SEFOP 1987:

FIELD GUIDE FOR THE FIRST ANNUAL MEETING OF THE SOUTHEASTERN FRIENDS OF THE PLEISTOCENE

6-8 November 1987

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INTRODUCTION

SEFOP 1987: THE FIRST ANNUAL MEETING OF THE SOUTHEASTERN FRIENDS OF THE PLEISTOCENE

by J. Steven Kite

The first annual Southeastern Friends of the Pleistocene field conference will convene at Canaan Valley Lodge, in Canaan Valley State Park, West Virginia, on 6-8 November, 1987. There are many reasons to run this trip at this time. We asssume that excellent weather will be delivered for our day and a half in the field. We believe that we have a viable trip for just about any weather that is likely to come our way, but rain or cold may tax your good spirits and warm clothing. We have written descriptions of 12 field trip stops (figure 0.1), but time limitations will prevent us from visiting more than eight or nine of these stops. We will not determine which stops will be deleted until the weekend of the trip.

The main objective of the field conference is to examine the effects of a low-frequency high-magnitude flood that occurred in West Virginia and Virginia on 4-5 November 1985. Runoff from parts of the Cheat and Potomac basins was among the highest ever recorded in the Appalachians. In addition to 70 deaths and over $750,000,000 property damage, this flooding caused intense scouring and significant deposition on floodplains throughout the area, and significant slope failures in parts of the Potomac Highlands. The trip nearly coincides with the second anniversary of the 1985 floods. This is a good time to look at the effects of this cataclysmic flood because the evidence will become less obvious as the years go by.

General geomorphology and Quaternary colluvial stratigraphy of the Potomac Highlands will be secondary foci of the conference. The area covered by the field trip has many textbook geomorphological features and is worth viewing anytime, but this late Autumn trip should provide an excellent look at the physical landscape because most of the leaves have fallen. Moreover, the 1985 floods scoured the many old colluvial and alluvial-fan deposits, providing a short-lived opportunity to look at the kind of stratigraphy that usually requires a back-hoe to study.

Much of the discussion at the conference will concern the field trip, but this will be a good time to air thoughts on the future direction of the group, particularly what trips should be run in the future. The trip leaders and organizers hope that you meet new colleagues and renew old friendships. If the conference does nothing more than facilitate the exchange of ideas concerning the Geomorphology and Late Cenozoic history of the Appalachians, we will consider the meeting a success.

SEFOP 1987 Field Trip Stops

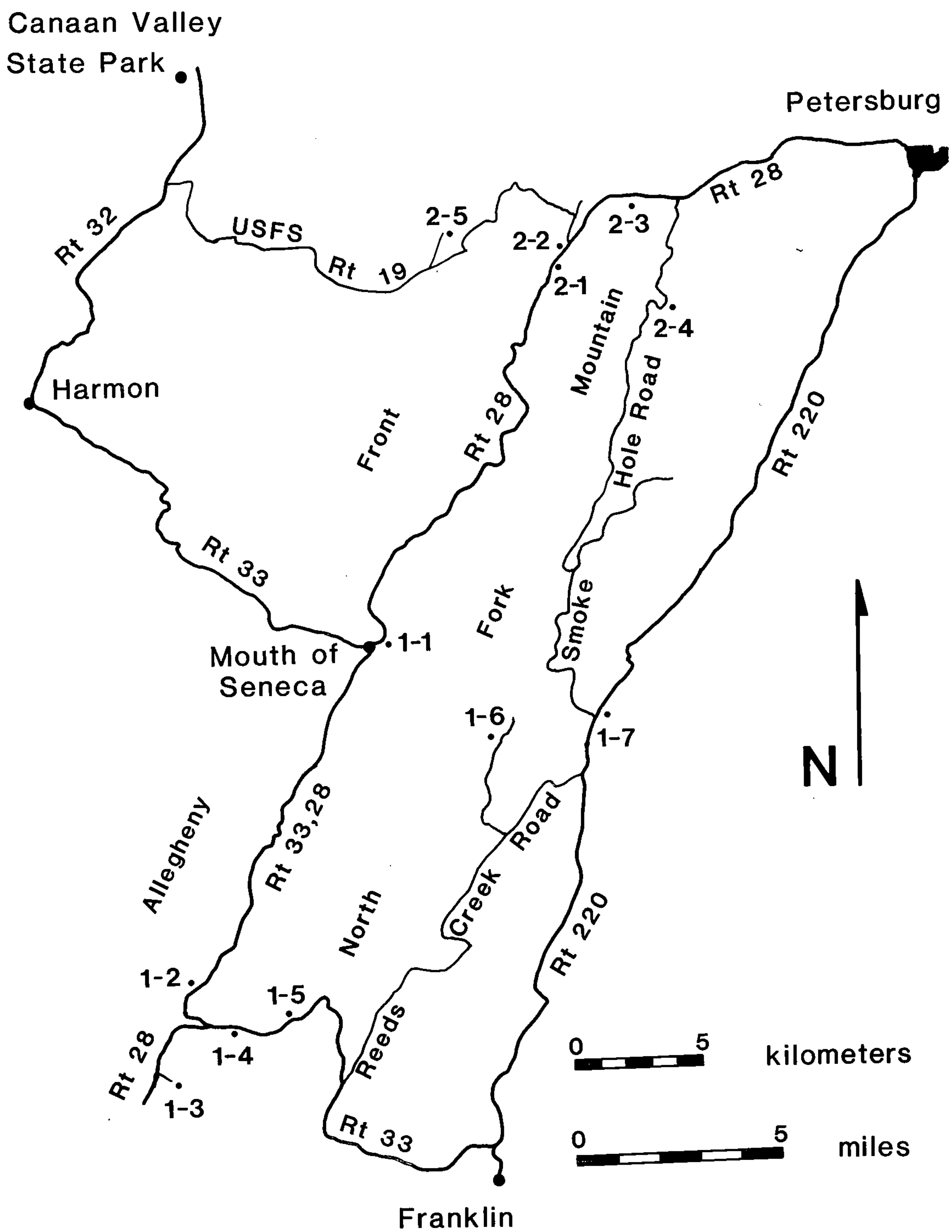


Figure 0.1. Southeastern Friends of the Pleistocene 1987 field trip stops. Stops 1-1 to 1-7 will be made on day 1; stops 2-1 to 2-5 on day 2. Stops may be run out of order.

METEOROLOGY OF THE NOVEMBER 1985 FLOOD EVENT

by Robert B. Jacobson

During the first week in November, 1985, the remnants of Hurricane Juan combined with several low-pressure cells on the eastern seaboard to form a single large, low-pressure system. Stalled by a high-pressure system off the New England coast, the moist low-pressure system moved slowly from the Carolinas north and east through the Appalachian Mountains producing extreme rainfall in the Cheat and Potomac basins on November 4 and 5 (Clark and others, 1987). Total rainfall for the period November 3-5 is shown in figure 0.2. These isohyets are drawn from the official N.O.A.A. rain gage network. Because of high relief and sparseness of the rain gage network, it is probable that local areas of greater rainfall are not represented in these data. In fact, measurements in non-standard rain gages by local residents show some areas of slightly greater rainfall to the south and east of the main cell along North Fork Mountain; however, these differences are not great and would not greatly alter the isohyets depicted in figure 0.2

The highest rainfall intensity record in the region was only 38.3 mm/h, an intensity with a return period of only 2 to 5 years (Hershfield, 1961). However, rainfall was steady over a large area, with many gages recording intensities of 10 mm/h for 8 hours or more. The highest 24-hour duration rainfall in the Cheat and Potomac basins was 191 mm at Franklin; the highest 48-hour rainfall was 241 mm recorded at Upper Tract. The geomorphic effectiveness of this storm was probably augmented by abundant antecedent rainfall in October which was up to 200 percent of normal over large parts of the area.

Daily rainfall for the period of record for rain gages at Franklin and Spruce Knob are shown in figure 0.3. The 24-hour rainfall for the 1985 storm is the greatest on record at both gages and is part of a subset of three to four 4 other extreme storms recorded at each site. At the Franklin gage the 1985 storm was much greater than the infamous storm of 1949; estimated 24-hour rainfall near Petersburg in 1949, however, was over 400 mm. The highly skewed distribution of rainfall events makes estimation of recurrence frequency for the rare events uncertain. Hershfield (1961) estimated that 24-hour rainfall of approximately 200 mm in the central Appalachians had a recurrence frequency of greater than 100 y. Frequency analysis of the records for the Franklin and Spruce Knob rain gages gives estimates of between 70 and 140 y recurrence for the maximum 24-hour rainfall recorded at those two sites and an estimate of greater than 80 y for recurrence of the maximum 24-hour rainfall recorded at those two sites and an estimate of greater than 80 y for recurrence of the maximum 2-day rainfall at Upper Tract.

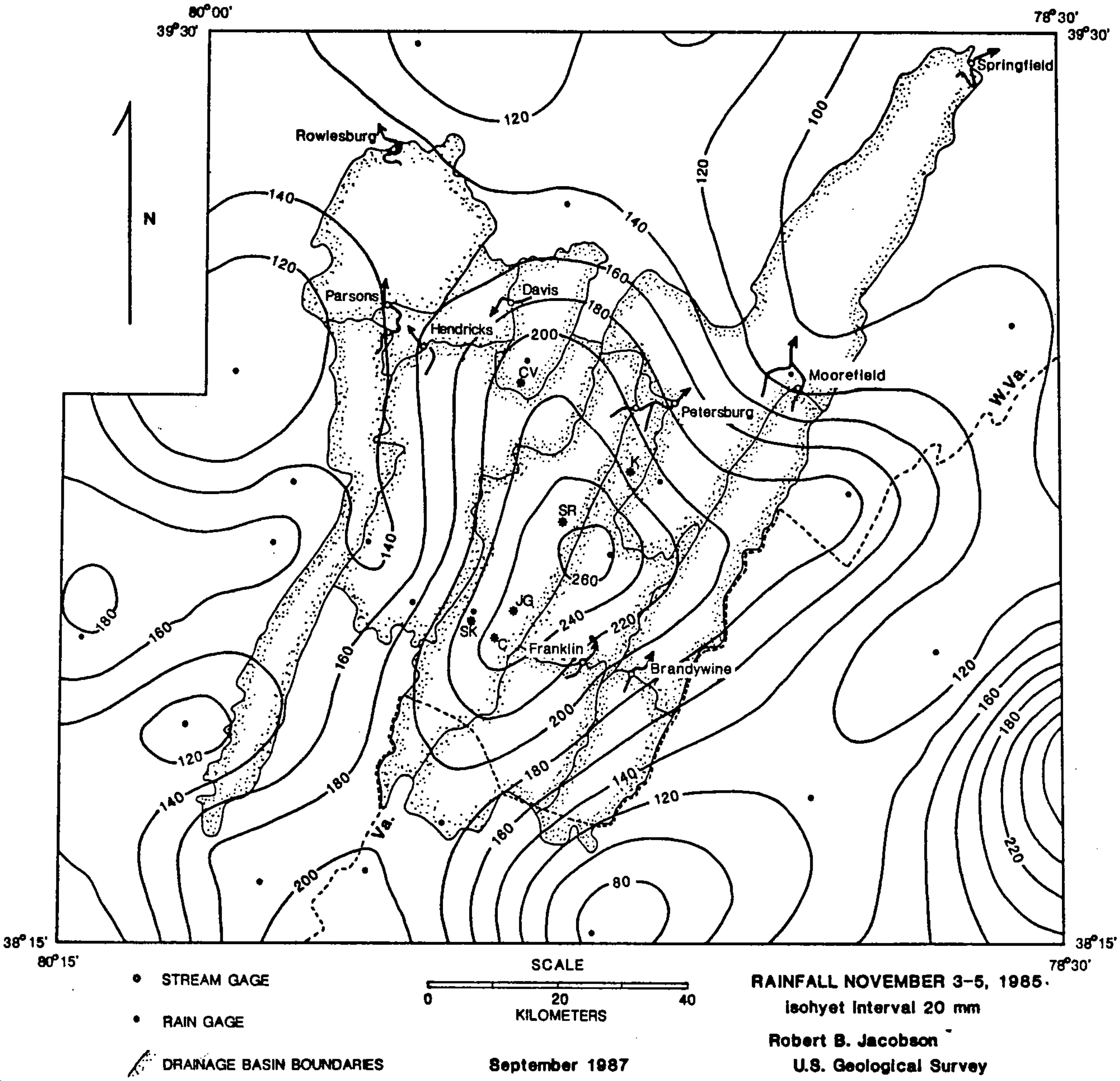


Figure 0.2. Isohyetal map of rainfall on 3-5 November 1985. CV = Canaan Valley, K = Ketterman, SR = Seneca Rocks, JG = Judy Gap, SK = Spruce Knob, C = Circleville.

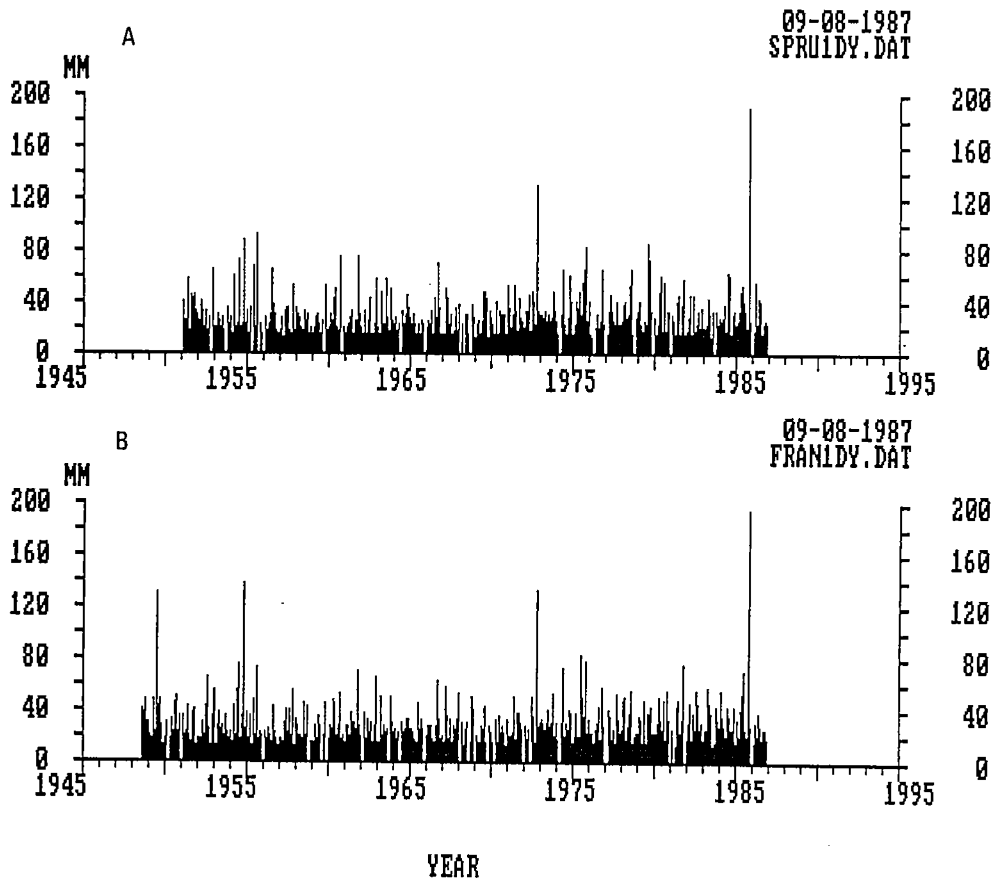


Figure 0.3. Daily rainfall records for (A) Spruce Knob, WV and (B) Franklin, WV.

SEFOP 1987 ITINERARY, ROAD LOG, AND STOP DESCRIPTIONS

(**ITINERARY** and **ROAD LOG** by J. Steven Kite and Ron C. Linton; **STOP DESCRIPTIONS** as noted.)

FRIDAY NIGHT, 6 NOVEMBER 1987

Posters available before and after banquet.

7:00 P.M. **BANQUET** in Pine Room, followed by

Welcome, Introductions, and Acknowledgements
J. Steven Kite

Discussion of Pre-1985 events
G. Michael Clark

Slope failures during the 1985 event
Robert B. Jacobson

Erosion and deposition on floodplains in the 1985 event
Andrew J. Miller

PROPOSALS AND SUGGESTIONS FOR 1988 SEFOP TRIP

DISCUSSION OF WHERE SEFOP SHOULD BE DIRECTED

TOPOGRAPHIC MAPS

The following maps give complete coverage of the field trip route. The most useful maps are given in **boldface.**

1:100,000 maps: **Elkins** and Kingwood.

1:24,000 quadrangles: Blackwater Falls, **Circleville**, Franklin, Harman, **Hopeville**, Laneville, Maysville, Mozer, **Onego**, Petersburg East, **Petersburg West**, and **Upper Tract.** (All 1:24,000 quads are in West Virginia.)

SATURDAY, 7 NOVEMBER: DAY 1 OF THE FIELD TRIP

BREAKFAST ON YOUR OWN. RESTAURANT OPENS AT 6:30 A.M.

DEPART FROM PARKING LOT OF CANAAN VALLEY LODGE AT 7:30 A.M.

TOTAL MILES	INTERVAL MILES	STOP, POINT OF INTEREST, ETC.
0.0	0.0	**Assemble in the Canaan Lodge Parking lot,** Tucker County, WV (Blackwater Falls quad; Kingwood 1:100,000 map). Proceed generally eastward toward park entrance on Route 32.
2.1	2.1	**Turn right** (south) on Route 32.
3.1	1.0	Quarry on right is in Mississippian Greenbrier Limestone.
3.6	0.5	Jennington-Lead Mine Road on left. This road leads to Dolly Sods (Stop 5, Day 2). Enter Laneville quad and Elkins 1:100,000 map.
6.2	2.6	Cross Red Creek and enter Randolph County.
6.7	0.5	Enter Harman quad.
7.2	0.5	Note evidence of flood mitigation efforts along Dry Fork, a tributary of Cheat River. Route 32 was much eroded in 1985.
8.6	1.4	Scour of floodplain to left (east) of road. Look on the right for remnants of an old concrete bridge in the bed of Dry Fork. It used to be 150 m upstream.
8.7	0.1	Note the rebuilt bridge over Dry Fork.
10.1	1.4	Slow down near the Seneca Caverns sign. Look to the right at a large exposure of alluvial-fan sediments on the other side of Dry Fork. Most of the sediment is boulder-cobble diamicton, but a thin lens of overbank sediments occurs several meters below the top of the exposure.
10.6	0.5	Slow down near the Big Injun/Big Lime highway marker. There is a good view of another alluvial fan to the right.

11.1	0.5	**Bear left** to Route 33 east in Harman.
11.2	0.1	**STOP SIGN.** Be careful at this dangerous intersection. **Turn left** (east) on Route 33.
12.7	1.5	Enter Laneville quad.
14.9	2.2	Enter Pendleton County at the Eastern Continental Divide: the divide between Cheat (Ohio) and Potomac River basins. Continue on Route 33, descending the Allegheny Front.
18.2	3.3	Seneca Creek on right. In 1985, there was considerable damage between here and Seneca Rocks. Look for new homes, new pavement, and a channelized stream bed.
20.4	2.2	Enter Onego (pronounced 1-go).
21.0	0.6	Cross Seneca Creek.
21.6	0.6	The burned area on the other (north) side of the valley is from a 1986 gas pipeline fire.
22.4	0.8	Good view of Seneca Rocks straight ahead. Those familiar with the rocks may be surprised to learn that the sandstone pinnacle known as the Gendarme fell on 22 October.
23.4	1.0	**Turn left** (north) on Route 28 in the community of Seneca Rocks (Mouth of Seneca).
23.5	0.1	Cross Seneca Creek; enter Upper Tract quad.
23.6	0.1	**Turn Right** (east) into the Seneca Rocks Visitor Center, operated by Monongahela National Forest, US Forest Service. Follow the lead vehicle after turning off Route 28.
23.7	0.1	**Turn left** (north) after passing through steel gate.
23.9	0.2	**Park** in lot near bathrooms.

STOP 1: SENECA ROCKS VISITOR CENTER

Text by Mark L. McKoy

Discussion led by Mark McKoy, Andy Miller, and Robb Jacobson

Effects of the flood of November 1985 on the floodplain of North Fork River at Seneca Rocks were typical of those on the upper tributaries of the South Branch basin. Because efforts of cleanup crews were restricted on National Forest property, parts of the flood-affected area at Seneca Rocks Visitor's Center remain relatively undisturbed. Much of the floodplain at Seneca Rocks has been "repaired". However, the Forest Service has decided to display the remaining undisturbed "damaged" area by establishing trails with information plaques.

