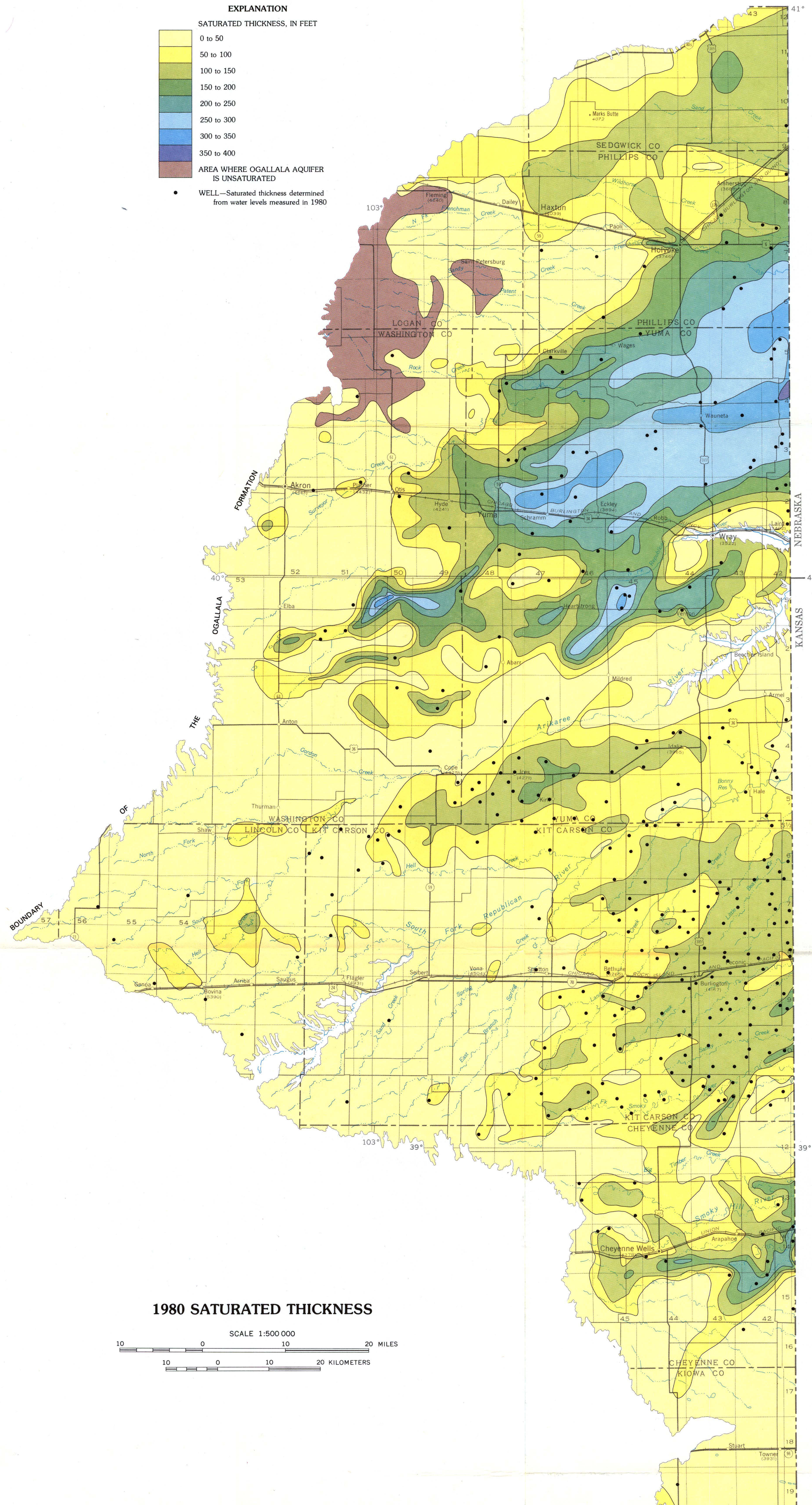
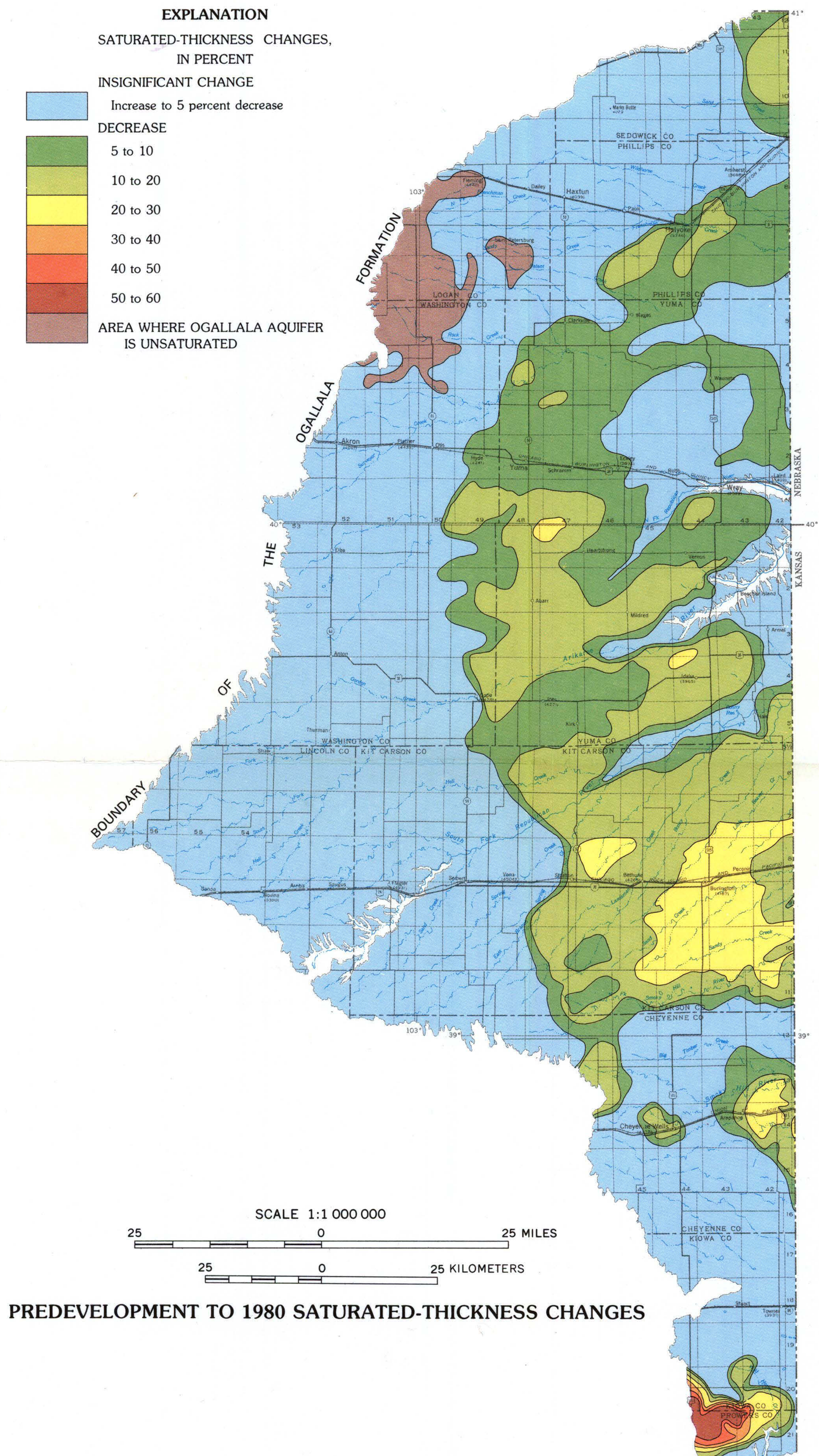
