GROUND WATER POLLUTION POTENTIAL OF LAKE COUNTY, OHIO

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ABSTRACT

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

Hydrogeologic settings incorporate the major hydrogeologic factors that control ground water movement and occurrence, including depth to water, net recharge, aquifer media, soil media, topography, impact of the vadose zone media, and hydraulic conductivity of the aquifer. The relative ranking scheme uses a combination of weights and ratings to produce a numerical value called the pollution potential index that helps prioritize areas with respect to ground water contamination vulnerability. Hydrogeologic settings and the corresponding pollution potential indexes are displayed graphically on maps.

Lake County lies within the Glaciated Central hydrogeologic region. The county is covered by variable thicknesses of glacial till, lacustrine deposits, beach ridges, and outwash. These unconsolidated glacial deposits are underlain by shale bedrock that is 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 and beach ridges have moderate to high vulnerabilities to contamination. Nine hydrogeologic settings were identified in Lake County with computed ground water pollution potential indexes ranging from 80 to 197.

The ground water pollution potential map of Lake County was 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 per cent of Ohio citizens rely on ground water for their drinking and household uses 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 6,750 of these wells exist in Lake 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 (now Division of Soil and Water Resources) 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 Environmental Protection Agency, 1986). Based on this recommendation, the Ohio General Assembly funded the mapping program. A dedicated mapping unit has been established in the Division of Soil and Water Resources, 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 partly 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 Lake County was 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 to assist 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 land disposal activities. Once these areas are 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 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.

These maps may 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 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 ground-water sensitive areas may be required to show how ground water will be protected.

Regardless of the application, the DRASTIC 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 (now National Ground Water 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 of an area 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 Lake 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

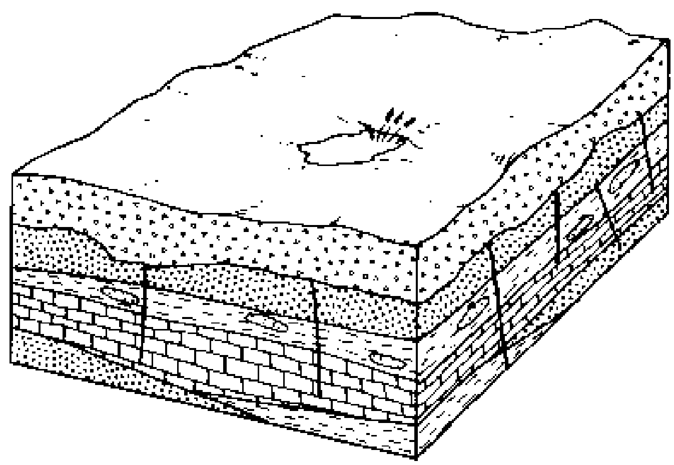
C - Conductivity (Hydraulic) of the Aquifer

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.

<u>Depth to water</u> 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.

<u>Net recharge</u> 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.

<u>Aquifer media</u> 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.



7Aa Glacial Till Over Bedded Sedimentary Rock

This hydrogeologic setting is characterized by low topography and relatively flat-lying, fractured sedimentary rocks consisting of sandstone, shale and limestone which are covered by varying thicknesses of glacial till. The till is principally unsorted deposits which may be interbedded with loess or localized deposits of sand and gravel. Although ground water occurs in both the glacial deposits and in the intersecting bedrock fractures, the bedrock is typically the principal aquifer. The glacial till serves as a source of recharge to the underlying bedrock. Although precipitation is abundant in most of the region, recharge is moderate because of the glacial till and soils which are typically clay loams. Depth to water is extremely variable depending in part on the thickness of the glacial till, but averages around 30 feet.

Figure 1. Format and description of the hydrogeologic setting - 7Aa Glacial Till Over Bedded Sedimentary Rock

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 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. Greater vulnerability to contamination is indicated by a higher DRASTIC index. 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 significantly differs. 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	

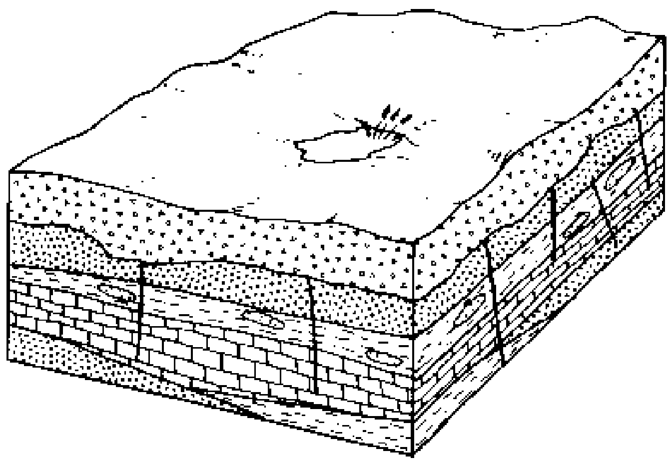
Table 8. Ranges and ratings for hydraulic conductivity

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 7Aa1 Glacial Till Over Bedded Sedimentary Rock, identified in mapping Lake 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 141. 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 Lake County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the nine settings identified in the county range from 80 to 197.

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 mapping in Lake County resulted in a map with symbols and colors that illustrate areas of varying ground water vulnerability. The map describing the ground water pollution potential of Lake County is included with this report.



SETTING 7Aa1		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	NUMBER
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Interbedded sst & sh	3	6	18
Soil Media	Silty Loam	2	4	8
Topography	0-2%	1	10	10
Impact Vadose Zone	Interbedded sst & sh	5	6	30
Hydraulic Conductivity	100-300	3	2	6
		DRASTIC	INDEX	141

Figure 2. Description of the hydrogeologic setting - 7Aa1 Glacial Till Over Bedded Sedimentary Rock

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. Greater susceptibility to contamination is indicated by a higher pollution potential index. 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:

7Aa1 - defines the hydrogeologic region and setting
141 - defines the relative pollution potential

Here the first number (7) refers to the major hydrogeologic region and the upper and lower case letters (Aa) 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 (141) 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.

The map also includes information on the locations of selected observation wells. Available information on these observation wells is referenced in Appendix A, Description of the Logic in Factor Selection. Large man-made features such as landfills, quarries or strip mines have also been marked on the map for reference.

GENERAL INFORMATION ABOUT LAKE COUNTY

Lake County occupies an area of approximately 231 square miles in northeastern Ohio (Figure 3). It is bounded on the north by Lake Erie, on the east by Ashtabula County, on the south by Geauga County and on the west by Cuyahoga County.

The county seat is Painesville, located approximately 32 miles northeast of Cleveland. The 2010 estimate of the population of Lake County was 230,041 (Ohio Department of Development, 2012).

The average annual precipitation for the city of Painesville during the thirty year period starting in 1971 and ending in 2000 was 37.85 inches. The average annual temperature for the same period was 50.8 degrees Fahrenheit (U.S. Department of Commerce, 2002).

Physiography

Lake County lies within two physiographic provinces: the Huron-Erie Lake Plains Section of the Central Lowland Province, and the Glaciated Allegheny Plateaus Section of the Appalachian Plateaus Province (Fenneman, 1938 and Brockman, 1998). The Huron-Erie Lake Plains Section occupies a belt three to five miles wide roughly paralleling the lake shore (White, 1980 and Brockman, 1998). This physiographic region typically exhibits low topography with a gentle slope towards the lake. Ancient beach ridges and deeply eroded river valleys provide the most pronounced surface relief within this province (White, 1980).

