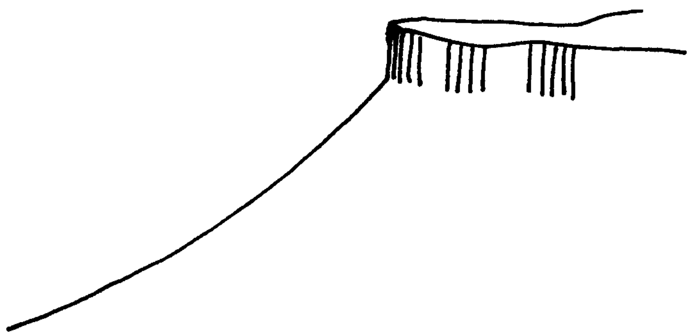

AMERICAN GEOMORPHOLOGICAL

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FIELD TRIP GUIDEBOOK

1982 CONFERENCE

PINEDALE, WYOMING

EDITED BY LUNA B. LEOPOLD

BEDLOAD TRAP, EAST FORK RIVER

by

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ABSTRACT

An open slot in the streambed of the East Fork River, Wyoming, continually excavated of trapped debris by a conveyor belt, provided a bedload trap and direct quantitative measurement of bedload-transport rates.

INTRODUCTION

The East Fork River heads in the Wind River Range of Wyoming west of the Continental Divide and east and south of Mt. Bonneville. From a series of small alpine lakes and an altitude of approximately 3,400 m, the East Fork River descends about 1,250 m in 50 river km to the project site described in this report. Downstream from the study reach, it continues another 50 km to its confluence with the New Fork River, tributary to the Green River.

The project site is at lat 42°40'23" N., long 109°34'16" W. The drainage area of the East Fork River at the project site is 466 km^2. About half of this basin area lies within the Wind River Mountains and is underlain by granitic and metamorphic rocks, mostly of Precambrian age; the other half of the basin area is provided by a major tributary, Muddy Creek, that enters the East Fork River about 5 km upstream of the project and drains an upland of rolling hills underlain by lower Tertiary sandstone and shale of the Wasatch Formation. Much of the sand portion of the sediment load for the East Fork River comes from the Muddy Creek basin, but most of the water during high flow comes from melting snow of the mountain area. The high-flow season is generally late May to mid-June, and little bedload movement occurs at other times in the year.

In the vicinity of the project, the East Fork River meanders in a flood plain averaging 120 m in width, which, in turn, is confined within a glacial outwash terrace of sand and gravel, the tread or surface of which is some 5 m above the flood plain. This terrace and outcrops of the Wasatch are sources of fresh sand and gravel debris wherever the river impinges laterally against them.

The level of the flood plain corresponds with the bankfull stage of the river, at which the water has an average depth of about 1.2 m. The bankfull discharge is about 20 m^3/s, which, in the annual flood series, has a recurrence interval of about 1.5 years. The water-surface slope in the vicinity of the project area is 0.0007, averaged over 1.5 km of river length.

Composition of the streambed of the East Fork River at the project site is predominantly sand, but in the 5-km reach of river from Muddy Creek to the project, gravel bars are spaced at regular intervals of about five to seven channel widths. Eight bed-material samples were collected at each of 29 sections along approximately a 200-m reach upstream and downstream of the bedload trap. Data of the composite size distribution of the 232 samples (about 200 kg) are included in table 1 and indicate a median bed-material particle size of 1.25 mm. The median bed-material particle sizes at each of the 29 sections are shown on the planimetric map of figure 1. The occurrence and location of gravel bars is apparent, as median particle sizes vary from 0.6 to 25 mm and indicate a large range of particle sizes available for transport. However, the majority of median particle-size data indicate an overwhelming abundance of medium to coarse sand available for transport.

CONVEYOR-BELT BEDLOAD TRAP

Across the East Fork River, a concrete trough was constructed in the bed, orthogonal to the flow direction, that would constitute an open slot into which would fall any sediment moving near or on the streambed. The trough is 0.4 m wide and 0.6 m deep; the level of the lip or top surface corresponds to the natural bed, lower in elevation at the thalweg than near the banks. Figure 2 is a cross section at the bedload trap; although at the trap the entire wetted perimeter is bounded by concrete construction, only at the definite angles at changes in boundary projections is the cross section different than the preconstruction cross section.

