SOILS OF DUNN COUNTY AND THEIR ABILITY TO ATTENUATE CONTAMINANTS

A.W. Sutherland and F.W. Madison

1987

Introduction

Soils usually compose only the upper 2 to 4 feet of unconsolidated materials 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 type, and type of rock will, in conjunction with the soil, determine the overall potential of the environment to protect groundwater.

Glaciers moved across Dunn County many thousands of years ago, leaving behind characteristic deposits of till (a poorly sorted mixture of sand, silt, and boulders) and outwash (sand and gravel carried off the ice by meltwater). Subsequent erosion has, however, removed many of these deposits, so evidence of this early glaciation is sparse.

The last glacier to invade Wisconsin terminated north of Dunn County and influenced the modern landscape significantly. Waters from the melting ice moved through from north to south following a major drainageway that nearly bisects the county. When that ice disappeared, silt-sized material called loess was deposited by the wind over much of the county to depths as great as 10 feet. The Chippewa River drainage system served as an outlet for the meltwaters.

Many factors influence the type of soil that develops in an area: the parent material from which the soil formed, relief, climate, natural vegetation, drainage and the time that the soil has had to form. In some parts of Dunn County, the loess has eroded away and soils have formed in residuum of the sandstone bedrock. Throughout much of the land area (238,000 acres or 43.6% of the county), bedrock is within 5 feet of the land surface. Some soils also have developed in alluvial deposits (flood plains) and in organic materials (peat and muck).

For mapping, classification, and interpretive purposes, soils are grouped into soil series on the basis of 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 actually a series of complex processes, all of which are not 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 soils that retain contaminants may themselves 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 helps evaluate 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 Dunn 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 Dunn County soil survey. All soil series mapped in the county were ranked based on their characteristics in a natural state. Man-induced changes, such as tiling and ditching, may affect the attenuation potential of a particular soil. In those instances where alteration has been extensive, a reassessment may be required. Those areas in Dunn County where the bedrock is within 5 feet of the land surface are indicated on the map. Sandstone is the most common, although limestone underlies about 5,000 acres, primarily in the west-central portion of the county. Even though the rock may be covered with 2 to 4 feet of soil materials that have good capacity for contaminant attenuation, the proximity of the bedrock to the surface still limits subsurface and surface land-use activities.

Soil attenuation potential

Slightly more than 15 percent of the land area in Dunn County is covered with soils that have the **best** potential for contaminant attenuation. Seaton soils are formed in more than 4 feet of loess; Dakota, Meridian, and Pillot soils developed under prairie grasses in 20 to 40 inches of silty or loamy materials over sand. Otterholt soils formed in 40 to 60 inches of silty materials over a dense sandy loam glacial till. These soils are well suited for a variety of land-use activities, such as those associated with dairy production and the application of municipal and industrial sludges.

The majority of the soils that have **good** potential for attenuating contamination are developed in 20 to 40 inches of loess over sandstone bedrock (Hixton, LaFarge, Norden, Tell). Dubuque and Dunbarton soils consist of up to 36 inches of loess over a clay residuum over dolomite bedrock. The clay residuum is thought to be the result of weathering of the dolomite. The soils in this association are well suited for agriculture, although they must be managed carefully. Subsurface uses are severely restricted where bedrock is close to the land surface.

Soils that have **marginal** potential for attenuation are dominated by the Urne-Elkmound and Urne-Norden complexes, which have developed in loamy materials up to 36 inches thick over sandstone. Attenuation is limited by the thickness and texture of the materials that overlie the bedrock; in addition, many of these soils occur on 12 to 40 percent slopes, which severely limits their use. These steep lands should be kept forested and should not be used for other purposes, not even for pasture.

Collectively, the soils in this association illustrate the basic principles of attenuation. The processes involved depend on water moving through the soil solum at a rate that ensures maximum contact between the percolating water that contains contaminants and the soil particles. Deep (>35 in.), medium- and fine-textured soils are best. Some soils that have marginal attenuation potential are sufficiently deep, but saturated totally or partly for at least part of the year. Presence of the saturated zone within the soil solum interrupts the attenuation process and allows contaminants to be introduced into the groundwater.

Water moves through coarse-textured materials very rapidly; contact between contaminants and soil particles is minimal and attenuation is reduced. Many soils in this association are shallow and coarse textured and have only a limited ability to reduce surface-applied contaminants.

