Summary of Results of a Seismic Survey of the Savannah River Adjacent to the Savannah River Plant Site, Burke County, Georgia

Vernon J. Henry

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GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

Atlanta
1995

PROJECT REPORT 24

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Georgia Environmental Protection Division Contract Number 702-390229

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EXECUTIVE SUMMARY

SUMMARY OF RESULTS OF A SEISMIC SURVEY OF THE SAVANNAH RIVER ADJACENT TO THE SAVANNAH RIVER PLANT SITE, BURKE COUNTY, GEORGIA

Vernon J. Henry
Applied Coastal Research Laboratory
Georgia Southern University

PURPOSE AND OBJECTIVES OF THE STUDY

The seismic survey was undertaken in order to assist the Georgia Department of Natural Resources in assessing the potential for, and source of, ground water contamination in the Burke County region. Specific objectives included:

1. evaluation of possible breaching of the shallow aquifers by the Savannah River.
2. evaluation of the thickness of the river alluvium.
3. correlation of seismic sequences with the Upper Cretaceous/Lower Tertiary stratigraphic units identified in regional water wells and field studies by the Environmental Protection Division of the Georgia Department of Natural Resources.
4. delineation of the Pen Branch Fault suspected to cross the Savannah River in the vicinity of Plant Vogtle and Fourmile Branch.

This research was financed through a grant from the Georgia Geologic Survey, Environmental Protection Division, Department of Water Resources funded by the United States Department of Energy.

SCOPE OF WORK ACCOMPLISHED

Pursuant to Objectives 1, 2, and 3 above, a high resolution seismic survey (Phase 1) was conducted in the Savannah River between the Richmond/Burke county line and the Burke/Screven county line. Continuous subbottom data was collected along both upstream and downstream survey lines, for a total of 70 river miles. Every effort was made to maintain a thalweg profile.

Pursuant to Objectives 3 and 4 above, a medium resolution seismic survey (Phase 2) was conducted in the Savannah River between the Georgia Power Company boat ramp and Hancock Landing.

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SUMMARY OF RESULTS

Phase 1. High Resolution Seismic Survey

The survey was conducted during the period October 10-13, 1992. An EG&G Model 225 UNIBOOM system was used in the survey. Data was recorded on both magnetic tape and a graphic (analog) recorder. The taped data was digitized and processed and, together with the analog records, examined to identify thickness of river alluvium, breaching of shallow aquifers and correlation with stratigraphic units.

Seismic and correlative data indicate that, in the study area, the downriver thalweg of the Savannah River and/or its alluvium is, respectively, underlain by the Early Paleocene Ellenton Formation (and an unnamed unit), the middle Eocene Lisbon Formation and the Late Eocene Dry Branch Formation. Direct breaching of these formations and associated aquifers appears to occur only where the river channel impinges the southwestern bank of river between Hancock Landing and Brighams Landing and, possibly, at Shell Bluff. The river channel averages 14 feet in depth and, except in the above areas, is above the base of the alluvial deposits which are approximately 50 feet thick.

Phase 2. Medium Resolution Seismic Survey

The survey was carried out during the period August 23-27, 1993 using a Bolt 600B air gun with 1 cubic inch and 10 cubic inch chambers. Data was digitally recorded and processed. A Magellan GPS was used to locate (lat./long.) shot points and features of interest.

The Pen Branch Fault was identified as crossing beneath the Savannah River approximately 1000 feet downstream from Hancock Landing at a geographic position of 81°45'43.23"N and 33°09'31.47"W. It appears as a high angle reverse growth fault that extends through the Early Paleocene Ellenton Formation to the base of the Savannah River alluvium.

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SUMMARY OF RESULTS OF A SEISMIC SURVEY OF THE SAVANNAH RIVER ADJACENT TO THE SAVANNAH RIVER PLANT SITE, BURKE COUNTY, GEORGIA

PURPOSE AND OBJECTIVES OF THE STUDY

A seismic survey of the Savannah River bordering Burke County, Georgia, was undertaken to provide subsurface information to the Georgia Department of Natural Resources (GaDNR) pertinent to hydrogeological investigations of tritium contamination within the Burke County region. Specific objectives of the survey were:

1. to evaluate the thickness of the Savannah River alluvium and possible breaching of the shallow aquifers by the Savannah River (Phase 1 Survey).
2. to correlate seismic stratigraphic sequences with the Upper Cretaceous/Lower Tertiary lithostratigraphic units identified in regional water wells and field studies by the Environmental Protection Division (EPD) of the Georgia Department of Natural Resources (Phase 1 Survey and Phase 2 Survey).
3. to delineate the Pen Branch Fault suspected to cross the Savannah River in the vicinity of Plant Vogtle and Fourmile Branch (Phase 2 Survey).

This research was financed through a grant from the Georgia Geologic Survey, Environmental Protection Division, Department of Natural Resources, funded by the United States Department of Energy.

DATA COLLECTION

Phase 1. High Resolution Seismic Survey

The location of the Phase 1 Survey is shown in Figure 1. The high resolution survey was conducted during the period October 10-13, 1992 using an EG&G Model 225 UNIBOOM system. Shallow (less than 150 feet) subsurface seismic stratigraphy was continuously recorded both up- and downriver between the Burke/Richmond County line and the Burke/Screven County line. Data was recorded on both magnetic tape and graphic (analog) records. The taped data was digitized and processed and, together with the analog records, examined to identify thickness of river alluvium, possible breaching of shallow aquifers and correlation with lithostratigraphic units. Because the river was in an unusually high flood stage, the resulting swift currents and turbulence caused record quality to be somewhat impaired. Record quality was particularly poor between Plant Vogtle and the Burke/Richmond County line. This could be due to river conditions and/or the acoustic nature of the suballuvial stratigraphic units. Between Plant Vogtle and the Burke/Screven County line the data was of sufficient clarity to allow a reasonable level of confidence in record interpretation, however. A total of 70 river miles of seismic line was collected. Efforts were made to maintain a thalweg profile.

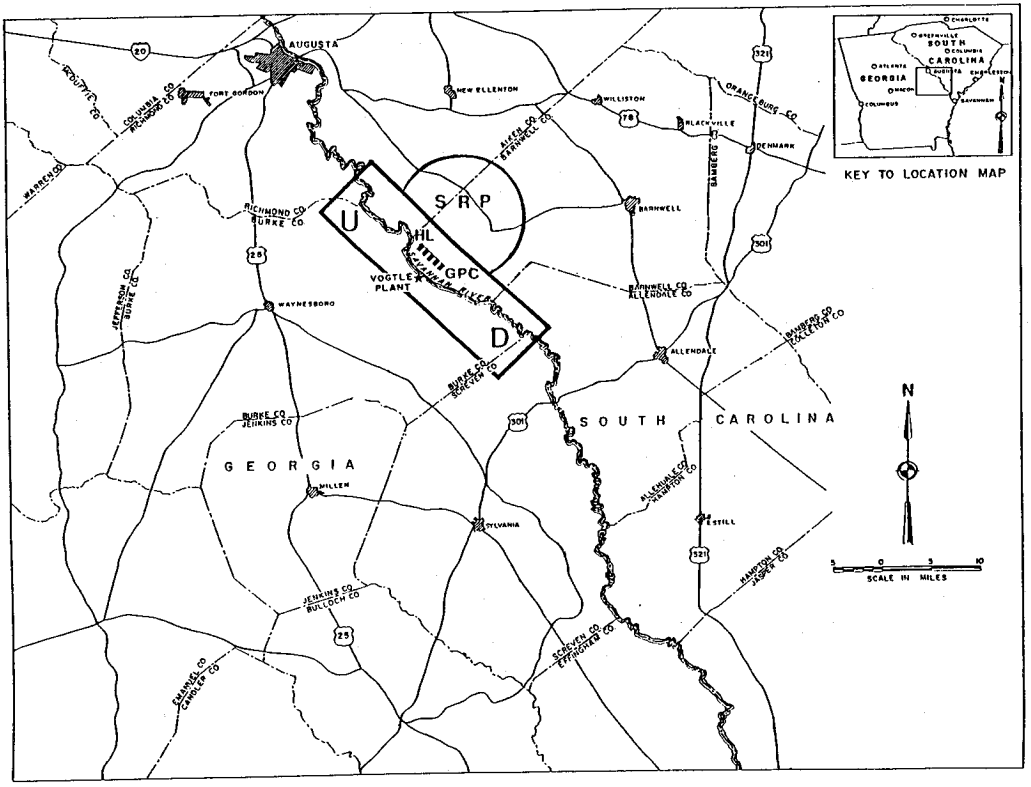


FIGURE 1. Regional location map of survey area. U = upstream and D = downstream extent of Phase 1 Survey. Dashed line = extent of Phase 2 Survey. HL = Hancock Landing and GPC = Georgia Power Company boat ramp. SRP = Savannah River Plant site. Modified from Bechtel, 1982.

Phase 2. Medium Resolution Seismic Survey

The Phase 2 Survey was carried out during the period August 23-27, 1993 using a Bolt 600B air gun with one (1) cubic inch and ten (10) cubic inch chambers. Data was digitally recorded and computer processed by personnel from the Mississippi Minerals Resources Institute. A Magellan Geographic Positioning System (GPS) was used to determine latitude and longitude of shot points and features of interest. Upstream and downstream seismic transects were run using both air gun chambers. Shown on Figure 1 as a dashed line, the survey covered the stretch of river from Hancock Landing (HL) downstream to the Georgia Power Company boat ramp (GPC), a distance of approximately 3 miles. The Pen Branch Fault was suspected to cross the river within this line segment.

DISCUSSION OF RESULTS

Phase 1. High Resolution Seismic Survey

Interpretation of high resolution seismic records as to the thickness of river alluvium, breaching of shallow aquifers and/or aquicludes and correlation with Tertiary stratigraphic units was significantly aided by information provided by Paul Huddlestun of the EPD's Georgia Geologic Survey (GGS), David Leeth of the United States Geological Survey (USGS) and selected literature (McClelland, 1987; and Fallow and Price, 1992).

Correlation of Seismic Reflectors with Tertiary Stratigraphy

The lithostratigraphic and associated hydrostratigraphic units present in the study area are shown in Figure 2. It is to be noted that the literature contains a plethora of unresolved regional stratigraphic nomenclature separated by the Savannah River. The terminology used in this report is that in current use by the Georgia Geologic Survey. Those units that appear to correlate with seismic signatures recorded during the Phase 1 Survey are shown in Figure 3. Correlations were based on strength and depth of seismic signatures relative to lithology (inferred acoustic reflectance), and depth of the stratigraphic units as depicted on regional dip cross-sections in several published and unpublished studies (McClelland, 1987; Huddlestun, personal communication; and Leeth, personal communication). It is doubtful that, in the study area, units older than Early Paleocene are in contact with the Quaternary alluvial deposits of the Savannah River. In any case, record quality upriver from Plant Vogtle was poor making correlation difficult. The above studies indicate that the Early Paleocene Ellenton Formation underlies the alluvium in that stretch of river, however.

