



# QUICK RESPONSE REPORT

## Public Awareness and Perceptions of Landslide Hazards after a Major Debris-Flow Episode in Glacier National Park, Montana

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*The views expressed in the report are those of the authors and not necessarily those of the Natural Hazards Center or the University of Colorado.*

### Introduction and Background

A large debris flow, referred to as a “rockslide” in the local media, blocked the Going-to-the-Sun (GS) Road in Glacier National Park, Montana, USA (Figure 1), in the early morning hours of August 21, 2004. The debris flow, reported by a visitor who was driving through the area when it occurred, measured about 30 meters wide and 4-5 meters deep in some places. The flow deposited tons of rocky-to-muddy debris on the surface of GS Road (Figure 2), completely destroying portions of the road surface. The flow also blocked Haystack Creek, causing the creek to flow over the road and leading to additional road damage. The visitor sustained some vehicle damage but escaped without injury. GS Road was closed until August 25, 2004, while National Park Service (NPS) crews worked to clear tons of debris from the road surface.

**Figure 1.**



GS Road is the only route through the center of Glacier National Park. It is an historic route and landmark and attracts over 1 million visitors per year, with the majority arriving during the summer tourist season. The two-lane road is narrow and winding and clings to steep mountain slopes in its upper reaches (Figure 3). The closure of GS Road, which links West Glacier on the west side of the Park to St. Mary on the eastern boundary (Figure 1), meant that visitors and NPS and concession employees located in St. Mary or West Glacier had to take a 160-kilometer detour (roughly 2 hours by vehicle) down the eastern side or around the southern end of the Park to reach the other side. The four-day road closure during the height of the summer tourist season also caused significant economic losses to the tourist-based businesses in St. Mary and West Glacier that are largely dependent on summer-season income.

Upon learning of the highway closures from my contacts in Glacier National Park, I traveled to West Glacier and St. Mary, with funding from the Quick Response Program of the Natural Hazards Research and Applications Information Center. The purposes of this study were to determine the level of Park employee knowledge of and reactions to a spatial hazard (debris flow) that does not occur in a specific geographic zone (i.e., the way snow avalanches do within demarcated and mapped snow-avalanche paths). Both governmental (U.S. NPS and U.S. Geological Survey) employees and staff members who work for business concessions operating tourist facilities within and adjacent to the Park were surveyed to compare how governmental versus non-governmental employees understand and deal with the local debris flow hazard. Specific goals were to obtain standard demographic data on surveyed respondents and to collect data on the following questions:

- What was the general knowledge base concerning landslide hazards and landslide frequency amongst the surveyed group?
- What were the individuals' reactions to the recent debris flow activity and road closure, and how were they affected by it?
- How did local residents gather information necessary for decision-making during times of high debris flow danger?
- How were driving habits affected by debris flow activity?
- What actions (if any) did residents believe should be taken by the state or U.S. federal governments to increase debris flow awareness?

Data analysis included a comparison of the survey responses to those compiled in response to a 1996 episode of snow-avalanche closure of nearby U.S. Highway 2 (Butler, 1997).

**Figure 2.**



**Figure 3.**



## Methods and Sample Size

Personal interviews were conducted and individuals were asked to complete written surveys in West Glacier and St. Mary, Montana (on the western and eastern termini of GS Road, respectively), on September 2-4, 2004. Approximately 60 individuals were approached and asked to complete a survey. The survey was a slight modification of the one used by Butler (1987, 1997) in an examination of resident knowledge of and response to the snow-avalanche hazard along the southern boundary of Glacier National Park. This modification was simply a replacement of the term "snow avalanche" with "landslide," the term used for the debris flow in local media reports. Several individuals did not wish to have their opinions formally recorded, but many of these graciously provided oral, anecdotal information that informed our perspectives. A total of 43 written surveys were completed. Of these, 32 were collected in West Glacier, where a larger population of workers was available, over a period of two days, and 11 were collected in St. Mary on one day. Oral interviews with long-term residents in both West Glacier and St. Mary provided extensive additional insight into our survey results.

The survey questions completed by the 43 respondents may be grouped into four primary categories: sample group characteristics, knowledge of the debris flow hazard, reactions to the debris flow hazard, and information gathering and awareness in the hazard zone, including attitudes about the role of governmental agencies in providing hazard information. A copy of the complete survey is provided in Appendix 1.

