

How the Bircher Fire of 2000 Affected Erosion in Mesa Verde National Park

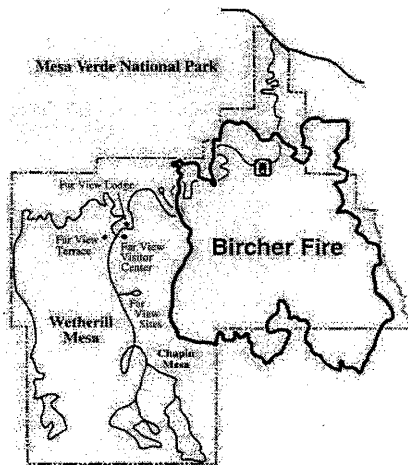
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Abstract

During the end of July and the beginning of August, 2000, the Bircher Fire burned 19,332 acres of land within the boundaries of Mesa Verde National Park. During the month of October, an erosion project was conducted along three burned drainages and one unburned drainage, all surrounding the Morfield Campground. This project consisted of multiple transects along each drainage as well as a sediment catchment at the base of each drainage. Results of this study show that erosion definitely increased within drainages found in the burned area as compared to the unburned study area. Because most of the erosion occurred in the form of rills from the hillslopes, with sediment being transported through the drainage path instead of incising of the drainage itself, future studies of the hillslopes might be more conclusive.

Introduction

During the summer of 2000 the Bircher Fire burned 23,220 total acres, 19,332 of which were within the boundaries of Mesa Verde National Park (Bircher Fire BAER Plan, 2000) (see Map 1). Subsequently, I conducted a research project within the Park in October and November of 2000. The purpose of this project was twofold: to provide data showing how much the Bircher Fire affected erosion within a portion of the Park, and provide data useful to Mary Gillam and Chris Wilbur, two



Map 1. Outline of Bircher Fire overlaid on a map of Mesa Verde National Park (Mesa Verde National Park, website.)

consulting geologists who are analyzing hazards of rock-fall, debris flow, and landslide reactivation within the Park.

The implications of this project are potentially many. Will it be possible after measuring erosion for one month in a limited portion of the park to extrapolate what the erosion will be in one year? Two years? What might the implications of this increased erosion mean to Park employees? What might this erosion mean in terms of artifacts? (The 1996 Chapin # 5 fire, which burned 4750 acres, uncovered 370 previously unknown archaeological locations [Mesa Verde National Park, website].) How might this erosion effect tourism at the Park?

Background/Previous Studies

Between January 1, 2000 and November 15, 2000, a total of 90,674 fires burned around the United States, consuming a total of 7,259,159 acres (National Interagency Fire Center, website). Within the state of Colorado alone, 2,096 fires burned a total of 126,745 acres. Two of these fires burned within the boundaries of Mesa Verde National Park; the Pony Fire and the Bircher Fire; burning an estimated 40% of the Park. These two fires are only the latest in a number of fires to burn within the Park in the last century. Major fires have burned in 1934, 1959, 1972, 1989, and the 1996 Chapin # 5 fire (Denver Post, website).

Although "scientific studies" have been done within Mesa Verde National Park on the latest two fires (Denver Post, website), these studies are not readily available. However, numerous studies have been done on fires and the subsequent erosion in other locations. In a study conducted in southern California by Florsheim and others, it was determined that up to 90% of the sediment found within a channel after the fire was derived from colluvium stored on

the hillslopes. This sediment traveled from the hillsides into the channel either from small debris flows, debris slides, or during a storm, by being transported in rills (Florsheim, 1991) (see Photo

1). Another study in California conducted by Booker found as little rainfall as 25mm per hour for a duration as short as 15 minutes was enough to cause significant hillslope erosion in small, steep basins after a burn (Booker, 1998). In New Mexico, Cannon and Reneau defined a number of factors influencing erosion after a burn. Of these factors, fire intensity and



Photo 1. Rills which formed along a hillslope.

extent of burned area, drainage basin morphology, and drainage basin lithology seemed to be the most important; with steep, poorly drained soils in drainages that experienced severe, extensive burns showing the most erosion (Cannon, 2000). Additionally, Cannon and Reneau found light material (pumice, ash, charcoal, and pine needles in their case) to “raft” down the hillsides during overland flow. Often this light material would form levees which lined the rills formed on the hillsides (see Photo 2). The passing surface water flows often cleared the light material from the surface with no incision, and these cleared paths would stop at the change in slope at the base of the hillsides (Cannon, 2000).