Along the bottom of the concrete trough passes an endless belt of rubber, 0.3 m wide; it is threaded around some drive and guidance cylinders, then returns overhead, where it is supported by a suspension bridge across the river. Thus, sediment falling into the open slot drops on the moving belt, then is carried laterally to a sump constructed in the riverbank, where it is scraped off the belt. From the sump, sediment is excavated by a series of perforated buckets on an endless belt. The buckets lift the sediment to an elevation 3 m above the riverbank and dump the load into a weighing hopper. When the hopper is periodically evacuated by opening a bottom door, accumulated sediment falls on a horizontal endless belt that carries it in a downstream direction 12 m and dumps the load on a transverse endless belt, which, in turn, carries the debris toward the river and dumps it into the flowing water, to be carried downstream in a normal manner. In this way, trapped sediment is collected, weighed continuously, and returned to the river. Figure 4 (A-D) shows some general views of the conveyor-belt bedload trap.

The concrete slot across the riverbed may be closed by a series of eight gates, each 1.83 m in length. The gated length of the slot is thus 14.6 m, constituting the full width of the bed active in bedload transport. The gates are actuated hydraulically and may be opened or closed individually. When the gates are open, the open slot or trap is 0.25 m wide. At low and moderate discharges, all gates are open so that the load accumulated in the weighing hopper represents the total for the river. At high discharges, gates are opened individually, and the transport rate for the whole river is computed by adding the rates recorded in the eight gates individually opened. The hopper collecting the debris stands on a large scale that may be read visually. The belt-and-bucket-transport system can accommodate a load received at a rate as great as 100 kg/min. The weight of the trapped load is recorded each minute as it accumulates in the hopper, so the weights represent a wet sample. Numerous comparisons of the weight of samples when wet and after drying give a consistent ratio of dry/wet weight of 0.85. Mean transport rates are determined by averaging the 1-minute recordings over a sampling duration of 30 minutes to several hours.

Samples of the trapped sediment for size analysis are scooped from the endless belt as the weighing hopper is periodically emptied. Samples were collected every time the hopper was emptied; each sample retained weighed about 2 kg. These samples were taken to the laboratory where they were dried, sieved, and weighed by size fractions. For small samples (single emptying of the hopper), the entire sample was used in the sieve analysis. For large samples (multiple emptying of the hopper), the entire sample was sieved for gravel-size sediment (>2.0 mm) and the remainder split to about 1 kg for sieving of the material smaller than 2.0 mm. In all instances, the sample retained was large enough to be representative of all sizes of material collected, and the sieving procedure maintained this accuracy throughout the analysis. For comparison with the bed-material size data in table 1, table 2 lists a transport-weighted particle-size distribution for the whole of bedload sampled in 1976. The median particle size of bedload is 1.13 mm, compared to 1.25 mm for bed material.

Although the median particle size of bedload and bed material is nearly the same, the bed material consists of some larger particles that are rarely moved. For bedload and bed material, table 3 lists particle size at given particle-size categories (given percentage, by weight, finer than values). Table 3 clearly indicates that some bed-material particle sizes are seldom involved in the sediment-transport process.

Discharge measurements by current meter are made nearly every day during the sampling season from the suspension bridge at the project site. At low flow, all discharge, Q, is within the 14.6-m width of the gated slot; at bankfull ($Q \approx 20\ m^3/s$) discharge, the water spreads over the full 19-m width of channel, but only 5 percent of this discharge is in the near-bank zones beyond the 14.6-m wide bedload trap; at maximum discharge ($45\ m^3/s$), about 8 percent of the discharge is beyond the ends of the bedload trap. Though overbank flow onto the flood plain occurs in other reaches of the river, at the project site a high natural bank on the right side and a short embankment on the left prevent any overbank flow. Essentially, all bedload is accounted for, and all the flow passes through the 19-m width of channel at the measuring section.

The hydraulic-geometry relations for the East Fork River at the bedload trap are shown in figure 3. In reality, the concrete trough and abutments of the bedload trap force small "kinks" in the hydraulic-geometry relations; the relations shown in figure 3 have been smoothed and reflect the hydraulic characteristics of the river if the bedload trap were not installed. For interpretative studies of bedload transport, the hydraulic conditions above the 14.6-m width of bedload trap are more significant than the whole-channel hydraulic conditions. These hydraulic conditions will be termed "effective hydraulics," and it is the effective hydraulic parameters that are listed in table 4 in this report. The reader may obtain corresponding stream-wide conditions by reference to figure 3.

The bedload trap was installed in fall and spring, 1972-73. Robert M. Myrick was project engineer for construction of the trap and is due much of the credit for subsequent successful operation of the installation. Data collection began in the spring of 1973 and continued during spring months through 1980.

EXAMPLES OF DATA

Basic data for the bedload trap have been previously published (Leopold and Emmett, 1976, 1977; Emmett, 1980; Emmett, et al, 1980, 1982). Table 4 provides a listing of data through the 1976 field season. In keeping with the additional explanation provided by Emmett elsewhere in this publication, the bedload-transport rates presented in table 4 are expressed in terms of dry mass per unit time per unit width of channel (kg/s-m).

