GEOLOGICAL SURVEY CIRCULAR 205

INVESTIGATIONS OF FLUVIAL SEDIMENTS OF THE NIOBRARA RIVER NEAR VALENTINE, NEBRASKA

By B. R. Colby, D. Q. Matejka, and D. W. Hubbell

UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

GEOLOGICAL SURVEY CIRCULAR 205

INVESTIGATIONS OF FLUVIAL SEDIMENTS OF THE NIOBRARA RIVER NEAR VALENTINE, NEBRASKA

By B. R. Colby, D. Q. Matejka, and D. W. Hubbell

Prepared as part of a program
of the Department of the Interior for
development of the Missouri River Basin

Washington, D. C., 1953

Free on application to the Geological Survey, Washington 25, D. C.

CONTENTS

ILLUSTRATIONS

TABLES

INVESTIGATIONS OF FLUVIAL SEDIMENTS OF THE NIOBRARA RIVER NEAR VALENTINE, NEBRASKA

ABSTRACT

This report contains results of observations that were made from the time when a natural constriction was formed in the Niobrara River near Valentine, Nebr., to the time when it was widened by high flows. After the constriction was widened, insufficient turbulence was developed to suspend most of the sediment. The report gives information on the amount and characteristics of the sediment that moves as unmeasured load at normal sections of the stream near the constriction and at the measuring sections at the Sparks gaging station.

Lateral distributions of depth, velocity, and concentration are shown for the sections where sediment discharge was measured. In addition, vertical distributions of concentration, velocity, and percentage of particles coarser than 0.25 mm are shown for the contracted section. The vertical distributions seem to indicate that the total sediment load of the stream was usually in suspension at the contracted section. Exclusive of the period during the winter when upstream reservoirs were not flushed, the measured discharge of suspended sediment at the normal sections near the contraction averaged 47 percent and at the Sparks gaging station 41 percent of the measured sediment discharge at the contracted section.

Particle sizes of suspended sediment and bed material are tabulated, and some size distributions are plotted. In conformity with bed-load theory, the computed particle sizes of the unmeasured load were slightly smaller than the average particle sizes in the samples of bed material.

INTRODUCTION

An investigation of sediment transport within a reach of the Niobrara River on the Fort Niobrara National Wildlife Refuge near Valentine and Sparks, Nebr. (fig. 1), was undertaken by the U. S. Geological Survey at the request of and in cooperation with the U. S. Bureau of Reclamation. This investigation to determine water and sediment discharges in and near a contracted channel was made as a part of the Department of Interior program for the development of the Missouri River basin. The contracted channel was formed about October 1, 1950, when bank caving constricted the low and medium flows of the Niobrara River east of Valentine to a chute about 30 ft wide. (See fig. 2.) During the period November 2 to 17, measurements relating to stream flow, suspended sediment, and bed material were made in the chute, at nearby sections, and at the gaging station near Sparks. On November 17, 1950, a meeting of representatives of the Bureau of Reclamation and of the Geological Survey was held to discuss future operations of the investigation. At this meeting the scope of the field work was limited to observations at the contracted section and at the Sparks gaging station. A similar meeting was held on May 8 and 9, 1951, at which time the investigation was expanded to include again the collection of data on stream flow, suspended sediment, and bed material at the previously investigated sections near the chute. However, two of these former sections were replaced by more completely alluvial sections.

The part of the investigation carried on by the Geological Survey was under the supervision of P. C. Benedict, regional engineer, Quality of Water Branch, and R. B. Vice, hydraulic engineer. D. Q. Matejka, hydraulic engineer, was in charge of field work. C. E. Burdick, area engineer, Bureau of Reclamation, assigned engineers from the Ainsworth office to do much of the field work. Mean daily water discharges at the Sparks gaging station for the 1951 water year were furnished by the Lincoln district office of the Surface Water Branch, D. D. Lewis, district engineer.

The field work included determinations of water and sediment discharges and the collection of samples of suspended sediment and bed material for particle-size analysis. Vertical and lateral distributions of velocity, concentration, and particle size were defined for the contracted section, five normal sections near the contraction, and two sections at the Sparks gaging station. Velocities and vertical distributions in the chute indicated that most, if not all, of the sediment load of the river was in suspension. Also, data from field measurements provided information as to the amount of sediment that is discharged as unmeasured load at normal sections near the chute. Indirectly they helped in computing the rate of sediment discharge as unmeasured load at the gaging station near Sparks, about 6 miles downstream, where daily discharges of suspended sediment were determined from May 1947 to January 1951.

This report contains a summary of the information that was obtained from November 2, 1950, to July 17, 1951. High flow on July 29

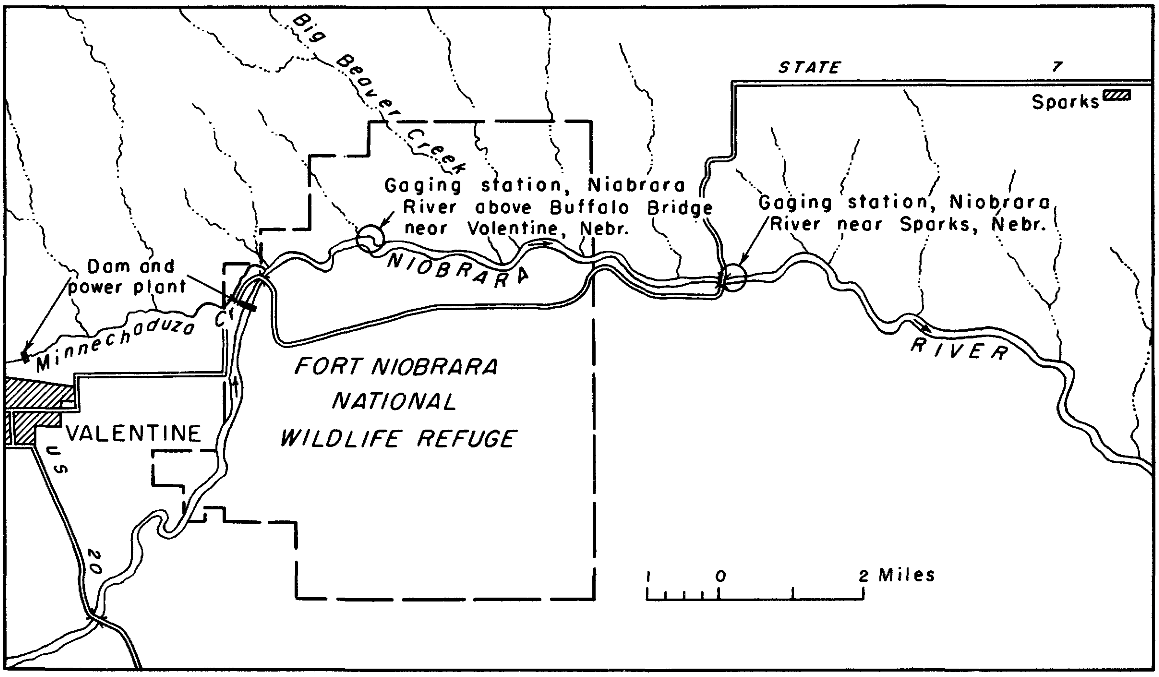

Figure 1.--Sketch map of the Niobrara River near Valentine and Sparks, Nebr.

widened the constriction to the extent that velocities and turbulence were not nearly sufficient to suspend the total sediment load. The final field data were collected on July 17.

In this report suspended sediment is that part of the sediment load of a stream that can be collected in a depth-integrating sediment sampler. Suspended-sediment discharge or suspended-sediment load is the sediment discharge that can be computed from water discharge and the concentration from depth-integrated sediment samples. The unmeasured load is the difference between the total sediment load of a stream and the suspended-sediment load.

RIVER CHANNEL

The channel of the Niobrara River in the Fort Niobrara National Wildlife Refuge averages about 150 ft in width. Most of the stream bed is composed of shifting sand, but in places the bed is scoured down to shale or firm clay. The channel banks are generally low and partly covered with brush except for an occasional place where the river flows at the base of a steep bank of Brule clay. The slope of the channel is about 8 ft per mile; the measured slopes downstream near the Sparks gaging station averaged 7.5 ft per mile.

A small power dam about 2½ miles upstream from the contraction forms a pool in which sediment is trapped. (See fig. 1.) During the summer this pool is flushed periodically to remove part of the accumulated sediment. A small power dam on Minnechaduza Creek about 6 miles upstream from the contraction forms another small pool that is also flushed occasionally. The flushing of these pools probably causes alternate fill and scour of the channel for several miles below the dams.

MEASURING SECTIONS

Contracted Section

Before the contracted section was formed, the channel was probably 100 to 150 ft wide. Immediately after, it was constricted to a width of about 30 ft for a distance of about 100 ft along the channel (fig. 3). A footbridge was built by the Bureau of Reclamation near the downstream end of the contracted channel, where the flow was swift and turbulent (fig. 4). The downstream side of the footbridge was the section, called section B, at which measurements were made to determine total sediment discharge of the river. Sampling stations were measured from the right bank. Mean velocities measured at section B during the period November through January ranged from 3.28 fps at a discharge of 237 cfs to 8.77 fps at a discharge of 1,140 cfs. Standing waves, high velocities, and an uneven stream bed were factors that limited the accuracy of measurements of stream flow at this section. During the early part of February, ice dislodged the footbridge and widened the constriction to about 40 ft. A second footbridge was constructed in April by personnel of the Bureau of Reclamation. It spanned the constriction at the original site; however, the bridge stationing was shifted 12 ft to the right so that station 0 would be over the right bank. After the channel was widened, measured velocities ranged from 6.00 fps at 990 cfs to 6.94 fps at 1,040 cfs. Standing waves, high velocities, and an uneven stream bed continued to limit the accuracy of streamflow measurements at the section.

On July 29, 1951, a flood collapsed the footbridge and further widened the constriction to about 75 ft. Resulting lower velocities and turbulence were sufficient to suspend

Errata -- Circular 205

Credit to the U. S. Bureau of Reclamation for figure 2 on page 3 was inadvertently omitted. The title for figure 2 on page 3 should read as follows:

Figure 2.--Looking upstream toward the contraction of the Niobrara River formed by bank caving (Photograph courtesy of U. S. Bureau of Reclamation).

Figure 2.--Looking upstream toward the contraction of the Niobrara River formed by bank caving.

Figure 3.--Looking downstream from the upper end of the contracted channel.

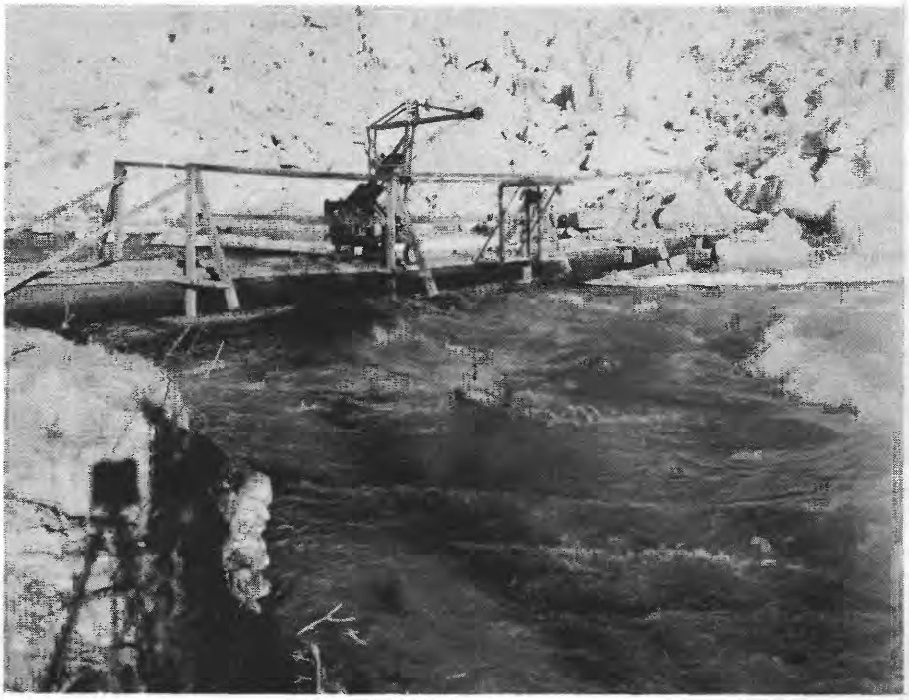

Figure 4.--Footbridge where samples were taken to determine total sediment discharge of the river--section B.

only a part of the sediment load that was unmeasured at the normal sections.

The locations of the contracted section, the five normal sections, and the staff gage in the reach of the Niobrara River near Valentine are shown in figure 5.

Normal Sections

Section A is the farthest upstream of any of the measuring sections. At this section the water surface is about 140 ft wide, and the stream bed is composed of shifting sand. Section A is about a quarter of a mile upstream from section B and is reasonably representative of this reach of the river channel; however, it is in a relatively inaccessible part of the stream.

On May 8, section A was replaced by section A' (fig. 6), which is 450 ft upstream from section B. Section A' is about 150 ft wide. Its bed is composed of relatively stable sand. Low standing waves sometimes are present near the center of the stream.

Section C (fig. 7) was selected as a typical section of the channel. It is about 500 ft downstream from section B and close below Buffalo Bridge. The bottom is shifting sand except for an occasional place where more stable material is exposed. The section is about 190 ft wide.

Section D, three-quarters of a mile downstream from section B, was initially a representative section of the channel. It was about 160 ft wide and had a sandy, shifting bottom. Subsequent measurements, however, indicated that section D is not a true alluvial section because it sometimes scours to its Brule clay bed.

On May 8, section D was replaced by section D' (fig. 8), about 1,500 ft downstream from section B. Section D' is about 140 ft wide, and its bed is composed of fairly firm sand. It is considered to be a representative section of the channel.

Sections A, A', C, D', and D (fig. 5) were all selected as sections at which the ratio of suspended-sediment discharge to total sediment discharge seemed likely to be representative of the normal river channel near the contracted section. In this report these five sections are frequently referred to as normal sections to contrast them with the natural constriction, section B.

Sections at Sparks Gaging Station

The gaging station near Sparks, Nebr., is about 6 miles downstream from section B. The channel under the bridge (fig. 9) is somewhat narrower than the average width of the river. Measurements of water discharge are made from the bridge, which is a few feet upstream from the recording gage, or at low stages, by wading at wider sections downstream from the bridge. (See fig. 10.) Samples for determining the average concentration of suspended sediment at a cross section were collected at the section where the measurement of stream flow was made on the same day.

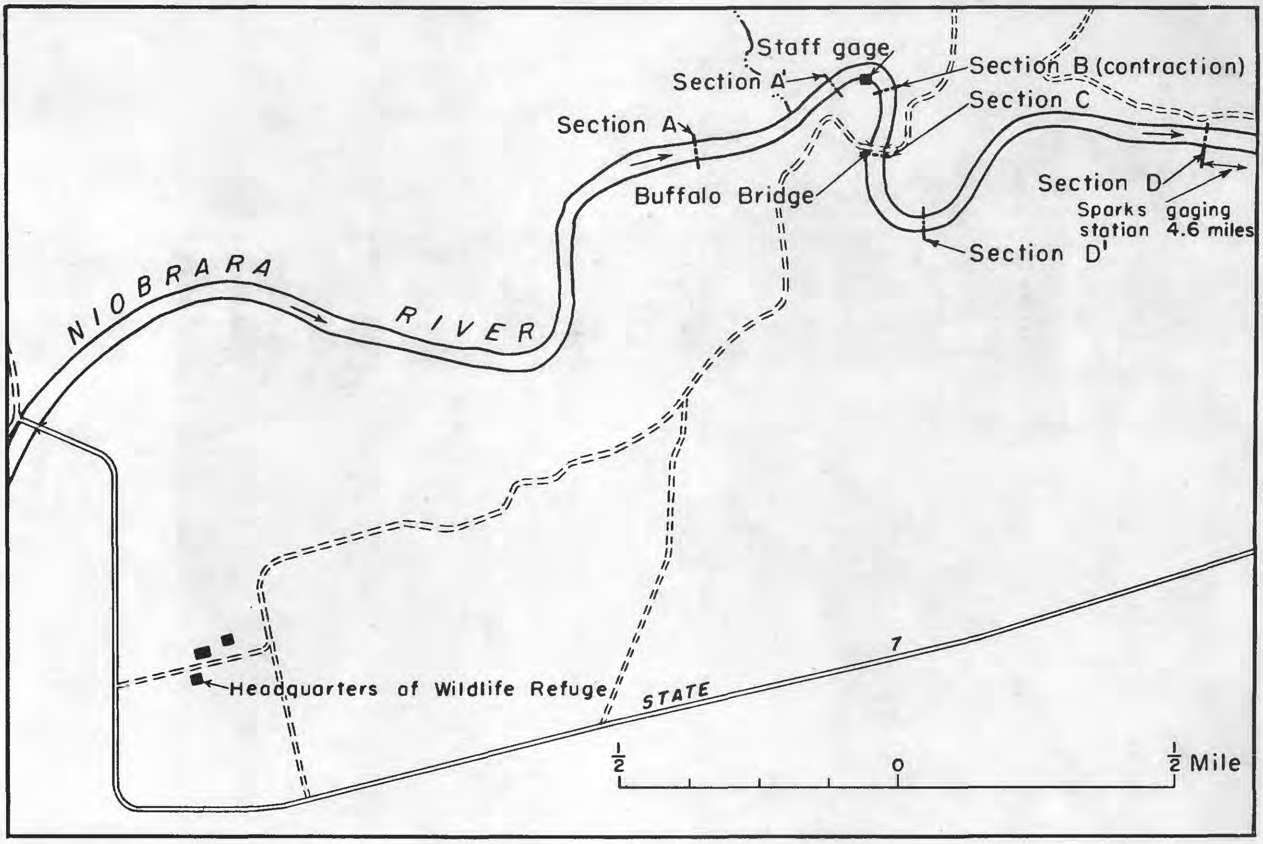

Figure 5.--Sketch map showing location of sampling sections of the Niobrara River above Buffalo Bridge, near Valentine, Nebr.

Figure 6.--View of section A' from right bank. Section extends directly across the channel.

Figure 7.--View of section C from left bank. Section is parallel to and about 40 ft downstream from Buffalo Bridge.

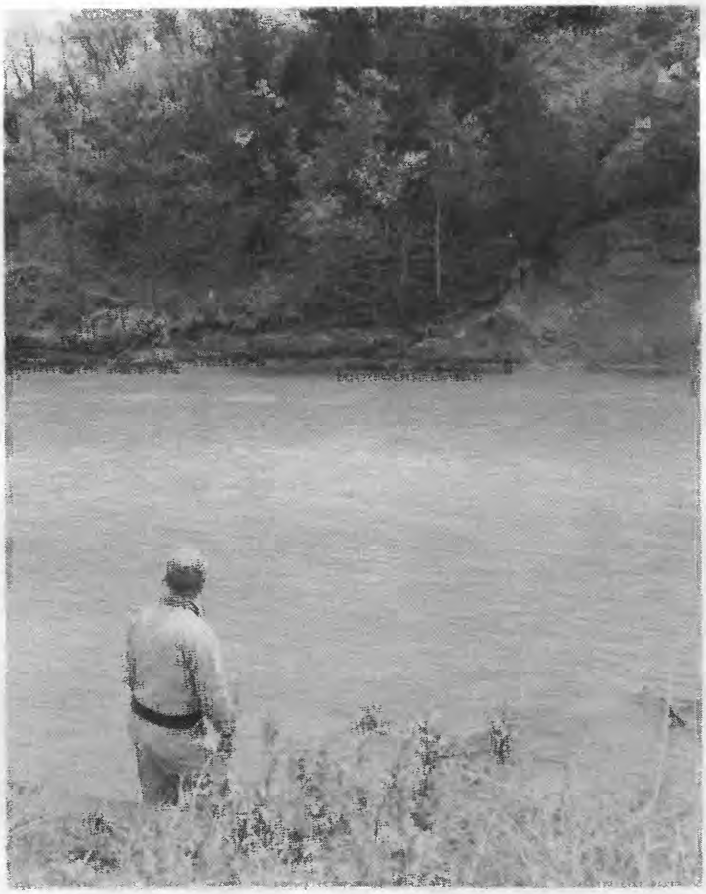

Figure 8.--View of channel at section D' from left bank.

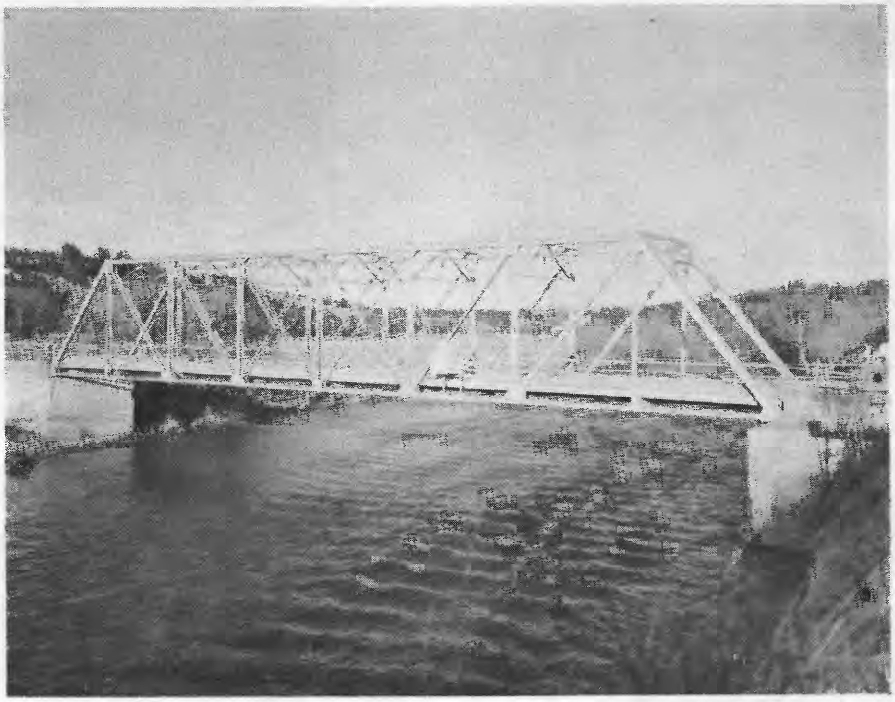

Figure 9.--View of bridge section, Sparks gaging station.

Figure 10.--View of wading sections, Sparks gaging station.

During the period of record, the numbers of determinations of suspended sediment at the different sections with each type of suspended-sediment sampler were as follows:

	Number of determinations with indicated sediment samples		
	US DH-48	US D-43 or US D-49	US P-46
Section A --------	3	----------	-------
Section A' -------	4	----------	-------
Section B --------	--------	8	a 5
Section B --------	--------	----------	b 38
Section C --------	11	----------	-------
Section D' -------	3	----------	-------
Section D --------	1	----------	-------
Sparks gaging sections -------	14	12	-------

a Point-integrated samples.
b Depth-integrated samples.

Usually the water discharge was measured on each day when samples were collected. All the stream-flow measurements are summarized in tables 1 and 2. Tables 3 to 5 show results of the sediment discharge measurements. Gage heights for measurements at all sections near Valentine were read on a staff gage that was installed on November 8 about 220 ft upstream from section B.

Figures 11 to 24 show the lateral distributions of depth, velocity, and concentration of suspended sediment at each section and the changes in the lateral distribution with time. Because the lateral distribution at section B for a given water discharge (figs. 13 to 15) changed slowly with time, the results were not plotted for all measurements. The velocity distribution changed considerably with changes in flow of the river. Scour of the bottom and sides of the channel was too slow to be detected by observation or by the measurements at section B.

The general hydraulic characteristics of sections A, A', C, D', and D are similar (figs. 11, 12, and 16 to 20), but both sections A and C shift considerably from time to time. At the Sparks gage the bridge section and the wading sections are more stable and seem to change less with time than do sections A and C. The channel at section A' is more stable than at any of the other sections where measurements were made.

A comparison between the suspended-sediment concentrations at section B and at all other sections is shown in table 6. Concentrations at the normal and Sparks sections, taken from tables 4 and 5, are listed along with observed concentrations at section B, taken from table 3, and also estimated concentrations at section B. These estimated concentrations at section B were computed from the observed concentrations and gage-height records. An allowance for the time of travel was made so that they would be comparable to measured suspended-sediment concentrations at the other sections.

An average of concentrations at each of the normal and Sparks sections, expressed as a percentage of the estimated concentrations at section B, is given in table 7. The percentages, within the limits of accuracy of the data, are also the percentages of the total sediment discharge that are in suspension if the following assumptions are correct:

1. For the given times, the stream flow at the uncontracted section was the same as at section B.
2. For the given times, the total sediment discharge at the uncontracted section was the same as at section B.

Actually, the assumption of equal flow at each section is substantially correct although the flow at the Sparks gage probably averages a few percent greater than at the other sections (table 8). The assumption of equal total sediment discharge is not always even approximately correct when section B and the sections at the Sparks gage are compared. Eight determinations of suspended-sediment concentrations during winter months indicate a greater suspended-sediment discharge at the Sparks station than total sediment discharge at section B. Evidently the channel between section B and the Sparks gage was degrading during this period. Probably total sediment discharge does not vary greatly between section B and any one of the normal sections near section B.

Twenty-one determinations of suspended-sediment concentration at the normal sections near section B ranged from 29 to 88 percent and averaged 47 percent of the concentration at section B at comparable times. Thus the discharge of sediment as unmeasured load at sections A, A', C, D', and D is about equal to the discharge of suspended sediment for the period when these concentrations were determined.

Six determinations of the ratio of suspended-sediment discharge at the gaging station near Sparks to the suspended-sediment discharge at section B, about 6 miles upstream, averaged 0.41 to 1 in the periods November 2 to 17, 1950, and May 8 to July 17, 1951. During the winter period, November 18, 1950, to May 7, 1951, this ratio was about 1.4 to 1. In general, the ratio increased with time within this winter period. The high ratios during the winter were due to low concentrations at the contracted section. These low concentrations were probably caused by entrapment of sediment in the upstream reservoirs after periodic flushing was discontinued. The recorder chart from the Sparks gage indicates that the last flushing of the reservoir on the Niobrara River near Valentine during the fall of 1950 was on November 18. It is also possible, but not likely, that the high ratios during the winter resulted from the seasonal effect of ice formation.

The assumption that the high ratios during the winter were caused by sediment entrapment in the reservoirs seems to be logical because the relatively clear water leaving the reservoirs would immediately begin to degrade the alluvial channel. Probably the most extensive degradation would at first occur directly below the dams. Because the supply of sediment in the channel immediately below the dams would not be replenished at a normal rate after November 18 when flushing operations ceased, scour could be expected in the river reach between the constricted section and the Sparks gage during most of the period until flushing is resumed. Scour between section B and the Sparks gage could cause the high ratio of concentration at the Sparks gage to

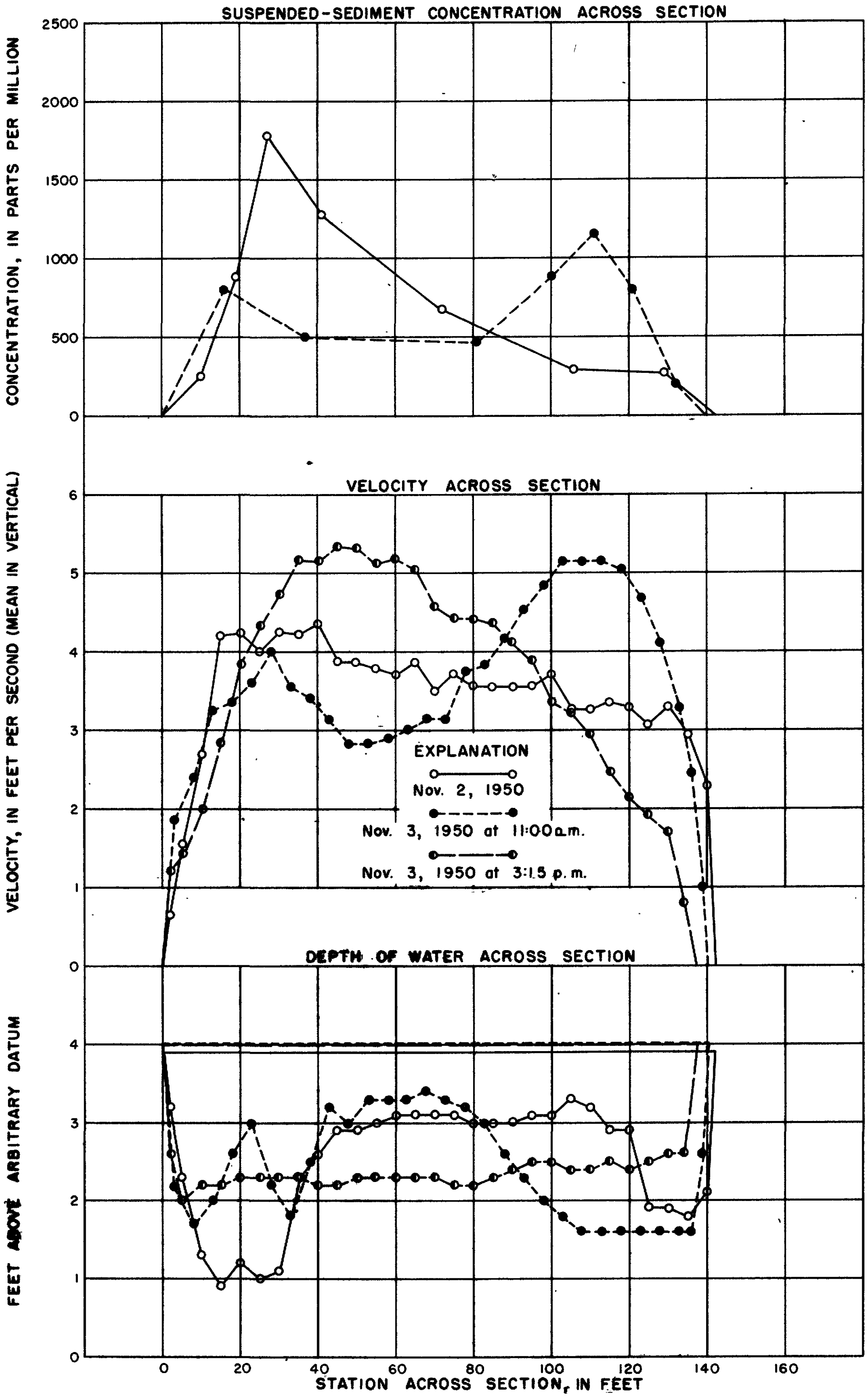

Figure 11.--Lateral distribution of depth, velocity, and concentration of suspended sediment, section A, Niobrara River near Valentine.

