Groundwater Sensitivity Regions of Kentucky

by

Kentucky Department for Environmental Protection
Division of Water
Groundwater Branch

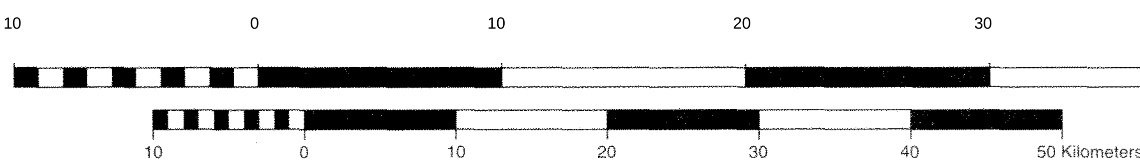
1994

Interpreted by

Joseph A. Ray   James S. Webb   Phillip W. O'dell

Scale

1:500000



1" = approximately 8 inches

Universal Transverse Mercator Projection, Zone 16. Polyconic grid,

IMPORTANT NOTE

This map is not designed for site specific use. Information used to construct this map was interpreted and generalized from over 800 Geologic Quadrangle Maps (1:24000) and selected Hydrologic Investigations Atlas Maps (1:24000) published by the USGS in cooperation with the KGS. The purpose of this map is to inform the public, land-use planners and managers, and governmental officials about the naturally occurring potential for groundwater contamination across the state. A rating of low sensitivity indicates that groundwater is naturally well protected from surface contaminants, although not necessarily immune from long-term pollution. High sensitivity ratings indicate that, in general, groundwater could be easily and quickly impacted by surface activities. For additional information about this map, please contact:

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The Commonwealth of Kentucky has produced this document using unverified data, and therefore makes no warranty, express or implied. With regard to it accuracy.

It should be assumed that boundaries are not precisely depicted, and should be surveyed if exactness is required.

INTRODUCTION

Groundwater is a vital, renewable natural resource that is widely used throughout Kentucky. Wells and springs provide approximately one third of public domestic water supplies in the state. Surface streams, the major source of Kentucky's water supply, are primarily sustained during base flow by groundwater discharge from adjacent aquifers. This resource is susceptible to contamination from a variety of activities at the land surface. Once contaminated, groundwater can be difficult or impossible to remediate. A priority of the Kentucky Department for Environmental Protection is the prevention of groundwater contamination. One important aspect of such efforts is recognition that sensitivity to groundwater contamination varies throughout the state. Clearly, appropriate land-use practices that address these differences can help prevent contamination. This map, therefore, is a step toward that goal. It presents a generalized assessment of the relative hydrogeologic sensitivity of groundwater in the state. The hydrogeologic sensitivity of an area is defined as the ease and speed with which a contaminant can move into and within a groundwater system. The major factors that control this sensitivity are recharge to the system and flow rate and dispersion potential within the system. These three essential components are illustrated in a rating graph (Figure 1) that is used to assess groundwater sensitivity. Estimated and measured parameters of a hydrogeologic setting are plotted graphically to obtain a sensitivity rating hat ranges from (low) #1 to (high) #5. Groundwater flow-velocities, as determined by tracer studies, can be used to establish a sensitivity range for various hydrogeologic settings. Also, overriding factors which can overwhelm associated hydrogeologic conditions must be considered. A detailed discussion of this assessment method is found in Ray and O'Dell (1993 a & b).

This sensitivity assessment addresses only the naturally occurring hydrogeologic characteristics of an area. Possible impacts of human activity upon groundwater, such as mining, logging, industry, and the use of pesticides, injection wells, and landfills, have not been considered in the production of this map. Because of its small scale and generalized nature, this map is not intended for site-specific use, such as facility-site selection of detailed local land-use planning for city, county, or state agencies. However, the map should prove useful as a broad-scale management, educational, and planning tool.

The primary data sources used in compiling this generalized map were the Geologic Quadrangle Maps (1:24000 scale) published by the United States Geologic Survey (USGS) in cooperation with the Kentucky Geologic Survey (KGS). These detailed geologic maps have been completed for the entire state. Hydrologic Investigations Atlas Maps (1:24000 scale), likewise produced by the USGS in cooperation with the KGS, describing groundwater characteristics of the Gulf Coastal Plain and the Ohio River alluvium were also utilized.

PHYSIOGRAPHIC REGIONS

Based upon differences in geology, topography, and hydrologic regime, Kentucky is divided into five physiographic regions, as shown in Figure 2. Each region has different groundwater characteristics, which are reflected in the sensitivity map. These regions are 1) Eastern Coal Field, 2) Bluegrass, 3) Mississippian Plateau, 4) Western Coal Field, and 5) Gulf Coastal Plain. Although not generally considered a physiographic region, the Ohio River alluvium is a distinct hydrogeologic setting and is included within these brief descriptions.

