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

Debris Flows Triggered by the El Niño Rainstorm of February 2-3, 1998, Walpert Ridge and Vicinity, Alameda County, California

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2001

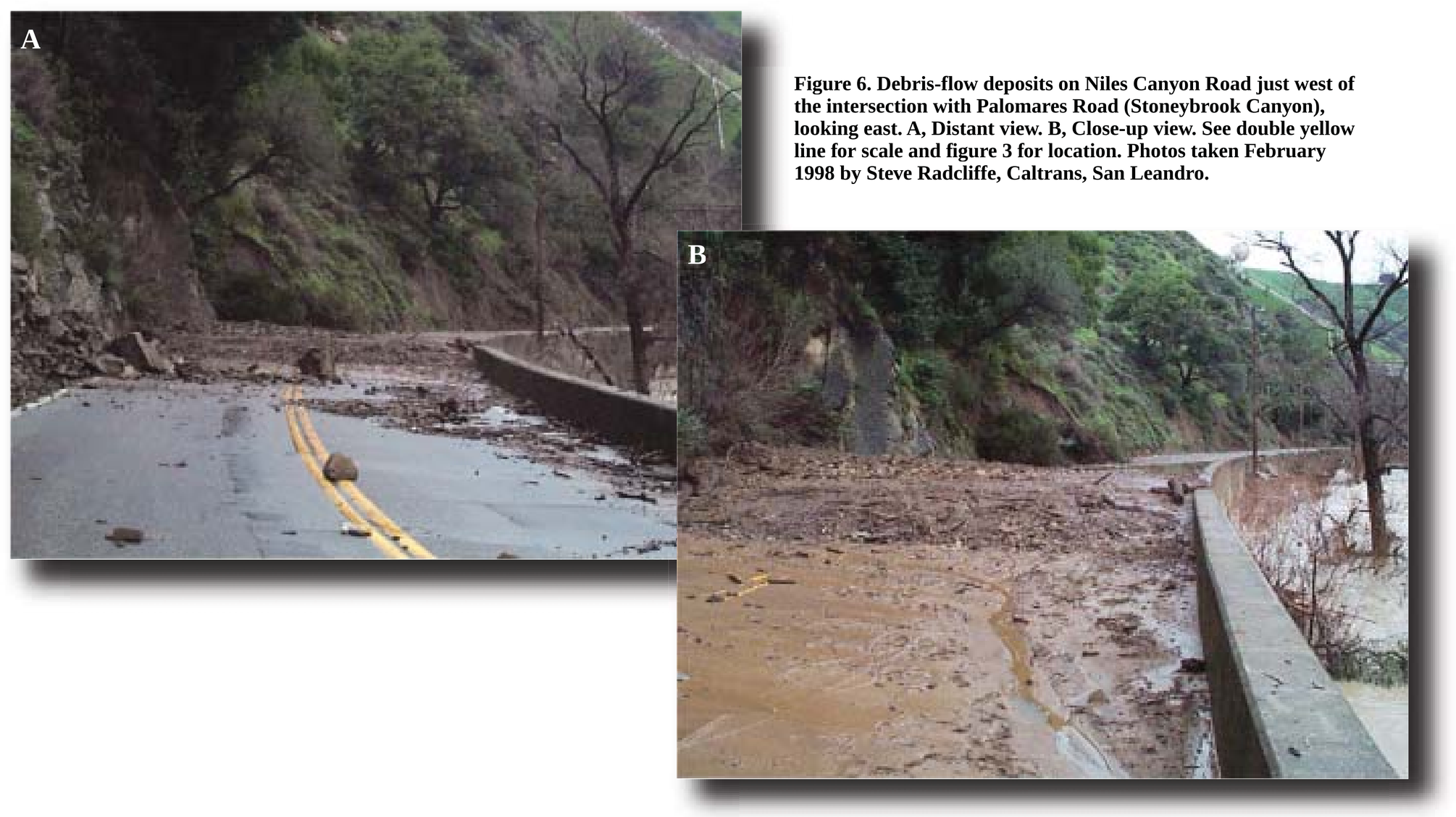


Figure 6. Debris-flow deposits on Niles Canyon Road just west of the intersection with Palomares Road (Stoneybrook Canyon), looking east. A, Distant view. B, Close-up view. See double yellow line for scale and figure 3 for location. Photos taken February 1998 by Steve Radcliffe, Caltrans, San Leandro.


Figure 7. Debris flows behind houses along Canyon Heights Drive in Fremont. See figure 3 for location and houses for scale. Photo taken April 22, 1998.


Figure 8. Plastic-covered debris flows above Faircliff Street in Hayward. Flooding and(or) blockage of the v-shaped ditch near base of the hillslope may have contributed to triggering some of the debris flows (see table 2). See figure 3 for location and houses for scale. Photo taken April 22, 1998.


Figure 9. Fresh debris flows (right) and healed debris-flow scar (left) near the end of Morrison Canyon Road. Healed debris flow occurred in January 1982, as documented by Wieczorek and others (1988). See utility poles for scale, figure 3 for location. Photo taken April 19, 1998.


Figure 10. Debris flows on hillside covered by terracettes (probably created by grazing animals), located about 1 km northeast of the Masonic Home in Union City. See figure 3 for location, utility poles for scale. Photo taken March 26, 1998.


Figure 11. Debris flow mobilized from the toe of an earth flow in Garin Park. See figure 3 for location. Horizontal distance from headscarp to distal end of deposit is about 23 m. Photo taken April 23, 1998.

