GROUND WATER POLLUTION POTENTIAL OF CLERMONT COUNTY, OHIO

BY

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AND

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ABSTRACT

A ground water pollution potential map of Clermont 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.

Clermont County lies within both the Glaciated Central and the Non-Glaciated Central hydrogeologic regions. The county is covered by variable thicknesses of glacial till, lacustrine deposits, and outwash. These unconsolidated glacial deposits are underlain by shale and shaley limestone bedrock that are capable of supplying only small quantities of ground water. Pollution potential indexes are relatively low to moderate in areas of till or lacustrine cover over bedrock. Buried valleys containing sand and gravel aquifers and areas covered by outwash have moderate to high vulnerabilities to contamination.

Ground water pollution potential analysis in Clermont County resulted in a map with symbols and colors which illustrate areas of varying ground water contamination vulnerability. Five hydrogeologic settings were identified in Clermont County with computed ground water pollution potential indexes ranging from 81 to 203.

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 Clermont 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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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 700,000 rural households depend on private wells; approximately 4,500 of these wells exist in Clermont 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 county-wide basis in Ohio.

The purpose of this report and map is to aid in the protection of our ground water resources. This protection can be enhanced by understanding and implementing the results of this study which utilizes the DRASTIC system of evaluating an area's potential for ground water pollution. The mapping program identifies areas that are more or less 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 results of 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 Clermont 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 more or less 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 also 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 vulnerabiltiy 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 as a result of land use activities 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 also 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 also 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.

Other beneficial uses of the pollution potential maps will be recognized by individuals in the county who are familiar with specific land use and management problems. Planning commissions and zoning boards can use these maps to help make informed decisions about the development of areas within their jurisdiction. Developments proposed to occur within sensitive ground-water 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

The system chosen for implementation of a ground water pollution potential mapping program in Ohio, DRASTIC, was developed by the National Water Well Association for the United States Environmental Protection Agency. 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. The 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 which 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, assuming a contaminant with the mobility of water introduced at the surface and flushed into the ground water by precipitation. Most important, DRASTIC cannot be applied to areas smaller than one-hundred 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 fifteen 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 Clermont County. Inherent within each hydrogeologic setting are the physical characteristics which 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

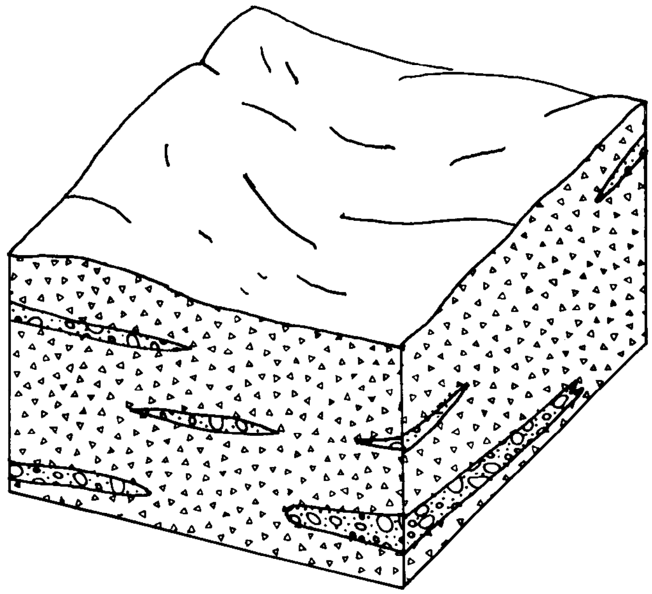
C - Conductivity (Hydraulic) of the Aquifer

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 into the aquifer measured in inches per year. Recharge water is available to transport a contaminant from the surface into the aquifer and also 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.



7Af Sand and Gravel Interbedded in Glacial Till

This hydrogeologic setting is characterized by low relief and flat-lying topography with sand and gravel deposits interbedded within glacial till. The till is composed primarily of clay with varying amounts of unsorted silt, sand, and gravel. The sand and gravel may be relatively thin and discontinuous lens-shaped bodies or they may be thick and cover a large area. These units are usually confined to common horizons within the till. Ground water occurs in both the till and the sand and gravel; however, the sand and gravel serves as the principal aquifer. Recharge to the sand and gravel is primarily due to infiltration of precipitation through the till. Depth to water is highly variable. Soils are typically classified as clay loam.

Figure 1. Format and description of the hydrogeologic setting - 7Af Sand and Gravel Interbedded in Glacial Till.

Soil media refers to the upper six feet of the unsaturated zone that is characterized by significant biological activity. The type of soil media can influence 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 amount of slope in an area affects the likelihood that a contaminant will run off from an area 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 significantly impacts 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 judgement. 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 to be used 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
Massive Shale	1-3	2
Metamorphic / Igneous	2-5	3
Weathered Metamorphic / Igneous	3-5	4
Glacial Till	4-6	5
Bedded Sandstone, Limestone and Shale Sequences	5-9	6
Massive Sandstone	4-9	6
Massive Limestone	4-9	6
Sand and Gravel	4-9	8
Basalt	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
Shrinking and / or Aggregated Clay	7
Sandy Loam	6
Loam	5
Silty Loam	4
Clay Loam	3
Muck	2
Nonshrinking and Nonaggregated 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
Bedded Limestone, Sandstone, Shale	4-8	6
Sand and Gravel with significant Silt and Clay	4-8	6
Metamorphic/Igneous	2-8	4
Sand and Gravel	6-9	8
Basalt	2-10	9
Karst Limestone	8-10	10
Weight: 5	Pesticide Weight: 4	

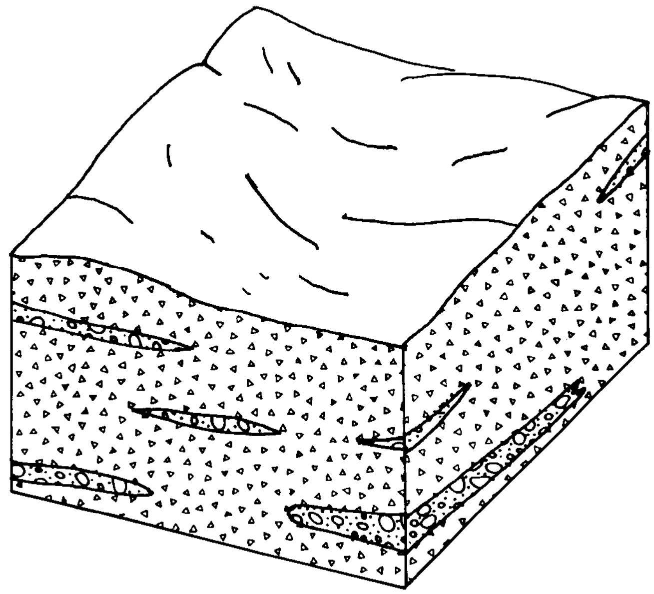
TABLE 8. RANGES AND RATINGS FOR HYDRAULIC CONDUCTIVITY

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 7Af1, Sand and Gravel Interbedded in Glacial Till, identified in mapping Clermont 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 98. 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 65 to 223. The diversity of hydrogeologic conditions in Clermont County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the five settings identified in the county range from 81 to 203.

