LANDSLIDE-HAZARD MAP OF THE LEAVENWORTH, WESTON, AND PLATTE CITY 7.5-MINUTE QUADRANGLES, LEAVENWORTH AND ATCHISON COUNTIES, KANSAS

KANSAS GEOLOGICAL SURVEY
THE UNIVERSITY OF KANSAS
MAP M-109B

2003

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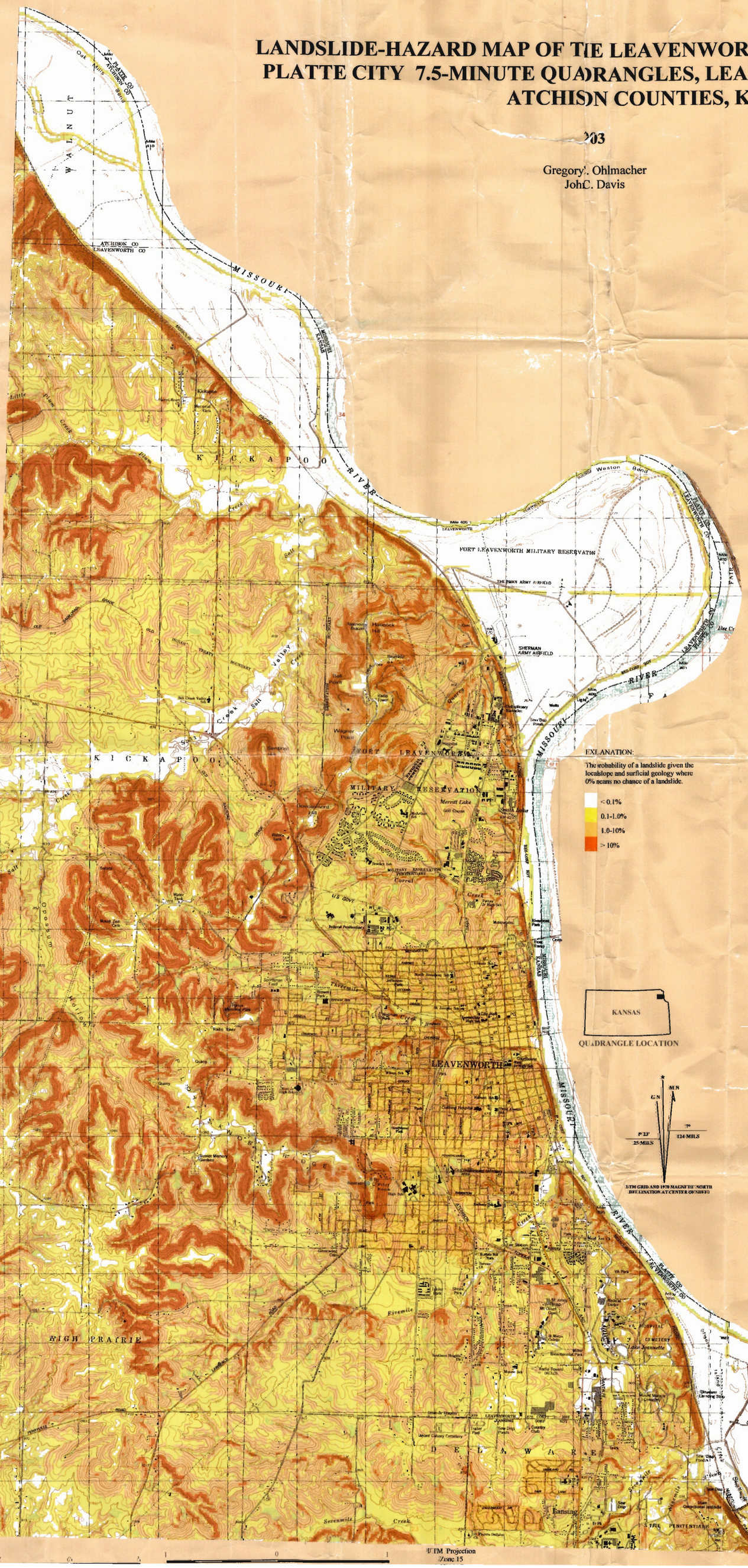

EXPLANATION:

The probability of a landslide given the localslope and surficial geology where 0% means no chance of a landslide.

- < 0.1%
- 0.1-1.0%
- 1.0-10%
- > 10%

QUADRANGLE LOCATION

UTM GRID AND 1978 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

UTM Projection
Zone 15

CONCEPTS

A landslide-hazard map depicts locations where landslides have occurred in the past and where conditions are such that landslides may occur in the future. No recurrence interval could be determined because too few historical dates of past landslides in Kansas exist to estimate an average rate of occurrence. It is assumed that the landslides mapped in the study area occurred after the retreat of the Pleistocene glaciers. Thus, this map depicts the long-term (thousands of years) probabilities of landslide occurrence. Short-term (100-year or 50-year) probabilities will likely have the same distribution but probability values may be lower. In Johnson County, damaging landslides in Leawood (1990), Overland Park (1995), Stanley (1998), and Shawnee (2001) highlight the need for landslide-hazard maps for the Kansas City metropolitan area. In addition to this map, a landslide-inventory map (Ohlmacher, 2003) depicts the distribution of landslide features for the study area.