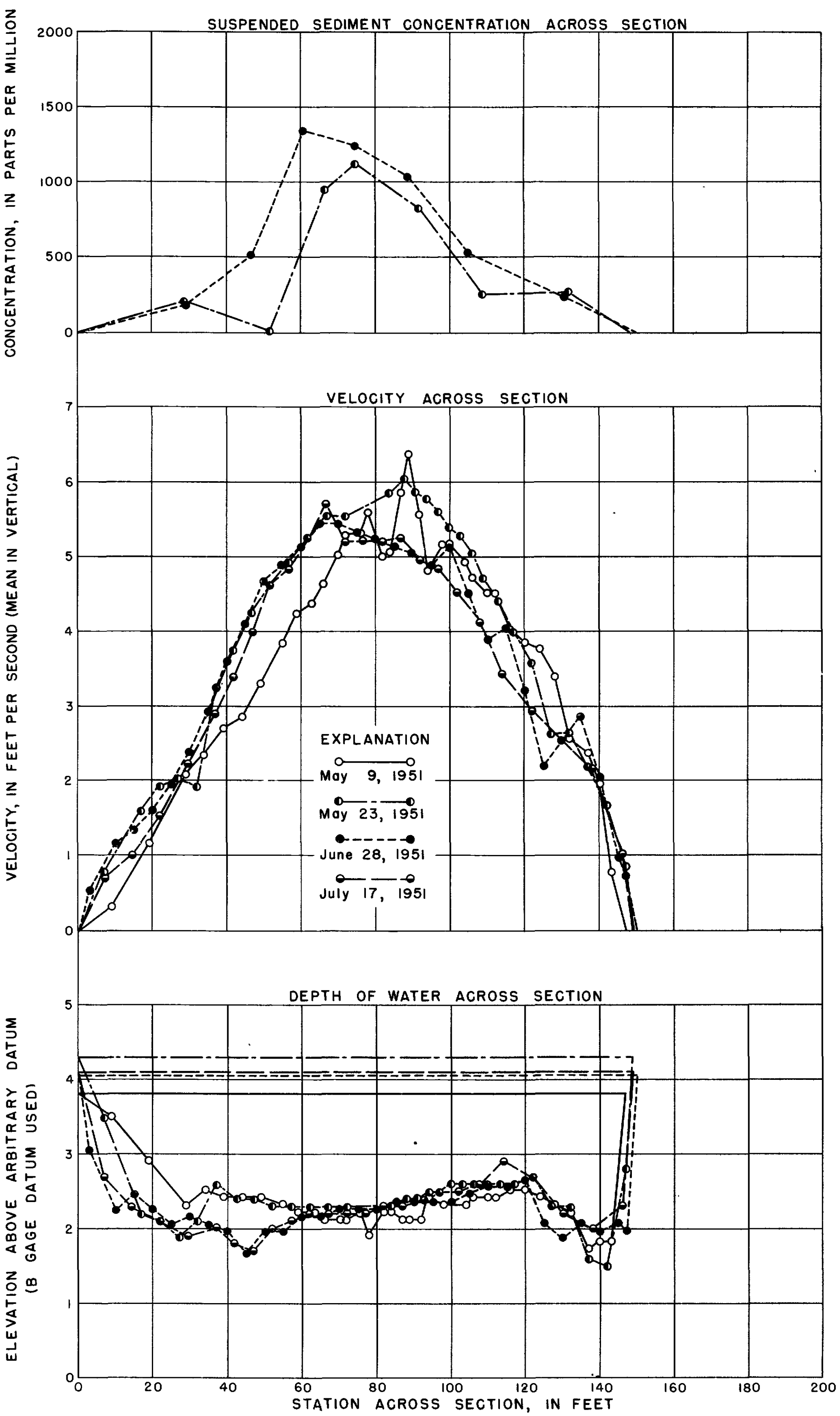

Figure 12.--Lateral distribution of depth, velocity, and concentration of suspended sediment, section A', Niobrara River near Valentine.

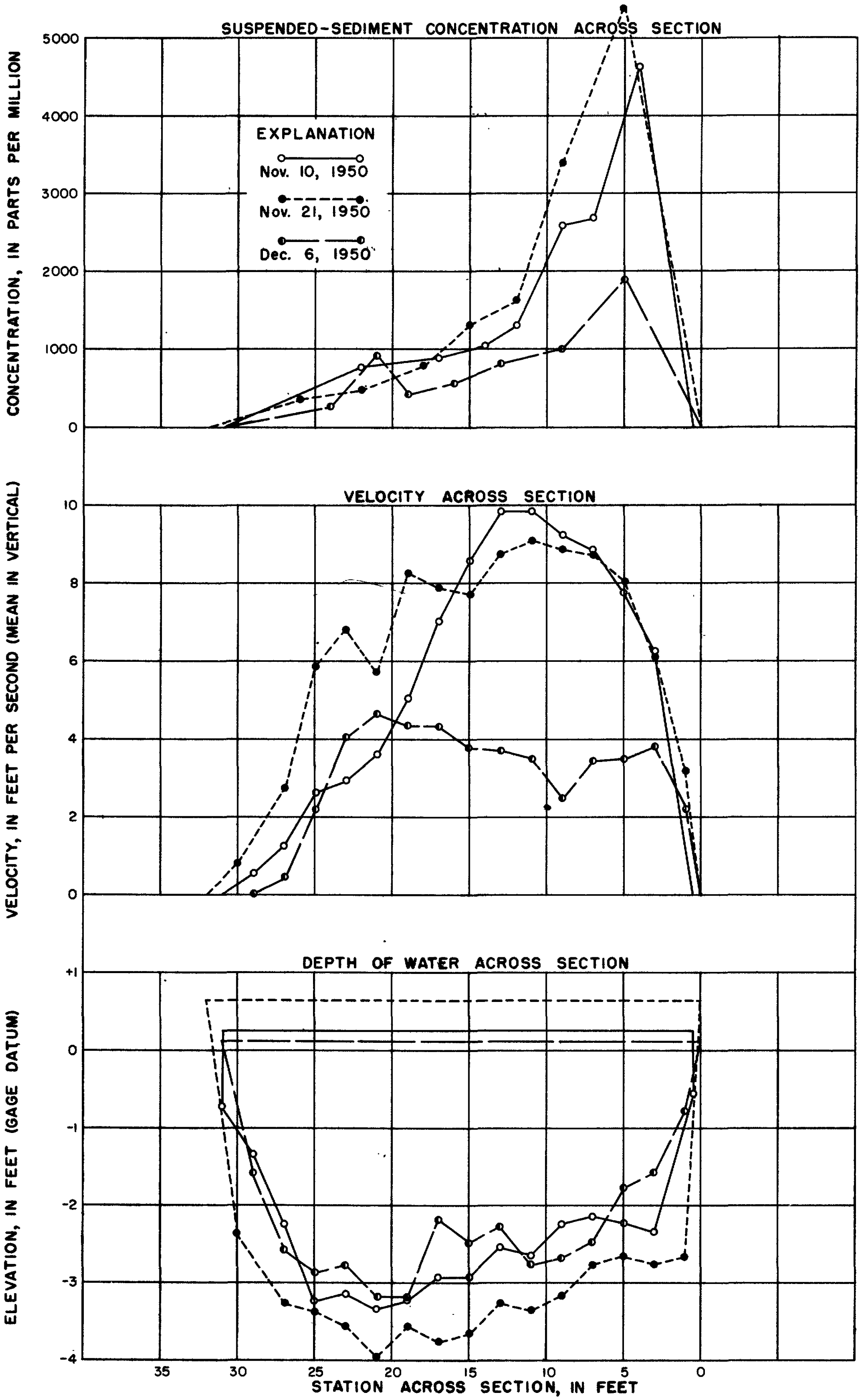

Figure 13.--Lateral distribution of depth, velocity, and concentration of suspended sediment, section B, Niobrara River near Valentine.

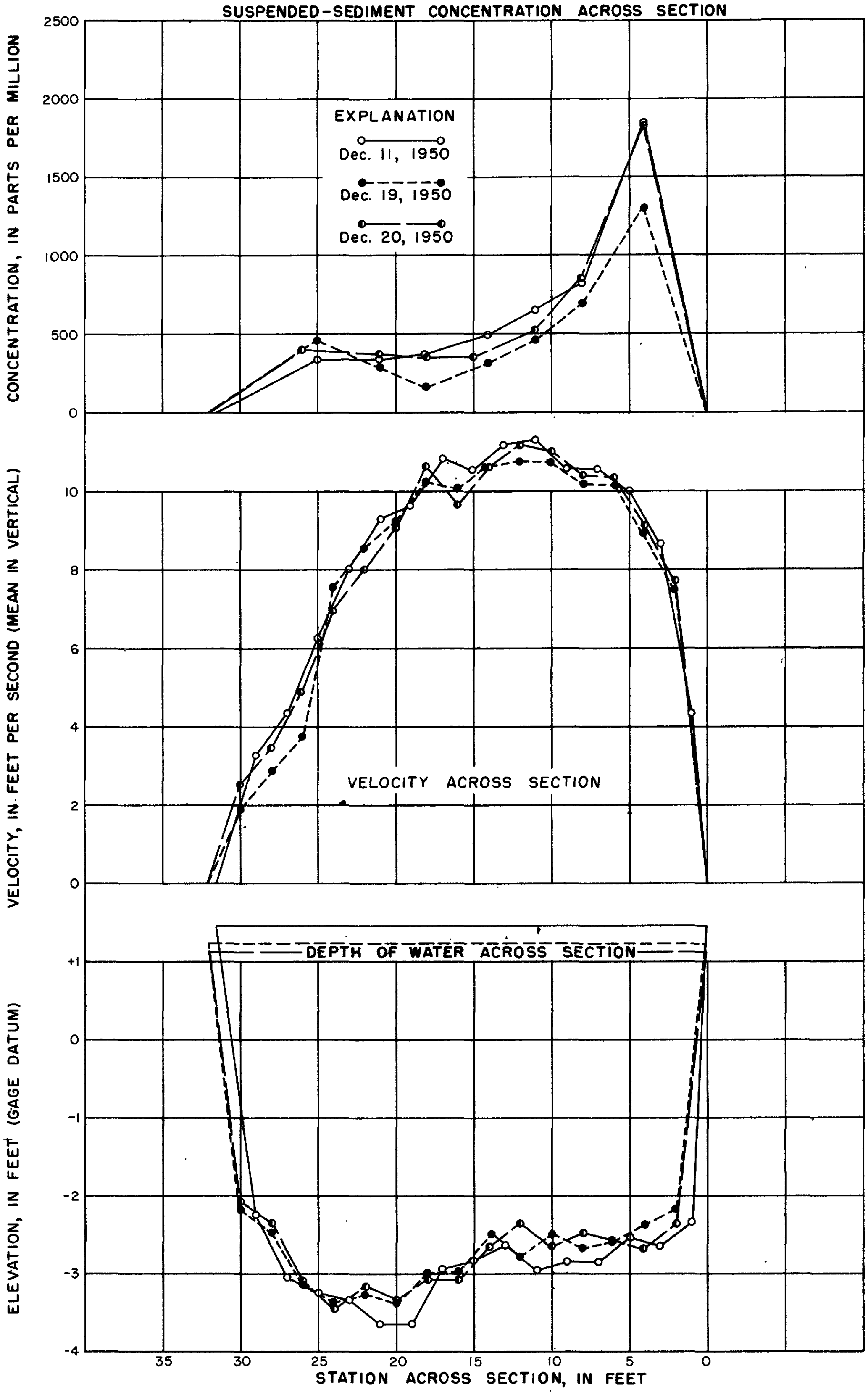

Figure 14.--Lateral distribution of depth, velocity, and concentration of suspended sediment, section B, Niobrara River near Valentine.

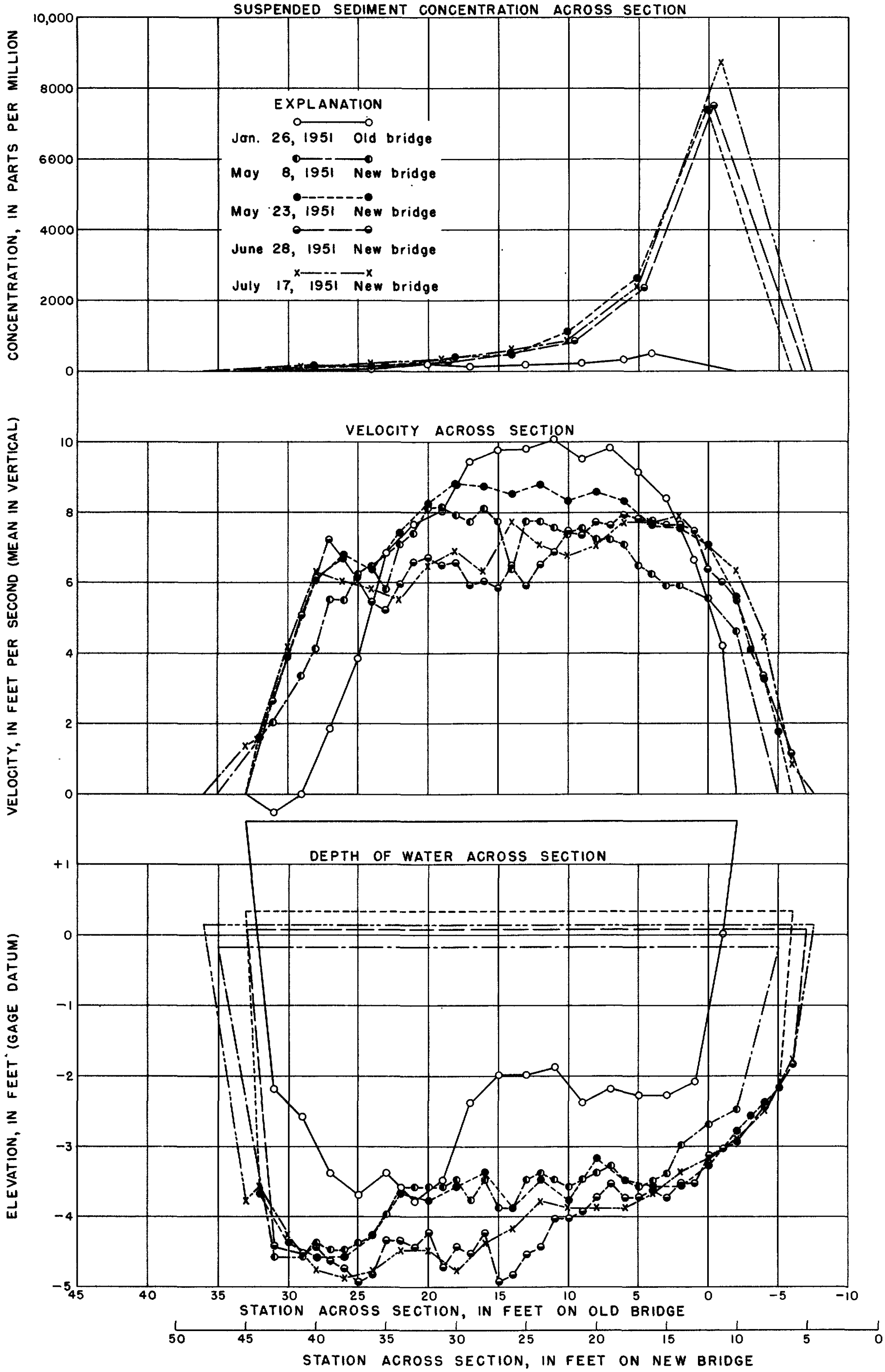

Figure 15.--Lateral distribution of depth, velocity, and concentration of suspended sediment, section B, Niobrara River near Valentine.

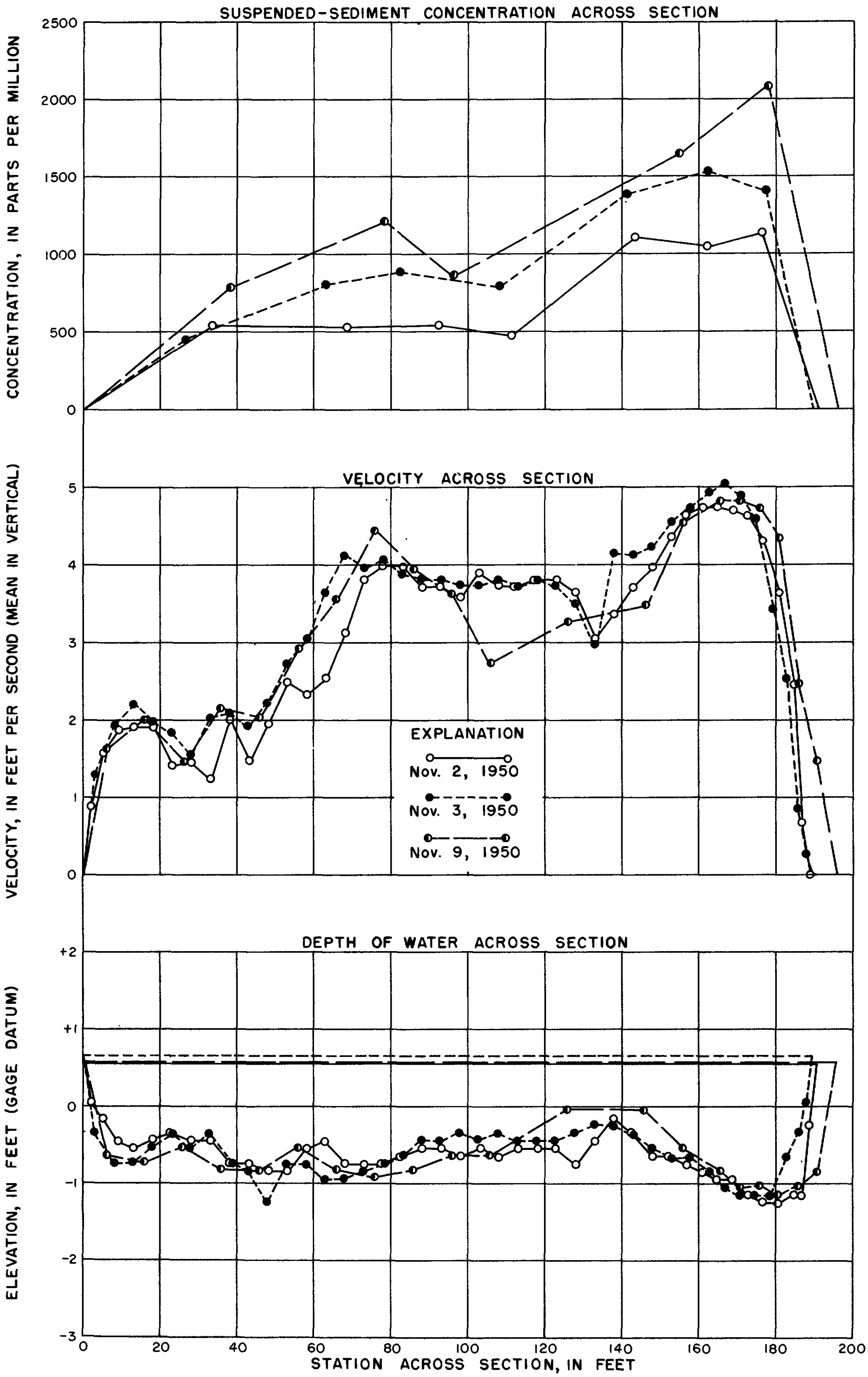

Figure 16.--Lateral distribution of depth, velocity, and concentration of suspended sediment, section C, Niobrara River near Valentine.

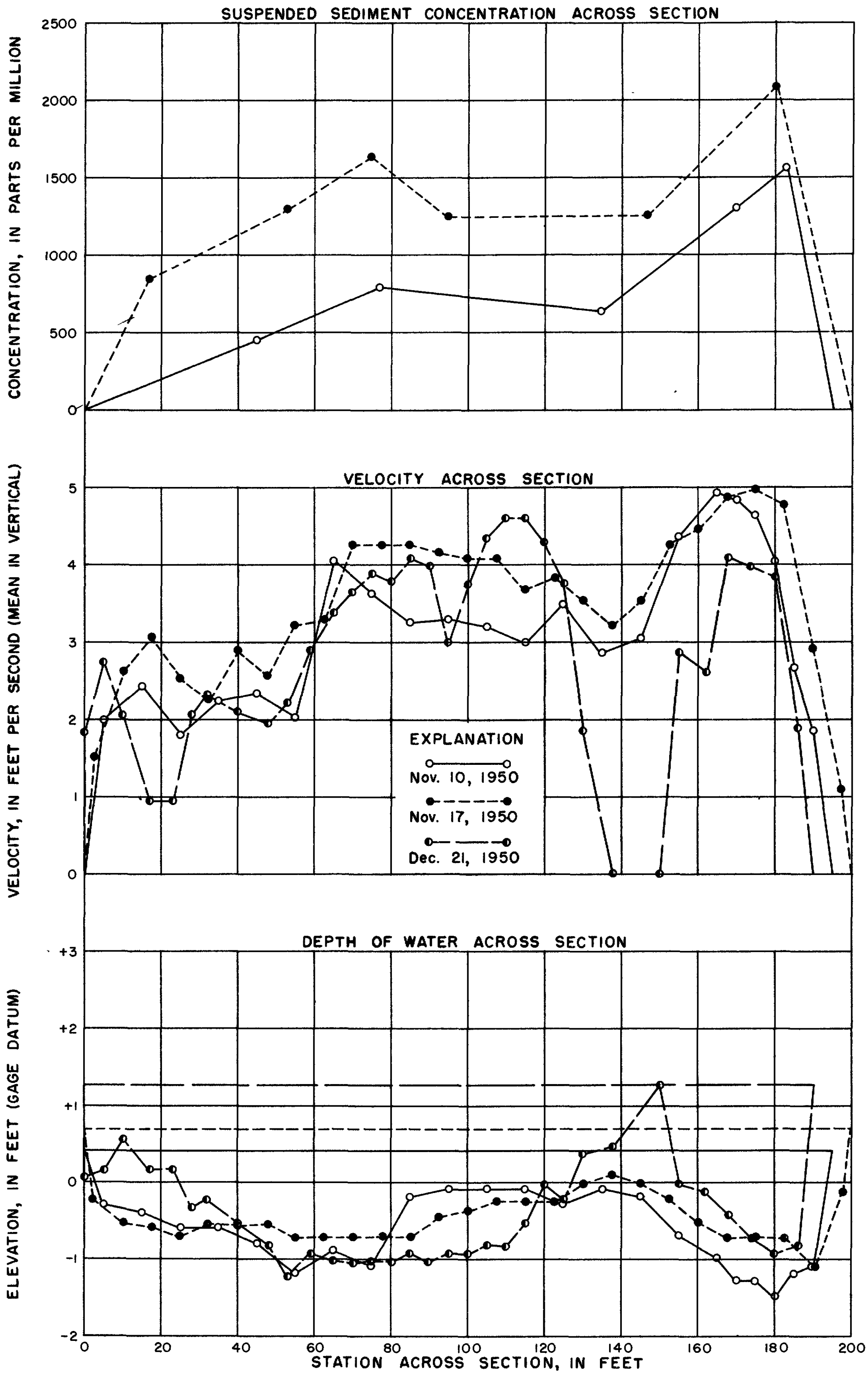

Figure 17.--Lateral distribution of depth, velocity, and concentration of suspended sediment, section C, Niobrara River near Valentine.

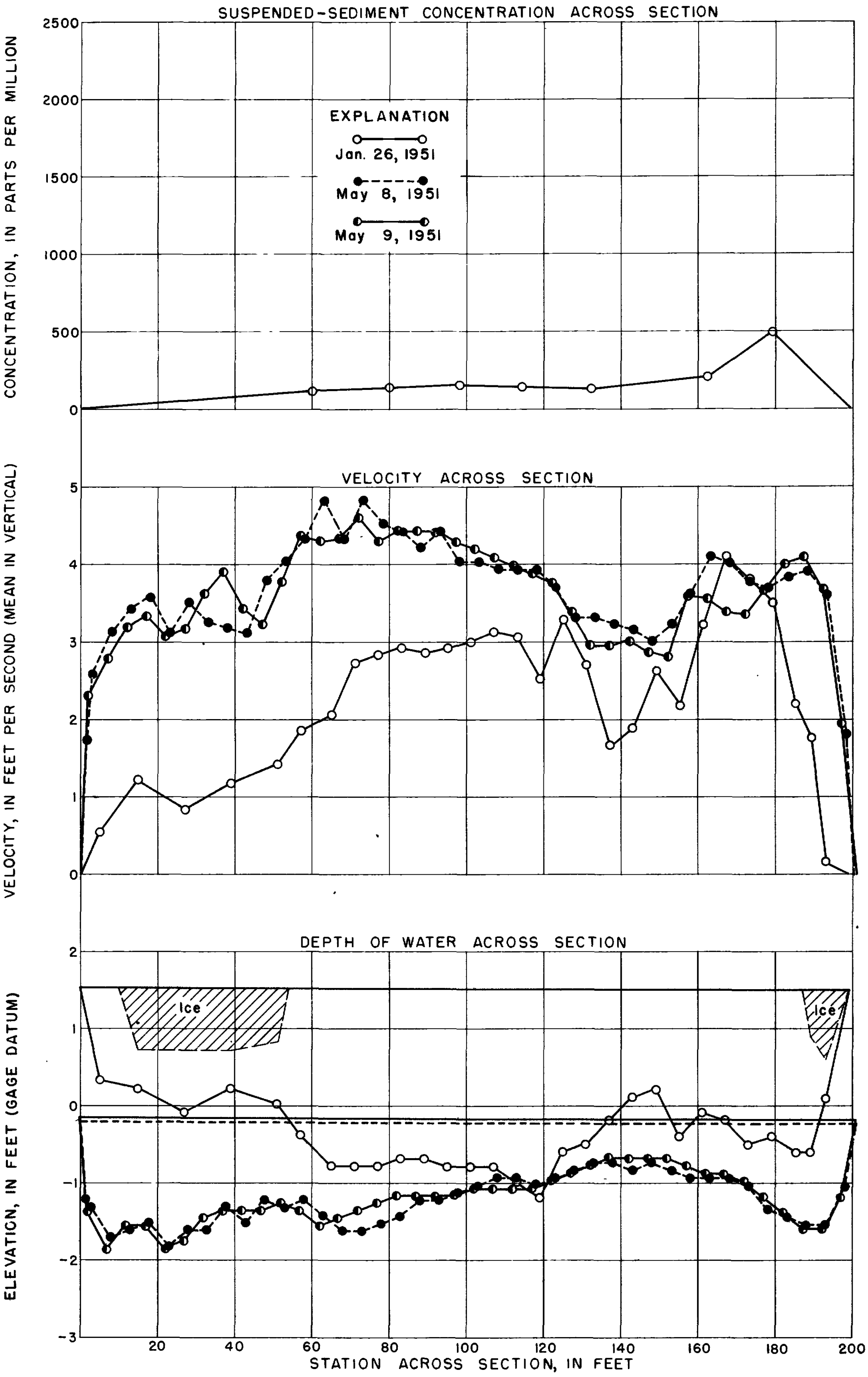

Figure 18.--Lateral distribution of depth, velocity, and concentration of suspended sediment, section C, Niobrara River near Valentine.

