TWO DATA SETS DESCRIBING CHANNEL-WIDE TEMPORAL VARIATIONS IN BEDLOAD-TRANSPORT RATES

By Basil Gomez

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CONTENTS

ILLUSTRATIONS

TABLES

Field Data

Laboratory Data

CONVERSION FACTORS

The following factors may be used to convert the metric (SI) units used herein to the inch-pound system of units:

Multiply metric units	by	to obtain inch-pound units
millimeter (mm)	0.03937	inch
square millimeter (mm^2)	1.550×10^{-3}	square inch
meter (m)	3.281	foot
meter per second (m/s)	3.281	foot per second
kilometer (km)	0.621	mile
cubic meter per second (m^3/s)	35.311	cubic foot per second
kilogram (kg)	2.205	pound
kilogram per meter per second [(kg/m)/s]	0.672	pound per foot per second

To convert degrees Celsius ($^{\circ}C$) to degrees Fahrenheit ($^{\circ}F$) use the following equation:

$$^{\circ}F = (9/5)^{\circ}C + 32$$

The following terms and abbreviations also are used in this report:

milligram per liter (mg/L)
Phi (Ø) [$-\log_2 D$ where: D is the particle size in millimeter]
Q water discharge
S water-surface slope
u flow velocity
W flow width
Y flow depth
ρ fluid mass density
ρ_s solid mass density

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ABSTRACT

Two data sets that consist of hydraulic and bedload-transport measurements are presented in this report. The data document channel-wide temporal variations in bedload-transport rates that occurred during steady, or almost steady, flow conditions and were caused by the progressive development of an armored surface in a small, mixed sand-and-gravel-bed stream in the Swiss Alps, and by the downstream migration of single-row alternating bars in a laboratory flume. The field data were obtained during sampling undertaken in the Borgne d'Arolla, Valais, Switzerland, in August 1979, and the laboratory data are the product of experiments undertaken at the Environmental Research Center, University of Tsukuba, Japan, in July 1987.

INTRODUCTION AND ACKNOWLEDGMENTS

Temporal variability (even during steady flow conditions) is recognized to be an inherent component of the bedload-transport process. However, continuous measurements of bedload-transport rates, which may facilitate the characterization of such variability, in well-defined circumstances, are rare. The purpose of this report is to present two data sets, consisting of channel-wide measurements of bedload-transport rates that were made continuously, over periods of several hours. The data document temporal variations in bedload-transport rates that occurred during essentially steady flow conditions and were associated with the progressive development of an armored surface, as indicated by the field data (Gomez, 1983), and the downstream migration of single-row alternating bars in the laboratory (Basil Gomez and others, U.S. Geological Survey, written commun., 1988)

The field data were collected during the course of a Natural Environment Research Council Studentship held at the University of Southampton, United Kingdom. The laboratory experiments were undertaken during a visit to the Environmental Research Center, University of Tsukuba, Japan, that was supported by the Royal Society of London and the Sasakawa Fund. Many people assisted with these investigations; however, I am particularly indebted to K.J. Gregory, Hiroshi Ikeda, Fujiko Iseya, H.C. Rossotti and R.J. Small for their help and advice. W.W. Emmett and H.H. Stevens kindly reviewed a preliminary draft of the report.

FIELD SETTING AND SAMPLING PROCEDURES

The Borgne d'Arolla is a northward-flowing, predominantly glacier-supplied stream which has its source in the Val d'Arolla, Valais, Switzerland (fig. 1). It joins the River Rhone about 2 km upstream from Sion. At the head of the Val d'Arolla, flows in the Borgne d'Arolla are regulated as part of a regional hydro-electric power scheme, and all meltwater from the five glaciers that normally would supply the stream is diverted, through a series of intakes, eastward across the drainage divide into the Lac des Dix. Consequently, flows in the Borgne d'Arolla, for a distance of 2 km downvalley from the terminus of the Bas Glacier d'Arolla are intermittent, and baseflows depend entirely on the water that is supplied from six small streams that drain the western slopes at the head of the valley. In addition to storm-generated flood peaks, peak flows were generated, almost on a daily basis, by controlled purges, designed to flush sediment from traps that were located immediately upstream from the intakes. In the section of the perennial channel upstream from Arolla, peak discharges during a major purge were about 1.83 m^3/s, and peak flows during minor purges approximately 0.65 m^3/s. Baseflows were of the order of 0.15 m^3/s.

Sampling was undertaken 2.45 km downstream from the terminus of the Bas Glacier d'Arolla, in a 4-m-long reach (fig. 1) where the bed was plane and predominantly composed of material that was finer than 16 mm in diameter. This reach was located at the downstream end of a steep, boulder-strewn section of the channel, at a point where the cross-section exhibits a stable, well-defined form that was maintained by the presence of two large boulders. The entire flow was routed between these boulders at all stages, except those approaching bankfull. A series of boulders marked the beginning of the succeeding steep, boulder-dominated reach. The approach to the reach was marked by a scour pool and a small, longitudinal bar, which was submerged during purges, but which protruded above the water surface during periods of baseflow. During periods of baseflow, streambed width was approximately 3.8 m, the flow depth rarely exceeded 0.15 m, and the water was clear. During minor purges, when the width of the flow expanded to 5.5 m and the mean depth increased to 0.25 m, suspended-sediment concentrations in excess of 190,000 mg/L were associated with the passage of the flood peak.

Hydraulic Data

Water temperature varied between 3 and 8 ^{o}C during the sampling period. The flow depth was measured at each bedload sampling point. A virtually coincident measure of the flow velocity was obtained at each bedload sampling point with a current meter. The current meter was mounted on a wading rod, and had a propeller located 19 mm above the bed on the same plane as the center of the sampler, 150 mm to one side and slightly forward of the entrance. The flow depth and flow velocity measurements made at each vertical are listed in table 1. The estimates of stream power (ρYSu) listed in table 2 are based on the active bed width and use unweighted averages of the flow depth and flow velocity for a single traverse (these unweighted averages are based upon the hydraulic data listed in table 1), and on the average water surface slope during the sampling period. The

water surface slope was computed in relation to two levelled stage markers located at either end of the reach, which were read periodically throughout the sampling period. It should be noted that the progressive decline in stream power, that apparently occurs towards the end of the sampling period (table 2), is an artifact of the computation of stream power with respect to the active bed width which contracted at that time, while the width of the cross section that was occupied by the flow remained virtually constant.

Bedload Sampling

Bedload was sampled in the Borgne d'Arolla on August 17, 1979, between 1021 and 1610 hours, and on August 19, 1979, between 0947 and 1402 hours, using a half-size version of the standard Helley-Smith sampler (Helley and Smith, 1971) with a geometrically similar nozzle, made from 6-mm mild steel. The sampler bag was made from 0.5-mm mesh poylester monofilament and the sampler was mounted on a wading rod. Samples were obtained at 0.2- or 0.3-m intervals across the 3.8 m width of the baseflow channel. The number of samples that was obtained during a single traverse depended on the width of the active bed. The sampler remained in position on the bed for 30 seconds at each sampling point. Each traverse of the stream took between 20 and 30 minutes to complete. The same traverse location was used throughout the sampling period. Baseflow conditions generally prevailed throughout the sampling period, except when minor purges occurred on August 17 at approximately 1057, 1455 and 1544 hours. Unit bedload-transport rates (immersed mass $[\rho_s - \rho/\rho_s]$) observed at each vertical, the median particle size and inclusive graphic standard deviation (Folk and Ward, 1957) of each bedload sample are listed in table 1. Unweighted average values for a single traverse of the stream are listed in table 2. The average particle size distributions for the 136 bedload samples that were collected on August 17, 1979, and the 109 bedload samples that were collected on August 19, 1979, are listed in table 3. The particle size distributions of the bedload samples have been truncated at 0.5 mm in accordance with the nominal retention property of the mesh from which the sampler bag was made.

