U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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Map showing the distribution of debris flows
during the New Year's Eve storm of 1987-1988
in southeastern Oahu, Hawaii

By
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This map shows the distribution of debris flows triggered by intense rainfall during the New Year's Eve storm of 1987-1988, which began on the evening of December 31, 1987, and continued through the early morning of January 1, 1988 (State of Hawaii, 1988; FEMA, 1988). Almost all the mapped debris flows began on steep hillslopes as landslides (Fig. 1). The sliding masses of earth, rock, and vegetation changed at least in part to slurries of mud and debris that generally were fluid enough to flow down hillslopes and channels (for further description of debris flows see Campbell, 1975; Varnes, 1978; Costa and Wieczorek, 1987; Ellen and Wieczorek, 1988). Most of the debris flows came to rest before reaching the residential developments in valley bottoms, but several overflowed debris catch basins and diversion ditches and damaged inhabited areas. Many of the debris flows introduced large amounts of coarse sediment to flooding streams, and this sediment added to the storm's damage, in large part by blocking drainage structures and thereby diverting flood waters.

Within the map area we recognized and mapped approximately 400 landslides. In almost all cases, the landslides were less than about 6 feet thick and involved mostly the soil cover and vegetation. These shallow landslides typically measured several tens of feet in width and length, and involved volumes of up to a few hundred cubic yards of earth material, but the largest ones involved as much as 1500 cubic yards of material. Approximately 80 percent of these landslides produced debris flows that left mappable travel paths, and at least 20 percent of these contributed sediment directly to major stream channels (those shown as blue lines on the U.S. Geological Survey Koko Head 7.5' quadrangle).

The storm triggered one exceptionally large landslide near the head of Kupaua Valley. This landslide measured approximately 150 feet wide, 300 feet long, and 60 feet deep, and involved about 45,000 cubic yards of material, mostly weathered bedrock. It split around a small ridge during its steep descent into Kupaua Stream, then flowed about 2 miles down the flooding stream channel into developed parts of Niu Valley.

Map Preparation

This map was compiled largely by stereoscopic examination of aerial photographs taken after the storm. The principal photographs were flown in 1988 for the U.S. Geological Survey by R.M. Towill, Inc. (flights 8534, 8540, and 8553). These black-and-white photographs are at scales of 1:12,400 to 1:15,000. Initial coverage was on March 25, 1988, several months after the storm, but some areas obscured by clouds required reflights on April 13 and July 6 of that year. A second set of photographs was used to provide an additional look at this steep landscape from different vantage points. These natural-color photographs were flown by Air Survey Hawaii on February 24, 1989, at a scale of 1:36,000 (project 1311: flight line 8A, frames 7-11; flight line 9, frames 4, 5).

All features recognized in the photographs were plotted by hand on the U.S. Geological Survey Koko Head 7.5' quadrangle. Some features from the 1988 photographs were plotted more accurately using a Kern PG2 stereoplotter. That mapping, illustrated in figure 1, was used principally to define the margins of major debris-flow paths.

Mapping from the aerial photographs was supplemented and checked by limited field observations during the period 1988 to 1990. The approximate downchannel limits of debris flow in the major drainages were determined by field observation during March 1988.

Limitations of the Map

During this storm, damage was produced by several distinct processes, including flooding, slow-moving large landslides, and debris flows (State of Hawaii, 1988; FEMA, 1988). The map shows only features produced by debris flows, and it shows these only in the area of their greatest impact. Debris flows occurred in lesser abundance in areas of Oahu beyond the limits of the map.

Recognition of debris-flow features on the photographs was hindered in many places by dense vegetation, and in some places by cloud cover and by shadows near steep parts of the landscape. Consequently, the map portrays the majority of debris-flow features produced by the storm, but some features undoubtedly are shown incompletely or not at all. The 1989 photographs helped fill in these gaps, but their usefulness was diminished by the 14 months that had elapsed since the storm. Features mapped from these 1989 photographs might include debris flows prior to the storm (because the freshness that linked debris-flow features to the storm had by then disappeared), as well as debris flows after the storm. Features from the 1989 photographs are distinguished on the map because their relation to the New Year's Eve storm is less certain.

