GROUND WATER POLLUTION POTENTIAL
OF DARKE COUNTY, OHIO

BY

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GROUND WATER POLLUTION POTENTIAL REPORT NO. 25

OHIO DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATER

GROUND WATER RESOURCES SECTION

SEPTEMBER, 1991

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

Darke County lies within the Glaciated Central hydrogeologic region. The county is covered by variable thicknesses of glacial till, lacustrine deposits, and outwash. These unconsolidated glacial deposits are underlain by limestone and dolomite bedrock capable of supplying large quantities of ground water. Pollution potential indexes are relatively low to moderate in areas of till or lacustrine cover over bedrock. Buried valleys containing sand and gravel aquifers, and areas covered by outwash have moderate to high vulnerabilities to contamination. Five hydrogeologic settings were identified in Darke County with computed ground water pollution potential indexes ranging from 89 to 179.

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 Darke 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 Darke 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:	Paul Spahr Mike Angle Mike Hallfrisch
Map print production and review:	Dave Orr Paul Spahr Mike Hallfrisch
Report production and review:	Paul Spahr Mike Hallfrisch Mike Angle
Report editing:	Dr. William Mattox Rebecca Petty
Desktop publishing and report design	Dave Orr

In addition, the author would like to thank the following people for their assistance on the project: Ken Coats and Greg Klosterman of American Aggregates; Tom Field of ANR Pipeline Inc.; and the geologists of the Regional Geology Section of the Ohio Dept. of Natural Resources, Div. of Geological Survey. A special thanks goes to Mike Angle for his patience and guidance throughout the entire project.

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 6,000 of these wells exist in Darke 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 Darke 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 one-hundred acres in size, and is not intended or designed to replace site-specific investigations.

Hydrogeologic Settings and Factors

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

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

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

D - Depth to Water

R - Net Recharge

A - Aquifer Media

S - Soil Media

T - Topography

I - Impact of the Vadose Zone Media

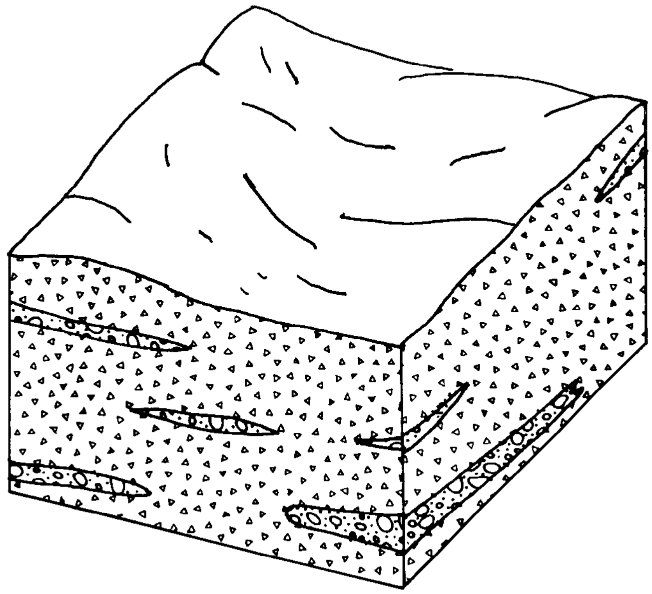
C - Conductivity (Hydraulic) of the Aquifer

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

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

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

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



7Af Sand and Gravel Interbedded in Glacial Till

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

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

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

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

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

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

Weighting and Rating System

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

Once a DRASTIC index has been calculated, it is possible to identify areas that are more likely to be susceptible to ground water contamination relative to other areas. The higher the DRASTIC index, the greater the vulnerability to contamination. The index generated provides only a relative evaluation tool and is not designed to produce absolute answers or to represent units of vulnerability. Pollution potential indexes of various settings should be compared to each other only with consideration of the factors that were evaluated in determining the vulnerability of the area.

Pesticide DRASTIC

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

TABLE 1. ASSIGNED WEIGHTS FOR DRASTIC FEATURES

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

TABLE 2. RANGES AND RATINGS FOR DEPTH TO WATER

DEPTH TO WATER (FEET)	
Range	Rating
0-5	10
5-15	9
15-30	7
30-50	5
50-75	3
75-100	2
100+	1
Weight: 5	Pesticide Weight: 5

TABLE 3. RANGES AND RATINGS FOR NET RECHARGE

NET RECHARGE (INCHES)	
Range	Rating
0-2	1
2-4	3
4-7	6
7-10	8
10+	9
Weight: 4	Pesticide Weight: 4

TABLE 4. RANGES AND RATINGS FOR AQUIFER MEDIA

AQUIFER MEDIA		
Range	Rating	Typical Rating
Massive Shale	1-3	2
Metamorphic/Igneous	2-5	3
Weathered Metamorphic / Igneous	3-5	4
Glacial Till	4-6	5
Bedded Sandstone, Limestone and Shale Sequences	5-9	6
Massive Sandstone	4-9	6
Massive Limestone	4-9	6
Sand and Gravel	4-9	8
Basalt	2-10	9
Karst Limestone	9-10	10
Weight: 3	Pesticide Weight: 3	

TABLE 5. RANGES AND RATINGS FOR SOIL MEDIA

SOIL MEDIA	
Range	Rating
Thin or Absent	10
Gravel	10
Sand	9
Peat	8
Shrinking and / or Aggregated Clay	7
Sandy Loam	6
Loam	5
Silty Loam	4
Clay Loam	3
Muck	2
Nonshrinking and Nonaggregated Clay	1
Weight: 2	Pesticide Weight: 5

TABLE 6. RANGES AND RATINGS FOR TOPOGRAPHY

TOPOGRAPHY (PERCENT SLOPE)	
Range	Rating
0-2	10
2-6	9
6-12	5
12-18	3
18+	1
Weight: 1	Pesticide Weight: 3

TABLE 7. RANGES AND RATINGS FOR IMPACT OF THE VADOSE ZONE MEDIA

IMPACT OF THE VADOSE ZONE MEDIA		
Range	Rating	Typical Rating
Confining Layer	1	1
Silt/Clay	2-6	3
Shale	2-5	3
LImestone	2-7	6
Sandstone	4-8	6
Bedded Limestone, Sandstone, Shale	4-8	6
Sand and Gravel with significant Silt and Clay	4-8	6
Metamorphic/Igneous	2-8	4
Sand and Gravel	6-9	8
Basalt	2-10	9
Karst Limestone	8-10	10
Weight: 5	Pesticide Weight: 4	

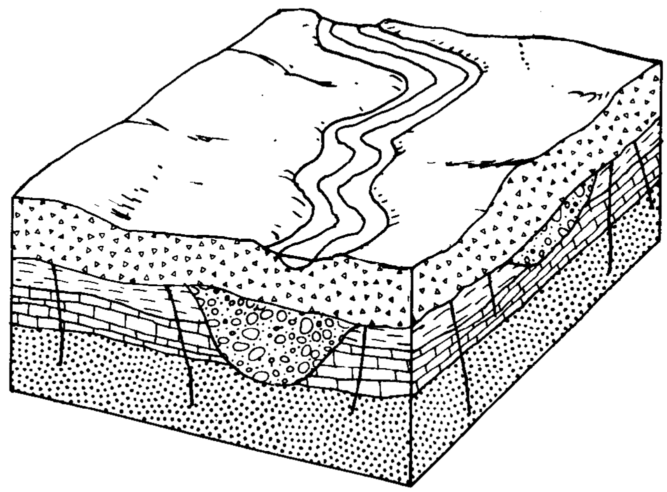
TABLE 8. RANGES AND RATINGS FOR HYDRAULIC CONDUCTIVITY

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

Integration of Hydrogeologic Settings and DRASTIC Factors

Figure 2 illustrates the hydrogeologic setting 7D1 Buried Valley, identified in mapping Darke County, and the pollution potential index calculated for the setting. Based on selected ratings for this setting, the pollution potential index is calculated to be 141. This numerical value has no intrinsic meaning, but can be readily compared to a value obtained for other settings in the county. DRASTIC indexes for typical hydrogeologic settings and values across the United States range from 65 to 223. The diversity of hydrogeologic conditions in Darke County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the five settings identified in the county range from 89 to 179.

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 Darke 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 Darke County is included with this report.



SETTING 7D1		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	NUMBER
Depth to Water	0-5	5	10	50
Net Recharge	4-7	4	6	24
Aquifer Media	Sand & Gravel	3	8	24
Soil Media	Clay Loam	2	3	6
Topography	0-2%	1	10	10
Impact Vadose Zone	Glacial Till	5	3	15
Hydraulic Conductivity	300-700	3	4	12
		DRASTIC	INDEX	141

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

INTERPRETATION AND USE OF A GROUND WATER POLLUTION POTENTIAL MAP

The application of the DRASTIC system to evaluate an area's vulnerability to contamination produces hydrogeologic settings with corresponding pollution potential indexes. The higher the pollution potential index, the greater the susceptibility to contamination. This numeric value determined for one area can be compared to the pollution potential index calculated for another area.

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

7D1 - defines the hydrogeologic region and setting
141 - defines the relative pollution potential

Here the first number (7) refers to the major hydrogeologic region and the upper and lower case letters refer (D) to a specific hydrogeologic setting. The following number (1) references a certain set of DRASTIC parameters that are unique to this setting and are described in the corresponding setting chart. The second number (141) is the calculated pollution potential index for this unique setting. The charts for each setting provide a reference to show how the pollution potential index was derived in an area.

The maps are color coded using ranges depicted on the map legend. The color codes used are part of a national color coding scheme developed to assist the user in gaining a general insight into the vulnerability of the ground water in the area. The color codes were chosen to represent the colors of the spectrum, with warm colors (red, orange, and yellow), representing areas of higher vulnerability (higher pollution potential indexes), and cool colors (greens, blues, and violet), representing areas of lower vulnerability to contamination.

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

GENERAL INFORMATION ABOUT DARKE COUNTY

Darke County occupies an area of approximately 605 square miles in west-central Ohio (U.S. Department of Agriculture, 1987). It has 20 townships and is bounded by Indiana on the west, to the north by Mercer County, to the northeast by Auglaize County, to the east by Shelby and Miami Counties, to the southeast by Montgomery County, and to the south by Preble County (Figure 3). The county seat is Greenville.

The 1986 estimate of population for the county was 54,000 (U.S. Dept. of Commerce, 1987). In 1978, 90.4 percent of the land in Darke County was used for agricultural purposes and approximately five percent was woodland area. The remaining land was used for residential and commercial purposes (U.S. Dept. of Agriculture, 1987).

