GROUND WATER POLLUTION POTENTIAL OF HOLMES COUNTY, OHIO

BY

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ABSTRACT

A groundwater pollution potential map of Holmes County has been prepared using the DRASTIC mapping process. The DRASTIC system consists of two major elements: the designation of mappable units, termed hydrogeologic settings, and the superposition of a relative rating system for pollution potential.

Hydrogeologic settings incorporate hydrogeologic factors that control ground water movement and occurrence including depth to water, net recharge, aquifer media, soil media, topography, impact of the vadose zone media, and hydraulic conductivity of the aquifer. These factors, which form the acronym DRASTIC, are incorporated into a relative ranking scheme that uses a combination of weights and ratings to produce a numerical value called the ground water pollution potential index. Hydrogeologic settings are combined with the pollution potential indexes to create units that can be graphically displayed on a map.

Ground water pollution potential analysis in Holmes County resulted in a map with symbols and colors, which illustrate areas of varying ground water pollution potential indexes ranging from 63 to 187.

The northern half of Homes County lies within the Glaciated Central hydrogeologic setting, while the southern half lies within the Nonglaciated Central hydrogeologic setting. The buried valley underlying the present main channel of Killbuck Creek contains sand and gravel outwash deposits that are capable of yielding up to 500 gallons per minute (gpm) from properly designed large diameter wells. Yields of 25-100 gpm to 5-25 gpm are obtained from buried valleys underlying tributaries of Sugar Creek and the Mohican River. Yields of 5-25 gpm to less than 5 gpm are obtained from thin lenses of sand and gravel interbedded with glacial till and lacustrine sediments along the margins of the buried valleys and in upland areas containing moderately thick drift.

Interbedded sandstones, shales, and siltstones of the Pennsylvanian System and interbedded sandstones and shales of the Mississippian System comprise the aquifer for the many of the upland areas in Holmes County. Wells developed from highly fractured sandstones of the Pennsylvanian Massillon and Sharon Formations have yields ranging from 25-100 County. Elsewhere in the county, yields in the Pottsville and Allegheny Groups range from 5-25 gpm to 0-5 gpm depending upon the proportion of sandstones to finer-grained rocks and presence of fractures. In the eastern half of the county, thin limestones, coals, and clays are encountered. These rocks commonly have yields around 5-10 gpm. Wells developed in the Mississippian Logan Formation and Black Hand Sandstone typically yield

from 5 to 25 gpm with limited yields up to 50 gpm. The Mississippian Cuyahoga Group consists of shales, fine-grained sandstones, and siltstones, which have yields in the 5-10 gpm range.

The ground water pollution potential mapping program optimizes the use of existing data to rank areas with respect to relative vulnerability to contamination. The ground water pollution potential map of Holmes County has been prepared to assist planners, managers, and local officials in evaluating the potential for contamination from various sources of pollution. This information can be used to help direct resources and land use activities to appropriate area, or to assist in protection, monitoring, and clean-up efforts.

TABLE OF CONTENTS

LIST OF FIGURES

Number Page

LIST OF TABLES

Number Page

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INTRODUCTION

The need for protection and management of ground water resources in Ohio has been clearly recognized. About 42 percent of Ohio citizens rely on ground water for drinking and household use from both municipal and private wells. Industry and agriculture also utilize significant quantities of ground water for processing and irrigation. In Ohio, approximately 750,000 rural households depend on private wells; 7200 of these wells exist in Holmes County.

The characteristics of the many aquifer systems in the state make ground water highly vulnerable to contamination. Measures to protect ground water from contamination usually cost less and create less impact on ground water users than remediation of a polluted aquifer. Based on these concerns for protection of the resource, staff of the Division of Water conducted a review of various mapping strategies useful for identifying vulnerable aquifer areas. They placed particular emphasis on reviewing mapping systems that would assist in state and local protection and management programs. Based on these factors and the quantity and quality of available data on ground water resources, the DRASTIC mapping process (Aller et al., 1987) was selected for application in the program.

Considerable interest in the mapping program followed successful production of a demonstration county map and led to the inclusion of the program as a recommended initiative in the Ohio Ground Water Protection and Management Strategy (Ohio EPA, 1986). Based on this recommendation, the Ohio General Assembly funded the mapping program. A dedicated mapping unit has been established in the Division of Water, Water Resources Section to implement the ground water pollution potential mapping program on a countywide basis in Ohio.

The purpose of this report and map is to aid in the protection of our ground water resources. This protection can be enhanced by understanding and implementing the results of this study, which utilizes the DRASTIC system of evaluating an area's potential for ground water pollution. The mapping program identifies areas that are vulnerable to contamination and displays this information graphically on maps. The system was not designed or intended to replace site-specific investigations, but rather to be used as a planning and management tool. The map and report can be combined with other information to assist in prioritizing local resources and in making land use decisions.

APPLICATIONS OF POLLUTION POTENTIAL MAPS

The pollution potential mapping program offers a wide variety of applications in many counties. The ground water pollution potential map of Holmes County has been prepared to assist planners, managers, and state and local officials in evaluating the relative vulnerability of areas to ground water contamination from various sources of pollution. This information can be used to help direct resources and land use activities to appropriate areas, or to assist in protection, monitoring, and clean-up efforts.

An important application of the pollution potential maps for many areas will be assisting in county land use planning and resource expenditures related to solid waste disposal. A county may use the map to help identify areas that are suitable for disposal activities. Once these areas have been identified, a county can collect more site-specific information and combine this with other local factors to determine site suitability.

Pollution potential maps may be applied successfully where non-point source contamination is a concern. Non-point source contamination occurs where land use activities over large areas impact water quality. Maps providing information on relative vulnerability can be used to guide the selection and implementation of appropriate best management practices in different areas. Best management practices should be chosen based upon consideration of the chemical and physical processes that occur from the practice, and the effect these processes may have in areas of moderate to high vulnerability to contamination. For example, the use of agricultural best management practices that limit the infiltration of nitrates, or promote denitrification above the water table, would be beneficial to implement in areas of relatively high vulnerability to contamination.

A pollution potential map can assist in developing ground water protection strategies. By identifying areas more vulnerable to contamination, officials can direct resources to areas where special attention or protection efforts might be warranted. This information can be utilized effectively at the local level for integration into land use decisions and as an educational tool to promote public awareness of ground water resources. Pollution potential maps may be used to prioritize ground water monitoring and/or contamination clean-up efforts. Areas that are identified as being vulnerable to contamination may benefit from increased ground water monitoring for pollutants or from additional efforts to clean up an aquifer.

Individuals in the county who are familiar with specific land use and management problems will recognize other beneficial uses of the pollution potential maps. Planning commissions and zoning boards can use these maps to help make informed decisions about the development of areas within their jurisdiction. Developers proposing projects within ground water sensitive areas may be required to show how ground water will be protected.

Regardless of the application, emphasis must be placed on the fact that the system is not designed to replace a site-specific investigation. The strength of the system lies in its ability to make a "first-cut approximation" by identifying areas that are vulnerable to contamination. Any potential applications of the system should also recognize the assumptions inherent in the system.

SUMMARY OF THE DRASTIC MAPPING PROCESS

DRASTIC was developed by the National Ground Water Association for the United States Environmental Protection Agency. This system was chosen for implementation of a ground water pollution potential mapping program in Ohio. A detailed discussion of this system can be found in Aller et al. (1987).

The DRASTIC mapping system allows the pollution potential of any area to be evaluated systematically using existing information. Vulnerability to contamination is a combination of hydrogeologic factors, anthropogenic influences, and sources of contamination in any given area. The DRASTIC system focuses only on those hydrogeologic factors that influence ground water pollution potential. The system consists of two major elements: the designation of mappable units, termed hydrogeologic settings, and the superposition of a relative rating system to determine pollution potential.

The application of DRASTIC to an area requires the recognition of a set of assumptions made in the development of the system. DRASTIC evaluates the pollution potential of an area under the assumption that a contaminant with the mobility of water is introduced at the surface and flushed into the ground water by precipitation. Most important, DRASTIC cannot be applied to areas smaller than 100 acres in size and is not intended or designed to replace site-specific investigations.

Hydrogeologic Settings and Factors

To facilitate the designation of mappable units, the DRASTIC system used the framework of an existing classification system developed by Heath (1984), which divides the United States into 15 ground water regions based on the factors in a ground water system that affect occurrence and availability.

Within each major hydrogeologic region, smaller units representing specific hydrogeologic settings are identified. Hydrogeologic settings form the basis of the system and represent a composite description of the major geologic and hydrogeologic factors that control ground water movement into, through, and out of an area. A hydrogeologic setting represents a mappable unit with common hydrogeologic characteristics and, as a consequence, common vulnerability to contamination (Aller et al., 1987).

Figure 1 illustrates the format and description of a typical hydrogeologic setting found within Holmes County. Inherent within each hydrogeologic setting are the physical characteristics that affect the ground water pollution potential. These characteristics or factors identified during the development of the DRASTIC system include:

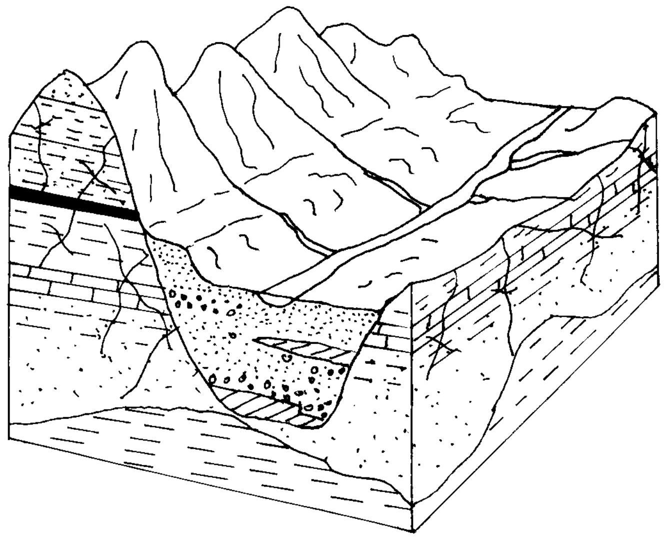
D – Depth to Water
R – Net Recharge
A – Aquifer Media
S – Soil Media
T – Topography
I – Impact of the Vadose Zone Media
C – Conductivity (Hydraulic) of the Aquifer

These factors incorporate concepts and mechanisms such as attenuation, retardation, and time or distance of travel of a contaminant with respect to the physical characteristics of the hydrogeologic setting. Broad consideration of these factors and mechanisms coupled with existing conditions in a setting provide a basis for determination of the area's relative vulnerability to contamination.

Depth to water is considered to be the depth from the ground surface to the water table in unconfined aquifer conditions or the depth to the top of the aquifer under confined aquifer conditions. The depth to water determines the distance a contaminant would have to travel before reaching the aquifer. The greater the distance the contaminant has to travel, the greater the opportunity for attenuation to occur or restriction of movement by relatively impermeable layers.

Net recharge is the total amount of water reaching the land surface that infiltrates the aquifer measured in inches per year. Recharge water is available to transport a contaminant from the surface into the aquifer and affects the quantity of water available for dilution and dispersion of a contaminant. Factors to be included in the determination of net recharge include contributions due to infiltration of precipitation, in addition to infiltration from rivers, streams and lakes, irrigation, and artificial recharge.

Aquifer media represents consolidated or unconsolidated rock material capable of yielding sufficient quantities of water for use. Aquifer media accounts for the various physical characteristics of the rock that provide mechanisms of attenuation, retardation, and flow pathways that affect a contaminant reaching and moving through an aquifer.



7D Buried Valley

This hydrogeologic setting is widespread through Holmes County. All of the major trunk streams and many modern tributaries overlie buried valley deposits. There are also former drainage ways overlying buried valleys that lack modern streams, particularly a broad valley extending from Loudonville to Big Prairie. The broad, flat-lying floodplains and gently sloping terraces characterize the setting. Depths to water are variable; they are typically less than 30 feet in valleys containing modern streams and are commonly over 45 feet in valleys lacking modern streams. Aquifers are composed of variable thicknesses of sand and gravel interbedded with finer-grained alluvium, till, and lacustrine deposits. The modern streams may be in direct hydraulic connection with the underlying aquifer. Yields up to 500 gpm have been reported for some of the coarser, thicker, more continuous sand and gravel outwash in Killbuck Creek near Millersburg. Yields up to 100 gpm are developed in the Middle Fork of Sugar Creek, Lake Fork of the Mohican River and Martins Creek southeast of Holmesville. Some valleys contain thin lenses of sand and gravel interbedded with much thicker sequences of finer-grained alluvial and lacustrine deposits. Soils on terraces are typically sandy loams derived from outwash; soils on floodplains are silt loams derived from modern alluvium. Recharge is typically relatively high due to the flat-lying topography, shallow depth to water, and the high permeability of the soils, vadose zone materials, and aquifer for buried valleys with modern overlying streams. Recharge tends to be less in valleys lacking modern streams, having greater depths to water, and less permeable soils and vadose media.

GWPP index values for the hydrogeologic setting of Buried Valley range from 86 to 187 with the total number of GWPP index calculations equaling 72.

Figure 1. Format and description of the hydrogeologic setting - 7D Buried Valley.

Soil media refers to the upper six feet of the unsaturated zone that is characterized by significant biological activity. The type of soil media influences the amount of recharge that can move through the soil column due to variations in soil permeability. Various soil types also have the ability to attenuate or retard a contaminant as it moves throughout the soil profile. Soil media is based on textural classifications of soils and considers relative thicknesses and attenuation characteristics of each profile within the soil.

Topography refers to the slope of the land expressed as percent slope. The slope of an area affects the likelihood that a contaminant will run off or be ponded and ultimately infiltrate into the subsurface. Topography also affects soil development and often can be used to help determine the direction and gradient of ground water flow under water table conditions.

The impact of the vadose zone media refers to the attenuation and retardation processes that can occur as a contaminant moves through the unsaturated zone above the aquifer. The vadose zone represents that area below the soil horizon and above the aquifer that is unsaturated or discontinuously saturated. Various attenuation, travel time, and distance mechanisms related to the types of geologic materials present can affect the movement of contaminants in the vadose zone. Where an aquifer is unconfined, the vadose zone media represents the materials below the soil horizon and above the water table. Under confined aquifer conditions, the vadose zone is simply referred to as a confining layer. The presence of the confining layer in the unsaturated zone has a significant impact on the pollution potential of the ground water in an area.

Hydraulic conductivity of an aquifer is a measure of the ability of the aquifer to transmit water, and is also related to ground water velocity and gradient. Hydraulic conductivity is dependent upon the amount and interconnectivity of void spaces and fractures within a consolidated or unconsolidated rock unit. Higher hydraulic conductivity typically corresponds to higher vulnerability to contamination. Hydraulic conductivity considers the capability for a contaminant that reaches an aquifer to be transported throughout that aquifer over time.

Weighting and Rating System

DRASTIC uses a numerical weighting and rating system that is combined with the DRASTIC factors to calculate a ground water pollution potential index or relative measure of vulnerability to contamination. The DRASTIC factors are weighted from 1 to 5 according to their relative importance to each other with regard to contamination potential (Table 1). Each factor is then divided into ranges or media types and assigned a rating from 1 to 10 based on their significance to pollution potential (Tables 2-8). The rating for each factor is selected based on available information and professional judgment. The selected rating for each factor is multiplied by the assigned weight for each factor. These numbers are summed to calculate the DRASTIC or pollution potential index.

