GROUND WATER POLLUTION POTENTIAL OF CUYAHOGA COUNTY, OHIO

BY

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GROUND WATER POLLUTION POTENTIAL REPORT NO. 4

OHIO DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATER

GROUND WATER RESOURCES SECTION

APRIL, 1994

ABSTRACT

A ground water pollution potential mapping program for Ohio has been developed under the direction of the Division of Water, Ohio Department of Natural Resources, 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.

Cuyahoga county lies within two physiographic provinces: the Eastern Lakes Section of the Central Lowland Province, and the Southern New York Section of the Appalachian Province (Fenneman, 1938). The county is overlain with a variable thicknesses of glacial till, lacustrine, silt and clay deposits. The unconsolidated glacial deposits are uderlain by sandstone and shale bedrock. Ground water yields are dependant on the type of aquifer and vary greatly throughout the county. Pollution potential indexes are moderate to high in the buried valleys and beach ridge deposits. Moderate vulnerability to contamination is found in the glacial lake deposits and in areas of alluvium over sedimentary rock. Areas of glacial till over sandstone and shale exhibit low to moderate susceptibility to contamination.

Ground water pollution potential mapping in Cuyahoga County resulted in a map with symbols and colors which illustrate areas of varying ground water contamination vulnerability. Six hydrogeologic settings were identified in Cuyahoga County with computed ground water pollution potential indexes ranging from 40 to 153.

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 Cuyahoga County has been prepared to assist planners, managers, and local officials in evaluating the potential for contamination from various sources of pollution. This information can be used to help direct resources and land use activities to appropriate areas, or to assist in protection, monitoring and clean-up efforts.

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ACKNOWLEDGEMENTS

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

Map preparation and review:	Douglas J. Barber
Map print production and review:	Douglas J. Barber David Orr
Report production and review:	Douglas J. Barber Michael Hallfrisch Rebecca J. Petty
Report editing:	Rebecca J. Petty William Mattox Michael Hallfrisch
Desktop publishing and report design:	David Orr Denise L. Spencer

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 6,500 of these wells exist in Cuyahoga 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, Ground 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 Cuyahoga 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 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 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 vulnerability can be used to guide the selection and implementation of appropriate best management practices in different areas. Best management practices should be chosen based upon consideration of the chemical and physical processes that occur from the practice, and the effect these processes may have in areas of moderate to high vulnerability to contamination. For example, the use of agricultural best management practices that limit the infiltration of nitrates, or promote denitrification above the water table, would be beneficial to implement in areas of relatively high vulnerability to contamination.

A pollution potential map can 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 ground water sensitive areas may be required to show how ground water will be protected.

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

SUMMARY OF THE DRASTIC MAPPING PROCESS

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 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 100 acres in size, and is not intended or designed to replace site-specific investigations.

Hydrogeologic Settings and Factors

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

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

Figure 1 illustrates the format and description of a typical hydrogeologic setting found within Cuyahoga 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

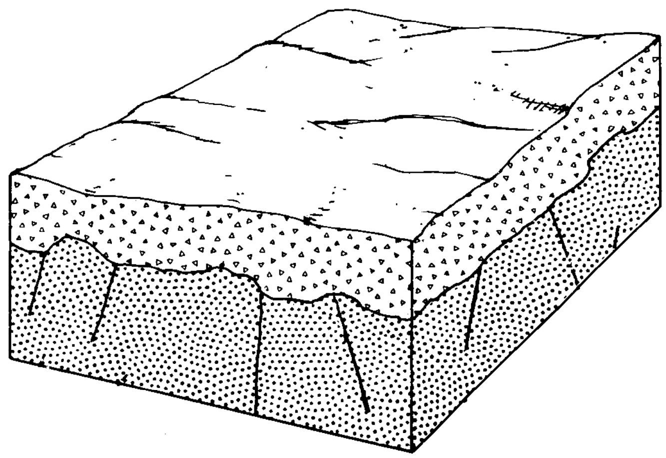
C - Conductivity (Hydraulic) of the Aquifer

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.



7Ad Glacial Till Over Sandstone

This hydrogeologic setting is characterized by low topography and relatively flay-lying, fractured sandstones which are covered by varying thicknesses of glacial till. The unsorted till deposits typically contain localized deposits of sand and gravel. Although ground water occurs in both the glacial till and the bedrock, the bedrock is 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 generally moderate due to the presence of the glacial tills which typically weather to a more impervious clay loam. Depth to water is variable, but is generally less than 30 feet.

Figure 1. Format and description of the hydrogeologic setting - 7Ad Glacial Till Over Sandstone.

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 7Ad1, identified in mapping Cuyahoga 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 108. 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 40 to 223. The diversity of hydrogeologic conditions in Cuyahoga County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the six settings identified in the county range from 40 to 153.

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 Cuyahoga 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 Cuyahoga County is included with this report.

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.

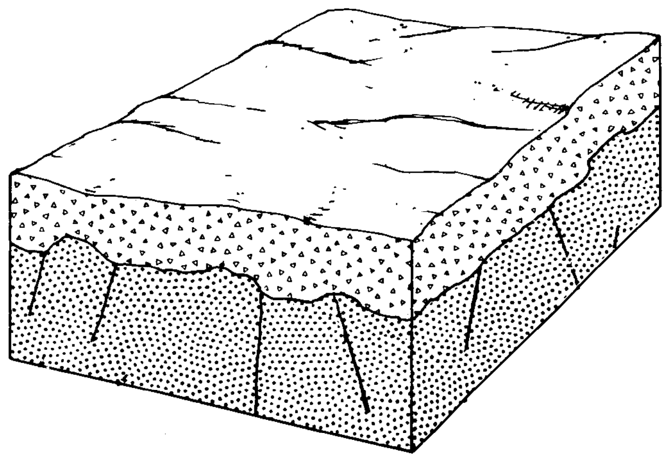
The map accompanying this report displays both the hydrogeologic settings identified in the county and the associated pollution potential indexes calculated in those hydrogeologic settings. The symbols on the map represent the following information:

7Ad1 - defines the hydrogeologic region and setting
108 - defines the relative pollution potential

Here the first number (7) refers to the major hydrogeologic region and the upper and lower case letters (Ad) 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 (108) 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.



SETTING 7Ad1		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	NUMBER
Depth to Water	5-15	5	9	45
Net Recharge	2 - 4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2%	1	10	10
Impact Vadose Zone	s & g w/ sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		DRASTIC	INDEX	108

Figure 2. Description of the hydrogeologic setting - 7Ad1 Glacial Till Over Sandstone.

GENERAL INFORMATION ABOUT CUYAHOGA COUNTY

Cuyahoga County, located in north-eastern Ohio, is bounded on the east by Lake and Geauga counties, on the south by Median and Summit counties, on the west by Lorain County, and on the north by Lake Erie. Figure 3 shows Cuyahoga County's location in relation to the rest of the state. The total area of this county is 456 miles.

Cleveland is the county seat and is among the largest cities in Ohio. The Census Bureau's 1990 population total for Cleveland is 505,616; the 1990 population of the entire county is 1,412,140 (Ohio Department of Development, 1991).

Land use in Cuyahoga County can be broken into three main types, urban/industrial (66%), forest (31%), and agricultural (3%) (Ohio Department of Natural Resources, Division of Soil and Water, unpublished data).

