GROUND WATER POLLUTION POTENTIAL OF CARROLL COUNTY, OHIO

BY

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GROUND WATER POLLUTION POTENTIAL REPORT NO. 59

OHIO DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATER

WATER RESOURCES SECTION

2003

ABSTRACT

A ground water pollution potential map of Carroll 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 form the basis of the system and incorporate the major hydrogeologic factors that affect and 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 Carroll County resulted in a map with symbols and colors that illustrate areas of varying ground water contamination vulnerability. Seven hydrogeologic settings were identified in Carroll County with computed ground water pollution potential indexes ranging from 55 to 198.

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 Carroll 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 areas, or to assist in protection, monitoring, and clean-up efforts.

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ACKNOWLEDGEMENTS

The preparation of the Carroll County Ground Water Pollution Potential report and map involved the contribution and work of a number of individuals in the Division of Water. Grateful acknowledgement is given to the following individuals for their technical review and map production, text authorship, report editing, and preparation:

Map preparation and review:	Michael P. Angle Brad Ziss Sarah Corbin
GIS coverage production and review:	Paul Spahr
Report production and review:	Michael P. Angle
Report editing:	Michael Hallfrisch Jim Raab

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; 7,675 of these wells exist in Carroll 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 clean up 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 that 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 Carroll 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 additional 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 Carroll County. Inherent within each hydrogeologic setting are the physical characteristics that affect the ground water pollution potential. These characteristics or factors identified during the development of the DRASTIC system include:

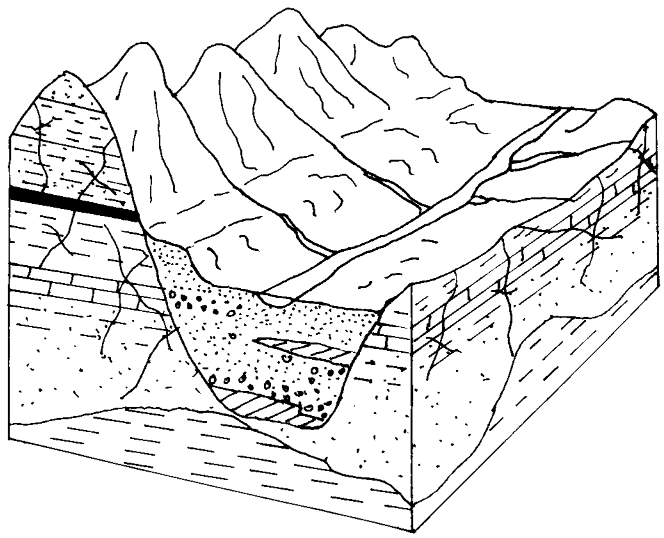
D – Depth to Water
R – Net Recharge
A – Aquifer Media
S – Soil Media
T – Topography
I – Impact of the Vadose Zone Media
C – Conductivity (Hydraulic) of the Aquifer

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

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

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

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



7D Buried Valley

This setting is characterized by thick deposits of sand and gravel that have been deposited in a former topographic low (usually a pre-glacial river valley) by glacial meltwater. Many of the buried valleys in Carroll County underlie the broad, flat lying floodplains of modern rivers. The boundary between the buried valley and the adjacent bedrock upland is usually prominent. The buried valleys contain substantial thicknesses of permeable sand and gravel that serve as the aquifer. The aquifer is typically in hydraulic connection with the modern rivers. The vadose zone is typically composed of sand and gravel but significant amounts of silt and clay can be found in discrete areas. Silt loams, loams, and sandy loams are the typical soil types for this setting. Depth to water is typically less than 30 feet for areas adjacent to modern rivers, and between 30 to 50 feet for terraces that border the bedrock uplands. Recharge is generally high due to permeable soils and vadose zones, shallow depth to water, and the presence of surface streams.

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

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

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

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

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

Weighting and Rating System

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

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

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

Pesticide DRASTIC

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

Table 1. Assigned weights for DRASTIC features

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

Table 2. Ranges and ratings for depth to water

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

Table 3. Ranges and ratings for net recharge

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

Table 4. Ranges and ratings for aquifer media

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

Table 5. Ranges and ratings for soil media

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

Table 6. Ranges and ratings for topography

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

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

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

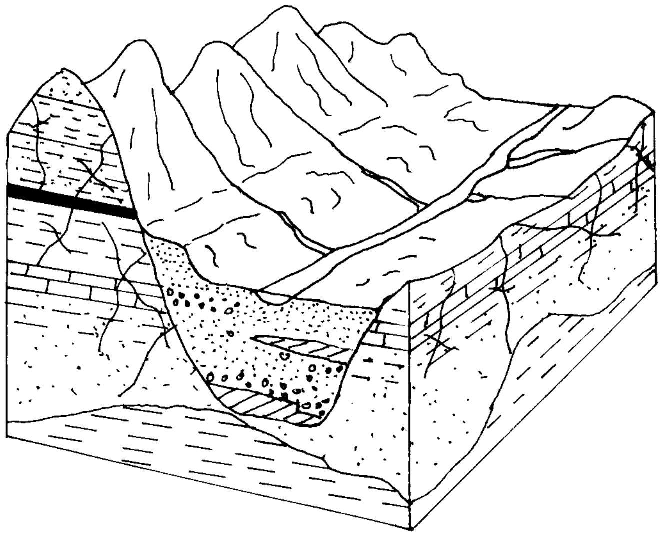
Table 8. Ranges and ratings for hydraulic conductivity

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

Integration of Hydrogeologic Settings and DRASTIC Factors

Figure 2 illustrates the hydrogeologic setting 7D1, Buried Valley, identified in mapping Carroll 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 137. 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 Carroll County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the seven settings identified in the county range from 55 to 198.

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 Carroll 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 Carroll County is included with this report.



SETTING 7D1		GENERAL		
FEATURE	**RANGE**	**WEIGHT**	**RATING**	**NUMBER**
Depth to Water	30-50	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand & Gravel	3	6	18
Soil Media	Silt Loam	2	4	8
Topography	0-2%	1	10	10
Impact of Vadose Zone	Sand&Gravel/Silt&Clay	5	6	30
Hydraulic Conductivity	300-700	3	4	12
		DRASTIC	INDEX	137

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

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
137 - 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 (**137**) 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 CARROLL COUNTY

Demographics

Carroll County occupies approximately 395 square miles in northeastern Ohio (Figure 3). Carroll County is bounded to the northwest by Stark County, to the northeast by Columbiana County, to the southeast by Jefferson County, to the south by Harrison County, and to the west by Tuscarawas County.

The approximate population of Carroll County, based upon 2000 estimates, is 28,836 (Department of Development, Ohio County Profiles, 1999). Carrollton is the largest community and county seat and has a population of 3,100. Agriculture accounts for roughly 42 percent of the land usage in Carroll County. Woodlands account for roughly 55 percent of the land usage in the county. Mining, including coal strip mines and sand and gravel pits is a common land use in eastern Carroll County. Two large reservoirs, Atwood and Leesville are located in southwestern Carroll County. More specific information on land usage can be obtained from the Ohio Department of Natural Resources, Division of Real Estate and Land Management (REALM), Resource Analysis Program (formerly OCAP).

Climate

The *Hydrologic Atlas for Ohio* (Harstine, 1991) reports an average annual temperature of approximately 50 degrees Fahrenheit for Carroll County. The average temperatures increase slightly towards the south. Harstine (1991) shows that precipitation approximately averages 38 inches per year for the county, with precipitation increasing towards the south. The mean annual precipitation for Carrollton is 38.4 inches per year based upon a twenty-year (1961-1980) period (Owenby and Ezell, 1992). The mean annual temperature at New Philadelphia in neighboring Tuscarawas County for the same twenty-year period is 49.6 degrees Fahrenheit (Owenby and Ezell, 1992).

Physiography

Carroll County lies within the Unglaciated 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. Relatively broad, flat-lying stream valleys separate the steep uplands, especially in western and northern Carroll County. The highest elevation of 1,375 feet above sea level is located in northern East Township. The lowest elevation of 900 feet is found where Beggar Run exits the county in southwestern Rose Township.

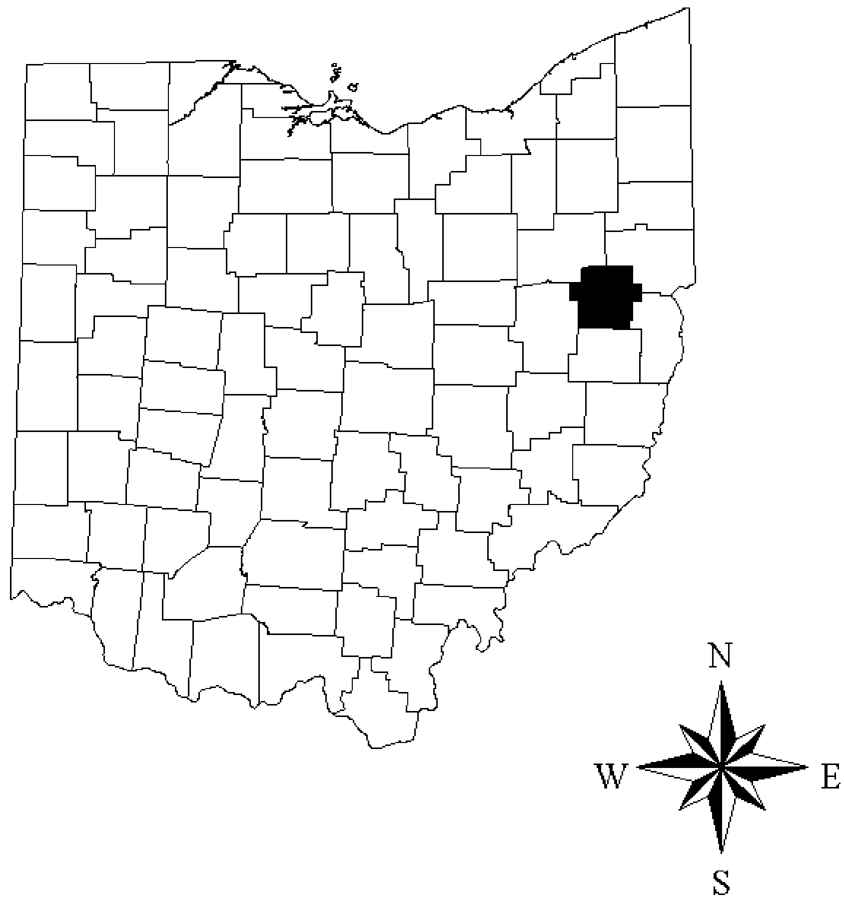


Figure 3. Location of Carroll County.