Bed-Material Sampling

Samples of the surficial and subsurface bed material were obtained on August 18, 1979, from within a 3-m-long by 4-m-wide area of the bed. The sampling area was centered upon the bedload-sampling traverse and located in the midsection of the active bed. Areal samples, from the mobile and static bed surfaces, were obtained using a 150 mm^2 adhesive pad, and the contact sampling technique described by Gomez (1979). A total of 40 samples were obtained from mobile areas of the bed surface, and 39 from those areas where the bed surface was static. A single 10-kg volumetric sample of the subsurface bed material was obtained from the center of the sampling area after the surficial material had been scraped away. Average particle-size distributions for the two sets of surficial samples and the particle size distribution of the subsurface bed material are listed in table 3. The particle size distributions of the surficial bed material have been truncated at 0.5 mm because the contact sampler was incapable of accurately sampling smaller particles. The areal samples were transformed to their

volumetric equivalents by applying a conversion factor of $D^{0.5}$. $D^{0.5}$ was selected, as opposed to the factor of 1/D which was recommended by Kellerhals and Bray (1971), purely as an empirical expedient to discount the appearance of (transient) fine material on the armored streambed.

LABORATORY SETUP AND OPERATING PROCEDURES

The laboratory experiment was undertaken in the 160-m-long, 4-m-wide, and 2-m-deep steel, fixed-bed flume (fig. 2) at the Environmental Research Center, University of Tsukuba, Japan, during July 1987. The flow rate was maintained by a constant head tank that was supplied with water from the main reservior by three pumps. Ungraded sediment, which initially was used to supply the feed system, was graded and dumped in stockpiles. Subsequently, sediment was drawn from the stockpiles and supplied to the flume. As a result, the particle-size distribution of the sediment and the rate at which it was supplied to the upstream end of the flume could be controlled precisely. At the downstream end of the flume, the water and sediment were discharged into a settling tank. The water then flowed into a pond, where it was returned to the main reservoir, and the sediment was removed by the recovery conveyor, which formed the floor of the settling tank. The recovery conveyor then dumped the sediment onto the weighing conveyor. This conveyor was connected to a load cell that continuously monitored the bedload-transport rate across the entire width of the flume. Thereafter, the sediment was returned to the sieves, graded and stockpiled. Further details about the 4-m wide flume are provided by Inokuchi and others (1980) and Ikeda (1983).

Flume Operation

Water discharge was set prior to the start of the experiment, as were the height of the tailgates, which controlled the elevation of the water surface and the bed at the downstream end of the flume, and the sediment-supply rate; this was done to create the desired bed slope. Equilibrium conditions were considered to have been established once the average bedload-transport rate which was measured at the downstream end of the flume, approximated over a period of several hours the rate at which sediment was being fed into the flume, and the bed slope had stabilized. Thereafter, the run commenced. The normal operating practice was to drain the flume and shut it down overnight. During startup, water was let into the channel and the flow deepened gradually, so as not to disturb the bed. The startup and shutdown procedures were usually accomplished within a few minutes, and little or no disruption to the transport process was occasioned by these practices. Water temperature varied between 24.8 and 26.1 ^{o}C during the experiment.

Steady flow ($Q = 0.542$ m^3/s) and equilibrium transport conditions were maintained throughout the experiment. The average supply rate was 0.134 (kg/m)/s (immersed mass). All sediment transport occurred in the form of bedload, and single-row alternating bars were the predominant bedform. The total run time of the three-day experiment was 19.5 hours.

Hydraulic Data and Bedload Measurements

Water surface-slope was calculated (at 5-minute intervals) with reference to the water level in two stilling wells located 64.2 m apart (89.7 m and 153.9 m downstream of the entrance to the channel). The inlets to these wells were located on one side of the flume (rather than in the center of the channel), and the data are biased accordingly. Estimates of stream power ($\rho QS/W$) based upon these data are listed in table 4. The continuous record of bedload transport was averaged for a 5-minute time interval to provide a temporally integrated measure of the prevailing bedload transport rate. Spatially integrated (stream-wide) unit bedload-transport rates (immersed mass) for each 5-minute interval are listed in table 4.

Volumetric samples of the bed material were removed from the weighing conveyor at 5-minute intervals throughout the experiment. The median particle size and sorting coefficient (Trask, 1930) of each sample are listed in table 5. Although the supply of sediment was a well-sorted gravel, the subsurface bed material, which already was present in the flume, contained an appreciable quantity (about 15 percent) of sand. This sandy substrate was scoured during the passage of bar troughs through the bedload trap. The size of the bedload generally was smaller than average at these times. Average particle-size distributions of the sediment supply and subsurface bed material are listed in table 5.

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FIGURES

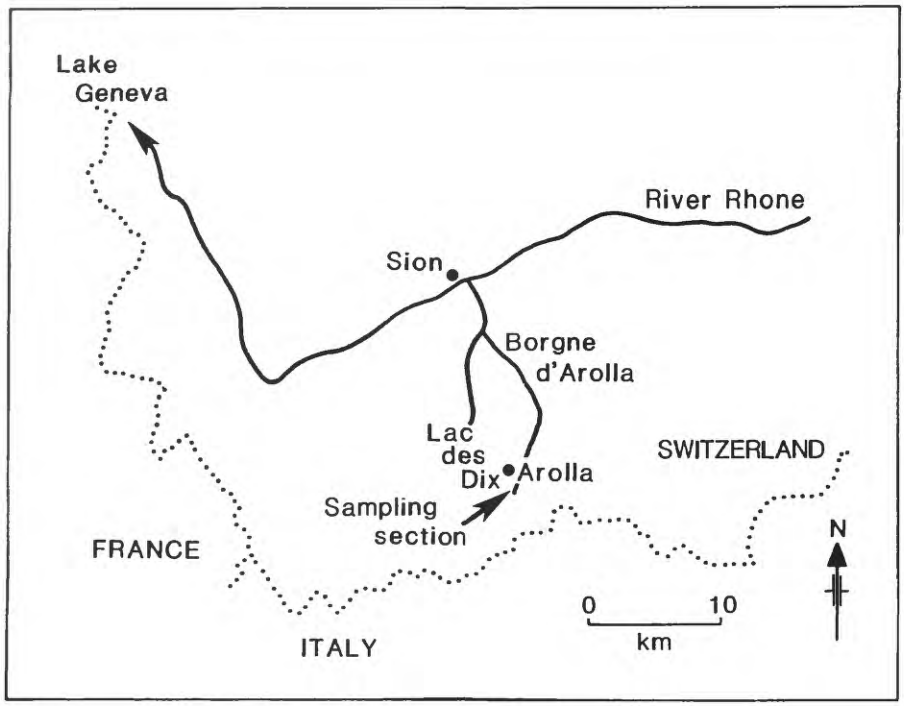
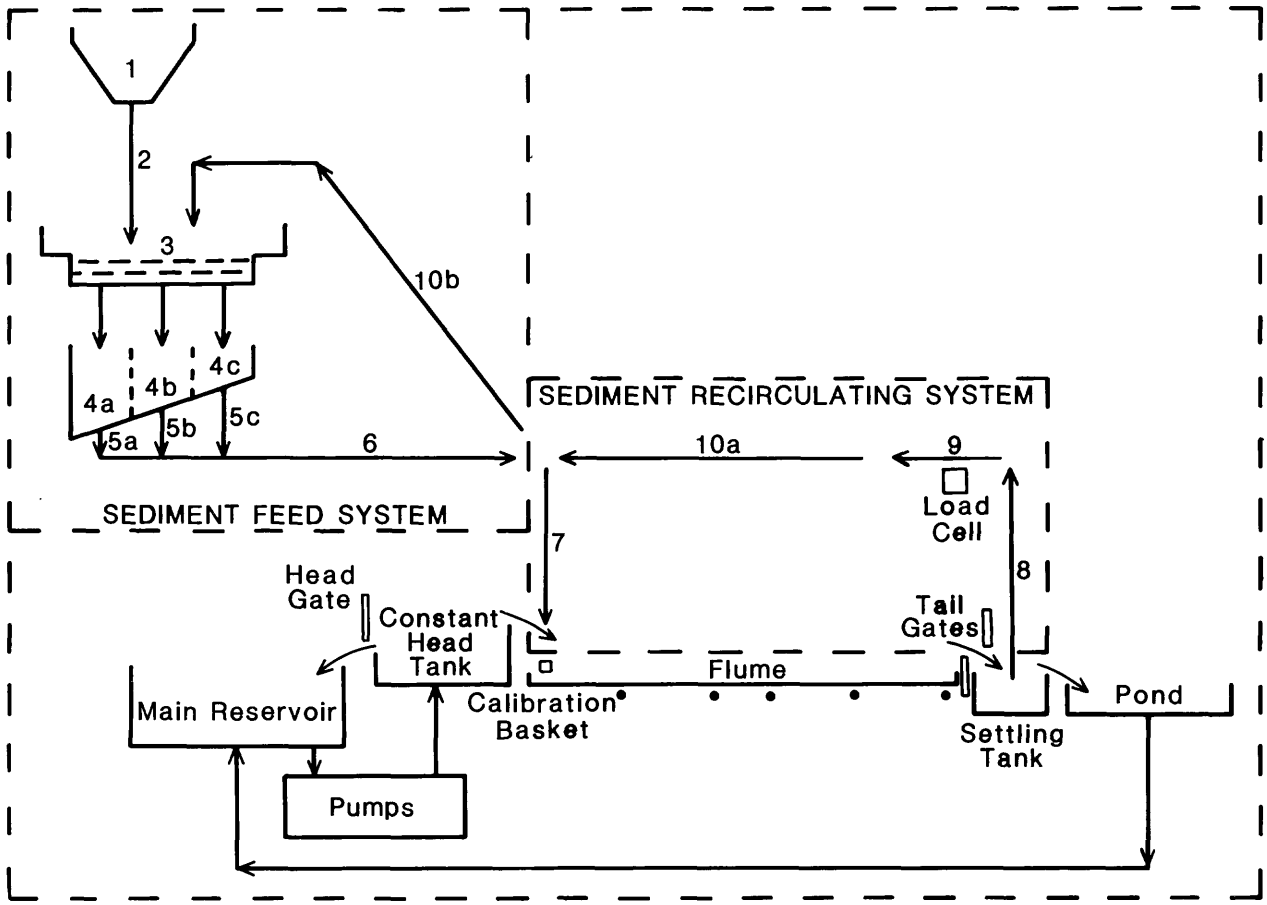