Physiography

Cuyahoga County lies within two physiographic provinces: the Eastern Lakes Section of the Central Lowland Province, and the Southern New York Section of the Appalachian Plateau Province (Fenneman, 1938). The Eastern Lakes Section, sometimes referred to as the “Lake Plain”, occupies the northern third of the county (Figure 4). Typically, this area has nearly flat lying topography with a gentle slope towards the lake. Beach ridges and wave cut cliffs provide the most pronounced surface relief within this region. These features are the remnants of ancient glacial lakes which stood at higher levels than Lake Erie.

The Portage Escarpment marks the boundary between the Central Lowland Province and the Appalachian Plateau Province (Figure 4). This feature occupies roughly the central third of the county. The escarpment is generally long and gentle where underlain by shales and steep where underlain by sandstone or conglomerate (Ford, 1987).

The Southern New York Section, sometimes called the “Allegheny Plateau”, comprises the southern third of the county (Figure 4). Topography in this region is gently rolling (Ford, 1987). All of the physiographic provinces in Cuyahoga County are dissected, or cut, by river valleys with broad, flat flood plains.

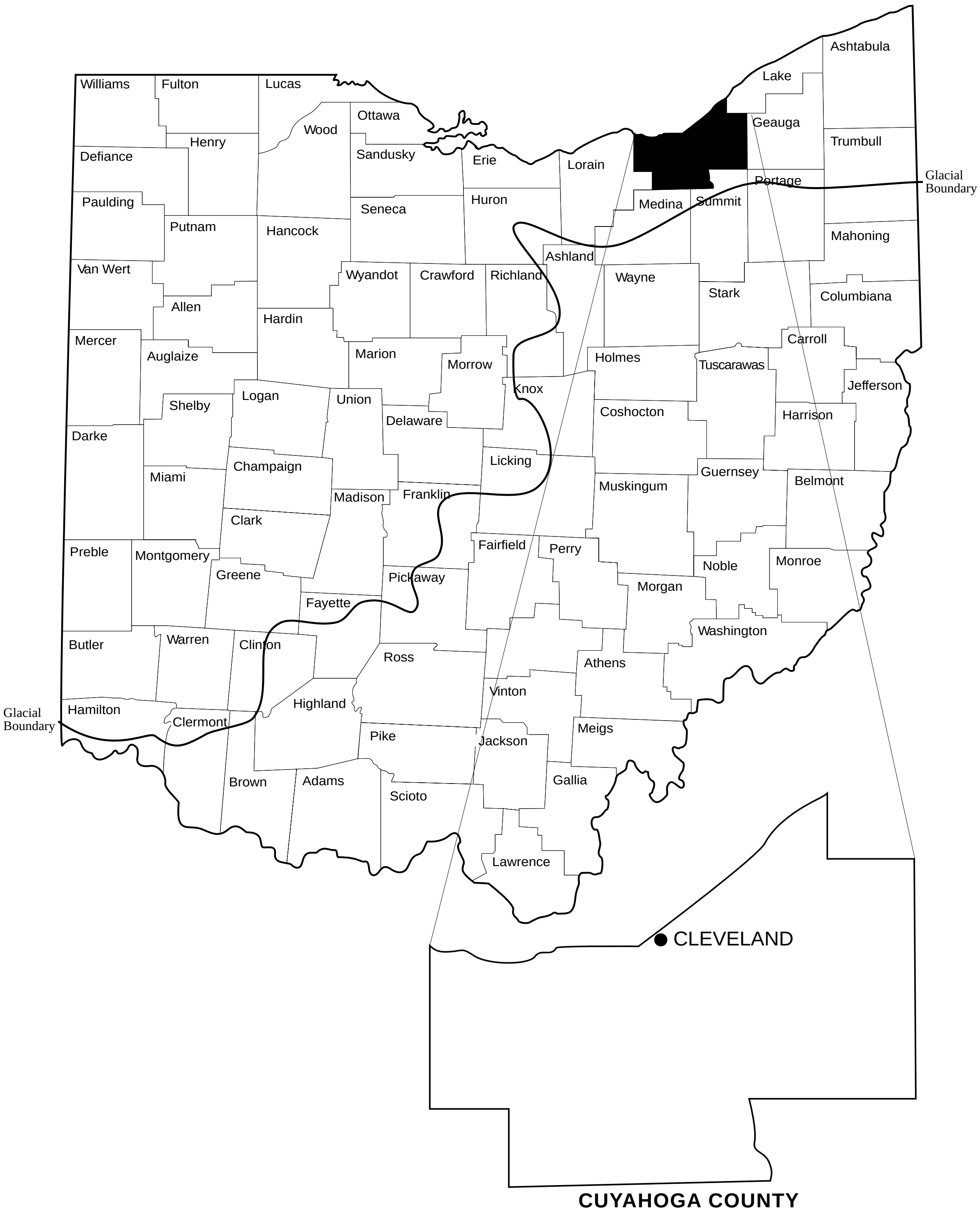


Figure 3. Location of Cuyahoga County in Ohio

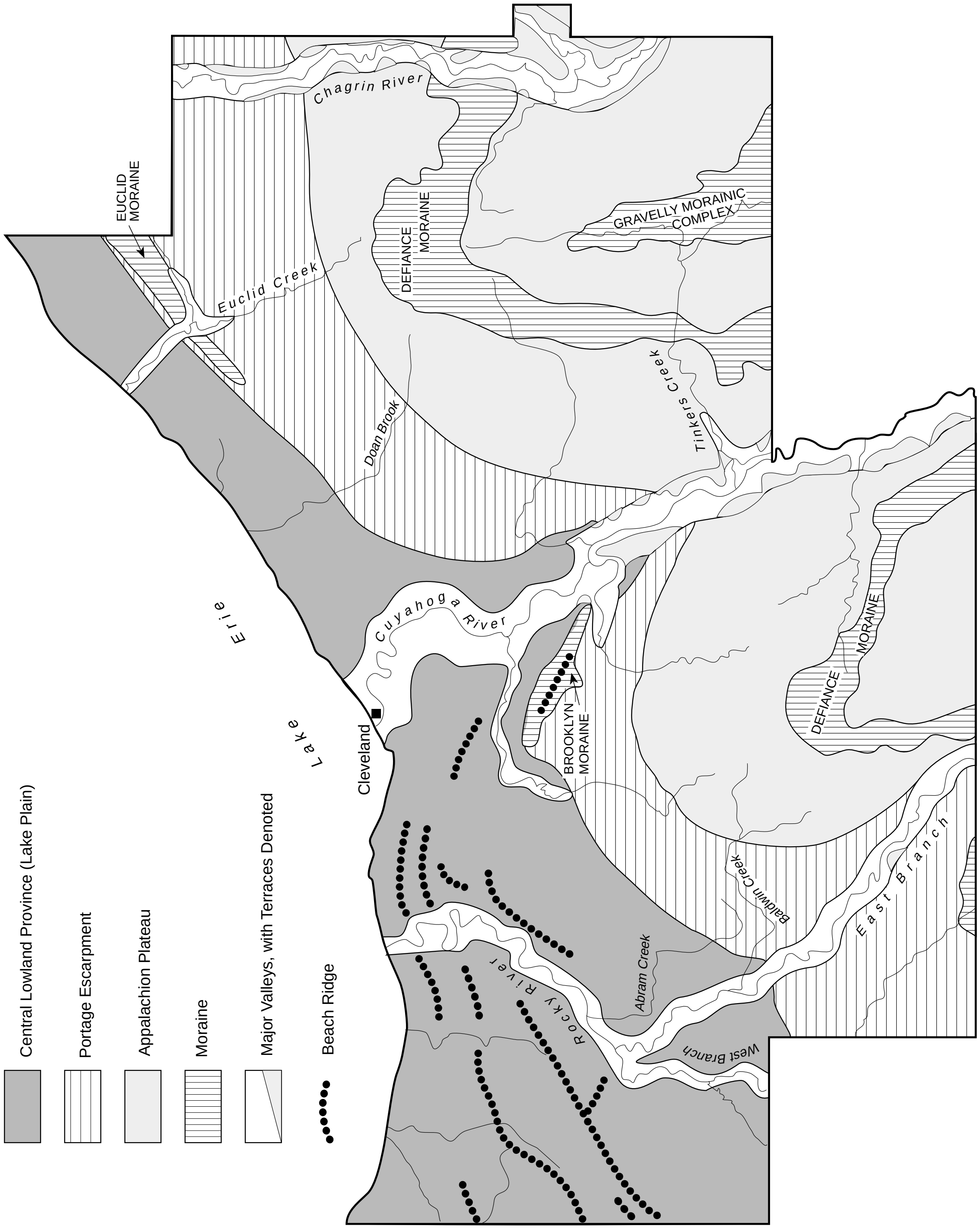


Figure 4. Physiographic features of Cuyahoga County

Drainage & Climate

Cuyahoga County is primarily drained by the Rocky River in the western portion of the county, the Cuyahoga River in the central part of the county, and the Chagrin River in the east. Average discharge over the last 57 years of the Cuyahoga River at Independence is 832 cubic feet per second (U.S. Department of Interior, 1988).

The climate of Cuyahoga County is typical of the temperate mid-continent region. Temperatures vary widely on an annual and daily basis. The annual mean temperature, as recorded at Cleveland Hopkins International Airport, is 49.6°F (U.S. Department of Commerce, 1982). The average annual precipitation at Cleveland Hopkins International Airport is 35.40 in., (U.S. Department of Commerce, 1981).

Glacial Geology

During the Pleistocene Epoch (2 million to 10,000 year ago), at least four episodes of glaciation occurred in northern north America. In Ohio, evidence exists for three of these periods: the pre-Illinoin (Kansian), the Illinoian, which occurred at least 120,000 years ago, and the Wisconsinan, which occurred between 70,000 and 10,000 years ago. Approximately two thirds of the state is covered by a mantle of glacial material deposited during these periods (Figure 3).

The majority of the surficial glacial materials 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 range from less than a foot to more than 500 feet (Stout et al., 1945).

Nearly all of Cuyahoga County is mantled by material of glacial or glacially related origin. Till (Wisconsinan age) is the most abundant glacial deposit in the county. Till, by definition, is deposited directly by glacial ice and is typically a poorly sorted mixture of clay, silt, sand, and gravel. In Cuyahoga County, the Wisconsinan tills range in texture from clay rich deposits with very little sand and gravel, to sandy deposits with a low clay content (Ford, 1987).

In addition to till, several other types of glacial related deposits are common in Cuyahoga County. In some parts of both physiographic provinces, but especially the Lake Plains region and the Cuyahoga River valley, lacustrine (lake bottom) silt and clay deposits overlie the glacial till. Where erosion stripped away the till, the lacustrine deposits may rest directly on bedrock (Ford, 1987). Lacustrine deposits were formed when surface water runoff washed fine grained sediments into lakes which covered parts of Cuyahoga County during or immediately after the last period of glaciation. Over time, the silt and clay settled to the bottom of the lakes and accumulated into thick layers.