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 Clermont 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 Clermont County is included with this report.



SETTING 7Af1		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	NUMBER
Depth to Water	15-30	5	7	35
Net Recharge	2 - 4	4	3	12
Aquifer Media	Sand & Gravel	3	4	12
Soil Media	Clay Loam	2	3	6
Topography	0-2%	1	10	10
Impact of Vadose Zone	Silt/Clay	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		DRASTIC	INDEX	98

Figure 2. Description of the hydrogeologic setting - 7Af1 Sand and Gravel Interbedded in Glacial Till.

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:

7Af1 - defines the hydrogeologic region and setting
98 - defines the relative pollution potential

Here the first number (7) refers to the major hydrogeologic region and the upper case (A) and lower case (f) refer 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 (98) 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 in an area.

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 CLERMONT COUNTY

Clermont County is located in the southwestern part of Ohio and occupies a total land area of 459 square miles (Lerch, et al., 1975). It is bordered to the north by Warren and Clinton Counties, to the South by the Ohio River, to the East by Brown County, and to the West by Hamilton County (Figure 3).

Climate

The climate of Clermont County is moderate and humid. The county's annual mean temperature over a 30 year period (1961 - 1990) at the Milford station in the north was 51.7 degrees Fahrenheit and at the Chilo station in the south was 53.3 degrees Fahrenheit (U.S. Department of Commerce, 1992). Annual average precipitation for the same time period at the same stations were 43.21 inches at Milford and 42.57 inches at Chilo (U.S. Department of Commerce, 1992).

Physiography

Clermont County is located in the Till Plains Section of the Central lowlands province (Fenneman, 1938). This area is characterized by broad, level to rolling uplands dissected by steep-sided stream valleys (Hunt, 1974). The topography in the upland areas primarily reflects the bedrock surface (i.e. "bedrock-controlled") due to the thin glacial cover in these areas.

Modern Drainage

Clermont County lies within the Ohio River Drainage Basin. Indian Creek, located in southern Clermont County, drains directly into the Ohio River. Most of the central and southern portion of the county drains into the East Fork Little Miami River. Stonelick Creek is the largest tributary and drains north central Clermont County. The East Fork Little Miami River empties into the Little Miami River in Hamilton County. O'Bannon Creek, which drains the far northern portion of the county, empties into the Little Miami River near the Warren County boundary.

Figure 3. Location of Clermont County in Ohio.

Pre-glacial and Pleistocene Drainage

The pre-glacial drainage of Clermont County is complex and still poorly understood. The major drainage pathway is represented by the westward-trending buried valley occupying central Clermont County. The present East Fork Little Miami River overlies this buried valley west of East Fork Reservoir (William H. Harsha Lake). The unnamed Teays-age stream which initially cut this buried valley flowed westward into Hamilton County. Two differing theories exist for drainage in Hamilton County at this time. Stout et al., (1943) speculated that the overall drainage was to the southwest via the Hamilton River. Stout et al., (1943) depict the Hamilton River following a course roughly similar to the ancestral Ohio River. Coffee (1956) and Durell (1982) proposed that the overall drainage was to the northeast via the Licking River. The Licking River flowed northeast, merging with the Teays River Drainage System north of Dayton. The Teays River entered Ohio at Portsmouth and flowed north to Chillicothe. From Chillicothe, the Teays flowed northwestward, passing north of Springfield and eventually entering Indiana near Celina in Mercer County (Ohio Department of Natural Resources, 1976).

With the advance of the initial ice sheet, the Teays drainage and the ancestral Ohio River drainage were blocked. Large lakes were created as streams backed up due to this blockage. Eventually, these lakes breached their divides and cut a new sequence of channels, creating a new drainage system (Coffee, 1956 and Smallwood, 1958). This new system is referred to as the Deep Stage, as it cut broad, deep channels into the bedrock. The westerly- flowing stream draining Clermont County was deepened considerably at this time. This new deeper drainage is referred to by Stout et al., (1943) as Batavia Creek.

Subsequent ice advances during the Illinoian glacial period filled this valley with a mixture of dense glacial till, fine lacustrine (lake) materials, and minor sands (Kohut et al., 1973, Gibbons et al., 1975 and Brockman, 1989). Meltwater from the later Wisconsinan glacial period deposited outwash within the Little Miami River Valley.

Glacial Geology

During the Pleistocene Epoch, several episodes of ice advance occurred throughout Ohio. The oldest advances are now conventionally referred to as pre-Illinoian (formerly Kansan) in age and are at least 730,000 years before present (Y.B.P.) in age. Evidence for these ancient deposits is lacking in Clermont County. Evidence for pre-Illinoian deposits has been inferred from buried soil profiles identified in western Hamilton County (Norton et al., 1983).

The ice advance associated with the Illinoian Stage (at least 120,000 Y.B.P.) covered all of Clermont County (White et al., 1961). It is not known how many ice advances occurred during the Illinoian or the amount of ice coverage that occurred with each advance. Each ice advance deposited variable thicknesses of glacial till across the county. Till is an unsorted, non-bedded mixture of clay, silt, sand, and gravel directly deposited by the ice sheet. There are two main types or facies, of till. Lodgement till tends to be dense, compact, and contain more angular rock fragments. Ablation, or "melt-out" till tends to be less dense and compacted, slightly sandier, and contains more rounded rock fragments and gravel. Specific tills have not been differentiated in Clermont County.