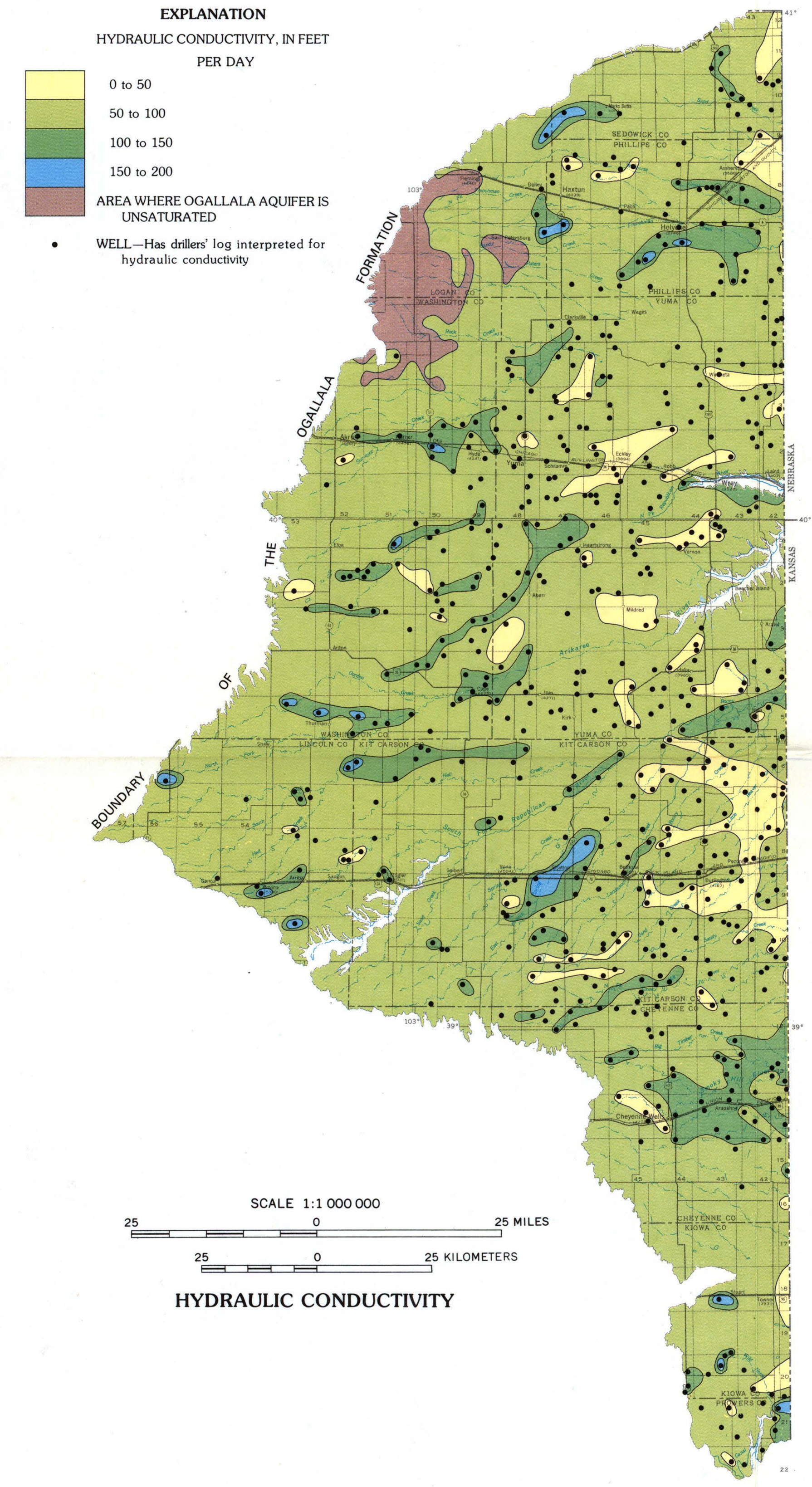