Eleven sites of interest within the preserved area have been selected for this stop. Their positions are shown by numbers on the map of "post-flood morphology of the floodplain" (figure 1.1). Because others may be interested in scours and deposits, we ask that you PLEASE DO NOT WALK ACROSS THESE FEATURES, except on established trails.

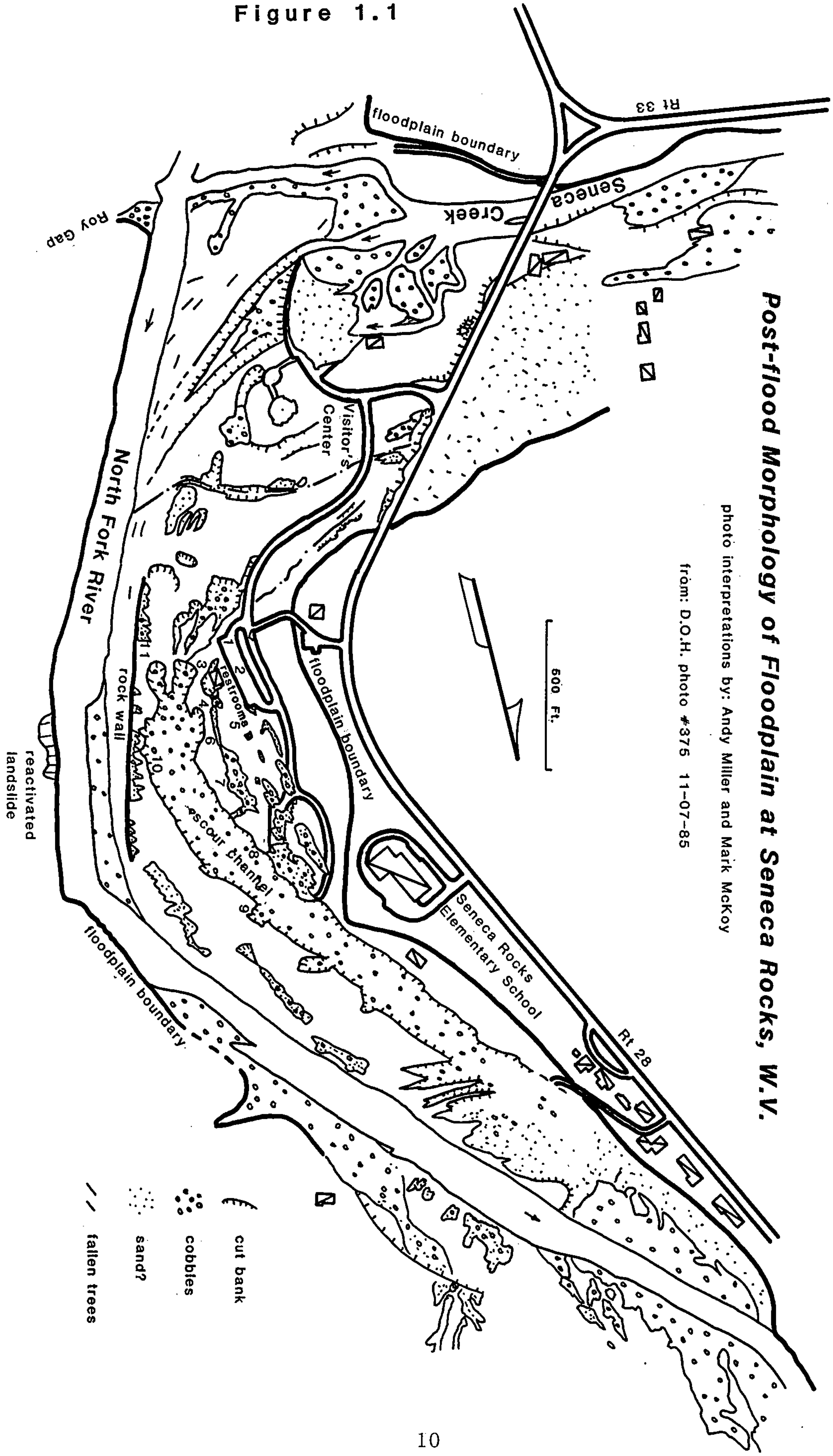
SITE DESCRIPTIONS

1. Unload vehicles at the south end of parking lot at the restrooms. View the delta of Seneca Creek to south. Swells and troughs mark old distributaries and flood scars on the delta. In the flood of 1985, troughs influenced flood-flow directions. Because of the increased depth and faster currents, troughs were also scoured out (compare map to topography).

Route 28 served as a dam for Seneca Creek and caused deposition of finer than usual sediments on the upstream side. Water flowing across the road eroded the roadbed on the downstream side and then followed a trough toward the restroom building.

2. Walk to the restroom building. The flood eroded a trench, estimated at 1 to 4 ft wide, around the base of the building and a larger scour on its upstream side. The room on the upstream side of the building (ladies' restroom) had water marks showing waves and splash. Apparently the flow had pushed the door open. Our best estimate of the water level in this room was about 3.2 ft higher than the single, well-defined high water mark in the men's restroom on the downstream side of the building. We attribute this to pressure differentials in fast flow on opposite sides of the building. A high water mark on a tree across the drive from the building is about 2.5 ft higher than in the men's restroom on the downstream side.

Figure 1.1


Post-flood Morphology of Floodplain at Seneca Rocks, W.V.
photo interpretations by: Andy Miller and Mark McKoy
from: D.O.H. photo #375 11-07-85
600 Ft.
Rt 33
floodplain boundary
Seneca
Creek
Roy Gap
Visitor's Center
North Fork River
floodplain boundary
restrooms
rock wall
scour channel
reactivated landslide
Seneca Rocks Elementary School
Rt 28
floodplain boundary
1
2
3
4
5
6
7
8
9
10
11
cut bank
cobbles
sand?
fallen trees

3. Walk behind the restroom building (east side) about 50 ft. The head of the main scour channel is seen in a topographic trough. Although the trough is part of a new surface created after the flood by clean-up crews who filled in the scour with a bulldozer, a trough existed there before the flood. The position and orientation of swells and troughs, small scour, splay deposits and branching headward erosion cuts (all seen on aerial photos) suggest that flow was received by the scour channel from both Seneca Creek and North Fork River at numerous input points.

4. Walk north to the picnic table under the trees. On the east side is a headward-eroded side-gully of the scour channel which advanced toward the northern part of Seneca Creek delta. Note the large lag boulders in the gully bottom and those exposed in the cut bank. On the west side of the table, a scour chute bearing approximately N1W and with maximum dimensions of 185 x 15 x 5 ft is seen. Boulders with an intermediate diameter up to 24 inches are embedded both in the soil and in the lag deposit.

5. Walk toward the northern edge of parking lot to the trail, and then follow the trail northwards. Trees in this area display wood debris wrapped around their trunks and circumstructural scours at their bases. Numerous small scour holes with cobble lags occur in this area. The development of such scours was typical on floodplains of South Branch basin.

6. After walking about 100 to 150 ft up the trail, walk east to the downstream end of the scour chute (same as at site 4). Here the scour continues as two parallel narrow tracks. Scour rills are common erosion features that occur at the heads and tails of chutes and channels as well as being unattached to any larger scour.

7. Follow scour rills to the east side of a cobble bar, which was deposited as scouring eddy currents waned. This bar was sampled for particle size analysis, and the results are given in table 1.1 with a Visher plot presented in figure 1.2. Particles with intermediate diameters of up to 20 inches moved 60 to 350 ft from the scour hole at site 4 to the cobble bar. Applying Hjulstrom's Diagram (as modified by Sundborg, 1956), current velocities must have exceeded 18 ft/s to have moved the largest particles. Also note that the cobble bar is longitudinally stratified with boulders and cobbles at the head of the deposit and finer size particles at the tail of the deposit.

Cobbles are well imbricated and show three imbrication directions: approximately N1W, N9W and N30W. Genetic relations between imbrications were not apparent.

8. Walk to the north loop parking lot, and then follow trail to the edge of the large scour channel, which is about 145 ft wide at this point. Our estimate of the volume of sediment eroded from this scour is 20,000 to 24,000 cubic yards. The point bar in the bend of the river confined the flow and encouraged erosion here. Had erosion continued, it could have lead to a chute (or "point bar") cutoff. Large particles in the eroding soil remained as lag armor. In this scour, we measured boulders having an intermediate diameter up to 24 inches. Cobbles are well imbricated here.

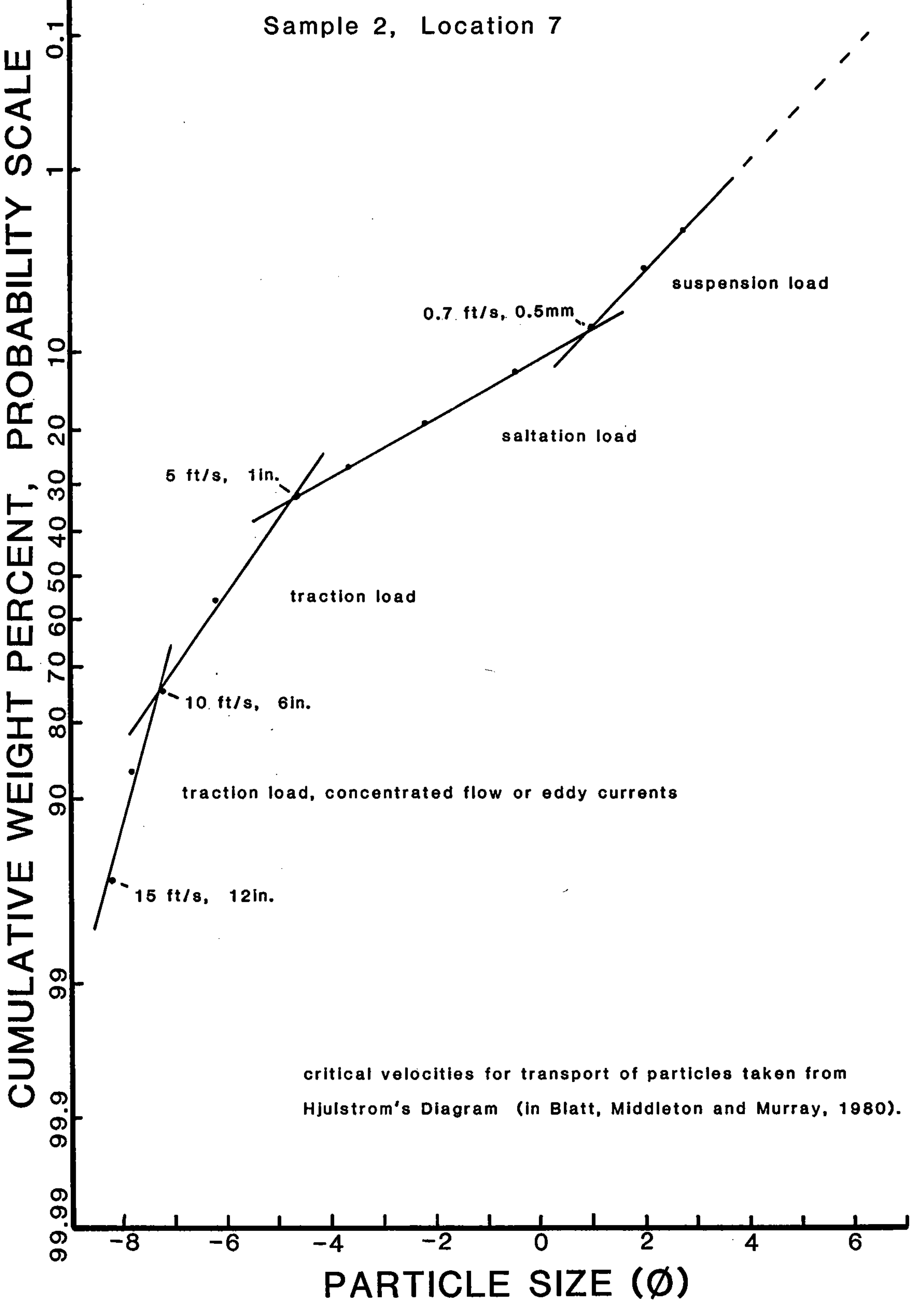
9. Cross the scour channel to the fork in the trail. Proceed in the downstream direction along the channel to the headward-cutting pocket on the scour channel. This cut appears to have been made by flow sweeping around the south side of the pointbar. A stepped, headward-cutting gully and a well-developed plunge pool or eddy scour are seen.

10. Traverse southeastwards (upstream direction) around the channel to another headcut area (see site on map). From a profile we surveyed across the floodplain and North Fork River in this vicinity, we estimate maximum flood flow depth in the river channel at between 19 and 22 ft (We are not yet exactly certain of the high water mark.) and in the scour channel at between 14 and 17 ft (if it existed at that time). Average flow velocity is tentatively estimated at between 10 and 15 ft/s, and maximum flow velocity (calculated at 0.95 channel depth) is thought to have been between 25 and 41 ft/s. Our current estimates of discharge range from 76,000 to 120,000 cfs for the flood peak. Near-normal flow discharge was determined to be about 530 cfs.

The USGS indirectly measured peak flood discharge downstream at Cabins (Zembrzuski, unpub.). Prorating their discharge estimate by drainage area, about 72,000 cfs would have flowed past here. This apparent disparity between their information and ours further indicates the magnitude of remaining uncertainties in flood flow data at this time.

11. Proceed along the trail southwards to the nearest picnic table. Looking across and down the river from here, slump scarps are seen in colluvium. This slide appears to have been reactivated by the flood, which cut away the slide's toe.

Figure 1.2



Sample 2, Location 7
CUMULATIVE WEIGHT PERCENT, PROBABILITY SCALE
0.01
0.1
1
10
20
30
40
50
60
70
80
90
99
99.9
99.99
suspension load
0.7 ft/s, 0.5mm
saltation load
5 ft/s, 1in.
traction load
10 ft/s, 6in.
traction load, concentrated flow or eddy currents
15 ft/s, 12in.
critical velocities for transport of particles taken from
Hjulstrom's Diagram (in Blatt, Middleton and Murray, 1980).
-8
-6
-4
-2
0
2
4
6
PARTICLE SIZE (Ø)

Table 1.1

Particle-Size Distribution Statistics for sample 2, site 7

Graphic Statistics (from equations of Folk and Ward, 1957)

statistic	phi	mm	inches	remarks
median	-5.90	59.7	2.35	coarse gravel
mean	-5.05	33.1	1.31	coarse gravel
dispersion	3.01	267-4.11	10.5-.162	very poorly sorted
skewness	-0.01			winnowed of fines
kurtosis	1.04			mesokurtic
D 100 *	-9	508	20	for whole cobble bar

sample size = 791 lbs (359 kg)
maximum particle weight = 36 lbs (16 kg)

* average maximum intermediate particle diameter

Return to Route 33.

24.1 0.2 **Turn right** (west) at stop sign.

24.2 0.1 **Turn left** (south) on to Route 28. Re-enter Onego quad.

24.3 0.1 Cross Seneca Creek.

24.4 0.1 **Turn left** (south) on to Route 33/28. Be careful, this is a dangerous intersection.

24.8 0.4 An over-grown shale quarry is on the right. This pit has a 1 to 2 m alluvial gravel cap. A hike to the top of Seneca Rocks gives an excellent view of well-developed alluvial terraces on both sides of Seneca Creek.

25.5 0.9 Road crosses the crest of a complex fan-like landform. The thickness of unconsolidated material in these landforms varies from less than 2 m to greater than 10 m. Route 33/28 crosses many of these complex forms in the next 9 miles.

28.1 2.6 Germany Valley Road to left. Germany Valley is a beautiful place to see karst features developed on Ordovician carbonates in the core of the Wills Mountain Anticline. We will **continue** south on Route 33/28.

31.4	3.3	Enter Circleville quad.
31.8	0.4	Riverton was badly damaged in 1985, especially parts of town that were built along an old abandoned channel. Some of the condemned buildings were not torn down until Summer 1987.
31.9	0.1	Germany Valley Road to left.
34.3	2.4	**Slow down.** Briery Gap Road on the right lead to Spruce Knob, the highest point in West Virginia (1482m, 4861 ft).
34.4	0.1	**(BAD-WEATHER STOP ONLY) Park on right** side of road, next to big sandstone boulders, beyond the gas station. Do not block station driveway. Beware of high-speed traffic on Route 33/28.

STOP 2: BRIERY GAP SHALE AND GRAVEL PIT

(BAD-WEATHER STOP ONLY)

Text by J. Steven Kite

Discussion by Kite, Robert B. Jacobson, and Andrew J. Miller

Most of the material extracted from this small quarry is black Devonian shale, but we are here to look at the natural landforms and the "overburden". Briery Run has a relatively narrow floodplain north of the quarry. East of Route 33/28, Briery Run has constructed a substantial alluvial fan in the broad valley of the North Fork. The surface sediments on the fan include many sub-angular boulders, including some very fresh-looking clasts that were transported in the 1985 flood. Most of the larger boulders appear to be Pottsville Sandstone, which crops out on top of the Allegheny Front, 4 km west of this stop. Air-photo interpretation suggests that the fan has draped over part of a terrace adjacent to the floodplain of the North Fork (Miller, personal correspondence, 1987). The North Fork now flows along the other side of the valley, approximately 18 m (60 ft) lower than Route 33/28 at this stop.

South of the quarry, Route 33/28 runs along the base of a scarp between the valley bottom and a higher landform that slopes toward the east. The surface morphology of this higher landform indicates it is a dissected fan (or pediment).

Sediments exposed at the top of the highest face of the quarry are not exactly what would be expected in a fan. About 1 m of material has been stripped by bulldozing of the surface; this material appears to have been mostly silty loam, possibly of overbank origin. The undisturbed boulder-cobble gravel at the top of the face has imbrication that shows it was deposited by flow to the north, parallel to the North Fork. This locality presents the conundrum of an alluvial fan composed of terrace deposits. The dissected fan must have draped over an old terrace like its younger counterpart east of route 33/28. Either the terrace sediments at the top of the cut have been exhumed from under now-eroded alluvial-fan deposits, or they may have persisted unburied right at the edge of the fan.

The poorly exposed face at the southern end of the quarry contains a variety of colluvium that formed along the scarp at the end of the dissected fan. At least one gravelly lens occurs next to the fan, but it is a colluvial gravelly diamicton, not a fluvial deposit. The colluvium is better exposed along Route 33/28, 5 to 10 meters south of the pit. A few reworked stream clasts are exposed in this road cut, but most of the stratified colluvium appears derived from the shale bedrock or the loamy alluvial unit.

		Return to the vehicles. Continue south on Route 33/28.
35.2	0.8	Cross the North Fork South Branch Potomac River. **Slow down.**
35.3	0.1	**Turn right** (south) on Route 28 just beyond bridge.
37.5	2.2	**Turn left** (southeast) on the gravel road just before crossing stream next to a white house and a cinderblock house. This stream is Harper Run. Go to the right of the barn, then travel southeast through the gap in vertically bedded Tuscarora Sandstone.
37.9	0.4	Note a wide spot in the road at junction with the second-order valley coming from the northeast and just before a small bridge. **Park** here on the left (A on figure 3.1).
		The trip continues on foot through the gate and up the dirt track along the second-order valley (figure 3.1). Be careful of the barbed wire and don't bother the sheep.

STOP 3: HARPER RUN SLOPE FAILURES

Text and discussion by Robert B. Jacobson

The Harper Run drainage basin is a good place to see some of the thousands of slope failures triggered by the storm of November 3-5, 1985. In fact, due to extensive landslide reclamation efforts of the Soil Conservation Service during the summer of 1987, this is one of the few sites in Pendleton County where evidence of slope failures remains. In Autumn 1987, much of the remaining evidence is being obscured by natural erosion and regrowth of vegetation.

STORM AND FAILURES

The isohyetal map presented in the introduction (figure 0.2) shows estimated storm-total rainfall at Harper Run was between 240 and 260 mm. Most of the failures triggered by the storm were shallow, rotational to planar slides of variably weathered regolith; many of the slides subsequently mobilized into mudflows. Field evidence at this site shows that slope failures were important sources of sediment to stream channels in these small drainage basins. In addition, much of the sediment mobilized by the storm remains in the basin subject to remobilization by subsequent storms of lesser magnitude.

GEOLOGY AND SURFICIAL GEOLOGY

This small drainage basin is situated in the interior of the Wills Mountain Anticline and is almost entirely underlain by Reedsville Shale (figure 3.1, geology after Perry, 1971). The Reedsville is dominantly clay shale with interbedded calcareous shale and calcarenite near the base (Diecchio, 1986). The Oswego Sandstone underlies the knob to the northeast.