The thickness of till in the uplands of Clermont County ranges from a few feet to upwards of 30 feet. An exposure of till near Batavia has been extensively studied for many years (Goldthwait et al., 1981 and Teller, 1970). Thicker till exists within the buried valley underlying East Fork Little Miami River. This buried valley also contains minor silts and outwash deposits (Brockman, 1989). Across the majority of Clermont County, the till has been mapped as Illinoian ground moraine by Forsyth et al., (1993) and Goldthwait et al., (1993). Clermont County lacks any identifiable end ("ridge") moraines. A portion of far southern Clermont County is mapped as dissected moraine (Goldthwait et al., 1993) where the till is particularly thin over the underlying bedrock. Till across Clermont County is highly weathered, particularly where the till thinly covers the underlying bedrock.

The majority of upland areas in Clermont County are covered by variable thicknesses of loess. Loess is a deposit derived from the wind picking up fine, silt-sized particles covering the floodplains of wide stream valleys. Loess is commonly found mantling till and bedrock uplands to the east ("downwind") of major valleys. Thickness of loess is typically under 10 feet. Weathering and soil development are in part dependent upon the amount of loess overlying till in given areas.

The ground moraine areas also contain thin slackwater or lacustrine deposits. These deposits consist of fine-grained materials washed into low, depressional areas during the melting of the ice sheets. These deposits tend to be poorly drained and may be difficult to distinguish from loess in some areas.

Ice from the last (Wisconsinan) ice advance (approximately 20,000 Y.B.P.) did not extend into Clermont County. Meltwater from this ice advance deposited outwash along the Little Miami River Valley. Outwash is a bedded, sorted meltwater deposit comprised of sand and gravel with minor silts. Outwash is typically deposited by braided streams which migrate across the valley floor and leave behind a complex record of deposition and erosion. Modern streams have since downcut and dissected the pre-existing outwash deposits. Remnants of the outwash are referred to as terraces and are typically found at higher elevations than the modern alluvium.

Deposits flanking the Ohio River include both sand and gravel outwash covered by varying thicknesses of finer-grained recent alluvium (Osborne, 1970, Kohut et al., 1973, and Gibbons et al., 1975). The coarser materials appear to extend upstream for short distances in some of the minor tributaries of the Ohio River.

Bedrock Geology

The bedrock exposed in Clermont County consists of interbedded thin limestones and shales of the Ordovician System. The exposed stratigraphic sequence ranges from the Point Pleasant Formation in the southern portion of the county to the Waynesville Formation in the northern end of the county.

Table 9 summarizes the bedrock stratigraphy in Clermont County. Excellent descriptions of the Ordovician rocks appear in Tobin (1986), Schumacher et al., (1987), and Schumacher et al., (1991).

The Ordovician System is characterized by thin, soft, calcareous shales interbedded with thin, hard layers of limestone. Both the shales and limestones are fossiliferous. The units are predominantly differentiated upon the relative proportion of shale versus limestone. Particular fossil assemblages are also useful in helping to differentiate units.

Sedimentation was influenced during the late Ordovician by the presence of the Cincinnati Arch, a broad, gently-sloping structural platform or ridge. The Arch plunges gently to the north and the flanks dip gently to the west and east (Green, 1957 and Schumacher et al., 1987). The development of the Arch coincided with the development of the Appalachian, Illinoian, and Michigan Basins (Janssens, 1967 and Schumacher et al., 1987). It is believed that the arch was formed by the subsidence of surrounding basins and not from a regional uplift (Scotford, 1964 and Schumacher et al., 1987).

Deposition occurred along a shallow marine shelf environment along the rise associated with the Cincinnati Arch. Limestones were deposited in these areas containing shallow, clear water and abundant marine life. The water deepened to the east of the arch where a shallow sea existed between the Arch and the ancestral Appalachian Mountain chain. The uplift and erosion of the ancestral Appalachians provided a source for abundant fine sediments. These sediments were washed into the shallow sea where storm events suspended them and redeposited them along the shelf. Shaley units reflect these clastic, land-derived deposits. The alternating shales and limestones reflect the cyclic fluctuation between the two modes of sedimentation.

TABLE 9. GENERALIZED BEDROCK STRATIGRAPHY OF CLERMONT COUNTY, OHIO

SYSTEM	SERIES	STAGE	FORMATION AND MEMBER		ROCK TYPE
ORDOVICIAN	CINCINNATIAN	RICHMONDIAN	Waynesville Formation		Interbedded shale and limestone (shale 65% or more of unit)
			Arnheim Formation		Interbedded limestone and shale
		MAYSVILLIAN	Grant Lake Foramtion	Mt. Auburn Member	Limestone and shale (shale 60% or more of unit)
				Corryville Member	Interbedded limestone and shale (shale 60% or more of unit)
				Bellevue Member	Limestone
			Miamitown Formation		Interbedded shale and limestone (shale averages 60% of unit)
			Fairview Formation		Interbedded shale and limestone (shale averages 60% of unit)
		EDENIAN	Kope Formation		Interbedded shale and limestone (shale 75% or more of unit)
			Point Pleasant Formation		Interbedded shale and limestone (shale averages 40-50% of unit)

Hydrogeology

Ground water in Clermont County is obtained from both glacial (unconsolidated) deposits and bedrock. Glacial aquifers are primarily limited to major buried valley systems (University of Cincinnati Ground Water Research Center, 1989). Sand and gravel lenses found in the valley underlying East Fork Little Miami River typically yield from 10 to 20 gallons per minute (gpm) (Walker, 1986). The best aquifers in the county are limited to areas immediately adjacent to the Little Miami River and the Ohio River. Yields from properly developed, large diameter wells range from 100 gpm to 800 gpm (Walker, 1986). Test drilling may be necessary to locate the higher yielding sand and gravel zones. Yields capable of supplying domestic needs can be obtained from sand and gravel lenses found within the short tributary valleys leading into the Ohio River Valley.

Throughout most of the uplands in Clermont County, the glacial drift is thin and is dominated by fine-grained glacial tills. Wells developed in the shallow sand and gravel lenses interbedded in the tills are rare. These wells typically have yields under 5 gpm and are suitable for domestic use. The ground water potential of the Ordovician bedrock is very limited. Yields from the interbedded limestones and shales generally average less than 3 gpm (Walker, 1986). Reports of dry holes are not uncommon and usage of low-yielding water systems and cisterns is necessary in many areas. Wells developed in bedrock are barely adequate for supplying domestic and small farm needs.