As shown in Figure 3, the three stratigraphic units dip downriver in offlap sequence, each subcrop being overlain by alluvial deposits. Unit 3 appears to correlate with the Blue Bluff member of the Lisbon Formation which consists predominantly of calcareous clay and sandy limestone and provides a strong acoustic reflector. The Gordon aquifer is associated with the Lisbon

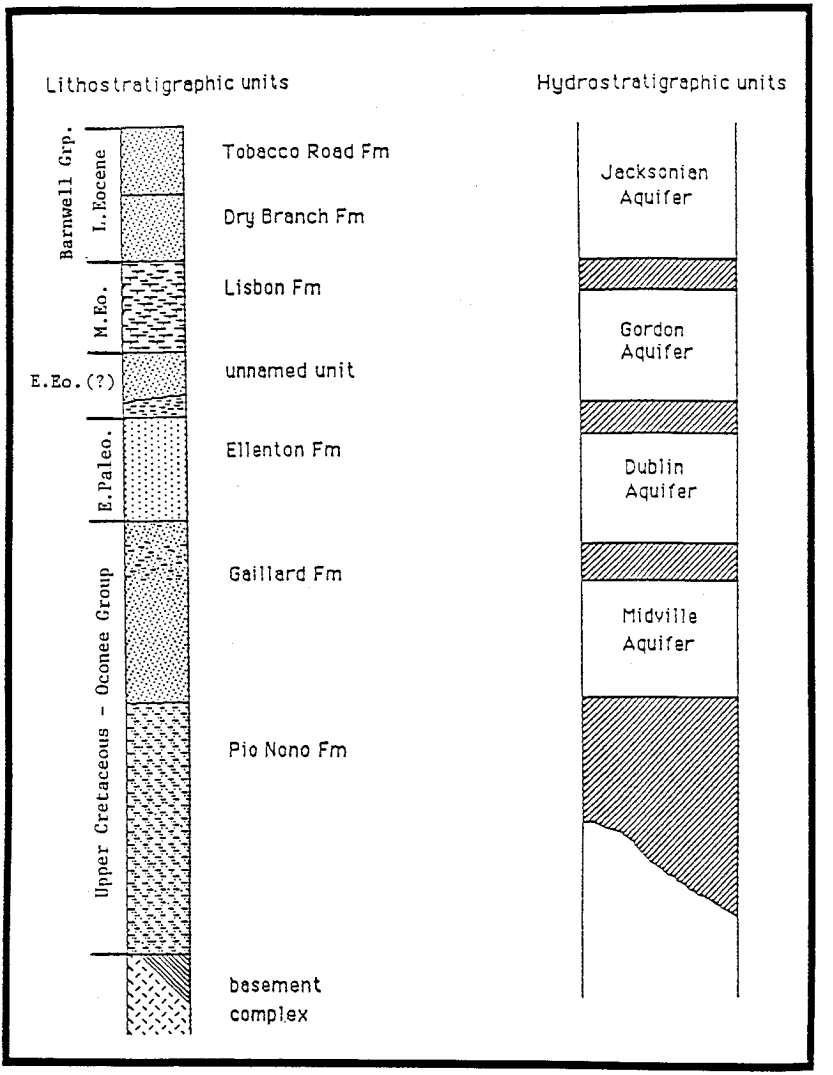


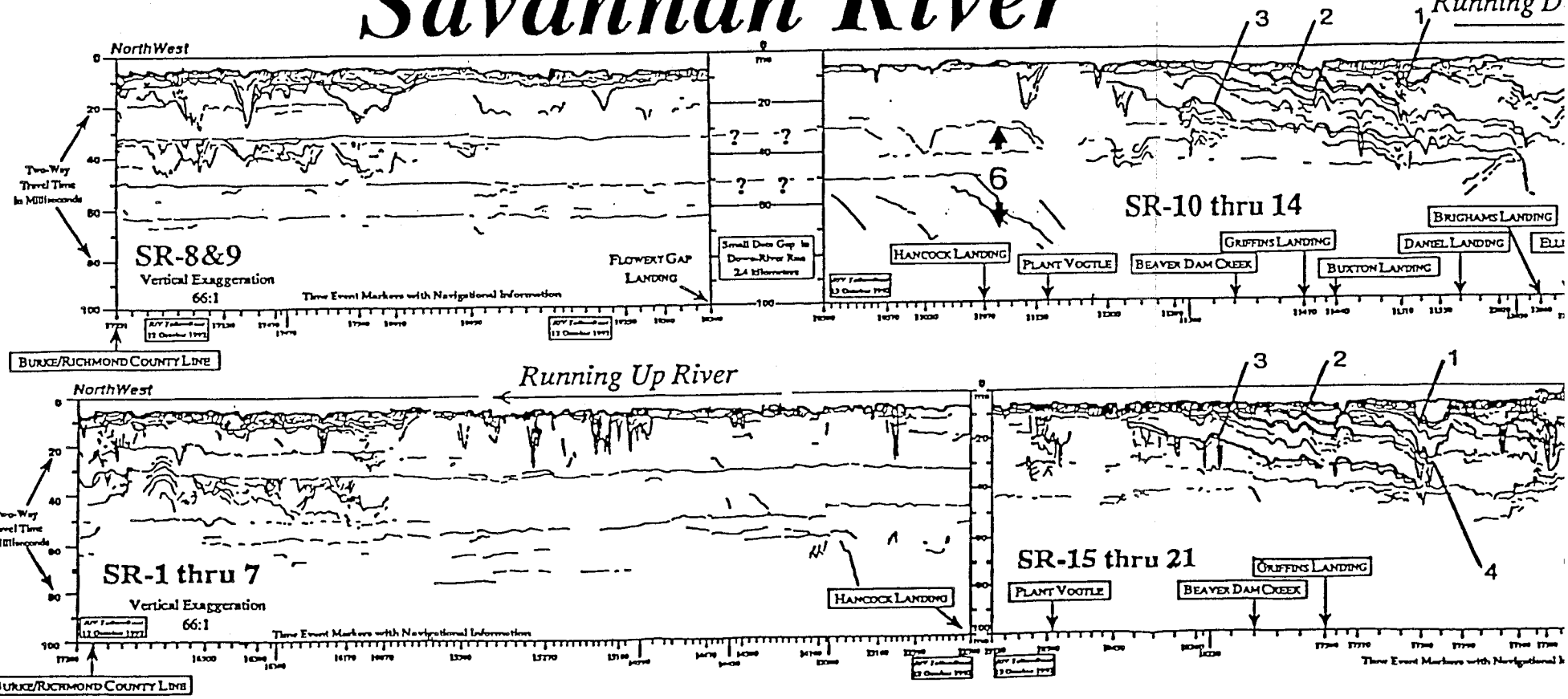
FIGURE 2. Lithostratigraphic and hydrostratigraphic units in eastern Burke County.

EXPLANATION — PH

(see Figure 2)

1 = Dry Branch Fm (Barnwell
2 = Utley Ls member (Barnwe
3 = Blue Bluff member (Lisb
4 = velocity pulldown (chan
5 = alluvium
6 = approximate location of

Savannah River



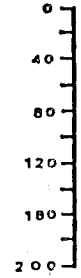
PART 1 of 2

EXPLANATION—PHASE I SEISMIC

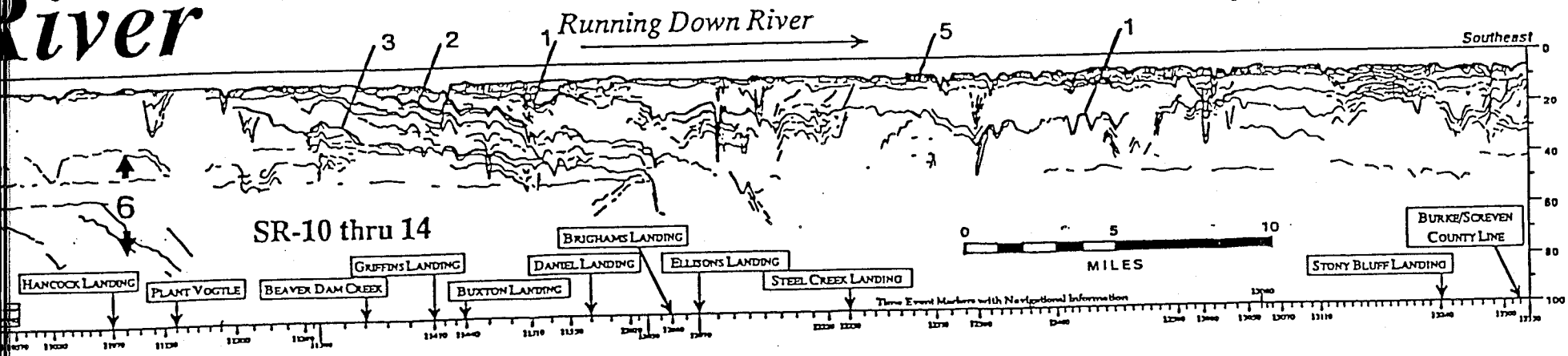
(see Figure 2)

1 = Dry Branch Fm (Barnwell Group)
2 = Utley Ls member (Barnwell Group)
3 = Blue Bluff member (Lisbon Fm)
4 = velocity pulldown (channel fill/sinkhole?)
5 = alluvium
6 = approximate location of Pen Branch Fault

Approximate Vertical Scale in Feet Using 5610 Ft/Sec Subbottom Velocity



River



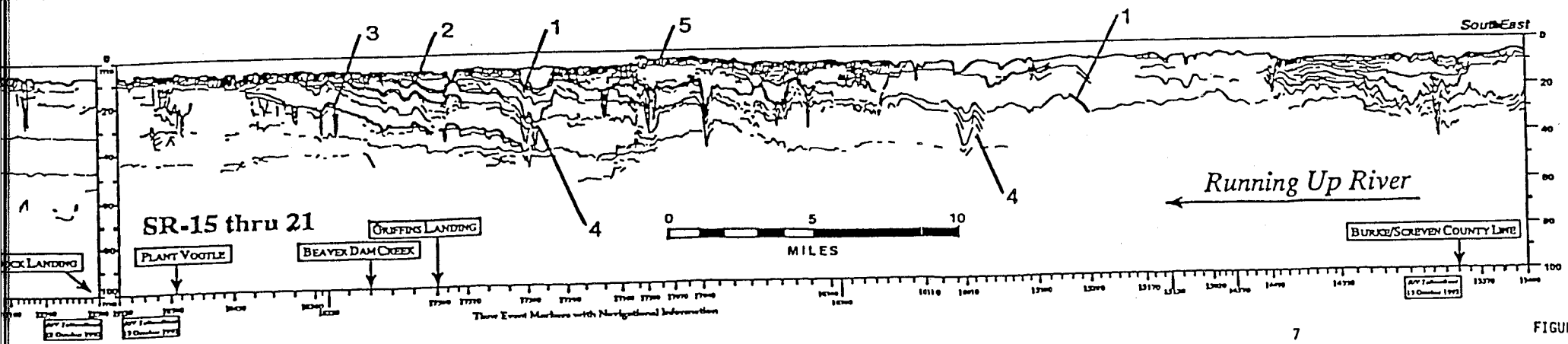


FIGURE 3

part 2 of 2

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Formation and together with the overlying Jacksonian aquifer, developed within the Barnwell Group, provide important drinking water sources in the Burke County region. Unit 2 is correlated with the Utley Limestone member which occurs in the lower part of the Dry Branch Formation. Unit 1 is correlated with the top of the Dry Branch Formation at the contact with the overlying Tobacco Road Formation. Both formations are within the Barnwell Group.