The surficial geology has been mapped in four distinct morphostratigraphic units according to a method devised for maps at 1:24,000 to 1:100,000 scales (figure 3.1). These units are described in more detail in the companion paper (Jacobson and others) and at stop 5. Debris is fine to coarse sediment that has been transported by flow, ranging from clear-water fluvial transport to debris flow. Sedimentologically, the critical point is the presence of matrix-supported, debris-flow diamicton. Morphologically, debris forms flattened terraces (indicative of flow of low-strength material) and fans. In contrast, alluvium is mapped according to the restrictive criterion that no debris-flow diamicton units are present. As a whole, alluvium is better sorted, more rounded, and more likely to have imbricated fabric. Many well-sorted alluvial units are interbedded with and inset laterally to debris because of the complex suite of transport processes occurring in these steep, small drainage basins. However, for the purposes of

Surficial geology and slope failures, Harper Run drainage basin

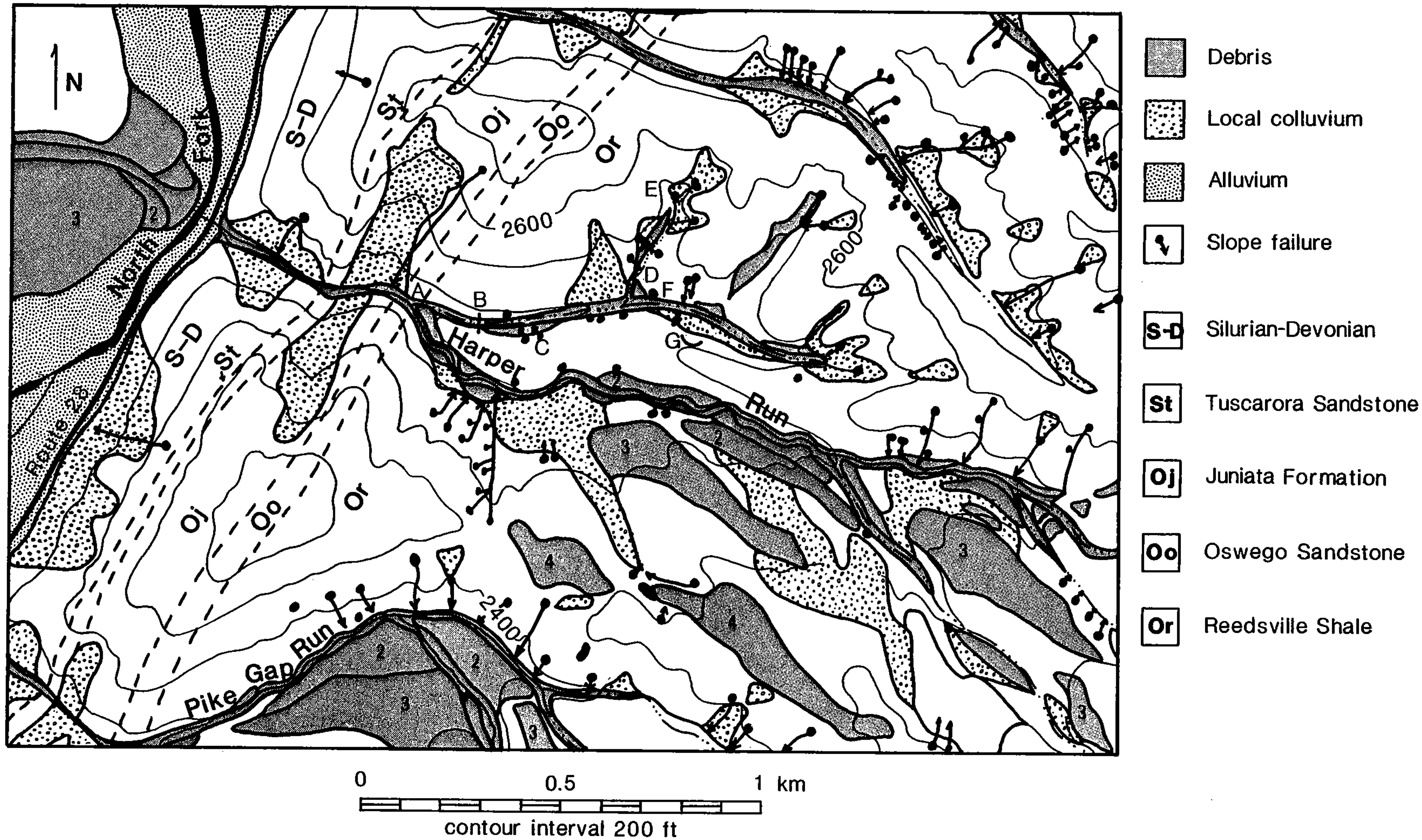


Figure 3.1. Harper Run area. Lettered sites are points of interest described in text. Numbers on debris terraces refer to preliminary correlations. Bedrock geology from Perry (1971).

these maps at the intended scales, small alluvial units are usually lumped with debris on the basis of their close association with matrix-supported diamicton.

The third unit, local colluvium, is defined to complement the fourth unit, thin colluvium over residuum (TC/R). Together these two units form a system for mapping hillslope surficial geology that is a compromise between a complete description of the complexity of the hillslope system and the reality of making maps at 1:24,000 scale and smaller. Local colluvium is defined as matrix-supported, poorly sorted diamicton that has been transported short distances downslope by non-flow processes including landsliding, seasonal creep, rheological creep, tree-throw, and faunal turbation. Local colluvium occurs in unchanneled valleys and as skirts at the base of slopes, often upslope from debris terraces. TC/R is defined as 1 ± 1 m of colluvium over weathered bedrock (on the assumption that in the limiting case all exposed bedrock is weathered). The definition allows colluvium to vary between 0 and 2 m before being mapped as local colluvium. Use of the 1 ± 1 m criterion is based on extensive field experience indicating that at thickness greater than 1 to 2 m slope morphology changes recognizably (in the field and on air photos) from those adjusted to bedrock lithology to smoother, flatter depositional forms. On figure 3.1, TC/R is simply mapped as the underlying bedrock unit.

FEATURES AT HARPER RUN

Proceeding up the dirt track along the stream, note that at first the stream channel shows no evidence of catastrophic erosion or deposition. Approximately 240-250 m up the track (B on figure 3.1) there is a large debris jam in the channel where an accumulation of logs wedged against standing trees and served to trap much of the sediment mobilized in the basin. Upstream from this spot, channel widening and erosion alternate with areas of deposition.

Approximately another 50 m upstream the track crosses the stream and mounts a small debris terrace remnant (C on figure 3.1). Two shallow slope failures on the southern valley wall mobilized into mudflows but the muddy debris came to rest on the debris terrace remnant with little actually being delivered to the stream channel. In this fashion, many debris terraces throughout the region acted to buffer the effects on the November 1985 storm.

Follow the track upstream along thick local colluvium and past the small barn, to the junction of the first order valley coming in from the northeast (D on figure 3.1). The channel of this valley was extensively eroded in 1985. An indistinct path leads up the first order valley over two prominent slope failures in local colluvium and debris. At E (figure 3.1) a stream-side failure in diamicton colluvium derived from Reedsville Shale revealed a 4-m-thick section with four apparent unconformities (figure 3.2). Samples from the section are now being analyzed at the U.S.G.S., including three samples for radiocarbon dating; analytical results were not available at press time. Presence of four distinct colluvial layers is evidence that deposition of colluvium in this unchanneled valley has been episodic (over an unspecified timescale). The youngest depositional unit is a 1985 mudflow mobilized from a large failure in local colluvium upslope.

Additional features at this stop are a stream-side slump that dammed the main channel and trapped additional sediment from upstream (F on figure 3.1) and a large, barely mobilized failure on the southern valley wall (G on figure 3.1).

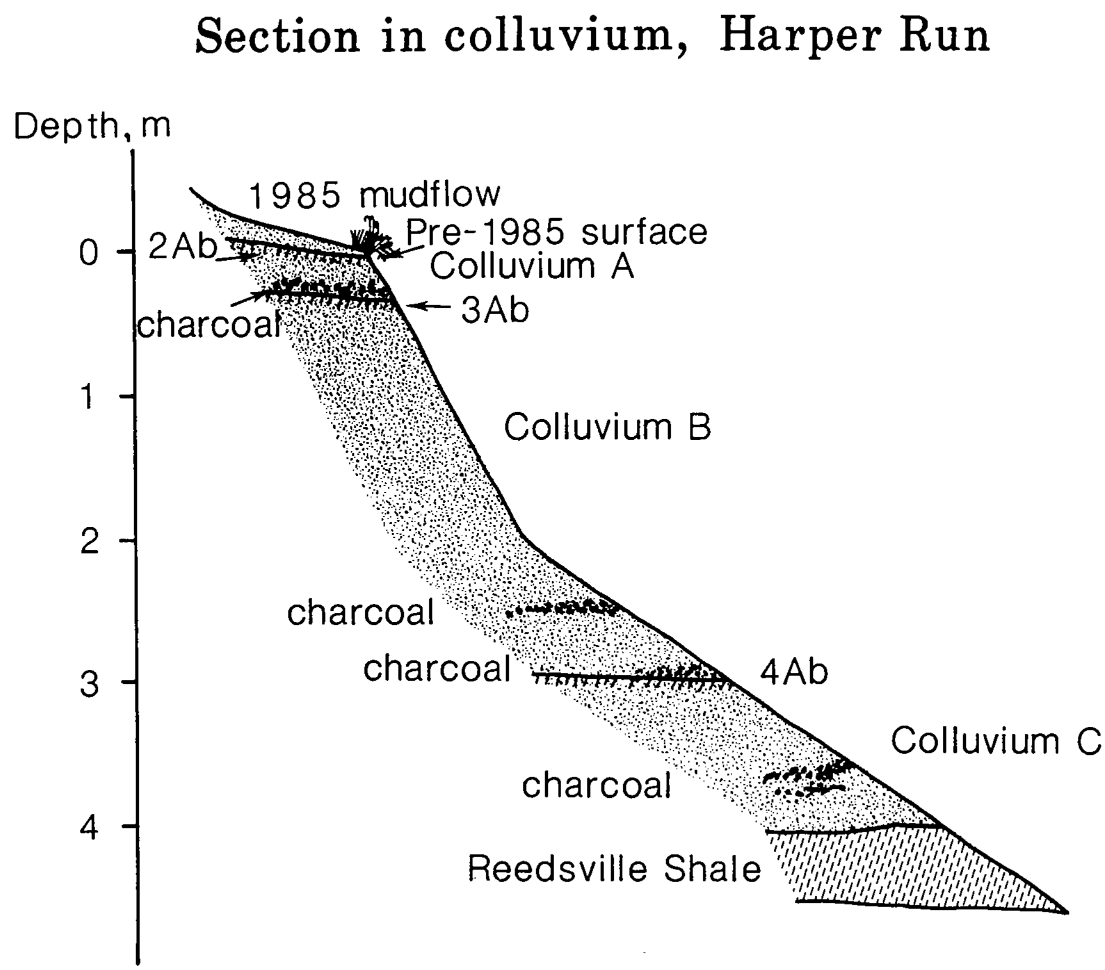


Figure 3.2. Colluvial section at Harper Run: described in text.

Back-track to return to Route 28.

38.3	0.4	**Turn right** (north) on Route 28.
40.5	2.2	**Turn right** (east) on Route 33.
40.8	0.3	**Slow down** for photo opportunity in Judy Gap. Note vertical beds of Tuscarora Sandstone on the west limb of the Wills Mountain anticline. Look straight ahead (east) for a view of a scar created by a debris avalanche on the west slope of North Fork Mountain. This avalanche transformed into a debris flow as it moved down Judy Run. The white bedrock outcrops at the head of the scar are Tuscaroara Sandstone on the east limb of the Wills Mountain anticline. Redbeds of the Juniata Formation crop out below the Tuscarora cap rock.
41.0	0.1	Route 33 curves sharply to left (north).
41.4	0.4	Look carefully for the bridge over Judy Run. Just before crossing the bridge look up the stream on the right (east). If you look carefully you will see the snout of the large debris flow that ended 70 m upstream from Route 33. You can imagine the problems this flow would have created if it had extended over the highway. We once hoped to use the snout of this debris flow as a bad-weather alternate Stop 6. However, the landowner has livestock grazing in the pasture along the debris flow and is worried about what her bull might do if he feels threatened by our large field group. We include the following brief discussion of the salient points of this debris flow so that smaller groups in the future might examine this locality, **with the landowner's permission.**
41.5	0.1	Park on right side of the road, near the white house. Do not block the driveway.

STOP 4: JUDY RUN DEBRIS AVALANCHE-DEBRIS FLOW

(STOP WILL NOT BE MADE ON 7 NOVEMBER 1987).

Text by J. Steven Kite and Ron C. Linton

Walk through the red gate; close the gate behind you. Continue south on the farm road for about 80 meters, then walk 30 m south to look over the snout of the debris flow. Around 9:00 P.M. on 4 November 1987, people in the white house heard a loud noise that sounded like a big jet right over the house. Using a flash light, the landowner's son-in-law witnessed the flow damage the turkey house that is still standing on the south side of Judy Run. Three other buildings were destroyed by the flow. The debris flow stopped at this point, but downstream reaches of Judy Run were intensely scoured by hyper-concentrated flow.

Tree trunks from the debris flow blocked the culvert under the earth bridge, so a bulldozer was used to open drainage. Most of the flow's lower 150 m has been modified by the mitigation efforts, but one can still get an appreciation of the size of clasts transported by the flow.

Walk 165 m upstream to an accumulation of very large boulders. The largest clast is 5.2 m X 2.9 m x 1.3 m, and weighs approximately 40,000 kg. Note the imbrication of the big boulders, which are at the front of a 40 m long lobe that is composed mostly of bouldery diamicton. The south side of the lobe has a sharp boulder margin, but stream flow seems to have modified the north side of the lobe. One other bouldery diamicton lobe occurs at the upstream end of the first lobe. Boulder fronts can be identified in the next few hundred meters upstream, but most of the landforms and deposits within easy walking distance have been either deposited or modified by normal stream flow or hyper-concentrated flow.

Note scour of bedrock outcrops on the outside of bends in the stream. In 1986, areas of scoured topsoil indicated that the flow super-elevated (i.e. banked steeply like a bob-sled) as it moved through bends. However, areas of scoured topsoil are much less visible in Autumn 1987.

Several slip-flows occured 150 to 250 m upstream from the huge boulders. As was the case along Harper Run, these slip-flows developed in shallow clayey soils formed on Ordovician rocks. A bouldery terrace occurs on the north side of the stream, 300 m upstream from the huge boulders. The are no exposures of sediments in the terrace, but the coarse texture of the surface clasts suggest it formed as the result of old debris flows.

Return to the vehicles. Continue on Route 33 east.

41.8 0.3 Note the reclaimed slip-flows in the hollow to the right.

44.5 2.7 **CAUTION THIS STOP REQUIRES THE VEHICLES CROSS A LANE OF TRAFFIC ON A CURVE WITH POOR VISIBILITY.** DRIVERS BE ALERT.

Park on the left at the Germany Valley Overlook. **Pull the vehicles up to the far end** of the parking area to allow plenty of room for vehicles at the end of the caravan. Beware that other vehicles may pull into this area while we are here.

STOP 5: GERMANY VALLEY OVERLOOK

Text and discussion by Robert B. Jacobson and Mark L. McKoy

The Germany Valley overlook provides a unique perspective on the complex relations between bedrock and surficial geology in the Appalachian Valley and Ridge. Interbedding of resistant and non-resistant rocks and their structural deformation are the primary controls on the distribution of landforms and geomorphic processes in this area. Rare meteorological events and/or climatic episodes play a secondary role in determining the distribution of erosional and depositional features.

BEDROCK STRATIGRAPHY

Recent guidebook reviews of the Paleozoic stratigraphy of eastern West Virginia are available in Diecchio (1986), Fichter and Diecchio (1986), and Fichter (1986). Most of the summary presented here is taken from Diecchio (1986). A generalized stratigraphic column for the region is shown in figure 5.1 and a simplified geologic map and structural cross section for the field trip area are shown in figure 5.2.

The oldest rocks exposed in the center of the doubly-plunging Wills Mountain anticline are cavernous Ordovician limestones of the New Market Limestone, Black River Group, and Trenton Group (Nealmont and Dolly Ridge limestones). Limestones of the Trenton Group are shaley, and thin-bedded and grade upward into the Reedsville Shale. The lower part of the Reedsville is calcareous gray to olive shale with abundant interbedded thin calcarenite beds. Upward, the Reedsville changes gradually to a shaley middle section and then to a mudstone zone transitional to the overlying Oswego Sandstone. The Oswego is a fine- to medium-grained sublitharenite.

The contact with the overlying Juniata Formation is transitional and is usually chosen as the base of the lowest red mudstone. The Juniata is composed of cyclically interbedded, red, fine-grained sandstone, burrowed siltstone, and bioturbated red mudstone. The transitional contact with the overlying white, very fine-grained to very coarse-grained quartzarenite of the Tuscarora Sandstone is regarded as the Ordovician-Silurian boundary. Although only 52 to 58 m thick, the Tuscarora is a very dramatic ridge-forming sandstone in this region.

The section immediately overlying the Tuscarora Sandstone represents a period of tectonic quiesence and is dominated by shales and shaley limestones. Parts of the Middle and Upper Silurian section are exposed at stop 6. Immediately overlying the Tuscarora is the Rose Hill Formation consisting of interbedded hematitic sandstone and green-gray shales. The Rose Hill is overlain by the thin (approximately 3 m) Keefer Sandstone, and interbedded shales, limestones, and dolomites up to the base of the Helderberg Group. The Devonian Helderberg is mostly cherty limestone and is very cavernous in the South Branch Valley.

The overlying Oriskany Sandstone is considered the base of the Acadian Orogeny (Fichter, 1986) and although generally only 15 to 55 m thick, the Oriskany is a locally important ridge former in the Middle Silurian to Upper Devonian section. The Oriskany is overlain by a thick sequence of dark Devonian shales grading upward into turbidites (Needmore to Brallier formations). This part of the section is responsible for the broad valley of the South Branch from north of Franklin to Petersburg. Overlying the Brallier is the Chemung Group (interbedded sandstones, siltstones, and mudstones) which is transitional to the alluvial-deltaic Hampshire Formation (interbedded sandstone and red mudstone). The Hampshire Formation concludes the Acadian clastic wedge.

The Pocono (Price) Group consists mainly of micaceous fine-grained to conglomeratic, marginal marine sandstone with occasional shale interbeds (Tilton, Prouty, and Price, 1927). The Pocono is a local ridge-former and holds up the Fore Knobs seen to the northwest of the Germany Valley overlook on the slope ascending from the North Fork valley to the Allegheny Plateau. The partially cleared slopes above the Pocono are underlain by the Greenbriar Group, consisting of interbedded blue, fossiliferous limestone and red shale, and the Mauch Chunk Group, consisting of gray, green, and red shale. The edge of the Plateau is underlain by the resistant quartz sandstones of the Pottsville Group. Spruce Knob, the highest point in West Virginia, can be seen to the west of the overlook on a clear day.

BEDROCK STRUCTURE

Valley and Ridge structure in this area was created by imbrication of blocks of the earth's crust at depth and by the folding and faulting of the overlying rock layers. It has been estimated that bedrock here moved more than 17 km to the west-northwest during the Middle and Late Pennsylvanian Allegheny Orogeny.

A cross-section from Kulander and Dean (1986) illustrates the structural complexity of the area, with more detail than protrayed on the geologic map (figure 5.2). Two dashed lines represent major decollements which developed at depth in weak rock layers, principally the Cambrian Rome Shale (also known as the Waynesboro Shale) and the Ordovician Reedsville Shale (also known as the Martinsburg Formtion). Each decollement separates two distinct crustal sheets which were thrust to the northwest. As compression and slippage continued, the Waynesboro Sheet, composed of a thick sequence of competent limestone and dolomite, buckled and ruptured progressively further westward into blocks, each of which ramped up on its western neighbor. When friction between the ramping blocks became sufficiently high, slippage would proceed on the decollement west of the last ramp. Because of internal weaknesses in the Waynesboro sheet, a new ramp would then form west of the last one. The less-competent Martinsburg Sheet ruptured and folded in response to movements of the sheet below. According to Kulander and Dean (1986) considerable deformation in the Martinsburg Sheet preceded ramping.

Bedrock in the Germany Valley was folded into the Wills Mountain anticline as the leading edge of a block ramping from the Waynesboro to Martinsburg decollement. According to Perry (1978), the Wills Mountain anticline has structural relief of more than 3,000 m and extends nearly 300 km southwestward from Bedford County, Pennsylvania to Alleghany County, Virginia. The northwestern limb is steeply dipping to overturned (seen in the River Knobs and Seneca Rocks along the North Fork) whereas the southeastern limb dips generally less than 30 degrees (as evident in the cliffs of Tuscarora Sandstone along the ridge to the east). Unlike the Ordovician strata exposed in the Germany Valley, Silurian and Devonian strata on the southeastern limb accomodated many closely spaced thrust faults (figure 5.2). The Wills Mountain anticline plunges to the southwest and northeast and the crest of the anticlinal axis occurs in the Germany Valley.