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APPENDIX A

DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

In determining the depth to water, approximately 600 well logs on file at the Ohio Department of Natural Resources Division of Water were used as a primary source of data. The majority of the logged wells were situated in the metropolitan areas of Clermont County in the buried valleys and along the Ohio River. Analysis of areas where well logs were scarce required interpretation of the topography and the surfical geology to determine the rating for the depth to water. In both the buried valley (7D), and river alluvium (7Ea) settings, the depth to water ranged from 5-15 feet (DRASTIC rating: 9) around the rivers and streams, and from 15-30 feet (7) where recharge from the rivers and streams was not a factor. In the upland areas of Clermont County (7Aa, 7G, and 7Af), depth to water was mainly 15-30 feet (7) although depth to water of 5-15 feet (9) and 30-50 feet (5) were found in localized areas.

In the hydrogeologic setting 7Aa18, a semi-confined aquifer condition exists. The DRASTIC method can only be used for confined and unconfined conditions. When semi-confined conditions exist, the aquifer must be selected as confined or unconfined (Aller, et al., 1987). Since in 7Aa18, the confining layer is approximately 30 feet in thickness, an unconfined condition was selected and the depth to water interpreted at the static water levels which ranged 5-15 feet (9) from the ground surface.

Net Recharge

As defined by the DRASTIC method, net recharge is the total quantity of water applied to the ground surface which infiltrates and reaches the aquifer (Aller, et al., 1987). Few quantative studies of net recharge have been conducted in southwestern Ohio (University of Cincinnati Ground Water Research Center, 1989). Values for net recharge were determined by meetings held with Rebecca Petty and Mike Hallfrish at the Ohio Department of Natural Resources, and use of professional judgement. Factors influencing net recharge values include slope of topography, soil media, vadose zone composition, and location of aquifers relative to rivers and streams.

In the upland areas (7Aa, 7G), net recharge values were 2-4 inches per year (1). Where sand and gravel lenses in glacial till were located (7Af), net recharge ranged from 4-7 inches per year (6) where depth to water was 15-30 feet, and 2-4 inches per year (1) where depth to water was 30-50 feet.

In the buried valley (7D) and along the Ohio river (7Ea), net recharge ranged from 7-10 (8), to 10+ (9), inches per year. The high values were influenced by the close proximity of the aquifers to the rivers and streams, flat topography, and the depth to water. Farther away from the rivers the net recharge values fell to 4-7 inches per year (6) due to the steeper slope in topography and higher silt/clay content in the soil, vadose, and aquifer materials.

Aquifer Media

Aquifer characteristics were evaluated from the well logs obtained from the Ohio Department of Natural Resources and from the Clermont County Ground Water Resource Map (Walker, 1986).

In the buried valley, aquifer material consisted of thick glacial outwash sand and gravel deposits with interbedded layers of clay and till. Deposits near the Little Miami River vary in lateral extent and contain less clay and till. A rating of (9) has been assigned to these deposits because of their capability for yielding large quantities of water. As the buried valley trends southwest, the clay and till content becomes greater, lowering the yield of the sand and gravel deposits. Ratings of (7) and (6) have been assigned to correspond to the decrease in the yield capability of the aquifer material.

Along the Ohio River, alluvial deposits consist of sand and gravel interbedded with clay and till. Ratings of (9) and (8) were assigned to the deposits close to the river because of the high yield capability and the recharge potential from the river. Deposits farther away from the river were given ratings of (7) and (6) because these aquifer materials increase in clay and till content and thin on approaching the valley wall.

In the upland areas, the principal aquifer materials are interbedded limestone and shale bedrock. Ratings of (2) and (3) were selected for these aquifer materials because of their high clay content and very low permeability. In scattered areas of the uplands where the glacial till was thick, interbedded sand and gravel lenses exist. These aquifers are high in clay content and are capable of low to moderate yields of water. Ratings of (5) and (4) were assigned to these sand and gravel lenses.

Soil Media

The Clermont County Soil Survey (Lerch, et al., 1975) was used to determine the soil parameter. The detailed aerial photographs of the soils were generalized for the DRASTIC method. The soils were classified according to U.S.D.A. categories for texture, permeability, and shrink-swell potential. Six DRASTIC soils were identified using this method. They are: clay loam (3), silt loam (4), loam (5), sandy loam (6), shrinking/aggregated clay (7), and sand (9).

Soils overlying the hydrogeologic settings 7D Buried Valley and 7Aa Glacial Till Over Bedded Sedimentary Rock were highly variable and ranged from clay loam (3) to sand (9).

In the hydrogeologic setting 7Ea River Alluvium With Overbank Deposits, three of the soil types covered the area. Silt loam (4) was the prominent soil, followed by sand (9), and loam (5).

The three soil types clay loam (3), loam (5), and shrinking/aggregated clay composed the soils for the setting 7Af Sand and Gravel Interbedded in Glacial Till.

The setting 7G Thin Till Over Interbedded Sedimentary Bedrock consisted of only two soil types. These soils were clay loam (3) and shrinking/aggregated clay (7).

Topography

Percent slope was calculated using 7 1/2 minute United States Geological Survey topographic quadrangle maps. The slope and topography of Clermont County is highly variable. Slopes ranged from 0-2% (10) in the buried valley, river alluvium, and upland areas to well over 18% (1) along hillsides.

Impact of the Vadose Zone Media

Decisions for determining the vadose parameter were made using well logs obtained from the Ohio Department of Natural Resources' files. Materials in the vadose zone were assumed to be homogeneous throughout Clermont County with respect to the hydrogeological settings (Wright State University Center For Ground Water Management, 1989).

In the upland areas, the vadose zone consisted of silt/clay and was given a rating of (3) and (4). In those areas in the uplands where the till was thicker the vadose was composed of sand and gravel with significant silt and clay and were given a rating of (5). The rating of (5) was established due to the high content of silt/clay associated with the sand and gravel.

In the buried valley and river alluvium settings the vadose materials consisted of sand and gravel with significant silt and clay. The rating of (6) was established for the parameters situated away from the rivers where recharge to the aquifer was not a factor. All other parameters close to the rivers were rated at (7).

Hydraulic Conductivity

Hydraulic conductivity ratings for the hydrogeologic settings were based on the Ground Water Resource Map of Clermont County, and boring logs from Dames and Moore of the Little Miami River Province VIII (Dames & Moore, 1971a), and Southwest One Test Well located 225 feet East of the Ohio River (Dames & Moore, 1971b).