REFERENCES

Emmett, W. W., 1980, A field calibration of the sediment-trapping characteristics of the Helley-Smith bedload sampler: U.S. Geological Survey Professional Paper 1139, 44 p.

Emmett, W. W., Myrick, R. M., and Meade, R. H., 1980, Field data describing the movement and storage of sediment in the East Fork River, Wyoming. Part I. River hydraulics and sediment transport, 1979: U.S. Geological Survey Open-File Report 80-1189, 43 p.

_____ 1982, Field data describing the movement and storage of sediment in the East Fork River, Wyoming. Part III. River hydraulics and sediment transport, 1980: U.S. Geological Survey Open-File Report 82-359, 289 p.

Leopold, L. B., and Emmett, W. W., 1976, Bedload measurements, East Fork River, Wyoming: [U.S.] National Academy of Sciences Proceedings, v. 73, no. 4, p. 1000-1004.

_____ 1977, 1976 bedload measurements, East Fork River, Wyoming: [U.S.] National Academy of Sciences Proceedings, v. 74, no. 7, p. 2644-2648.

NOTE

Figures 1-4 and tables 1-4 from Emmett (1980).

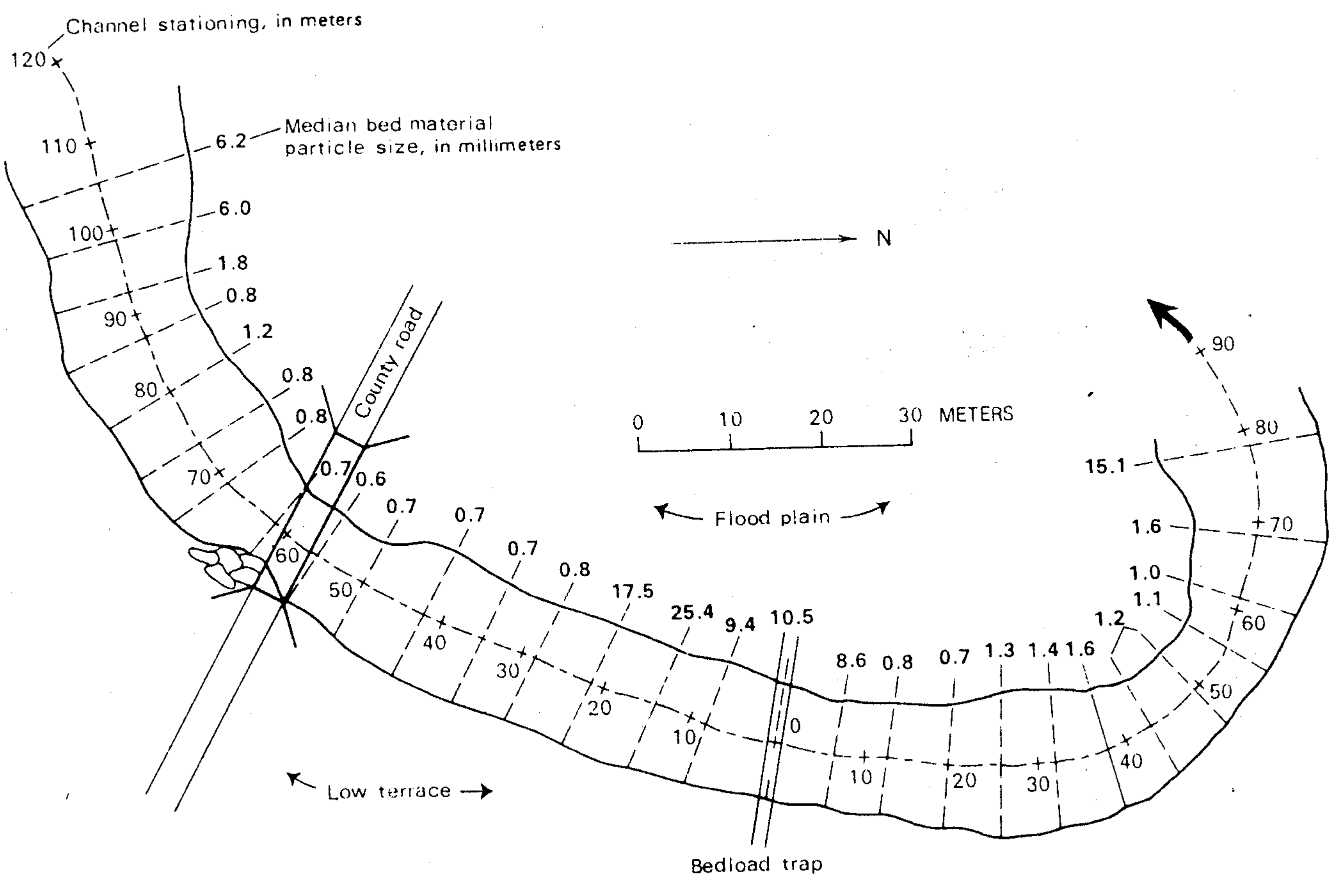


Figure 1. Map of East Fork River in vicinity of bedload trap; data show median diameter of bed material at sections along river.