Periodically interrupting the generally flat topography of the Lake Plains region are linear ridges of sand containing some gravel. These features are the remnants of beaches deposited along the shores of ancient glacial lakes. In Cuyahoga County the beach ridges range from 500 to 1500 feet in width (Ford, 1987). Figure 4 shows the location of beach ridges within the county.

Other types of deposits found in some parts of Cuyahoga County include kames and valley terraces. Kames are one type of sand and gravel deposit left behind by melting glaciers. When glacial ice melts, a tremendous volume of water is released. This melt water carries with it sand, gravel, silt, and clay previously trapped within the ice. The moving water sorts these materials by size, depositing the coarse sand and gravel near the source of the melt water and carrying away the silt and clay downstream. If the sand and gravel were 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 Cuyahoga County, kames are found primarily in the Appalachian Plateau Province south of Solon (Ford, 1987).

The valley terraces in Cuyahoga County are erosional remnants of lacustrine and floodplain deposits (sand and gravel interbedded with silt and clay) that accumulated in river valleys during intervals of glacial ponding (Ford, 1987). Valley terraces are most prominent in the Cuyahoga and Chagrin River valleys.

Bedrock Geology

Bedrock underlying Cuyahoga County was deposited during the Pennsylvanian, Mississippian and Devonian Periods, 280 to 395 million years ago. Major Formations include the Ohio Shale, Bedford Shale, Berea Sandstone, Cuyahoga Formation, and Sharon Conglomerate (Table 9). Bedrock in Cuyahoga County dips, or slopes, to the south at about 20 feet per mile (Winslow et al., 1953).

The Sharon Conglomerate forms the northwestern edge of the Allegheny Plateau along the Portage Escarpment. This formation is composed primarily of sandstone with intermittent silica cemented conglomerate (pebbly) zones. Glacial and stream erosion have cut the Sharon into discontinuous patches and outliers that form knobs and promontories in the southern and eastern parts of the county (Winslow et al., 1953).

TABLE 9. GENERALIZED BEDROCK STRATIGRAPHY OF CUYAHOGA COUNTY

SYSTEM	SERIES	GROUP	FORMATION	SIGNIFICANT BEDROCK MEMBERS	DESCRPITION
PENNSYLVANIAN		POTTSVILLE	Sharon Conglomerate		Gray-white to light red-tan, coarse- to medimum-grained sandstone
MISSISSIPPIAN			Cuyahoga	Meadville Formation	Gray shale alternating with thin sandstone beds
				Sharpsville Sandstone	Interbedded blue-gray shales and thin gray-broun to tan-gray fine-grained sandstones
				Orangeville Shale	Dark-blue to tan-gray shale
			Berea Sandstone		Light-gray to tan to red-brown, fine- to coarse-grained sandstone
			Bedford Shale		Blue-gray to maroon to black shale
				Euclid Sandstone	Blue-gray, fine-grained sandstone
DEVONIAN			Ohio Shale	Cleveland Shale	Black bituminous shale
				Chagrin Shale	Blue-gray to dark-gray silty shale

The Cuyahoga Formation is composed predominantly of shales. The members of this formation are the principal bedrock units underlying the Allegheny Plateau.

The Berea Sandstone forms a northeast-southwest trending escarpment extending from Mayfield to Dover township. The escarpment ranges from 5 to 50 feet in height, with the greatest relief in the eastern part of the county (Winslow et al., 1953). The Berea also outcrops along the slopes of many of the tributaries of the Cuyahoga and Chagrin River (Ford, 1987).

The Bedford and Ohio Shales outcrop along the face of the Portage Escarpment in the northeastern part of the county. These units also form the walls of the major valleys within the county. In addition, the Bedford and Ohio Shales form the bedrock underlying most of the Lake Plain.