Modern Drainage

The Flushing Escarpment serves as a drainage divide in eastern Carroll County, separating drainage between the Tuscarawas River and the Ohio River. Eastern Carroll County drains into tributaries of the Ohio River, primarily West Fork of Little Beaver Creek and Yellow Creek. Northern Carroll County drains into Sandy Creek and its tributary, Still Fork. The southwestern part of Carroll County drains into Conotton Creek and two major tributaries, McGuire Creek and Indian Fork.

Pre- and Inter-Glacial Drainage Changes

Carroll County lies entirely beyond the glacial boundary; however, the drainage patterns of the county were influenced by the multiple glaciations. The drainage changes are complex and not yet fully understood. More research and data are necessary in Carroll County and surrounding counties. Particularly, well log data for deeper wells that penetrate the entire drift thickness would be helpful in making further interpretations. As ice advanced through Ohio and northwestern Pennsylvania during the pre-Illinoian (Kansan) glaciation, the Steubenville River became blocked by ice. Flow backed-up in the main trunk of the Steubenville River 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 valleys. The new drainage system is referred to as the Deep Stage due to this increased downcutting. The ponded water overtopped and cut a new channel in the divide in Monroe County and drainage reversed, changing to southward flow. The newly created river was referred to as the Pomeroy River (Stout et al., 1943). It was at this time that the ancestral channel of the Ohio River was primarily created.

During the time that many of the stream valleys east of the Flushing Escarpment were ponded, abundant sediments were deposited into these streams. The deposits were typically clayey to silty with thin layers of fine-grained sand (Stout et al., 1943). These fine-grained lacustrine (lake) deposits have been referred to as the Minford Silts.

Drainage systems west of the Flushing Escarpment also experienced change due to the pre-Illinoian ice advance. The advancing ice sheet blocked the northerly flowing Dover River (Stout et al., 1943 and Lamborn, 1956). Water in the blocked river rose and breached a

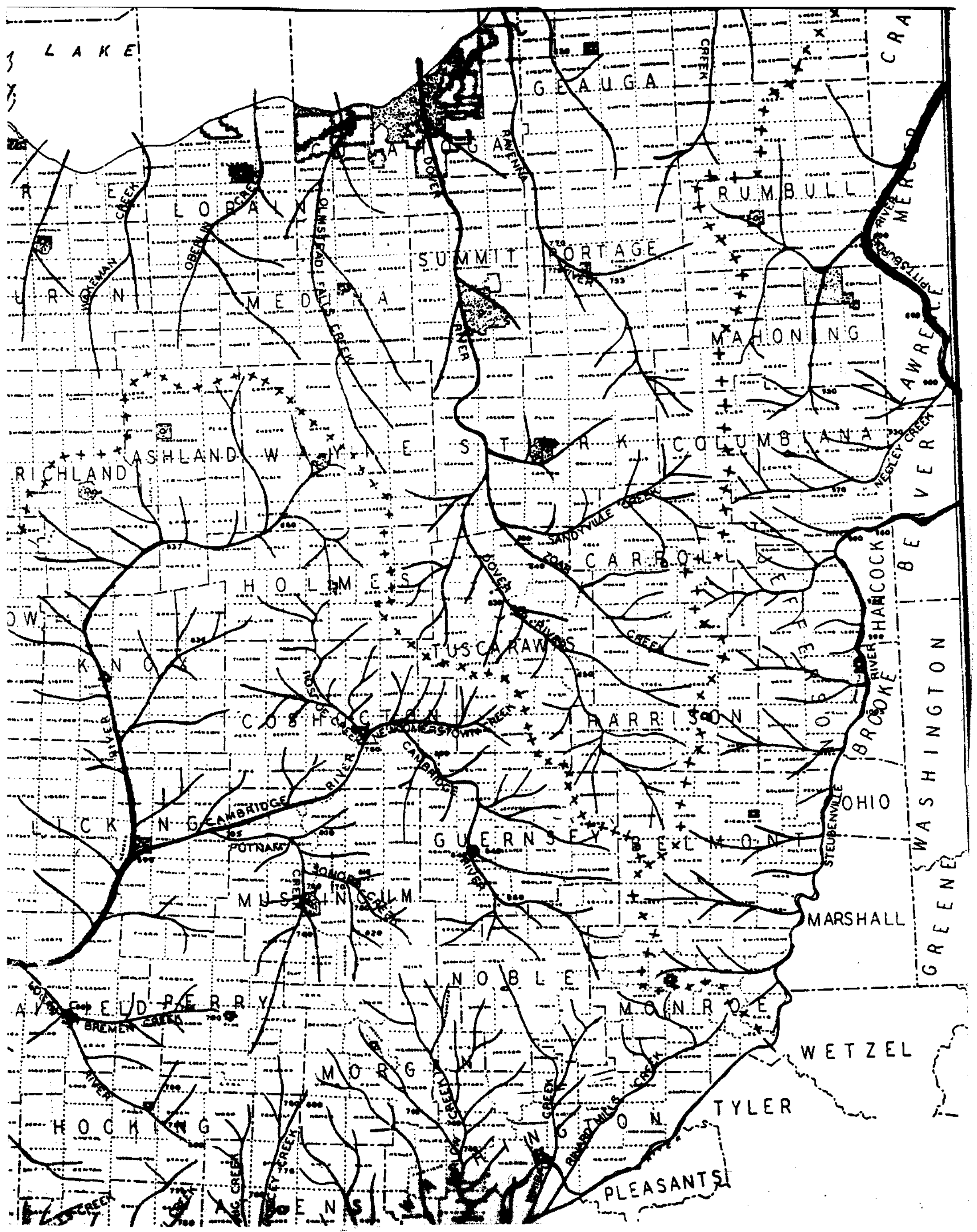


Figure 4. Pre-glacial (Teays Stage) drainage in eastern Ohio. The line of x's in Carroll County indicate the Flushing Escarpment (after Stout et al., 1943).

new channel draining toward the southwest referred to as the Newark River (Figure 5). The Newark River replaced the Dover River as it downcut and eroded eastward. The headwaters of the Newark River drainage system extended into Carroll County, as the erosion continued. Sherodsville Creek, which roughly followed the course of present day Conotton Creek, drained southern Carroll County. Sherodsville Creek was a major tributary of the Newark River. Fine-grained lacustrine and silty alluvium was deposited in these tributary valleys.

The Illinoian ice advance brought further changes to the drainage systems. Drainage to the west of the Flushing Escarpment was still toward the headwaters of the Newark River (Stout et al., 1943).

To the east, drainage followed the New Martinsville River. The New Martinsville River roughly followed the course of the Pomeroy River.

The most recent ice age, the Wisconsinan, brought further drainage changes to eastern Ohio (Stout et al., 1943). The silty alluvial (floodplain) and finer lacustrine (lake) sediments continued to be deposited over this time on both sides of the Flushing Escarpment. During the Wisconsinan, the large, abandoned stream channel underlying present Conotton Creek continued to fill with fine-grained alluvial and lacustrine deposits (Walker, 1991, Pavey et al., 2002 and ODNR, Div. of Water, Open File, Glacial State Aquifer Map). Ancestral stream channels filled with glacial/alluvial sediments are referred to as buried valleys. 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.

During the Wisconsinan, abundant sand and gravel outwash was deposited into the valley underlying present Sandy Creek. 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 called terraces. White and Totten (1985) and Pavey et al. (2002) delineated some of the major terraces in neighboring Columbiana County.

Bedrock Geology

Bedrock exposed at the surface in Carroll County belongs to the Pennsylvanian Systems. Table 9 summarizes the bedrock stratigraphy found in Carroll County. The ODNR, Division of Geological Survey, has Open-File Reconnaissance Bedrock Geological Maps done on a 1:24,000 scale USGS topographic map base available for the entire county. The ODNR, Division of Water, has Open File Bedrock State Aquifer mapping available for the county also.

Figure 5. Pre-Illinoian (Deep Stage) drainage in eastern Ohio (after Stout et al., 1943).

Table 9. Bedrock Stratigraphy of Carroll County, Ohio

System	Group/Formation (Symbol)	Lithologic Description
Pennsylvanian	Pennsylvanian Undifferentiated (Pu)	Interbedded dirty sandstones, shales, and siltstones with thin coal, limestone and clay layers. Poor aquifer with yields of less than 5 gpm.
	Allegheny and Pottsville Groups (Pap) Allegheny and Upper Pottsville Groups (Pa-up)	Gray to black interbedded sandstone, siltstone and shale, with thin layers of coal, clay and limestone. May include the Homewood Sandstone. Poor to moderate aquifer with yields from 0 to 25 gpm.
	Massillon through Sharon Formations (Pms)	Coarse to medium grained cross-bedded sandstones. Gray-white sandstones may have conglomerate zones. May also contain thin shale and coal layers. Good aquifer with yields ranging from 5 to 100 gpm
Mississippian	Cuyahoga Group (Mcg)	Gray to brown shale with thin interbedded siltstone and sandstone. Poor to moderate aquifer with yields ranging from 5 to 25 gpm.

Interbedded sandstones, siltstones, and shales of the Mississippian age Cuyahoga Formation are encountered in the subsurface of far northern Carroll County. These formations tend to have better yields than the overlying Pennsylvanian units. Farther south in the county, these rocks are too deep and the water may not be potable.

Pennsylvanian System rocks are present in upland areas and along slopes in valleys throughout the county. In the far northwestern corner of Brown and Rose Townships rocks of the Pennsylvanian Pottsville Group, Sharon and Massillon Formation (ODNR, Div. Of Water, Open File, Bedrock State Aquifer Map) are encountered. These are the oldest of the Pennsylvanian formations within the county. These rocks include sandstones, conglomerates and sandy shales. Steep, high gradient streams and alluvial fans deposited these sediments. Rocks of the Pottsville and Allegheny Group are encountered along stream valleys and slopes in the western third of the county. These formations include interbedded dirty sandstones, shales, siltstones, and thin limestones, clays, and coals of the Pottsville Group and Lower Allegheny Group (Sedam, 1973 and ODNR, Div. of Geological Survey, Open File Reconnaissance Bedrock Geological Maps, ODNR, Div. of Water, Open File, Bedrock State Aquifer Map). Overlying these units are rocks of the Pennsylvanian Conemaugh and Monongahela Group. These rocks are exposed in much of central and eastern Carroll County. These formations include interbedded dirty sandstones, shales, mudstones, thin hard limestones, clays, and coals.