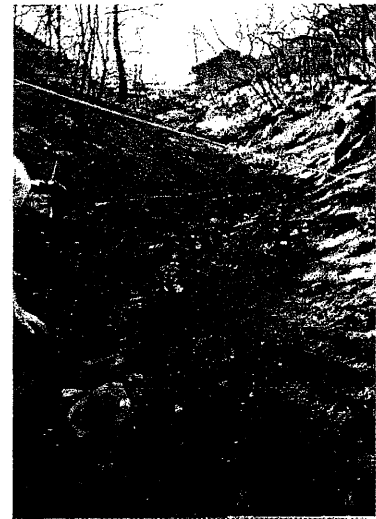
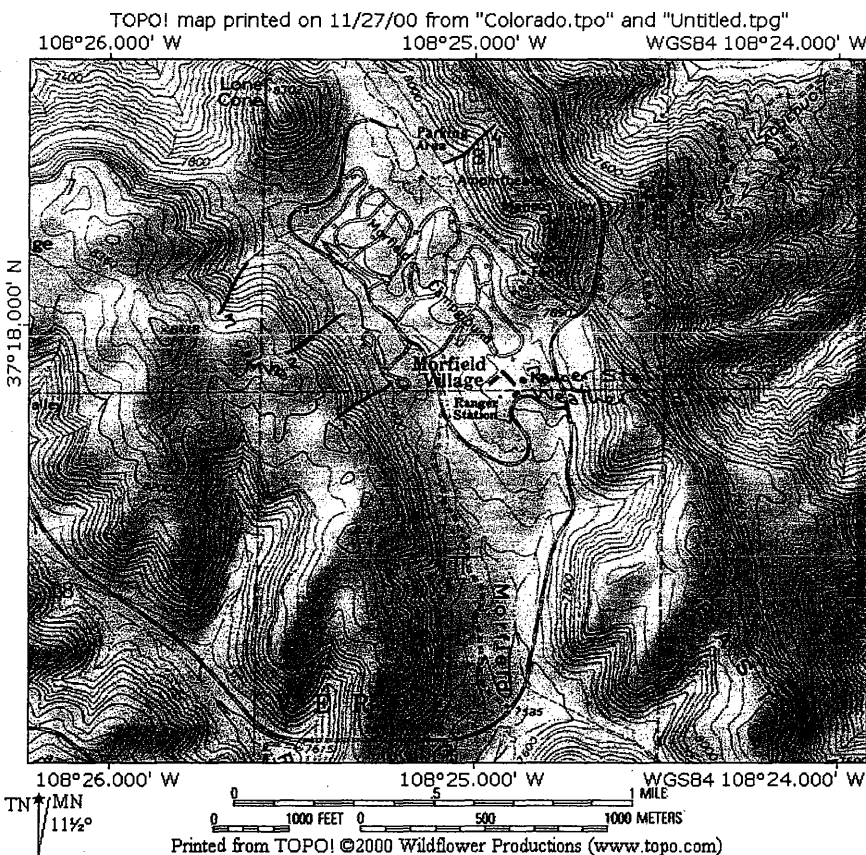


Photo 2. Levees formed from low density material surrounding a rill (looking up drainage 3).

Description

This project was conducted along four drainages which enter into Morfield Canyon at the Morfield Campground (see Map 2). Three of the drainages are located to the southwest of the campground on a burned hillside of Prater Ridge facing to the northeast. These drainages range in size as well as severity of burn. The fourth drainage is located to the northeast of the campground on an unburned hillside facing to the southwest. Although the aspect of this fourth

drainage is nearly opposite that of the other drainages, the geology, steepness, basin area, original vegetation (based upon aerial photographs from 1996), and proximity to weather stations are such that this fourth drainage is a suitable control drainage for this project.



Map 2. Locations of drainages chosen for research project as well as locations of weather stations.

The geomorphology of the research area includes nearly

flat-topped, long mesas or ridges surrounding Morfield Canyon. The mesas are distinguished by a distinctive, and laterally extensive, cliff made of Point Lookout Sandstone. In some portions of the research area the Point Look Sandstone is overlain by gentle rolling hills of the Menefee

Formation. These hills add to the surface area of each drainage and so are integral to the study; however, limited erosion appears to have occurred on the gentle slopes of the Menefee Formation and so the focus of study was elsewhere. Directly off the edge of the mesas, the Point Lookout Sandstone creates cliffs to very steep slopes. Lower down off the mesas, the Point Lookout Sandstone interbeds with the Mancos Shale and less steep slopes are formed. Below that, where the rock type is composed of solely Mancos Shale, the slope is gentle to very gentle, possibly forming small alluvial fans where larger drainages meet the canyon floor. Over the top of much of the rock a thick layer of colluvium has formed.

For this project a series of transects were set up and measured. Each transect consists of two pieces of rebar hammered a foot or more into the ground, one on either side of the drainage. Then a piece of light line was strung taut between the rebar stakes. This line was tied so that it was horizontal (which was determined using a line level). A metric tape-measure was also strung between the rebar stakes to ease measuring (see Photo 3). Finally, a second metric tape-measure with a pendulum bob attached was used to measure the depth from the taut line to the ground.



