U.S. DEPARTMENT OF THE INTERIOR
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MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF POLLUTION CONTROL and the
MISSISSIPPI DEPARTMENT OF AGRICULTURE AND COMMERCE
BUREAU OF PLANT INDUSTRY

HYDROLOGIC INVESTIGATIONS ATLAS HA-739
Susceptibility of ground water to contamination in Mississippi — SHEET 4 OF 4
O'Hara, C.G., 1996, Susceptibility of ground water to surface and shallow sources of contamination in Mississippi

SUSCEPTIBILITY OF GROUND WATER TO SURFACE AND SHALLOW SOURCES OF CONTAMINATION

The U.S. Geological Survey (USGS), in cooperation with the Mississippi Department of Environmental Quality, Office of Pollution Control, and the Mississippi Department of Agriculture and Commerce, Bureau of Plant Industry, conducted an investigation to evaluate the susceptibility of ground water to contamination from surface and shallow sources in Mississippi. The evaluation was accomplished by using a geographic information system (GIS) to develop and analyze statewide spatial data layers that contain geologic, hydrologic, physiographic, and cultural information. The relative susceptibility of ground water in major aquifers to surface and shallow sources of contamination in Mississippi was evaluated based on the combination of selected factors (sheet 2) that contribute to the likelihood that contaminants from surface and shallow sources will follow the path of aquifer recharge and reach the water table. The selected contributing factors, in the form of GIS spatial data layers, are provided in the following list:

- Hydraulic Conductance - the transmitting capability of a block of earth material (Franke and others, 1990). Vertical series hydraulic conductance, hereafter referred to as conductance (fig. 9 on sheet 3), provides a single, integrated value for the capacity of the entire sequence of earth materials that overlie the saturated zone to transmit water (with or without contaminants) from the land surface to the water table.
- Land-Surface Slope - the inclination or slope of the land surface, expressed in percent (fig. 6 on sheet 2), provides data about the likelihood that surface water or precipitation will run off or pond due to land-surface slope.
- Land Use/Land Cover - the classification of the type of cover and/or use of the land surface (fig. 7 on sheet 2) provides data about the likelihood that land use and/or land cover will influence the infiltration and/or generation of potential contaminants.

SOURCES OF DATA

The GIS data sets used in this investigation were obtained from many sources. For the purposes of this investigation, all GIS data sets were converted into grids with grid cells measuring 300 feet on a side. The 300-foot grid-cell size was selected because of the approximate 300-foot resolution of the land-surface altitude data (generated from USGS DEM's).

- Conductance was determined through the combined use of spatial data layers that provided data about soil permeability and thickness, aquifer media hydraulic conductivity, and the depth to the water table (used as the total thickness of the unsaturated zone). Where available, the reported thickness of clay units in the upper part of the outcrop was used as supplemental data in determining the hydraulic conductance. A detailed description of the determination of conductance is provided on sheet 3, as well as other tabular data in table 2 on sheet 2.
- Slope of the land surface throughout the State was determined from a statewide-altitude model. This model (grid) was created by combining all of the U.S. Geological Survey, 1:250,000 scale digital elevation models (DEM's) for Mississippi. The 1:250,000 DEM's provided the best available source of digital altitude data and are based on 1:250,000 quadrangle maps with a contour interval of 50 feet. Altitudes at this scale are interpolated at a 3-arc-second interval which was resampled to an even 300-foot interval in the construction of the statewide-altitude model. The statewide map of slope on sheet 2 is accompanied by text further describing this data layer.
- Land-use maps were created from Geographic Information Retrieval and Analysis System (GIRAS) data sets (U.S. Geological Survey, 1978a, 1978b, 1980a, 1980b). These data sets generally are compiled at a scale of 1:250,000 (U.S. Geological Survey, 1986) and are based on the land use and land cover classification system developed by Anderson and others (1976). The classification system is multi-level wherein each successive level is a more detailed characterization of land use and land cover than the previous level. In the evaluation of the relative susceptibility of ground water to contamination, ratings for each land-use area are based on how the land use/land cover type influences runoff, the relative contamination risk of anthropogenic and natural activities occurring in that area, as well as hydrologic properties particular to each area (table 3). Because land cover and land-use activities substantially influence ground-water contamination risk, this factor was included in the evaluation.

COMPILATION OF THE MAP

In conducting the evaluation of relative ground-water susceptibility, hydraulic conductance, land-surface slope, and land use/land cover are each treated as contributing factors and rated on a scale of 1 to 10. A rating of 1 is the lowest ground-water susceptibility rating for a given factor and 10 is the highest ground-water susceptibility rating for a factor. The assignment of rating values for each factor is detailed in tables 2 and 3. The rated factors are assigned weights of 3 for hydraulic conductance, 1 for land-surface slope, and 1 for land use/land cover. Hydraulic conductance is given a weight of 3 because data are combined from many sources in determining the conductance. After the factors are rated and weighted, they are then combined, resulting in a relative susceptibility value. Finally, relative susceptibility values are divided into five relative susceptibility categories. Relative susceptibility categories are based on the percent of the highest possible relative susceptibility value of 50. The categories are formed by five equal percentile ranges with a 20 percent category interval and are given a subjective relative-susceptibility descriptor from lowest to highest relative susceptibility corresponding to categories 1 to 5, respectively.