Rau (1970) and Sedam (1973) discuss the depositional environments of the coarse-grained Sharon Sandstone and Massillon Sandstone. Weedman (1990) provides an excellent account of the complex depositional environments, which created the rocks of the Pennsylvanian System, particularly of the Allegheny Group. These highly transitional environments included both terrestrial ("land-based") and marine derived sediments. The terrestrial environment was dominated by large river systems featuring broad alluvial plains upland from coastal areas. Stream channels and point bar deposits were the source of sandstones and conglomerates. Shales and siltstones were derived from fine-grained floodplain deposits. Freshwater limestones were deposited in shallow, rapidly evaporating lakes and ponds found on the alluvial plain. The terrestrial environment was highly transitional with a marine environment over time. The position of the shoreline and the depth of water varied with the rate of sediment input into the basin, sea level, and the rate of subsidence. Subsidence refers to an uneven "settling" during the relatively rapid accumulation of sediments. In the Allegheny Group, sandstones and shales represent deltaic/shoreline environments. Marine limestones formed in slightly deeper waters, which lacked clastic input from rivers and deltas. Coal and clay were deposited in two different environments. Coal was deposited in either a "back-barrier" environment along the shoreline or in "deltaic-plain" environment in swamps formed in abandoned river channels (Horne et al., 1978). Similarly, clay was deposited in either quiet lagoonal areas directly behind the shoreline or in abandoned "oxbow" river channels (Ferm, 1974). Higher in the section, the rocks tend to include more fine-grained mudstones and claystones (Collins, 1979). These rocks are commonly reddish and color and reflect deposition in a more arid alluvial environment (Collins, 1979).

Ground Water Resources

Ground water in Carroll 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 Sandy Creek Valley (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 25 to 100 gpm are obtained from wells drilled along the margins and tributaries of Sandy Creek. Thin lenses of sand and gravel interbedded with thick sequences of fine-grained lacustrine and alluvial materials are found in Conotton Creek and its tributaries yield 5 to 25 gpm (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 are available from the deeper Mississippian formations in northern Carroll County and from the Pottsville Group, Sharon and Massillon Formations and from lower portions of the Pottsville and Allegheny Group (Walker, 1991 and ODNR, Div. of Water, Open File, Glacial State Aquifer Map, 2000). These higher-yielding units are limited to the northwestern corner of Carroll County. Yields from the Pottsville and Allegheny Group located in the remaining valleys of western Carroll County commonly have yields in the 5 to 10 gpm range or less (Walker, 1991 and ODNR, Div. of Water, Open File, Glacial State Aquifer Map, 2000). Wells developed in the Conemaugh or Monongahela Groups commonly have yields less than 5 gpm and are capable of supplying only minimal domestic needs (Walker, 1991 and ODNR, Div. of Water, Open File, Glacial State Aquifer Map, 2000). 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 increase along hill slopes and valleys. This increase may be related to stress relief as shown by Wyrick and Borchers (1981) and Kipp et al. (1983). The net result is that there is usually a decrease in the depth to water (i.e. – a shallower static water level) and slightly higher yields. Fracturing is also an influence on the direction of ground water flow (Schubert, 1980) and affects the amount of recharge.

Strip and Underground Mined Areas

The pollution potential of strip-mined and abandoned underground mined areas were not evaluated in Carroll 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, respectively. 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 Carroll County. Delineations of mined areas were made using information from the *Soil Survey of Carroll County* (Gerber and Buzard, 1983), abandoned underground mine maps (ODNR, Division of Geological Survey, open file maps), and the Carroll 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., 1994. Ground water pollution potential of Columbiana County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report No. 35, 105 pp.

Angle, M. P. and D.D. Walker, 2002. Ground water pollution potential of Harrison County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report No. 56.

Angle, M.P., and J. Baker, 2001. Ground water pollution potential of Tuscarawas County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report No. 52.

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.

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.

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.

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.

Gerber, T.D. and R.W. Buzard, 1983, Soil Survey of Carroll County, Ohio. U.S. Department of Agriculture, Natural Resources Conservation Service, 157 pp.

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.

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.

Lamborn, R.E., 1956. Geology of Tuscarawas County. Ohio Department of Natural Resources, Division of Geological Survey, Bulletin 55, 269 pp.

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.

Ohio Department of Natural Resources, Division of Water, 2002. Open File Potentiometric-Surface Map of the Sandy Creek Buried Valley Aquifer: Carroll, Columbiana, and Stark Counties, Ohio. Done in conjunction with Ohio EPA Source Water Protection Plan.

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., G.A. Schumacher, G.E. Larsen, E.M. Swinford and K.E. Vorbau, 2002. 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.

Rau, J.L., 1970. Pennsylvanian System of northeast Ohio: in Banks, P.O. and Feldmann, R.M., eds.: Guide to the geology of northeast Ohio: Northern Ohio Geological Society, p. 69-89.

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.

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.

Sedam, A.C., 1973. Hydrogeology of the Pottsville Formation in northeastern Ohio. U.S. Geological Survey Hydrologic Investigations, Atlas Ha-494, 2 maps with text. Columbus, Ohio, 167 pp.

Spahr, P.N., 1995. Ground Water Pollution Potential of Coshocton County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report No. 32, 74 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.

Szmuc, E.J., 1957. Stratigraphy and Paleontology of the Cuyahoga Formation of northern Ohio. Unpublished Ph.D. dissertation, The Ohio State University, Columbus, Ohio, 607 pp.

Szmuc, E.J., 1970. The Mississippian System in: Banks, P.O. and R.M. Feldman, eds.: Guide to the geology of Northeastern Ohio: Northern Ohio Geological Society, p. 23-68.

Totten, S.M., 1969. Overridden recessional moraines of north-central Ohio. Geological Society of America Bulletin, v. 80, pp. 1931-1946.

Totten, S.M., 1987. Stratigraphy of tills in northern Ohio: in Totten S.M. and J.P. Szabo, eds.: Pre-Woodfordian stratigraphy of north-central Ohio. Guidebook, 34th Annual Field Conference, Mid-West Friends of the Pleistocene, Ohio Department of Natural Resources, Division of Geological Survey, 25 pp.

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

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

White, G.W. and S.M. Totem, 1985. Glacial geology of Columbiana County, Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Report of Investigations No. 129, 25 pp.

Williams, S., 1991. Ground Water Pollution Potential of Stark County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report No. 6, 75 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 Natural Resources, unpublished data. Well log and drilling reports for Carroll County, Division of Water, Water Resources Section.

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

APPENDIX A

DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

This factor was primarily evaluated using information from water well log records on file at the Ohio Department of Natural Resources (ODNR), Division of Water, Water Resources Section (WRS). Approximately 7,675 water well log records are on file for Carroll County. Data from roughly 3,800 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 were taken from these records. The *Ground Water Resources of Carroll County* (Walker, 1991) provided generalized depth to water information throughout the county. Depths to water along Sandy Creek were obtained from potentiometric-surface mapping completed for the buried valley (ODNR, Div. of Water, 2002, Open-File). Depth to water trends mapped in adjoining Stark County (Williams, 1991), Tuscarawas County (Angle and Baker (2001), Harrison County (Angle and Walker, 2002), and Columbiana County (Angle, 1994) were used as a guideline. Topographic and geomorphic trends were utilized in areas where other sources of data were lacking.

Depths to water of 5 to 15 feet (9) were typical of areas associated with floodplains of major streams. Depths of 15 to 30 feet (7) were used for stream terraces adjacent to major streams and along smaller tributaries. Depths of 30 to 50 feet (5) were utilized for valley sides and slopes of upland areas. Depths to water of 50 to 75 feet (3) were utilized for steeper, higher slopes and moderately high ridges in the uplands. Depths to water of 75 to 100 feet (2) and greater than 100 feet (1) were applied to steep, high ridge tops.

Net Recharge

Net recharge is the precipitation that reaches the aquifer after evapotranspiration and run-off. This factor was evaluated using many criteria, including depth to water, topography, soil type, surface drainage, vadose zone material, aquifer type, and annual precipitation. General estimates of recharge provided by Pettyjohn and Henning (1979) and Dumouchelle and Schiefer (2002) proved to be helpful. Recharge ratings from adjoining Stark County (Williams, 1991), Tuscarawas County (Angle and Baker (2001), Harrison County (Angle and Walker, 2002), and Columbiana County (Angle, 1994) were used as a guideline.

Recharge values of 7 to 10 inches per year (8) were assigned to floodplains overlying outwash buried valley deposits adjacent to Sandy 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 almost all of the other stream valleys and buried valley settings within 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. Values of recharge less than 2 inches per year (1) were utilized for limited steep ridge tops and slopes. These areas have moderate to great depths to water, soils are thin or absent and slopes are very steep which contribute to very high run-off.

Aquifer Media

Information on evaluating aquifer media was obtained from Sedam (1973), and Walker (1991). Aquifer media mapping in adjoining Stark County (Williams, 1991), Tuscarawas County (Angle and Baker (2001), Harrison County (Angle and Walker, 2002), and Columbiana County (Angle, 1994) proved helpful. Aquifer information was inferred for the surficial geology of northeastern Holmes County from Pavey et al. (2002). Open File Bedrock Reconnaissance Maps and Open File Bedrock Topography Maps, based upon U.S.G.S. 7-1/2 minute topographic maps from the ODNR, Division of Geological Survey proved helpful. The ODNR, Division of Water, Glacial State Aquifer Map and Bedrock State Aquifer Map were an important source of aquifer data. Water well log records on file at the ODNR, Division of Water, were the primary source of aquifer information.