Once a DRASTIC index has been calculated, it is possible to identify areas that are more likely to be susceptible to ground water contamination relative to other areas. The higher the

DRASTIC index, the greater the vulnerability to contamination. The index generated provides only a relative evaluation tool and is not designed to produce absolute answers or to represent units of vulnerability. Pollution potential indexes of various settings should be compared to each other only with consideration of the factors that were evaluated in determining the vulnerability of the area.

Pesticide DRASTIC

A special version of DRASTIC was developed for use where the application of pesticides is a concern. The weights assigned to the DRASTIC factors were changed to reflect the processes that affect pesticide movement into the subsurface with particular emphasis on soils. Where other agricultural practices, such as the application of fertilizers, are a concern, general DRASTIC should be used to evaluate relative vulnerability to contamination. The process for calculating the Pesticide DRASTIC index is identical to the process used for calculating the general DRASTIC index. However, general DRASTIC and Pesticide DRASTIC numbers should not be compared because the conceptual basis in factor weighting and evaluation differs significantly. Table 1 lists the weights used for general and pesticide DRASTIC.

Table 1. Assigned weights for DRASTIC features

Feature	**General DRASTIC Weight**	**Pesticide DRASTIC Weight**
Depth to Water	5	5
Net Recharge	4	4
Aquifer Media	3	3
Soil Media	2	5
Topography	1	3
Impact of the Vadose Zone Media	5	4
Hydraulic Conductivity of the Aquifer	3	2

Table 2. Ranges and ratings for depth to water

Depth to Water (feet)	
Range	**Rating**
0-5	10
5-15	9
15-30	7
30-50	5
50-75	3
75-100	2
100+	1
Weight: 5	Pesticide Weight: 5

Table 3. Ranges and ratings for net recharge

Net Recharge (inches)	
Range	**Rating**
0-2	1
2-4	3
4-7	6
7-10	8
10+	9
Weight: 4	Pesticide Weight: 4

Table 4. Ranges and ratings for aquifer media

Aquifer Media		
Range	**Rating**	**Typical Rating**
Shale	1-3	2
Glacial Till	4-6	5
Sandstone	4-9	6
Limestone	4-9	6
Sand and Gravel	4-9	8
Interbedded Ss/Sh/Ls/Coal	2-10	9
Karst Limestone	9-10	10
Weight: 3	Pesticide Weight: 3	

Table 5. Ranges and ratings for soil media

Soil Media	
Range	**Rating**
Thin or Absent	10
Gravel	10
Sand	9
Peat	8
Shrink/Swell Clay	7
Sandy Loam	6
Loam	5
Silty Loam	4
Clay Loam	3
Muck	2
Clay	1
Weight: 2	Pesticide Weight: 5

Table 6. Ranges and ratings for topography

Topography (percent slope)	
Range	**Rating**
0-2	10
2-6	9
6-12	5
12-18	3
18+	1
Weight: 1	Pesticide Weight: 3

Table 7. Ranges and ratings for impact of the vadose zone media

Impact of the Vadose Zone Media		
Range	**Rating**	**Typical Rating**
Confining Layer	1	1
Silt/Clay	2-6	3
Shale	2-5	3
Limestone	2-7	6
Sandstone	4-8	6
Interbedded Ss/Sh/Ls/Coal	4-8	6
Sand and Gravel with Silt and Clay	4-8	6
Glacial Till	2-6	4
Sand and Gravel	6-9	8
Karst Limestone	8-10	10
Weight: 5	Pesticide Weight: 4	

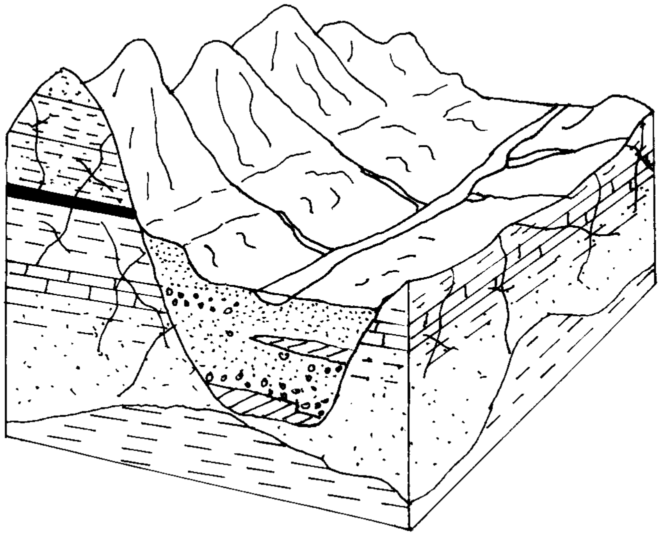
Table 8. Ranges and ratings for hydraulic conductivity

Hydraulic Conductivity (GPD/FT^2)	
Range	**Rating**
1-100	1
100-300	2
300-700	4
700-1000	6
1000-2000	8
2000+	10
Weight: 3	Pesticide Weight: 2

Integration of Hydrogeologic Settings and DRASTIC Factors

Figure 2 illustrates the hydrogeologic setting 7D1, Buried Valley, identified in mapping Holmes County, and the pollution potential index calculated for the setting. Based on selected ratings for this setting, the pollution potential index is calculated to be 129. This numerical value has no intrinsic meaning, but can be readily compared to a value obtained for other settings in the county. DRASTIC indexes for typical hydrogeologic settings and values across the United States range from 45 to 223. The diversity of hydrogeologic conditions in Holmes County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the 9 settings identified in the county range from 63 to 187.

Hydrogeologic settings identified in an area are combined with the pollution potential indexes to create units that can be graphically displayed on maps. Pollution potential analysis in Holmes County resulted in a map with symbols and colors that illustrate areas of ground water vulnerability. The map describing the ground water pollution potential of Holmes County is included with this report.



SETTING 7D1		GENERAL		
FEATURE	**RANGE**	**WEIGHT**	**RATING**	**NUMBER**
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand & Gravel	3	5	15
Soil Media	Silt Loam	2	4	8
Topography	0-2%	1	10	10
Impact of Vadose Zone	Sand & Gravel with Silt & Clay	5	5	25
Hydraulic Conductivity	300-700	3	4	12
		DRASTIC	INDEX	129

Figure 2. Description of the hydrogeologic setting - 7D1 Buried Valley.

INTERPRETATION AND USE OF GROUND WATER POLLUTION POTENTIAL MAPS

The application of the DRASTIC system to evaluate an area's vulnerability to contamination produces hydrogeologic settings with corresponding pollution potential indexes. The susceptibility to contamination is greater as the pollution potential index increases. This numeric value determined for one area can be compared to the pollution potential index calculated for another area.

The map accompanying this report displays both the hydrogeologic settings identified in the county and the associated pollution potential indexes calculated in those hydrogeologic settings. The symbols on the map represent the following information:

7D1 - defines the hydrogeologic region and setting
129 - defines the relative pollution potential

Here the first number (**7**) refers to the major hydrogeologic region and the upper case letter (**D**) refers to a specific hydrogeologic setting. The following number (**1**) references a certain set of DRASTIC parameters that are unique to this setting and are described in the corresponding setting chart. The second number (**129**) is the calculated pollution potential index for this unique setting. The charts for each setting provide a reference to show how the pollution potential index was derived.

The maps are color-coded using ranges depicted on the map legend. The color codes used are part of a national color-coding scheme developed to assist the user in gaining a general insight into the vulnerability of the ground water in the area. The color codes were chosen to represent the colors of the spectrum, with warm colors (red, orange, and yellow) representing areas of higher vulnerability (higher pollution potential indexes), and cool colors (greens, blues, and violet) representing areas of lower vulnerability to contamination. The maps also delineate large man-made and natural features such as lakes, landfills, quarries, and strip mines, but these areas are not rated and therefore not color-coded.

GENERAL INFORMATION ABOUT HOLMES COUNTY

Demographics

Holmes County occupies approximately 424 square miles in northeastern Ohio (Figure 3). Holmes County is bounded to the north by Wayne County, to the northeast by Stark County, to the east by Tuscarawas County, to the south by Coshocton County, to the southwest by Knox County and to the northwest by Ashland County.

The approximate population of Holmes County, based upon year 2000 census estimates, is 38,943 (Department of Development, Ohio County Profiles, 2002). Millersburg is the largest community and the county seat. Agriculture accounts for roughly 63 percent of the land usage in Holmes County. Row crops account for over 40 percent of the land usage and pasture/grazing over 20 percent. Holmes County is well known for small family farms operated by Amish/ Mennonite settlers. Woodlands, industry, and residential are the other major land uses in the county. Residential growth is increasing primarily in the areas adjacent to Millersburg. Mining, including coal strip mines and sand and gravel pits is a common land use in eastern Holmes County. More specific information on land usage can be obtained from the Ohio Department of Natural Resources, Division of Real Estate and Land Management (REALM), Resource Analysis Program (formerly OCAP).

Climate

The *Hydrologic Atlas for Ohio* (Harstine, 1991) reports an average annual temperature of approximately 50 degrees Fahrenheit for Holmes County. The average temperatures increase slightly towards the south. Harstine (1991) shows that precipitation approximately averages 38 inches per year for the county, with precipitation decreasing towards the south. The mean annual precipitation for Millersburg is 37.4 inches per year based upon a twenty-year (1961-1980) period (Owenby and Ezell, 1992). The mean annual temperature at Millersburg for the same twenty-year period is 50.3 degrees Fahrenheit (Owenby and Ezell, 1992).

Physiography and Topography

Northern Holmes County lies within the Glaciated Allegheny Plateau section of the Appalachian Plateau Province and southern Holmes County lies within the Unglaciated Allegheny Plateau section of the Appalachian Plateau Province (Frost, 1931; Fenneman, 1938, and Bier, 1956). The county is characterized by broad, flat modern stream valleys, which overlie buried valley systems. These streams separate rolling to moderate steep topography in northern Holmes County. South of the glacial boundary, the relief becomes

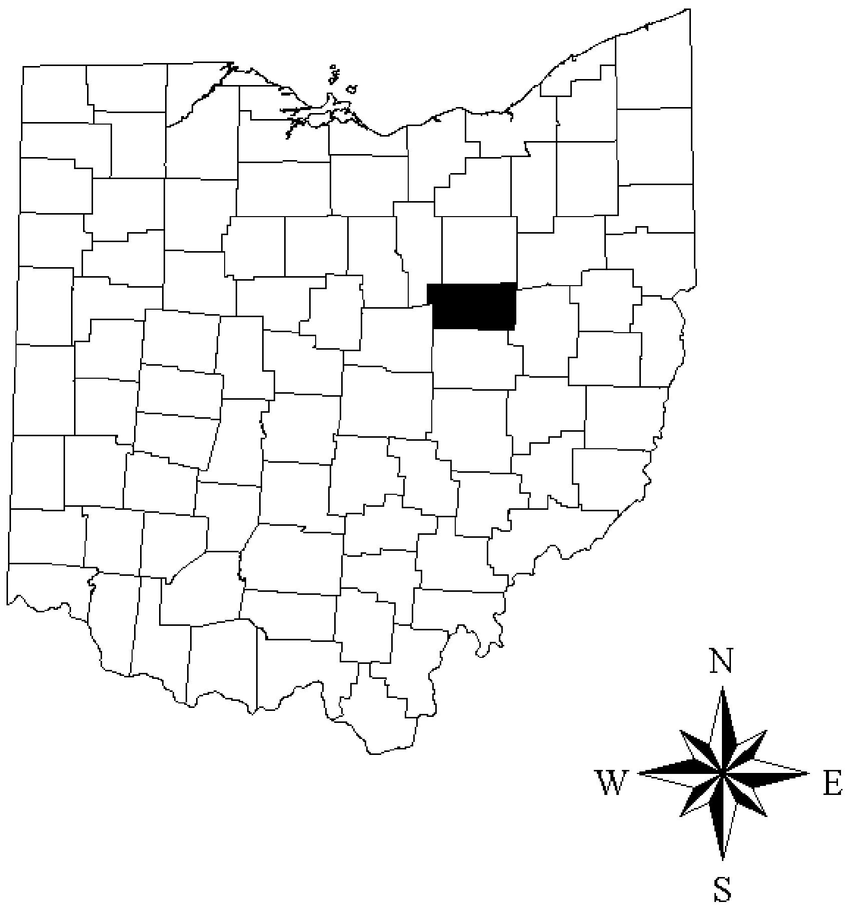


Figure 3. Location of Holmes County, Ohio.

greater, the topography is steeper and more rugged. The steepest relief is in the areas immediately adjacent to Black Creek and the Mohican River Valley.

Modern Drainage

Killbuck Creek and its tributaries drain Central Holmes County, including Salt Creek, Black Creek, and Doughty Creek. The western margin of the county is drained by Lake Fork of the Mohican River and the Mohican River. Drainage from the eastern margin of the county empties into Sugar Creek. Ultimately, all of the streams empty into the Muskingum River in southeastern Ohio.

Pre- and Inter-Glacial Drainage Changes

The drainage patterns of Holmes County have changed significantly as a result of the multiple glaciations. The drainage changes are complex and not yet fully understood. More research and data are necessary in both Holmes County and adjacent counties. Particularly, well log data for deeper wells that penetrate the entire drift thickness would be helpful in making interpretations.

Prior to glaciation, the Teays River System drained much of Ohio. Western and north central Holmes County was part of the headwaters of the Groveport River (Figure 4), which was the primary eastern tributary of the Teays River (Stout et al., 1943). This stream flowed to the west, cutting across Ashland County before curving south. Roscoe Creek, a tributary of the Cambridge River that ultimately joined the Groveport River at Newark, drained south-central Holmes County. The Groveport River flowed southwest from Newark eventually merging with the Teays River south of Columbus. The eastern margin of the county drained eastward into the northerly-flowing Dover River.

As ice advanced through Ohio during the pre-Illinoian (Kansan) glaciation, the Teays Drainage System was blocked. Flow backed up in the main trunk of the Teays River Valley as well as in many tributaries, forming several large lakes. These lakes over-topped, creating spillways and cutting new channels. New drainage systems began to evolve (Stout et al., 1943). Downcutting by these new streams was believed to be relatively rapid and, in many places, the new channels were cut over 100 feet deeper than the previous Teays River System valleys. The new drainage system is referred to as the Deep Stage due to this increased downcutting. In southwestern Holmes County, the drainages became entrenched deeper and eroded northeastward (Figure 5). Now referred to as the Utica River, this system continued to drain northern Holmes County. The Utica River roughly followed the course of the Groveport River (Stout et al., 1943). Southern Holmes County continued to be drained by Roscoe Creek, which had down cut deeper.