Soils that have the **least** potential for attenuation include deep sands and sandy loams, like Plainfield or Morocco, that are poorly drained (water stands in the soil solum) or excessively drained (water moves through the solum very rapidly) as well as organic soils (Houghton) that are under water all year. Plainbo soils are developed in shallow, sandy residuum from sandstone bedrock. Many of these soils are found in flood plains adjacent to perennial or intermittent streams or where natural drainage has been disrupted. Shallow, residual soils often occupy steep slopes. None are particularly well suited for any type of land-use activity.

This map shows the distribution of soils in Dunn County. Soils with bedrock within 5 feet of the surface are found throughout the county. Uses of these soils are limited, especially when they occur on extremely steep slopes. Where the silt coverings are greater than 30 inches and slopes are moderate, the possibilities for a wide variety of land uses exist. Soils along modern rivers and streams are coarse-textured and somewhat poorly or poorly drained, which restricts their use.

Soils that occupy terraces on the flanks of major glacial drainageways in the central and southeastern portion of the county are deep, well drained and well suited for many land uses. Soils formed in varying thicknesses of loess over glacial till occupy a narrow strip of land along the western edge of the county from north to south.

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

Physical/chemical characteristics	Classes	Weighted values
Texture[1]—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]—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 (A + B horizons)	>40 in.	10
	30-40 in.	8
	20-30 in.	3
	<20 in.	1
Permeability[3]—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; 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.

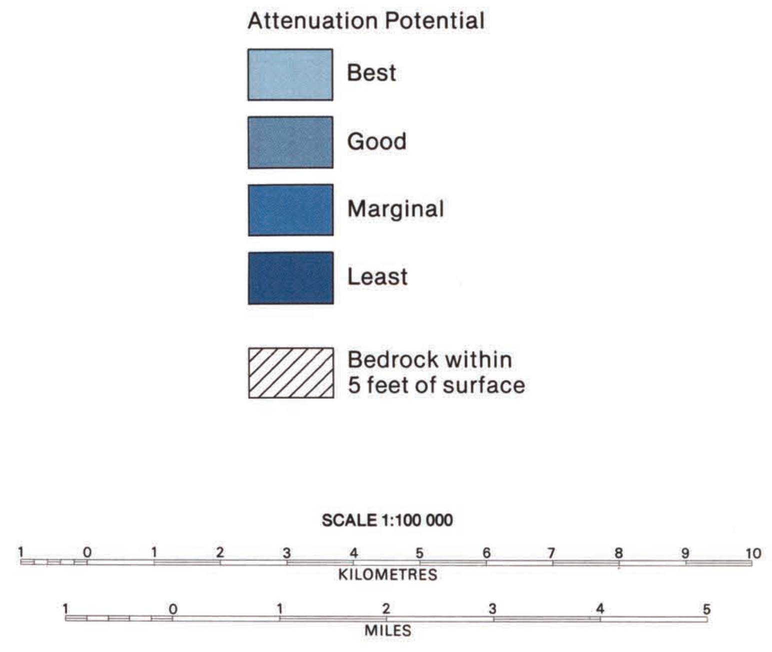
[2] Based on the ordinal, subordinal, or subgroup levels of the soil classification system; soils are assigned a lower number if they are wet or less than 20 inches thick over bedrock; see county soil survey report.

[3] Based on the particle-size class at the family level of the soil classification system, type and grade of structure, and consistency; see county soil survey report.

Table 2. Soil series in Dunn County listed by attenuation potential

	Least potential	Marginal potential	Good potential	Best potential
Sum of weighted values	0-30	31-40	41-50	51+
	Alluvial land* Billett variant Brems Burkhardt Cathro Chetek Dickinson Houghton Markey Morocco Newton Plainbo Plainfield Riverwash* Steep stony rock land* Terrace escarpments—* sandy loamy	Almena Arland Billett Boaz Caryville Eleva Elkmound Gotham Hixton variant Kickapoo Lows Marshan Northfield Poskin Rib Shiffer Stronghurst Urne-Elkmound complex Urne-Norden complex Wallkill	Amery Arenzville Campia Dubuque Dunbarton Hixton LaFarge Norden Tell	Dakota Dunnville Meridian Otterholt Pillot Renova Santiago Seaton Terril
Acreage	196,440	227,222	38,920	83,210
Percent of total land area	36.0%	41.6%	7.1%	15.3%