EASTERN COAL FIELD

The Eastern Coal Field (also known as the Cumberland Plateau) consists predominantly of deeply dissected, Pennsylvanian-age, clastic sedimentary rocks, such as sandstone, siltstone, and shale interbedded with coal and some limestone. Shallow groundwater flow available for use is largely through fractures rather than primary porosity and permeability. Groundwater yield to wells and springs is generally low, but usually enough so sustain domestic use. High-yield municipal or industrial supply wells are uncommon. The Eastern Coal Field generally rates as moderately sensitive (#3) on the rating scale. The sensitivity factor of groundwater velocity may locally exceed the moderate category, especially along coal seams and enlarged stress-relief fractures.

BLUEGRASS

The Bluegrass Region is underlain primarily by Ordovician-age, interbedded limestone and shale. Although some typical karst topography, such as sinkhole-dominated areas, does occur in the Inner Bluegrass, most terrain is moderately dissected by surface streams. Although a few relatively large groundwater basins do not exist in the Bluegrass, a majority of the area contains more locally integrated karst drainage. Groundwater yield to springs and wells is highly variable, but usually enough to meet domestic needs. Municipal and industrial supply wells and springs are rare. Sensitivity ratings in the Bluegrass are highly variable. Hydrology is strongly influenced by the amount of shale in the subsurface, which generally impedes the infiltration of precipitation. The Inner Bluegrass is composed of limestones that contain the largest karst groundwater basins in the region and rate as highly too extremely sensitive (#4 to #5). Rocks of the Outer Bluegrass contain higher percentages of shale layers, do not develop extensive karst features, and generally rate lower in sensitivity (#2 or #3). The Knobs, which generally border the southern portion of the Bluegrass, are composed of fractured shale and rate as #2 sensitivity.

MISSISSIPPIAN PLATEAU

The Mississippian Plateau (also known as the Pennyroyal or Pennyrile) is a moderately dissected region composed of low-relief plateaus and cuestas and is predominantly underlain by relatively pure Mississippian-age limestone. Karst topography and hydrology is well developed in much of the area. Groundwater yield to springs can be very large (up to 0.7m3/sec [25 ft3/sec] during summer base runoff), with several springs and wells in the area serving as municipal and industrial supplies. Domestic wells are common; although in some areas contaminated water is a problem because of polluted surface runoff into sinkholes and sinking streams. Yields to wells can very greatly, depending on whether or not the well intersects fissures and conduits enlarged by the slow dissolving of limestone. Recharge, flow, and dispersion potential are usually characterized by high rates. Therefore, most of the Mississippian Plateau is rated as extremely sensitive (#5).

WESTERN COAL FIELD

The Western Coal Field is similar to the Eastern Coal Field in that the bedrock consists mostly of Pennsylvanian-age sedimentary rocks, primarily sandstone, siltstone, and shale, with coal and some limestone. This region is generally composed of moderately dissected low plateaus and broad alluvial bottomlands. With the exception of localized sandstone bodies, most groundwater flow within bedrock is through fractures rather than intergranular flow. Alluvial aquifers, especially along the Green River and its tributaries, are also utilized. Well yield is generally adequate for domestic needs, but municipal and industrial supply wells are uncommon. The Western Coal Field generally rates as moderately sensitive (#3). The relatively thick alluvial aquifers in this region proved difficult to rate because of the occurrence of interbedded, clayey lacustrine deposits. Although these sediments are generally fine-grained enough to rank as #2 sensitivity, sand and gravel layers are generally interbedded with the finer sediments; this justifies an upgrade in sensitivity to #3. This problem was resolved by mapping these areas as a combination of both #2 and #3, and is shown with a diagonal grid pattern.

GULF COASTAL PLAIN

The Gulf Coastal Plain, in far-western Kentucky, is also known as the Mississippi Embayment or the Jackson Purchase. This region is generally underlain by semi-consolidated Cretaceous-age and younger sand, silt, gravel, and clay deposits. The coarser sediments are prolific aquifers for industrial, municipal, and domestic water-supply wells, although they are sensitive to contamination, especially at shallow depth. In general, the relatively low flow velocity within deeper saturation zones provides significant protection from contamination. Consequently, the sensitivity of this region usually ranges from moderate to slight (#3 to #2), with some areas, where the depth to water is greater than 30 m (100 ft), rated as the lowest sensitivity in the state (#1). Mapped areas with the depth to water table exceeding 100-ft were obtained from Hydrologic Investigation Atlas Maps (1:24000 scale).