The Illinoian ice advance brought further changes to the drainage systems. Most of Holmes County was drained by the Millersburg River (Figure 6), an ancestral stream with

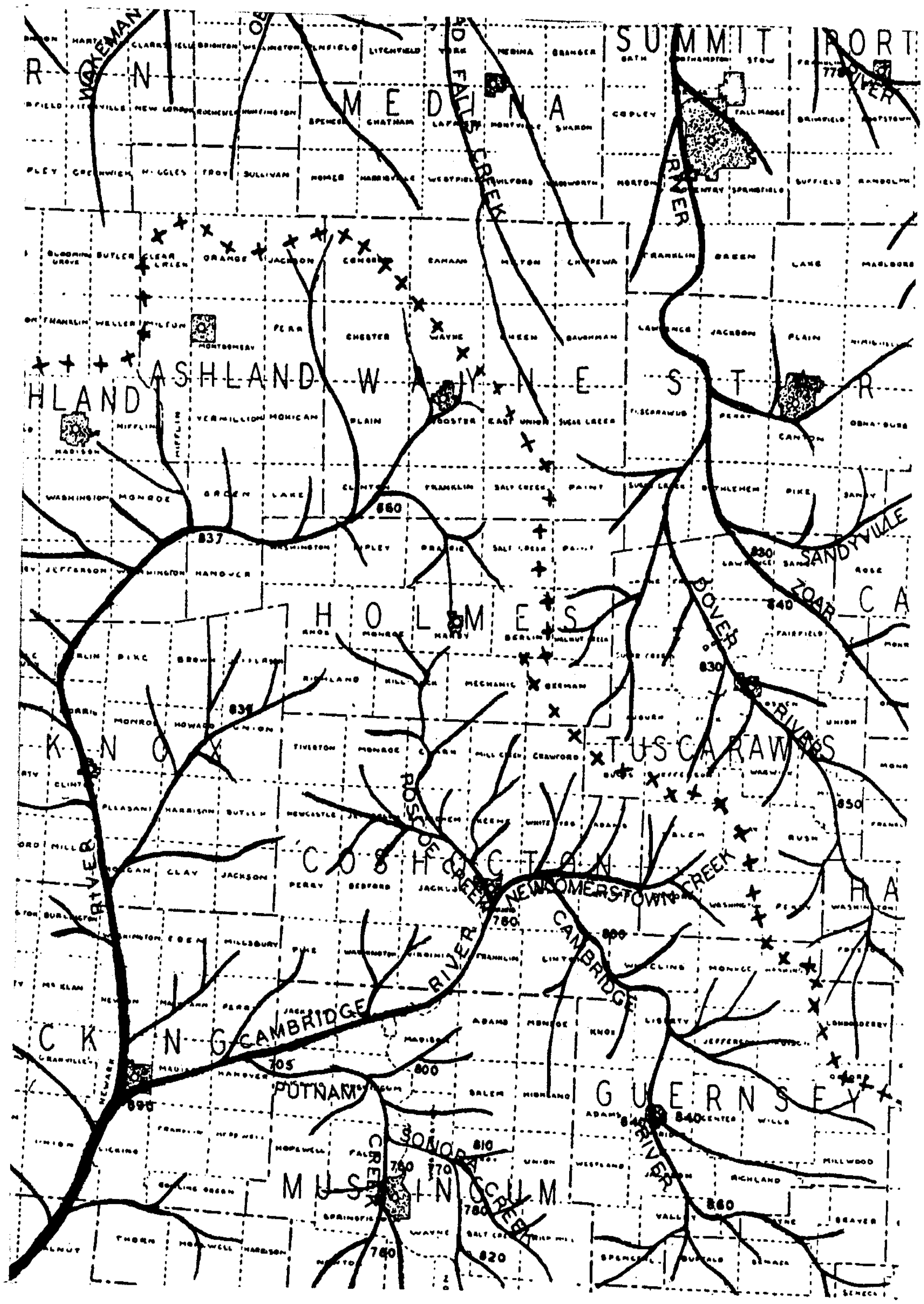


Figure 4. Pre-glacial Teays Stage drainage (after Stout et al., 1943).

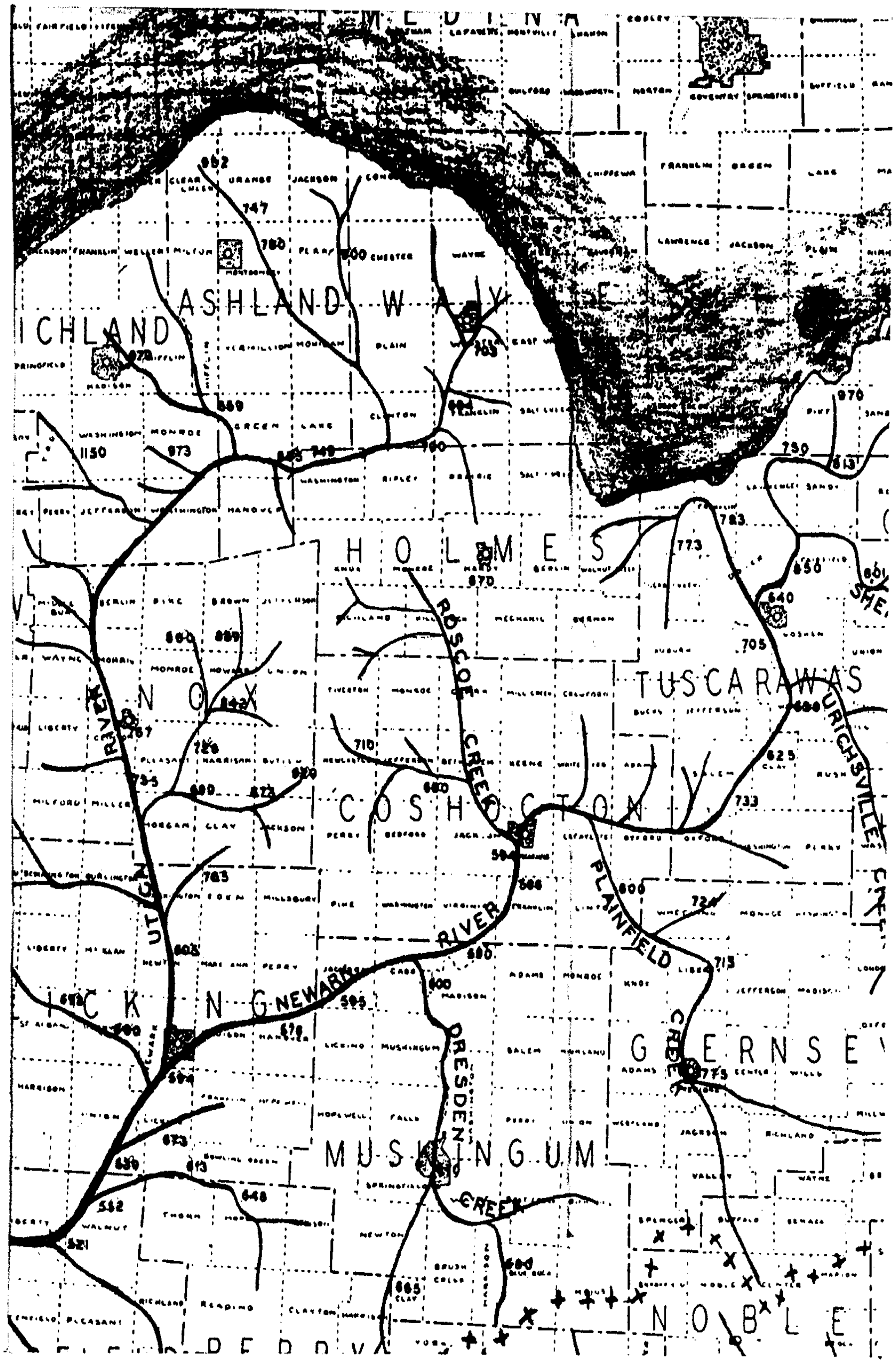


Figure 5. Deep Stage drainage (after Stout et al., 1943).

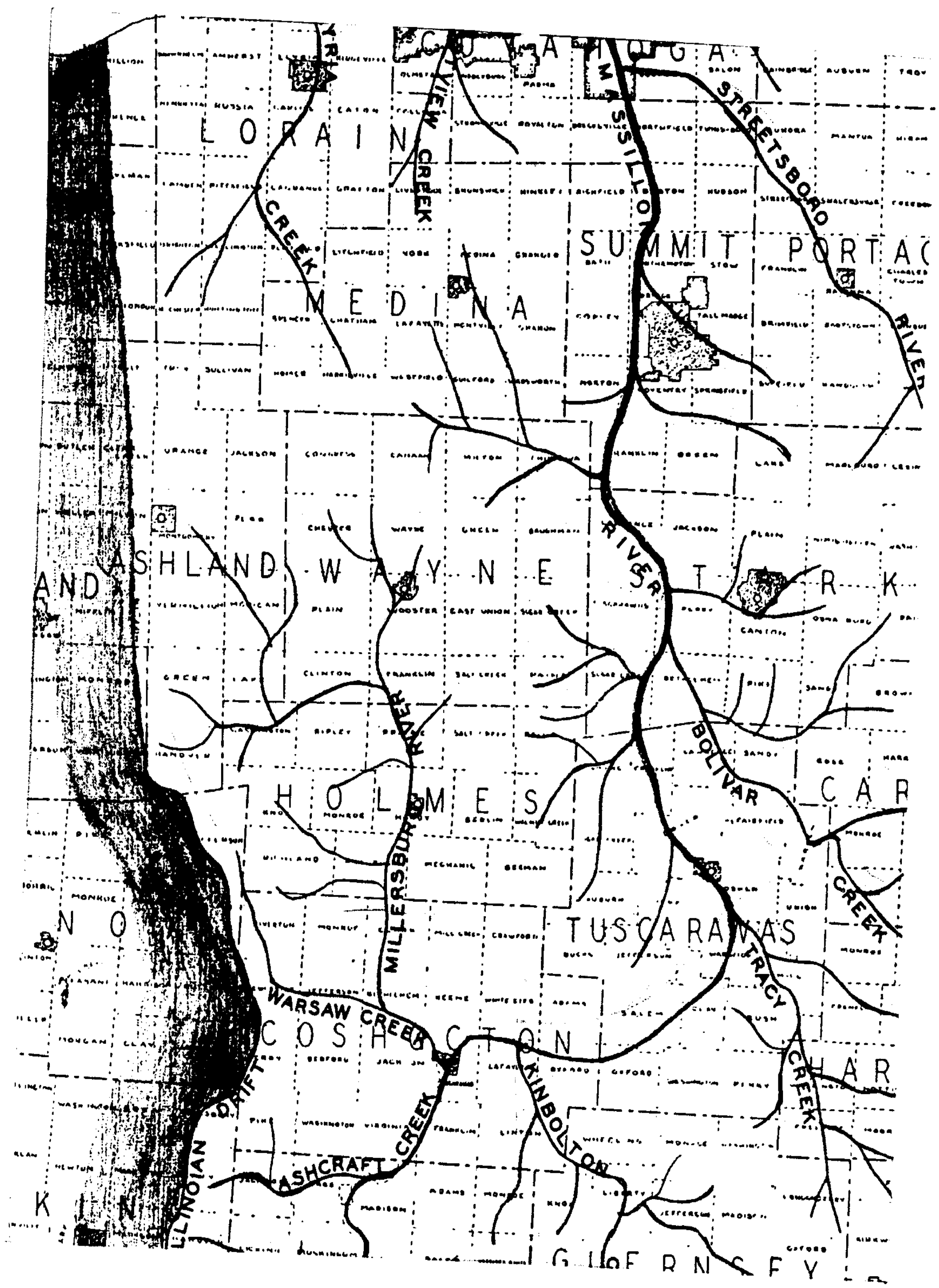


Figure 6. Illinoian-age drainage (after Stout et al., 1943).

roughly the same course as Killbuck Creek south of Wooster (Stout et al., 1943). Eastern Holmes County appears to have drained eastward into Stark County. Opinions as to the nature of drainage changes as a result of the advancing Illinoian ice front differ and more research is needed.

The most recent ice advance, the Wisconsinan, brought further drainage changes to Holmes County (Stout et al., 1943 and White, 1973). The modern drainage system was slowly created. Southward flowing streams, especially the Mohican River and Killbuck Creek, tended to become conduits for meltwater discharge and contain thick sequences of sand and gravel outwash along with finer alluvial (floodplain) deposits. In the northern part of the county, advancing ice blocked many tributaries, causing the water to pond and the deposition of fine-grained lacustrine or slack water deposits. Some valleys contain both types of deposits because the environments changed over time. Ancestral stream channels that become filled in with glacial drift are referred to as buried valleys. A wide, prominent valley extends from Loudonville eastward to Big Prairie. This abandoned drainage way no longer contains an active stream; it is dissected by Lake Fork of the Mohican River. This valley is predominantly filled with fines interbedded with lenses of sand and gravel.

Glacial Geology

During the Pleistocene Epoch (2 million to 10,000 years before present (Y.B.P.)) several episodes of ice advance occurred in northeastern Ohio. Table 9 summarizes the Pleistocene deposits found in Holmes County. Older ice advances that predate the most recent (Brunhes) magnetic reversal (about 730,000 Y.B.P.) are now commonly referred to as pre-Illinoian (formerly Kansan). White (1973 and 1982) reports that the Killbuck Lobe of the late Wisconsinan Ice Sheet deposited the surficial till in Holmes County. Pavey et al. (2002) delineate the surficial geology of northeastern Holmes County.

The majority of the glacial deposits fall into four main types: (glacial) till, lacustrine, outwash, and ice-contact sand and gravel (kames). Buried valleys may contain a mix of all of these types of deposits. Drift is an older term that collectively refers to the entire sequence glacial deposits.

Till is an unsorted, non-stratified (non-bedded), mixture of sand, gravel, silt, and clay deposited directly by the ice sheet. There are two main types or facies of glacial till. Lodgement till is "plastered-down" or "bulldozed" at the base of an actively moving ice sheet. It tends to be relatively dense and compacted, and pebbles typically are angular, broken, and have a preferred direction or orientation. "Hardpan" and "boulder-clay" are two common terms used for lodgement till. Ablation or "melt-out" till occurs as the ice sheet melts or stagnates away. Debris bands are laid down or stacked as the ice between the bands melts. Ablation till tends to be less dense, less compacted, and slightly coarser as meltwater commonly washes away some of the fine silt and clay. Till has relatively low inherent permeability. Permeability in till is in part dependent upon the primary porosity of the till, which reflects how fine-textured the particular till is.

Table 9. Pleistocene stratigraphy of Holmes County, Ohio

Age (years ago)	**Epoch**	**Stage**	**Killbuck Lobe** Central/northern Holmes County
25,000 to 70,000		Wisconsinan	Hiram Till Hayesville Till Navarre Till
			?
70,000 to 120,000	Pleistocene	Sangamonian	Lake and alluvial deposits
120,000 to 730,000		Illinoian	Millbrook Till
			Kame deposits
730,000 to 2,000,000		Pre-Illinoian	Sediments in deep buried valleys

Vertical permeability in till is controlled largely by factors influencing the secondary porosity such as fractures (joints), worm burrows, root channels, sand seams, etc.

At the land surface, till accounts for two primary landforms: ground moraine and end moraine. Ground moraine (till plain) is relatively flat to gently rolling. End moraines are ridge-like, with terrain that is steeper and more rolling or hummocky. White (1973 and 1982) mapped these landforms in detail for Holmes County; however, in much of the county, the topography is bedrock-controlled due to the overall thin nature of the drift. This makes it difficult to distinguish glacial landforms. In many of the upland areas (i.e. areas between the major stream valleys) depth to bedrock is commonly less than 25 feet and is almost always less than 40 feet. Steep stream dissection also makes it hard to delineate these glacial features.

Exposed Illinoian-age deposits in Holmes County are limited to Illinoian till found at the base of exposures, road-cuts and stream-cuts. Some of the till, outwash, and lacustrine deposits found in the deeper buried valley systems are also Illinoian in age. Wisconsinan-age till, outwash, or lacustrine deposits overlie these deposits.