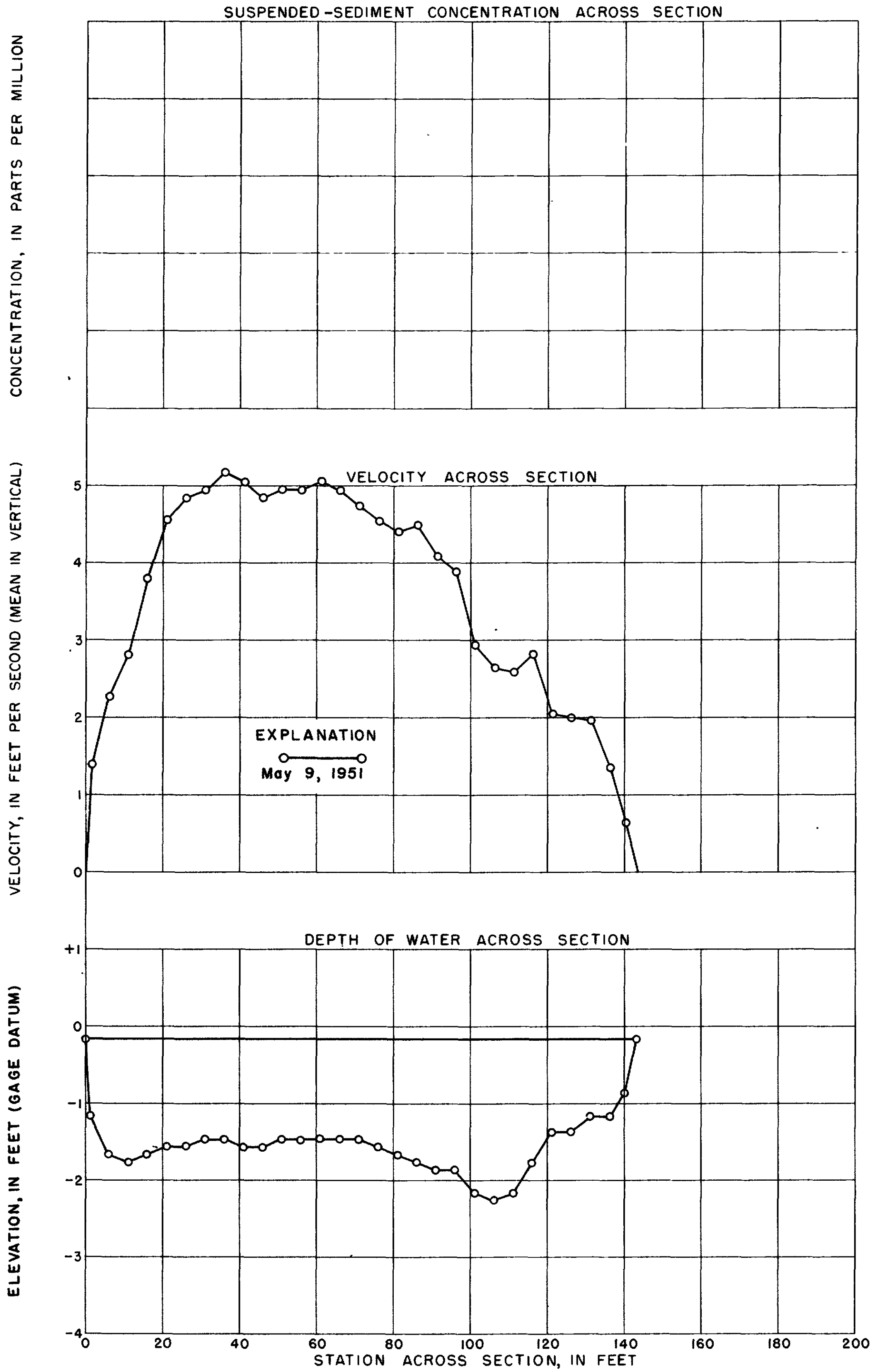

Figure 19.--Lateral distribution of depth, velocity, and concentration of suspended sediment, section D', Niobrara River near Valentine.

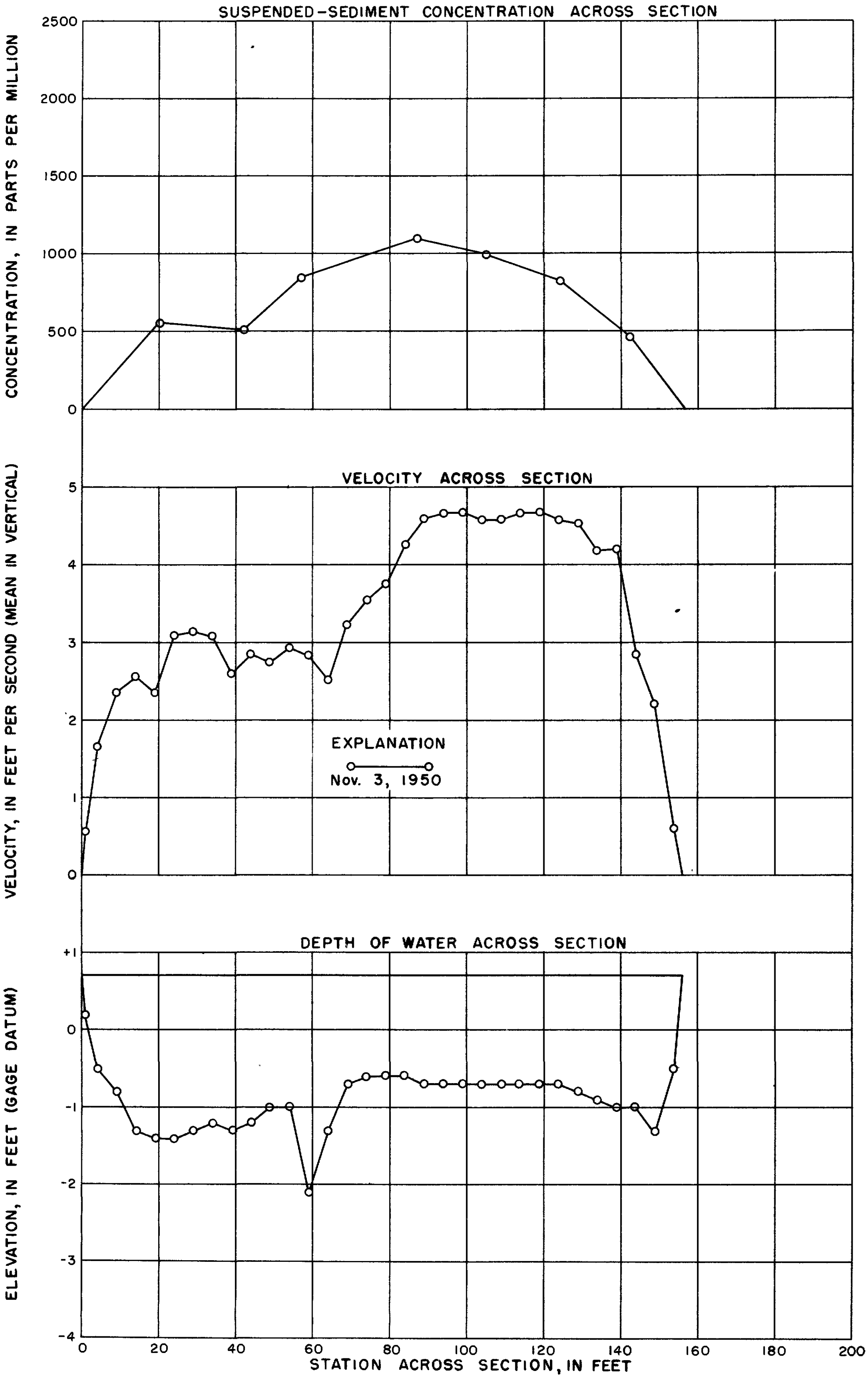

Figure 20.--Lateral distribution of depth, velocity, and concentration of suspended sediment, section D, Niobrara River near Valentine.

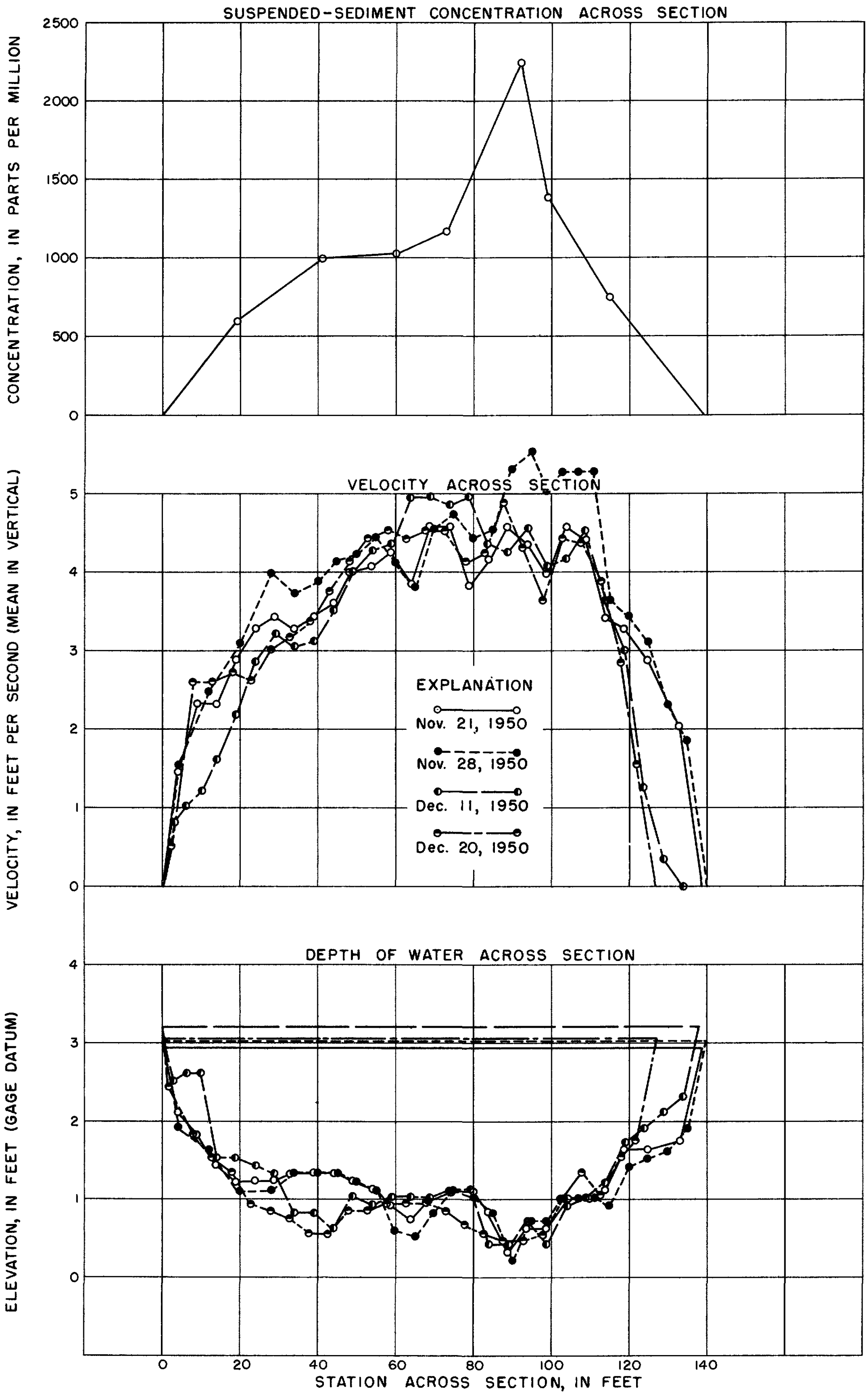

Figure 21.--Lateral distribution of depth, velocity, and concentration of suspended sediment, bridge section, Niobrara River near Sparks.

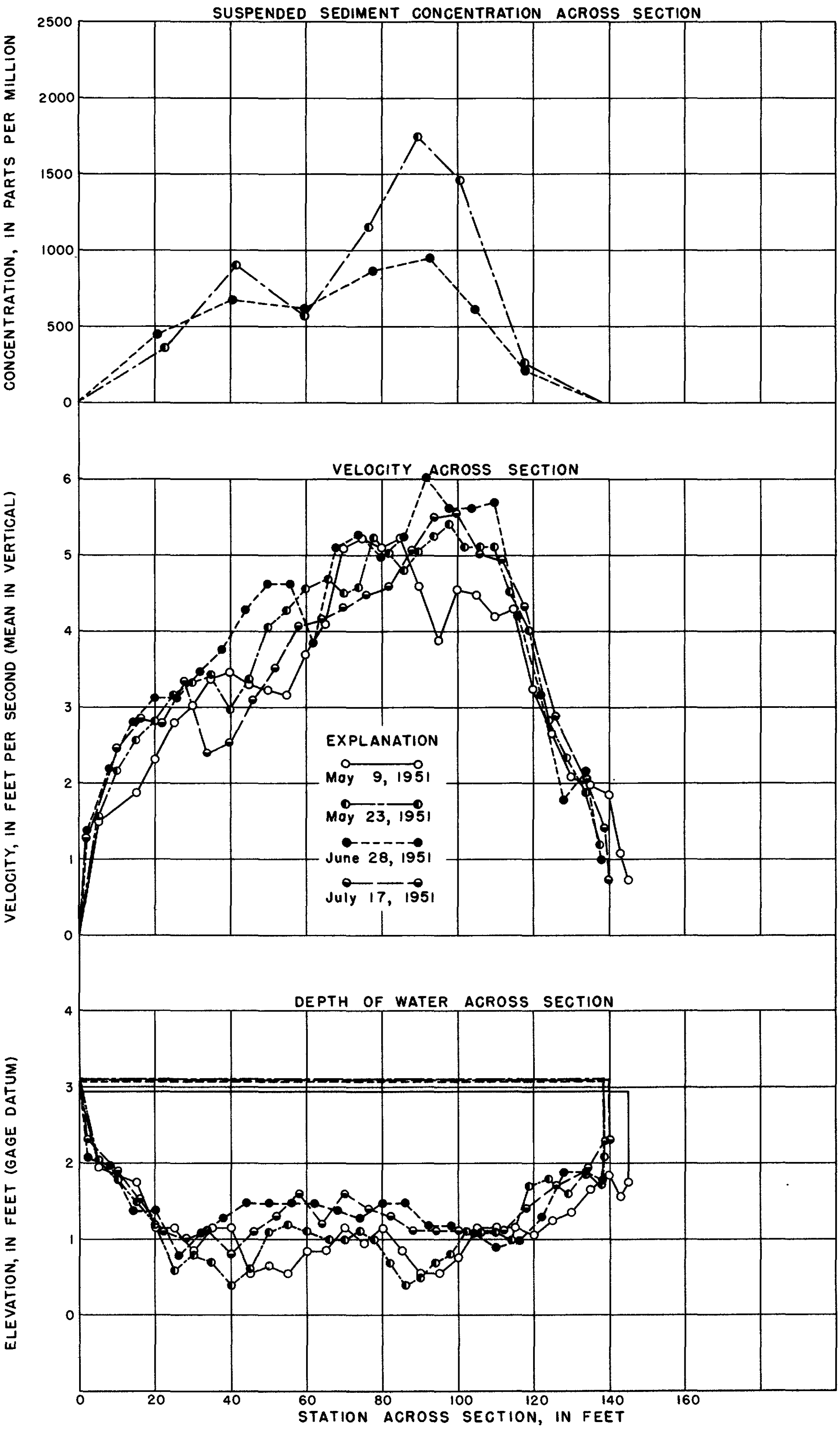

Figure 22.--Lateral distribution of depth, velocity, and concentration of suspended sediment, bridge section, Niobrara River near Sparks.

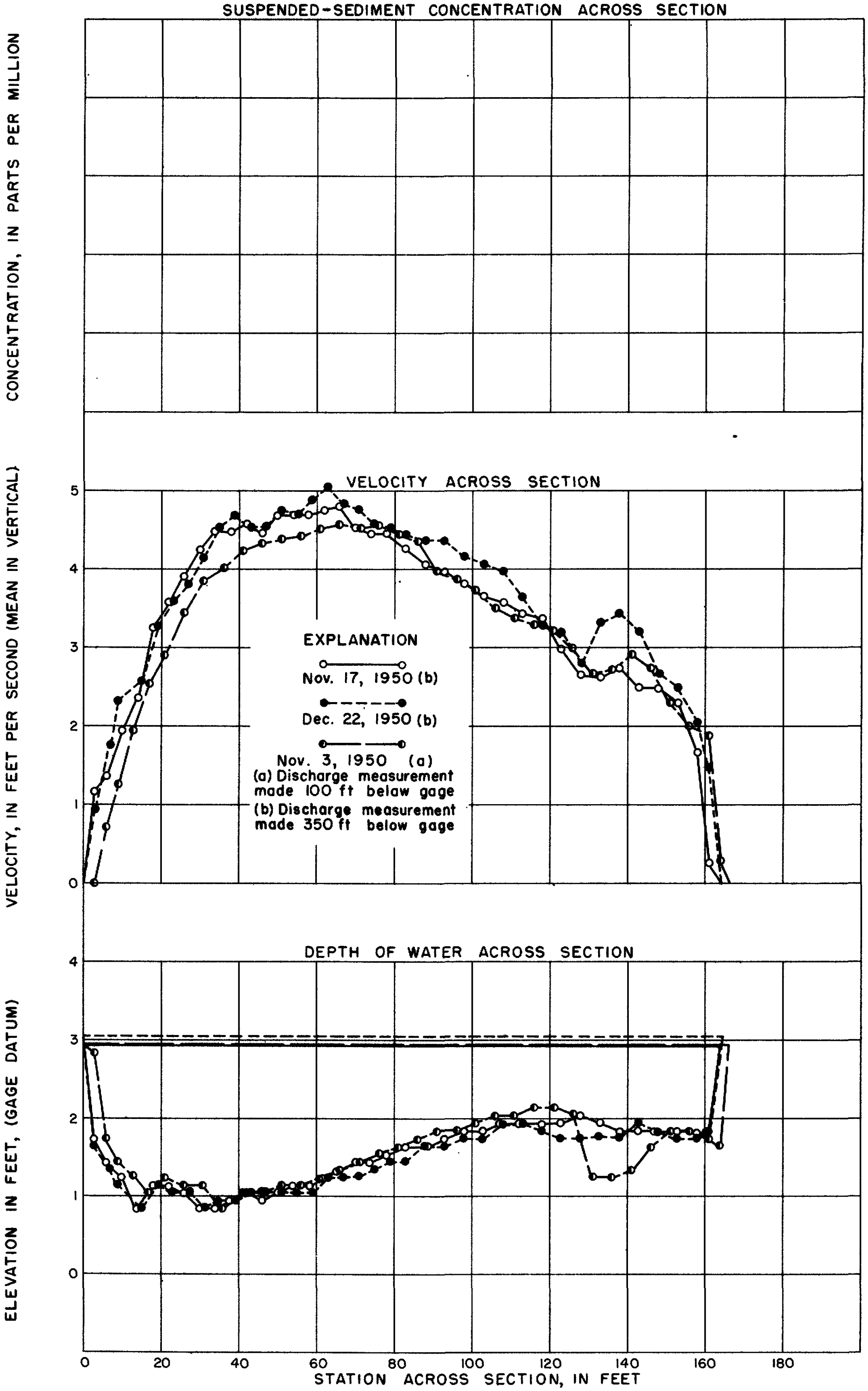

Figure 23.--Lateral distribution of depth, velocity, and concentration of suspended sediment, wading sections, Niobrara River near Sparks.

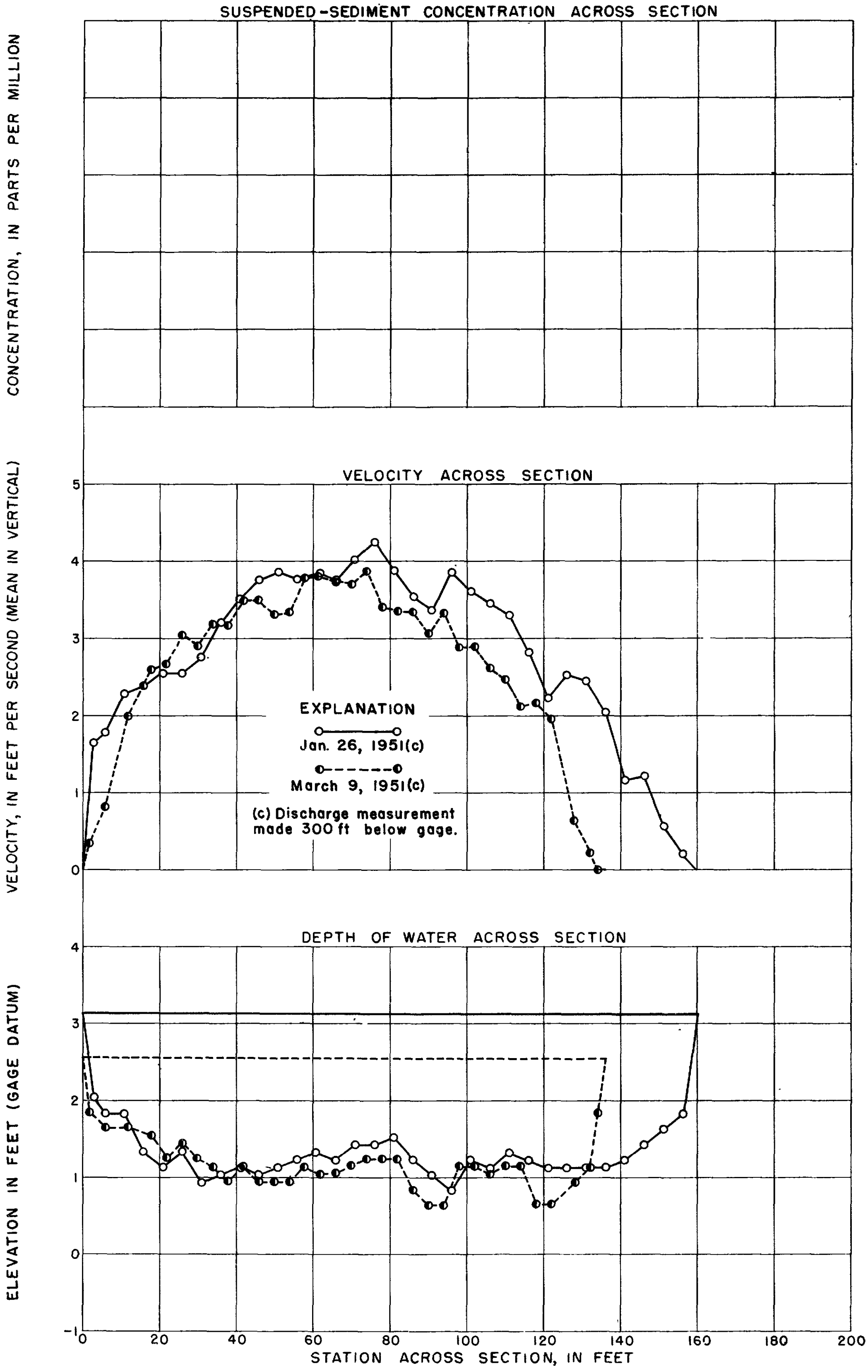

Figure 24.--Lateral distribution of depth, velocity, and concentration of suspended sediment, wading section, Niobrara River near Sparks.

that at section B even though the concentration at the Sparks gage was lower than at other seasons of the year.

DAILY WATER AND SEDIMENT DISCHARGES

Daily water discharge of the Niobrara River above Buffalo Bridge, near Valentine, was computed for the period November 28 to December 21. Gage heights read on the staff gage upstream from section B were plotted on a print of the recorder chart for the Sparks gaging station. A continuous graph of estimated gage height at the staff gage was drawn for all this period of the record except December 16 to 19. Between gage readings, the graph was based on the changes in gage height at the Sparks station and on temperature records. The gage-height graph and a rating table based on the rating curve shown in figure 25 were used to compute the daily water discharges for use at section B and at the normal sections near Valentine. Mean daily water discharges for December 16 to 19 were estimated on the basis of records for the Sparks station. When daily water discharges at the staff gage were compared with those for the Sparks gaging station, some inconsistencies were found. The stage-discharge relation shifted considerably at each place because of (a) changes in bed elevation and (b) backwater from ice at times. Records of daily discharge at the staff gage were revised slightly on a few days when the revisions were not inconsistent with measured discharges. On other days when the water discharge at the two sites seemed to be inconsistent by only a small percentage, no revisions were made.

Daily discharges of suspended sediment for November 28 to December 21 were computed for section B and for the gaging station near Sparks from daily water discharges and graphs of sediment concentration. The daily figures of water discharge, suspended-sediment discharge, and sediment concentration are listed in table 8. For December 2 to 5 and 7, when no daily samples were collected at the Sparks station, the sediment discharge was computed from a water-sediment discharge curve (fig. 26).

MEASURED SLOPES OF THE WATER SURFACE

Water-surface slopes were recorded for the reach of river above the Sparks gaging station. Simultaneous gage readings were obtained at the Sparks water-stage recorder and at a staff gage 890 ft upstream. Staff gage and recording gage were at the same datum. The average slope was 7.5 ft per mile. (See table 9.) Water-surface slope readings were discontinued after the staff gage was removed by ice. The last reading was obtained November 21, 1950.

DISTRIBUTION OF SEDIMENT IN SECTION B

Point-integrated samples of suspended sediment were collected at section B on November 30 and December 7 and 21, 1950, and on May 8 and June 28, 1951. Two samples were taken at each sampling point. Concentrations, velocities, and particle sizes for each sampling point are listed in table 10. These velocities were computed from the filling time of the samples. Figures 27 to 31 show the vertical distribution in section B of concentration, velocity, and percentage of particles larger than 0.25 mm. The 0.25-mm size was used for comparison; it approximates the median particle size. Each discontinuous line connecting the plotted points is only one interpretation of the distribution that seems to be indicated by the points and may be inaccurate, especially near the bottom of each vertical.

Samples collected on November 30 and December 21 show little increase in sediment concentration from top to bottom of the verticals. Also the percentage of particles larger than 0.25 mm does not increase appreciably with depth below the surface of the water. The sediment load must be far below the maximum carrying capacity at any section where the turbulence is sufficient to maintain nearly uniform vertical distribution of coarse sediment particles. The sediment transported as unmeasured load at such a section is probably a minute fraction of the total sediment discharge.

On December 7 the water discharge was low, and the mean velocity by current-meter measurement at 10:20 a.m. was 4.11 fps. Vertical distributions show an increase of concentration and of percentage of particles coarser than 0.25 mm toward the bottom of the section at four of the seven sampling stations. At the other three verticals the concentration and the percentage of particles coarser than 0.25 mm did not show a significant increase with depth. Perhaps an appreciable amount of sediment was discharged as bed load on December 7, but the engineers who took the samples did not report any deposits of sand on the bottom of the channel at section B at that time. In general, during the period before the channel widened to about 40 ft it is probably safe to assume that, except when the stream flow was exceptionally low or there was backwater from an ice jam, almost all the sediment passed section B in suspension.

On both May 8 and June 28, 1951, vertical distributions showed an increase of concentration and of the percentage of particles coarser than 0.25 mm toward the bottom of the section at one of the three verticals that were sampled. The vertical showing this increase was at about the same location on both days. Soundings on May 8, 1951, indicated a wedge of deposited material from the right bank to station 8. In this part of the cross section the velocities of flow were low and the alluvial bank was being undercut. On May 8 and June 28 at the other two verticals in the cross sections, the concentration and distribution of materials coarser than 0.25 mm did not change appreciably with depth. During the period from May 8 to July 17, 1951, probably somewhat less than the total sediment load was transported in suspension.

