Mount Everts debris flow and damming of the Gardner River on 21 July 2008
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Mount Everts Debris Flows and Damming of the Gardner River on 21 July 2008

FIGURE 1: Photograph of Gardner River flowing through a pinch caused by the 21 July debris flow. This flow was triggered by high precipitation rates in a 15 minute-interval. Notice that the mud reached the opposite bank of the river. This debris flow is suspected to have temporarily dammed the Gardner River. Photograph taken 25 July 2008.

YELLOWSTONE NATIONAL PARK
GEOLOGY
Safety • Protection • Education • Monitoring

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Executive Summary

Intense precipitation on 21 July 2008 triggered debris flows from Mount Everts. Based on past research and observations it is known that a rain fall event that drops 1.016cm (0.40in) or more in a 15 minute-interval, has caused debris slides to occur along the flanks of Mount Everts (Jaworowski & Heasler, 2006). The precipitation during the 21 July rain event dropped 1.016cm (0.40in) in one 15 minute-interval and continued to drop another 0.889cm (0.35in) in the preceding 15 minute-interval. With this rainfall occurring in such a short time period two debris flows came down Mount Everts and temporarily dammed the Gardner River. On 23 and 25 July 2008 YNP Geology Volunteers photo-documented the area and mapped debris flows that dammed the Gardner River.

Introduction

On the evening of the 21st of June 2008, a rain event dropped just over 3.048cm (1.2in) of water in approximately one hour. The rain storm caused major debris flows in the Mammoth Hot Springs area of Yellowstone National Park. At least two major debris flows occurred along the Gardner River. Based on field observations, two debris flows are known to have temporarily dammed the Gardner River.

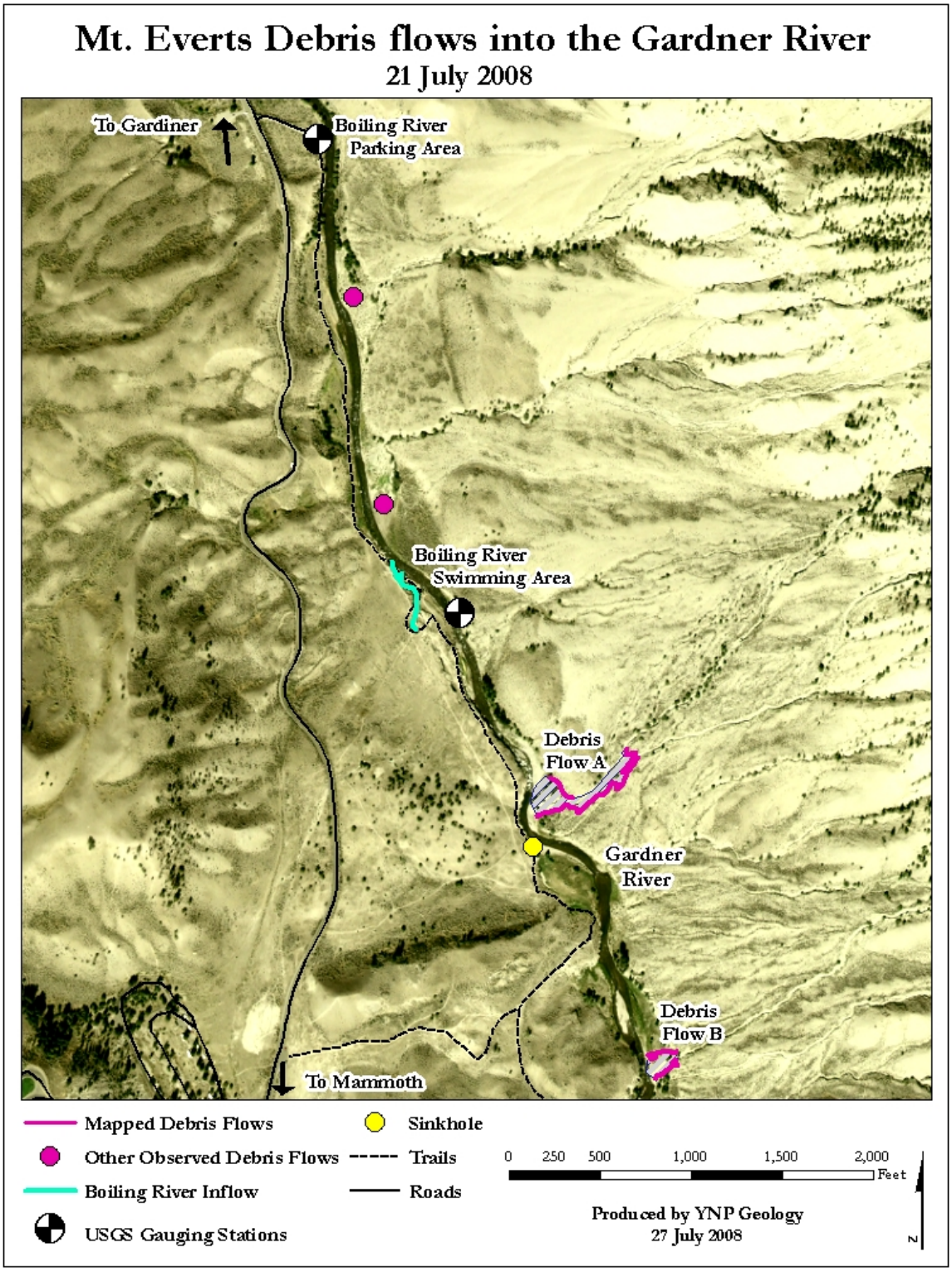
Natural color aerial photographs (Maps 1and 2) show debris flows forcing the Gardner River toward its west bank. The 21 July rain event caused new debris flows to enter the Gardner River at this location labeled debris flow A (DFA) and at a second location near the Lava Creek Bridge labeled debris flow B (DFB). These two major debris flows formed mud dams and blocked the Gardner River upstream of the swimming area.

