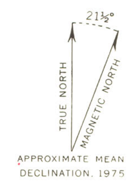
Base from U.S. Geological Survey 1:24,000 Maple Valley, Renton, Des Moines, and Vashon, 1949; Olalla 1953. All photorevised 1968



SCALE 1:48 000

1 ½ 0 1 2 3 MILES

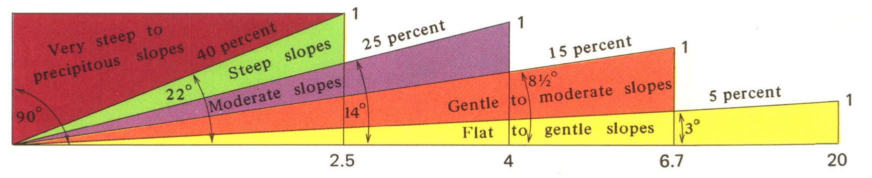
1 .5 0 1 2 3 4 5 KILOMETRES

CONTOUR INTERVAL 25 FEET
(EXCEPT IN WESTERN VASHON ISLAND WHERE THE CONTOUR INTERVAL IS 20 FEET)
DATUM IS MEAN SEA LEVEL

Interior — Geological Survey, Reston, Va. — 1975

Prepared by Western Mapping Center, Topographic Division, U.S. Geological Survey by photomechanical methods, 1973

SLOPE CATEGORIES EXPRESSED AS PERCENTAGES, DEGREES, AND RATIOS



Text by
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INTRODUCTION

Information about natural slopes of the land surface is necessary for land-use decisions that involve engineering design and cost analysis as well as for comprehensive planning and land-use regulation. This map was prepared using a recently developed, rapid photomechanical process from topographic base maps. This report describes some uses of such maps, methods of map preparation, and some limitations on map use. The map was used by Miller (1973) in interpreting slope stability of the area and is one of a series being prepared in cooperation with several agencies to present basic information and interpretations of an environmental nature to assist land-use planning, resource development, and environmental protection in parts of the Puget Sound basin. We hope that users of this map will comment on its usefulness for their purposes and offer suggestions for its improvement.

SOME POSSIBLE ENGINEERING AND PLANNING APPLICATIONS

The slope categories mapped—0-5 percent, 5-15 percent, 15-25 percent, 25–40 percent, and greater than 40 percent—were selected by the King County Department of Budget and Program Planning to satisfy the greatest number of expected requirements. Delineation of slopes into categories greater and less than 15 percent was needed for preparation of a slope-stability map of the area because slopes steeper than 15 percent tend to become more unstable (Miller, 1973).

Engineering applications of slope maps include: (1) designing excavation walls in uncemented granular deposits, most of which have a natural angle of repose between 40 and 70 percent; (2) rapid estimation of generalized earthmoving requirements for large construction projects such as highways and airfields. For accurate estimates of project costs, detailed slope studies must be made of each site.

Knowledge of land slopes is important in many phases of the planning process. For example, some jurisdictions prohibit all residential development on slopes greater than 50 percent; others prohibit road construction on slopes greater than 70 percent, limiting some activities such as logging. (The steepest street in Seattle has a 26-percent slope.) In addition, local ordinances are commonly related to slopes; for example, grading codes are commonly invoked where slopes exceed certain limits, health codes may prohibit septic drain fields in materials that have slopes greater than specified amounts, and placement of sewer and water lines in areas of excessive slopes often becomes impracticable without pumping stations.

From a planning standpoint, areas of steep slope may (a) limit and define urban areas, (b) provide linear open spaces for park and trail uses, and (c) serve as a buffer between incompatible uses. To assist in maintaining these attributes, as well as to lower disaster risk and reduce construction and maintenance costs for public facilities, it is necessary to identify the steep slopes to provide objective standards and criteria for regulation of development on them.

The comprehensive plan for King County, Washington (as augmented by the steep-slopes section) (King County Department of Budget and Program Planning, 1973) states that, "Rarely are slopes over 40 percent built on, and most sources recommend against any development on slopes over 25 percent unless it is highly regulated and engineered and of very low density" (Meshenberg, 1970). The plan defines certain slopes in terms of criteria for open space:

(1) "Preserve in open space those slopes and ravines over 40% slope;"
(2) "preserve in open space uses, to the greatest extent feasible . . . steep slope and ravine areas . . . that are moderately hazardous or unsuitable for development . . . where slope is from 25-40 %. . . "
(3) "Retain low-density uses or apply appropriate development controls on those lands . . . with a slope of from 16%-25%." (King County Department of Budget and Program Planning, 1973, p. 15-17.)

METHODS OF PREPARATION

The slope map was prepared by a photomechanical process from 1:48,000-scale topographic maps (reduced from 1:24,000 scale) of the Maple Valley, Renton, Des Moines, Vashon, and a small part of the Olalla quadrangles. The base maps were published with 25-foot contours by the U.S. Geological Survey in 1949 except for the Olalla quadrangle, which was published in 1953 with a 20-foot contour interval.