The northwestern limb of the Wills Mountain anticline also marks the Allegheny Structural Front, the boundary between the intensively folded and faulted rocks of the Valley and Ridge and the more gently folded rocks of the Allegheny Plateau (figure 5.2).

SURFICIAL GEOLOGY

The Valley and Ridge landscape of the Wills Mountain anticline illustrates the familiar adjustment of slope form to rock type: ridges are underlain by sandstones and valleys are underlain by less-resistant rocks such as limestones and shales. The landscape also reflects the structural influence on outcrop area: all other factors being equal, gently dipping sandstone having greater outcrop area will underlie higher ridges than equivalent, more steeply dipping sandstone. An example is seen here at the overlook in the contrast between the northwestern and southeastern Tuscarora Sandstone ridges.

Bedrock structure and lithology also have had important influences on genesis and preservation of surficial stratigraphy in the valley. Coarse sandstone debris shed from the ridges has been deposited and preserved on the softer rocks in the center of the anticline. Preservation of these debris deposits can be attributed to their relatively high resistance to erosion compared to the limestone and shale bedrock. On the Reedsville Shale each subsequent episode of debris deposition has created a terrace inset at a lower elevation (figures 3.1 and 5.3). In contrast, debris has tended to build up in thickness and fan out over Ordovician carbonates because underdraining in the karst terrane has minimized stream incision between events.

The narrow, sandstone-defended gaps also probably have worked to increase debris residence times by acting as valves that limit the rate at which sediment can be flushed from the basins in the interior of the anticline.

Debris consists of a range of materials from well-sorted alluvium to matrix-supported diamicton. It is mapped as "debris" based on the presence of matrix-supported diamicton beds. Most of the debris is relatively coarse, consisting of angular to sub-rounded sandstone cobbles and boulders ranging up to the size of small suburban houses. Sedimentologically similar debris deposited in 1985 appears to have been transported mainly as non-Newtonian debris flows that were extensively reworked by later clearwater flows. The later reworking removed much of the original interstitial matrix.

Multiple cross-cutting debris terraces indicate that debris deposition is an ongoing, episodic process in this region. Preliminary correlations have been attempted by simply counting debris terraces up from the bottom, comparing surface morphology (rockiness), and by comparing spatial extent. The maximum number of debris terraces identified in the interior basins is five. Most basins have only three to four terrace levels preserved (figures 3.1 and 5.3).

Surficial geology, Germany Valley overlook

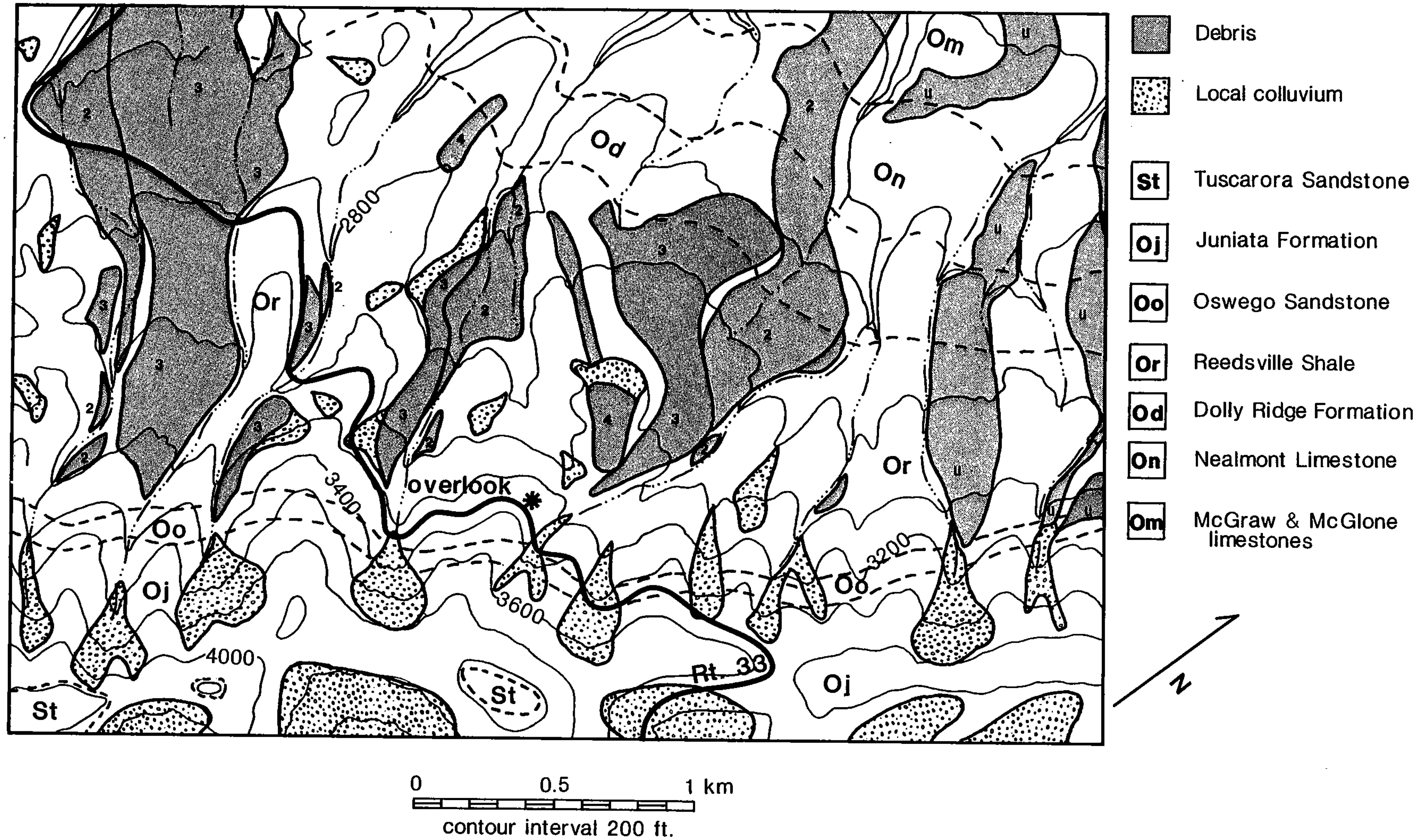


Figure 5.3. Surficial units described in text. Numbers on debris terraces refer to preliminary correlations. Bedrock geology from Perry (1971).

The number one terrace (T1) is slightly above most of the 1985 depositional surface and is underlain by unweathered debris identical to that deposited in 1985. T1 is discontinuous along valleys and was extensively reworked in 1985. T2 is distinctly higher than T1. The elevation difference is highly variable, but it is usually in excess of 2 m. The surface is extremely rocky and appears to have larger material than the T1 or 1985 deposits. T2 is often continuous along valleys for distances of 0.5 km or more, it is generally wider than T1, and it can often be traced up into unchanneled valleys along ridges. T2 does not appear to be very weathered. However, pedologic assessment is complicated by the extreme coarse-fragment content and the poorly drained landscape position; evaluation to date has been very qualitative. T2 terraces have trees and stumps that clearly indicate that deposition does not date from the last 250 y.

The T3 debris terrace is much more extensive, covering broad areas high above present-day streams. Multiple scarps and elevations within the T3 terrace unit suggest accumulation under varying conditions. Debris remobilized from T3 as colluvium often grades down to T2 terraces. T3 is often discordant with modern stream channels and cannot be traced directly to its presumed source areas in unchanneled valleys; soils on T3 debris have red (7.5YR to 5YR) argillic B horizons. T4 and T5 remnants are small, more deeply weathered, and are usually isolated on Reedsville or carbonate ridgetops, totally cut off from the present-day sediment source. An example is the T4 remnant mapped directly below the Germany Valley overlook.

No woody material has been found in these coarse debris deposits for radiocarbon dating, with the exception of that which was clearly deposited in 1949. However, trenches in debris are planned for the 1988 field season and there are some promising indications that paleomagnetics and vertebrate paleontology of cave sediments and new methods in in situ production of Beryllium-10 and Aluminum-26 isotopes can be applied to dating the deposits.

Ultimately, absolute age control on these deposits is necessary to determine whether they are the product of Pleistocene climates or if they could be the product of the present-day climate. The companion article by Jacobson and others discusses constraints on the ages of the debris terrace deposits.

		Continue east on Route 33.
45.3	0.8	Top of North Fork Mountain: drainage divide between the North Fork South Branch Potomac River and the South Branch Potomac River. (Don't blame us, we didn't name them.)
48.0	2.7	**Turn left** on Reeds Creek Road. (Watch carefully for small green sign and brown fish hatchery sign.)
50.5	2.5	Enter Franklin quad.
51.5	1.0	Note Reeds Creek Church on left. Look for a slip-flow on the slope to the right.
52.8	1.3	Note remnants of slip flows on left.
53.3	0.5	**Turn left** (northwest) at T-intersection.
54.1	0.8	At crest of hill, look ahead left (west) at a debris-flow scar on at the south end of a line of Tuscarora Sandstone outcrops on North Fork Mountain.
54.5	0.4	Small slip-flows behind building on right.
54.8	0.3	Reeds Creek Fish Hatchery on left.
55.8	1.0	Enter Upper Tract quad.
56.4	0.6	Saprolite pit on right.
57.0	0.6	Bridge over Reeds Creek. **Turn left** (west) on gravel road 50 m north of bridge.
57.9	0.9	Bear right (north-northeast) at intersection with farm road.
58.7	0.9	Bear right (north-northeast) again.
58.8	0.1	Look ahead left (north) for upper end of Twin Run debris-avalanche/flow scar. We will investigate this debris flow at length.
59.4	0.6	Sinkhole on right.
59.5	0.1	**PARK** on either the northwest side of the road or at the campsite on the southeast side of the road. Do not block the road.

STOP 6: THE TWIN RUN DEBRIS AVALANCHE-DEBRIS FLOW

Text by J. Steven Kite, Ron C. Linton, and Steve Gerritsen

Discussion led by Steve Kite, Robb Jacobson, Ron Linton, Bob Behling, and others

This stop will allow you to get some exercise, and to be exposed to whatever meterological conditions exist here at this moment. We are aware that there will be many different paces at this outcrop, in part because of the physical demands, in part because of varied topics and levels of interest. We will attempt to provide as many leaders as possible, and to allow the Friends to proceed in small groups at different paces. We will try to keep tabs on roughly where everyone is at any given time. Please help us by checking in with people who are keeping track. **DO NOT GO OFF ON YOUR OWN** for anything longer than a brief "rest". There is great potential for getting lost or injured or being caught on the mountain after dark. **BE CAREFUL.** Try not to knock loose debris on to the heads of those who are walking behind you. **DO NOT OVER-EXERT.** We do not know your limits, so it is your responsibility to know when to stop and turn around. **WATCH FOR SNAKES**, especially if it a sunny afternoon. Keep your fingers out of crevices. Other precautions may be mentioned at the beginning of the stop.

This stop has four main objectives:

1. To look at the physical evidence of the largest debris flow that occurred in this area during the 1985 flood. You will get an impression of the great momentum of debris flows, and will see why we believe they present a great risk to life and property in parts of the Appalachians. Moreover, we will discuss the mode of debris movement (hyperconcentrated flow vs. slurry flow vs. sliding) along the path of this flow.

2. To discuss which characteristic criteria are apt to be preserved long after the event, and which are apt to be modified by later events. This consideration is very important if we are to use field evidence to identify old debris flows.

3. To briefly discuss the evidence of older debris flows along Twin Run.

4. A final, but important objective is to look at the old sediments, soils, and saprolites exposed by scour along the debris flow track.

There are two possible routes to the Twin Run debris flow (figure 6.1). Both can be navigated using four-wheel-drive vehicles during dry conditions, but we will walk approximately 2 km to get to the site. Most of the route

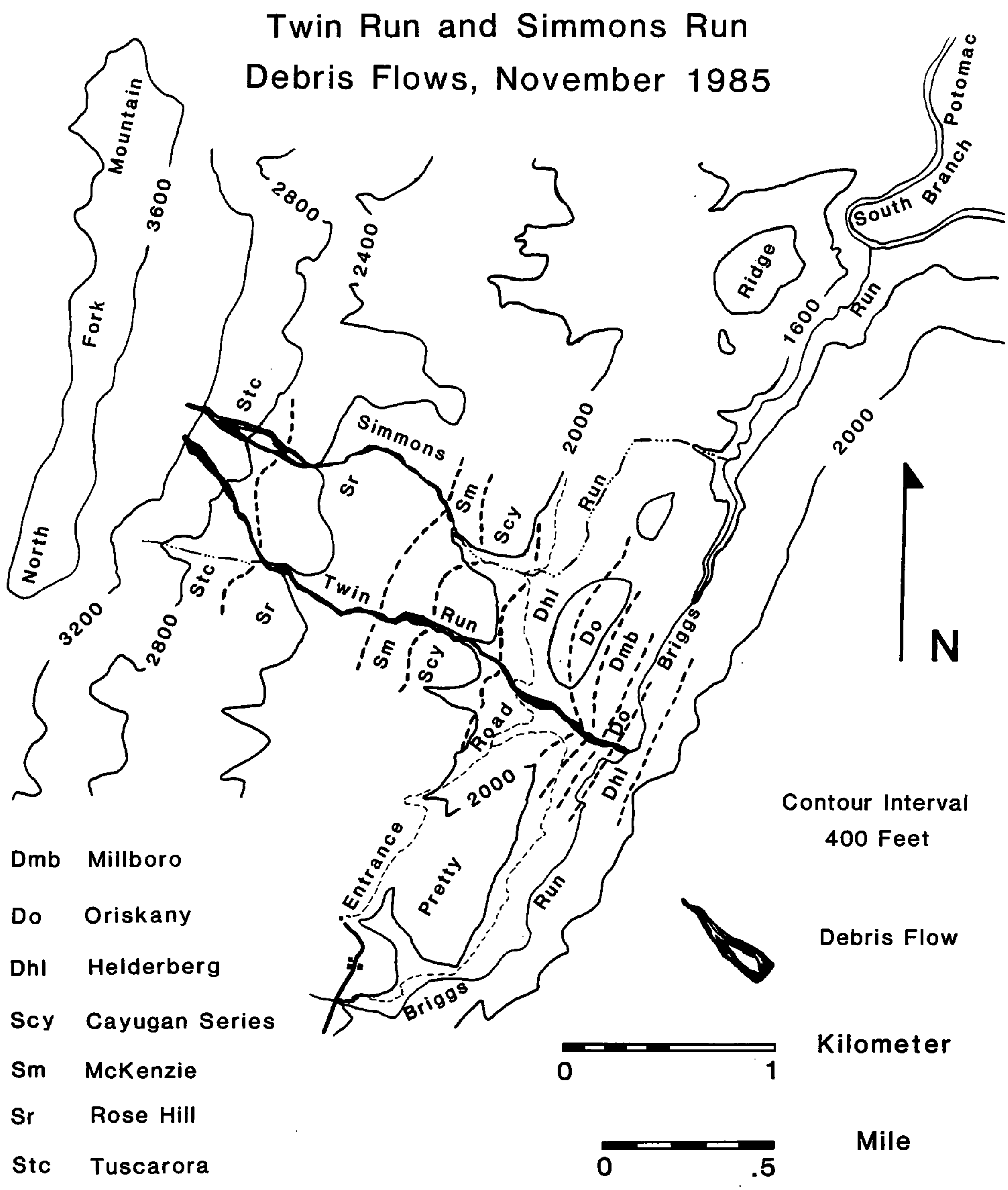


Figure 6.1. Physical setting and bedrock geology of Twin Run and Simmons Run.

described below traverses private land along a trail that is shown on the 1981 photorevision of the Upper Tract quad. The other route is a USFS road that begins about 100 m southwest of where we have parked. This route is about the same length as the one we will take, but it is not as scenic. The USFS road runs southeast of Pretty Ridge, but is not shown on the 1981 photorevision of the Upper Tract quad.

Proceed northeast on the gravel road. After passing trailers and hunting camps, go through the first gate at 250 m from the parking spot. **CLOSE THE GATE BEHIND YOU.** Note the view of the largest of the 1985 debris flows to the north. We know of no one who heard or saw this event, but the landowner, Mr. Charles Sites, said that it occurred sometime during the night of November 4-5, and that on the morning of the 5th he saw a great amount of ground-water coming out of the mountain at the scar. A second debris flow scar occurs in the next hollow north of Twin Run, but this scar is not visible along our route into the scar.

Stay on the gravel/dirt road past the farmhouse. Don't hassle the dog. At about 475 m pass through a second gate. Note the well-developed sinkholes at 900 m. The road will enter open forest after 1 km, then bend sharply to the left and descend into a ravine. Cross an unnamed intermittent stream at 1100 m. Make a sharp bend to the right, soon followed by a USFS boundary marker and a third gate. The trail forks at 1850 m (figure 6.1). The right fork is not shown on the 1981 Upper Tract quad, but leads to the downstream end of the Twin Run debris flow.

If the group is short on time, a most likely circumstance, we will not have time to look at the terminus of the flow but will **proceed on the left fork** directly to the most interesting part of the debris flow. The road (i.e. the left fork) crosses the debris flow at 2050 m (200 m north of the fork in the road). Pick up the log at the entry number 16 in the text that follows.

If the group has ample time and the weather is co-operative, proceed on the right fork. Find the clearing on the left side of the dirt road at 2150 m (300 m east of the fork). Leave the road at the clearing and walk 200 m east though the forest, along the drainage divide between Twin Run and Briggs Run. Walk 30 m north-northeast to the edge of the debris flow, carefully picking a good route to avoid large accumulations of wood debris. Walk east-southeast 60 m to the end of the debris flow, near the confluence of Briggs Run and Twin Run (total walking distance = 2450 m). **We will use the confluence point (altitude = 1720 ft, 525 m) to start a new tabulation of distances.**

SITE DESCRIPTIONS

1. (0 m) The debris flow track ends here, where Twin Run flows into Briggs Run. Compare the the channel of Twin Run with that of Briggs Run upstream and downstream of the confluence. Upstream, Briggs Run show evidence of minor scour and deposition of relatively minor amounts of cobbles. Moss- and lichen-covered boulders hint of more dramatic past events, but the 1985 flood was unspectactular in this stream.

A look downstream from the terminus reveals that the first 25 m has seen limited deposition of boulder and wood debris, suggesting a short transition from debris-flow deposition to stream-flow scour. Beyond this transition zone, the channel of Briggs Run experienced scour down to Lower Devonian Helderberg cherty limestone bedrock. Very few clasts were deposited in this reach, although many cobbles and some boulders were deposited farther downstream. We speculate erosion was extreme in this reach because runoff beyond the debris flow had a high viscosity because of its very high suspended load.

If we had more time, we might bushwhack around the margins of Briggs Run downstream from this point. In the next 100 m, several curvilinear boulder deposits occur that may represent levees from older, more far-traveled debris flows. However, there are many boulder accumulations composed of angular Devonian Oriskany Sandstone boulders derived from the hills on either side of Briggs Run. Large trees growing on the old levees suggest that any older debris flows occurred at least one century ago.

The bed of Twin Run has been the site of extensive deposition. The most obvious depositional features are 3 m high piles of tree trunks and the accumulation of many subangular boulders of Tuscarora Sandstone with long axes greater than 1 m. The nearest Tuscaraora outcrops are over 2 km up Twin Run. Large far-traveled boulders and large tree jams are common near the terminus of debris flows; however, these are not unique or diagnostic debris-flow criteria.

Proceed up Twin Run; subsequent distances will be measured from the confluence of Twin and Briggs Runs, up the middle of the debris flow track. Figures 6.2 and 6.3 will be of assistance in finding points of interest.

2. (75 m) Note boulders and outcrop of Devonian Oriskany Sandstone on northeast side of the track. We are walking through the west limb of the Cave Mountain anticline, whose axis runs roughly along Briggs Run. The Devonian black shales above the Oriskany is not exposed here.