## Sample Group Characteristics

Results of the general demographics of surveyed individuals are illustrated in Tables 1-3. The majority of the survey respondents in West Glacier were U.S. federal government employees. Those employees may typically be dichotomized into two groups: career NPS professionals who transfer frequently in their careers in order to advance within the agency, and local residents who work for the NPS but are not in the "professional hierarchy" that is involved in advancing within the agency. Individuals in this category include mechanics, road equipment operators, office staff, and related service positions. The difference between the two types of federal employees in West Glacier accounts for the relatively low number of years in residence, and the high standard deviation reflects the long-term residence of the other subgroup. In St. Mary, a similar but even more pronounced dichotomy was illustrated in Table 1. Respondents were either permanent residents of St. Mary or temporary summer employees (usually college or foreign-exchange students).

Table 2 illustrates that the vast number of individuals surveyed were Caucasian, that a few more women than men completed surveys in both West Glacier and St. Mary,

and that the average respondent in West Glacier was nine years older than in St. Mary. The latter result is attributable to the student worker segment of the St. Mary sample, and the high age standard deviation there shows the dichotomy between these young respondents and long-term, permanent residents of St. Mary. One of the 11 respondents in St. Mary was a member of the Blackfeet Indian Tribe (St. Mary lies outside the National Park boundary and within the adjacent Blackfeet Indian Reservation).

All but 2 of the 43 total respondents had at least a high school education, and the overall population on both sides of the Park was well educated (Table 3). The higher percentage of respondents with post-graduate education in West Glacier is a reflection of the education requirements associated with local management and scientist positions within the NPS.

### **Knowledge of and General Attitude Toward the General Debris Flow Hazard**

Few survey respondents had experience with landslides or debris flows prior to the August 2004 episode (Table 4), with 75% and 90% (West Glacier and St. Mary) indicating that they had very little to no experience with landslides. Despite this lack of direct experience with the landslide hazard, the survey group collectively correctly identified (63% of respondents, Table 5) that the frequency of landslides/debris flows on GS Road was several times per year. However, only 20-23% of respondents (Table 5) believed the landslide/debris flow hazard on GS Road to be “very serious.”

### **Responses Related to the Debris Flow of August 2004**

Slightly more than one-third of the respondents were “very aware” that the meteorological conditions of August 2004 could generate landslides or debris flows (Table 6), and about half were “somewhat aware,” suggesting that the residents of both West Glacier and St. Mary are generally attuned to the natural environment and conditions that might produce hazardous mass movements. More than 90% of the West Glacier respondents and 80% of the St. Mary respondents were aware of the debris flow event and associated closure of GS Road, after its occurrence (Table 7). Nevertheless, less than one-third of the total respondents felt “directly impacted” by the debris flow incident, although a significantly higher number of West Glacier respondents felt impacted than did residents of St. Mary. This result probably reflects the differing employment situations of the two groups: West Glacier respondents were primarily federal employees directly involved with Glacier National Park and GS Road and may have been involved in travel on or clearance of the road; whereas the St. Mary employees were concessionaires not directly involved with the federal government or GS Road on a daily basis.

## **Driving Habits and the Landslide Hazard**

The majority of respondents on both sides of the Continental Divide (Table 8) only drive across GS Road once or twice a month, thus illuminating why many residents were aware of the debris flow event but did not feel directly impacted by it (Table 7). Twelve percent of West Glacier respondents drive across GS Road at least once a week, whereas none of the respondents from St. Mary do (Table 8), illustrating the differences in employment between the two sample groups – St. Mary employees were associated with site-specific, in-town jobs, whereas federal employees in West Glacier occasionally need to cross the Continental Divide for business in St. Mary.

Roughly half of both groups are willing to travel on GS Road at night, but substantially more West Glacier respondents will not travel at night if warnings have been posted that suggest landslides or debris flows may occur (Table 8). No daily newspaper exists in either St. Mary or West Glacier, but NPS employees in West Glacier receive a “daily report” that provides information about weather and road conditions on GS Road. This “daily report” may make West Glacier residents more aware of and more cautious within the landslide/debris flow-prone zone of GS Road.

### **The Role of Local Schools and Government Agencies in Hazards Education**

Residents on both sides of the Park are uninformed as to whether their local public schools do an adequate job of providing information about landslides and landslide hazards in the local area (Table 9). Only a minority of respondents from either village believes it is the government’s job to improve awareness of the landslide hazard in the area (Table 10); however, ten percent more respondents in both groups felt it was appropriate for the federal government, rather than the state of Montana, to undertake any such awareness improvement.