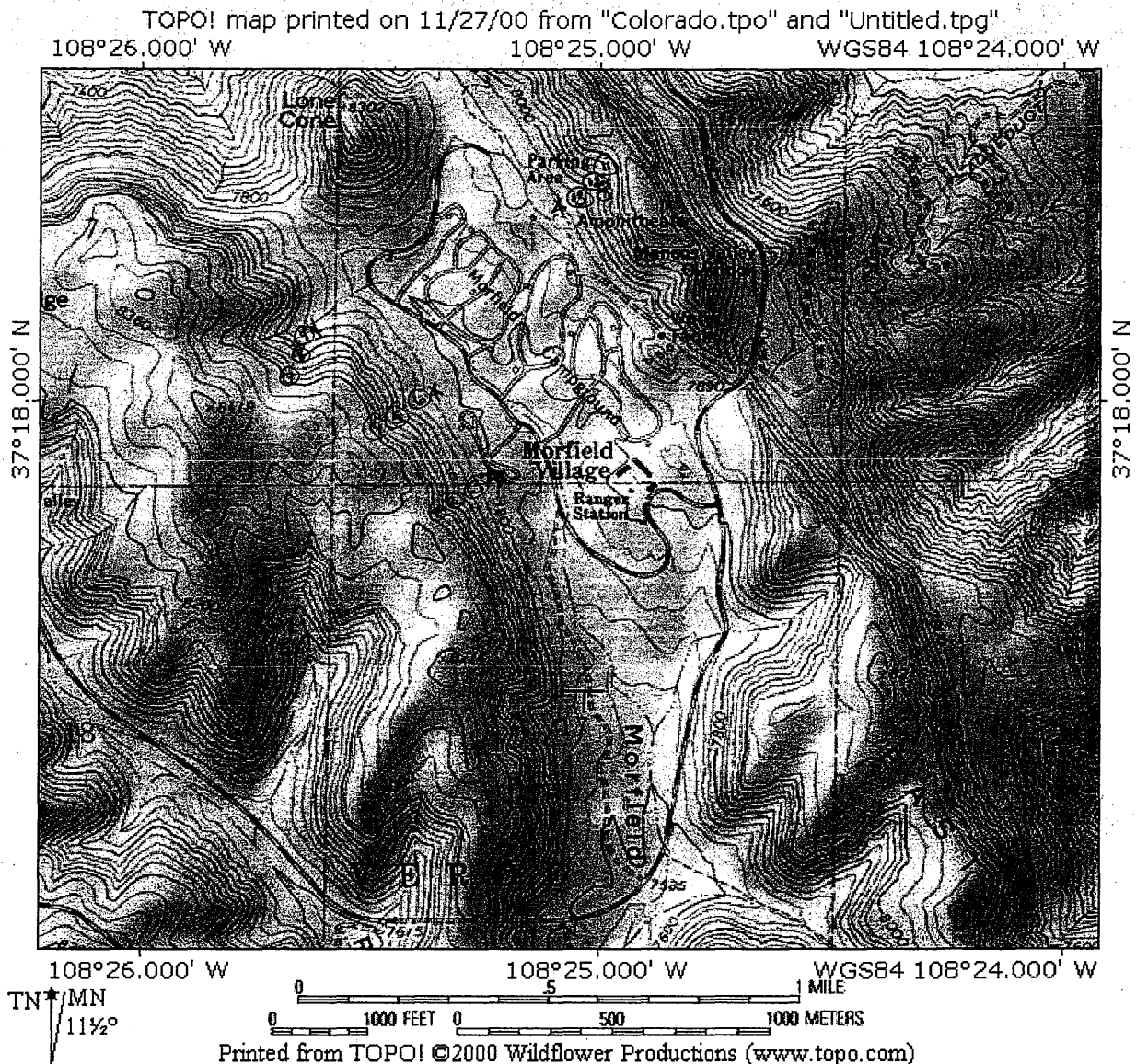
Photo 3. An example of a transect. Thin white line is the horizontal line and the thick white line is the metric tape measure.

This depth was measured every ten centimeters along the transect. Each transect

was eye-balled to be perpendicular to the apparent path of flow at each location.

Along each chosen drainage, three transects were set up: one near the top of the hillside just below a dominate Point Lookout cliff, one partway down the slope in the interbedded sandstone and shale, and the final one near the bottom of the hillside where the slope was least

severe (see Map 3). These particular locations for the transects were selected to determine along which section of the slope the erosion of sediment was actually taking place. Of these twelve transects, ten were then re-measured after at least one storm event. The top and middle transect along the fourth (unburned) drainage were not re-measured due to two factors: measurements



Map 3. Location of transects along each drainage. The numbering system for the transects starts with number one at the top of drainage 1, number 2 in the middle of drainage 1, number 3 at the bottom of drainage one, and so on, ending with number 12 at the bottom of drainage 4. The locations of the sediment catchments are also marked.

along the lowest transect of that drainage not having changed, and my being very sick on that day.

