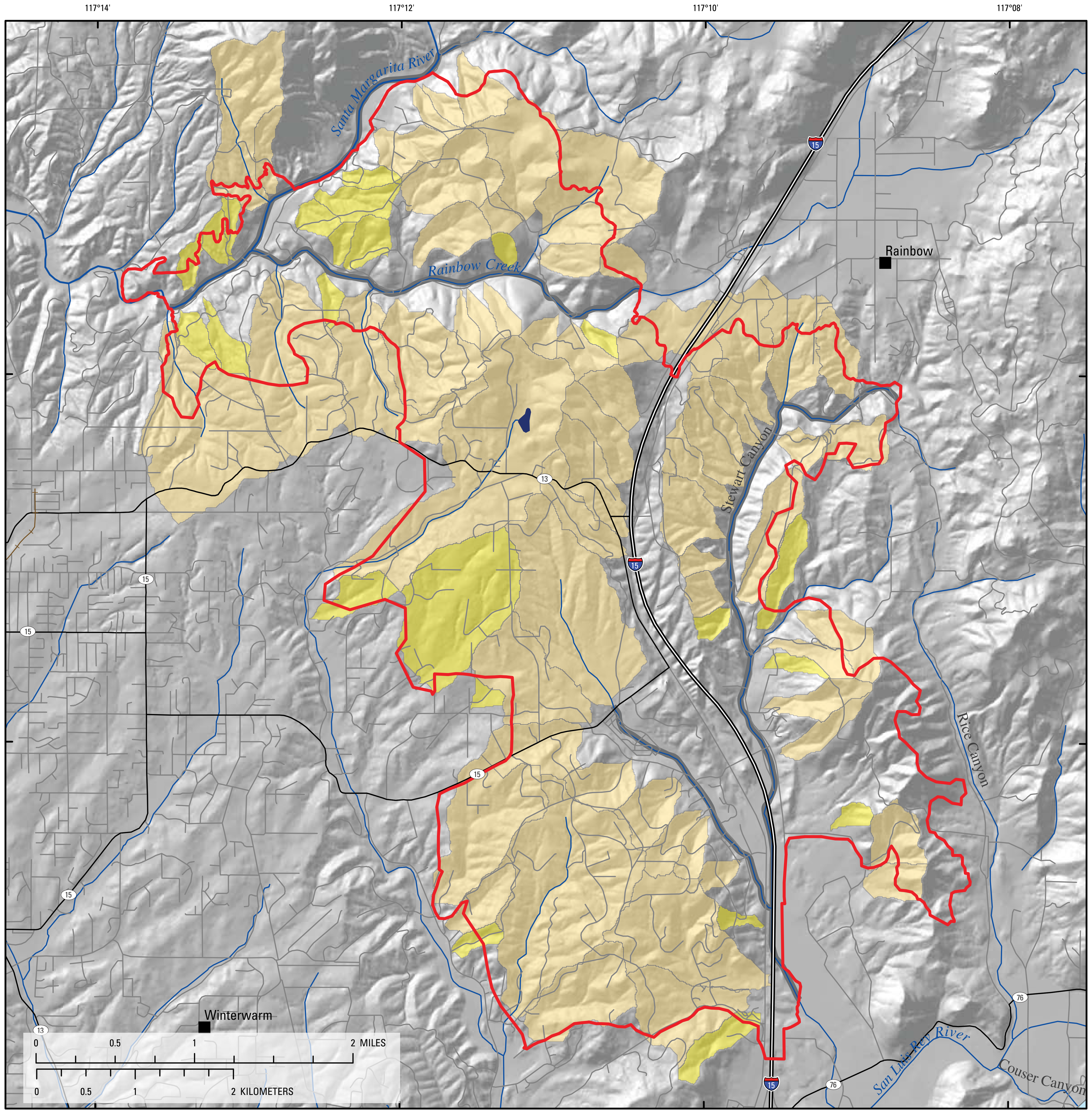

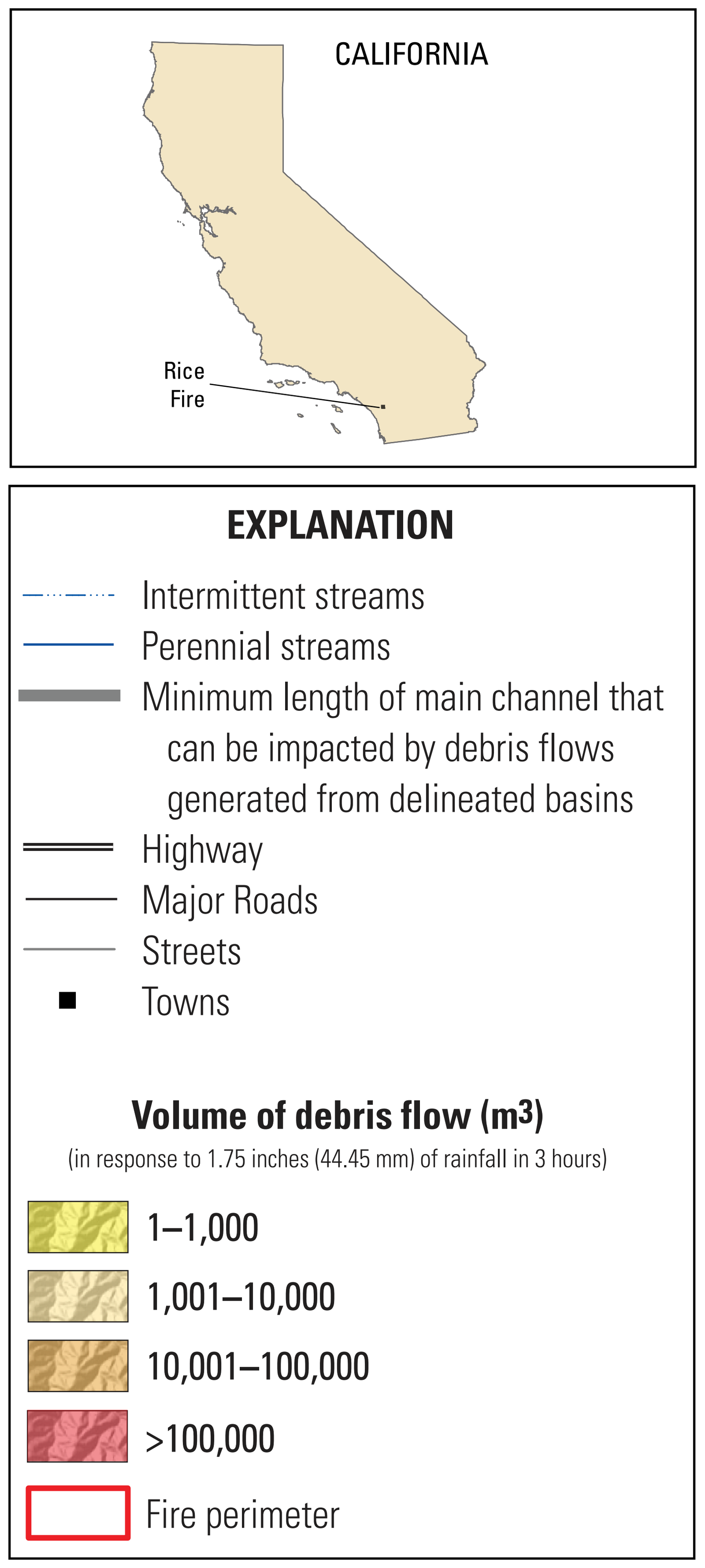

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EMERGENCY ASSESSMENT OF DEBRIS-FLOW HAZARDS FROM BASINS BURNED BY THE 2007 RICE FIRE, SAN DIEGO COUNTY, SOUTHERN CALIFORNIA

By
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Introduction

The objective of this report is to present a preliminary emergency assessment of the potential for debris-flow generation from basins burned by the Rice Fire in San Diego County, southern California, in 2007. Debris flows are among the most hazardous geologic phenomena (Turner and Schuster, 1996); debris flows that followed wildfires in southern California in 2003 killed 16 people and caused tens of millions of dollars of property damage (NOAA-USGS Debris Flow Task Force, 2005). A short period of even moderate rainfall on a burned watershed can lead to debris flows (Cannon and others, 2008). Rainfall that is normally absorbed into hillslope soils can run off almost instantly after vegetation has been removed by wildfire. This causes much greater and more rapid runoff than is normal from creeks and drainage areas. Highly erodible soils in a burn scar allow flood waters to entrain large amounts of ash, mud, boulders, and unburned vegetation. Within the burned area and downstream, the force of rushing water, soil, and rock can destroy culverts, bridges, roadways, and buildings, potentially causing injury or death.

This emergency debris-flow hazard assessment is presented as a relative ranking of the predicted volume of debris flows that can issue from basin outlets in response to 1.75 inches (44.45 mm) of rainfall over a 3-hour period. Such a storm has a 10-year return period (Hershfield, 1961). The calculation of debris-flow volume is based on a multiple-regression statistical model that describes the median volume of material that can be expected from a recently burned basin as a function of the area burned at high and moderate severity, the basin area with slopes greater than or equal to 30 percent, and triggering storm rainfall (Gartner and others, 2008). Cannon and others (2007) describe the methods used to generate the hazard maps. Identification of potential debris-flow hazards from burned drainage basins is necessary to issue warnings for specific basins, to make effective mitigation decisions, and to help plan evacuation timing and routes.