Methodology

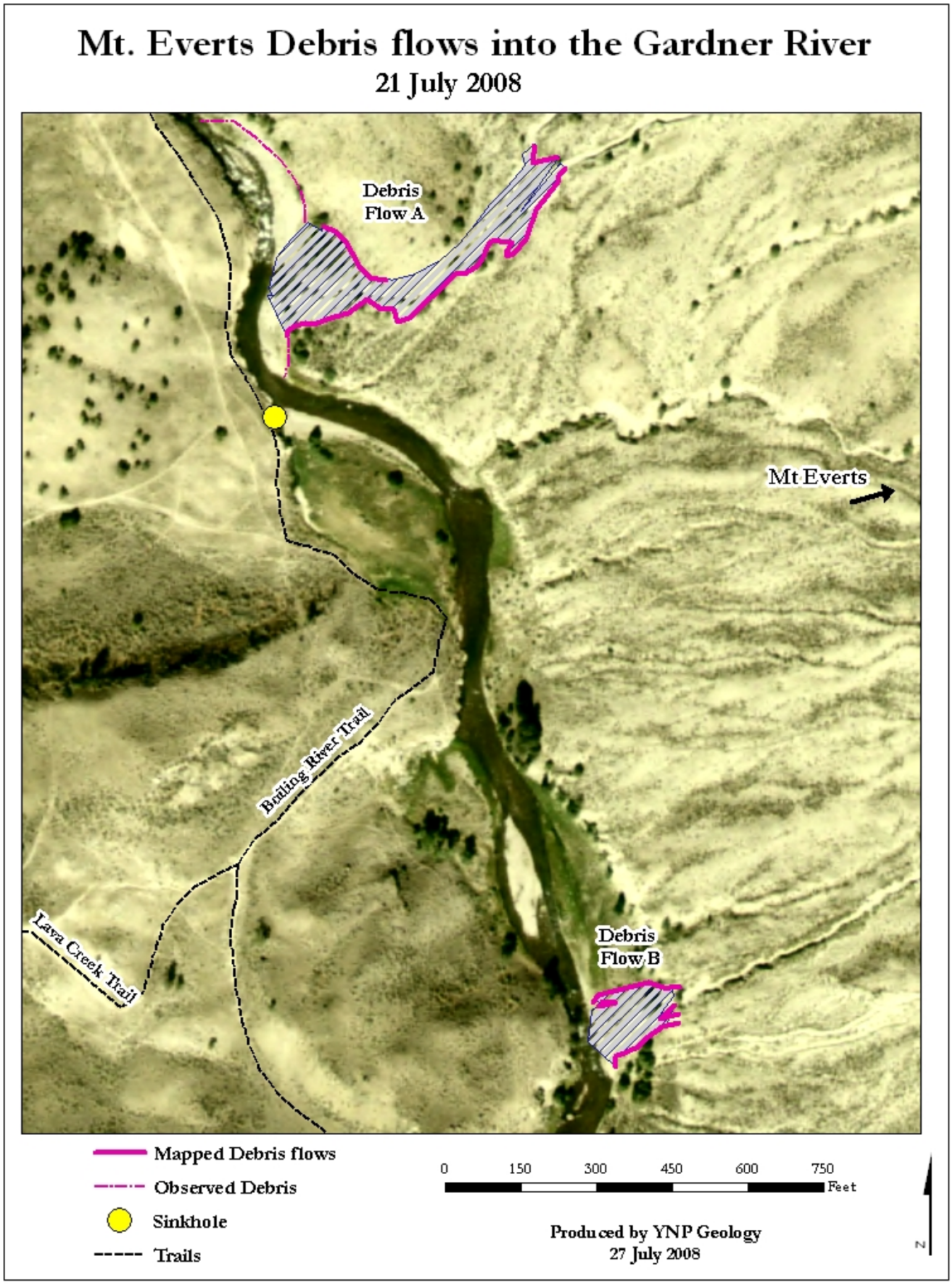
Yellowstone National Park geology personnel examined the area on 23 July and 25 July 2008 to photo-document the effects of the 21 July rain event and map the debris flows triggered by intense rains. A Trimble ProXH GPS receiver with a Zepher antenna provided accurate location of the debris flow boundaries, the gullies the mud flowed through, and the debris fan into the Gardner River.

Data and Observations

Temperature, discharge data and gage height show the effects of 21 July rain event and the temporary mud dams along the Gardner River. Before the 21 July rain event, the average discharge of the Gardner River was 5776.64 L/s (204cfs). During the 21 July rain event, the Gardner River rapidly increased flow from 8070.30 L/s (285cfs) to approximately 14158.42 L/s (500cfs) (Figure 3). Stream gage data show changes in water depth (from 0.677m (2.22ft) to 0.789m (2.59ft)) of the Gardner River related to 21 July rain event and mud dams along the river (Figure 4).



Map 1: Natural color aerial photograph (2004-2006) showing recent and previous debris flows on the flank of Mount Everts. Pink areas show locations of recent debris flows from the 21 July rain event.



MAP 2: Natural color aerial photograph (2004-2006) showing mapped debris flows on the flank of Mount Everts. Pink lines show locations of recent debris flows from the 21 July rain event. Notice how the debris flows push the Gardner River towards its west bank.

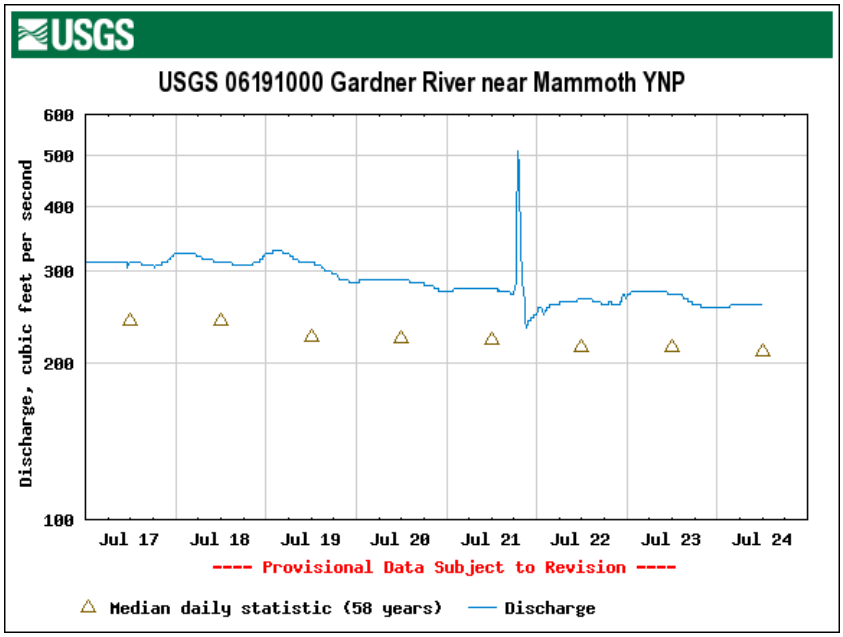
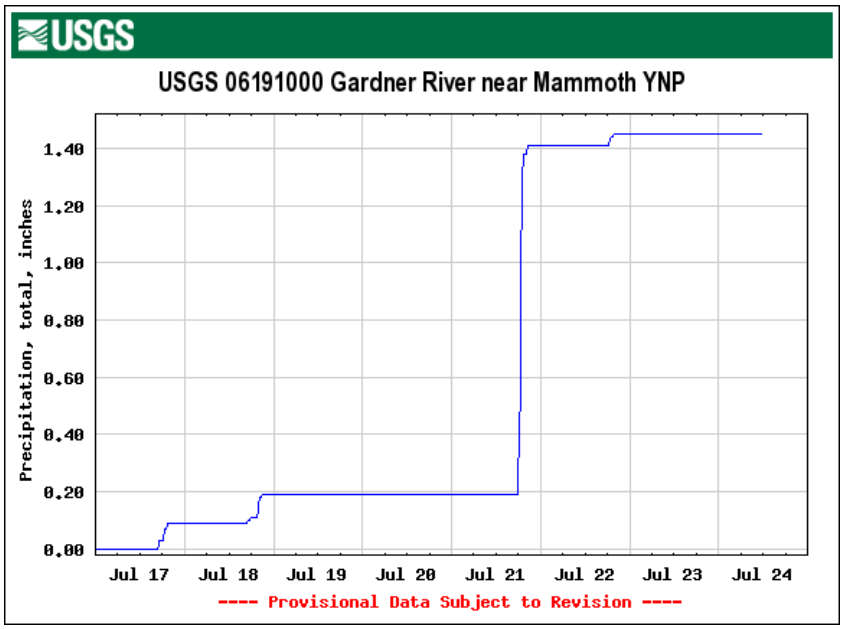


FIGURE 3: Graph of discharge data for the Gardner River. Note the rapid rise in discharge associated with the 21 July rain event. After the rapid rise in discharge, there is a decrease in discharge associated with the temporary damming of the Gardner River.