In the upland areas, hydraulic conductivity for the interbedded limestone and shale aquifer was rated 1-100 gallons per day per foot squared (gpd/ft^2) (1). Where the till was thicker and aquifers with lenses of sand and gravel were found, hydraulic conductivity ranged from 1-100 gpd/ft^2 (1) to 300-700 gpd/ft^2 (4).

The river alluvium aquifer along the Ohio River had a varying range of hydraulic conductivities. Tests made by Dames & Moore at the Southwest One test well in 1971 showed a transmissivity of 100,000 gallons per day per foot (Dames & Moore, 1971b). This well was located 225 feet east of the river. The average thickness of the aquifer is approximately 50 feet.

Due to these data and the high recharge rate of the aquifer from the river, a hydraulic conductivity of 2000+ gpd/ft^2 (10) was selected for areas adjacent to the Ohio River. Farther away from the river, hydraulic conductivity values ranged from 1000-2000 gpd/ft^2 (8) and 700-1000 gpd/ft^2 (6) to 300-700 gpd/ft^2 (4). Ratings were selected for these areas depending on the clay content associated with the aquifer. Generally the aquifer material has more clay content as it approaches the valley wall, thus lowering the hydraulic conductivity.

The buried valley aquifer also had varying ranges of hydraulic conductivity. A hydraulic survey conducted by Dames & Moore (Buried Valley 8) showed hydraulic conductivities of 2000+ gpd/ft^2 (10) close to the Little Miami River (Dames & Moore, 1971a). Following the trend of the buried valley to the southeast, the silt/clay content increased and thereby decreased the hydraulic conductivity. The Ground Water Resource Map of Clermont County, made by Walker, was used to designate the change in the aquifer, and the hydraulic conductivity was rated accordingly. Hydraulic conductivity for this area ranged from 700-1000 gpd/ft^2 (6) in the northwest part of the buried valley and from 300-700 gpd/ft^2 (4) in the southeastern section.

APPENDIX B

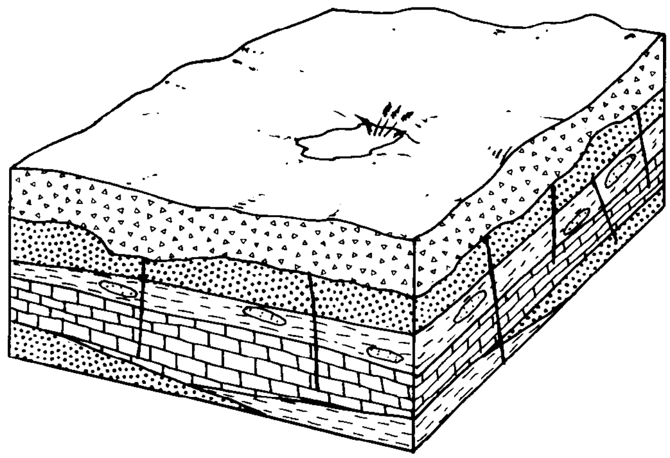
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Clermont County resulted in the identification of nine 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 10. Computed pollution potential indexes for Clermont County range from 81 to 203.

Table 10. Hydrogeologic Settings Mapped in Clermont County, Ohio

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
7Aa - Glacial Till Over Bedded Sedimentary Rock	83 - 114	45
7Af - Sand & Gravel Interbedded in Glacial Till	81 - 140	18
7D - Buried Valley	130 -196	18
7Ea - River Alluvium With Overbank Deposits	142 - 203	11
7G - Thin Till Over Bedded Sedimentary Rock	86 - 94	3

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 indexes were 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.



7Aa Glacial Till Over Bedded Sedimentary Rock

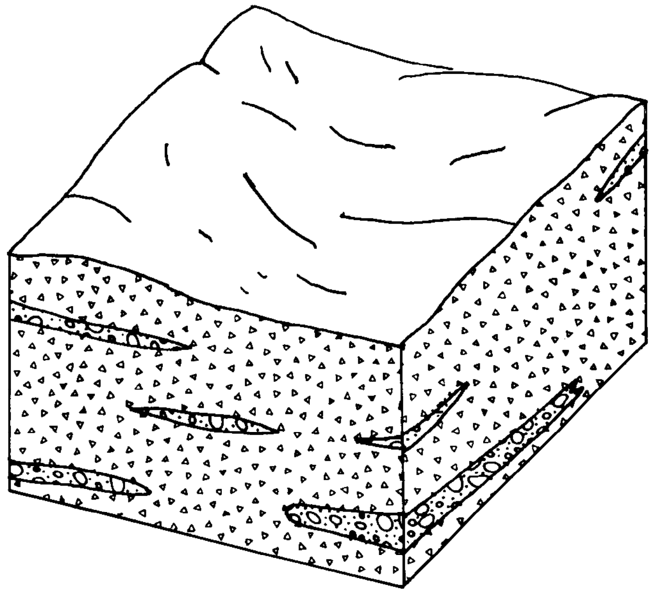
This hydrogeologic setting is characterized by low topography and relatively flat-lying, fractured sedimentary interbedded shale and limestone of Ordovician age. The bedrock is covered by varying thickness of glacial till, which is interbedded with sand, gravel, silt, and clay. Although ground water does occur in the glacial deposits, the bedrock is the principal aquifer. The glacial till serves as a source of recharge to the aquifer. Recharge to the area is low to moderate because of the high silt/clay content both in the glacial till and the soils. Depth to water is extremely variable, but usually ranges anywhere between 15 to 30 feet.

GWPP index values for the hydrogeologic setting of glacial till over bedded sedimentary rock range from 83 to 114 with a total number of GWPP index calculations equaling 45.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Aa1	15-30	2-4	Interbedded Limestone and Shale	Clay Loam	0-2	Silt/Clay	1-100	95	119
7Aa2	15-30	2-4	Interbedded Limestone and Shale	Clay Loam	18+	Silt/Clay	1-100	86	92
7Aa3	5-15	2-4	Interbedded Limestone and Shale	Clay Loam	18+	Silt/Clay	1-100	93	99
7Aa4	5-15	2-4	Interbedded Limestone and Shale	Loam	18+	Silt/Clay	1-100	97	109
7Aa5	5-15	2-4	Interbedded Limestone and Shale	Sandy Loam	12-18	Silt/Clay	1-100	101	120
7Aa6	5-15	2-4	Interbedded Limestone and Shale	Sand	18+	Silt/Clay	1-100	105	129
7Aa7	5-15	2-4	Interbedded Limestone and Shale	Sand	0-2	Silt/Clay	1-100	114	156
7Aa8	30-50	2-4	Interbedded Limestone and Shale	Clay Loam	0-2	Silt/Clay	1-100	85	109
7Aa9	15-30	2-4	Interbedded Limestone and Shale	Clay Loam	12-18	Silt/Clay	1-100	88	98
7Aa10	5-15	2-4	Interbedded Limestone and Shale	Clay Loam	12-18	Silt/Clay	1-100	98	108