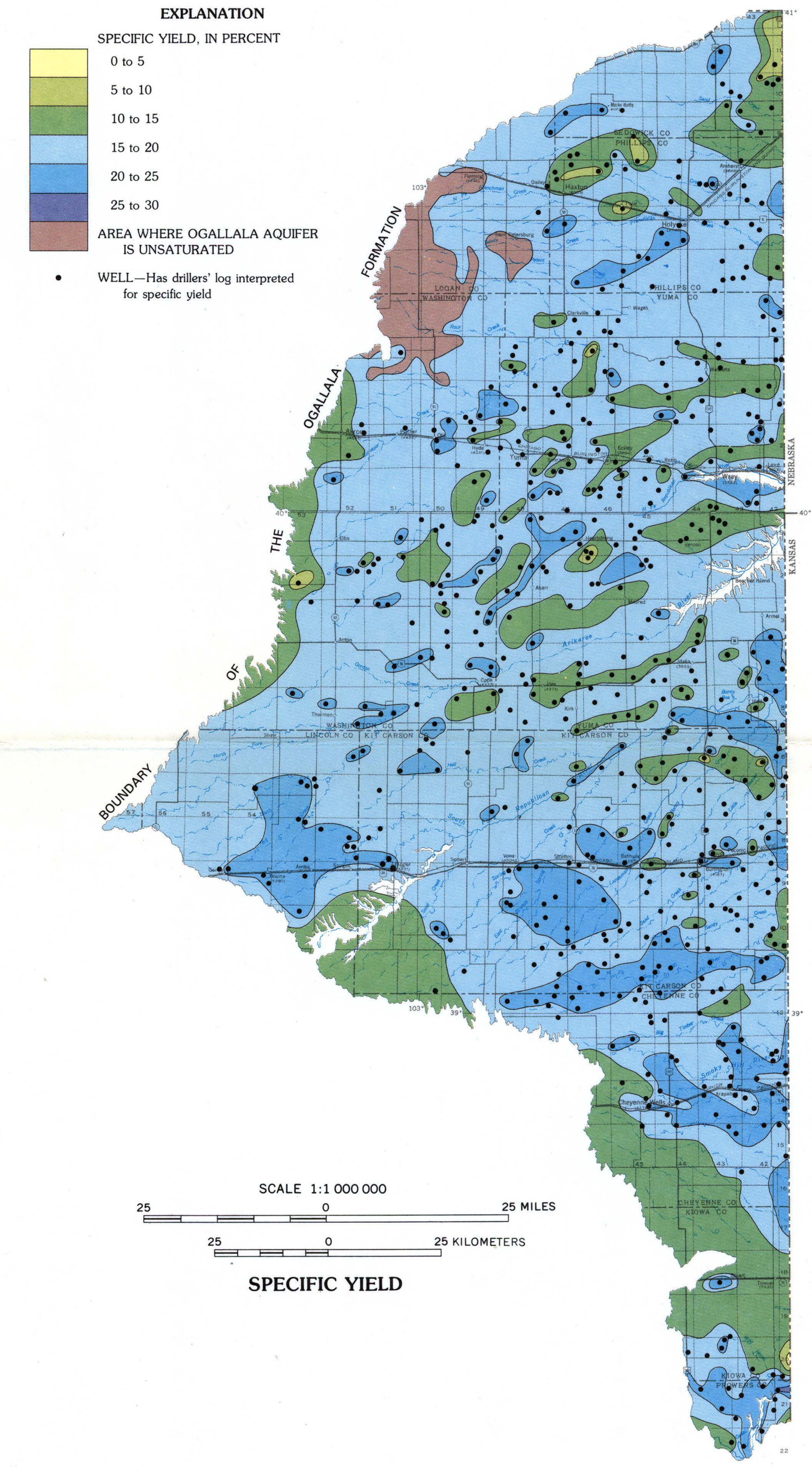
1980 SATURATED THICKNESS



PREDEVELOPMENT TO 1980 SATURATED-THICKNESS CHANGES



HYDRAULIC CONDUCTIVITY



SPECIFIC YIELD

INTRODUCTION

The northern High Plains of Colorado, an area of about 9,500 mi^2 in the eastern part of the State (see index map), is underlain by the Ogallala Formation of Late Tertiary age. The northern High Plains extend from the Colorado State line on the east to the edge of the Ogallala Formation on the north, west, and south. The Ogallala Formation is an unconsolidated or partly consolidated deposit of sand, gravel, clay, silt, and caliche.

The Ogallala aquifer consists of the Ogallala Formation and overlying sediments and is the major source of water for irrigation as well as for industrial, municipal, and domestic use. The aquifer will not be able to supply enough water in the future to support irrigated agriculture to the same extent as today (1982) because of declining water levels. This report presents hydrologic maps needed to understand the ground-water hydrology and to help manage the remaining water resources in the most beneficial manner.