Additionally, sediment catchments were set up below the lowest transects. These catchments consist of a long section of black mesh cloth strung across the drainage and held up by wooden stakes which were driven a foot or more into the ground (see Photo 4). Each catchment was placed at a point where the drainage is still a bit constricted but starting to fan out and deposit material. At the base of drainage 1 a restroom blocks the path of the drainage. Right around the restroom the ground was dug out and leveled to make the foundation for the restroom, and the fire sediment has since started filling this flat area. Due to its placement, the restroom at



Photo 4. Example of a sediment catchment.

the base of drainage 1 was used as a “natural” catchment (see Photo 5) and no other catchment was set up along drainage 1 (see Map 3).

On top of the mesa to the southwest of

Morfield Canyon two weather stations had been set up after the July fire by Mary Gillam and



Photo 5. Catchment at the base of drainage 1.

Chris Wilbur for their analysis. Weather station MV1 (located above the tunnel for the road) is at an elevation of about 8038 feet above sea level. Situated roughly one mile essentially north of MV1 lies MV2. Weather station MV2 (located above the campground) is at an elevation of about 8300 feet above sea level (see Map 2). These two weather stations record differing amounts of rain. Given their distance from each other, their differences in elevation, and the variability of weather within the Park, this is to be expected (see Figure 1). Additionally, there is a man-operated weather station at the Ranger Station right outside Morfield Campground at the Morfield Village. Although information from this weather station is not currently available for the time period of this study, its information has been correlated to determine which of the other two stations would be more accurate given the locations of the drainages, and it was found that MV2 was more appropriate.

Rainfall Differences Between MV1 and MV2

Weather Station	T1, T2 10/6 - 10/27	T3 10/9 - 10/27	T4, T5, T6 10/9 - 10/29	T7, T8, T9 10/20 - 10/29	T12 10/27 - 11/3
MV1	74 mm	67 mm	87 mm	74 mm	31 mm
MV2	94 mm	80 mm	102 mm	84 mm	41 mm

Figure 1. Rainfall data from MV1 and MV2 for the time period of each transect.

Results

The first drainage had a basin area (planar view) of 37,000 square meters. The transects and sediment catchment for this drainage were set up for a total of 21 days and during that time a

total of 94 mm of rain fell. The top transect along this drainage changed by a total of +0.43 cubic meters. The middle transect along this drainage changed by a total of -0.05 cubic meters. The bottom transect changed by a total of +0.02 cubic meters (see Figure 2). The catchment at the base of this first drainage caught 3.4 cubic meters.

The second drainage, which was not as severely burned, had a basin area of 45,000 square meters. The transects and sediment catchment for this drainage were set up for a total of 20 days, during which 102 mm of rain fell. The top transect along this drainage changed by a total of -0.02 cubic meters. The middle transect along this drainage did not change enough to measure. The bottom transect changed by a total of +0.01 cubic meters (see Figure 3). The catchment at the base of this second drainage caught 0.5 cubic meters.

The third drainage, once again severely burned, had a basin area of 60,000 square meters; being by far the largest. The transects and sediment catchment for this drainage were set up for a total of only 9 days, during which 84 mm of rain fell. The top transect along this drainage changed by a total of +0.06 cubic meters. The middle transect along this drainage changed by a total of +0.02 cubic meters, as did the bottom transect



Photo 6. Blown-out catchment at base of Drainage

(see Figure 4). The catchment at the base of this third drainage blew-out and produced no measurable results (see Photo 6).

The fourth drainage, the unburned control, had a basin area of 37,000 square meters; being the same size at the first drainage. The transects and sediment catchment for this drainage

were set up for a total of 7 days, during which 41 mm of rain fell. The top and middle transects were not re-measured due to the fact that the bottom transect had not changed within estimated human error (see Figure 5). In addition, the catchment at the base of this control drainage did not catch any sediment.

Discussion

In the first drainage the top transect (or T1) had an estimated 0.425 cubic meter gain, which was unexpected. However, due to the intensive winds during the second set of measurements I am not real confident in the accuracy of these measurements. Another factor which points to this transect's data being faulty is the fact that this change in sediment is on the order of ten times the changes seen in the other transects. Although this was by far the longest transect, it was in the order of two or three times the length of the other transects (not ten fold), so this data is thrown out. The slight gain in material from the middle transect (T2) was expected given this transect's location. Similarly, the slight loss in material from the bottom transect (T3) was also expected. The "natural" sediment catchment at the base of this drainage caught a minimum of 3.4 cubic meters, consisting primarily of fine grained sands and ash with occasional burned logs up to nearly a meter in length. Before the drainage actually runs into the restroom some water paths split off from the main drainage path, leaving piles of sediment in other locations, which is why only a minimum of 3.4 cubic meters was caught and measured for this drainage.

In the second drainage the top transect (T4) lost a small amount of material as expected. The middle transect along this drainage (T5) gained material, but such an insignificant amount that there was no change within significant range. This gain in material was primarily pine needles and other low density material which had apparently rafted down the drainage and formed levees along the sides of the actual path of water, as seen in Cannon and Reneau's study.