Other features of interest shown on Figure 3 are structures, denoted by the number 4, which are suggestive of filled channels or sink holes or perhaps even slump features. Because the fill material usually has a contrasting acoustic impedence, the resulting signature is exaggerated and often repeated with depth. In the case of channel fills and sinkholes, their significance is in their potential as pathways for interaquifer water and pollutant exchange. River alluvium is indicated by the number 5. The maximum thickness encountered, assuming a thalweg profile, was approximately 25 feet; however, thicknesses of 15 feet were more common. It is interesting to note that the beginning of poor upriver record quality coincided with the location of the Pen Branch Fault (number 6) as identified by the Phase 2 study.

Thickness of River Alluvium and Possible Breaching of Shallow Aquifers

The possibility for tritium-polluted river water infiltrating the shallow Jacksonian and Gordon aquifers where the active Savannah River channel is in direct contact with the underlying formations is a major concern that was addressed by this study.

Even in those areas where actual breaching does not occur, the permeable alluvial deposits could provide pathways for tritiated water to invade unconfined shallow aquifers. Transmissivity and thickness of the alluvium are important factors. As indicated in Figure 3 the thickness of the alluvial deposits beneath the active (modern) river channel ranged from zero to approximately 25 feet, assuming a thalweg profile. According to river navigation charts prepared by the U.S. Army Corps of Engineers (1990), the average depth of the modern channel thalweg in the study area is approximately 14 feet. Maximum depths exceeding 25 feet are exceptional. Based on these figures and the elevation of the floodplain surface, the estimated total thickness of the Savannah River alluvium in the study area is 50 feet.

Three recently completed auger-hole transects across the alluvial valley of the Savannah River in the study area by the U.S. Geological Survey show the maximum alluvial thickness to be 50 feet and concluded that, except where the modern river impinged on the upland, the channel thalweg was far above the base of the alluvium (David Leeth, personal communication). The implication for the present study is that there is probable breaching of formations and associated aquifers by the modern Savannah River between Hancock Landing and Brighams Landing, and possibly at Shell Bluff Landing. In these localities the sidecrop, if not the subcrop of the Ellenton, Lisbon and Dry Branch formations appear to be successively impinged along the southwestern (Georgia) bank of the river (see Figure 5, page 12).

Phase 2. Medium Resolution Seismic Survey

The principle objective of the Phase 2 Survey was to identify and locate the trace of the Pen Branch Fault projected by earlier studies to cross beneath the Savannah River between Plant Vogtle and Hancock Landing as shown in Figure 4. The presence of this major fault that shallowly underlies the Savannah River Plant (SRP) site is of concern because it could provide a pathway for radioactive elements from the site to infiltrate Georgia aquifers. A recent report by Snipes and others (1993) describes the feature as a Late Cretaceous-Tertiary fault that has been mapped for 15 miles across the central portion of the SRP site. It was shown by geophysical and drill core studies to be a sub-vertical reverse fault with down-to-northwest movement that extends from the Mesozoic basement to the top of the late Eocene Dry Branch Formation.

Delineation of the Pen Branch Fault

The Phase 2 Survey identified the Pen Branch Fault as crossing beneath the Savannah River approximately 100 feet downstream from Hancock Landing (Figure 5). Figures 6 and 7 show the upstream (Line 1) and downstream (Line 2) traverses of the survey and the location of the Pen Branch Fault relative to designated shot points. Table 1 provides the geographic positions of the shot points. The interpolated geographic position where the Pen Branch Fault crosses under the Savannah River is 81°45'43.23"N and 33°09'31.47"W.

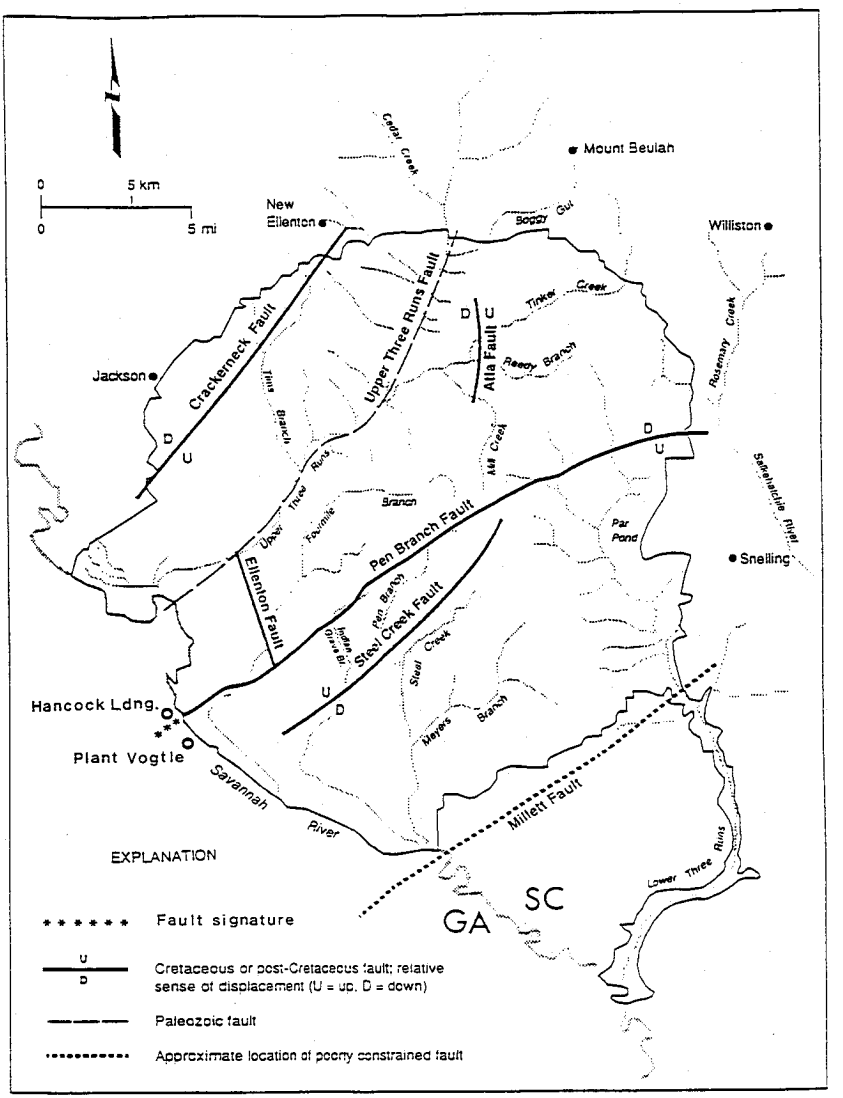

FIGURE 4. Location of the Pen Branch Fault in the subsurface at the Savannah River Plant site and extension under the Savannah River as indicated in this study. Modified from Geomatrix, 1993.