Table 4. Relative susceptibility percentile ranges and categories

Percent of highest possible relative susceptibility value	Relative susceptibility category (and susceptibility descriptor)
Less than or equal to 20	1 (lowest)
Greater than 20 to less than or equal to 40	2 (low)
Greater than 40 to less than or equal to 60	3 (moderate)
Greater than 60 to less than or equal to 80	4 (high)
Greater than 80	5 (highest)

The relative susceptibility of ground water to contamination from surface and shallow sources was evaluated for all aquifer outcrop areas in Mississippi. The final values, expressed as relative susceptibility values, were then converted to a percentage of the maximum possible value and divided into relative susceptibility categories 1 through 5 for the aquifer outcrop areas. Ground-water resources in aquifer outcrop areas mapped as category 1 areas are least susceptible and category 5 areas are most susceptible to potential contamination from surface or shallow sources. The relative susceptibility results are provided in figure 10 mapped in categories 1 through 5. An example calculation of the susceptibility of ground water to surface and shallow sources of contamination follows:

Table 5. Example calculation of relative susceptibility value

Factor	Data value (from GIS)	Assigned rate (R)	Weight (W)	Total (R*W)
Conductance (ft-sq/day)	21, 030	7	3	21
Slope (percent)	4	9	1	9
Land use/land cover	Agricultural	10	1	10
		Relative susceptibility value		40
		Percent of possible total (50)		80
		Relative susceptibility category		4 (high)

The numerical values derived from the application of the rating system, although based on quantitative data, provide only a relative measure of ground-water susceptibility to contamination. The relative susceptibility categories are intended only to provide a comparison of contamination risks for different aquifers or parts of the same aquifer. Other investigations [with different objectives] analyzing the same data might use different weighting values for factors, but these weighting values were selected based upon relative hydrologic significance.

Generally, the results of the study indicate patterns that are related closely to the physiographic (fig. 1) and hydrologic factors which predominate in each region. Ground-water susceptibility is shown in figure 10 with decreasing gray and increasing blue indicating an increase in relative susceptibility. Areas shown in dark gray-brown are "confining unit outcrops" in which unconfined conditions do not occur. Ground-water susceptibility values are low for broad areas of the Delta where hardpan clay is thick and extensive, soils are "tight," and the DTW is not shallow. However, some of the highest susceptibility values occur along the alluvial margin that bounds the eastern part of the Delta where the hardpan clay is thin or absent, soils are less tight, and the DTW is shallow. In the alluvial margin along the eastern boundary of the Delta, coarser-grained outwash materials and very shallow depths to water combine to increase susceptibility ratings, especially in areas where stream dissection has incised the landscape and bluffs. Along the western part of the Delta, susceptibility values are more variable and appear to generally follow patterns dictated by soil permeability and land-surface slope as influenced by recent Mississippi River channel and overbank sediments and levee features. Similar susceptibility value patterns within the Delta are apparent in areas of major streams that drain the region. The northeastern part of the State has susceptibility values that vary from "low" to "high" due, in large part, to the variability of physiography and hydrology of the area; the steeper slope of land surface, fine-grained sedimentary textures, and relatively low-permeability soils which have arisen from the underlying fine-grained lithologies. In the northeastern part of the State, susceptibility values are generally lower for areas in the Pontotoc Ridge district and higher for areas in the Fall Line Hills district. In the north-central and eastern part of the State, the evaluated susceptibility values are mostly moderate to high. Much of the central and eastern part of the State lies in the outcrop of confining units and as such, water-table conditions do not exist. In the southern and coastal parts of the State, the evaluated susceptibility of ground water to contamination is generally higher than other parts of the State. In the coastal and southern areas, terrace and coastal features cover large areas of the land surface, soil permeabilities are moderate to high, and the lithology of sedimentary units generally is coarse-grained to sandy with some silt and clay. These factors, combined with generally shallow water-table conditions in the coastal areas led to higher susceptibility values than values for other areas of the State.

The analytical technique detailed above was performed by using customized GIS data bases and Arc Macro Language (AML) programs all done within the ArcInfo environment.[1] Most of the procedures discussed above were done in the GRID module of ArcInfo.

SELECTED REFERENCES: SHEET 4

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_____1987h, Memphis, Mississippi digital elevation model, scale 1:250,000.