The bottom transect in this drainage (T6) also gained material, once again consisting primarily of levees formed of pine needles and twigs and burned wood. The sediment catchment at the base of this drainage caught an estimated 0.5 cubic meters consisting of fine material, ash, pine needles, and hail stones. On top of this sediment was a pile of medium- to large-grained sand. This sand, in addition to some structures seen in the pine needles on the top of the sediment, indicates that a second storm had washed material through the drainage, leaving only a small amount of its heaviest material (sand) within the catchment and the rest spilling over the top of the mesh cloth.

The third drainage was by far the largest in basin area. Unexpectedly, the top transect (T7) and middle transect (T8) both gained material. As in the middle transect of the previous drainage, the gain in material at these locations came from levees formed of low density material. In this drainage though, the low density material consisted primarily of ash and fine- to very fine-grained sand as well as silt. The gain at in the bottom transect (T9) was expected. Unfortunately this catchment was blown out and so there was no measurable amount of sediment caught.

Along the fourth, or control, drainage, the top and middle transects were not re-measured due to the fact that the bottom transect (T12) had not changed. The sediment catchment for this drainage caught nothing.

A question arises: Are the changes seen in the transects and sediment catchments a function of the duration of the study, or a function of the basin area and thereby the total amount of water moving through the drainage? Because the largest drainage, drainage 3, was set up for only 9 days during which only 84 mm of rain fell, and because within these nine days enough sediment laden water passed through the drainage to knock down the catchment, I believe that the basin area is a more significant factor in erosion.

None of the changes seen in the transect were as large as expected. I believe that a base level of erosion in the drainages had already been achieved by the time I started my study. Sediment was moving from the hillslopes (as evident from the numerous rills which formed along the hillsides, sometimes right above a transect which did not display a change) and along the drainage, but the actual drainages were not changing as expected. The numerous rills which did form on the slopes are consistent with Florsheim's study.

Other questions arise, such as rainfall intensity and its effects. As Booker found in his 1998 study, as little rainfall as 25mm per hour for a duration as short as 15 minutes was enough to cause significant hillslope erosion in small, steep basins after a burn (Booker, 1998). Although my basins were certainly small and steep, the rainfall intensities never reached this critical level. What about extrapolating my data out for the entire burned area? My chosen drainage basins comprise only 0.15% of the area burned by the Bircher Fire. How much sediment will be found clogging the rivers downstream of Mesa Verde National Park?

Conclusions

The Bircher Fire of 2000, which burned 19,332 acres (or 78,536,250 cubic meters) of land within the boundaries of Mesa Verde National Park, has definitely increased erosion along the steep slopes found therein. With the study conducted, 3.4 cubic meters minimum was caught for a basin area of 37,000 cubic meters. Additionally, a minimum of 0.5 cubic meters was caught for a basin area of 45,000 cubic meters in a drainage which did not burn as intensely. Combined, I studied only 0.15% of the burned area of the Park, and that percent only for one month. Due to the fact that I set my project up to study the established drainage paths, and that the drainages had apparently achieved a base level prior to my study, I feel that in the future a more appropriate

project would include studying the hillslopes; for example, GIS 3D mapping done repeatedly, or

repeat photography

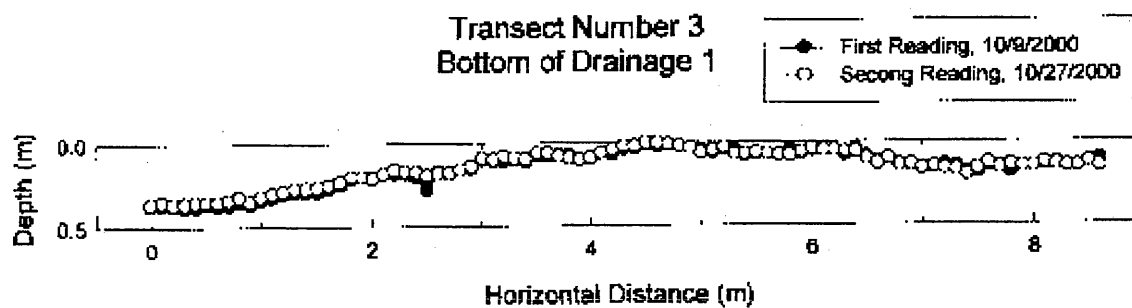
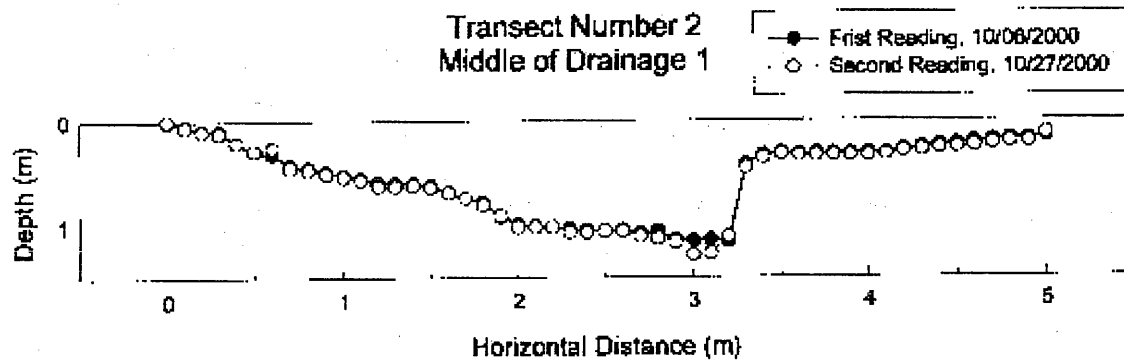
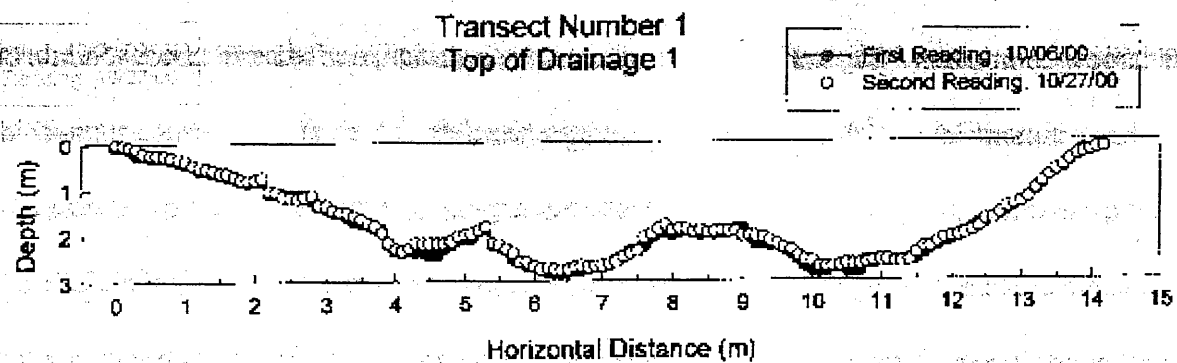