Figure 1. Location and view (upstream) of the sampling section (X - Y) in the Borgne d'Arolla [the position of the sampling verticals was calculated from the right-hand bank (Y)].



1	Supply Hopper	6	Supply Conveyor	•	Stilling Well
2	Hopper Conveyor	7	Input Conveyor		
3	Sieves (2.5 & 5 mm)	8	Recovery Conveyor		
4	Sediment Stockpiles	9	Weighing Conveyor		
5	Sediment Supply	10	Return Conveyors		

Figure 2. Diagram of the flume facility used in the laboratory experiments.

FIELD DATA

Table 1.--Borgne d'Arolla - Hydraulic and bedload-transport data

[m, meter; m/s, meter per second; (kg/m)/s, kilogram per meter per second; mm, millimeter]

Sample	Time (hours)	Traverse	Position of vertical (m)	Flow depth (m)	Flow velocity (m/s)	Unit bedload-transport rate [(kg/m)/s]	Median particle size (mm)	Inclusive graphic standard deviation
				August 17, 1979				
1	1021	1	0.6	0.093	0.59	0.0467	1.00	1.07
2	1023	1	0.9	0.085	0.75	0.2888	1.04	1.03
3	1025	1	1.2	0.098	0.97	0.6248	1.41	1.42
4	1027	1	1.5	0.087	1.13	0.7193	1.28	1.50
5	1029	1	1.8	0.096	0.86	0.7586	1.86	1.95
6	1035	1	2.1	0.097	0.98	0.4804	4.76	1.45
7	1037	1	2.4	0.089	0.68	0.2289	4.29	1.62
8	1040	2	0.6	0.103	0.79	0.1916	1.80	1.26
9	1042	2	0.9	0.087	0.98	0.4699	1.04	1.33
10	1045	2	1.2	0.091	1.04	0.6563	1.46	1.33
11	1050	2	1.5	0.086	0.95	0.7035	2.83	1.49
12	1054	2	1.8	0.096	1.21	0.9109	3.86	1.42
13	1056	2	2.1	0.095	1.26	0.7455	6.73	1.36
14	1059	2	2.4	0.087	0.96	0.0604	3.03	1.86
15	1100	3	0.6	0.113	0.67	0.0470	1.23	1.05
16	1104	3	0.9	0.088	0.72	0.1523	1.46	1.33
17	1106	3	1.2	0.093	0.82	0.3814	2.14	1.36
18	1108	3	1.5	0.087	1.10	0.5171	3.25	0.96
19	1111	3	1.8	0.097	1.17	0.5513	3.61	1.40
20	1113	3	2.1	0.097	0.93	0.8138	3.61	1.50
21	1116	3	2.4	0.086	0.80	0.6266	3.61	1.36
22	1120	4	0.6	0.122	0.54	0.3281	1.41	1.21
23	1122	4	0.9	0.089	0.79	0.2179	1.52	1.20
24	1124	4	1.2	0.086	1.13	0.3491	1.68	1.31
25	1125	4	1.5	0.086	1.16	0.4463	2.38	1.21
26	1127	4	1.8	0.098	1.19	0.6799	3.14	1.47
27	1129	4	2.1	0.097	1.07	0.5066	2.93	1.41
28	1138	4	2.4	0.084	0.75	0.1523	4.93	1.12
29	1139	5	0.6	0.128	0.60	0.0709	1.04	1.32
30	1141	5	0.9	0.105	0.77	0.0814	2.07	1.02
31	1142	5	1.2	0.079	0.92	0.3911	1.46	1.25
32	1143	5	1.5	0.089	1.10	0.5171	1.46	1.12
33	1146	5	1.8	0.092	1.22	0.5775	2.22	1.24
34	1148	5	2.1	0.103	1.14	0.0814	1.63	1.44
35	1149	5	2.4	0.094	0.62	0.1024	2.83	1.42
36	1151	6	0.6	0.124	0.61	0.0055	1.63	1.00
37	1152	6	0.9	0.094	0.79	0.2501	1.46	0.94
38	1154	6	1.2	0.079	1.16	0.3150	1.93	1.14
39	1155	6	1.5	0.082	1.07	0.3229	1.19	1.41
40	1158	6	1.8	0.114	1.14	0.5933	1.74	1.25
41	1200	6	2.1	0.097	1.08	0.5250	3.36	1.37
42	1201	6	2.4	0.083	0.94	0.2179	2.73	1.56