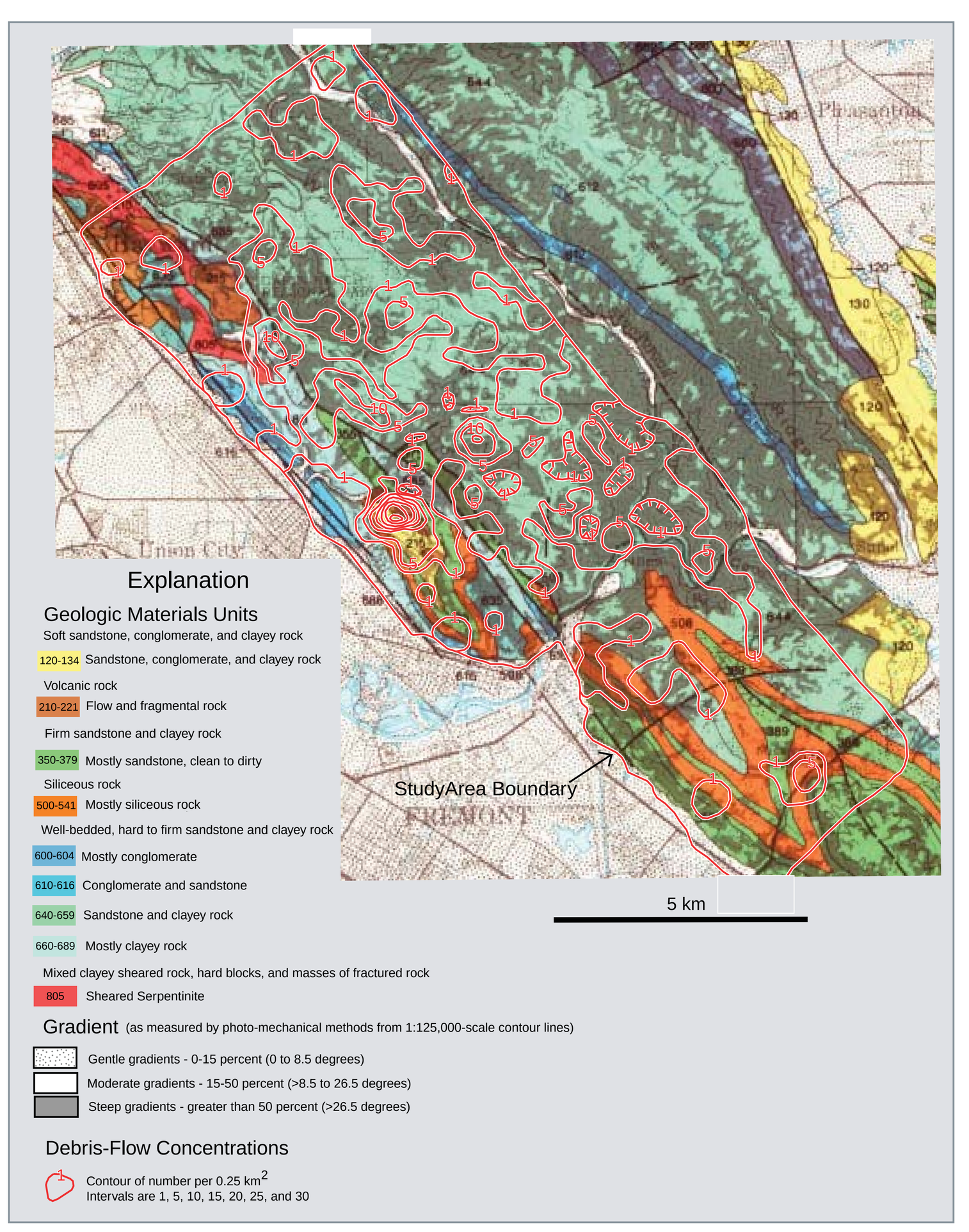


Figure 12. Debris-flow isopleths overlain on map of geologic materials and gradient by Ellen and Wentworth (1995).