The Portage Escarpment separates the Appalachian Plateau Province from the Central Lowland Province (Ritchie and Reeder, 1979). In Lake County, the Portage Escarpment consists of a belt from one to three miles wide formed by two glacial end moraines that topographically form a ridge trending from southwest to northeast across the county. The north margin of the escarpment is marked by either a shore cliff or beach sands left behind by an ancient high stage of glacial Lake Erie (White, 1980).

The Appalachian Plateau Province has much greater topographic relief than the Central Lowland Province. Only a thin layer of till covers the bedrock in most of this region. In some areas, streams have eroded away the till and flow directly on the bedrock surface (White, 1980). All of Lake County lies within the Lake Erie drainage basin. Principal streams within the county are the Chagrin and Grand Rivers.

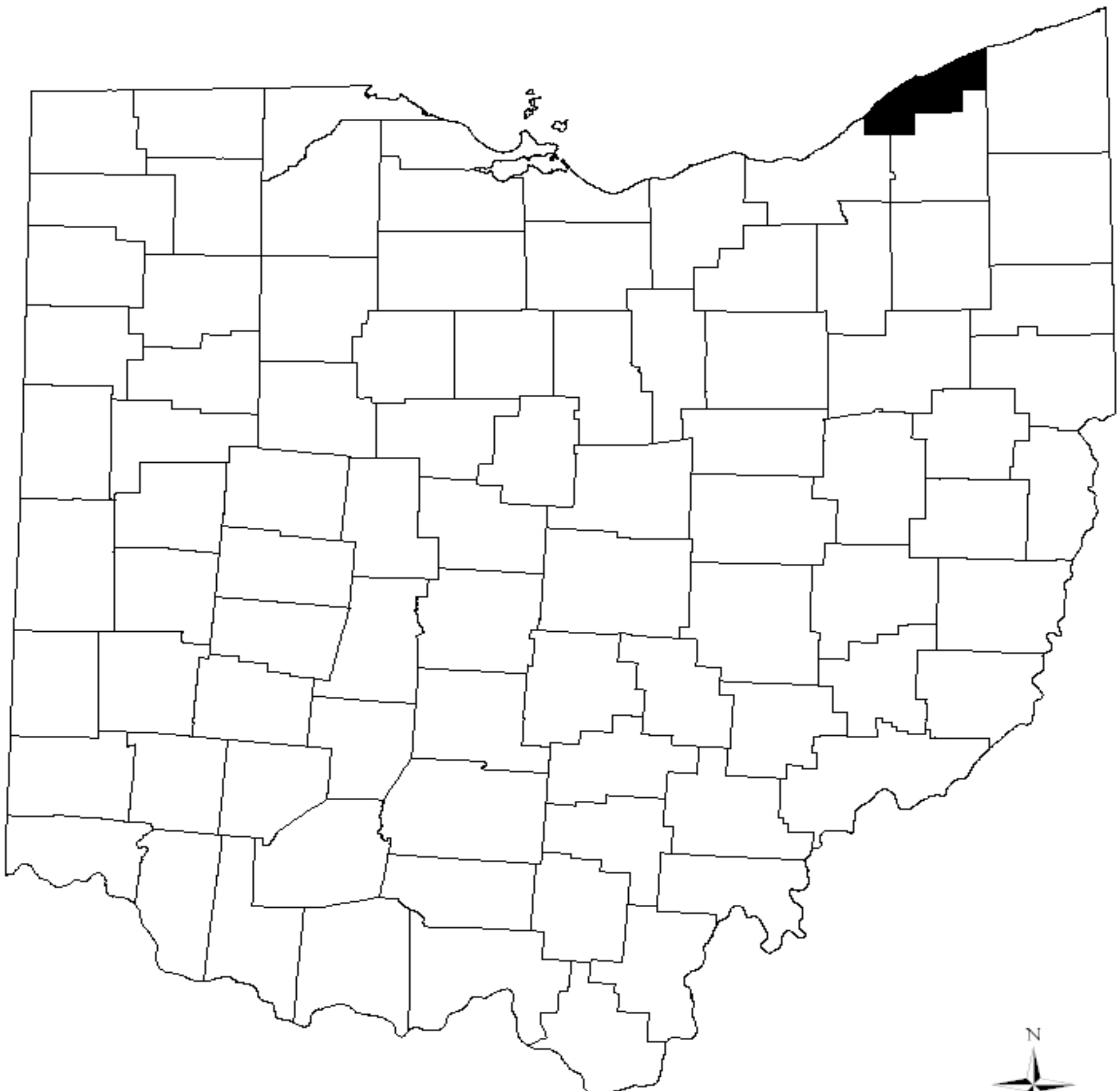


Figure 3. Location of Lake County in Ohio

Glacial Geology

During the Pleistocene Epoch (2 million to 10,000 years ago), at least four episodes of glaciation occurred in North America. In Ohio, evidence exists for three of these periods: the Wisconsinan which occurred between 70,000 and 10,000 years ago, the Illinoian which occurred at least 120,000 years ago, and the pre-Illinoian (Kansan). Approximately two-thirds of the state is covered by a mantle of glacial material deposited during these periods.

The majority of the glacial materials at the surface in Ohio were deposited by the Wisconsinan glaciers. Less extensive Illinoian–age deposits are found in the southwestern counties of the state and along most of the glacial boundary. Pre–Illinoian (Kansan) deposits are evident at the surface only in Hamilton County. Glacial deposits in Ohio average 35 to 40 feet in thickness. However, thicknesses can range from less than a foot to more than 500 feet (Stout et al., 1943).

Wisconsinan till covers most of the Appalachian Plateau in Lake County. Glacial till is deposited directly by glacial ice and is typically a poorly sorted mixture of clay, silt, sand, and gravel. These tills range in texture from clay–rich deposits with very little sand and gravel, to sandy deposits with low clay content (White, 1980). There have been six distinct glacial till deposits identified in Lake County (Table 9). The composition of the till will vary greatly from place to place depending on the kind of bedrock incorporated into the ice sheet and the kind of deposits the glacier overrode. Till deposits in the county typically average 25 feet in thickness, although they are much thinner in many parts of the Appalachian Plateau (Ohio Department of Natural Resources, unpublished well logs).

Two glacial end moraines are present along the Portage Escarpment (White, 1980). End moraines represent thicker deposits of glacial till that formed hummocky ridges or hills that may be underlain by outwash deposits of sand and gravel. These deposits are composed of layered fine grained silts and clays, with varying amounts of sand. Wave erosion along the shoreline of the glacial lakes cut steep cliffs into the end moraines. The end moraines in Lake County have been interpreted as indicating the farthest extent of the advance of a glacier. According to White (1980), the till in the end moraines may be up to 100 feet thick in some areas.

As glacial ice melts, a tremendous volume of water is released. This meltwater carries with it sand, gravel, silt and clay previously trapped within the glacial ice. The moving water sorts these materials by size, depositing the coarse sand and gravel near the source of the meltwater and carrying away the silt and clay downstream. If the sand and gravel is deposited directly on the land surface in front of glacial ice the resulting formation is referred to as an outwash deposit. If the sand and gravel was deposited in holes or depressions on the ice, and then laid down on the land surface as the ice melted, the resulting deposit is referred to as a kame. In

Table 9. Tills of Lake County (modified from White, 1980)

Stage	Substage	Unit	Color (oxidized)	Color (unoxidized)	Texture
Wisconsinan Till	Woodfordian	Ashtabula Till	Brown	Gray	Silty, clayey
		Hiram Till	Dark brown	Gray	Clayey, few pebbles
		Lavery Till	Brown	Gray	Silty, clayey, moderate number of pebbles
		Kent Till	Yellow brown	Gray	Sandy, coarse
	Altonian	Titusville Till	Olive brown	Gray	Sandy, stony, hard
Pre-Wisconsinan Till			Rare weathered till		

areas where ice remained in the valleys while the uplands were ice-free, meltwater deposited sand and gravel sometimes accumulated in bands along the margins between the ice and the uplands. Sand and gravel deposits of this type are called kame terraces.