Table 1.--Borgne d'Arolla - Hydraulic and bedload-transport data--Continued

Sample	Time (hours)	Traverse	Position of vertical (m)	Flow depth (m)	Flow velocity (m/s)	Unit bedload-transport rate [(kg/m)/s]	Median particle size (mm)	Inclusive graphic standard deviation
43	1213	7	0.6	0.129	0.56	0.0436	0.62	0.96
44	1214	7	0.9	0.096	0.84	0.1864	1.28	1.00
45	1215	7	1.2	0.089	0.93	0.2888	1.57	1.10
46	1217	7	1.5	0.092	0.98	0.3386	1.37	1.22
47	1218	7	1.8	0.108	1.12	0.3385	1.87	1.38
48	1219	7	2.1	0.096	1.11	0.5177	2.07	1.45
49	1221	7	2.4	0.091	0.77	0.1525	3.61	1.63
50	1222	8	0.6	0.125	0.78	0.0284	1.00	0.98
51	1224	8	0.9	0.081	0.52	0.1906	0.84	1.15
52	1225	8	1.2	0.093	0.86	0.3323	1.41	1.19
53	1227	8	1.5	0.099	1.10	0.3651	2.00	1.30
54	1228	8	1.8	0.111	1.21	0.4305	1.46	1.28
55	1230	8	2.1	0.096	1.07	0.4686	2.64	1.62
56	1232	8	2.4	0.089	0.67	0.0761	2.30	1.61
57	1233	9	0.6	0.118	0.64	0.0207	0.97	0.96
58	1236	9	0.9	0.107	0.74	0.2179	1.37	1.03
59	1237	9	1.2	0.095	0.83	0.3675	1.23	1.17
60	1238	9	1.5	0.103	1.04	0.2615	1.52	1.19
61	1239	9	1.8	0.114	0.85	0.4515	2.39	1.62
62	1241	9	2.1	0.117	0.90	0.3869	1.87	1.60
63	1242	9	2.4	0.116	0.68	0.0284	1.15	0.96
64	1357	10	0.8	0.106	0.68	0.0814	2.38	0.84
65	1358	10	1.0	0.108	0.86	0.1743	1.46	1.08
66	1400	10	1.2	0.098	0.86	0.2234	1.19	1.02
67	1401	10	1.4	0.112	1.01	0.2179	1.23	1.12
68	1402	10	1.6	0.111	1.07	0.3651	1.41	1.07
69	1404	10	1.8	0.118	1.08	0.2342	2.55	1.63
70	1405	10	2.0	0.109	0.84	0.0764	3.36	1.45
71	1407	10	2.2	0.131	0.71	0.0305	3.86	1.59
72	1409	10	2.4	0.096	0.84	0.0000	0.00	0.00
73	1411	11	0.8	0.101	0.63	0.0092	1.68	1.69
74	1413	11	1.0	0.106	0.74	0.0234	2.38	1.02
75	1415	11	1.2	0.119	0.73	0.1252	1.80	1.03
76	1416	11	1.4	0.106	0.99	0.2126	2.00	1.18
77	1419	11	1.6	0.112	1.02	0.2289	1.80	1.22
78	1420	11	1.8	0.108	1.03	0.1362	3.73	1.35
79	1421	11	2.0	0.119	0.95	0.1155	6.06	1.01
80	1423	11	2.2	0.121	0.64	0.0709	3.61	1.41

Table 1.--Borgne d'Arolla - Hydraulic and bedload-transport data--Continued

Sample	Time (hours)	Traverse	Position of vertical (m)	Flow depth (m)	Flow velocity (m/s)	Unit bedload-transport rate [(kg/m)/s]	Median particle size (mm)	Inclusive graphic standard deviation
81	1425	12	1.0	0.123	0.62	0.1171	1.93	1.07
82	1427	12	1.2	0.128	0.97	0.1234	1.63	1.03
83	1428	12	1.4	0.104	0.91	0.2507	2.00	1.10
84	1429	12	1.6	0.112	1.10	0.2993	2.14	1.13
85	1431	12	1.8	0.098	1.13	0.2730	3.86	1.09
86	1432	12	2.0	0.098	0.89	0.2943	4.14	1.57
87	1434	12	2.2	0.111	0.86	0.2289	4.44	1.57
88	1435	13	0.8	0.105	0.77	0.0000	0.00	0.00
89	1436	13	1.0	0.099	0.89	0.2071	1.41	1.02
90	1438	13	1.2	0.098	0.87	0.2730	1.41	1.02
91	1439	13	1.4	0.112	1.03	0.2888	1.63	1.12
92	1441	13	1.6	0.103	0.97	0.2995	1.41	1.07
93	1442	13	1.8	0.105	1.09	0.4095	2.46	0.98
94	1443	13	2.0	0.109	1.07	0.2507	2.93	1.48
95	1445	13	2.2	0.113	0.76	0.4568	3.03	1.43
96	1446	14	0.8	0.112	0.76	0.0866	1.11	0.78
97	1449	14	1.0	0.107	0.86	0.2234	1.07	0.75
98	1450	14	1.2	0.099	0.95	0.2888	1.15	1.17
99	1455	14	1.2	0.103	1.07	0.5224	1.93	1.22
100	1457	14	1.4	0.104	0.98	0.5565	1.74	1.26
101	1459	14	1.6	0.123	0.93	0.3754	3.03	1.40
102	1502	14	1.8	0.128	0.96	0.3229	4.60	1.72
103	1503	14	2.0	0.139	1.15	0.2998	5.66	1.29
104	1504	14	2.2	0.123	0.88	0.2507	5.86	1.38
105	1506	15	0.8	0.119	0.75	0.0866	0.81	1.20
106	1519	15	1.0	0.123	0.70	0.2092	1.63	1.19
107	1520	15	1.2	0.119	0.77	0.1307	1.68	1.14
108	1521	15	1.4	0.103	0.98	0.3541	1.32	0.99
109	1522	15	1.6	0.115	1.06	0.3378	3.25	1.40
110	1524	15	1.8	0.111	0.92	0.3281	2.14	1.28
111	1525	15	2.0	0.112	1.03	0.1307	4.93	1.17
112	1526	15	2.2	0.122	0.98	0.4959	4.00	1.37
113	1528	16	0.8	0.104	0.66	0.0284	2.30	1.44
114	1530	16	1.0	0.105	0.78	0.1798	1.32	1.00
115	1531	16	1.2	0.091	0.85	0.2885	1.74	1.46
116	1532	16	1.4	0.103	1.05	0.3105	2.22	1.15
117	1533	16	1.6	0.097	1.03	0.3491	2.83	1.16
118	1535	16	1.8	0.101	1.09	0.4856	2.93	1.52
119	1536	16	2.0	0.113	1.05	0.3229	4.76	1.16
120	1537	16	2.2	0.100	0.91	0.6221	3.14	1.39

Table 1.--Borgne d'Arolla - Hydraulic and bedload-transport data--Continued

Sample	Time (hours)	Traverse	Position of vertical (m)	Flow depth (m)	Flow velocity (m/s)	Unit bedload-transport rate [(kg/m)/s]	Median particle size (mm)	Inclusive graphic standard deviation
121	1539	17	0.8	0.139	0.96	0.4848	1.68	1.45
122	1545	17	1.0	0.119	0.94	0.4463	1.68	1.25
123	1546	17	1.2	0.100	0.91	0.5880	1.57	1.14
124	1547	17	1.4	0.118	0.92	0.6274	1.80	1.30
125	1549	17	1.6	0.098	1.08	0.2769	2.73	1.63
126	1551	17	1.8	0.138	1.05	0.3544	3.86	1.46
127	1552	17	2.0	0.137	1.13	0.5177	3.03	1.34
128	1554	17	2.2	0.133	1.01	0.0305	5.10	1.76
129	1556	17	2.4	0.158	0.89	0.0491	1.93	1.61
130	1558	18	0.6	0.085	0.64	0.0517	1.15	0.87
131	1559	18	0.8	0.092	0.71	0.1525	1.28	1.05
132	1600	18	1.0	0.097	0.85	0.1496	1.32	1.52
133	1602	18	1.2	0.105	0.77	0.1798	1.52	1.24
134	1604	18	1.4	0.129	0.94	0.1662	1.46	0.82
135	1605	18	1.6	0.128	1.00	0.0551	3.03	1.47
136	1606	18	1.8	0.123	1.09	0.1200	3.36	1.63
137	1607	18	2.0	0.129	0.98	0.2016	4.00	1.59
138	1609	18	2.2	0.123	0.93	0.0764	2.46	1.69
139	1610	18	2.4	0.136	0.88	0.0709	7.21	1.60
				August 19, 1979				
140	0947	19	1.0	0.128	0.64	0.0071	1.41	1.01
141	0949	19	1.2	0.127	0.71	0.0774	2.64	0.84
142	0951	19	1.4	0.104	0.75	0.1032	2.55	0.11
143	0953	19	1.6	0.114	0.93	0.1499	2.55	0.94
144	0954	19	1.8	0.128	0.95	0.2578	2.46	1.22
145	0956	19	2.0	0.136	1.04	0.3176	3.03	1.18
146	0958	19	2.2	0.127	0.99	0.6011	3.03	1.27
147	0959	19	2.4	0.113	0.96	0.7298	4.44	1.29
148	1002	19	2.6	0.098	0.92	0.1922	4.60	1.49
149	1003	19	2.8	0.097	0.82	0.2483	2.46	1.55
150	1004	19	3.0	0.086	0.74	0.1922	1.63	1.21
151	1008	20	1.0	0.122	0.69	0.0751	1.28	0.81
152	1010	20	1.2	0.092	0.72	0.2155	1.23	0.93
153	1011	20	1.4	0.108	0.87	0.2157	1.41	1.07
154	1013	20	1.6	0.127	0.83	0.1992	1.46	1.08
155	1014	20	1.8	0.129	0.96	0.3518	1.63	1.19
156	1016	20	2.0	0.137	0.79	0.2678	2.07	1.17
157	1017	20	2.2	0.147	0.97	0.4725	3.86	1.14
158	1019	20	2.4	0.144	0.74	0.3334	4.00	1.57
159	1020	20	2.6	0.118	0.99	0.3092	4.93	1.28
160	1023	20	2.8	0.117	0.54	0.0257	1.93	1.26
161	1028	20	3.0	0.108	0.63	0.0024	0.93	0.77

