GROUND WATER POLLUTION POTENTIAL OF HOCKING COUNTY, OHIO

BY

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ABSTRACT

A ground water pollution potential map of Hocking 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 Hocking County resulted in a map with symbols and colors, which illustrate areas of varying ground water pollution potential indexes ranging from 61 to 187.

The majority of Hocking County lies within the Non-Glaciated Central hydrogeologic setting. The Glaciated Central hydrogeologic setting includes the far western edge of the county and the northern margin of Marion Township. The buried valley underlying the present main channel of the Hocking River contains sand and gravel outwash deposits that are capable of yielding up to 500 gallons per minute (gpm) from properly designed large diameter wells. The higher yields are located northwest of Rockbridge and southeast of Logan. Yields of 5 to 100 gpm to are obtained from different segments of the buried valley aquifer. Water in these valleys is obtained from thin lenses of sand and gravel interbedded with alluvial and lacustrine sediments.

Interbedded sandstones, shales, and siltstones of the Mississippian Cuyahoga Formation comprise the aquifer in the southwestern corner and far northern edge of the county. These units have yields ranging from 5 to 25 gallons per minute (gpm) to the north to less than 5 gpm to the southwest. The massive sandstones of the Black Hand Formation and Logan Formation occupy the central portion of the county. These units are good aquifers with maximum sustainable yields ranging from 25 to 100 gpm. In eastern Hocking County, interbedded dirty sandstones, shales, siltstones, clay, thin limestones, flint, and coal of the Pennsylvanian System comprise the aquifer. These units tend to be poor aquifers, supplying only marginal yields for domestic use. Yields are usually less than 5 gpm for these aquifers in the Pennsylvanian System.

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 Hocking 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.

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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; 6400 of these wells exist in Hocking 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 Hocking 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).

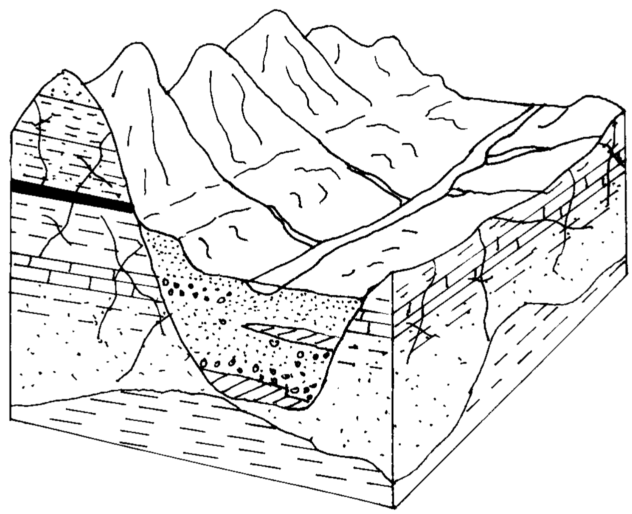
Figure 1 illustrates the format and description of a typical hydrogeologic setting found within Hocking County. Inherent within each hydrogeologic setting are the physical characteristics that affect the ground water pollution potential. These characteristics or factors identified during the development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



7D Buried Valley

This hydrogeologic setting is limited to the valley underlying the modern Hocking River and Rush Creek along the Fairfield County border. This setting is similar to the 7Bf Outwash over Massive Sandstone except that the drift is thicker and wells are almost always completed in the sand and gravel outwash instead of the underlying bedrock. Broad, flat-lying floodplains and gently sloping terraces characterize the setting. Depths to water are shallow, typically less than 30 feet. 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 the Hocking River. Yields along Rush Creek typically are limited to 25 gpm. This valley underlying Rush Creek contains thin lenses of sand and gravel interbedded with much thicker sequences of finer-grained alluvial and lacustrine deposits. Soils on terraces and floodplains are usually 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.

GWPP index values for the hydrogeologic setting of Buried Valley range from 110 to 182 with the total number of GWPP index calculations equaling 5.

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

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.

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	9
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 Hocking 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 182. 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 Hocking County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the twelve settings identified in the county range from 61 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 Hocking 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 Hocking County is included with this report.

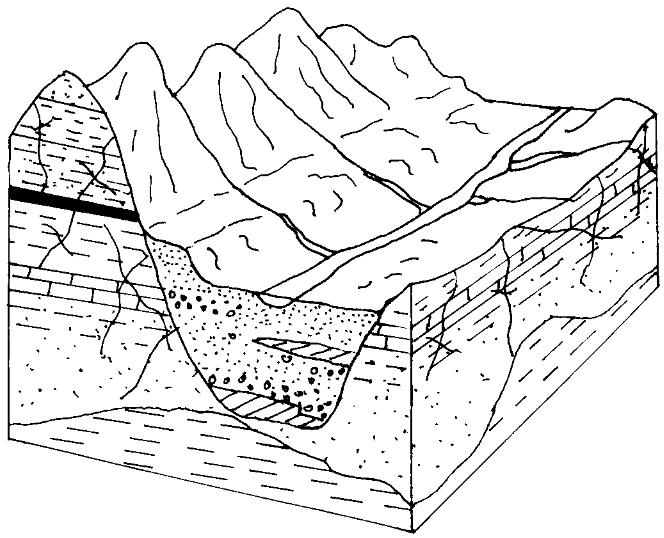


Figure 2. Description of the hydrogeologic setting - 7D1 Buried Valley.

SETTING 7D1		GENERAL		
FEATURE	**RANGE**	**WEIGHT**	**RATING**	**NUMBER**
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	Sand & Gravel	3	8	24
Soil Media	Sandy Loam	2	6	12
Topography	0-2%	1	10	10
Impact of the Vadose Zone	Sand & Gravel w/Silt & Clay	5	7	35
Hydraulic Conductivity	1000-2000	3	8	24
			DRASTIC INDEX	182

INTERPRETATION AND USE OF A GROUND WATER POLLUTION POTENTIAL MAP

The application of the DRASTIC system to evaluate an area's vulnerability to contamination produces hydrogeologic settings with corresponding pollution potential indexes. The higher the pollution potential index, the greater the susceptibility to contamination. 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
182 - 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 (**182**) 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. Large man-made features such as landfills, quarries, or strip mines have also been marked on the map for reference.

GENERAL INFORMATION ABOUT HOCKING COUNTY

Demographics

Hocking County occupies approximately 422 square miles in south central Ohio (Figure 3). Hocking County is bounded to the northwest by Fairfield County, to the northeast by Perry County, to the southeast by Athens County, to the south by Vinton County, to the southwest by Ross County, and to the west by Pickaway County.

The approximate population of Hocking County, based upon year 2000 estimates, is 28,241 (Department of Development, Ohio County Profiles, 2002). Logan is the largest community and county seat and has a population of 6,700. Woodlands and forests account for over 70 percent of the land usage. Agriculture accounts for roughly 20 percent of the land usage in Hocking County. Mining, including coal strip mines and sand and gravel pits is a common land use in eastern Hocking County. Recreation, based upon the scenic Hocking Hills State Park and surrounding areas, is an important local source of revenue. 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 52 degrees Fahrenheit for Hocking County. The average temperatures increase slightly towards the south. Harstine (1991) shows that precipitation approximately averages 40 inches per year for the county, with precipitation increasing towards the east. The mean annual precipitation for Laurelville is 40.4 inches per year based upon a twenty-year (1961-1980) period (Owenby and Ezell, 1992). The mean annual temperature at Lancaster in neighboring Fairfield County for the same twenty-year period is 50.5 degrees Fahrenheit (Owenby and Ezell, 1992).

Figure 3. Location map of Hocking County, Ohio.

Physiography and Topography

The majority of Hocking County lies within the Unglaciated Allegheny Plateau section of the Appalachian Plateau Province (Frost, 1931; Fenneman, 1938, and Bier, 1956). The northern margin of Marion Township and the far western edge of the county lie within the Glaciated Allegheny Plateau section of the Appalachian Plateau Province (Frost, 1931; Fenneman, 1938, and Bier, 1956). Relatively high relief and rugged topography, featuring narrow ridges, steep slopes, and a high degree of stream dissection characterize the county. The massive sandstone units of the Black Hand and Logan Formations are highly resistant to erosion, creating very steep relief in central Hocking County. The relatively broad, flat-lying stream valleys of the Hocking River and Salt Creek provide contrast to the steep uplands. The relief in the glaciated portions of the county is slightly less pronounced and the topography is less steep and more rolling.

Modern Drainage

The Hocking River drains the northern, central, and eastern portions of Hocking County. Important local tributaries of the Hocking River include Clear Creek, Rush Creek, and Monday Creek. The southeastern corner of the county is drained by the headwaters of Raccoon Creek. Salt Creek, a major tributary of the Scioto River, drains the southwestern corner of Hocking County.

Pre- and Inter-Glacial Drainage Changes

The drainage patterns of Hocking County have changed significantly as a result of the multiple glaciations, even though the majority of the county lies outside of the glacial boundary. The drainage changes are complex and not yet fully understood. More research and data are necessary in Hocking County and surrounding counties. Well log data for deeper wells that penetrate the entire drift thickness would be particularly helpful in making further interpretations.

Prior to glaciation, the Teays River System drained much of Ohio. The Teays River entered Ohio nearby present-day Portsmouth and flowed to the northwest, eventually exiting Ohio in Mercer County. The Teays drainage system differs greatly from the modern drainage patterns. The resistant sandstone highlands in central Hocking County (Figure 4) served as the headwaters for numerous tributaries to the Teays (Stout et al., 1943 and Kempton, 1956). There was a major

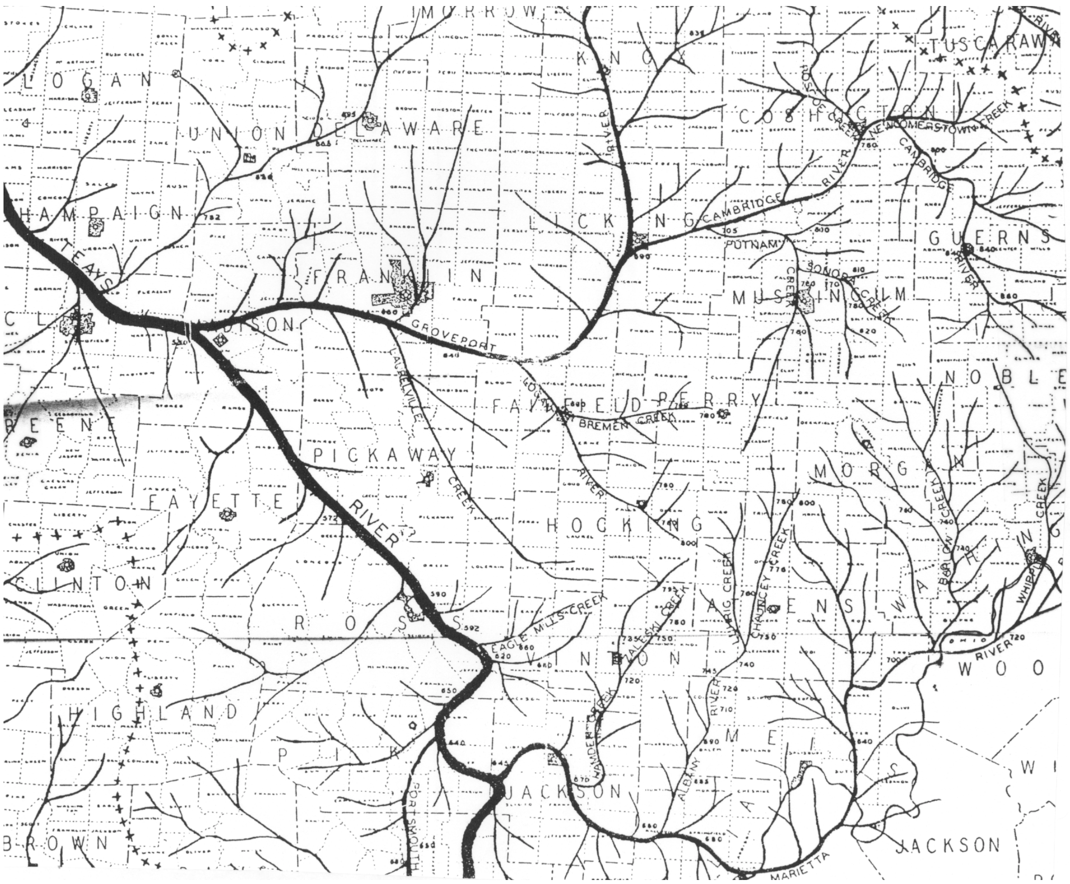


Figure 4. Teays Stage drainage of south-central Ohio (after Stout et al., 1943).

drainage divide, caused by an upland ridge or col, located approximately along the Hocking County-Athens County line. The area south of this divide drained to the south; this area served as the headwaters for the Albany River. To the north of this divide, the Logan River roughly followed a course similar to that of the modern Hocking River. Flow was to the north, the Logan River eventually emptied into the Groveport River, a major tributary of the Teays. Laurelville Creek, another northerly flowing tributary of the Groveport River, roughly followed the course of Salt Creek. This ancestral stream drained most of western Hocking County.

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). This 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. North of the divide, a new trunk stream referred to as the Lancaster River down-cut and its headwaters eroded southward toward Athens County (Figure 5). The Lancaster River replaced the Logan River and continued to drain central and northern Hocking County. The Lancaster River flowed north, eventually emptying into the Newark River. The Newark River flowed westward and eventually turned and flowed southward. This southward flow was directly opposite that of the previous Teays Drainage.

Northup Creek drained the area south of the divide at the Athens County line. Northup Creek had a more easterly course and a deeper channel than the previous Albany River. Adelphi Creek drained the southwestern corner of Hocking County. Adelphi Creek flowed due west as opposed to due north as the previous Laurelville Creek had (Stout et al., 1943). Alternatively, Merrill (1950 and 1953) and Smith (1996) referred to this southerly flowing stream as Stewart Creek.