Physiography

Darke County lies within the Till Plains section of the Central Lowlands physiographic province (Fenneman, 1938). The county is characterized by gently rolling topography with steeper slopes near glacial end moraines and along streams. The surface features are glacial in origin with the exception of modern stream drainage patterns. Maximum relief in the county is 310 feet.

Climate

The climate of Darke County is described as humid-continental, warm-summer type by Selby (1978). Darke County has a thirty-year (1951-1980) average annual precipitation of 38.85 inches and an annual mean temperature of 49.4 degrees Fahrenheit (U.S. Dept. of Commerce, 1982). Sixty percent of the precipitation falls in April through September. January is the coldest month with an average temperature of 24.2 degrees Fahrenheit, whereas July is the warmest month with an average temperature of 72.0 degrees Fahrenheit

Modern Drainage

Darke County lies within the Wabash River and the Miami River Basins. The northwestern corner of Darke County is drained by streams in the Ohio portion of the Wabash River Basin (Walker, 1961a). The remainder of the county is drained by streams in the Miami River Basin. The Miami River Basin in Darke County is divided into the Stillwater River Basin (Walker, 1960a), the Loramie and Mosquito Creek area (Walker, 1960b), the Twin Creek Basin and the Ohio portion of the East Fork of the Whitewater River Basin, (Walker, 1961b).

Figure 3. Location of Darke County, Ohio

The Ohio portion of the Wabash River Basin in northwestern Darke County is primarily drained by the Mississinawa and the Wabash Rivers. Their headwaters originate on the Mississinewa end moraine and flow east and north, respectively, away from the crest of the moraine.

The Stillwater River Basin in central Darke County is primarily drained by the Stillwater River, Greenville Creek, and their tributaries. The Stillwater River flows east into Miami County and its channel follows the southern margin of the Bloomer Moraine. Greenville Creek also flows east into Miami County where it then joins the Stillwater River. Greenville Creek follows the southern margin of the Union City Moraine.

The Miami River Basin in the northeastern corner of Darke County is drained by small streams (Mile Creek, Honsapple Ditch, Spring Creek) whose headwaters originate along the northern slope of the Missisinewa Moraine. These streams and their tributaries primarily flow north.

The southwestern corner of Darke County lies within the Ohio portion of the East Fork of the Whitewater River Basin and the Twin Creek Basin. The Ohio portion of the Whitewater River Basin is drained by Mud Creek and the East Fork of the Whitewater River. Mud Creek, whose headwaters originate at the Farmersville Moraine, flows southwest over the Sunbeam Prairie into Indiana. The East Fork of the Whitewater River flows south into Preble County. The Twin Creek Basin in Darke County is primarily drained by the southerly-flowing Twin Creek, Mud Creek, and their tributaries.

Pre- and Inter-glacial Drainage and Topography

Little study has been done in regards to pre-glacial (Teays Stage) drainage in Darke County. A study of Ohio by Stout et al. (1943) revealed three prominent streams separated by drainage divides in Darke County during Teays Stage drainage times (Figure 4a). The most prominent of these streams was New Paris Creek. New Paris Creek had its headwaters in what is now Wayne Township and then flowed southwest into what is now Harrison Township, and through Preble County before flowing into Indiana. The northernmost townships of Darke County were drained by northerly-flowing tributaries of Montezuma Creek. Stout et al. (1943) also showed a tributary of a larger stream (Sidney Creek), having its headwaters in Franklin Township and flowing northeast into Miami County.

During the Pleistocene Epoch (2 million to 10 thousand years ago) at least four stages (episodes) of glaciation occurred in north-central North America. These stages experienced numerous periods of advancing and retreating ice known as sub-stages. Each of these sub-stages resulted in geomorphological changes in Darke County.

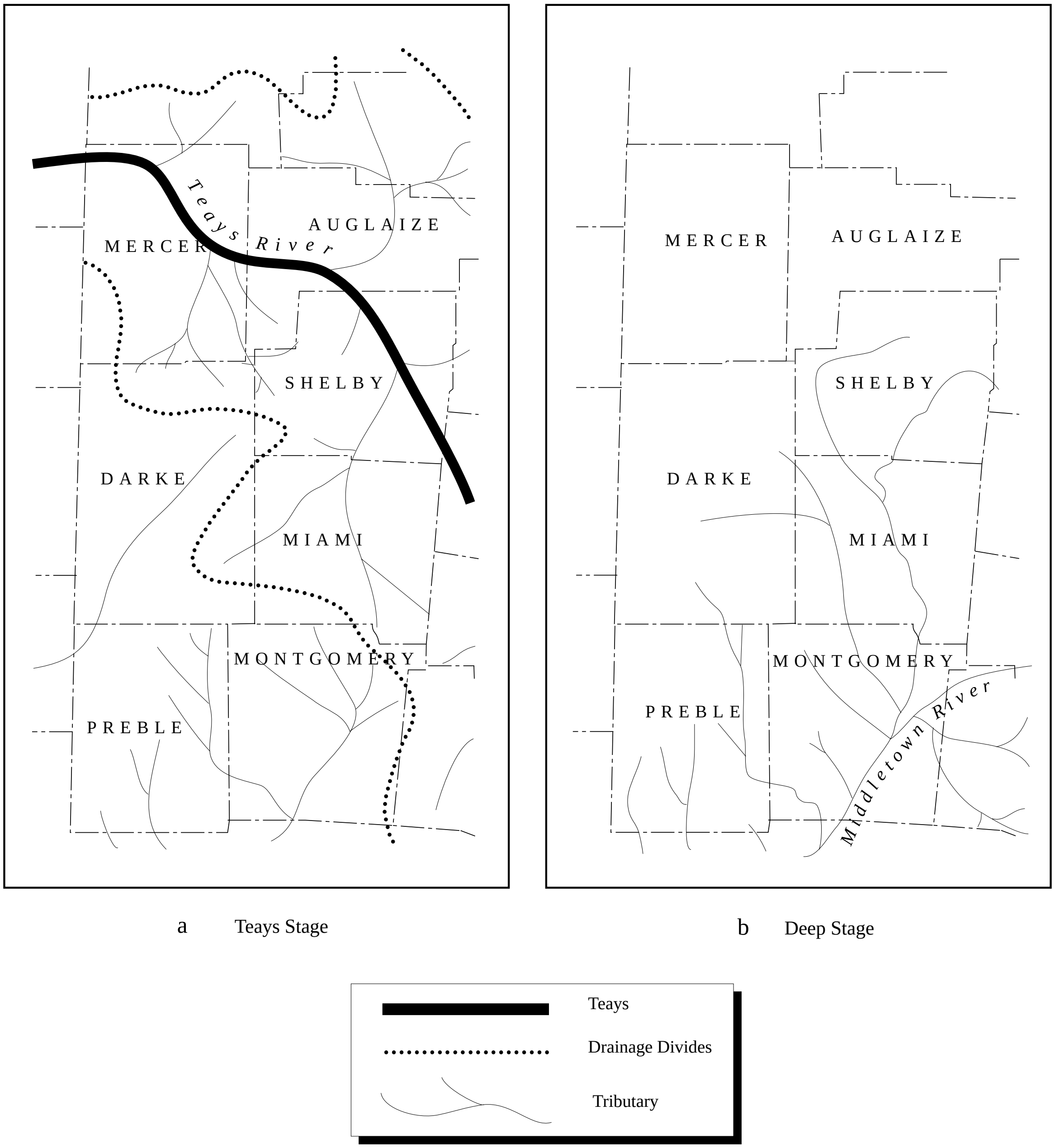


Figure 4. Teays and Deep Stage drainage in western Ohio
(modified from Stout et al., 1943)

The southerly advance of a pre-Illinoian glacier caused the Teays Stage drainage to be blocked by a mass of ice. Subsequent flooding forced waters to form a new drainage pattern. This drainage pattern, referred to as Deep Stage Drainage (Figure 4b), is evident in Darke County (Stout et al., 1943). An easterly-flowing tributary to West Milton Creek formed its headwaters near what is now the City of Greenville, and subsequently flowed east into Miami County.

Following the Kansan glaciation, the ice advanced and retreated several more times. This ice, of the Illinoian and Wisconsinan glacial period, eroded bedrock, dammed pre-existing drainage patterns, and subsequently covered all of Darke County with varying thicknesses of glacial drift (Leow, 1988b).

The resulting bedrock topography of Darke County is depicted in maps by Cummins (1959), Leow (1988a), and Clinch (unpublished). The Cummins (1959) bedrock topography map of Ohio shows a prominent buried valley trending southwest to northeast in Darke County. Cummins (1959) also showed another valley, trending in the same direction, going through Monroe Township in southeast Darke County. Leow (1988a) depicts a prominent buried valley with smaller tributaries that trends southwest to northeast with up to 400 feet of relief. Leow (1988a) also shows the buried valley in Monroe Township trending northeast to southwest with drainage to the southwest.

Glacial Geology

The unconsolidated material (drift) deposited by the glaciers varies in thickness in Darke County (Leow, 1988b). The thickest deposits are found in buried valleys (Leow, 1988a), and end moraines. In these areas the drift reaches a maximum thickness of 400 feet in Darke County. The thinnest covering of drift can be found in isolated areas in the south-central part of the county where approximately 20 feet of drift is present.

The drift deposits of Darke County can be divided into till and sand and gravel. Till is predominantly unsorted, unstratified and unconsolidated drift composed of a heterogeneous mixture of sand, silt, clay, and boulders. No pre-Illinoian deposits are recognized in Darke County (Selby, 1978) (Table 9). The oldest glacial till is believed to be the Whitewater Till (Table 9) of either early Wisconsinan or Illinoian age. This till unit is buried under late Wisconsinan (Woodfordian) till which covers all of Darke County. The surfical tills are the Arcanum, Yorkshire, and Woodington tills (Selby, 1978) (Table 1).

TABLE 9. GENERALIZED PLEISTOCENE (GLACIAL) STRATIGRAPHY OF DARKE COUNTY, OHIO (modified from Selby, 1978)

EPOCH	STAGE		SUBSTAGE	UNIT OR INTERVAL
PLEISTOCENE	WISCONSINAN	Late	Woodfordian	Yorkshire Woodington Arcanum
		Middle	Farmdalian	
		Early	Altonian ?	Whitewater?
	SANGAMONIAN			
	ILLINOIAN			Whitewater?
	Pre-ILLINOIAN			

In Darke County, the surficial tills were deposited as either till plains (ground moraine) or end moraines. The till plains in Darke County are extensive, flat to slightly-undulating areas that are found between end moraines. The end moraines of Darke County (Farmersville, Union City, Bloomer, Mississinewa) are accumulations of till characterized by topographically high ridges that are hummocky in form. They also can serve as surfical drainage divides, with runoff leading away from the crest. End moraines are commonly believed to have formed at ice margins where the glacier was stagnant or retreating.