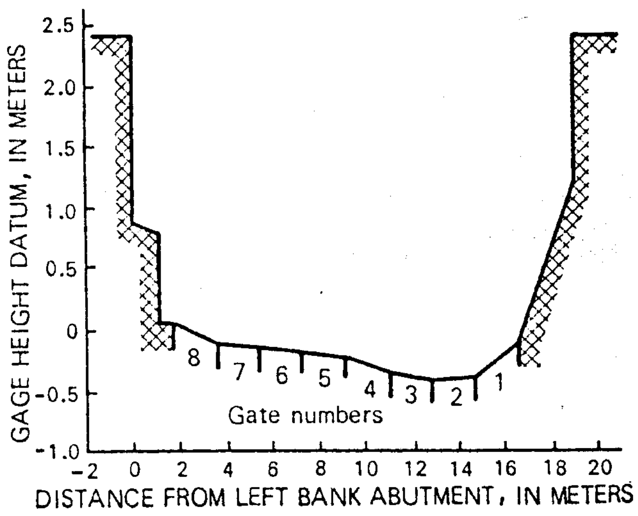


Figure 2. Cross section of the East Fork

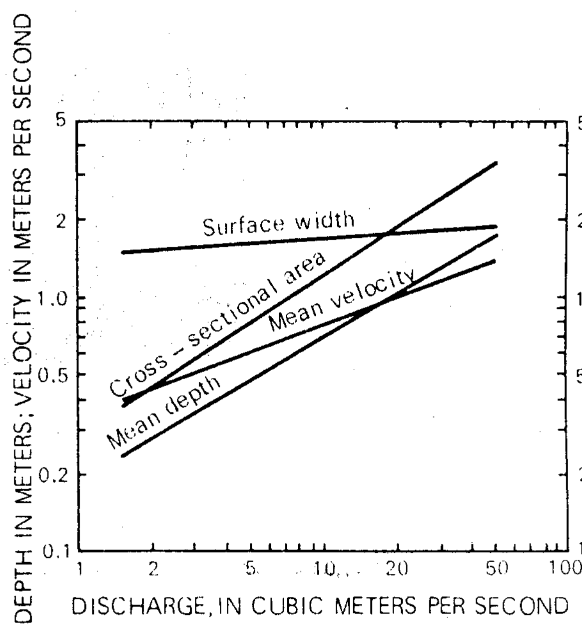
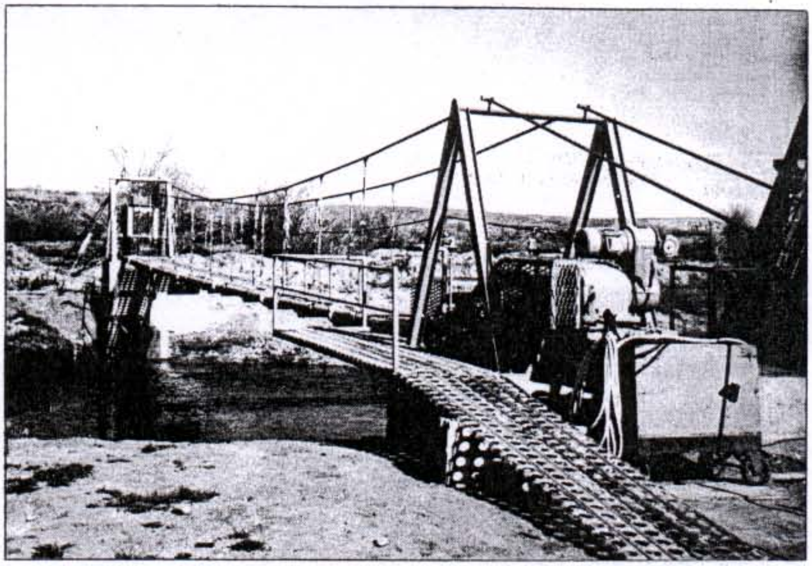
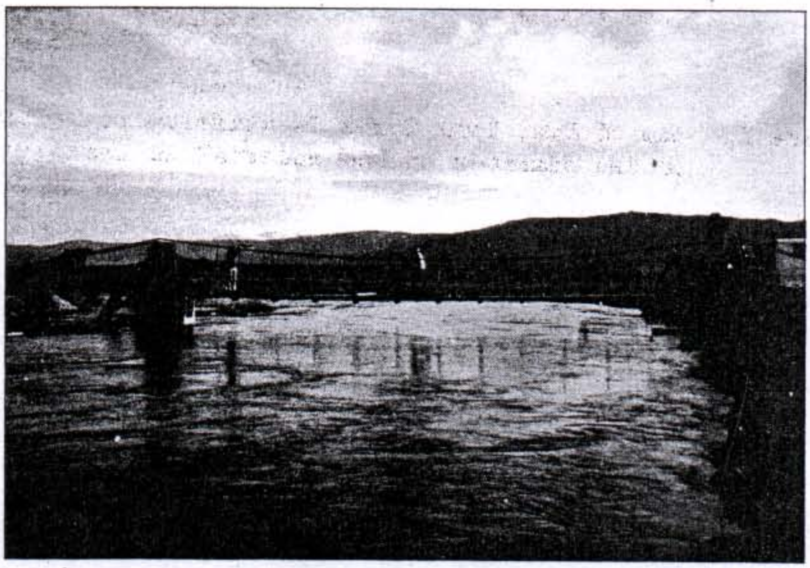