Wisconsin-age deposition is associated with the advance of the Killbuck Lobe into north central Ohio (Goldthwait et al., 1961, Pavey et al., 1999, Pavey et al., 2002, and White, 1982). The first till deposited by the Killbuck Lobe is the Millbrook Till. The Millbrook Till is dense, silty to sandy and stony. This till is associated with the Mogadore Till, found to the northeast in Wayne and Summit County, and the Titusville Till, found in the Grand River Lobe east of Akron (White, 1982). The Titusville Till was proposed as being older than 40,000 Y.B.P. based upon radiocarbon (C^{14}) dates from exposures in northwestern Pennsylvania (White et al., 1969). Current thinking (Totten, 1987 and Eyles and Westgate, 1987) suggests that there was probably insufficient ice available in North America for a major ice advance into the Great Lakes area until the Late Wisconsinan Woodfordian sub-stage (approximately 25,000 Y.B.P.). The age of deposits previously determined to be early to mid-Wisconsinan in age is therefore being re-evaluated. The Killbuck Lobe deposited the Millbrook Till over the remainder of the county. This till is dense, silty, and pebbly. It is the thickest till in the county; however, it has not been reported at the surface. It is found at the base of excavations and stream cuts.

The Navarre Till is the oldest of the Late Wisconsinan Woodfordian tills (White, 1973). This till extends across most of northern Holmes County and is typically the surficial till. The Navarre Till is friable (loose), non-compact, sandy, and stony. Sand and gravel lenses are common in this till. Many of the surficial kame and outwash deposits found in the county are associated with this till unit (White, 1982).

The Hayesville Till is commonly thin and discontinuous ("patchy") in Holmes County (White, 1973). This till typically consists of a thin mantle covering the underlying, sandier Navarre Till. The Hayesville Till is thickest along the border with Wayne County. The Hayesville Till is moderately compact, dense, sparingly to moderately pebbly, and has a clayey-silty texture.

Lacustrine deposits were created as a result of the formation of numerous shallow lakes. Within stream valleys, the damming of streams by advancing ice sheets formed lakes. Some buried valleys may contain appreciable thicknesses of lacustrine deposits (White, 1967 and 1973). Typically, lacustrine deposits are composed of fairly dense, cohesive, uniform silt and clay with minor fine sand. Thin bedding, referred to as laminations, is common in these deposits. Such sediments were deposited in quiet, low-energy environments with little or no current.

Outwash deposits are created by active deposition of sediments by meltwater streams. These deposits are generally bedded (stratified) and sorted. Outwash deposits in Holmes County are predominantly located in stream valleys. Such deposits were referred to in earlier literature as valley trains. Sorting and degree of coarseness depend upon the nature and proximity of the melting ice sheet. Braided streams usually deposited the outwash. Such streams have multiple channels, which migrate across the width of the valley floor, leaving behind a complex record of deposition and erosion. As modern streams downcut, the older, now higher elevation remnants of the original valley floor are called terraces. White (1973) has delineated some of the major terraces in the county. All of the surficial terraces were reported as being Wisconsinan in age (White, 1973). Areas of extensive outwash deposits include Killbuck Creek near the village of Killbuck, the Mohican River, and Doughty Creek in Mechanic Township.

Kames and eskers are ice contact features. They are composed of masses of generally poorly sorted sand and gravel with minor till, deposited in depressions, holes, tunnels, or other cavities in the ice. As the surrounding ice melts, a mound of sediment remains behind. Typically, these deposits may collapse or flow as the surrounding ice melts. These deposits may display high angle, distorted or tilted beds, faults, and folds. In Holmes County, the majority of the kames are deposited along the margins or flanks of valleys, particularly within the headwaters of the drainage systems. These kames tend to coalesce together along the valley margins. Such features are referred to as kame terraces. They represent deposition of materials between the melting ice sheet and the bedrock and till slopes flanking the ice-filled valleys. Areas with abundant kame deposits include the Muddy Fork and the Lake Fork of the

Mohican River, the unoccupied (by a stream) valley extending from Loudonville to Big Prairie, Martins Creek southeast of Holmesville, and in an upland area east of Mount Hope.

Peat and muck are organic-rich deposits associated with low-lying depression areas, bogs, kettles, and swamps. Muck is a dense, fine silt with a high content of organics and a dark black color. Peat is typically brownish and contains pieces of plant fibers, decaying wood, and mosses. The two deposits commonly occur together, along with lacustrine or slack water clays and silts. The majority of these deposits are found along lower-lying portions of valley floors including margins of floodplains and terraces. There is a large swampy area near the confluence of Black Creek and Killbuck Creek.

Bedrock Geology

Bedrock exposed at the surface in Holmes County belongs to the Mississippian and Pennsylvanian Systems. Table 10 summarizes the bedrock stratigraphy found in Holmes County. The ODNR, Division of Geological Survey, has open-file reconnaissance bedrock geological maps done on a 1:24,000 scale USGS topographic map base available for the entire county. The ODNR, Division of Water, has open file bedrock state aquifer mapping available for the county also.

Interbedded sandstones, siltstones, and shales of Mississippian age are encountered at the surface of much of western and central Holmes County. The oldest rocks belong to the Cuyahoga Formation. These interbedded, fine-grained sandstones and shales typically are found flanking valleys and along hillsides. Overlying these units are the sandstones and conglomerates of the Black Hand Sandstone. Drillers commonly refer to these sandstones as the “Big Injun”. Overlying the Black Hand Sandstone are the members of the Logan Formation. The Logan is composed of sandstones, conglomerates, and shales. Farther to the east and southeast in Holmes County, these formations become deeper and tend to be encountered in the subsurface.

The Mississippian rocks were deposited by a series of deltas, bars, and shoreline environments. The transition between shales and sandstones reflects the transition between coarser and finer stream deposition. The gradation also reflects the relative position of the shoreline over time, with coarser deposition closer to land and finer-grained sediments more distal from the shore. Szmuc (1957 and 1970), Rau (1969) and Bork and Malcuit (1979) discuss Mississippian depositional systems in detail.

Pennsylvanian System rocks are present in the upland areas across the county and along slopes in valleys in southern and eastern Holmes County. Pennsylvanian rocks fall into two main categories. The basal Pottsville Group contains sandstones and conglomerates of the Sharon Sandstone and Massillon Sandstone. These rocks form moderately steep ridges and are in found in the northeastern corner of the county. Steep, high gradient streams and alluvial fans deposited these sediments. Overlying them are interbedded dirty sandstones, shales, siltstones, and thin limestones, clays, and coals of the Pottsville Group and Lower Allegheny Group (Multer, 1967 and Rau, 1970).

Table 10. Bedrock stratigraphy of Holmes County, Ohio

System	**Group/Formation (Symbol)**	**Lithologic Description**
Pennsylvanian	Allegheny-Upper Pottsville (Pa-up)	Thin brown to gray sandstones, siltstones, shale, and coal. Local thickness <100 feet. Poor to moderate aquifer yielding 5-25gpm. Found throughout southern and eastern Holmes County.
	Massillon through Sharon Formations (Pm-s)	The Massillon Formation is a coarse to medium-grained gray-white cross-bedded sandstone. The Sharon is a loosely cemented, cross-grained, gray to tan sandstone with conglomerate zones. This aquifer exceeds 100 feet in thickness. The best bedrock aquifer in the area, yields range from 5 to 100 gpm. Found in upland areas in northeastern Holmes County.
Mississippian	Logan and Black Hand Formations (Mlb)	The Logan consists of reddish-brown fine-grained sandstones interbedded with siltstones and shales. The Black Hand is a massive, coarse-grained sandstone yellow to brown in color. Thickness exceeds 100 feet. Yields range from 5 to 100 gpm. Widespread in central Holmes County.
	Cuyahoga Formation (Mcg)	Gray to brown shale with thin sandstone and siltstone interbeds. Thickness commonly greater than 100 feet. Yields range from 5 to 25 gpm. Found in western and central Holmes County.

Rau (1970) and Sedam (1973) discuss the depositional environments of the coarse-grained Sharon Sandstone and Massillon Sandstone. Weedman (1990) provides an excellent account of the complex depositional environments, which created the rocks of the Pennsylvanian System, particularly of the Allegheny Group. These highly transitional environments included both terrestrial ("land-based") and marine-derived sediments. The terrestrial environment was dominated by large river systems featuring broad alluvial plains upland from coastal areas. Stream channels and point bar deposits were the source of sandstones and conglomerates. Shales and siltstones were derived from fine-grained floodplain deposits. Freshwater limestones were deposited in shallow, rapidly evaporating lakes and ponds found on the alluvial plain. The terrestrial environment was highly transitional with a marine environment over time. The position of the shoreline and the depth of water varied with the rate of sediment input into the basin, sea level, and the rate of subsidence. Subsidence refers to an uneven "settling" during the relatively rapid accumulation of sediments. In the Allegheny Group, sandstones and shales represent deltaic/shoreline environments. Marine limestones formed in slightly deeper waters, which lacked clastic input from rivers and deltas. Coal and clay were deposited in two different environments. Coal was deposited in either a "back-barrier" environment along the shoreline or in "deltaic-plain" environment in swamps formed in abandoned river channels (Horne et al.., 1978). Similarly, clay was deposited in either quiet lagoonal areas directly behind the shoreline or in abandoned "oxbow" river channels (Ferm, 1974).

Ground Water Resources

Ground water in Holmes County is obtained from both unconsolidated (glacial-alluvial) and consolidated (bedrock) aquifers. Glacial aquifers are primarily associated with the buried valleys and thicker alluvial deposits. In upland areas where the drift is sufficiently thick, water is obtained from sand and gravel lenses interbedded in the glacial till. In areas where the drift is thinner, the drift serves as storage for extra recharge to the underlying bedrock aquifers.

Yields from 100 to 500 gpm and yields exceeding 500 gpm are obtainable from the coarse, well-sorted sand and gravel outwash deposits in the Killbuck Creek Valley (ODNR, Div. Of Water Open File, Glacial State Aquifer Map and Crowell, 1979). Test drilling or geophysical methods are recommended to help locate the higher yielding zones. Proper well construction and development is also needed to insure the high sustainable yields capable from these larger diameter wells. Smaller diameter wells should be suitable for serving domestic/farm needs within this aquifer. Yields of 25 to 100 gpm are obtained from wells drilled along the margins of Killbuck Creek, along Martins Creek southeast of Holmesville, in the Middle Fork of Sugar Creek Valley in the northeastern corner of the county, and in the Muddy Fork and Lake Fork of the Mohican River Valley. Thin lenses of sand and gravel interbedded with thick sequences of fine-grained materials are found in some of the smaller tributary buried and alluvial valleys and upland areas with thicker drift yield 5 to 25 gpm (ODNR, Div. Of Water Open File, Glacial State Aquifer Map and Crowell, 1979).

Yields from the consolidated, bedrock aquifers throughout the county are variable. Overall, yields tend to be better adjacent to stream valleys and poorer along ridge tops.

Crowell (1979) reports yields from highly fractured zones of the Sharon Sandstone and Massillon Sandstone ranging from 25 to 100 gpm in northeastern Holmes County. Wells developed in the Mississippian Black Hand Sandstone and coarser units of the Logan Formation have yields ranging from 25 to 100 gpm in many portions of central and northeastern Holmes County (Crowell, 1979 and ODNR, Div. of Water, Bedrock State Aquifer Map). Yields ranging from 10 to 25 gpm are associated with the interbedded shales, fine-grained sandstones, and siltstones of the Cuyahoga Formation, and finer-grained portions Logan Formation and the Pennsylvanian Pottsville and Allegheny Groups (Crowell, 1979 and ODNR, Div. of Water, Bedrock State Aquifer Map). Yields from wells developed in the dirty sandstones, shales, siltstones, coals, and thin limestones of the Allegheny Group in the south central part of Holmes County usually range from 3 to 10 gpm (ODNR, Div. of Water, Open File, Bedrock State Aquifer Map). The yield in any particular area is dependent upon the number and type of formations drilled. Wells drilled in bedrock often intersect several aquifers or water-producing zones. Sandstones and conglomerates tend to be water-bearing units, whereas underclays, mudstones, siltstones, thin limestones, and shales tend to be aquitards that impede the flow of water. Water tends to "perch" or collect on top of lower permeability units (e.g. shale) and move laterally along the base of an overlying unit with higher permeability (e.g. sandstone). Springs and seeps mark where these contacts meet the slope or land surface. Peffer (1991) demonstrated that shales could provide sufficient water to serve domestic needs and still behave as an aquitard.

The number of fractures and bedding planes intersected by the well also influences yields. The amount of fracturing tends to increase along hill slopes and valleys. This increase may be related to stress relief as shown by Wyrick and Borchers (1981) and Kipp et al. (1983). The net result is that there is usually a decrease in the depth to water (i.e. – a shallower static water level) and slightly higher yields. Fracturing is also an influence on the direction of ground water flow (Schubert, 1980) and affects the amount of recharge.

Strip and Underground Mined Areas

The pollution potential of strip-mined and abandoned underground mined areas were not evaluated in Holmes County. Although *DRASTIC: A Standardized System for Evaluating Ground Water Pollution Using Hydrogeologic Settings* (Aller et al., 1987) does identify mining as a possible source of ground water contamination, it does not discuss a methodology to evaluate the vulnerability of aquifers to contamination in these areas.

Many geologic and hydrogeologic changes occur in areas that have undergone or are undergoing mining and reclamation activities (Bonta et al., 1992 and Razem, 1983). The extent of these changes may not be known or may have a high degree of variability from one location to another.

Mining and reclamation activities have the ability to affect all DRASTIC parameters. Tables 11 and 12 list the DRASTIC parameters and the possible impacts that mining may have on rating the parameters in strip-mined and underground mined areas. These tables are not meant to be a comprehensive listing of the impacts of mining on ground water systems.

They are provided to illustrate the uncertainty of evaluating the pollution potential of mined areas.

Although the pollution potential of strip and abandoned underground mined areas were not evaluated, they were delineated. Only the most prominent and conspicuous mined areas were delineated on the Pollution Potential Map of Holmes County. Delineations of mined areas were made using information from the *Soil Survey of Holmes County* (Seaholm and Graham, 1998), abandoned underground mine maps (ODNR, Division of Geological Survey, open file maps), and the Holmes County portion of U.S.G.S. 7-1/2 minute quadrangle maps. Site-specific information for mined areas can be obtained from the ODNR, Division of Geological Survey and Division of Mineral Resources Management.