Figure 2. Transects of the first drainage. In each case north is to the left, and the view is down the drainage

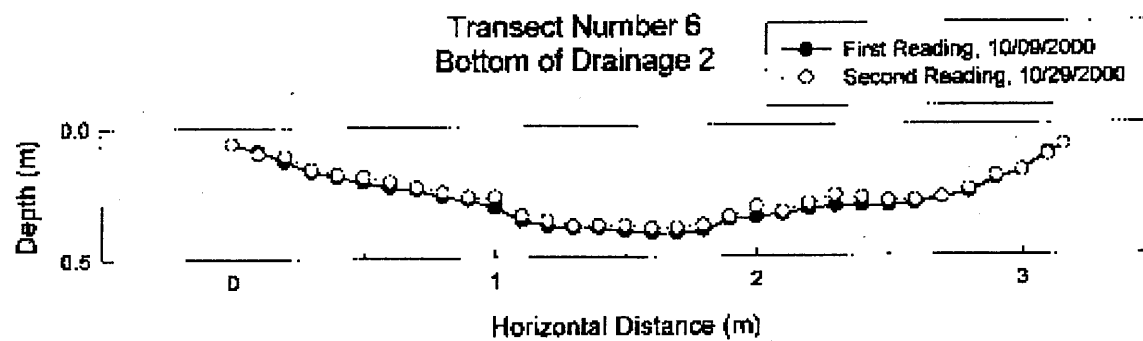
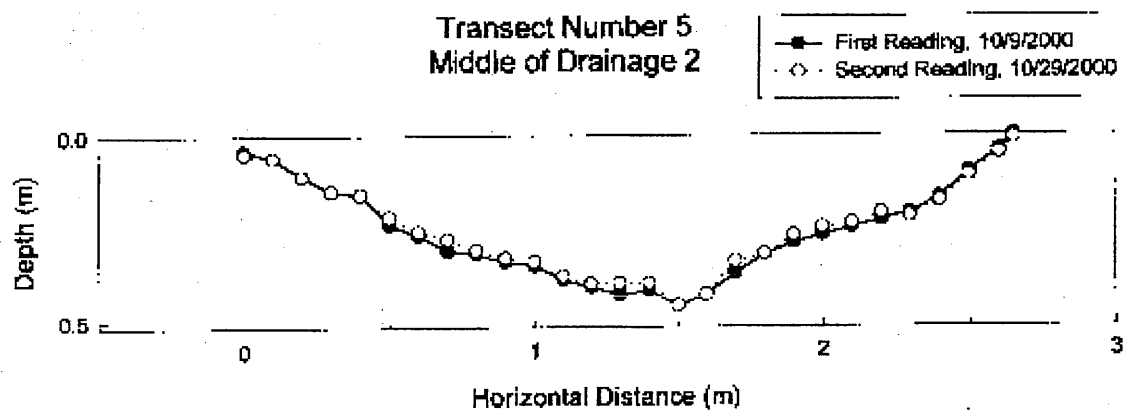
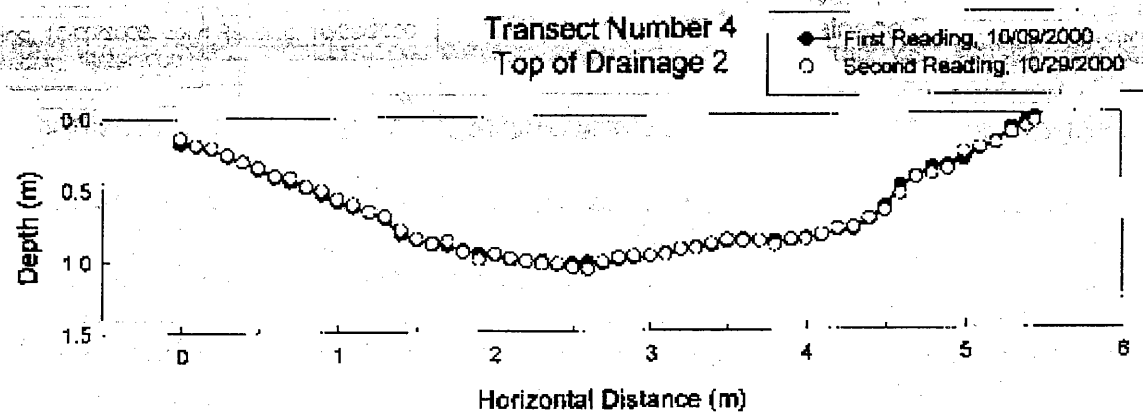