Figure 3. Hydraulic-geometry relatic

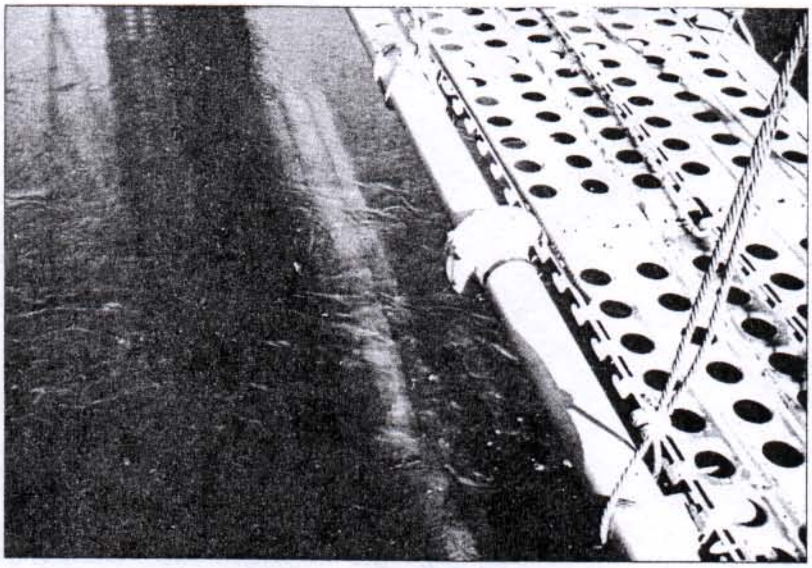


A. View across river showing suspension bridge and drive mechanism of conveyor-belt bedload sampler; flow is relatively low.

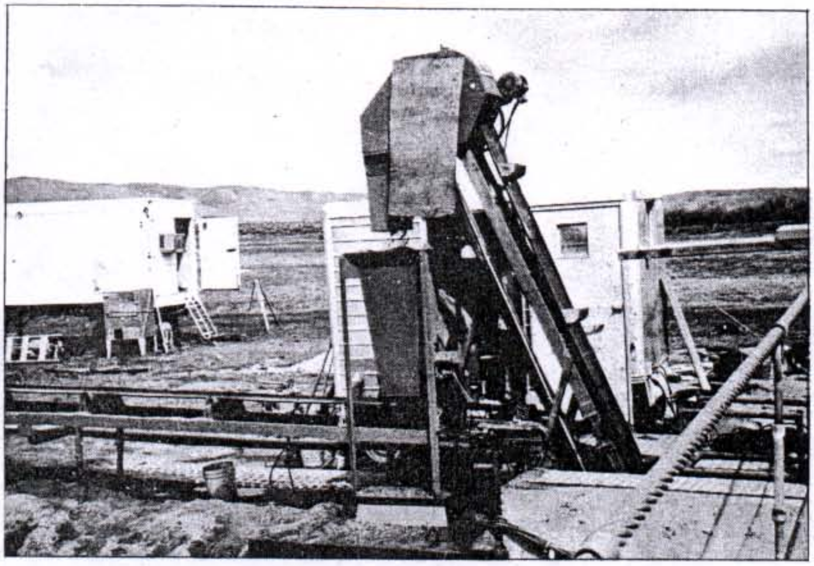


B. View downstream at suspension bridge; flow is relatively high.

Figure 4.--Conveyor-belt bedload sampler, East Fork River, Wyoming.



