	369620	968065	10	71	40	203	1200	08	50	20		INS
30	GA. PACIFIC CORP.				7	65	18	135		06				IND
31	GA. PACIFIC CORP.													IND
32	GA. PACIFIC CORP.							65		06				IND
33	TOWN OF GRUNDY					56		305		10				ABD
34	HARMAN MINING CORP. NO. 1	2	369665	922135				62	1260	06				IND
35	HARMAN MINING CORP. NO. 2	2	369962	922309				162	1260	08 06				IND
36	HARMAN MINING CORP.							106						IND
37	EDNA LESTER ESTATE							150		06	20			PUB
38	EDNA LESTER ESTATE							62		08	20			PUB
39	HURLEY ELEM. SCHOOL										20			INS
40	ISLAND CREEK COAL CO.				4	70	85	465		06	6	285		IND
41	ISLAND CREEK COAL CO., VA. POC. MINE 1				3	66	43	125		10	180		D	IND
42	ISLAND CREEK COAL CO., VA. POC. MINE 2				9	68	70	205		12 08	185	100		IND
43	ISLAND CREEK COAL CO., VANSANT, VA.				11	68	80	205		08	185	110		IND
44	ISLAND CREEK COAL CO., VA. POC. MINE 3				5	69	140	200		08	175	20		IND
45	ISLAND CREEK COAL CO., VA. POC. MINE 3				5	71	50	130		08	140	10		IND

SUMMARY OF WATER WELL DATA FOR BUCHANAN COUNTY (Cont'd)

SWCB NO.	NAME AND LOCATION	Z	VIRGINIA PLANE COORD. NORTH	EAST	DATE MO.	YR.	SWL LSD	TD (FT.)	ELEV.	CAS. DIA.	PUMP YIELD	TEST DRDN.	LOG	USE
46	ISLAND CREEK COAL CO., VA. POC. MINE 3				10	72		335		08	110			IND
47	ISLAND CREEK COAL CO., VA. POC. MINE 4				5	70	150	225		08	175	25		IND
48	ISLAND CREEK COAL CO., BEATRICE POC. MINE				12	65	35	200		10 08			D	ABD
49	JEWELL RIDGE COAL, LYNN CAMP MINE 11-A				9	70	60	205		08	180	15		IND
50	JEWELL RIDGE COAL CO., LAUREL CK. MINE 12				10	70	60	300		08	80	20		IND
51	JEWELL RIDGE COAL CO., LAUREL CK. MINE 12				2	71	160	305		08	12	50		ABD
52	JEWELL RIDGE COAL CO., LAUREL CK. MINE 12				2	71	120	225		08	140	40		IND
53	JEWELL COAL & COKE CO.				2	70	50	85		06	30	40		IND
54	JEWELL COAL & COKE CO., COKE PLANT NO. 2				2	71	40	145		06	13	40		IND
55	JEWELL SMOKELESS COAL CO., PREP. PLANT 2													IND
56	JEWELL SMOKELESS COAL													IND
57	CLINCHFIELD COAL CO.				2	70		105		06	100			IND
60	KEEN DRILLING CO., ISLAND CREEK COAL				1	74	50	205		06	20	20		IND
61	ISLAND CREEK COAL CO.				12	65	24	125		13 10	130	8		IND
62	DEPT. OF STATE POLICE, VANSANT HEADQUARTER	2	340112	945585	10	65	65	187	1340	06	10	1		GOV
63	CORRECTIONAL UNIT NO. 29				8	74	70	150		06	6			INS
64	JEWELL RIDGE COAL CO., 11-C MINE				8	74	40	304		07	30			IND
65	ISLAND CREEK COAL CO.				8	74	30	304		08	15	40		IND
66	IKE'S 3-WAY SER. STAT.	2	331800	0994100		50		48	1520					COM
67	MILTON RATLEY	2	335000	0989850				42	1420					DOM
68	ISLAND CREEK COAL CO., CENTRAL SHOP	2	340500	0977250				120	1290	08				IND
69	BUCHANAN CO. SCHOOLS, VANSANT ELEM.SC.	2	349350	0950950				153	1110					INS
70	BUCHANAN CO. SCHOOLS, HARMAN ELEM. SC.	2	373750	0929200					1030					INS
71	SANDY VALLEY BOWL. LA.	2	349600	0954600				175	1200	06				COM
72	BIG ROCK ELEM. SCHOOL	2	392750	0927200					925					INS
73	FERN WHITEY TRAILER PARK	2	388500	0936700		68		60	1000					PUB
74	SIDNEY OWENS, OWENS ELECTRIC SHOP	2	367400	0945800				78	1020	06				COM

