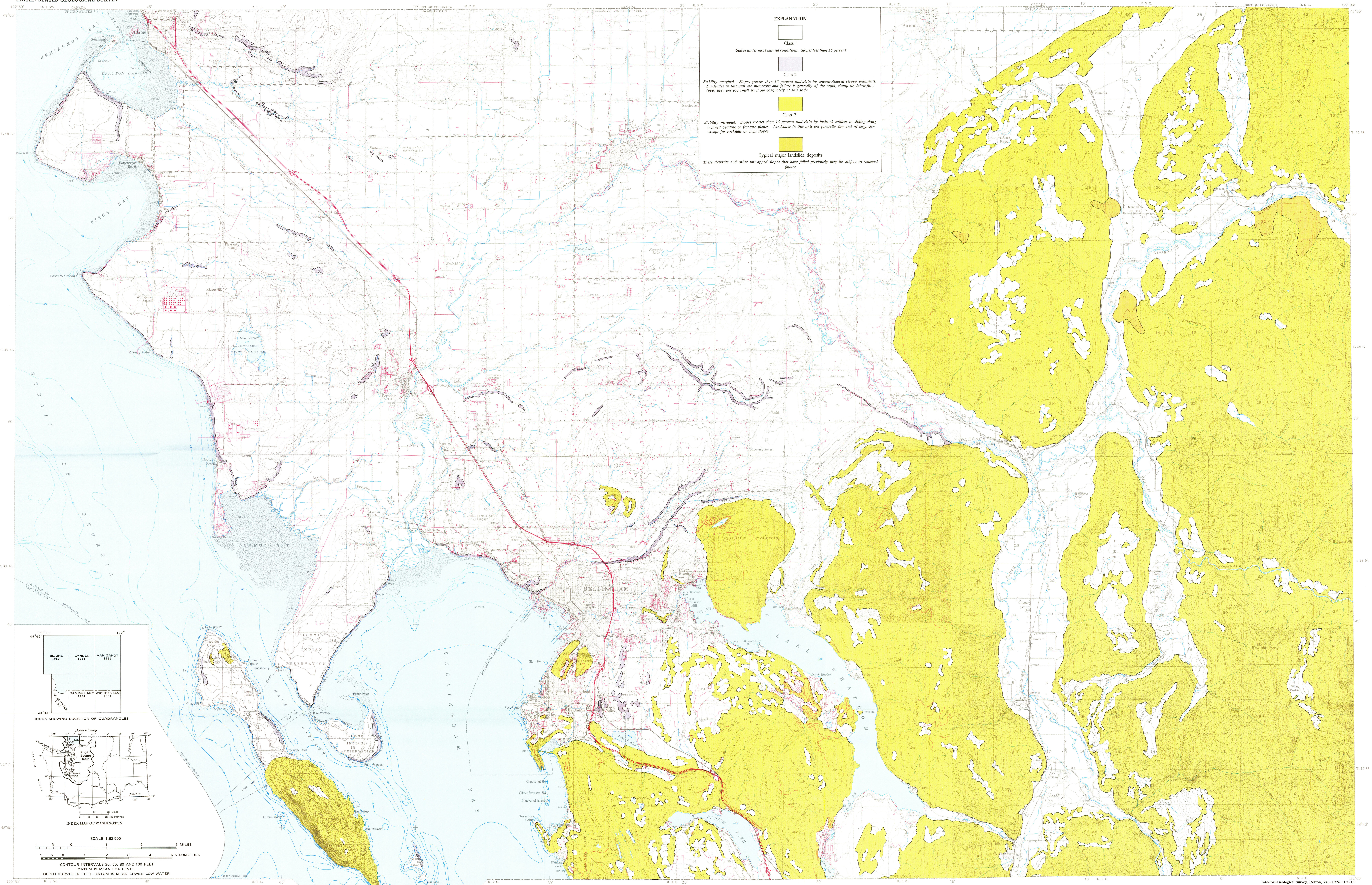
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

FOLIO OF WHATCOM COUNTY, WASHINGTON
MAP I-854-C



Base from U.S. Geological Survey Anacortes, 1951;
Van Zandt and Wickersham, 1951; Blaine, 1952;
Lynden and Samish Lake, 1954
Photorevisions as of 1973, shown in red, from
aerial photographs taken in 1972