Table 1.--Borgne d'Arolla - Hydraulic and bedload-transport data--Continued

Sample	Time (hours)	Traverse	Position of vertical (m)	Flow depth (m)	Flow velocity (m/s)	Unit bedload-transport rate [(kg/m)/s]	Median particle size (mm)	Inclusive graphic standard deviation
162	1030	21	1.0	0.103	0.62	0.0609	1.11	0.79
163	1031	21	1.2	0.116	0.75	0.0585	1.63	1.05
164	1033	21	1.4	0.124	0.87	0.0819	5.28	1.23
165	1035	21	1.6	0.109	0.95	0.2084	2.55	1.03
166	1036	21	1.8	0.118	0.98	0.2250	3.73	1.29
167	1038	21	2.0	0.127	1.03	0.3150	3.73	1.42
168	1039	21	2.2	0.119	1.01	0.4883	4.76	1.33
169	1041	21	2.4	0.130	0.92	0.1499	4.75	1.87
170	1043	21	2.6	0.113	0.88	0.2100	6.28	1.47
171	1044	21	2.8	0.111	0.82	0.1076	2.22	1.24
172	1046	21	3.0	0.096	0.60	0.0000	0.00	0.00
173	1050	22	1.0	0.136	0.60	0.0257	1.28	0.95
174	1052	22	1.2	0.101	0.67	0.2108	1.80	1.20
175	1053	22	1.4	0.098	0.75	0.1922	1.80	1.20
176	1054	22	1.6	0.111	0.91	0.2084	2.07	1.07
177	1056	22	1.8	0.119	0.95	0.2250	1.87	1.10
178	1058	22	2.0	0.132	1.04	0.2084	2.55	1.27
179	1059	22	2.2	0.142	0.99	0.1147	3.36	1.45
180	1101	22	2.4	0.137	0.92	0.1780	6.06	1.05
181	1102	22	2.6	0.118	0.85	0.1218	5.66	1.38
182	1103	22	2.8	0.123	0.55	0.0186	1.74	1.12
183	1105	22	3.0	0.108	0.51	0.0000	0.00	0.00
184	1109	23	1.0	0.113	0.56	0.0281	1.15	1.01
185	1110	23	1.2	0.118	0.57	0.1124	1.23	0.84
186	1112	23	1.4	0.126	0.68	0.1523	1.37	1.09
187	1114	23	1.6	0.121	0.79	0.0281	1.63	1.08
188	1115	23	1.8	0.124	0.80	0.1360	2.46	1.23
189	1116	23	2.0	0.149	0.81	0.1428	4.29	1.11
190	1119	23	2.2	0.169	1.04	0.0186	3.86	1.92
191	1121	23	2.4	0.139	0.95	0.1452	6.06	1.03
192	1123	23	2.6	0.116	0.81	0.0890	5.66	1.13
193	1124	23	2.8	0.108	0.65	0.2436	2.46	1.07
194	1126	23	3.0	0.103	0.52	0.0165	1.37	0.91
195	1128	23	3.2	0.065	0.47	0.0000	0.00	0.00
196	1130	24	1.0	0.114	0.58	0.0446	1.15	0.81
197	1132	24	1.2	0.101	0.75	0.1194	1.23	0.91
198	1133	24	1.4	0.110	0.84	0.0751	1.41	1.26
199	1134	24	1.6	0.116	0.82	0.0538	1.93	1.37
200	1135	24	1.8	0.123	0.91	0.0914	1.93	1.05
201	1137	24	2.0	0.125	0.96	0.1289	4.00	0.99
202	1138	24	2.2	0.124	0.95	0.4226	1.87	1.27
203	1140	24	2.4	0.138	0.81	0.1079	3.86	1.44
204	1142	24	2.6	0.125	0.76	0.0281	2.30	1.28
205	1143	24	2.8	0.128	0.73	0.1712	5.86	1.78
206	1145	24	3.0	0.109	0.60	0.0000	0.00	0.00

Table 1.--Borgne d'Arolla - Hydraulic and bedload-transport data--Continued

Sample	Time (hours)	Traverse	Position of vertical (m)	Flow depth (m)	Flow velocity (m/s)	Unit bedload-transport rate [(kg/m)/s]	Median particle size (mm)	Inclusive graphic standard deviation
207	1149	25	1.0	0.098	0.68	0.0515	1.15	0.89
208	1150	25	1.2	0.096	0.69	0.1032	0.90	0.90
209	1152	25	1.4	0.104	0.76	0.1664	1.32	1.05
210	1153	25	1.6	0.113	0.81	0.0352	1.46	1.05
211	1155	25	1.8	0.130	0.85	0.0118	2.07	1.87
212	1156	25	2.0	0.139	0.90	0.1922	5.66	0.95
213	1158	25	2.2	0.132	0.94	0.2578	6.06	1.10
214	1159	25	2.4	0.130	0.99	0.2250	4.44	0.97
215	1201	25	2.6	0.137	0.85	0.0538	4.14	1.01
216	1202	25	2.8	0.119	0.63	0.0305	2.30	1.17
217	1203	25	3.0	0.087	0.58	0.0000	0.00	0.00
218	1253	26	1.0	0.119	0.53	0.0071	1.46	1.06
219	1255	26	1.2	0.112	0.66	0.0234	0.68	0.82
220	1256	26	1.4	0.101	0.72	0.1452	1.57	0.88
221	1258	26	1.6	0.113	0.71	0.1194	1.41	0.90
222	1259	26	1.8	0.109	0.77	0.1827	1.41	1.11
223	1300	26	2.0	0.118	0.98	0.1803	2.14	1.19
224	1302	26	2.2	0.127	1.00	0.2321	2.46	1.17
225	1303	26	2.4	0.108	0.83	0.2483	3.25	1.18
226	1304	26	2.6	0.135	0.78	0.0515	5.86	1.37
227	1306	26	2.8	0.111	0.73	0.1688	4.93	1.79
228	1307	26	3.0	0.105	0.53	0.0000	0.00	0.00
229	1309	27	1.0	0.096	0.68	0.0914	0.90	0.75
230	1311	27	1.2	0.103	0.63	0.1194	1.32	0.98
231	1312	27	1.4	0.109	0.76	0.1641	1.32	1.00
232	1314	27	1.6	0.112	0.85	0.0727	1.15	1.17
233	1315	27	1.8	0.121	0.88	0.0727	1.63	1.18
234	1317	27	2.0	0.110	0.92	0.2436	1.68	1.22
235	1321	27	2.2	0.134	0.97	0.0937	2.38	1.29
236	1323	27	2.4	0.139	0.84	0.0399	7.46	1.72
237	1324	27	2.6	0.127	0.69	0.0095	1.41	1.57
238	1325	27	2.8	0.116	0.58	0.0000	0.00	0.00
239	1326	27	3.0	0.098	0.60	0.0000	0.00	0.00
240	1327	28	0.8	0.121	0.47	0.0375	1.04	0.78
241	1329	28	1.0	0.097	0.61	0.0470	0.90	0.75
242	1331	28	1.2	0.098	0.67	0.1593	1.00	0.78
243	1334	28	1.4	0.098	0.66	0.0727	1.28	0.94
244	1335	28	1.6	0.107	0.85	0.0562	1.87	1.27
245	1337	28	1.8	0.128	0.71	0.0491	1.15	1.19
246	1339	28	2.0	0.141	0.79	0.0024	1.07	1.02
247	1340	28	2.2	0.149	0.76	0.0281	7.73	1.14
248	1344	28	2.4	0.161	0.81	0.0000	0.00	0.00
249	1345	28	2.6	0.127	0.82	0.0000	0.00	0.00