An aquifer rating of (8) was designated for the high-yielding sand and gravel outwash deposits underlying Sandy Creek. An aquifer rating of (7) was assigned to thinner, less continuous sand and gravel outwash deposits associated with margins and tributaries of the buried valley adjacent to Sandy Creek. Aquifer ratings of (6) and (5) were used for some thinner sand and gravel deposits associated with tributaries to Sandy Creek, and for the main trunk buried valley and tributaries of Conotton Creek.

An aquifer rating of (6) was assigned to limited areas of higher-yielding Sharon Sandstone and Massillon Sandstone and highly fractured rocks of the lower Pottsville-Allegheny Groups in northwestern Carroll County along the Stark County boundary. Wells developed in these sandstone aquifers may include some overlying interbedded shales, siltstones, and thin coals and limestones. An aquifer rating of (5) was utilized for areas of the Pottsville-Allegheny Group in northwestern Carroll County that were transitional between higher and lower yielding units. An aquifer rating of (4) was designated for central and northern Carroll County. These rocks include the interbedded dirty sandstones, shales, thin limestones, and coals of the Allegheny Group. An aquifer rating of (3) was assigned to rocks of the Conemaugh and Monongahela Groups in southern and eastern Carroll County. These rocks also occupy some of the higher ridge tops in the west-central portions of the county. These sequences contain dirty sandstones, shales, mudstones, clays, thin limestones and coals and are fairly restrictive to water movement.

Soils

Soils were mapped using the data obtained from the *Soil Survey of Carroll County* (Gerber and Buzard, 1983). 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 Carroll 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 Carroll County.

Soils were considered to be thin or absent (10) along many steep ridge tops and slopes where bedrock was exposed. These soils are prevalent in eastern Carroll County. Soils were evaluated as being sand (9) for limited outwash terraces along Sandy Creek valley. Shrink-swell (aggregated) clay (7) was selected for some ridge tops and slopes where the soils were developed from very clayey shales. Sandy loams (6) were selected for soils overlying outwash terraces, plains, and kames overlying buried valleys. Sandy loam soils (6) were also selected for steep, residual sandstone ridges throughout the county. Loam soils (5) were designated for medium-textured soils on floodplain terraces. Silt loam (4) was selected for silty alluvial and lacustrine deposits on floodplains. Silt loam (4) was also selected for residual bedrock soils. Clay loam (3) soils were evaluated for the widespread residual shale bedrock slopes throughout the county.

Topography

Topography, or percent slope, was evaluated using U.S.G.S. 7-1/2 minute quadrangle maps and the *Soil Survey of Carroll County* (Gerber and Buzard, 1983). 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, particularly in southern and eastern Carroll County.

Table 12. Carroll County Soils.

Soil Name	Parent Material Or Setting	DRASTIC Rating	Soil Media
Berks	Shale	10	Thin or absent
Bethesda	Strip mine	NA	Non-rated
Boyer	Outwash terraces	6	Sandy loam
Chili	Outwash terraces	6	Sandy loam
Coshocton	Shale, siltstone bedrock	3	Clay loam
Culleoka	Siltstone ridge tops	10	Thin or absent
Elba	Shale, claystone	7	Shrink-swell clay
Elkinsville	Alluvium	4	Silt loam
Fairport	Strip mine	NA	Non-rated
Fitchville	Alluvium	3	Clay loam
Glenford	Alluvium, lacustrine	4	Silt loam
Guernsey	Shale, siltstone	7	Shrink-swell clay
Hazelton	Sandstone	6	Sandy loam
Holly	Alluvium	4	Silt loam
Jimtown	Outwash terrace	6	Sandy loam
Library	Shale	3	Clay loam
Lorain	Alluvium	3	Clay loam
Morristown	Strip mine	NA	Not rated
Orrville	Alluvium	4	Silt loam
Oshtemo	Coarse alluvium, outwash	6	Sandy loam
Peoga	Fine alluvium	3	Clay loam
Rigley	Sandstone slopes	6	Sandy loam
Sebring	Alluvium	3	Clay loam
Tioga	Outwash	6	Sandy loam
Upshur	Shale	7	Shrink-swell clay
Wellston	Siltstone	4	Silt loam
Westmoreland	Shale, siltstone	4	Silt loam

Impact of the Vadose Zone Media

Information on evaluating vadose zone media was obtained from Sedam (1973), and Walker (1991). Vadose zone media mapping in adjoining Stark County (Williams, 1991), Tuscarawas County (Angle and Baker (2001), Harrison County (Angle and Walker, 2002), and Columbiana County (Angle, 1994) proved helpful. Vadose information was inferred for the surficial geology from Pavey et al. (2002). Open File Bedrock Reconnaissance Maps and Open File Bedrock Topography Maps, based upon U.S.G.S. 7-1/2 minute topographic maps from the ODNR, Division of Geological Survey proved helpful. The ODNR, Division of Water, Glacial State Aquifer Map and Bedrock State Aquifer Map were an important source of aquifer data. Information on parent materials derived from the *Soil Survey of*

Carroll County (Gerber and Buzard, 1983), also proved useful in evaluating vadose zone materials. Water well log records on file at the ODNR, Division of Water, were the primary source of information on vadose zone media for the county.

Sand and gravel, with a vadose zone media rating of (9) was utilized for some of the very gravelly outwash terraces found along the banks of Sandy Creek adjacent to Stark County. Sand and gravel interbedded with silt and clay was given a vadose zone media ratings of (8) for outwash terraces along the main trunk of Sandy Creek. Vadose zone media ratings of (5) and (6) were selected for sand and gravel interbedded with silt and clay layers for deposits along the margins and tributaries of Sandy Creek and for the buried valley deposits adjacent to Conotton 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 (4) and (5) were selected as vadose zone media for floodplains for upland tributaries and headwaters.

A vadose zone media rating of (6) was assigned to limited areas of higher-yielding Sharon Sandstone and Massillon Sandstone in northwestern Carroll County along the border with Stark County. A vadose zone media rating of (5) was utilized for bedrock aquifers that had an aquifer rating of (5). The (5) rating included the interbedded sandstones, shales, thin limestones, and coals of the Pennsylvanian Pottsville Group and Allegheny Group. A vadose zone rating of (4) was designated for some of the bedrock aquifers with an aquifer rating of (4). 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 Carroll County is limited. Mapping in adjoining Stark County (Williams, 1991), Tuscarawas County (Angle and Baker (2001), Harrison County (Angle and Walker, 2002), and Columbiana County (Angle, 1994) was used as a guideline. The *Ground Water Resources of Carroll 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 2,000 plus gallons per day per square foot (gpd/ft^2) (10) or 1,000-2,000 gpd/ft^2 (8) were selected. These high values were limited to the clean outwash deposits adjacent to Sandy Creek. The values varied depending upon how clean and coarse the sediments were. For sand and gravel deposits associated with buried valleys with an aquifer media rating of (7), hydraulic conductivities of 700-1000 gpd/ft^2 (6) were chosen. For sand and gravel deposits with aquifer ratings of (6) or (5), hydraulic conductivity values of 300-700 gpd/ft^2 (4) were assigned. In these deposits, thin sand and gravel lenses are interbedded within thicker sequences of finer-grained materials.

Bedrock aquifers with an aquifer rating of (6) have been assigned a hydraulic conductivity rating of 100-300 gpd/ft^2 (2). These rocks tend to be coarser-grained, more porous, and more highly fractured. Bedrock aquifers with aquifer ratings of (3), (4) or (5) were given hydraulic conductivity ratings of 1-100 gpd/ft^2 (1).

APPENDIX B

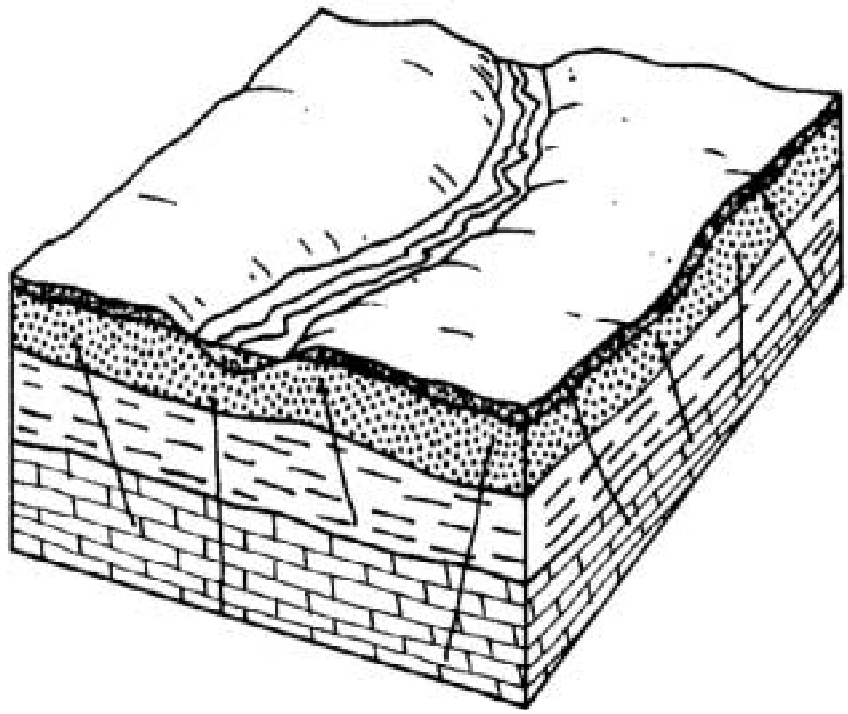
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Carroll County resulted in the identification of seven hydrogeologic settings within the 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 Carroll County range from 55 to 198.