All of the bedrock formations exposed in Cuyahoga County were originally deposited as sediments in or near one of several shallow seas which covered Ohio at various times in the geologic past. The Berea Sandstone was formed by a river system depositing sand and silt along a broad delta slowly building into a shallow sea (Szmuc, 1970b). The sands were deposited along the leading edge of a delta and in stream channels feeding the delta. In this way both thick masses and elongate stringers of sandstones were formed.

The depositional history of the Sharon Conglomerate is a matter of some controversy. The classical interpretation states the Sharon is deltaic in origin (somewhat like the Berea); the coarse grained conglomeratic zones are the result of strong current action (Heimlich et al., 1970). However, based on his study of cross bedding, Mrakovich (1969) theorized that the Sharon was deposited by a braided stream complex.

Like the Berea Sandstone, the Bedford Shale originated as a delta building out into a shallow sea (Szmuc, 1970b). The stream(s) feeding sediment to the delta, however, flowed at a much lower velocity than the streams which deposited the Berea. These streams, therefore, carried a much higher percentage of fines (silt and clay) than did the streams responsible for depositing the Berea. The small amount of sand these streams did carry was usually deposited in the stream bed before it reached the seaward edge of the delta. These conditions resulted in the delta being formed almost entirely of silt and clay with a few sand stringers.

The Orangeville Shale of the Cuyahoga Formation was formed as a layer of clay which settled to the bottom of a sea (Szmuc, 1957). The clay settled in a relatively deep basin of quiet water, well away from any streams which may have introduced silt or sand into the deposit. The Sharpville Sandstone and Meadville Shale were deposited in an environment much like the Orangeville Shale. However, the characteristics of the basin were such that storms and currents periodically introduced silt and sand onto the clay deposits. This accounts for the many siltstone beds found within these formations.

The Chagrin Shale originated as a clay layer deposited in a shallow sea (Szmuc, 1970a). Some portions of this basin were subject to wave and current action as is documented in the abundant ripple marks found in some parts of the formation.

The Cleveland Shale was deposited in a basin or portion of a sea with restricted circulation (Szmuc, 1970a). The tranquil water allowed very fine sediments and organic particles to settle to the bottom. The lack of circulation quickly resulted in unoxygenated bottom waters as the organic debris began to decay. These conditions are responsible for the black bituminus nature of this formation.

Buried Valleys

Prior to, and between, periods of Pleistocene glaciation, streams cut deep valleys into the bedrock underlying Cuyahoga County. Except for the areas where the glacial deposits have been eroded away, these valleys, some of them several hundred feet deep, are now filled with glacial drift and lacustrine deposits (Winslow et al., 1953).

The course of modern streams often follow buried valleys in Cuyahoga County (Winslow et al., 1953). The three largest buried valleys in the county roughly underlie the Cuyahoga, Rocky, and Chagrin rivers.

Hydrogeology

The availability and quantity of ground water in Cuyahoga County is dependent on aquifer type and location. Information on the ground water resources of Cuyahoga County is provided in Crowell (1974), Winslow et al., (1953) and Rau (1969).

The most important bedrock aquifers in Cuyahoga County are the Berea and Sharon Sandstones. These aquifers typically yield 3 to 25 gallons per minute under long-term pumping conditions. The Berea and Sharon underlie portions of nearly all of the central and southern townships of the county.

Unconsolidated aquifers composed of sand and gravel layers in thick clay are located sporadically throughout the buried valleys. Most of these deposits are discontinuous lenses which typically produce long-term safe yields between 3 and 10 gallons per minute. Some of the sand and gravel layers, however, are relatively thick and areally extensive. These aquifers may be capable of producing several hundred gallons per minute to large diameter wells (Crowell, 1974).

In areas of the county where neither the sandstone nor sand and gravel aquifers are present, ground water supplies must be developed in shale bedrock, or glacial till. In either case, yields of less than three gallons per minute are the norm.

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APPENDIX A

DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

Depth to water was evaluated using information obtained from over 6,500 well logs (Ohio Department of Natural Resources, Division of Water, unpublished data) and from inference based on topographic expression of the land surface. The depth to water in unconfined aquifer systems is typically less than 30 feet, DRASTIC rating (7) to (10), regardless of hydrogeologic setting. In areas where a confined aquifer system is present, depth to water represents the distance from the ground surface to the top of the aquifer. Confined aquifers in Cuyahoga County were identified as those areas where the aquifer is overlain by thick clay till and at least 40 feet of shale.

Net Recharge

This factor was evaluated using many different criteria, including depth to water, topography, soil type, annual precipitation, evapotranspiration, and runoff values for selected watersheds. Precipitation ranges from 39 in./yr. in the southern portion of Cuyahoga County, to 33 in./yr. in the northern part of the county (Ohio Department of Natural Resources, 1962). Approximately 10 in./yr. represents runoff, about 2 inches is retained at the surface, and roughly 20 inches remains in the unsaturated zone and is later lost to evapotranspiration (U.S. Department of Interior, 1988). This leaves approximately 1 to 7 in./yr. available to infiltrate into the aquifers of the county. On a more local scale other factors influence net recharge including surface slope and soil type. Areas with little or no slope have minimal runoff, allowing more water to infiltrate the soil and eventually reach the aquifer.

Runoff and infiltration rates are also dependent on soil types. Generally, soils with high clay content have low infiltration and high runoff rates. Conversely, coarse or sandy soils allow more precipitation to infiltrate the soil and percolate into the aquifer. Based on the above factors, the northern third of the county was given a base net recharge of 2-4 in./yr. (3). The Southern two-thirds of this county was given a base net recharge of 4-7 in./yr. (6).

Aquifer Media

Both consolidated (shale and sandstone) and unconsolidated (sand and gravel) aquifers are present in Cuyahoga County. The selection of ratings for aquifer media was made using information obtained from well logs on file with Ohio Department of Natural Resources, Division of Water; Crowell (1974); Rau (1969); Ford (1987); Winslow et al. (1953); Sedam (1973).

In the hydrogeologic setting, Glacial Till Over Shale (7Ae), the aquifer media are the various shale formations present in the county. A rating of (2) was selected based on descriptions from well logs and information in Rau (1969) and Winslow et al. (1953). This information indicates that ground water in the shales typically occurs in the upper two to three feet of weathered and fractured bedrock. Domestic wells are often completed deeper into the shales only to provide additional storage in the borehole.

The aquifer media in the hydrogeologic setting Beaches and Beach Ridges (7H) varies depending on the location in the county and the underlying bedrock. The beaches and beach ridges present in Cuyahoga County represent thin deposits of sand and gravel that are typically not saturated (Ford, 1987). The aquifers beneath the beaches and beach ridges include both sandstone (4), shales (2), and possibly sand and gravel (5) in buried valleys.

The aquifer media for the hydrogeologic setting Glacial Lake Deposits (7F) also varies depending on location. The aquifer media in this setting includes sandstone (4), shales (2), and sand and gravel (5).

The principal aquifers for the hydrogeologic setting, Glacial Till Over Sandstone (7Ad), are either the Berea Sandstone or Sharon Conglomerate. Both units were assigned a rating of (4) based on descriptions from well logs and information in Rau (1969), Winslow et al. (1953), and Sedam (1973).

Sand and Gravel aquifers are located in buried valleys and assigned a rating of (5). In most cases these aquifers are relatively thin discontinuous lenses. However, evidence from Ohio Department of Natural Resources, well logs suggest that in some areas the sand and gravel aquifers are really extensive and thick enough to yield over 100 gpm.