During the Illinoian glaciation, ice advanced through southern Fairfield County, blocking the northerly flow of the Lancaster River. Ponding occurred and eventually the rising waters breached the former divide at the Hocking County-Athens County line (Stout et al., 1943, Wolfe et al., 1962, and Angle, 2000). A new, deeper channel was cut and the stream merged with the older, southerly flowing drainage south of Nelsonville. Stout et al. (1943) referred to this as the Haydenville River and its course was very close to that of the present Hocking River (Figure 6).

At some time following the earlier glaciations, the Hocking River may have used a smaller channel to the southwest of the main channel. This channel is now occupied in part by Lake Logan and Clear Fork. The association between the main channel of the Hocking and this tributary channel is not known.

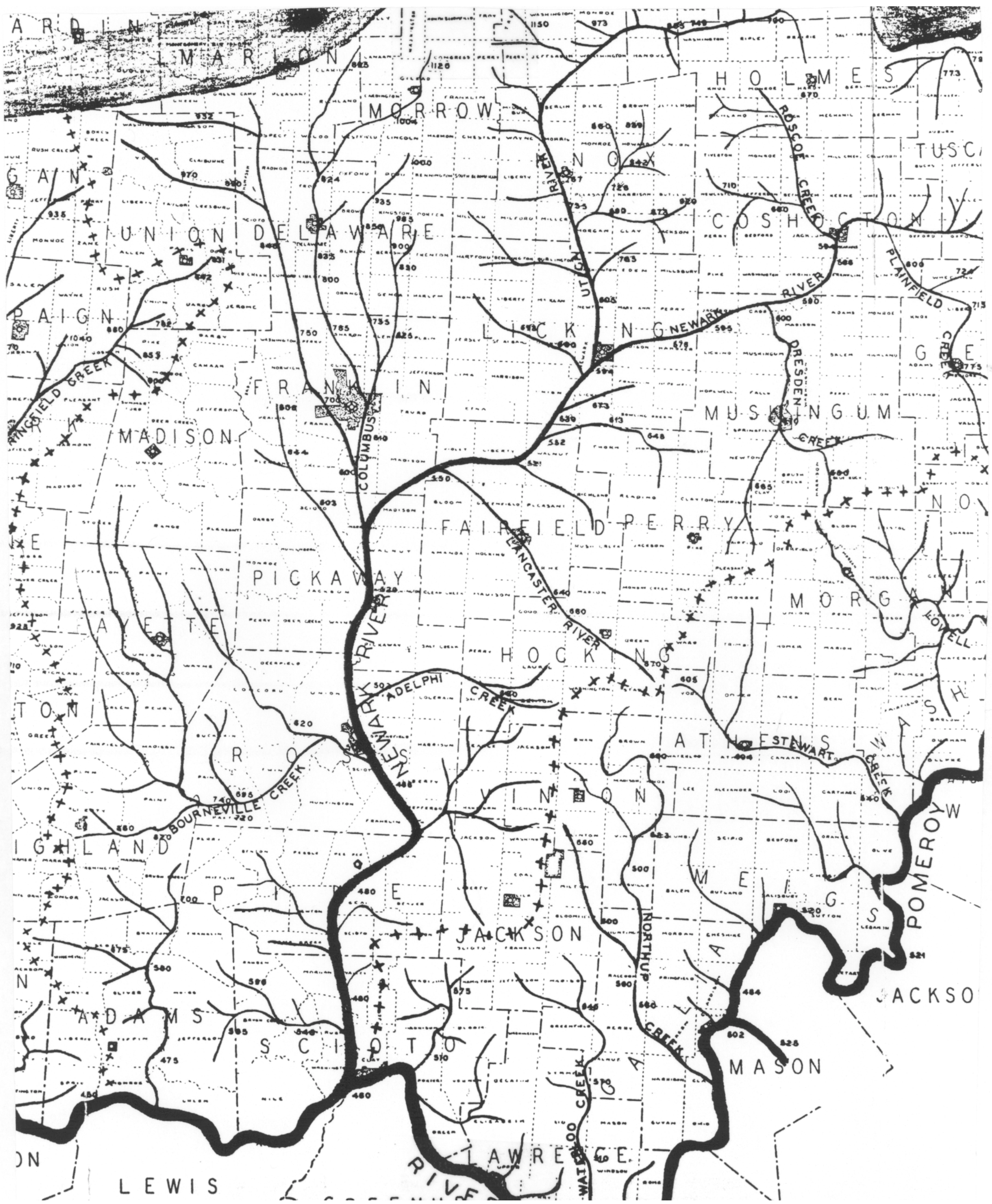


Figure 5. Deep Stage drainage of south-central Ohio (after Stout et al., 1943).

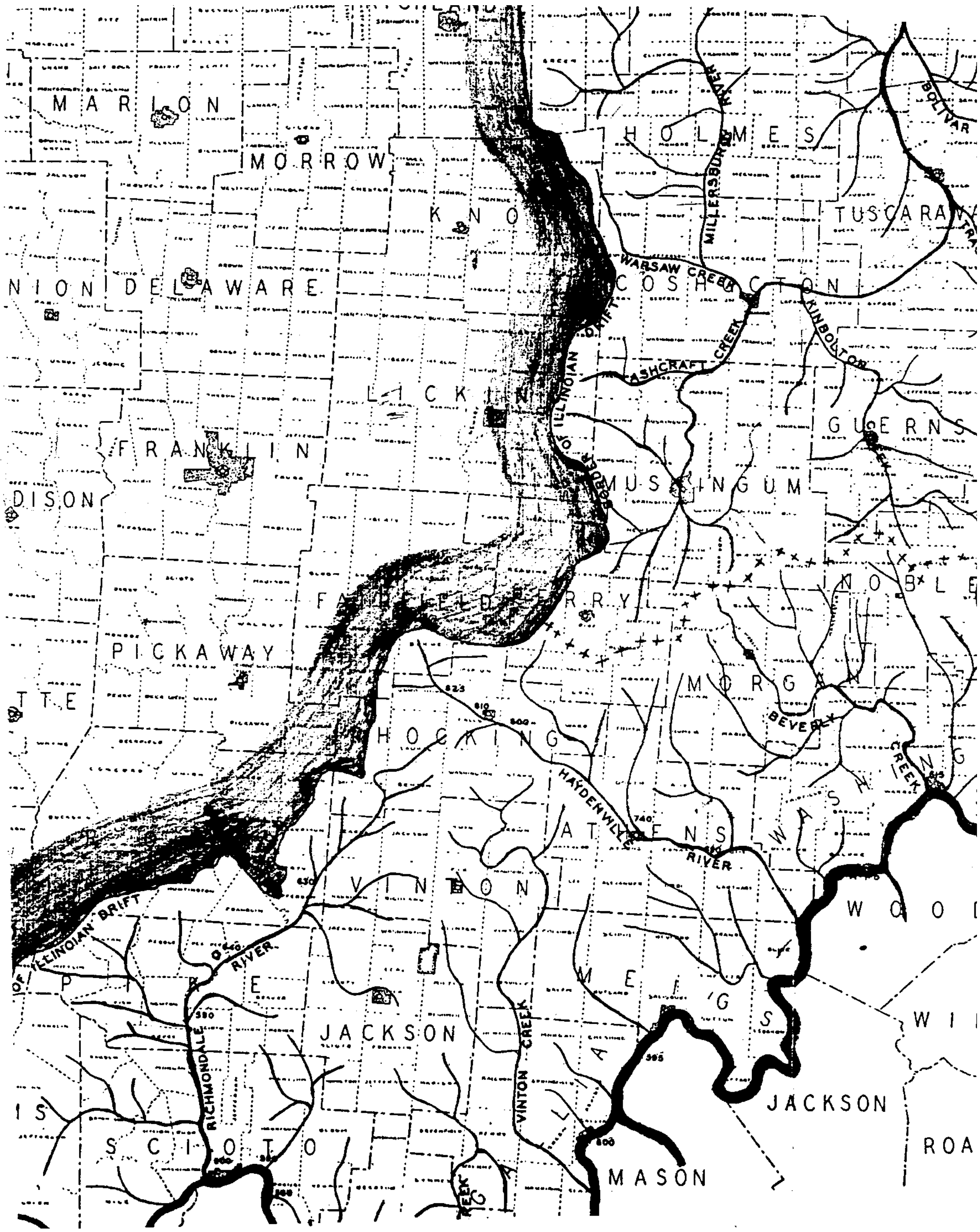


Figure 6. Illinoian and post-Illinoian drainage in south-central Ohio (Stout et al., 1943).

The ancestral Hocking River valley became a major conduit for glacial meltwater flow throughout the Illinoian and Wisconsinan ice advances. The valley was subjected to numerous sequences of cut and fill (Merrill, 1950 and 1953, Wolfe et al., 1962 and Angle, 2000). Figure 7 portrays the various terrace levels of the ancestral Hocking River. Initially, the valley was filled with Illinoian outwash to a level 60 to 90 feet higher than the present river. Much of this material was eroded away over time, leaving only high terraces adjacent to the bedrock valley walls as erosional remnants. Kempton (1956) and Smith (1996) referred to this high Illinoian terrace as the Hocking Terrace Level.

Southeastern Hocking County was drained by Vinton Creek, which had a course similar to modern Raccoon Creek. The Richmondale River drained southwestern Hocking County (Stout et al., 1943). The upper part of this river followed the course of modern Salt Creek.

Ancestral stream channels filled with glacial/alluvial sediments are referred to as buried valleys. Outwash deposits are created by active deposition of sediments by meltwater streams. These deposits are generally bedded (stratified) and sorted. Outwash deposits confined to stream valleys 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 call 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.

The most recent ice age, the Wisconsinan, brought further drainage changes to Hocking County (Stout et al. 1943). The tributaries and streams began to more closely resemble modern drainage patterns (Figure 8). During the Wisconsinan, the sequence of cut and fill continued in the Hocking River Valley. The higher Early Wisconsinan terrace is referred to as the Lancaster Terrace (Kempton, 1956 and Smith, 1996) level and is roughly 25 to 30 feet higher than the modern river. The lower, Late Wisconsinan Terrace is referred to as the Carroll Terrace (Kempton, 1956 and Smith, 1996) level and is roughly 10 to 15 feet higher than the modern river terraces.

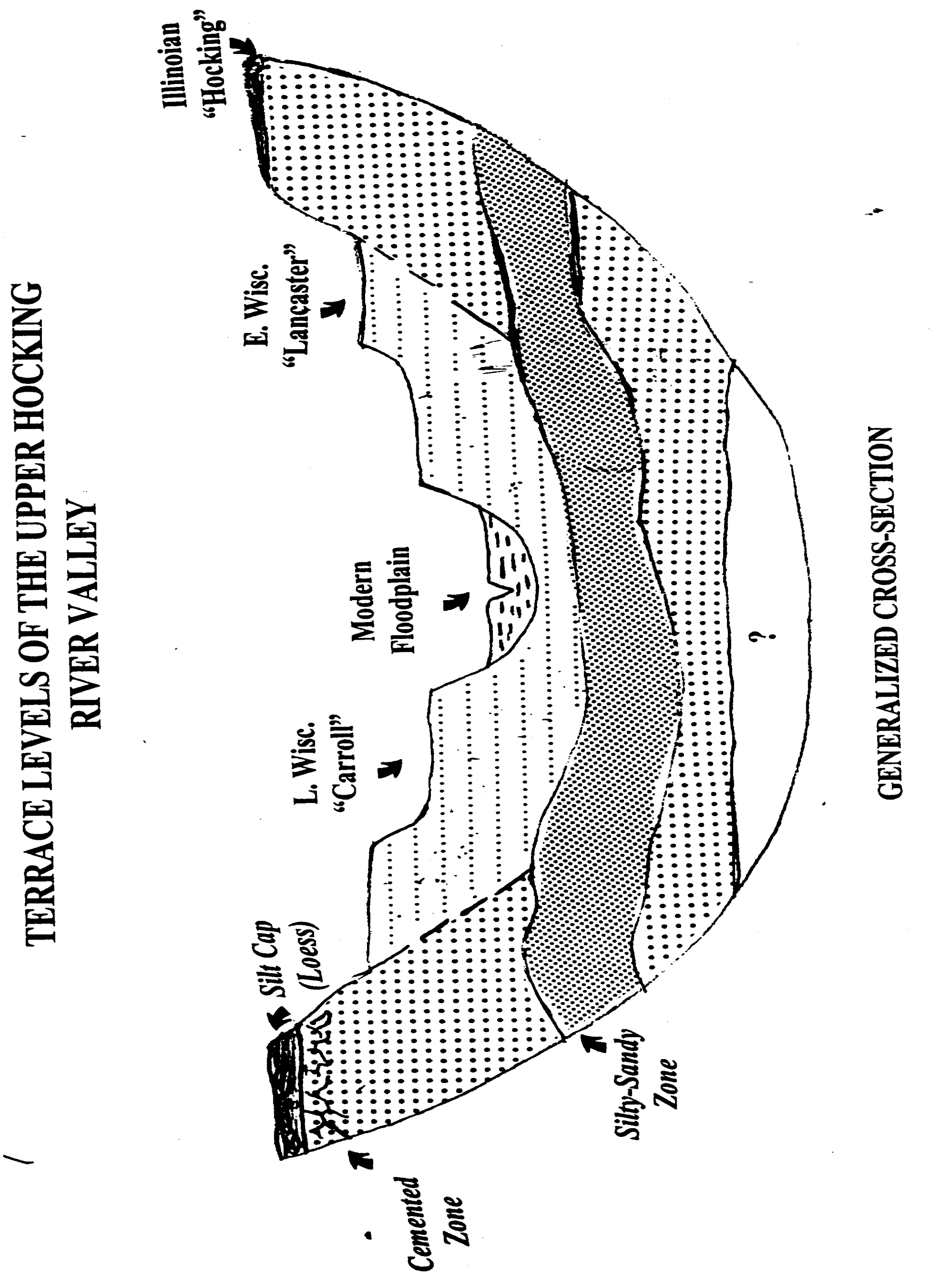


Figure 7. Terrace levels of the Upper Hocking River Valley (after Angle, 2000).