In Lake County, kames and kame terraces are found in the southeast corner of Kirtland Township and in the south-central portion of Madison Township. Outwash deposits are found scattered along the valleys of the major streams throughout the county.

Lacustrine (lake-bottom) deposits cover most of the Central Lowlands Province. Surface runoff washed these sediments into glacial lakes that formed between glacial ice to the north and the escarpment to the south. A series of glacial lakes covered Lake County prior to the existence of Lake Erie. Over a period of time the silt and sand settled to the bottom of the lakes and accumulated into thick deposits. Lacustrine deposits within the county average 25 feet in thickness, although they are thinner in many places (White, 1980). Typically, the lacustrine deposits are underlain by a layer of glacial till (White, 1980).

Also occurring within the Central Lowlands Province are linear ridges of coarse-textured sand and gravel. These ridges are the remnants of beaches deposited along the shoreline of ancient glacial lakes. Ranging from 10 to 30 feet in height, the ridges form topographic highs in the otherwise flat terrain. Beach ridges are often formed in high energy environments and overlie wave–eroded till and bedrock (White, 1980).

Bedrock Geology

Bedrock underlying the glacial deposits of Lake County was deposited during the Devonian, Mississippian, and Pennsylvanian Periods, 395 to 280 million years ago (Table 10). North of the Portage Escarpment the bedrock is primarily dense shales and thin, hard sandstones. Bedrock in this region belongs to the Ohio Shale (Devonian System) (Stout et al., 1943; Delong, unpublished manuscript, Slucher et al., 2006).

Most of the bedrock south of the escarpment belongs to the Devonian and Mississippian Systems. The formations found within these systems include: the Bedford Shale, a blue to buff, argillaceous shale with thin sandstone interbeds; the Berea Sandstone, a gray to buff, coarse to fine grained sandstone with occasional shaley zones, and the Logan and Cuyahoga Formations, undivided. All of these formations consist of interbedded shales and thin sandstones (Delong, unpublished manuscript; Slucher et al., 2006). The Pennsylvanian Sharon Conglomerate overlies the Mississippian rocks on the tops of some of the higher ridges along the southeastern margin of the county. Typically, the Sharon Conglomerate consists of well-rounded pebbles in a sand matrix.

Hydrogeology

Lake County lies within the Glaciated Central hydrogeologic region (Heath, 1984). The entire county is covered by variable thicknesses of glacial till and outwash sand and gravel. The coarser–grained deposits constitute the major ground water resources; yields from the tills are variable but typically low. The glacial deposits are underlain predominantly by shale bedrock except in the southeastern corner of the county where the bedrock consists of interbedded sandstone and shale sequences. Ground water yields from the bedrock formations are usually only adequate for domestic use. The overlying glacial deposits serve as a source of recharge for the bedrock aquifers.

Table 10. Generalized bedrock stratigraphy of Lake County (modified from Delong, unpublished manuscript; Hull, 1990; Slucher et al., 2006)

System	Group (Symbol)	Formation/Members	Lithologic Description
Pennsylvanian	Allegheny and Pottsville Groups, undifferentiated (Pap)	Sharon Sandstone	The Sharon Sandstone is a coarse- to medium-grained, light colored sandstone and may contain conglomeratic zones. Also known as Sharon Conglomerate.
Mississippian		Logan and Cuyahoga Formations, undivided (Mlc)	The Logan Formation is not found in Lake County. The Cuyahoga Formation consists of alternating, thin-bedded, gray silty shales, sandy shales, siltstones and fine-grained sandstones.
Devonian		Berea Sandstone and Bedford Shale, undivided (Dbb)	The Berea Sandstone is a thin- to thick-bedded, fine to medium-grained light greenish-gray to brown sandstone. The Bedford Shale is a gray to brown to reddish-brown shale with thin interbeds of sandstone and siltstone.
	Ohio Shale (Doh)	Cleveland Member Chagrin Member Huron Member	Consists of three members, Cleveland, Chagrin, and Huron Shales. Cleveland member is absent in northeastern Ohio. Chagrin consists of shale, siltstone, and very fine-grained sandstone, gray to greenish gray. Huron is black, carbonaceous shale with calcareous concretions common in the lower portion.

Aquifers within Lake County are divided into two general categories: sandstone and shale formations within the bedrock, and unconsolidated glacial deposits. North of the escarpment the most pervasive aquifer is the thick layer of glacial till between the lacustrine deposits and the bedrock. This unit typically yields only meager ground water supplies to large diameter dug wells or wells drilled to the interface between the till and the bedrock. Other less widespread aquifers in this region include the beach ridge sand deposits, and alluvial sand and gravel units underlying portions of the floodplains of the major streams. In the extreme eastern portion of the county, underlying Willowick and the surrounding area, the glacial till is relatively thin. In this region the uppermost aquifer is the shale bedrock.

South of the escarpment several different types of aquifers are common. The uppermost aquifer underlying most of the upland areas are shales with occasional thin, tight sandstone layers. These units belong to the Ohio Shale, Bedford Shale, and the Cuyahoga and Logan Formations. Yields from these aquifers are meager, averaging less than two gallons per minute (Schmidt, 1979). In the southeastern portion of the upland areas the aquifer is the Berea Sandstone. Yields from this formation are generally in the 3 to 10 gallon per minute range.

In the lowland areas south of the escarpment the uppermost aquifer is usually some type of unconsolidated deposit. Within the valleys of the major streams the principal aquifers are either alluvial sand and gravel deposits or glacial outwash sand and gravel deposits. Lowland areas outside of the river valleys south of the escarpment often have thick deposits of glacial till; where this is the case the till is identified as the aquifer. The southeastern corner of Kirtland Township is underlain by a pre-glacial river valley filled with glacial drift. Sand and gravel deposits within the drift serve as the aquifer for this area.

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APPENDIX A

DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

Water-level information was obtained by using located water well completion reports available at the Ohio Department of Natural Resources, Division of Soil and Water Resources. All located wells were plotted and data were interpreted with respect to geology and topography. Water levels along the rivers in the River Alluvium hydrogeologic setting, the Mentor Marsh area and the Beach Ridges setting that roughly parallel the existing shoreline averaged 5 to 15 feet (9). Shallow water levels, 5 to 15 feet (9), were also present in the Glacial Lake Plains in the northern one-half of the county. Water levels in the Glacial Lake Deposits setting deepen to 15-30 feet (7) only along the escarpment that dissects the county east to west. Water levels in the outwash deposits were also typically shallow with depths of 5 to 15 feet (9) except for one isolated area in the eastern part of the county where depths ranged from 30 to 50 feet (5). Where glacial till overlies shale bedrock, water levels are extremely variable ranging from 5 to 15 feet (1), 15 to 30 feet (7), 30 to 50 feet (5), 50 to 75 feet (3) and 75 to 100 feet (2). In general, the water levels deepen toward the southern part of the county although no distinct trend is apparent. Water levels in areas where the glacial till overlies interbedded sandstone and shale bedrock are also variable, with depths ranging from 5 to 15 feet (9), 15 to 30 feet (7), 30 to 50 (5), 50 to 75 (3), 75 to 100 (2), and 100+ (1). Water levels in the buried valleys are somewhat variable as well. Shallow water levels of 5 to 15 feet (9) are common along river valleys, 30 to 50 (5) feet are common in areas where known outwash deposits are present and 50 to 75 feet (3) and 75 to 100 feet (2) are common in some of the deeper valleys.