Interior—Geological Survey, Reston, Va.—1976

MAP SHOWING SLOPE STABILITY IN WESTERN WHATCOM COUNTY, WASHINGTON

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INTRODUCTION

Landslides pose a significant hazard to the public in parts of western Whatcom County because they usually occur without warning, are seldom recognized in advance, and may be triggered by any one of several causes. Although geologists experienced in analysis of surface geologic processes generally can recognize potentially hazardous areas and can provide information regarding slope stability, planners and the general public usually have few means of anticipating slope failures that might have costly consequences. This map is intended to aid planners and the public in recognizing areas of possible instability; it is not intended, nor should it be used, to assess the stability of individual sites.

This map is one of a series being prepared by the U.S. Department of the Interior in cooperation with several agencies to present basic environmental information and interpretations to assist land-use planning in the Puget Sound area.

TYPES OF LANDSLIDES IN WHATCOM COUNTY

Slope failures in western Whatcom County are generally one of three general types—rockfalls, debris flows, and slumps: *Rockfalls* consist of pieces and blocks of rock that suddenly break away from bedrock masses and fall, tumble, or slide to the slopes below (fig. 1). Many blocks may be large, and where their movement is rapid, they generate considerable energy and land with great impact. The frequency of rockfalls in any given area depends largely on the steepness of the surface slope and the physical characteristics of the rock. Rocks that weather mechanically into discrete blocks provide a ready source of debris, and where they also stand in steep cliffs, rockfalls may occur frequently. These conditions are particularly common to areas in the Cascade foothills of western Whatcom County underlain by the Chuckanut Formation, in which failure may be initiated along inclined bedding and fracture planes that intersect steep slopes.

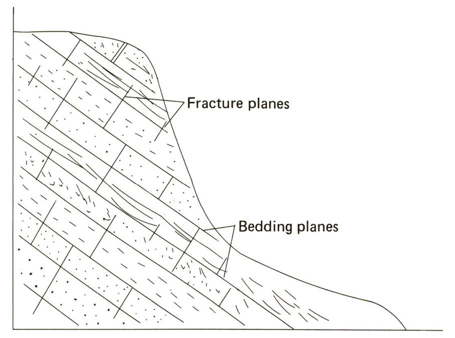

Figure 1.—Rockfall

Debris flows occur where saturated unconsolidated material flows downslope as an incoherent mass and result in an irregular hummocky deposit (fig. 2). Debris-flow deposits differ from rockfall deposits in that any coarse fragments present are generally incorporated in a matrix of finer grained materials. Some debris flows have a composite origin; they can start as large rockfalls high on slopes and, as the blocks break up during downslope movement, the rock debris is incorporated with finer grained material and water, whereupon the movement changes from freefall to flowage.

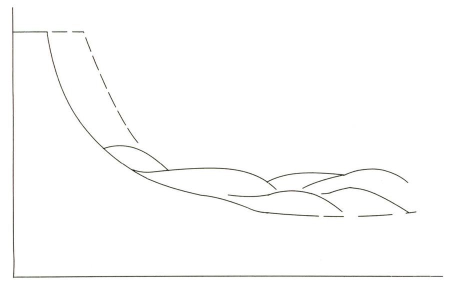

Figure 2.—Debris flow

Slumps develop from the downward and outward movement of masses of weak rock or unconsolidated material along one or more curved, concave-upward shear planes, usually with some backward rotation of the sliding blocks (fig. 3). Flowage may take place at the base of the slump, causing a bulge of moving debris at the toe. Areas of former slumps are often potentially hazardous because of possible renewed movement along the already developed shear planes. In places, such areas can be recognized by one or more of the following features: (1) parallel fissures or cracks in the ground, (2) scarps near the top of a slope, usually concave downslope, (3) marshy areas or ponds of water against scarps, (4) backward rotated blocks of ground, and (5) irregular or hummocky bulges in the ground near the base of a slope.