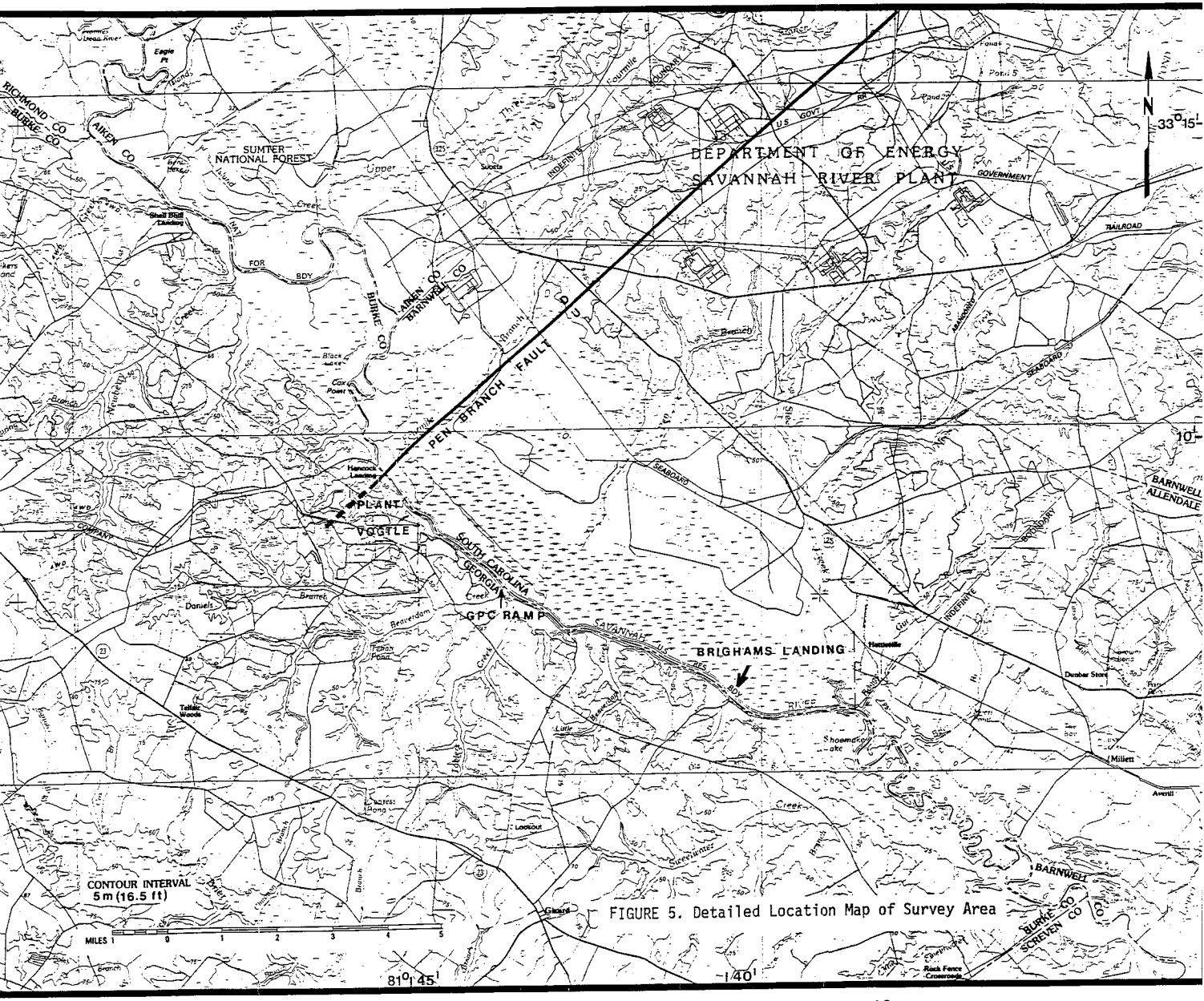

FIGURE 5. Detailed Location Map of Survey Area

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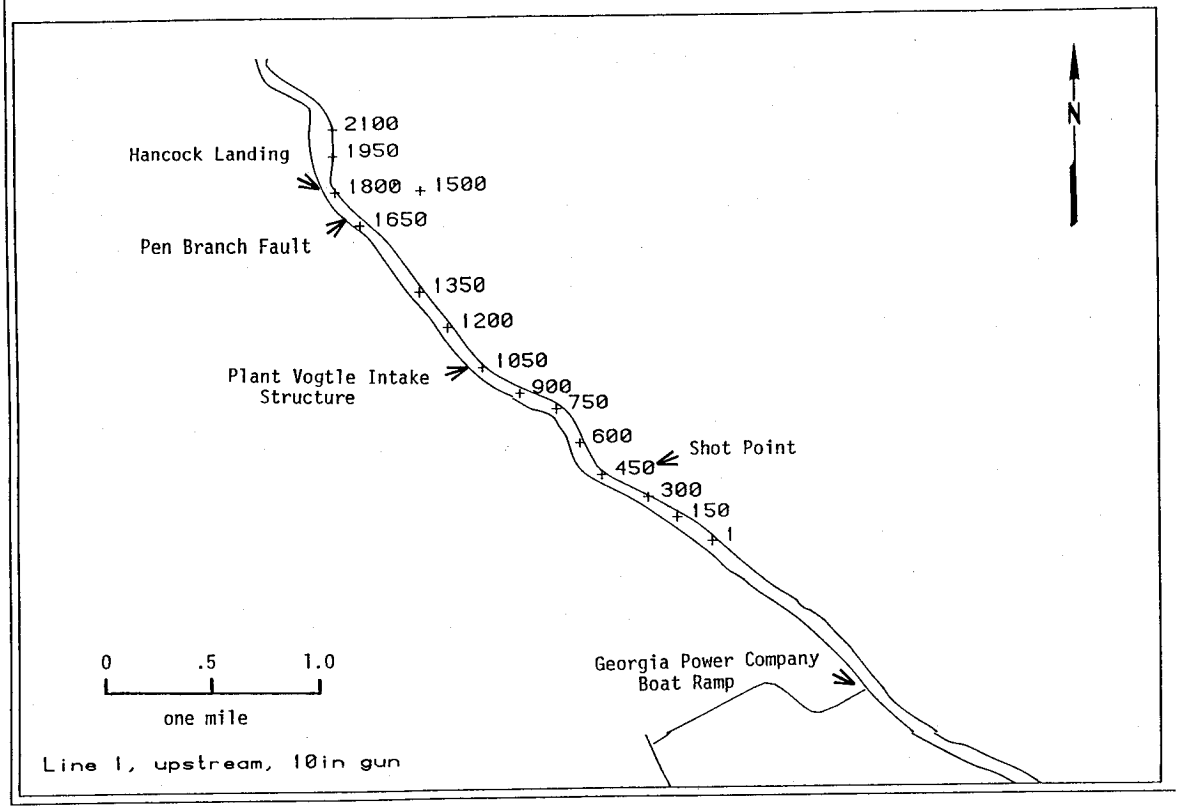

FIGURE 6. Line 1 of Phase 2 seismic survey showing location of the Pen Branch Fault relative to shot points, Hancock Landing and Plant Vogtle.

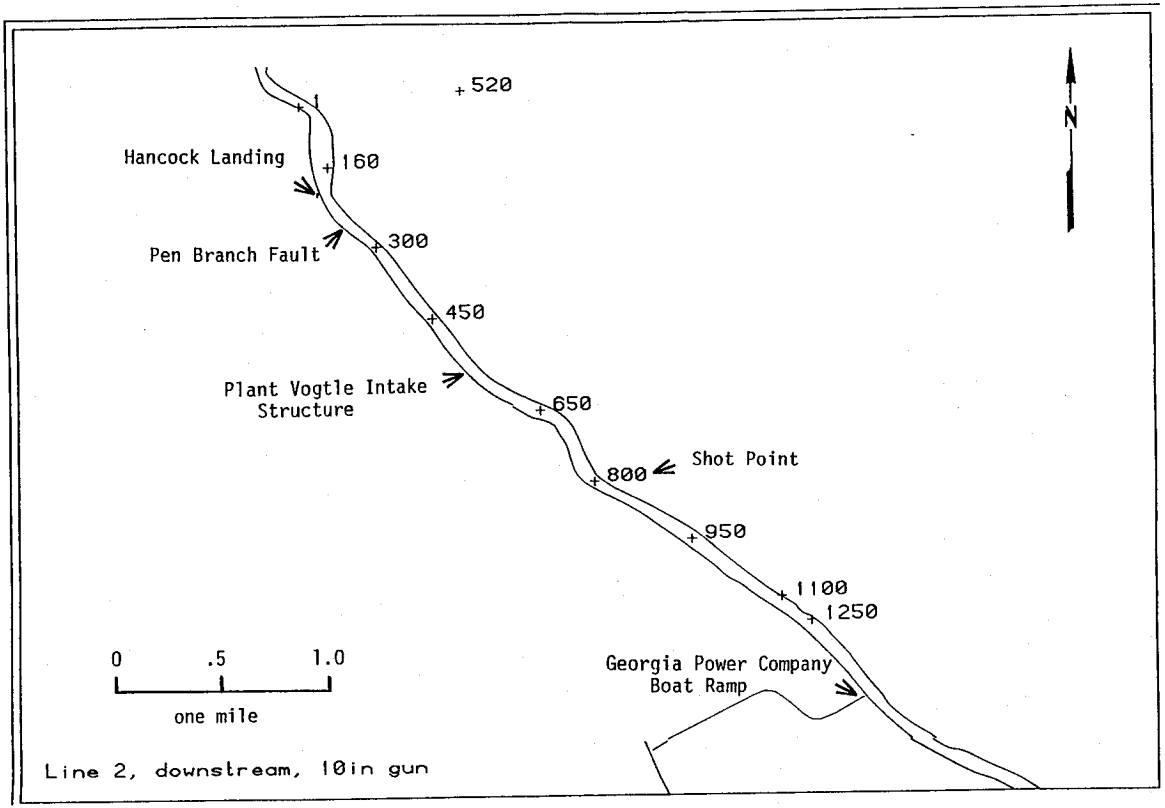

FIGURE 7. Line 2 of Phase 2 seismic survey showing location of Pen Branch Fault relative to shot points, Hancock Landing and Plant Vogtle.

TABLE 1

Savanah River Seismic Navigation Records

Line SAV2_1 Bolt 600B air gun, 10in chamber, 1500 psi, bandpass filter, 300hz, Q = 1, ITI eel

Shot	Geographic (DMS) Longitude			Latitude			UTM (zone 17) Easting	Northing	Remarks UPSTREAM
1	81	44	6.50	33	8	13.83	431430.58	3666543.22	
150	81	44	15.81	33	8	19.45	431190.58	3666717.98	
300	81	44	23.40	33	8	24.24	430994.97	3666866.87	
450	81	44	35.69	33	8	29.40	430677.67	3667028.03	
600	81	44	41.60	33	8	36.99	430526.21	3667262.86	
750	81	44	47.93	33	8	44.93	430363.95	3667508.54	
900	81	44	57.85	33	8	48.70	430107.78	3667626.47	
1050	81	45	8.00	33	8	54.91	429846.19	3667819.59	
1200	81	45	17.32	33	9	3.98	429606.76	3668100.64	
1350	81	45	24.80	33	9	11.84	429414.73	3668344.09	
1500	81	45	24.39	33	9	34.38	429430.36	3669038.14	
1650	81	45	40.37	33	9	26.32	429014.62	3668792.93	
1800	81	45	47.15	33	9	33.94	428840.70	3669028.87	
1950	81	45	47.72	33	9	42.38	428827.83	3669288.89	
2100	81	45	47.87	33	9	48.91	428825.41	3669490.02	

Line SAV2_2 Bolt 600B air gun, 10in chamber, 1500 psi, bandpass filter, 300hz, Q = 1, ITI eel

Shot	Geographic (DMS) Longitude			Latitude			UTM (zone 17) Easting	Northing	Remarks DOWNSTREAM
1	81	45	57.01	33	9	56.00	428590.26	3669710.08	
160	81	45	49.24	33	9	41.91	428788.35	3669274.71	
300	81	45	36.16	33	9	23.73	429123.10	3668712.38	
450	81	45	21.15	33	9	7.53	429508.32	3668210.68	
520	81	45	13.67	33	9	59.79	429713.68	3669818.65	
650	81	44	52.33	33	8	46.55	430250.31	3667559.24	
800	81	44	37.44	33	8	29.91	430632.44	3667044.06	
950	81	44	11.43	33	8	16.36	431303.39	3666622.02	
1100	81	43	47.76	33	8	2.63	431913.73	3666194.92	
1250	81	43	39.66	33	7	57.13	432122.44	3666024.08	

Figures 8, 9, and 10 (in pocket) are photocopies of analog records obtained using the 10 cubic inch air gun. The records of the 1 cubic inch air gun survey were of poor quality for reasons unknown. In each of the above figures the Pen Branch Fault appears as a high angle reverse growth fault that extends through the Ellenton Formation and underlying stratigraphic units to the base of the Savannah River alluvium. On Figure 8 the fault is shown to occur between Shot Points 1670 and 1810 on the Line 1 (upriver) traverse. On Figures 9 and 10 it appears between Shot Points 180 and 280 on the Line 2 (downriver) traverse. Except for a difference in processing, the analog records depicted by Figures 9 and 10 are from the same data set.

Stratigraphic Correlation

Several seismic signatures that represent reflectors are present to a depth of 500 feet below the river bed. Under this stretch of the river this seismic section should include Upper Cretaceous to Middle Eocene stratigraphic units. Specific formational contacts could not be identified with confidence, however. A more rigorous processing technique, not available at the time the survey was completed, should provide better definition of the fault as well as underlying formational contacts.

SUMMARY AND CONCLUSIONS

A seismic survey was conducted in the Savannah River between the Burke/Richmond County line and the Burke/Screven County line to provide information concerning ground water contamination in the Burke County area. Specific objectives were:

1. evaluation of possible breaching of the shallow aquifers by the Savannah River.
2. evaluation of the thickness of the river alluvium.
3. correlation of seismic sequences with the Upper Cretaceous/Lower Tertiary stratigraphic units identified in regional water wells and field studies by the Environmental Protection Division of the Georgia Department of Natural Resources.
4. delineation of the Pen Branch Fault suspected to cross the Savannah River in the vicinity of Plant Vogtle and Fourmile Branch.

Relative to the above objectives, the following conclusions were reached:

1. breaching of Tertiary formations and associated aquifers probably occur where the Savannah River impinges the southwestern bank of the river between Hancock Landing and Brighams Landing and, possibly in the Shell Bluff area.
2. thickness of river alluvium is approximately 50 feet.
3. downriver from the Burke/Richmond County line to the Burke/Screven County line, the Tertiary formations

identified as being in contact with the river alluvium and/or thalweg are the Ellenton, Lisbon and Dry Branch formations.

4. the Pen Branch Fault was identified as crossing beneath the Savannah River approximately 1000 feet downstream from Hancock Landing. It appears to terminate in the Early Paleocene Ellenton Formation overlain by the Savannah River alluvium.

ACKNOWLEDGEMENTS

The contributions of the following persons and organizations are gratefully acknowledged: Dr. Steve Snyder and technicians from North Carolina State University and Dr. Faisal Idris for Phase 1 data collection and processing; Dr. Jim Harding, Dr. Bob Woolsey, Mr. Doug Lockhart and Mr. Brian Noakes of the Mississippi Minerals Resources Institute, University of Mississippi for Phase 2 data collection and processing; Georgia Power Company/Plant Vogtle personnel for research vessel docking facilities and other assistance; Dr. Paul Huddlestun of the Georgia Geologic Survey and Mr. David Leeth of the U.S. Geological Survey for providing stratigraphic and other relevant information; and to Mr. Lewis Taylor for helping prepare this report.

