Soil-Attenuation-Potential Map of Pepin County, Wisconsin

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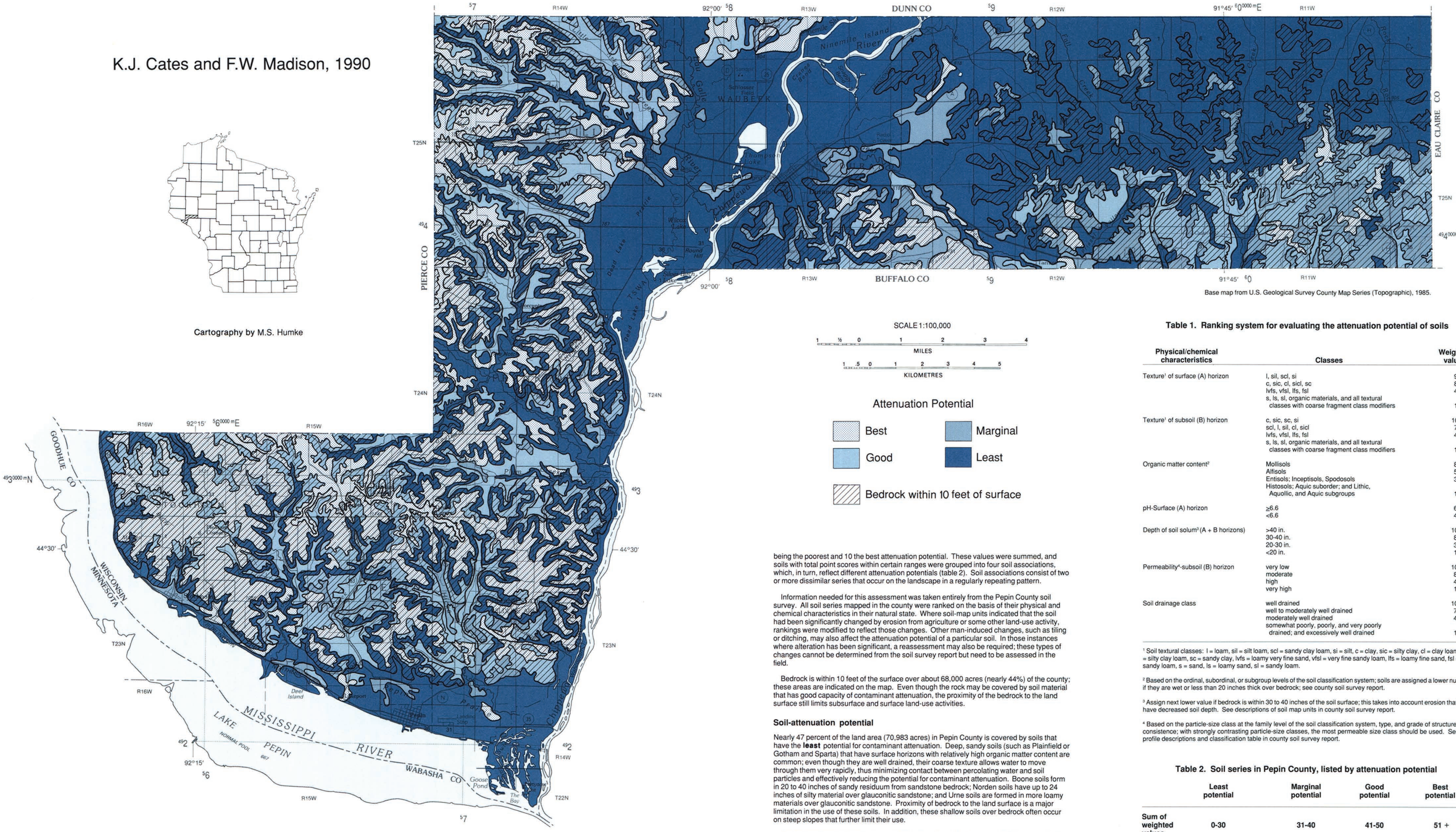
Cartography by M.S. Humke



Base map from U.S. Geological Survey County Map Series (Topographic), 1985.