In the hydrogeologic setting Alluvium Over Sedimentary Rock (7Ec) the aquifer media varies depending on the area within the county. Aquifer media varies from sandstone (4) to shale (2), and in some cases sand and gravel (5), where the thickness of alluvium are significant.

Soil Media

This factor was evaluated using the soil survey for Cuyahoga County (Holloran, et al., 1980). Information on each soil type found within the county was evaluated based on the DRASTIC criteria, and appropriate ratings were selected. Computer generated maps were then prepared using digitized data on file with Ohio Department of Natural Resources, Division of Soil And Water Conservation, Ohio Capability Analysis Program (OCAP).

The soils of Cuyahoga County are strongly influenced by the nature of the glacial deposits present in an area. In the southern two-thirds of the county, the Lavery Till is pervasive. Soils developed on this formation are typically clay loams and are assigned a rating as a (3). Clay loams (3) are also found in areas where fine-grained glacial tills and glacial lake deposits are present in the northern third of the county. Both the Lavery Till and the glacial lake deposits have weathered to a silt loam (4) in some areas of these hydrogeologic settings. Soils developed in the beach and beach ridges areas are typically sandy loams (6).

Topography

Topography was analyzed by reviewing slope changes from USGS 7 1/2 minute topographic quadrangle maps and by information provided in the soil survey of Cuyahoga County (Holloran, et al., 1980). Computer generated maps of topography defined as percent slope were prepared using digitized data on file at the Ohio Department of Natural Resources, Division of Soil and Water Conservation, Ohio Capability Analysis Program (OCAP).

In most portions of the county, the topography represents gently rolling hills of till plains and glacial lake deposits with slopes of 0-2 percent (10) and 2-6 percent (9). The topography steepens from 6-12 percent (5) to over 18+ percent (1) in areas forming steep-sided valley walls.

Impact of the Vadose Zone Media

This factor was evaluated using information obtained from well logs on file with Ohio Department of Natural Resources, Division of Water, Ford (1987), Sedam (1973), Winslow et al. (1953). The vadose zone materials are significantly affected by the types of glacial deposits present in the county. The southern two-thirds of the county is covered by the Lavery Till and other underlying clay rich tills (Ford 1987). Where these materials occur as a significant thickness of the vadose zone, they are rated as a (4).

Lake deposits in portions of the northern one-third of the county are also given a rating of (4). Although these lake deposits are clay rich, their overall texture was influenced by their close proximity to the sandy beach deposits. In glacial lake areas where the beach deposits were not present, a rating of (3) was assigned to denote an almost total clay or silt composition in the vadose zone material. Where fractures were apparent in this material a rating of (5) was assigned.

In areas of the county where the glacial deposits were thin, sandstone was rated as the vadose zone media. A rating of (6) was assigned based on information in well logs, Rau (1969), Winslow et al. (1953), Ford (1987). Sandstones are typically more permeable than the glacial deposits and may be fractured.

In areas of beaches and beach ridges, the vadose zone media is sand and gravel. Information on these deposits was obtained from Ford (1987) and from water well logs. The beach and beach ridge deposits are among the most permeable deposits in the county and were rated as (7). In addition, fluvial deposits in Flood Plains are given either a rating of (5) or (7) based on their descriptions from well logs and Ford (1987).

Hydraulic Conductivity

Hydraulic conductivity was evaluated using a compilation of several different sources of information including: Crowell (1974), Rau (1969), Sedam, (1973), Winslow et al. (1953), and well logs on file with the Ohio Department of Natural Resources, Division of Water.

The hydraulic conductivity of the shale bedrock was evaluated as 1-100 gpd/ft. sq. (1). This information was based on known characteristics of the shales, and a review of the well log files.

The hydraulic conductivity for the lenticular sand and gravel aquifers in the county were estimated at 1-100 gpd/ft sq. (1). These sand and gravel lenses are typically glacial in origin, exhibit poor sorting and low permeabilities, and provide limited yields to wells. Hydraulic conductivity for the Berea Sandstone fell with the 1-100 gpd/ft. sq. (1) range based on information in Rau (1969). Hydraulic conductivity for the Sharon Conglomerate was estimated between 1-100 gpd/ft. sq. (1) based on information found in Sedam (1973).

APPENDIX B

DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

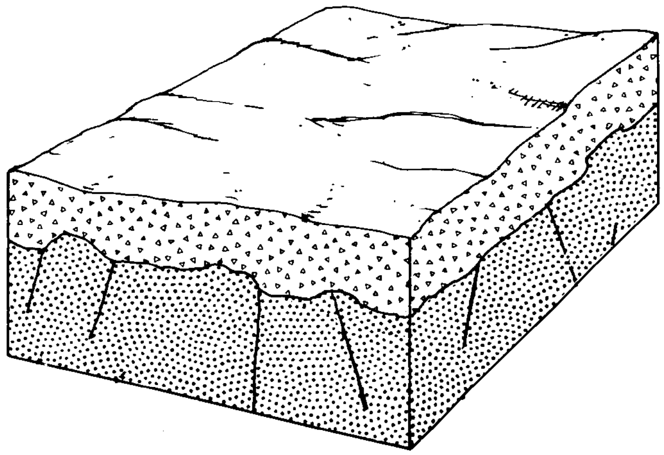
TABLE 10 . HYDROGEOLOGIC SETTINGS MAPPED IN CUYAHOGA COUNTY, OHIO

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
7Ad - Glacial Till Over Sandstone	40-122	32
7Ae - Glacial Till Over Shale	63-125	25
7D - Buried Valley	85-153	36
7Ec - Alluvium Over Sedimentary Rock	104-141	4
7F - Glacial Lake Deposits	82-131	20
7H - Beaches & Beach Ridges	116-146	12

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.

NOTE:

Setting tables marked with an "*" in Appendix D reflect corrected GWPP index values that were labled incorrectly on the GWPP map.



7Ad Glacial Till over Sandstone

This hydrogeologic setting is characterized by low topography and relatively flat-lying, fractured sandstones 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 tills which typically weather to clay loam. Depth to water is extremely variable, depending in part on the thickness of the glacial till.

GWPP index values for the hydrogeologic setting of glacial till over sandstone ranges from 40-122 with a total number of GWPP index calculations equaling 32.

Setting 7Ad1		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	108

Setting 7Ad2		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	silty loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	110

Setting 7Ad3		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	98

Setting 7Ad4		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	88

Setting 7Ad5		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	75-100	5	2	10
Net Recharge	0-2	4	1	4
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	confined	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	50

Setting 7Ad6		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	100+	5	1	5
Net Recharge	0-2	4	1	4
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	confined	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	45

Setting 7Ad7		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	75-100	5	2	10
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	18+	1	1	1
Impact of Vadose Zone	confined	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	49

Setting 7Ad8		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	silt loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	122

Setting: 7Ad9		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	100+	5	1	5
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	confined	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	52

Setting: 7Ad10		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	100+	5	1	5
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	confined	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	53

Setting: 7Ad11		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	100+	5	1	5
Net Recharge	0-2	4	1	4
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	confined	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	40

Setting: 7Ad12 "*"		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	100+	5	1	5
Net Recharge	0-2	4	1	4
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	confined	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	44

Setting: 7Ad13		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	100+	5	1	5
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	confined	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	48

Setting: 7Ad14		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	sandstone	5	6	30
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	120

Setting: 7Ad15		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	115

Setting: 7Ad16		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	120

Setting: 7Ad17		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	75-100	5	2	10
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	confined	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	53

