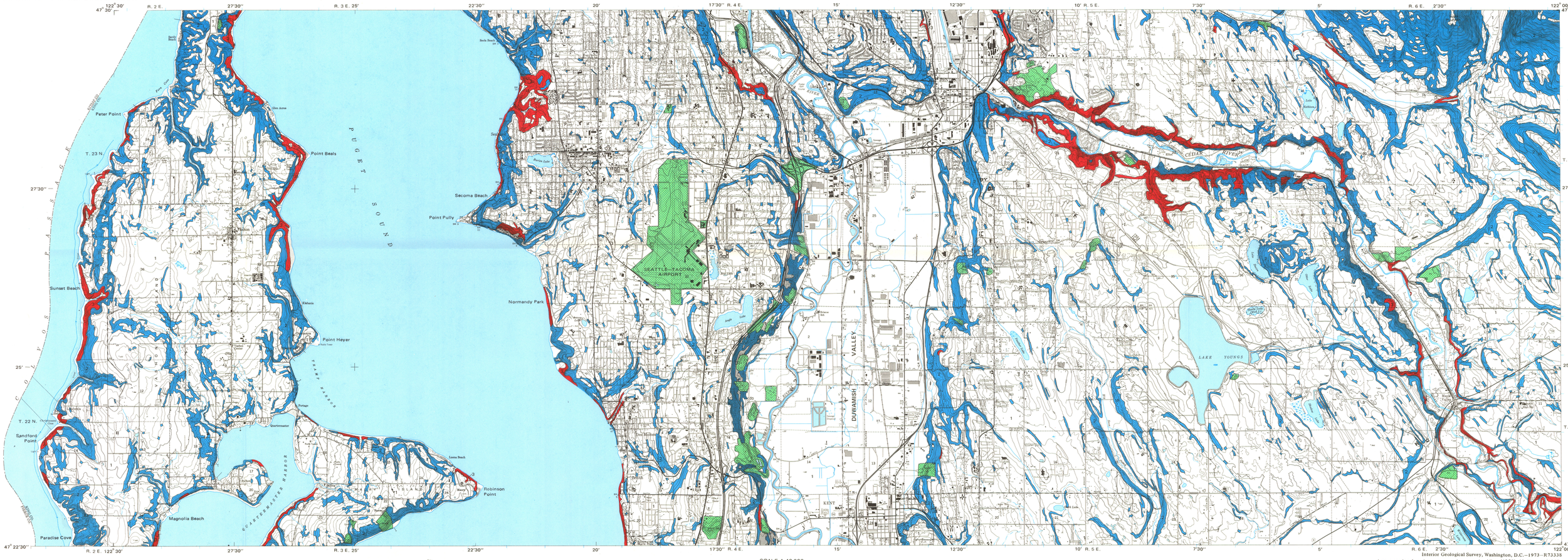

Base from U.S. Geological Survey, 1949 and 1953
Photorevision as of 1968

APPROXIMATE MEAN DECLINATION, 1973

SCALE 1:48 000

1 ½ 0 1 2 3 MILES

1 .5 0 1 2 3 4 5 KILOMETERS

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

Interior Geological Survey, Washington, D.C.—1973—R73338

Interpretation based on maps and reports by Vine (1962), Mullineaux (1965, 1970), Waldron (1962), Molenaar (1965), Luzier (1969), and discussions in 1973 with E. R. Artim and G. W. Thorsen, Washington Dept. Natural Resources; D. W. Tubbs, Univ. of Washington; D. R. Mullineaux and H. H. Waldron, U.S. Geol. Survey.

EXPLANATION

1

Class 1

Slopes stable even where modified by man. Slopes low, generally lower than 15%.

2

Class 2

Slopes normally stable, but may become unstable due to man's activities. Slopes moderate, generally steeper than 15%. Not underlain by clay beds, but may include ancient inactive landslides.

3

Class 3

Slopes readily become unstable due to natural events and to man's activities. Slopes moderate to steep, generally steeper than 15% and in places steeper than 40%. Probably underlain by tight silt or clay beds.

Modified land

Slopes not classified. Large excavations and fills made after the topographic map was prepared, so that map contours cannot be used to classify slope stability.

Old landslide deposits

A single deposit may include areas of different slope stability classes. Apparently stable now, but stability could change with changes in climate or slope.

PURPOSE

This map classifies part of west-central King County, Washington into areas of differing relative slope stability. Slope stability is a variable natural condition that may pose problems and should be evaluated before land use is changed. Knowledge of the distribution of areas of differing slope stability can help land planners and decision makers. Urbanization engulfs areas of different natural characteristics; failure to identify areas having potential problems can result in physical or financial difficulty.