SUMMARY OF WATER WELL DATA FOR BUCHANAN COUNTY (Cont'd)

SWCB NO.	NAME AND LOCATION	Z	VIRGINIA PLANE COORD. NORTH	EAST	DATE MO.	YR.	SWL LSD	TD (FT.)	ELEV.	CAS. DIA.	PUMP YIELD	TEST DRDN.	LOG	USE
75	BUCHANAN CO. FUN. HOME	2	332400	0990400	7	73		206	1480					COM
76	BUCHANAN CO. SCHOOLS, QUILLEN & GARDEN SC.	2	338900	0978950					1320					INS
77	W. C. HARRIS STORE	2	299900	0939750				73	1460					COM
78	HURLEY HIGH SCHOOL	2	397460	984136					1180					INS
79	LONNIE DUTY	2	419987	974398					960	06				COM
80	KELSA SNACK BAR	2	416758	958052					1040					COM
81	EDWARD BELCHER	2	404558	938367					1260	06				DOM
82	JOYCE EDWARDS				3	75		420	1600	06				PUB
83	BILLY K. HARRIS	2	300100	0940000				200	1480					DOM
84	KEEN DRILLING CO., INC.				10	74	50	224		06	25			IND
85	KEEN DRILLING CO., INC.				10	74	30	344		08	200			IND
86	ISLAND CREEK COAL CO., SKIP SHAFT WELL	2	347368	951690				415	1100		30			IND
87	ISLAND CREEK COAL COL, SUPPLY SHAFT WELL	2	347566	954449				415	1250		50			IND
88	PAUL YATES	2	336652	954034				46	1350					DOM
89	CO. SANITARY LANDFILL	2	361554	943334					2000					OBS
90	CO. SANITARY LANDFILL	2	361370	942841					1920					GOV
91	M. C. MATTNIC	2	363741	992834					1840	06				PUB
92	PERMAC, INC. NO. 1				12	75	30	305		08	25	64	D	IND
93	PERMAC, INC. NO. 2				12	75	65	280		08	45	70	D	IND
94	A. M. RATLIFF, JR.					75		125	1160	06				COM
95	UNITED COAL CO.					75					300			IND
96	TOWN OF GRUNDY	2	365984	962510	12	75		350	1180		15		G	ABD
97	BURL RIFE	2	372496	996955				145	1520					COM
98	ISLAND CREEK COAL CO.				11	76	12	205		08	50	150	D	IND
99	ISLAND CREEK COAL CO.				11	76	16	305		08	5	218	D	IND
100	HAGY NO. 1 MINES				9	76	130	275		05	20	145	D	IND
101	KEEN DRILLING CO.				5	76	40	305		08	200	60	D	IND

APPENDIX C

SUMMARY OF GROUNDWATER QUALITY ANALYSES FOR BUCHANAN COUNTY

The following pages have been compiled from computer printout sheets for the Buchanan County area. The information from which they were obtained are on permanent file in the offices of the Virginia State Water Control Board. The locations for many of the wells may be found in Appendix A.