Table 13. Hydrogeologic Settings Mapped in Carroll County, Ohio for General DRASTIC

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
6Da - Alternating Sandstone, Limestone, and Shale – Thin Regolith	55 – 116	115
6Db – Alternating Sandstone, Limestone, and Shale – Thick Regolith	96-147	2
6Fa – River Alluvium with Overbank Deposits	90-117	9
6Fb - River Alluvium Without Overbank Deposits	102-116	4
7Bb – Outwash over Bedded Sedimentary Rocks	126–164	3
7D - Buried Valley	127-198	29
7Fa – Glacial Lake and Slackwater Terraces	101-133	14

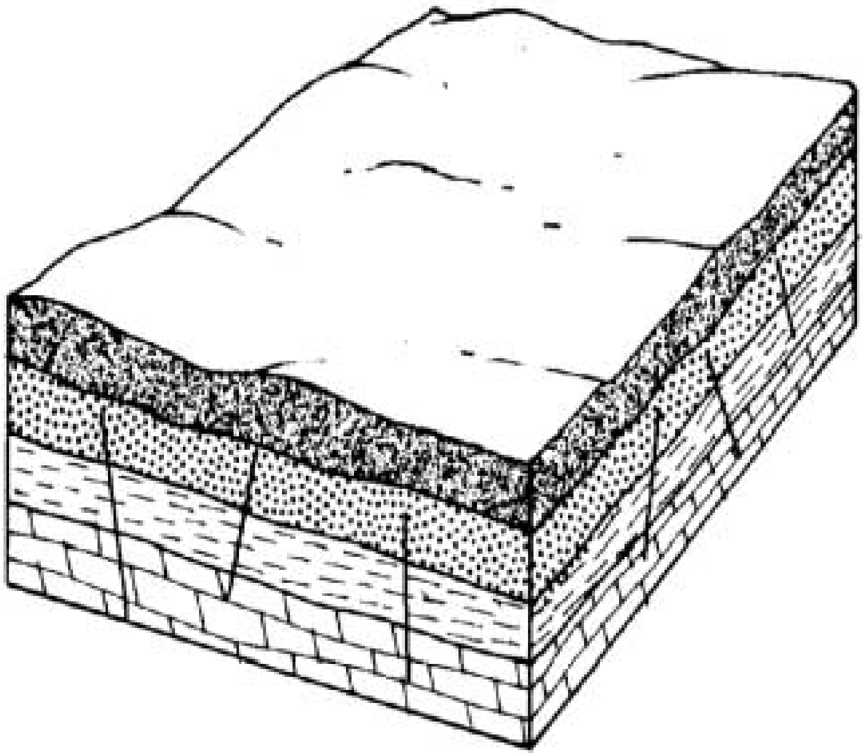
The following information provides a description of each hydrogeologic setting identified in the county, a block diagram illustrating the characteristics of the setting, and a listing of the charts for each unique combination of pollution potential indexes calculated for each setting. The charts provide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



6Da Alternating Sandstone, Limestone, Shale – Thin Regolith

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

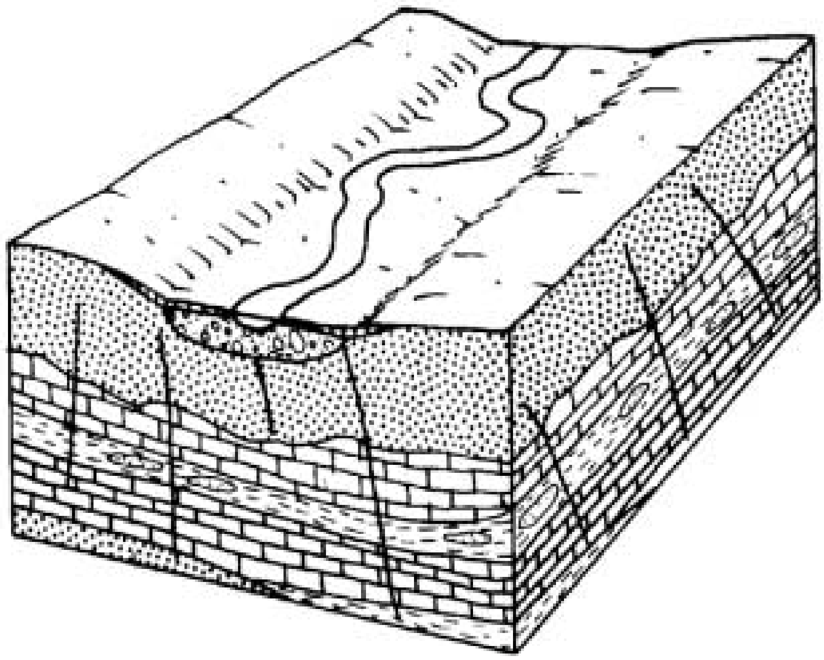
GWPP index values for the hydrogeologic setting of Alternating Sandstone, Limestone, Shale – Thin Regolith range from 55 to 116 with the total number of GWPP index calculations equaling 115.



6Db Alternating Sandstone, Limestone, Shale – Thick Regolith

This hydrogeologic setting is limited to slopes found along the northern margin of Carroll County, bordering Stark 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 flat-lying toe at the base of the slopes. 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. Multiple aquifers are typically present. Depth to water is moderately deep and transitional between stream valleys and ridge tops. Soils are silt loams that formed in 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 due to the moderate depth to water, flat-lying slope, and layers of impermeable bedrock.

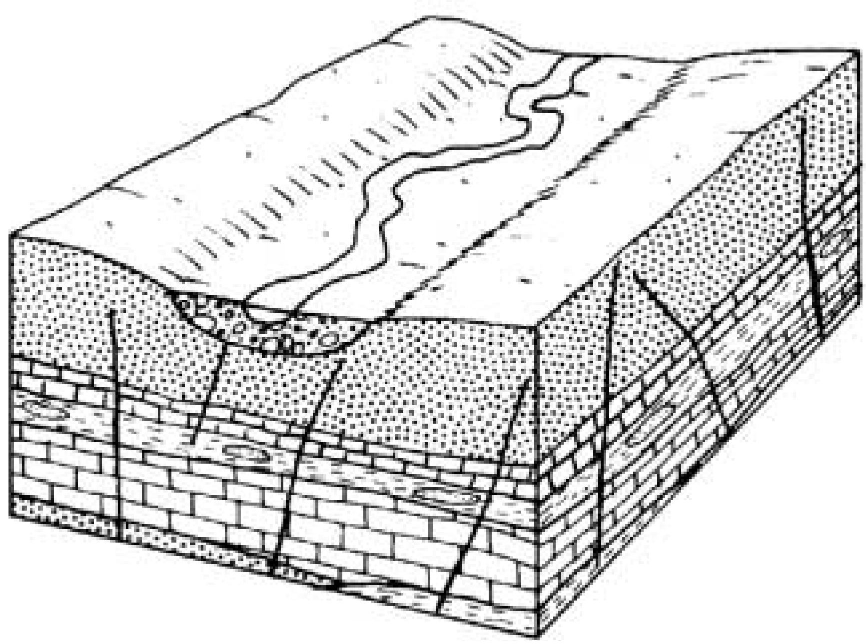
GWPP index values for the hydrogeologic setting of Alternating Sandstone, Limestone, and Shale – Thin Regolith range from 96 to 147 with the total number of GWPP index calculations equaling 2.



6Fa River Alluvium with Overbank Deposits

This hydrogeologic setting is limited to tributary valleys and headwaters of streams in uplands adjacent to Sandy Creek and Conotton Creek. This setting is similar to the 7Fa Glacial Lakes and Slackwater Terraces setting; however, the drift is somewhat thinner, the valleys are narrower and the setting is typically further removed from buried valley deposits. The setting is similar to the 6Fb River Alluvium without Overbank Deposits except that the valleys are narrower and the alluvium is thinner and coarser. Depth to water is usually shallow to moderate, averaging less than 40 feet. Soils are variable but generally 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. Groundwater 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.

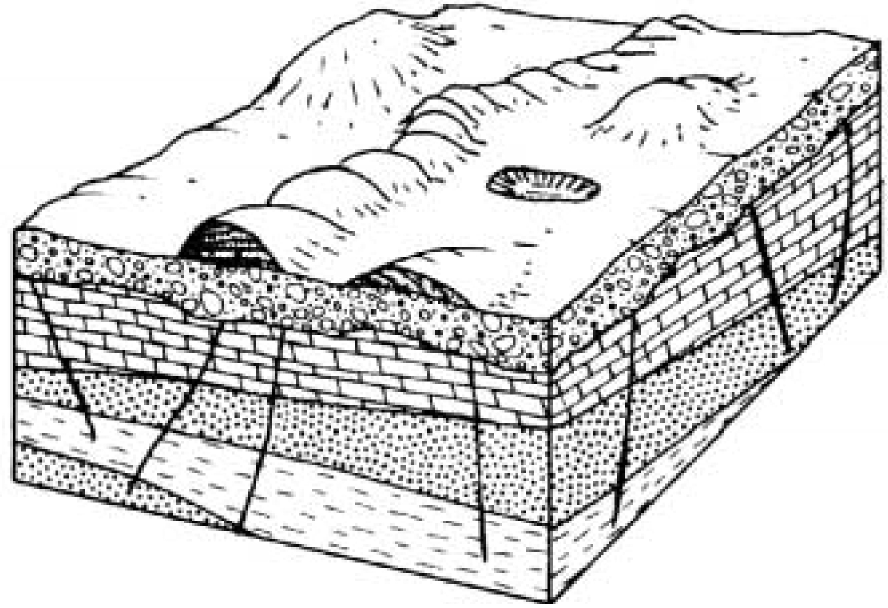
GWPP index values for the hydrogeologic setting of River Alluvium with Overbank Deposits range from 90 to 117 with the total number of GWPP index calculations equaling 9.



6Fb River Alluvium without Overbank Deposits

This hydrogeologic setting is limited to the headwaters of small tributary valleys in the uplands of Carroll County. This setting is somewhat similar to the 7Fa Glacial Lakes and Slackwater Terraces setting and the 6Fa River Alluvium with Overbank Deposits; however, the valleys and floodplains are narrower and the alluvial deposits are usually thinner and coarser. Wide floodplains are lacking. Areas in this setting are similar to the adjacent uplands, which belong to the 6Da Alternating Sandstone, Limestone, Shale - Thin Regolith setting. Narrow, relatively flat-bottomed stream valleys flanked by steep bedrock ridges characterize the setting. Depth to water is usually shallow to moderate, averaging less than 40 feet. Soils are generally silt loams or loams. The alluvial deposits are typically saturated; however, the alluvium is generally too thin to be utilized as an aquifer. The aquifer is the underlying dirty sandstones, shales, thin limestones, claystones, clays and coals of the Pennsylvanian System. In most areas, the alluvium is in direct connection with the underlying bedrock aquifers. Groundwater yields range from 5 to 25 gpm. Recharge is moderate due to the relatively shallow depth to water, flatter topography, and the relatively low permeability of the bedrock. Recharge is higher than the surrounding uplands.