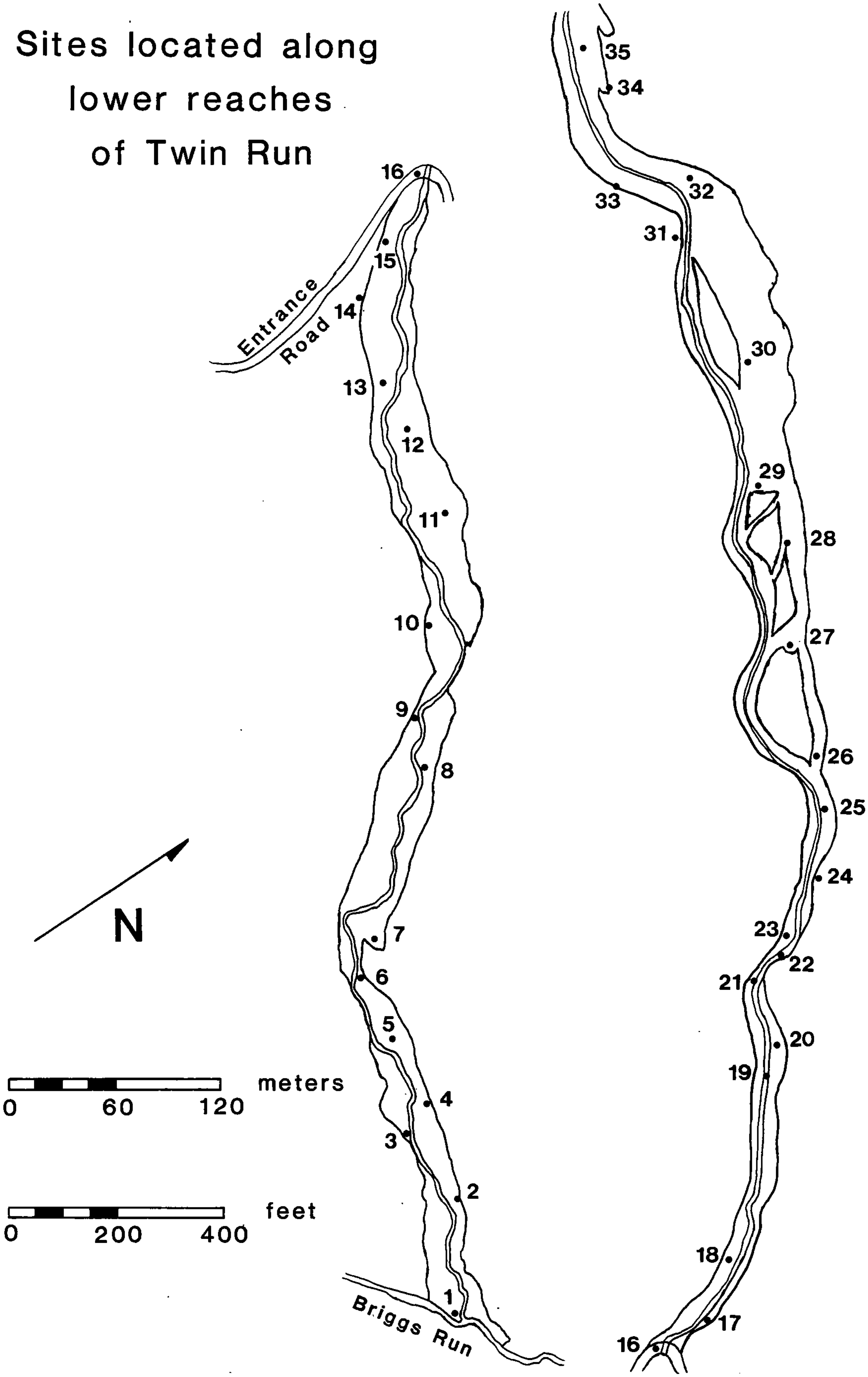


Figure 6.2. Numbered sites referenced in discussion of stop 6: lower reaches of Twin Run.

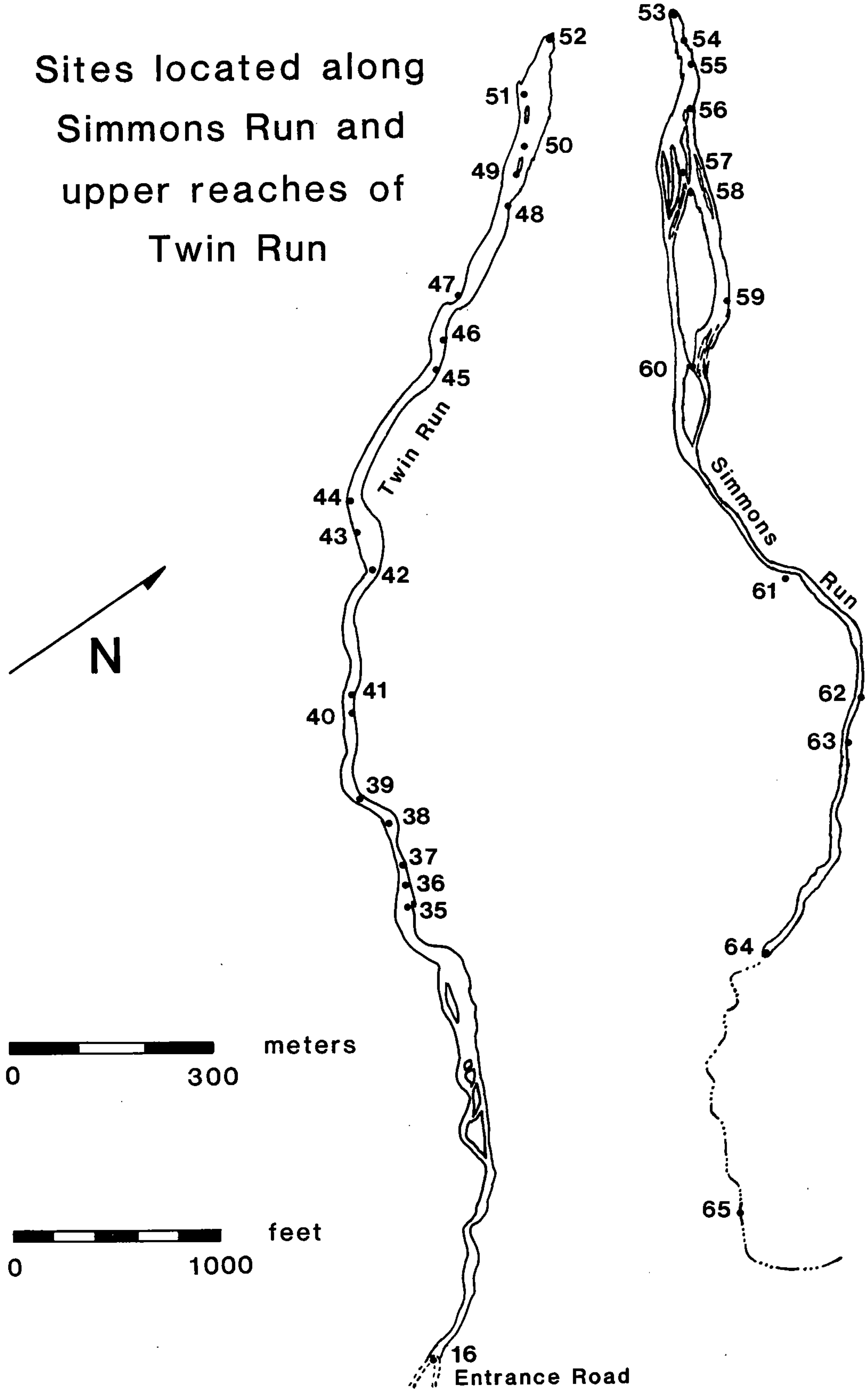


Figure 6.3. Numbered sites referenced in discussion of stop 6: Simmons Run and upper reaches of Twin Run.

3. (100 m) Note large levee composed of wood and other debris on the southwest side. Imagine what this deposit will look like after the wood rots away.

4. (135 m) Note that the northeast bank has experienced scour of vegetation well above the thalweg of the channel. This is common along debris flows, but again probably cannot be considered diagnostic. Except for possible truncated soil profiles, there would be little long-lived evidence that this has occurred.

5. (180 m) Note the "boulder" berm northeast of the thalweg. Boulder berms (gravel berms is be a much more useful term) form as the result of normal streamflow or hyperconcentrated flow, not true debris flow. This deposit ranges from cobble-boulder gravel upstream to pebble-cobble gravel downstream. It is not attached to the northeast wall of the valley, suggesting flow separation. The boulder berm was deposited on top of a valley-bottom surface which had previously had much of its vegetation scoured, probably by debris flow.

6. (205 m) Note the sheared tree trunks near where the boulder berm attaches to the northeast side of the valley wall.

7. (225 m) A lobate deposit composed of sandy diamicton occurs on the northeast side. This feature, which has small but distinctive levees, is diagnostic of debris flow. This deposit escaped obliteration by later stream flow or debris flow because it is slightly above the rest of the valley bottom. Not the well-developed levee on the northeast side between 235 m and 320 m.

8. (330 m) Near the thalweg, another tree has been sheared off at its roots. At 340 m, there is another outcrop of Oriskany sandstone. We are now on the east limb of the Wills Mountain anticline, the large structure that underlies North Fork Mountain. We will traverse two bedrock units that are not exposed along Twin Run as we walk to the northwest: the Silurian-Devonian Helderberg Limestone, and the Upper Silurian Tonoloway shaley limestone.

9. (360 m) Note the large rock on the southwest side of the flow. This boulder was moved only 25 to 50 cm during the 1985 event.

10. (425 m) The levee on the southwest side was deposited adjacent to a pre-existing levee. Boulders in the old levee are covered with lichens and mosses and the entire landform is overgrown with substantial trees. A 3 m high exposure of colluvium derived from nearby Oriskany outcrops is exposed by scour and slumping on the northeast side.

11. (460 m) A curious 20 m wide boulder-cobble bar occurs in the middle and northeast side of the valley. It has some attributes suggesting it is a debris-flow lobe (large clasts with a sharp boulder front along its northeast side) and some suggesting it is a large boulder berm (surface appearences suggests that there is little diamicton in this deposit, and many of the clasts show weak imbrication). Whatever the exact origin, the sharp boulder front is detached from the northeast side of the valley, again demonstrating flow separation. Tree trunks and boulders have been jammed along either side of the valley. Although it may not be obvious from this point, a glance back from farther upstream shows that a small amount of super-elevation has occurred on the southwest side of the valley as the flow moved though the gentle bend along this reach. It is not clear that the pulse of debris flow that formed the curious boulder-cobble bar was the same event that produced the super-elevation and tree-trunk and boulder levees. Could this landform represent a late debris-flow lobe that has been modified by de-watering and subsequent hyper-concentrated stream flow?

12. (530 m) Note the large boulder and the 1-2 m break in slope at the upstream end of the curious boulder-cobble bar.

13. (550 m) Small cobble-boulder bar occurs southwest of the thalweg. Two larger cobble-boulder bars occur between 565 m and 620 m. One item for debate: how much of the deposits have been eroded or otherwise modified after deposition?

14. (610 m) Another site where the 1985 levee was deposited adjacent to or on top of an older levee.

15. (645 m) Erosion has revealed a soil profile buried during the 1985 debris flow. A 0.5 m cap of cobble-boulder diamicton lies over well-developed E and B horizons that have formed in an older diamicton.

(The abbreviated version of this stop begins here.)

16. (690 m) **Note the road crossing Twin Run.** Later we will follow this road to the southwest to return to our cars. Beware that there has been a limited amount of bulldozing near the road.

The stream that flows in from the west did not experience debris flow during 1985, but forest-covered boulder deposits in its channel are very similar to fresh deposits that occur downstream.

The character of Twin Run changes dramatically at this point, as do the effects of the 1985 debris flow. Below the road, the relatively wide valley floor has a slope of 0.08, and is dominated by depositional forms. The narrow valley in the next 1.7 km has a slope of 0.12 to 0.30 and is dominated by sediment transfer, with considerable scour of the channel margins, but only local deposition. The great momentum of the debris flow can be seen from the degree of super-elevation (i.e. bob-sledding) around bends and obstructions adjacent to Twin Run.

17. (710 m) Excellent exposures of boulder-cobble diamicton with a sandy matrix, over the next 100 m. There is some crude bedding and imbrication in these sediments. Almost all of the boulders are white Tuscarora Sandstone, whereas many cobbles are red sandstone of the Rose Hill Formation. Elsewhere, Tuscarora clasts are notoriously very hard, but many Tuscarora clasts in this outcrop are so weathered that they crumble easily. Most fresh clasts in the outcrop are angular to subangular, but many show spheroidal weathering. A few secondary ironstone layers, typically 3 to 5 cm thick, occur in the diamicton. The matrix is sandy, but there is enough clay to make the matrix fairly cohesive. Although the tops of the soil profiles developed in this boulder-cobble diamicton are not well exposed, the sediment appears quite old. We have no absolute dates to share as to how old, possibly the Friends can offer some suggestions based on comparison with dated deposits from other localities.

Note the variation in the nature of the sediment exposed along this outcrop: very bouldery diamicton occurs at 775 m; gravelly sand occurs at 805 m; very coarse sediment that is locally clast supported at 830 m.

18. (770 m) Two trees have been sheared off at their roots, typical of debris flow. Look for iron-stained clasts along the stream bed and in outcrop.

19. (845 m) Note the sandy sediment that has accumulated behind the fallen tree that is damming the channel of Twin Run. Is this analogous to the sandy sediments seen previously?

20. (860 m) A tree, which once grew about 5 m above the bottom of the channel, has been sheared off 0.7 m above the root flare. Most trunks elsewhere along Twin Run are sheared off at the root flare. It might be interesting to consider whether the tree was broken well above the root flare because debris was riding on a cushion of air or water. If many trees were decapitated at this site, basal detachment might be a likely interpretation, but this tree shows some abrasion all the way down to the root flare and there are few similar trees along this reach.

21. (880 m) A sharp bend in the channel makes this an excellent place to see the effects of super-elevation. Look for the limit of scour and lodged debris on either side of the bend. The topsoil on the outside (southwest side) of

the bend is scoured at least 7 m higher than on the inside. (You may choose to carefully scramble up the side of the channel to get a better view of what occurred along the margins.)

22. (900 m) Note that the evidence of super-elevation is now on the other side of the ravine. A small portion of the flow actually super-elevated completely out of the ravine and destroyed several trees. Levees built by this "spill-over" show that the out-of-ravine flow was at least 90 cm deep, although scars on trees extend over 80 cm higher. Note the boulders and cobbles caught behind tree dams in the "spill-over" chute. Note that the outside of this bend experienced erosion to a level below old the root zone. Well-indurated ironstone cemented gravels are exposed in this cut.

Find the 2.9 m X 2.3 m X 0.7 m boulder of Tuscarora Sandstone in the ravine. Note the accumulation of wood debris and coarse clasts just upstream of the boulder, opposite the spill-over chute. This material was deposited on top of a relatively undisturbed topsoil surface, probably in a relatively quiet zone on the inside of the bend. The deposits suggest either back-eddying or debris-flow separation from the inside of the bend. Others may have better terms but we will call these slack-flow deposits in following discussion. The high level of this and other slack-flow deposits suggests that the limit of scour is not a good marker of the limits of flow. One point to consider: what was the nature of the transporting medium inside the super-elevated bends? Was it a slurry like the rest of the debris flow? Or was it a pocket of hyperconcentrated water displaced by the rapid debris flow?

23. (920 m) Note the shelf or berm on the southwest side of the channel.

24. (960 m) The gnarled tree on the northeast side of the ravine is tilted down the axis of the ravine, not down slope. This tree may have been damaged by an older debris flow. The first encounter with saprolite occurs at 970 m. This saprolite is developed from shales, limestones and dolomite of the Upper Silurian Wills Creek Formation. Note the post-debris flow slumping on the southwest side of the ravine.

25. (1000 m) This outcrop is capped with about 4 m of saprolite. Note the super-elevation of the debris flow; if the limit of scour matches the margins of flow, then debris was banked 27 degrees as it sped though this bend.

We will climb up the northeast side of the ravine at about 1020 m (look for flagging). This is done for two reasons: first, to avoid climbing over 200 m of slippery saprolite outcrops and a sandstone waterfall and, second, to look at another site where the debris flow super-elevated out of the ravine.

26. (1040 m) The trees on top of the surface were able to dam much of the debris from the distal end of this "spill-over", just a meter or two before it re-entered the main debris flow. Some boulders were lodged against trees in orientations that are likely to collapse once the trees die and rot, but much of the tree-dammed lobes and levees are apt to be preserved for hundreds of years or longer. An old 1 to 1.5 m high boulder levee can be seen on the northeast side of this spill-over chute, showing that an older debris flow once followed a similar route.

27. (1090 m) Here are good examples of the numerous tree dams and debris levees that form in spill-over chutes. The large dam deflected most of the flow back into the ravine at this point, but some component of flow was able to partly breach this dam and continue down slope to site 26. The is a distinct particle-size differentiation in this dam: the boulder at the debris dam give way to pebbles and small cobbles farther up the chute. This particle-size differentiation is typical of debris flows.

28. (1130 m) Some of the diverted flow made its way back to the ravine here; look at the orientation of tree scars and debris jams. In general the levee formed in 1985 is better devloped on the outside (northeast side) of the spill-over chute that on the inside. This is consistent with the fact that the older levee (or levees) seem better developed on this side, too.

29. (1180 m) Stand near the debris-flow scarred trees just east of the waterfall and face nothwest, looking toward North Fork Mountain. There is much to see from this vantage. Although not visible when tree foilage is out, it may be possible to see the head of the debris scar 1.5 km from this site. To the right, see the wide spill-over chute in which many trees have been destroyed and the topsoil has been much eroded. Contrast that feature with the relatively undisturbed ravine on the left. It appears that most of the flow left the ravine due to super-elevation farther upstream.

The waterfall on your left is formed by the Williamsport Sandstone of the Cayugan Series. Outcrops of McKenzie Formation shale and limestone occur in the channel upstream.

Much of the flow re-entered the ravine at the waterfall. Try to imagine the incredible scene during the night of 4-5 November 1985. Some of the trees behind you were killed by scour during the debris flow. You may find a hole left by an increment borer in a dead >90 year old oak. Saplings wrapped around standing trees and boulders and cobbles in levees along the margins of the flow indicate that up to 1.5

m of debris was flowing out of the ravine in the spill-over chute at this point.

If we have the time, we may walk into the forest on our right (northeast). Beyond the large levee created in 1985, there are a series of elongate boulder ridges overgrown with substantial trees. These old levees show that this dramatic spill-over chute appears to have been a common route for older debris flows, some of which were significantly larger than the 1985 event.

Walk up the middle of the spill-over chute.

30. (1255 m) Find one of the more deeply eroded areas in the spill-over chute. Although the effects of debris flow are clear, the erosional channel in this chute appears to be the product of stream flow. It is likely that hyper-concentrated water flow at the end of each debris flow pulse produced these channels. The high-flow marks are 2.5 m above the lowest part of this wide spill-over chute.

From this point to 1300 m, an old boulder levee can be discerned along the southwest side of the spill-over chute. Note the high debris jams and levee on the other side.

31. (1310 m) A large slack-flow deposit occurs on the southwest side of the ravine. If you could not see the debris flow scar earlier, try again from this vantage. Contrast this with the considerable amount of scour on the opposite bank, where the debris flow super-elevated out into the forest.

32. (1360 m) Stand at the upstream end of the spill-over chute. There is a distinct bouldery deposit that is lower than, but adjacent to the tree jams. Look at the little over-run knoll on the south side of the ravine. This knoll shows topsoil erosion on its entire surface, showing that the flow was attached to the base of the ravine, not riding on a cushion of air or water.

33. (1400 m) An excellent scoured trim line occurs on the southwest side.

34. (1420 m) The tree jam on the northeast side suggest that a spill-over nearly occurred here.

35. (1460 m) The small terrace-like bench on the northeast side has been severely eroded. Locally, the erosion has removed material below the root zone, and interpolation between adjacent uneroded surfaces indicte that 1 to 3 m of material has been eroded here.

A paltry outcrop of the thin (2 m) Keefer Sandstone occurs in the ravine near this bench. The Keefer is often used as the top unit of the Rose Hill Formation, which is dominated by non-calcareous olive-gray shale.

36. (1490 m) A silty, shaley colluvial diamicton is exposed in the stream channel.

37. (1510 m) First outcrops of red sandstone: the Cacapon Member of the Rose Hill Formation. Note slickensides for comparison with tools marks at next site.

38. (1580 m) Note the tool marks on the bedrock outcrop. These tool marks demonstrate that the base of the mass movement was in contact with underlying surfaces, so the debris was not riding on a cushion of air or water. Moving clasts were dragging along the bed, not saltating or rolling as would be expected in stream flow. The two modes of transport that are likely to produce tool marks are sliding and slurry flow. The short lengths of individual striations suggests that clasts were retracting into the moving mass after a relatively short contact with the bed. If the striations are not seen easily here, be patient, many more occur upslope.

39. (1620 m) Axis of a northeast-plunging anticline; red beds of the Cacapon Member will be repeated upstream, followed by a wide belt of highly deformed Rose Hill shale.

Note the super-elevated levees at these two bends. The limit of scour suggests banking of 14 to 20 degrees. Another slack-flow deposit occurs on the inside of the upstream bend. This might be a good place to debate what type of high-flow marks should be used to reconstruct debris-flow surfaces.

This point is a good turn around for our hike up Twin Run. The next major point of interest is 350 m upslope, and we are 3 km from our vehicles.

40. (1780 m) This boulder berm is detached from the valley wall, and occurs where the ravine widens.