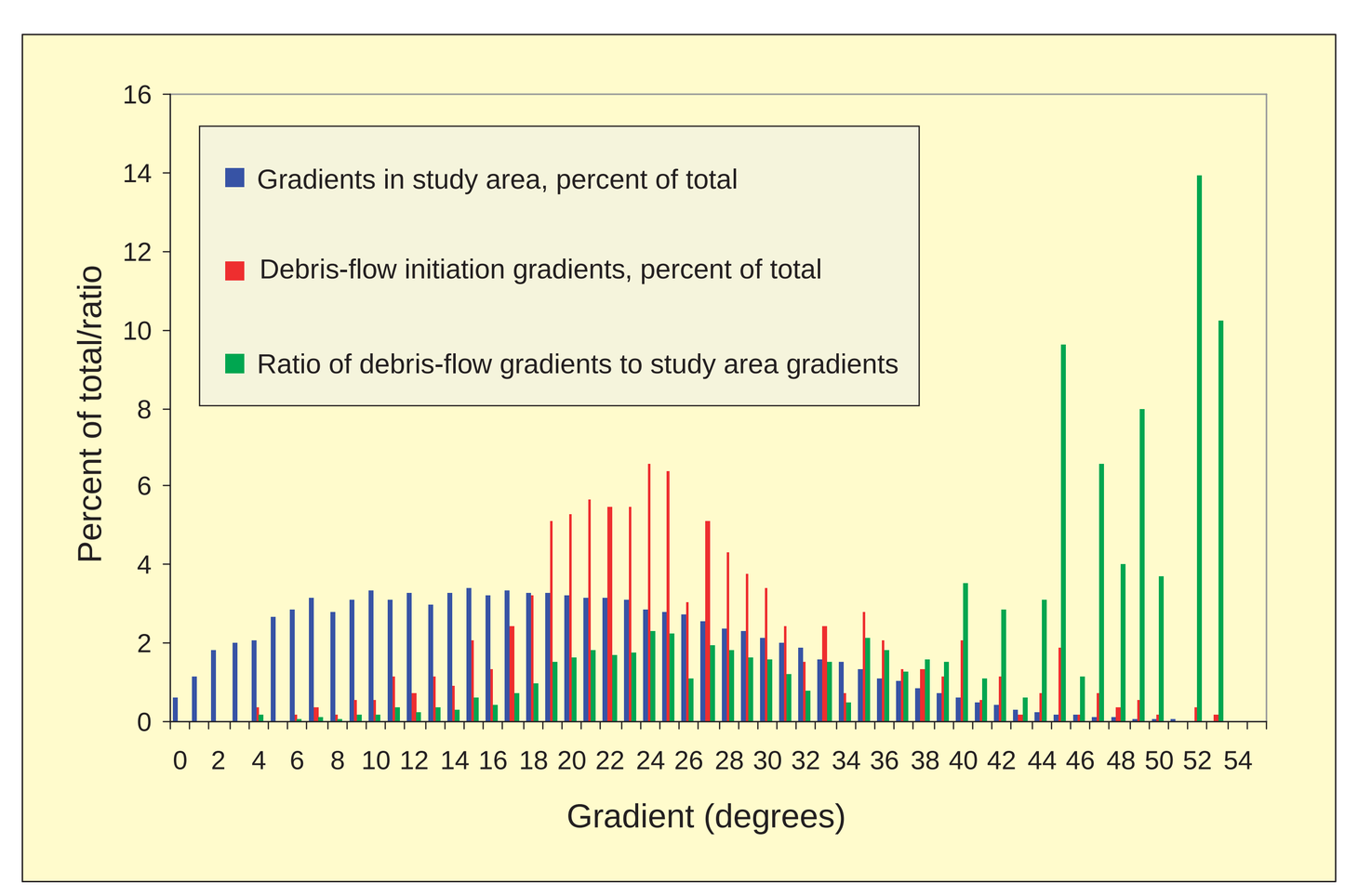


Figure 13. Histograms of gradients measured from 10-m DEMs. Number of 10-m cells in the study area is about 913,200. Number of debris flows is 531. Data are not shown above 55 . One debris flow occurred at 58 and resulted in a debris-flow gradient/study-area gradient ratio of 52 percent.