Table 11. Potential factors influencing DRASTIC ratings for strip mined areas

Parameter	Impact of Activity/Effects on DRASTIC Ratings
Depth to water	Removal of material overlying the aquifer will decrease the depth to water (i.e. increase DRASTIC rating); removal of uppermost aquifer will increase the depth to water (i.e. decrease DRASTIC rating)
Net Recharge	Mineral extraction and reclamation could increase the degree of fracturing, increase the permeability of the vadose zone and soils and therefore increase the amount of recharge (i.e. increase DRASTIC rating); compaction of fine grained spoils could decrease the amount of recharge to the aquifer (i.e. decrease DRASTIC rating)
Aquifer media	Mineral extraction could remove the uppermost aquifer
Soil media	Removal of soils will provide less of a barrier for contaminant transport (i.e. increase soil rating); reclaimed soils may have a lower permeability than the original cover (i.e. decrease soil rating)
Topography	Strip mining can change the contour of the land surface making delineation of this parameter virtually impossible
Impact of the vadose zone	Fracturing of vadose zone media could increase the permeability (i.e. increase rating); compaction of spoils during reclamation could decrease the permeability (i.e. decrease rating)
Hydraulic Conductivity	Fracturing of aquifer media could increase the conductivity (i.e. increase DRASTIC rating)

Table 12. Potential factors influencing DRASTIC ratings for underground mined areas

Parameter	Impact of Activity/Effects on DRASTIC Ratings
Depth to water	Collapse of underground mines has the potential to fracture overlying confining units, therefore causing a dewatering of overlying aquifers (i.e. decrease rating)
Net Recharge	Fracturing of overlying strata can increase amount of recharge to the aquifer (i.e. increase rating)
Aquifer media	Upper aquifers could be dewatered and underground mine could become the aquifer
Soil media	Fractures may extend to the land surface
Topography	This factor will not be affected unless severe subsidence occurs
Impact of the vadose zone	Fracturing and air shafts in the vadose zone could increase the permeability and provide a direct conduit for contamination (i.e. increase rating)
Hydraulic Conductivity	Upper aquifers not dewatered as a result of fracturing or subsidence would have higher conductivity values; underground mines serving as the aquifer media will have high conductivity values (i.e. higher rating)

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APPENDIX A
DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

This factor was primarily evaluated using information from water well log records on file at the Ohio Department of Natural Resources (ODNR), Division of Water, Water Resources Section (WRS). Approximately 7,200 water well log records are on file for Holmes County. Data from roughly 2,000 located water well log records were analyzed and plotted on U.S.G.S. 7-1/2 minute topographic maps during the course of the project. Static water levels and information as to the depths at which water was encountered were taken from these records. The *Ground Water Resources of Holmes County* (Crowell, 1979) provided generalized depth to water information throughout the county. Depth to water trends mapped in adjoining Wayne County (Angle, 2002), Stark County (Williams, 1991), Tuscarawas County (Baker and Angle (2001), Knox County (Aller and Ballou, 1991), and Coshocton County (Spahr, 1995) were used as a guideline. Topographic and geomorphic trends were utilized in areas where other sources of data were lacking.

Depths to water of 5 to 15 feet (9) were typical of areas associated with floodplains of major streams. Depths of 15 to 30 feet (7) were used for stream terraces adjacent to major streams and along smaller tributaries. Depths of 30 to 50 feet (5) were utilized for upland areas, particularly with areas of thinner drift. Depths to water of 50 to 75 feet (3) were utilized for higher ridges in the uplands and in deeper buried valleys, which lack modern surficial streams. Depths to water greater than 100 feet (1) were applied to isolated areas where deep sandstone aquifers were evaluated as being limited to very high, isolated ridge tops.

Net Recharge

Net recharge is the precipitation that reaches the aquifer after evapotranspiration and run-off. This factor was evaluated using many criteria, including depth to water, topography, soil type, surface drainage, vadose zone material, aquifer type, and annual precipitation. General estimates of recharge provided by Pettyjohn and Henning (1979) and Dumouchelle and Schiefer (2002) proved to be helpful. Recharge ratings from adjoining Wayne County (Angle, 2002), Stark County (Williams, 1991), Tuscarawas County (Baker and Angle, 2001), Knox County (Aller and Ballou, 1991), and Coshocton County (Spahr, 1995) were used as a guideline.

Recharge values of greater than 10 inches per year (9) and 7 to 10 inches per year (8) were assigned to floodplains adjacent to modern streams overlying outwash buried valley deposits. These areas contain highly permeable soils, vadose, and aquifer materials, have shallow depths to water, gentle slopes, and surficial streams. These areas are limited to terraces and floodplains underlain by coarse-grained outwash deposits. Values of 4 to 7 inches per year (6) were used for areas with moderate recharge. These areas include margins of buried valleys and tributary streams. These areas tend to have moderately shallow depths to water and lower permeability soils, or areas with moderate depths to water and moderately permeable soils, vadose, and aquifers. Values of 2 to 4 inches per year (3) were utilized for some upland areas and some buried valley areas lacking modern overlying streams. Greater depths to water, lower permeability soils, lower permeability glacial till, finer-grained bedrock, and greater depths to water characterize these areas. In upland areas, higher amounts of run-off due to steeper slopes were a factor for assigning the low recharge values. Values of recharge less than 2 inches per year (1) were utilized for limited steep ridge tops and slopes. These areas have moderate to great depths to water, soils are thin or absent, and slopes are very steep, which contributes to very high run-off.

Aquifer Media

Information on evaluating aquifer media was obtained from the reports or maps of the Ohio Drilling Co. (1971), Sedam (1973), and Crowell (1979). Aquifer media mapping in adjoining Wayne County (Angle, 2002), Stark County (Williams, 1991), Tuscarawas County (Angle and Baker, 2001), Knox County (Aller and Ballou, 1991), and Coshocton County (Spahr, 1995) proved helpful. Aquifer information was inferred for the surficial geology of northeastern Holmes County for Pavey et al. (2002). Open File Bedrock Reconnaissance Maps and Open File Bedrock Topography Maps, based upon U.S.G.S. 7-1/2 minute topographic maps from the ODNR, Division of Geological Survey proved helpful. The ODNR, Division of Water, Glacial State Aquifer Map and Bedrock State Aquifer Map were an important source of aquifer data. Water well log records on file at the ODNR, Division of Water, were the primary source of aquifer information.

An aquifer rating of (8) was designated for the high-yielding sand and gravel outwash deposits underlying Killbuck Creek and limited parts of the Mohican River bordering Knox County. An aquifer rating of (7) was assigned to thinner, less continuous sand and gravel outwash deposits associated with margins of buried valleys and terraces flanking floodplains. The rating of (7) was selected for parts of Killbuck Creek, Muddy Fork and Lake Fork of the Mohican River, the Mohican River, and Martins Creek, the unoccupied alley between Loudonville and Big Prairie, and Middle Fork of Sugar Creek. An aquifer rating of (6) and (5) was used for some thinner sand and gravel deposits associated with tributaries to Killbuck Creek, especially Doughty Creek and Wolf Creek, the Mohican River and Middle Fork of Sugar Creek.

An aquifer rating of (6) was assigned to limited areas of higher-yielding Sharon Sandstone and Massillon Sandstone in northeastern Holmes County. Wells developed in these aquifers may include some overlying interbedded shales, siltstones, and thin coals and limestones. An aquifer rating of (5) was utilized for most of the bedrock aquifers in Holmes County. The (5) rating included the interbedded sandstones and shales of the Mississippian Black Hand Sandstone, Logan Formation, and some units of the Cuyahoga Formation and the Pennsylvanian Pottsville Group and Allegheny Group. An aquifer rating of (4) was designated for some of the lower, shaley units of the Cuyahoga Formation containing abundant shales along the northern boundary adjacent to Wayne County and for some of the interbedded dirty sandstones, shales, thin limestones, and coals of the Allegheny Group in southern and southeastern Holmes County.

Soils

Soils were mapped using the data obtained from the *Soil Survey of Holmes County* (Seaholm and Graham, 1998). Each soil type was evaluated and given a rating for soil media. Evaluations were based upon the texture, permeability, and shrink-swell potential for each soil material. The soils of Holmes County showed a high degree of variability. This is a reflection of the parent material. Table 13 is a list of the soils, parent materials, setting, and corresponding DRASTIC values for Holmes County.

Soils were considered to be thin or absent (10) along many steep ridge tops and slopes where bedrock was exposed. These soils are prevalent in southwestern Holmes County. Soils were evaluated as being gravel soils (10) for a limited number of outwash terraces flanking the Mohican River. Soils were rated as being a peat (8) for organic soils in depressions or kettles on the floodplain of Martins Creek. Shrink-swell (aggregated) clay (7) was selected for some ridge tops in eastern Holmes County where the soils were developed from very clayey shales. Sandy loams (6) were selected for soils overlying outwash terraces, plains, and kames overlying buried valleys. Sandy loam soils (6) were also selected for steep, residual sandstone ridges throughout the county. Loam soils (5) were designated for medium-textured soils on floodplain terraces. Loam soils (5) were also used for slopes with interbedded sandstones and shales in southern Holmes County. Silt loam (4) soils were evaluated for loamy glacial till found in much of northern Holmes County. Silt loam (4) was also selected for silty alluvial and lacustrine deposits on floodplains. Silt loam (4) was also selected for residual bedrock soils. Clay loam (3) soils were evaluated for areas with clay-rich glacial till along the Wayne County boundary. Clay loam (3) soils were also evaluated for residual shale bedrock slopes in southern Holmes County.

The Ravenna-Canfield-Wooster soils that are associated with the Millbrook and Navarre Tills in northern Holmes County contain fragipans. A fragipan is a dense, impermeable zone found within certain loamy, till-derived soils. Fragipans may notably restrict the downward movement of water (Seaholm and Graham, 1998 and Williams, 1990). The net effect of the fragipan is to reduce the overall permeability of a soil within a given textural range (Aller et al., 1987). Hence, a soil with a loam (5) texture would be evaluated as a silt loam (4) due to the presence of a fragipan (see Table 13).

Topography

Topography, or percent slope, was evaluated using U.S.G.S. 7-1/2 minute quadrangle maps and the *Soil Survey of Holmes County* (Seaholm and Graham, 1998). Slopes of 0 to 2 percent (10) and 2 to 6 percent (9) were selected for flat-lying floodplains, valley floors, and terraces. Slopes of 0 to 2 (10) and 2 to 6 percent (9) were also used for flat-lying ground

Table 13. Holmes County soils

Soil Name	Parent Material Or Setting	DRASTIC Rating	Soil Media
Amanda	Loamy till	4	Silt loam
Berks	Thin till over sandstone/shale	10	Thin or absent
Bethesda	Strip mine	NR	
Bogart	Outwash, kame	6	Sandy loam
Brownsville	Interbedded sandstone, shale	10	Thin or absent
Canfield*	Loamy till	4	Silt loam
Centerburg	Loamy till	4	Silt loam
Chili	Outwash, kame	6	Sandy loam
Chili-Amanda	Till over kames	6	Sandy loam
Cidermill	Alluvium over outwash terraces	6	Sandy loam
Coshocton	Shale, siltstone bedrock	3	Clay loam
Euclid	Alluvium, floodplain	4	Silt loam
Fairpoint	Strip mine	NR	
Farmerstown	Strip mine	NR	
Fitchville	Alluvium, lacustrine	4	Silt loam
Gilpin	Clayey shale bedrock	10	Thin or absent
Glenford	Lacustrine, alluvium	4	Silt loam
Hazelton	Sandstone bedrock	10	Thin or absent
Keene	Shale, siltstone bedrock	4	Silt loam
Killbuck	Alluvium, floodplain	4	Silt loam
Lobdell	Alluvium, floodplain	4	Silt loam
Loudonville	Thin till over sandstone	4	Silt loam
Luray	Lacustrine, slack water	4	Silt loam
Mechanicsburg	Thin till over shale	4	Silt loam
Melvin	Floodplain alluvium	4	Silt loam
Orrville	Coarse alluvium	6	Sandy loam
Ravenna*	Loamy till	4	Silt loam
Rigley	Thick sandstone residuum	6	Sandy loam
Schaffenaker	Sandstone outcrops	10	Thin or absent
Sebring	Alluvium over till	3	Clay loam
Tioga	Coarse alluvium, outwash	6	Sandy loam
Westmoreland	Shale, siltstone bedrock	4	Silt loam
Wooster*	Loamy till	4	Silt loam
Wooster-Chili*	Till over kames	6	Sandy loam

* denotes soil containing a fragipan

moraine or till plain areas on the uplands. Slopes of 6 to 12 percent (5) were also used for less steep bedrock-controlled topography and for areas of end moraines. Slopes of 12 to 18 percent (3) and greater than 18 percent (1) were selected for steeper slopes in higher relief, upland areas. These areas have bedrock-controlled topography and drift is thin or absent. These steep areas are primarily found in southwestern Holmes County, flanking Killbuck Creek Valley south of Holmesville and the Mohican River Valley.

Impact of the Vadose Zone Media

Information on evaluating vadose zone media was obtained from the Ohio Drilling Co. (1971), Sedam (1973), and Crowell (1979). Vadose zone mapping in adjacent Wayne County (Angle, 2002), Stark County (Williams, 1991), Tuscarawas County (Angle and Baker, 2001), Knox County (Aller and Ballou, 1991), and Coshocton County (Spahr, 1995) provided valuable information. Information on the surficial geology was obtained from Pavey et al. (2002). Open File Bedrock Reconnaissance Maps based upon U.S.G.S. 7-1/2 minute topographic maps from the ODNR, Division of Geological Survey proved helpful. The ODNR, Division of Water, Glacial State Aquifer Map and Bedrock State Aquifer Map were an important source of vadose zone media data. Information on parent materials derived from the *Soil Survey of Holmes County* (Seaholm and Graham, 1998), also proved useful in evaluating vadose zone materials. Water well log records on file at the ODNR, Division of Water, were the primary source of information on vadose zone media for the county.

Sand and gravel, with a vadose zone media rating of (9) was utilized for some of the very gravelly outwash terraces found along the banks of the Mohican River adjacent to Knox County. Sand and gravel was given a vadose zone media ratings of (8) for outwash terraces along Killbuck Creek near Millersburg. Vadose zone media ratings of (5), (6) and (7) were selected for sand and gravel interbedded with silt and clay layers for deposits overlying buried valleys and alluvium. These ratings depend upon the proportion of coarse, well-sorted outwash to the finer-grained alluvial and lacustrine deposits. Sand and gravel with silt and clay was also evaluated for some upland areas containing ablational materials or materials that the well logs were not detailed enough to allow for more positive identification. Silt and clay with ratings of (4) and (5) were selected for vadose zone media for floodplains in many tributary valleys containing predominantly finer-grained alluvial and lacustrine deposits.

Till with a rating of (5) was utilized for loamy glacial tills associated with the Millbrook Till and Navarre Till found across most of the glaciated part of the county. Till was also given a rating of (5) where the till was relatively thin, weathered, and presumably fractured through much of its extent. Till with a rating of (4) was used for more clayey-textured tills and for tills of significant thickness in which the majority of the till would be unweathered and fractured to a lower degree.

A vadose zone media rating of (6) was assigned to limited areas of higher-yielding Sharon Sandstone and Massillon Sandstone in northeastern Holmes County. A vadose zone media rating of (5) was utilized for most of the bedrock aquifers in Holmes County. The (5) rating included the interbedded sandstones and shales of the Mississippian Black Hand Sandstone, Logan Formation, and some units of the Cuyahoga Formation and the Pennsylvanian Pottsville Group and Allegheny Group. A vadose zone rating of (4) was designated for some of the lower, shale units of the Cuyahoga Formation containing abundant shales along the northern boundary adjacent to Wayne County and for some of the interbedded dirty sandstones, shales, thin limestones, and coals of the Allegheny Group in southern and southeastern Holmes County.

Hydraulic Conductivity

Published data for hydraulic conductivity for Holmes County included the reports of the Ohio Drilling Co. (1971) and Sedam (1973). Mapping in adjoining Wayne County (Angle, 2002), Stark County (Williams, 1991), Tuscarawas County (Angle and Baker, 2001), Knox County (Aller and Ballou, 1991), and Coshocton County (Spahr, 1995) were used as a guideline. Mapping conducted by the ODNR, Division of Water, Glacial State Aquifer Map and Bedrock State Aquifer Map proved valuable. Water well log records on file at the ODNR, Division of Water, were the primary sources of information. Textbook tables (Freeze and Cherry, 1979, Fetter, 1980, and Driscoll, 1986) were useful in obtaining estimated values for hydraulic conductivity in a variety of sediments.