FRIGURE 4: Graph of gage height for the Gardner River. Note the general decrease in gage height from 19 July to 25 July. The gage height rises on 21 July but decreases on 22 July. The decrease in gage height probably relates to mud dams along Gardner River.

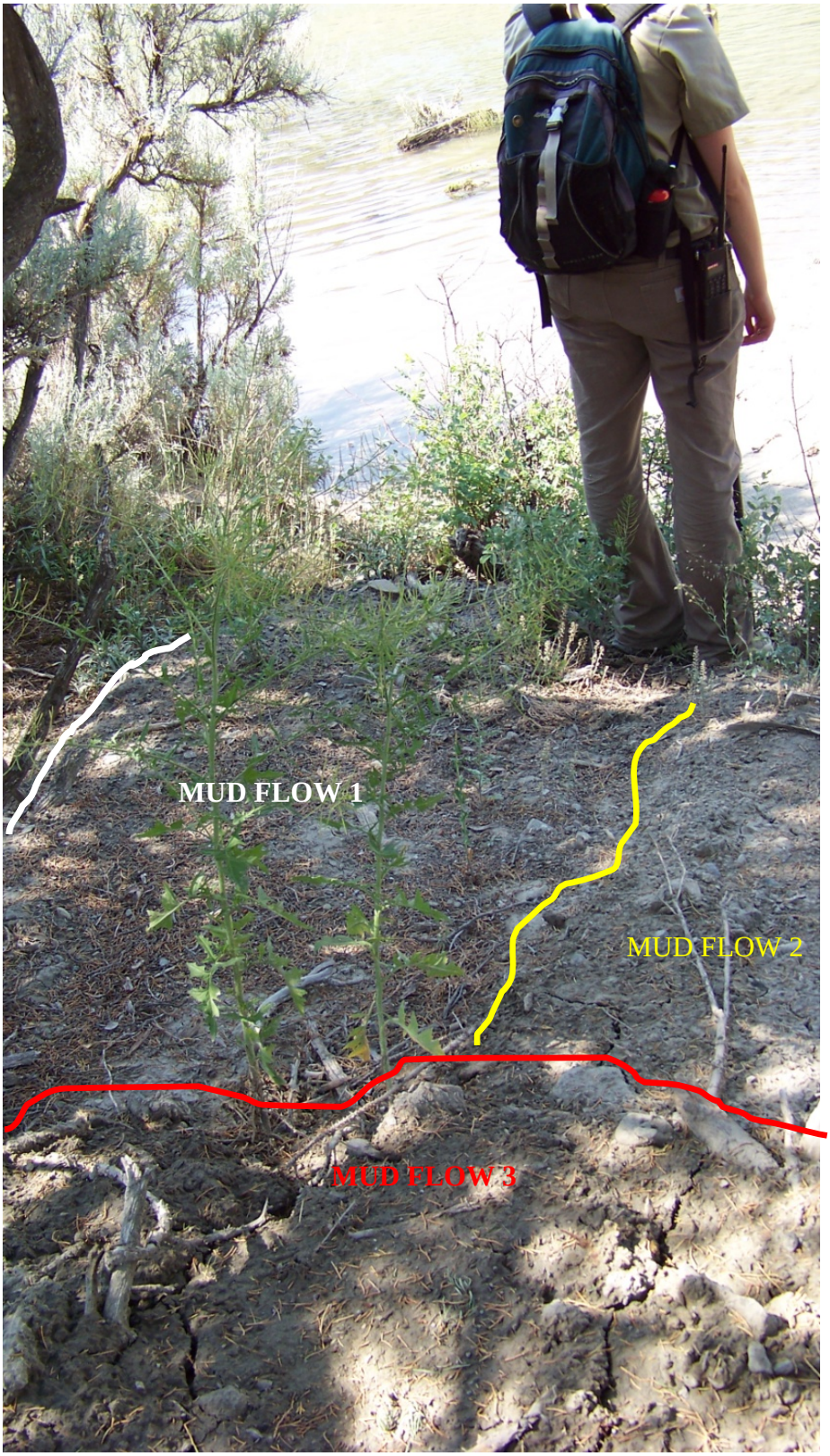
Intense precipitation on the evening of the 21 July dropped about 3.048cm (1.2 inches) of water over a period of one hour. Precipitation data from the Gardner River gage showed two periods of intense rain: at 18:45Mountain Daylight Time (MDT) the rain gage recorded 1.016cm (0.40in) over a 15 minute-interval and at 19:00 MDT the rain gage recorded 0.889cm (0.35in) over a 15 minute-interval. Based on previous investigations on Mount Everts debris flows, it is known that intense precipitation greater than 1.016cm (0.40in) over 15 minute-intervals triggers debris flows along the flanks of Mount Everts (Jaworowski & Heasler, 2006). Precipitation on 22 July (0.127cm/hr or 0.05 in/hr) and 24 July (no substantial rain recorded) did not trigger any debris flows. These debris flows rushed down the gully with such intensity they breached the levees of the gully and piled mud high along the edges and the mud flowed out as lobes for up to 8 meters (Figure 7). In one case closer to the base of Mt. Everts, a large lobe flowed out about 15 yards from the over taken levee of a 10 meter deep gully. The intensity of these debris flows ripped branches from trees (Figure 8) and completely removed trees leaving only a short stump of splintered wood (Figure 9). Along the upstream edge of the DFA older debris flows can be seen (Figure 10). These debris flows show an active history, at least for DFA, in slowly constricting the Gardener River (Map 2).

The intense rain event of 21 July also allowed for flowing water, not associated with the debris flows, to wash down through the alluvial bench of Mt. Everts. This water flattened tall grasses (Figure 11) and brought down a mummified carcass of an elk, tangled in small branches and grasses (Figure 12). This body was seen amongst the trees on the upstream side of DFB. Another carcass of a pronghorn, was found stuck in the roots of a small tree, upstream and on the opposite bank of the Gardner River of DFA. This carcass may not have been washed down with the rains but was observed during the first visit to the site on 23 July.

FIGURE 7: Photograph of DFA, taken 30 July 2008 facing north. Lighter brown is mud that overtook the levees of the gullies. Larger lobe of mud flowing out over the alluvial fan

Figure 8: Photograph of low hanging branches torn off the trees by 21 July debris flow at DFB. Taken 25 July facing Gardner River, west.

Figure 9: Photograph of splintered wood from trees removed by the debris flow at DFA. Taken 25 July facing west, Gardner River in background.