The moraine setting was not used for the pollution potential map of Darke County since the moraine areas essentially represent a thickening of the glacial till. Hydrogeologic settings which more closely approximate the conditions of the end moraines were used (i.e. Till over Limestone (7Ac), Sand and Gravel within Till (7Af), and Buried Valley (7D)). Furthermore, the end moraines are not well defined in the northern part of the county and thus mapping these features is extremely difficult.

The other common drift material found in Darke County is sand and gravel deposited within the till and as outwash. Outwash is stratified sand and gravel that was deposited by meltwater streams flowing in front of the glacier. The largest deposit of outwash can be found extending southwest of Greenville to the southwestern corner of the county. Sand and gravel can also be found within kame deposits. Kames are isolated mounds of sand and gravel that were deposited in openings or cracks in the glacial ice.

Southwestern Darke County is covered by the Farmersville Moraine. The Farmersville Moraine is characterized by a hummocky, topographic high that has been dissected by modern drainage. The Farmersville Moraine is primarily composed of Arcanum Till underlain by sand and gravel, and possibly the Whitewater Till (Selby, 1978) (Figure 5). The Arcanum Till is commonly light gray where unoxidized and yellow-brown where oxidized. The Arcanum Till is friable, poorly compacted, and contains fractures. The thickness of the Arcanum Till is variable. Average percentages by particle size for the matrix of the Arcanum Till are 29.3% sand, 54.9% silt, and 15.8% clay (Selby, 1978). Within the Arcanum Till are lenses of sand and gravel which can yield sufficient amounts of water for domestic use (Raab, in progress). These lenses vary in thickness and may overlie the Whitewater Till (Selby, 1978). There is one known exposure of the Whitewater Till in Darke County. Selby (1978) describes the buried till located at the American Aggregates Quarry at Fort Jefferson, as being calcareous, gray, dense, pebbly, and sandy.

The Farmersville Moraine is dissected by the East Fork of the Whitewater River. Outwash sands and gravels deposited by meltwater streams can be found underlying the present Whitewater River and on the adjacent uplands bordering the flood plain. These outwash sands and gravels were deposited prior to the readvancing ice that deposited the overlying Arcanum Till (Selby, 1978). These outwash deposits extend up to Greenville.

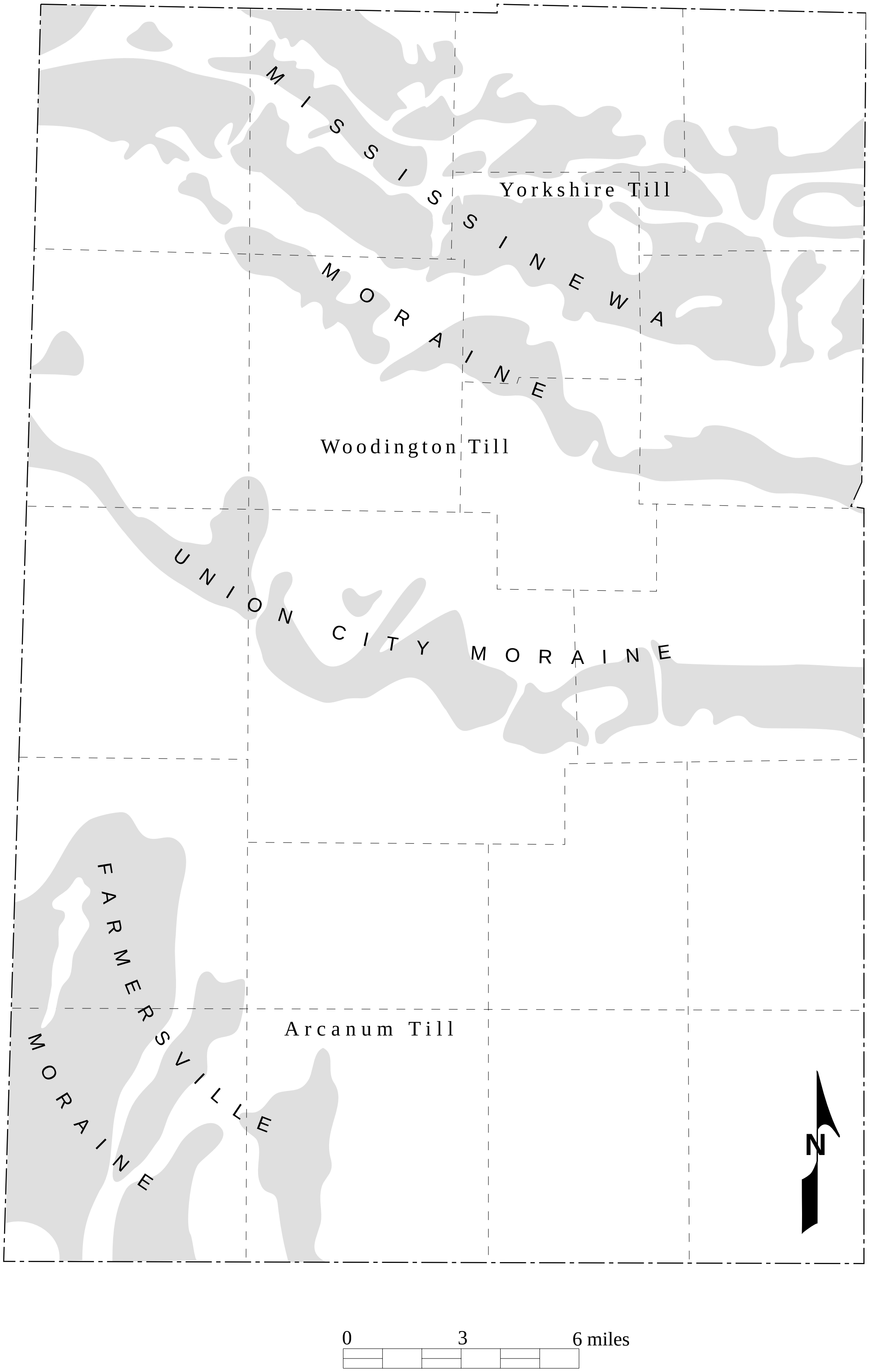


Figure 5. End moraines of Darke County, (modified from Selby, 1978).

A branch of the meltwater channel that dissects the Farmersville Moraine is present in the extreme southwestern corner of Darke County. As the ice retreated, the channel was abandoned, and a shallow lake formed. This area gradually drained to become the Sunbeam Prairie. The stratigraphy of the Sunbeam Prairie is described as 24 inches (61 centimeters) of compact, non-calcareous, brownish-black humus, overlying 98 inches (250 centimeters) of fine, gray, fossilferous marl overlying sand and gravel (outwash), (Camp and Ginder, 1978).

The Farmersville Moraine and the southern side of the Union City Moraine are noted for a high concentration of boulders known as the "Boulder Belt" (Goldthwait et al., 1961). These boulders are approximately 90 percent crystalline erratics (Goldthwait and Rosengreeen, 1969). The origin of this high concentration of boulders remains a mystery, but several theories exist. Selby (1978) theorizes that superglacial streams may have concentrated the boulders on the ice surface and then deposited them on the till plain and end moraines as the ice melted. Goldthwait and Rosengreen (1969) state that "surface concentrations of scattered boulders without equivalent till matrix are similar to debris patterns left by recently surging glaciers".

North of the Farmersville Moraine lies the Arcanum Till Plain (Selby, 1978). The Arcanum Till Plain extends northward to the Union City Moraine and is characteristically flat. Arcanum Till is present at the surface. Well logs indicate that discontinuous lenses of sand and gravel are present within the till.

North of the Arcanum Till Plain is the Union City Moraine. Greenville Creek follows the southern margin of the moraine. The topography of the Union City Moraine is gently rolling to hummocky and exhibits up to 40 feet of relief above the surrounding till plains. The surficial material of the Union City Moraine is composed of the Woodington Till which is underlain by lenses of sand and gravel, and commonly an older buried till (Selby, 1978). The slightly-compacted Woodington Till is yellowish-brown where oxidized and light gray where unoxidized. The average percentages for particle sizes of the Woodington Till are 19.6 % sand, 52.5 % silt, and 27.9% clay (Selby, 1978).

North of the Union City moraine lies the Woodington Till Plain. The Woodington Till Plain extends northward to the Stillwater River, and is flattest in the west and gently to moderately rolling in the eastern part of the county. Selby (1978) states that approximately 2.5 miles west of Ansonia "the ground moraine of this area is so undulating that it has the aspects of an end moraine". Also associated with the Woodington Till Plain are numerous kettles. Kettles are enclosed depressions that were formed by the melting of detached, stagnant blocks of glacial ice. Occasionally, these depressions are filled with water and aquatic vegetation.

North of the Woodington Till Plain lies the Mississinewa Moraine. It is composed of several elements, the southernmost outer element of which is considered to be a separate and distinct moraine called the Bloomer Moraine (Goldthwait et al., 1961). The Mississinewa Moraine acts as a surficial drainage divide and exhibits 50 to 100 feet of relief above the surrounding ground moraine. The moraine is hummocky to gently rolling. The Stillwater River flows along the margin of the southernmost element of the moraine.

The surficial material of the Mississinewa Moraine and the Yorkshire Till Plain (to the north) is the Yorkshire Till (Selby, 1978). The Yorkshire Till is yellowish-brown where oxidized and light gray where unoxidized. Statistics for the average particle size analyses of the Yorkshire Till reveal 4.9 % pebbles, 16.2% sands, 48.5 % silt, and 35.3 % clay (Selby, 1978).

The Yorkshire Till Plain lies to the north of the Mississinewa Moraine; it is flat to gently rolling. Remnants of an intermorainal lake exist on the border between Darke and Mercer counties. Intermorainal lakes are formed as water is trapped between a moraine and a slowly-retreating ice sheet. Augering and well logs show that these lake deposits do not exceed five to six feet in thickness and are underlain by Yorkshire Till (Selby, 1978).

Bedrock Geology

The bedrock formations that underlie Darke County are Silurian and Ordovician limestones, dolomites and shales (Table 10) (Bownocker, 1920). The Silurian rocks were deposited during three periods of sedimentation and primarily represent an ocean shelf facies (Horvath and Sparling, 1967). These formations lie on the western flank of the Cincinnati Arch and have an approximate dip of five to ten feet per mile to the northwest (Norris and Fidler, 1973).

There is one natural exposure of bedrock in Darke County (Selby, 1978). This outcrop is located in Lake Branch Ditch in Neave Township. The remainder of the bedrock in Darke County is buried under varying thicknesses of drift (Leow, 1988b). The bedrock surface exhibits up to 450 feet of relief beneath the glacial drift (Leow, 1988a).