Introduction

Soils usually compose only the upper 2 to 4 feet of unconsolidated material at the earth's surface. Soils are the basis of agricultural production; they provide the foundation for buildings and roads; and, if properly used, they aid in the treatment and recycling of wastes from homes, from the production of livestock and poultry, and from municipal and industrial sewage treatment plants. Soil characteristics (depth, texture, and permeability) are among the most significant factors that determine the rate and extent of groundwater recharge and the degree of natural protection against contamination. Land characteristics (such as slope, vegetation, and type of subsoil materials) in conjunction with the soil determine the overall potential of the environment to protect groundwater.

Glaciers moved across most of Pepin County many thousands, or perhaps millions, of years ago, leaving behind characteristic deposits of till (a poorly sorted mixture of sand, silt, and boulders) and outwash (sand and gravel carried away from the ice by meltwater). All of the county, except the far southeastern corner, probably was covered by glacial ice at some time in the past. Subsequent erosion and other geomorphic processes have removed many of these deposits; evidence of early glaciations is sparse at or near the modern land surface. In the northwestern part of the county, limited acreages of soils formed in glacial drift (Otterholt and Almena) have been identified.

Although the last glacier to invade Wisconsin did not reach Pepin County, its influence on the modern landscape of the county was significant. Water from the melting ice moved along the Chippewa River drainage system, which nearly bisects the county, leaving behind extensive flat-lying, coarse-textured (sand-sized) deposits. Silt-sized particles were carried greater distances by the meltwater until the flow slowed enough for the materials in transport to be deposited. Following the disappearance of the glacial ice, these fine particles were picked up by the wind and deposited as a blanket on the land surface. Many of the modern soils in Pepin County are formed in this wind-deposited material, which is called loess.

A variety of factors influence the soil that develops in an area: the parent material from which the soil formed, relief, climate, natural vegetation, and the time that the soil has had to form. Although geologic erosion and the early glaciers modified and smoothed the landscape in the county to a limited degree, areas of steep slopes are common and soil erosion is a serious problem, particularly where the land is farmed intensively. In some parts of Pepin County, the protective loess cover has been eroded and bedrock, or bedrock residue, is at the land surface. These erosional losses increase the potential for groundwater contamination because the bedrock, either sandstone or limestone, has much less ability to attenuate contaminants than the medium-textured, loessial material that covered the county.

For mapping, classification, and interpretive purposes, soils are grouped into soil series on the basis of similar physical and chemical characteristics, type of parent material, and arrangement of horizons or layers. A grouping of individual soils based solely on physical and chemical characteristics is required to evaluate the potential of soils for attenuating contaminants. An evaluative system was developed to assess those soil properties that play a role in the attenuation of potential groundwater contaminants resulting from land-use activities.

Capacity of soils to attenuate pollutants

Attenuation is a series of complex processes, none of which are clearly understood. During attenuation, the soil holds essential plant nutrients for uptake by agronomic crops, immobilizes metals that might be contained in municipal sewage sludge, or removes bacteria contained in animal or human wastes. The soil is an integral part of the natural protection of groundwater from surface-applied contaminants. However, the natural purification capacity of the soil, like that of any other natural resource, is limited, and sometimes soil that retains contaminants become contaminated. Cleaning contaminated soil can be as difficult as cleaning contaminated groundwater.

The evaluation system presented here must be looked upon as a supplemental planning tool only, as a time- and cost-saving guide for preliminary screening of the county for areas sensitive to the impact of normal land-use activities. This soil-potential map does not replace the need for detailed on-site investigations. It does, however, reduce the number of areas to be studied in detail by identifying the areas of best and least attenuation potential. Local details have been generalized to fit the mapping scale, which cannot accommodate small, local variations in soil characteristics.

This system evaluates the ability of the soil solum (the A and B horizons) to attenuate potential contaminants resulting from activities above or within the soil zone. The soil-attenuation capacity is considered here only in general terms and is not contaminant-specific. Different contaminants may behave differently — some may be completely eliminated by soil organisms, some may be used by plants, some may be adsorbed on soil particles, and some may eventually pass through the soil solum unchanged.