FIRGURE 10: Photograph at edge of DFA. Note three debris flows, debris flow 3 is the most recent from the 21 July event. This photo shows how the debris flows accumulate overtime. Taken 25 July 2008 facing south west, Gardner River in background.

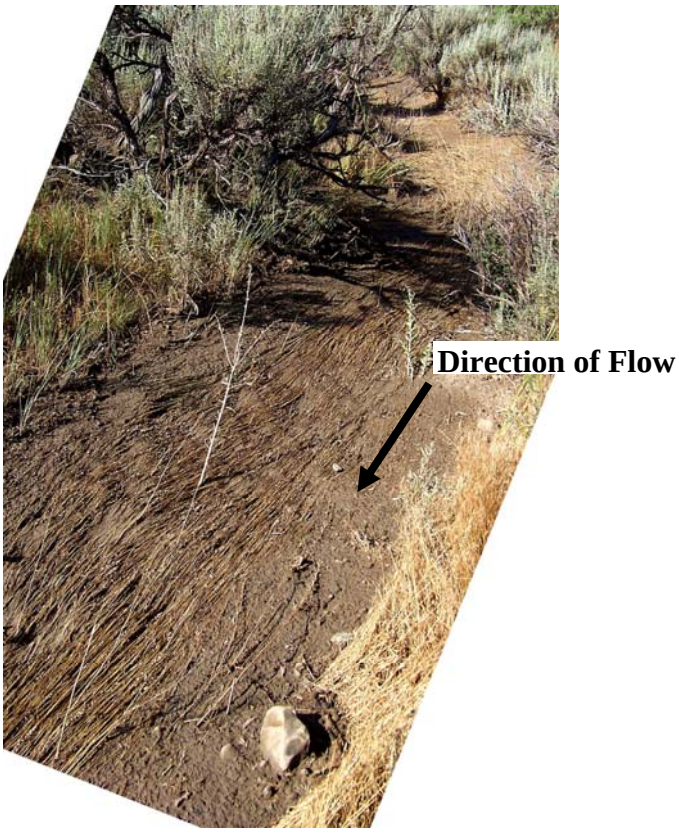


FIGURE 11: Photograph of tall grasses matted down by high water flow from the 21 July rain event. Taken 25 July facing Mt. Everts, northwest.