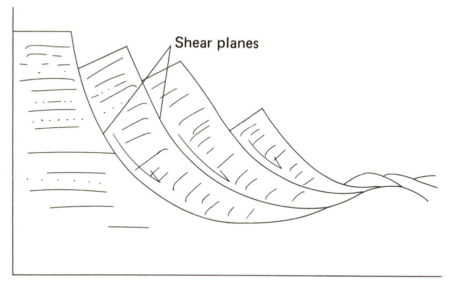

Figure 3.—Slump

COMMON CAUSES OF LANDSLIDES

Causes of landslides can be many and often are not known until after a slide occurs and it is too late to take preventive action. All landslides develop where shear forces in a mass, primarily caused by the downward pull of gravity, exceed the cohesion of the material or its frictional resistance to movement. A stable slope is one in which the shear forces are less than the strength of the material making up the slope. An unstable slope is one in which the shear forces exceed or equal the cohesion of the underlying materials. Stable slopes can be made unstable by external forces that produce an increase in shear stress along potential surfaces of sliding or by internal forces that reduce the strength of cohesion in the material.

Examples of conditions that increase external forces acting on slopes are: (1) oversteepening by roadcut excavations, or undercutting along the base of a sea cliff or a streambank by water erosion, (2) overloading by artificial fill or heavy structures, and (3) shaking from strong earthquake ground motion. Some internal conditions that reduce the strength of materials are: (1) saturation of pore spaces in earth materials and an increase in water pressure that tends to push grains apart and cause loss of cohesion, and (2) liquefaction of certain types of sediment by shaking.

Among the methods commonly used to prevent slope failure are: (1) reduction of the slope angle, (2) increase of the resistance to movement by loading or bulkheading the base of slopes, (3) reduction of the soil moisture by draining subsurface water or by diversion of surface drainage, and (4) removal of all weak or unstable material.

Steep slopes composed of materials that are stable under most natural conditions may become unstable if shaken by an earthquake. Natural slope stability also may be sharply reduced by actions of man. Surface runoff and saturation of near-surface layers is increased where vegetation has been cleared for logging, roadbuilding, or real estate development, and where septic-tank drainage or watering of lawns concentrate moisture. Slopes are often oversteepened or overloaded by road and housing construction. Thus site investigations should be made of steep individual slopes before development.

SLOPE STABILITY MAP

The map classifies slope stability on the basis of slope angle and the nature of underlying materials.

Class 1 areas are those areas underlain by all types of earth materials with slopes less than 15 percent; they are stable under most natural conditions. Because these areas include some weak earth materials that may become unstable when oversteepened, excavations in them should be carefully designed. Local areas of instability may occur where slopes greater than 15 percent are present but are too small to detect at the map scale. While not unstable themselves, class 1 areas immediately downslope from class 2, 3, and 4 areas could be endangered by failures in slopes above them.

Class 2 areas are those areas underlain by weak, fine-grained, unconsolidated sediments with slopes greater than 15 percent. Most of these sediments consist of pebbly silt and clay of the Bellingham Drift, which has rather low strength, especially when wet. The most hazardous areas occur at the base of steep bluffs along sea cliffs and stream valleys. Slump failures and debris flows are common in such areas, particularly in the fall and winter wet seasons when the silty clay becomes saturated. Geologic and engineering investigations should be made prior to modification of natural slopes or construction in order to assess the potential hazard and to incorporate in design measures to insure stability.

Class 3 areas are those areas underlain by bedrock with slopes generally greater than 15 percent. Although the rock itself may appear to be strong, the slope of bedding and fracture planes within the rock determines the true stability of the slopes. Slopes in which bedding or fracture planes dip downward toward an open slope are particularly susceptible to failure. Much of the area in the Cascade foothills of the southern and eastern part of the county is underlain by the Chuckanut Formation which has abundant fracture and inclined bedding planes that transect steep slopes. These areas are potentially hazardous and have produced most of the larger landslides in Whatcom County, several of which are shown on the map. Large parts of Class 3 areas are underlain by bedrock that dips away from open slopes and are quite stable. However, because of the large size of many landslides and the difficulty of controlling them, construction projects in Class 3 areas should be preceded by careful geologic studies to attempt, wherever possible, to avoid sites of greatest potential danger.

Landslide deposits. Only a few large landslides are shown to illustrate the size and topographic setting of these features; numerous small rockfall, slump, and debris-flow deposits occur along sea cliffs, river valleys, and mountain slopes but were not mapped. Construction on landslide deposits that may still be unstable should be discouraged or should proceed only after geologic and engineering studies have demonstrated the future stability of a prospective site.

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