

Figure 1
Distribution of landslides that damaged manmade structures during the 1972-73 rainy season. Each dot represents the location of one or more landslides.

Planimetric base from San Francisco Bay Region ABAG 1:250,000 map. Shaded relief from 1:100,000 State Map of California.

INTRODUCTION

This report presents data on the location and cost of damage related to landslides in the San Francisco Bay region during the rainy season of 1972-73 (Figs. 1 and 2). By showing the general location of landslides that caused damage during that season, the report also shows which parts of the region have the most severe problems. These data supplement earlier reports by the U.S. Geological Survey on the damage caused by landsliding throughout the bay region during the rainy season of 1968-69 (Taylor and Brabb, 1972), in Contra Costa County from 1950 to 1971 (Nilsen and Turner, 1975), in Alameda County from 1940 to 1971 (Nilsen and others, 1975), and in the northeastern part of the city of San Jose from 1967 to 1971 (Nilsen and Brabb, 1972).

The nine San Francisco Bay region counties are included in this investigation: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma. Landslide costs for these counties during the 1972-73 rainy season (Table 1) were at least \$9,716,220. This total, \$3,284,918 was direct loss of or damage to private property, mainly by lowering the property market value, and \$6,431,302 was for public property, chiefly for repair or relocation of roads. The data used to compile these costs are incomplete, thus the total cost could be significantly greater.

DEFINITION OF LANDSLIDES

In this study, landslides are defined as the downward and outward movement of slope-forming materials, which may be composed of natural rock, colluvium, soil, alluvium, artificial fill, or combinations thereof. Landslides can be subdivided in many different ways, such as by manner of movement, age and type of materials, but no such differentiation is made in this report. Some agencies reporting landslide data commonly use the term "slipout" to describe areas where a section of a road has moved downward or the underlying material has "slipped" out from beneath the road. "Slipouts" are included here as landslides. The landslides that are recorded ranged in size from a few tens to several hundreds of feet in maximum dimension.

REPORTING PERIOD

Most of the data in this report are for the rainy season of 1972-73. However, because the various agencies involved used different reporting intervals—fiscal year, calendar year, or seasonal year—and different procedures, some data from other rainy periods may be included. As far as we can determine, this discrepancy is not significant enough to affect the total cost estimate.

METHOD

Agencies that were thought to have data about damage caused by landsliding in the bay region were contacted. These included federal, state, county, and city agencies, road departments, planning commissions and assessors, and utility companies, sewage disposal districts, and consulting geologists. In most cases, only one individual per agency was contacted, and his information may not be complete or even representative for the agency as a whole. Because the information in these reports could not be attributed to a particular source, no individual or agency is listed. However, in order to establish for the record which agencies were contacted so that the scope of sampling can be assessed, we are including here a list by county of offices or individuals that were contacted or that contributed information.