### **Discussion and Comparison with Snow-Avalanche Survey Results**

The overall demographic make-up of the debris-flow survey respondents was similar to those reported in the snow-avalanche hazard zone by Butler (1997), although the current group had more female respondents. As in the snow avalanche survey (Butler, 1997), respondents generally had either lived in the area a relatively short time or for well over 15 years (essentially had lived there most of their lives). Caucasians dominated both sample groups. The education level of the current sample was higher than the snow-avalanche survey group.

Self-reported personal “level of experience” with snow avalanches was considerably higher than with the current group’s self-reported experience with landslides and debris flows. The snow-avalanche survey group was drawn from a village along U.S. Highway 2 on the south-

ern border of Glacier National Park, and that village is frequently isolated by avalanche-caused highway closures (Butler, 1987, 1997; Sawyer and Butler, 2006).

When asked about the frequency of hazard occurrence, the current sample group identified the hazard frequency more correctly than did respondents concerning snow-avalanche hazards in the area. This may be a reflection of the employment categories of West Glacier respondents (i.e., federal government employees versus avalanche-hazard respondents who were primarily drawn either from workers in a local hotel along U.S. Highway 2 or railroad workers in the local rail yard).

A substantially greater number of avalanche-hazard respondents (74%) reported experience with a snow avalanche than did landslide-hazard respondents (Table 4). This dichotomy reflects the limited driving of current-group respondents through the landslide hazard zone, whereas avalanche respondents frequently needed to drive through the known avalanche-hazard zone. Avalanche respondents were also significantly more likely to drive through the hazard zone at night (38% responded "several times per week," compared to a combined total of only 6% of the current group). Many of the avalanche respondents were laborers for the local railroad, so their daily journey from home to work took them through the avalanche hazard zone area. Avalanche-hazard respondents also drove through the avalanche hazard zone at night in substantially larger numbers than debris-flow respondents through the landslide zone (68% vs. 48% of total). Avalanche-hazard respondents were also significantly more likely (49%) to travel through the avalanche hazard zone both day and night if warnings existed than were debris-flow respondents (only 14% of the total, and only 7% in West Glacier). This may reflect the greater site-specific nature of the snow-avalanche hazard, where avalanches occur within well-demarcated avalanche paths, versus the debris-flow hazard zone where debris flows may occur anywhere within a broad geographic stretch of GS Road. Alternatively, however, it may simply reflect the necessity for residents of the avalanche-hazard zone to travel farther for shopping and other activities than is necessary in West Glacier or St. Mary.

## Summary and Conclusions

Thousands of debris flows occur in the United States each year, but little is known about public knowledge of debris flow hazards, the effects of living in a debris-flow prone landscape on driving decisions, and resident beliefs about the role of state or federal government in increasing awareness of the hazard. The August 2004 debris flow on GS Road in Glacier National Park blocked access across the Park for four days during the height of the tourist season and offered an opportunity to advance our knowledge of debris-flow hazards knowledge, decision making, and responses. Results from this study were compared to those from a previous Quick Response Grant examining public

knowledge and reactions to snow-avalanche hazards in the same general area. Although sample group demographics were similar in the two studies, avalanche-hazard zone residents were more likely to find it necessary to drive through the hazard-prone region than were those in the debris-flow zone. The avalanche survey group had a less accurate understanding of avalanche frequency than did the debris-flow group, but greater experience with the hazard itself.

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## References

- Butler, David R., 1987. Snow-avalanche hazards, southern Glacier National Park, Montana: the nature of local knowledge and individual responses. *Disasters* 11(3), 214-220.
- Butler, David R., 1997. A major snow-avalanche episode in northwest Montana, February, 1996. Natural Hazards Research and Applications Information Center Quick Response Report #100, Boulder, Colorado, October 1997.
- Sawyer, Carol F., and David R. Butler, 2006. A chronology of high-magnitude snow avalanches reconstructed from archived newspapers. *Disaster Prevention and Management* 15(2), 313-324.



## References

Greene, R.W. 2002. *Confronting catastrophe: A GIS handbook*. Redlands, CA: ESRI Press.

Thomas, Deborah S.K., Susan L.Cutter, Michael Hodgson, Mike Gutekunst, and Steven Jones. 2002. *Use of spatial data and geographic technologies in response to the September 11 terrorist attack*. Quick Response Report 153. Boulder, CO: University of Colorado Natural Hazards Center. <http://www.colorado.edu/hazards/qr/qr153/qr153.html>.



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