Physical and chemical characteristics to establish soil ratings

For assessing soil potential for attenuation of contaminants in Pepin County, seven physical and chemical characteristics were selected for each soil series and were given weighted values (table 1). Values assigned to each characteristic were determined subjectively, with 1 being the poorest and 10 the best attenuation potential. These values were summed, and soils with total point scores within certain ranges were grouped into four soil associations, which, in turn, reflect different attenuation potentials (table 2). Soil associations consist of two or more dissimilar series that occur on the landscape in a regularly repeating pattern.

Information needed for this assessment was taken entirely from the Pepin County soil survey. All soil series mapped in the county were ranked on the basis of their physical and chemical characteristics in their natural state. Where soil-map units indicated that the soil had been significantly changed by erosion from agriculture or some other land-use activity, rankings were modified to reflect those changes. Other man-induced changes, such as tiling or ditching, may also affect the attenuation potential of a particular soil. In those instances where alteration has been significant, a reassessment may also be required; these types of changes cannot be determined from the soil survey report but need to be assessed in the field.

Bedrock is within 10 feet of the surface over about 68,000 acres (nearly 44%) of the county; these areas are indicated on the map. Even though the rock may be covered by soil material that has good capacity of contaminant attenuation, the proximity of the bedrock to the land surface still limits subsurface and surface land-use activities.

Soil-attenuation potential

Nearly 47 percent of the land area (70,983 acres) in Pepin County is covered by soils that have the **least** potential for contaminant attenuation. Deep, sandy soils (such as Plainfield or Gotham and Sparta) that have surface horizons with relatively high organic matter content are common; even though they are well drained, their coarse texture allows water to move through them very rapidly, thus minimizing contact between percolating water and soil particles and effectively reducing the potential for contaminant attenuation. Boone soils form in 20 to 40 inches of sandy residuum from sandstone bedrock; Norden soils have up to 24 inches of silty material over glauconitic sandstone; and Urne soils are formed in more loamy materials over glauconitic sandstone. Proximity of bedrock to the land surface is a major limitation in the use of these soils. In addition, these shallow soils over bedrock often occur on steep slopes that further limit their use.

Many miscellaneous land types (such as loamy alluvial land; see table 2) also occur in the least potential association. These are often found on modern floodplains and areas of high water tables. In areas where the water table is close to the land surface, the ability of soil materials to attenuate contaminants is severely limited because the soil column through which contaminants move is not sufficiently deep enough to remove them.

Soils with **marginal** potential to attenuate contaminants occupy about 10 percent of the land area in Pepin County (15,469 acres) and include those formed in up to 30 inches of silty materials over sandstone (Norden, Gale) and in similar thicknesses of loamy materials over sandstone (Hixton). Some soils in this association (Zwingle, Rowley) have morphological features in their subsurface horizons, indicating periods of saturation. Presence of a saturated zone within the soil solum interrupts the attenuation processes and may allow contaminants to be introduced into the groundwater.

Soils with **good** and **best** potential to attenuate contaminants cover about 43 percent of the land area of Pepin County (65,228 acres); most are formed in deep silt (loess) over bedrock (Seaton, Fayette, Dubuque, Downs) or over sand (Bertrand, Jackson, Toddville) and in deep, loamy material over sand (Dakota). Differences in attenuation potential are dependent on the thicknesses of the medium-textured material in which the soils have formed. Maximum contaminant attenuation is directly related to the amount of contact between percolating waters and soil particles. The soils in these associations are characterized by medium-textured, well structured surface horizons that enhance infiltration of water and by finer-textured, well structured subsoil horizons that allow maximum contact between contaminants and soil particles; differences between the two associations are a function of the thickness of the soil materials.

Soils in the good and best associations are well suited to a wide variety of land-use activities. All must be managed carefully to avoid the loss of topsoil material, which results in reduced infiltration, reduced thickness of materials well suited for contaminant attenuation, and reduced cover for bedrock which, due to its primary or secondary porosity, has only very limited ability to attenuate contaminants. Erosion in Pepin County has reduced the attenuation potential of many soils from best (in their natural state) to good.

This map shows the distribution of soils in Pepin County on the basis of their potential for contaminant attenuation, which is, in turn, a measure of their ability to protect groundwater from surface-applied contaminants. Soils that have special management requirements dominate the county. Those with bedrock within 10 feet of the land surface are found throughout the county. Deep, flat-lying sandy soils lend themselves well to intensive, irrigated agriculture; however, because of their limited ability to attenuate contaminants, they must be managed carefully to avoid nutrient and pesticide movement to the groundwater. Soils on steep slopes are often shallow and simply are not suited to many land uses other than forestry. Deeper soils on steep slopes can be used in a variety of ways but must be carefully managed to reduce erosion.