PARTICLE SIZE

Analyses of Suspended Sediment

The particle-size distributions of suspended sediment were determined 44 times at section B, 22 times at the normal sections near B, and 16 times at the gaging station near Sparks. Usually less than 6 percent of the suspended sediment was coarser than 0.5 mm. (See tables 11 to 13.) Some of the

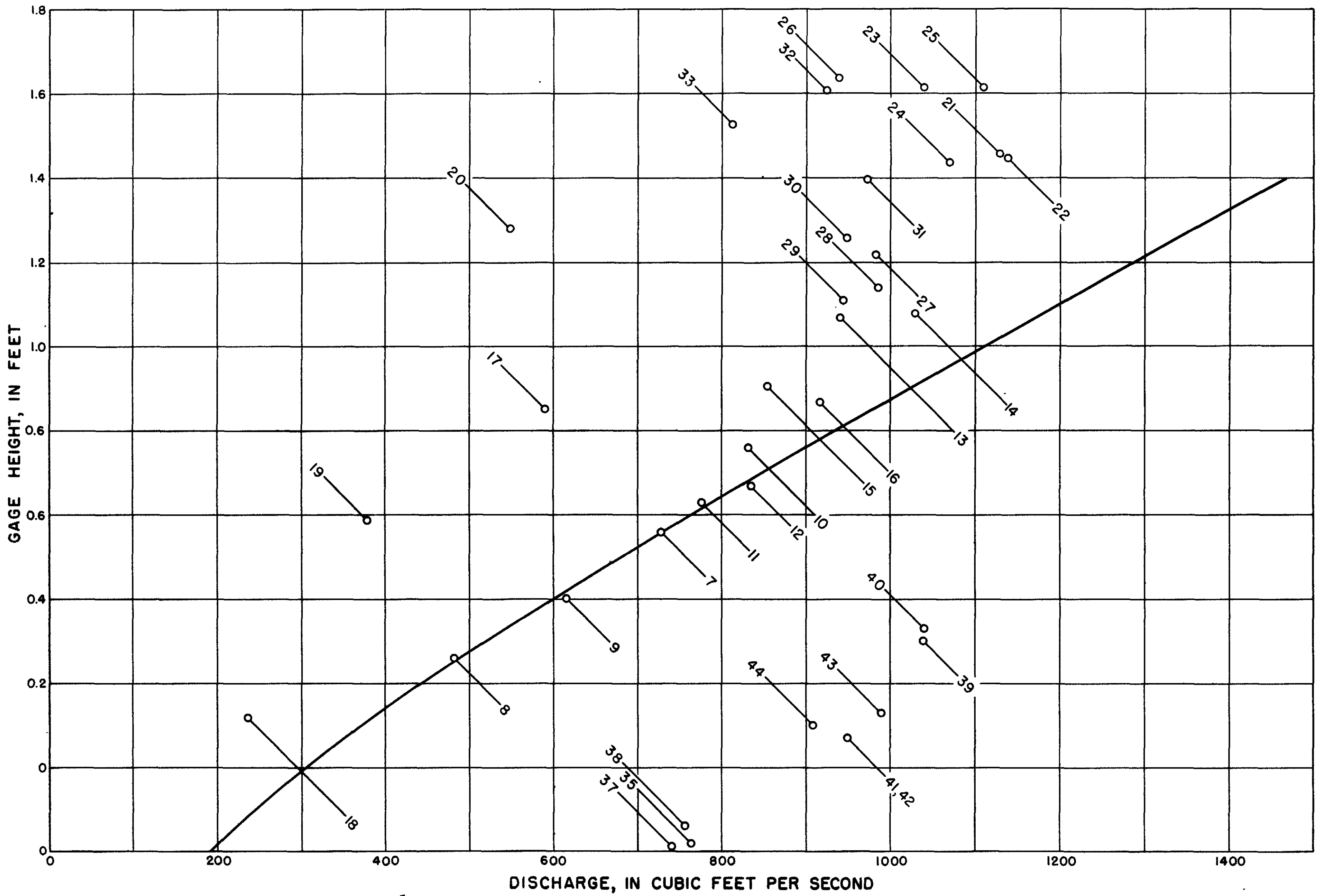

Figure 25.--Rating curve for the Niobrara River above Buffalo Bridge, near Valentine, Nebr

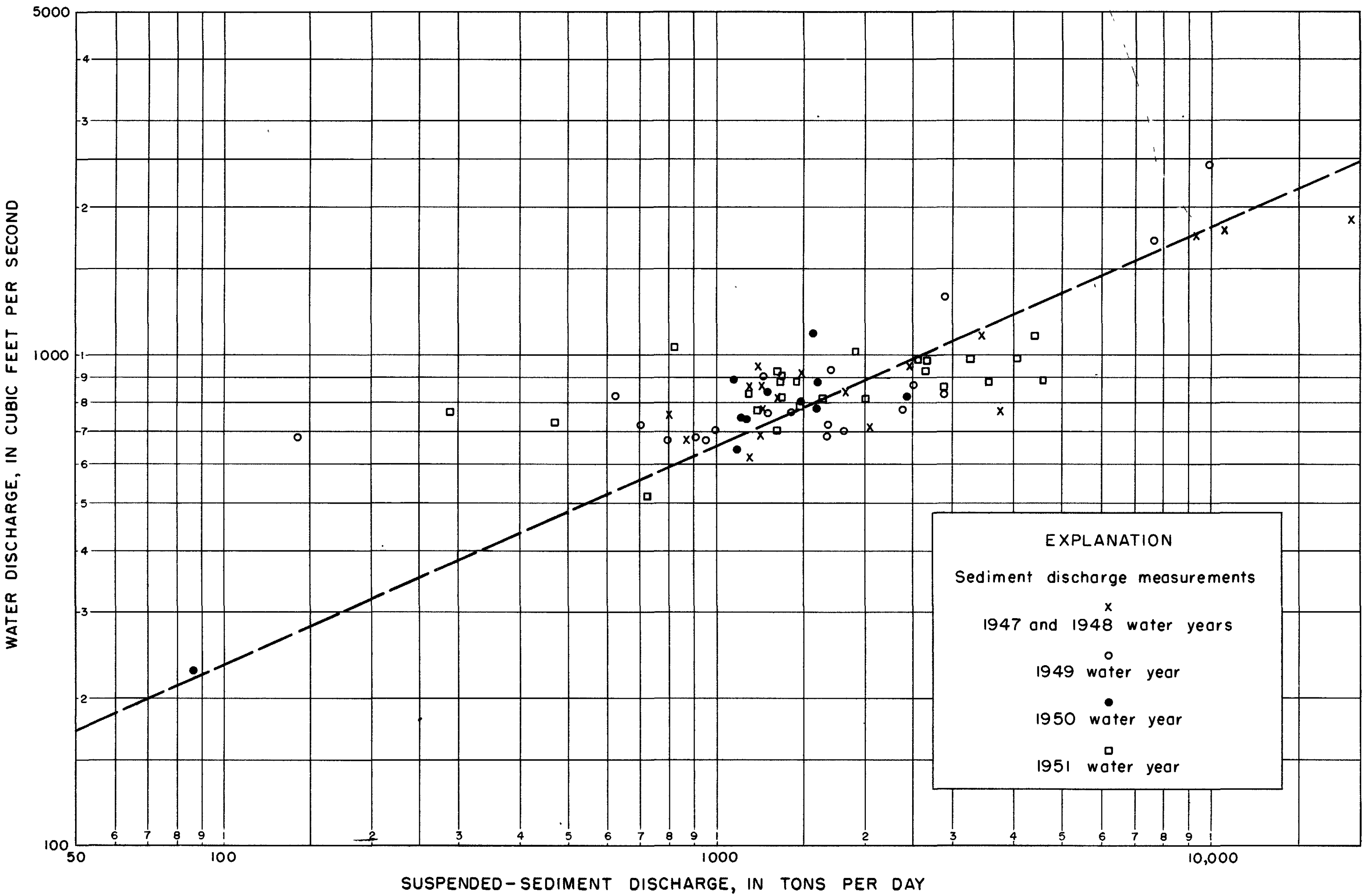

Figure 26.--Water-sediment discharge curve for the Niobrara River near Sparks, Nebr.

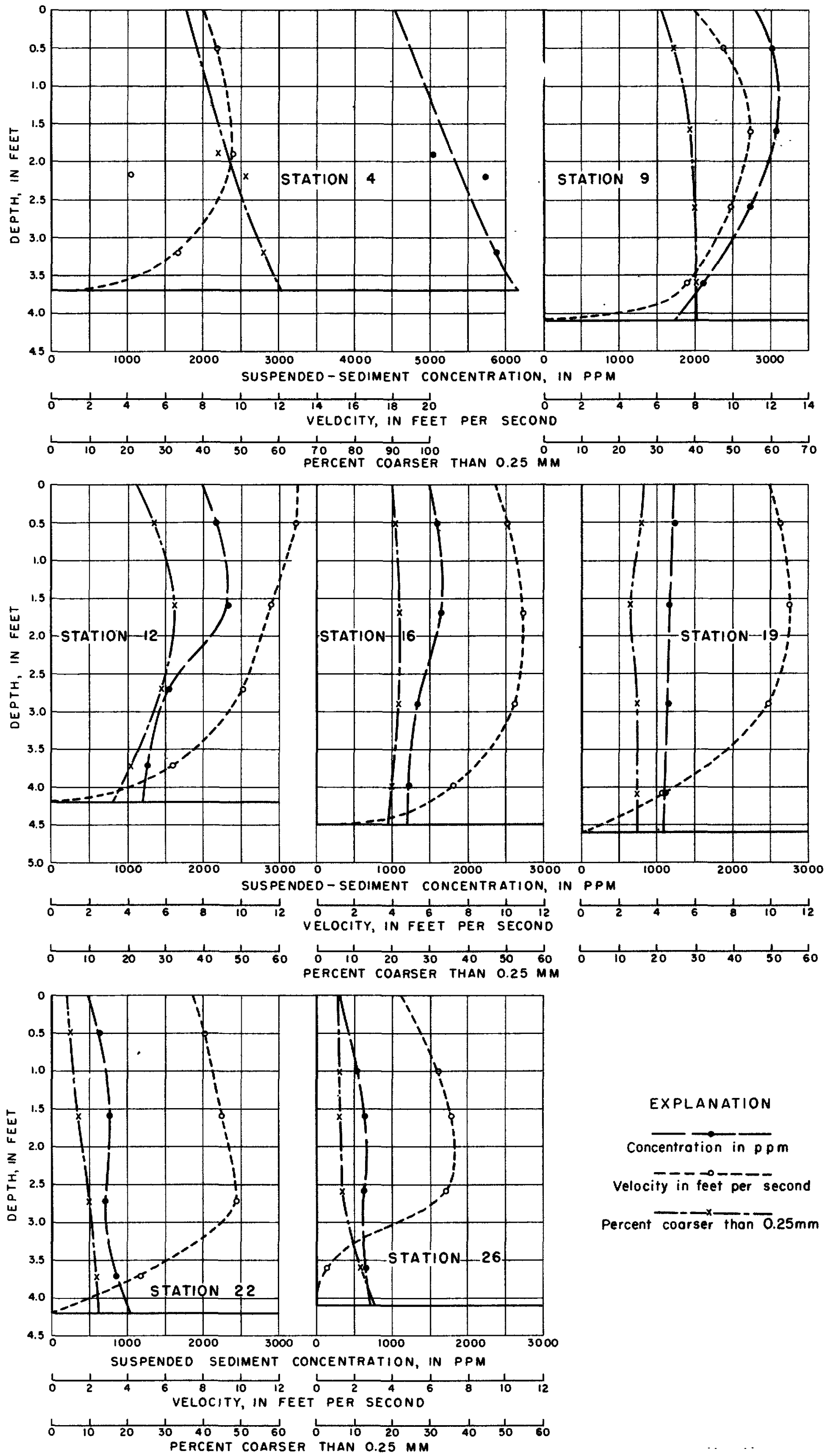

Figure 27.--Vertical distributions at section B, Nov. 30, 1950.

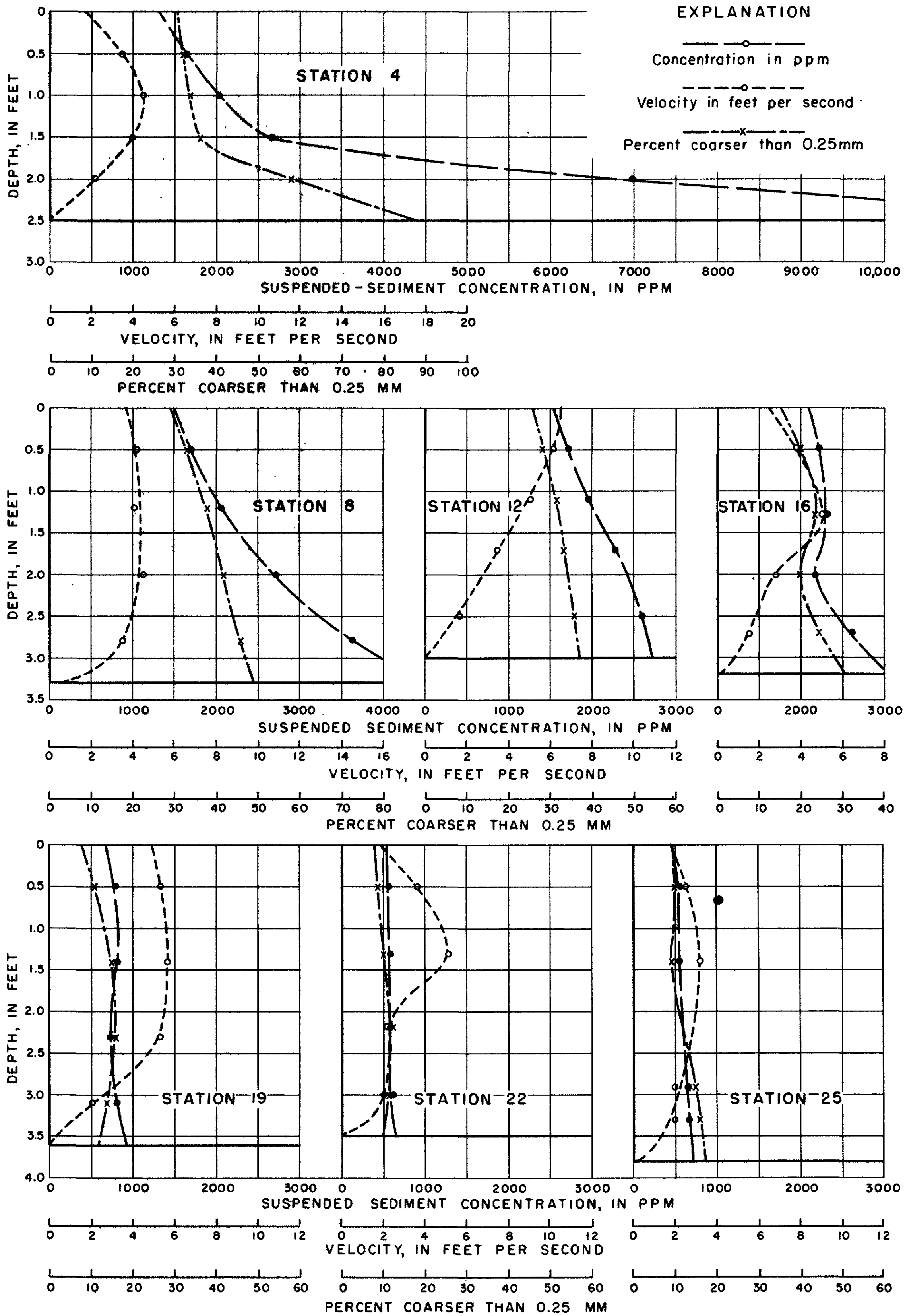

Figure 28.--Vertical distributions at section B, Dec. 7, 1950.

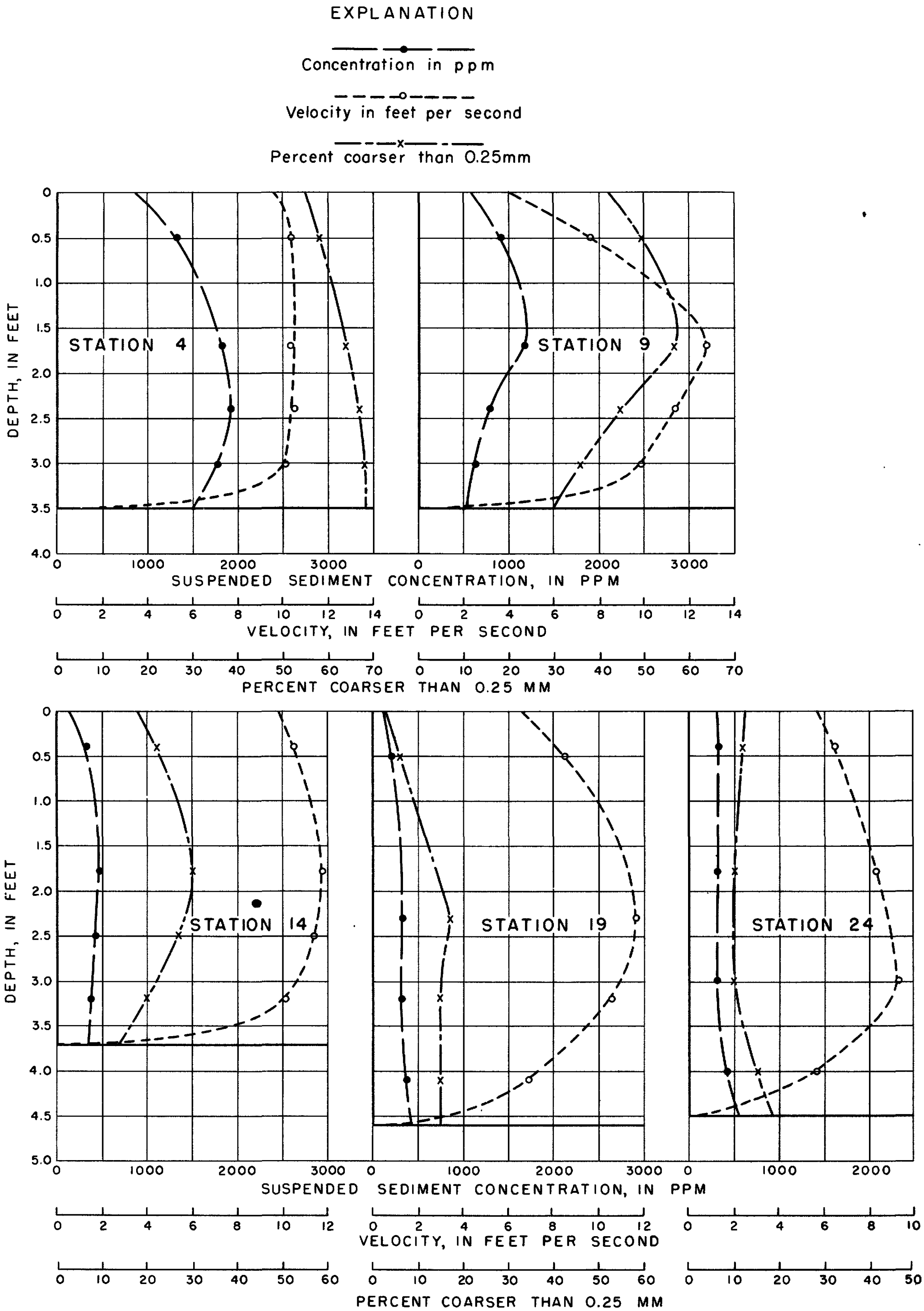

Figure 29.--Vertical distributions at section B, Dec. 21, 1950.

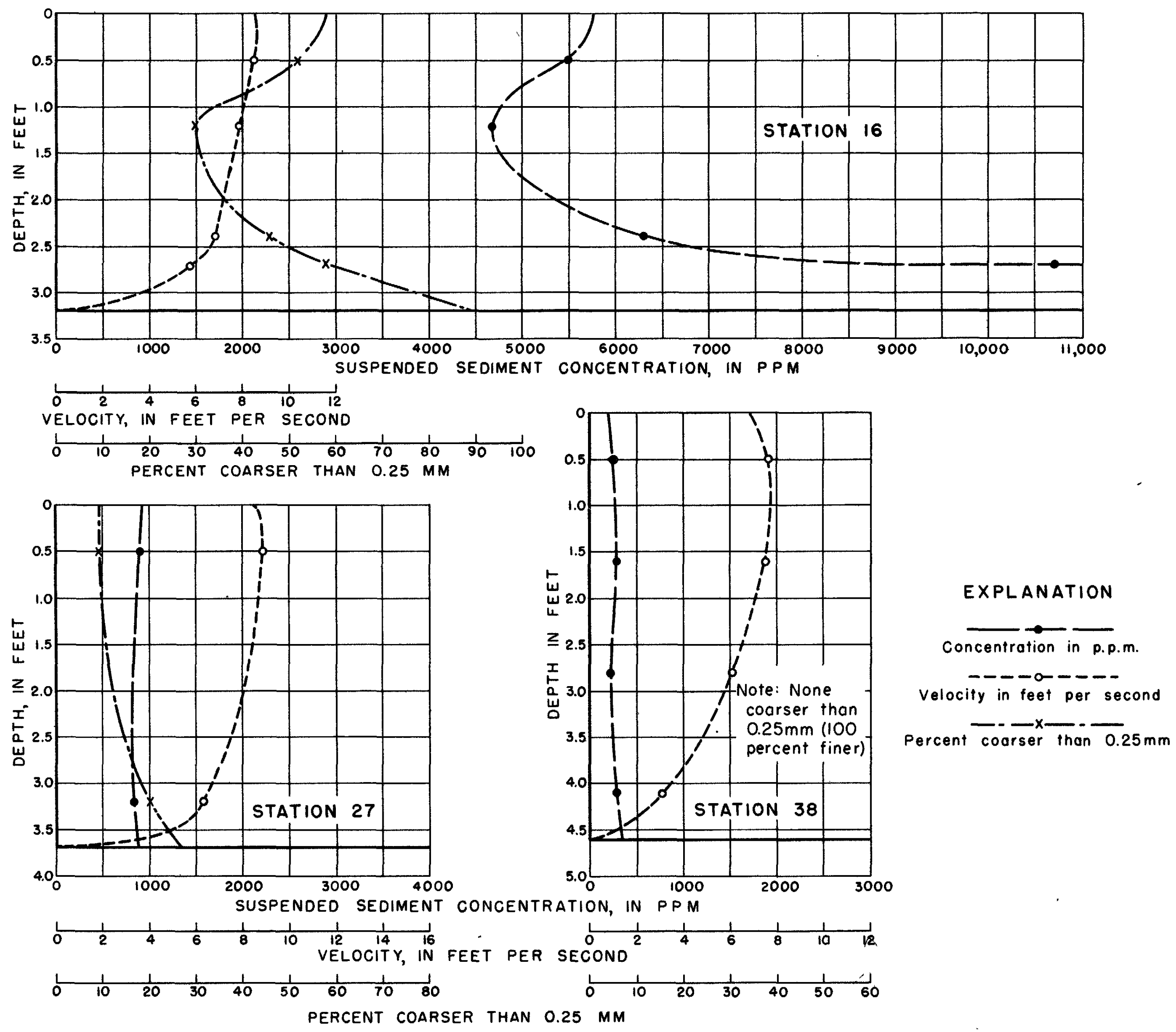

Figure 30.--Vertical distributions at section B, May 8, 1951.

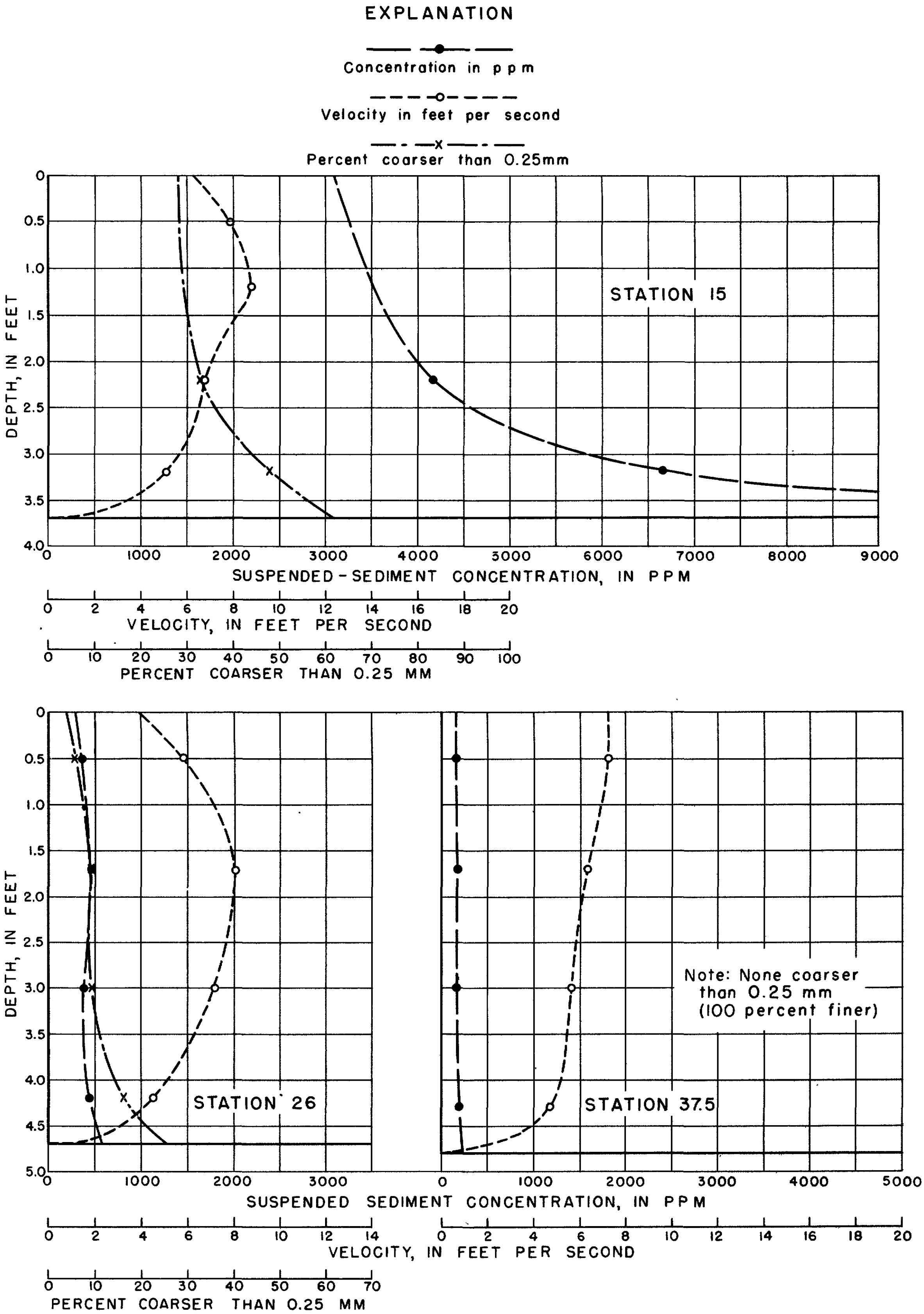

Figure 31.--Vertical distributions at section B, June 28, 1951.

particle-size analyses are shown in figures 32 to 43. The size distribution of the sediment at all the Valentine and Sparks sections for the entire period of record did not seem to vary appreciably with either time or water discharge. In addition, no apparent differences existed in the size distributions between the normal sections near Valentine and the Sparks gaging station.

Analyses of Bed Material

Fifteen sets of bed-material samples from the normal sections and ten sets from the Sparks bridge section were analyzed for particle size by sieving. Each set consisted of samples from two to four points in the section. Only a few percent of the particles from any analysis were larger than 0.5 mm. Although the size distributions of the different sets of samples varied considerably, the analyses showed that the bed material near the Sparks gage averaged finer than the bed material at the normal sections during the winter period. (See tables 14 and 15 and figs. 44 to 49.) Presumably, the finer materials were depleted from the bed by selective sorting near the normal sections. This selective scour probably continued downstream at a decreasing rate while flushing of the small reservoirs above the power plants was discontinued because of ice. After flushing was resumed in the spring, the size distribution of the streambed material of the two reaches resembled each other more closely.

UNMEASURED SEDIMENT DISCHARGE

For the period of record exclusive of winter months, the assumption can be made that probably most of the sediment that passed section B was in suspension. (See figs. 27 to 31.) Also an average of 47 percent of the suspended-sediment discharge at section B was in suspension at the normal sections (table 7). Thus, over half of the total sediment discharge was transported as unmeasured load at the normal sections according to samples collected from November 2, 1950, to July 17, 1951. During other periods and at different rates of water discharge, this ratio of unmeasured load to total load might be significantly different.

Information on particle sizes can be used to compute the size distribution of the sediment that passes the normal section as unmeasured load. The averages of the size distributions of the 20 sets of samples from sections A, A', C, D', and D during the period November 2 to 17, 1950, and May 8 to July 17, 1951, and of the 11 sets of size distributions from section B during the same period are shown in the following table:

Average particle size of sediments of the Niobrara River near Valentine for the periods Nov. 2 to 17, 1950, and May 8 to July 17, 1951

Type and location of sampling	Percent finer than indicated size (mm)		
	0.125	0.25	0.5
Suspended sediment at sections A, A', C, D', and D	35	92	100
Suspended sediment at contracted section B	19	72	99
Unmeasured load at sections A, A', C, D', and D (computed)	5	55	98
Bed material at sections A, A', C, and D'	5	46	93

If the suspended-sediment discharge is 47 percent of the total sediment discharge and all the sediment is in suspension at section B, then the size distribution of the sediment that is discharged as unmeasured load at sections A, A', C, D', and D can be readily computed. If the percentages of particles finer than any particular size are represented by P_B, P_n, and P_u, for suspended sediment at section B, suspended sediment at any normal section, and sediment transported as unmeasured load at the same normal section, respectively; then for measuring sections near Valentine

$$P_B = 0.47\ P_n + 0.53\ P_u$$

This equation was solved for P_u to compute the figures in the next to the last line of the above table. The size distribution of the bed material is also shown in this same table.

Although the size distribution of bed material is not necessarily the same as the size distribution of the sediment that moves as unmeasured load, the two probably are similar for the range of particle sizes that are found in appreciable quantities in the bed of this reach of the Niobrara River. The relatively close agreement between the particle size of unmeasured load and bed material for sections A, A', C, and D' (see above table) may indicate that the computed size distribution for the sediment that moves as unmeasured load at the normal sections is reasonable.