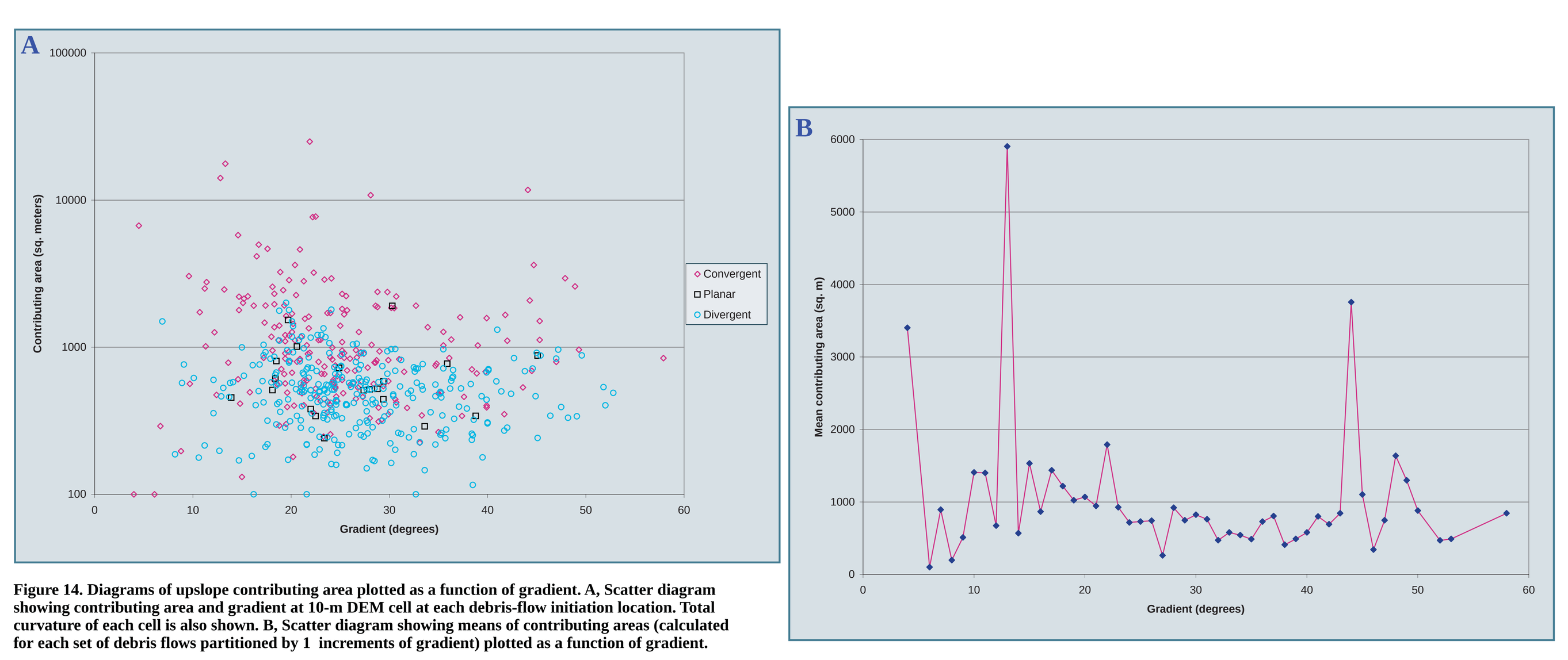


Figure 14. Diagrams of upslope contributing area plotted as a function of gradient. A, Scatter diagram showing contributing area and gradient at 10-m DEM cell at each debris-flow initiation location. Total curvature of each cell is also shown. B, Scatter diagram showing means of contributing areas (calculated for each set of debris flows partitioned by 1 increments of gradient) plotted as a function of gradient.

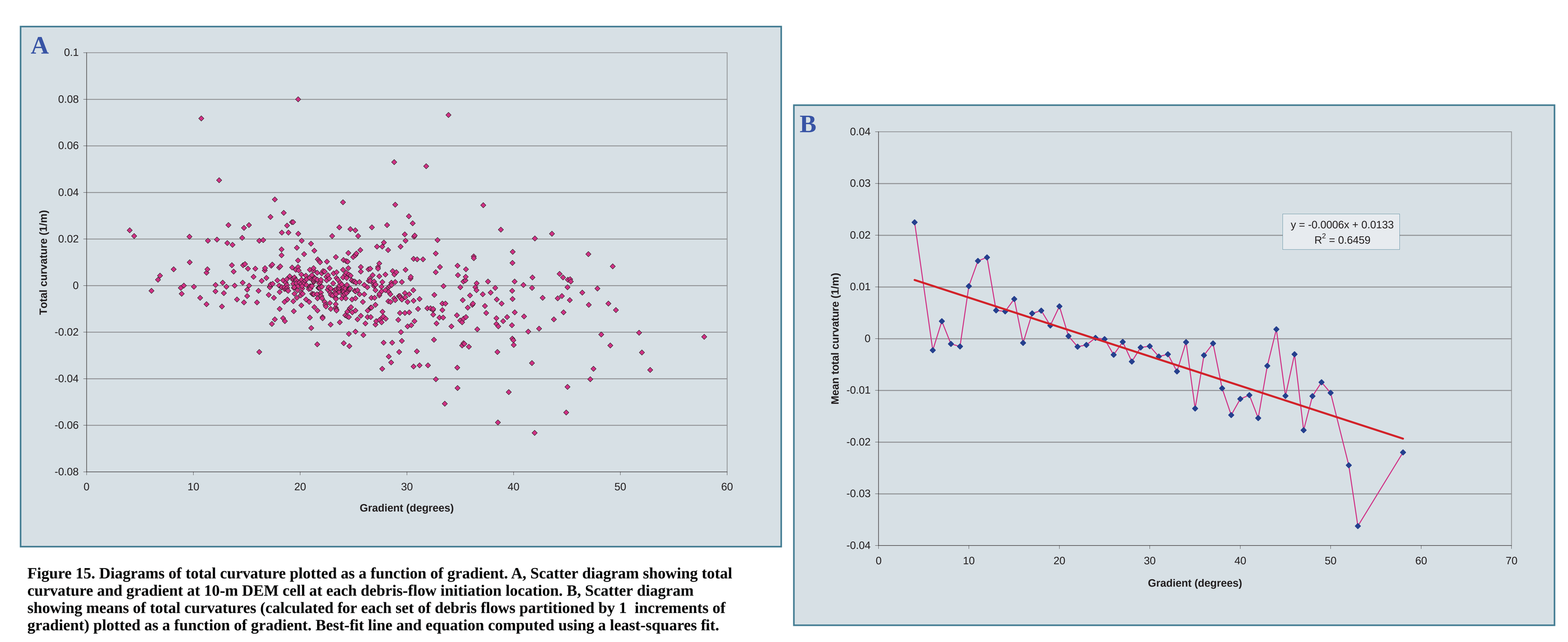


Figure 15. Diagrams of total curvature plotted as a function of gradient. A, Scatter diagram showing total curvature and gradient at 10-m DEM cell at each debris-flow initiation location. B, Scatter diagram showing means of total curvatures (calculated for each set of debris flows partitioned by 1 increments of gradient) plotted as a function of gradient. Best-fit line and equation computed using a least-squares fit.