Figure 3. Transects of the second drainage. In each case north is to the left, and the view is down the drainage

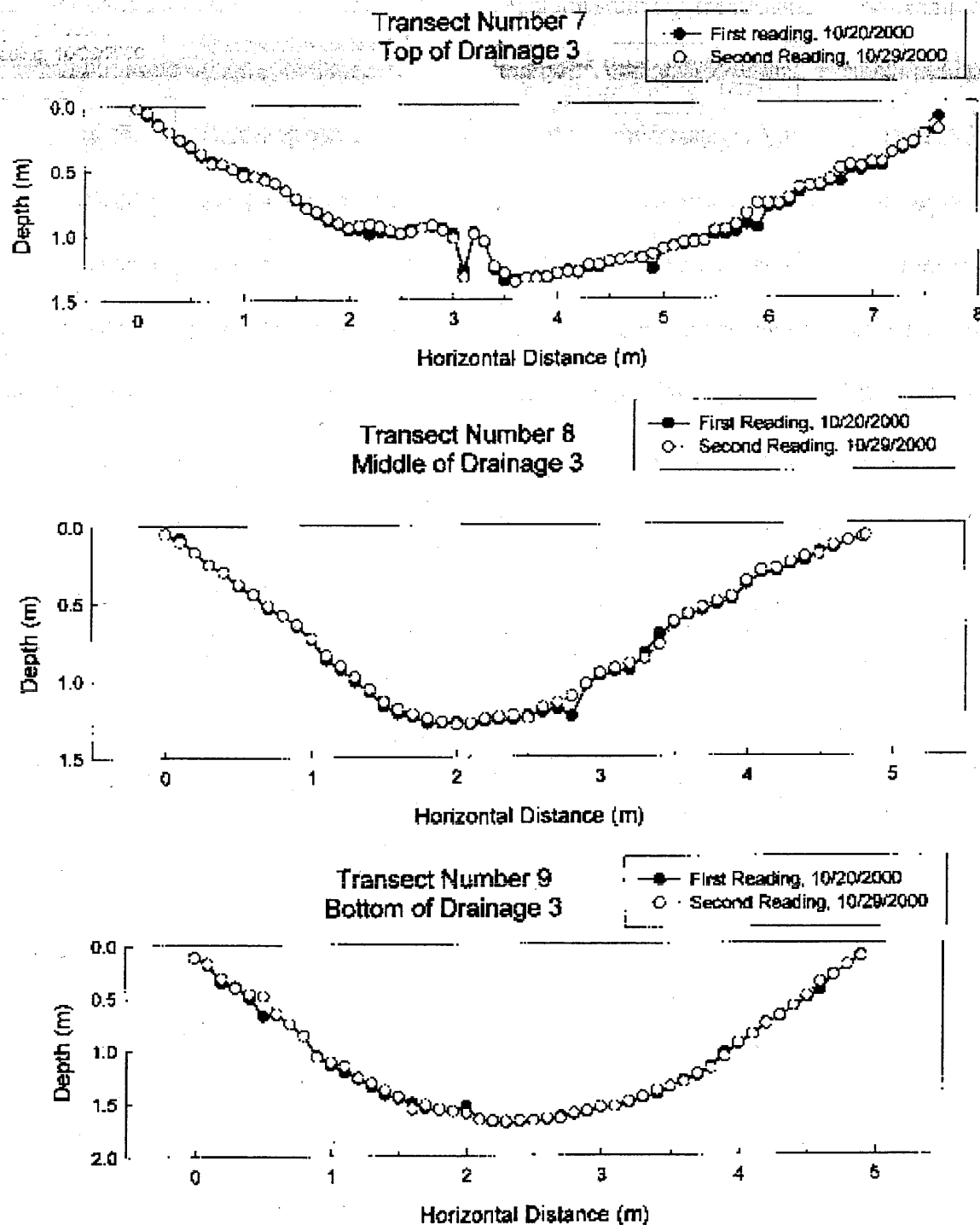


Figure 4. Transects of the third drainage. In each case north is to the left, and the view is down the drainage.