Table 4

VIRGINIA STATE WATER CONTROL BOARD
BUREAU OF SURVEILLANCE AND FIELD STUDIES

SUMMARY OF GROUNDWATER QUALITY ANALYSES FOR BUCHANAN COUNTY

THE FOLLOWING LIST OF GROUNDWATER DATA SUMMARIZES BASIC DATA OBTAINED FROM GROUNDWATER ANALYSES WHICH ARE ON PERMANENT FILE IN THE OFFICES OF THE VIRGINIA STATE WATER CONTROL BOARD. ADDITIONAL QUALITY INFORMATION FOR MANY OF THESE WELLS AND SPRINGS IS AVAILABLE BY CONTACTING THE RESPECTIVE OFFICE OR THE BUREAU OF SURVEILLANCE AND FIELD STUDIES AT THE AGENCY HEADQUARTERS OFFICE IN RICHMOND.

EXPLANATION OF PARAMETERS

SWCB NO.: STATE WATER CONTROL BOARD NUMBER - A SEQUENTIAL NUMBERING SYSTEM USED WITHIN A COUNTY: WHEN REFERRING TO A SPECIFIC WELL USE THIS NUMBER.

OWNER AND/OR PLACE: IDENTIFIES ORIGINAL (SOMETIMES CURRENT) WELL OWNER AND/OR LOCATION OF WELL IF TENANT DIFFERENT FROM OWNER.

DATE SAMP.: DATE SAMPLED - MONTH AND YEAR IN WHICH WATER SAMPLE WAS COLLECTED (DOES NOT REFLECT DATE SAMPLE WAS ANALYZED).

pH: HYDROGEN ION CONCENTRATION - INDICATES WHETHER WATER WILL ACT LIKE A WEAK ACID OR AS AN ALKALINE (BASIC) SOLUTION; ON SCALE OF 1 THROUGH 14, 7 IS NEUTRAL, BELOW IS ACIDIC, ABOVE IS ALKALINE.

SPEC. COND.: SPECIFIC CONDUCTIVITY - AN INDICATOR OF THE RELATIVE AMOUNT OF DISSOLVED MINERALS IN WATER: HIGHER VALUES INDICATE GREATER AMOUNTS OF DISSOLVED MINERALS. UNIT OF MEASUREMENT IS MICROMHO.

T. DIS. SOLIDS: TOTAL DISSOLVED SOLIDS - INDICATES TOTAL AMOUNT OF DISSOLVED MINERALS IN WATER; UNIT OF MEASUREMENT IS MILLIGRAMS PER LITER.

HARDNESS: TOTAL HARDNESS - UNIT OF MEASUREMENT IS MILLIGRAMS PER LITER.

ALKALINITY: TOTAL ALKALINITY - A MEASURE OF THE WATER'S ABILITY TO NEUTRALIZE ACIDS; UNIT OF MEASUREMENT IS MILLIGRAMS PER LITER.

PARAMETERS LISTED BELOW ARE MEASURED IN MILLIGRAMS PER LITER

Fe: IRON	Na: SODIUM	Cl: CHLORIDES
Mn: MANGANESE	K: POTASSIUM	F: FLUORIDES
Ca: CALCIUM	SO_4: SULFATES	NO_3: NITRATES
Mg: MAGNESIUM		

NOTE: ALL ZERO'S (00.00) ANALYZED, NOT DETECTED.