Values for hydraulic conductivity correspond to aquifer ratings; i.e., the more highly rated aquifers have higher values for hydraulic conductivity. For sand and gravel aquifers with an aquifer rating of (8), hydraulic conductivity values of 1,000-2,000 gallons per day per square foot (gpd/ft^2) (8) or 700-1,000 gpd/ft^2 (6) were selected. These high values were limited to the clean outwash deposits of Killbuck Creek, the Mohican River, and the Middle Fork of Sugar Creek. The values varied depending upon how clean and coarse the sediments were. For sand and gravel deposits associated with buried valleys with an aquifer media rating of (7), hydraulic conductivities of 700-1000 gpd/ft^2 (6) and 300-700 gpd/ft^2 (4) were chosen. For sand and gravel deposits with an aquifer rating of (6) or (5), hydraulic conductivity values ranged from 300-700 gpd/ft^2 (4) to or 100-300 gpd/ft^2 (2). In these deposits, thin sand and gravel lenses are interbedded with thicker sequences of finer-grained materials.

Bedrock aquifers with an aquifer rating of (6) have been assigned a hydraulic conductivity rating of 100-300 gpd/ft^2 (2). These rocks tend to be coarser-grained, more porous, and more highly fractured. Bedrock aquifers with an aquifer rating of (4) or (5) were given hydraulic conductivity ratings of 1-100 gpd/ft^2 (1) or 100-300 gpd/ft^2 (2) depending upon the amount of fracturing. These bedrock aquifers assigned a hydraulic conductivity value 100-300 gpd/ft^2 (2) typically underlie stream valleys where there is increased fracturing.

APPENDIX B

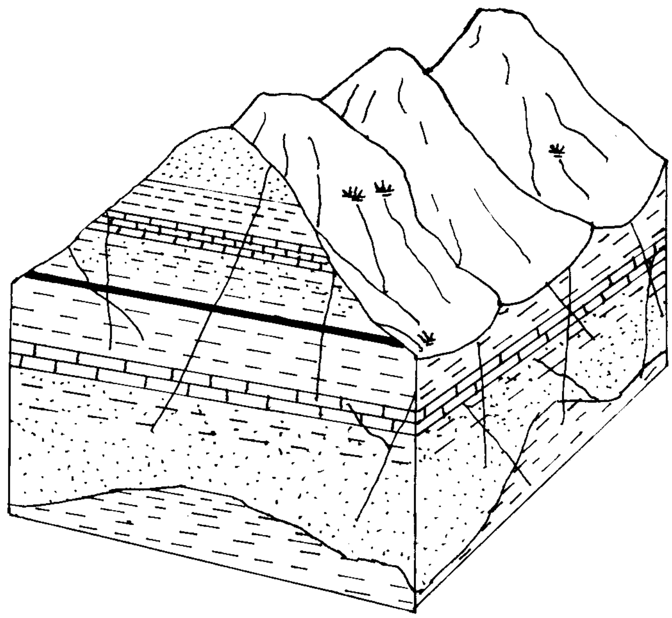
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Holmes County resulted in the identification of 9 hydrogeologic settings within the Glaciated and Non-Glaciated Central Region. The list of these settings, the range of pollution potential index calculations, and the number of index calculations for each setting are provided in Table 14. Computed pollution potential indexes for Holmes County range from 63 to 187.

Table 14. Hydrogeologic settings mapped in Holmes County, Ohio

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
6Da-Alternating sandstone, limestone, shale-thin regolith	63-102	49
6Fa–River alluvium with overbank deposits	133-179	3
6Fb-River alluvium without overbank deposits	118-160	9
7Aa-Glacial till over bedded sedimentary rock	71-108	53
7Bb–Outwash over bedded sedimentary rocks	121-124	2
7D-Buried valley	86-187	72
7Ed–Alluvium over glacial till	129-133	2
7Fa-Glacial lakes and slack water terraces	108-141	20
7G–Thin glacial till over bedded sedimentary rock	69-92	19

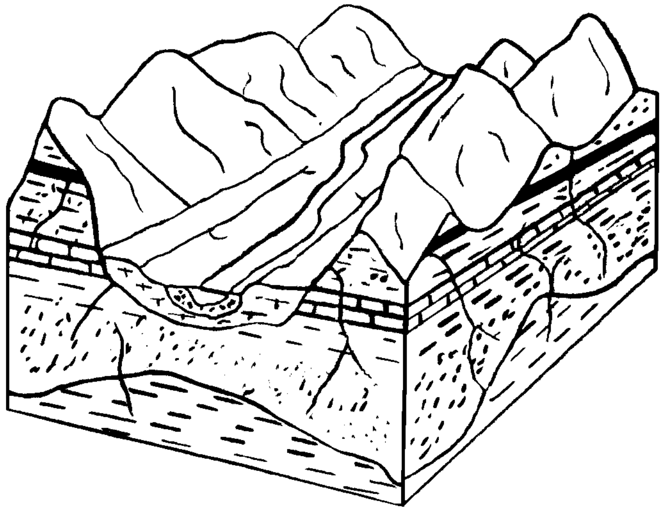
The following information provides a description of each hydrogeologic setting identified in the county, a block diagram illustrating the characteristics of the setting, and a listing of the charts for each unique combination of pollution potential indexes calculated for each setting. The charts provide information on how the ground water pollution potential index was derived and are a quick and easy reference for the accompanying ground water pollution potential map. A complete discussion of the rating and evaluation of each factor in the hydrogeologic settings is provided in Appendix A, Description of the Logic in Factor Selection.



6Da Alternating Sandstone, Limestone, Shale – Thin Regolith

This hydrogeologic setting is widespread, encompassing the upland areas south of the glacial margin in Holmes County. The area is characterized by high relief with broad, steep slopes and narrow, somewhat flatter ridge tops. The vadose zone and aquifers consist of slightly dipping, fractured, alternating sequences of dirty sandstones, shales, thin limestones, clays, and coals of the Mississippian and Pennsylvanian Systems. Multiple aquifers are typically present. Depth to water is generally deep; shallower perched zones may overlie low permeability shales, limestones, and clays. Soils are generally thin to absent on steeper slopes. On gentler slopes, soils vary with the bedrock lithology. Variable supplies of ground water are obtained from intersecting bedding planes or vertical fractures. Ground water yields average 25-100 gpm for the Pottsville Group - Massillon and Sharon Sandstone and the Mississippian Black Hand Sandstone, 10 to 25 gpm for the Cuyahoga Group and Logan Formation of the Mississippian System and portions of the Pennsylvanian Pottsville and Allegheny Groups, and 5-10 gpm for the Allegheny Group. Recharge is limited due to the steep slopes, deep aquifers, and layers of impermeable bedrock.

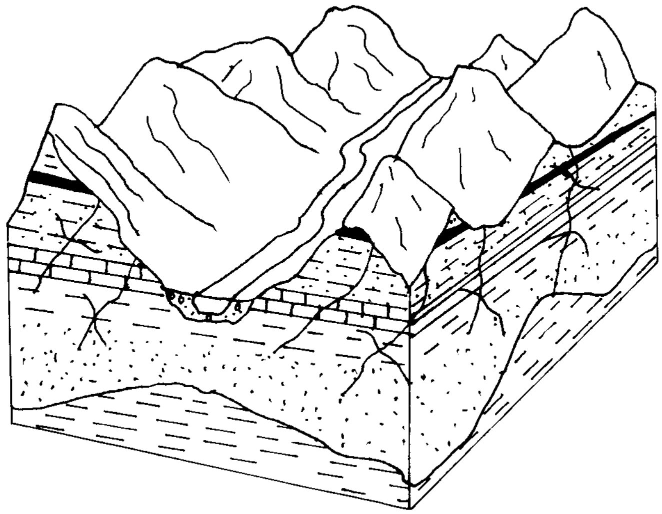
GWPP index values for the hydrogeologic setting of Alternating Sandstone, Limestone, Shale – Thin Regolith range from 63 to 102 with the total number of GWPP index calculations equaling 49.



<u>6Fa River Alluvium with Overbank Deposits</u>

This hydrogeologic setting is limited to tributary valleys and terraces adjacent to the Mohican River in southwestern Holmes County. This setting is adjacent to the 7D- Buried Valley setting; the drift is somewhat thinner, the valleys are narrower. The drift and soil tends to be coarser-grained than the somewhat similar to the 7Fa Glacial Lakes and Slackwater Terraces setting. Depth to water is usually shallow, averaging less than 30 feet. Soils are generally sandy loams. Thin alluvium, composed primarily of fine-grained floodplain (“overbank”) sediments, overlies coarser outwash deposits. The alluvial deposits and underlying outwash are typically saturated. Wells are completed in the outwash. Groundwater yields average 25-100 gpm. Recharge is moderate to high due to the relatively shallow depth to water, flatter topography, and the relatively high permeability of the alluvium and outwash. Recharge is much higher than the surrounding uplands.

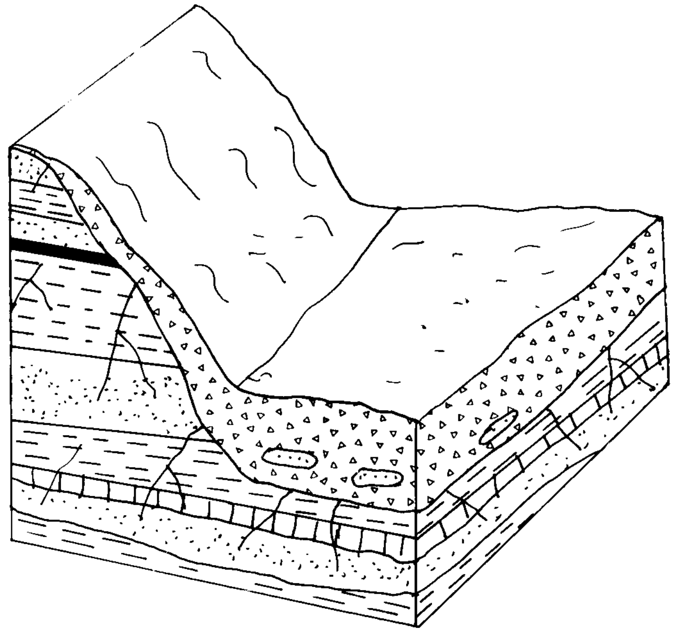
GWPP index values for the hydrogeologic setting of River Alluvium with Overbank Deposits range from 133 to 179 with the total number of GWPP index calculations equaling 3.



<u>6Fb River Alluvium without Overbank Deposits</u>

This hydrogeologic setting is limited to small tributary valleys in the uplands of Holmes County. This setting is somewhat similar to the 7Fa Glacial Lakes and Slackwater Terraces setting; however, the valleys and floodplains are narrower and the alluvial deposits are usually thinner. Areas in this setting are similar to the adjacent uplands, which belong to the 6Da Alternating Sandstone, Limestone, Shale - Thin Regolith setting. Narrow, relatively flat-bottomed stream valleys flanked by steep bedrock ridges characterize the setting. Depth to water is usually shallow, averaging less than 30 feet. Soils are generally silt loams or loams. The alluvial deposits are typically saturated; however, the alluvium is generally too thin to be utilized as an aquifer. The aquifer is the underlying dirty sandstones, shales, thin limestones, claystones, clays and coals of the Mississippian and Pennsylvanian System. In most areas, the alluvium is in direct connection with the underlying bedrock aquifers. Groundwater yields range from 5 to 25 gpm. Recharge is moderate due to the relatively shallow depth to water, flatter topography, and the relatively low permeability of the bedrock. Recharge is higher than the surrounding uplands.

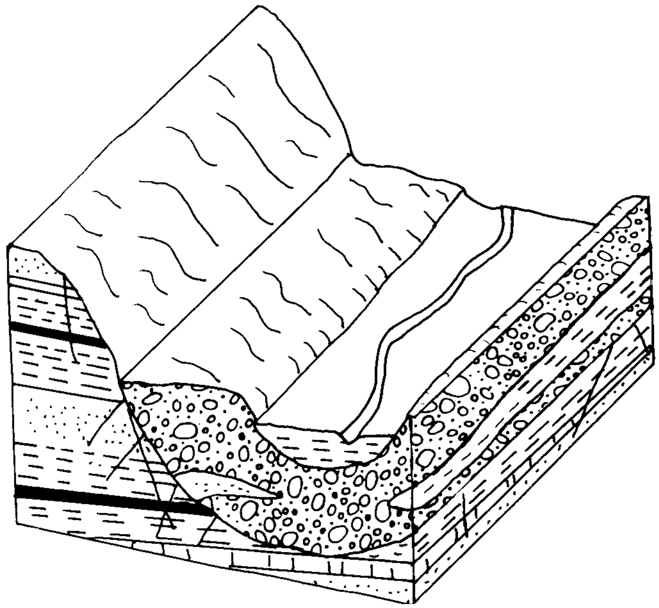
GWPP index values for the hydrogeologic setting of River Alluvium without Overbank Deposits range from 118 to 160 with the total number of GWPP index calculations equaling 9.



7Aa Glacial Till Over Bedded Sedimentary Rocks

This hydrogeologic setting is variable and widespread across the uplands of northern Holmes County. This setting is associated with upland areas featuring bedrock-controlled topography. Topography varies from rolling, moderate relief areas to steeper, higher relief areas. The steeper areas usually reflect stream dissection adjacent to major stream valleys. The aquifer consists of thin interbedded shales, sandstones, siltstones, limestones, clay, and coal of the Pennsylvanian System and interbedded shale, siltstones, and fine-grained sandstones of the Mississippian Cuyahoga Formation, Logan Formation, Berea Sandstone, and Black Hand Sandstone. Yields range from 3 to 25 gpm for wells completed in rocks of the Allegheny Group and Cuyahoga Formation, to yields up to100 gpm for massive, fractured sandstones of the Black Hand, Sharon, and Massillon Formations. Varying thicknesses of glacial till typically overlie the aquifer. Thickness of the till cover varies from under 25 feet up to 70 feet. The various till units commonly weather into either silt loams or clay loams. The till may be fractured or jointed, particularly in areas where it is predominantly thin and weathered. The depth to water is variable, averaging from 50 to 75 feet. Recharge is typically low due to low permeability soils, moderate to steep slopes, thickness of the till cover, and depth to water.

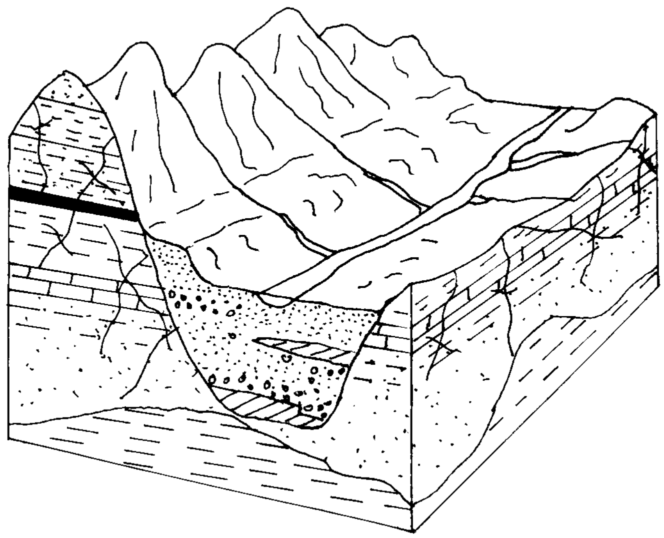
GWPP index values for the hydrogeologic setting of glacial till over bedded sedimentary rocks range from 71 to 108 with the total number of GWPP index calculations equaling 53.