This part of the Puget Sound lowland is separated into three classes of stability: terrain virtually free of stability problems (class 1), terrain almost certain to be susceptible to such problems (class 3), and terrain that is stable under natural conditions, but which may become unstable owing to man's activities, and which should be examined in detail before changes in land use are adopted (class 2).

The boundaries shown on the map are arbitrary lines based on available information. Areas of different classes too small to identify at this map scale, or changes in steepness of slope confined to the zone between contours so that these changes do not show on the map, are included within each classified area.

The map was compiled from data collected by others (see references). Their work and published descriptions of slope failures in the Seattle area has indicated that the presence or absence of tight silt or clay beds beneath sand beds is a principal geologic criterion for potential slope instability.

The selection of 15% slopes to separate classes 1 and 2 is also based on recorded experience of others.

The validity of this three-fold slope-stability classification has been checked briefly in the field.

DESCRIPTION OF SLOPE STABILITY CLASSES

In this report, slope stability refers to the resistance to gravitational forces of earth materials underlying an inclined surface; instability results in outward and downward movement of these underlying materials.

Class 1: characterized by slopes less than 15%, and by near-surface materials that probably do not include silty or clayey beds. Includes some hard glacial drift on gently rolling uplands. Slopes tend to be stable unless deeply excavated; subsequent instability generally is confined to excavation walls or embankments of artificial fill.

Class 2: characterized by slopes that are steeper than 15% and by absence of silty or clayey beds near the surface. Includes some hard glacial drift that generally forms steep slopes along bluffs and ravines, and caps small hills and ridges within the upland. Tends to be stable under natural conditions.

Class 3: characterized by slopes steeper than 15% and by silty or clayey beds near the surface, beneath sand. Includes glacial drift that generally forms steep slopes along bluffs and ravines. Although most slopes in class 3 are stable, all are believed to be potentially unstable and ready to slide from sufficient natural or man-made causes.

LANDSLIDES AND SLOPE INSTABILITY

The material that moves as a result of instability is a landslide. The general term landslide is applied here to (1) earthflows, (2) debris flows, and (3) slumps. Of these, earthflows are the most widespread (fig. 1) and debris flows (fig. 2) the next most common form in this part of the Puget Sound lowland. Landslides in this area generally have a complex origin. Masses that start as slides of coherent blocks break up into flows of deformed materials as they move downslope.

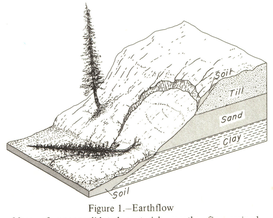

Figure 1.—Earthflow

Mass of unconsolidated material, mostly fine-grained. Rate of movement dependent on water content; the greater the water content, the faster the movement. Tilted trees are indicative of past movement.

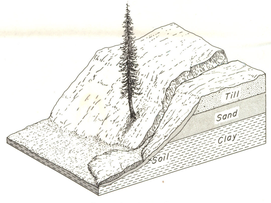

Figure 2.—Debris flow

Mass of unconsolidated material, fine- to coarse-grained. Generally moves rapidly, having an excess of water. Usually caused by heavy rainfall.

Earthflows are found along many class 3 slopes. The flows generally are less than 50 feet wide, and rarely cover more than 1 acre. They occur most commonly in the soil and slope debris overlying glacial deposits, but locally they also involve the glacial deposits. Earthflows also occur in thin soil and debris mantling hard rock.

Because earthflows are generally small, their areas of damage are restricted. They can engulf small buildings or partially bury or impinge upon larger structures, obstruct transportation routes, block drainageways, and disrupt surface or subsurface utilities.

Debris flows (also called mudflows) are less common but more noticeable than earthflows. They typically follow narrow ravines that extend into the uplands; streams of debris may flow from these drainageways and come to rest on flatter surfaces below the bluffs, as along Cedar River valley where old debris-flow deposits form an apron.

Debris flows can crush walls of residential structures, dislodge buildings from their foundations, enter and fill structures to depths of several feet or more, obstruct transportation routes, and disrupt surface and subsurface utilities.

A slump (fig. 3) is a form of landslide whose movement takes places along deep internal slip surfaces. The scarp at the head of the slump may be almost vertical, and forms a recognizable land feature.

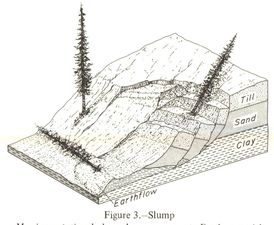

Figure 3.—Slump

Massive rotational downslope movement. Earth materials commonly remain relatively undeformed, but material in lower part may be severely broken and may advance as an earthflow.