Setting: 7Ad18		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	100+	5	1	5
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	18+	1	1	1
Impact of Vadose Zone	confined	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	44

Setting: 7Ad19		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	110

Setting: 7Ad20		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	99

Setting: 7Ad21		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	109

Setting: 7Ad22		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	105

Setting: 7Ad23		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	119

Setting: 7Ad24		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	silty loam	2	4	8
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	107

Setting: 7Ad25		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	75-100	5	2	10
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	confined	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	58

Setting: 7Ad26		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	75-100	5	2	10
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	silt loam	2	4	8
Topography	6-12	1	5	5
Impact of Vadose Zone	confined	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	55

Setting: 7Ad27		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	silty loam	2	4	8
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	117

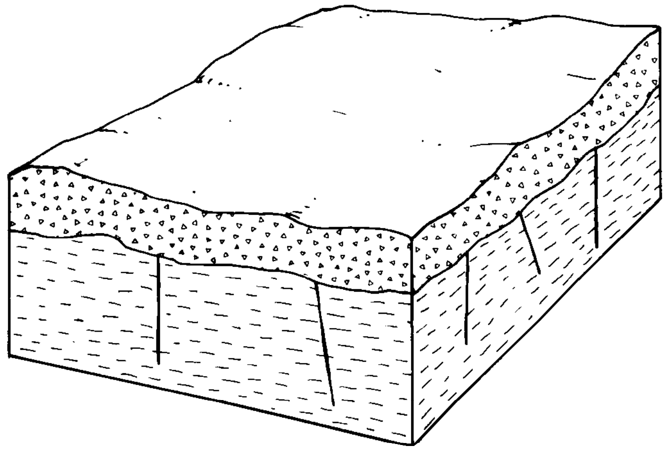
Setting: 7Ad28		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	95

Setting: 7Ad29		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	100

Setting: 7Ad30		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	114

Setting: 7Ad31		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	75-100	5	2	10
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	silty loam	2	4	8
Topography	2-6	1	9	9
Impact of Vadose Zone	confinded	5	1	5
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	59

Setting: 7Ad32		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	12-18	1	3	3
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	93



7Ae Glacial Till over Shale

This hydrogeologic setting is similar to (7Ad) Glacial Till Over Sandstone except that varying thickness of till overlie fractured, flat-lying shales. The till is principally unsorted deposits with interbedded lenses of loess and sand and gravel. The shale is relatively impermeable and does not serve as a source of ground water. Although precipitation is abundant, recharge is minimal through the till.

GWPP index values for the hydrogeologic setting of glacial till over shale ranges from 65-125 with a total number of GWPP index calculations equaling 25.

Setting: 7Ae1		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	0-2	4	1	4
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	18+	1	1	1
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	85

Setting: 7Ae2		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	102

Setting: 7Ae3		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	87

Setting: 7Ae4		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	114

Setting: 7Ae5		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	silty loam	2	4	8
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	99

Setting: 7Ae6		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	92

Setting: 7Ae7		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	101

Setting: 7Ae8		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	12-18	1	3	3
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	95

Setting: 7Ae9		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	97

Setting: 7Ae10		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	104

Setting: 7Ae11		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	silt loam	2	4	8
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	105

Setting: 7Ae12		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	99

Setting: 7Ae13		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	113

Setting: 7Ae14		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	103

Setting: 7Ae15		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	18+	1	1	1
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	83

Setting: 7Ae16		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	93

Setting: 7Ae17		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	shrink / swell clay	2	7	14
Topography	18+	1	1	1
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	91

Setting: 7Ae18		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sandy loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	120

Setting: 7Ae19		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	50-75	5	3	15
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	18+	1	1	1
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	63

Setting: 7Ae20		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	silty loam	2	4	8
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	115

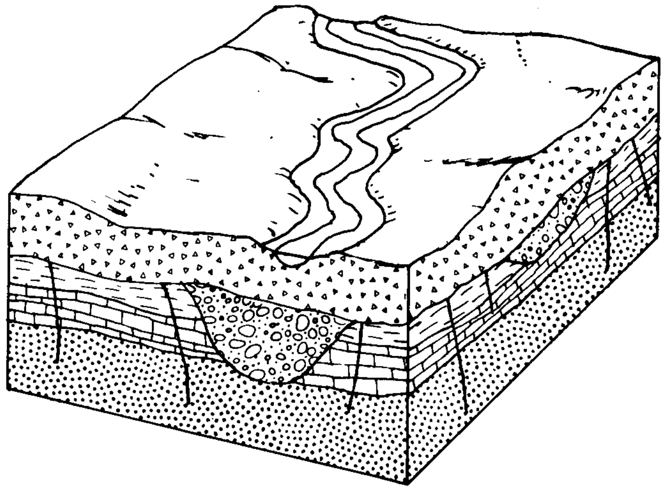
Setting: 7Ae21		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	silt loam	2	4	8
Topography	18+	1	1	1
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	85

Setting: 7Ae22		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sand	2	9	18
Topography	18+	1	1	1
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	107

Setting: 7Ae23		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	shrink / swell	2	7	14
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	107

Setting: 7Ae24		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sandy loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	125

Setting: 7Ae25		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sandy loam	2	6	12
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	105



7D Buried Valley

This hydrogeologic setting is characterized by thick deposits of sand and gravel that have been deposited in a former topographic low (a pre-glacial or inter-glacial river valley) by glacial melt waters. These deposits are capable of yielding large quantities of ground water. The deposits may or may not underlie a present-day stream and may or may not be in direct hydraulic connection with a stream. Glacial till or recent alluvium often overlies the buried valley. The sand and gravel deposits are several times more permeable than the surrounding bedrock and till. Soils are highly variable ranging from clay loam to sand, but are typically a silty loam. Static water levels are typically shallow, but may be highly variable depending on surficial deposits. Recharge to the aquifer can be attributed to infiltration of precipitation, and regional ground-water flow from the surrounding till plains and bedrock.

GWPP index values for the hydrogeologic setting of buried valleys ranges from 85-153 with a total number of GWPP index calculations equaling 36.

Setting: 7D1		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	sand	5	7	35
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	141

Setting: 7D2		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	116

Setting: 7D3		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	silt loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	128

Setting: 7D4		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	50-75	5	3	15
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	95

Setting: 7D5		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	105

Setting: 7D6		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	115

Setting: 7D7		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	111

Setting:7D8		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	106

Setting: 7D9		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	103

Setting: 7D10		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	93

Setting: 7D11		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	113

Setting: 7D12		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sand	2	9	18
Topography	2-6	1	9	9
Impact of Vadose Zone	sand	5	7	35
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	140

Setting: 7D13		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	sand & gravel	5	7	35
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	129

Setting: 7D14		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	sand & gravel	5	7	35
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	153

Setting: 7D15		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	sand & gravel	5	7	35
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	141

Setting: 7D16		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	7	35
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	131

Setting: 7D17		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	126

Setting: 7D18		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	silty loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	118

Setting: 7D19		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	101

Setting: 7D20		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	sandy loam	2	6	12
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	111

Setting: 7D21		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	sand & gravel	3	5	15
Soil Media	shrink swell / clay	2	7	14
Topography	18+	1	1	1
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	103

Setting: 7D22		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	sandy loam	2	6	12
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	121

Setting: 7D23		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	sandy loam	2	6	12
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	131

Setting: 7D24		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	sand & gravel	3	5	15
Soil Media	sand	2	9	18
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	145