41. (1800 m) The bouldery accumulation in the channel appears to be a late pulse of debris flow that came to rest in the channel. The deposit has a steep boulder snout, but becomes progressively finer grained upstream.

42. (2000 m) This is the downstream end of another spill-over chute. Note the slack-flow deposit on the south side of the chute. There has been considerable scour in the chute, and there are substantial wood jams adjacent to the chute.

43. (2070 m) Find the large (85 cm diameter) gnarly oak on the south side of the chute. This would be an interesting tree to cut or bore to look for evidence of older debris flows. The forest island between the ravine and the chute has many standing trees that were killed by scour during the 1985 debris flow.

44. (2130 m) Climb up the south side of the ravine to the super-elevated levee. A good view of the head of the scar can be seen from this point, even when leaves are out. Note the tributary that flows in from the west. (The 1981 Upper Tract quad shows this tributary as an intermittent stream, whereas the path of the debris flow is shown only by contour crenulations.)

The contact between the Rose Hill and Tuscarora Formations occurs here. The upper Tuscarora in not as resistant as the rest of the unit, so the slopes are not as steep as farther up the mountain.

45. (2400 m) The Tuscarora is very resistant from here to the top of the scar as evidenced by the steep dip-slope in front of you. As we climb to the top of the scar we will be working our way down the Tuscarora stratigraphy. The scar ahead has a slope of 0.44 and represents the zone of production for the debris avalanche/flow.

46. (2440 m) Another gravel lobe with a steep boulder front: a late pulse of debris flow. Proceed up a few more meters for a good view of the head of the scar. This is a good spot to introduce an argument over what was the material that failed to get this debris flow started in the first place. As we proceed you will see that the southwest side of the scar is dominated by dipping beds of Tuscarora sandstone, whereas the northeast side is dominated by colluvium and residuum composed of weathered Tuscarora clasts. Was the initial failure a slide along Tuscarora bedding planes or a slide of unconsolidated material overlying the sandstone?

47. (2510 m) Examine the dipping sandstone on the southwest side. This surface did not fail in 1985, so it is a good place to look at the vegetation and surface-weathering phenomena that will be useful in identifying undisturbed bedrock surfaces in the scar.

48. (2550 m) Look for tool marks on Tuscarora bedding planes over the next 120 m.

49. (2610 m) Near the center of the scar, about 15 m south of an "island" of undisturbed trees, there is a 2 m x 0.3 m bedrock surface that supports a substantial growth of mosses and lichens. The surface, which slopes steeply down slope was not eroded by the debris that moved over this surface, indicating that the debris was not in contact with the

bedrock at this point. Similar patches of undisturbed vegetation occur elsewhere on this scar.

This small detachment surface shows that the debris was sliding, but simply was moving too fast remain in contact at this steeply-dipping face. This is what one would expect in a debris avalanche, but it is important to distinguish that the debris was not riding on a cushion of air or water (as in a typical snow avalanche). **Proceed up to the top of the scar.**

50. (2670 m) Shallow channels show that the failure transferred debris from the northeast side of the scar to the southwest side of the scar. The topsoil has been stripped from the colluvium/residuum over much of the scar, but the depth or erosion is not great, as evidenced by the numerous intact roots.

51. (2740 m) Note the small slide that contributed to the flow from the south.

52. (2850 m) The top of the Twin Run "debris-flow" scar has an altitude of about 3240 ft (990m), approximately 465 m higher than its terminus (figure 6.1, 6.3). This is a good vantage to enjoy the view to the southeast, and to resume the discussion over what type of material contributed the most to the onset of the failure. Clearly failure over dipping Tuscarora beds was the major source of debris, but the question remains as to whether the failing material was bedrock or unconsolidated debris. This may also be a good place to summarize our conclusions about the modes of sediment transport along the different reaches of this "debris-flow" scar.

It is again time to consider getting back to the vehicles, parked 4.2 km down the mountain. If there is less that 2 hours of daylight left, head back downslope the way that we walked up. If time allows, you may want to examine a debris flow that heads about 300 m northeast of this spot.

THE SIMMONS RUN DEBRIS FLOW

Another debris flow occurred during the November 1985 flood in Simmons Hollow (unnamed on the Upper Tract quad) just north of Twin Run (figure 6.1, 6.3). This debris flow is smaller, extending only 1.45 km (vertical drop = approximately 385 m), but displays many interesting sedimentary structures and landforms. The two debris flows are very different, and offer a informative 8 hour loop hike.

How to get to the Simmons Run debris flow: Back-track 50 m down slope from the top of the Twin Run scar. Bushwhack northeast (027 degree bearing) following the 3200 ft contour. Do not gain altitude, or you may miss the upper end of the debris flow. Note 2 or 3 asymetrical bedrock swales that have a configuration very similar to the top of the Twin Run scar. You should encounter the Simmons Run debris flow about 300 m from the larger Twin Run scar.

Start a new distance log at the top of the Simmons Run scar (= 0 m). We will continue the site-number count to avoid creating two sites with the same number on figure 6.3.

53. (0 m) The top of the Simmons Run scar is slightly (about 5 m) higher than the Twin Run scar. The failure appears to have been triggered as a 0.5 to 1 m deep slide of colluvium/residuum overlying a Tuscarora bedding plane.

54. (40 m) Here is the first of two zones where the pre-1985 surface was disturbed very little. Except for some stripping of surface vegetation, the only erosion occurred in a gulley that is less than 1 m deep and only 2-3 m wide. This could be interpreted as a "skim zone" characterisitic of detached-base debris avalanching, but we prefer to interpret it as a zone in which erosion was minor because of the small amount of debris that was sliding down slope.

55. (80 m) Another zone of little erosion. From this vantage, one is stuck with the opinion that the debris flow had difficulty "getting its act together", probably because of its small size. Small, but well-developed debris lobes and levees are common; very few contain enough matrix for the sediment to be called a diamicton.

56. (165 m) The flow bifurcated at this point. Three standing trees on the northeast side of the flow have created substantial debris jams. Much of the flow was deflected to the southwest track, but another flow reformed (possibly because of another shallow slide) in a northeast track down slope from the three trees. Look for levees, lobes, and tree jams. It is easy to get lost in the multiple debris-flow tracks over the next 200 m; we recommend the northeast track because of its text-book depositional features.

57. (250 m) More bifurcations; up to 8 individual tracks occur here, and most coalesce into a single track on the southwest side of the scar at 350 m.

58. (285 m) This is the upslope end of a large forest "island", surrounded by scars. This island is 300 m long and up to 60 m wide. A 0.5 to 1.5 m deep channel occurs in the middle of the main flow path. This channel probably was created by hyper-concentrated stream flow.

59. (450 m) The northeast track has many standing trees. At 500 m the track becomes diffuse, with standing trees providing much resistance to flow. Look for clast-supported boulder levees on the margins. A lobate, 2-3 m thick, clast-supported deposit formed at the base of the steep slope. A similar older deposit can be found in the forest north of the 1985 flow.

60. (570 m) Just at the point where the northeast flow was about to die out, some of the debris flowing in the southwest track super-elevated into the northeast track. A huge debris jam occurs where the flow left the ravine. In the next 20-40 m, psuedo-terraces composed of up to 3 m of boulders and cobbles have jammed behind fallen trees. The northeast flow contined downslope to re-enter the main flow at 700 m. The flow was confined to one track below this point.

61. (915 m) An excellent example of super-elevation occurs from this bend to 1000 m. Another good example of super-elevation occurs on the northeast side at 1080 m.

62. (1140 m) Two 40 m long diamicton lobes with bouldery fronts (southwest side of Simmons Run) are indicative of debris flow. Smaller cobble bars (near stream's thalweg) are indicative of streamflow.

63. (1200 m) Stream-flow deposits, such as gravel berms and diagonal bars dominate Simmons Run below this point, but debris-flow levees and tree jams are obvious along the margins of the fluvial deposits.

64. (1700 m) This is the terminus of the zone of extensive erosion and deposition. Levees indicate this was the downstream limit of debris flow, just before the stream entered a sharp bend. Considerable scour of the channel occurred downstream, probably the result of hyper-concentrated flow. Isolated tree jams, gravel berms, and boulder bars occur downstream, but these are not the product of debris flow.

65 (2200 m) Intersection of Simmons Run and the dirt road that leads to our parking spot. This road is shown as a trail on the 1981 version of the Upper Tract quad. Follow this road to the south. A large swampy sinkhole occurs at 2450 m. Cross Twin Run at 2800 m. Continue south-southwest on this trail (back-tracking our route in) until you come to the parking area 4850 m from the top of the Simmons Run scar.

Back-track on the gravel road to Reeds Creek Road.

62.0	2.5	**Turn left** (northeast) on Reeds Creek Road. Note exposure of colluvial diamicton ahead on southeast side of Reeds Creek. There are several good exposures of colluvium in the next 1.7 mi.
63.7	1.7	Bridge across Reeds Creek. There was major modification of the narrow floodplain of the creek through the water gap between here and Route 220.
64.0	0.3	Temporary bridge across Reeds Creek. A new bridge was under construction in mid-October 1987.
64.6	0.6	Turn left (north) on Route 220.
64.8	0.2	Enter community of Upper Tract.
66.1	1.3	**Slow down and prepare to stop.** Note the brown sign for road to Smoke Hole/Big Bend. If we had more time we would travel this difficult gravel road to examine the scour along the South Branch Potomac River. There are many points of interest, but the going is very slow, and we have little time left in the day.
66.2	0.1	**Park in the dirt area** northeast of the intersection, immediately before crossing the bridge. We will make a 5 minute stop to see the physical backdrop for Stop 7.

In the 12 km reach south of the bridge, the South Branch flows through a relatively wide valley underlain by non-resistant Devonian shale. About 200 m downstream of the bridge the river makes a sharp bend and leaves the Devonian shale strike belt, flowing through a water gap at the northeast end of Little Mountain. This water gap is the entrance to the Smoke Hole, a narrow, irregular canyon in which the South Branch flows across the highly resistant Tuscarora Sandstone six times and the resistant Oriskany Sandstone at least 30 times (Dunne and Gerritsen, unpublished data). The strike belt of the non-resistant Devonian shales continues for over 25 km northeast to Petersburg. The surface expression of the shale bedrock is a broad valley drained by North Mill Creek, which empties into the South Branch at

Petersburg. North Mill Run does not cut across any resistant units, and flows along a much more logical path for the South Branch River to follow, given the local bedrock structure and lithology.

The drainage divide between the South Branch and North Mill Creek lies 0.5 km east of this spot, where Route 220 makes a sharp left curve. The height of the divide above the South Branch is less than one 40 ft contour interval on the Upper Tract quad. During the 1985 flood, the South Branch was hydraulicly dammed by the water gap. The damming may have been aggravated by the remains of an old mill that wash into the gap. The partially dammed floodwaters flowed over the low drainage divide and into the North Mill Creek basin.

Cross the bridge and continue north on Route 220.

66.4	0.2	Route 220 curves to the left (north).
66.5	0.1	Drainage divide between the South Branch and a small tributary to North Mill Creek. Ditches on either side of Route 220 were scoured by South Branch floodwaters pouring over the divide.
66.6	0.1	The new log building next to the Motel-Beer-Eat sign replaced a structure that was destroyed by floodwaters that spilled over the drainage divide.
66.7	0.1	**Park** in gravel lot on right.

STOP 7: SOUTH BRANCH FLOW OVER DRAINAGE DIVIDE; ORIGIN OF THE SMOKE HOLE REACH OF THE SOUTH BRANCH

Text by J. Steven Kite

Discussion by G. Michael Clark and Doug Parkinson

One of the most interesting geomorphological events noted during the 1985 flood was the spill-over of the South Branch Potomac River into the North Mill Creek drainage basin. Ths amount of water that spilled over was enough to cause some damage, but this discharge was a minor fraction of the discharge on the South Branch. What would happen to structures along North Mill Creek if a even-higher stage flood topped the divide? Could enough water spill over to erode the shale-floored divide? Is so, the South Branch might be completely pirated away from the Smoke Hole. Such an event would be a great curiosity to geomorphologists, but would have profound environmental and economic implications.

In the companion volume prepared for this field conference, Clark (1987B) briefly reviews the debate by Fridley (1939, 1940) and Ver Steeg (1940) over the origin of the Smoke Hole. As Clark no doubt will discuss at this stop, the origin of this reach should be considereed in context of the larger problem of the long-term evolution of transverse and longitudinal drainage in the Valley and Ridge Physiographic Province.

		Continue north on Route 220 to Petersburg. Look for terraces, particularly on the left (northwest) side of the road.
68.6	1.9	Enter the Mozer quad.
72.2	3.6	Enter Grant County
73.3	0.1	This stretch of road was scoured by North Mill Creek in 1985.
73.7	0.4	Enter the Petersburg West quad.
83.2	9.5	Enter Petersburg at the southern limit of the 1 km wide floodplain of the South Branch, about 7 km downstream from its confluence with the North Fork South Branch.
83.5	0.3	Enter Petersburg West quad.
		As we will drive through Petersburg, please look for new buildings, open lots where you might expect buildings, and a very wide channelized South Branch Potomac River.

		All are evidence of the 1985 flood. The red B-10 spray-painted on the damaged service station denotes that the building has been condemned.
83.9	0.4	Intersection regulated by a traffic light; this intersection was the high-water mark on the northern side of the river during the 1985 flood.
		Go straight through the traffic light; **do not turn right on Route 220.** Proceed ahead on Route 28 toward Seneca Rocks.
84.2	0.3	**Bear left** on Route 28. Re-enter Petersburg East quad.
84.5	0.2	Enter Maysville quad and re-enter Kingwood 1:100,000 map.
84.7	0.3	**Bear left** on Route 28 at intersection with Route 42.
85.6	0.9	View ahead (west) of North Fork Gap and Allegheny Front, areas of interest during tomorrow's stops.
87.9	2.3	Look ahead, to the left of the water gap, at debris avalanche scar formed in 1949. There will be a closer, but less complete, view of this scar tommorrow. Re-enter Petersburg West quad and Elkins 1:100,000 map.
89.6	1.7	Southeast-dipping Oriskany Sandstone on the left (south).
90.8	1.2	Steel bridge and gravel Smoke Hole Road on left represent the "short cut" to Upper Tract. This "short cut" often takes twice as long as Route 28 and Route 220, but it leads to nearby Stop 4 on day 2.
91.7	0.9	Enter Hopeville quad.
94.0	2.3	Note Jordan Run Road on right; continue on Route 28.
97.3	3.3	Enter Pendleton County.
99.7	2.4	View of Champe Rocks on left (southeast).
102.4	2.7	Re-enter Upper Tract quad.

106.0	3.6	**Turn right** (west) on Route 33 at Seneca Rocks (Onego quad). We will now back-track the route taken this morning.
118.2	12.2	**Turn right** (north) on Route 32 at Harman.
127.3	9.1	**Turn left** (west) at the Canaan Valley Lodge entrance. **END of field trip for day 1.**

We will return to the lodge after dark.

SATURDAY NIGHT

DINNER ON YOUR OWN.

West Virginia Association of Professional Soil Scientists
Fall Meeting: Discussion of State Certification
Hemlock Room: 8:00 P.M.

Posters and more discussion on the future of SEFOP.
Pine Room: 8:00 P.M.

SUNDAY, 8 NOVEMBER: DAY 2 OF THE FIELD TRIP

BREAKFAST ON YOUR OWN. RESTAURANT OPENS AT 6:30 A.M.

DEPART FROM PARKING LOT OF CANAAN VALLEY LODGE AT 7:30 A.M.

TOTAL MILES	INTERVAL MILES	STOP, POINT OF INTEREST, ETC.
0.0	0.0	**Assemble in the Canaan Lodge Parking lot.** Proceed to Route 32. The trip log for yesterday has a more detailed description of the route to Seneca Rocks. The important navigation points are repeated below.
2.1	2.1	**Turn right** (south) on Route 32.
11.1	8.9	Bear left (east) to Route 33 in Harman.
11.2	0.1	**STOP SIGN.** Be careful at this dangerous intersection. Head east (left) on Route 33.
23.4	12.2	**Turn left** (north) on Route 28.
23.6	0.2	Continue past Seneca Rocks Visitor Center, down the valley of the North Fork South Branch Potomac River.
29.2	5.6	Champe Rocks, on the right (east), is another example of the topography associated with vertically dipping beds of Tuscarora Sandstone on the west limb of the Wills Mountain anticline.
30.3	1.1	Much of the floodplain in this reach, was reworked during the 1985 flood, including Route 28. Mitigation efforts have made it impossible to identify the many anastamosing channels that can be seen on air photos taken within a week of the flood.
31.3	1.0	Coarse-textured fan on other side of river experienced a lot of deposition during the 1949 debris flows. Some of the sediment was remobilized in 1985.
31.5	0.2	Another 1949 debris fan. Nearly every tributary on North Fork Mountain experienced debris flow during 1949 storm.
31.8	0.3	Cave in outcrop of Helderberg Limestone.
32.1	0.3	Enter Grant County.

32.3	0.2	North Fork enters Hopewell Canyon ahead.
34.7	2.4	Quarry in Devonian shale on right. **Prepare to stop** near guardrail at the end of the quarry.
34.8	0.1	**Park vehicles on right** side of road near end of quarry.

STOP 1: HOPEVILLE CANYON OVERLOOK

Text by Andrew J. Miller

Discussion led by Andrew J. Miller and John Harper

This stop allows us to look down on the North Fork as it crosses through a steep, narrow reach bounded for the most part by bedrock walls. Broader sections of the canyon are characterized by limited development of point bars and alluvial bottomland, and these were particularly susceptible to erosion during the November 1985 flood. The point bar directly below the overlook was a pasture before the flood and the channel immediately downstream was overgrown with trees. The flood stripped away most of the turf and underlying fine-grained alluvium, leaving a surface strewn with cobbles and boulders. Most trees along the channel were uprooted and some were actually broken off above the surface without being toppled, leaving a vertical stump standing in or adjacent to what is now the channel.

Upstream and around the bend is a section of the valley, several hundred meters wide, that was almost entirely stripped of all fine-grained alluvium with the exception of a single remnant island. This area is covered mostly by imbricated cobbles and boulders with uprooted trees visible at several points. Several large boulders with long dimensions on the order of 2-2.6 m have been observed on this surface and may have been moved during the flood; one boulder with dimensions 1.6 x 1.4 x 0.9 m was found resting on imbricated cobbles and boulders. Other features of interest that can be seen in this area include a prominent elongate scour mark at a point where flow emerged from a narrow erosion channel, and an alluvial fan that was truncated by the flood, with a vertical exposure of fan stratigraphy that is about 10-12 m high. These features are not visible from the overlook but the area is accessible on foot from the mouth of Hopeville Canyon. We will not have time to visit the fan exposure on this trip, as we would need to cross the channel several times and we would need a couple of hours to make the round trip.

Continue north on Route 28.

35.1 0.3 Note church on right.

35.2 0.1 **Park on right** side, well off Route 28.

STOP 2: MOUTH OF HOPEVILLE CANYON

Text by Andrew J. Miller and J. Steven Kite

Discussion led by Andrew J. Miller and John Harper

This was the site of the worst loss of life at any single location during the November 1985 flood. The setting is dramatic, as the North Fork emerges from the canyon through a narrow opening bounded on the right by a vertical sandstone wall and then makes a sharp turn to the right. On the left side of the channel opposite from the mouth of the canyon there is a trace of an ancient meander extending several hundred meters back from the road, indicating that the channel has taken a more leisurely route through this section of the valley in the past. Even before the flood there was a prominent pool at the mouth of the canyon, indicative of the erosive power of high-discharge flows emerging from the constriction. However, a two-story house on a low terrace to the west of the road apparently were not severely damaged by the previous flood of record in 1949. Geomorphological evidence shows that the 1985 peak flood stage was at least 5 m above the low-water channel of the North Fork along this reach. One eye-witness estimated that there was 3 to 4 m of water above the floodplain at this site (West Virginia Advocate, 1986).

During the flood, flow in the canyon stripped the point bar at the first bend upstream of the mouth of the canyon and destroyed several houses. As flood waters emerged from the constriction, they demolished the road, stripped away the floodplain along the left side of the channel, and left a surface covered with cobbles and small boulders. The comparison of pre- and post-flood aerial photographs of this site leaves one in awe of the power of the flood: the stripped area to the east of the road, which is now a barren wasteland, was formerly covered by a thick grove of trees. Repair work after the flood included some channel work and rebuilding of the road, but visual evidence of the flood's impact here is still quite obvious. The scoured depression just west of the road embankment is bounded by a vertical scarp that marks the furthest extent of lateral erosion during the flood; the land is owned by the Forest Service and they have chosen to leave this scar open, at least for the time being. The cut-bank exposure consists of about 3 m of fine-grained alluvium, with some textural variation but virtually no gravel or cobbles other than at the base of the section. The floor of the scar is a pavement of gravel and cobbles with some large boulders; how much of this is natural and how much is residue from the rebuilding of the road is uncertain.