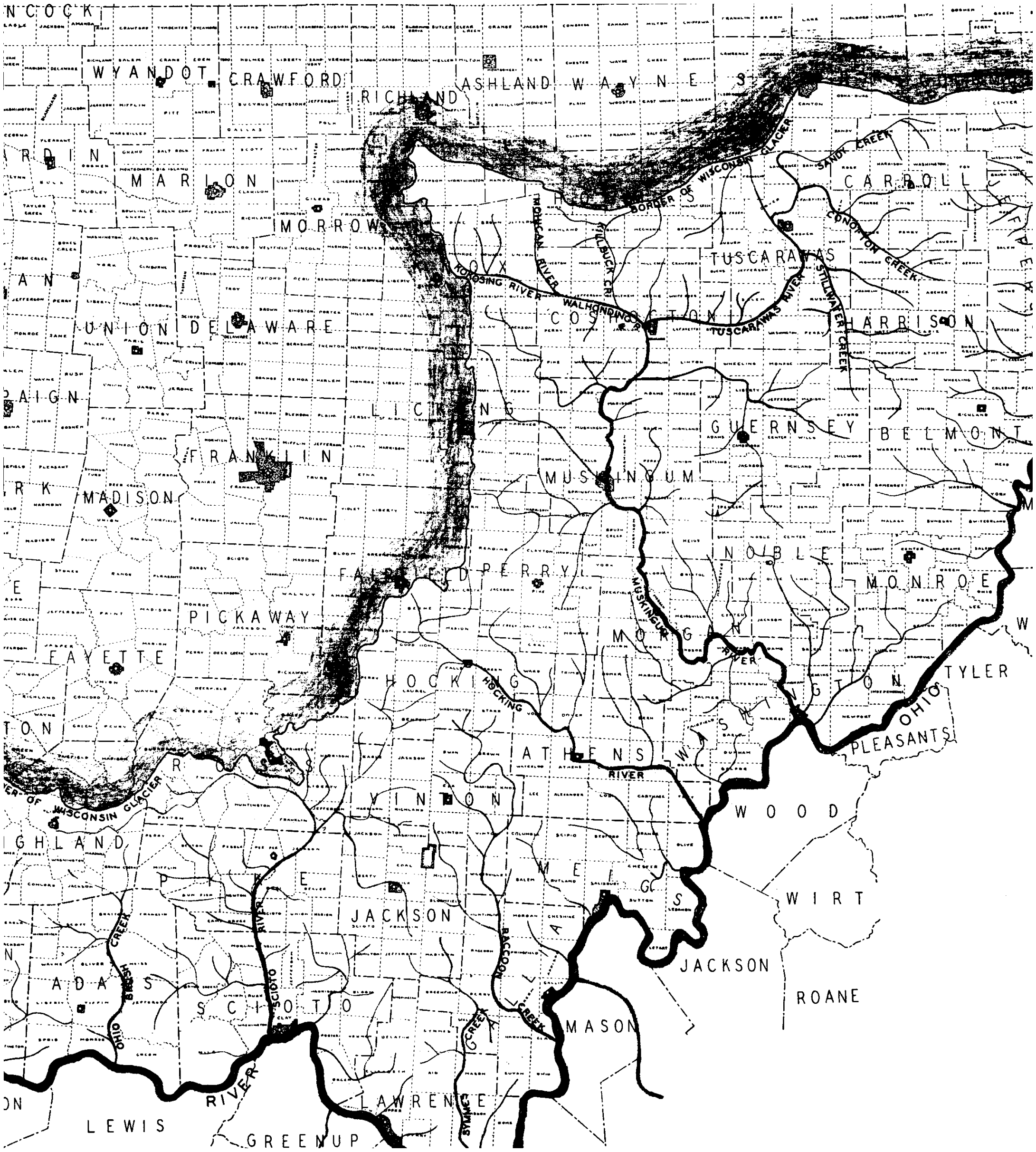


Figure 8. Post-Wisconsinan drainage in south-central Ohio (after Stout et al., 1943).

Besides elevation, the terraces also vary somewhat in pebble lithology and sorting (Kempton, 1956). Perhaps more importantly, the surface of the terraces also differs significantly in the depth of weathering and soil formation. Weathering over 20 feet thick occurs in the Illinoian terraces, 8-10 feet in the Early Wisconsinan terraces and 4-6 feet in the Late Wisconsinan terraces. The terraces, especially the Illinoian, are mantled by a silt cover or cap. This silt cap is believed to be either loess or floodplain / slack water in origin, or perhaps a combination of the two.

Following the Wisconsinan ice advance, the modern drainage patterns for Salt Creek and Rush Creek evolved. These drainages were both filled with interbedded alluvial and lacustrine deposits. The sediments were a mixture derived from both glacial meltwater and debris from surrounding upland slopes.

Glacial Geology

During the Illinoian ice advance, the margin of the ice sheet left a thin mantle of Illinoian till along the western edge of the county and along the northern margin of Marion Township (Goldthwait et al., 1961, Smith (1996), and Pavey et al., 1999). 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. Lodgement till 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. Vertical permeability in till is controlled largely by factors influencing the secondary porosity such as fractures (joints), worm burrows, root channels, sand seams, etc.

The Illinoian till in Hocking County is commonly thin and patchy in nature. The till is typically highly weathered and fractured. It is not of sufficient thickness to contain sand and gravel lenses of adequate thickness to be considered aquifers. The till-mantled slopes are commonly slightly less steep and rugged than those beyond the glacial margin.

The other effects of the glaciation largely occurred in the stream valleys, which was discussed in the previous section entitled Pre- and Inter-Glacial Drainage Changes.

Bedrock Geology

Bedrock exposed at the surface in Hocking County belongs to the Mississippian and Pennsylvanian Systems. Table 9 summarizes the bedrock stratigraphy found in Hocking County. The ODNR, Division of Geological Survey, has Open-File Reconnaissance Bedrock Geological Maps done on a 1:24,000 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 the Mississippian age Cuyahoga Formation are encountered at the surface in southwestern Hocking County. They are also exposed at the surface near the base of some of the deeper stream valleys in east central Hocking County. Massive sandstone of the Black Hand Formation and Logan Formation are exposed throughout central and northwestern Hocking County. The Logan Formation also includes some thin interbedded siltstones and shales. Spectacular outcrops of these formations can be observed at Hocking Hills State Park.

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. Wolfe et al., (1962), DeLong (1967) and Bork and Malcuit (1979, 1985, and 1988) discuss Mississippian depositional systems in detail.

Rocks of the Pennsylvanian System Pottsville Group and Allegheny Group are exposed along ridge tops in central Hocking County and are present along slopes and valleys in east central and eastern Hocking County. These formations consist of interbedded dirty sandstones, shales, clay, flint, coal, and thin limestones. Rocks from younger, undifferentiated Pennsylvanian formations outcrop along ridge tops and upper slopes in eastern Hocking County (ODNR, Div. of Geological Survey, Open File, Reconnaissance Bedrock Geology Maps and ODNR, Div. of Water, Open File, Bedrock State Aquifer Map, 2000).

Table 9. Bedrock stratigraphy of Hocking County, Ohio

System	Group/Formation (Symbol)	Lithologic Description
Pennsylvanian	Pennsylvanian Undivided (Pu)	Interbedded dirty sandstones, shales, and siltstones with thin coal, limestones, and clay. Poor aquifer, yields less than 5 gallons per minute.
	Pottsville Group Allegheny Group (Pap)	Interbedded gray to black sandstones, shale, and siltstone with thin limestone, coal, clay, and flint. Poor aquifer, yields less than 5 gallons per minute.
Mississippian	Mississippian Undivided (Mu)	Gray to brown thin sandstones, shales, and siltstones. Poor aquifer, yields less than 5 gallons per minute.
	Logan Formation Black Hand Formation (Mlb)	The Logan is a thin brown sandstone with minor siltstone and shale. The Black Hand is a massive sandstone with conglomerate and fractured zones. Moderate to good aquifers with yields ranging from 25 to 100 gallons per minute.
	Logan and Cuyahoga Group (Mlcg) Cuyahoga Group (Mcg)	Dark thin shales and siltstones with minor fine-grained sandstones that are stratigraphic equivalents of the Logan and Black Hand Formations. Moderate to poor aquifers, yields range from 5to 25 gallons per minute.

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). Higher in the section, the rocks tend to include more fine-grained mudstones and claystones (Collins, 1979). These rocks are commonly reddish in color and reflect deposition in a more arid alluvial environment (Collins, 1979).

Ground Water Resources

Ground water in Hocking 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.

Yields from 100 to 500 gallons per minute (gpm) are obtainable from the coarse, well-sorted sand and gravel outwash deposits in portions of the Hocking River Valley north of Rockbridge and from the city of Logan south (ODNR, Div. Of Water Open File, Glacial State Aquifer Map and Walker, 1991). 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 5 to 100 gpm are obtained from wells drilled along the margins and tributaries of the Hocking River. Yields of 5 to 100 gpm are also obtained from the segment of the Hocking River between Rockbridge and Logan (ODNR, Div. of Water, Open File, Glacial State Aquifer Map, 2000) and Walker, 1991). Similar yields are available from the channel to the west of the Hocking River now occupied by Lake Logan and Clear Fork. The lower yields are obtained from channels containing thin lenses of sand and gravel interbedded with thick sequences of fine-grained lacustrine and alluvial materials (ODNR, Div. Of Water Open File, Glacial State Aquifer Map, 2000 and Walker, 1991).

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. Yields of 5 to 25 gpm up to 25 to 100 gpm are available from the coarse-grained, fractured, conglomeratic massive sandstone of the Mississippian Black Hand and Logan Formations. These formations constitute the best bedrock aquifers in the county (Walker, 1991 and ODNR, Div. of Water, Open File, Glacial State Aquifer Map, 2000). Yields of 5 to 25 gpm are obtained from wells completed in the Mississippian Cuyahoga Formation in east central Hocking County. Yields of 0 to 5 gpm are obtained from the shaley sequences of Mississippian rock in the southwestern corner of the county (Walker, 1991 and ODNR, Div. of Water, Open File, Glacial State Aquifer Map, 2000). Yields of 0 to 5 gpm are obtained from all of the various Pennsylvanian formations (Walker, 1991 and ODNR, Div. of Water, Open File, Glacial State Aquifer Map, 2000). These wells tend to be marginal for uses other than small household. Wells completed in these units may require extra storage capacity or a back-up system such as a cistern.

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 be greater in the valleys than at the ridge tops. 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 in the valleys. 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 Hocking 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 10 and 11 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 Hocking County. Delineations of mined areas were made using information from the *Soil Survey of Hocking County* (Lemaster and Gilmore, 1989), abandoned underground mine maps (ODNR, Division of Geological Survey, open file maps), and the Hocking County portion of U.S.G.S. 7-1/2 minute quadrangle maps. Site-specific information for mined area can be obtained from the ODNR, Division of Geological Survey and Division of Mineral Resources Management.

Table 10. 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 11. 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)

REFERENCES

Aller, L., T. Bennett, J.H. Lehr, R.J. Petty, and G. Hackett, 1987. DRASTIC: A standardized system for evaluating ground water pollution potential using hydrogeologic settings. U.S. Environmental Protection Agency EPA/600/2-87-035, 622 pp.

Angle, M.P., 2000. Glacial aquifer stop, upper Hocking River Valley aquifer. Excerpted from The 45th Annual Midwest Ground Water Conference Field Trip Guidebook. Ohio Department of Natural Resources, Division of Water,

Bier, J.A., 1956. Landforms of Ohio. Ohio Department of Natural Resources, Division of Geological Survey, map.

Bonta, J.V., C.R. Amerman, W.A. Dick, G.F. Hall, T.J. Harlukowicz, A.C. Razem, and N.E. Smeck, 1992. Impact of surface coal mining on three Ohio watersheds – physical conditions and groundwater hydrology. Water Resources Bulletin, Volume 28, No. 3, PP. 577-596.

Bork, K.B. and R.J. Malcuit, 1979. Paleoenvironments of the Cuyahoga and Logan Formations (Mississippian) of central Ohio. Geological Society of America Bulletin, V. 90, p. 1782-1838.

Bork, K. B. and R. J. Malcuit, 1985. Lower Carboniferous clastic sequence of central Ohio. Guidebook Field Excursion #4, Sixth Gondwana Symposium, Institute of Polar Science, The Ohio State University, Columbus, Ohio, Miscellaneous Publication # 227, 31 p.

Bork, K. B. and R. J. Malcuit, 1988. A Lower Mississippian deltaic, shallow-marine complex in central Ohio. Society of Economic Paleontologist and Mineralogists, Fifth Midyear Meeting, Guidebook, Field Trip 6, 32 pp.

Collins, H.R., 1979. The Mississippian and Pennsylvanian (Carboniferous) systems in the United State-Ohio. U.S. Geological Survey Professional Paper 1110-E, 25 pp.

DeLong, R. M., 1967. Bedrock geology of the South Bloomingville quadrangle, Hocking and Vinton Counties, Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Report of Investigations No. 63, map / plates with text.

Driscoll, F.G., 1986. Groundwater and wells. Johnson Filtration Systems , St. Paul, Mn, 1089 pp.