In the photomechanical process, distance (spacing) between the centerline of adjacent contours is measured to determine slope. This is accomplished by manipulating contour-line weights (widths). For example, on the Olalla base map, where 1 inch equals 2,000 feet (0.1 in. = 20 ft), contour lines with a 20-foot interval spaced every 0.04 inch would represent a slope of 25 percent (equivalent to a 20-ft difference in elevation in a horizontal distance of 80 ft). Likewise, on the same map, where lines are spaced every 0.2 inch, a slope of 5 percent is indicated. This relationship is characterized by the formula:

$$D = \frac{100\,I}{PS}$$

Where D = Distance between contours in inches
I = Contour interval in feet
P = Percent slope
S = Scale of map in feet per inch.

Rather than manually scaling the contour spacing throughout the map area, the contour lines (originally about 0.004 in. wide) were photographically widened, or "fattened," to 0.04 inch. In all areas where the centerlines were originally 0.04 inch apart or closer, adjacent lines then touched or overlapped. This yielded a map with wide contours plus black areas of merged contours representing a slope of 25 percent or more. Subsequently, the image was photographically narrowed, or "slenderized," so that the contours disappeared, leaving only the areas having slopes of 25 percent and more. Using the same technique, but a different amount of "fattening," separate plates were made to depict the upper limit of each slope category. Each plate was printed in color and combined to print the final map.

LIMITATIONS ON MAP USE

This slope map has not been rigorously tested to determine the precision with which the slope category boundaries are located and the accuracy with which each category represents the range of slopes assigned to it. However, it is very similar to a slope map carefully prepared manually of a smaller part of western King County and is a good general representation of the relative steepness of the terrain. It also expresses considerable detail by showing small flat areas within steep areas and even some very short steep slopes in areas of more gentle slopes.

Because this map has been derived from contour maps, it cannot be more accurate than the contour maps from which it is made. In this area, the land surface has been greatly modified over the past 25 years, and the contours (and slopes) from the base maps do not reflect these changes. In addition, certain inherent "artifacts" (false representations of categories) are formed as a result of the process itself, caused by such things as variations in the weight of contour lines. Moreover, the method does not distinguish adjacent contour lines of different altitude from adjacent lines representing the same altitude, so that apparent steep slopes for some gully bottoms and ridge crests need careful interpretation. To minimize these anomalies, the map was edited manually to eliminate a few exceedingly small areas of apparent artifacts and to remove many obvious anomalies, such as along dikes where contour lines on each side were so close as to produce a false slope pattern. The amount and type of editing that may be required for maps prepared by this method depends on how slope maps are to be used, the background of the user, the character of the terrain, the amount of generalization desired, and the scale of the interpretive product.

The precision of the map also varies with the steepness of the terrain because, with increasing slope, contour line width becomes an increasing proportion of the line spacing. Thus, the precision with which the boundaries of steep slope categories are located is considerably less than that for the gentler slope intervals. Many of these same problems are also present in slope maps that are prepared manually.

In spite of the problems created by the "artifacts" and the variable precision of the limiting values, maps prepared by photomechanical methods are generally excellent and of great value. However, the user should be aware of some of the inherent problems so that he will (a) be able to recognize and evaluate the artifacts by examining the contours on the base map, (b) not be tempted to use the slope categories alone as a means for evaluating slope conditions at a single site (any more than he would use the contour map alone) but will use it as a guide to areas where additional detailed surveys should be made, and (c) not be tempted to enlarge the map to a more detailed scale and use it uncritically as a basis for detailed grading plans.

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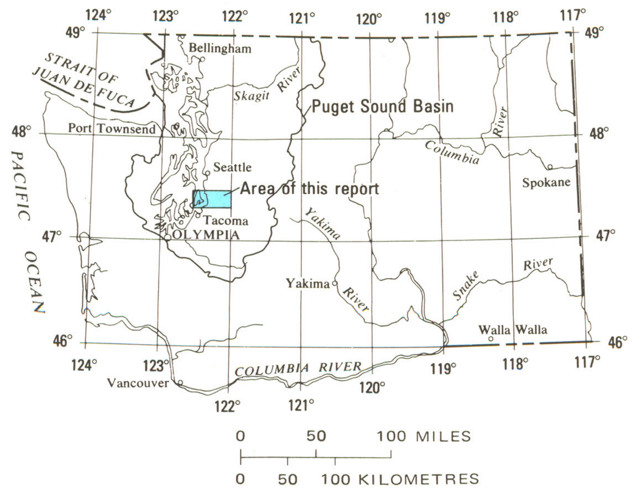

INDEX MAP OF WASHINGTON

SLOPE MAP OF PART OF WEST-CENTRAL KING COUNTY, WASHINGTON

By

U.S. Geological Survey

1975

For sale by U.S. Geological Survey, Denver, Colo. 80225 and Reston, Va. 22092, price $.75