The following account of the tragedy at this site is taken from the West Virginia Advocate (1986). On the afternoon of 4 November, the flow of the North Fork across Route 28 became too deep for cars and pickup trucks to ford. Unfortunately, another flood barrier developed at Jordan Run, about 3 km downstream. Three trucks carrying a total of 10 people became stranded between the two torrents across Route 28. After some abortive efforts to drive through the waters, and a tragic refusal of a ride to safety on a tractor-trailer, the 10 people sought refuge on an isolated low terrace, the site of the two-story house and several mobile homes. Two men were waiting out the flood in one of the mobile homes, giving a total of 12 people on the low terrace, each thinking it high enough above the river to be safe.

By the time it was apparent that the flood was going to inundate the low terrace, the flow was too deep and rapid to wade to the valley sides. Ten men took shelter in one of the mobile homes that was on slightly higher ground than the house. The other two people, a married couple returning from a marathon race in Washington, D.C., sought shelter in the house, retreating to the second floor as the waters rose. When the 10 men realized that the mobile home was in danger of washing away, they tried to push a boat to the house. The boat was swept away when they encountered eddies on the upstream side of the house. All 10 men died. The husband and wife were thrown into the flood when the house rolled over in the currents. The wife drowned. The husband survived by climbing a tree, then climbing a second tree after the first one was swept away.

		Continue north on Route 28.
35.4	0.2	On the left is the site where 11 people were swept to their deaths.
35.5	0.1	Jordan Run Road is on the left. This is the road we will take to Dolly Sods for Stop 5.
35.9	0.4	The limestone boulders in the channel of the North Fork of the South Branch are not natural. Initial mitigation efforts removed most of the irregularities that provide good sheltered fish habitat in the channel. The boulders were introduced to remedy this problem, but they now present a hazard for

		white-water canoeing. **Keep looking for debris fans** on the other side of the river.
37.0	1.1	Cross Jordan Run near entrance to Smoke Hole Caverns.
37.3	0.3	Outcrop of Tuscarora Sandstone on steep western limb of Wills Mountain anticline.
37.6	0.3	**(BAD WEATHER ONLY)** Park on right side, well off Route 28. We will discuss the fan exposure across the river, but we will not wade the North Fork today.

STOP 3: DEBRIS FAN NEAR NORTH FORK GAP

(BAD-WEATHER STOP ONLY)

Text by J. Steven Kite and Ron C. Linton

Discussion led by Kite, G. Michael Clark, and Linton

This locality is near the core of the Wills Mountain anticline. Look down-valley (east) at the eastward-dipping outcrops of Tuscarora Sandstone in North Fork Gap, the east limb of the anticline. Note the large scree slopes fed by Tuscarora outcrops near the crest of the anticline, on New Creek Mountain, north of the water gap.

Much of the following discussion of the fan stratigraphy is taken from Kite (1987), with some revision. The exposure shows the variety of deposits within colluvial-alluvial fans in the region (figure 3.1). The fan occurs at the mouth of a second-order drainage basin with over 600 m of relief (figure 3.2). Bedrock units within the basin include the Tuscarara, Juniata, and Oswego Formations (Cardwell and others, 1968). The fan has been mapped as part of a large debris flow during a major storm in 1949 (Felton, 1978; Stringfield and Smith, 1956), an observation recently confirmed by local residents.

A cursory examination of the outcrop reveals a simple stratigraphy of three unconsolidated units above Oswego sandstone bedrock: at least 1.5 m of alluvial cobble gravel overlain by 1 m of inverse-graded alluvial sand and silt, which is overlain by up to 10 m of colluvial diamicton. Detailed work at the exposure shows that the outcrop is actually much more complex than a simple three-fold stratigraphy. Although no tree-ring studies have been conducted, it is clear that only the central portion of the fan is devoid of large trees that appear to predate the 1949 debris flow. Photographs taken soon after the 1949 debris flow confirm that much of the fan surface stabilized prior

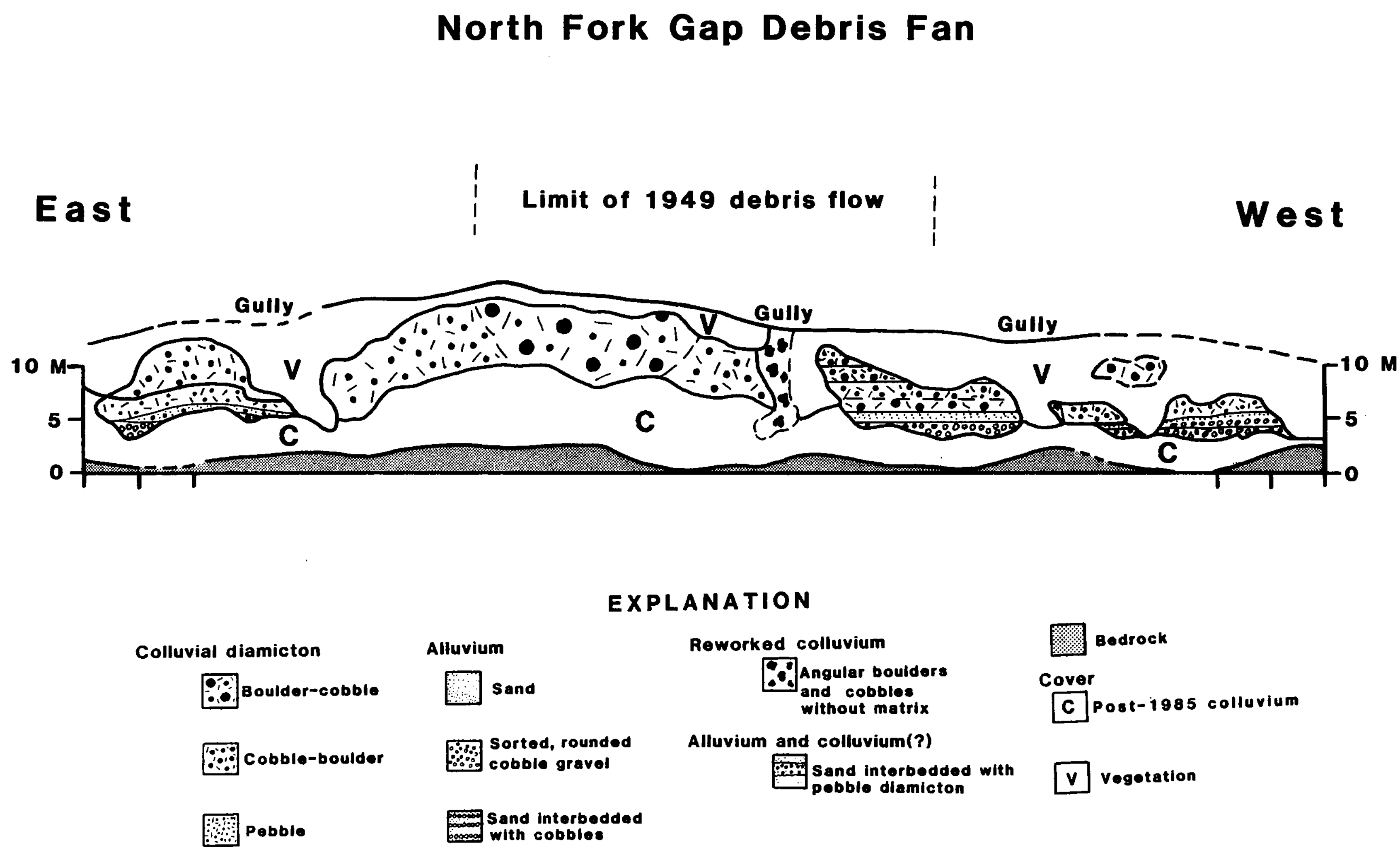


Figure 3.1. Stratigraphic cross-section of the colluvial-alluvial fan near North Fork Gap. Top line represents the fan surface; bottom line represents water level of the North Fork South Branch Potomac on 26 September 1986. No vertical exaggeration. Modified after Kite (1987).

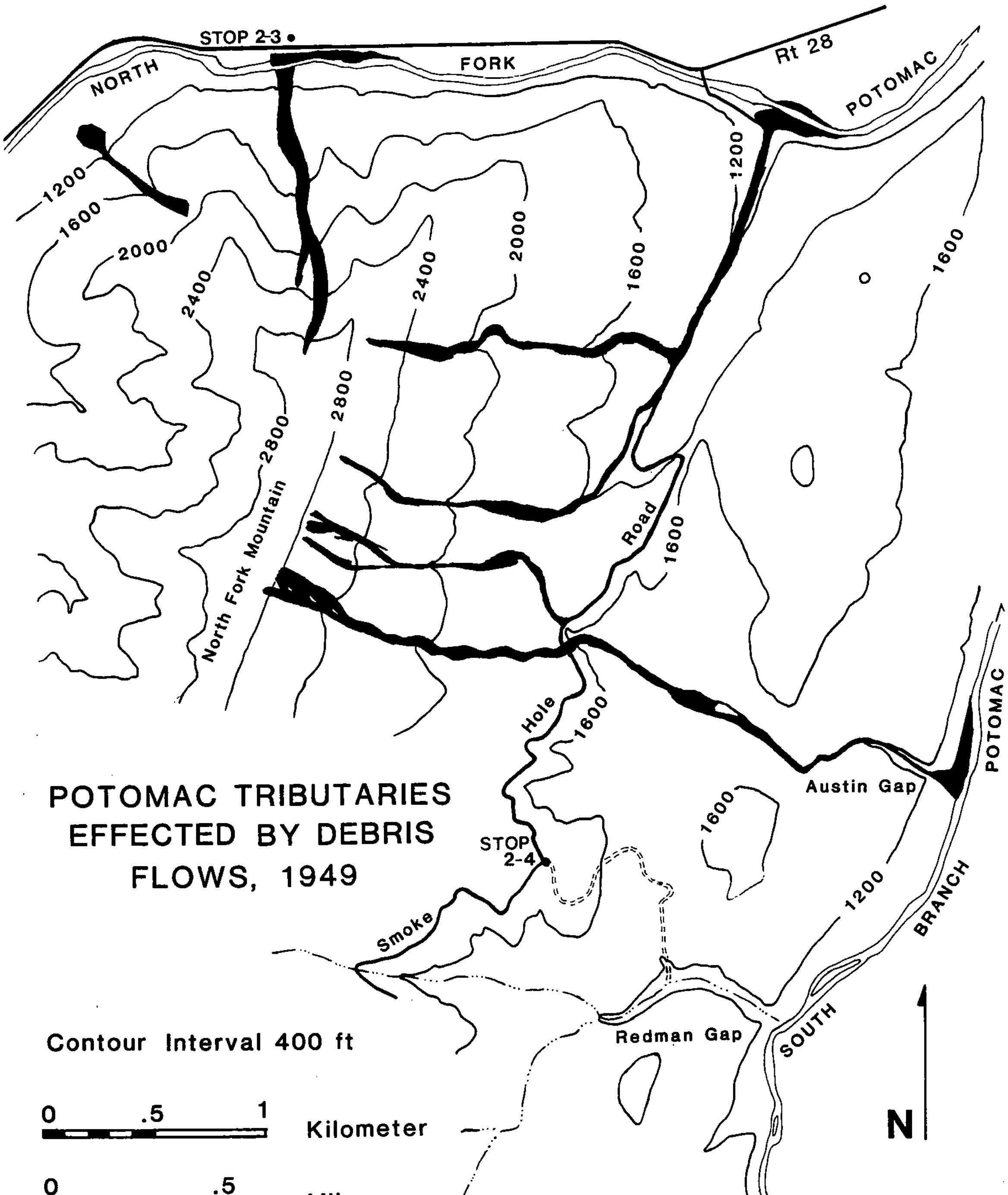


Figure 3.2. Streams effected by debris avalanche/debris flow in 1949: northeastern end of North Fork Mountain. Some are not shown (see photo in Clark, 1987A). These failures occurred on both dip slopes and anti-dip slopes.

to 1949; the colluvial deposits under these surfaces must have formed during earlier events. The alluvial gravel is too poorly exposed to allow good correlation, but the sandy alluvium may not be relict from a single floodplain surface. The sandy alluvium occurs at slightly different elevations, is dissimilar from one part of the outcrop to another, and is overlain by at least two different types of colluvial diamicton at different parts of the outcrop. It is possible that the sandy alluvium was deposited on different-aged floodplain surfaces at nearly the same level that were buried by different colluvial events. Although minor amounts of organic matter occur in the sandy alluvium, the quantity sampled has been insufficient for conventional radiocarbon dating.

The colluvial units overlying the sandy alluvium are quite varied. The central part of the fan is underlain by at least 8 m of unstratified, boulder-cobble diamicton, the coarsest sediment in the exposure. There is no apparent change in particle size throughout this unit, except for a few pods of clast-supported cobbles and lenses of cobble-boulder diamicton. White boulders of Tuscarora Sandstone are most abundant in this unit, although most of the clasts are red sandstone of the Juniata. The boundary with the adjacent cobble-boulder diamicton unit is very subtle, although it coincides with a debris-flow levee at the eastern limit of the 1949 flow. The boulder-cobble diamicton at the center of the exposure probably was deposited by the 1949 debris flow. Some of the diamictons near the large gully near the center of the exposure were deposited during or soon after 1949.

Cobble-boulder diamicton occurs at at least four sites on the exposure. It is the uppermost sediment exposed on either side of the fan, and is adjacent to, and somewhat overlapped by, the boulder-cobble diamicton. This diamicton may be very poorly stratified. As in the coarser diamicton there is no obvious change in particle size throughout the unit. The origin of this sediment is unclear, but its gross similarity with the bouldery 1949 debris-flow deposits suggests that the cobble-boulder diamicton also was formed by debris flows.

Pebble diamicton is exposed above the alluvium on either side of the fan. It commonly is weakly stratified, and contains very few clasts of white Tuscarora sandstone. Pebble diamicton is very common in colluvial aprons in the area, and may represent local slope colluvium, possibly delivered to the site by creep or small landslides.

A sequence of three relatively thin (1 to 3 m) normally graded diamicton beds occurs just west of the center of the fan. Cobble-boulder or cobble diamictons are the basal sediments in these packages, which fine upward to pebble diamicton. A few cm of sand caps two of these graded beds.

These graded packages occur as repetitive sequences that become thinner and finer-grained up sequence. The origin of this sequence is unknown, but the poor sorting and graded bedding suggest pulses of hyper-concentrated flow, possibly at the distal end of small debris flows. Some of these sediments may date to small pulses that occurred late in the 1949 event.

Small steep-sided lenses of angular boulder-cobble gravel occur at the distal ends of gullies eroded into the fan, apparently because of post-colluvial reworking by overland flow or stream flow in small drainageways. These lenses are relatively minor in this exposure, but many other fans exposed in the region are mostly composed of similar sediment. Indeed, the frequency of debris flow and other colluvial events in the region may be difficult to assess because stream flow quickly winnows away the matrix from the diamictons and destroys the primary landforms and sedimentary structures.

		Continue (east) on Route 28.
37.8	0.2	Note another exposure of colluvial sediments on the right.
38.1	0.3	Enter Petersburg West quad.
38.8	0.7	Tuscarora Sandstone outcrops have been scoured by flooding and the modified by post-flood blasting and bulldozing.
39.1	0.3	**Turn right at new steel bridge** marked by sign indicating Big Bend Campground, 16 miles. This is Smoke Hole Road. This gravel road is rough, so we may try to consolidate our caravan by parking cars before crossing the bridge.
39.3	0.2	The road turns right (south) up an unnamed creek that experienced debris flow during 1949. The channel shows scour, but there is little evidence of debris flow except for the diamicton fan here.
39.7	0.4	Cross one of the tributaries that contributed to the debris flow. Look for scour and other evidence of the effects of past floods.
40.2	0.5	Look west for large debris-avalanche scar on North Fork Mountain. (Scar is show on Hopeville quadrangle.) The scar formed in 1949, it is interesting to see how limited

vegetation recovery has been on the Tuscarora bedding planes.

40.1	0.1	Hairpin curve. More views of 1949 debris-avalanche scar to right.
40.4	0.3	View of debris-avalanche scars on Cave Mountain, 2.5 km to the east. Compare these with the larger and longer scars on North Fork Mountain. Hundreds of these smaller failures occurred during the 1949 event. Most of these head at Oriskany-Helderberg outcrops and have very short or non-existent run-outs on the floodplain of the South Branch Potomac River.
40.6	0.2	Cross stream at end of clearing. This stream was another 1949 debris-flow track.
40.7	0.1	Note "Eggs For Sale" sign. We will return to this spot after our walk to Stop 4. Look for a large space where our vehicles will be parked after a short shuttle.
41.0	0.3	USFS trail heads on the right. Continue south on Smoke Hole Road.
41.4	0.4	Clearing on right.
41.6	0.2	**Stop at grey-brown house** with several small buildings in back. This is the beginning of the path to Stop 4. **DRIVERS: Prepare to receive directions for a vehicle shuttle** back to the "Eggs For Sale" location.

STOP 4: SOUTH BRANCH POTOMAC RIVER BETWEEN REDMAN RUN AND AUSTIN RUN

Text by Andrew J. Miller and John Harper.

Discussion led by Miller, Harper, Doug Parkinson, Ron C. Linton, and G. Michael Clark

The valley floor along the South Branch Potomac River between Redman Run and Austin Run was greatly affected by the November 1985 flood. This section of the valley floor is located in a gorge, known locally as the Smoke Hole, that extends from just downstream of Upper Tract to the confluence with the North Fork near Cabins. The site we will visit is not readily accessible to bulldozers and was not reworked in post-flood reclamation efforts. Most other areas affected by the flood have been completely reworked; this reach of the South Branch valley thus offers a rare opportunity for study of the features produced in an extreme flood. Although the damage to this section of floodplain did not reach the level seen in other parts of the South Branch basin, a range of features, both large and small scale, can still be found at this site. There is a progression of features visible as one traverses the length of this reach.

We will reach the site by walking down the valley of Redman Run, which joins the South Branch at the upstream end of the area of interest. From the mouth of Redman Run we will walk downstream along the floodplain on the left side of the channel. At the downstream end of the floodplain reach we will walk back up along the valley of Austin Run. All references to "left" and "right" in the ensuing discussion assume that the reader is facing downstream along the main channel of the South Branch.

We begin our walk down Redman Run from the east flank of North Fork Mountain. Structurally we are on the southeast limb of the Wills Mountain anticline and our downhill walk takes us upward in the stratigraphic section through a series of Silurian and Devonian units. Tuscarora sandstone is on the ridge behind us; at lower elevations we cross through the remainder of the Silurian section, consisting of interbedded shales, sandstones, and shaly limestones. The high valley visible at several places along the road on the way to Redman Run (generally below the elevation of the road) is in the Helderberg limestone. The first of two distinct ridges that we cross on our walk down Redman Run is held up by Oriskany sandstone. Between the first ridge and the river there is a small syncline, with a probable thrust fault oriented along strike near the axis of the fold. The second ridge, which is a tightly folded anticline, is also held up by the Oriskany; Helderberg limestone is exposed in the core of the anticline. Note the beautiful cross-section of this fold that is exposed as you reach river level. Although the same structures recur in the valleys of Redman and Austin Run, their topographic expression will be more obvious on the walk back along Austin Run.

SITE DESCRIPTIONS

Please use figure 4.1 (the photograph inserted as the next page) to find the numbered sites described below.

1. Coming down Redman Run towards the South Branch Potomac River, the tributary valley widens and flattens out. At the mouth of Redman Run we find a slackwater delta, deposited during the November 1985 flood when sediment moving down Redman Run toward the tributary mouth was ponded by high water on the South Branch. The delta surface slopes toward the main channel but at a much lower gradient than the

channel of Redman Run itself. The deposit is wedge-shaped in relation to the tributary valley axis, and also slopes toward the southern valley wall. This wedge is approximately 1.2 m thick at its distal end and consists of coarse cobbles with a gravelly-sand matrix. It overlies an older deposit approximately 1-2 m thick; trees growing on the surface of this older deposit were partially buried in the 1985 event and provide the strongest evidence for the amount of deposition. The estimated height of the delta surface above the low water channel of the South Branch is 4.8 m, with tentative evidence of peak stage 0.3 m higher. After depostion of the slackwater delta, during waning flow, Redman Run cut through the delta, exposed the underlying stratigraphy and built a secondary delta extending into the channel of the South Branch. Post-1985 reworking may also have contributed to the development of the secondary delta. The top of this lower deposit is 1.8-2.0 m above the low-water channel of the South Branch.