Neither the quantity nor the size distribution of the sediment that is discharged as unmeasured load at the Sparks gaging station can be computed directly during the period November 19 to March 26, the period during which flushing of the reservoirs was discontinued. The average suspended-sediment discharge during this period was greater at the Sparks station than it was at the normal sections near the contraction or even than it was at section B. (See table 6.) Evidently scour during this time, as described previously, prevents any direct determination of the percentage of the total sediment discharge that is in suspension at the Sparks gaging station during the winter months.

Throughout the remainder of the period of record, when neither ice nor discontinuance of flushing affected the water-sediment relationships, the six determinations of suspended-sediment discharge at the Sparks gaging station averaged 41 percent of the total sediment discharge at section B. Thus, during this period the relationship for the sections at the Sparks station is

$$P_B = 0.41\ P_n + 0.59\ P_u$$

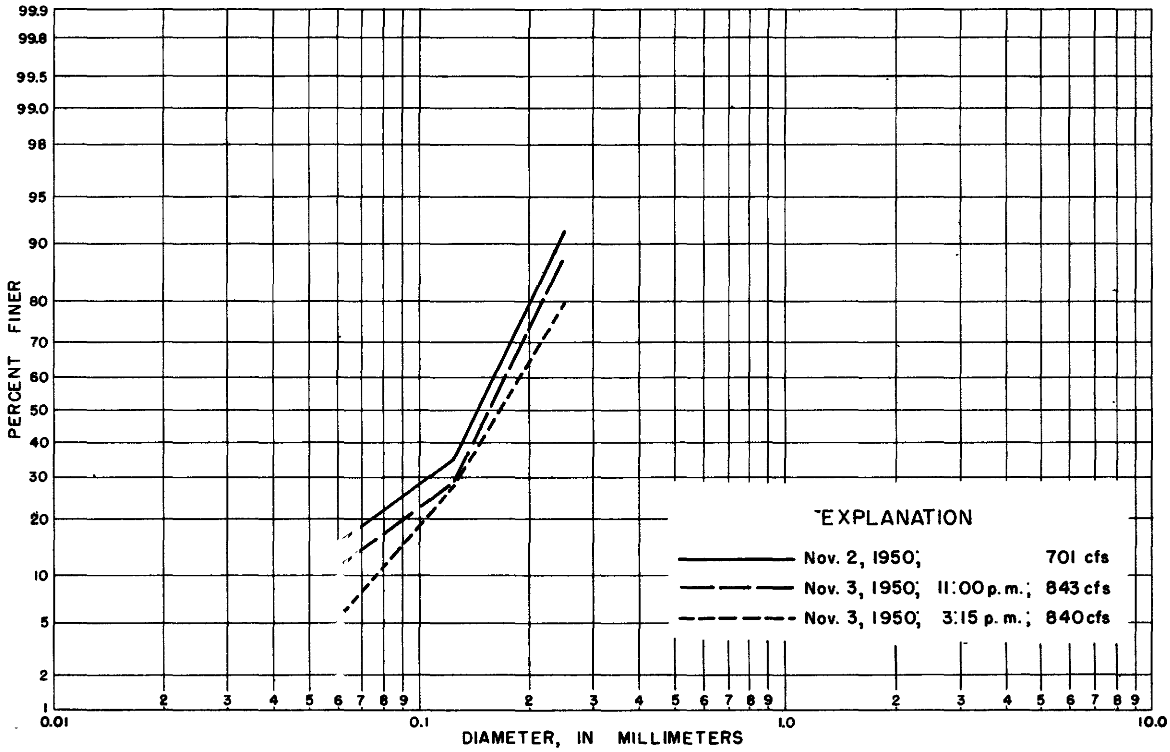

Figure 32.--Particle-size analyses of suspended sediment, section A, Niobrara River near Valentine.

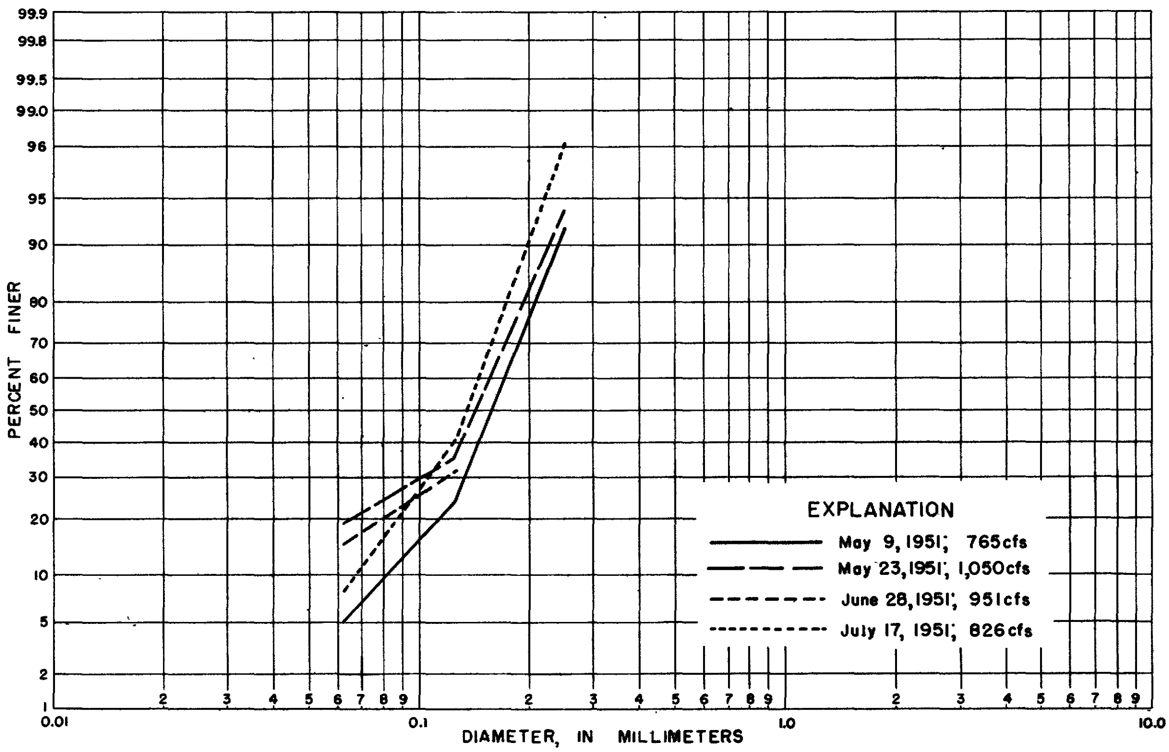

Figure 33.--Particle-size analyses of suspended sediment, section A', Niobrara River near Valentine.

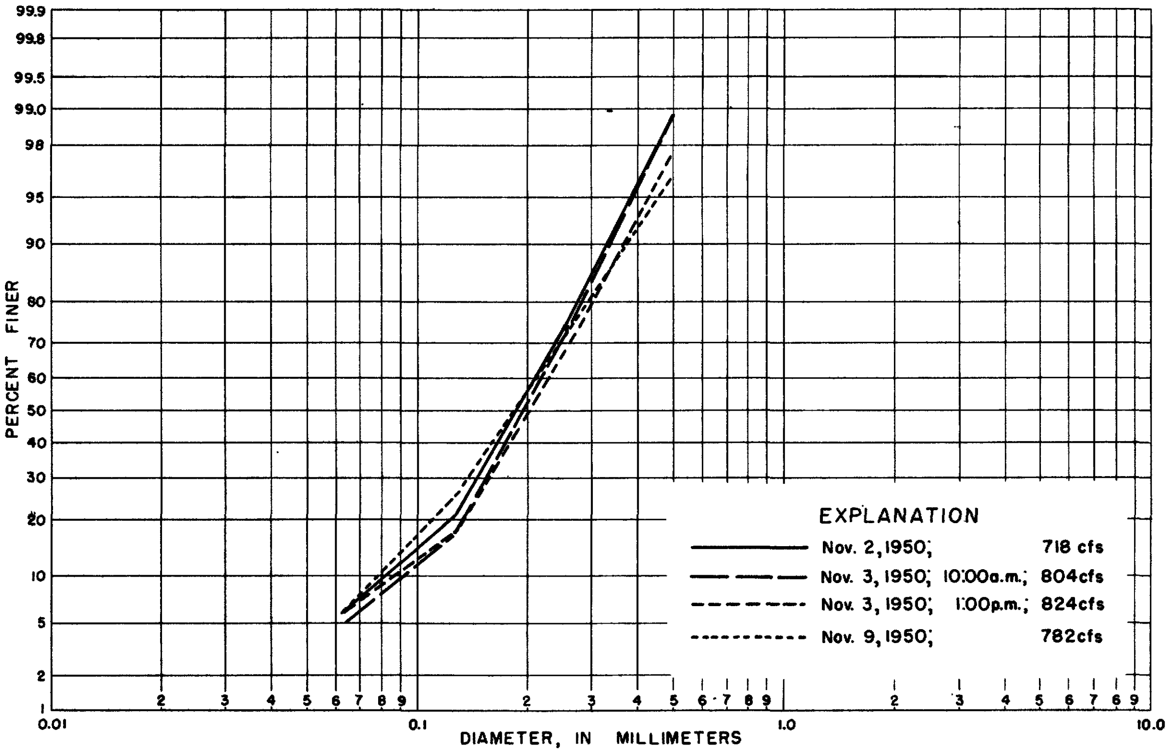

Figure 34.--Particle-size analyses of suspended sediment, section B, Niobrara River near Valentine.

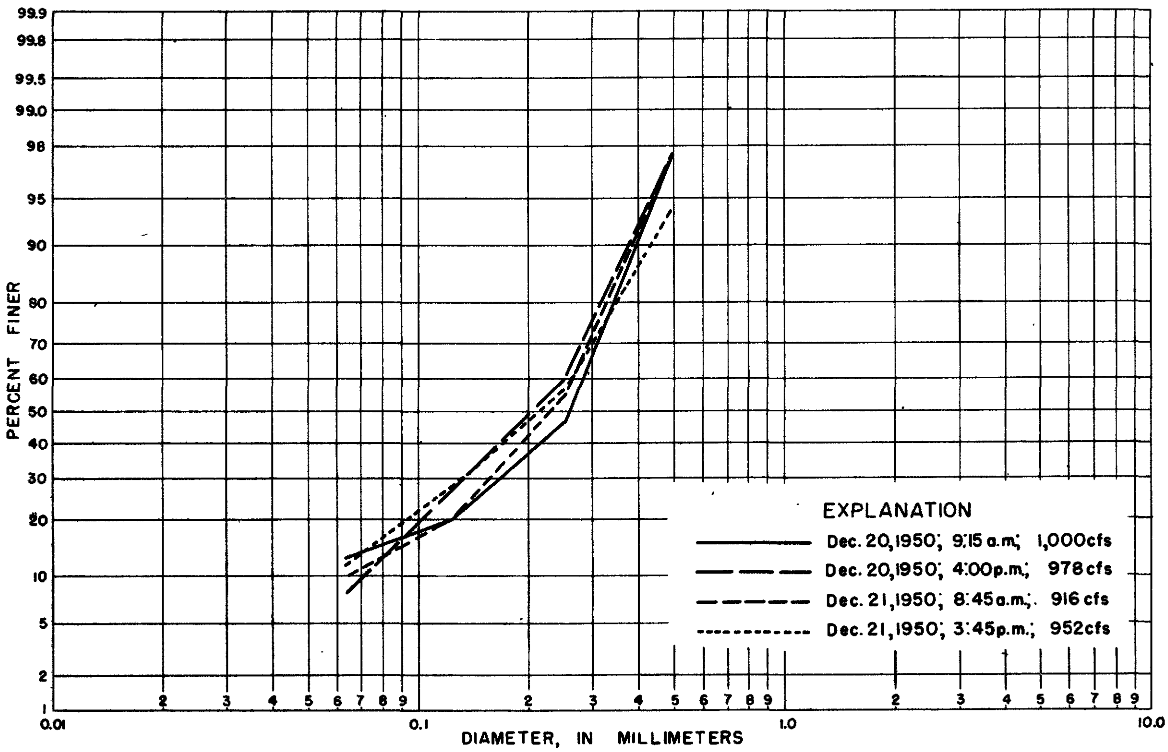

Figure 35.--Particle-size analyses of suspended sediment, section B, Niobrara River near Valentine.

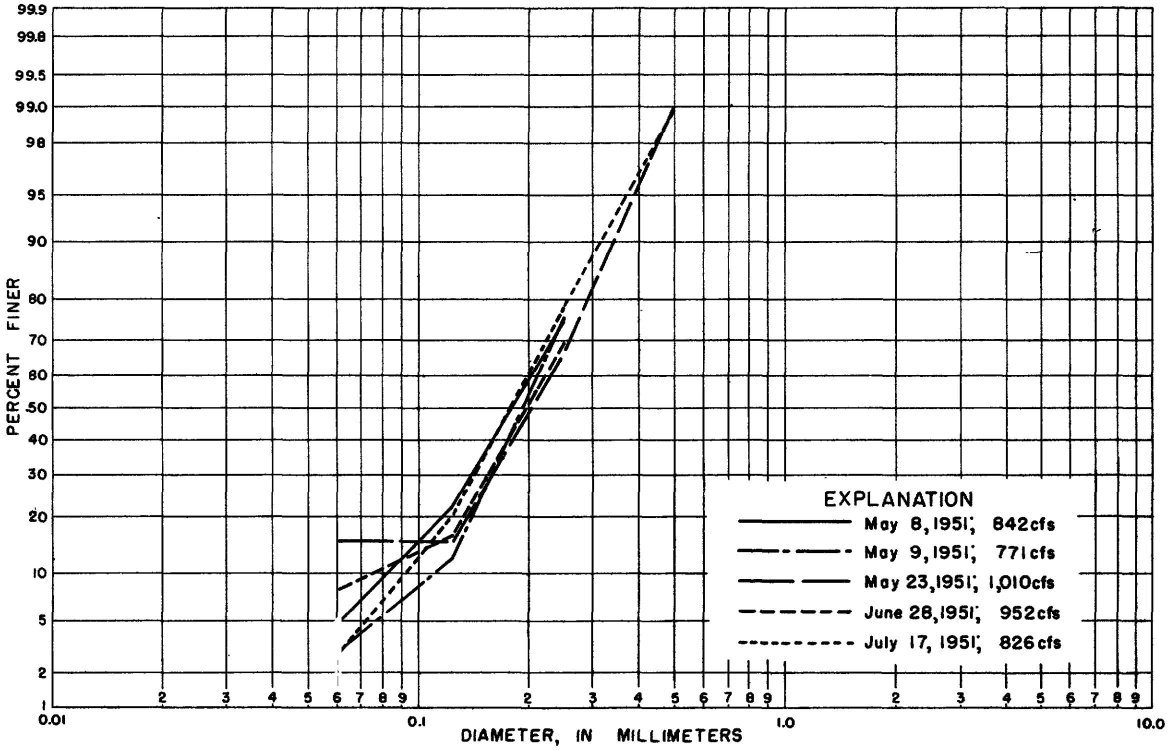

Figure 36.--Particle-size analyses of suspended sediment, section B, Niobrara River near Valentine.

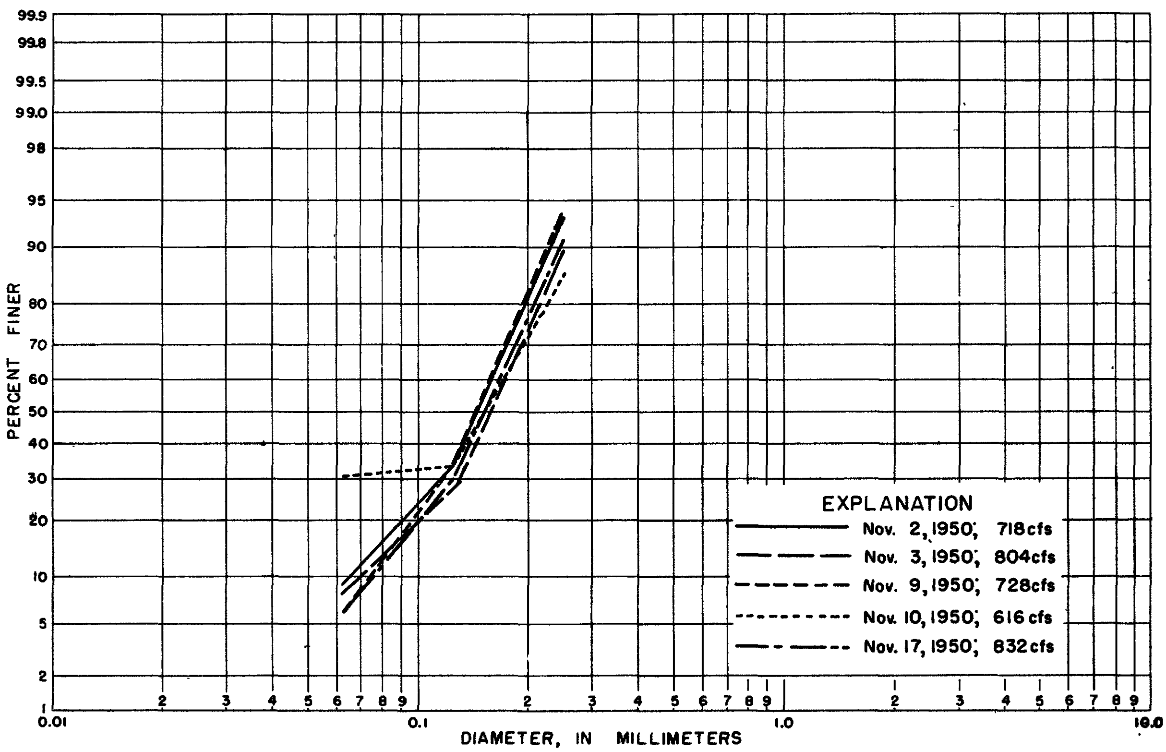

Figure 37.--Particle-size analyses of suspended sediment, section C, Niobrara River near Valentine.

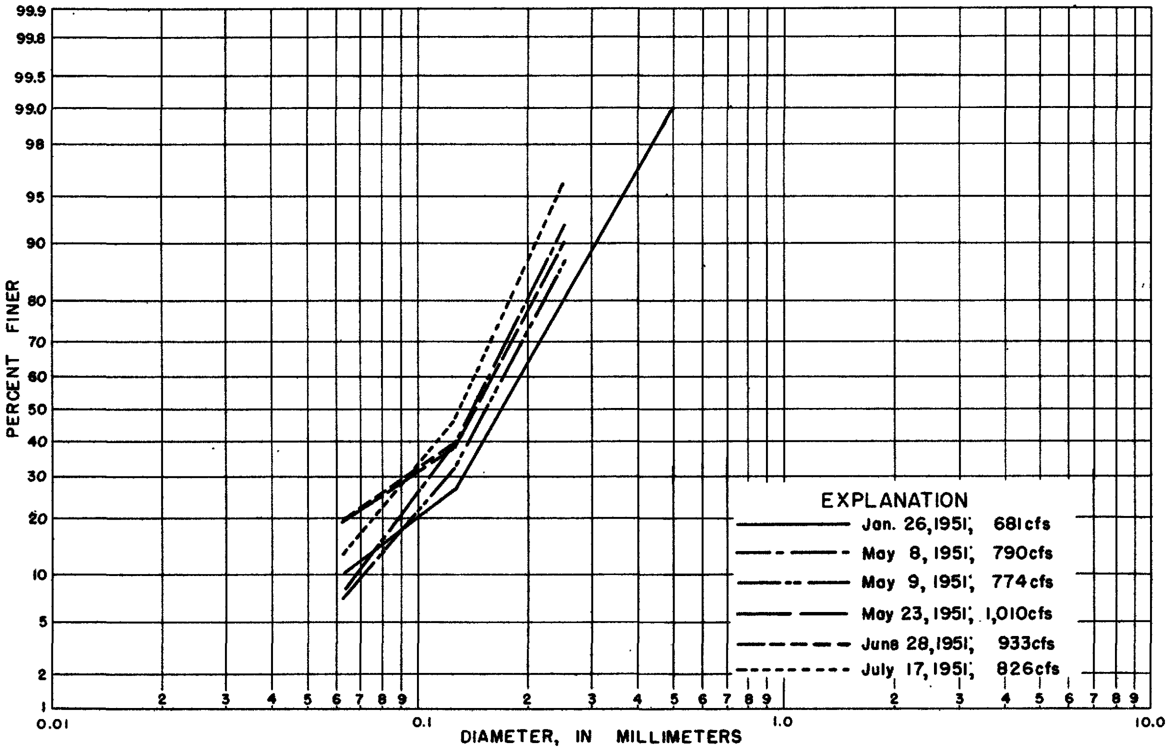

Figure 38.--Particle-size analyses of suspended sediment, section C, Niobrara River near Valentine.

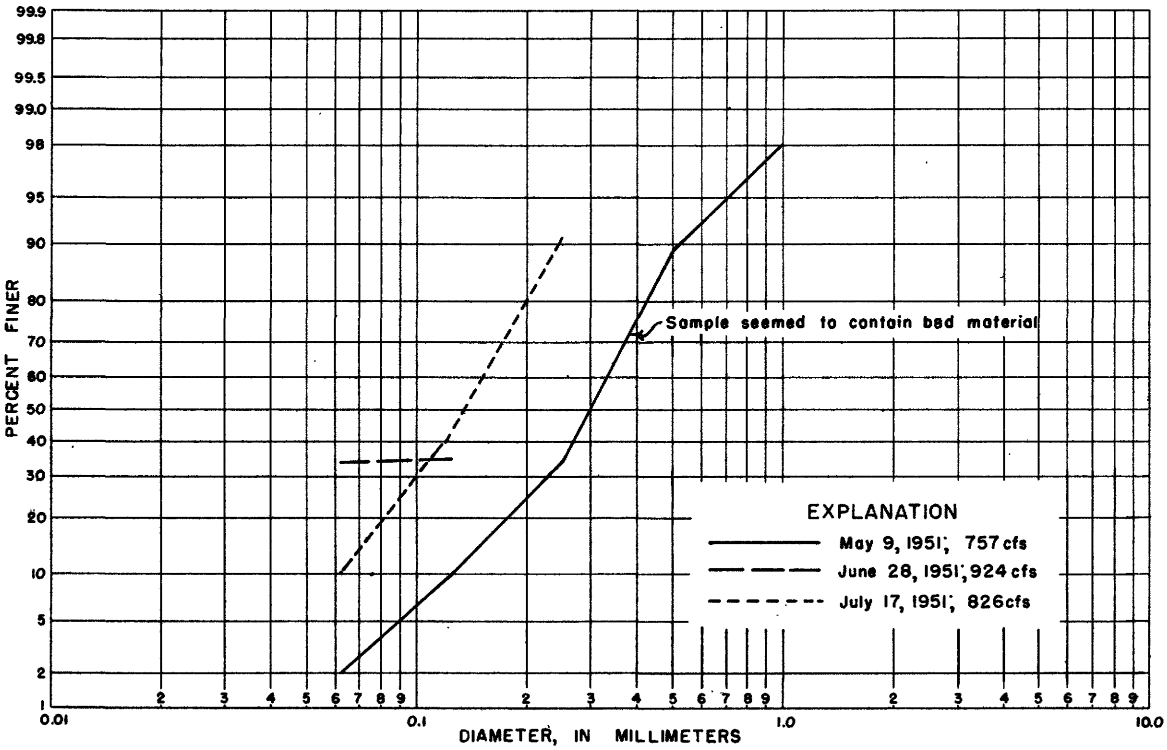

Figure 39.--Particle-size analyses of suspended sediment, section D', Niobrara River near Valentine.

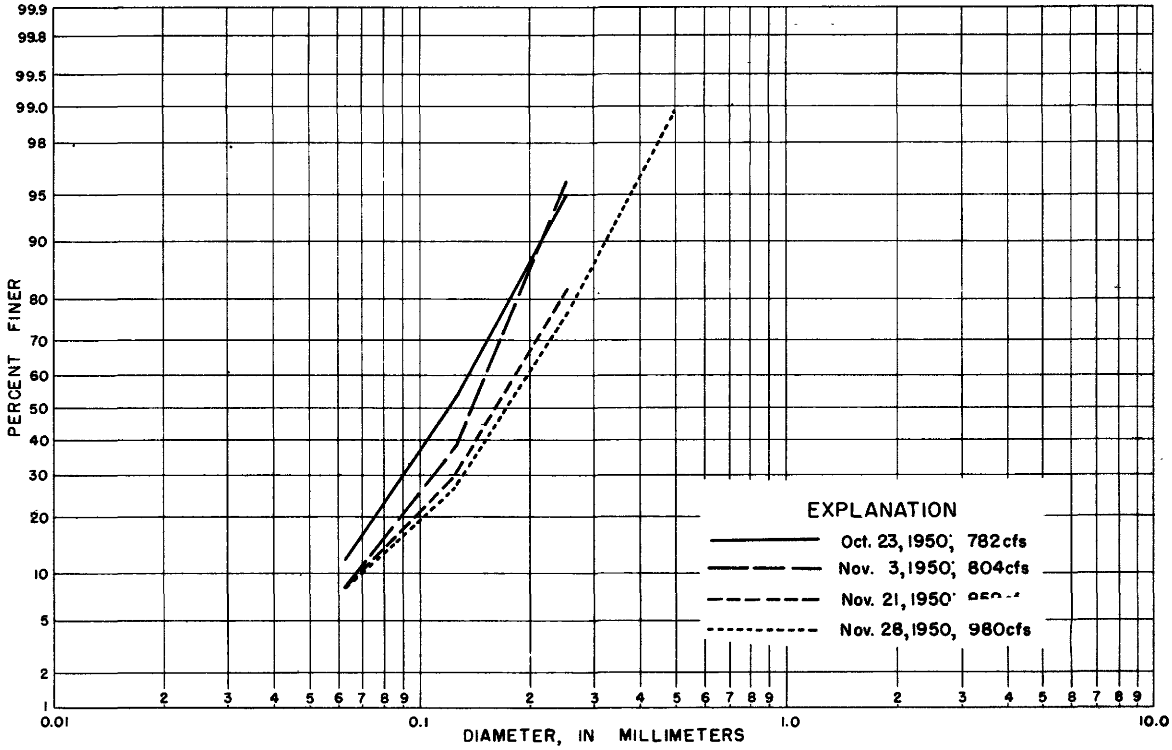

Figure 40.--Particle-size analyses of suspended sediment of the Niobrara River near Sparks.

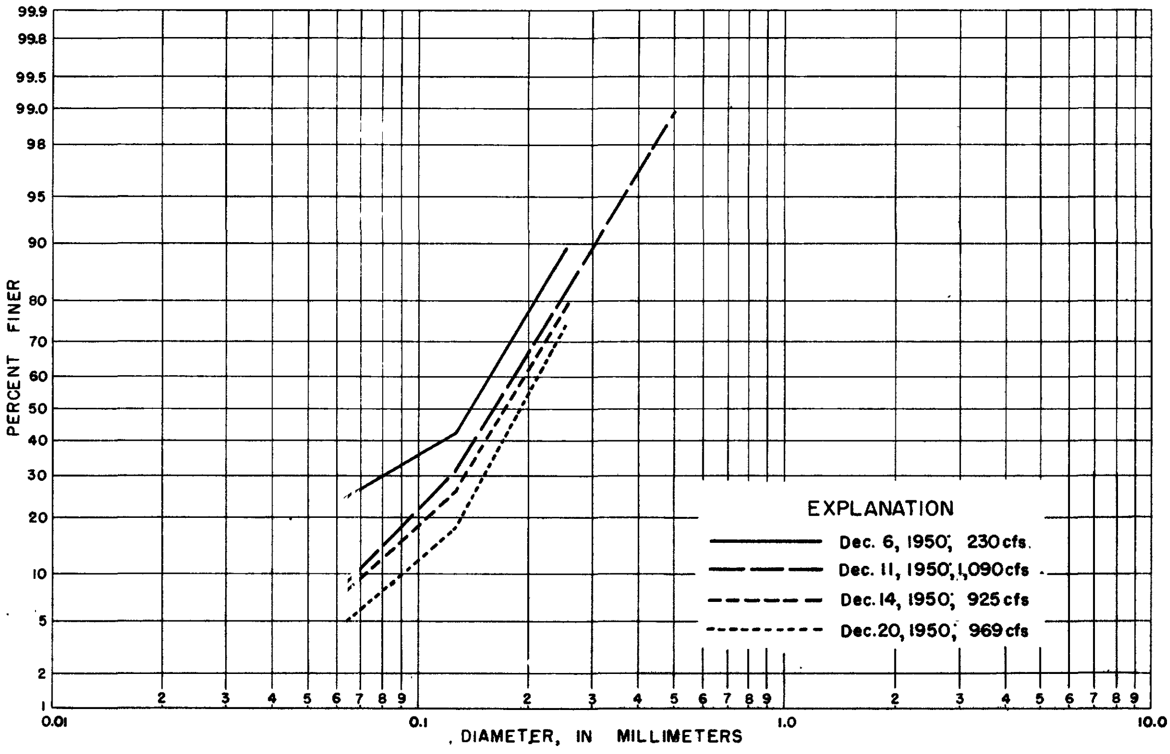

Figure 41.--Particle-size analyses of suspended sediment of the Niobrara River near Sparks.