- Alameda County**—Alameda, Building Inspector; Albany, Office of the City Engineer; Berkeley, Department of Public Works; Emeryville, Fremont, Maintenance Engineers; Hayward, Department of Public Works; Livermore, Building Inspector; Newark, Office of the City Engineer; Oakland, City Engineer; Piedmont, Building Inspector; Pleasanton, Office of the City Engineer; San Leandro, Department of Public Works; Union City, Department of Public Works; County Flood Control and Water Conservation District, County Public Works Planning Department, County Public Works Road Division, County Assessor; California Department of Transportation, and the Pacific Gas and Electric Company.
- Contra Costa County**—Concord, Department of Public Works; El Cerrito, Office of the City Engineer; Martinez, Building Inspector; Pittsburg, Department of Public Works; Pleasant Hill, Richmond, Building Inspector; San Pablo, Department of Public Works; Walnut Creek, Community Developer; County Design Office, County Disaster Office, County Assessor; East Bay Municipal Utilities District; East Bay Regional Park District; Mt. Diablo State Park; California Department of Transportation, and the Pacific Gas and Electric Company.
- Marin County**—Belvedere, Department of Public Works; Corte Madera, City Engineer; Fairfax, Building Inspector and Road Superintendent; Larkspur, Department of Public Works; Mill Valley, Office of the City Engineer; Novato, Department of Public Works; Ross, Department of Public Works; San Anselmo, Department of Public Works; San Rafael, Department of Public Works; Sausalito, Department of Public Works; Tiburon, Office of the City Engineer; County Department of Public Works, County Assessor; Small Business Association Disaster Offices; Private consulting geologists; California Department of Transportation.
- Napa County**—Calistoga, Napa, Department of Public Works; St. Helena, Department of Public Works; Yountville, Office of the City Engineer; Department of Public Works; County Assessor; County Public Works Department; County Park Department; State Forestry Division; California Department of Transportation; and the Pacific Gas and Electric Company.
- San Francisco County**—San Francisco, City Engineer; County Assessor; Department of Survey and Mapping; and the California Department of Transportation.
- San Mateo County**—Atherton, City Engineer; Belmont, Office of the City Engineer; Brisbane, Burlingame, Office of the City Engineer; Daly City, Department of Public Works; Menlo Park, City Engineer and Menlo Park Sanitary District; Millbrae, Public Works Department; Pacifica, Engineering Department; Redwood City, Department of Public Works; San Bruno, Assistant Engineer; San Carlos, Department of Maintenance; San Mateo, Office of the City Engineer; South San Francisco, Department of Public Works; County Planning Commission, County Engineers, County Department of Roads, County Assessor; and the California Department of Transportation.
- Santa Clara County**—Campbell, Department of Public Works; Cupertino, Department of Public Works; Gilroy, Los Altos, City Engineer; Morgan Hill; Mountain View; Palo Alto, Department of Public Works; Santa Clara, Department of Public Works; San Jose, Department of Public Works; Sunnyvale; County Planning Commission, County Assessor, County Director of Public Works; County Road District; County Flood Control, Water District, County Parks and Recreation Department; California Department of Transportation; U.S. Department of Agriculture Soil Conservation Service; and the Pacific Gas and Electric Company.
- Solano County**—Benicia, Department of Public Works; Fairfield, Office of the City Engineer; Suisun City; Vacaville, Department of Public Works; Vallejo, Office of the City Engineer; County Public Works Department, County Assessor, County Farm Advisor; Vallejo Water Department; California Department of Transportation; and the Pacific Gas and Electric Company.
- Sonoma County**—Cotati, Healthsburg, Department of Public Works; Petaluma; Santa Rosa, Building Inspector; Sebastopol; Sonoma; County Public Works Department, County Department of Admision, County Agricultural Commission, County Appraiser, County Department of Roads, County Department of Parks and Recreation, County Department of Sanitation; State Forestry and State Park Departments; U.S. Department of Agriculture Soil Conservation Service; and the Pacific Gas and Electric Company.

We wish to thank the agencies and individuals listed above for their cooperation and assistance in this study.

EXPLANATION OF RESULTS

Costs are reported under two main categories—public and private. Public costs are dollars spent or lost by governmental agencies, costs ultimately paid by the taxpayer. Private costs are expenses to individuals and nonpublic groups.

The method of recording information about landslides differed greatly from county to county. Some counties compiled separate files for each landslide, whereas others included landslide cleanup and repair in a total maintenance budget. No single department in any county had a complete record relating to landslides within that county. The use of different maps and map scales sometimes caused difficulties in making our compilation. The apportioning of costs was occasionally a problem, as agencies sometimes involved major projects of time, as some landslides undergo repeated movement each year and hence require continuing repairs. The assignment of these costs to a particular period of time varied with the individuals or agencies involved but may have resulted in costs being assigned to years other than the one in which the movement took place. Several sources of information for private costs requested that specific data be kept confidential, so that a breakdown of total cost was not always listed. Storm Damage Reports, required by the Federal Government for disaster relief, were found to be very useful in Marin and Contra Costa Counties. As a result, the compilation of dates, locations, and costs of landslides varies considerably in accuracy and completeness.