Much of the information used in the preparation of the maps showing the saturated thickness, hydraulic conductivity, specific yield, and probable well yields from the Ogallala aquifer was collected in cooperation with the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer.

SATURATED THICKNESS OF THE OGALLALA AQUIFER IN 1980

The saturated thickness of the Ogallala aquifer is the difference in altitude between the water table and the top of the less permeable bedrock underlying the aquifer. The data for preparing the saturated thickness map were obtained from maps showing contours on top of the bedrock underlying the aquifer (Borman and Meredith, 1982) and on the 1980 water table (Borman, 1982). The data were supplemented with information on the depth to bedrock and the depth to water measured in January 1980 from the wells shown on the map. The Ogallala Formation may be overlain by saturated alluvium, colluvium, or eolian deposits that may extend beyond the study area. These deposits are included as part of the Ogallala aquifer where they overlie the Ogallala Formation; therefore, a few areas with more than 50 ft of saturated thickness are shown to extend to the boundary of the Ogallala Formation.

The saturated thickness of the Ogallala aquifer in 1980 in the northern High Plains of Colorado ranged from zero northeast of Akron to about 400 ft in a small area northeast of Wray. About one-half of the northern High Plains is underlain by more than 50 ft of saturated Ogallala aquifer, and it is in this area that most of the irrigation wells are located.

PREDEVELOPMENT TO 1980 SATURATED-THICKNESS CHANGES

The saturated-thickness change map shows the percentage change in saturated thickness of the Ogallala aquifer from predevelopment conditions (before a significant quantity of water was pumped from the aquifer) to 1980. The map was prepared using the 1980 saturated-thickness map and a map of water-level changes from predevelopment conditions to 1980 (Borman, 1982). About 60 percent of the northern High Plains has had an insignificant change in saturated thickness (increase to 5-percent decrease). This area generally has a saturated thickness less than 50 ft and few irrigation wells. A small area along the Kiowa-Prowers County line had a 50 to 60-percent decrease in saturated thickness. An area near Burlington with a large number of irrigation wells, many of which were drilled before 1970, has had a 20- to 30-percent decrease in saturated thickness from predevelopment to 1980. Much of the area in Yuma County north of Wray has a large number of irrigation wells and water-level declines of more than 10 ft, yet has had less than a 5-percent decrease in saturated thickness because of the large thickness of saturated Ogallala aquifer.

HYDRAULIC CONDUCTIVITY

Hydraulic conductivity is a measure of the ability of an aquifer to transmit water and is defined as the volume of water that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. The hydraulic conductivity is greater for materials with large, well-connected pore spaces, such as sand and gravel, and lesser for materials with small, poorly-connected pore spaces, such as silt and clay. Transmissivity is the rate at which water is transmitted through a unit width of the entire saturated thickness of the aquifer under a unit hydraulic gradient and can be estimated by multiplying the hydraulic conductivity by the saturated thickness of the aquifer as shown by the saturated thickness map on this sheet.

The data used to compile the hydraulic-conductivity map of the Ogallala aquifer were determined by assigning values of hydraulic conductivity from laboratory tests on materials from the Ogallala Formation to lithologic descriptions in drillers' logs for the wells shown on the map. In the northern High Plains of Colorado, the hydraulic conductivity for the Ogallala aquifer ranges from less than 50 to about 200 ft/d, but in most of the area the hydraulic conductivity ranges between 50 and 100 ft/d.

SPECIFIC YIELD

Specific yield is a measure of the ability of an aquifer to store water and is defined as the ratio of (1) the volume of water which rock or soil, after being saturated, will yield by gravity to (2) the volume of the rock or soil. Specific yield depends on particle size and sorting: coarse, well-sorted materials generally have a greater specific yield than fine or poorly sorted materials. Specific yield multiplied by saturated thickness provides an estimate of the volume of water recoverable in an area.

The data used to compile the specific-yield map of the Ogallala aquifer were determined by assigning values of specific yield from laboratory tests on materials from the Ogallala Formation to lithologic descriptions in drillers' logs for the wells shown on the map. In the northern High Plains of Colorado the specific-yield values for most of the Ogallala aquifer range from 10 to 20 percent.