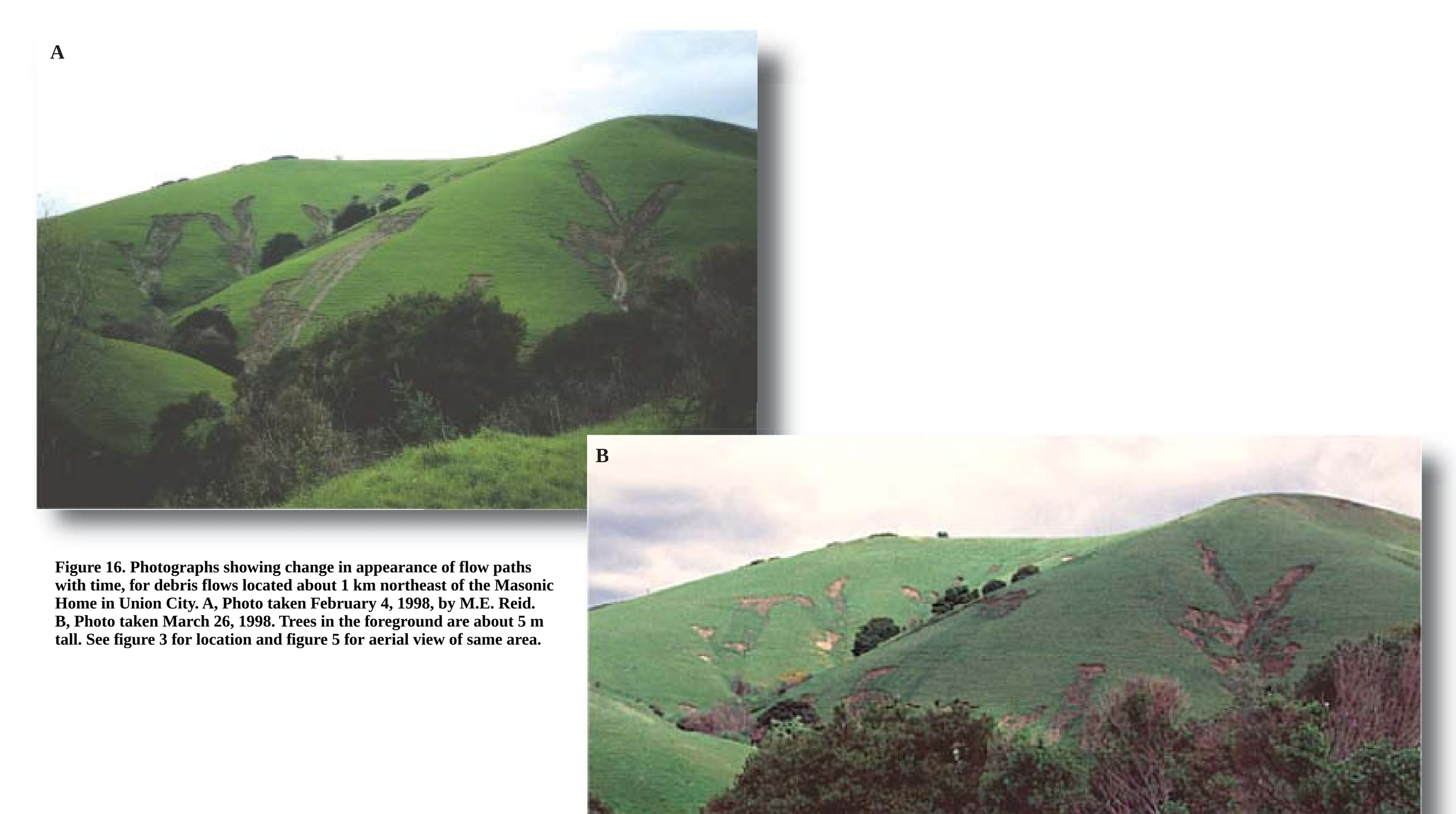


Figure 16. Photographs showing change in appearance of flow paths with time, for debris flows located about 1 km northeast of the Masonic Home in Union City. A, Photo taken February 4, 1998, by M.E. Reid. B, Photo taken March 26, 1998. Trees in the foreground are about 5 m tall. See figure 3 for location and figure 5 for aerial view of same area.