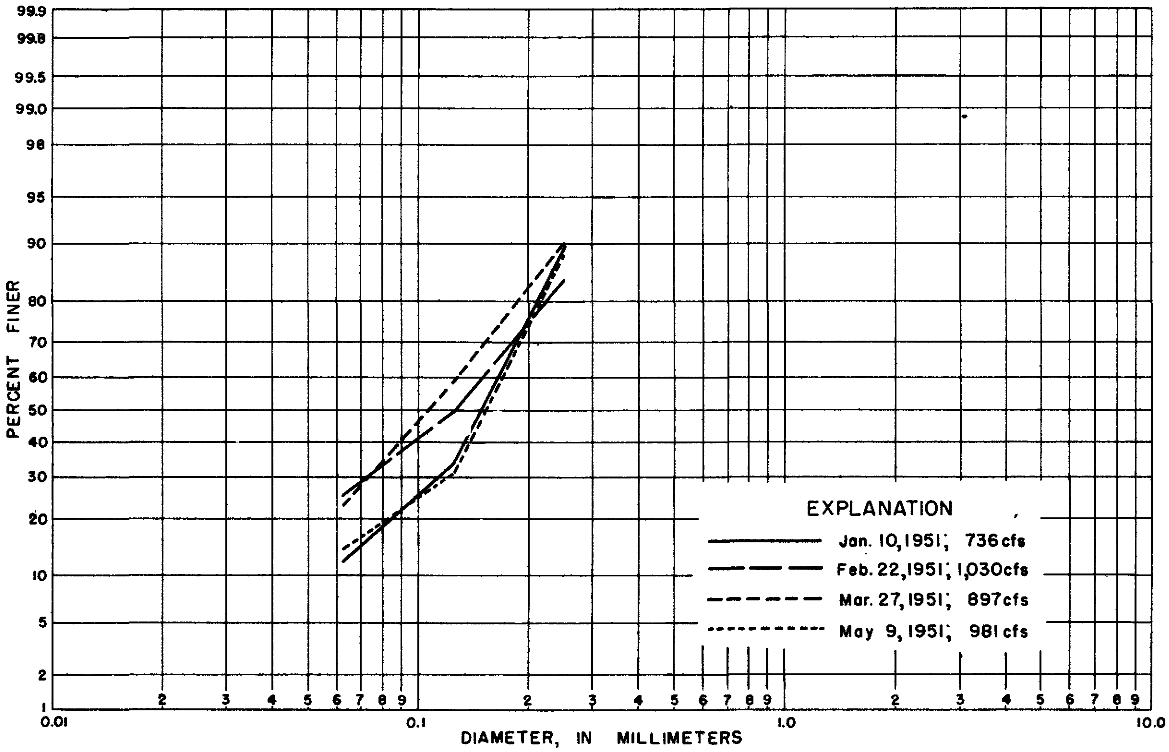

Figure 42.--Particle-size analyses of suspended sediment of the Niobrara River near Sparks.

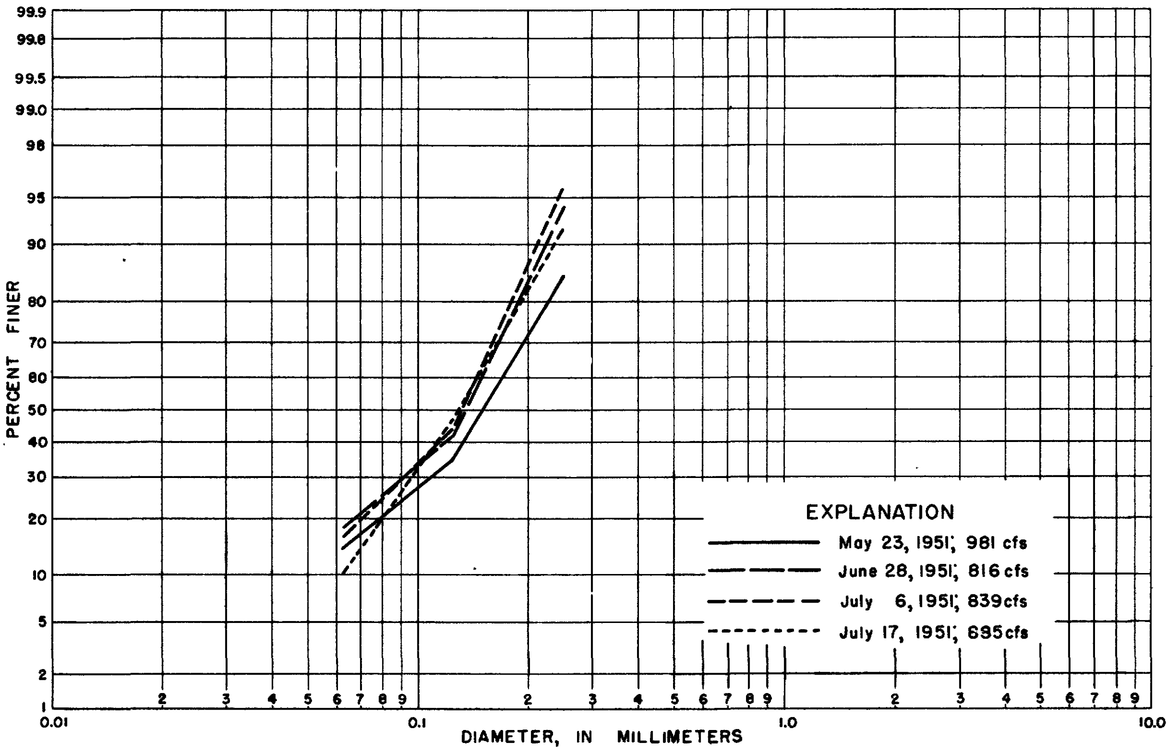

Figure 43.--Particle-size analyses of suspended sediment of the Niobrara River near Sparks.

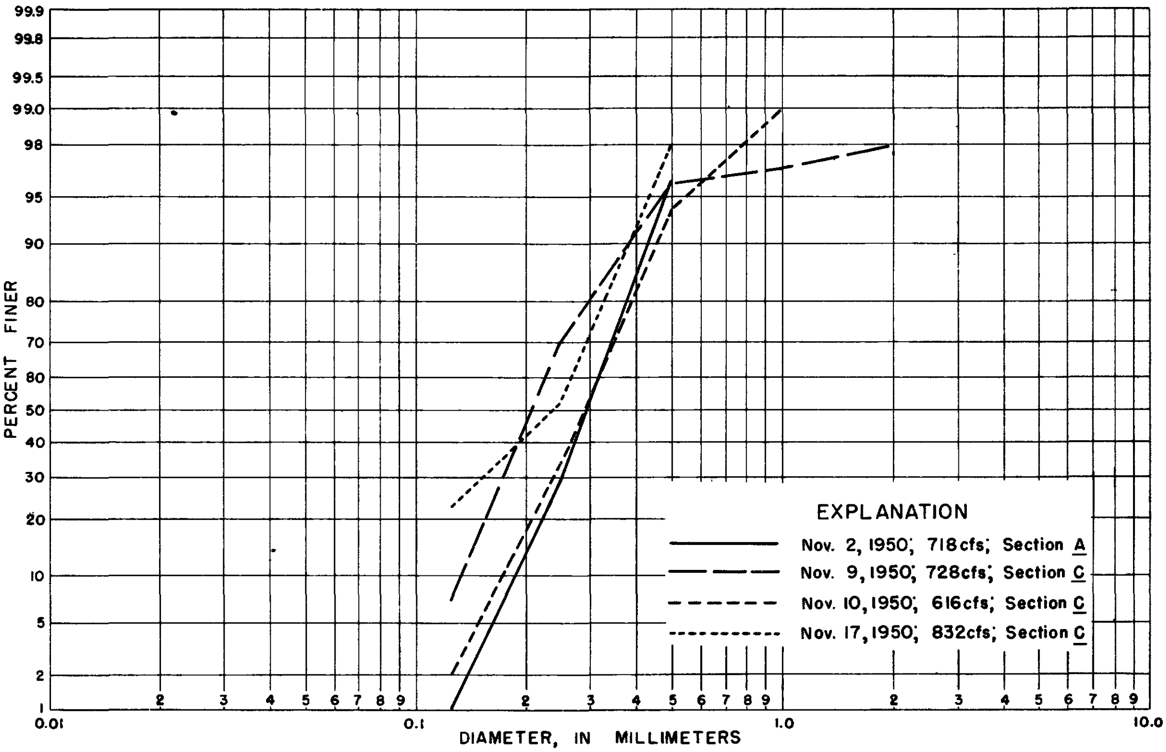

Figure 44.--Particle-size analyses of bed material of the Niobrara River near Valentine.

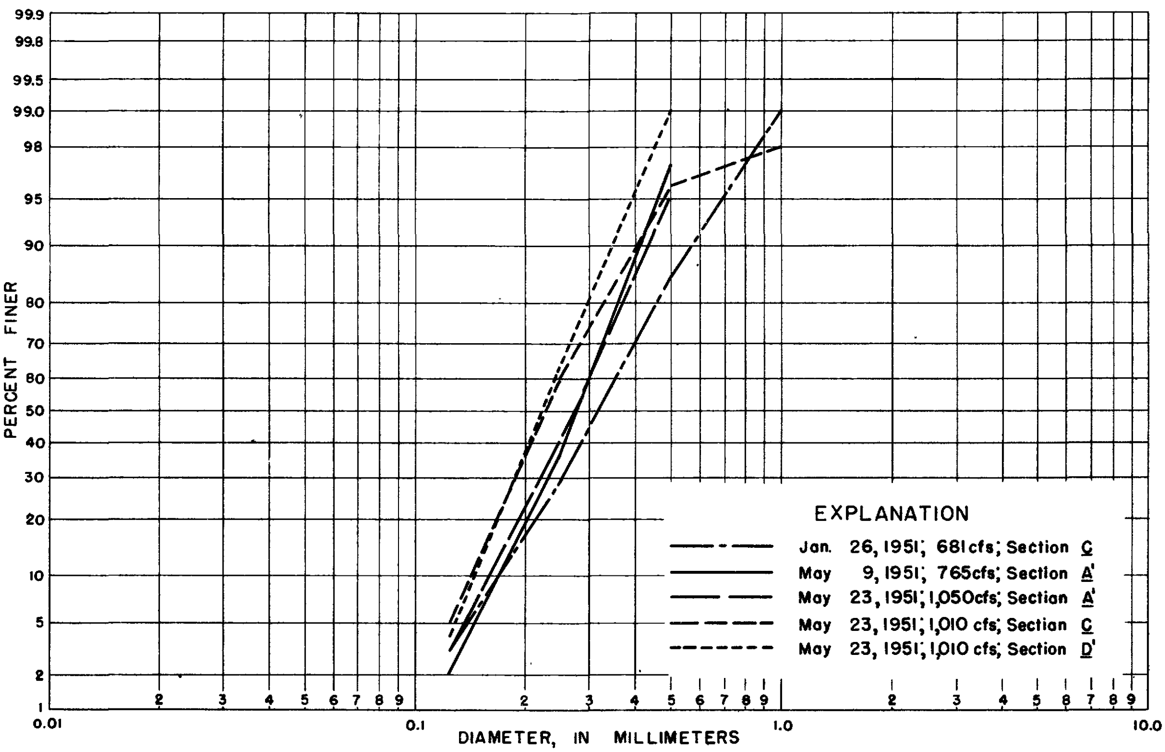

Figure 45.--Particle-size analyses of bed material of the Niobrara River near Valentine.

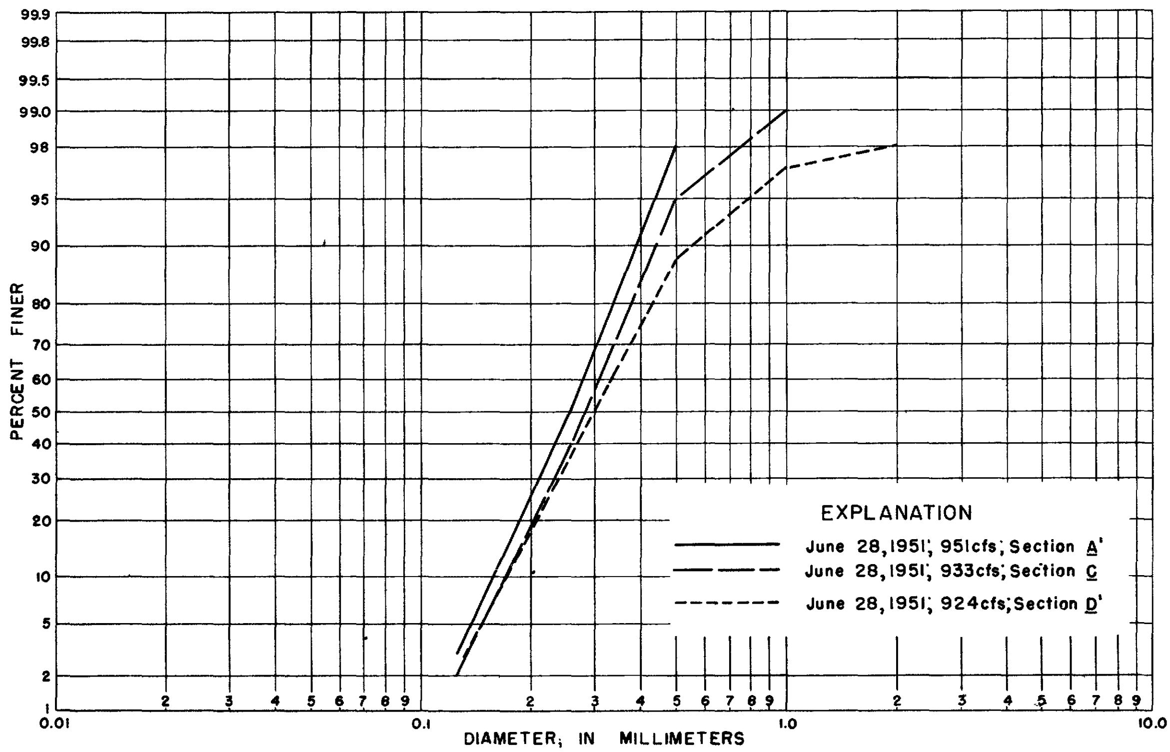

Figure 46.--Particle-size analyses of bed material of the Niobrara River near Valentine.

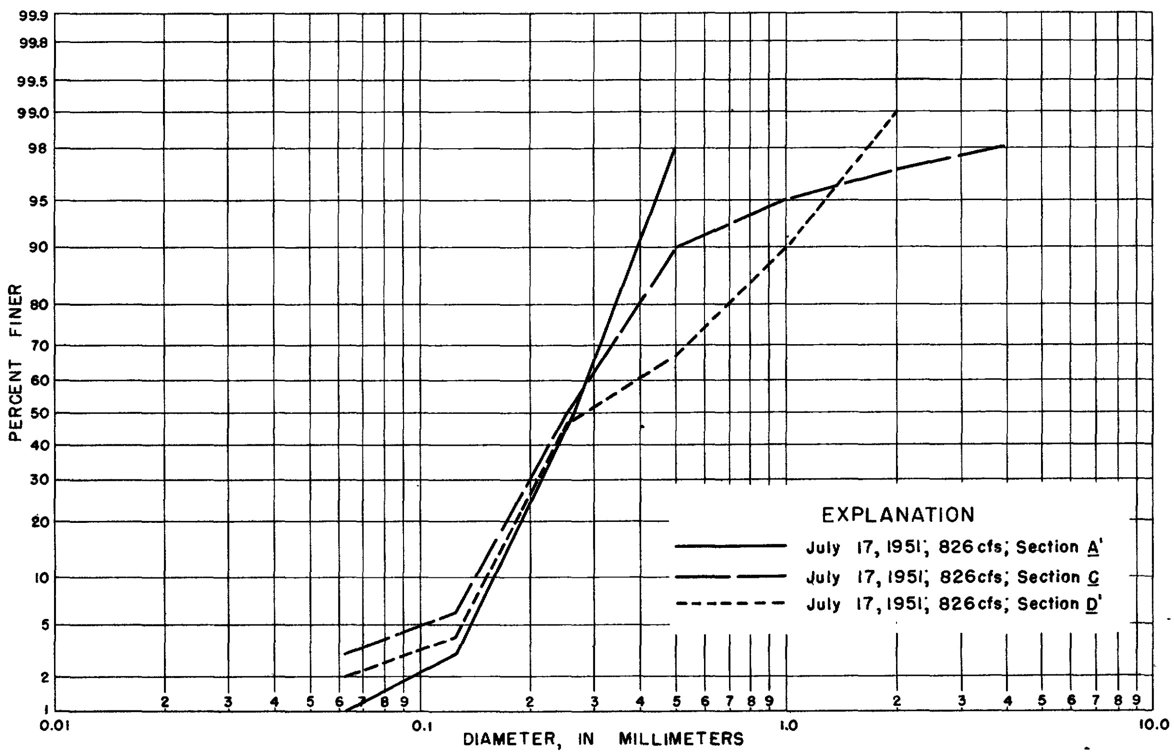

Figure 47.--Particle-size analyses of bed material of the Niobrara River near Valentine.

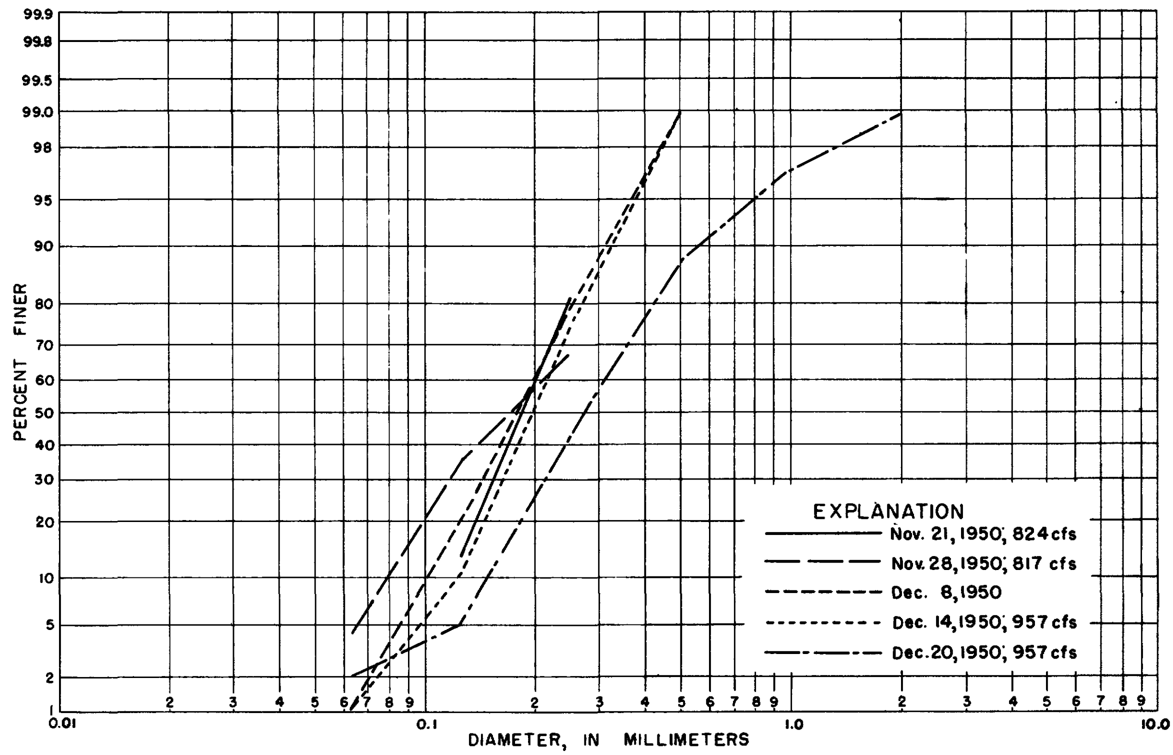

Figure 48.--Particle-size analyses of bed material of the Niobrara River near Sparks.

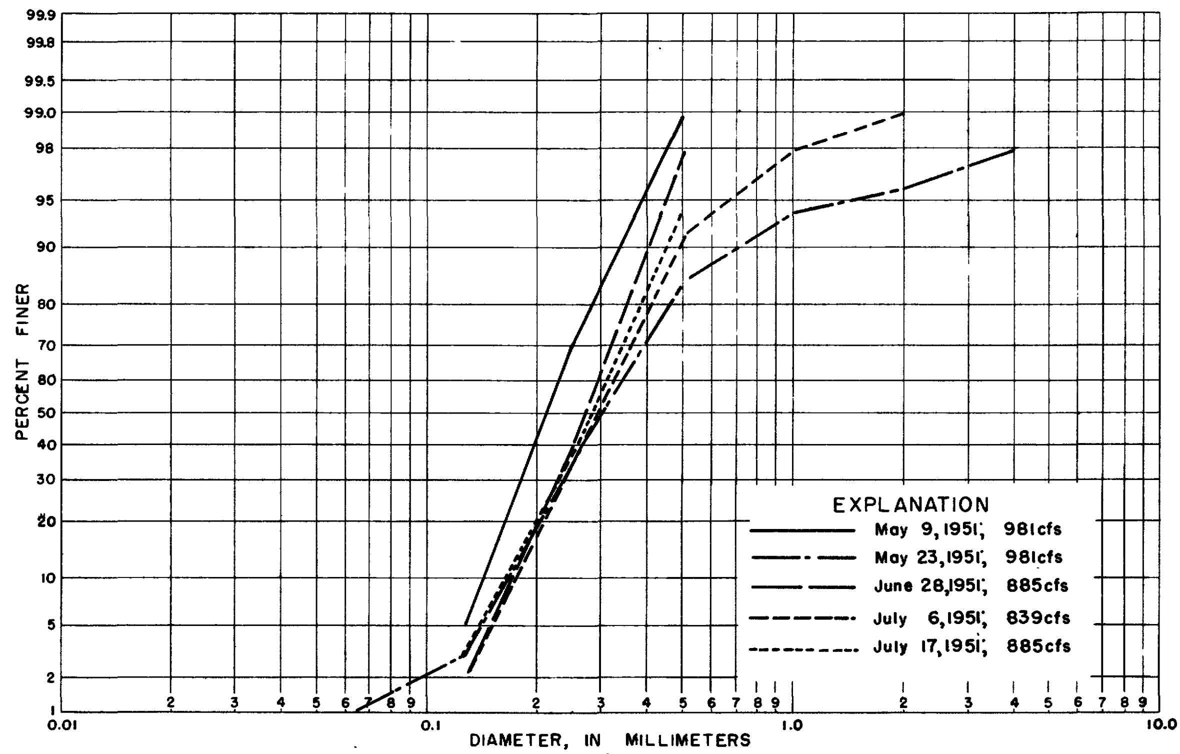

Figure 49.--Particle-size analyses of bed material of the Niobrara River near Sparks.

When the equation is solved for P_u, the computed size distribution compares favorably with the measured size distribution of bed material from the Sparks station, as shown by the following table. This favorable comparison may indicate that the computed size distribution of the material that moves as unmeasured load is reasonably accurate.

Average particle size of sediments of the Niobrara River near Sparks for the periods Nov. 2 to 17, 1950, and May 8 to July 17, 1951

Type and location of sampling	Percent finer than indicated size (mm)		
	0.125	0.25	0.5
Suspended sediment at Sparks gaging section	41	92	100
Suspended sediment at contracted section B	18	68	96
Unmeasured load at Sparks gaging section	2	51	93
Bed material at Sparks gaging section	3	45	94

CONCLUSIONS

1. During the periods November 2 to 17, 1950, and May 8 to July 17, 1951, nearly all the sediment was probably in suspension at the contracted section, section B, although a small amount of sediment may have moved through the contracted section as unmeasured load during May, June, and July, 1951. At times during the winter when the flow was exceptionally low or there was backwater from ice, appreciable quantities of sediment may have been discharged through section B as unmeasured load.

2. Twenty-one determinations of suspended-sediment concentration at the normal sections A, A', C, D', and D averaged 47 percent of the concentration at section B at comparable times. Thus at the times of measurement an average of about 53 percent of the total sediment load of the Niobrara River near Valentine was discharged as unmeasured load through the normal sections. During other seasons and at other rates of water discharge the percentage of sediment that moves as unmeasured load might be considerably different.

3. The characteristics of sediment discharge gradually changed during the winter months while the periodic flushing of the upstream reservoirs was discontinued. Theoretically, the low concentrations at the outlets of the unflushed reservoirs should begin to increase downstream by the scouring of the finer materials from the stream bed. Both the rate of degradation and the particle sizes of the bed material should decrease downstream, but the concentration should increase downstream. However, even as far downstream as the Sparks gage the concentration may be lower than normal. The greater observed suspended-sediment concentrations at the Sparks gaging station than at the contracted section B show that the stream bed in this reach was degrading during the winter. The few samples of bed material collected during the winter seem to show the expected decrease of particle size from the normal sections near Valentine to the Sparks gage.

4. Six determinations of suspended-sediment concentration at the Sparks gaging station averaged 41 percent of the concentration at section B at comparable times. The standard error of the mean for this average indicates that there is 1 chance in 20 that the actual average would be less than 31 percent or greater than 51 percent. The standard error of the mean may not be very significant for a small sample of this type. Other errors may be more significant than sampling errors.

   At the times of measurement an average of about 59 percent of the total sediment load was transported as unmeasured load at the Sparks gage. The average percentage of unmeasured load may be different at other times or at other rates of water discharge. Certainly during the winter the suspended-sediment concentration at the Sparks gaging station was a much larger percentage of the concentration at section B than during the summer.

5. The computed particle sizes of the sediment that moved as unmeasured load at the normal sections near Valentine, but was presumably suspended in the contracted section, were slightly smaller than the average particle sizes in the samples of the bed material. Only small amounts of material coarser than 0.5 mm were found either in the suspended sediment or the bed material.

6. During this investigation certain items of base data that were not obtained would have been useful particularly in explaining the results in terms of theories of sediment transportation. Some of these are:

   a. A continuous gage-height record from a water-stage recorder installed at the staff gage site above the contraction.

   b. Water-surface slopes and enough cross sections at each normal section near the contraction to determine the energy gradient even though the Niobrara River is not a strictly alluvial stream at all sections near Valentine.

   c. Occasional point-integrated samples at the normal sections near the contraction and at the measuring sections at the Sparks gaging station. These data would help to define vertical distributions of velocity, concentration, and particle size and to indicate approximate amounts of unmeasured sediment that is carried in suspension below the sampling range of depth-integrating samplers.

d. Daily suspended-sediment samples at the contracted section and at the Sparks gaging station.

e. A few series of samples of suspended sediment and of bed material every mile or two from just below the dam on the Niobrara River near Valentine to the Sparks gaging station.

f. Soundings in the chute to locate any possible areas of deposition, undercutting, or other changes in the channel cross section.