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Maroon	Coastal Plain mapping and stratigraphy
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Lt. Blue	Coastal Zone studies
Dk. Green	Geochemical and geophysical studies
Dk. Blue	Hydrology
Olive	Economic geology
	Mining directory
Yellow	Environmental studies
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Dk. Orange	Bibliographies and lists of publications
Brown	Petroleum and natural gas
Black	Field trip guidebooks
Dk. Brown	Collections of papers

Colors have been selected at random, and will be augmented as new subjects are published.

Editor: Melynda Lewis

PLATE NO. 1
(FIGURE 8)
SAV2-1A
SEISMIC RECORD

Line name : \SAU2\SAU2_1

Acquisition

Recording length 513 ms
Recording delay 31 ms
Shooting interval 2000 ms
Input level Line input
Analog attenuation 135
Sampling frequency 4000 Hz
Synchronization INT

Processing

FILTERS

High pass filter 4 Hz
Low pass filter 640 Hz

AGC

Lang. Monitor
(Up : 2274 Down : 2274)

Stack

number of stacked traces : 5

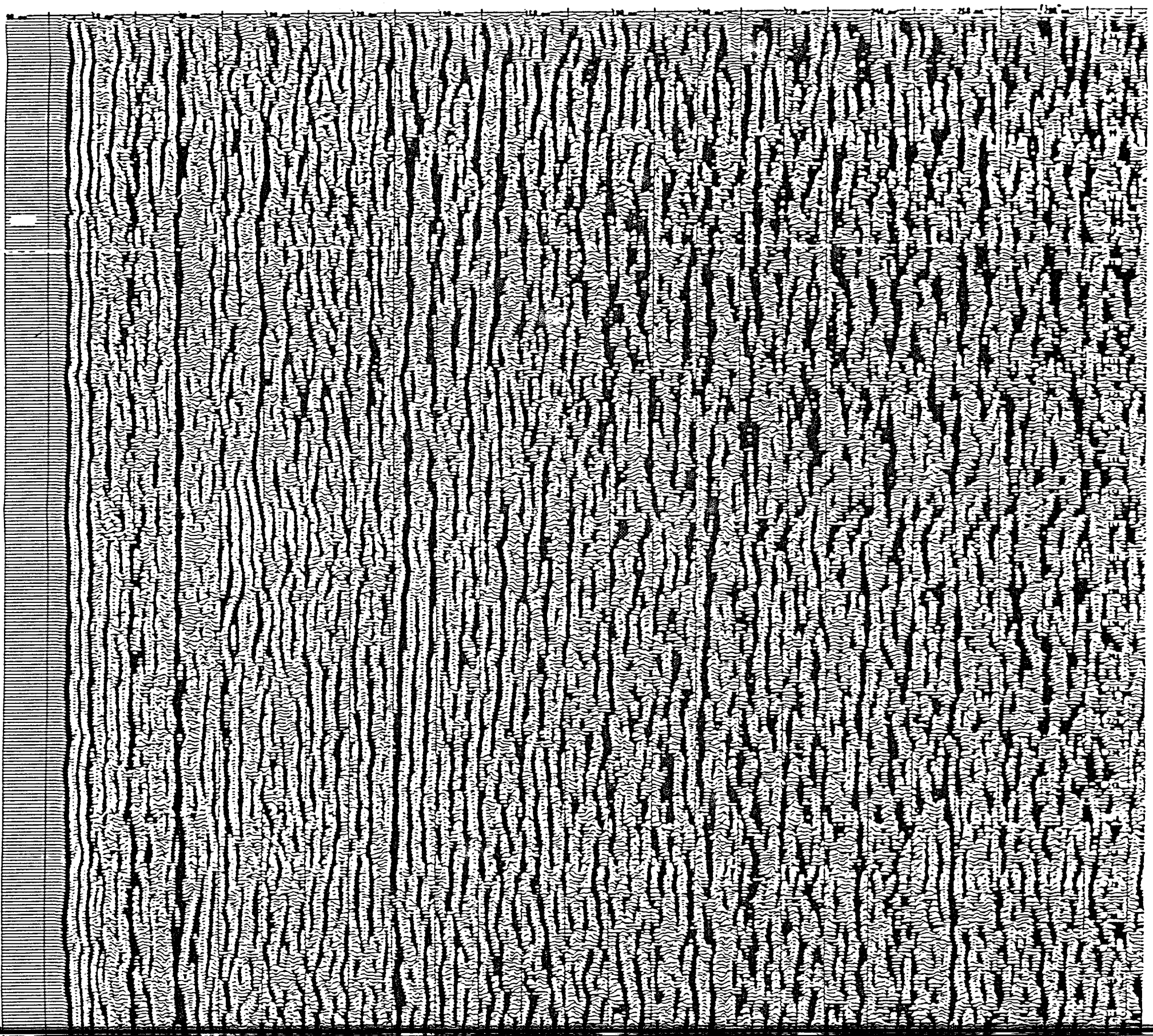
Speed filter

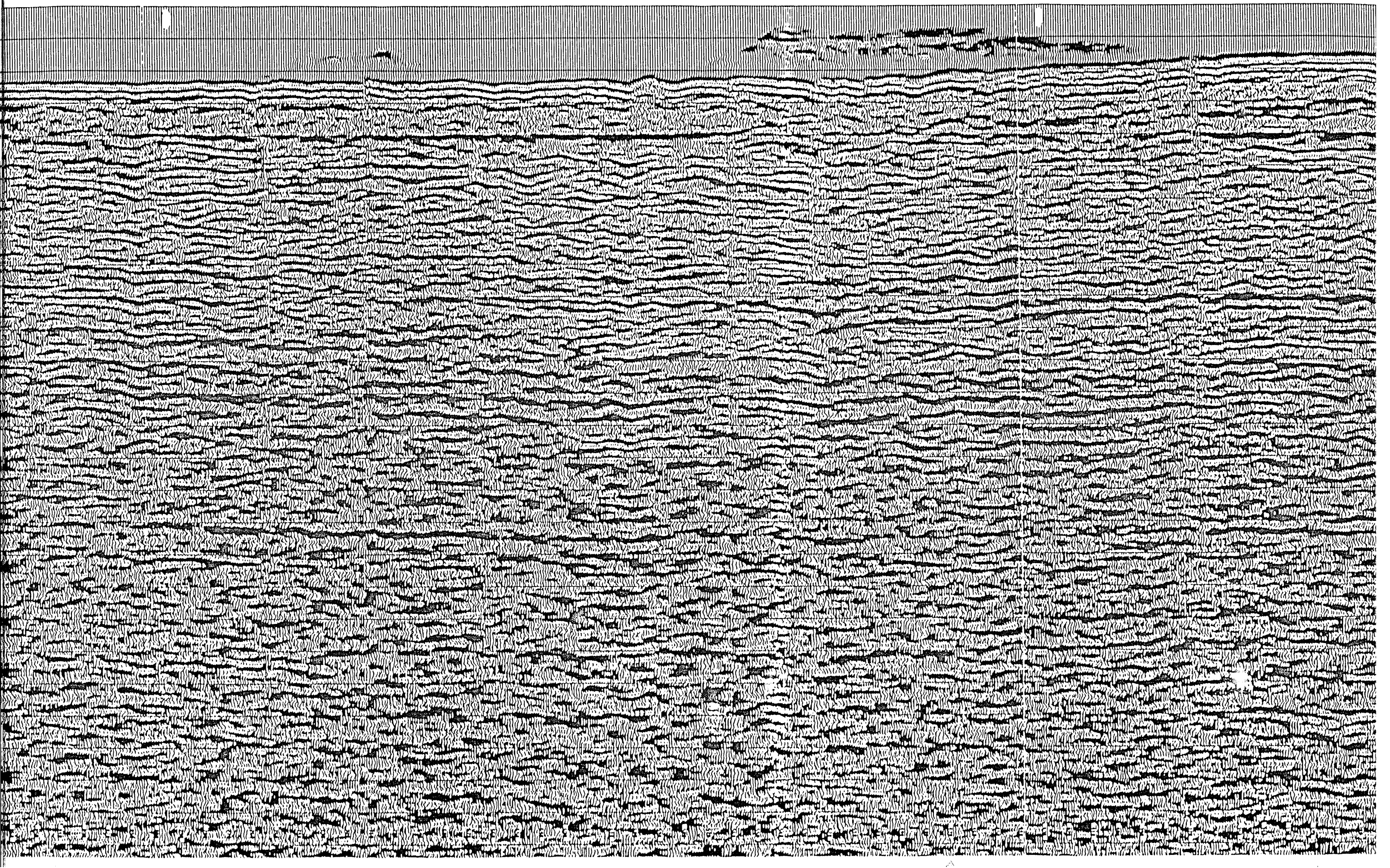
Sea bottom time 55 ms
Filter constant 1
Speed trigger 145 microsl
Trigger window 1 ms
Flat bottom Off