VIRGINIA STATE WATER CONTROL BOARD
BUREAU OF SURVEILLANCE AND FIELD STUDIES

SUMMARY OF GROUNDWATER QUALITY ANALYSES FOR BUCHANAN COUNTY

SWCB NO.	OWNER AND/OR PLACE	DATE SAMP.	pH	SPEC. COND.	T. DIS. SOLIDS	HARD-NESS	Fe	Mn	Ca	Mg	Na	K	ALKA-LINITY	SO_4	Cl	F	NO_3
6	OAKWOOD HIGHWAY SHOP	8 74	7.1	801	510	70	0.00		16.0	8.5	172.0	0.4	571	88.0	3.0		0.04
7	N & W RAILROAD	10 62	7.3		434		0.00	0.75					119		86.0	0.8	0.0
15	GRUNDY NO. 2	7 72	8.0		229	111	1.44	0.20	32.1	7.53	36.9	0.80		27.2	21.0	0.18	0.18
15	GRUNDY NO. 2	8 58	8.0		233	63	0.17	0.00	18.3	4.11			159	0.4	55.7	0.10	1.31
16	EASTERN ISLES CORP.	9 65	7.6		212	31	0.83	0.03	11.7	0.6	81.2		114	0.9	16.5	0.4	0.18
17	GRUNDY	7 74	7.8	280	223	45	0.28	0.04	16.4	3.7	56.0	1.7	141	10.4	15.5	0.2	0.04
17	GRUNDY	2 67	7.9		144	60	0.50	0.03	17.6	3.6	25.6		97	7.5	3.5	0.3	0.04
18	GRUNDY	11 66	7.5		445	193	1.00	0.30	56.1	12.8			180	136.0	39.5	0.03	0.09
18	GRUNDY	7 65	7.4		286	201	0.15	0.11	11.7	2.7			141	11.1	28.5	0.5	0.35
24	OBS. WELL NO. 51, GRUNDY	11 71	6.3	590	398		0.12		46.0	19.0	54.0	2.6		220.0	16.0	0.3	0.00
25	NICHOLS WELL	3 75	7.1	350	272	174	0.40	0.00	68.0	12.9	15.4	1.5	173	18.5	2.0		0.71
29	BUCHANAN COUNTY VOC. SCH.	8 74	6.7	253	106	50	3.70		16.0	3.8	44.0	1.5	128	1.2	12.0		
33	GRUNDY NO. 1	7 72	8.0		229	111	1.44	0.20	32.0	7.5	36.9	0.8	136	27.2	21.0	0.2	0.18
37	HURLEY	7 72	8.1		105	82	0.74	0.09	32.9	5.5	18.2	2.6	129	15.0	4.5	0.1	
44	VA. POCAHONTAS MINE NO. 3	7 71	6.7		320	210	1.40	10.00+					100		390.0		
48	KEEN MOUNTAIN	4 64	7.0		128	84	8.00	0.22					100	90.0	12.0	0.1	
49	LYNN CAMP MINE 11-A	3 71	6.5		70	50	2.60	Trace					70	15.0	5.0	0.3	
57	LAMBERT FORK MINE	10 70	7.3		130	90	0.10	Trace					190	90.0	20.0		
62	STATE POLICE	8 74	6.5	250	148	78	3.90		24.0	6.1	33.0	0.7	98	27.2	17.0		0.04
63	FIELD UNIT NO. 29	8 74	7.5	159	71	55	1.15	0.09	22.0	5.4	12.5	1.1	71	00.0	9.5	0.0	0.00
66	IKE'S WELL	8 74	7.5	370	212	100	0.60		31.0	6.6	48.0	0.9	147	0.8	41.0		0.00
67	RATLEY WELL	8 74	7.8	395	222	114	0.80		32.0	8.7	47.3	0.6	172	40.0	11.0		0.00
68	ISLAND CREEK SHOP	8 75	8.2	405	267	110	0.47	0.18	32.0	7.9	57.0	1.3	184	22.8	14.0		0.00
68	ISLAND CREEK SHOP	8 74	7.9	367	227	100	0.20		30.0	7.3	49.5	0.9	193	10.0	3.0		0.04
69	VANSANT ELEMENTARY SCHOOL	8 74	7.2	1700	1027	310	13.20		91.0	24.0	260.0	1.9	200	10.7	437.0		0.13

SUMMARY OF GROUNDWATER QUALITY ANALYSES FOR BUCHANAN COUNTY (Cont'd)