Dumouchelle, D.H. and M.C. Schiefer, 2002. Use of streamflow records and basin characteristics to estimate ground-water recharge rates in Ohio. Ohio Department of Natural Resources, Division of Water, Bulletin 46, 45 pp.

Fenneman, N.M., 1938. Physiography of the eastern United States. McGraw-Hill Book Co., New York, New York, 714 pp.

Ferm, J.C., 1974. Carboniferous environmental models in eastern United States and their significance. In G. Briggs, ed. Carboniferous of the southern United States. Geological Society of America Special Paper 148.

Fetter, C.W., 1980. Applied hydrogeology. Charles E. Merrill Publishing Co., Columbus, Ohio, 488 pp.

Frederick, C.L., 1991. Ground water pollution potential of Ross County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report No. 24, 400 pp.

Freeze, R.A. and J.A. Cherry, 1979. Ground water. Prentice-Hall, Englewood Cliffs, N.J., 604 pp.

Frost, R.B., 1931. Physiographic map of Ohio. Oberlin College, The Geographical Press, Columbia Univ., N.Y., N.Y., map with text.

Goldthwait, R.P., G.W. White, and J.L. Forsyth, 1961. Glacial geology of Ohio. Division of Water and Geological Survey, Ohio Department of Natural Resources, Misc. Geological Investigation Map I-316, 1 map.

Harstine, L.J., 1991. Hydrologic atlas for Ohio. Ohio Department of Natural Resources, Division of Water, Water Inventory Report, No. 28, 13 pp.

Heath, R.C., 1984. Ground-water regions of the United States. U.S.Geological Survey, Water Supply Paper 2242, 78 pp.

Horne, J.C., J.C. Ferm, F.T. Carrucio, and B.P. Baganz, 1978. Depositional models in coal exploration and mine planning in Appalachian region. American Association of Petroleum Geologists Bulletin, Vol. 62, No. 12, pp.2379-2411.

Kempton, J.P., 1956. Outwash terraces of the Hocking River Valley. Unpublished M. A. Thesis, The Ohio State University, Columbus, Ohio, 100 pp.

Kipp, J.A., F.W. Lawrence, and J.S. Dinger, 1983. A conceptual model of ground-water flow in the eastern Kentucky coalfield. 1983 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation. University of Kentucky, Lexington, Kentucky, pp. 543-548.

Lemaster, D.D. and G.M. Gilmore, 1989. Soil survey of Hocking County, Ohio. U. S. Department of Agriculture, Natural Resources Conservation Service, 236 pp.

Merrill, W.M., 1950. The geology of northern Hocking County, Ohio. Unpublished PhD. Dissertation, The Ohio State University, Columbus, Ohio, 245 pp.

Merrill, W.M., 1953. Pleistocene history of a part of the Hocking River Valley, Ohio. The Ohio Journal of Science, Vol. 53, No. 3, pp 143-158.

Ohio Department of Natural Resources, Division of Geological Survey, Open File, Reconnaissance Bedrock Geology Maps. Available on a U.S.G.S. 7-1/2 minute quadrangle basis.

Ohio Department of Natural Resources, Division of Geological Survey, Open File, Bedrock Topography Maps. Available on a U.S.G.S. 7-1/2 minute quadrangle basis.

Ohio Department of Natural Resources, Division of Water, Open File Bedrock State Aquifer Maps. Available on a U.S.G.S. 7-1/2 minute quadrangle basis.

Ohio Department of Natural Resources, Division of Water, Open File Glacial State Aquifer Maps. Available on a U.S.G.S. 7-1/2 minute quadrangle basis.

Owenby, J.R. and D.S. Ezell, 1992. Monthly station normals of temperature, precipitation, and heating and cooling degree days, 1961-1990. Climatography of the United States No. 81, OHIO. U.S. Department of the Interior, Project A-051-OHIO,

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 30 pp.

Pavey, R.R., R.P. Goldthwait, C.S. Brockman, D.N. Hull, E.M. Swinford, and R. Van Horn, 1999. Survival geology of the Canton 30 x 60 minute quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Map No.SG-2, map with text.

Peffer, J.R., 1991. Complex aquifer-aquitard relationships at an Appalachian Plateau site. Ground Water, Vol. 29, No.2, pp.209-217.

Pettyjohn, W.A. and R. Henning, 1979. Preliminary estimate of ground-water recharge rates, related streamflow and water quality in Ohio. U.S. Department of the Interior, Project A-051-OHIO, Project Completion Report No. 552, Water Resources Center, The Ohio State University, Columbus, Ohio, 323 pp.

Razem, A.C., 1983. Ground-water hydrology before, during, and after coal strip mining of a small watershed in Jefferson County, Ohio. U.S. Geological Survey, Water Resources Investigations Report 83-4215, 36 pp.

Schmidt, J. J., 1996. Ground water pollution potential of Fairfield County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report, No. 41, 174 pp.

Schubert, J.P., 1980. Fracture flow of groundwater in coal-bearing strata. Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Kentucky, Lexington, Kentucky, pp. 61-73.

Smith, J., 1996. Glacial geology field trip. Unpublished Class Field Trip Guidebook, Ohio University, Athens, Ohio, 30 pp.

Spahr, P. N., 1997a. The water resources of Perry County, Ohio. Ohio Department of Natural Resources, Division of Water, 105 pp.

Spahr, P.N., 1997b. Ground water pollution potential of Perry County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report No. 42, 67 pp.

Stout W., K. Ver Steeg, and G.F. Lamb, 1943. Geology of water in Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Bulletin 44, 694 pp.

Sugar, D.J., 1990. Ground water pollution potential of Pickaway County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report NO. 3, 67 pp.

Walker, A.C., 1991. Ground water resources of Carroll County. Ohio Department of Natural Resources, Division of Water, map with text.

Walker, A.C., 1991. Ground water resources of Hocking County. Ohio Department of Natural Resources, Div. of Water, map with text.

Weedman, S.D., 1990. Freshwater limestones of the Allegheny Group. Pennsylvania Geology, Vol. 21, NO. 1, pp. 9-16.

Wolfe, E.W., J.L. Forsyth, and G.D. Dove, 1962. Geology of Fairfield County. Ohio Department of Natural Resources, Division of Geological Survey, Bulletin 60, 230 pp.

Wyrick, G.G. and J.W. Borchers, 1981. Hydrologic effects of stress-relief fracturing in an Appalachian valley. U.S. Geological Survey, Water Supply Paper 2177, 51 pp.

UNPUBLISHED DATA

Ohio Department of Development. Office of Strategic Research, Countywide profiles, 2002.

Ohio Department of Natural Resources, Division of Water. Well log and drilling reports for Hocking County.

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 6,400 water well log records are on file for Hocking County. Data from roughly 1,430 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 water was encountered at were taken from these records. The *Ground Water Resources of Hocking County* (Walker, 1991) provided generalized depth to water information throughout the county. The *Water Resources of Perry County* (Spahr, 1997a) provided useful data on aquifer depths. Depth to water trends mapped in adjoining Perry County (Spahr, 1997b), Ross County (Frederick, 1991), Fairfield County (Schmidt, 1996), and Pickaway County (Sugar, 1990) were used as a guideline. Topographic and geomorphic trends were utilized in areas where other sources of data were lacking.

Depths to water of 0 to 5 feet (10) were used for the floodplains of the main trunk of the Hocking River and for Monday Creek. Depths to water of 5 to 15 feet (9) and 15 to 30 feet (7) were assigned to low terraces and tributary valleys of the Hocking River, Rush Creek, Salt Creek and Monday Creek. Depths of 30 to 50 feet (5) were utilized for valley slides and slopes of upland areas in eastern Hocking County and for the headwaters of many small tributaries throughout the county. Depths to water of 50 to 75 feet (3) were utilized for slopes and valleys in western and central Hocking County and for ridge tops in eastern Hocking County. Depths to water of 75 to 100 feet (2) were used for ridge tops in the northwestern corner of the county. Depths to water greater than 100 feet (1) were applied to steep, high sandstone ridge tops in central and western Hocking County.

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 Perry County (Spahr, 1997b), Ross County (Frederick, 1991), Fairfield County (Schmidt, 1996), and Pickaway County (Sugar, 1990) were used as a guideline.

Recharge values of greater than 10 inches per year (9) were selected for the trunk floodplain of the Hocking River. Recharge values of 7 to 10 inches per year (8) were assigned to terraces and tributaries of the Hocking River and to the floodplains overlying Salt Creek, Monday Creek, and Rush Creek. 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 included the headwaters of smaller tributaries and ridge tops and slopes in the northwestern portion of the county. 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 most upland areas. 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.

Aquifer Media

Information on evaluating aquifer media was obtained from Wolfe et al. (1962), DeLong (1967), (Bork and Malcuit (1979 and 1988), and Walker (1991). The *Water Resources of Perry County* (Spahr, 1997a) provided useful data on aquifer media. Aquifer media mapped in adjoining Perry County (Spahr, 1997b), Ross County (Frederick, 1991), Fairfield County (Schmidt, 1996), and Pickaway County (Sugar, 1990) were used as a guideline. Aquifer information was inferred for the surficial geology of northern and western Hocking County from Pavey et al. (1999). 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 the Hocking River. An aquifer rating of (6) was assigned to thinner, less continuous sand and gravel outwash deposits associated with margins and tributaries of the buried valley underlying the Hocking River. An aquifer rating of (6) was used for some thinner sand and gravel deposits associated with the main valley and tributaries associated with Salt Creek and Monday Creek. An aquifer rating of (5) was used for thin lenses of sand and gravel interbedded with thicker sequences of silt and clay. This rating was used for the buried valley underlying Rush Creek and for some small tributaries to Salt Creek.

Massive sandstone with an aquifer rating of (6) was assigned to sandstones of the Black Hand and Logan Formations in central Hocking County. Massive sandstone with an aquifer rating of (5) was selected for sandstones of the Logan, Cuyahoga, and Black Hand Formations in western Hocking County. The lower rated massive sandstones commonly are thinner; less fractured and typically are slightly lower yielding. Sandstones with a rating of (6) were evaluated for some thinner-bedded, finer-grained, highly fractured ridge tops in central Hocking County. Sandstones with an aquifer rating of (5) were assigned to the Cuyahoga and Logan Formations along the western and northern fringes of Hocking County. These thin sandstones and sandy shales are finer-grained, thinner- bedded, and less fractured than the other sandstones units in the county. Bedded limestone, sandstone, and shale with an aquifer rating of (5) or (4) was selected for the lower Pottsville-Allegheny Group in east central Hocking County. Wells developed in these aquifers may include some interbedded siltstones, flint, clay, and thin coals. Bedded limestone, sandstone, and shale with an aquifer rating of (3) were used for the undifferentiated Pennsylvanian formations in the eastern margin of Hocking County. These sequences of rock contain formations from the Conemaugh and Monongahela Groups. These rocks tend to have a higher percentage of lower permeability units such as shales, mudstones, and limestones than the Pottsville-Allegheny Group rocks did. Aquifers evaluated as sandstone, shale were assigned ratings of (4) or (3) depending upon the proportion of sandstone and shale. These aquifers included limited sequences of the Cuyahoga Formation along the border with Fairfield County. An aquifer rating of (3) was selected for shale. Shale aquifers were limited to some very shaley sequences within the Cuyahoga Formation bordering Pickaway County.

Soils

Soils were mapped using the data obtained from the *Soil Survey of Hocking County* (Lemaster and Gilmore, 1989). 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 Hocking County showed a high degree of variability. This is a reflection of the parent material. Table 12 is a list of the soils, parent materials, setting, and corresponding DRASTIC values for Hocking 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 along sandstone ridges in western Hocking County. Soils were evaluated as being sand (9) for some moderately steep sandstone ridges in central Hocking County. The sand was derived from weathered sandstone regolith. Shrink-swell (aggregated) clay (7) was selected for some ridge tops and slopes where the soils were developed from very clayey shales in western Hocking County. Sandy loams (6) were selected for soils overlying sandstone slopes and ridges. These soils were derived from weathering sandstones; however, the regolith included more fine-grained particles. Loam soils (5) were designated for certain medium-textured soils on floodplain terraces and along tributary streams. Silt loam (4) was selected for silty alluvial and lacustrine deposits on floodplains. Silt loam (4) was also selected for residual bedrock soils throughout the county. Clay loam (3) soils were evaluated for residual shale bedrock slopes in the northern portion of the county. Clay loam (3) soils were evaluated for areas with clay-rich glacial till along the Pickaway and Fairfield County boundaries.

Table 12. Hocking County soils

Soil Name	Parent Material Or Setting	DRASTIC Rating	Soil Media
Alexandria	Till	3	Clay loam
Alford	Loess	4	Silt loam
Allegheny	Old alluvial terraces	5	Loam
Bennington	Till	3	Clay loam
Bethesda	Strip mine	NR	Not rated
Cana Variant	Till over shale	10	Thin or absent
Cardington	Till	3	Clay loam
Cedarfalls	Sandstone	9	Sand
Chagrin	Alluvium	4	Silt loam
Chili	Outwash terraces	6	Sandy loam
Cincinnati	Till	3	Clay loam
Cruze	Clayey shale	7	Shrink-swell clay
DeKalb	Sandstone	10	Thin or absent
Euclid	Alluvium	4	Silt loam
Glenford	Lacustrine, alluvium	4	Silt loam
Guernsey	Shale	7	Shrink-swell clay
Hickory	Till	3	Clay loam
Licking	Lacustrine terrace	7	Shrink-swell clay
Lily	Loess over sandstone	10	Thin or absent
McGary	Lacustrine terrace	7	Shrink-swell clay
Melvin	Alluvium	4	Silt loam
Negley	Outwash terrace	4	Silt loam
Orrville	Alluvium	4	Silt loam
Otwell	Loess over lacustrine, outwash	3	Clay loam
Pope	Alluvium	6	Sandy loam
Shelocta	Siltstone colluvium	4	Silt loam
Shelocta-Berks	Shale-siltstone colluvium	10	Thin or absent
Shelocta-Cruze	Siltstone-shale colluvium	7	Shrink-swell clay
Stonelick	Coarse alluvium	6	Sandy loam
Wellston	Sandstone-siltstone	4	Silt loam
Wellston-Cruze	Shale-siltstone	7	Shrink-swell clay
Wellston-Guernsey	Shale-siltstone	7	Shrink-swell clay
Westmore	Shale	7	Shrink-swell clay
Westmoreland	Shale-siltstone	4	Silt loam
Westmoreland-Berks	Shale-siltstone	10	Thin or absent
Westmoreland-Guernsey	Shale-siltstone	7	Shrink-swell clay
Wheeling	Alluvium over outwash terraces	5	Loam
Zanesville	Sandstone and siltstone	4	Silt loam

Topography

Topography, or percent slope, was evaluated using U.S.G.S. 7-1/2 minute quadrangle maps and the *Soil Survey of Hocking County* (Lemaster and Gilmore, 1989). 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 2 to 6 percent (9) were used for flat lying ridge tops. Slopes of 6 to 12 percent (5) were also used for less steep slopes and moderately flat ridge tops. Slopes of 12 to 18 percent (3) and greater than 18 percent (1) were selected for steeper slopes in higher relief, upland areas.