Net Recharge

Published references for net recharge were not located during reference-searching for this county. Net recharge rates were estimated based on precipitation and predicted infiltration due to geology, soils, and topography. General statements about the relationship of cover materials were found in Ohio Department of Natural Resources (1961). Values of 4 to 7 inches per year (6) were assigned to the majority of the county recognizing that recharge most likely is in the lower portion of this range. Where sandy beach deposits and more permeable outwash deposits were delineated, values of 10+ inches per year (9) were chosen. River alluvium and the Mentor Marsh were assigned values of 7 to 10 inches per year (8). Values of 4 to 7 inches per year (6), 7 to 10 inches per year (8) and 10+ inches per year (9) were chosen in the buried valleys based on the character of the overlying surficial deposits.

Aquifer Media

Information on aquifer media was primarily derived from: White (1980), White (1982), Cummins (1959), and well log and drilling reports from the Ohio Department of Natural Resources, Division of Soil and Water Resources. Additional information was gleaned from Ohio Department of Natural Resources (1959), Forsyth (1959), Read (1873), Bownocker (1965) and Goldthwait et al. (1967). Sand and gravel was chosen as the aquifer in the Glacial Lake area and assigned a typical value of (5) because ground water frequently occurs in sand and gravel lenses within the glacial till or at the till/bedrock interface. Where the unconsolidated deposits were thinner than 25 feet (primarily in the western part of the county), the underlying shale was considered the aquifer and assigned a value of (2). In other parts of the county where glacial deposits overlie shale bedrock, the same criteria and ratings were used to delineate the aquifer. In the southern part of the county where the till overlies interbedded sandstone and shale bedrock, the glacial till is thinner and the underlying sandstone and shale was chosen as the aquifer and assigned a value of (6). The aquifer in the beach ridges was identified as sand and gravel and assigned a value of (8). Even though the beach ridges are of limited thickness, as described by White (1980), these deposits serve as an important source of ground water. Sand and gravel was also chosen as the aquifer in the outwash areas. Where the deposits were noted as Kames, a value of (9) was assigned because of the abundance of coarser-grained material; a value of (8) was assigned in the terrace deposit areas. In the alluvium along the rivers and in the Mentor Marsh, sand and gravel was chosen as the aquifer and assigned a typical value of (8). Although sand and gravel was chosen as the aquifer in the buried valley regions, little information was available on the type of material within the valleys. Values of (5) were chosen for the buried valley area in the southwestern part of the county based on information from Barber (1994), and values of (6) were chosen for the remaining buried valleys.

Soil

Soils were mapped based on the *Soil Survey of Lake County* (Ritchie and Reeder, 1979). The soil media was assigned using the general soil association map in approximately 80 percent of the county; the remainder was re-mapped using DRASTIC-based parameters. Soils formed in the glacial lake and glacial till areas are predominantly silty loam (4) with loam (5) soils found along the rivers. Sand (9) or gravel (10) predominates in the beach ridges, but may also be found in other areas of the county. Sandy loam (6) also occurs in some locations. Soils found in the organic deposits of the Mentor Marsh were called muck (2).

Topography

Percent slope was estimated by using 7 1/2 minute USGS topographic quadrangle maps. Contour intervals on the topographic maps were 10 feet on all quadrangles except Eastlake, Ohio which was 5 feet. Topography averages 0 to 2 percent (10) in the part of the county north of the Portage Escarpment. South of the escarpment, slope averages 2 to 6 percent (9). Areas along the river valleys have steeper slopes of 6 to 12 percent (5), 12 to 18 percent (3) and 18+ percent (1).

Vadose Zone Media

Information on the vadose zone media was primarily obtained from White (1980), White (1982) and well log and drilling completion reports from the Ohio Department of Natural

Resources, Division of Soil and Water Resources. Additional information was gleaned from Forsyth (1959), Read (1873), Bownocker (1965), and Goldthwait et al. (1967). Silt/clay was chosen as the vadose zone media in most of the Glacial Lake hydrogeologic settings, and was assigned a value of (4). Till was chosen as the vadose media for the Glacial Till over Sedimentary Rocks and Glacial Till over Shale settings. A rating of (5) was used in areas where the Ashtabula Till predominates, while a rating of (4) was used in areas where Hiram Till is found. Where the glacial till is thin, and/or water levels deeper, shale (2) or interbedded sandstone and shale (6) were chosen as the vadose zone media. Vadose zone media in the beach ridges was chosen as sand and gravel and assigned a typical value of (8). Sand and gravel was also chosen as the vadose zone media in the outwash areas. A value of (9) was assigned in areas where kames were present and a value of (8) was assigned in the terrace areas. The vadose zone media in the river alluvium and marsh was designated as sand and gravel with significant silt and clay and assigned a typical value of (6) based on the amount of fines usually in these deposits. In the buried valley areas, the vadose zone media was chosen based on the type of overlying deposit. The vadose zone media ranged from sand and gravel (9) in areas of kame deposits to sand and gravel with significant silt and clay (6) in river alluvium to till (4). The vadose zone media in the buried valley in the southwestern part of the county was chosen as sand and gravel with significant silt and clay and assigned a value of (5) based on information contained in Barber (1994).

Hydraulic Conductivity

Published data on hydraulic conductivity of the aquifer media were not found for this county. Values of hydraulic conductivity were estimated by reading descriptions of aquifer media and referring to the appropriate values referenced by Freeze and Cherry (1979). Values of 1 to 100 gallons per day per square foot (gpd/ft^2) (1) were assigned to the glacial deposits and shale bedrock settings. The interbedded sandstone and shale bedrock setting was assigned a hydraulic conductivity of 100-300 gpd/ft^2 (2). Values of 100 to 300 gpd/ft^2 (2) were also chosen for the buried valley aquifer based on anticipated higher yields from these areas. River alluvium, marsh areas and beach ridges were estimated to have values of 700 to 1000 gpd/ft^2 (6). Outwash deposits and areas of the buried valley containing outwash were estimated to have values of 1000 to 2000 gpd/ft^2 based on their coarser nature.

APPENDIX B

DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Lake 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 11. Pollution potential indexes computed for Lake County range from 80 to 197.

Table 11. Hydrogeologic settings mapped in Lake County, Ohio

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
7Aa Glacial Till Over Bedded Sedimentary Rock	84-141	10
7Ae Glacial Till Over Shale	80-129	31
7Ba Outwash	174	1
7Bb Outwash Over Bedded Sedimentary Rock	187-197	3
7D Buried Valley	87-197	7
7Eb River Alluvium Without Overbank Deposits	167-182	3
7F Glacial Lake Deposits	115-135	7
7H Beaches, Beach Ridges & Sand Dunes	181-193	4
7I Swamp/Marsh	163	1

In general, the location of the designated hydrogeologic settings within Lake County can be described as follows:

1. The Glacial Lake Deposits (7F) occur in the northern half of the county, north of the ridge, known as the Painesville Escarpment, that parallels Lake Erie;

2. The Beaches, Beach Ridges and Sand Dunes (7H) occur in the central portion of the county in thin bands parallels to the lake;

3. Glacial Till Over Shale (7Ae) predominates in the southern half of the county south of the Painesville Escarpment;

4. Glacial Till Over Bedded Sedimentary Rock (7Aa) occurs only in the southern part of the county primarily in Kirtland and Concord Townships;

5. Buried Valleys (7D) occur in two areas in the southern part of the county; a) adjacent to Cuyahoga County along the Chagrin River and b) adjacent to Geauga County in Kirtland Township;