PROBABLE WELL YIELDS

The probable well-yield maps show the well yields that probably could have been obtained from the Ogallala aquifer under predevelopment conditions and in 1980. The maps are based on the predevelopment saturated thickness, as determined from a map of the bedrock surface (Borman and Meredith, 1982) and a map of the predevelopment water table (Borman, 1982), the 1980 saturated thickness, and the hydraulic conductivity of the Ogallala aquifer. Probable well yields were computed assuming a well with a 30-in effective diameter (irrigation wells typically have a 16-in diameter screen or perforated casing and are gravel packed to 30-in diameter) that penetrates and is open to the entire saturated thickness of the aquifer. Also, it was assumed that each well was pumping for 90 days, was pumping at 65 percent of the maximum theoretical yield (E. D. Gutentag, verbal commun., 1983), and that pumping water levels were allowed to be drawn down to within 15 ft of the bottom of the aquifer. The shape of the areas on the 1980 probable well yield map and those on the 1980 saturated thickness map are similar because saturated thickness is the most important variable in determining well yield in the northern High Plains of Colorado. The probable well-yield maps need to be used with caution because there may be areas too small to be mapped that will yield more or less water than that shown on the maps.

Probable well yields range from less than 300 gal/min in much of the western part of the northern High Plains to more than 1,200 gal/min, principally in the northeastern part of the area. Well yields of less than 300 gal/min were likely in about 55 percent of the area in 1980, an increase in area of about 6 percent from predevelopment conditions. Well yields of less than 300 gal/min generally are insufficient for irrigation, but multiple-well systems may yield enough water to irrigate small acreages.

Flood irrigation can be done economically with single-well yields of 300 to 600 gal/min, provided that acreages are selected according to the yields of the wells. Multiple-well systems may be required, however, to operate a quarter-section center-pivot sprinkler (irrigating about 130 acres). Well yields greater than 600 gal/min are sufficient to operate a quarter-section center-pivot sprinkler, and these yields were likely in about 34 percent of the northern High Plains in 1980. Under predevelopment conditions, well yields of more than 600 gal/min were likely in about 39 percent of the northern High Plains. The most extensive area with the largest probable well yields is in northern Yuma and southeastern Phillips Counties. The Ogallala aquifer is unsaturated in parts of Logan and northern Washington Counties. In these areas, the water table is in the underlying White River Formation, and well yields generally are less than 100 gal/min.

In many places in the northern High Plains, such as in east-central Kit Carson County, the 1980 probable well yield is less than the pre-development probable well yield. The decrease in well yield in east-central Kit Carson County is caused by a decline in water levels resulting in a 20- to 30-percent decrease in the saturated thickness of the aquifer. Well yields will continue to decrease in this and other areas as irrigation pumpage continues to dewater the aquifer.