Use of the Map

By documenting the debris flows produced by the New Year's Eve storm, the map serves as an example of the distribution of debris flows that might be expected in future intense storms. Field observations and examination of historical aerial photographs indicate that debris flows of this type have long been a naturally occurring process in Oahu, a process in which successive storm events tend to initiate debris flows at different locations in steep parts of the landscape. Certain hillslopes may produce uncommonly abundant debris flows for decades or even centuries, but in the long term most of the steep landscape probably produces debris flows. As a consequence, future intense storms can be expected to produce debris flows that are similar to those mapped here but that originate largely from new sources. The distribution of these sources will be determined by the interaction of each storm with the landscape. By illustrating the results of one such storm-landscape interaction, this map serves to portray the likely nature of future events.

References Cited

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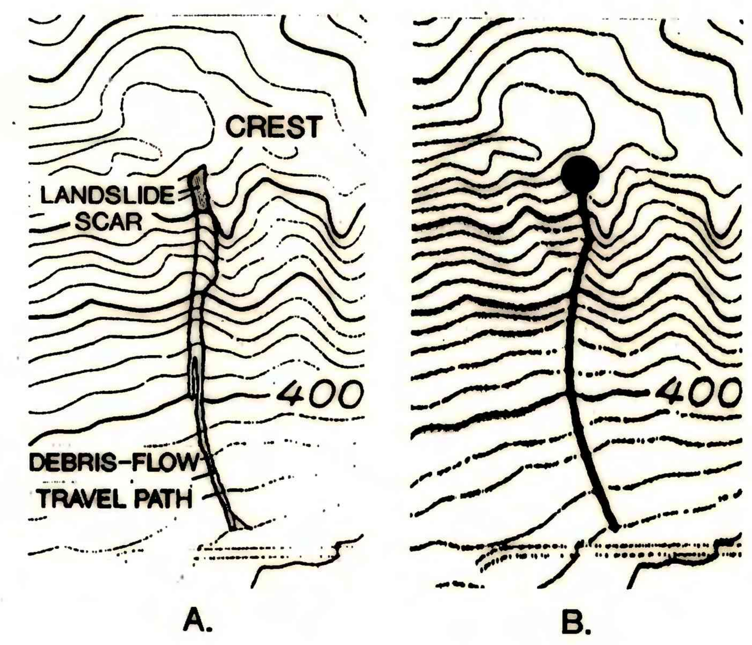
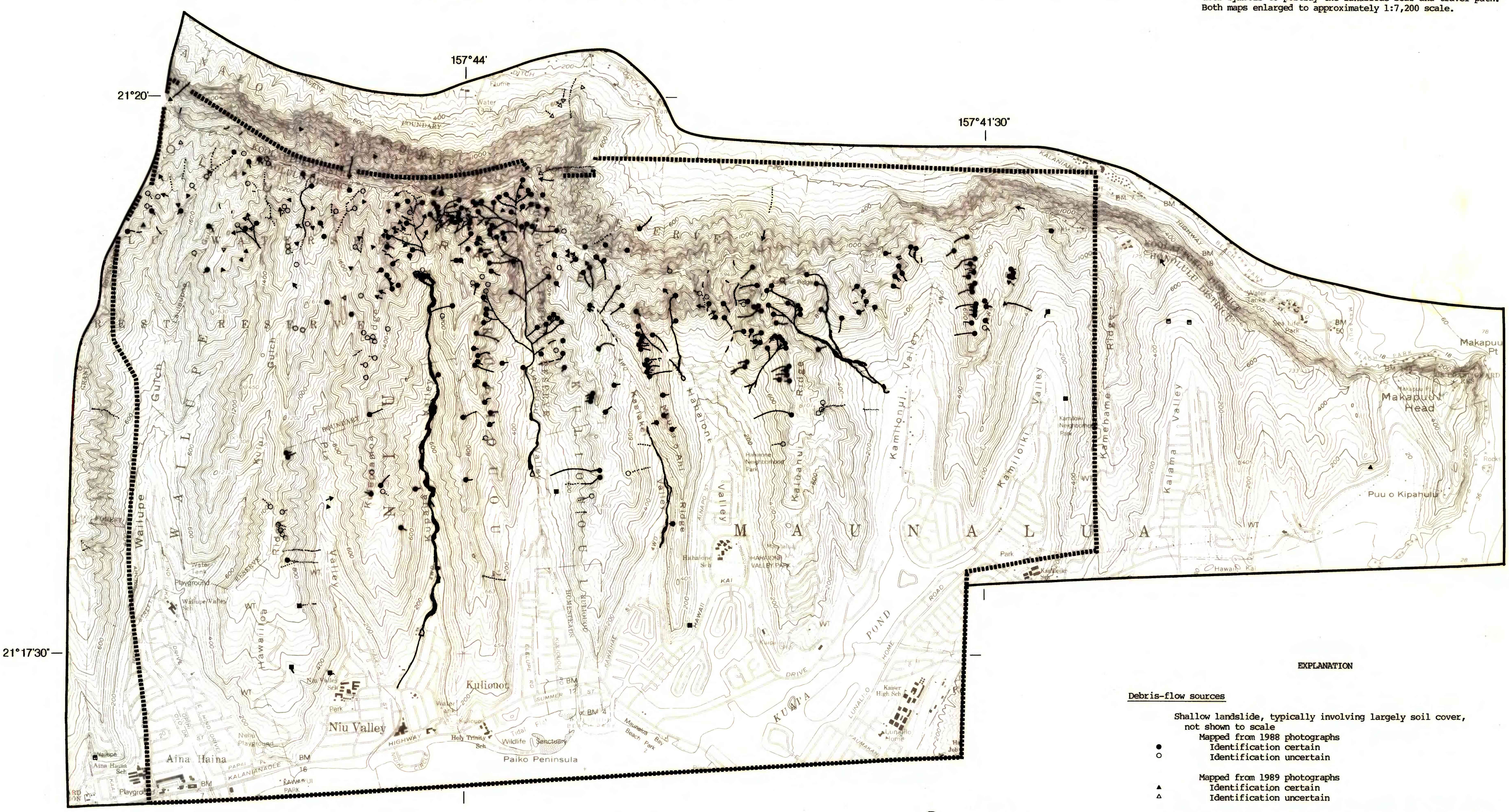
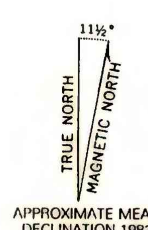