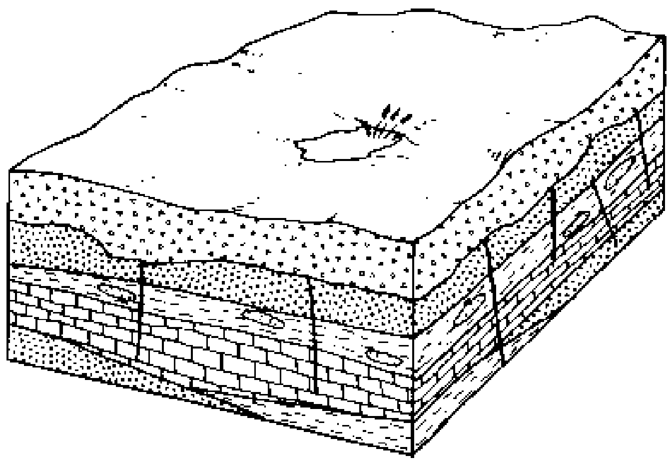
6. The Swamp/Marsh (7I) corresponds to an area known as the Mentor Marsh near Mentor, Ohio;

7. River Alluvium Without Overbank Deposits (7Eb) occurs along the valleys and major tributaries of the Chagrin and Grand Rivers and along Arcola Creek; the River Alluvium setting is obscured by the Buried Valley setting in Kirtland Township;

8. Outwash Over Bedded Sedimentary Rocks (7Bb) occurs along the Grand and Chagrin Rivers on the river terraces; and

9. Outwash (7Ba) occurs only in an isolated area in Madison Township north of the Grand River, and a small area in Kirtland Township near the Geauga County border. This setting is used to designate these as kames. The rest of the kame areas in southern Kirtland Township are obscured by the Buried Valley setting.

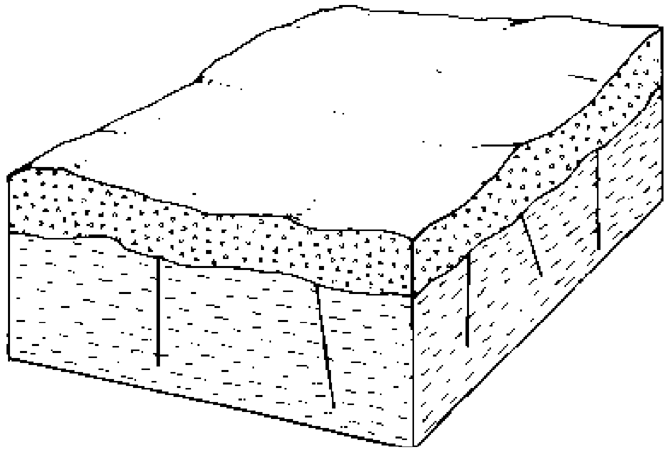
The following information provides a description of each hydrogeologic setting identified in the county, a block diagram illustrating the characteristics of the setting and a listing of the charts for each unique combination of pollution potential indexes calculated for each setting. The charts provide 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.



(7Aa) Glacial Till Over Bedded Sedimentary Rock

This hydrogeologic setting is characterized by low topography and relatively flat-lying, fractured sedimentary rocks consisting of sandstone, shale and limestone which are covered by varying thicknesses of glacial till. The till is principally unsorted deposits which may be interbedded with loess or localized deposits of sand and gravel. Although ground water occurs in both the glacial deposits and in the intersecting bedrock fractures, the bedrock is typically the principal aquifer. The glacial till serves as a source of recharge to the underlying bedrock. Although precipitation is abundant in most of the region, recharge is moderate because of the glacial till and soils which are typically clay loams. Depth to water is extremely variable depending in part on the thickness of the glacial till, but averages around 30 feet.

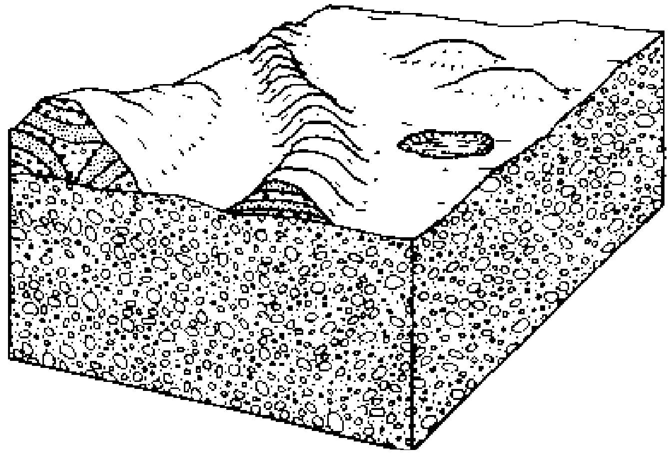
The GWPP index values for the hydrogeologic setting of Glacial Till over Bedded Sedimentary Rock range from 84 to 141, with the total number of GWPP index calculations equaling 9.



(7Ae) Glacial Till Over Shale

This hydrogeologic setting consists of varying thicknesses of glacial till overlying fractured, flat-lying shales. The till is principally unsorted deposits with interbedded lenses of loess and sand and gravel. Ground water is derived from either localized sources in the overlying till or from deeper, more permeable formations. The shale is relatively impermeable and does not serve as a source of ground water. Although precipitation is abundant, recharge is minimal from the till to deeper formations and occurs only by leakage of water through the fractures.

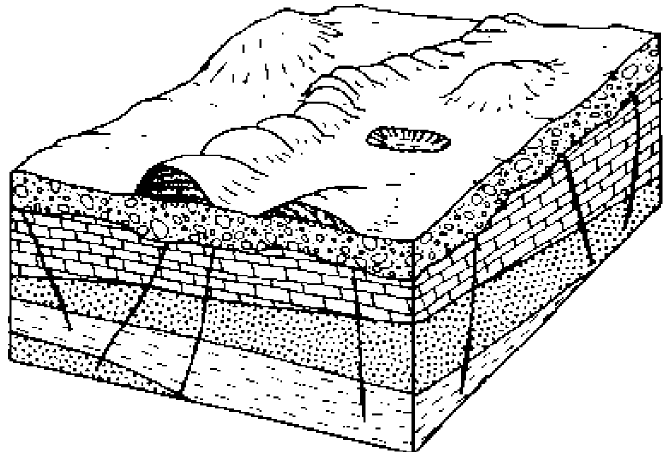
The GWPP index values for the hydrogeologic setting of Glacial Till over Shale range from 80 to 129 with the total number of GWPP index calculations equaling 31.



(7Ba) Outwash

This hydrogeologic setting is characterized by moderate to low topography and varying thicknesses of outwash which overlie sequences of fractured sedimentary rocks. The outwash consists of water-washed deposits of sand and gravel which serve as the principal aquifer in the area. The outwash also serves as a source of recharge to the underlying bedrock. Precipitation is abundant throughout most of the area and recharge is moderate to high. Recharge is somewhat restricted by the sandy loam soil which typically develops in this setting. Water levels are extremely variable, but relatively shallow. Outwash generally refers to water-washed or ice-contact deposits, and can include a variety of morphogenic forms. Outwash plains are thick sequences of sands and gravels that are laid down in sheet-like deposits from sediment-laden waters draining off, and from within a glacier. These deposits are well-sorted and have relatively high permeabilities. Kames and eskers are ice-contact deposits. A kame is an isolated hill or mound of stratified sediments deposited in an opening within or between ice blocks, or between ice blocks and valley walls. An esker is a sinuous or meandering ridge of well-sorted sands and gravels that are remnants of streams that existed beneath and within the glaciers. These deposits may be in direct hydraulic connection with underlying fractured bedrock.