Impact of the Vadose Zone Media

Information on evaluating vadose zone media was obtained from Wolfe et al. (1962), DeLong (1967), Bork and Malcuit (1979 and 1988), and Walker (1991). The *Water Resources of Perry County* (Spahr, 1997a) provided useful data on vadose zone media. Vadose zone media mapped in adjoining Perry County (Spahr, 1997b), Ross County (Frederick, 1991), Fairfield County (Schmidt, 1996), and Pickaway County (Sugar, 1990) were used as a guideline. Vadose zone information was inferred for the surficial geology of northern and western Hocking County from Pavey et al. (1999). 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. Information on parent materials derived from the *Soil Survey of Hocking County* (Lemaster and Gilmore, 1989), 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 and sand and gravel with significant silt and clay, both with a vadose zone media rating of (7) was utilized for the terraces and floodplains occupying the Hocking River Valley. Sand and gravel interbedded with silt and clay was given a vadose zone media ratings of (6) for the margins and tributaries of the Hocking River and for the trunk stream and tributaries of Salt Creek and Monday Creek. Vadose zone media ratings of (5) were selected for sand and gravel interbedded with silt and clay layers for deposits underlying and adjacent to Rush Creek. These ratings depend upon the proportion of coarse, well-sorted outwash to the finer-grained alluvial and lacustrine deposits. Silt and clay with ratings of (5), (4), and (3) were selected as vadose zone media for floodplains of upland tributaries and headwaters. The rating depended upon the relative proportion and permeability of the fines. Till (4) was selected as the vadose zone media for the thinly glaciated areas fringing the boundaries of Pickaway and Fairfield Counties.

Massive sandstone with a vadose zone media rating of (6) was assigned to areas of higher-yielding Black Hand Sandstone in central Hocking County. A vadose zone media rating of (6) was utilized for sandstone aquifers in western Hocking County. Sandstone and shale with vadose zone ratings of (5) and (6) was assigned to interbedded sandstone and shale aquifers bordering Fairfield County. Fractured shale with a vadose zone media rating of (5) was used for portions of the Cuyahoga Formation bordering Pickaway County. Bedded Sandstone, Limestone, and shale with vadose zone media ratings of (3) and (4) was selected as the vadose zone media for the Pennsylvanian formations in eastern Hocking County. This vadose zone media includes thin coals, flint, clay, and mudstones of the Pennsylvanian Pottsville Group and Allegheny Group. Shale with a vadose zone rating of (3) was designated for the majority of ridge tops in most of eastern Hocking County. For bedrock aquifers with an aquifer rating of (4) that occupy ridges capped by low permeability dirty sandstones, clay, shales, and mudstones, a vadose zone media rating of (3) was applied. For bedrock aquifers with an aquifer rating of (3), a bedrock vadose zone rating of (3) was selected. These units include the interbedded dirty sandstones, shales, clays, mudstones, thin limestones, and coals of the Conemaugh and Monongahela Groups.

Hydraulic Conductivity

Published data for hydraulic conductivity for Hocking County is limited. The *Water Resources of Perry County* (Spahr, 1997a) provided useful data on hydraulic conductivity. Hydraulic conductivity ratings mapped in adjoining Perry County (Spahr, 1997b), Ross County (Frederick, 1991), Fairfield County (Schmidt, 1996), and Pickaway County (Sugar, 1990) were used as a guideline. The *Ground Water Resources of Hocking County* (Walker, 1991) was useful for establishing ranges of hydraulic conductivity. 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 to 2,000 plus gallons per day per square foot (gpd/ft^2) (8) or 700 to 1,000 gpd/ft^2 (6) were selected. These high values were limited to the clean outwash deposits adjacent to the Hocking River. The values varied depending upon how clean and coarse the sediments were. Hydraulic conductivities of 300 to 700 gpd/ft^2 (4) were selected for sand and gravel deposits associated with the tributaries of the Hocking River and the trunk of Salt Creek that were assigned an aquifer media rating of (6). For sand and gravel deposits with an aquifer rating of (6), hydraulic conductivity values of 100-300 gpd/ft^2 (2) were assigned. In these deposits, thin sand and gravel lenses are interbedded with thicker sequences of finer-grained materials. These hydraulic conductivity values in this range were used for tributaries to Salt Creek and the Hocking River and for the trunk stream and tributaries to Monday Creek and Rush Creek.

Massive sandstones and sandstones in central Hocking County 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. All other bedrock aquifers were assigned hydraulic conductivity ratings of 1-100 gpd / ft^2 (1).

APPENDIX B

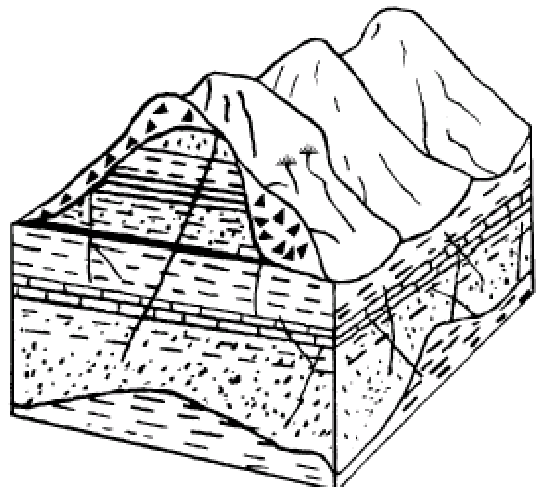
DESCRIPTION OF HYDROGEOLOGIC SETTINGS

Ground water pollution potential mapping in Hocking County resulted in the identification of eleven hydrogeologic settings within the Glaciated Central Region 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 13. Computed pollution potential indexes for Hocking County range from 61 to 187.

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.

Table 13. Hydrogeologic settings mapped in Hocking County, Ohio

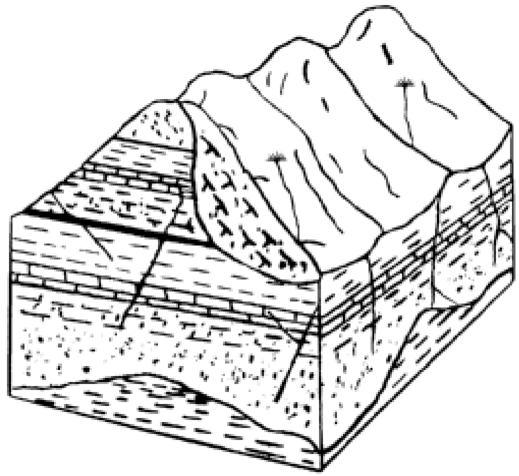
Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
6Da - Alternating Sandstone, Limestone, Shale - Thin Regolith	63-121	23
6Db - Alternating Sandstone, Limestone, Shale - Thick Regolith	87-97	3
6Fa - River Alluvium with Overbank Deposits	111-127	4
6M - Massive Sandstone	61-123	37
7Aa - Glacial Till over Bedded Sedimentary Rocks	75-93	5
7Ad - Glacial Till over Sandstone	71-120	33
7Ae - Glacial Till over Shale	70-104	11
7Bb - Outwash over Bedded Sedimentary Rocks	96-127	3
7Bf - Outwash over Massive Sandstone	90-187	19
7D - Buried Valleys	110-182	5
7Ec - Alluvium over Bedded Sedimentary Rock	97-159	38



6Da Alternating Sandstone, Limestone, Shale – Thin Regolith

This hydrogeologic setting is common in the eastern third of Hocking County as well as along the boundary with Fairfield 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 Pennsylvanian System and dirty sandstones, shales, and siltstones of the Mississippian System. 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 are silt loams or clay loams and vary with the bedrock lithology. Slopes are commonly steep. Variable supplies of ground water are obtained from intersecting bedding planes or vertical fractures in the bedrock. Ground water yields of 5-25 gpm are obtained from the Mississippian units bordering Fairfield County. Yields of 5-10 gpm are obtained from the lower units of the Pottsville and Allegheny Groups in eastern Hocking County. Yields of 0-5 gpm are common from interbedded dirty sandstones, shales, clay, mudstones, thin limestones, and coal of the Conemaugh and Monongahela Groups. Recharge is low to moderate depending upon the depth to the aquifers, steep slopes, and layers of impermeable bedrock.

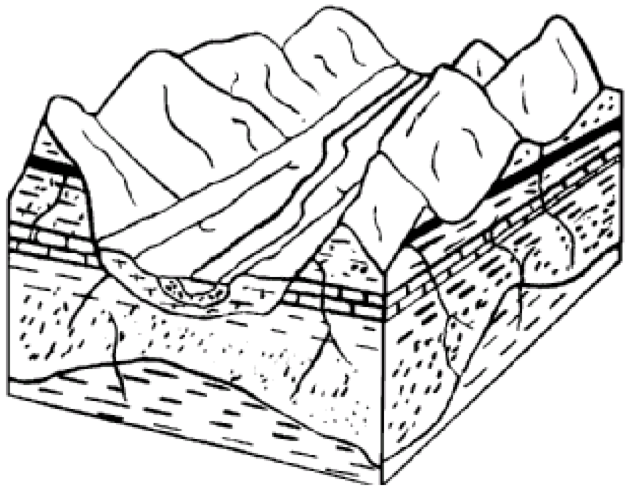
GWPP index values for the hydrogeologic setting of Alternating Sandstone, Limestone, Shale – Thin Regolith range from 63 to 121, with the total number of GWPP index calculations equaling 23.



<u>6Db Alternating Sandstone, Limestone, Shale – Thick Regolith</u>

This hydrogeologic setting is limited to slopes found along the northern margin of Hocking County, bordering Fairfield County. The area is similar to the 6Da Alternating Sandstone, Limestone, and Shale-Thin Regolith setting except that the regolith is much thicker, creating a thick accumulation of steeply dipping colluvium along the slope. The vadose zone and aquifers consist of slightly dipping, fractured, alternating sequences of dirty sandstones, shales, and siltstones of the Mississippian System. Multiple aquifers are typically present. Depth to water is typically deep. Soils are clay loams that formed in the fine-grained thick regolith and colluvium derived from shales and siltstones. Small supplies of ground water are obtained from intersecting bedding planes or vertical fractures. Ground water yields average less than 25 gpm. Recharge is moderate to low due to the greater depth to water, steep slope, and layers of moderately permeable bedrock.

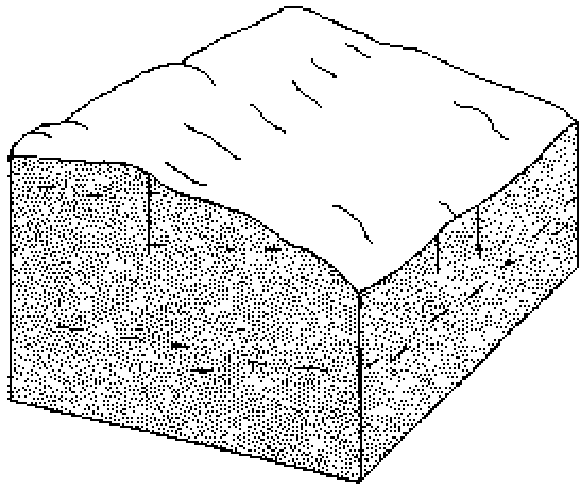
GWPP index values for the hydrogeologic setting of Alternating Sandstone, Limestone, Shale – Thin Regolith range from 87 to 97, with the total number of GWPP index calculations equaling 3.



6Fa River Alluvium with Overbank Deposits

This hydrogeologic setting is limited to tributary valleys and headwaters of streams in uplands adjacent to Perry County in the northeastern corner of Hocking County. This setting is similar to the 7Ec Alluvium over Sedimentary Rock setting; however, the drift is somewhat thinner, the valleys are narrower and the setting is typically further removed from buried valley deposits. Depth to water is usually shallow to moderate, averaging less than 30 feet. Soils are silt loams. Thin alluvium, composed primarily of fine-grained floodplain ("overbank") sediments, overlies bedrock. The alluvial deposits are typically saturated. Wells are completed in the underlying bedrock. The bedrock may be in direct hydraulic connection with the overlying alluvium. Ground water yields average in the 5-25 gpm range. Vadose zone material is silty to clayey alluvium. Where the alluvium is very thin, fractured bedrock may locally serve as the vadose zone media. 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.