TABLE 10. GENERALIZED BEDROCK STRATIGRAPHY OF DARKE COUNTY, OHIO (Horvath and Sparling, 1967)

SYSTEM	SERIES	GROUP	FORMATION
SILURIAN	Niagara	Lockport	Cedarville Dolomite
			Springfield Dolomite
			Euphemia Dolomite
	Alexandrian	Sub Lockport	Laurel Dolomite
			Osgood Shale
			Dayton Limestone
			Brassfield Limestone
ORDOVICIAN	Cinicinnatian	Richmond	

The youngest formation is the Silurian Cedarville Dolomite of the Lockport Group (Table 2). Based on a measured section at the Fort Jefferson Quarry, the Cedarville Dolomite is 51 feet thick at this location. It is described as a gray, massive, poorly-bedded, vuggy, sucrosic dolomite (Norris et al., 1956; Horvath and Sparling, 1967). The Cedarville Dolomite is fossiliferous and contains diverse marine fauna such as brachiopods, crinoids, cystoids and corals (Kleffner and Ausich, 1988).

The Cedarville Dolomite rests conformably on the Silurian Springfield Dolomite of the Lockport Group (Table 2). The Springfield Dolomite is approximately six feet thick at the Fort Jefferson Quarry. This formation is described as more evenly and thinly-bedded, and denser than the Cedarville Dolomite (personal comm. Ken Coats, American Aggregates, 1990). The Springfield Dolomite is light gray, fine grained, sparsely fossiliferous, and contains an insoluble silt residue (Norris et al., 1956; Horvath and Sparling, 1967; Kleffner and Ausich, 1988).

The Springfield Dolomite lies conformably on the Silurian Euphemia Dolomite of the Lockport Group (Table 10). The Euphemia is approximately 27 feet thick at the Fort Jefferson Quarry and resembles the Cedarville Dolomite in appearance (Horvath and Sparling, 1967; personal comm. Ken Coats, American Aggregates, 1990). The Euphemia is massive, porous fossiliferous, and gray in color (Kleffner and Ausich, 1988; Horvath and Sparling, 1967).

Below the Euphemia is the Laurel Limestone (Table 10). The contact between the Euphemia is described as conformable, although abrupt (Horvath and Sparling, 1967). The Laurel formation is a recrystalized, fossiliferous limestone that is gray to dark gray, dense, and evenly bedded. It contains minor clay, chert, silt, pyrite, and glauconite residues.

The Osgood Shale lies below the Laurel formation (Table 10). At the Fort Jefferson Quarry, the Osgood Shale is four feet thick. Typically, this formation is an interbedded blue-gray, silty shale with recrystalized dolomite that contains some fossils (Horvath and Sparling, 1967; Kleffner and Ausich, 1988).

Below the Osgood formation is the Dayton Limestone (Table 10). The Dayton Limestone is six feet thick at the Fort Jefferson Quarry in Darke County (Horvath and Sparling, 1967). It is coarsely crystalline, evenly bedded, gray limestone that contains numerous fossils (Horvath and Sparling, 1967; Kleffner and Ausich, 1988). The contact between the Osgood and Dayton is unconformable.

The Brassfield formation, a basal Silurian Limestone, lies unconformably below the Dayton Formation (Table 10). At the Fort Jefferson Quarry, the Brassfield is approximately 14 feet thick and lithologically varied (Horvath and Sparling, 1967). The lower units of the Brassfield Limestone are generally characterized by a medium to coarse grain texture, pink to white color, and massive bedding. The upper part of the Brassfield contains thinner beds and is fossiliferous (Horvath and Sparling, 1967; Norris et al., 1956).

The Brassfield is underlain by the Ordovician Richmond Group. This contact is unconformable (Table 10). The Richmond Group are thin, blue-gray shales that are interbedded with thin, hard layers of limestone that are fossiliferous (Norris et al., 1956). Selby (1978) feels that the older Silurian and Ordovician rocks make up the bedrock surface in the buried valleys. Well logs in Harrison Township (southwestern Darke County) support this theory.

Hydrogeology

Ground water in Darke County can be found in two distinct aquifer media. Ground water exists in sand and gravel and also in the underlying bedrock (Walker, 1960a,b; 1961a,b; Raab, in progress). These aquifers are used equally for sources of domestic water supplies.

The sand and gravel aquifer in Darke County can be found within the outwash, in buried valleys, end moraines, and in sand and gravel lenses found within the till. The depth and areal extent of these deposits vary throughout the county. Yields for wells developed within the sand and gravel are dependent on the lateral extent and thickness of the deposits and the characteristic nature (sorting, heterogeneity) of the aquifer. Yield is also determined by the design and construction of the well itself.

Sand and gravel deposits within buried valleys are capable of producing 25 to 500 gallons per minute (Raab, in progress). Sand and gravel lenses found within the till commonly yield 10 to 25 gallons per minute (Leow, 1988; Raab, in progress). These deposits can be found throughout Darke County except in the extreme north, northwest, and the southeast part of the county.

The bedrock aquifer of Darke County consists of the Silurian limestone and dolomites (Table 10). This aquifer is present and can be developed throughout the county, except in the deeper buried valleys where only low yielding Ordovician Age rocks are present. The permeability of the bedrock aquifer is dependent on the amount of solutioning of the rock by water moving through the joints and fractures. Norris and Fidler (1973) show Darke County as an area in which the upper bedrock units were removed by erosion and the Lockport Group dolomite is exposed. A cavitated zone (known as the "Newburg Zone") is believed to exist near the top of the Lockport. Yields for wells developed in the bedrock at depths up to 340 feet range from 100 to 500 gallons per minute in the northwestern third of Darke County (Raab, in progress). The remaining southeastern two-thirds of the county can obtain yields of 25 to 100 gallons per minute at depths up to 225 feet.

A "historical" potentiometric surface map was prepared by the author. This map was prepared by plotting static water level data from all available well logs on 7 1/2 minute quadrangle maps. These data points were coded dependent on the aquifer medium in which the wells were developed. Although the data came from wells of different depths and the statics were taken at different seasonal periods, the results of this map reveal a predominant northeasterly regional ground water flow. Ground water elevations ranged from 1120 feet in the southwestern part of the county to 940 feet in the northeastern area of the county.

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APPENDIX A

DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

Depth to water is the distance from the land surface to the surface below the ground where all pore spaces are filled with water. The depth to water was evaluated, primarily, using static water level information contained within water well logs on file at the Ohio Department of Natural Resources, Division of Water. There are approximately 6,000 well logs on file for Darke County. Other sources of information included the Dames and Moore reports (1971a, b, c, d, e), and field observations made by the author. Supplemental values were interpreted from the geomorphology in areas where little or no data were available.

Floodplains and areas adjacent to modern drainage have shallow depths to water ranging from 30 feet to less than 5 feet (10 to 7). End moraines and till plains, (7Af) show a broad range of values. Where the till is thickest, depth to water ranges from 30 feet to greater than 100 feet (1 to 5). Typically, however, the depth to water within the till ranges from 5 to 30 feet (7 to 9). Outwash and kame deposits (7Ba) have depths to water of 30 to 50 feet (5) and 5 to 15 feet (9).

Net Recharge

Net recharge was evaluated as the quantity of water that reaches the aquifer through infiltration. Net recharge values were primarily derived from Pettyjohn and Henning (1979). Additional values were obtained from Hallfrisch (in progress), Sugar (1989), Indiana Department of Natural Resources (1988), and the Soil Survey of Darke County (U. S. Dept. of Agriculture, 1987).

According to Pettyjohn and Henning (1979), the average effective recharge rate during a year of normal precipitation for till (little relief, variable thickness) in Darke County is 220,000 gallons per day per square mile (gpd/sq mi) or 4.6 inches per year. Hydrogeologic settings with a substantial thickness of till over the aquifer (7Af, 7Ac, and portions of 7D) were therefore assigned a rating of 4 to 7 inches/year (6).

A net recharge rating of 7 to 10 inches per year (8) was assigned to the Outwash/Kame/Ice Contact setting (7Ba), the Alluvium Over Till setting (7Ed) and to portions of the Buried Valley setting (7D). The higher recharge value was given to these settings because of the higher permeability of the soil and the coarseness of the vadose zone in these areas. Also, streams within the 7Ed (Alluvium Over Till) setting may have increased periods of recharge during storm events. Pettyjohn and Henning (1979) assigned a value of 350,000 gpd/sq mi or 7.3

inches per year for outwash and till and a value of 426,000 gpd/sq mi or 8.9 inches per year for extensive and permeable outwash deposits.

Aquifer Media

This factor was evaluated using data obtained from well logs on file at the Ohio Department of Natural Resources, field observations by the author, and from the following reports and maps: Dames and Moore (1971a, b, c, d, e), Horvath and Sparling (1967), Indiana Department of Natural Resources (unpublished well logs), Kleffner and Ausich (1988), Kostelnick, (1983), Leow (1988a, b), Norris and Fidler (1973), Schmidt (1984), Shaver (1989), Stout et al. (1943), Sugar (1989), Walker (1960a, b; 1961a, b; 1986), Raab (in progress), Hallfrisch (in progress), Jones (in progress).

The aquifer systems in Darke County consist of either sand and gravel aquifers or limestone aquifers. Sand and gravel is considered the aquifer media in areas of the county where these deposits yield sufficient quantities of water for domestic use. The sand and gravel aquifers in Darke County can be found as lenses within till, extensive outwash deposits, and as fill material contained within the buried valleys. The sand and gravel aquifers were rated based on their yields, and from the amount of fine or coarse material within the sand and gravel.

The Outwash setting (7Ba) was assigned a rating of (7) or (8) depending on the coarseness and sorting of the deposit. The Sand and Gravel Within Till (7Af) was given an aquifer media rating of (6) to (8). The Alluvium Over Till (7Ed) setting was given a rating of (6) or (7) (portions of this setting were rated as having a limestone aquifer). The Buried Valley setting (7D) was assigned a rating of (8) in most areas because of the extensive, permeable, high-yielding nature of the aquifer. Small areas within the buried valley that are less permeable were assigned a rating of (6).

The Silurian age limestone and dolomite bedrock aquifer underlies all of Darke County. It was chosen as the aquifer media in areas of the county where the overlying material is predominantly a clay-rich till without lenses of sand and gravel. Limestone was chosen as the aquifer media for the Till Over Limestone setting (7Ac), and for small areas in the Alluvium Over Till setting (7Ed).