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Aa11	5-15	2-4	Interbedded Limestone and Shale	Loam	0-2	Silt/Clay	1-100	109	139
7Aa12	15-30	2-4	Interbedded Limestone and Shale	Clay Loam	6-12	Silt/Clay	1-100	90	104
7Aa13	15-30	2-4	Interbedded Limestone and Shale	Loam	12-18	Silt/Clay	1-100	92	108
7Aa14	15-30	2-4	Interbedded Limestone and Shale	Sand	12-18	Silt/Clay	1-100	100	128
7Aa15	15-30	2-4	Interbedded Limestone and Shale	Sandy Loam	0-2	Silt/Clay	1-100	101	134
7Aa16	15-30	2-4	Interbedded Limestone and Shale	Loam	0-2	Silt/Clay	1-100	99	129
7Aa17	15-30	2-4	Interbedded Limestone and Shale	Loam	2-6	Silt/Clay	1-100	98	126
7Aa18	5-15	2-4	Interbedded Limestone and Shale	Clay Loam	0-2	Silt/Clay	1-100	105	129
7Aa19	5-15	2-4	Interbedded Limestone and Shale	Loam	6-12	Silt/Clay	1-100	104	124
7Aa20	15-30	2-4	Interbedded Limestone and Shale	Shrinking and/or Aggregated C	6-12	Silt/Clay	1-100	98	124
7Aa21	5-15	2-4	Interbedded Limestone and Shale	Shrinking and/or Aggregated C	6-12	Silt/Clay	1-100	108	134
7Aa22	15-30	2-4	Interbedded Limestone and Shale	Shrinking and/or Aggregated C	12-18	Silt/Clay	1-100	96	118
7Aa23	15-30	2-4	Interbedded Limestone and Shale	Silty Loam	18+	Silt/Clay	1-100	83	93
7Aa24	5-15	2-4	Interbedded Limestone and Shale	Clay Loam	12-18	Silt/Clay	1-100	95	105
7Aa25	15-30	2-4	Interbedded Limestone and Shale	Clay Loam	12-18	Silt/Clay	1-100	85	95
7Aa26	15-30	2-4	Interbedded Limestone and Shale	Clay Loam	2-6	Silt/Clay	1-100	94	116
7Aa27	15-30	2-4	Interbedded Limestone and Shale	Loam	18+	Silt/Clay	1-100	90	102
7Aa28	5-15	2-4	Interbedded Limestone and Shale	Shrinking and/or Aggregated C	18+	Silt/Clay	1-100	101	119
7Aa29	5-15	2-4	Interbedded Limestone and Shale	Silty Loam	12-18	Silt/Clay	1-100	100	113
7Aa30	5-15	2-4	Interbedded Limestone and Shale	Shrinking and/or Aggregated C	12-18	Silt/Clay	1-100	103	125
7Aa31	5-15	2-4	Interbedded Limestone and Shale	Silty Loam	0-2	Silt/Clay	1-100	107	134
7Aa32	5-15	2-4	Interbedded Limestone and Shale	Loam	12-18	Silt/Clay	1-100	102	118
7Aa33	5-15	2-4	Interbedded Limestone and Shale	Loam	12-18	Silt/Clay	1-100	99	115
7Aa34	15-30	2-4	Interbedded Limestone and Shale	Silty Loam	18+	Silt/Clay	1-100	88	97
7Aa35	15-30	2-4	Interbedded Limestone and Shale	Sand	0-2	Silt/Clay	1-100	107	149
7Aa36	5-15	2-4	Interbedded Limestone and Shale	Silty Loam	2-6	Silt/Clay	1-100	98	124
7Aa37	5-15	2-4	Interbedded Limestone and Shale	Clay Loam	18+	Silt/Clay	1-100	96	102
7Aa38	5-15	2-4	Interbedded Limestone and Shale	Loam	2-6	Silt/Clay	1-100	100	129
7Aa39	15-30	2-4	Interbedded Limestone and Shale	Silty Loam	12-18	Silt/Clay	1-100	90	103

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Aa40	15-30	2-4	Interbedded Limestone and Shale	Sandy Loam	12-18	Silt/Clay	1-100	91	110
7Aa41	15-30	2-4	Interbedded Limestone and Shale	Silty Loam	0-2	Silt/Clay	1-100	97	124
7Aa42	5-15	2-4	Interbedded Limestone and Shale	Clay Loam	2-6	Silt/Clay	1-100	104	126
7Aa43	5-15	2-4	Interbedded Limestone and Shale	Clay Loam	6-12	Silt/Clay	1-100	100	114
7Aa44	5-15	2-4	Interbedded Limestone and Shale	Shrinking and/or Aggregated C	2-6	Silt/Clay	1-100	112	146
7Aa45	15-30	2-4	Interbedded Limestone and Shale	Shrinking and/or Aggregated C	18+	Silt/Clay	1-100	94	112



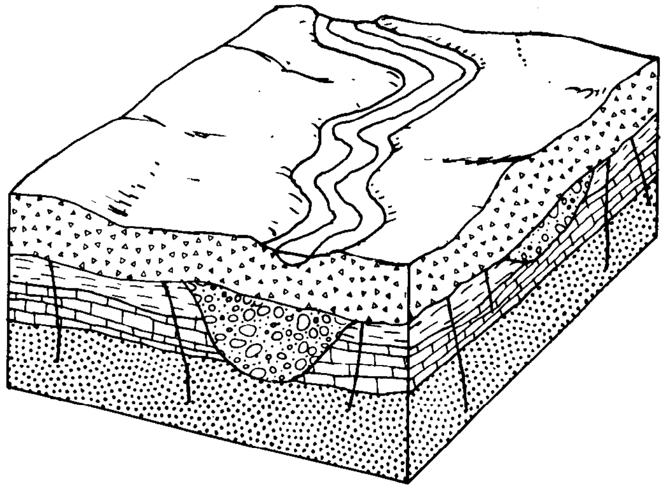
7Af Sand and Gravel Interbedded in Glacial Till

This hydrogeologic setting is characterized by low relief with sand and gravel deposits interbedded within glacial till. The till is composed primarily of clay with varying amounts of unsorted silt, sand, and gravel. The sand and gravel deposits may be relatively thin and discontinuous lens-shaped bodies or they may be thick and cover a large area. These units are usually confined to common horizons within the till. Ground water occurs in both the till and the sand and gravel. However, the sand and gravel serves as the principal aquifer. Recharge to the sand and gravel is primarily due to infiltration of precipitation through the till. Depth to water is highly variable. Soils are typically classified as clay loam.