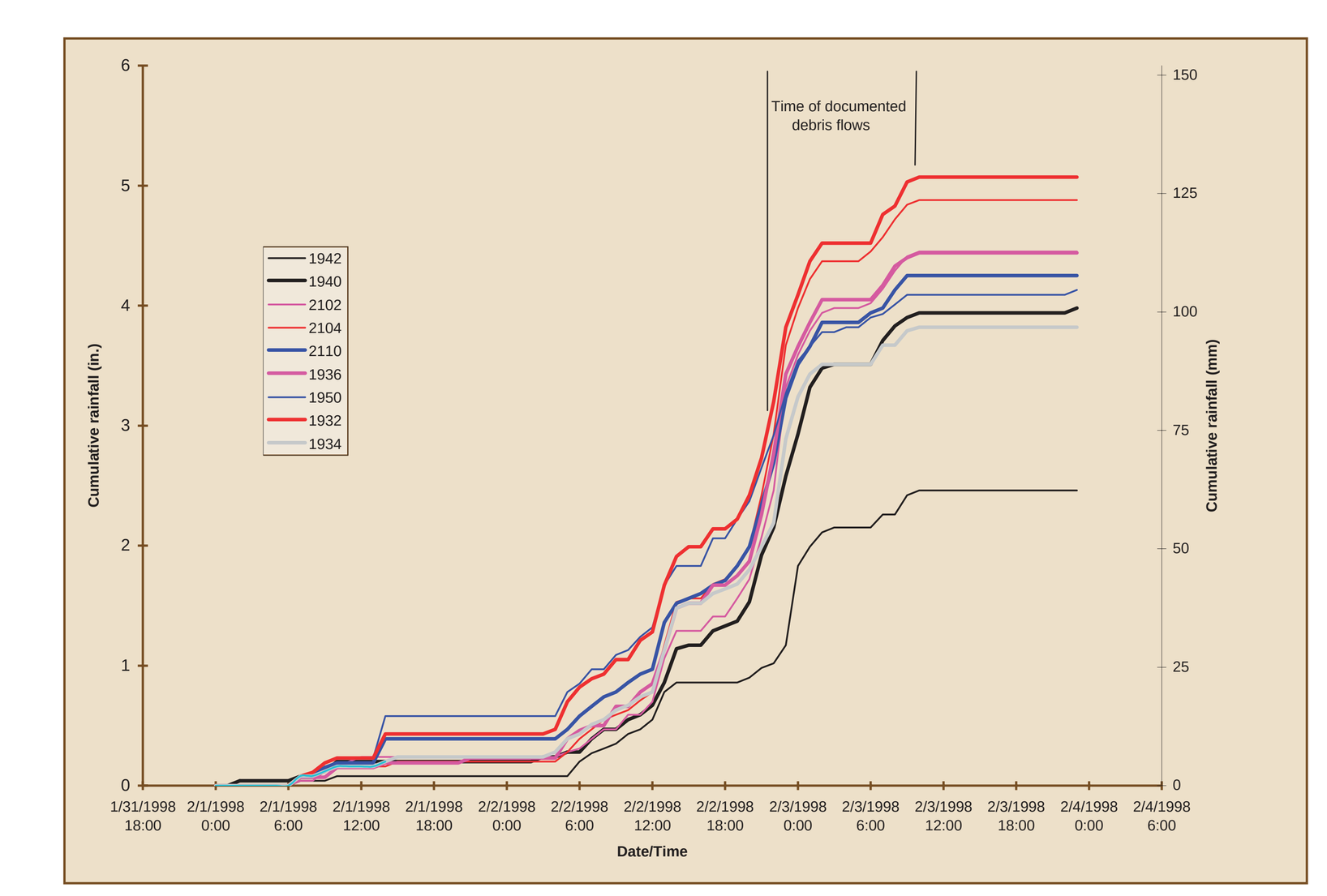


Figure 17. Cumulative rainfall at East-Bay ALERT gages, February 1-3, 1998. See figure 2b and table 6 for location of gages and table 2 for documented times of debris flows. All rainfall data provided by Andreas Godfrey of the Alameda County Public Works Agency.