Table 1. Ranking system for evaluating the attenuation potential of soils

Physical/chemical characteristics	Classes	Weighted values
Texture[1] of surface (A) horizon	l, sil, scl, si	9
	c, sic, cl, sicl, sc	8
	lvfs, vfsl, lfs, fsl	4
	s, ls, sl, organic materials, and all textural classes with coarse fragment class modifiers	1
Texture[1] of subsoil (B) horizon	c, sic, sc, si	10
	scl, l, sil, cl, sicl	7
	lvfs, vfsl, lfs, fsl	4
	s, ls, sl, organic materials, and all textural classes with coarse fragment class modifiers	1
Organic matter content[2]	Mollisols	8
	Alfisols	5
	Entisols; Inceptisols, Spodosols	3
	Histosols; Aquic suborder; and Lithic, Aquollic, and Aquic subgroups	1
pH-Surface (A) horizon	≥6.6	6
	<6.6	4
Depth of soil solum[3] (A + B horizons)	>40 in.	10
	30-40 in.	8
	20-30 in.	3
	<20 in.	1
Permeability[4]-subsoil (B) horizon	very low	10
	moderate	8
	high	4
	very high	1
Soil drainage class	well drained	10
	well to moderately well drained	7
	moderately well drained	4
	somewhat poorly, poorly, and very poorly drained; and excessively well drained	1

[1] Soil textural classes: l = loam, sil = silt loam, scl = sandy clay loam, si = silt, c = clay, sic = silty clay, cl = clay loam, sicl = silty clay loam, sc = sandy clay, lvfs = loamy very fine sand, vfsl = very fine sandy loam, lfs = loamy fine sand, fsl = fine sandy loam, s = sand, ls = loamy sand, sl = sandy loam.

[2] Based on the ordinal, subordinal, or subgroup levels of the soil classification system; soils are assigned a lower number if they are wet or less than 20 inches thick over bedrock; see county soil survey report.

[3] Assign next lower value if bedrock is within 30 to 40 inches of the soil surface; this takes into account erosion that may have decreased soil depth. See descriptions of soil map units in county soil survey report.

[4] Based on the particle-size class at the family level of the soil classification system, type, and grade of structure, and consistence; with strongly contrasting particle-size classes, the most permeable size class should be used. See soil profile descriptions and classification table in county soil survey report.

Table 2. Soil series in Pepin County, listed by attenuation potential

	Least potential	Marginal potential	Good potential	Best potential
Sum of weighted values	0-30	31-40	41-50	51 +
	Boone Burkhardt Dillon (Newton)[3] Ettrick Gotham Loamy alluvial land[1] Loamy alluvial land, wet[1] Loamy wet terrace land[1] Loamy very wet terrace land[1] Morocco Norden fine sandy loam[2] Norden loam Northfield Peat and muck, deep[4] Peat and muck, shallow[4] Plainfield Riverwash[1] Sandy alluvial land[1] Sparta Steep stony and rocky land[1] Terrace escarpments, loamy[1] Terrace escarpments, sandy[1] Urne Urne and Norden complex Watseka	Curran Dakota fine sandy loam, moderately eroded[2] Gale Hixton Hubbard Jackson, severely eroded[2] Meridian Norden Norden silt loam, moderately eroded[2] Norden silt loam, severely eroded[2] Rowley Wallkill Zwingle, poorly drained[2]	Almena Arenzville Bertrand, severely eroded[2] Chaseburg Dakota Dakota loam, moderately eroded[2] Dubuque Jackson Norden silt loam[2] Orion Seaton and Fayette complex, moderately eroded[2] Toddville Zwingle	Bertrand Dakota loam[2] Downs Dubuque, deep[2] Huntsville Judson Lindstrom Medary Otterholt Richwood Seaton and Fayette complex Waukegan
Acreage	70,983	15,469	31,088	34,140
Percent of total land area	46.8	10.2	20.5	22.5

[1] miscellaneous land type
[2] soil phase
[3] modern soil series name
[4] organic soils

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