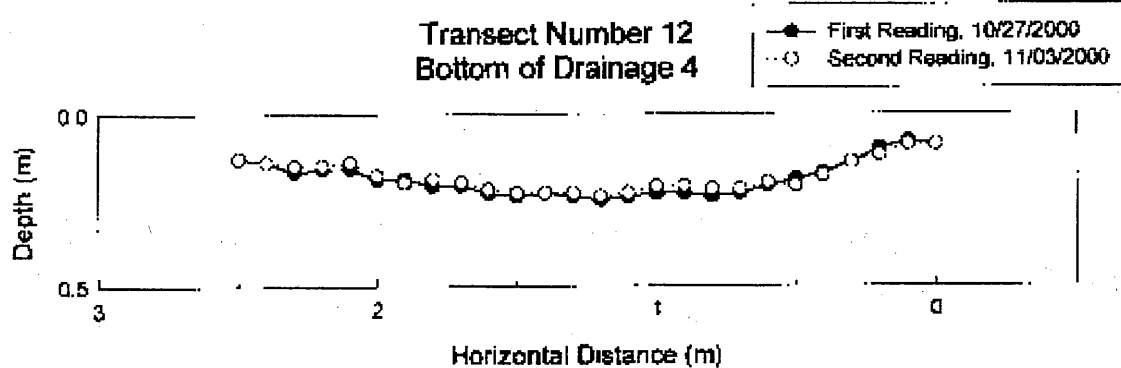
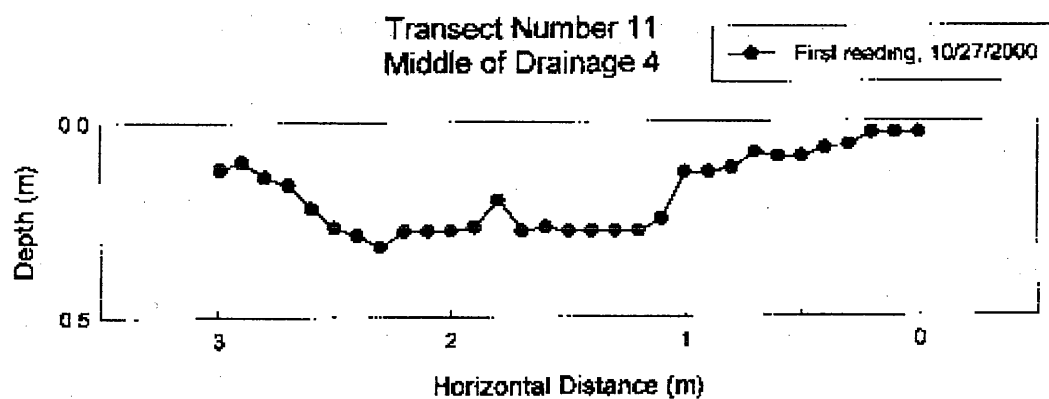
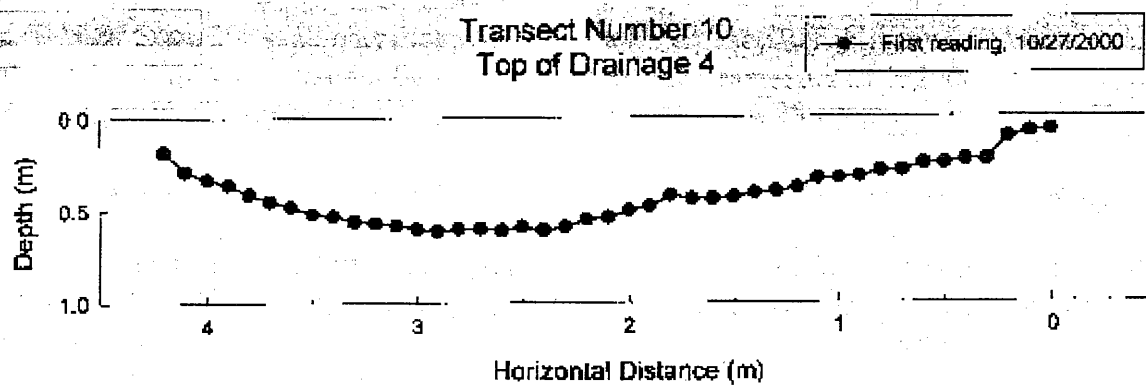


Figure 5. Transects of the fourth drainage. In each case north is to the right, and the view is looking down the drainage.

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