C. Bedload trap on streambed is visible below suspension bridge; gates are in closed position.



D. Vertical-lift assembly, weighing hopper and conveyor belt for return of sampled sediment to stream.

Figure 4.--Continued

TABLE 1.—*Size distribution of composited bed material, East Fork River, Wyoming, at bedload-transport research project*

Sieve diameter (mm)	Percentage, by weight, retained on sieve	Percentage, by weight, finer than sieve
Pan	0.3	0.0
0.062	.1	.3
.088	.4	.4
.125	1.0	.8
.177	2.4	1.8
.250	6.6	4.2
.350	12.0	10.8
.500	13.5	22.8
.710	9.1	36.2
1.00	7.4	45.3
1.40	6.1	52.7
2.00	4.7	58.8
2.80	4.3	63.5
4.00	3.6	67.8
5.60	3.6	71.4
8.00	3.6	75.0
11.3	4.3	78.5
16.0	4.1	82.8
22.6	5.1	86.9
32.0	5.2	92.0
45.0	2.8	97.2
64.0	.0	100.0

TABLE 2.—*Size distribution of transport-weighted composite bedload (1976 conveyor belt), East Fork River, Wyoming, at bedload-transport research project*

Sieve diameter (mm)	Percentage, by weight, retained on sieve	Percentage, by weight, finer than sieve
Pan	0.3	0.0
0.062	.1	.3
.088	.2	.4
.125	.4	.6
.177	1.0	1.0
.250	5.3	1.9
.350	11.8	7.2
.500	15.1	19.0
.710	11.8	34.1
1.00	11.9	45.9
1.40	12.0	57.8
2.00	9.9	69.9
2.80	7.4	79.8
4.00	5.5	87.2
5.60	3.4	92.7
8.00	1.8	96.1
11.3	1.0	97.9
16.0	.5	98.9
22.6	.4	99.4
32.0	.2	99.8
45.0	.0	100.0

TABLE 3—*Comparison of bed material and bedload particle sizes*

Particle-size category (d percentage finer than)	Particle size (mm) Bed material	Bedload
d_5	0.27	0.32
d_{16}	.42	.47
d_{25}	.53	.58
d_{35}	.69	.73
d_{50}	1.25	1.13
d_{65}	3.20	1.73
d_{75}	8.00	2.37
d_{84}	17.6	3.42
d_{95}	37.6	7.01

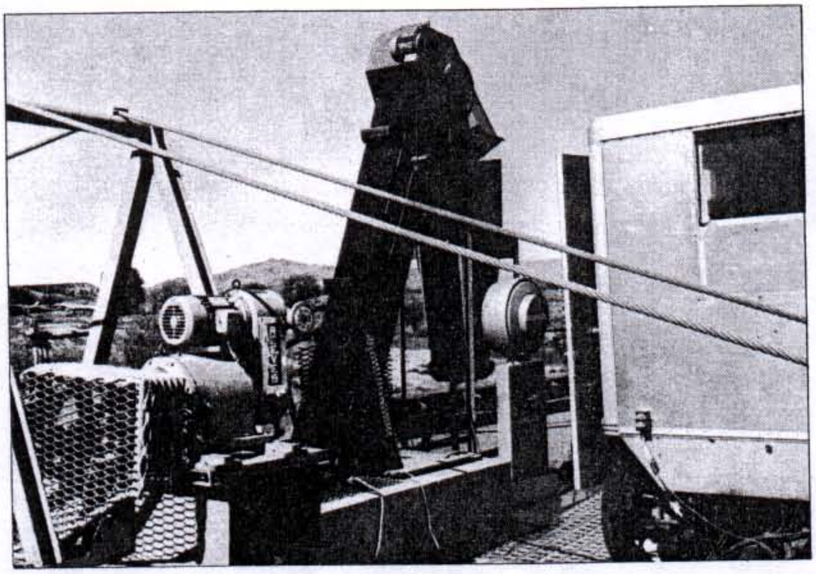
TABLE 4.—*Summary data of river hydraulics and bedload transport, conveyor-belt sampler*