SWCB NO.	OWNER AND/OR PLACE	DATE SAMP.	pH	SPEC. COND.	T. DIS. SOLIDS	HARD-NESS	Fe	Mn	Ca	Mg	Na	K	ALKA-LINITY	SO_4	Cl	F	NO_3
70	HARMAN ELEMENTARY SCHOOL	9 74	7.1	475	376	148	5.40		47.0	12.8	67.0	2.2	119	116.0	13.0		0.00
71	SANDY VALLEY LANES	9 74	7.6	1560	991	112	13.90		50.0	13.7	12.6	1.1	291	0.8	384.0		0.00
72	BIG ROCK SCHOOL	9 74	6.8	490	314	112	5.90		33.0	11.0	75.0	1.4	116	15.0	93.0		0.00
73	WHITEY WELL	9 74	6.7	350	252	138	2.80		17.0	4.8	33.0	1.4	47	102.0	11.0		0.00
74	OWENS WELL	9 74	6.9	200	146	50	0.00		36.0	8.5	340.0	1.5	90	4.3	11.0		0.00
75	BUCHANAN CO. FUNERAL HOME	10 74	7.2	225	155	88	0.60		23.0	5.0	35.0	1.0	118	3.0	1.0		0.00
76	QUILLEN & GARDEN SCHOOL	8 74	7.0	443	276	112	14.20		28.0	9.1	70.0	1.4	117	92.0	22.0		0.04
76	QUILLEN & GARDEN SCHOOL	6 65	6.9				16.50	3.15	110.0	37.5			74	945.0	38.3	0.3	0.09
77	HARRIS STORE WELL	9 74	7.4	980	570	114	1.00		38.0	7.90	190.0	1.30	165	0.00	218		0.00
78	HURLEY HIGH SCHOOL	3 75	7.7	240	208	34	0.16	0.00	14.0	3.1	35.0	1.3	133	1.9	4.0		0.00
79	DUTY WELL	3 75	6.4	260	145	66	5.30	0.20	21.0	6.0	10.8	1.1	58	15.3	5.0		0.00
80	KELSA SNACK BAR	3 75	6.4	480		216	1.20	0.17	78.0	16.5	36.0	1.9		135.6			0.00
81	BELCHER WELL	3 75	6.7	200	171	80	10.80	0.50	31.0	6.5	13.3	1.0	79	18.3	2.5		0.00
82	EDWARDS WELL	6 75	7.2	320	247		0.05	0.00	22.0	7.2	41.0	1.0	180	11.3	1.0		1.15
83	HARRIS WELL	9 74	7.2	550	397								184	6.4	3.2		0.00
86	VA. POCAHONTAS MINE NO. 3	6 75	7.8	2000	1112		0.36	0.00	18.0	5.2	310.0	1.6	324	2.2	505		0.00
87	VA. POCAHONTAS MINE NO. 3	6 75	8.3	2800	1667		0.53	0.00	27.0	7.8	660	1.6	323	2.6	805		0.00
88	YATES WELL	6 75	6.4	310	202		0.24	1.75	17.0	7.9	2.2	1.2	71	15.9	51.9		0.00
90	LANDFILL WELL	8 75	6.3	520	445		0.65	0.90	60.0	28.0	14.4	3.0	69	426.0	1.0		0.00
91	MATTNIC WELL	8 75	7.0	270	208	250	1.30	0.10	35.0	10.4	12.5	1.0	118	40.0	1.0		0.00

GLOSSARY

A-horizon	The uppermost zone of a soil profile, from which soluble salts and colloids have been leached, and organics have accumulated, i.e., topsoil.
Alluvium	Geologic recent water deposited detritus.
Anticline	A convex fold or arch of rock strata with the two edges or limbs dipping in opposite directions from the crest.
Aquiclude	A formation with such a low permeability as to render it useless as a source of water or conveyance of recharge.
Aquifer	A formation, group of formations, or part of a formation that is water bearing.
Arenaceous	Rocks that contain sand.
Argillaceous	Rocks that contain large amounts of clay.
Axis	The linear trend of the axis of an anticline, or the trough of a syncline.
Bedding	Planes which divide sedimentary rocks of the same or different composition.
Bedrock	Any solid rock either exposed at the surface, or overlain by soil or unconsolidated deposits.
B-horizon	A zone of soil below the A-horizon in which soluble salts, colloids, and fine mineral particles accumulate.
Bog	Swamp or wet land commonly covered by decaying vegetation or peat.
Breccia	A sedimentary rock consisting of angular detrital fragments cemented together by finer material.
Calcareous	Containing calcium carbonate ($CaCO_3$).
Carbonate Rock	A rock consisting largely of a mineral or minerals containing the radical CO_3^{--}.
Cementation	The precipitation of a binding material around minerals or rock grains. An example would be a quartz cemented sandstone.