Most of the public landslide cost is the direct expense of repairing, restoring, or relocating roads. This includes expenses readily attributed to specific large landslides and an educated guess for smaller landslides that are commonly included with budgets for routine road maintenance and repair. Lesser expenses resulting from damage to sewer lines, street lighting, sidewalks, and other public facilities are also included. Public agencies must sometimes obtain title to privately owned land to further protect property or to repair existing landslides. In addition to the cost of procurement, the agency assumes costs for erosion control, weed abatement, and other minor costs. It is difficult to assign the exact costs of some landslide damage to a given period of time, as some landslides undergo repeated movement each year and hence require continuing repairs. The assignment of these costs to a particular period of time varied with the individuals or agencies involved but may have resulted in costs being assigned to years other than the one in which the movement took place. Several sources of information for private costs requested that specific data be kept confidential, so that a breakdown of total cost was not always listed. Storm Damage Reports, required by the Federal Government for disaster relief, were found to be very useful in Marin and Contra Costa Counties. As a result, the compilation of dates, locations, and costs of landslides varies considerably in accuracy and completeness.

COST OF LANDSLIDE DAMAGE

Identified costs were as follows:

| | |
|-----------------------------------|-----------|
| Public costs | \$270,845 |
| state | \$191,000 |
| county | 20,000 |
| city | 57,500 |
| tax loss on property depreciation | 2,345 |
| Private costs | 88,400 |
| Total | \$359,245 |

State, county, and city costs are basically those reported for roadway repair. Private costs include \$67,900 loss in assessed valuation of nine parcels of land due to landslide damage. All incorporated cities were contacted, but only Hayward reported a landslide involving city expense. Berkeley had an estimate for minor landslide cleanup, and Oakland spent a small amount for landslide investigations.

Contra Costa County

Identified costs were as follows:

| | |
|---|-------------|
| Public costs | \$974,628 |
| state | \$40,243 |
| county | 901,400 |
| city | 0 |
| tax loss on property depreciation | 22,140 |
| regional and state parks | 10,945 |
| Private costs | \$712,550 |
| property depreciation, repair and physical loss | \$656,150 |
| utility companies | 56,400 |
| Total | \$1,687,178 |

County road maintenance accounts for the major portion of total public costs. Private costs include \$485,300 for property depreciation on 82 parcels due to landslides. One hundred and ten landslides were recorded within the county. A high concentration is present in the Orinda-Lafayette area and a lesser concentration in the El Sobrante region. The city of Pinole reported one landslide but had no cost estimate for repair. All other cities reported no landslide damage.

Marin County

Identified costs were as follows:

| | |
|-----------------------------------|-------------|
| Public costs | \$1,970,540 |
| state | \$340,000 |
| county | 630,570 |
| city | 967,150 |
| tax loss on property depreciation | 32,820 |
| Private costs | 1,093,950 |
| Total | \$3,064,490 |

Only 111 of the 153 reported landslides are shown on the map owing to scale limitations. The mapping shows a high concentration of reported landslides in the Mill Valley and Fairfax-San Anselmo regions and lesser concentrations throughout the county.

Napa County

Identified costs were as follows:

| | |
|---------------|-----------|
| Public costs | \$129,300 |
| state | \$87,000 |
| county | 42,000 |
| city | 0 |
| parks | 300 |
| Private costs | 2,000 |
| Total | \$131,300 |

The assessor's office had no requests for reappraisals of property due to landslide damage. With one exception, all reported landslides occurred along roadways.

Alameda County

Identified costs were as follows:

| | |
|---------------|---------------|
| Public costs | \$490,000 |
| state | \$400,000 |
| county | 90,000 |
| city | none reported |
| Private costs | none reported |
| Total | \$490,000 |

All reported costs were along roadways.

San Mateo County

Identified costs were as follows:

| | |
|-----------------------------------|-------------|
| Public costs | \$2,311,310 |
| state | \$2,182,500 |
| county | 50,000 |
| city | 49,000 |
| tax loss on property depreciation | 29,810 |
| Private costs | 1,284,000 |
| Total | \$3,595,310 |

County road personnel report no major landslides on county roads and estimate debris removal for minor landslides at \$50,000. State highway figures include an amount in excess of \$1,200,000 for a single landslide.

Santa Clara County

Identified costs were as follows:

| | |
|---------------|-----------|
| Public costs | \$75,543 |
| state | \$41,000 |
| county | unknown |
| parks | 30,543 |
| Private costs | 4,000 |
| Total | 74,518 |
| Total | \$150,061 |

Most landslides occurred on county roads for which officials had no estimate of costs for repairs or maintenance. Cities within the county reported only four landslides.