Table 1.--Borgne d'Arolla - Hydraulic and bedload-transport data--Continued

Sample	Time (hours)	Traverse	Position of vertical (m)	Flow depth (m)	Flow velocity (m/s)	Unit bedload-transport rate [(kg/m)/s]	Median particle size (mm)	Inclusive graphic standard deviation
250	1346	29	0.8	0.133	0.51	0.0000	0.00	0.00
251	1347	29	1.0	0.109	0.55	0.0399	1.04	0.94
252	1348	29	1.2	0.104	0.61	0.0795	1.19	1.18
253	1349	29	1.4	0.101	0.62	0.0328	1.28	1.04
254	1350	29	1.6	0.114	0.68	0.0281	1.57	1.05
255	1351	29	1.8	0.127	0.76	0.0071	1.87	1.60
256	1353	29	2.0	0.143	0.87	0.0000	0.00	0.00
257	1354	30	0.8	0.116	0.49	0.0000	0.00	0.00
258	1355	30	1.0	0.111	0.61	0.0305	1.19	0.96
259	1356	30	1.2	0.116	0.63	0.0562	1.37	0.97
260	1357	30	1.4	0.111	0.69	0.0210	1.28	1.19
261	1358	30	1.6	0.113	0.81	0.0000	0.00	0.00
262	1400	31	1.0	0.104	0.54	0.0000	0.00	0.00
263	1401	31	1.2	0.104	0.54	0.0517	1.41	1.02
264	1402	31	1.4	0.104	0.68	0.0000	0.00	0.00
265	1403	32	1.2	0.104	0.54	0.0000	0.00	0.00

Table 2.--Borgne d'Arolla - Average values of hydraulic and bedload-transport data for a single traverse
[m, meter; m/s, meter per second; (kg/m)/s, kilogram per meter per second; mm, millimeter.
Water-surface slope = 0.03 m/m]

Traverse	Number of verticals in traverse	Active bed width (m)	Mean flow depth (m)	Mean flow velocity (m/s)	Stream power [(kg/m)/s]	Unit bedload-transport rate [(kg/m)/s]	Median particle size (mm)	Inclusive graphic standard deviation	Transport efficiency (percent)
				August 17, 1979					
1	7	2.2	0.092	0.851	2.358	0.439	2.23	1.44	11.7
2	7	2.2	0.092	1.027	2.843	0.521	2.97	1.44	11.6
3	7	2.2	0.094	0.887	2.501	0.431	2.70	1.28	10.9
4	7	2.2	0.095	0.947	2.642	0.374	2.57	1.27	8.9
5	7	2.2	0.099	0.910	2.641	0.254	1.82	1.26	6.1
6	7	2.2	0.096	0.970	2.752	0.313	2.01	1.24	7.1
7	7	2.2	0.100	0.901	2.672	0.262	1.77	1.25	6.2
8	7	2.2	0.099	0.887	2.679	0.264	1.67	1.30	6.2
9	7	2.2	0.110	0.811	2.665	0.228	1.50	1.22	5.4
10	9	2.0	0.112	0.889	2.974	0.171	2.18	1.22	3.6
11	8	1.8	0.112	0.841	2.812	0.113	2.88	1.23	2.5
12	7	1.6	0.111	0.926	3.050	0.221	2.88	1.22	4.6
13	8	1.6	0.106	0.954	2.991	0.308	2.04	1.18	6.5
14	9	1.8	0.115	0.949	3.296	0.308	2.91	1.20	5.9
15	8	1.8	0.115	0.899	3.175	0.256	2.47	1.22	5.1
16	8	1.8	0.103	0.941	2.834	0.318	2.65	1.29	7.1
17	9	2.0	0.127	0.988	3.751	0.395	2.60	1.44	6.6
18	10	2.0	0.116	0.885	3.081	0.121	2.68	1.28	2.5
				August 19, 1979					
19	11	2.0	0.105	0.937	2.964	0.255	2.80	1.19	5.4
20	11	2.0	0.123	0.789	2.943	0.221	2.25	1.12	4.7
21	11	2.0	0.115	0.897	3.117	0.187	3.60	1.27	3.8
22	11	2.0	0.121	0.831	3.026	0.146	2.82	1.17	3.1
23	12	2.0	0.126	0.758	2.884	0.100	2.87	1.04	2.2
24	11	1.8	0.120	0.813	2.938	0.121	2.55	1.22	2.6
25	11	1.8	0.120	0.817	2.950	0.110	2.95	1.10	2.4
26	11	1.8	0.115	0.773	2.678	0.133	2.52	1.15	3.1
27	11	1.6	0.117	0.935	3.294	0.100	2.14	1.21	1.9
28	10	1.2	0.117	0.779	2.735	0.056	2.33	0.98	1.3
29	7	1.0	0.111	0.731	2.441	0.036	1.39	1.16	0.9
30	5	0.6	0.113	0.723	2.456	0.035	1.28	1.04	0.9
31	3	0.3	0.104	0.610	1.904	0.051	1.41	1.02	1.7

Table 3.--Borgne d'Arolla - Particle size distributions of bed material and bedload

[1, Surficial bed material 08/18/79 (mobile surface), average of 40 samples;
2, Surficial bed material 08/18/79 (stable surface), average of 39 samples;
3, Subsurface bed material 08/18/79;
4, Bedload 08/17/79, average of 136 samples;
5, Bedload: 08.19.79, average of 109 samples;
mm, millimeter]

Sample	Percentage by weight finer than sieve size (mm) indicated								
	0.25	0.5	1.0	2.0	4.0	8.0	16.0	32.0	64.0
1	---	0.0	11.6	36.6	70.2	88.7	97.3	100.0	---
2	---	---	0.0	1.0	4.2	13.1	42.5	85.5	100.0
3	3.1	13.2	28.3	45.2	63.0	80.0	92.5	98.4	100.0
4	---	0.0	10.4	39.9	80.3	93.5	98.8	100.0	---
5	---	0.0	7.2	27.4	79.2	93.4	98.4	100.0	---

LABORATORY DATA

Table 4.--Environmental Research Center - Hydraulic and bedload-transport data, July 15, 16, and 17, 1987

[(kg/m)/s, kilogram per meter per second; mm, millimeter]