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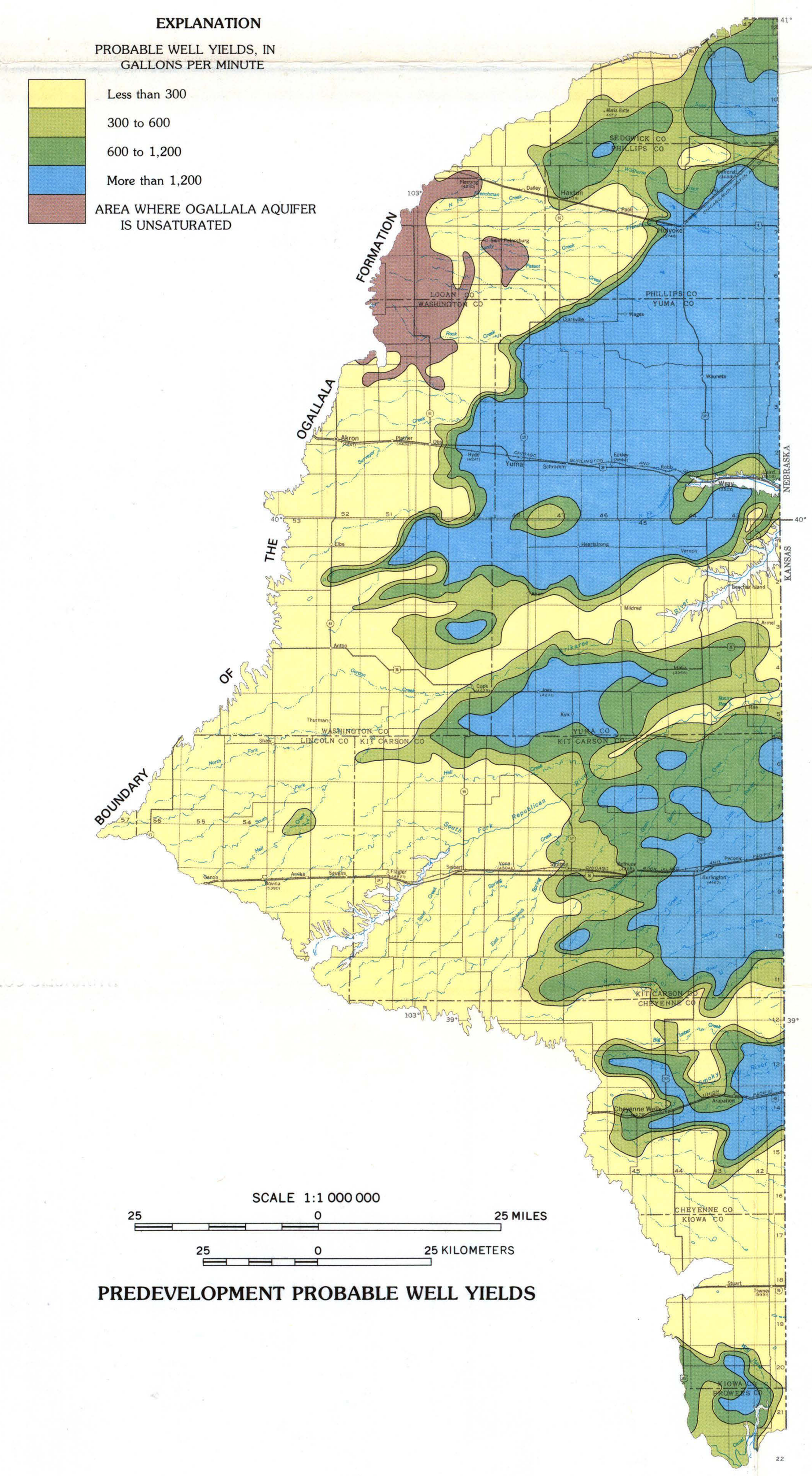
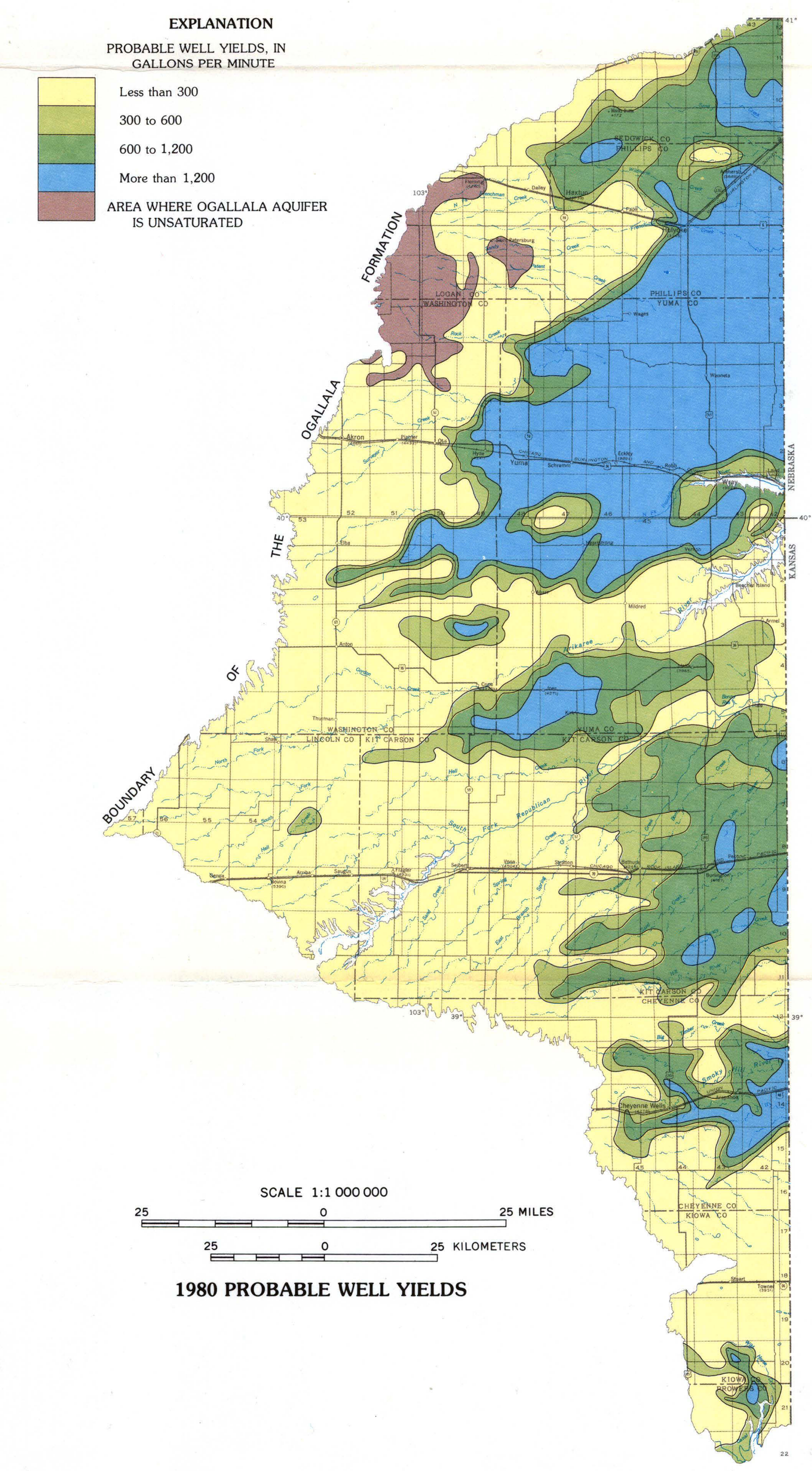