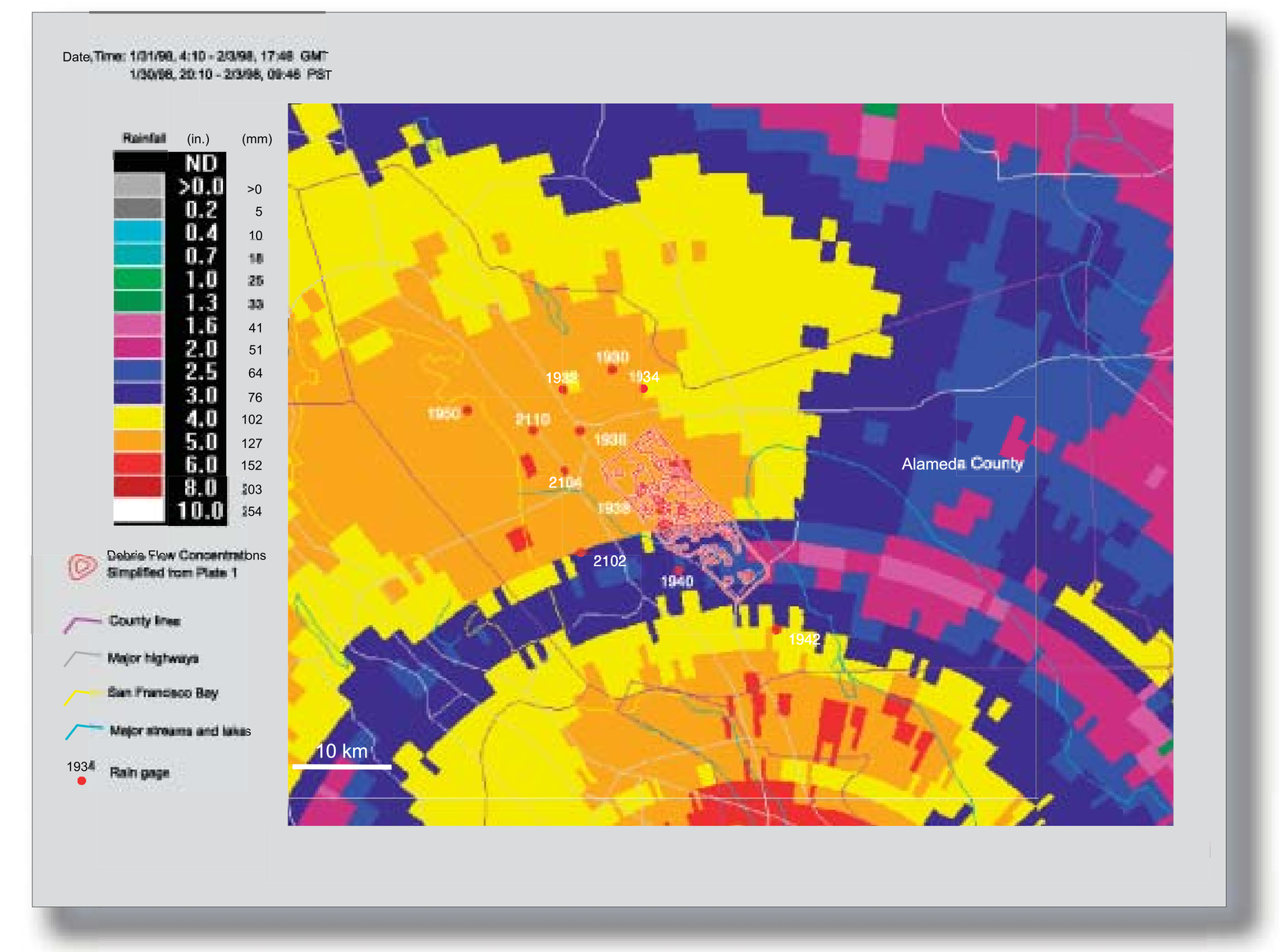
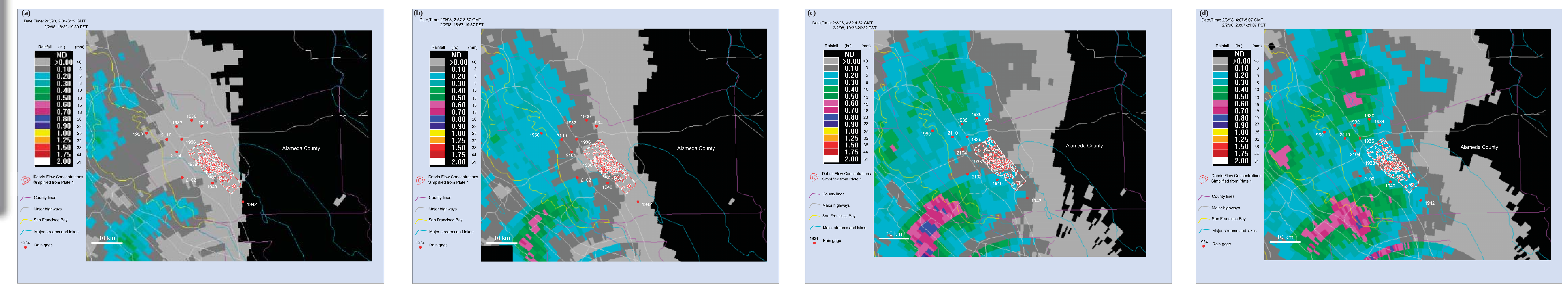
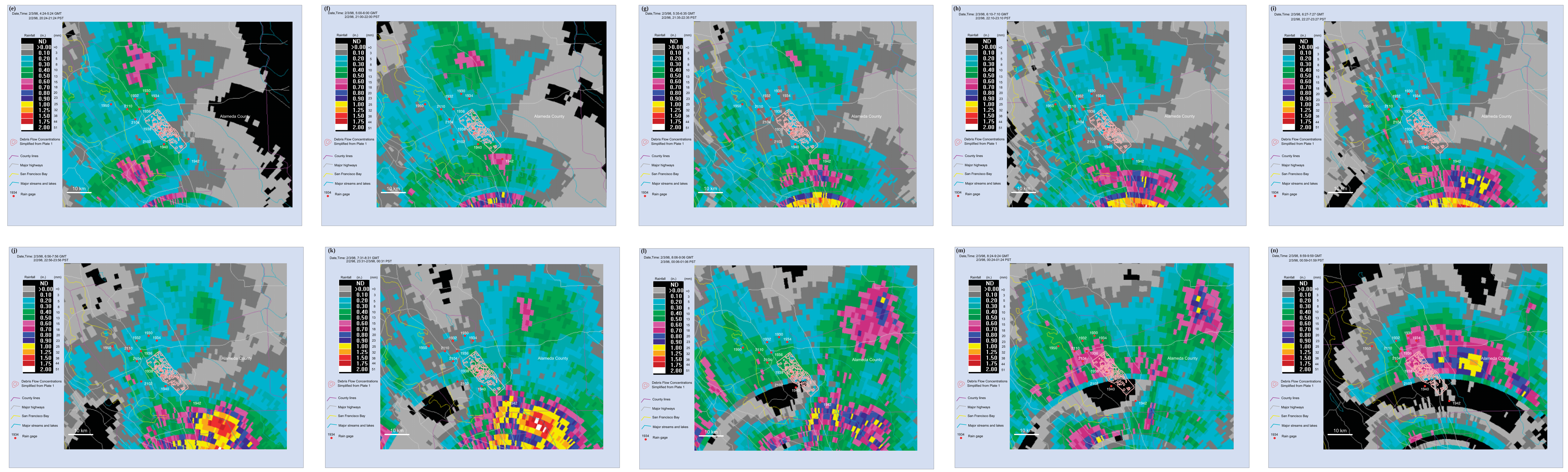
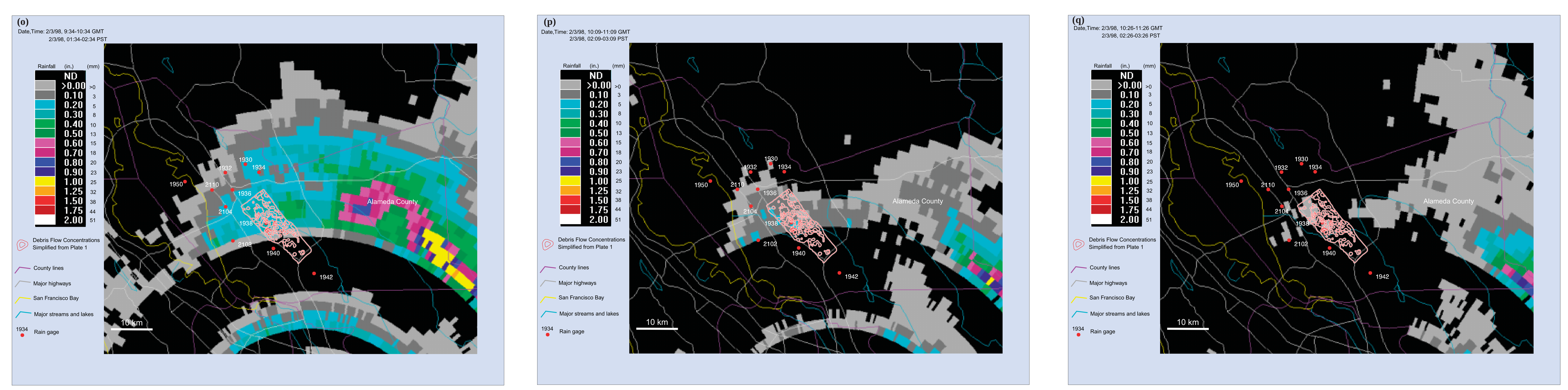