<u>7Bb Outwash over Bedded Sedimentary Rocks</u>

This hydrogeologic setting consists of relatively small, high-level outwash terraces overlying bedrock benches. These terraces are limited to the margins or tributaries to the buried valleys. The total thickness of drift is not adequate to be considered buried valleys. Relief is low and the flat to rolling terraces occurs at higher elevations than the modern floodplain. Vadose zone media consists of bedded sandy to gravelly outwash interbedded with finer alluvial deposits. Soils vary from silt loam to sandy loam, depending upon whether fine alluvial material is capping the coarser outwash. The outwash terraces are not thick enough to comprise the aquifer; underlying fractured, interbedded sandstones, shales, limestones, and coals of the Mississippian and Pennsylvanian Systems serve as the aquifer. Yields average 10 to 25 gpm. The overlying terraces are typically in direct contact with the underlying bedrock aquifer. Depth to water is moderate due to the steep, local relief. Recharge is moderately high due to the relatively permeable soils and vadose, moderate to shallow depth to water, and relatively flat to rolling topography.

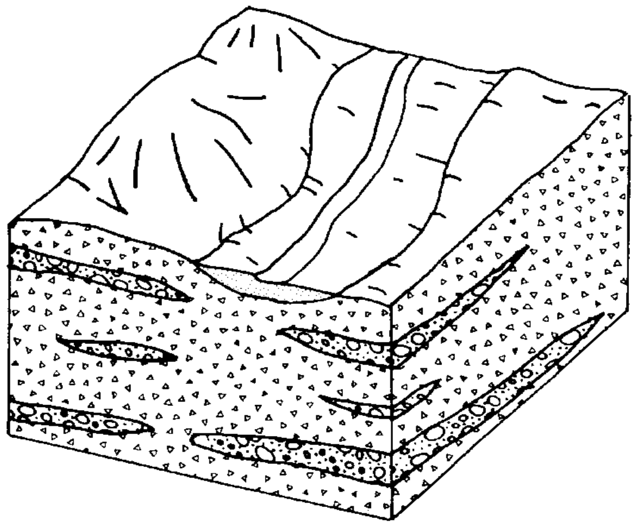
GWPP index values for the hydrogeologic setting of Outwash over Bedded Sedimentary Rocks range from 121 to 124 with the total number of GWPP index calculations equaling 2.



<u>7D Buried Valley</u>

This hydrogeologic setting is widespread through Holmes County. All of the major trunk streams and many modern tributaries overlie buried valley deposits. There are also former drainage ways overlying buried valleys that lack modern streams, particularly a broad valley extending from Loudonville to Big Prairie. The broad, flat-lying floodplains and gently sloping terraces characterize the setting. Depths to water are variable; they are typically less than 30 feet in valleys containing modern streams and are commonly over 45 feet in valleys lacking modern streams. Aquifers are composed of variable thicknesses of sand and gravel interbedded with finer-grained alluvium, till, and lacustrine deposits. The modern streams may be in direct hydraulic connection with the underlying aquifer. Yields up to 500 gpm have been reported for some of the coarser, thicker, more continuous sand and gravel outwash in Killbuck Creek near Millersburg. Yields up to 100 gpm are developed in the Middle Fork of Sugar Creek, Lake Fork of the Mohican River and Martins Creek southeast of Holmesville. Some valleys contain thin lenses of sand and gravel interbedded with much thicker sequences of finer-grained alluvial and lacustrine deposits. Soils on terraces are typically sandy loams derived from outwash; soils on floodplains are silt loams derived from modern alluvium. Recharge is typically relatively high due to the flat-lying topography, shallow depth to water, and the high permeability of the soils, vadose zone materials, and aquifer for buried valleys with modern overlying streams. Recharge tends to be less in valleys lacking modern streams, having greater depths to water, and less permeable soils and vadose media.

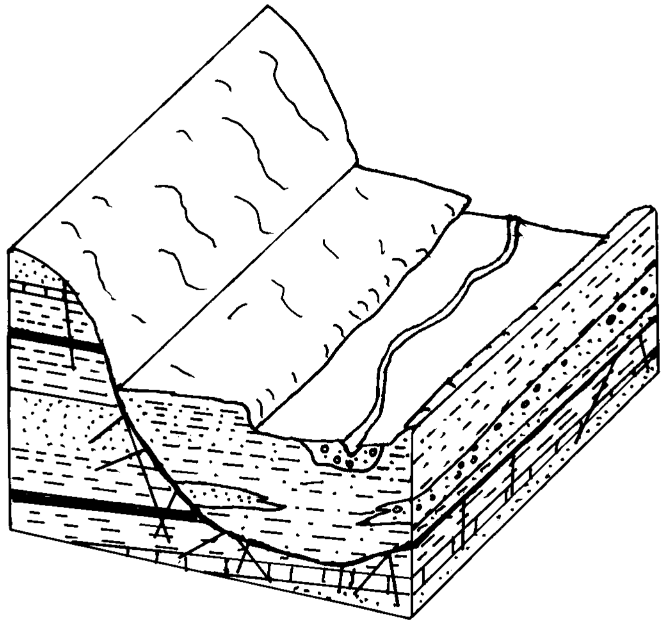
GWPP index values for the hydrogeologic setting of Buried Valley range from 86 to 187 with the total number of GWPP index calculations equaling 72.



7Ed Alluvium Over Glacial Till

This hydrogeologic setting is comprised of flat-lying floodplains and stream terraces containing thin to moderate thicknesses of modern alluvium. This setting is similar to the 7Aa – Glacial Till Over Bedded Sedimentary Rocks setting except for the presence of the modern stream and related deposits. This setting is found in upland areas in the northeastern corner of the county where drift is moderately thick. The stream may or may not be in direct hydraulic connection with the underlying sand and gravel lenses, which constitute the aquifer. The surficial, silty alluvium is typically more permeable than the surrounding till. The alluvium is too thin to be considered the aquifer. Soils are sandy loams or silt loams. Yields commonly range from 10 to 25 gpm. Depth to water is typically shallow with depths averaging less than 30 feet. Recharge is moderate due to the shallow depth to water, flat-lying topography, and the moderate permeability of the glacial till and alluvium.

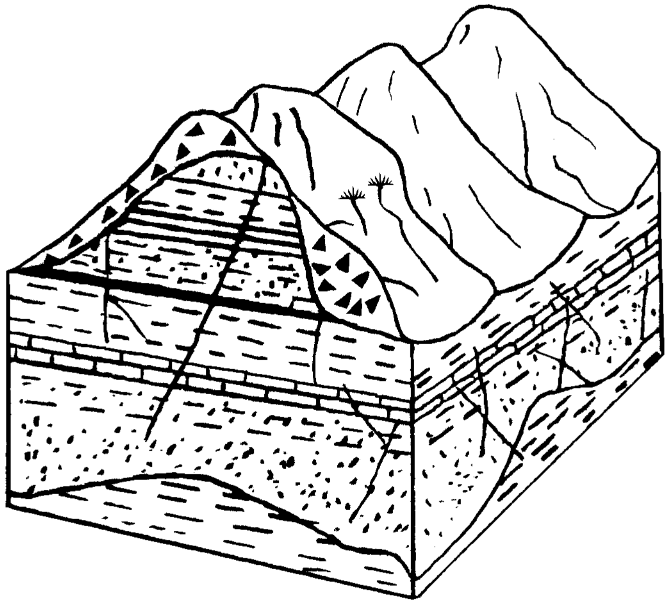
GWPP index values for the hydrogeologic setting Alluvium Over Glacial Till range from 129 to 133 with the total number of GWPP index calculations equaling 2.



7Fa Glacial Lakes and Slackwater Terraces

Flat-lying areas that were formed in low velocity water of glacial and slack water lakes that filled pre-existing drainage systems characterize this setting. These areas are typically dissected by modern streams and contain remnant low-lying terraces. This setting is common in southern Holmes County. The valleys are typically broader and contain thicker, fine-grained, alluvial or lacustrine deposits than the somewhat similar 6Fa- River Alluvium with Overbank Deposits and the 6Fb River Alluvium without Overbank Deposits. The setting is bordered by steep bedrock uplands. The drift is not as thick or as coarse as in adjacent 7D Buried Valley settings. The aquifer consists of thin sand and gravel lenses interbedded with finer lacustrine and alluvial deposits. If sand and gravel is not encountered, wells are completed in the underlying interbedded sedimentary rock. Depth to water is commonly shallow due to the presence of streams found within this setting. Soils are silt loams. Recharge in this setting is moderate due to the relatively shallow depth to water, flat-lying topography, and the moderate to low permeability soils, vadose, and underlying bedrock.

GWPP index values for the hydrogeologic setting of Glacial Lakes and Slackwater Terraces range from 108 to 141 with the total number of GWPP index calculations equaling 20.



<u>7G Thin Glacial Till Over Bedded Sedimentary Rock</u>

This hydrogeologic setting is characterized by rolling to steep bedrock-controlled topography and deposits of thin, patchy glacial till overlying alternating layers of fractured sedimentary rock. This setting is common in the northern, glaciated part of the county. It is associated with steep slopes flanking bedrock highs. The till is less than 25 feet thick and consists of varying amounts of unsorted clay, silt, and sand with minor pebbles and cobbles. Ground water is obtained from the underlying, fractured Mississippian or Pennsylvanian bedrock. Depth to water is typically fairly deep due to the high relief of the bedrock ridges. Soils are silt loams or clay loams except along steep faces where soils are evaluated as thin or absent. Recharge is low due to depth to water, relatively steep slopes, and relatively impermeable nature of these soils.

GWPP index values for the hydrogeologic setting of Thin Glacial Till Over Bedded Sedimentary Rock range from 69 to 92 with the total number of GWPP index calculations equaling 19.

Table 15. Hydrogeologic Settings, DRASTIC Factors, and Ratings

Setting	Depth To Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating
6Da01	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Shrink/ Swell Clay	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	90
6Da02	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	82
6Da03	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	77
6Da04	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	83
6Da05	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Shrink/ Swell Clay	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	85
6Da06	30-50	4-7	Interbedded Ss/Sh/Ls/Coal	Silty Loam	0-2	Interbedded Ss/Sh/Ls/Coal	1-100	102
6Da07	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Shrink/ Swell Clay	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	100
6Da08	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	79
6Da09	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	85
6Da10	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	18+	Interbedded Ss/Sh/Ls/Coal	1-100	70
6Da11	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Shrink/ Swell Clay	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	77
6Da12	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	74
6Da13	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	88
6Da14	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	66
6Da15	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	12-18	Interbedded Ss/Sh/Ls/Coal	1-100	63
6Da16	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	84
6Da17	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	87
6Da18	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	18+	Interbedded Ss/Sh/Ls/Coal	1-100	69
6Da19	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	79
6Da20	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	77
6Da21	50-75	0-2	Interbedded Ss/Sh/Ls/Coal	Thin or Absent	18+	Interbedded Ss/Sh/Ls/Coal	100-300	86
6Da22	75-100	0-2	Interbedded Ss/Sh/Ls/Coal	Thin or Absent	18+	Interbedded Ss/Sh/Ls/Coal	100-300	81
6Da23	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	73
6Da24	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	79
6Da25	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	84

Setting	Depth To Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating
6Da26	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	81
6Da27	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	80
6Da28	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Interbedded Ss/Sh/Ls/Coal	1-100	73
6Da29	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	12-18	Interbedded Ss/Sh/Ls/Coal	1-100	71
6Da30	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	74
6Da31	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	75
6Da32	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	71
6Da33	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	75
6Da34	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	69
6Da35	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	75
6Da36	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	67
6Da37	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	79
6Da38	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	81
6Da39	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	72
6Da40	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	86
6Da41	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	77
6Da42	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	75
6Da43	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	70
6Da44	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	79
6Da45	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	72
6Da46	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	81
6Da47	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	83
6Da48	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	77
6Da49	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	84
6Fa1	5-15	7-10	Sand & Gravel	Gravel	0-2	Sand & Gravel	700-1000	179
6Fa2	15-30	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	141

Setting	Depth To Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating
6Fa3	15-30	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	133
6Fb1	15-30	4-7	Interbedded Ss/Sh/Ls/Coal	Silty Loam	0-2	Silt/Clay	100-300	118
6Fb2	15-30	4-7	Interbedded Ss/Sh/Ls/Coal	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	100-300	123
6Fb3	15-30	4-7	Interbedded Ss/Sh/Ls/Coal	Loam	0-2	Sand & Gravel w/Silt & Clay	100-300	125
6Fb4	15-30	4-7	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	122
6Fb5	15-30	4-7	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	100-300	127
6Fb6	15-30	4-7	Interbedded Ss/Sh/Ls/Coal	Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	124
6Fb7	15-30	4-7	Interbedded Ss/Sh/Ls/Coal	Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	124
6Fb8	5-15	4-7	Sand & Gravel	Loam	2-6	Sand & Gravel w/Silt & Clay	100-300	142
6Fb9	30-50	10+	Sand & Gravel	Gravel	0-2	Sand & Gravel	100-300	160
7Aa01	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Till	1-100	82
7Aa02	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	1-100	87
7Aa03	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Till	100-300	89
7Aa04	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Till	1-100	83
7Aa05	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	98
7Aa06	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	94
7Aa07	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Till	100-300	99
7Aa08	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	92
7Aa09	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	96
7Aa10	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	0-2	Interbedded Ss/Sh/Ls/Coal	1-100	88
7Aa11	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Till	100-300	93
7Aa12	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	0-2	Till	100-300	94
7Aa13	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	0-2	Interbedded Ss/Sh/Ls/Coal	1-100	98
7Aa14	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	1-100	97
7Aa15	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Till	1-100	97
7Aa16	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Till	1-100	92

Setting	Depth To Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating
7Aa17	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	108
7Aa18	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	104
7Aa19	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	1-100	82
7Aa20	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	12-18	Interbedded Ss/Sh/Ls/Coal	1-100	81
7Aa21	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Interbedded Ss/Sh/Ls/Coal	1-100	83
7Aa22	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Till	1-100	93
7Aa23	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	79
7Aa24	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Till	100-300	86
7Aa25	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	85
7Aa26	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Till	100-300	90
7Aa27	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Till	100-300	103
7Aa28	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	86
7Aa29	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	81
7Aa30	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	79
7Aa31	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Till	100-300	100
7Aa32	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	90
7Aa33	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Till	1-100	88
7Aa34	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	1-100	79
7Aa35	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Till	1-100	89
7Aa36	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Till	1-100	85
7Aa37	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	12-18	Interbedded Ss/Sh/Ls/Coal	1-100	83
7Aa38	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	2-6	Till	1-100	87
7Aa39	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	2-6	Till	1-100	77
7Aa40	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	85
7Aa41	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	96
7Aa42	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Till	100-300	81
7Aa43	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	12-18	Till	100-300	84