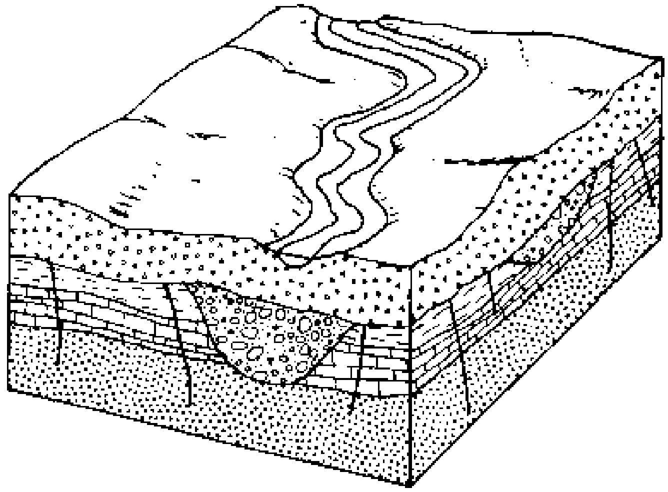
The GWPP index value for the hydrogeologic setting of Outwash is 174, with the total number of GWPP index calculations equaling 1.



(7Bb) Outwash Over Bedded Sedimentary Rock

This hydrogeologic setting is characterized by moderate to low topography and relatively flat-lying, fractured sedimentary rocks consisting of sandstone, shales and limestone which are covered by varying thicknesses of glacial outwash. The outwash consists of a variety of water-washed deposits of sand and gravel which serve as the principal aquifer in the area. The outwash also serves as a source of recharge to the underlying bedrock. Precipitation is abundant throughout most of the area and recharge is moderate to high. Water levels are extremely variable, but typically shallow.

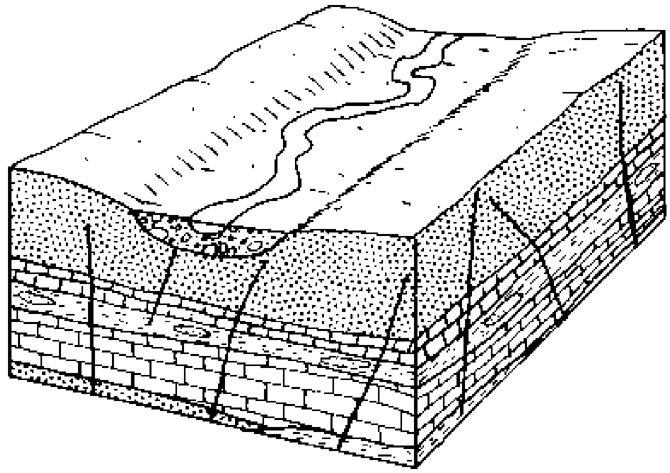
The GWPP index values for the hydrogeologic setting of Outwash over Bedded Sedimentary Rock range from 187 to 197, with the total number of GWPP index calculations equaling 3.



(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 pre-glacial river valley) by glacial meltwaters. These deposits are capable of yielding large quantities ground water. The deposits may or may not underlie a present-day river and may or may not be in direct hydraulic connection with a stream. Glacial till or recent alluvium often overlies the buried valley. Usually the deposits are several times more permeable than the surrounding bedrock, with finer-grained alluvium covering the underlying sand and gravel. Soils are typically a sandy loam. Recharge to the sand and gravel is moderate and water levels are commonly relatively shallow, although they may be quite variable.

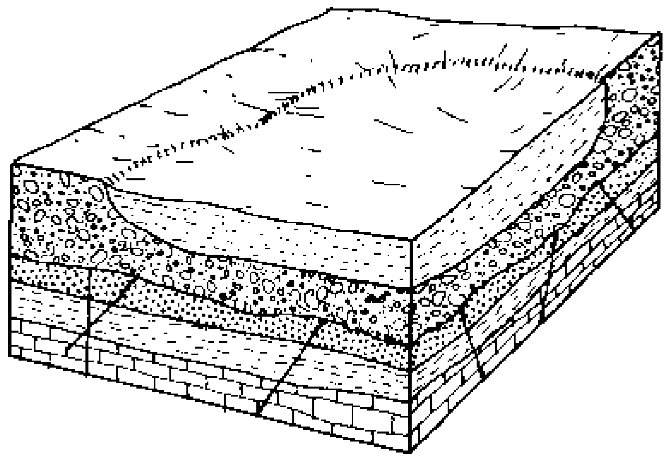
The GWPP index values for the hydrogeologic setting of Buried Valley range from 87 to 197, with the total number of GWPP index calculations equaling 7.



(7Eb) River Alluvium Without Overbank Deposits

This hydrogeologic setting is characterized by low topography and deposits of alluvium along parts of stream valleys. Water is obtained from sand and gravel layers deposited within the valley. Significant fine-grained floodplain deposits are present in the stream valley. This results in significantly higher recharge where precipitation is adequate and sandy soils occur at the surface. Water levels are moderate to shallow in depth. Hydraulic contact with the surface stream is usually excellent, with alternating recharge/discharge relationships varying with stream stage. These deposits also serve as a good source of recharge to the underlying fractured bedrock.

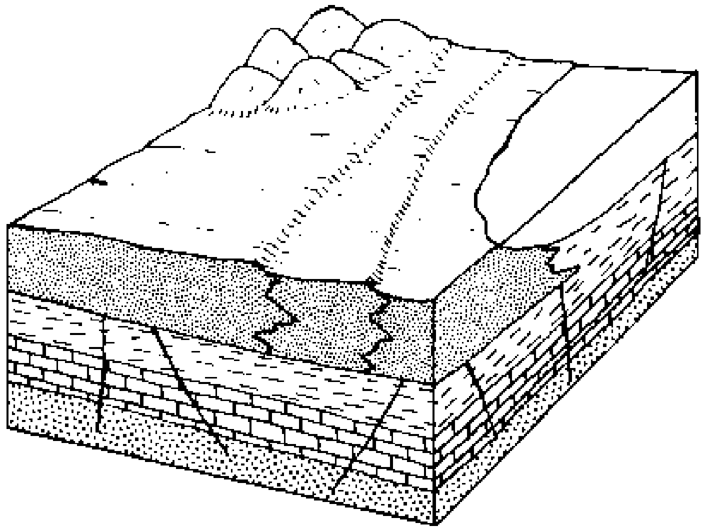
The GWPP index values for the hydrogeologic setting of River Alluvium Without Overbank Deposits range from 167 to 182, with the total number of GWPP index calculations equaling 3.



(7F) Glacial Lake Deposits

This hydrogeologic setting is characterized by flat topography and varying thicknesses of fine-grained sediments that overlie sequences of fractured sedimentary rocks. The deposits are composed of fine-grained silts and clays interlayered with fine sand that settled out in glacial lakes and exhibit alternating layers relating to seasonal fluctuations. As a consequence of the thin, alternating layers there is a substantial difference between the vertical and horizontal permeability with the horizontal commonly two or more orders of magnitude greater than the vertical. Due to their fine-grained nature, these deposits typically weather to organic-rich sandy loams with a range in permeabilities reflecting variations in sand content. Underlying glacial deposits or bedrock serve as the major source of ground water in the region. Although precipitation is abundant, recharge is controlled by the permeability of the surface clays; however, in all instances recharge is moderately high because of the impact of the low topography. Water levels are variable, depending on the thickness of the lake sediments and the underlying materials.