OHIO RIVER ALLUVIUM

The Ohio River Alluvium, predominantly Pleistocene glacial-outwash sediments, consists of unconsolidated sand, gravel, silt and clay deposits along the Ohio River. The coarse sand and gravel beds supply large volumes of water to industrial, municipal, and domestic wells. Groundwater can migrate quickly through these coarser sediments and consequently is rated as highly sensitive, a #4. Other aquifers in river alluvium, which are located throughout Kentucky, are not delineated on this map, but should be considered less sensitive than the coarser-grained Ohio River Alluvium.

ACKNOWLEDGMENTS

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Figure 1: Hydrogeologic Sensitivity Rating Graph

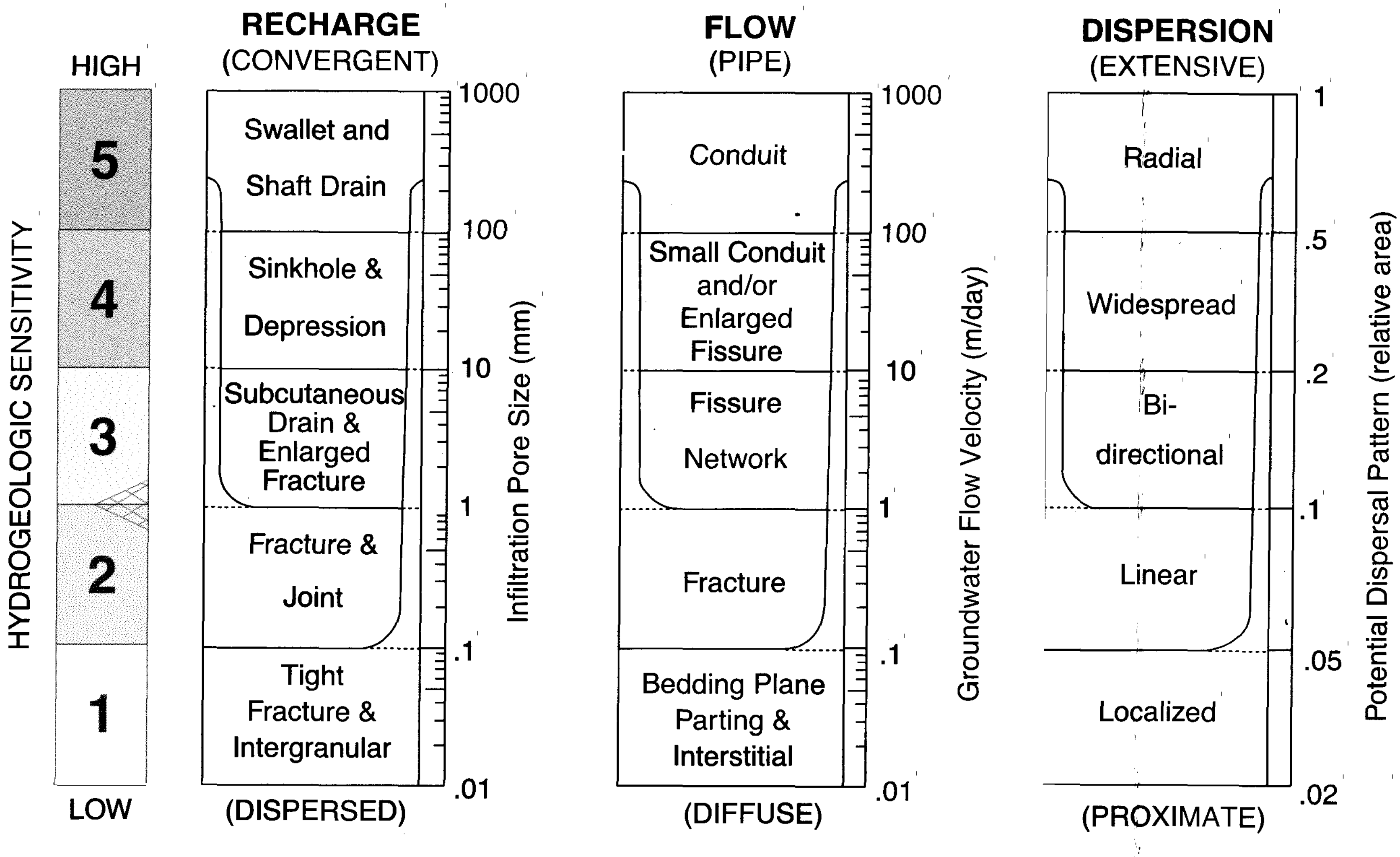
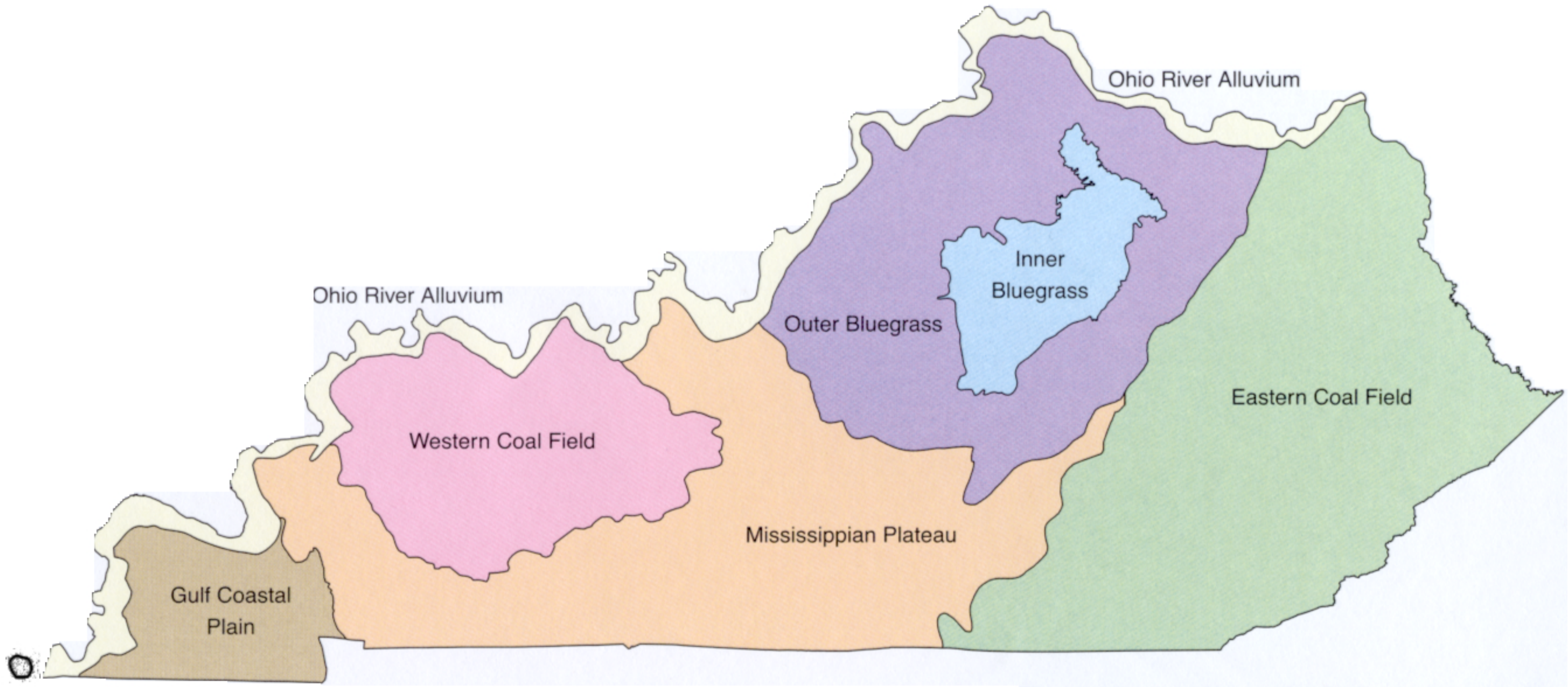


Figure 1. Hydrogeologic sensitivity rating graph, employing three primary hydrologic components: Recharge, Flow, and Dispersion. Recharge ranges from dispersed to convergent and is calibrated with an infiltration pore-size in mm. The lower two blocks of the recharge column are elevated to moderate sensitivity (#3) because the presence of soil macropores, ranging from 1-10 mm, increases groundwater recharge significantly. Flow ranges from diffuse to pipe and is calibrated with a flow-velocity scale expressed in meters per day. Dispersion ranges from proximate to extensive and is calibrated with dimensionless units that express relative area of the potential dispersion pattern. Hydrogeologic sensitivity ratings range from (low) #1 to (high) #5. The diagonal grid pattern represents lacustrine deposits which are rated #2 and #3. For the lower two sensitivity zones of all three hydrologic components, overriding factors (such as coarse, granular media or enlarged stress-relief fractures) were recognized which elevate the sensitivity ratings. In order to illustrate these overriding factors, spikes were extended from the lower sensitivity zones to show the potential for elevation to higher sensitivity ratings. Many of the qualitative descriptions used in this graph have been adapted from Quinlan and others (1992).

Figure 2: Physiographic Regions of Kentucky



Physiographic Map Source: KNREPC, Data Processing Branch

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