TABLES

Table 1.--Discharge measurements of the Niobrara River above Buffalo Bridge, near Valentine, Nebr., during the year ending Sept. 30, 1951

Date	Made by	Width (feet)	Area (sq ft)	Mean velocity (fps)	Gage [1] height (feet)	Discharge (cfs)	Method	Meas. secs. (no.)	Gage-height change (feet)	Time (mst)	Meas. rated	Remarks
Nov. 2, 1950	Matejka, Raitt	142	198	3.54	------	701	0.6, .2-.8	-----	------	10:15 a.m.	Good	Section A.
Do	McKim, Zellers	191	225	3.19	------	718	.6, .2-.8	-----	------	10:45 a.m.	Good	Section C̄.
Nov. 3	Raitt, Walker	140	219	3.58	------	843	.6, .2-.8	31	------	9:50 a.m.	-----	Section Ā.
Do	Whitsel, Zentner	190	239	3.36	------	804	.6, .2-.8	42	------	11:00 a.m.	-----	Section C.
Do	-----do-----	137	224	3.76	------	840	.6, .2-.8	-----	------	2:25 p.m.	-----	Section A.
Do	Raitt, Wertenberger	156	247	3.42	------	845	.6, .2-.8	34	------	3:00 p.m.	-----	Section D̄.
Nov. 9	Thrun, Wark	196	228	3.20	0.56	728	.5, .6	20	-0.12	3:15 p.m.	Good	Section C̄.
Nov. 10	-----do-----	30.5	80.8	5.97	.26	482	.6, .2-.8	14	+.04	8:40 a.m.	Fair	Section B̄.
Do	-----do-----	195	192	3.22	.40	616	.6, .2-.8	22	+.16	12:15 p.m.	Good	Section C.
Nov. 17	Macias, Raitt	200	232	3.60	------	832	.6, .2-.8	29	------	12:50 p.m.	-----	Do.
Nov. 21	Matejka, McKim, Raitt	32	119	6.54	.63	778	.6, .2-.8	17	+.02	8:35 a.m.	Good	Section B.
Nov. 22	Matejka, McKim	32	115	7.28	.67	835	.6, .2-.8	17	+.08	9:15 a.m.	Fair	Do.
Nov. 28	McKim, Raitt, Whitsel	31	113	8.34	1.07	941	.6, .2-.8	16	-.06	10:00 a.m.	Fair	Do.
Nov. 29	McKim, Whitsel	32	124	8.30	1.08	1,030	.6, .2-.8	18	+.03	1:50 p.m.	Fair	Do.
Nov. 30	-----do-----	32	121	7.06	.91	855	.6, .2-.8	17	-.07	9:15 a.m.	Good	Do.
Dec. 1	-----do-----	32	116	7.92	.87	916	.6, .2-.8	-----	-.05	10:55 a.m.	Good	Do.
Dec. 4	Raitt, Whitsel	31	110	5.40	.85	590	.6, .2-.8	17	-.06	2:30 p.m.	-----	Do.
Dec. 6	McKim, Miller, Raitt	31	72.3	3.28	.12	237	.6	13	+.10	2:20 p.m.	Poor	Do.
Dec. 7	-----do-----	31	92.6	4.11	.59	378	.6, .2-.8	13	-.14	10:20 a.m.	Poor	Do.
Dec. 8	-----do-----	31	110	5.00	1.28	550	.6, .2-.8	13	0	9:20 a.m.	Poor	Do.
Dec. 11	Raitt, Wark, Whitsel	31.5	130	8.69	1.46	1,130	.6, .2-.8	15	+.03	2:55 p.m.	Fair	Do.
Dec. 12	Wark, Whitsel	31.5	130	8.77	1.45	1,140	.6, .2-.8	15	-.08	2:00 p.m.	Fair	Do.
Dec. 13	Raitt, Wark	31	133	7.76	1.62	1,040	.6, .2-.8	15	-.30	9:50 a.m.	Poor	Do.
Do	-----do-----	31.5	132	8.12	1.44	1,070	.6, .2-.8	15	-.09	11:30 a.m.	Fair	Do.
Dec. 14	Busalacchi, Wark, Raitt	34.5	143	7.76	1.62	1,110	.6, .2-.8	17	-.33	9:40 a.m.	Fair	Do.
Dec. 15	Raitt, Wark	33	136	6.90	1.64	939	.6, .2-.8	15	-.14	10:05 a.m.	Poor	Do.
Dec. 19	McKim, Whitsel	32	119	8.24	1.22	984	.6, .2-.8	17	-.10	2:30 p.m.	Fair	Do.
Dec. 20	-----do-----	32	117	8.43	1.14	986	.6, .2-.8	17	0	3:00 p.m.	Fair	Do.
Dec. 21	McKim, Vice, Whitsel	33	122	7.74	1.11	944	.6, .2-.8	18	-.09	9:40 a.m.	Fair	Do.
Do	McKim, Whitsel	190	309	3.07	1.26	949	.6, .2-.8	34	+.01	2:15 p.m.	Good	Section C.
Dec. 22	McKim, Vice, Whitsel	33	136	7.17	1.40	974	.6, .2-.8	17	-.36	9:50 a.m.	Fair	Section B̄.
Jan. 26, 1951	Colby, Evjen, Wark	35	138	6.70	1.61	924	.6, .2-.8	19	-.26	9:30 a.m.	Poor	Do.
Do	-----do-----	199	318	2.56	1.53	813	0.5, .6, .2-.8	31	-.22	9:50 a.m.	Good	Section C.
May 8	Whitsel	200	200	3.76	------	750	.6, .2-.8	43	------	11:20 a.m.	-----	Do.
Do	Hubbell, Wark	40	127	6.01	-.18	763	.6, .2-.8	33	-.19	4:05 p.m.	Fair	Section B.
May 9	Steele, Whitsel	143	201	3.73	------	750	.6, .2-.8	31	------	9:45 a.m.	-----	Section D̄'.
Do	Hubbell, Wark	147	200	3.70	-.19	741	.6, .2-.8	37	-.01	8:50 a.m.	Good	Section A'.
Do	-----do-----	201	206	3.68	-.14	758	.6, .2-.8	42	+.09	10:30 a.m.	Good	Section C̄.
May 23	Chadwick, Whitsel	149	277	3.76	.30	1,040	.6, .2-.8	30	0	9:05 a.m.	Fair	Section Ā'.
Do	Chadwick, Davis	39	150	6.94	.33	1,040	.2-.8	21	0	8:45 a.m.	Fair	Section B.

June 28 -----	Raitt, Whitsel --------	150	270	3.52	.07	949	.6, .2-.8	32	0	9:31 a.m.	Good	Section A'.
Do --------	Anderson, Hubbell -----	40	155	6.11	.07	949	s, .6, .2-.8	35	-.06	10:10 a.m.	Good	Section B.
July 17 -----	Wark, Whitsel ---------	43.5	165	6.00	.13	990	.6, .2-.8	23	-.04	9:35 a.m.	Fair	Do.
Do --------	Raitt, Whitsel --------	149	264	3.44	.10	908	.6, .2-.8	26	-.06	10:00 a.m.	Fair	Section A'.

[1] Staff gage located on right bank 650 ft above Fish and Wildlife Service Buffalo Bridge.

Note.--Employees of Bureau of Reclamation are J. Busalacchi, F. G. Macias, C. R. Miller, D. B. Raitt, D. Walker, R. Wertenberger, G. J. Whitsel, and K. Zentner.

Table 2.--Discharge measurements of the Niobrara River near Sparks, Nebr., during the year ending Sept. 30, 1951

Date	Made by	Width (feet)	Area (sq ft)	Mean velocity (fps)	Gage height (feet)	Dis-charge (cfs)	Method	Meas. secs. (no.)	Gage-height change (feet)	Time (mst)	Meas. rated	Remarks
Oct. 23, 1950	Zellars ---------------	165	231	3.55	2.95	819	0.5, .6, .2-.8	36	------	11:30 a.m.	-----	300 ft below gage.
Nov. 3 ------	Macias, Zellars -------	166	228	3.43	2.94	781	.6, .2-.8	37	+0.01	10:35 a.m.	Good	100 ft below gage.
Nov. 17 -----	Zellars ---------------	164	229	3.60	2.93	825	.6, .2-.8	37	------	12:50 p.m.	-----	350 ft below gage.
Nov. 21 -----	Matejka, McKim, Raitt -	139	231	3.71	2.93	859	.6, .2-.8	28	+.02	1:30 p.m.	Good	Downstream side of bridge, 15 ft above gage.
Nov. 28 -----	McKim, Raitt, Whitsel -	140	255	4.00	3.02	1,020	.6, .2-.8	28	-.01	1:25 p.m.	-----	Do.
Dec. 11 -----	Zellars ---------------	138	265	3.66	3.22	971	s,.5,.6, .2-.8	28	------	10:30 a.m.	-----	Do.
Dec. 14 -----	Busalacchi, Raitt, Wark	142	277	3.61	3.11	1,000	.6, .2-.8	22	-.06	12:35 p.m.	Fair	Do.
Dec. 20 -----	McKim, Whitsel --------	127	252	3.78	3.05	953	.6, .2-.8	27	-.02	11:00 a.m.	Good	Do.
Dec. 22 -----	Zellars ---------------	164	256	3.74	3.06	959	.6, .2-.8	37	------	10:35 a.m.	-----	350 ft below gage.
Jan. 10, 1951	-----do----------------	160	302	2.77	3.23	836	.6, .2-.8	34	-.07	11:35 a.m.	-----	300 ft below gage.
Jan. 26 -----	-----do----------------	160	289	2.91	3.14	841	.6, .2-.8	33	-.08	12:07 p.m.	-----	Do.
Feb. 22 -----	-----do----------------	160	324	3.15	3.29	1,020	.6, .2-.8	35	0	12:50 p.m.	-----	Do.
Mar. 9 ------	Blessum, Caughran -----	136	188	2.77	2.56	521	.6, .2-.8	34	-.02	11:25 a.m.	Good	Do.
Mar. 23 -----	Blessum ---------------	140	309	3.72	3.08	1,150	.5, .6	30	+.07	1:25 p.m.	Poor	Downstream side of bridge, 15 ft above gage.
Mar. 27 -----	Blessum, Raitt --------	140	316	4.27	3.30	1,350	.6, .2-.8	31	+.04	11:13 a.m.	Fair	Do.
Apr. 9 ------	Zellars ---------------	163	244	3.66	2.94	893	.5, .6, .2-.8	35	0	10:20 a.m.	-----	300 ft below gage.
Apr. 30 -----	-----do----------------	163	259	3.76	3.06	974	.6, .2-.8	35	-.02	12:10 p.m.	-----	250 ft below gage.
May 7 -------	-----do----------------	161	222	3.41	2.87	758	.6, .2-.8	36	+.04	11:42 a.m.	-----	Do.
May 9 -------	Wark, Hubbell, Steele, Whitsel --------------	145	261	3.62	2.93	923	.6	30	+.03	3:48 p.m.	Fair	Downstream side of bridge, 15 ft above gage.
May 23 ------	Davis, Chadwick, Raitt, Whitsel --------------	138	270	3.92	3.09	1,060	.6, .2-.8	31	-.01	2:33 p.m.	Good	Do.
May 26 ------	Zellars ---------------	165	251	3.74	3.04	940	.6, .2-.8	36	0	10:35 a.m.	-----	250 ft below gage.
June 8 ------	-----do----------------	165	249	3.49	2.97	869	.6, .2-.8	39	+.02	10:03 a.m.	-----	300 ft below gage.
June 22 -----	-----do----------------	164	264	3.90	3.21	1,030	.6, .2-.8	42	+.02	10:45 a.m.	-----	250 ft below gage.
June 28 -----	Raitt, Whitsel --------	138	234	4.15	3.06	971	.5, .6	26	-.01	3:57 p.m.	Good	Downstream side of bridge, 15 ft above gage.
July 6 ------	Zellars ---------------	139	212	4.00	3.04	848	.5, .6, .2-.8	37	+.02	9:48 a.m.	-----	Do.
July 17 -----	Raitt, Wark, Whitsel --	140	239	3.77	3.10	900	.6, .2-.8	25	+.01	2:30 p.m.	Fair	Do.

Note.--Employees of Bureau of Reclamation are J. Busalacchi, F. G. Macias, D. B. Raitt, R. Steele, and G. J. Whitsel.

Table 3.--Sediment discharge measurements of the Niobrara River near Valentine, Nebr. (contracted section)

Date	Time (mst)	Water discharge (cfs)	Suspended sediment		Gage height[1]
			Mean concentration (ppm)	Discharge (tons per day)	
Nov. 2, 1950	2:30 p.m.	b 718	1,560	3,020	-------
Nov. 3	10:00 a.m.	b 804	2,030	4,410	-------
Do	1:00 p.m.	bb 824	1,790	3,980	-------
Nov. 8	12:45 p.m.	-----------	c 1,510	---------------	1.34
Nov. 9	2:15 p.m.	782	2,210	4,670	.62
Nov. 10	9:40 a.m.	502	1,990	2,700	.28
Nov. 17	9:30 a.m.	-----------	2,410	---------------	.76
Nov. 21	10:00 a.m.	816	1,800	3,960	.66
Do	4:00 p.m.	969	1,210	3,170	.84
Nov. 22	8:10 a.m.	790	1,810	3,860	.63
Do	10:30 a.m.	790	1,540	3,280	.63
Nov. 28	11:15 a.m.	858	1,850	4,290	.97
Do	4:40 p.m.	1,330	1,350	4,850	1.41
Nov. 29	10:10 a.m.	867	1,710	4,000	.89
Do	3:05 p.m.	1,080	1,500	4,370	1.14
Dec. 1	8:55 a.m.	918	1,320	3,270	.87
Do	12:00 m.	944	1,770	4,510	.90
Dec. 4	11:20 a.m.	638	440	758	.91
Dec. 5	2:10 p.m.	222	1,770	1,060	.16
Dec. 6	3:30 p.m.	250	830	560	.21
Dec. 8	10:25 a.m.	605	510	833	1.41
Do	4:25 p.m.	589	1,260	2,000	1.39
Dec. 11	10:10 a.m.	918	670	1,660	1.22
Do	3:50 p.m.	1,150	690	2,140	1.48
Dec. 12	10:00 a.m.	1,050	610	1,730	1.35
Do	3:10 p.m.	1,070	560	1,620	1.38
Dec. 13	10:40 a.m.	1,050	440	1,250	1.49
Do	4:45 p.m.	1,030	690	1,920	1.22
Dec. 14	8:40 a.m.	1,100	340	1,010	1.94
Do	4:00 p.m.	850	700	1,610	1.16
Dec. 15	8:40 a.m.	935	120	303	1.88
Do	11:00 a.m.	935	150	379	1.52
Dec. 19	10:05 a.m.	1,000	130	351	1.44
Do	4:00 p.m.	978	510	1,350	1.15
Dec. 20	9:15 a.m.	1,000	210	567	1.45
Do	4:00 p.m.	978	670	1,770	1.15
Dec. 21	8:45 a.m.	916	350	866	1.23
Do	3:45 p.m.	952	620	1,590	1.26
Dec. 22	8:40 a.m.	960	120	311	1.65
Do	11:20 a.m.	1,000	770	2,080	.97
Jan. 26, 1951	10:50 a.m.	681	247	454	1.40
May 8	5:10 p.m.	842	1,640	3,730	-.09
May 9	12:00 m.	771	2,040	4,250	-.10
May 23	11:30 a.m.	1,010	1,880	5,130	.30
June 28	12:25 p.m.	952	1,680	4,320	.07
July 17	11:40 a.m.	826	2,080	4,640	.02

b Discharge measurement.
bb Discharge is average from two measurements made on this day.
c For one vertical only.
[1] Staff gage located on right bank 650 ft above Fish and Wildlife Service Buffalo Bridge.

Table 4.--Sediment discharge measurements of the Niobrara River near Valentine, Nebr. (normal sections)

Date	Time (mst)	Water discharge (cfs)	Suspended sediment		Water temperature (°F)	Gage height [1]
			Mean concentration (ppm)	Discharge (tons per day)		
Nov. 2, 1950 ---	11:30 a.m.	b 701	780	A 1,480	-----------	------
Do -----------	1:00 p.m.	b 718	770	C 1,490	-----------	------
Nov. 3 ---------	11:00 a.m.	b 843	700	A 1,590	-----------	------
Do -----------	12:00 m.	b 804	1,040	C 2,260	-----------	------
Do -----------	3:15 p.m.	b 840	1,340	A 3,040	-----------	------
Do -----------	3:30 p.m.	b 845	750	D 1,710	-----------	------
Nov. 9 ---------	4:00 p.m.	b 728	1,400	C 2,750	-----------	0.50
Nov. 10 --------	1:00 p.m.	b 616	1,000	C 1,660	-----------	.48
Nov. 17 --------	1:45 p.m.	b 832	1,440	C 3,230	-----------	------
Jan. 26, 1951 --	10:30 a.m.	681	218	C 401	-----------	1.40
May 8 ----------	1:00 p.m.	790	811	C 1,730	-----------	-.15
May 9 ----------	11:55 a.m.	774	758	C 1,580	-----------	-.10
Do -----------	12:15 p.m.	765	881	A' 1,820	-----------	-.10
Do -----------	1:00 p.m.	757	c 2,680	D' 5,480	-----------	-.10
May 23 ---------	11:15 a.m.	1,050	602	A' 1,710	-----------	.34
Do -----------	11:40 a.m.	1,010	563	C 1,540	-----------	.30
June 28 --------	10:40 a.m.	951	752	A' 1,930	67	.07
Do -----------	12:30 p.m.	933	490	C 1,230	70	.05
Do -----------	2:20 p.m.	924	566	D' 1,410	-----------	.04
July 17 --------	11:40 a.m.	826	982	A' 2,190	-----------	.02
Do -----------	12:40 p.m.	826	683	C 1,520	-----------	.02
Do -----------	1:10 p.m.	826	808	D' 1,800	-----------	.02

b Discharge measurement.
c This sample apparently contained bed material.
[1] Staff gage located on right bank 650 ft above Fish and Wildlife Service Buffalo Bridge.
Note.--Capital letters indicate sections.

Table 5.--Sediment discharge measurements of the Niobrara River near Sparks, Nebr.

Date	Time (mst)	Water discharge (cfs)	Suspended sediment		Water temperature (°F)	Gage height
			Mean concentration (ppm)	Discharge (tons per day)		
Oct. 23, 1950 --	1:40 p.m.	793	700	1,500	-----------	2.92
Nov. 3 ---------	11:40 a.m.	816	760	1,670	-----------	2.94
Nov. 17 --------	1:40 p.m.	782	920	1,940	-----------	2.91
Nov. 21 --------	2:30 p.m.	804	1,240	2,690	-----------	2.93
Nov. 28 --------	2:25 p.m.	817	1,530	3,370	-----------	2.99
Dec. 6 ---------	11:35 a.m.	a 250	140	94	-----------	------
Dec. 11 --------	12:20 p.m.	1,140	1,490	4,590	-----------	3.32
Dec. 14 --------	2:40 p.m.	957	1,060	2,740	-----------	3.06
Dec. 20 --------	12:35 p.m.	957	1,020	2,640	-----------	3.06
Dec. 22 --------	12:40 p.m.	687	700	1,300	-----------	2.82
Jan. 10, 1951 --	1:35 p.m.	736	237	471	-----------	3.13
Jan. 26 --------	1:00 p.m.	768	140	290	-----------	3.07
Feb. 22 --------	2:45 p.m.	1,040	293	823	-----------	3.30
Mar. 9 ---------	12:15 p.m.	517	520	726	-----------	2.55
Mar. 27 --------	1:30 p.m.	897	1,900	4,600	49	2.92
Apr. 9 ---------	12:20 p.m.	885	560	1,340	-----------	2.91
Apr. 30 --------	1:50 p.m.	897	558	1,350	-----------	3.01
May 7 ----------	1:35 p.m.	770	580	1,210	-----------	2.90
May 9 ----------	7:10 p.m.	981	1,240	3,280	-----------	3.08
May 23 ---------	4:00 p.m.	981	1,010	2,680	-----------	3.08
May 26 ---------	12:15 p.m.	933	528	1,330	-----------	3.04
June 8 ---------	11:40 a.m.	885	1,490	3,560	-----------	3.00
June 22 --------	12:40 p.m.	1,020	697	1,920	-----------	3.20
June 28 --------	5:00 p.m.	885	608	1,450	-----------	3.03
July 6 ---------	12:30 p.m.	839	510	1,160	-----------	3.05
July 17 --------	3:30 p.m.	885	608	1,450	-----------	3.09

a Mean daily discharge.

Table 6.--Comparison of suspended-sediment concentrations of measuring sections of the Niobrara River near Valentine and Sparks, Nebr., from Nov. 2, 1950, to July 17, 1951

Date	Section B		For comparison		Section A			Section C			Section D			Sparks gaging station		
	Time (mst)	Concentration (ppm)	Time (mst)	Estimated concentration (ppm)	Time (mst)	Concentration (ppm)	Percentage of concentration at section B	Time (mst)	Concentration (ppm)	Percentage of concentration at section B	Time (mst)	Concentration (ppm)	Percentage of concentration at section B	Time (mst)	Concentration (ppm)	Percentage of concentration at section B
Nov. 2			11:30 a.m.	1,560	11:30 a.m.	780	50									
Do			1:00 p.m.	1,560				1:00 p.m.	770	49						
Do	2:30 p.m.	1,560														
Nov. 3			9:40 a.m.	2,040										11:40 a.m.	760	37
Do	10:00 a.m.	2,030														
Do			11:00 a.m.	1,960	11:00 a.m.	700	36									
Do			12:00 m.	1,880				12:00 m.	1,040	55						
Do	1:00 p.m.	1,790														
Do			3:10 p.m.	1,740												
Do			3:15 p.m.	1,750	3:15 p.m.	1,340	77				3:30 p.m.	750	43			
Nov. 9	2:15 p.m.	2,210														
Do			4:00 p.m.	2,210				4:00 p.m.	1,400	63						
Nov. 10	9:40 a.m.	1,990														
Do			1:00 p.m.	1,900				1:00 p.m.	1,000	53						
Nov. 17	9:30 a.m.	2,410														
Do			11:40 a.m.	2,400										1:40 p.m.	920	38
Do			1:45 p.m.	2,400				1:45 p.m.	1,440	60						
Nov. 21	10:00 a.m.	1,800														
Do			12:30 p.m.	1,500										2:30 p.m.	1,240	83
Do	4:00 p.m.	1,210														
Nov. 22	8:10 a.m.	1,810														
Do	10:30 a.m.	1,540														
Nov. 28	11:15 a.m.	1,850														
Do			12:25 p.m.	1,780										2:25 p.m.	1,530	86
Do	4:40 p.m.	1,350														
Nov. 29	10:10 a.m.	1,710														
Do	3:05 p.m.	1,500														
Nov. 30	2:30 p.m.	a 2,040														
Dec. 1	8:55 a.m.	1,320														
Do	12:00 m.	1,770														
Dec. 4	11:20 a.m.	440														
Do	2:10 p.m.	1,770														
Dec. 6			9:35 a.m.	840										11:35 a.m.	140	17
Do	3:30 p.m.	830														
Dec. 7	1:25 p.m.	a 1,490														
Dec. 8	10:25 a.m.	510														
Do	4:25 p.m.	1,260														
Dec. 11	10:10 a.m.	670														
Do			10:20 a.m.	670										12:20 p.m.	1,490	222

Do	3:50 p.m.	690														
Dec. 12	10:00 a.m.	610														
Do	3:10 p.m.	560														
Dec. 13	10:40 a.m.	440														
Do	4:45 p.m.	690														
Dec. 14	8:40 a.m.	340														
Do			12:40 p.m.	520										2:40 p.m.	1,060	204
Do	4:00 p.m.	700														
Dec. 20	9:15 a.m.	210														
Do			10:35 a.m.	300										12:35 p.m.	1,020	340
Do	4:00 p.m.	670														
Dec. 21	8:45 a.m.	350														
Do	12:00 m.	a 520														
Do	3:45 p.m.	620														
Dec. 22	8:40 a.m.	120														
Do			10:40 a.m.	680										12:40 p.m.	700	103
Do	11:20 a.m.	770														
Jan. 26			10:30 a.m.	247				10:30 a.m.	218	88						
Do	10:50 a.m.	247														
Do			11:00 a.m.	247										1:00 p.m.	140	57
	Section B				Section A'			Section C			Section D'			Sparks gaging station		
May 8			1:00 p.m.	1,510				1:00 p.m.	811	54						
Do	5:10 p.m.	1,640														
May 9			11:55 a.m.	2,040				11:55 a.m.	758	37						
Do	12:00 m.	2,040														
Do			12:15 p.m.	2,050	12:15 p.m.	881	43									
Do			12:53 p.m.	2,060												
Do			5:10 p.m.	2,560										7:10 p.m.	1,240	48
May 23			11:15 a.m.	1,890	11:15 a.m.	602	32									
Do	11:30 a.m.	1,880														
Do			11:40 a.m.	1,870				11:40 a.m.	563	30						
Do			2:00 p.m.	1,770										4:00 p.m.	1,010	57
June 28			10:40 a.m.	1,710	10:40 a.m.	752	44									
Do	12:25 p.m.	1,680														
Do			12:30 p.m.	1,670				12:30 p.m.	490	29						
Do			2:13 p.m.	1,680							2:20 p.m.	556	33			
Do			3:00 p.m.	1,690										5:00 p.m.	608	36
July 17	11:40 a.m.	2,080														
Do			11:40 a.m.	2,080	11:40 a.m.	982	47									
Do			12:40 p.m.	2,020				12:40 p.m.	683	34						
Do			1:03 p.m.	2,010							1:10 p.m.	808	40			
Do			1:30 p.m.	2,010										3:30 p.m.	608	30

a From point-integrated samples.

Table 7.--Suspended-sediment concentrations at cross sections of the Niobrara River near Valentine and Sparks, Nebr., from Nov. 2, 1950, to July 17, 1951, in average percentage of the concentration at the contracted section B

Section	Number of concentration comparisons with section B	Average concentration in percent of concentration at section B
A ----------------------------------	3	54
A' ---------------------------------	4	42
C ----------------------------------	11	50
D' ---------------------------------	2	36
D ----------------------------------	1	43
All normal sections ------------------	21	47
Sparks gaging station ----------------	14	97
Sparks gaging station (Nov. 2 to 17, 1950, and May 8 to July 17, 1951) ----	6	41

Table 8.--Daily suspended-sediment discharge of the Niobrara River near Valentine, section B, and near Sparks, Nebr., 1950-51 water year

Niobrara River near Valentine, section B				Niobrara River near Sparks			
Date	Water discharge (cfs)	Concentration (ppm)	Sediment discharge (tons per day)	Date	Water discharge (cfs)	Concentration (ppm)	Sediment discharge (tons per day)
Nov. 28	1,090	1,600	4,700	Nov. 28	1,000	1,380	3,730
29	986	1,630	4,300	29	957	1,460	3,770
30	926	-------	3,800	30	885	1,540	3,680
Dec. 1	952	1,520	3,900	Dec. 1	885	1,570	3,750
2	714	-------	2,200	2	720	-------	1,230
3	434	-------	680	3	450	-------	430
4	541	450	660	4	520	-------	590
5	274	1,300	960	5	300	-------	170
6	228	930	570	6	250	140	90
7	384	-------	810	7	400	-------	330
8	494	860	1,100	8	500	690	930
9	614	-------	1,700	9	650	1,050	1,840
10	833	-------	2,000	10	850	790	1,810
11	1,040	690	1,900	11	1,050	910	2,580
12	1,090	600	1,800	12	1,100	1,100	3,270
13	1,000	560	1,500	13	1,100	1,160	3,450
14	960	530	1,400	14	1,020	1,100	3,030
15	901	200	490	15	957	1,020	2,640
16	850	-------	320	16	897	1,020	2,470
17	950	-------	490	17	969	1,110	2,900
18	900	-------	530	18	921	1,140	2,830
19	944	280	710	19	945	1,110	2,830
20	986	380	1,000	20	957	1,060	2,740
21	944	450	1,100	21	969	1,180	3,090
Total	19,035	-------	38,620	Total	19,252	-------	54,180

Table 9.--Slope observations on the Niobrara River near Sparks, Nebr.

Date	Time (mst)	Staff reading (feet)	Recorder reading (feet)	Difference (feet)	Slope (ft per mile)
June 24, 1950 ------------	1:00 p.m.	4.20	3.03	1.17	6.94
July 13 ------------------	10:40 a.m.	4.26	2.96	1.30	7.71
July 30 ------------------	10:00 a.m.	4.20	2.96	1.24	7.36
Aug. 19 ------------------	10:10 a.m.	4.23	2.94	1.29	7.65
Aug. 25 ------------------	10:20 a.m.	4.13	2.87	1.26	7.48
Aug. 28 ------------------	7:50 a.m.	4.63	3.25	1.38	8.19
Aug. 30 ------------------	5:40 p.m.	4.28	2.94	1.34	7.95
Sept. 15 -----------------	12:35 p.m.	4.26	2.92	1.34	7.95
Nov. 3 -------------------	9:25 a.m.	4.10	2.94	1.16	6.88
Nov. 21 ------------------	1:45 p.m.	4.15	2.93	1.22	7.24
Do -----------------------	4:15 p.m.	4.20	2.98	1.22	7.24
Average ------------------					7.51

Note.--Staff gage and Sparks recorder set to same datum. Staff gage on right bank 890 ft upstream from recorder.