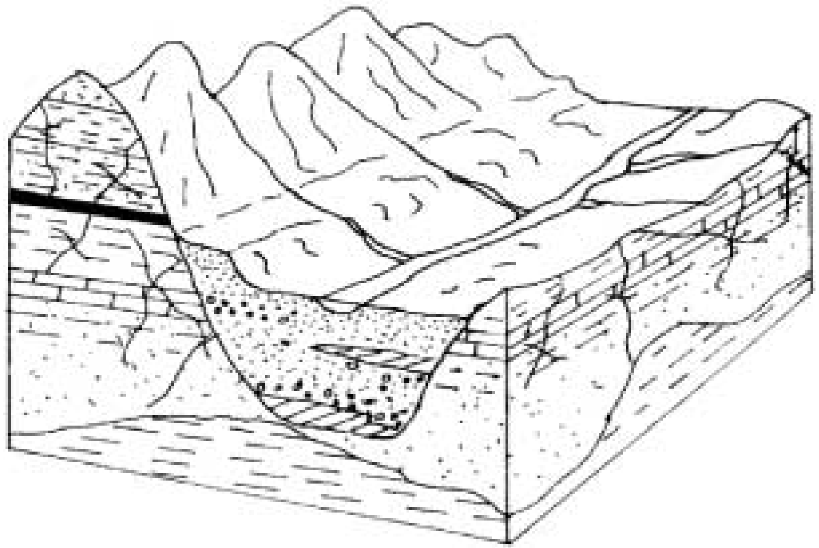
GWPP index values for the hydrogeologic setting of River Alluvium without Overbank Deposits range from 102 to 116 with the total number of GWPP index calculations equaling 4.



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

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

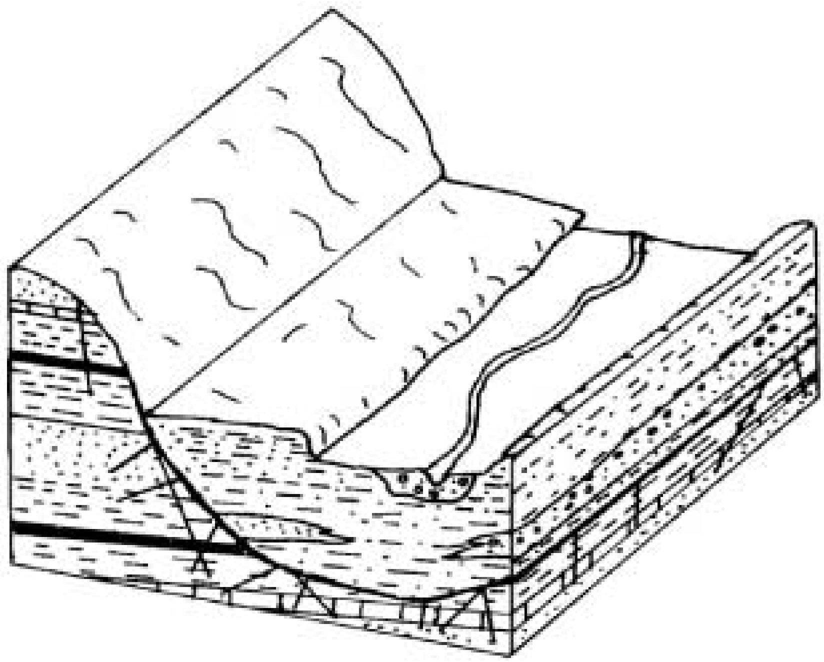
GWPP index values for the hydrogeologic setting of Outwash over Bedded Sedimentary Rocks range from 126 to 164 with the total number of GWPP index calculations equaling 3.



7D Buried Valley

This hydrogeologic setting is limited to the valley underlying modern Sandy Creek and Conotton Creek   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 Sandy Creek. Yields up to 100 gpm are obtained from wells in some of the tributaries to Sandy Creek.   The valley underlying Conotton Creek contains thin lenses of sand and gravel interbedded with much thicker sequences of finer-grained alluvial and lacustrine deposits. Yields are usually less than 25 gpm for these sediments. Soils on terraces are typically sandy loams or sand derived from outwash; soils on floodplains are silt loams derived from modern alluvium. Recharge is typically relatively high due to the flat-lying topography, shallow depth to water, and the high permeability of the soils, vadose zone materials, and aquifer for buried valleys with modern overlying streams.

GWPP index values for the hydrogeologic setting of Buried Valley range from 127 to 198 with the total number of GWPP index calculations equaling 29.



7Fa Glacial Lakes and Slackwater Terraces

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

GWPP index values for the hydrogeologic setting of Glacial Lakes and Slackwater Terraces range from 101 to 133 with the total number of GWPP index calculations equaling 14.

Table 14. Hydrogeologic Settings, DRASTIC Factors, and Ratings

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
6Da001	30-50	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/c	1-100	87	119
6Da002	30-50	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	85	113
6Da003	30-50	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/c	1-100	95	126
6Da004	50-75	2-4	interbedded ss/sh/ls/c	Silty Loam	18+	interbedded ss/sh/ls/c	1-100	71	80
6Da005	75-100	2-4	interbedded ss/sh/ls/c	Clay Loam	6-12	interbedded ss/sh/ls/c	1-100	60	75
6Da006	30-50	2-4	interbedded ss/sh/ls/c	Clay Loam	18+	interbedded ss/sh/ls/c	1-100	71	78
6Da007	50-75	2-4	interbedded ss/sh/ls/c	Silty Loam	18+	interbedded ss/sh/ls/c	1-100	63	73
6Da008	50-75	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	75	103
6Da009	50-75	2-4	interbedded ss/sh/ls/c	Shrink/Swell Clay	6-12	interbedded ss/sh/ls/c	1-100	73	100
6Da010	30-50	2-4	interbedded ss/sh/ls/c	Sandy Loam	18+	interbedded ss/sh/ls/c	1-100	85	100
6Da011	50-75	2-4	interbedded ss/sh/ls/c	Silty Loam	6-12	interbedded ss/sh/ls/c	1-100	67	85
6Da012	50-75	2-4	interbedded ss/sh/ls/c	Clay Loam	12-18	interbedded ss/sh/ls/c	1-100	63	74
6Da013	30-50	2-4	interbedded ss/sh/ls/c	Clay Loam	12-18	interbedded ss/sh/ls/c	1-100	81	91
6Da014	30-50	2-4	interbedded ss/sh/ls/c	Shrink/Swell Clay	18+	interbedded ss/sh/ls/c	1-100	87	105
6Da015	50-75	2-4	interbedded ss/sh/ls/c	Shrink/Swell Clay	18+	interbedded ss/sh/ls/c	1-100	69	88
6Da016	50-75	2-4	interbedded ss/sh/ls/c	Sandy Loam	18+	interbedded ss/sh/ls/c	1-100	75	90
6Da017	30-50	2-4	interbedded ss/sh/ls/c	Silty Loam	18+	interbedded ss/sh/ls/c	1-100	78	87
6Da018	50-75	2-4	interbedded ss/sh/ls/c	Clay Loam	18+	interbedded ss/sh/ls/c	1-100	66	72
6Da019	30-50	2-4	interbedded ss/sh/ls/c	Clay Loam	12-18	interbedded ss/sh/ls/c	1-100	81	91
6Da020	50-75	2-4	interbedded ss/sh/ls/c	Clay Loam	18+	interbedded ss/sh/ls/c	1-100	69	75
6Da021	75-100	2-4	interbedded ss/sh/ls/c	Clay Loam	18+	interbedded ss/sh/ls/c	1-100	64	70
6Da022	30-50	2-4	interbedded ss/sh/ls/c	Shrink/Swell Clay	18+	interbedded ss/sh/ls/c	1-100	84	102
6Da023	100+	2-4	interbedded ss/sh/ls/c	Clay Loam	6-12	interbedded ss/sh/ls/c	1-100	55	70
6Da024	50-75	2-4	interbedded ss/sh/ls/c	Clay Loam	2-6	interbedded ss/sh/ls/c	1-100	69	92
6Da025	50-75	2-4	interbedded ss/sh/ls/c	Clay Loam	6-12	interbedded ss/sh/ls/c	1-100	65	80
6Da026	30-50	2-4	interbedded ss/sh/ls/c	Clay Loam	18+	interbedded ss/sh/ls/c	1-100	79	85

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
6Da027	50-75	2-4	interbedded ss/sh/ls/c	Sandy Loam	18+	interbedded ss/sh/ls/c	1-100	72	87
6Da028	50-75	2-4	interbedded ss/sh/ls/c	Sandy Loam	18+	interbedded ss/sh/ls/c	1-100	83	97
6Da029	50-75	4-7	interbedded ss/sh/ls/c	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/c	100-300	116	144
6Da030	30-50	2-4	interbedded ss/sh/ls/c	Shrink/Swell Clay	18+	interbedded ss/sh/ls/c	100-300	98	114
6Da031	50-75	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	100-300	102	126
6Da032	30-50	2-4	interbedded ss/sh/ls/c	Clay Loam	12-18	interbedded ss/sh/ls/c	1-100	89	98
6Da033	75-100	2-4	interbedded ss/sh/ls/c	Shrink/Swell Clay	6-12	interbedded ss/sh/ls/c	1-100	68	95
6Da034	50-75	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	83	110
6Da035	30-50	2-4	interbedded ss/sh/ls/c	Shrink/Swell Clay	6-12	interbedded ss/sh/ls/c	1-100	91	117
6Da036	30-50	2-4	interbedded ss/sh/ls/c	Clay Loam	2-6	interbedded ss/sh/ls/c	1-100	87	109
6Da037	50-75	2-4	interbedded ss/sh/ls/c	Sandy Loam	6-12	interbedded ss/sh/ls/c	1-100	71	95
6Da038	75-100	2-4	interbedded ss/sh/ls/c	Sandy Loam	6-12	interbedded ss/sh/ls/c	1-100	66	90
6Da039	75-100	2-4	interbedded ss/sh/ls/c	Clay Loam	2-6	interbedded ss/sh/ls/c	1-100	64	87
6Da040	30-50	2-4	interbedded ss/sh/ls/c	Clay Loam	6-12	interbedded ss/sh/ls/c	1-100	83	97
6Da041	50-75	2-4	interbedded ss/sh/ls/c	Clay Loam	18+	interbedded ss/sh/ls/c	1-100	61	68
6Da042	75-100	2-4	interbedded ss/sh/ls/c	Clay Loam	18+	interbedded ss/sh/ls/c	1-100	56	63
6Da043	50-75	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/c	1-100	77	109
6Da044	75-100	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/c	1-100	74	110
6Da045	75-100	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	70	98
6Da046	75-100	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/c	1-100	72	104
6Da047	75-100	2-4	interbedded ss/sh/ls/c	Sandy Loam	2-6	interbedded ss/sh/ls/c	1-100	70	102
6Da048	50-75	2-4	interbedded ss/sh/ls/c	Clay Loam	12-18	interbedded ss/sh/ls/c	1-100	71	81
6Da049	100+	2-4	interbedded ss/sh/ls/c	Sandy Loam	6-12	interbedded ss/sh/ls/c	1-100	61	85
6Da050	50-75	2-4	interbedded ss/sh/ls/c	Sandy Loam	18+	interbedded ss/sh/ls/c	1-100	67	83
6Da051	75-100	2-4	interbedded ss/sh/ls/c	Silty Loam	6-12	interbedded ss/sh/ls/c	1-100	62	80
6Da052	30-50	2-4	interbedded ss/sh/ls/c	Sandy Loam	18+	interbedded ss/sh/ls/c	1-100	77	93
6Da053	50-75	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	67	95