Results

Of the 83 basins evaluated in this assessment, 23 were identified as having the potential to produce debris flows with volumes less than 1,000 m^3 in response to the 10-year-recurrence, 3-hour rainstorm. These are primarily the small (0.06 to 1.3 km^2) basins that drain into Rainbow Creek, the Santa Margarita River, and Stewart Canyon. The remaining 60 basins showed the potential to produce debris flows with volumes between 1,001 and 10,000 m^3. These are basins with areas between 0.08 to 2.3 km^2 that drain into the Santa Margarita River, Rainbow Creek, the Interstate 15 corridor, and Stewart Canyon. Debris flows issuing from these basins can impact highways and roads in the area. In addition, neighborhoods, buildings, and people within, or immediately below, any of the burned basins can be impacted by debris flows.

Use and Limitations of the Map

This map shows potential hazards posed by debris flows as estimates of the median volumes of material that may issue from the outlets of basins burned by the Rice Fire of 2007 in southern California in response to a 10-year-recurrence, 3-hour-duration rainstorm. The map identifies the range of potential debris-flow volumes that can issue from individual basin outlets. This information can be used to issue warning for specific locations, to prioritize mitigation efforts, to aid in the design of mitigation structures, and to guide decisions for evacuation, shelter, and escape routes in the event that storms of similar magnitude to that evaluated here are forecast for the area.

In addition to the potential dangers within the basins, areas downstream from the basin outlets are also at risk. The danger is particularly high in canyon bottoms (shown as shaded areas on the map). In some of these areas homes were destroyed by the fire, and workers and residents may be busy cleaning and rebuilding sites. The potential for debris flows during rainfall events places these people at high risk. In addition, if culverts are plugged or overwhelmed by flows, or if roads wash out, motorists may be stranded for long periods of time. In some cases, channels cross roads on blind curves where motorists could abruptly encounter debris-flow deposits on the road.

In addition to the colored drainage basins, small debris flows can be generated from non-colored areas within the burn perimeter. These areas were not included in the analysis because they are occupied by either planar hillslopes or basins that are smaller than those used in the model development (Cannon and others, 2007).

We expect that the map presented here may be applicable for approximately three years after the fires for the storm conditions considered. The potential for debris-flow activity decreases with time following fire and the concurrent revegetation and stabilization of hillslopes. A compilation of information on post-fire runoff events from throughout the western U.S. indicates that under normal rainfall conditions most debris-flow activity occurs within about two years following a fire. If dry conditions slow re-growth of vegetation, this recovery period will be longer. Our assessment is specific to post-fire debris flows; significant hazards from flash flooding can remain for many years after a fire.

This assessment is based on the assumption that all basins are equally prone to debris flows (Cannon and others, 2007). Recent work has indicated that, in addition to the volume, the probability of debris flow will vary with burn severity, basin gradient, material properties, and storm rainfall. Unfortunately, a determination of debris-flow probability cannot yet be incorporated into this hazard assessment.

Suggested Actions

People occupying businesses, homes, and recreational facilities downstream of the basins identified as the most hazardous must be informed of the potential dangers from debris flows and flooding. Warning must be given even for those basins with engineered mitigation structures at their mouths in the event that the structures are not adequate to contain potential debris flows. Site-specific debris-flow hazard assessments ought to be performed upslope from structures and facilities in areas identified as being at risk.

Because this assessment is specific to post-fire debris flows, further assessment of potential hazards posed by flash floods is needed. Continued operation of the early-warning system for both flash floods and debris flows established by NOAA's National Weather Service and the U.S. Geological Survey (http://www.wrh.noaa.gov/sgx/hydro/debris_flow.php; NOAA-USGS Debris Flow Task Force, 2005) would help local officials make decisions about evacuations and inform the public about potential dangers of debris flows in advance of rainfall events. The system consists of an extensive reporting rain-gage and stream-gage network coupled with National Weather Service weather forecasts and radar rainfall measurements. Any early-warning system should be coordinated with existing county and flood district facilities.

An evaluation of the effectiveness of hillslope and channel mitigation approaches focused on the ability of different treatment methods to decrease the potential volume of debris flows (deWolfe, 2006; deWolfe and others, 2008). This work found that extensive applications of treatments that promote rainfall infiltration into hillslopes combined with engineered works that control incision in low-gradient channel reaches can effectively mitigate debris-flow impacts in basins less than about two km^2 in area that are expected to produce debris-flow volumes of less than 10,000 m^3. Large engineered check dams or collection basins are necessary to effectively mitigate hazards posed by events from basins larger than about two km^2 that are expected to produce debris-flow volumes greater than about 10,000 m^3 (Hungr and others, 1987; Fiebiger, 1997; Okubo and others, 1997; Heumader, 2000; deWolfe, 2006).

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