Ratings were dependent on the degree of fracturing, the amount of solutioning, and yields obtained from the aquifer. Higher ratings were assigned to areas where the carbonate bedrock aquifer has a greater degree of fracturing and solutioning. A rating of (8) was given to the bedrock aquifer north of Greenville Creek and a rating of (6) was assigned to the bedrock aquifer south of Greenville Creek.

Soil Media

This factor was evaluated using the soil survey of Darke County, Ohio Capability Analysis Program (OCAP) maps, Forsyth (1965), and field observations made by the author. Each soil type was evaluated for texture, permeability and shrink/swell potential (Table 11). Ratings were then based on the most hydrologically restrictive soil horizon, and ranged from muck (2) to peat (8). The majority of soils in the uplands in Darke County are clay loams (3), whereas the floodplains and outwash areas range from silt loams (4) to sandy loams (6).

Topography

Topography was evaluated using USGS 7 1/2 minute quadrangle maps, Ohio Capability Analysis Program (OCAP) Maps, and the Soil Survey of Darke County. Floodplains and till plains are the flattest areas in the county with slopes ranging from 0 to 6% (10 to 9). Margins of moraines and floodplains, and areas where modern drainages have dissected the topography, exhibited 6 to 12% slope (3 to 5).

Impact of the Vadose Zone Media

This factor was evaluated using information obtained from well logs, Forsyth (1965), Selby (1978), Sugar (1989), Jones (in progress), Hallfrisch (in progress), Indiana Department of Natural Resources (1988), Walker (1960 a, b; 1961 a, b). Evaluations were also made based on field observations by the author.

The vadose zone of Darke County can be divided into glacial till, silt and clay, sand and gravel with significant silt and clay, and sand and gravel. These media were rated based on permeability, and the amount of fine material in comparison to the amount of coarse material. Till as the vadose zone can be found in parts of the Buried Valley setting (7D), the Till Over Limestone setting (7Ac), and parts of the Sand and Gravel Within Till setting (7Af).

TABLE 11. DARKE COUNTY SOILS

Soil Name	DRASTIC Rating	Soil Media
Algiers	3	clay loam
Blount	3	clay loam
Brookston	3	clay loam
Carlisle	2	muck
Celina	3	clay loam
Crosby	3	clay loam
Del Rey	3	clay loam
Edwards	2	muck
Eel	5	loam
Eldean	6	sandy loam
Glynwood	3	clay loam
Lewisburg	5	loam
Linwood	4	silty loam
Lippincott	6	sandy loam
Medway	4	silty loam
Miamian	3	clay loam
Montgomery	7	shrinking/aggregated clay
Ockley	4	silty loam
Odell	3	clay loam
Patton	3	clay loam
Pewamo	3	clay loam
Pyrmont	3	clay loam
Saranac	3	clay loam
Savona	6	sandy loam
Shoals	4	silty loam
Treaty	3	clay loam
Wallkill	8	peat
Wea	4	silty loam
Westland	6	sandy loam

The till of Darke County becomes more clay rich and less sandy in the northern part of the county (Forsyth, 1965; Selby, 1978) . The tills north of Greenville Creek (Yorkshire and Woodington) were given a rating of (3). The till south of Greenville Creek (Arcanum) contains a higher percentage of sand and a lower percentage of clay, is less compacted, and more fractured than the till north of Greenville Creek. Therefore, the Arcanum Till was assigned a rating of (4).

Sand and gravel with significant silt and clay serves as the vadose zone in selected areas for all of the settings in Darke County. Ratings for sand and gravel with significant silt and clay ranged from (5) to (7) based on the amount of fine to coarse deposits. This vadose zone material can be found adjacent to Swamp Creek, Greenville Creek, Dismal Creek, Stillwater River, the East Fork of the Whitewater River, and around Sunbeam Prairie. This material is also associated with the outwash deposits found southeast of the city of Greenville.

Silt and clay, as a vadose zone material, is found along the northeastern border with Mercer County. This inter-morainal lake deposit was given a rating of (5). The inter-morainal lake is in the Till Over Limestone setting (7Ac).

Sand and gravel is the vadose zone material in the outwash deposits in the southwestern part of Darke County. Ratings ranged from (6) to (8) for this material.

Hydraulic Conductivity

This factor was evaluated using information obtained from well logs, pump-test data, Raab (in progress), Dames and Moore (1971 a,b,c,d), Fetter (1988), Freeze and Cherry (1979), Hallfrisch (in progress), Indiana Department of Natural Resources (1988), Norris and Fidler (1973), and Walker (1960a,b; 1961a, b).

The Buried Valley (7D), Outwash (7Ba), and portions of the Alluvium Over Till (7Ed) settings have hydraulic conductivities that ranged from 300 to 700 gpd / sq ft (4). The Sand and Gravel Within Till (7Af) setting and portions of the Alluvium Over Till (7Ed) setting have hydraulic conductivities that range from 100-300 gpd / sq ft (2).

The hydraulic conductivity of the limestone and dolomite aquifer in Darke County is dependent primarily on the secondary porosity (solutioning and fracturing) of the bedrock. Settings with this aquifer are: Till Over Limestone (7Ac) and small areas within the Alluvium Over Till setting (7Ed).

The limestone aquifer north of Greenville Creek has hydraulic conductivities that range from 300-700 gpd/sq ft (4). The limestone aquifer south of Greenville Creek has hydraulic conductivities that range from 100 to 300 gpd/sq ft (2). This difference is attributed to an increase in yields for the limestone aquifer in northern Darke County which presumably reflects the presence of more permeable formations.

APPENDIX B

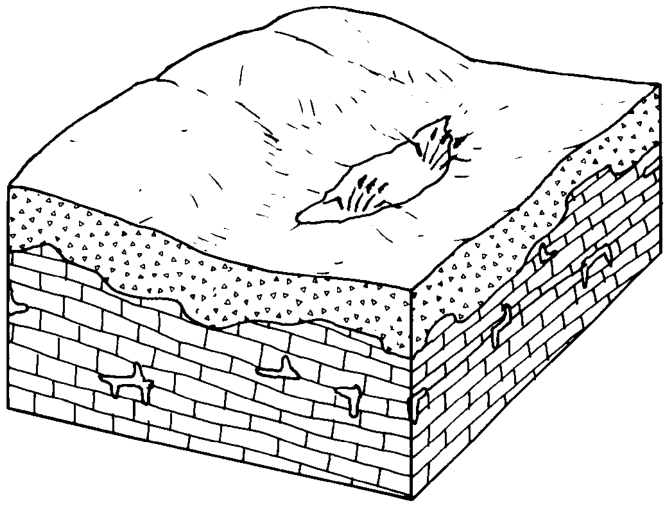
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Darke County resulted in the identification of five hydrogeologic settings within the Glaciated Central Region. The list of these settings, the range of pollution potential index calculations, and the number of index calculations for each setting are provided in Table 12. Computed pollution potential indexes for Darke County range from 89 to 179.

TABLE 12. HYDROGEOLOGIC SETTINGS MAPPED IN DARKE COUNTY, OHIO

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
7Ac - Glacial Till Over Limestone	95-154	39
7Af - Sand & Gravel Interbedded in Glacial Till	89-161	76
7Ba - Outwash	122-179	49
7D - Buried Valley	99-170	75
7Ed - Alluvium Over Glacial Till	115-162	21

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.

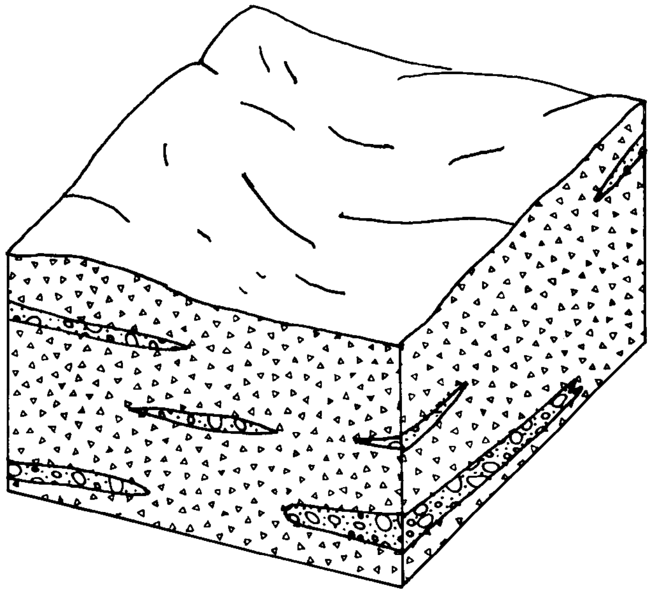


7Ac Glacial Till Over Limestone

This hydrogeologic setting is characterized by low relief with limestone or dolomite bedrock covered by varying thicknesses of glacial till. The till consists primarily of clay with varying amounts of silt, sand, and gravel. Sand and gravel layers within the till are extremely thin or nonexistent. The limestone or dolomite bedrock serves as the aquifer in this setting. Ground water occurs in fractures and solution channels within the formation. The limestone is in direct hydraulic connection with the glacial till and precipitation infiltrating through the till serves as a source of recharge for the underlying limestone. Depth to water is extremely variable depending in part on the thickness of the glacial till, but is usually moderately deep. Soils are typically clay loam.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ac1	5-15	4-7	Limestone	Shrink-swell (Aggregated) Clay	0-2	Silt/Clay	300-700	154	186
7Ac2	0-5	4-7	Limestone	Clay Loam	0-2	Till	300-700	141	163
7Ac3	5-15	4-7	Limestone	Clay Loam	0-2	Till	300-700	136	158
7Ac4	15-30	4-7	Limestone	Clay Loam	2-6	Till	300-700	125	145
7Ac5	30-50	4-7	Limestone	Clay Loam	2-6	Till	300-700	115	135
7Ac6	50-75	4-7	Limestone	Clay Loam	0-2	Till	300-700	106	128
7Ac7	30-50	4-7	Limestone	Clay Loam	0-2	Till	300-700	116	138
7Ac8	50-75	4-7	Limestone	Clay Loam	2-6	Till	300-700	105	125
7Ac9	5-15	4-7	Limestone	Clay Loam	2-6	Till	300-700	135	155
7Ac10	15-30	4-7	Limestone	Clay Loam	0-2	Till	300-700	126	148
7Ac11	15-30	4-7	Limestone	Clay Loam	6-12	Till	300-700	121	133
7Ac13	5-15	4-7	Limestone	Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	150	176
7Ac14	15-30	4-7	Limestone	Loam	6-12	Sand and Gravel w/sig Silt and Clay	300-700	135	151
7Ac15	15-30	4-7	Limestone	Clay Loam	2-6	Till	300-700	130	149
7Ac16	50-75	4-7	Limestone	Shrink-swell (Aggregated) Clay	0-2	Till	300-700	114	148
7Ac17	75-100	4-7	Limestone	Clay Loam	2-6	Till	300-700	100	120
7Ac18	75-100	4-7	Limestone	Clay Loam	0-2	Till	300-700	101	123