Figure 18. NEXRAD cumulative rainfall and debris-flow isopleth map. Cumulative rainfall measured between 20:10 on January 30 and 10:03 on February 3, 1998. See figure 3 for isopleth values. Registration of the NEXRAD map to the debris-flow concentrations was accomplished using the Alameda County boundary, which was common to both data sets, and the image registration tools in ArcInfo.

Figure 19. NEXRAD hourly rainfall and debris-flow isopleth map. Hourly rainfall recorded about every half hour starting at 18:39 PST on February 2 (18a) and ending at 03:26 on February 3 (18q). See figure 3 for debris flow isopleth values. Registration of the NEXRAD map to the debris-flow concentrations was accomplished using the Alameda County boundary, which was common to both data sets, and the image registration tools in ArcInfo.







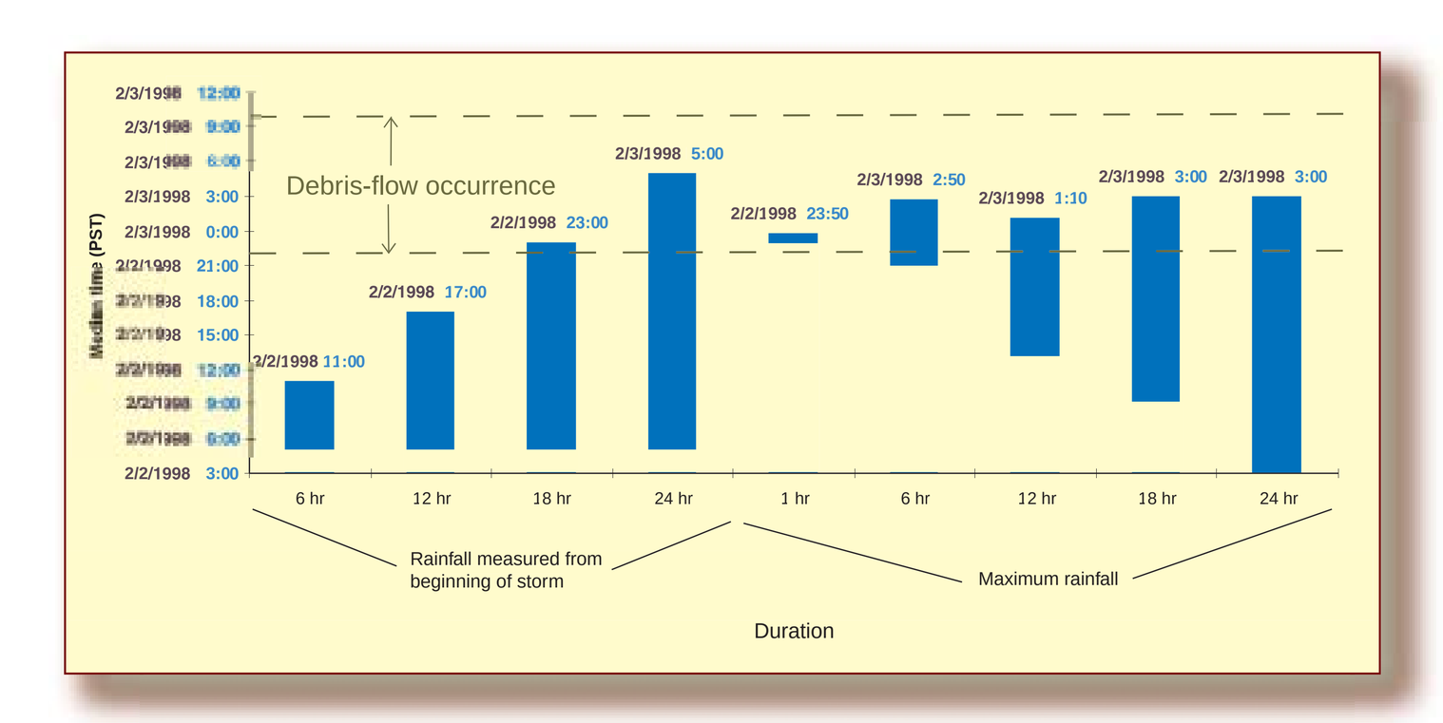


Figure 20. Rainfall for various durations compared with time of debris-flow occurrence. Range in time of debris-flow occurrence from table 2. Rainfall times are median values of all gages near study area (table 6). Plots of rainfall measured from beginning of the storm drawn from median value of start times. Plots of maximum duration drawn from median values of end times.

Digital data prepared using ARC/INFO 7.1.2 running under Solaris 2.6 on a UNIX workstation. Map formatted using Adobe Illustrator 8.0 running under Mac OS 8.6.

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