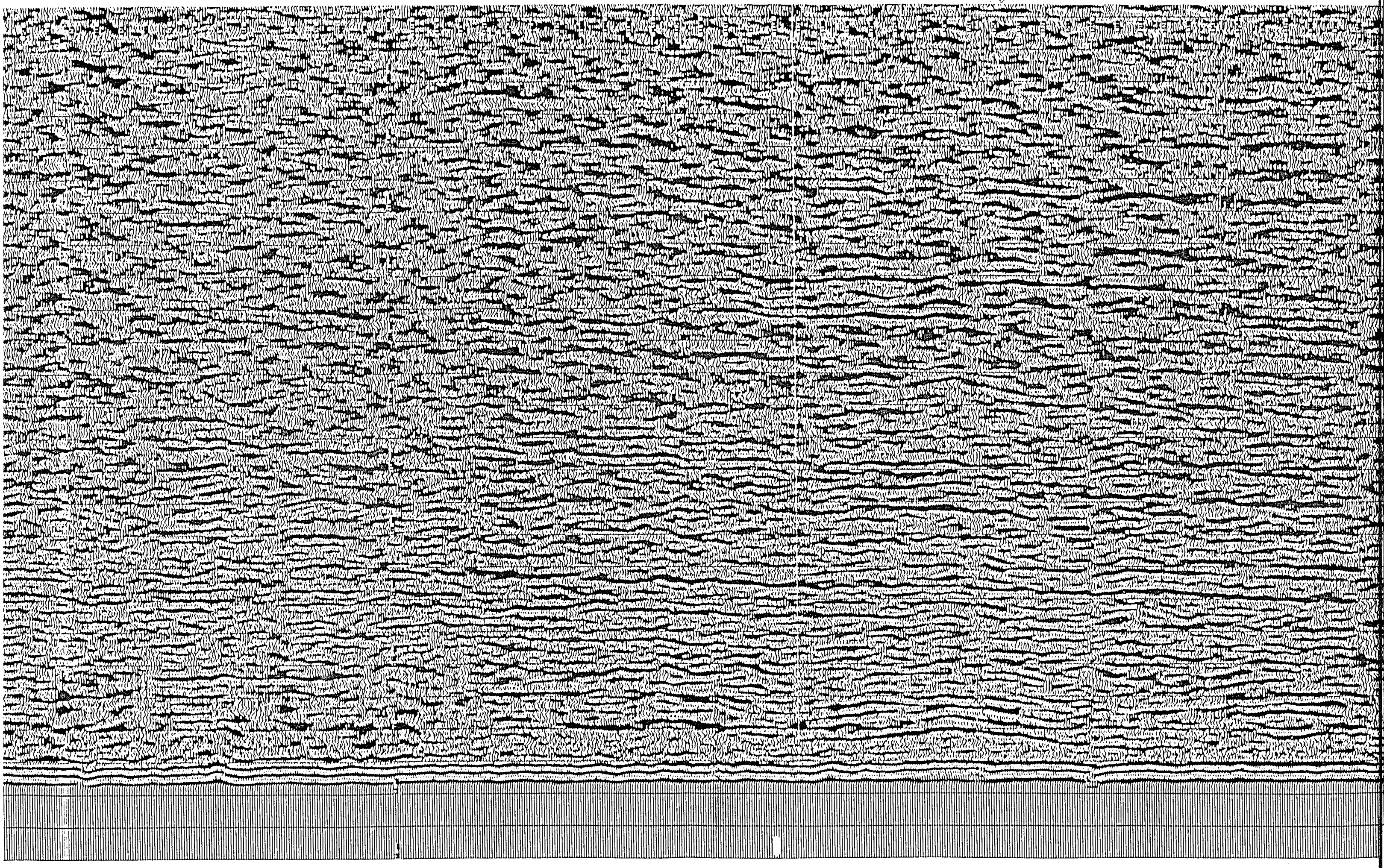
Predictive decon

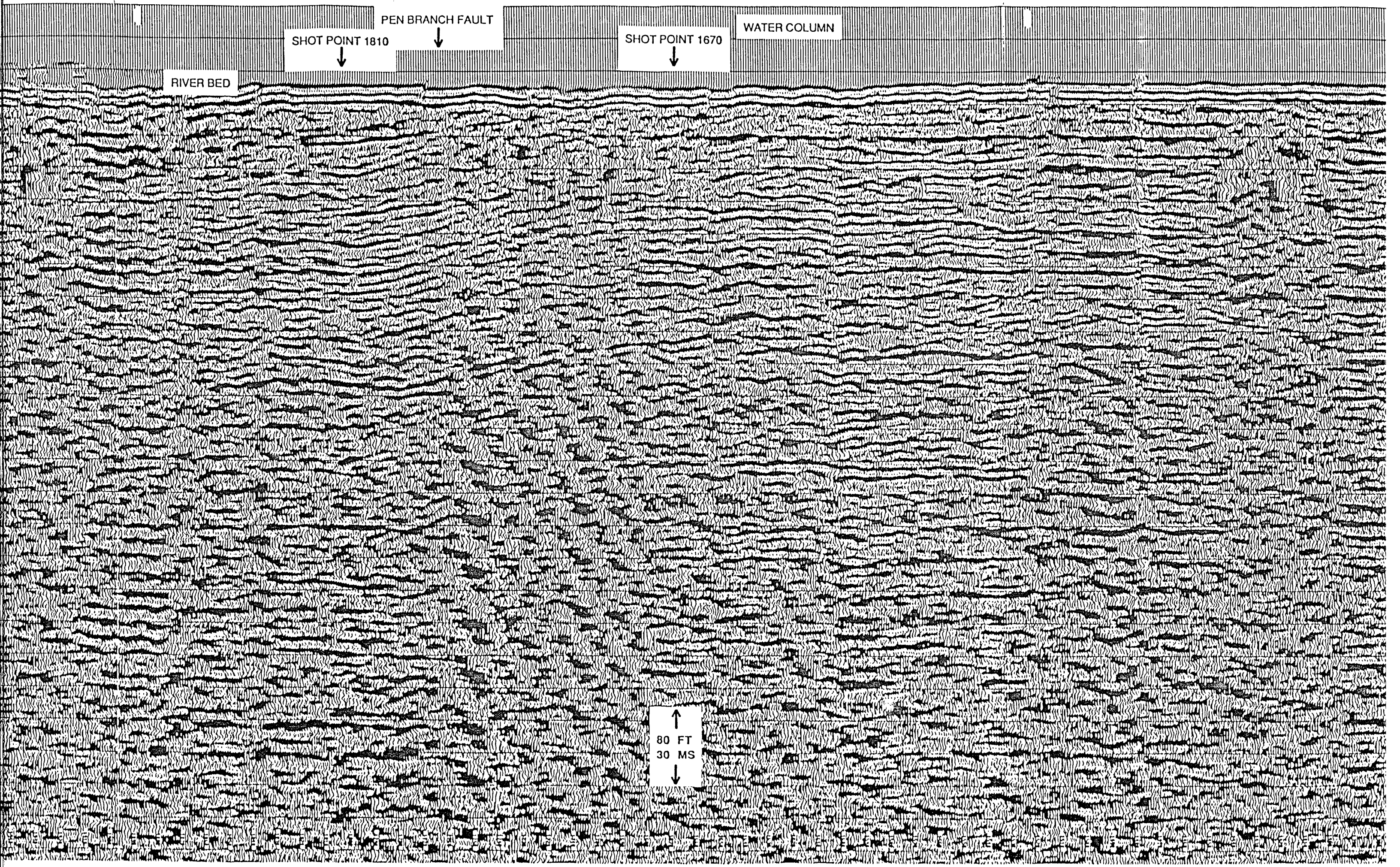
Off

Figure 8. SAV2-1A Seismic Record








PEN BRANCH FAULT
SHOT POINT 1810
SHOT POINT 1670
WATER COLUMN
RIVER BED
80 FT
30 MS

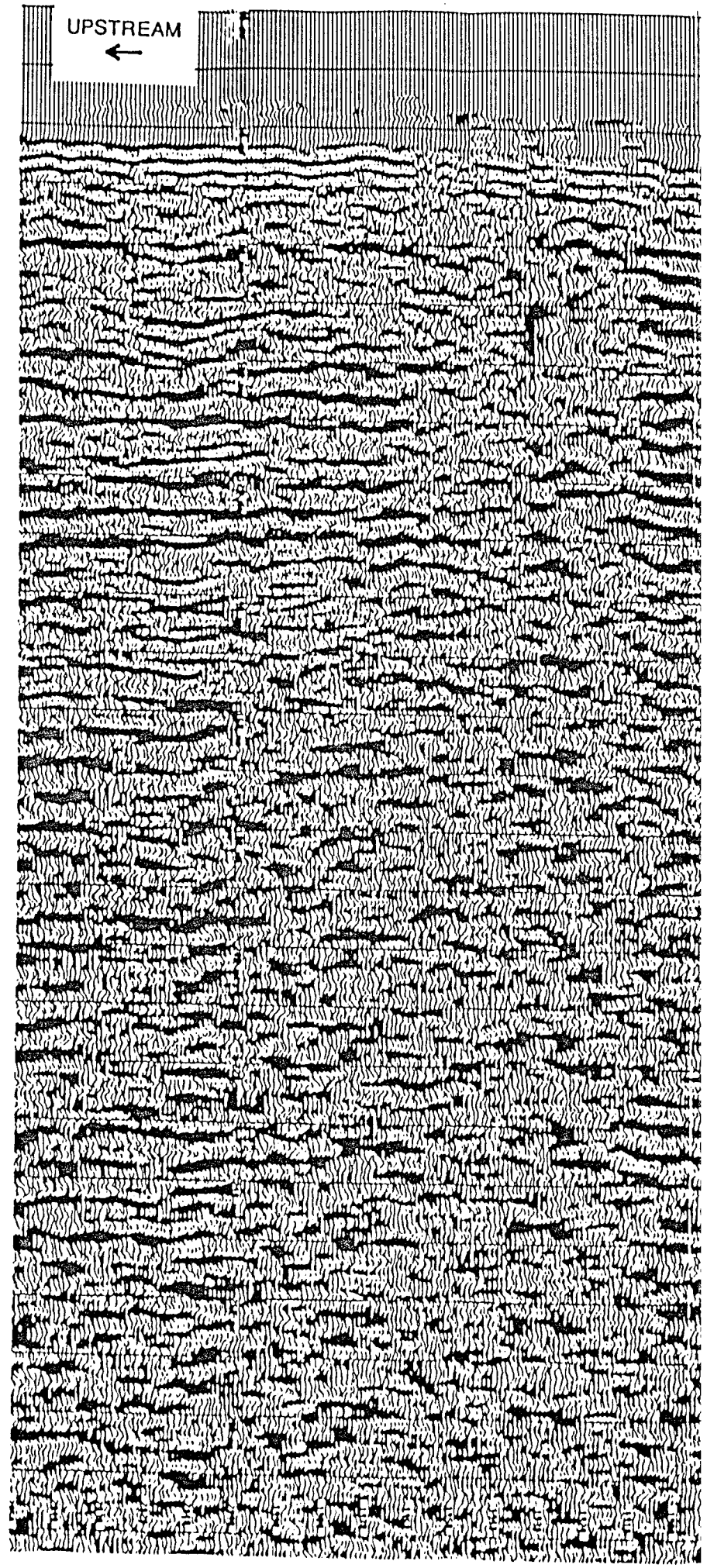

UPSTREAM

PLATE NO. 2
(FIGURE 9)
SAV2-2A
SEISMIC RECORD

Line name : \SAV2\SAV2_2

Acquisition

Recording length 513 ms
Recording delay [illegible] ms
Shooting interval 2000 ms
Input level Line input
Analog attenuation 135
Sampling frequency 4000 Hz
Synchronization INT

Processing

FILTERS

High pass filter [illegible] Hz
Low pass filter [illegible] Hz

AGC

Expo. Adaptation
(Up : 1400 Down : 1400)