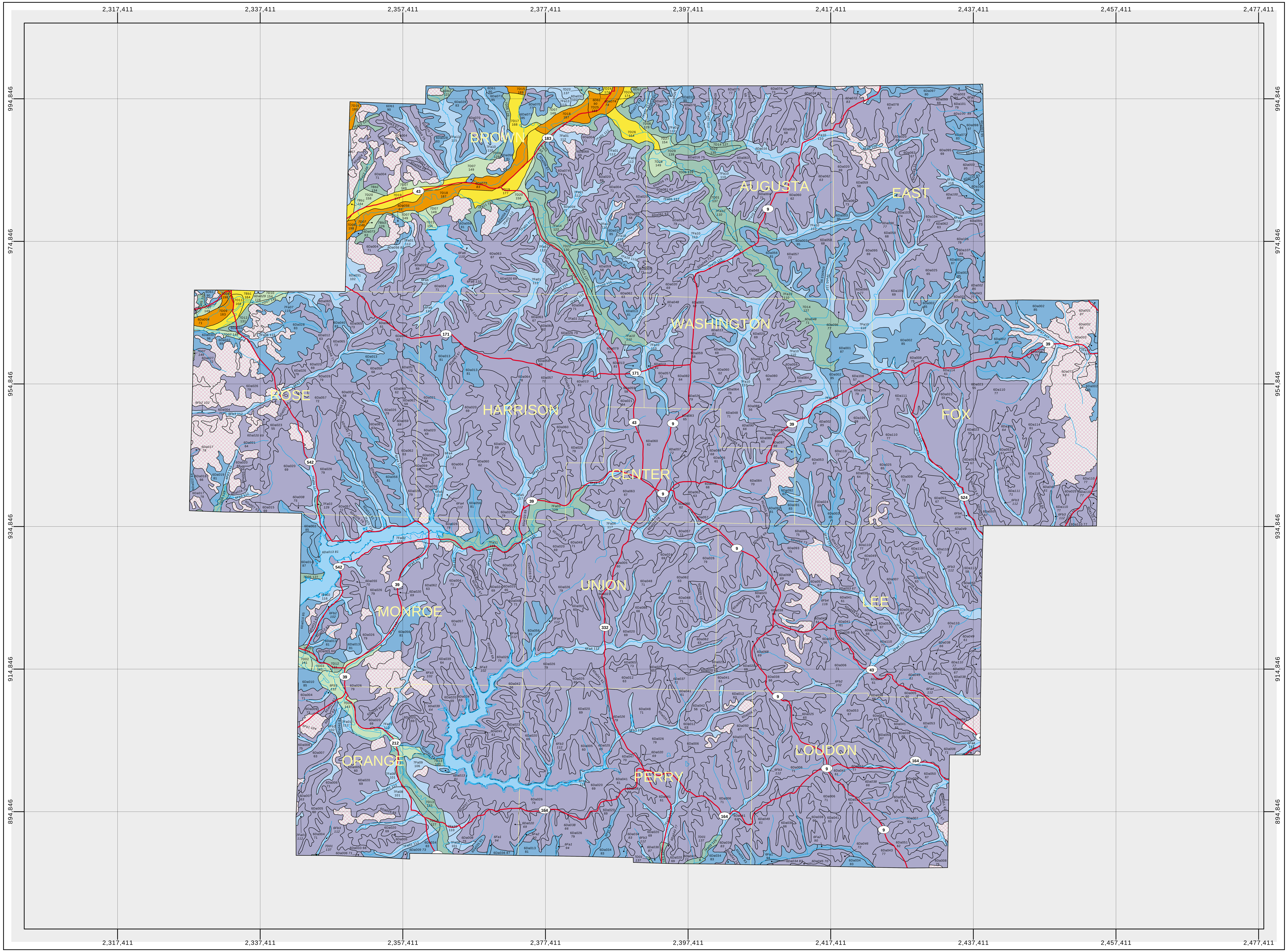
Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
6Da054	75-100	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/c	1-100	66	102
6Da055	50-75	2-4	interbedded ss/sh/ls/c	Silty Loam	6-12	interbedded ss/sh/ls/c	1-100	70	88
6Da056	30-50	2-4	interbedded ss/sh/ls/c	Silty Loam	18+	interbedded ss/sh/ls/c	1-100	81	90
6Da057	50-75	2-4	interbedded ss/sh/ls/c	Clay Loam	2-6	interbedded ss/sh/ls/c	1-100	72	95
6Da058	50-75	2-4	interbedded ss/sh/ls/c	Clay Loam	6-12	interbedded ss/sh/ls/c	1-100	68	83
6Da059	100+	2-4	interbedded ss/sh/ls/c	Clay Loam	6-12	interbedded ss/sh/ls/c	1-100	58	73
6Da060	100+	2-4	interbedded ss/sh/ls/c	Clay Loam	2-6	interbedded ss/sh/ls/c	1-100	62	85
6Da061	100+	2-4	interbedded ss/sh/ls/c	Clay Loam	18+	interbedded ss/sh/ls/c	1-100	59	65
6Da062	75-100	2-4	interbedded ss/sh/ls/c	Clay Loam	6-12	interbedded ss/sh/ls/c	1-100	63	78
6Da063	75-100	2-4	interbedded ss/sh/ls/c	Clay Loam	2-6	interbedded ss/sh/ls/c	1-100	67	90
6Da064	30-50	2-4	interbedded ss/sh/ls/c	Clay Loam	6-12	interbedded ss/sh/ls/c	1-100	78	93
6Da065	50-75	2-4	interbedded ss/sh/ls/c	Clay Loam	6-12	interbedded ss/sh/ls/c	1-100	73	87
6Da066	75-100	2-4	interbedded ss/sh/ls/c	Clay Loam	12-18	interbedded ss/sh/ls/c	1-100	61	72
6Da066	75-100	2-4	interbedded ss/sh/ls/c	Clay Loam	12-18	interbedded ss/sh/ls/c	1-100	61	72
6Da067	50-75	4-7	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	100-300	114	138
6Da068	75-100	2-4	interbedded ss/sh/ls/c	Sandy Loam	6-12	interbedded ss/sh/ls/c	1-100	69	93
6Da069	50-75	2-4	interbedded ss/sh/ls/c	Silty Loam	18+	interbedded ss/sh/ls/c	1-100	79	87
6Da070	100+	2-4	interbedded ss/sh/ls/c	Sandy Loam	6-12	interbedded ss/sh/ls/c	1-100	77	99
6Da071	50-75	2-4	interbedded ss/sh/ls/c	Sandy Loam	12-18	interbedded ss/sh/ls/c	1-100	85	103
6Da072	30-50	2-4	interbedded ss/sh/ls/c	Silty Loam	12-18	interbedded ss/sh/ls/c	1-100	83	96
6Da073	30-50	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	93	120
6Da074	75-100	2-4	interbedded ss/sh/ls/c	Sandy Loam	6-12	interbedded ss/sh/ls/c	1-100	74	97
6Da075	50-75	2-4	interbedded ss/sh/ls/c	Sandy Loam	12-18	interbedded ss/sh/ls/c	1-100	77	96
6Da076	50-75	2-4	interbedded ss/sh/ls/c	Silty Loam	12-18	interbedded ss/sh/ls/c	1-100	73	86
6Da077	30-50	2-4	interbedded ss/sh/ls/c	Sandy Loam	12-18	interbedded ss/sh/ls/c	1-100	87	106
6Da078	100+	2-4	interbedded ss/sh/ls/c	Clay Loam	2-6	interbedded ss/sh/ls/c	1-100	67	89
6Da079	75-100	2-4	interbedded ss/sh/ls/c	Clay Loam	12-18	interbedded ss/sh/ls/c	1-100	66	76