Table 10.--Particle-size analyses of suspended sediment (point-integrated samples), Niobrara River near Valentine, Nebr., section B, 1950-51 water year
[Methods of analysis: S, sieve; W, in distilled water]

Date	Time (mst)	Water discharge (cfs)	Sampling station	Total depth (feet)	Suspended sediment: Sampling point: Velocity (fps)	Depth (feet)	Concentration (ppm)	Percent finer than indicated size, in millimeters: 0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	2.000	Methods of analysis
Nov. 30, 1950	4:41 p.m.	926	4	3.7	8.74	0.5	-------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	--------
Do --------	4:08 p.m.	926	4	3.7	9.59	1.9	5,040	-----	-----	-----	-----	-----	4	15	56	96	100	-----	SW
Do --------	3:38 p.m.	926	4	3.7	4.16	2.2	5,720	-----	-----	-----	-----	-----	3	12	49	96	100	-----	SW
Do --------	3:31 p.m.	926	4	3.7	6.68	3.2	5,870	-----	-----	-----	-----	-----	3	12	44	93	100	-----	SW
Do --------	3:24 p.m.	926	9	4.1	9.50	.5	3,010	-----	-----	-----	-----	-----	6	21	66	98	100	-----	SW
Do --------	3:20 p.m.	926	9	4.1	10.86	1.6	3,080	-----	-----	-----	-----	-----	5	20	61	99	100	-----	SW
Do --------	3:14 p.m.	926	9	4.1	9.98	2.6	2,740	-----	-----	-----	-----	-----	6	20	60	98	100	-----	SW
Do --------	3:05 p.m.	926	9	4.1	7.64	3.6	2,130	-----	-----	-----	-----	-----	8	24	59	97	100	-----	SW
Do --------	2:59 p.m.	926	12	4.2	12.96	.5	2,180	-----	-----	-----	-----	-----	8	27	73	100	-----	-----	SW
Do --------	2:54 p.m.	926	12	4.2	11.66	1.6	2,340	-----	-----	-----	-----	-----	7	25	67	99	100	-----	SW
Do --------	2:48 p.m.	926	12	4.2	10.12	2.7	1,550	-----	-----	-----	-----	-----	10	31	71	98	100	-----	SW
Do --------	2:43 p.m.	926	12	4.2	6.51	3.7	1,260	-----	-----	-----	-----	-----	12	38	79	99	100	-----	SW
Do --------	2:36 p.m.	926	16	4.5	10.05	.5	1,570	-----	-----	-----	-----	-----	10	34	79	100	-----	-----	SW
Do --------	2:32 p.m.	926	16	4.5	10.84	1.7	1,660	-----	-----	-----	-----	-----	10	33	78	99	100	-----	SW
Do --------	2:16 p.m.	926	16	4.5	10.45	2.9	1,340	-----	-----	-----	-----	-----	12	38	78	99	100	-----	SW
Do --------	2:10 p.m.	926	16	4.5	7.28	4.0	1,220	-----	-----	-----	-----	-----	12	38	80	99	100	-----	SW
Do --------	2:03 p.m.	926	19	4.6	10.52	.5	1,240	-----	-----	-----	-----	-----	12	42	84	100	-----	-----	SW
Do --------	1:58 p.m.	926	19	4.6	11.00	1.6	1,150	-----	-----	-----	-----	-----	14	43	87	100	-----	-----	SW
Do --------	1:49 p.m.	926	19	4.6	9.84	2.9	1,150	-----	-----	-----	-----	-----	15	46	85	99	100	-----	SW
Do --------	1:40 p.m.	926	19	4.6	4.38	4.1	1,070	-----	-----	-----	-----	-----	16	47	85	99	100	-----	SW
Do --------	1:32 p.m.	926	22	4.2	8.04	.5	620	-----	-----	-----	-----	-----	22	62	95	100	-----	-----	SW
Do --------	1:29 p.m.	926	22	4.2	9.01	1.6	780	-----	-----	-----	-----	-----	18	54	93	100	-----	-----	SW
Do --------	1:19 p.m.	926	22	4.2	9.79	2.7	710	-----	-----	-----	-----	-----	17	53	90	100	-----	-----	SW
Do --------	1:14 p.m.	926	22	4.2	4.64	3.7	870	-----	-----	-----	-----	-----	15	47	88	100	-----	-----	SW
Do --------	1:07 p.m.	926	26	4.1	6.40	1.0	510	-----	-----	-----	-----	-----	23	63	94	100	-----	-----	SW
Do --------	1:01 p.m.	926	26	4.1	7.16	1.6	640	-----	-----	-----	-----	-----	21	58	94	100	-----	-----	SW
Do --------	12:57 p.m.	926	26	4.1	6.84	2.6	630	-----	-----	-----	-----	-----	20	58	93	100	-----	-----	SW
Do --------	12:21 p.m.	926	26	4.1	.60	3.6	660	-----	-----	-----	-----	-----	21	53	88	100	-----	-----	SW
Dec. 7 ------	3:18 p.m.	384	4	2.5	3.47	.5	1,660	-----	-----	-----	-----	-----	5	22	68	99	100	-----	SW
Do --------	3:14 p.m.	384	4	2.5	4.46	1.0	2,040	-----	-----	-----	-----	-----	4	19	66	100	-----	-----	SW
Do --------	3:10 p.m.	384	4	2.5	4.00	1.5	2,650	-----	-----	-----	-----	-----	4	16	64	99	100	-----	SW
Do --------	3:02 p.m.	384	4	2.5	2.30	2.0	6,980	-----	-----	-----	-----	-----	1	8	42	98	100	-----	SW
Do --------	2:48 p.m.	384	8	3.3	4.18	.5	1,700	-----	-----	-----	-----	-----	6	23	67	99	100	-----	SW
Do --------	2:42 p.m.	384	8	3.3	4.04	1.2	2,060	-----	-----	-----	-----	-----	5	20	62	98	100	-----	SW
Do --------	2:36 p.m.	384	8	3.3	4.52	2.0	2,700	-----	-----	-----	-----	-----	4	18	58	97	100	-----	SW
Do --------	2:32 p.m.	384	8	3.3	3.55	2.8	3,630	-----	-----	-----	-----	-----	3	15	54	97	100	-----	SW

Table 10.--Particle-size analyses of suspended sediment (point-integrated samples), Niobrara River near Valentine, Nebr., section B, 1950-51 water year--Con.
[Methods of analysis: S, sieve; W, in distilled water]

Date	Time (mst)	Water discharge (cfs)	Sampling station	Total depth (feet)	Suspended sediment: Sampling point: Velocity (fps)	Depth (feet)	Concentration (ppm)	Percent finer than indicated size, in millimeters: 0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	2.000	Methods of analysis
Dec. 7, 1950	2:27 p.m.	384	12	3.0	6.18	0.5	1,720	-----	-----	-----	-----	-----	7	27	72	99	100	-----	SW
Do	2:24 p.m.	384	12	3.0	5.02	1.1	1,960	-----	-----	-----	-----	-----	6	25	68	99	100	-----	SW
Do	2:12 p.m.	384	12	3.0	3.48	1.7	2,300	-----	-----	-----	-----	-----	5	22	67	98	100	-----	SW
Do	2:02 p.m.	384	12	3.0	1.64	2.5	2,600	-----	-----	-----	-----	-----	4	20	64	98	100	-----	SW
Do	1:56 p.m.	384	16	3.2	3.78	.5	1,220	-----	-----	-----	-----	-----	7	30	80	99	100	-----	SW
Do	1:52 p.m.	384	16	3.2	5.21	1.3	1,310	-----	-----	-----	-----	-----	6	29	76	100	-----	-----	SW
Do	1:33 p.m.	384	16	3.2	2.85	2.0	1,170	-----	-----	-----	-----	-----	7	28	80	100	-----	-----	SW
Do	1:26 p.m.	384	16	3.2	1.54	2.7	1,610	-----	-----	-----	-----	-----	5	24	75	99	100	-----	SW
Do	1:11 p.m.	384	19	3.6	5.37	.5	790	-----	-----	-----	-----	-----	9	38	89	100	-----	-----	SW
Do	1:06 p.m.	384	19	3.6	5.70	1.4	820	-----	-----	-----	-----	-----	8	34	85	99	100	-----	SW
Do	1:02 p.m.	384	19	3.6	5.33	2.3	750	-----	-----	-----	-----	-----	7	31	84	100	-----	-----	SW
Do	12:56 p.m.	384	19	3.6	2.05	3.1	810	-----	-----	-----	-----	-----	8	30	86	100	-----	-----	SW
Do	12:08 p.m.	384	22	3.5	3.59	.5	560	-----	-----	-----	-----	-----	14	41	91	100	-----	-----	SW
Do	12:16 p.m.	384	22	3.5	5.11	1.3	580	-----	-----	-----	-----	-----	12	38	90	100	-----	-----	SW
Do	12:02 p.m.	384	22	3.5	2.38	2.2	570	-----	-----	-----	-----	-----	12	38	88	99	100	-----	SW
Do	11:57 a.m.	384	22	3.5	2.10	3.0	600	-----	-----	-----	-----	-----	12	36	89	100	-----	-----	SW
Do	11:50 a.m.	384	25	3.8	2.44	.5	530	-----	-----	-----	-----	-----	15	42	90	100	-----	-----	SW
Do	11:44 a.m.	384	25	3.8	3.20	1.4	560	-----	-----	-----	-----	-----	13	38	91	100	-----	-----	SW
Do	11:38 a.m.	384	25	3.8	1.00	2.9	670	-----	-----	-----	-----	-----	13	36	85	99	100	-----	SW
Do	11:30 a.m.	384	25	3.8	1.08	3.3	650	-----	-----	-----	-----	-----	10	32	84	97	100	-----	SW
Dec. 21	12:48 p.m.	918	4	3.5	10.36	.5	1,300	-----	-----	-----	-----	-----	7	18	42	96	100	-----	SW
Do	12:45 p.m.	910	4	3.5	10.32	1.7	1,820	-----	-----	-----	-----	-----	5	13	36	92	100	-----	SW
Do	12:42 p.m.	910	4	3.5	10.56	2.4	1,920	-----	-----	-----	-----	-----	4	11	33	90	100	-----	SW
Do	12:35 p.m.	892	4	3.5	10.11	3.0	1,760	-----	-----	-----	-----	-----	4	12	32	90	100	-----	SW
Do	12:30 p.m.	884	9	3.5	7.46	.5	890	-----	-----	-----	-----	-----	8	21	51	98	100	-----	SW
Do	12:10 p.m.	842	9	3.5	12.78	1.7	1,170	-----	-----	-----	-----	-----	6	16	43	97	100	-----	SW
Do	12:05 p.m.	824	9	3.5	11.36	2.4	780	-----	-----	-----	-----	-----	9	22	55	99	100	-----	SW
Do	12:05 p.m.	824	9	3.5	9.84	3.0	610	-----	-----	-----	-----	-----	11	27	64	99	100	-----	SW
Do	12:00 m.	808	14	3.7	10.48	.4	310	-----	-----	-----	-----	-----	20	43	78	100	-----	-----	SW
Do	11:55 a.m.	790	14	3.7	11.80	1.8	460	-----	-----	-----	-----	-----	15	33	70	100	-----	-----	SW
Do	11:55 a.m.	790	14	3.7	11.39	2.5	420	-----	-----	-----	-----	-----	15	36	73	100	-----	-----	SW
Do	11:50 a.m.	782	14	3.7	10.12	3.2	380	-----	-----	-----	-----	-----	16	36	80	100	-----	-----	SW
Do	11:45 a.m.	765	19	4.6	8.54	.5	200	-----	-----	-----	-----	-----	28	59	94	100	-----	-----	SW
Do	11:40 a.m.	748	19	4.6	11.61	2.3	310	-----	-----	-----	-----	-----	18	41	83	100	-----	-----	SW
Do	11:35 a.m.	740	19	4.6	10.56	3.2	320	-----	-----	-----	-----	-----	16	41	85	100	-----	-----	SW
Do	11:35 a.m.	740	19	4.6	6.94	4.1	360	-----	-----	-----	-----	-----	16	39	85	100	-----	-----	SW
Do	11:30 a.m.	722	24	4.5	6.44	.4	340	-----	-----	-----	-----	-----	18	47	88	100	-----	-----	SW
Do	11:30 a.m.	722	24	4.5	8.30	1.8	320	-----	-----	-----	-----	-----	17	48	90	100	-----	-----	SW
Do	11:25 a.m.	714	24	4.5	9.24	3.0	310	-----	-----	-----	-----	-----	21	47	90	100	-----	-----	SW

Do --------	11:20 a.m.	706	24	4.5	5.72	4.0	420	-----	-----	-----	-----	-----	15	39	85	100	-----	-----	SW
May 8, 1951 -	5:38 p.m.	843	16	3.2	8.50	.5	5,480	-----	-----	-----	-----	-----	2	10	48	96	-----	-----	SW
Do --------	5:41 p.m.	843	16	3.2	7.85	1.2	4,670	-----	-----	-----	-----	-----	12	14	70	99	-----	-----	SW
Do --------	5:30 p.m.	843	16	3.2	6.80	2.4	6,290	-----	-----	-----	-----	-----	2	9	54	98	100	-----	SW
Do --------	5:48 p.m.	843	16	3.2	5.78	2.7	10,700	-----	-----	-----	-----	-----	1	6	42	97	100	-----	SW
Do --------	6:04 p.m.	843	27	3.7	8.89	.5	894	-----	-----	-----	-----	-----	10	36	91	-----	-----	-----	SW
Do --------	5:57 p.m.	843	27	3.7	6.32	3.2	834	-----	-----	-----	-----	-----	10	32	80	-----	-----	-----	SW
Do --------	6:28 p.m.	843	38	4.6	7.62	.5	250	-----	-----	-----	-----	-----	27	64	100	-----	-----	-----	SW
Do --------	6:32 p.m.	843	38	4.6	7.51	1.6	282	-----	-----	-----	-----	-----	23	58	100	-----	-----	-----	SW
Do --------	6:33 p.m.	843	38	4.6	6.07	2.8	220	-----	-----	-----	-----	-----	27	63	100	-----	-----	-----	SW
Do --------	6:24 p.m.	843	38	4.6	3.05	4.1	280	-----	-----	-----	-----	-----	24	56	100	-----	-----	-----	SW
June 28 -----	2:10 p.m.	908	15	3.7	7.88	.5	-------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	---------
Do --------	2:11 p.m.	908	15	3.7	8.82	1.2	-------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	---------
Do --------	2:12 p.m.	908	15	3.7	6.75	2.2	4,170	-----	-----	-----	-----	-----	3	10	67	99	-----	-----	SW
Do --------	2:13 p.m.	908	15	3.7	5.10	3.2	6,660	-----	-----	-----	-----	-----	5	6	52	96	100	-----	SW
Do --------	2:41 p.m.	908	26	4.7	5.80	.5	350	-----	-----	-----	-----	-----	27	52	94	-----	-----	-----	SW
Do --------	2:54 p.m.	908	26	4.7	8.07	1.7	450	-----	-----	-----	-----	-----	21	41	91	-----	-----	-----	SW
Do --------	2:55 p.m.	908	26	4.7	7.14	3.0	370	-----	-----	-----	-----	-----	26	50	91	-----	-----	-----	SW
Do --------	2:36 p.m.	908	26	4.7	4.48	4.2	442	-----	-----	-----	-----	-----	20	41	84	-----	-----	-----	SW
Do --------	3:27 p.m.	908	37.5	4.8	7.26	.5	169	-----	-----	-----	-----	-----	52	76	100	-----	-----	-----	SW
Do --------	3:11 p.m.	908	37.5	4.8	6.38	1.7	179	-----	-----	-----	-----	-----	49	74	100	-----	-----	-----	SW
Do --------	3:31 p.m.	908	37.5	4.8	5.64	3.0	170	-----	-----	-----	-----	-----	55	81	100	-----	-----	-----	SW
Do --------	3:26 p.m.	908	37.5	4.8	4.72	4.3	191	-----	-----	-----	-----	-----	58	79	100	-----	-----	-----	SW

Table 11.--Particle-size analyses of suspended sediment, Niobrara River near Valentine, Nebr., section B, 1950-51 water year
[Methods of analysis: S, sieve; W, in distilled water]

Date	Time (mst)	Water discharge (cfs)	Concentration of sample (ppm)	Suspended sediment: Percent finer than indicated size, in millimeters: 0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	2.000	Methods of analysis
Nov. 2, 1950	2:30 p.m.	b 718	1,560	------	------	------	------	------	6	21	75	99	100	------	SW
Nov. 3	10:00 a.m.	b 804	2,030	------	------	------	------	------	5	17	73	99	100	------	SW
Do	1:00 p.m.	bb 824	1,790	------	------	------	------	------	6	18	68	98	100	------	SW
Nov. 9	2:15 p.m.	782	2,210	------	------	------	------	------	6	26	72	97	100	------	SW
Nov. 10	9:40 a.m.	502	1,990	------	------	------	------	------	5	21	70	98	100	------	SW
Nov. 17	9:30 a.m.	------	2,410	------	------	------	------	------	4	20	69	98	100	------	SW
Nov. 21	10:00 a.m.	816	1,800	------	------	------	------	------	5	19	74	99	100	------	SW
Do	4:00 p.m.	969	1,210	------	------	------	------	------	------	------	------	------	------	------	------
Nov. 22	8:10 a.m.	790	1,810	------	------	------	------	------	4	12	62	98	100	------	SW
Do	10:30 a.m.	790	1,540	------	------	------	------	------	5	14	64	98	100	------	SW
Nov. 28	11:15 a.m.	858	1,850	------	------	------	------	------	7	25	66	99	100	------	SW
Do	4:40 p.m.	1,330	1,350	------	------	------	------	------	8	26	65	97	99	100	SW
Nov. 29	10:10 a.m.	867	1,710	------	------	------	------	------	6	18	59	98	100	------	SW
Do	3:05 p.m.	1,080	1,500	------	------	------	------	------	9	30	69	98	100	------	SW
Dec. 1	8:55 a.m.	918	1,320	------	------	------	------	------	11	33	74	99	100	------	SW
Do	12:00 m.	944	1,770	------	------	------	------	------	11	30	68	98	100	------	SW
Dec. 4	11:20 a.m.	638	440	------	------	------	------	------	5	17	67	98	100	------	SW
Dec. 5	2:10 p.m.	222	1,770	------	------	------	------	------	2	10	55	96	99	100	SW
Dec. 6	3:30 p.m.	250	830	------	------	------	------	------	3	22	64	98	100	------	SW
Dec. 8	10:25 a.m.	605	510	------	------	------	------	------	4	17	66	98	100	------	SW
Do	4:25 p.m.	589	1,260	------	------	------	------	------	4	25	70	98	100	------	SW
Dec. 11	10:10 a.m.	918	670	------	------	------	------	------	7	29	65	98	100	------	SW
Do	3:50 p.m.	1,150	690	------	------	------	------	------	9	38	76	98	100	------	SW
Dec. 12	10:00 a.m.	1,050	610	------	------	------	------	------	5	22	68	99	100	------	SW
Do	3:10 p.m.	1,070	560	------	------	------	------	------	7	31	81	100	------	------	SW
Dec. 13	10:40 a.m.	1,050	440	------	------	------	------	------	7	21	76	99	100	------	SW
Do	4:45 p.m.	1,030	690	------	------	------	------	------	5	20	67	99	100	------	SW
Dec. 14	8:40 a.m.	1,100	340	------	------	------	------	------	3	12	62	99	100	------	SW
Do	4:00 p.m.	850	700	------	------	------	------	------	8	29	70	97	100	------	SW
Dec. 15	8:40 a.m.	935	120	------	------	------	------	------	24	34	55	90	100	------	SW
Do	11:00 a.m.	935	150	------	------	------	------	------	17	37	71	94	100	------	SW
Dec. 19	10:05 a.m.	1,000	130	------	------	------	------	------	18	27	55	96	100	------	SW
Do	4:00 p.m.	978	510	------	------	------	------	------	8	17	57	98	100	------	SW
Dec. 20	9:15 a.m.	1,000	210	------	------	------	------	------	13	21	48	98	100	------	SW
Do	4:00 p.m.	978	670	------	------	------	------	------	8	28	61	98	100	------	SW
Dec. 21	8:45 a.m.	916	350	------	------	------	------	------	10	21	56	98	100	------	SW
Do	3:45 p.m.	952	620	------	------	------	------	------	12	29	57	95	100	------	SW
Dec. 22	8:40 a.m.	960	120	------	------	------	------	------	32	41	59	96	100	------	SW
Do	11:20 a.m.	1,000	770	------	------	------	------	------	10	24	61	98	100	------	SW
May 8, 1951	5:10 p.m.	842	1,640	------	------	------	------	------	5	22	74	------	------	------	SW

May 9 ----------	12:00 m.	771	2,040	-------	-------	-------	-------	-------	3	12	75	100	-------	-------	SW
May 23 ----------	12:30 p.m.	1,010	1,880	-------	-------	-------	-------	-------	15	15	66	99	100	-------	SW
June 28 ---------	1:25 p.m.	952	1,680	-------	-------	-------	-------	-------	8	16	68	-------	-------	-------	SW
July 17 ---------	12:40 p.m.	826	2,080	-------	-------	-------	-------	-------	3	20	78	99	-------	-------	SW

b Discharge measurement.
bb Discharge is average of two measurements made on this day.

Table 12.--Particle-size analyses of suspended sediment, Niobrara River near Valentine, Nebr., normal sections, 1950-51 water year
[Methods of analysis: S, sieve; W, in distilled water]

Date	Time (mst)	Water discharge (cfs)	Suspended sediment												Methods of analysis	Location
			Concentration of sample (ppm)	Percent finer than indicated size, in millimeters												
				0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	2.000		
Nov. 2, 1950 -	11:30 a.m.	b 701	780	-------	-------	-------	-------	-------	16	35	92	100	-------	-------	SW	Section A.
Do ---------	1:00 p.m.	b 718	770	-------	-------	-------	-------	-------	9	34	94	100	-------	-------	SW	Section $\overline{C}$.
Nov. 3 -------	11:00 a.m.	b 843	700	-------	-------	-------	-------	-------	12	29	88	100	-------	-------	SW	Section $\overline{A}$.
Do ---------	12:00 m.	b 804	1,040	-------	-------	-------	-------	-------	8	28	90	100	-------	-------	SW	Section $\overline{C}$.
Do ---------	3:15 p.m.	b 840	1,340	-------	-------	-------	-------	-------	6	28	80	100	-------	-------	SW	Section $\overline{A}$.
Do ---------	3:30 p.m.	b 845	750	-------	-------	-------	-------	-------	10	34	92	100	-------	-------	SW	Section D.
Nov. 9 -------	4:00 p.m.	b 728	1,400	-------	-------	-------	-------	-------	6	34	94	100	-------	-------	SW	Section $\overline{C}$.
Nov. 10 ------	1:00 p.m.	b 616	1,000	-------	-------	-------	-------	-------	31	34	86	100	-------	-------	SW	Do.
Nov. 17 ------	1:45 p.m.	b 832	1,440	-------	-------	-------	-------	-------	6	32	92	100	-------	-------	SW	Do.
Jan. 26, 1951-	11:30 a.m.	681	218	-------	-------	-------	-------	-------	10	26	80	99	-------	-------	SW	Do.
May 8 --------	2:00 p.m.	790	811	-------	-------	-------	-------	-------	8	38	92	100	-------	-------	SW	Do.
May 9 --------	12:15 p.m.	765	881	-------	-------	-------	-------	-------	5	24	92	-------	-------	-------	SW	Section A'.
Do ---------	11:55 a.m.	774	758	-------	-------	-------	-------	-------	7	32	87	-------	-------	-------	SW	Section $\overline{C}$.
Do ---------	1:00 p.m.	757	2,680	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	Section $\overline{D}$'.
May 23 -------	12:15 p.m.	1,050	602	-------	-------	-------	-------	-------	19	36	94	-------	-------	-------	SW	Section A'.
Do ---------	12:40 p.m.	1,010	563	-------	-------	-------	-------	-------	19	38	90	-------	-------	-------	SW	Section $\overline{C}$.
June 28 ------	11:40 a.m.	951	752	-------	-------	-------	-------	-------	15	32	100	-------	-------	-------	SW	Section $\overline{A}$'.
Do ---------	1:30 p.m.	933	490	-------	-------	-------	-------	-------	19	39	100	-------	-------	-------	SW	Section $\overline{C}$.
Do ---------	2:20 p.m.	924	566	-------	-------	-------	-------	-------	34	35	100	-------	-------	-------	SW	Section $\overline{D}$'.
July 17 ------	12:40 p.m.	826	982	-------	-------	-------	-------	-------	8	41	98	-------	-------	-------	SW	Section A'.
Do ---------	1:40 p.m.	826	683	-------	-------	-------	-------	-------	13	46	96	100	-------	-------	SW	Section $\overline{C}$.
Do ---------	2:10 p.m.	826	808	-------	-------	-------	-------	-------	10	43	91	-------	-------	-------	SW	Section $\overline{D}$'.

b Discharge measurement.

Table 13.--Particle-size analyses of suspended sediment, Niobrara River near Sparks, Nebr., 1950-51 water year
/Methods of analysis: S, sieve; W, in distilled water/

Date	Time (mst)	Water discharge (cfs)	Suspended sediment: Concentration of sample (ppm)	Percent finer than indicated size, in millimeters: 0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	2.000	Methods of analysis
Oct. 23, 1950	1:40 p.m.	793	700	-------	-------	-------	-------	-------	12	53	95	100	-------	-------	SW
Nov. 3	11:40 a.m.	816	760	-------	-------	-------	-------	-------	8	38	96	100	-------	-------	SW
Nov. 21	2:30 p.m.	804	1,240	-------	-------	-------	-------	-------	8	30	82	100	-------	-------	SW
Nov. 28	2:25 p.m.	817	1,530	-------	-------	-------	-------	-------	8	27	76	99	100	-------	SW
Dec. 6	11:35 a.m.	a 250	140	-------	-------	-------	-------	-------	25	43	90	100	-------	-------	SW
Dec. 11	12:20 p.m.	1,140	1,490	-------	-------	-------	-------	-------	9	32	83	99	100	-------	SW
Dec. 14	2:40 p.m.	957	1,060	-------	-------	-------	-------	-------	8	27	79	100	-------	-------	SW
Dec. 20	12:35 p.m.	957	1,020	-------	-------	-------	-------	-------	5	18	75	100	-------	-------	SW
Jan. 10, 1951	1:35 p.m.	736	237	-------	-------	-------	-------	-------	12	34	89	100	-------	-------	SW
Feb. 22	2:45 p.m.	1,040	293	-------	-------	-------	-------	-------	25	49	84	-------	-------	-------	SW
Mar. 27	1:30 p.m.	897	1,900	-------	-------	-------	-------	-------	23	59	90	-------	-------	-------	SW
May 9	7:10 p.m.	981	1,240	-------	-------	-------	-------	-------	14	31	88	100	-------	-------	SW
May 23	5:00 p.m.	981	1,010	-------	-------	-------	-------	-------	14	35	85	100	-------	-------	SW
June 28	6:00 p.m.	885	608	-------	-------	-------	-------	-------	18	42	94	-------	-------	-------	SW
July 6	12:30 p.m.	839	510	-------	-------	-------	-------	-------	16	44	96	-------	-------	-------	SW
July 17	4:30 p.m.	885	608	-------	-------	-------	-------	-------	10	47	92	-------	-------	-------	SW

a Mean daily discharge.

Table 14.--Particle-size analyses of bed material, Niobrara River near Valentine, Nebr., normal sections
/Analysis by sieve only/

Date	Number of sampling points	Deposited sediment, percent finer than indicated size, in millimeters: 0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	2.000	4.000	Location
Nov. 2, 1950	4	-------	-------	-------	-------	0	1	30	96	100	-------	-------	Section A.
Nov. 9	3	-------	-------	-------	-------	0	7	70	96	97	98	100	Section C̄.
Nov. 10	2	-------	-------	-------	-------	0	2	34	94	99	100	-------	Do.
Nov. 17	3	-------	-------	-------	-------	0	23	53	98	100	-------	-------	Do.
Jan. 26, 1951	3	-------	-------	-------	-------	0	3	29	85	99	100	-------	Do.
May 9	3	-------	-------	-------	-------	0	2	36	97	100	-------	-------	Section A'.
May 23	3	-------	-------	-------	-------	0	3	40	95	100	-------	-------	Do.
Do	3	-------	-------	-------	-------	0	5	60	96	98	100	-------	Section C.
Do	3	-------	-------	-------	-------	0	4	63	99	100	-------	-------	Section D̄'.
June 28	3	-------	-------	-------	-------	0	3	47	98	100	-------	-------	Section Ā'.
Do	2	-------	-------	-------	-------	0	2	36	95	99	100	-------	Section C.
Do	3	-------	-------	-------	-------	0	2	34	88	97	98	100	Section D̄'.
July 17	3	-------	-------	-------	-------	1	3	44	98	100	-------	-------	Section Ā'.
Do	3	-------	-------	-------	-------	3	6	49	90	95	97	98	Section C̄.
Do	3	-------	-------	-------	-------	2	4	45	67	90	99	100	Section D̄'.

Table 15.--Particle-size analyses of bed material, Niobrara River near Sparks, Nebr.
[Analysis by sieve only]

Date	Number of sampling points	Deposited sediment											Location
		Percent finer than indicated size, in millimeters											
		0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	2.000	4.000	
Nov. 21, 1950-	3	-------	-------	-------	-------	0	13	81	100	-------	-------	-------	Sparks gage (bridge).
Nov. 28 ------	3	-------	-------	-------	-------	4	35	68	100	-------	-------	-------	Do.
Dec. 8 -------	3	-------	-------	-------	-------	1	20	79	99	100	-------	-------	Do.
Dec. 14 ------	3	-------	-------	-------	-------	1	11	75	99	100	-------	-------	Do.
Dec. 20 ------	3	-------	-------	-------	-------	2	5	43	88	97	99	100	Do.
May 9, 1951 --	2	-------	-------	-------	-------	0	5	72	99	100	-------	-------	Do.
May 23 -------	3	-------	-------	-------	-------	1	3	37	85	94	96	98	Do.
June 28 ------	3	-------	-------	-------	-------	0	2	42	98	100	-------	-------	Do.
July 6 -------	3	-------	-------	-------	-------	0	2	36	92	98	99	99	Do.
July 17 ------	3	-------	-------	-------	-------	0	3	39	95	100	-------	-------	Do.

INT.-DUP. SEC., WASH., D.C. 32366