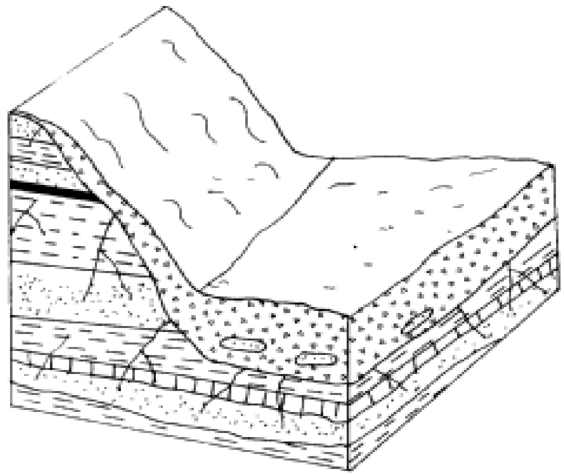
GWPP index values for the hydrogeologic setting of River Alluvium with Overbank Deposits range from 111 to 127, with the total number of GWPP index calculations equaling 4.



6M Massive Sandstone

This hydrogeologic setting is widespread through central Hocking County. The area is roughly analogous to the outcrop area of the Mississippian Black Hand Sandstone and Logan Formations. The area is characterized by high relief with steep slopes and broad, relatively flat ridge tops. The setting is typified by the scenic Hocking Hills State Park. The aquifer and vadose consist of relatively dense, massive sandstone. On some of the higher ridge tops, the vadose may include shales and other interbedded rocks of the Pennsylvanian System. The sandstone is moderately coarse-grained and contains conglomeratic zones. Additional permeability depends upon fractures, joints, and bedding planes. Depth to water is commonly deep. Soils are variable, silt loams and sandy loams are common. Where the sandstone is outcropping, the soils may be sand or considered to be thin or absent. Slopes are commonly steep. Ground water supplies are typically good with yields averaging 10 to 25 gpm and some areas producing from 25 to 100 gpm. Recharge is low due to steep slopes and greater depth to water.

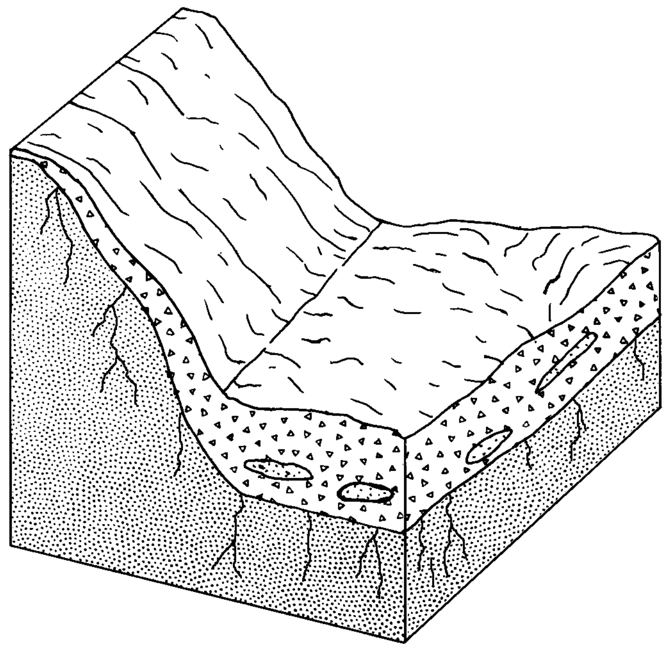
GWPP index values for the hydrogeologic setting Massive Sandstone range from 61 to 123, with the total number of GWPP index calculations equaling 37.



7Aa Glacial Till Over Bedded Sedimentary Rocks

This hydrogeologic setting is limited to northern Hocking County and fringes the border of Fairfield County. The setting includes small areas where thin Illinoian glacial till had advanced into Hocking County. This setting is associated with upland areas featuring bedrock-controlled topography. Topography varies from rolling, moderate relief areas to steeper, high relief areas. The topography is slightly less steep and rugged than the adjacent unglaciated slopes. The aquifer consists of thin interbedded shales, sandstones, and siltstones of the Mississippian Cuyahoga Formation. Yields range from 5 to 10 gpm for wells completed in these units. The Illinoian till overlying the bedrock is typically thin, highly weathered and patchy in nature. It may be highly fractured due to the weathering. The till weathers into clay loams. The depth to water is moderately deep, averaging from 50 to 75 feet. Recharge is moderately low due to low permeability soils, moderate to steep slopes, thickness of the till cover, and depth to water.

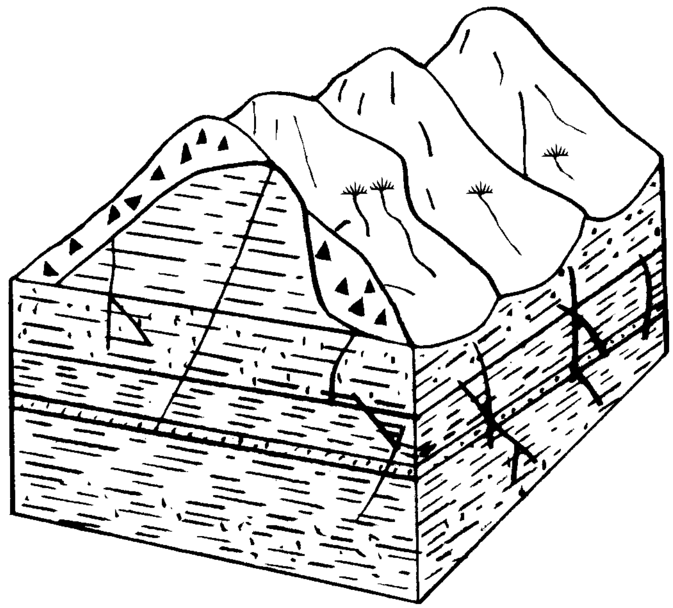
GWPP index values for the hydrogeologic setting of glacial till over bedded sedimentary rocks range from 75 to 93, with the total number of GWPP index calculations equaling 5.



7Ad Glacial Till over Sandstone

This hydrogeologic setting is found along the western margin of Hocking County, bordering Ross County and Pickaway County, and along the northern fringe of Marion Township, bordering Fairfield County. The setting includes areas where thin Illinoian glacial till had advanced into Hocking 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 topography is slightly less steep and rugged than the adjacent unglaciated slopes. The aquifer consists of sandstones of the Mississippian Cuyahoga Formation, Black Hand Sandstone, and Logan Formation. Soils are clay loams or silt loams derived from tills. Where the drift is very thin, the soils are considered to be thin or absent or sandy loams. The vadose zone varies from glacial till to sandstone depending upon the drift thickness. Yields are commonly 5 to 10 gpm as these sandstones are fine-grained. The Illinoian till overlying the bedrock is typically thin, highly weathered and patchy in nature. It may be highly fractured due to the weathering. Recharge is commonly low due to low permeability soils and vadose, depth to water, and moderately steep slopes.

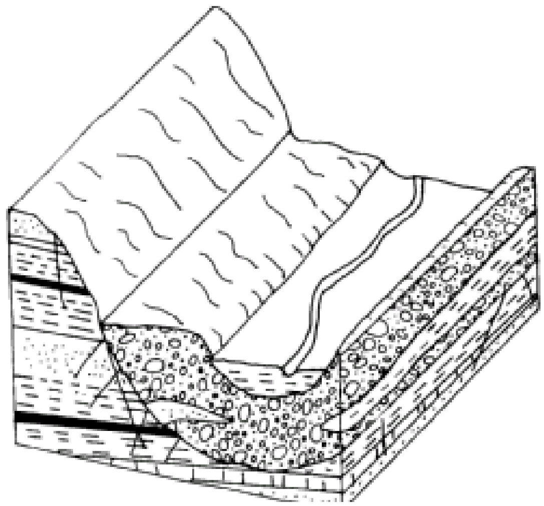
GWPP index values for the hydrogeologic setting of glacial till over sandstone ranges from 71 to 120, with the total number of GWPP index calculations equaling 33.



7Ae Glacial Till over Shale

This hydrogeologic setting is limited to portions of the western margin of Hocking County along the Pickaway County boundary. This setting is characterized by clayey glacial till overlying shaley bedrock of the lower Cuyahoga Formation. The setting includes areas where thin Illinoian glacial till had advanced into Hocking County. This setting is associated with upland areas featuring bedrock-controlled topography. Topography varies from rolling, moderate relief areas to steeper, high relief areas. The topography is slightly less steep and rugged than the adjacent unglaciated slopes. Wells are completed in the shale and siltstone bedrock. Yields are commonly less than 5 gpm. Topography is highly variable, ranging from gently rolling to very steep. Soils are clay loams. The vadose zone media varies from clayey glacial till to shale depending upon the drift thickness. The Illinoian till overlying the bedrock is typically thin, highly weathered and patchy in nature. It may be highly fractured due to the weathering. Depths to water vary from shallow to moderate depending upon how thick the drift overlying the shale is. Recharge is low due to the low permeability of the soils, vadose, and aquifer media itself.

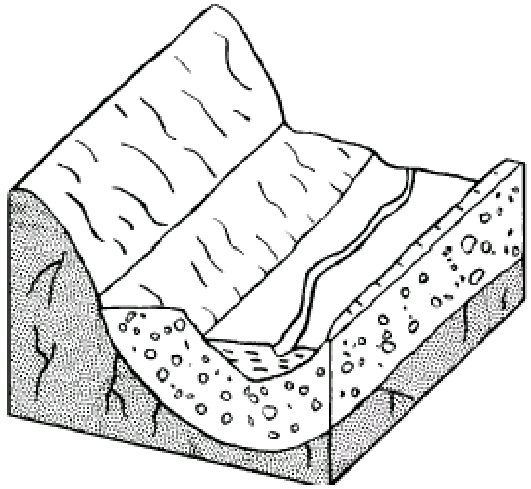
GWPP index values for the hydrogeologic setting of glacial till over shale ranges from 70 to 104, with the total number of GWPP index calculations equaling 11.



7Bb Outwash over Bedded Sedimentary Rocks

This hydrogeologic setting consists of relatively small, high-level outwash terraces that set on top of bedrock benches. These terraces are limited to the southern margin of the valley adjacent to Salt Fork in southwestern Hocking County. The total thickness of drift is not adequate to be considered buried valleys. Relief is low and the flat to rolling terraces occur 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 sandstone and shale of the Mississippian System serve as the aquifer. Yields average 5 to 10 gpm. The overlying terraces are typically in direct contact with the underlying bedrock aquifer. Depth to water is shallow due to the close proximity of modern streams. Recharge is moderately high due to the relatively permeable soils and vadose, moderate to shallow depth to water, and relatively flat to rolling topography.

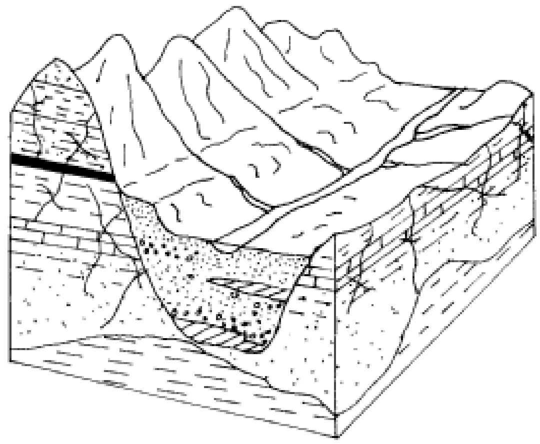
GWPP index values for the hydrogeologic setting of Outwash over Bedded Sedimentary Rocks range from 96 to 127, with the total number of GWPP index calculations equaling 3.



7Bf Outwash over Massive Sandstone

This hydrogeologic setting is limited to the valley underlying the modern Hocking River and tributaries. This setting is similar to the 7D Buried Valley setting except that the overall drift thickness is thinner and that a higher proportion of wells are completed in the underlying bedrock. Broad, flat-lying floodplains and gently sloping terraces characterize the setting. Depths to water are shallow, typically less than 30 feet. Aquifers are composed of variable thicknesses of sand and gravel interbedded with finer-grained alluvium and lacustrine deposits. Wells also may be completed in the underlying, fractured sandstone bedrock. The modern streams may be in direct hydraulic connection with the underlying aquifer. Yields up to 500 gpm have been reported from some of the coarser, thicker, more continuous sand and gravel outwash in the Hocking River north of Rockbridge and south of Logan. Yields tend to be less than 25 gpm for the narrow portion of the Hocking River between Rockbridge and Logan. This includes the more westerly abandoned channel of the Hocking River now partially occupied by Lake Logan. The lower yields associated with these portions of the valley contain thin lenses of sand and gravel interbedded with thicker sequences of finer-grained alluvial and lacustrine deposits. Soils on terraces are typically sandy loams; 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.

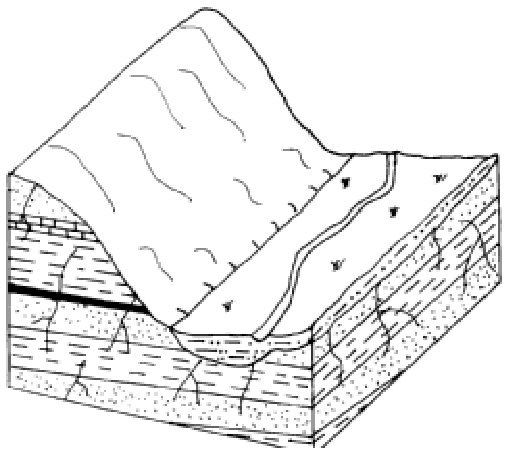
GWPP index values for the hydrogeologic setting of Buried Valley range from 90 to 187, with the total number of GWPP index calculations equaling 19.