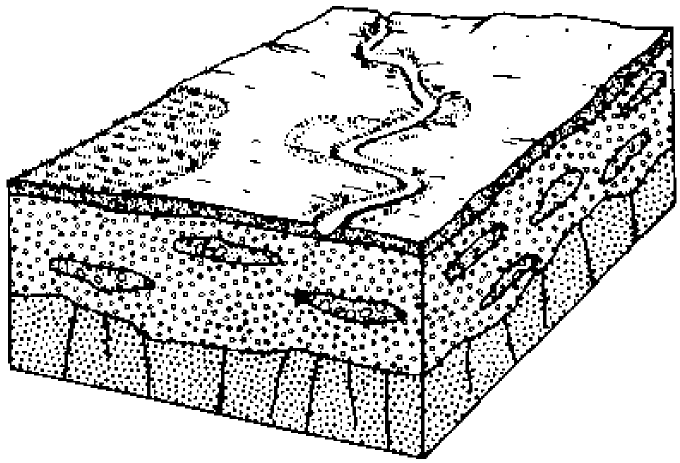
The GWPP index values for the hydrogeologic setting of Glacial Lake Deposits range from 115 to 135, with the total number of GWPP index calculations equaling 7.



(7H) Beaches, Beach Ridges and Sand Dunes

This hydrogeologic setting is characterized by low relief, sandy surface soil that is predominantly silica sand, extremely high infiltration rates and low sorptive capacity in the thin vadose zone. The water table is very shallow beneath the beaches bordering the Great Lakes. These beaches are commonly ground-water discharge areas. The water table is slightly deeper beneath the rolling dune topography and the vestigial inland beach ridges. All of these areas serve as recharge sources for the underlying sedimentary bedrock aquifers, and they often serve as local sources of water supply.

The GWPP index values for the hydrogeologic setting of Beaches, Beach Ridges, and Sand Dunes range from 181 to 193, with the total number of GWPP index calculations equaling 4.



(7I) Swamp/Marsh

This hydrogeologic setting is characterized by low topographic relief, high water levels and high organic silt and clay deposits. These wetlands occur along the courses of floodplains and in upland areas as a result of vertically restricted drainage. Common features of upland wetlands include those characteristics attributable to glacial activity such as filled-in glacial lakes, potholes and cranberry bogs. Recharge is moderate in most of the region due to restriction by clayey soils and limited by precipitation. The swamp deposits very rarely serve as significant aquifers but frequently recharge the underlying sand and gravel or bedrock aquifers.

The GWPP index value for the hydrogeologic setting of Swamp/Marsh is 163, with the total number of GWPP index calculations equaling 1.

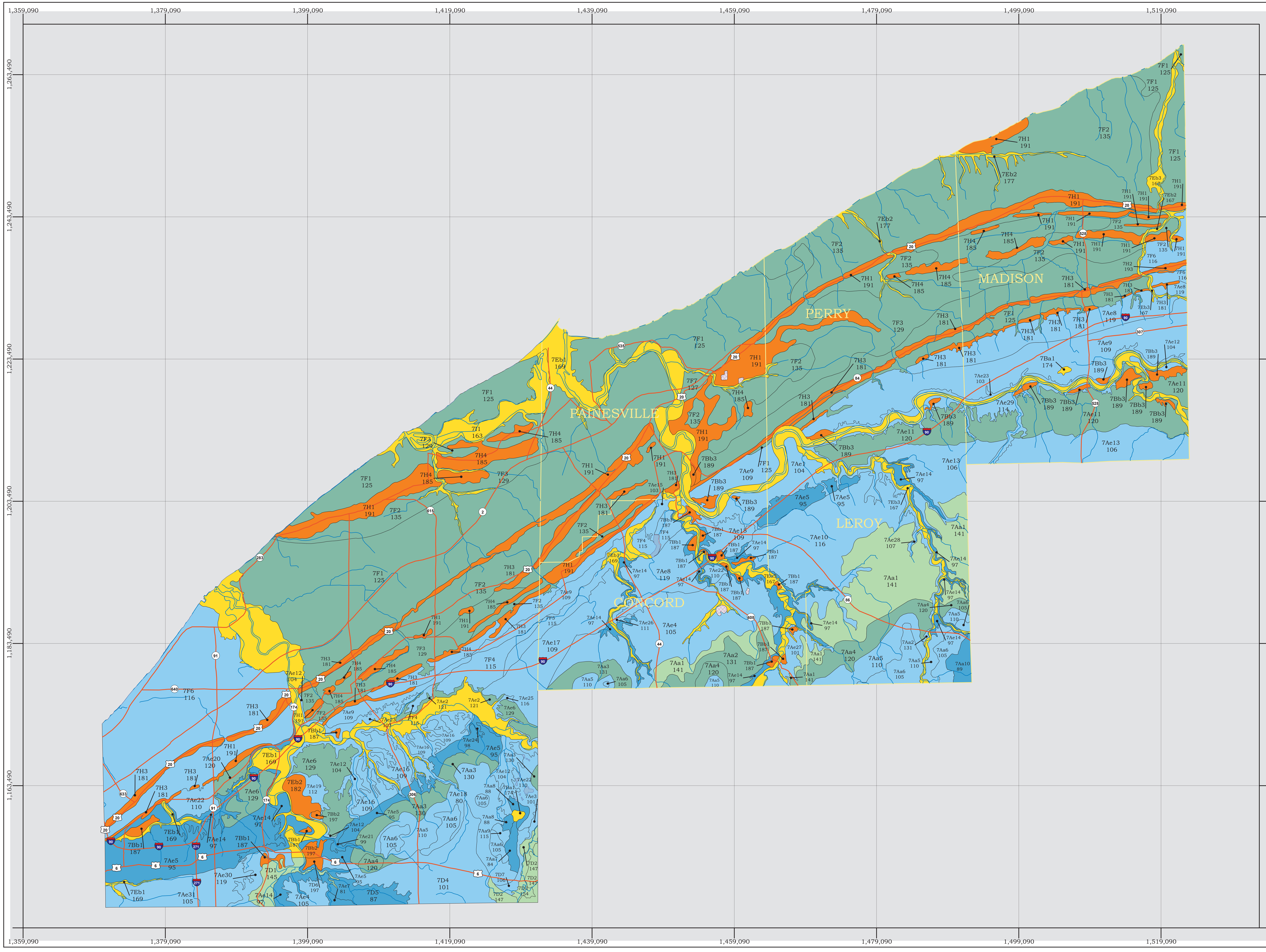
Table 12. Hydrogeologic settings, DRASTIC factors, and ratings