A landslide is the downslope movement of a mass of soil, rock, and other materials (Cruden, 1991). Landslides in the Leavenworth area are dominantly shallow (confined to the soil and weathered bedrock) earth flows and earth slides. No deep landslides having failure planes that extend into fresh bedrock were found in the Leavenworth area; however, deep landslides have been recognized in Johnson and Riley counties and may be present in the Leavenworth area. Rock falls are landslides involving blocks of rock that drop from cliffs, road cuts, and mine or quarry faces. Areas where rock falls might occur are depicted on the landslide-inventory map (Ohlmacher, 2003). Data on rock falls were not used to create this map.

CAUSES OF LANDSLIDES

Landslides are natural phenomena that occurred in Kansas long before human occupation and that continue to occur today. The basic causes of landslides are gravity, the susceptibility of soil and rock to downslope movement, the relative steepness of the ground slope, and the water content of or ground-water level within the soil and rock. Steeper ground slopes are more prone to landslides. Pore-water pressure acts to decrease the strength of soil and rock and is related to the water content and ground-water level. The pore-water pressure at which landslide movement occurs is highly variable and is influenced by the duration and intensity of recent precipitation, the length of time between the most recent precipitation events, and the amount of residual moisture from preceding precipitation events (Haneberg and Gökce, 1994). In Kansas precipitation is so erratic, both in time and space, that pore-water pressure cannot be mapped in detail even though moisture is an important influence on the mechanical properties of soil and rock.

METHODOLOGY

This study uses a statistical approach called multiple logistic regression to estimate the landslide hazard. This statistical methodology assumes a relationship between locations of past landslides and characteristics of the landscape at these locations. An analogous approach was used to develop a map depicting the spatial landslide probabilities for the Tully Valley, New York (Jäger and Wieczorek, 1994). The distribution of these landscape characteristics can be used to indicate locations where landslides are most likely to occur in the future. In the Leavenworth area, the landscape characteristics that are most indicative of landslides are the steepness of the local ground surface and the types of rock exposed at the surface or just below the soil. The geologic units in the Leavenworth area include shale and limestone bedrock, glacial drift, loess, and alluvium. Details about the statistical methodology are given in Davis and Ohlmacher (2002) and Ohlmacher and Davis (2003).

The Leavenworth map area was subdivided into a grid of square cells, each 10 meters on a side. The slope angle and geologic units within each grid cell were used to estimate a probability of landslide occurrence for the cell. The slope-angle data were derived from a digital elevation model (DEM) that consists of regularly spaced elevations taken at points 30 meters apart. Slope angles were calculated from the data to create a grid of slopes with 30-m cells. The 30-m grid was resampled to create a new grid with 10-m cells. Geologic units were mapped at 1:24,000-scale and published at 1:50,000 scale (McCauley, 1998). A digital version of the geologic map is available at the State of Kansas Geographic Information Systems Initiative's Data Access and Support Center (http://gisdasc.kgs.ku.edu). The geologic map was sampled at 10-m spacing to produce the geologic grid. The final hazard map has 10-m cells; however, the resolution of the map is approximately 30 m, which is the spacing of the DEM data.

Probabilities ranged from zero (certainty that no landslide exists or will occur) to 100% (a landslide is certain to exist or will occur). This range was subdivided into four intervals. The highest interval includes areas where the probability is greater than 10% (greater than 1 chance in 10); these areas consist predominantly of steep bluffs and hilly terrain along the Missouri River and its tributaries, and are shown on the map in red. The next interval, colored orange, includes areas where probability is between 1% and 10% (between 1 chance in 100 and 1 chance in 10). The third interval, colored yellow, includes areas where the probability of occurrence of a landslide is between 0.1% and 1% (between 1 chance in 1,000 and 1 chance in 100). The interval with the lowest probability of occurrence of landslides includes areas where the probability is less than 0.1% (less than 1 chance in 1,000) and is colored white. These areas are relatively flat; however, they may include very small areas where conditions are favorable for landslides, such as along the banks of streams. In addition, modification of the ground slope by grading or erosion, or changes in the flow of surface water as the result of improper grading, can lead to landslides in any interval.

USE OF THIS MAP

The primary purpose of this map is to portray the potential for occurrence of landslides, providing a tool for users such as local government officials, planners, developers, engineers, insurance companies, lending institutions, and landowners to assess the risk and take appropriate actions. The information presented on this map is intended as a guide to potentially hazardous areas and not as a substitute for a detailed engineering study. A map is no better than the data used in its creation. Local variations in slope and geologic materials, not detected in the original data, may mean that at any specific location the hazard may be greater or less than the estimate shown on this map. If the possible occurrence of a landslide is a concern, a site evaluation by a professional engineer or licensed geologist is recommended.

REFERENCES

Cruden, D. M., 1991, A simple definition of a landslide: Bulletin of the International Association of Engineering Geology, v. 43, p. 27-29.

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Haneberg, W. C., and Gökce, A. O., 1994, Rapid water-level fluctuations in a thin colluvium landslide west of Cincinnati: U.S. Geological Survey, Professional Paper 2059-C, 11 p.

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McCauley, J. R., 1998, Geologic map of Leavenworth County, Kansas: Kansas Geological Survey, Map M-53, scale 1:50,000.

Ohlmacher, G. C., 2003, Landslide-inventory map of the Leavenworth, Weston, and Platte City 7.5-minute quadrangles, Leavenworth and Atchison counties, Kansas: Kansas Geological Survey, Map M-109A, scale 1:36,000.

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ROAD CLASSIFICATION

- Primary highway, hard surface
- Secondary highway, hard surface
- Light-duty road, hard or improved surface
- Unimproved road
- Interstate Route
- U.S. Route
- State Route

Map symbols and conventions are those used by the USGS and are explained in the USGS brochure, Topographic Map Symbols, available without charge from the Kansas Geological Survey.