C-horizon	The weathered zone of a soil profile directly beneath the B-horizon, and extending down to unweathered rock.
Clastic Rock	A sedimentary rock composed of fragmented materials derived from pre-existing rocks.
Colluvium	Gravity transported loose deposits usually found at the foot of a slope or cliff.
Compaction	A decrease in the volume of sediments due to the compression of overlying strata.
Cone of Depression	A conical depression in the water table that is formed around a water well when it is being pumped.
Conglomerate	A clastic sedimentary rock consisting of rounded rocks or minerals cemented together by a finer matrix.
Degradation	The process of lowering a land surface by erosion.
Denudation	The laying bare of a strata by removing its cover or overburden.
Detritus	Accumulations resulting from the breaking up and decay of pre-existing rocks.
Dip	The angle at which a rock bed is inclined from the horizontal.
Discharge	The volume of a stream flow, per unit of time, through a given cross section of the stream.
Dissection	The transformation by erosion of flat upland areas into rugged hills, valleys and ravines.
Dolomite	A sedimentary rock composed largely of calcium magnesium carbonate ($CaMg(CO_3)_2$).
Drawdown	The depth to which the water table is lowered below the static level due to well pumping.
Evapo-transpiration	That portion of precipitation which is returned to the air by evaporation and vegetation.
Fault	A fracture or fracture zone along which there has been displacement of the two sides relative to one another, and parallel to the fracture. The displacement may be a few inches or many miles.
Fault Breccia	An assembly of broken rock fragments ferquently found along faults. They are often recemented.

Fissile	A property of splitting easily along closely spaced parallel planes. Thin bedded shales are often fissile.
Flood Plain	An area adjacent to a river (or stream) which is composed of sediments deposited by the river, and which is covered by water when the river overflows its banks during flooding.
Flowing Well	A well from which water flows at the surface without pumping due to hydrostatic pressure.
Fold	A bend in the rock strata.
Formation	A geologic mapping unit consisting of a large and persistent stratum of common rock.
Fossils	The remains or traces of plants or animals preserved in rock.
Fracture	A break in a rock usually due to faulting or intense folding.
Groundwater	Subsurface water below the water table in the zone of saturation.
Hydrologic Cycle	The cycle in which water is evaporated from the sea, precipitates from the atmosphere, infiltrates into the land, and returns either to the sea or atmosphere by transportation, evaporation or transpiration.
Impervious	The term applied to a bed or stratum through which water will not move under normal hydrostatic pressure.
Infiltration	The flow or movement of water through the soil surface into the ground.
Interstitial Water	Water contained in the small pores or spaces between the grains of rock.
Joint	A rock fracture, usually vertical to bedding, along which no appreciable movement has occurred.
Karst Topography	The name given to terrains that are underlain by limestones and dolomites that have been weathered and dissolved by groundwater, forming such features as caves, sinkholes, disappearing and reappearing streams. Named after the Karst Mountains of the eastern Adriatic.
Leaching	The process by which soluble mineral compounds are removed in solution by percolating groundwaters.