Sample number	Time (hours)	Water-surface slope	Stream power [(kg/m)/s]	Unit bedload-transport rate [(kg/m)/s]	Median particle size (mm)	Sorting coefficient
1	1035	0.00651	0.882	0.111	3.66	1.34
2		0.00657	0.891	0.114	3.86	1.37
3		0.00648	0.878	0.120	3.66	1.33
4		0.00650	0.880	0.127	3.78	1.33
5		0.00651	0.882	0.137	3.97	1.36
6	1100	0.00659	0.893	0.155	3.66	1.32
7		0.00659	0.893	0.150	3.76	1.30
8		0.00665	0.901	0.143	3.81	1.32
9		0.00653	0.884	0.128	4.11	1.34
10		0.00662	0.897	0.133	3.76	1.35
11	1125	0.00668	0.905	0.136	3.95	1.38
12		0.00673	0.912	0.128	3.81	1.33
13		0.00667	0.903	0.133	4.00	1.40
14		0.00673	0.912	0.136	4.06	1.29
15		0.00679	0.920	0.128	4.11	1.29
16	1150	0.00676	0.916	0.144	3.92	1.32
17		0.00685	0.929	0.137	4.00	1.36
18		0.00685	0.929	0.137	3.92	1.30
19		0.00685	0.929	0.133	3.86	1.31
20		0.00699	0.948	0.134	4.00	1.31
21	1215	0.00699	0.948	0.127	4.26	1.31
22		0.00696	0.943	0.127	4.23	1.31
23		0.00707	0.958	0.125	4.20	1.32
24		0.00713	0.967	0.124	4.41	1.30
25		0.00715	0.969	0.115	4.35	1.29
26	1240	0.00717	0.971	0.110	4.41	1.31
27		0.00721	0.977	0.114	4.29	1.30
28		0.00703	0.952	0.115	3.84	1.32
29		0.00681	0.922	0.118	3.73	1.30
30		0.00682	0.924	0.117	4.14	1.34
31	1305	0.00679	0.920	0.115	4.06	1.33
32		0.00687	0.931	0.105	4.03	1.33
33		0.00682	0.924	0.101	4.35	1.31
34		0.00664	0.899	0.096	4.06	1.32
35		0.00664	0.899	0.092	3.86	1.37
36	1330	0.00668	0.905	0.095	4.14	1.38
37		0.00665	0.901	0.092	3.61	1.30
38		0.00651	0.882	0.089	3.61	1.30
39		0.00646	0.876	0.092	3.78	1.33
40		0.00636	0.861	0.095	3.97	1.35

Table 4.--Environmental Research Center - Hydraulic and bedload-transport data July 15, 16, and 17, 1987--Continued

Sample Number	Time (hours)	Water-surface slope	Stream Power [(kg/m)/s]	Unit bedload-transport rate [(kg/m)/s]	Median particle diameter (mm)	Sorting coefficient
41	1355	0.00609	0.825	0.104	3.89	1.35
42		0.00622	0.842	0.111	3.71	1.30
43		0.00626	0.849	0.109	3.92	1.35
44		0.00629	0.853	0.118	3.78	1.30
45		0.00653	0.884	0.121	3.86	1.34
46	1420	0.00646	0.876	0.123	3.81	1.30
47		0.00664	0.899	0.128	3.86	1.30
48		0.00670	0.908	0.133	4.00	1.28
49		0.00679	0.920	0.134	3.86	1.27
50		0.00665	0.901	0.136	4.06	1.28
51	1445	0.00678	0.918	0.133	3.97	1.27
52		0.00679	0.920	0.130	3.78	1.27
53		0.00671	0.910	0.124	4.03	1.37
54		0.00682	0.924	0.118	4.08	1.39
55		0.00687	0.931	0.115	4.03	1.38
56	1510	0.00675	0.914	0.111	4.29	1.29
57		0.00671	0.910	0.108	4.14	1.25
58		0.00659	0.893	0.102	4.17	1.36
59		0.00671	0.910	0.102	3.81	1.29
60		0.00671	0.910	0.105	3.76	1.31
61	1535	0.00665	0.901	0.107	4.11	1.33
62		0.00662	0.897	0.108	4.06	1.30
63		0.00662	0.897	0.112	4.14	1.30
64		0.00667	0.903	0.114	4.26	1.29
65		0.00657	0.891	0.121	4.41	1.31
66	1600	0.00665	0.901	0.118	3.92	1.30
67		0.00665	0.901	0.121	4.11	1.31
68		0.00667	0.903	0.128	4.23	1.31
69		0.00654	0.887	0.144	4.14	1.34
70		0.00671	0.910	0.140	4.67	1.34
71	1625	0.00656	0.889	0.133	4.08	1.33
72	1630	0.00660	0.895	0.102	3.86	1.30
73	0930	0.00643	0.872	0.088	3.73	1.35
74	0935	0.00659	0.893	0.098	3.86	1.39
75	0940	0.00651	0.882	0.105	3.97	1.40
76	0945	0.00657	0.891	0.108	3.63	1.34
77		0.00643	0.872	0.108	3.89	1.39
78		0.00660	0.895	0.109	4.32	1.41
79		0.00662	0.897	0.112	4.14	1.33
80		0.00670	0.908	0.117	3.95	1.31

Table 4.--Environmental Research Center - Hydraulic and bedload-transport data July 15, 16, and 17, 1987--Continued

Sample Number	Time (hours)	Water-surface slope	Stream power [(kg/m)/s)	Unit bedload-transport rate [(kg/m)/s)	Median particle size (mm)	Sorting coefficient
81	1010	0.00678	0.918	0.124	3.97	1.32
82		0.00679	0.920	0.120	3.86	1.36
83		0.00695	0.941	0.118	4.00	1.29
84		0.00707	0.958	0.118	4.11	1.33
85		0.00706	0.956	0.117	3.92	1.31
86	1035	0.00696	0.943	0.107	4.06	1.33
87		0.00707	0.958	0.107	4.14	1.34
88		0.00696	0.943	0.108	4.00	1.33
89		0.00690	0.935	0.109	3.78	1.32
90		0.00687	0.931	0.101	3.92	1.31
91	1100	0.00676	0.916	0.102	4.00	1.34
92		0.00667	0.903	0.095	4.00	1.36
93		0.00659	0.893	0.085	3.41	1.35
94		0.00646	0.876	0.074	3.86	1.39
95		0.00646	0.876	0.069	3.66	1.36
96	1125	0.00642	0.870	0.073	3.76	1.30
97		0.00650	0.880	0.086	3.68	1.31
98		0.00636	0.861	0.091	3.71	1.30
99		0.00646	0.876	0.093	3.66	1.29
100		0.00646	0.876	0.101	3.81	1.32
101	1150	0.00639	0.865	0.104	3.78	1.26
102		0.00643	0.872	0.109	3.89	1.30
103		0.00631	0.855	0.111	3.81	1.30
104		0.00614	0.832	0.111	4.06	1.27
105		0.00631	0.855	0.108	3.86	1.24
106	1215	0.00650	0.880	0.117	4.23	1.29
107		0.00653	0.884	0.115	4.26	1.30
108		0.00651	0.882	0.115	4.03	1.31
109		0.00667	0.903	0.115	4.35	1.34
110		0.00671	0.910	0.112	4.20	1.31
111	1240	0.00667	0.903	0.112	4.29	1.32
112		0.00673	0.912	0.109	4.14	1.32
113		0.00675	0.914	0.111	4.06	1.29
114		0.00678	0.918	0.112	4.14	1.31
115		0.00679	0.920	0.111	4.14	1.28
116	1305	0.00681	0.922	0.115	4.11	1.33
117		0.00681	0.922	0.109	3.97	1.32
118		0.00684	0.927	0.109	4.11	1.30
119		0.00675	0.914	0.108	3.95	1.32
120		0.00656	0.889	0.109	4.14	1.27

Table 4.--Environmental Research Center - Hydraulic and bedload-transport data July 15, 16, and 17, 1987 -Continued