*Undifferentiated land type

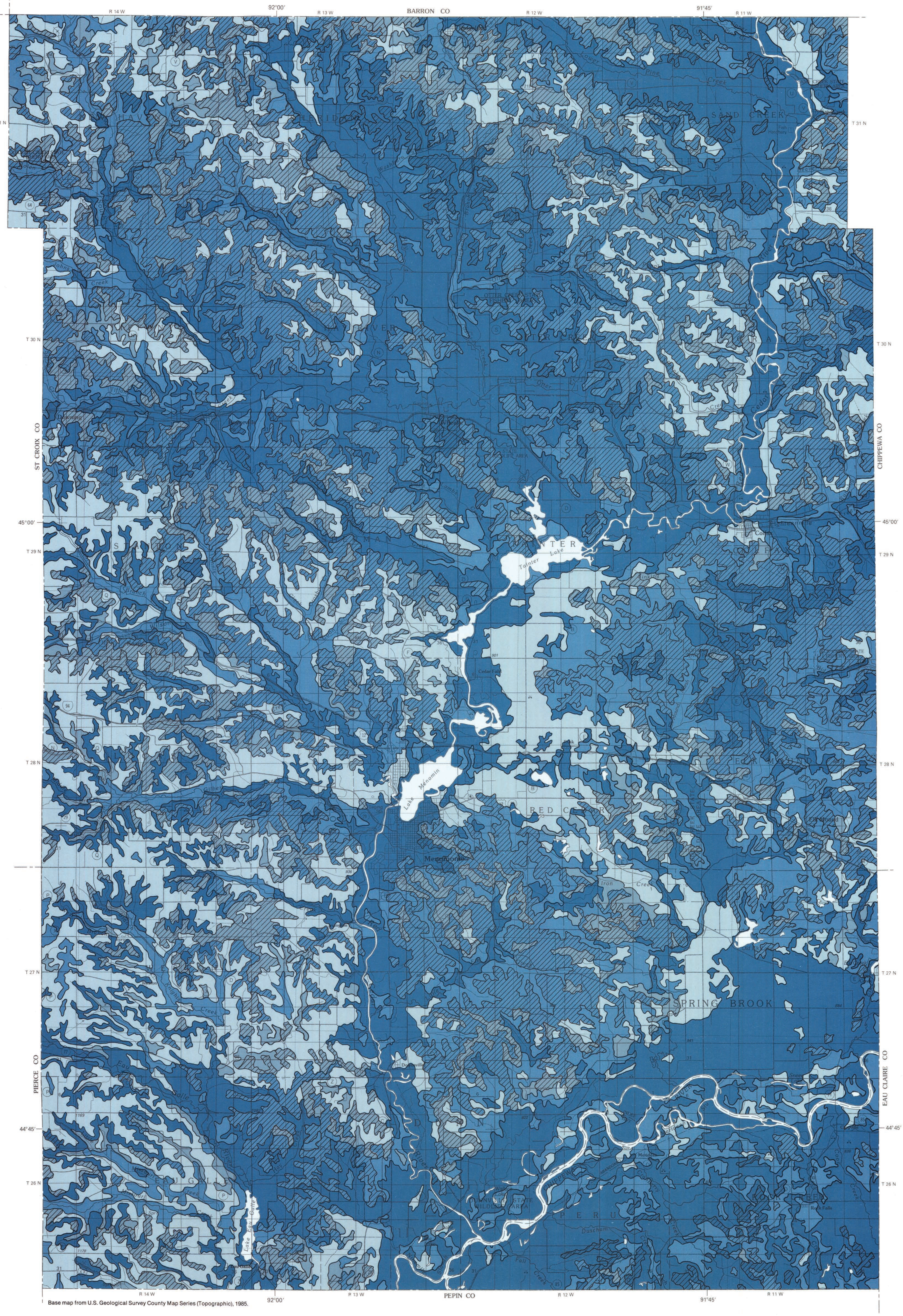


University of Wisconsin—Extension

Published by and available from
Wisconsin Geological and Natural History Survey
M.E. Ostrom, Director and State Geologist
3817 Mineral Point Road, Madison, Wisconsin 53705

Cartography by D.L. Patterson

Map 87-4



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