Limestone	A sedimentary rock consisting predominantly of calcium carbonate ($CaCO_3$).
Lithology	The physical character of a rock as can be determined visually by the unaided eye, or with a small power (10 x) hand lens.
Marsh Gas	Methane. Derived from the decay of plant tissue. Often found in the groundwater of coal producing regions. Often known as "fire-damp" in coal mining regions.
Outcrop	The part of a rock formation which appears at the surface.
Peat	A dark brown residue formed by partially decomposed vegetation in bogs and swamps. The formation of peat beds is the first stage in the development of coal.
Perched Water Table	Groundwater which lies above the regional water table, but is separated from it by an impervious strata.
Permeability	The capacity of rock or soil to transmit a fluid. It is measured by the rate at which a fluid of a standard viscosity can move a given distance over a certain period of time.
Pervious Rock	A stratum or formation that contains voids through which water will move under normal hydrostatic conditions.
Poorly Graded Deposits	Unconsolidated deposits of essentially the same grain size. Such deposits have a high porosity.
Porosity	The ratio of the volume of voids of a rock or soil to the total volume. This ratio is usually expressed as a percent.
Potentiometric Surface	The level to which groundwater rises in a well or an aquifer. In a water table or unconfined aquifer, it is the water table; in an artesian or confined aquifer, it is the piezometric surface, also called the artesian head: water level above the top of the penetrated aquifer.
Pyrite	Iron sulfide (FeS_2). A mineral often associated with coal deposits and believed to contribute both iron and sulfur compounds to the groundwater.
Quartzite	A firm sandstone in which silica has grown between the individual grains.

Recharge	The addition of water to an aquifer by natural infiltration or artificial means.
Residual Soil	Soil formed in place by the disintegration and decomposition of the underlying rock.
Runoff	Water which flows on the surface, such as in streams.
Saltwater Encroachment	The replacement of fresh groundwater by brackish or saline waters often due to the overpumping of an aquifer.
Sandstone	A sedimentary rock consisting predominantly of sand-size particles.
Saprolite	A thoroughly decomposed, earthy, but untransported rock.
Sedimentary Rocks	Those rocks formed by the consolidation of accumulated sediments in water (aqueous) or air (eolian). The sediments may be rock fragments (sandstones, shales); animal or plant remains (limestones, coal); or the product of chemical action or evaporation (salt, gypsum). The deposits are layered, and nearly flat as deposited.
Shale	A laminated sedimentary rock consisting largely of clay-sized particles. In coal mining regions these rocks are often termed "slate."
Sinkhole	A land surface depression usually found in limestone regions. They are often topographic reflections of collapsed subsurface caves. Sinkholes are also found in regions underlain by salt and gypsum.
Slate	A metamorphosed shale with well developed fissility. Also a coal miner's term for any shale which accompanies coal.
Solution Cavities	Openings in limestones and other soluble rocks caused by percolating water.
Specific Yield	The volume of water (expressed as a percent) that a fixed volume of rock or soil will surrender to a well. For example, if 100 cubic feet of saturated rock with a porosity of 25 percent yields 15 gallons of water to a well, the specific yield will be 15 percent.
Stratum	A single sedimentary bed or layer, regardless of thickness.

Strike	The bearing of a horizontal line on the plane of a stratum, joint, fault, or cleavage plane. It is perpendicular to the direction of dip.
Structure	The general disposition, attitude, arrangement, or relative positions of the rock masses of a region.
Subsidence	The lowering of the earth's surface. It may be extensive, such as the relative lowering of portions of continents, or local due to overpumping of groundwater, collapsed mines, or consolidation of soils in fill areas.
Syncline	A concave fold or trough of rock strata with the two edges or limbs dipping in the same direction toward the axis of the trough.
Talus	A pile of coarse waste at the foot of a cliff or steep slope.
Terrace Deposits	Deposits of alluvium which are elevated, usually level, older flood plains, and which are bounded by an escarpment.
Topography	The relief and form of a land surface.
Unconformity	An old erosion surface that separates younger strata from older rocks.
Vadose Water	Subsurface water in the zone of aeration, above the zone of saturation.
Water Table	The upper surface of the zone of saturation. The surface in a water table aquifer at which the water level stands.
Water Well	An artificial excavation placed into the ground to such a depth as to penetrate water-yielding rock or deposits, thus allowing the removal of that water by flow or pumping.
Weathering	A complex set of natural processes, both chemical and mechanical, involving the decay and breaking up of rocks.
Well Graded Deposits	Unconsolidated deposits consisting of a wide distribution of grain sizes from extremely fine to large. Because the finer particles fill the voids between the larger particles, well sorted deposits have lower porosities than poorly sorted deposits.