Setting: 7D25		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	sandy loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	132

Setting: 7D26		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	7-10	4	8	32
Aquifer Media	sand & gravel	3	5	15
Soil Media	sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	136

Setting: 7D27		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	sand	2	9	18
Topography	18+	1	1	1
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	119

Setting: 7D28		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	50-75	5	3	15
Net Recharge	2-4	4	3	12
Aquifer Media	sand & gravel	3	5	15
Soil Media	shrink swell / clay	2	7	14
Topography	18+	1	1	1
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	83

Setting: 7D29		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquirfer Media	sand & gravel	3	5	15
Soil Media	sandy loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	145

Setting: 7D30		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	silty loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	108

Setting: 7D31		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	101

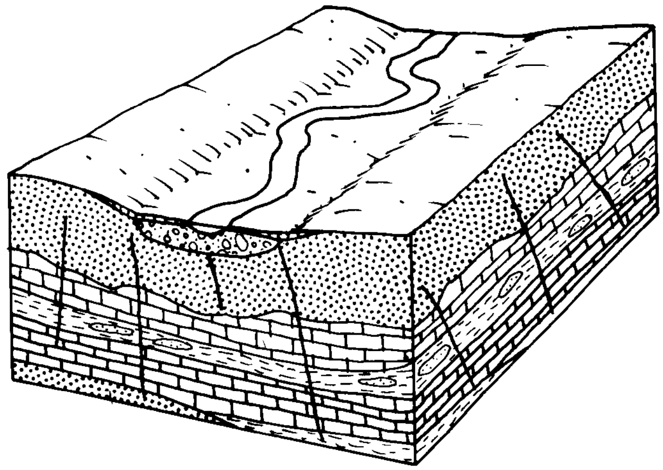
Setting: 7D32 "*"		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	sand & gravel	3	5	15
Soil Media	clay loam	2	3	6
Topography	18+	1	1	1
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	95

Setting: 7D33		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	shrink swell / clay	2	7	14
Topography	6-12	1	5	5
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	119

Setting: 7D34		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sand & gravel	3	5	15
Soil Media	silt loam	2	4	8
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	117

Setting: 7D35		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	7-10	4	8	32
Aquifer Media	sand & gravel	3	5	15
Soil Media	sand	2	9	18
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	135

Setting: 7D36		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	50-75	5	3	15
Net Recharge	4-7	4	6	24
Aquifer Media	sand & clay	3	5	15
Soil Media	clay	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	96



7Ec Alluvium over Bedded Sedimentary Rocks

This hydrogeologic setting is characterized by low relief with thin to moderate thicknesses of modern, stream-deposited alluvium. The alluvium is composed of silt, sand, gravel, and clay. Depth to water is shallow, and the stream is usually in hydraulic contact with the alluvial deposits. The alluvial deposits are underlain by fractured sandstone, limestone, shale, or bedded sedimentary sequences. These rocks are described in settings 7Ac, 7Ad, 7Ae, and 7G. Usually the upper, weathered portion of the bedrock serves as the principal aquifer in this setting. The alluvial deposits may serve as a source of recharge to the bedrock. Soils are typically silty loams.

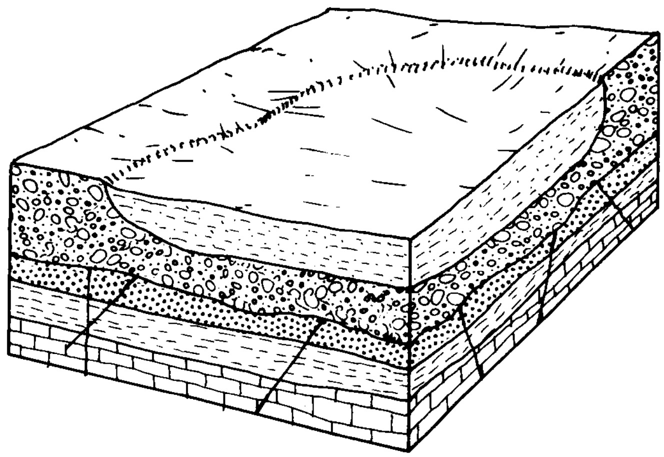
GWPP index values for the hydrogeologic setting of alluvium over bedded sedimentary rocks ranges from 104-141 with a total number of GWPP index calculations equaling 4.

Setting: 7Ec1		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	silt loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	104

Setting: 7Ec2		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	silt loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	110

Setting: 7Ec3 "*"		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sand	2	9	18
Topography	2-6	1	9	9
Impact of Vadose Zone	sand & gravel	5	7	35
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	140

Setting: 7Ec4		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	sandy clay	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	131



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. Water levels are variable, depending on the thickness of the lake sediments and the underlying materials.

GWPP index values for the hydrogeologic setting of the glacial lake deposits ranges from 82-131 with a total number of GWPP index calculations equaling 20.

Setting: 7F1		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	clay / silt	5	3	15
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	97

Setting: 7F2		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	102

Setting: 7F3		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	108

Setting: 7F4		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	sandstone	3	4	12
Soil Media	silt loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	110

Setting: 7F5		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	101

Setting: 7F6		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	clay / silt	5	3	15
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	92

Setting: 7F7		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay	2	1	2
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	98

Setting: 7F8		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	clay / silt	5	3	15
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	96

Setting: 7F9		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	clay / silt	5	3	15
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	82

Setting: 7F10		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	silt loam	2	4	8
Topography	2-4	1	9	9
Impact of Vadose Zone	silt / clay	5	3	15
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	100

Setting: 7F11		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	silty loam	2	4	8
Topography	6-12	1	5	5
Impact of Vadose Zone	silt / clay	5	3	15
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	94

Setting: 7F12 "*"		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	sl & cl w/ frac's	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	131

Setting: 7F13 "*"		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	1-18	1	1	1
Impact of Vadose Zone	silt / clay	5	3	15
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	88

Setting: 7F14		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	sl & cl w/ frac's	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	119

Setting: 7F15		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	sl & cl w/ frac's	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	114

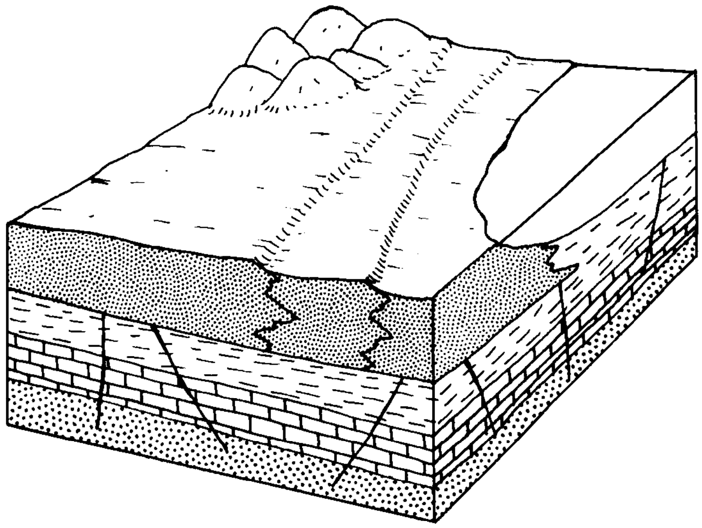
Setting: 7F16		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	silt loam	2	4	8
Topography	6-12	1	5	5
Impact of Vadose Zone	silt / clay	5	3	15
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	106

Setting: 7F17		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	silt loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	silt / clay	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	108

Setting: 7F18		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	silt loam	2	4	8
Topography	18+	1	1	1
Impact of Vadose Zone	shale	5	3	15
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	102

Setting: 7F19		GENERAL		
	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	silt loam	2	4	8
Topography	2-6	1	9	9
Impact of Vadose Zone	shale	5	3	15
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	100

Setting: 7F20		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	silt loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	silt clay w/ frac's	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	121



7H Beaches and Beach Ridges

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.