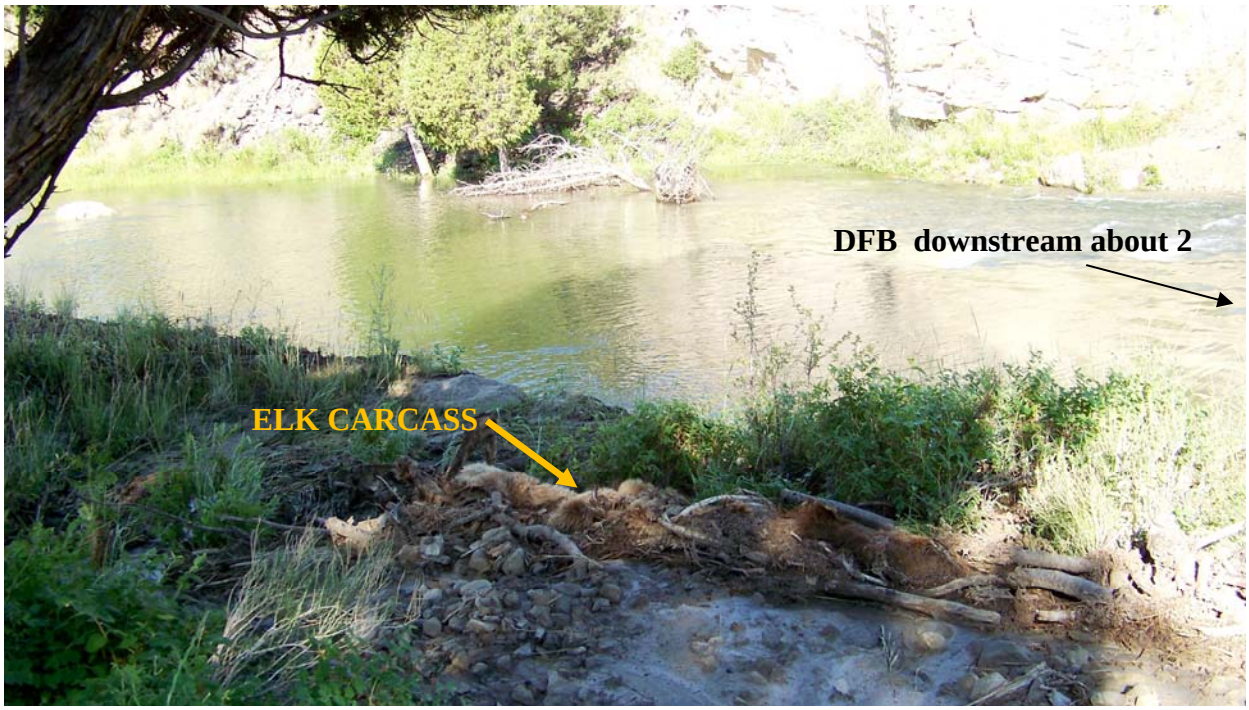


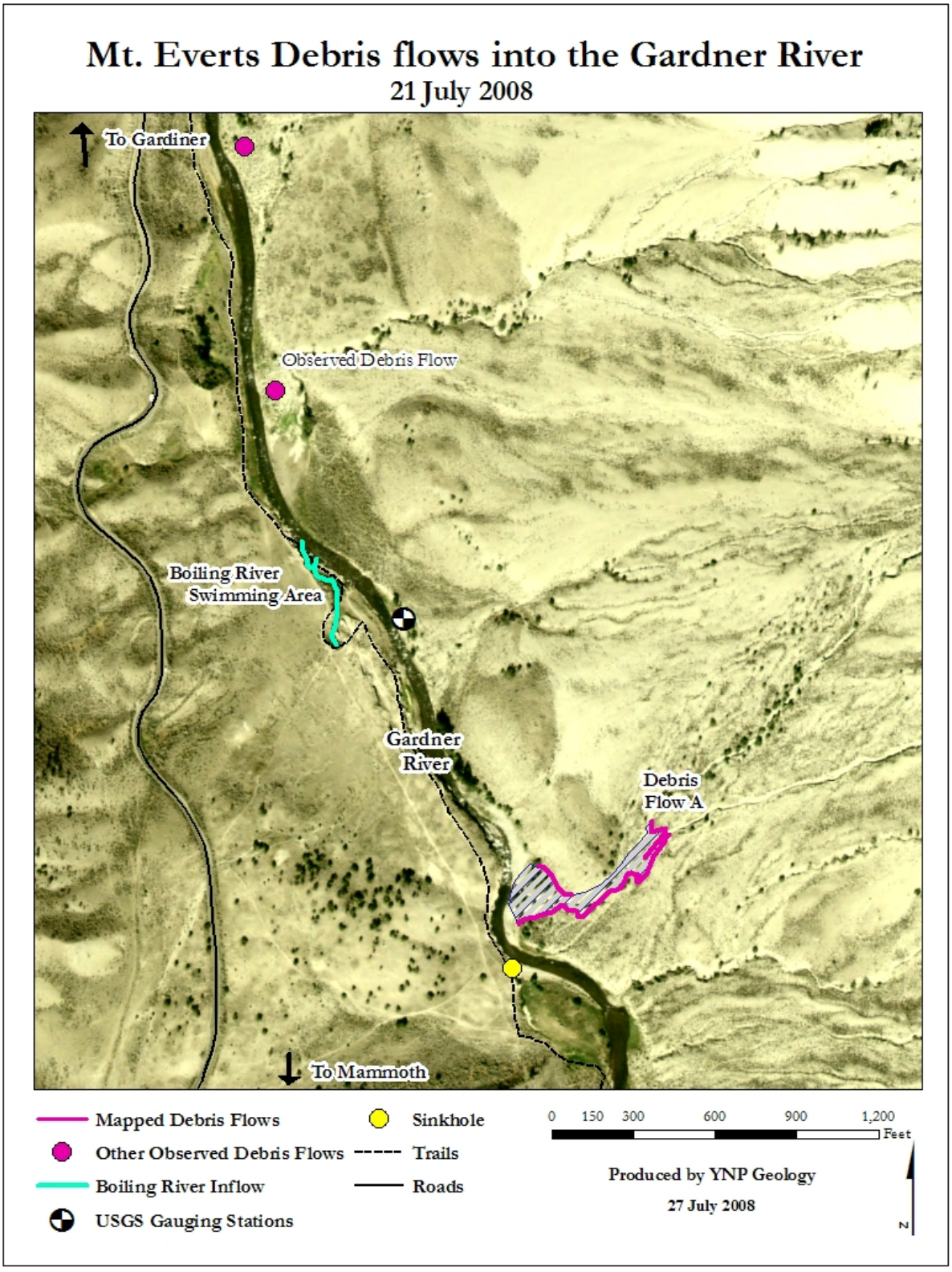
FIGURE 12: Photograph of elk carcass brought down by flowing water, just upstream from DFB. Taken 25 July facing west, Gardner River in background.

Gullies along Mount Everts transport mud and water triggered by intense precipitation over 1.016cm (0.40in) per 15 minute-interval, these gullies are fed by drainage channels coming from Mount Everts (Figure 14). Figure 15 shows two gullies of DFAs outflow converging into a single gully. Figure 8 shows the same gully further down river just before it empties into the Gardner River. These gullies that transported the debris and mud were extremely variable in depth; however, all the gullies became shallower as they neared the river's edge (Figures 17 and 18). Each of the two debris flows had two contributing gullies which converged about 60m (196.85ft) from the river's edge. In each case the gully further upstream, to the east, was the shallower of the two. DFB had a deep gully of about 7-8m (23-26ft) and a shallow gully of about 0.5-4m (1.64-13ft). The gully that empties into the Gardner River was at its deepest 7-8m (23-26ft) deep. DFA had a 5m (16.4ft) deep gully and a shallower gully of about 2-3m (6.56-9.84ft). The gully that emptied into the Gardner River was at its deepest about 3m (9.84ft). The mud from these gullies flowed across the Gardner River and deposited mud along the river's west bank (Figures 19 and 20). The debris exiting out of this gully (Figure 21) constricted the flow of the Gardner River and caused ponding (Figure 22) of the Gardner River upstream from the Boiling River outflow. DFB also deposited mud on the east bank of the Gardner River and constricted its' flow, momentarily ponding the water (Figure 24). At both locations, the depth of the debris on these banks ranged from approximately 15.24cm to 30.48cm (6-12in).

Gardner River occupies a deep ravine in Cretaceous sandstone shale that does not allow for much variation in the rivers path. Aerial photographs show little change in the meandering of the river (Figure 25) from 1969 to 2006. The areas of the river pinched by debris flows seen in Maps 1 and 2 are also seen in the digitized outline of the Gardner River and Mt Everts drainage pattern from a 1969 photograph and the 2006 photograph (Figure 26). The debris flows in the area have been able to build up over the years due to the consistency of the drainage channels from the runoff of Mt Everts. This consistency with the drainage channels and the lack of divergence of the rivers' path, allows for annual debris slides to accumulate. The accumulation of this debris causes the pinching in the Gardner River, a possible slow creep toward a permanent dam.

Discussion

Debris flows off the south flank of Mount Everts were triggered by substantial rain fall on the evening of 21 July 2008. USGS rain gages located at the Gardner and Boiling Rivers recorded the rain event beginning at 18:00 MDT and lasted approximately 1 hour and 15minutes. The intense rains that dropped the 1.016cm (0.040in) and 0.0889cm (0.35in) in two 15 minute-intervals, began at 18:45 MDT. The total precipitation dropped by this one rain event over the hour was about 3.048cm (1.2in) (Figure 4). The mud from the two debris flows that entered the Gardner River, upstream of the Boiling River outflow, extended across the river causing temporary dams to form (Figures 19 & 23). This temporary damming can be seen on the discharge data recorded by the USGS gauging stations at the Gardner Rivers (Figures 3 & 6). Because of the damming water backed up along Gardner River causing ponding. On 23 July the ponding behind DFA was still present (Figure 22).



MAP 3: Natural color aerial photograph (2004-2006) showing mapped debris flows on the flank of Mount Everts. Pink dots mark observed debris flows from the 21 July rain event. The one marked Observed Debris Flow possibly momentarily obstructed the flow of the Gardner River.

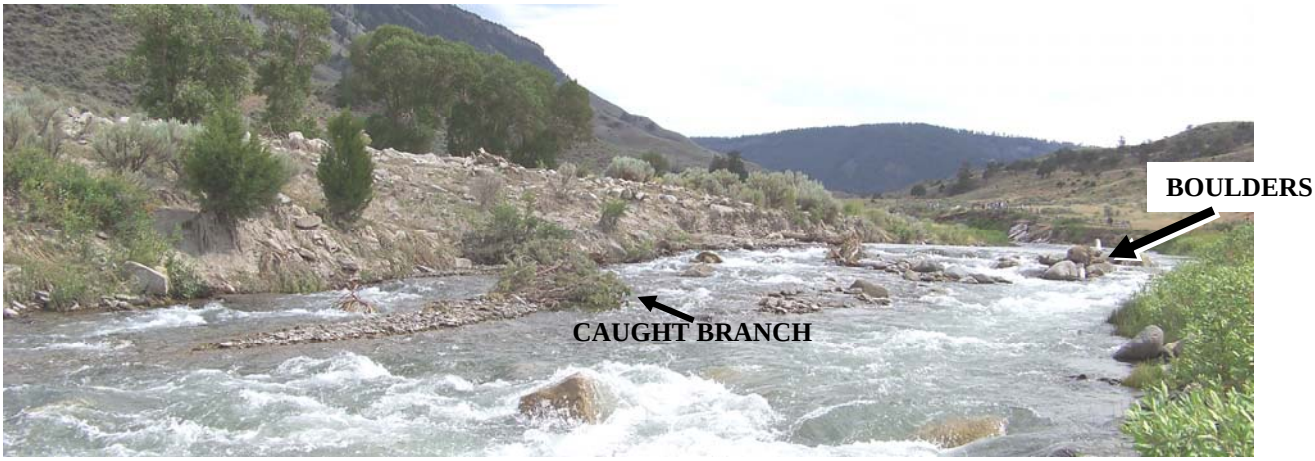


FIGURE 13: Photograph of Observed Debris Flow (ODF) downstream from Boiling River swimming area. Note the large boulders in the center of the river and the tree branch caught on the pile of smaller rocks in the river.