Sample Number	Time (hours)	Water-surface slope	Stream power [(kg/m)/s]	Unit bedload-transport Rate [(kg/m)/s]	Median particle size (mm)	Sorting coefficeint
121	1330	0.00667	0.903	0.108	4.17	1.33
122		0.00657	0.891	0.105	3.95	1.33
123		0.00671	0.910	0.101	4.14	1.32
124		0.00648	0.878	0.099	4.03	1.35
125		0.00657	0.891	0.092	4.11	1.35
126	1355	0.00654	0.887	0.091	4.26	1.36
127		0.00656	0.889	0.091	3.81	1.37
128		0.00650	0.880	0.080	3.89	1.39
129		0.00640	0.868	0.079	4.20	1.39
130		0.00640	0.868	0.076	4.06	1.34
131	1420	0.00642	0.870	0.076	3.78	1.33
132		0.00645	0.874	0.091	3.92	1.33
133		0.00637	0.863	0.091	4.17	1.35
134		0.00637	0.863	0.095	3.84	1.30
135		0.00643	0.872	0.096	4.23	1.34
136	1445	0.00634	0.859	0.102	3.78	1.29
137		0.00640	0.868	0.108	3.95	1.29
138		0.00637	0.863	0.114	4.11	1.32
139		0.00643	0.872	0.121	3.78	1.31
140		0.00645	0.874	0.123	4.20	1.30
141	1510	0.00648	0.878	0.124	4.00	1.27
142		0.00653	0.884	0.123	3.89	1.33
143		0.00645	0.874	0.126	3.86	1.30
144		0.00645	0.874	0.123	3.73	1.31
145		0.00648	0.878	0.121	3.78	1.28
146	1535	0.00646	0.876	0.123	4.00	1.29
147		0.00656	0.889	0.126	3.97	1.30
148		0.00657	0.891	0.126	3.73	1.33
149		0.00657	0.891	0.128	4.29	1.27
150		0.00659	0.893	0.130	4.14	1.29
151	1600	0.00671	0.910	0.128	4.03	1.30
152		0.00678	0.918	0.134	4.26	1.29
153		0.00699	0.948	0.143	4.00	1.28
154		0.00710	0.962	0.134	3.89	1.29
155		0.00693	0.939	0.134	3.84	1.28
156	1625	0.00692	0.937	0.127	3.89	1.30
157	1630	0.00639	0.865	0.120	3.92	1.28
158	0905	0.00657	0.891	0.115	3.71	1.28
159	0910	0.00653	0.884	0.109	3.63	1.30
160	0915	0.00657	0.891	0.115	3.78	1.29

Table 4.--Environmental Research Center - Hydraulic and bedload-transport data July 15, 16, and 17, 1987--Continued

Sample number	Time (hours)	Water-surface slope	Stream power [(kg/m)/s]	Unit bedload-transport rate [(kg/m)/s]	Median particle size (mm)	Sorting coefficient
161	0920	0.00651	0.882	0.109	3.81	1.31
162		0.00646	0.876	0.104	4.14	1.31
163		0.00643	0.872	0.101	4.00	1.29
164		0.00653	0.884	0.093	3.78	1.33
165		0.00646	0.876	0.086	3.66	1.28
166	0945	0.00648	0.878	0.091	3.86	1.28
167		0.00645	0.874	0.104	3.73	1.27
168		0.00639	0.865	0.114	3.71	1.27
169		0.00643	0.872	0.121	3.68	1.26
170		0.00640	0.868	0.128	3.73	1.27
171	1010	0.00653	0.884	0.130	3.95	1.27
172		0.00645	0.874	0.144	3.89	1.28
173		0.00653	0.884	0.146	3.73	1.39
174		0.00660	0.895	0.144	3.86	1.37
175		0.00667	0.903	0.149	3.51	1.30
176	1035	0.00659	0.893	0.137	4.11	1.34
177		0.00653	0.884	0.139	3.86	1.27
178		0.00614	0.832	0.136	3.81	1.32
179		0.00623	0.844	0.128	3.89	1.28
180		0.00629	0.853	0.120	3.95	1.27
181	1100	0.00645	0.874	0.117	3.84	1.32
182		0.00645	0.874	0.118	3.97	1.27
183		0.00653	0.884	0.111	3.92	1.30
184		0.00667	0.903	0.109	4.17	1.32
185		0.00667	0.903	0.101	3.97	1.30
186	1125	0.00657	0.891	0.096	3.89	1.33
187		0.00659	0.893	0.074	3.84	1.32
188		0.00660	0.895	0.082	3.97	1.32
189		0.00648	0.878	0.085	3.89	1.31
190		0.00668	0.905	0.092	3.95	1.36
191	1150	0.00657	0.891	0.095	4.08	1.32
192		0.00639	0.865	0.102	3.84	1.33
193		0.00664	0.899	0.101	4.29	1.27
194		0.00634	0.859	0.107	4.20	1.30
195		0.00646	0.876	0.111	3.89	1.30
196	1215	0.00650	0.880	0.111	4.26	1.30
197		0.00646	0.876	0.118	4.00	1.27
198		0.00643	0.872	0.118	4.06	1.28
199		0.00637	0.863	0.126	4.14	1.27
200		0.00640	0.867	0.121	4.00	1.28

Table 4.--Environmental Research Center - Hydrualic and bedload-transport data July 15, 16, and 17, 1987--Continued

Sample Number	Time (hours)	Water-surface slope	Stream power [(kg/m)/s]	Unit bedload-transport rate [(kg/m)/s]	Median particle size (mm)	Sorting Coefficient
201	1240	0.00639	0.865	0.124	3.89	1.29
202		0.00642	0.870	0.121	3.95	1.26
203		0.00626	0.849	0.123	3.86	1.26
204		0.00631	0.855	0.121	4.03	1.23
205		0.00634	0.859	0.121	3.86	1.27
206	1305	0.00639	0.865	0.124	4.17	1.29
207		0.00651	0.882	0.128	4.00	1.30
208		0.00625	0.846	0.130	4.11	1.30
209		0.00650	0.880	0.127	3.95	1.27
210		0.00639	0.865	0.133	4.00	1.32
211	1330	0.00643	0.872	0.134	3.89	1.31
212		0.00628	0.851	0.134	3.73	1.27
213		0.00642	0.870	0.137	3.95	1.31
214		0.00648	0.878	0.161	4.08	1.29
215		0.00622	0.842	0.134	3.89	1.28
216	1355	0.00637	0.863	0.147	3.84	1.30
217		0.00645	0.874	0.139	4.14	1.33
218		0.00646	0.876	0.124	3.76	1.30
219		0.00640	0.868	0.124	3.92	1.31
220		0.00643	0.872	0.126	3.86	1.32
221	1420	0.00648	0.878	0.136	3.56	1.30
222		0.00662	0.897	0.130	4.08	1.28
223		0.00662	0.897	0.130	4.03	1.32
224		0.00673	0.912	0.127	3.97	1.30
225		0.00682	0.924	0.130	4.06	1.32
226	1445	0.00692	0.937	0.126	4.14	1.30
227		0.00689	0.933	0.120	4.20	1.30
228		0.00683	0.927	0.121	4.26	1.32
229		0.00675	0.914	0.117	3.81	1.35
230		0.00684	0.927	0.109	4.08	1.31
231	1510	0.00664	0.899	0.115	4.41	1.33
Average for 19.5 hour period		0.00660	0.894	0.115	3.97	1.31

Table 5.--Environmental Research Center - Particle size distributions of sediment feed and subsurface bed material

Sample	Percent by weight finer than sieve size indicated, in millimeter														
	1.00	1.41	2.00	2.38	2.83	3.36	4.00	4.76	5.66	6.73	7.93	9.52	11.1	12.7	15.9
Sediment[1] feed	0.1	0.3	1.2	4.3	14.1	29.3	50.6	73.7	85.8	92.5	96.6	98.1	99.1	99.9	100.0
Subsurface[2] Bed Material	9.9	11.2	13.2	19.1	26.5	39.5	52.1	67.7	79.0	87.7	94.5	96.6	98.5	99.5	100.0

[1]Median Particle Diameter = 3.97 millimeter; Sorting Coefficient = 1.23
[2]Median particle Diameter = 3.86 millimeter; Sorting Coefficient = 1.39