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
6Da080	100+	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	60	88
6Da081	100+	2-4	interbedded ss/sh/ls/c	Clay Loam	6-12	interbedded ss/sh/ls/c	1-100	63	77
6Da082	100+	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/c	1-100	64	100
6Da083	75-100	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	65	93
6Da084	50-75	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	70	98
6Da085	50-75	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	75	102
6Da086	100+	2-4	interbedded ss/sh/ls/c	Clay Loam	12-18	interbedded ss/sh/ls/c	1-100	56	67
6Da087	30-50	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	88	116
6Da088	100+	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	2-6	interbedded ss/sh/ls/c	1-100	68	112
6Da089	100+	2-4	interbedded ss/sh/ls/c	Sandy Loam	6-12	interbedded ss/sh/ls/c	1-100	64	88
6Da090	100+	2-4	interbedded ss/sh/ls/c	Shrink/Swell Clay	6-12	interbedded ss/sh/ls/c	1-100	66	93
6Da091	30-50	2-4	interbedded ss/sh/ls/c	Shrink/Swell Clay	6-12	interbedded ss/sh/ls/c	1-100	83	110
6Da092	30-50	2-4	interbedded ss/sh/ls/c	Shrink/Swell Clay	12-18	interbedded ss/sh/ls/c	1-100	81	104
6Da093	30-50	2-4	interbedded ss/sh/ls/c	Clay Loam	6-12	interbedded ss/sh/ls/c	1-100	75	90
6Da094	30-50	2-4	interbedded ss/sh/ls/c	Clay Loam	12-18	interbedded ss/sh/ls/c	1-100	73	84
6Da095	75-100	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/c	1-100	69	105
6Da096	50-75	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/c	1-100	77	108
6Da097	50-75	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/c	100-300	80	110
6Da098	30-50	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/c	1-100	97	132
6Da099	100+	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/c	1-100	69	104
6Da100	30-50	2-4	interbedded ss/sh/ls/c	Shrink/Swell Clay	12-18	interbedded ss/sh/ls/c	1-100	89	111
6Da101	50-75	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/c	1-100	79	114
6Da102	15-30	4-7	interbedded ss/sh/ls/c	Clay Loam	2-6	interbedded ss/sh/ls/c	1-100	109	131
6Da103	50-75	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/c	1-100	74	110
6Da104	50-75	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/c	1-100	72	104
6Da105	50-75	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/c	1-100	69	101
6Da106	50-75	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/c	1-100	79	115

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
6Da107	30-50	2-4	interbedded ss/sh/ls/c	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/c	1-100	89	125
6Da108	100+	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	57	85
6Da109	30-50	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/c	1-100	79	111
6Da110	30-50	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	18+	interbedded ss/sh/ls/c	1-100	77	105
6Da111	50-75	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/c	1-100	71	107
6Da112	30-50	2-4	interbedded ss/sh/ls/c	Silty Loam	18+	interbedded ss/sh/ls/c	1-100	73	83
6Da113	75-100	2-4	interbedded ss/sh/ls/c	Silty Loam	18+	interbedded ss/sh/ls/c	1-100	58	68
6Da114	100+	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/c	1-100	61	97
6Da115	75-100	0-2	interbedded ss/sh/ls/c	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/c	1-100	64	96
6Db1	50-75	2-4	interbedded ss/sh/ls/c	Silty Loam	18+	interbedded ss/sh/ls/c	100-300	90	96
6Db2	15-30	4-7	interbedded ss/sh/ls/c	Silty Loam	0-2	silt/clay	100-300	121	147
6Fa1	30-50	2-4	interbedded ss/sh/ls/c	Sandy Loam	0-2	silt/clay	1-100	94	127
6Fa2	30-50	2-4	interbedded ss/sh/ls/c	Silty Loam	0-2	silt/clay	1-100	90	117
6Fa3	30-50	4-7	interbedded ss/sh/ls/c	Silty Loam	0-2	silt/clay	1-100	102	129
6Fa4	15-30	4-7	interbedded ss/sh/ls/c	Silty Loam	0-2	silt/clay	1-100	112	139
6Fa5	15-30	4-7	interbedded ss/sh/ls/c	Silty Loam	0-2	sd + gvl/silt + clay	1-100	117	143
6Fa6	15-30	4-7	interbedded ss/sh/ls/c	Clay Loam	0-2	silt/clay	1-100	110	134
6Fa7	15-30	4-7	interbedded ss/sh/ls/c	Loam	0-2	interbedded ss/sh/ls/c	1-100	114	144
6Fa8	15-30	4-7	interbedded ss/sh/ls/c	Sandy Loam	0-2	interbedded ss/sh/ls/c	1-100	116	149
6Fa9	30-50	4-7	interbedded ss/sh/ls/c	Clay Loam	0-2	silt/clay	1-100	100	124
6Fb1	30-50	4-7	interbedded ss/sh/ls/c	Loam	0-2	silt/clay	1-100	104	134
6Fb2	30-50	4-7	interbedded ss/sh/ls/c	Silty Loam	0-2	silt/clay	1-100	102	129
6Fb3	15-30	4-7	interbedded ss/sh/ls/c	Silty Loam	0-2	silt/clay	1-100	112	139
6Fb4	15-30	4-7	interbedded ss/sh/ls/c	Sandy Loam	0-2	silt/clay	1-100	116	149
7Bb1	15-30	7-10	interbedded ss/sh/ls/c	Sand	0-2	sand + gravel	100-300	164	200

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Bb2	15-30	7-10	interbedded ss/sh/ls/c	Sandy Loam	0-2	sd + gvl/silt + clay	1-100	134	165
7Bb3	15-30	4-7	interbedded ss/sh/ls/c	Sandy Loam	0-2	sd + gvl/silt + clay	1-100	126	157
7D01	15-30	4-7	sand + gravel	Silty Loam	0-2	sd + gvl/silt + clay	300-700	137	159
7D02	15-30	4-7	sand + gravel	Sandy Loam	0-2	sd + gvl/silt + clay	300-700	141	169
7D03	5-15	4-7	sand + gravel	Sandy Loam	0-2	sd + gvl/silt + clay	300-700	151	179
7D04	5-15	4-7	sand + gravel	Sandy Loam	0-2	sd + gvl/silt + clay	300-700	143	172
7D05	30-50	4-7	sand + gravel	Silty Loam	0-2	sd + gvl/silt + clay	300-700	127	149
7D06	15-30	4-7	sand + gravel	Silty Loam	0-2	sd + gvl/silt + clay	300-700	129	152
7D07	15-30	7-10	sand + gravel	Sandy Loam	0-2	sd + gvl/silt + clay	300-700	149	177
7D08	5-15	7-10	sand + gravel	Sand	0-2	sand + gravel	1000-2000	198	228
7D09	15-30	7-10	sand + gravel	Sandy Loam	0-2	sand + gravel	2000+	183	203
7D10	30-50	7-10	sand + gravel	Sandy Loam	0-2	sand + gravel	300-700	154	179
7D11	15-30	7-10	sand + gravel	Sandy Loam	0-2	sd + gvl/silt + clay	700-1000	168	192
7D12	30-50	4-7	sand + gravel	Sandy Loam	0-2	sd + gvl/silt + clay	300-700	131	159
7D13	15-30	4-7	sand + gravel	Sandy Loam	0-2	sd + gvl/silt + clay	300-700	133	162
7D14	15-30	4-7	sand + gravel	Clay Loam	0-2	sd + gvl/silt + clay	300-700	127	147
7D15	5-15	7-10	sand + gravel	Sand	0-2	sand + gravel	700-1000	189	221
7D16	5-15	7-10	sand + gravel	Sand	0-2	sand + gravel	300-700	180	214
7D17	5-15	7-10	sand + gravel	Sandy Loam	0-2	sd + gvl/silt + clay	700-1000	168	194
7D18	5-15	7-10	sand + gravel	Sandy Loam	0-2	sd + gvl/silt + clay	1000-2000	187	209
7D19	15-30	7-10	sand + gravel	Sandy Loam	0-2	sd + gvl/silt + clay	1000-2000	177	199
7D20	15-30	7-10	sand + gravel	Sandy Loam	0-2	sd + gvl/silt + clay	700-1000	158	184
7D21	5-15	7-10	sand + gravel	Silty Loam	0-2	sd + gvl/silt + clay	300-700	155	177
7D22	15-30	4-7	sand + gravel	Clay Loam	0-2	sd + gvl/silt + clay	300-700	130	150
7D23	5-15	4-7	sand + gravel	Silty Loam	0-2	silt/clay	300-700	137	161
7D24	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gravel	300-700	174	199

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7D25	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gravel	700-1000	183	206
7D26	5-15	7-10	sand + gravel	Silty Loam	0-2	sd + gvl/silt + clay	700-1000	164	184
7D27	15-30	7-10	sand + gravel	Silty Loam	0-2	sd + gvl/silt + clay	700-1000	154	174
7D28	5-15	4-7	sand + gravel	Clay Loam	0-2	sd + gvl/silt + clay	700-1000	149	167
7D29	15-30	4-7	sand + gravel	Clay Loam	0-2	sd + gvl/silt + clay	700-1000	139	157
7Fa01	15-30	4-7	interbedded ss/sh/ls/c	Silty Loam	0-2	silt/clay	1-100	112	139
7Fa02	15-30	4-7	interbedded ss/sh/ls/c	Silty Loam	2-6	sd + gvl/silt + clay	1-100	116	140
7Fa02	15-30	4-7	interbedded ss/sh/ls/c	Silty Loam	2-6	sd + gvl/silt + clay	1-100	116	140
7Fa03	15-30	4-7	sand + gravel	Silty Loam	0-2	sd + gvl/silt + clay	300-700	129	152
7Fa04	15-30	4-7	interbedded ss/sh/ls/c	Silty Loam	0-2	sd + gvl/silt + clay	1-100	117	143
7Fa05	15-30	4-7	interbedded ss/sh/ls/c	Sandy Loam	0-2	sd + gvl/silt + clay	100-300	130	161
7Fa06	15-30	4-7	interbedded ss/sh/ls/c	Clay Loam	0-2	silt/clay	100-300	116	139
7Fa07	15-30	4-7	interbedded ss/sh/ls/c	Clay Loam	0-2	silt/clay	100-300	119	142
7Fa08	30-50	4-7	interbedded ss/sh/ls/c	Silty Loam	2-6	interbedded ss/sh/ls/c	1-100	101	126
7Fa09	30-50	4-7	interbedded ss/sh/ls/c	Silty Loam	2-6	silt/clay	1-100	106	130
7Fa10	15-30	4-7	interbedded ss/sh/ls/c	Clay Loam	0-2	silt/clay	1-100	110	134
7Fa11	15-30	4-7	sand + gravel	Sandy Loam	0-2	sd + gvl/silt + clay	300-700	133	162
7Fa12	15-30	4-7	interbedded ss/sh/ls/c	Silty Loam	0-2	sd + gvl/silt + clay	1-100	120	146
7Fa13	15-30	4-7	interbedded ss/sh/ls/c	Silty Loam	0-2	interbedded ss/sh/ls/c	1-100	115	142
7Fa14	15-30	4-7	sand + gravel	Clay Loam	0-2	silt/clay	300-700	122	143



Ground Water Pollution Potential of Carroll County

by

Mike Angle, Brad Ziss, and Sarah Corbin

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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