7D Buried Valley

This hydrogeologic setting is limited to the valley underlying the modern Hocking River and Rush Creek along the Fairfield County border. This setting is similar to the 7Bf Outwash over Massive Sandstone except that the drift is thicker and wells are almost always completed in the sand and gravel outwash instead of the underlying bedrock. Broad, flat-lying floodplains and gently sloping terraces characterize the setting. Depths to water are shallow, typically less than 30 feet. 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 the Hocking River. Yields along Rush Creek typically are limited to 25 gpm. This valley underlying Rush Creek contains thin lenses of sand and gravel interbedded with much thicker sequences of finer-grained alluvial and lacustrine deposits. Soils on terraces and floodplains are usually 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.

GWPP index values for the hydrogeologic setting of Buried Valley range from 110 to 182, with the total number of GWPP index calculations equaling 5.



7Ec Alluvium Over Bedded Sedimentary Rock

This hydrogeologic setting is found throughout Hocking County. This setting includes most of the tributaries of the Hocking River and both the trunk stream and tributary valleys of Salt Creek, Rush Creek, and Monday Creek. The setting is characterized by narrow, flat-bottomed stream valleys, which are flanked by rolling to steep bedrock-controlled uplands. The valleys are typically broader and contain thicker, fine-grained, alluvial or lacustrine deposits than the somewhat similar 6Fa-River Alluvium with Overbank Deposits. The aquifer consists of fractured, interbedded sandstones, shales, limestones, and coals of the Pennsylvanian System and interbedded shales, siltstones, and fine-grained sandstones of the Mississippian System. In some of these streams, sand and gravel lenses interbedded with the finer-grained alluvium may be the aquifer. Yields developed from the fractures and bedding planes of the bedrock range from 10 to 25 gpm. Similar yields are developed from the sand and gravel lenses. Soils are silt loams. Vadose zone media is typically either silty alluvium or fractured bedrock depending upon the thickness of the drift locally. The depth to water is commonly shallow, averaging from 10 to 35 feet. The alluvium is commonly in direct hydraulic connection with the underlying aquifer. Recharge is moderately high due to the shallow depth to water, flat-lying topography, proximity of modern streams, and the moderately low permeability of the soils, alluvium, and bedrock.

GWPP index values for the hydrogeologic setting of alluvium over bedded sedimentary rocks ranges from 97 to 159, with the total number of GWPP index calculations equaling 38.

Table 14. Hydrogeologic Settings, DRASTIC Factors, and Ratings

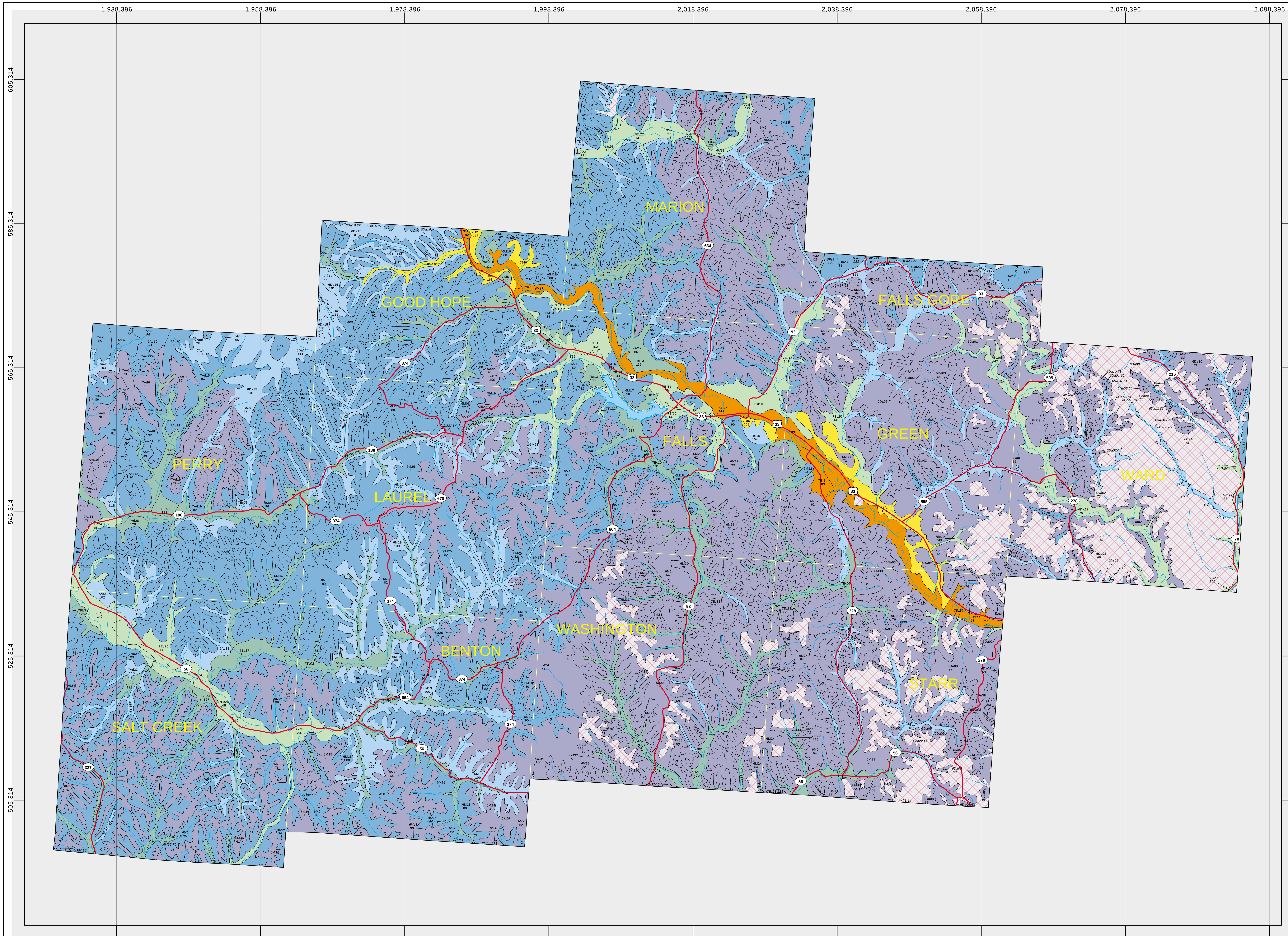
Setting	Depth To Water (ft)	Recharge (in/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydro. Cond	DRASTIC Rating	Pesticide DRASTIC Rating
6Da01	50-75	2-4	Bedded LS, SS, SH	Silty Loam	18+	Shale	1-100	66	76
6Da02	30-50	2-4	Bedded LS, SS, SH	Silty Loam	18+	Shale	1-100	76	86
6Da03	50-75	2-4	Bedded LS, SS, SH	Silty Loam	12-18	Shale	1-100	68	82
6Da04	15-30	2-4	Bedded LS, SS, SH	Silty Loam	2-6	Shale	1-100	94	120
6Da05	50-75	2-4	Bedded LS, SS, SH	Clay Loam	12-18	Shale	1-100	66	77
6Da06	30-50	2-4	Bedded LS, SS, SH	Clay Loam	6-12	Shale	1-100	78	93
6Da07	50-75	2-4	Bedded LS, SS, SH	Shrink/Swell Clay	12-18	Shale	1-100	71	94
6Da08	50-75	2-4	Bedded LS, SS, SH	Silty Loam	12-18	Shale	1-100	65	79
6Da09	50-75	2-4	Bedded LS, SS, SH	Silty Loam	18+	Shale	1-100	63	73
6Da10	30-50	2-4	Bedded LS, SS, SH	Silty Loam	18+	Bedded LS, SS, SH	1-100	73	83
6Da11	15-30	2-4	Bedded LS, SS, SH	Silty Loam	18+	Bedded LS, SS, SH	1-100	83	93
6Da12	30-50	2-4	Bedded LS, SS, SH	Clay Loam	18+	Bedded LS, SS, SH	1-100	74	81
6Da13	15-30	2-4	Bedded LS, SS, SH	Silty Loam	18+	Bedded LS, SS, SH	1-100	86	96
6Da14	50-75	2-4	Bedded LS, SS, SH	Silty Loam	6-12	Bedded LS, SS, SH	1-100	70	88
6Da15	100+	4-7	Sandstone	Thin or Absent	18+	Sandstone, Shale	100-300	101	125
6Da16	100+	4-7	Sandstone	Clay Loam	18+	Sandstone, Shale	100-300	87	90
6Da17	50-75	4-7	Sandstone	Thin or Absent	18+	Sandstone, Shale	100-300	111	135
6Da18	30-50	4-7	Sandstone	Thin or Absent	18+	Sandstone, Shale	100-300	121	145
6Da19	50-75	4-7	Sandstone	Thin or Absent	12-18	Sandstone, Shale	100-300	113	141
6Da20	30-50	4-7	Sandstone	Clay Loam	18+	Sandstone, Shale	100-300	107	110
6Da21	100+	4-7	Sandstone	Clay Loam	12-18	Sandstone, Shale	100-300	89	96
6Da22	50-75	4-7	Sandstone	Clay Loam	18+	Sandstone, Shale	100-300	97	100
6Da23	30-50	2-4	Bedded LS, SS, SH	Silty Loam	18+	Bedded LS, SS, SH	1-100	81	90
6Db1	50-75	4-7	Sandstone	Clay Loam	18+	Sandstone	100-300	97	100
6Db2	100+	4-7	Sandstone	Clay Loam	18+	Sandstone, Shale	100-300	87	90
6Db3	50-75	4-7	Sandstone	Clay Loam	18+	Sandstone	100-300	97	100
6Fa1	15-30	4-7	Bedded LS, SS, SH	Silty Loam	2-6	Bedded LS, SS, SH	100-300	122	145
6Fa2	15-30	4-7	Bedded LS, SS, SH	Silty Loam	0-2	Silt, Clay	100-300	123	148
6Fa3	15-30	4-7	Bedded LS, SS, SH	Silty Loam	2-6	Bedded LS, SS, SH	1-100	111	136
6Fa4	5-15	4-7	Bedded LS, SS, SH	Silty Loam	0-2	Silt, Clay	1-100	127	153
6M01	100+	2-4	Massive Sandstone	Sandy Loam	18+	Sandstone	1-100	78	91
6M02	50-75	2-4	Massive Sandstone	Silty Loam	18+	Sandstone	1-100	84	91
6M03	100+	2-4	Massive Sandstone	Thin or Absent	18+	Sandstone	1-100	86	111
6M04	50-75	2-4	Massive Sandstone	Thin or Absent	18+	Sandstone	1-100	96	121
6M05	75-100	2-4	Massive Sandstone	Thin or Absent	18+	Sandstone	1-100	91	116
6M06	50-75	2-4	Massive Sandstone	Sandy Loam	18+	Sandstone	1-100	88	101
6M07	100+	2-4	Massive Sandstone	Silty Loam	18+	Sandstone	1-100	74	81
6M08	100+	2-4	Massive Sandstone	Thin or Absent	18+	Sandstone	100-300	92	116
6M09	100+	2-4	Massive Sandstone	Sandy Loam	2-6	Sandstone	100-300	92	120
6M10	50-75	4-7	Massive Sandstone	Thin or Absent	18+	Sandstone	100-300	114	138
6M11	50-75	4-7	Massive Sandstone	Sand	18+	Sandstone	100-300	112	133
6M12	100+	2-4	Massive Sandstone	Sandy Loam	6-12	Sandstone	100-300	88	108