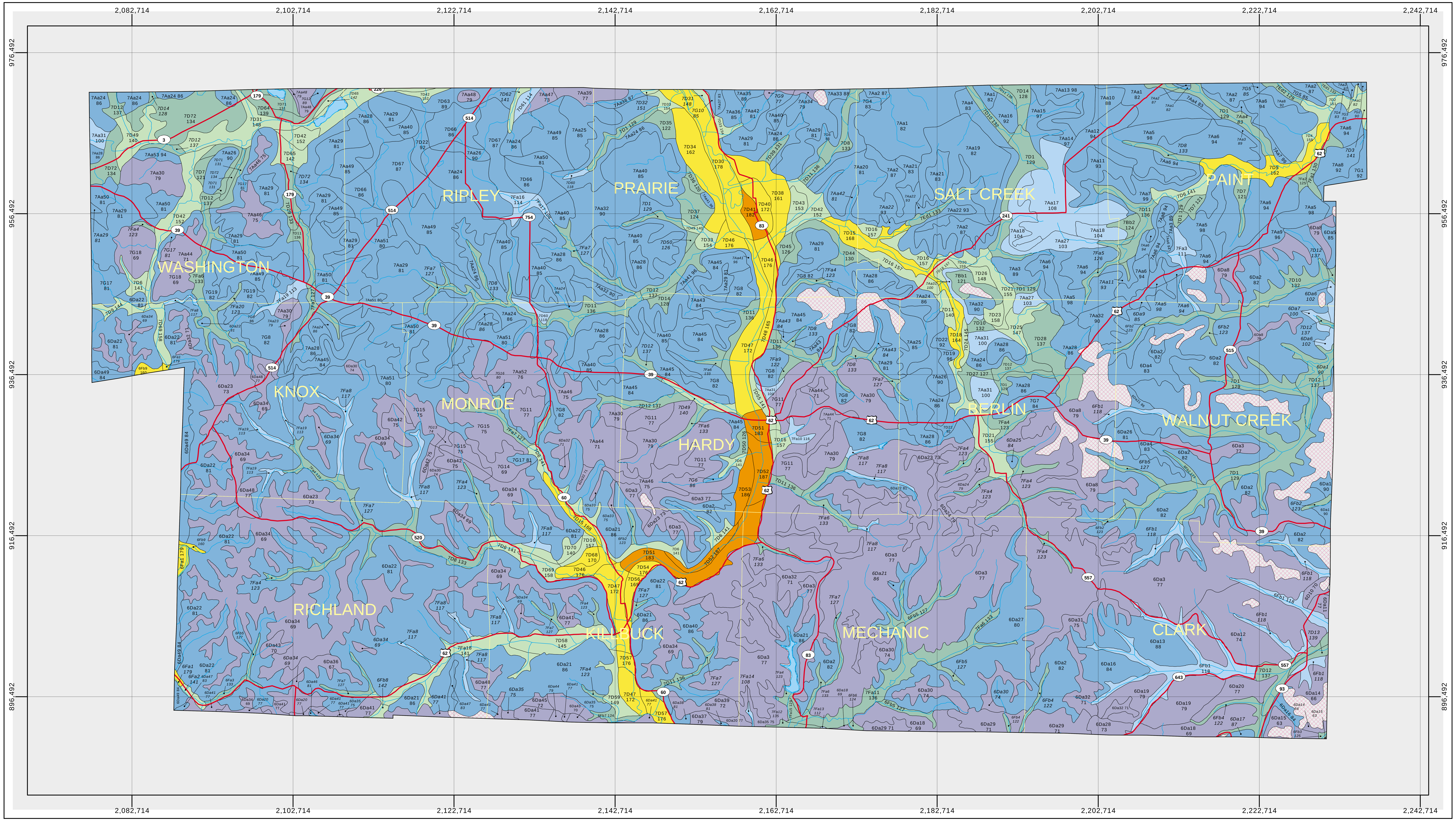
Setting	Depth To Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating
7Aa44	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	71
7Aa45	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	84
7Aa46	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	75
7Aa47	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Till	1-100	73
7Aa48	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Till	1-100	79
7Aa49	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Till	100-300	85
7Aa50	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Till	100-300	81
7Aa51	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	100-300	80
7Aa52	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	76
7Aa53	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	2-6	Till	100-300	94
7Bb01	30-50	4-7	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	2-6	Sand & Gravel w/Silt & Clay	100-300	121
7Bb02	30-50	4-7	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	2-6	Sand & Gravel w/Silt & Clay	100-300	124
7D01	15-30	4-7	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	129
7D02	15-30	4-7	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	700-1000	151
7D03	30-50	4-7	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	700-1000	141
7D04	15-30	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	700-1000	155
7D05	5-15	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	162
7D06	15-30	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	141
7D07	30-50	4-7	Sand & Gravel	Silty Loam	2-6	Till	300-700	121
7D08	15-30	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	133
7D09	15-30	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	144
7D10	15-30	4-7	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	132
7D11	15-30	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	136
7D12	15-30	4-7	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	137
7D13	15-30	4-7	Sand & Gravel	Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	139
7D14	15-30	4-7	Sand & Gravel	Silty Loam	2-6	Sand & Gravel w/Silt & Clay	300-700	128

Setting	Depth To Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating
7D15	5-15	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	700-1000	168
7D16	15-30	7-10	Sand & Gravel	Sandy Loam	2-6	Sand & Gravel w/Silt & Clay	700-1000	157
7D17	15-30	4-7	Sand & Gravel	Silty Loam	2-6	Till	700-1000	140
7D18	5-15	7-10	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	700-1000	164
7D19	50-75	2-4	Sand & Gravel	Silty Loam	2-6	Sand & Gravel w/Silt & Clay	300-700	96
7D20	5-15	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	159
7D21	5-15	7-10	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	155
7D22	50-75	2-4	Sand & Gravel	Silty Loam	6-12	Till	300-700	92
7D23	5-15	7-10	Sand & Gravel	Peat	0-2	silt/clay	300-700	158
7D24	15-30	4-7	Sand & Gravel	Silty Loam	2-6	Sand & Gravel w/Silt & Clay	700-1000	145
7D25	5-15	7-10	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	147
7D26	15-30	7-10	Sand & Gravel	Sandy Loam	2-6	Sand & Gravel w/Silt & Clay	300-700	148
7D27	15-30	4-7	Sand & Gravel	Silty Loam	6-12	Till	300-700	127
7D28	15-30	4-7	Sand & Gravel	Sandy Loam	2-6	Sand & Gravel w/Silt & Clay	300-700	137
7D29	30-50	4-7	Sand & Gravel	Sandy Loam	2-6	Sand & Gravel w/Silt & Clay	300-700	133
7D30	5-15	7-10	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	1000-2000	178
7D31	15-30	7-10	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	148
7D32	15-30	7-10	Sand & Gravel	Clay Loam	2-6	Till	700-1000	151
7D33	15-30	7-10	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	700-1000	154
7D34	15-30	7-10	Sand & Gravel	Sandy Loam	2-6	Sand & Gravel w/Silt & Clay	700-1000	162
7D35	30-50	4-7	Sand & Gravel	Silty Loam	6-12	Sand & Gravel w/Silt & Clay	300-700	122
7D36	30-50	4-7	Sand & Gravel	Silty Loam	6-12	Till	300-700	120
7D37	30-50	4-7	Sand & Gravel	Silty Loam	2-6	Till	300-700	124
7D38	15-30	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	700-1000	161
7D39	15-30	4-7	Sand & Gravel	Silty Loam	2-6	Till	300-700	131
7D40	15-30	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	1000-2000	172
7D41	5-15	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	1000-2000	182
7D42	15-30	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	152
7D43	15-30	7-10	Sand & Gravel	Sandy Loam	6-12	Sand & Gravel w/Silt & Clay	700-1000	153

Setting	Depth To Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating
7D44	30-50	4-7	Sand & Gravel	Sandy Loam	2-6	Sand & Gravel w/Silt & Clay	300-700	130
7D45	30-50	4-7	Sand & Gravel	Silty Loam	2-6	Sand & Gravel w/Silt & Clay	300-700	126
7D46	5-15	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	700-1000	176
7D47	5-15	7-10	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	700-1000	172
7D48	5-15	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	700-1000	165
7D49	15-30	4-7	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	140
7D50	30-50	4-7	Sand & Gravel	Sandy Loam	6-12	Sand & Gravel w/Silt & Clay	300-700	126
7D51	5-15	7-10	Sand & Gravel	Silty Loam	0-2	Sand & Gravel	1000-2000	183
7D52	5-15	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel	1000-2000	187
7D53	5-15	7-10	Sand & Gravel	Sandy Loam	2-6	Sand & Gravel	1000-2000	186
7D54	15-30	7-10	Sand & Gravel	Sandy Loam	2-6	Sand & Gravel	1000-2000	176
7D55	15-30	4-7	Sand & Gravel	Silty Loam	6-12	Sand & Gravel w/Silt & Clay	700-1000	141
7D56	15-30	7-10	Sand & Gravel	Sandy Loam	2-6	Sand & Gravel w/Silt & Clay	700-1000	165
7D57	5-15	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	700-1000	176
7D58	15-30	7-10	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	145
7D59	15-30	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	149
7D60	30-50	4-7	Sand & Gravel	Silty Loam	2-6	Till	300-700	118
7D61	30-50	4-7	Sand & Gravel	Clay Loam	2-6	Sand & Gravel w/Silt & Clay	300-700	114
7D62	15-30	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	141
7D63	50-75	2-4	Sand & Gravel	Clay Loam	2-6	Sand & Gravel w/Silt & Clay	300-700	89
7D64	30-50	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	139
7D65	30-50	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	142
7D66	75-100	2-4	Sand & Gravel	Silty Loam	2-6	Till	300-700	86
7D67	50-75	2-4	Sand & Gravel	Silty Loam	6-12	Till	300-700	87
7D68	5-15	7-10	Sand & Gravel	Sandy Loam	2-6	Sand & Gravel w/Silt & Clay	700-1000	170
7D69	15-30	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	700-1000	158
7D70	15-30	4-7	Sand & Gravel	Sandy Loam	2-6	Sand & Gravel w/Silt & Clay	300-700	140
7D71	30-50	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	131

Setting	Depth To Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating
7D72	30-50	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	134
7Ed1	15-30	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	133
7Ed2	15-30	4-7	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	129
7Fa01	15-30	4-7	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	100-300	130
7Fa02	30-50	4-7	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	0-2	Interbedded Ss/Sh/Ls/Coal	100-300	125
7Fa03	30-50	4-7	Interbedded Ss/Sh/Ls/Coal	Silty Loam	0-2	Silt/Clay	100-300	111
7Fa04	15-30	4-7	Interbedded Ss/Sh/Ls/Coal	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	100-300	123
7Fa05	15-30	4-7	Interbedded Ss/Sh/Ls/Coal	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	100-300	126
7Fa06	15-30	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	133
7Fa07	15-30	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	100-300	127
7Fa08	30-50	4-7	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	100-300	117
7Fa09	15-30	4-7	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Sand & Gravel w/Silt & Clay	100-300	122
7Fa10	30-50	4-7	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	2-6	Sand & Gravel w/Silt & Clay	100-300	116
7Fa11	15-30	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	136
7Fa12	5-15	4-7	Sand & Gravel	Silty Loam	2-6	Sand & Gravel w/Silt & Clay	100-300	135
7Fa13	30-50	4-7	Interbedded Ss/Sh/Ls/Coal	Sandy Loam	6-12	Silt/Clay	100-300	112
7Fa14	30-50	4-7	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Silt/Clay	100-300	108
7Fa15	15-30	4-7	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	129
7Fa16	30-50	4-7	Sand & Gravel	Silty Loam	0-2	Silt/Clay	300-700	114
7Fa17	30-50	4-7	Interbedded Ss/Sh/Ls/Coal	Silty Loam	0-2	Silt/Clay	100-300	108
7Fa18	15-30	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	141
7Fa19	30-50	4-7	Interbedded Ss/Sh/Ls/Coal	Silty Loam	0-2	Sand & Gravel w/Silt & Clay	100-300	113
7Fa20	30-50	4-7	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/Silt & Clay	300-700	123
7G01	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	92
7G02	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	90

Setting	Depth To Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating
7G03	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	12-18	Interbedded Ss/Sh/Ls/Coal	1-100	81
7G04	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	6-12	Interbedded Ss/Sh/Ls/Coal	1-100	83
7G05	50-75	0-2	Interbedded Ss/Sh/Ls/Coal	Thin or Absent	12-18	Interbedded Ss/Sh/Ls/Coal	1-100	85
7G06	50-75	0-2	Interbedded Ss/Sh/Ls/Coal	Thin or Absent	18+	Interbedded Ss/Sh/Ls/Coal	100-300	86
7G07	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	84
7G08	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	82
7G09	50-75	0-2	Interbedded Ss/Sh/Ls/Coal	Thin or Absent	12-18	Interbedded Ss/Sh/Ls/Coal	1-100	77
7G10	30-50	0-2	Interbedded Ss/Sh/Ls/Coal	Thin or Absent	18+	Interbedded Ss/Sh/Ls/Coal	1-100	85
7G11	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	77
7G12	30-50	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	2-6	Interbedded Ss/Sh/Ls/Coal	1-100	89
7G13	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	74
7G14	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	6-12	Interbedded Ss/Sh/Ls/Coal	100-300	69
7G15	75-100	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	75
7G16	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Clay Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	80
7G17	75-100	0-2	Interbedded Ss/Sh/Ls/Coal	Thin or Absent	18+	Interbedded Ss/Sh/Ls/Coal	100-300	81
7G18	100+	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	12-18	Interbedded Ss/Sh/Ls/Coal	100-300	69
7G19	50-75	2-4	Interbedded Ss/Sh/Ls/Coal	Silty Loam	18+	Interbedded Ss/Sh/Ls/Coal	100-300	82



Ground Water Pollution Potential of Holmes County

by
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Ground Water Pollution Potential maps are designed to evaluate the susceptibility of ground water to contamination from surface sources. These maps are based on the DRASTIC system developed for the USEPA (Aller et al., 1987). The DRASTIC system consists of two major elements: the designation of mappable units, termed hydrogeologic settings, and a relative rating system for determining the ground water pollution potential within a hydrogeologic setting. The application of DRASTIC to an area requires the recognition of a set of assumptions made in the development of the system. The evaluation of pollution potential of an area assumes that a contaminant with the mobility of water is introduced at the surface and is flushed into the ground water by precipitation. DRASTIC is not designed to replace specific on-site investigations.

In DRASTIC mapping, hydrogeologic settings form the basis of the system and incorporate the major hydrogeologic factors that affect and control ground water movement and occurrence. The relative rating system is based on seven hydrogeologic factors: Depth to water, net Recharge, Aquifer media, Soil media, Topography, Impact of the vadose zone media, and hydraulic Conductivity. These factors form the acronym DRASTIC. The relative rating system uses a combination of weights and ratings to produce a numerical value called the ground water pollution potential index. Higher index values indicate higher susceptibility to ground water contamination. Polygons (outlined in black on the map at left) are regions where the hydrogeologic setting and the pollution potential index are combined to create a mappable unit with specific hydrogeologic characteristics, which determine the region's relative vulnerability to contamination. Additional information on the DRASTIC system, hydrogeologic settings, ratings, and weighting factors is included in the report.

Description of Map Symbols

Hydrogeologic Region → 7D24 ← Hydrogeologic Setting
170 ← Relative Pollution Potential

Legend

Colors are used to depict the ranges in the pollution potential indexes shown below. Warm colors (red, orange, yellow) represent areas of higher vulnerability (higher pollution potential indexes), while cool colors (green, blue, violet) represent areas of lower vulnerability to contamination (lower pollution potential indexes).

- Roads
- Streams
- Lakes
- Townships

Index Ranges

- Not Rated
- Less Than 79
- 80 - 99
- 100 - 119
- 120 - 139
- 140 - 159
- 160 - 179
- 180 - 199
- Greater Than 200

N

Black grid represents the State Plane South Coordinate System (NAD27, feet).

0 1 2 3 4 5
Miles

0 1 2 4 6 8
Kilometers

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