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ac19	100+	4-7	Limestone	Clay Loam	2-6	Till	300-700	95	115
7Ac20	15-30	4-7	Limestone	Shrink-swell (Aggregated) Clay	0-2	Till	300-700	134	168
7Ac21	5-15	4-7	Limestone	Shrink-swell (Aggregated) Clay	0-2	Till	300-700	144	178
7Ac22	30-50	4-7	Limestone	Sandy Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	132	161
7Ac23	15-30	4-7	Limestone	Sandy Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	142	171
7Ac24	5-15	4-7	Limestone	Sandy Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	152	181
7Ac25	15-30	4-7	Limestone	Clay Loam	0-2	Till	100-300	119	142
7Ac26	5-15	4-7	Limestone	Clay Loam	0-2	Till	100-300	129	152
7Ac27	0-5	4-7	Limestone	Clay Loam	0-2	Till	100-300	134	157
7Ac28	5-15	4-7	Limestone	Loam	2-6	Till	100-300	132	159
7Ac29	30-50	4-7	Limestone	Clay Loam	0-2	Till	100-300	104	128
7Ac30	15-30	4-7	Limestone	Clay Loam	0-2	Till	100-300	114	138
7Ac31	15-30	4-7	Limestone	Clay Loam	12-18	Till	100-300	107	117
7Ac32	30-50	4-7	Limestone	Clay Loam	12-18	Till	100-300	97	107
7Ac33	5-15	4-7	Limestone	Clay Loam	2-6	Till	100-300	128	149
7Ac34	30-50	4-7	Limestone	Clay Loam	0-2	Till	100-300	109	132
7Ac35	5-15	4-7	Limestone	Loam	0-2	Sand and Gravel w/sig Silt and Clay	100-300	138	166
7Ac36	15-30	4-7	Limestone	Clay Loam	6-12	Till	100-300	114	127
7Ac38	15-30	4-7	Limestone	Clay Loam	2-6	Till	100-300	118	139
7Ac39	15-30	4-7	Limestone	Clay Loam	12-18	Till	100-300	112	121



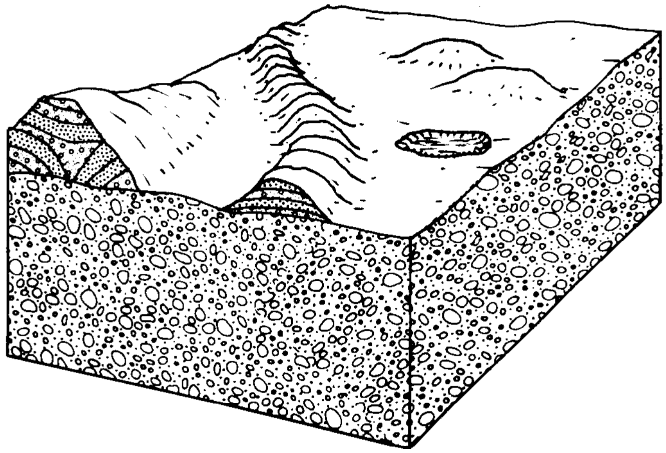
7Af Sand and Gravel Interbedded in Glacial Till

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

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Af1	5-15	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	136	158
7Af2	15-30	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	126	148
7Af3	30-50	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	115	135
7Af4	50-75	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	105	125
7Af5	50-75	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	106	128
7Af7	15-30	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	125	145
7Af8	5-15	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	135	155
7Af9	0-5	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	132	156
7Af10	15-30	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	117	141
7Af11	5-15	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	127	151
7Af12	30-50	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	107	131
7Af13	5-15	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	132	155
7Af14	15-30	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	122	145
7Af15	5-15	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	126	148
7Af16	15-30	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	112	126
7Af17	5-15	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	122	136
7Af18	15-30	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	116	138

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Af19	15-30	4-7	Sand and Gravel	Clay Loam	12-18	Till	100-300	110	120
7Af20	30-50	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	102	116
7Af21	50-75	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	92	106
7Af22	30-50	4-7	Sand and Gravel	Clay Loam	12-18	Till	100-300	100	110
7Af23	50-75	4-7	Sand and Gravel	Clay Loam	12-18	Till	100-300	90	100
7Af24	30-50	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	106	128
7Af25	0-5	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	137	160
7Af26	0-5	4-7	Sand and Gravel	Shrink-swell (Aggregated) Clay	0-2	Till	100-300	145	180
7Af27	0-5	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	132	145
7Af28	5-15	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	127	151
7Af29	5-15	4-7	Sand and Gravel	Shrink-swell (Aggregated) Clay	2-6	Till	100-300	134	168
7Af30	15-30	4-7	Sand and Gravel	Shrink-swell (Aggregated) Clay	0-2	Till	100-300	125	161
7Af31	15-30	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	114	138
7Af32	15-30	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	113	135
7Af33	5-15	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	124	148
7Af34	15-30	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	109	123
7Af35	30-50	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	99	113
7Af36	30-50	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	104	128
7Af37	5-15	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	129	152
7Af38	15-30	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	119	142
7Af39	15-30	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	114	127
7Af40	30-50	4-7	Sand and Gravel	Clay Loam	12-18	Till	100-300	97	107
7Af41	15-30	4-7	Sand and Gravel	Clay Loam	12-18	Till	100-300	107	117
7Af42	30-50	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	103	125
7Af43	5-15	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	128	149
7Af44	15-30	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	118	139
7Af45	30-50	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	108	129
7Af46	15-30	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	132	150
7Af47	15-30	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	133	153
7Af48	30-50	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	123	143
7Af49	5-15	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	146	166
7Af50	30-50	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	109	132
7Af51	5-15	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	142	160
7Af52	15-30	4-7	Sand and Gravel	Muck	2-6	Till	300-700	130	145
7Af53	5-15	7-10	Sand and Gravel	Sandy Loam	2-6	Sand & Gravel w/sig Silt &Clay	300-700	161	187
7Af54	30-50	7-10	Sand and Gravel	Clay Loam	0-2	Sand & Gravel w/sig Silt & Clay	300-700	136	155
7Af55	15-30	7-10	Sand and Gravel	Clay Loam	0-2	Sand & Gravel w/sig Silt & Clay	300-700	146	165
7Af56	15-30	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	121	142
7Af57	15-30	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	117	130
7Af58	30-50	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	107	120
7Af59	50-75	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	97	110
7Af61	30-50	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	112	135
7Af62	50-75	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	102	125

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Af63	5-15	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	127	140
7Af64	30-50	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	104	117
7Af65	50-75	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	94	107
7Af66	75-100	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	89	102
7Af67	50-75	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	98	119
7Af68	50-75	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	99	122
7Af69	75-100	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	93	114
7Af70	75-100	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	94	117
7Af71	30-50	4-7	Sand and Gravel	Clay Loam	6-12	Sand & Gravel w/sig Silt & Clay	300-700	118	128
7Af72	30-50	4-7	Sand and Gravel	Clay Loam	2-6	Sand & Gravel w/sig Silt & Clay	300-700	122	140
7Af73	50-75	4-7	Sand and Gravel	Clay Loam	2-6	Sand & Gravel w/sig Silt & Clay	300-700	112	130
7Af74	50-75	4-7	Sand and Gravel	Clay Loam	6-12	Sand & Gravel w/sig Silt & Clay	300-700	108	118
7Af75	30-50	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	111	132
7Af76	50-75	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	101	122

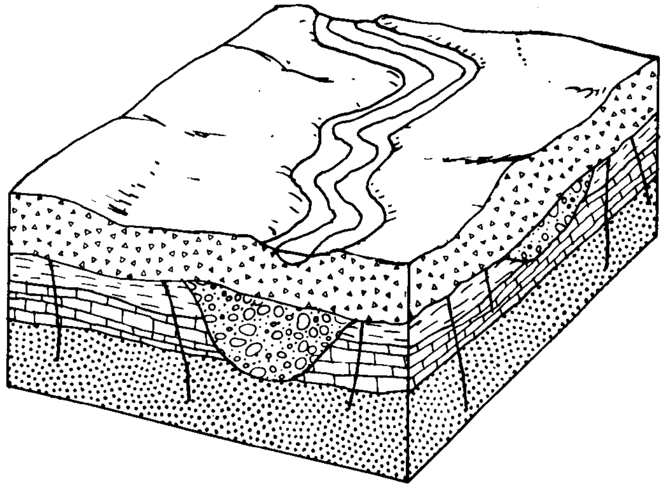


<u>7Ba Outwash</u>

This hydrogeologic setting is characterized by moderate to low topography and ice-contact deposits overlying glacial till or fractured sedimentary bedrock. Outwash generally refers to water-lain or ice-contact deposits. Kames and eskers represent typical ice-contact deposits that occur in this setting. A kame is an isolated hill or mound of stratified sediments deposited in an opening within or between ice blocks, or between ice blocks and valley walls. An esker is a sinuous or meandering ridge of well-sorted sands and gravels that are remnants of streams that existed beneath and within the glaciers. These deposits may be in direct hydraulic connection with the underlying till or bedrock. The principal aquifers in this setting are sand and gravel deposits or the sedimentary bedrock. Recharge to the aquifer is primarily due to precipitation infiltrating through the surficial deposits. Soils are highly variable, ranging from clay loam to sand. Water levels are highly variable.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ba1	5-15	7-10	Limestone	Silty Loam	2-6	Sand and Gravel	100-300	148	170
7Ba2	15-30	7-10	Sand and Gravel	Sandy Loam	2-6	Sand and Gravel	300-700	151	177
7Ba3	5-15	7-10	Sand and Gravel	Sandy Loam	2-6	Sand and Gravel	300-700	161	187
7Ba4	5-15	7-10	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	162	190
7Ba5	5-15	7-10	Sand and Gravel	Silty Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	158	180
7Ba6	15-30	7-10	Sand and Gravel	Clay Loam	2-6	Sand and Gravel w/sig Silt and Clay	300-700	145	162
7Ba7	15-30	7-10	Sand and Gravel	Clay Loam	6-12	Sand and Gravel w/sig Silt and Clay	300-700	144	153
7Ba8	15-30	7-10	Sand and Gravel	Clay Loam	6-12	Sand and Gravel	300-700	141	150
7Ba9	30-50	7-10	Sand and Gravel	Clay Loam	6-12	Sand and Gravel	300-700	131	140
7Ba10	5-15	7-10	Sand and Gravel	Clay Loam	6-12	Sand and Gravel w/sig Silt and Clay	300-700	151	160
7Ba11	5-15	7-10	Sand and Gravel	Silty Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	158	180
7Ba12	15-30	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel	300-700	147	165
7Ba13	5-15	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel	300-700	157	175
7Ba14	5-15	7-10	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel	300-700	167	194
7Ba15	30-50	7-10	Sand and Gravel	Sandy Loam	12-18	Sand and Gravel	300-700	135	149