Setting	Depth To Water (ft)	Recharge (in/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydro. Cond	DRASTIC Rating	Pesticide DRASTIC Rating
6M13	100+	2-4	Massive Sandstone	Silty Loam	6-12	Sandstone	100-300	84	98
6M14	100+	2-4	Massive Sandstone	Silty Loam	12-18	Shale	100-300	67	80
6M15	100+	2-4	Massive Sandstone	Sandy Loam	12-18	Shale	100-300	71	90
6M16	50-75	2-4	Massive Sandstone	Clay Loam	18+	Sandstone	100-300	88	91
6M17	50-75	2-4	Massive Sandstone	Silty Loam	18+	Sandstone	100-300	90	96
6M18	100+	2-4	Massive Sandstone	Silty Loam	18+	Massive Sandstone	100-300	80	86
6M19	50-75	2-4	Massive Sandstone	Sand	18+	Massive Sandstone	100-300	100	121
6M20	50-75	2-4	Massive Sandstone	Clay Loam	12-18	Massive Sandstone	100-300	90	97
6M21	50-75	2-4	Massive Sandstone	Thin or Absent	18+	Massive Sandstone	100-300	102	126
6M22	50-75	4-7	Massive Sandstone	Thin or Absent	0-2	Massive Sandstone	100-300	123	165
6M23	100+	2-4	Massive Sandstone	Sandy Loam	18+	Massive Sandstone	100-300	84	96
6M24	100+	2-4	Massive Sandstone	Silty Loam	12-18	Shale	1-100	64	78
6M25	100+	2-4	Massive Sandstone	Silty Loam	12-18	Massive Sandstone	100-300	82	92
6M26	30-50	2-4	Massive Sandstone	Silty Loam	18+	Massive Sandstone	100-300	100	106
6M27	100+	2-4	Massive Sandstone	Silty Loam	18+	Shale	1-100	62	72
6M28	30-50	2-4	Massive Sandstone	Silty Loam	18+	Shale	1-100	82	92
6M29	100+	2-4	Massive Sandstone	Silty Loam	12-18	Massive Sandstone	1-100	79	90
6M30	100+	2-4	Sandstone	Shrink/Swell Clay	12-18	Shale	1-100	70	93
6M31	100+	2-4	Massive Sandstone	Silty Loam	18+	Massive Sandstone	1-100	77	84
6M32	50-75	2-4	Massive Sandstone	Silty Loam	6-12	Massive Sandstone	100-300	94	108
6M33	50-75	2-4	Massive Sandstone	Silty Loam	18+	Shale	1-100	72	82
6M34	100+	2-4	Sandstone	Sandy Loam	12-18	Sandstone	1-100	80	97
6M35	100+	2-4	Sandstone	Silty Loam	12-18	Sandstone	1-100	76	87
6M36	100+	2-4	Sandstone	Silty Loam	12-18	Bedded LS, SS, SH	1-100	61	75
6M37	30-50	2-4	Massive Sandstone	Sandy Loam	18+	Sandstone	1-100	98	111
7Aa1	50-75	4-7	Sandstone, Shale	Clay Loam	6-12	Sandstone, Shale	1-100	85	99
7Aa2	100+	4-7	Sandstone, Shale	Silty Loam	6-12	Sandstone, Shale	1-100	77	94
7Aa3	30-50	4-7	Sandstone, Shale	Clay Loam	12-18	Till	1-100	93	103
7Aa4	50-75	4-7	Sandstone, Shale	Clay Loam	18+	Sandstone, Shale	1-100	81	87
7Aa5	100+	4-7	Sandstone, Shale	Clay Loam	6-12	Till	1-100	75	89
7Ad01	30-50	4-7	Sandstone	Clay Loam	18+	Sandstone	100-300	107	110
7Ad02	100+	4-7	Sandstone	Clay Loam	18+	Sandstone	100-300	87	90
7Ad03	100+	4-7	Sandstone	Clay Loam	2-6	Sandstone	100-300	95	114
7Ad04	100+	4-7	Sandstone	Thin or Absent	18+	Sandstone	100-300	101	125
7Ad05	100+	4-7	Sandstone	Clay Loam	12-18	Sandstone	100-300	89	96
7Ad06	100+	4-7	Massive Sandstone	Clay Loam	12-18	Silt, Clay	1-100	71	82
7Ad07	100+	4-7	Massive Sandstone	Sandy Loam	18+	Silt, Clay	1-100	75	91
7Ad08	100+	4-7	Massive Sandstone	Clay Loam	2-6	Sandstone	1-100	92	112
7Ad09	50-75	2-4	Massive Sandstone	Clay Loam	6-12	Sandstone	1-100	86	98
7Ad10	100+	4-7	Sandstone	Thin or Absent	18+	Sandstone	100-300	91	117
7Ad11	100+	4-7	Massive Sandstone	Clay Loam	2-6	Sandstone	1-100	92	112
7Ad12	50-75	2-4	Massive Sandstone	Clay Loam	2-6	Sandstone	1-100	90	110
7Ad13	30-50	4-7	Massive Sandstone	Clay Loam	2-6	Sandstone	1-100	112	132
7Ad14	50-75	2-4	Massive Sandstone	Clay Loam	18+	Sandstone	1-100	82	86
7Ad15	50-75	2-4	Massive Sandstone	Silty Loam	18+	Sandstone	1-100	84	91

Setting	Depth To Water (ft)	Recharge (in/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydro. Cond	DRASTIC Rating	Pesticide DRASTIC Rating
7Ad16	75-100	2-4	Massive Sandstone	Shrink/Swell Clay	18+	Sandstone	1-100	85	101
7Ad17	100+	2-4	Massive Sandstone	Clay Loam	18+	Sandstone	1-100	72	76
7Ad18	100+	2-4	Massive Sandstone	Sandy Loam	18+	Sandstone	1-100	78	91
7Ad19	50-75	2-4	Massive Sandstone	Clay Loam	18+	Sandstone	1-100	82	86
7Ad20	100+	4-7	Sandstone	Silty Loam	6-12	Sandstone	100-300	93	107
7Ad21	50-75	4-7	Massive Sandstone	Clay Loam	12-18	Sandstone	1-100	96	104
7Ad22	100+	4-7	Massive Sandstone	Clay Loam	12-18	Sandstone	1-100	86	94
7Ad23	30-50	4-7	Massive Sandstone	Loam	12-18	Sandstone	1-100	110	124
7Ad24	100+	2-4	Sandstone	Thin or Absent	18+	Sandstone	1-100	86	111
7Ad25	50-75	2-4	Sandstone	Thin or Absent	18+	Sandstone	1-100	96	121
7Ad26	100+	2-4	Massive Sandstone	Sandy Loam	12-18	Sandstone	1-100	80	97
7Ad27	30-50	4-7	Massive Sandstone	Shrink/Swell Clay	12-18	Sandstone, Shale	1-100	114	134
7Ad28	30-50	4-7	Massive Sandstone	Shrink/Swell Clay	2-6	Sandstone	1-100	120	152
7Ad29	50-75	2-4	Massive Sandstone	Clay Loam	12-18	Sandstone	1-100	87	95
7Ad30	50-75	4-7	Massive Sandstone	Silty Loam	2-6	Sandstone	1-100	104	127
7Ad31	50-75	4-7	Massive Sandstone	Shrink/Swell Clay	18+	Sandstone	1-100	102	118
7Ad32	100+	4-7	Sandstone	Thin or Absent	12-18	Sandstone, Shale	100-300	93	123
7Ad33	50-75	4-7	Sandstone	Clay Loam	6-12	Sandstone, Shale	100-300	91	104
7Ae01	100+	4-7	Shale	Clay Loam	6-12	Shale	1-100	77	90
7Ae02	30-50	4-7	Sandstone, Shale	Loam	12-18	Sand+Gravel w/ Silt+Clay	1-100	104	118
7Ae03	50-75	2-4	Shale	Sandy Loam	2-6	Shale	1-100	85	115
7Ae04	50-75	2-4	Shale	Clay Loam	6-12	Shale	1-100	75	88
7Ae05	100+	4-7	Shale	Clay Loam	18+	Shale	1-100	73	78
7Ae06	100+	4-7	Shale	Sandy Loam	18+	Shale	1-100	79	93
7Ae07	75-100	4-7	Shale	Clay Loam	2-6	Shale	1-100	86	107
7Ae08	75-100	4-7	Shale	Clay Loam	18+	Shale	1-100	78	83
7Ae09	100+	4-7	Shale	Clay Loam	2-6	Shale	1-100	81	102
7Ae10	75-100	2-4	Shale	Clay Loam	6-12	Shale	1-100	70	83
7Ae11	50-75	2-4	Shale	Clay Loam	2-6	Shale	1-100	79	100
7Bb1	15-30	4-7	Shale	Sandy Loam	6-12	Sand+Gravel w/ Silt+Clay	100-300	127	147
7Bb2	30-50	2-4	Shale	Silty Loam	12-18	Sand+Gravel w/ Silt+Clay	1-100	96	107
7Bb3	30-50	4-7	Sand+Gravel	Silty Loam	2-6	Sand+Gravel w/ Silt+Clay	300-700	126	146
7Bf01	5-15	7-10	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	700-1000	161	181
7Bf02	0-5	10+	Sand+Gravel	Loam	0-2	Sand+Gravel	700-1000	183	205
7Bf03	0-5	10+	Sand+Gravel	Silty Loam	0-2	Sand+Gravel	700-1000	181	200
7Bf04	30-50	4-7	Sand+Gravel	Sand	12-18	Sand+Gravel	300-700	141	163
7Bf05	30-50	7-10	Massive Sandstone	Shrink/Swell Clay	0-2	Massive Sandstone	100-300	135	168
7Bf06	5-15	7-10	Sand+Gravel	Loam	0-2	Sand+Gravel	300-700	168	192
7Bf07	0-5	10+	Sand+Gravel	Shrink/Swell Clay	0-2	Sand+Gravel	700-1000	187	215
7Bf08	15-30	7-10	Sand+Gravel	Clay Loam	0-2	Sand+Gravel w/ Silt+Clay	100-300	137	158
7Bf09	50-75	7-10	Sand+Gravel	Clay Loam	0-2	Sand+Gravel w/ Silt+Clay	100-300	117	138
7Bf10	5-15	7-10	Sand+Gravel	Clay Loam	0-2	Sand+Gravel w/ Silt+Clay	300-700	153	172
7Bf11	5-15	7-10	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	300-700	155	177

Setting	Depth To Water (ft)	Recharge (in/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydro. Cond	DRASTIC Rating	Pesticide DRASTIC Rating
7Bf12	5-15	4-7	Sand+Gravel	Clay Loam	12-18	Sand+Gravel w/ Silt+Clay	300-700	138	143
7Bf13	30-50	7-10	Sand+Gravel	Clay Loam	0-2	Sand+Gravel w/ Silt+Clay	300-700	133	152
7Bf14	5-15	4-7	Sand+Gravel	Loam	6-12	Sand+Gravel w/ Silt+Clay	300-700	144	159
7Bf15	50-75	4-7	Massive Sandstone	Clay Loam	6-12	Sand+Gravel w/ Silt+Clay	100-300	104	115
7Bf16	5-15	4-7	Sand+Gravel	Silty Loam	2-6	Sand+Gravel w/ Silt+Clay	300-700	146	166
7Bf17	50-75	2-4	Massive Sandstone	Silty Loam	18+	Sand+Gravel w/ Silt+Clay	100-300	90	96
7Bf18	15-30	7-10	Sand+Gravel	Loam	0-2	Sand+Gravel	700-1000	158	180
7D1	5-15	7-10	Sand+Gravel	Sandy Loam	0-2	Sand+Gravel w/ Silt+Clay	1000-2000	182	205
7D2	5-15	7-10	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	1000-2000	178	195
7D3	15-30	4-7	Sand+Gravel	Silty Loam	0-2	Till	1-100	115	142
7D4	15-30	4-7	Sand+Gravel	Silty Loam	0-2	Silt, Clay	1-100	110	138
7D5	5-15	4-7	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	1-100	127	153
7Ec01	30-50	7-10	Sand+Gravel	Sandy Loam	2-6	Sand+Gravel w/ Silt+Clay	100-300	132	160
7Ec02	30-50	7-10	Sand+Gravel	Sandy Loam	2-6	Sand+Gravel w/ Silt+Clay	100-300	132	160
7Ec03	30-50	4-7	Massive Sandstone	Sandy Loam	0-2	Sand+Gravel w/ Silt+Clay	1-100	119	150
7Ec04	30-50	4-7	Massive Sandstone	Loam	0-2	Massive Sandstone	100-300	123	150
7Ec05	15-30	4-7	Massive Sandstone	Silty Loam	0-2	Massive Sandstone	100-300	131	155
7Ec06	30-50	4-7	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	100-300	121	145
7Ec07	50-75	4-7	Massive Sandstone	Silty Loam	0-2	Massive Sandstone	100-300	111	135
7Ec08	0-5	4-7	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	100-300	146	170
7Ec09	15-30	4-7	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	300-700	137	159
7Ec10	15-30	4-7	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	100-300	131	155
7Ec11	5-15	7-10	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	300-700	155	177
7Ec12	30-50	4-7	Sand+Gravel	Clay Loam	0-2	Sand+Gravel w/ Silt+Clay	100-300	119	140
7Ec13	30-50	7-10	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	700-1000	141	161
7Ec14	30-50	2-4	Massive Sandstone	Silty Loam	0-2	Massive Sandstone	100-300	109	133
7Ec15	15-30	4-7	Massive Sandstone	Clay Loam	0-2	Shale	1-100	111	136
7Ec16	15-30	4-7	Massive Sandstone	Silty Loam	0-2	Shale	1-100	113	141
7Ec17	15-30	4-7	Bedded LS, SS, SH	Silty Loam	0-2	Shale	1-100	107	135
7Ec18	15-30	4-7	Bedded LS, SS, SH	Clay Loam	0-2	Shale	1-100	105	130
7Ec20	5-15	7-10	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	100-300	149	173
7Ec21	0-5	7-10	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	100-300	154	178
7Ec22	5-15	7-10	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	100-300	141	166

Setting	Depth To Water (ft)	Recharge (in/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydro. Cond	DRASTIC Rating	Pesticide DRASTIC Rating
7Ec23	15-30	4-7	Sandstone	Silty Loam	0-2	Silt, Clay	100-300	123	148
7Ec24	5-15	4-7	Sand+Gravel	Sandy Loam	0-2	Sand+Gravel w/ Silt+Clay	300-700	151	179
7Ec25	15-30	7-10	Sand+Gravel	Sandy Loam	0-2	Sand+Gravel w/ Silt+Clay	300-700	149	177
7Ec26	15-30	7-10	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	300-700	145	167
7Ec27	15-30	7-10	Sandstone	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	100-300	136	160
7Ec28	5-15	10+	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	300-700	159	181
7Ec29	15-30	4-7	Sand+Gravel	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	100-300	128	152
7Ec30	15-30	4-7	Sand+Gravel	Sandy Loam	12-18	Sand+Gravel w/ Silt+Clay	100-300	129	147
7Ec31	30-50	4-7	Sand+Gravel	Loam	2-6	Sand+Gravel w/ Silt+Clay	1-100	116	142
7Ec32	30-50	4-7	Sand+Gravel	Loam	0-2	Sand+Gravel w/ Silt+Clay	100-300	120	147
7Ec33	50-75	4-7	Massive Sandstone	Silty Loam	0-2	Sand+Gravel w/ Silt+Clay	1-100	108	133
7Ec34	15-30	4-7	Massive Sandstone	Silty Loam	2-6	Sandstone	100-300	130	152
7Ec35	30-50	4-7	Massive Sandstone	Thin or Absent	12-18	Sandstone	1-100	115	145
7Ec36	15-30	4-7	Massive Sandstone	Silty Loam	2-6	Sandstone	1-100	119	143
7Ec37	15-30	4-7	Massive Sandstone	Silty Loam	0-2	Silt, Clay	1-100	123	149
7Ec38	50-75	4-7	Bedded LS, SS, SH	Silty Loam	0-2	Silt, Clay	1-100	97	123



Ground Water Pollution Potential of Hocking County

by
Franklin L. Fugitt

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 wtih 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 0.5 1 2 3 4 5
Miles

0 1 2 4 6 8
Kilometers

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