Date[1]	River discharge: Total,[2] Q (m^3/s)	River discharge: Effective,[3] Q' (m^3/s)	Mean depth,[4] D (m)	Mean velocity,[5] V (m/s)	Unit bedload-transport rate,[6] j_b (kg/m−s)	Bedload size,[7] d_{50} (mm)
5–26–73	17.0	16.1	1.04	1.06	0.0122	1.35
5–28–73	6.66	6.50	.55	.81	.0009	------
5–29–73	7.50	7.30	.59	.84	.0011	------
6–01–73	17.0	16.1	1.04	1.06	.0190	------
6–02–73	18.8	17.8	1.11	1.09	.0235	.74
6–03–73	17.5	16.6	1.06	1.07	.0240	------
6–06–73	11.8	11.3	.81	.96	.0133	------
6–07–73	16.7	15.9	1.03	1.06	.0260	------
6–08–73	20.3	19.2	1.17	1.19	.0218	.98
5–25–74	5.44	5.34	.48	.76	.0056	.54
5–26–74	10.3	9.92	.74	.92	.0822	.59
5–27–74	22.9	21.5	1.27	1.15	.1758	1.03
5–28–74	32.0	29.8	1.60	1.28	.2255	1.40
5–29–74	45.0	41.5	2.01	1.41	.2912	1.52
5–30–74	34.6	32.2	1.68	1.31	.0786	1.51
5–31–74	24.4	22.9	1.33	1.18	.0647	1.40
6–01–74	25.9	24.3	1.38	1.20	.0206	.94
6–02–74	27.2	25.5	1.43	1.22	.0130	.99
6–03–74	31.9	29.7	1.59	1.27	.0172	.88
6–04–74	29.9	27.9	1.52	1.25	.0285	.92
6–05–74	28.3	26.5	1.47	1.23	.0305	.81
5–27–75	2.44	2.44	.28	.61	.0021	------
5–30–75	2.04	2.04	.24	.57	.0016	------
6–02–75	5.98	5.82	.51	.78	.0484	.74
6–03–75	9.52	9.13	.70	.90	.0791	------
6–04–75	10.5	10.0	.74	.92	.0812	1.16
6–05–75	11.2	10.7	.78	.94	.0972	1.26
6–06–75	21.3	20.0	1.21	1.13	.3114	1.36
6–07–75	26.6	24.8	1.40	1.21	.2069	1.28
6–08–75	27.5	25.6	1.44	1.22	.1733	1.41
6–09–75	26.2	24.3	1.38	1.20	.0833	1.35
6–10–75	15.3	14.4	.96	1.03	.0348	------
6–11–75	10.6	10.1	.75	.92	.0110	------
6–13–75	16.7	15.8	1.02	1.06	.0277	.50
6–14–75	27.6	25.7	1.44	1.22	.0926	1.27
6–15–75	31.4	29.0	1.57	1.27	.1190	1.05
6–16–75	32.8	30.3	1.62	1.28	.1190	1.19
6–17–75	23.8	22.2	1.30	1.17	.0796	1.36
6–18–75	13.5	12.8	.88	.99	.0106	------
6–19–75	10.5	10.1	.75	.92	.0097	.73
6–21–75	7.48	7.23	.59	.84	.0032	.70
6–22–75	7.25	7.01	.58	.83	.0047	.64
6–23–75	8.55	8.24	.65	.87	.0062	.77
6–24–75	11.3	10.8	.78	.94	.0194	.98
6–25–75	23.2	21.7	1.28	1.16	.0838	1.10
6–26–75	13.8	13.1	.90	1.00	.0396	.99
7–01–75	24.8	23.1	1.34	1.18	.2159	1.63
7–08–75	23.0	21.5	1.27	1.16	.0317	.91
5–18–76	10.4	9.87	.78	.87	.0838	.98
5–19–76	15.7	14.8	1.01	1.00	.1359	1.04
5–20–76	20.3	18.9	1.19	1.09	.1163	.96
5–20–76	21.0	19.6	1.22	1.10	.1295	1.04
5–21–76	24.0	22.4	1.33	1.15	.1769	1.52
5–22–76	18.6	17.5	1.13	1.06	.0754	1.56
5–26–76	10.3	9.77	.77	.87	.0130	.71

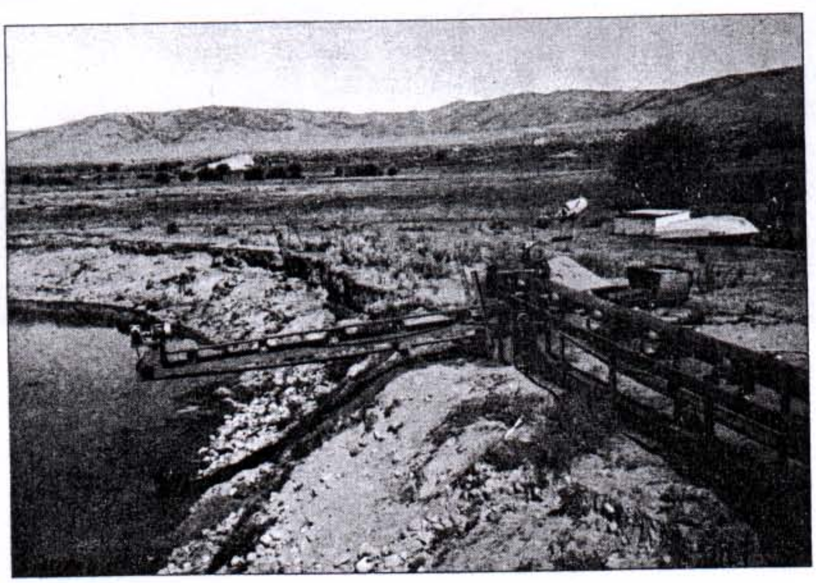
TABLE 4.—*Summary data of river hydraulics and bedload transport, conveyor-belt sampler*—Continued