_____1987i, Mobile, Mississippi digital elevation model, scale 1:250,000.

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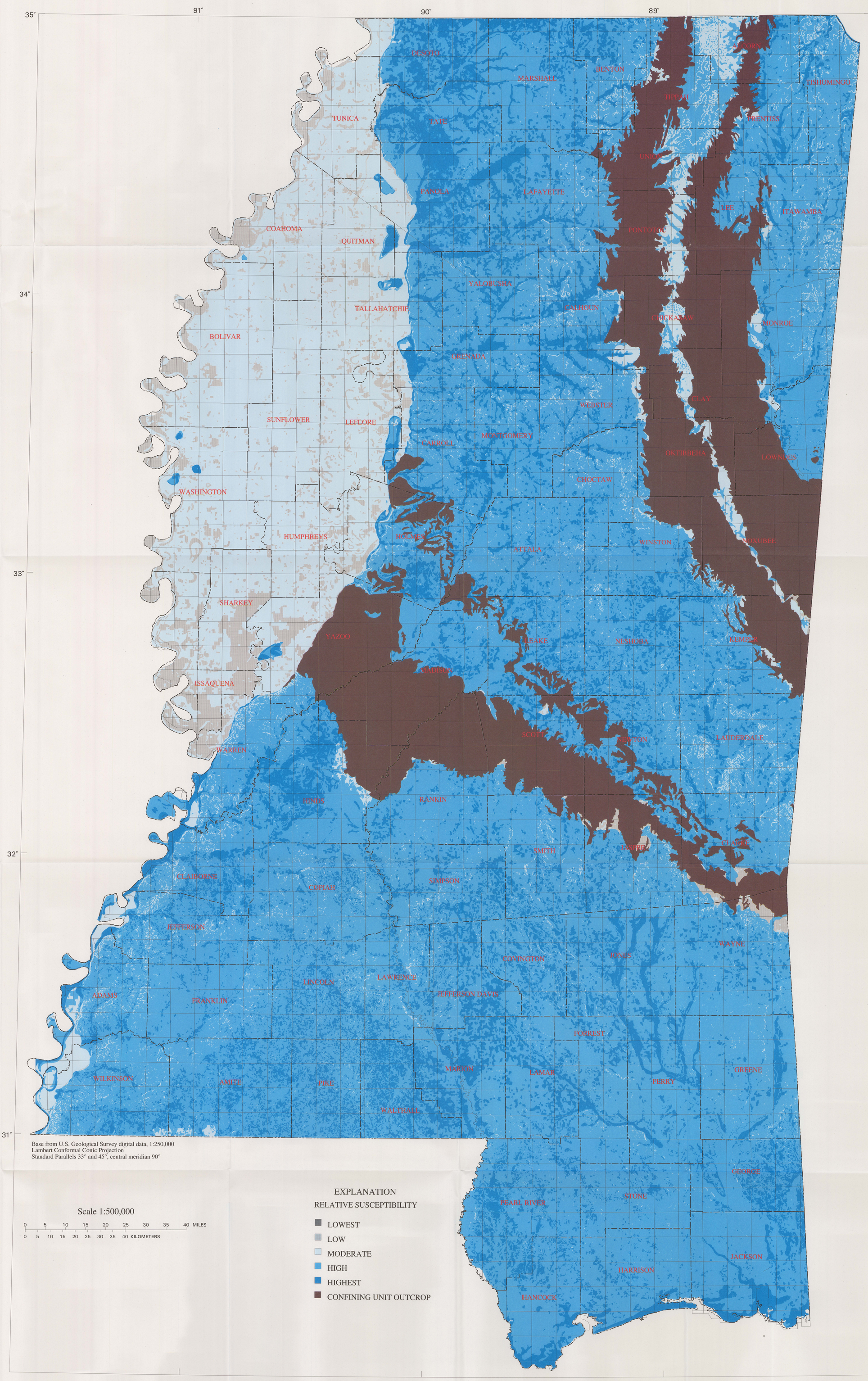
_____1987k, Tupelo, Mississippi digital elevation model, scale 1:250,000.

_____19871, Digital elevation models: National Mapping Program Technical Instructions Data Users Guide 5, 38 p.

[1]The use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.



Base from U.S. Geological Survey digital data, 1:250,000
Lambert Conformal Conic Projection
Standard Parallels 33° and 45°, central meridian 90°

Scale 1:500,000

0 5 10 15 20 25 30 35 40 MILES
0 5 10 15 20 25 30 35 40 KILOMETERS

EXPLANATION
RELATIVE SUSCEPTIBILITY

- LOWEST
- LOW
- MODERATE
- HIGH
- HIGHEST
- CONFINING UNIT OUTCROP

Figure 10. Relative susceptibility of ground water to contamination in Mississippi.

For additional information write to:

U.S. Geological Survey
308 South Airport Road
Pearl, Mississippi 39208-6649

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By
Charles G. O'Hara
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Copies of this report can be purchased from:

U.S. Geological Survey
Information Services
Box 25286
Federal Center
Denver, CO 80225