Stack

stacking Off

Speed filter

Off

Predictive Decon

Off

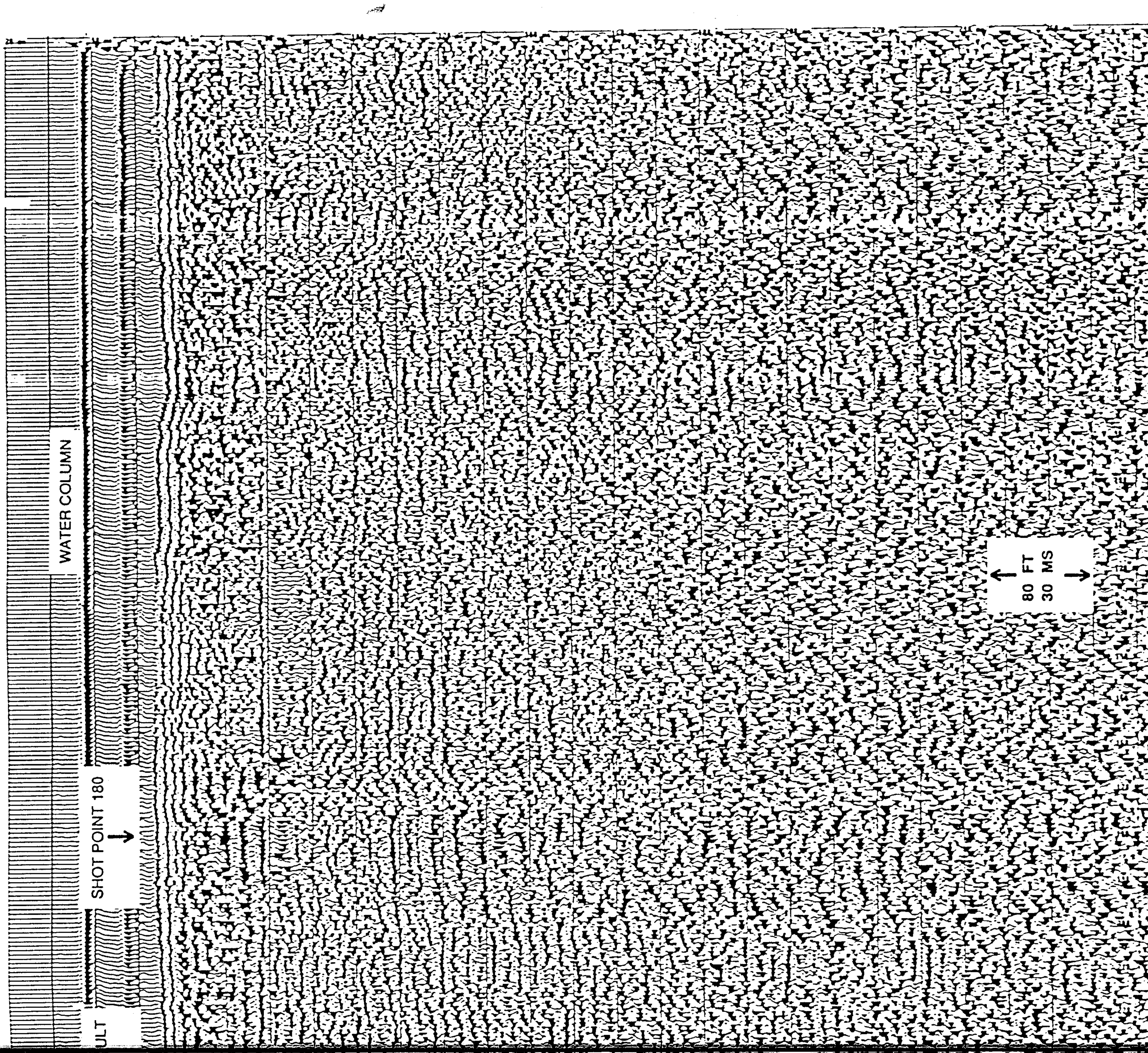
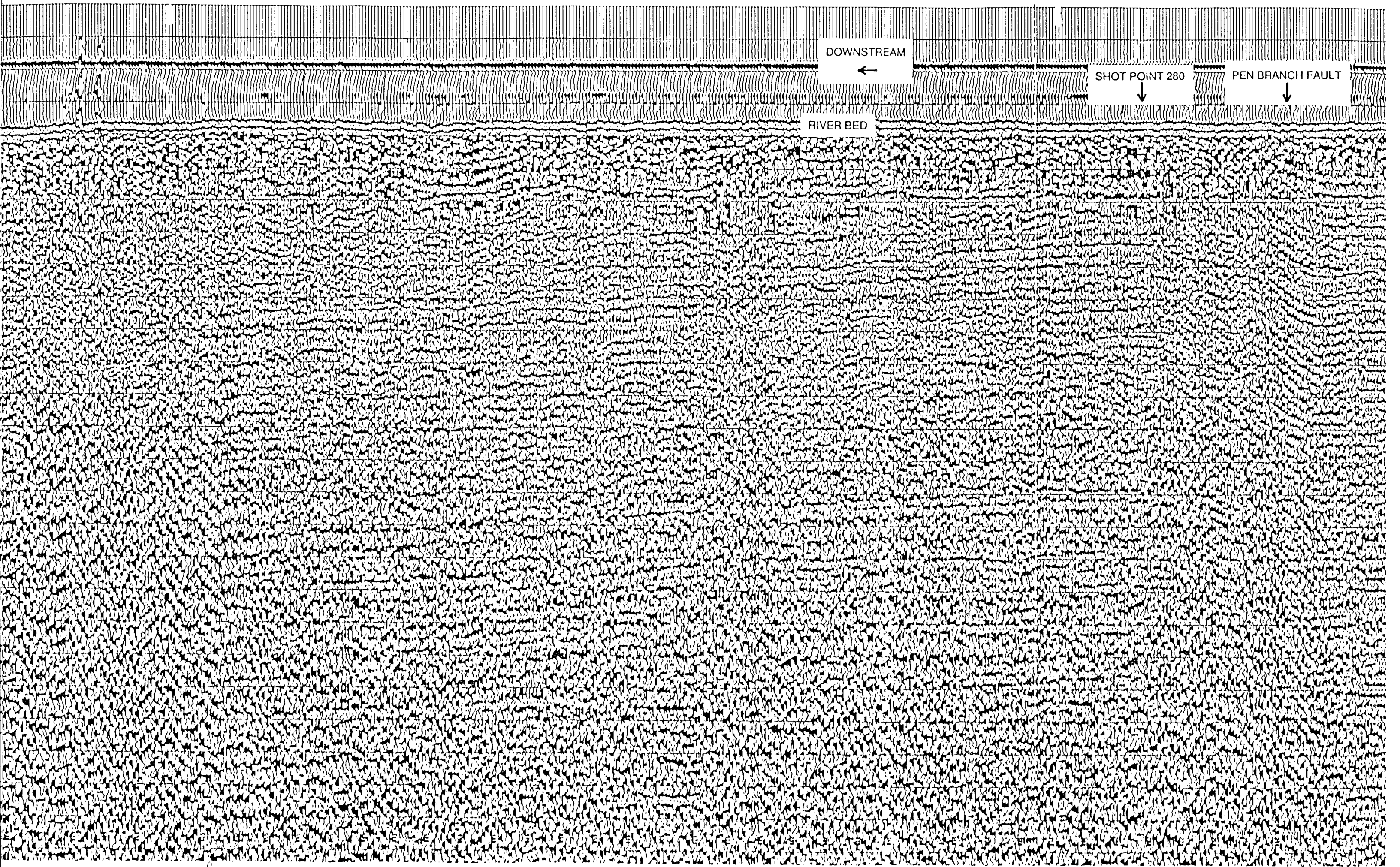
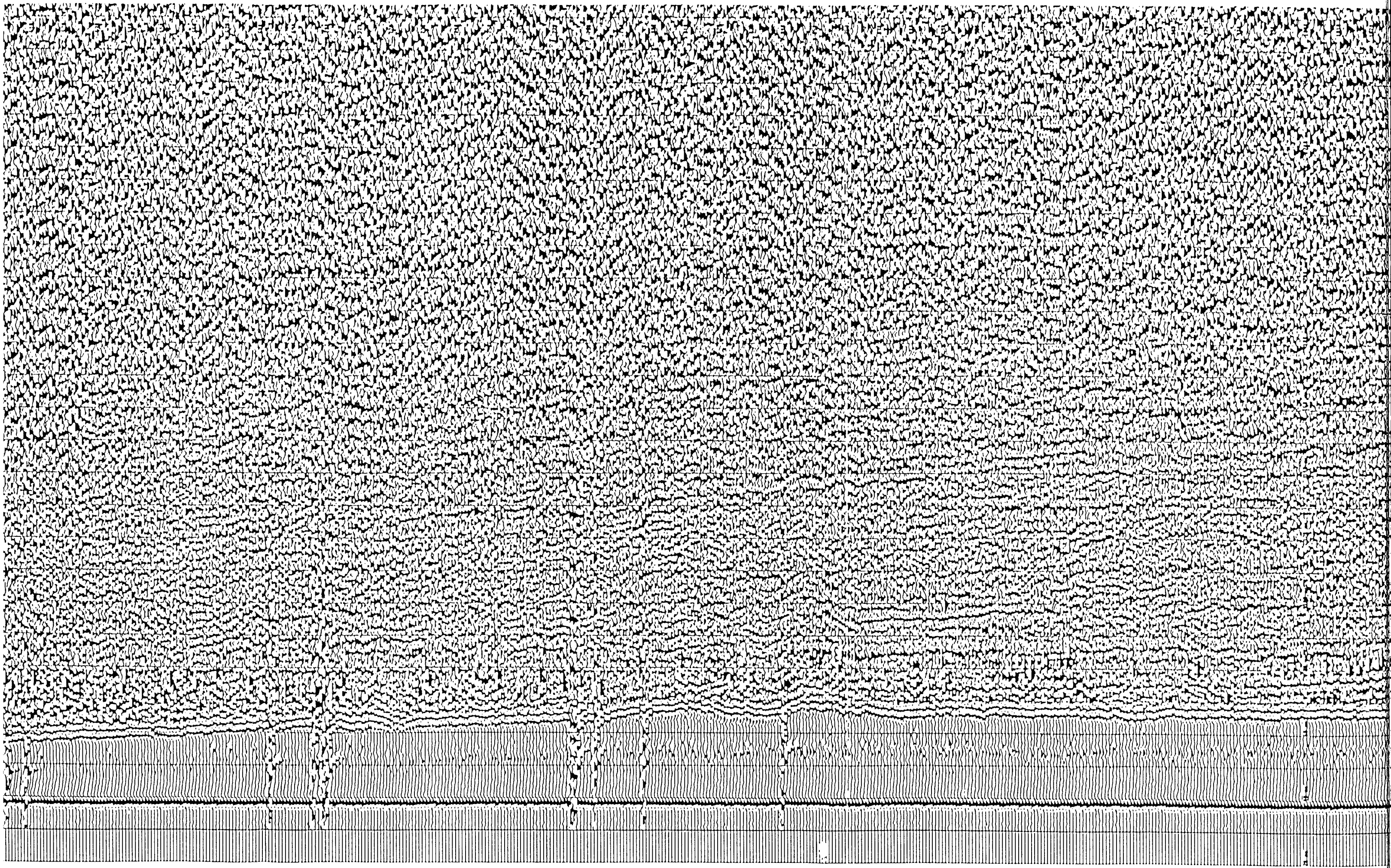