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ba17	15-30	7-10	Sand and Gravel	Clay Loam	2-6	Sand and Gravel w/sig Silt and Clay	300-700	145	162
7Ba18	15-30	7-10	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	152	180
7Ba19	5-15	7-10	Sand and Gravel	Gravel	2-6	Sand and Gravel	300-700	179	215
7Ba20	30-50	7-10	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	142	170
7Ba21	15-30	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel w/sig Silt and Clay	300-700	147	165
7Ba22	5-15	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel	300-700	162	179
7Ba23	15-30	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel	300-700	152	169
7Ba24	5-15	7-10	Sand and Gravel	Clay Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	156	175
7Ba25	30-50	7-10	Sand and Gravel	Clay Loam	2-6	Sand and Gravel w/sig Silt and Clay	300-700	135	152
7Ba26	30-50	7-10	Sand and Gravel	Clay Loam	2-6	Sand and Gravel	300-700	140	156
7Ba27	15-30	7-10	Sand and Gravel	Sandy Loam	2-6	Sand and Gravel w/sig Silt and Clay	100-300	145	173
7Ba28	5-15	7-10	Sand and Gravel	Sandy Loam	2-6	Sand and Gravel w/sig Silt and Clay	100-300	155	183
7Ba29	5-15	7-10	Sand and Gravel	Clay Loam	2-6	Sand and Gravel w/sig Silt and Clay	300-700	160	176
7Ba30	15-30	7-10	Sand and Gravel	Clay Loam	2-6	Sand and Gravel w/sig Silt and Clay	300-700	150	166
7Ba31	30-50	7-10	Sand and Gravel	Clay Loam	2-6	Sand and Gravel w/sig Silt and Clay	300-700	140	156
7Ba32	30-50	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel w/sig Silt and Clay	300-700	142	159
7Ba33	30-50	7-10	Sand and Gravel	Clay Loam	2-6	Sand and Gravel w/sig Silt and Clay	300-700	130	148
7Ba34	15-30	7-10	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	157	184
7Ba35	50-75	7-10	Sand and Gravel	Clay Loam	6-12	Sand and Gravel w/sig Silt and Clay	300-700	116	126
7Ba36	15-30	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel	300-700	157	173
7Ba37	50-75	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel w/sig Silt and Clay	300-700	132	149
7Ba38	5-15	7-10	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel	100-300	156	186
7Ba39	5-15	7-10	Sand and Gravel	Clay Loam	6-12	Sand and Gravel	100-300	145	156
7Ba40	5-15	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel	100-300	151	171
7Ba41	30-50	7-10	Sand and Gravel	Silty Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	138	160
7Ba42	30-50	7-10	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	147	174
7Ba43	15-30	7-10	Sand and Gravel	Muck	0-2	Sand and Gravel w/sig Silt and Clay	300-700	144	160
7Ba44	30-50	7-10	Sand and Gravel	Sandy Loam	2-6	Sand and Gravel w/sig Silt and Clay	300-700	141	167
7Ba45	50-75	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel w/sig Silt and Clay	300-700	127	145
7Ba46	30-50	7-10	Sand and Gravel	Silty Loam	6-12	Sand and Gravel w/sig Silt and Clay	300-700	133	145
7Ba47	50-75	7-10	Sand and Gravel	Silty Loam	0-2	Sand and Gravel w/sig Silt and Clay	300-700	128	150
7Ba48	30-50	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel w/sig Silt and Clay	300-700	137	155
7Ba49	15-30	7-10	Sand and Gravel	Silty Loam	6-12	Sand and Gravel w/sig Silt and Clay	300-700	143	155



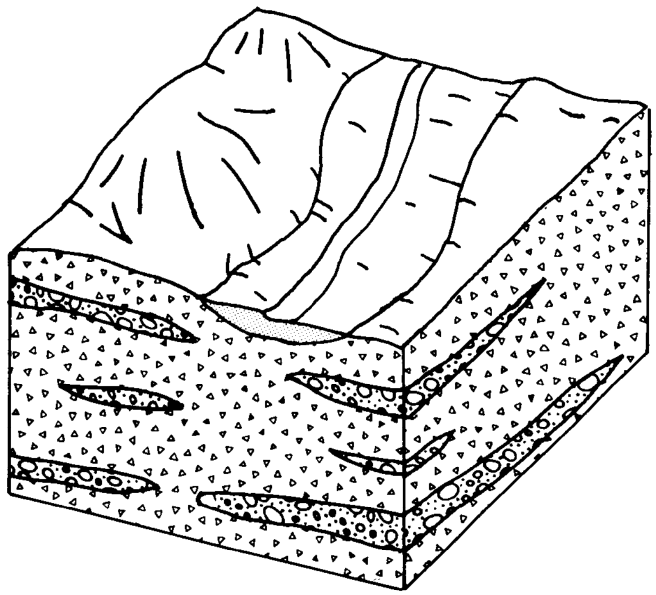
7D Buried Valley

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.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7D1	0-5	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	141	163
7D2	5-15	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	136	158
7D3	15-30	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	125	145
7D4	30-50	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	115	135
7D5	50-75	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	105	125
7D6	50-75	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	106	128
7D7	30-50	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	116	138
7D8	30-50	4-7	Sand and Gravel	Clay Loam	6-12	Till	300-700	111	123
7D9	15-30	4-7	Sand and Gravel	Clay Loam	6-12	Till	300-700	121	133
7D10	5-15	7-10	Sand and Gravel	Sandy Loam	0-2	Sand & Gravel w/sig Silt & Clay	300-700	170	197
7D11	5-15	7-10	Sand and Gravel	Clay Loam	0-2	Sand & Gravel w/sig Silt & Clay	300-700	164	182
7D12	5-15	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	135	155
7D13	50-75	4-7	Sand and Gravel	Clay Loam	6-12	Till	300-700	101	113
7D14	15-30	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	126	148
7D15	5-15	4-7	Sand and Gravel	Sandy Loam	0-2	Till	300-700	142	173
7D16	30-50	4-7	Sand and Gravel	Shrink-swell (Aggregated) Clay	0-2	Silt/Clay	300-700	134	166

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7D17	15-30	4-7	Sand and Gravel	Shrink-swell (Aggregated) Clay	0-2	Silt/Clay	300-700	144	176
7D18	5-15	4-7	Sand and Gravel	Shrink-swell (Aggregated) Clay	0-2	Silt/Clay	300-700	154	186
7D19	5-15	4-7	Sand and Gravel	Clay Loam	6-12	Till	300-700	136	147
7D20	15-30	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	131	152
7D21	5-15	7-10	Sand and Gravel	Sandy Loam	12-18	Till	300-700	148	164
7D22	15-30	7-10	Sand and Gravel	Sandy Loam	12-18	Sand & Gravel w/sig Silt & Clay	300-700	148	162
7D23	5-15	7-10	Sand and Gravel	Sandy Loam	0-2	Sand & Gravel w/sig Silt & Clay	300-700	165	193
7D24	0-5	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	140	160
7D25	5-15	4-7	Sand and Gravel	Clay Loam	6-12	Till	300-700	131	143
7D26	0-5	4-7	Sand and Gravel	Shrink-swell (Aggregated) Clay	6-12	Silt/Clay	300-700	149	172
7D27	0-5	4-7	Sand and Gravel	Shrink-swell (Aggregated) Clay	0-2	Silt/Clay	300-700	154	187
7D28	5-15	4-7	Sand and Gravel	Shrink-swell (Aggregated) Clay	0-2	Silt/Clay	300-700	149	182
7D29	5-15	4-7	Sand and Gravel	Shrink-swell (Aggregated) Clay	2-6	Till	300-700	143	175
7D30	5-15	7-10	Sand and Gravel	Loam	2-6	Sand & Gravel w/sig Silt & Clay	300-700	162	185
7D31	5-15	7-10	Sand and Gravel	Loam	2-6	Sand & Gravel	300-700	167	189
7D32	5-15	7-10	Sand and Gravel	Sandy Loam	2-6	Sand & Gravel	300-700	169	194
7D33	5-15	7-10	Sand and Gravel	Loam	0-2	Sand & Gravel	300-700	168	192
7D34	15-30	7-10	Sand and Gravel	Clay Loam	6-12	Sand & Gravel w/sig Silt & Clay	300-700	149	157
7D35	30-50	4-7	Sand and Gravel	Clay Loam	12-18	Till	300-700	109	117
7D36	15-30	4-7	Sand and Gravel	Clay Loam	12-18	Till	300-700	119	127
7D37	5-15	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	129	152
7D38	15-30	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	119	142
7D40	5-15	7-10	Sand and Gravel	Silty Loam	0-2	Sand & Gravel w/sig Silt & Clay	300-700	161	183
7D41	15-30	7-10	Sand and Gravel	Clay Loam	6-12	Sand & Gravel w/sig Silt & Clay	300-700	144	153
7D42	15-30	7-10	Sand and Gravel	Clay Loam	2-6	Sand & Gravel w/sig Silt & Clay	300-700	148	165
7D43	15-30	7-10	Sand and Gravel	Sandy Loam	2-6	Sand & Gravel w/sig Silt & Clay	300-700	154	180
7D44	5-15	7-10	Sand and Gravel	Clay Loam	2-6	Sand & Gravel w/sig Silt & Clay	300-700	158	175
7D45	15-30	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	135	153
7D46	15-30	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	136	156
7D47	5-15	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	146	166
7D48	15-30	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	130	149
7D49	5-15	4-7	Sand and Gravel	Clay Loam	0-2	Till	300-700	141	162
7D50	30-50	7-10	Sand and Gravel	Clay Loam	6-12	Sand & Gravel w/sig Silt & Clay	300-700	134	143
7D51	15-30	7-10	Sand and Gravel	Sandy Loam	0-2	Sand & Gravel w/sig Silt & Clay	300-700	155	183
7D52	15-30	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel	300-700	150	168
7D53	15-30	7-10	Sand and Gravel	Clay Loam	0-2	Sand & Gravel w/sig Silt & Clay	300-700	149	168
7D54	5-15	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	145	163