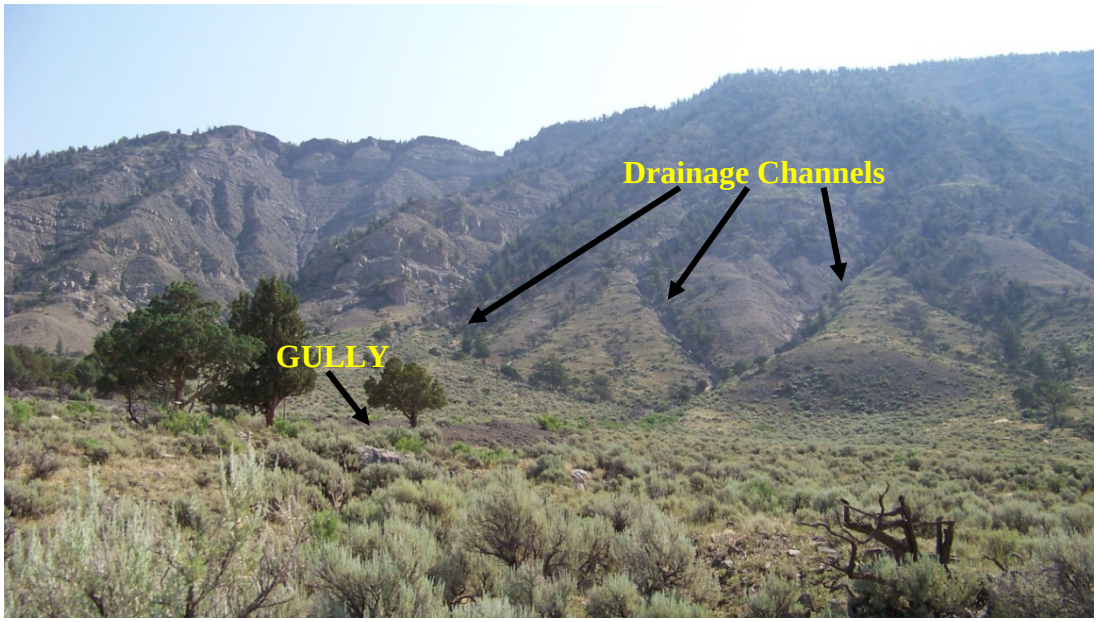


FIGURE 14: Photograph of tributaries from Mount Everts that brought mud into the Gardner River through Debris Flow A (DFA), downstream of Boiling River. Refer to Map 2 for the location of this debris flow. Photograph taken 25 July 2008, facing northeast toward Mount Everts.

FIGURE 15: Photograph of DFA gullies. This is one of the locations were the debris temporarily dammed the Gardner River on 21 July. Photograph taken 25 July 2008 facing north toward Mount Everts.

FIGURE 16: Photograph of DFAs gully that empties into the Gardner River, nearest Boiling River outflow and the Gardner River, downstream from Figure 7. The 21 July debris flow deposited dark brown mud on both sides of this gully. The dark brown mud is the zone of deposition and the pale brown mud shows the area of erosion. Photograph taken 25 July 2008, facing northeast toward Mount Everts.

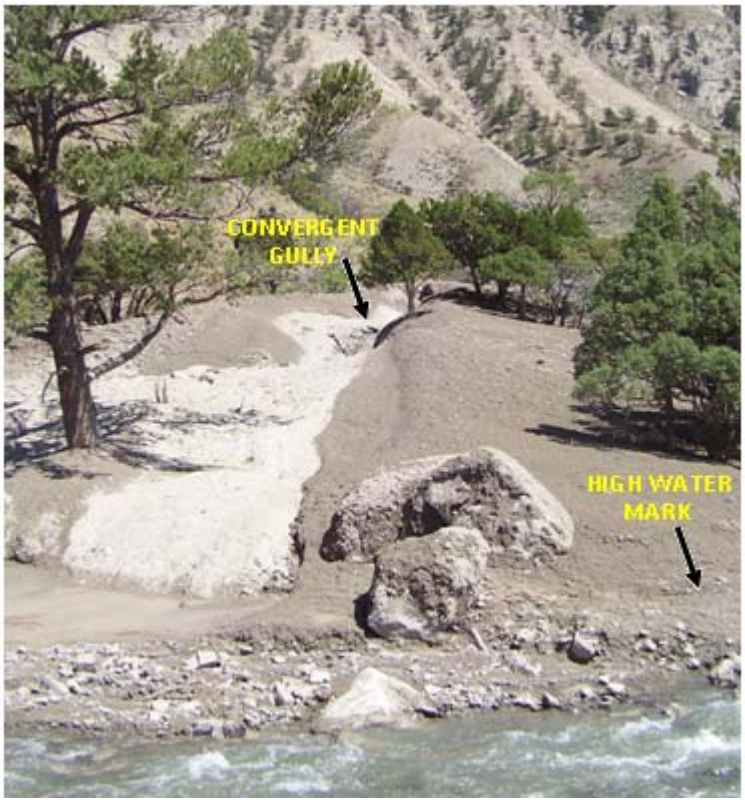


FIGURE 17: Photograph of DFA, taken on 23 July showing where 21 July debris flow entered the Gardner River, facing northeast toward Mount Everts.

FIGURE 18: Photograph of DFAs gully empting into the Gardner River. Photograph taken on 25 July facing east toward Mount Everts. This is one of the major debris flows that temporarily dammed the Gardner River.

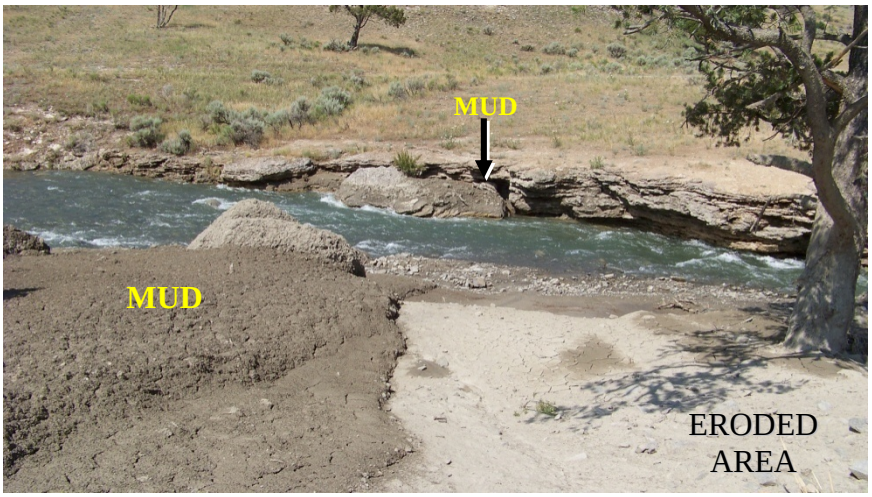


FIGURE 19: Photograph of DFA, facing west. Photograph taken on 25 July. Notice the mud on the west bank of Gardner River. This is the location of the one of the mud dams along the Gardner River.