PREDEVELOPMENT PROBABLE WELL YIELDS



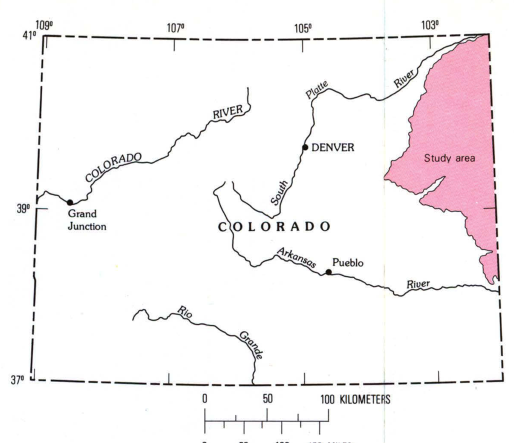
1980 PROBABLE WELL YIELDS

CONVERSION FACTORS

Inch-pound units used in this report may be converted to SI (International System) units by the following conversion factors:

Multiply inch-pound units	By	*To obtain SI units*
inch (in)	0.0254	meter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
acre	0.4047	hectare
square mile (mi^2)	2.590	square kilometer
gallon per minute (gal/min)	0.06309	liter per second
foot per day (ft/d)	0.3048	meter per day

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada. Formerly called mean sea level.



INDEX MAP SHOWING LOCATION OF STUDY AREA

Base from U.S. Geological Survey 1:500 000
State base map, 1969

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1983—W83015

THE OGALLALA AQUIFER IN THE NORTHERN HIGH PLAINS OF COLORADO—SATURATED THICKNESS IN 1980; SATURATED-THICKNESS CHANGES, PREDEVELOPMENT TO 1980; HYDRAULIC CONDUCTIVITY; SPECIFIC YIELD; AND PREDEVELOPMENT AND 1980 PROBABLE WELL YIELDS

By
R. G. Borman, J. B. Lindner, Sean M. Bryn, and John Rutledge

1983

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