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% slope)	Vadose	Hydraulic Conductivity	Rating	Pesticide Rating
7Aa1	5-15	4-7	Interbedded sandstone & shale	Silty Loam	0-2	Interbedded sandstone & shale	100-300	141	165
7Aa2	15-30	4-7	Interbedded sandstone & shale	Silty Loam	0-2	Interbedded sandstone & shale	100-300	131	155
7Aa3	15-30	4-7	Interbedded sandstone & shale	Silty Loam	2-6	Interbedded sandstone & shale	100-300	130	152
7Aa4	30-50	4-7	Interbedded sandstone & shale	Silty Loam	2-6	Interbedded sandstone & shale	100-300	120	142
7Aa5	50-75	4-7	Interbedded sandstone & shale	Silty Loam	2-6	Interbedded sandstone & shale	100-300	110	132
7Aa6	75-100	4-7	Interbedded sandstone & shale	Silty Loam	2-6	Interbedded sandstone & shale	100-300	105	127
7Aa7	100+	2-4	Interbedded sandstone & shale	Silty Loam	6-12	Sand & gravel w/sig silt & clay	100-300	84	98
7Aa8	100+	2-4	Interbedded sandstone & shale	Silty Loam	2-6	Sand & gravel w/sig silt & clay	100-300	88	110
7Aa9	30-50	4-7	Interbedded sandstone & shale	Silty Loam	2-6	Sand & gravel w/sig silt & clay	100-300	115	138
7Aa10	100+	2-4	Interbedded sandstone & shale	Silty Loam	0-2	Interbedded sandstone & shale	100-300	89	113
7Ae1	15-30	4-7	Shale	Silty Loam	12-18	Till	1-100	104	116
7Ae2	15-30	4-7	Sand & Gravel	Sand	18+	Till	1-100	121	144
7Ae3	15-30	4-7	Shale	Silty Loam	6-12	Till	1-100	101	118
7Ae4	5-15	4-7	Shale	Silty Loam	2-6	Shale	1-100	105	132
7Ae5	15-30	4-7	Shale	Silty Loam	2-6	Shale	1-100	95	122
7Ae6	15-30	4-7	Sand & Gravel	Sand	2-6	Till	1-100	129	168
7Ae7	75-100	4-7	Sand & Gravel	Silty Loam	18+	Till	1-100	81	90
7Ae8	15-30	4-7	Sand & Gravel	Silty Loam	2-6	Till	1-100	119	143
7Ae9	30-50	4-7	Sand & Gravel	Silty Loam	2-6	Till	1-100	109	133
7Ae10	5-15	4-7	Shale	Silty Loam	0-2	Till	1-100	116	143

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% slope)	Vadose	Hydraulic Conductivity	Rating	Pesticide Rating
7Ae11	5-15	4-7	Shale	Silty Loam	2-6	Till	1-100	120	144
7Ae12	15-30	4-7	Shale	Loam	18+	Till	1-100	104	115
7Ae13	5-15	4-7	Shale	Silty Loam	0-2	Shale	1-100	106	135
7Ae14	5-15	4-7	Shale	Silty Loam	18+	Shale	1-100	97	108
7Ae15	30-50	4-7	Sand & Gravel	Silty Loam	12-18	Till	1-100	109	115
7Ae16	30-50	4-7	Sand & Gravel	Silty Loam	2-6	Till	1-100	109	133
7Ae17	5-15	4-7	Shale	Sandy Loam	2-6	Shale	1-100	109	142
7Ae18	50-75	4-7	Shale	Silty Loam	2-6	Shale	1-100	80	106
7Ae19	15-30	4-7	Shale	Sand	18+	Till	1-100	112	135
7Ae20	15-30	4-7	Shale	Sand	2-6	Till	1-100	120	159
7Ae21	15-30	4-7	Shale	Loam	18+	Till	1-100	99	111
7Ae22	15-30	4-7	Shale	Silty Loam	2-6	Till	1-100	110	134
7Ae23	30-50	4-7	Sand & Gravel	Loam	18+	Till	1-100	103	114
7Ae24	30-50	4-7	Sand & Gravel	Loam	18+	Till	1-100	98	110
7Ae25	15-30	4-7	Sand & Gravel	Sand	18+	Till	1-100	116	140
7Ae26	15-30	4-7	Sand & Gravel	Silty Loam	18+	Till	1-100	111	119
7Ae27	30-50	4-7	Sand & Gravel	Silty Loam	18+	TIll	1-100	101	109
7Ae28	5-15	4-7	Shale	Silty Loam	18+	Till	1-100	107	116
7Ae29	5-15	4-7	Shale	Loam	18+	Till	1-100	114	125
7Ae30	5-15	4-7	Shale	Clay Loam	0-2	Till	1-100	119	142
7Ae31	5-15	4-7	Shale	Clay Loam	18+	Till	1-100	105	111
7Ba1	30-50	10+	Sand & Gravel	Silty Loam	2-6	Sand & Gravel	1000-2000	174	187
7Bb1	5-15	10+	Sand & Gravel	Silty Loam	0-2	Sand & Gravel	1000-2000	187	203
7Bb2	5-15	10+	Sand & Gravel	Sand	0-2	Sand & Gravel	1000-2000	197	228
7Bb3	5-15	10+	Sand & Gravel	Loam	0-2	Sand & Gravel	1000-2000	189	208
7D1	5-15	7-10	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel w/sig silt & clay	100-300	145	176
7D2	30-50	10+	Sand & Gravel	Silty Loam	2-6	Sand & Gravel	100-300	147	166

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% slope)	Vadose	Hydraulic Conductivity	Rating	Pesticide Rating
7D3	5-15	7-10	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/sig silt & clay	100-300	154	177
7D4	50-75	4-7	Sand & Gravel	Silty Loam	2-6	Till	100-300	101	127
7D5	75-100	4-7	Sand & Gravel	Silty Loam	18+	TIll	100-300	87	95
7D6	5-15	10+	Sand & Gravel	Sand	0-2	Sand & gravel w/sig silt & clay	1000-2000	197	228
7D7	50-75	4-7	Sand & Gravel	Silty Loam	6-12	Sand & gravel w/sig silt& clay	100-300	106	120
7Eb1	5-15	7-10	Sand & Gravel	Loam	0-2	Sand & Gravel w/sig silt & clay	700-1000	169	192
7Eb2	5-15	7-10	Sand & Gravel	Sand	0-2	Sand & Gravel w/sig silt & clay	700-1000	182	212
7Eb3	5-15	7-10	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/sig silt & clay	700-1000	167	187
7F1	5-15	4-7	Sand & Gravel	Silty Loam	0-2	Silt/Clay	1-100	125	152
7F2	5-15	4-7	Sand & Gravel	Sand	0-2	Silt/Clay	1-100	135	177
7F3	5-15	4-7	Sand & Gravel	Sandy Loam	0-2	Silt/Clay	1-100	129	162
7F4	15-30	4-7	Sand & Gravel	Silty Loam	0-2	Silt/Clay	1-100	115	142
7F5	5-15	4-7	Shale	Silty Loam	2-6	Silt/Clay	1-100	115	140
7F6	5-15	4-7	Shale	Silty Loam	0-2	Silt/Clay	1-100	116	143
7F7	5-15	4-7	Sand & Gravel	Loam	0-2	Silt/Clay	1-100	127	157
7H1	5-15	10+	Sand & Gravel	Sand	0-2	Sand & Gravel	700-1000	191	224
7H2	5-15	10+	Sand & Gravel	Gravel	0-2	Sand & Gravel	700-1000	193	229
7H3	5-15	10+	Sand & Gravel	Silty Loam	0-2	Sand & Gravel	700-1000	181	199

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% slope)	Vadose	Hydraulic Conductivity	Rating	Pesticide Rating
7H4	5-15	10+	Sand & Gravel	Sandy Loam	0-2	Sand & Gravel	700-1000	185	209
7I1	5-15	7-10	Sand & Gravel	Muck	0-2	Sand & Gravel w/sig silt & clay	700-1000	163	177



Ground Water Pollution Potential of Lake County

by
Linda Aller and Karen Ballou, 1991
Revised by
Kathy Sprowls, 2013
Ohio Department of Natural Resources
Division of Soil and Water Resources

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

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

Description of Map Symbols

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

Legend

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

Roads
Streams
Lakes
Townships

<u>Index Ranges</u>
- Not Rated
- Less Than 79
- 80 - 99
- 100 - 119
- 120 - 139
- 140 - 159
- 160 - 179
- 180 - 199
- Greater Than 200

N

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

0 1 2 3 4 5
Miles

0 2 4 6 8
Kilometers

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Cartography by Rachel Pohnan, 2013