Slump deposits probably account for most of the uneven terrain mapped as landslide deposits. One large slump lies along the south side of the Cedar River valley about 1 mile east of Renton, and another along Puget Sound about 1 mile southeast of Point Pully.

Some large slumps and earthflows were activated along the west side of the Duwamish Valley during construction of the Seattle Freeway, during relocation of other roads, and during excavations for sand and gravel. The earth materials along this valley wall consist of several types of glacial deposits. It is likely that the initial landslides here took place as the glacial ice melted and permitted the sands and gravels to collapse; recent modification by man helped activate the present landslides. The likelihood of naturally occurring, large-scale slump movement becoming a problem under present climatic conditions is remote.

Soil creep (fig. 4). Class 3 slopes are particularly susceptible to creep. Field examination is required to locate specific creep areas. Because soil creep can affect small surface structures or shallow underground utilities, it should be considered during detailed investigations on any site. The presence of creep can serve as a warning of potentially more serious ground movement if massive land modifications are undertaken.

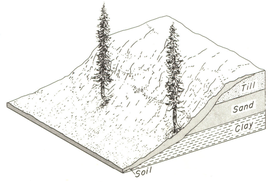

Figure 4.—Soil creep

Uppermost soil and debris material moves imperceptibly downslope

SOME POSSIBLE IMPLICATIONS TO LAND USE

Slopes potentially most troublesome to land use are those classified as 2 and 3. Landslides are an especially common risk in class 3 areas. Costly construction, such as large-scale excavation and removal of unstable ground, installation of drains, and special foundations may be necessary to insure stability. Some alternative land uses include open space for greenbelts, refuges for wildlife, park land, golf courses, and hiking trails.

In class 2 areas, minor changes made by man may or may not affect slope stability. The apparent stability of class 2 slopes can be deceptive; their potential instability might be obscured and the necessity for special regulation of land developments might not be apparent.

Land areas of class 1 generally should pose few stability problems during land development. Uncontrolled construction activities, however, can convert stable slopes into unstable ones.

UNDERSTANDING SLOPE STABILITY

Stability of slopes is influenced by two general kinds of conditions: constant and changing. The constant factors, such as the general steepness of the land surface and the types and interrelation of geologic materials, tend to determine the location of slope instability. Changing factors, such as erosion, man's activities, and addition of moisture tend to determine the timing and frequency of landslides. Of these changing factors, the addition of excess moisture, most commonly by rainfall, is probably the most crucial in the Puget Sound region. As a result, most landslides occur during the rainy season.

Geologic conditions may strongly influence relative stability on slopes of similar steepness. Most of the geologic materials in the map area are flat-lying and relatively weak glacial or alluvial deposits. The composition and physical characteristics of such deposits vary greatly, both laterally and vertically. Of particular importance is the occurrence of relatively impermeable materials, such as tight silt or clay, beneath or within more permeable materials, such as sand or gravel (figs. 1-4). Water moving through earth materials can saturate those which are permeable (sand or gravel) and is impeded by beds which are impermeable (silt or clay). The result may be to cause springs to flow from a hillside near the contact between the sand and clay, or to saturate the thin overlying soil materials that blanket the slopes, or to saturate the sand above the silt or clay; such saturation may cause the materials to lose cohesion and move downslope.

Other kinds of geologic materials also are important to the stability of a slope. Hard rock forms steep, normally stable slopes along some of the bluffs bounding mainland stream valleys; it also forms slopes of variable steepness in the mountains in the eastern part of the mapped area. In most places, slopes on hard rocks are stable. However, soil and slope debris overlying the rock may be unstable. Commonly, the thin soil and debris are highly permeable but the underlying rock is not. When saturated, the soil and debris move downward and the surface of the rock acts as a slip surface.

Two aspects of slope stability are not evaluated on this map. No attempt is made to determine or depict the effect of landslide debris encroaching upon flat, stable surfaces from unstable slopes uphill; sites along the base of class 3 slopes should be evaluated for this potential risk. Also, no assessment is made of the stability of man-made cuts and fills.

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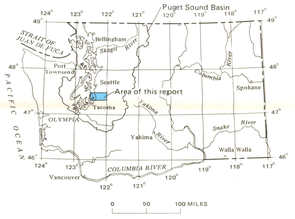

INDEX MAP OF WASHINGTON

MAP SHOWING RELATIVE SLOPE STABILITY IN PART OF WEST–CENTRAL KING COUNTY, WASHINGTON

Compiled by
Robert D. Miller
1973

For sale by U.S. Geological Survey, price 75 cents