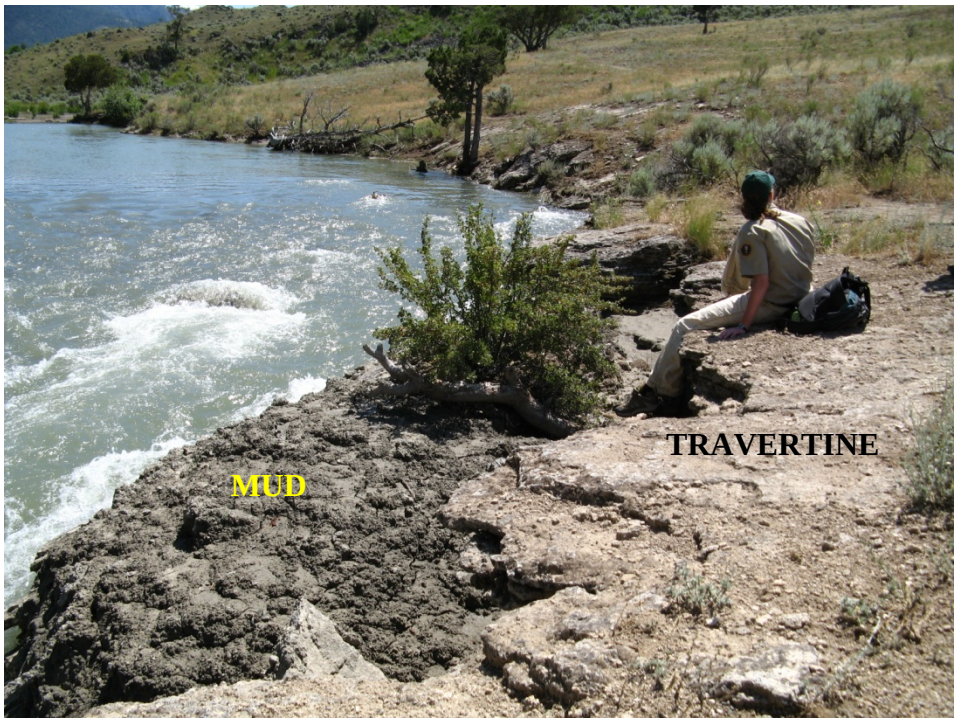


FIGURE 20: Photograph of DFA, facing south looking at west bank of Gardner River. Photograph taken on 23 July. Note the muddy debris surrounding currant bush. YNP Geology volunteer for scale.

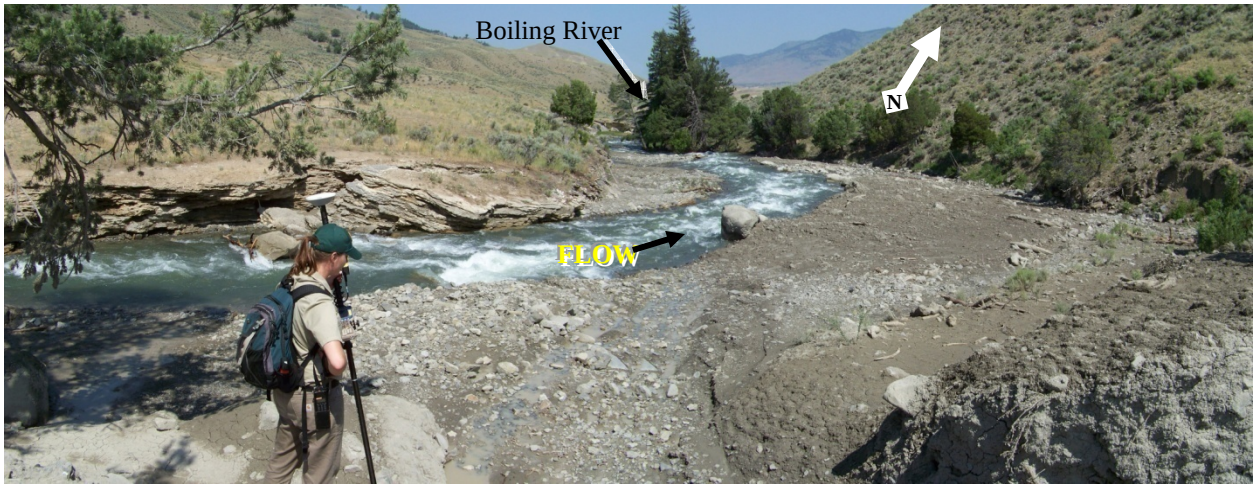


FIGURE 21: Photograph of DFAs gully's termination into the Gardner River. Recent debris flows along northeast bank of the Gardner River were deposited during the 21 July rain event. Photograph taken 25 July facing northwest.

FIGURE 22: Photograph of Gardner River upstream from DFA. Note the ponding of the Gardner River caused by the constriction of the river channel. Water level is raised about 1.5ft. Brown area is organic matter floating on water surface. Sink hole cannot be seen from photograph, arrow points to general location, see Map 2 for regional location. Photograph taken 25 July, facing east.

Debris Flow Near Lava Creek Bridge

FIGURE 23: Photograph of DFB, near Lava Creek Bridge. This is one of the locations were the debris temporarily dammed the Gardner River on 21 July. Notice mud on opposite bank. Photograph taken 25 July 2008, facing north.

FIRGURE 24: Photograph of high water mark along east bank of river, height is estimated about 0.46cm (1.5ft). Note debris from 21 July debris flow in foreground. Photograph taken 25 July 2008, facing east from the center of the debris fan.