Zone of Aeration	The zone in which permeable rock interstices are not filled (except occasionally) with water.
Zone of Saturation	The zone in which an aquifer is saturated with water under pressure equal to or greater than atmospheric pressure.

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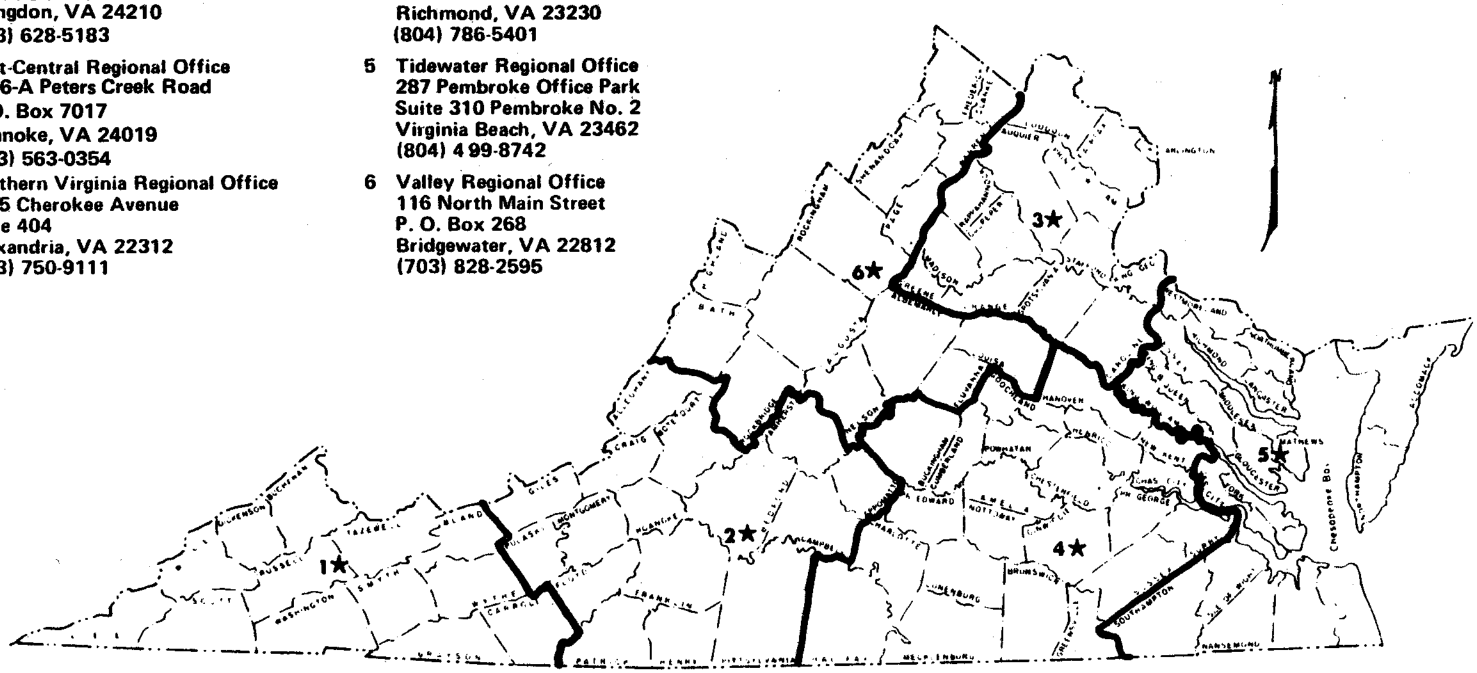

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