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7D55	30-50	4-7	Sand and Gravel	Clay Loam	2-6	Till	300-700	125	143
7D56	30-50	7-10	Sand and Gravel	Sandy Loam	6-12	Sand & Gravel w/sig Silt & Clay	300-700	140	158
7D58	30-50	7-10	Sand and Gravel	Clay Loam	6-12	Sand & Gravel w/sig Silt & and Clay	300-700	129	139
7D59	30-50	7-10	Sand and Gravel	Clay Loam	2-6	Till	300-700	133	151
7D60	15-30	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel	300-700	160	176
7D61	5-15	7-10	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel	300-700	170	197
7D62	15-30	7-10	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel	300-700	160	187
7D63	50-75	7-10	Sand and Gravel	Clay Loam	6-12	Sand & Gravel w/sig Silt & Clay	300-700	119	129
7D64	50-75	7-10	Sand and Gravel	Clay Loam	2-6	Sand & Gravel w/sig Silt & Clay	300-700	123	141
7D65	30-50	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	109	132
7D66	15-30	4-7	Sand and Gravel	Clay Loam	6-12	Till	100-300	114	127
7D67	5-15	4-7	Sand and Gravel	Loam	0-2	Sand & Gravel w/sig Silt & Clay	100-300	138	166
7D68	50-75	4-7	Sand and Gravel	Clay Loam	0-2	Till	100-300	99	122
7D69	15-30	4-7	Sand and Gravel	Clay Loam	12-18	Till	100-300	112	121
7D70	15-30	4-7	Sand and Gravel	Clay Loam	2-6	Till	100-300	118	139
7D71	15-30	7-10	Sand and Gravel	Clay Loam	2-6	Till	300-700	143	161
7D72	50-75	4-7	Sand and Gravel	Clay Loam	6-12	Till	300-700	106	117
7D73	30-50	4-7	Sand and Gravel	Clay Loam	6-12	Till	300-700	116	127
7D74	15-30	4-7	Sand and Gravel	Clay Loam	6-12	Till	300-700	126	137
7D75	5-15	7-10	Sand and Gravel	Clay Loam	0-2	Sand & Gravel w/sig Silt & Clay	300-700	159	178



7Ed Alluvium Over Glacial Till

This setting is characterized by low relief with thin to moderate thicknesses of present-day, stream-deposited alluvium. The alluvium is composed of silt, sand, gravel, and clay. The underlying sand and gravel lenses within the till (where present) serve as the aquifer. The depth to the water table is shallow and the stream is usually in hydraulic contact with the deposits. Soils are usually classified as silty loam. The underlying till deposits are described in setting 7Af. The alluvial deposits serve as a medium for recharge to infiltrate the sand and gravel lenses within the till.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ed1	5-15	4-7	Sand and Gravel	Loam	0-2	Sand and Gravel w/sig Silt and Clay	100-300	141	169
7Ed2	5-15	7-10	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel w/sig Silt and Clay	100-300	156	186
7Ed3	5-15	7-10	Sand and Gravel	Silty Loam	0-2	Sand and Gravel	100-300	152	176
7Ed4	15-30	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel w/sig Silt and Clay	100-300	141	161
7Ed5	15-30	7-10	Sand and Gravel	Sandy Loam	6-12	Sand and Gravel	100-300	141	161
7Ed6	15-30	7-10	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel	100-300	146	176
7Ed7	15-30	7-10	Sand and Gravel	Sandy Loam	12-18	Sand and Gravel w/sig Silt and Clay	100-300	139	155
7Ed8	5-15	7-10	Sand and Gravel	Sandy Loam	12-18	Sand and Gravel w/sig Silt and Clay	100-300	149	165
7Ed9	5-15	7-10	Sand and Gravel	Loam	0-2	Sand and Gravel w/sig Silt and Clay	100-300	159	185
7Ed10	15-30	7-10	Sand and Gravel	Clay Loam	6-12	Sand and Gravel w/sig Silt and Clay	100-300	140	150
7Ed11	30-50	7-10	Sand and Gravel	Clay Loam	6-12	Sand and Gravel w/sig Silt and Clay	100-300	130	140
7Ed12	15-30	7-10	Sand and Gravel	Loam	0-2	Sand and Gravel w/sig Silt and Clay	100-300	149	175
7Ed13	5-15	7-10	Limestone	Sandy Loam	0-2	Sand and Gravel w/sig Silt and Clay	100-300	153	183

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ed14	5-15	7-10	Sand and Gravel	Silty Loam	0-2	Sand and Gravel w/sig Silt and Clay	100-300	149	173
7Ed15	5-15	7-10	Sand and Gravel	Sandy Loam	0-2	Sand and Gravel	300-700	162	190
7Ed16	5-15	7-10	Sand and Gravel	Silty Loam	0-2	Sand and Gravel	300-700	158	180
7Ed17	5-15	7-10	Sand and Gravel	Loam	0-2	Sand and Gravel	300-700	160	185
7Ed18	5-15	7-10	Sand and Gravel	Clay Loam	6-12	Sand and Gravel	300-700	151	160
7Ed19	5-15	4-7	Limestone	Loam	0-2	Sand and Gravel	100-300	138	166
7Ed20	5-15	4-7	Limestone	Sandy Loam	0-2	Sand and Gravel	100-300	140	171
7Ed21	75-100	7-10	Sandy Gravel	Loam	6-12	Sand and Gravel	300-700	115	131

ERRATA FOR DARKE COUNTY GROUND WATER POLLUTION POTENTIAL MAP

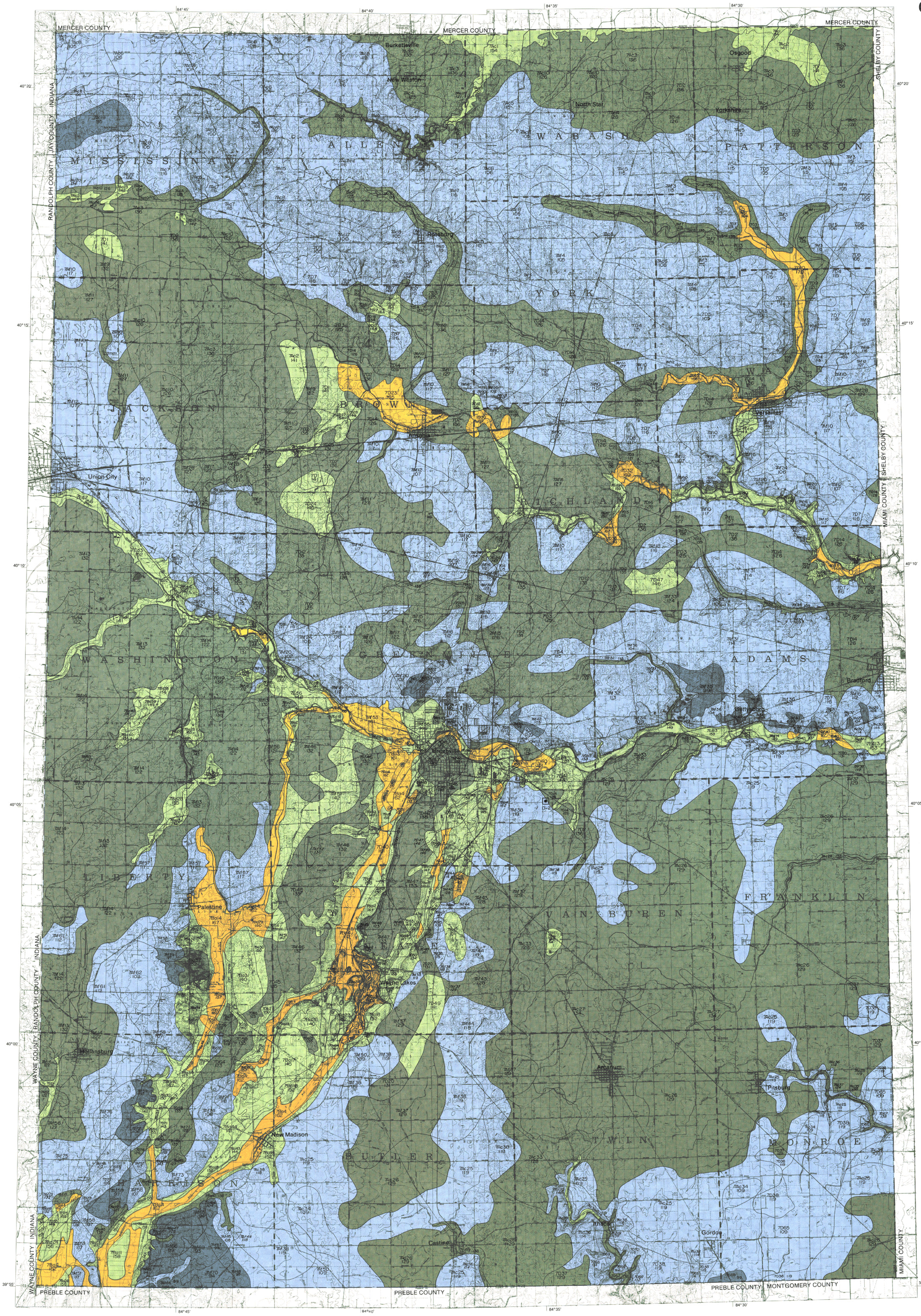
Changes to the Report

The following settings; (7Ac12, 7Ac37; 7Af6, 7Af60; 7D57), have been omitted from this edition of the report. They were included in the original release of this report but do not appear on the printed map, and so have been removed from this editions' setting tables.

Setting 7D39 is intentionally omitted in this edition as it was in the original.

Ground Water Pollution Potential of DARKE COUNTY

by
Paul N. Spahr



1 0 1 2 Miles
1 0 1 2 Kilometers

CONTOUR INTERVAL 5 FEET

N

County Line
Township Line
Incorporated City Limit

Description of Map Symbols

Hydrogeologic Region
Hydrogeologic Setting
7Ad 6
98
Relative Pollution Potential
Observation Well Site*

Pollution Potential Index Range

Higher	160 - 179
	140 - 159
to	120 - 139
	100 - 119
Lower	80 - 99

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)".

Hydrogeologic Settings

- 7 Ac - Glacial Till Over Limestone
- 7Af - Sand and Gravel Interbedded in Glacial Till
- 7Ba - Outwash
- 7Ed - Alluvium Over Glacial Till
- 7D - Buried Valley

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 Darke County," GWPP Report No. 25, Ohio Department of Natural Resources, Division of Water.

* Observation well sites indicate the location of wells used to collect ground water level information. These wells are part of the State observation well network. Hydrographs of the water levels recorded in these and other State observation wells can be obtained through ODNR-Division of Water.

Published 1991
Ohio Department of Natural Resources
Division of Water
Ground Water Resources Section
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Total copies printed: 500
Unit Cost: $5.20
Publication date: 9/91

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