GWPP index values for the hydrogeologic setting of sand and gravel interbedded in glacial till range from 81 to 140 with a total number of GWPP index calculations equaling 17.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Af1	15-30	2-4	Sand and Gravel	Clay Loam	0-2	Silt/Clay	1-100	98	122
7Af2	5-15	2-4	Sand and Gravel	Clay Loam	18+	Silt/Clay	1-100	99	105
7Af3	30-50	2-4	Sand and Gravel	Clay Loam	12-18	Silt/Clay	1-100	81	91
7Af4	30-50	2-4	Sand and Gravel	Clay Loam	0-2	Silt/Clay	1-100	88	112
7Af5	30-50	2-4	Sand and Gravel	Loam	18+	Silt/Clay	1-100	83	95
7Af6	15-30	4-7	Sand and Gravel	Clay Loam	12-18	Sand and Gravel w/ Silt and Clay	300-700	120	126
7Af7	15-30	4-7	Sand and Gravel	Clay Loam	0-2	Sand and Gravel w/ Silt and Clay	300-700	127	147
7Af8	5-15	4-7	Sand and Gravel	Loam	12-18	Sand and Gravel w/ Silt and Clay	300-700	134	146
7Af9	50-75	4-7	Sand and Gravel	Clay Loam	0-2	Sand and Gravel w/ Silt and Clay	300-700	107	127

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Af10	50-75	4-7	Sand and Gravel	Clay Loam	0-2	Sand and Gravel w/ Silt and Clay	300-700	107	127
7Af11	50-75	4-7	Sand and Gravel	Loam	12-18	Sand and Gravel w/ Silt and Clay	300-700	104	116
7Af12	15-30	4-7	Sand and Gravel	Loam	12-18	Sand and Gravel w/ Silt and Clay	300-700	124	136
7Af14	15-30	4-7	Sand and Gravel	Loam	0-2	Sand and Gravel w/ Silt and Clay	300-700	131	157
7Af16	5-15	4-7	Sand and Gravel	Loam	2-6	Sand and Gravel w/ Silt and Clay	300-700	140	164
7Af17	15-30	4-7	Sand and Gravel	Shrinking and/or Aggregated C	12-18	Sand and Gravel w/ Silt and Clay	300-700	128	146
7Af18	5-15	2-4	Sand and Gravel	Loam	2-6	Sand and Gravel w/ Silt and Clay	300-700	125	149
7Af19	30-50	2-4	Sand and Gravel	Clay Loam	2-6	Sand and Gravel w/ Silt and Clay	300-700	101	119



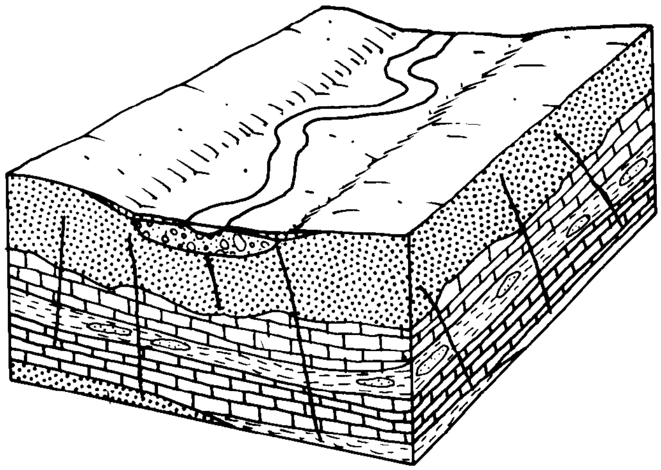
7D Buried Valley

This hydrogeologic setting is characterized by thick deposits of sand and gravel that have been deposited in a former topographic low (usually a preglacial river valley) by glacial meltwaters. The East Fork of the Little Miami River and the Little Miami River overlie the buried valley deposits and are in direct hydraulic connection with them. The deposits are made up of recent alluvial sand, gravel, silt, and clay. Soils in the buried valley are highly variable, ranging from clay loam to sand. Recharge to the sand and gravel deposits is high close to the Little Miami River and moderate as the buried valley trends southeast. Depth to water is usually shallow (5-15 ft.), although it can be quite variable.

GWPP index values for the hydrogeologic setting of buried valley range from 130 to 196 with a total number of GWPP index calculations equaling 17.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7D1	15-30	4-7	Sand and Gravel	Clay Loam	0-2	Sand and Gravel w/ Silt and Clay	300-700	135	154
7D2	5-15	4-7	Sand and Gravel	Loam	0-2	Sand and Gravel w/ Silt and Clay	300-700	149	174
7D5	15-30	4-7	Sand and Gravel	Silty Loam	0-2	Sand and Gravel w/ Silt and Clay	300-700	137	159
7D6	5-15	4-7	Sand and Gravel	Loam	0-2	Sand and Gravel w/ Silt and Clay	700-1000	158	181
7D7	15-30	4-7	Sand and Gravel	Silty Loam	0-2	Sand and Gravel w/ Silt and Clay	700-1000	146	166
7D8	5-15	4-7	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel w/ Silt and Clay	700-1000	160	186
7D9	15-30	4-7	Sand and Gravel	Shrinking and/or Aggregated C	0-2	Sand and Gravel w/ Silt and Clay	700-1000	152	181
7D10	15-30	10+	Sand and Gravel	Sand	0-2	Sand and Gravel	2000+	196	225
7D11	15-30	10+	Sand and Gravel	Loam	0-2	Sand and Gravel	2000+	188	205
7D12	15-30	10+	Sand and Gravel	Sand	0-2	Sand and Gravel w/ Silt and Clay	700-1000	176	210
7D13	15-30	10+	Sand and Gravel	Silty Loam	0-2	Sand and Gravel	2000+	186	200