Solano County

Identified costs were as follows:

| | |
|---------------|----------|
| Public costs | \$8,950 |
| state | 0 |
| county | \$8,750 |
| city | 200 |
| Private costs | 19,500 |
| Total | \$28,450 |

Nineteen small landslides occurred throughout the western part of the county, and nineteen affected county roads.

Sonoma County

Identified costs were as follows:

| | |
|----------------|------------|
| Public costs | \$200,250 |
| state | \$195,000 |
| county | unreported |
| city | 1,000 |
| parks | 4,250 |
| Private costs | 10,000 |
| utilities only | 10,000 |
| Total | \$210,250 |

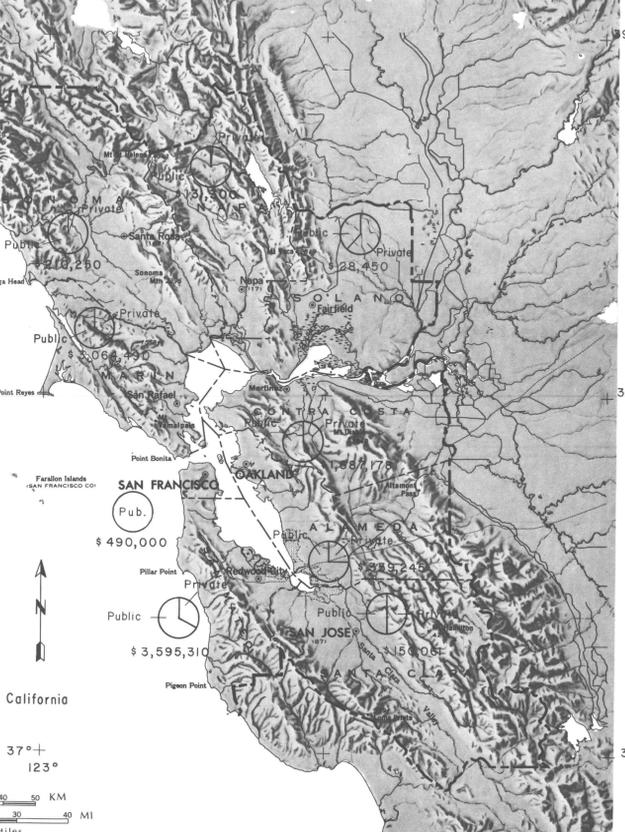


Figure 2
Distribution by county of landslide damage costs for 1972-73.

Base from State Map of California

REFERENCES CITED

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Table 1. Economic loss due to landslides in 1972-73 (in dollars).

| | Public | | | | | Private | Total |
|---------------|-------------|-------------|-----------|----------|------------|-------------|-------------|
| | State | County | City | Parks | Tax loss | | |
| Alameda | \$ 191,000 | \$ 20,000 | \$ 57,500 | \$ 0 | \$ 2,345 | \$ 88,400 | \$ 359,245 |
| Contra Costa | 40,243 | 901,400 | 0 | 10,845 | 22,140 | 712,550 | 1,687,178 |
| Marin | 340,000 | 630,570 | 967,150 | 0 | 32,820 | 1,093,950 | 3,064,490 |
| Napa | 87,000 | 42,000 | 0 | 300 | 0 | 2,000 | 131,300 |
| San Francisco | 400,000 | see city | 90,000 | 0 | 0 | 0 | 490,000 |
| San Mateo | 2,182,500 | 50,000 | 49,000 | 0 | 29,810 | 1,284,000 | 3,595,310 |
| Santa Clara | 41,000 | unknown | 30,543 | 4,000 | 0 | 150,061 | 210,250 |
| Solano | 0 | 8,750 | 200 | 0 | 0 | 19,500 | 28,450 |
| Sonoma | 195,000 | no report | 1,000 | 4,250 | unreported | 10,000 | 210,250 |
| Totals | \$3,476,743 | \$1,652,220 | 1,195,393 | \$19,395 | \$87,115 | \$3,204,918 | \$9,716,284 |

DISTRIBUTION AND COST OF LANDSLIDES THAT HAVE DAMAGED MANMADE STRUCTURES DURING THE RAINY SEASON OF 1972-1973 IN THE SAN FRANCISCO BAY REGION, CALIFORNIA

by Fred A. Taylor, Tor H. Nilsen, and Robert M. Dean — 1975