Date[1]	River discharge Total,[2] Q (m^3/s)	River discharge Effective,[3] Q' (m^3/s)	Mean depth,[4] D (m)	Mean velocity,[5] V (m/s)	Unit bedload-transport rate,[6] j_b (kg/m−s)	Bedload size,[7] d_{50} (mm)
5-27-76	15.2	14.3	.99	.99	.0232	.59
5-27-76	14.5	13.7	.96	.97	.0301	.61
5-27-76	13.8	13.0	.93	.96	.0233	.77
5-28-76	20.1	18.8	1.18	1.08	.0437	.95
5-28-76	21.2	19.8	1.23	1.10	.0454	1.11
5-29-76	22.0	20.5	1.25	1.12	.0712	1.30
5-29-76	22.4	20.9	1.27	1.12	.0618	1.67
5-30-76	22.4	20.9	1.27	1.12	.0774	1.29
5-31-76	17.7	16.6	1.09	1.04	.0621	1.09
5-31-76	16.8	15.8	1.06	1.02	.0405	.98
6-01-76	15.2	14.3	.99	.99	.0361	.81
6-01-76	14.7	13.9	.97	.98	.0325	.80
6-02-76	19.1	17.9	1.15	1.07	.0576	.94
6-02-76	19.0	17.8	1.14	1.06	.0463	1.04
6-03-76	23.2	21.6	1.30	1.14	.0834	1.18
6-04-76	23.4	21.8	1.30	1.14	.0871	1.40
6-05-76	23.0	21.4	1.29	1.13	.0918	1.76
6-05-76	24.0	22.4	1.33	1.15	.0784	1.51
6-06-76	24.2	22.6	1.33	1.16	.0908	1.30
6-07-76	26.5	24.6	1.41	1.19	.0869	1.35
6-08-76	22.7	21.1	1.28	1.13	.0570	1.24
6-09-76	20.1	18.8	1.18	1.08	.0513	1.03
6-09-76	20.3	18.9	1.19	1.09	.0346	1.08
6-10-76	19.5	18.2	1.16	1.07	.0290	1.06
6-11-76	14.6	13.8	.97	.98	.0253	.84
6-11-76	15.4	14.5	1.00	.99	.0289	1.05
6-11-76	16.6	15.7	1.05	1.02	.0280	1.02
6-11-76	16.1	15.2	1.03	1.01	.0629	1.07
6-11-76	15.3	14.4	.99	.99	.0236	.79
6-12-76	13.9	13.1	.93	.96	.0181	.81
6-12-76	13.2	12.5	.90	.94	.0169	.77
6-12-76	11.8	11.2	.84	.91	.0162	.81
6-12-76	11.0	10.5	.81	.89	.0145	.82
6-12-76	10.1	9.64	.76	.86	.0106	.82
6-12-76	8.89	8.50	.70	.83	.0084	.77
6-13-76	6.80	6.55	.59	.76	.0028	.49
6-14-76	5.13	4.97	.50	.69	.0022	.41
6-14-76	4.79	4.65	.47	.67	.0020	.53
6-15-76	3.96	3.87	.42	.64	.0003	.66
6-15-76	3.51	3.44	.39	.61	.0004	.88
6-16-76	5.13	4.97	.50	.69	.0009	.50
6-18-76	3.99	3.90	.42	.63	.0006	.42
6-19-76	4.30	4.20	.44	.65	.0009	.44
6-20-76	4.70	4.57	.47	.67	.0023	.43
6-21-76	10.0	9.53	.76	.86	.0181	.68

[1]Dates correspond to dates listed in table 5.
[2]Complete river discharge including overbank flow.
[3]Discharge over 14.6-m width of bedload trap; includes all flow over the active width of the streambed.
[4]Mean depth over effective width W; $D = \dfrac{Q'}{VW}$
[5]Mean velocity of effective discharge; $V = \dfrac{Q'}{WD} = \dfrac{Q'}{14.6D}$
[6]Unit transport rate of solids in dry weight per second, over 14.6-m width of bedload trap.
[7]d_{50} is median diameter of grains; complete grain-size data are given in table 5.



LIFT BUCKETS DUMP INTO HOPPER THAT STANDS ON WEIGHING SCALE



DOWNSTREAM BELT DELIVERS SEDIMENT TO RIVER BELT AND THUS TO RIVER