GWPP index values for the hydrogeologic setting of beaches and beach ridges ranges from 116-146 with a total number of GWPP index calculations equaling 12.

Setting: 7H1		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sand	2	9	18
Topography	2-6	1	9	9
Impact of Vadose Zone	sand	5	7	35
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	140

Setting: 7H2		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	126

Setting: 7H3		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	sand	5	7	35
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	129

Setting: 7H4		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sand	2	9	18
Topography	2-6	1	9	9
Impact of Vadose Zone	silt / clay	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	125

Setting: 7H5		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	sand	2	9	18
Topography	2-6	1	9	9
Impact of Vadose Zone	sand	5	7	35
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	146

Setting: 7H6		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sandy loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	120

Setting: 7H7		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	sandy loam	2	6	12
Topography	2-6	1	9	9
Impact of Vadose Zone	sand & gravel	5	7	35
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	140

Setting: 7H8		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	sandstone	3	4	12
Soil Media	sandy loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	116

Setting: 7H9		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	clay loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	sand	5	7	35
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	129

Setting: 7H10		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	sand & gravel	5	7	35
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	141

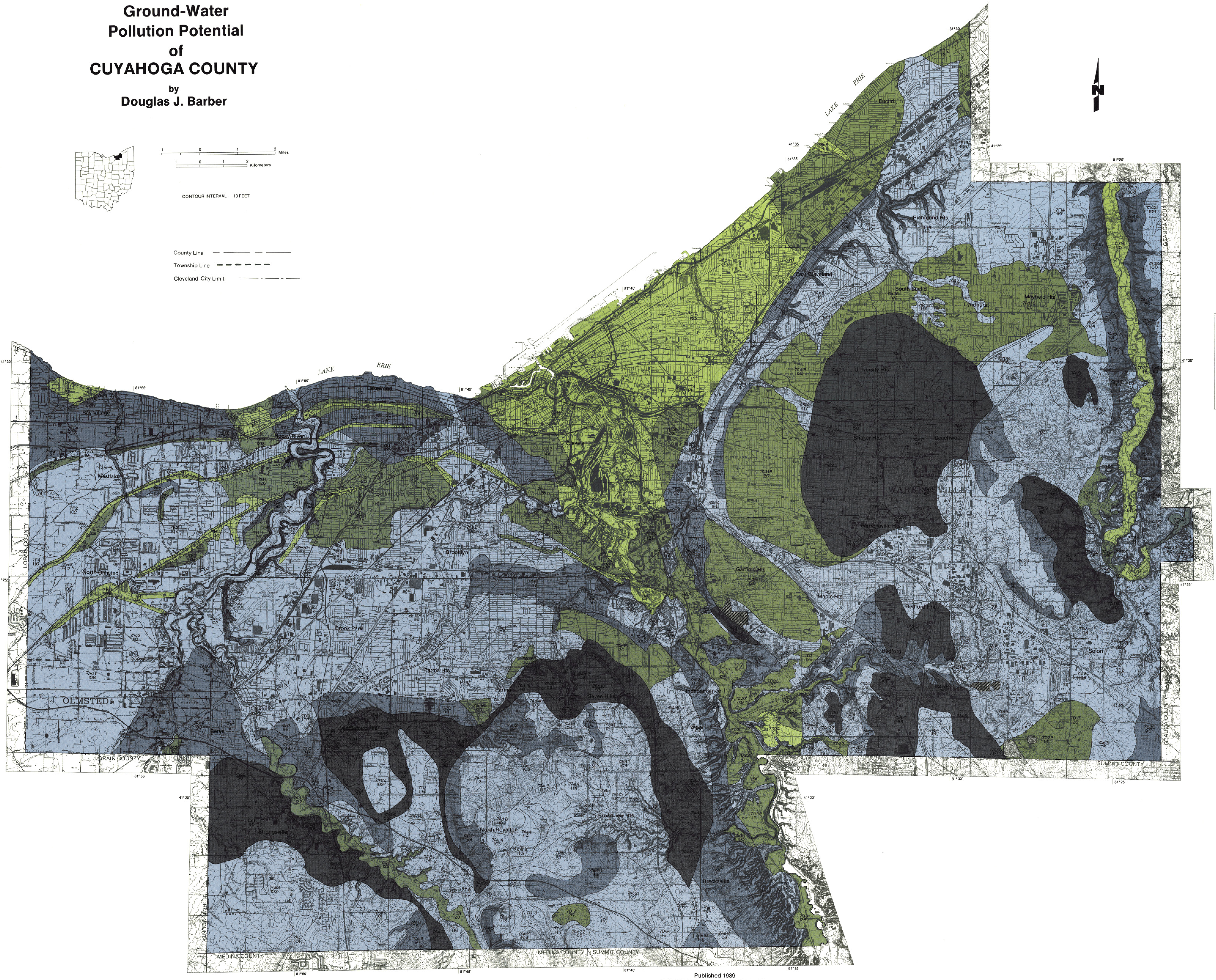
Setting: 7H11		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	126

Setting: 7H12		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	shale	3	2	6
Soil Media	sand	2	9	18
Topography	2-6	1	9	9
Impact of Vadose Zone	s & g w / sl & cl	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	125

Ground-Water Pollution Potential of CUYAHOGA COUNTY

by

Douglas J. Barber



Pollution Potential Index Range

Higher		140 - 159
		120 - 139
to		100 - 119
		80 - 99
Lower		<79

Description of Map Symbols

Hydrogeologic Region → 7Ad 6 ← Hydrogeologic Setting
98 ← Relative Pollution Potential

Gravel Pit / Quarry

Landfill

Hydrogeologic Settings Mapped in Cuyahoga County

7H	Beaches and Beach Ridges
7F	Glacial Lake Deposits
7Ec	Alluvium over Bedded Sedimentary Rocks
7D	Buried Valley Deposits
7Ae	Glacial Till over Shale
7Ad	Glacial Till over Sandstone

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 Cuyahoga County", GWPP Report No. 4, Ohio Dept. of Natural Resources, Division of Water.

Note

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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Published 1989
Ohio Department of Natural Resources
Division of Water
Ground-Water Resources Section
1939 Fountain Square
Columbus, Ohio 43224

Total copies printed: 500
Unit cost: $4.190
Publication date: 4/89

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ERRATA SHEET CUYAHOGA COUNTY
Ground Water Pollution Potential No. 4

Changes in Report

Changes in Tables

General Changes

Vadose zone media
- Silt/clay and clay/silt are the same
- Silt clay w/ fracís and silt & clay w/fracís are the same

Soil media-
- Change silty loam to silt loam
- Changes to individual settings
- Change 7F17 soil from silt loam to clay loam
- Change 7D32 depth to water range from 30-50 to 15-30
- Change 7F12 recharge rate from 2-4 to 4-7
- Change 7Ec4 soil from snady clay to sandy loam
- Change 7D36 aquifer from sand & clay to sand & gravel