Figure 1: Accurate map (A) of single debris flow, compared to schematic portrayal (B) used for small features on the map below. The accurate portrayal (A), plotted using a Kern PG2 stereoplotter, shows the size and shape of the landslide scar as well as the width and other details of the debris-flow travel path. The schematic portrayal (B), plotted by hand, uses symbols to portray the landslide scar and travel path. Both maps enlarged to approximately 1:7,200 scale.



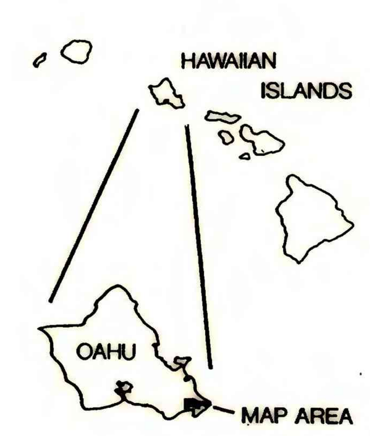
Base from U.S. Geological Survey
Koko Head Quadrangle 1983, scale 1:24,000



SCALE 1:20000

1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOWER LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE RELATIONSHIP BETWEEN THE TWO DATUMS IS VARIABLE
THE AVERAGE RANGE OF TIDE IS APPROXIMATELY 1 FOOT



EXPLANATION

Debris-flow sources

Shallow landslide, typically involving largely soil cover, not shown to scale
- Mapped from 1988 photographs
  - ● Identification certain
  - ○ Identification uncertain
- Mapped from 1989 photographs
  - ▲ Identification certain
  - △ Identification uncertain

Shallow landslide in cut slope or fill slope, not shown to scale. Identification and relation to debris flow is uncertain
- ■ Mapped from 1988 photographs
- ▪ Mapped from 1989 photographs

Scarp of deep landslide source for debris flow in Kupaua Valley, shown approximately to scale

Debris-flow travel paths (Includes areas of stripped and flattened vegetation, scoured ground, and deposits)

Path of debris flow on hillslope, shown schematically. Dotted where identification is uncertain

Broad path of debris flow in valley, shown approximately to scale

Other symbols

Debris catch basin affected by debris flow in the storm, shown approximately to scale

Boundary of mapping from 1988 photographs

Boundary of mapping from 1989 photographs

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