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7D14	15-30	10+	Sand and Gravel	Shrinking and/or Aggregated C	0-2	Sand and Gravel w/ Silt and Clay	2000+	187	211
7D15	15-30	10+	Sand and Gravel	Loam	0-2	Sand and Gravel	2000+	193	209
7D16	5-15	4-7	Sand and Gravel	Loam	0-2	Sand and Gravel w/ Silt and Clay	100-300	140	167
7D17	15-30	4-7	Sand and Gravel	Loam	0-2	Sand and Gravel w/ Silt and Clay	100-300	130	157
7D18	15-30	4-7	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel w/ Silt and Clay	100-300	132	162
7D19	5-15	7-10	Sand and Gravel	Loam	0-2	Sand and Gravel w/ Silt and Clay	1000-2000	180	200

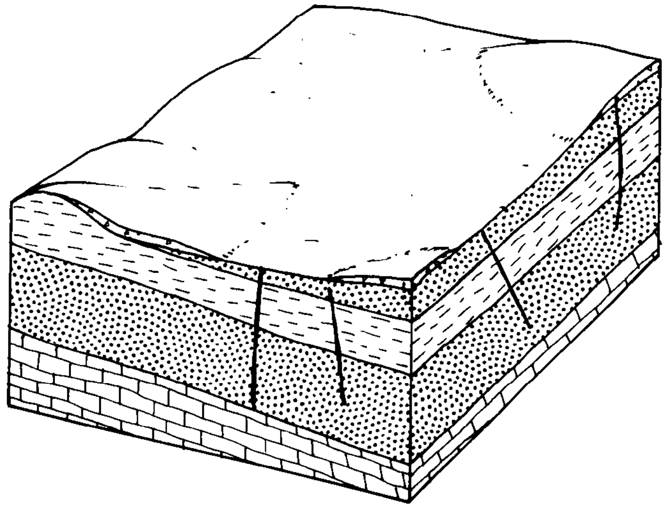


7Ea River Alluvium With Overbank Deposits

This hydrogeologic setting is characterized by low topography and thin to moderately thick layers of flood-deposited alluvium along portions of the river valley. The alluvium is underlain by fractured bedrock of sedimentary origin. Water is obtained from sand and gravel layers which are interbedded with finer overbank deposits of varying thicknesses of silt and clay. Water levels are moderately shallow. Ground water usually is in direct hydraulic connection with the surface stream. Alluvium serves as a significant source of water and may also be in direct hydraulic connection with the underlying sedimentary rocks.

GWPP index values for the hydrogeologic setting of river alluvium with overbank deposits range from 142 to 203 with a total number of GWPP index calculations equaling 10.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ea1	5-15	10+	Sand and Gravel	Silty Loam	0-2	Sand and Gravel w/ Silt and Clay	2000+	191	206
7Ea4	15-30	10+	Sand and Gravel	Silty Loam	0-2	Sand and Gravel w/ Silt and Clay	2000+	181	196
7Ea5	5-15	4-7	Sand and Gravel	Loam	0-2	Sand and Gravel w/ Silt and Clay	700-1000	158	181
7Ea6	5-15	4-7	Sand and Gravel	Loam	0-2	Sand and Gravel w/ Silt and Clay	300-700	149	174
7Ea7	5-15	4-7	Sand and Gravel	Sand	0-2	Sand and Gravel w/ Silt and Clay	300-700	157	194
7Ea8	15-30	4-7	Sand and Gravel	Silty Loam	0-2	Sand and Gravel w/ Silt and Clay	300-700	142	163
7Ea9	15-30	10+	Sand and Gravel	Loam	0-2	Sand and Gravel w/ Silt and Clay	2000+	183	201
7Ea10	15-30	10+	Sand and Gravel	Silty Loam	0-2	Sand and Gravel	2000+	191	204
7Ea11	5-15	10+	Sand and Gravel	Gravel	0-2	Sand and Gravel w/ Silt and Clay	2000+	203	236
7Ea12	15-30	4-7	Sand and Gravel	Sand	0-2	Sand and Gravel w/ Silt and Clay	300-700	147	184



7G Thin Till Over Sedimentary Rocks

This hydrogeologic setting is characterized by moderate to low topography. It has deposits of thin glacial till overlying the interbedded limestone and shale bedrock of Ordovician age. Since the till is so thin, the bedrock is the principal aquifer. Ground water does occur in the till and is a source of recharge to the bedrock aquifer. Although precipitation is abundant in most of the region, recharge is moderate because of the glacial tills and clay-rich soils. Water levels are extremely variable, but depths to water are usually moderate.

GWPP index values for the hydrogeologic setting of thin till over sedimentary rocks range from 86 to 94 with a total number of GWPP index calculations equaling 3.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7G1	15-30	2-4	Interbedded Limestone and Shale	Shrinking and/or Aggregated C	18+	Silt/Clay	1-100	94	112
7G2	15-30	2-4	Interbedded Limestone and Shale	Shrinking and/or Aggregated C	18+	Silt/Clay	1-100	86	105
7G3	15-30	2-4	Interbedded Limestone and Shale	Clay Loam	6-12	Silt/Clay	1-100	90	104

Ground Water Pollution Potential of
CLERMONT COUNTY

by
Ohio Department of Natural Resources, Division of Water
and
The Center for Ground Water Management, Wright State University
Ronald G. Schmidt, Project Manager
James A. Wasserbauer, Project Assistant
Lori L. Wenz, Project Assistant

County Line
Township Line
Incorporated City Limit

Miles
Kilometers

CONTOUR INTERVAL 10 FEET OR 20 FEET

Pollution Potential Index Range

Higher	200+
	180 - 199
	160 - 179
to	140 - 159
	120 - 139
	100 - 119
Lower	80 - 99

Hydrogeologic Settings

7Aa - Glacial Till Over Bedded Sedimentary Rock
7Af - Sand and Gravel Interbedded in Glacial Till
7D - Buried Valley
7Ea - Alluvium With Overbank Deposits
7G - Thin Till Over Bedded Sedimentary Rock

A more detailed description of the hydrogeologic settings and the evaluation of the pollution potential may be found in the publication "Ground-Water Pollution Potential of Clermont County", GWPP Report No. 18, Ohio Department of Natural Resources, Division of Water.

Description of Map Symbols

Hydrogeologic Region
Hydrogeologic Setting
7Ad6
98 - Relative Pollution Potential

Gravel Pit / Quarry

The ground water pollution potential of this county has been mapped using the methodology described in U.S. EPA Publication EPA/600-2-87/035, "DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings" (Aller et al., 1987).

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