2. Prior to the flood, the channel of the South Branch at the mouth of Redman Run was bounded on the right by a bedrock wall and was flanked on the left by a floodplain that began at the mouth of Redman Run and extended continuously all the way to Austin Run. The flood removed the portion of this floodplain closest to Redman Run and deposited a large gravel bar along the right bank, thus shifting the position of the channel to the left. The locus of deposition is just downstream of a bend in the valley and was probably the site of a recirculating eddy formed as the main thread of flow detached from the right bank and crossed over toward the left bank. Slower velocities in the eddy were thus responsible for the formation of this bar, which is a typical example of a pendant bar. The top of the bar is approximately 3 m above low water.

Note: **Take care** as you traverse around the rock outcrop as you go downstream on the left bank. Depending on the water stage at the time of the field trip, we may rig a handline along the upper part of this traverse.

3. As you walk along the left bank toward the main part of the floodplain, you can see the deep channel on the right. This entire area was occupied by wooded floodplain prior to the flood. At low flows, sections of intact sod can be seen in the channel. About halfway down to where the remaining section of floodplain begins, there is an overturned sycamore tree lying in the channel, at or close to its original position. Also in this area are several trees along the bank which have debris on and around them.

4. The next section of floodplain consists of a large area that has been stripped of soil and trees, exposing a bare surface composed of cobbles and small boulders. Although many of these may have been moved short distances by the flood, the surface here is erosional rather than

depositional and the texture is representative of the material that was below the turf layer before the flood. The same material can be found at shallow depth underneath the remnant patch of turf layer along the left margin of the floodplain. Stripped surfaces like this generally grade into depositional lobes as we continues downstream, but the transition from an erosional surface to a depositional surface is difficult to locate precisely. Stripping actually began upstream of here, but this is the first section of the floodplain that has not been totally removed by the flood.

On the left side of the stripped area is a depression that carried part of the flood flow in the November 1985 event; this is the upstream extension of a channel that continues along the left margin of the floodplain for some distance and then crosses the floodplain to join the main channel of the South Branch. A large log jam is also visible along the left margin of the floodplain at this location. Adjacent to and just downstream of the jam is an intact pre-flood surface, clearly indicated by the presence of a thin turf layer with some cobbles deposited on it. Closer to the main channel of the South Branch, along the right margin of the stripped area, are remnants of the forest cover that was present here before the flood.

5. Near the right margin of the stripped area is an erosional channel scoured 0.3-1.0 m below the original surface, whereas the rest of the stripped area is scoured 0.1-0.3 m. The plan form of this channel is shaped like the point of a spear protruding into the floodplain and resembles other forms that we have described elsewhere as incipient chutes. The cobbles exposed in the floor of this chute are already starting to fill in with fine-grained sediment deposited in subsequent events. The distal end of the chute drains off toward the right in two distinct channels into the main stream. There are amphitheater-shaped plunge pools and headcuts at the point where the chute starts to break back towards the main channel. A 1.3 m section of the underlying stratigraphy is present in the wall of the first diversion channel. It consists of two coarse cobble-gravel deposits with a fine sand matrix, separated by a lens of silty sand containing some fine gravel.

6. The next region of interest is to the left of the downstream end of site 5. As you walk from site 5 to site 6, the transition is made from a stripped area of the floodplain to a region where there has been net deposition. The specific feature of interest here is a tree with a large debris jam and scour hole on the upstream side and a remnant of the pre-flood surface overlain by two lobes of coarse sediment extending downstream. The debris jam is much denser than the ones seen further upstream. Turbulent flow around and beneath the debris jam excavated a large

horseshoe-shaped scour hole with a maximum depth of approximately 2.3 m. An abandoned farmhouse was located just upstream of this area on the pre-flood surface. The remnants of the foundation are exposed and boards and planks can be seen in the debris jam. Cinder blocks, bricks, and a piece of the chimney located in the lobes downstream of the jam attest to the competence of the flood flow.

Along the left leg of the horseshoe on the inside of the scour hole you can see an exposure of the material underlying the floodplain at this location. This is a sequence of rounded cobbles and gravels in a sand matrix, with some finer layers interbedded but without any significant thickness of fine-grained sediment. This material looks very much the way the material deposited on the surface by the flood might look if sand were to infiltrate into the interstices between the coarser particles during a series of later flows of lower magnitude. Thus the available evidence suggests that this portion of the valley has experienced floods in the past that were capable of carrying particles of the same size range as those carried in the 1985 flood, and these may in fact be the dominant events in sculpting the valley floor. If we further imagine the eventual filling of scour holes and erosional channels by fines, a rather complex stratigraphic profile may result from the effects of an extreme flood followed by a prolonged period of recovery. Such a profile might well be misinterpreted by someone unfamiliar with the effects of extreme floods in this environment.

7. There are two distinct lobes of coarse sediment downstream of the tree. The left one is smaller and thins at its distal end, whereas the right lobe thickens to a slipface approximately 1.0-1.4 m high at its downstream end. Both lobes thicken away from the tree, where the deposit is only a few cobbles thick. It is likely that there was a bulge in the preflood surface downstream of the tree, although trenching would be necessary in order to prove this point. The overall deposit also thins towards both lateral margins. The right side of the right lobe grades into the stripped surface, but the exact location of the transition could not be pinpointed.

A much larger deposit, composed of material derived from the stripping and chute incision that took place upstream, is found slightly downstream and to the right of these two lobes. This deposit ends abruptly in a steep slipface connected to the downstream tips of the other two lobes in a continuous arc. The vertical drop over the slipface to the intact pre-flood surface is about 1.5 m.

One of the interesting characteristics of the slipfaces is their orientation. They are facing toward the left valley wall rather than downstream. This suggests the influence of flow coming laterally across the floodplain from the direction of the South Branch channel and draining into the flood channel that runs along the left margin of the floodplain. The orientations of trees emplaced on the surface of the sediment lobes, as well as sublobes extending out from the slipface, seem to support this hypothesis.

8. Downstream of the major gravel-cobble deposits, there is another debris jam plastered around the upstream side of a tree with sediment deposited in the wake of the tree. The debris jam is much smaller than the one upstream, and the material deposited is primarily sand rather than gravel. The gravel lobes upstream may have protected the tree from the full force of the flow; velocities in the wake were low enough to allow deposition of sand, and velocities around the tree evidently were insufficient to allow substantial transport of gravel and cobbles. We have also speculated that resistance offered by the tree may actually have retarded the flow enough to bring the advancing gravel lobe to a halt before it reached the tree.

9. Along the right margin of the floodplain, adjacent to the channel of the South Branch and stretching much of the length of the floodplain, are substantial areas of deposition of debris and fine-grained (mostly sand-sized) sediment. Vegetation growing along the channel margin formed a discontinuous barrier to flow crossing onto the floodplain from the main channel here. Trees in the path of the flow trapped organic matter, sediment, and assorted other debris, and scour marks on their upstream sides are visible in several cases. Sand deposits are found in the areas of separated flow that formed in the wakes of trees and shrubs or in the paths of narrow threads of flow that crossed through openings in the vegetation barrier. Some isolated gravel and cobble deposits, probably derived from the South Branch channel, are also found in this area.

10. Downstream of the large lobes of coarse sediment deposited on the floodplain, flow spilling out of the main channel of the South Branch (and across the lobes) converged with flow traveling in the flood channel along the left margin of the valley. An extension of the flood channel continues down the middle third of the floodplain reach before crossing over to the right and entering the main channel of the South Branch. Diffuse threads of flow from location site 9 probably drained into this channel at many points along its length as the flood stage waned.

11. The next point of interest is another debris jam and scour hole around a tree on the right side of the main flood channel. Note the large propane tanks embedded in the debris jam. This is the last large example of this phenomenon as we progress down- stream. Deposition in the wake of the tree is not as thick or as extensive as at similar sites upstream, consisting primarily of small, thin lobes of sand and gravel. This example comes close to the

ideal form of an obstacle mark or current crescent as described in connection with much smaller-scale features reported in the sedimentology literature.

12. Along the right side of the main flood channel there are small lobes of gravel coming from the direction of the South Branch channel. These lobes were deposited as floodwaters broke through points along the debris levee bordering the main channel and drained toward the flood channel.

13. In this area we find a complex pattern of patchy, localized scour and deposition. Subtle variations in surface topography and local obstructions probably influenced the path of flow and caused local variations in the intensity of flood impacts. Both gravels and sands are present.

14. As you move downstream along the flood channel, you come to a point where it starts to cut back toward the South Branch. At this site the channel runs along the base of a low scarp that forms the boundary between the floodplain area upstream and a higher floodplain or low terrace surface that extends downstream.

The lower floodplain surface is approximately 1.4 m above low water on the South Branch; the higher surface is approximately 2.7-3.4 m above low water. If you follow the flood channel over to the right, you will find dissected remnants of cohesive alluvium as well as fallen trees, some of which have been uprooted and transported and some of which have been toppled in place. Substantial accumulations of debris are to be found in this area and may have retarded the progress of flow draining back into the channel of the South Branch.

15. On the left side of the flood channel at site 14, there is a tree on the higher surface that retains evidence of peak flood stage. The limb projecting horizontally to the left has fine sediment and organic litter deposited on it. There is also a trash line along the fence behind the tree. Peak flood stage here was about 5.8 m above low water on the South Branch and was deep enough to inundate the upstream floodplain to a depth of 4-4.5m and to cover the higher surface downstream with 2-3m of water.

16. As flood waters rose, the terrace scarp bordering the flood channel was no longer capable of diverting all of the flow back towards the main channel. As a result, it was overtopped and a shallow channel was scoured into the upper floodplain/low terrace surface. Fine-grained alluvium is exposed in this scour channel. Note that there are several remnant patches of the intact surface within the scoured area, resembling in miniature the pattern of residual islands left behind when an anastomosing channel system is

created by flood erosion.

As you walk up onto this surface, look at the secondary scarp to your left. Exposed here is a buried soil interbedded with coarse angular clasts that are part of a small fan deposit extending out from the valley wall; the portion of the fan closest to the scarp is itself partially buried by overbank alluvium.

Although the upper floodplain has some scoured areas with gravel and cobbles deposited within the limits of the scour, there is relatively little coarse sediment deposited up here by comparison with the deposits observed on the floodplain upstream. The available stratigraphic evidence suggests that past floods generally were not competent to transport large clasts onto this surface.

17. At the downstream end of the main scour channel on the upper floodplain there are excellent examples of rolled-back sod. This provides evidence of progressive scour from the upstream end of the channel to the downstream end.

18. Further downstream on the right are several coalescing scour pits. Some of these have one or more steep headcuts, suggesting that both headward and downstream growth of erosion features occurred during the flood. Small elliptical or circular scour pits are also visible; some of these may have been formed at sites where vegetation was uprooted or where local obstructions caused flow separation and highly turbulent flow. Erosion and formation of scour holes probably was concentrated along local weaknesses in the turf cover.

19. Approaching the downstream end of this section of floodplain, several longitudinal grooves can be seen. They are on the order of 20-50 m long and vary in width and depth; the largest examples are about 50 cm across and about 30 cm deep. The origin of these particular grooves is uncertain. They are remarkably straight and they are aligned parallel to a road that once ran along this section of the valley, but they do not occupy the actual position of the road. At present we have no field evidence to suggest that they occupy abandoned crop rows or other linear features created by human activity, but these explanations cannot be ruled out. Grooves created by dragging of trees across the floodplain have been observed at other sites, but we have no evidence to suggest that these were formed as drag marks either. Several of the grooves have gravel and cobbles embedded in their floors; we have trenched them and found that these clasts must have been deposited in the flood. Features of this type are generally associated with streamwise longitudinal vortex action, with the highest stresses occurring where downward flow impinges on the bed. Abrasion by coarse clasts embedded in the vortex may account for the formation of grooves, but there are no definitive

observations that would allow a more complete description of the process. Note that the grooves are parallel to the larger elongate scour channels on this surface; it is possible that some of the larger scours formed by incision and widening along the trend of a groove.

20. At the right downstream terminus of the upper floodplain, a headward retreating scour with an irregular outline was formed by turbulent flow spilling back into the channel of the South Branch. Similar features have been observed at other sites.

21. At the far end of the reach, the floodplain area meets the debris fan deposited at the mouth of Austin Run. This fan was deposited as a result of debris flows down Austin Run during the 1949 floods (Figure 3.2). Evidence of these flows can be seen as we progress up the hollow towards the vans, including levees and curious boulder accumulations. The flora show that much of the hollow was reworked in 1949, but locally older trees survived the debris flow. There was some reworking in the 1985 flood but the modification of Austin Run and its debris fan was minor by comparison with what happened in 1949.

As you begin to walk up Austin Run, note the beautifully exposed anticlinal ridge in the Oriskany sandstone; this is the same structure we observed at the mouth of Redman Run. The anticline is cored by Helderberg limestone. Watch out for the slippery, steeply dipping beds of Helderberg limestone that form a narrow V-notch on the stream bed, and note the large chert nodules that are visible in these rocks as you make your way upstream. Further upstream the bed is characterized by large blocks of Oriskany sandstone. Structure and stratigraphy on the way up Austin Run are basically similar to the patterns observed on the way down Redman Run, but differences in detail are caused both by thrust faults of uncertain extent and by strike-slip faults that run perpendicular to strike along or between the tributary valleys. The opening in the valley of Austin Run between the two prominent sandstone ridges is located along the axis of a small syncline (see description of walk down Redman Run) and the stream here is floored by Needmore shale.

42.5	0.9	Additional mileage has been added during vehicle shuttle. Return to Route 28 by heading north (back-tracking) on Smoke Hole Road.
44.1	1.6	**Turn left** on Route 28 after crossing the steel bridge.
45.1	1.0	Re-enter Petersburg West quad.

47.7	2.6	**Turn right** (north) on Jordan Run Road. Our altitude is approximately 1150 ft.
		(If weather or road conditions are bad, we will return to Canaan Valley via Seneca Rocks. Refer to road log for Day 1.)
48.6	0.9	**Turn left** (west) on gravel USFS Route 19, at wooden sign indicating 6 mi to Dolly Sods. From our current altitude of 1400 ft, we will climb up the Allegheny Front.
52.3	3.7	Pastures are underlain by limestones of Mississippian Greenbrier Formation.
54.9	2.6	**Turn right** (north) on gravel road. Follow sign to Red Creek Campground. We are on top of Allegheny Front, approximately 3950 ft above sea level. As we head north, note block fields on either side of road.
55.6	0.7	**Turn right** into parking loop.
55.7	0.1	**Park** along loop and walk along trail to sandstone outcrop 100 m south of loop.

STOP 5: DOLLY SODS OVERLOOK

(ROAD CONDITIONS AND WEATHER PERMITTING)

Text by J. Steven Kite

Discussion by G. Michael Clark

This overlook provides an excellent view of the area covered during the second day of the field trip. We are looking from the edge of the Allegheny Plateau down into the Ridge and Valley Province. The bedrock geology is very similar to that discussed at the Germany Valley Overlook (Stop 5, Day 1). We are standing on outcrops of Lower Pennsylvanian Pottsville Sandstone, the cap rock that holds up most of West Virginia's highest mountains. To the east is a view of the North Fork South Branch Potomac River flowing through North Fork Gap, revealing white outcrops of Silurian Tuscarora Sandstone within the Wills Mountain anticline. The anticlinal ridge south of the water gap is North Fork Mountain, but the ridge north of the gap is called New Creek Mountain. Other, lower ridges are held up by Oriskany, Chemung, or Pocono (Price) Sandstones.

Petersburg can be seen east of North Fork Gap. Note the scree slopes on New Creek Mountain and the debris avalanche/flow scars on North Fork Mountain. It is interesting to note that New Creek Mountain experienced very few slope failure during 1949, while debris flows and debris avalanches occured in nearly every tributary on nearby North Fork Mountain.

Dolly Sods is an excellent area to explore an ecosystem that one might expect to see in southern Canada. In addition to relict periglacial features, one can see flag-pole trees and other flora that demonstrates the severity of climate at this altitude. Those following this guide in the future will want to drive about 5.5 mi farther north to the stark, barren landscape at Bear Rocks.

		Return to the vehicles. Back-track (south) to USFS Route 19.
56.4	0.7	Turn right (west) on USFS Route 19.
57.0	0.6	Dolly Sods Picnic area.
58.8	1.8	Re-enter Laneville quad.
60.2	1.4	Hard-top road begins.
60.3	0.1	Bridge over Red Creek. A new bridge was under construction in October 1987. Note the large boulders transported during the 1985 flood.
60.8	0.5	Two-meter-high artificial boulder ridge between channel and roadside.
61.6	0.8	Bear right at intersection.
64.0	2.4	Look back (east) to see numerous benches on Mt. Porte Crayon (4770 ft), underlain by horizontal sedimentary rocks.
65.5	1.5	Enter Blackwater Falls quad and Kingwood 1:100,000 map for next 0.3 mi, then briefly back on Laneville quad and Elkins 1:100,000 map.
66.0	0.5	**Turn right** on Route 32.
66.1	0.1	Re-enter Blackwater Falls quad and Kingwood 1:100,000 map.
67.5	1.4	**Turn left** at entrance to Canaan Valley Lodge.
69.6	2.1	**END of trip** at Canaan Valley Lodge.

GLOSSARY

This field guide uses some terms that either may be unfamiliar to some of the trip participants or may not follow conventional usage. The following glossary was compiled by the editors to clarify our usage. Individual contributers may use somewhat different terminology (e.g. tree jam).

Boulder berm: Relatively straight to slightly curved continuous ridge of boulders, or boulders and cobbles, that form in overbank areas near the margins of steep stream channels during extraordinary water floods. Boulder berms form in reaches where stream flow expands and undergoes flow separation. (After Costa, 1986.)

Debris avalanche: Very rapid sliding of a body of granular solids, water and air. Debris avalanches commonly translate into debris flows as they move downslope.

Debris flow: Rapid mass movement of a body of granular solids, water and air (Costa, 1984). Often used in a general sense that would include debris avalanches. In the description of the Twin Run and Simmons Run mass movements, we attempt to restrict debris flow to those parts of the failure that were flowing as a slurry (vs. debris avalanches that were sliding).

Diamicton (or diamict): Very poorly sorted sediment with a wide range in particle size. Modifiers may be used to denote the most abundant clasts (e.g. boulder-cobble diamicton). The term diamicton does not have any genetic implications, unlike other terms commonly applied to these sediments, such as colluvium, till, etc.

Gravel berm: A deposit similar to a boulder berm in form and origin, but with a grain-size distribution dominated by clasts smaller than boulders.

Hyper-concentrated flow: A flowing mixture of water and sediment that has a measurable yield strength, but that still appears to flow like a liquid. Typically these flows have sediment concentrations of 40 to 80 percent by weight (Pierson and Costa, 1987).

Debris-flow levee: Linear to curvi-linear deposit, composed of debris lodged along the margins of a slurry flow. Levees are generally parallel to flow direction, whereas lobate boulder fronts and debris jams are generally transverse to flow.

Slack-flow deposits: Debris, including tree trunks, cobbles, and boulders, deposited in zones of flow separation along a debris-flow track; typically these deposits occur on the insides of bends in which flow was super-elevated high on the outside bank, (i.e. the bank opposite the slack-flow deposit). Slack-flow deposits occur on top of relatively undisturbed topsoil, up to 2 m above the limit of scour on the inside bend of the debris-flow channel. Accurate reconstruction of debris-flow cross-sections in super-elevated bends requires a clear model for the nature of debris flow at slack-flow deposits. It may be inappropriate to use the upper limit of topsoil scour as the upper limit of debris flow throughout the entire debris-flow track.

Spill-over chute: The feature left by a debris-flow that has so much momentum that part of the flow temporarily flows out of the pre-existing stream channel (or ravine) as it becomes super-elevated at a bend. Spill-over chutes re-attach to the channel farther downslope, unlike spill-over splays. Spill-over chutes on North Fork Mountain have experienced a meter or more of erosion at their base, and have well-developed levees and debris jams. Spill-over is common where stream channels are not deeply incised, such as dip-slopes on North Fork Mountain. **Bifurcations** of debris flow because of debris jams and other obstacles in the debris-flow path are not considered spill-over chutes.

Spill-over splay: The feature left by a debris-flow that has so much momentum that part of the flow flows out of the pre-existing stream channel. Spill-over splays terminate before re-attaching to the main channel.

Super-elevation: Phenomena common wherever a debris flow passes through a meandering ravine; moving as a slurry, the debris flow will bank, flowing at a much higher level on the outside of each bend than on the inside. Super-elevation is sometimes called the bob-sled effect. The degree of super-elevation may be used to determine the momentum and velocity of the flow (Costa, 1984).

Tree jam: A collection of debris that is composed almost entirely of tree trunks, large branches, and wood fragments. The term tree jam is used in Kite and Linton's discussion of debris flows to differentiate deposits composed almost entirely of wood from deposits that include significant fraction of clastic debris. Similar deposits that include wood and clastic debris are called debris jams in Miller and Harper's discussions of floodplain deposits.

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