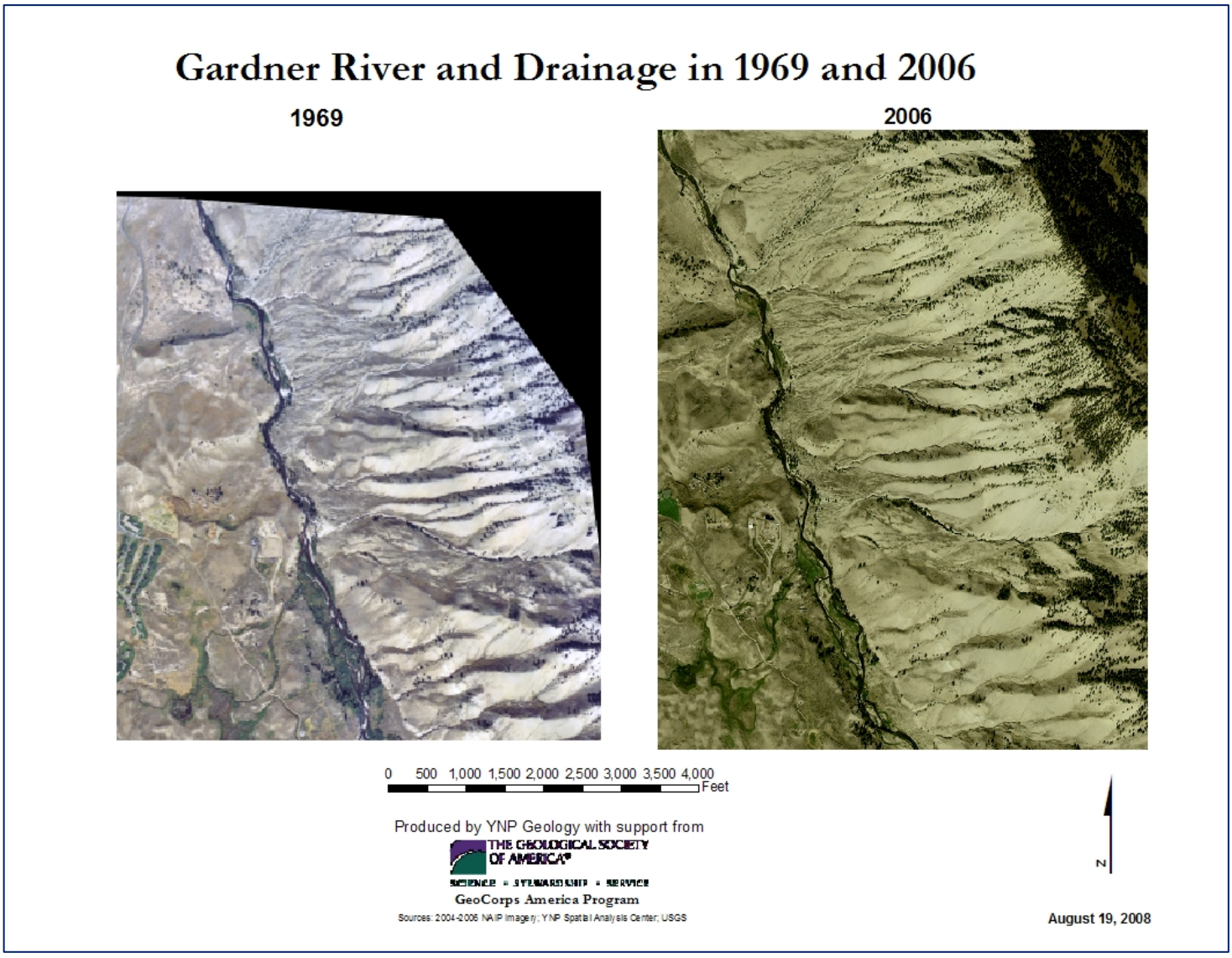


FIGURE 25: Aerial photographs of the Gardner River and the west flank of Mt Everts taken in 1969 and 2006. Note that there is very little change in the Gardner River's course and in the drainage pattern on the flank of Mt. Everts.

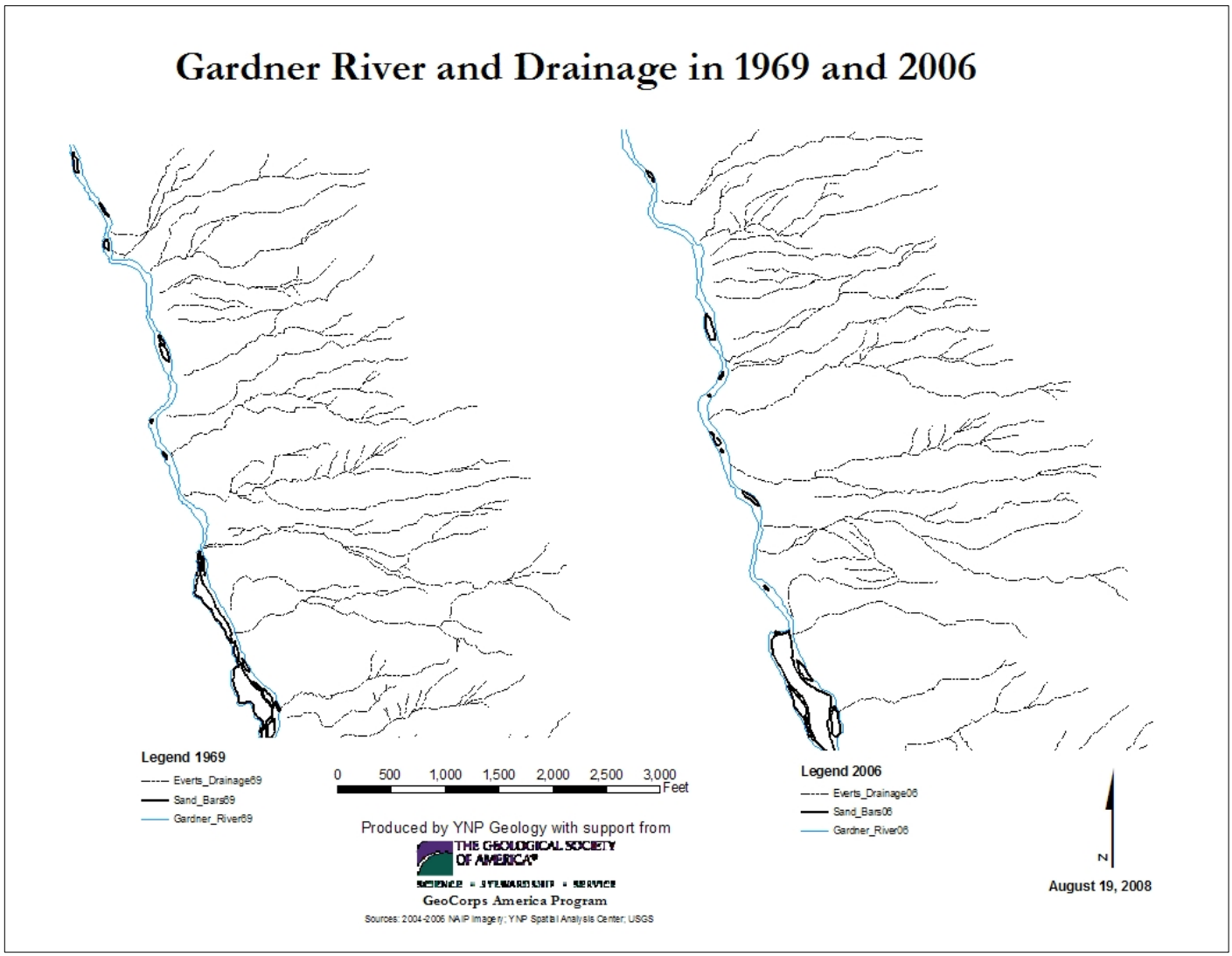


FIGURE 26: Map comparison of the Gardener River and Mt. Everts drainage channels from 1969 and 2006. Side by side the most noticeable change to the Gardner River is the movement of the unstable sand bars. The drainage pattern from Mt. Everts has remained very stable over the 37 years between taking the aerial photographs. Images digitized from aerial photograph 2006 and 1969.

References Cited

Jaworowski, Cheryl and Heasler, H.P., 2006, Gardiner River debris flow and the North Entrance Road, 6p