Figure 9. SAV2-2A Seismic Record


DOWNSTREAM
SHOT POINT 280
PEN BRANCH FAULT
RIVER BED



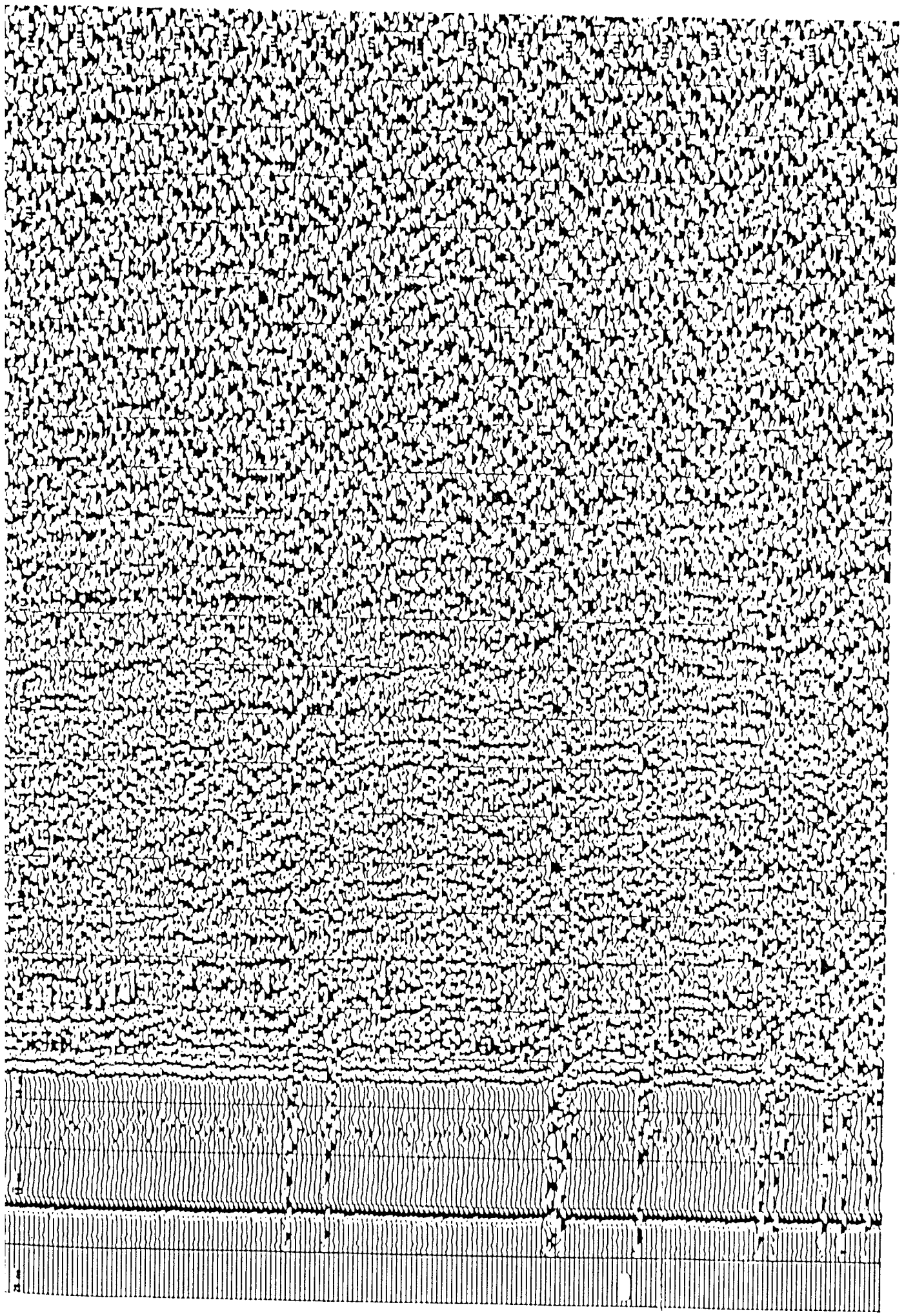


PLATE NO. 3
(FIGURE 10)
SAV2-2B
SEISMIC RECORD

Line name : \SAV2\SAV2_2

Acquisition		Processing
Recording length	513 ms	FILTERS
Recording delay	30 ms	
Shooting interval	2000 ms	High pass filter 80 Hz
Input level	Line input	Low pass filter 800 Hz
Analog attenuation	135	
Sampling frequency	4000 Hz	AGC
Synchronization	INT	
		Expo. Adaptativ
		(Up : 1400 Down : 1400)
		Stack
		number of stacked traces : 3
		Swell filter
		Off
		Predictiv Decon
		Off

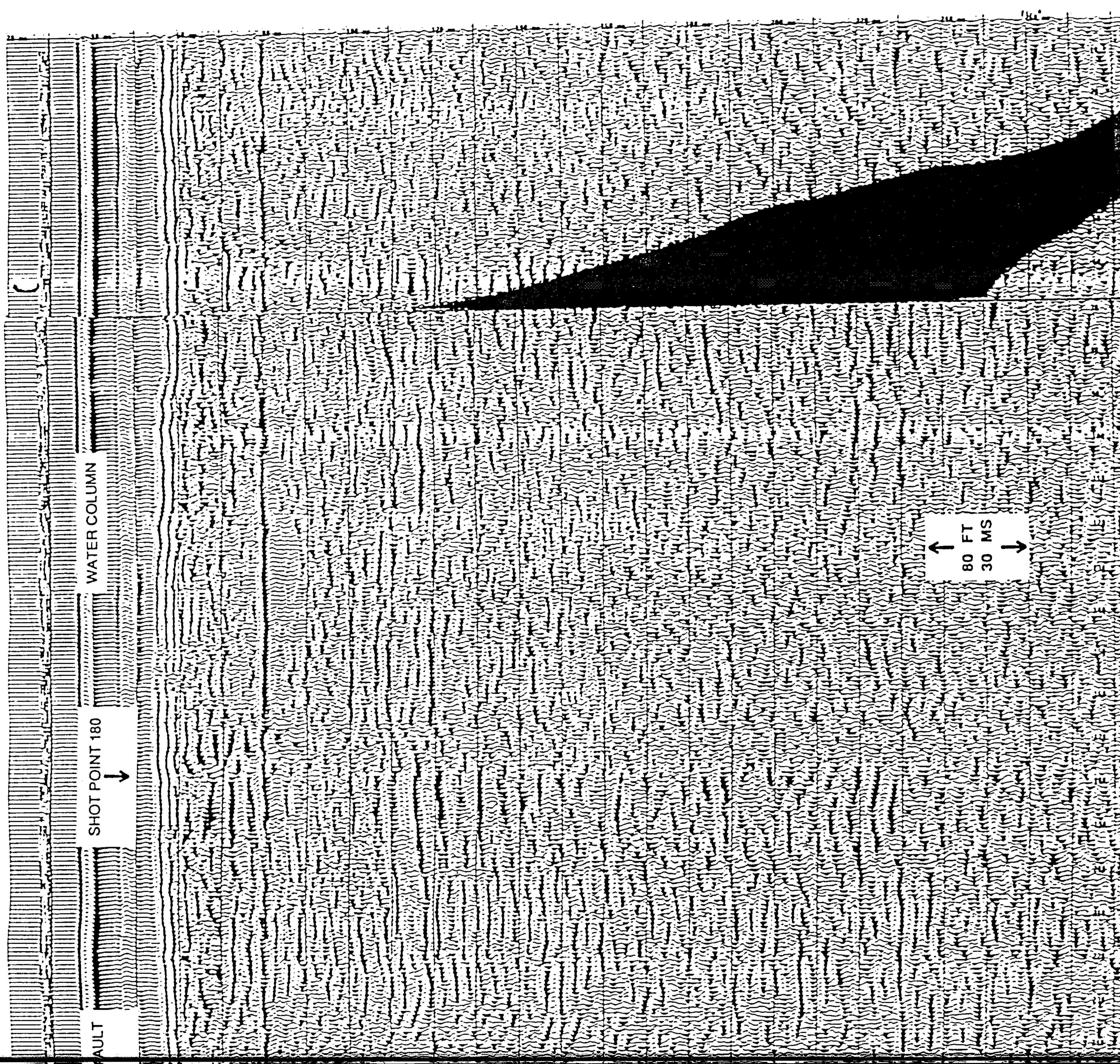
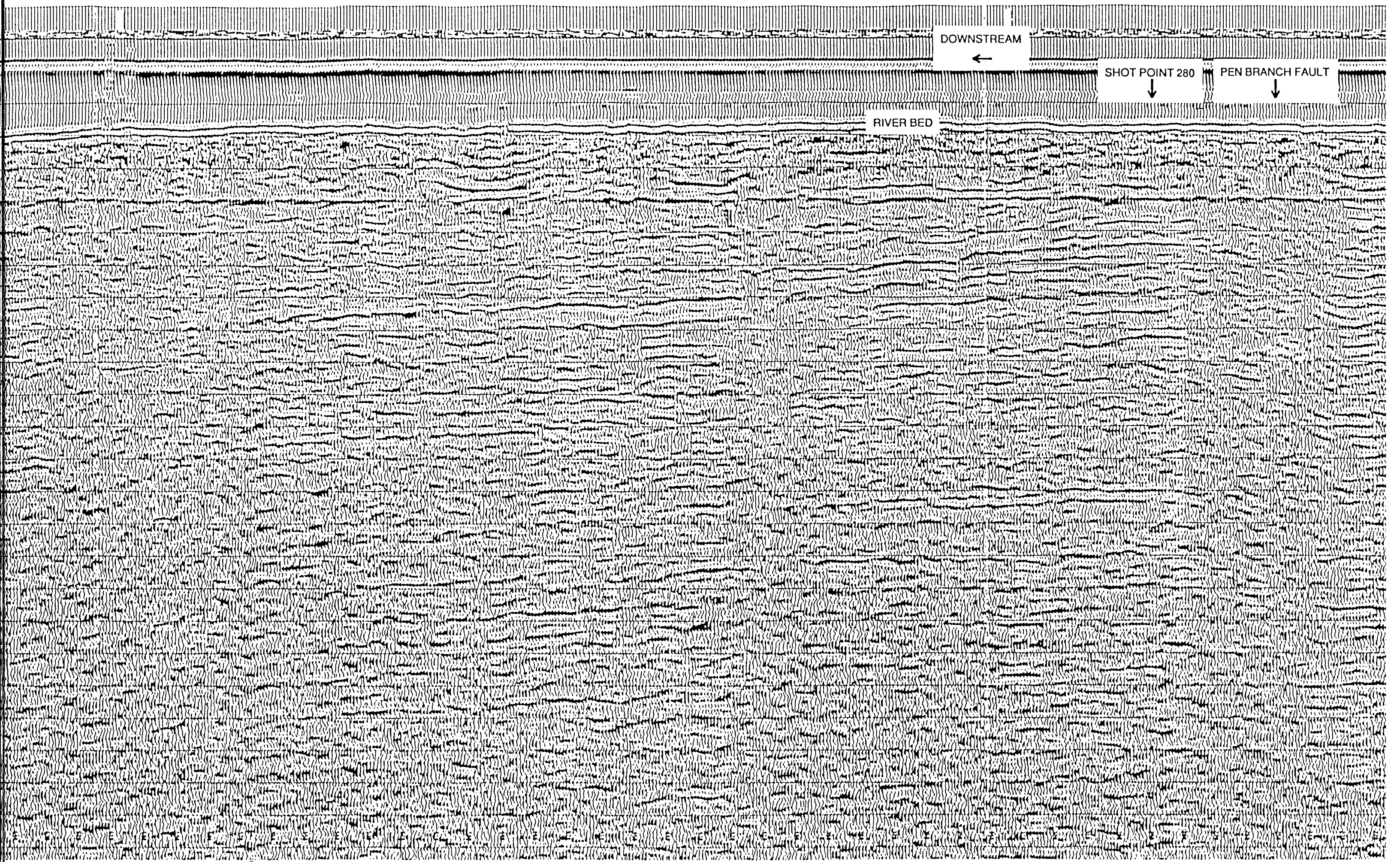


Figure 10 SAV2-2B Seismic Record


DOWNSTREAM
SHOT POINT 280
PEN BRANCH FAULT
RIVER BED