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Janice M. Fulford
U.S. Geological Survey

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Characteristics of U.S. Geological Survey Discharge Measurements for Water Year 1990

Janice M. Fulford[1]

Abstract

The U.S. Geological Survey (USGS) Water Resources Division makes ten of thousands of stream discharge measurements each year throughout the United States and Puerto Rico. The majority of the measurements requires the use of point velocity instrumentation. Interest in new instrumentation technology and the performance of in-use instrumentation prompted a survey of current-meter usage and discharge measurement data for water year 1990. This paper is a summary of survey results: the velocity, discharge and depth ranges measured; the types of meters used; and the measurement problems encountered.

Introduction

Most discharge measurements made by the USGS require the use of point-velocity instruments commonly known as current meters. Rantz (1982) describes the technique and equipment commonly used by the USGS for stream gaging. The development of new instrumentation technology and the investigation of in-use instrument performance prompted interest in quantifying the characteristics of discharge measurements made by the USGS. A survey of discharge measurements made during water year 1990 was undertaken to fulfill this task.

The survey contains two separate parts: a written questionnaire and a computerized data-base retrieval. The questionnaire asked about the conditions under which meters were used and about the quantity and quality of discharge measurements. The computerized data-base retrieval

[1]Hydrologist, U.S. Geological Survey, Stennis Space Center, MS 39529

contained information summarizing each discharge measurement made in the 1990 water year. Each USGS district participated in the data-base retrieval.

Written questionnaire

WRD District data-section chiefs and (or) their selected field personnel filled out the written questionnaires. Ninety-two questionnaires were received. All districts except one responded to the questionnaire. Some states sent multiple responses. California sent the most (10) and 30 states sent one each (the minimum requested). The questionnaire contained questions about types of meters used, meter-fouling and measurement conditions that contributed to poor discharge measurements. Questions required either an estimated percentage or a count for a response. The presented results have not been weighted or adjusted by state or by number of measurements.

The questionnaire respondents indicated the percentage of time that Price AA, Pygmy, electromagnetic, acoustic, Ott[2] type and ice meters are used. From the responses, the most frequently used current meter is the Price AA meter.

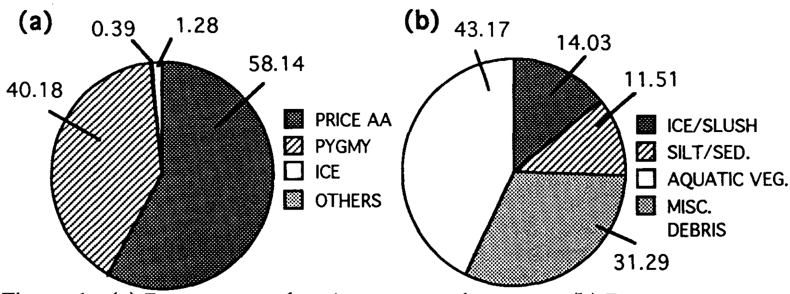

Figure 1.--(a) Percent use of various types of meters. (b) Percent meter fouling due to various fouling agents.

The pie chart in figure 1a shows the percent use of various types of meters as indicated by the respondents. For a question on Price AA and pygmy meter fouling, the respondents entered the percent of measurements that aquatic vegetation, ice/slush, silt/sediment, and miscellaneous debris fouled Price and pygmy meters. Aquatic vegetation was most frequently cited as fouling Price and pygmy meters. Figure 1b shows how often respondents indicated that vegetation, ice, silt and miscellaneous debris

[2]Use of trade names is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

fouled meters. Respondents were also asked to indicate what percentage of measurements that various measurement conditions resulted in fair or poor rating of discharge measurements. Table 1 lists the categories and mean percent for each condition. Measurement conditions with vegetation were cited most often as resulting in poor discharge measurements. Other conditions frequently cited as causing poor measurements were shallow streams and low velocities.

Table 1. -- How often measurement conditions result in measurements being rated fair or poor.

Condition	% of time	Condition	% of time
vegetation	13.6	ice problems	5.7
irregular cross-section	12.0	floating debris	5.4
shallow depths	10.9	submerged debris	4.1
low velocities	9.7	surface waves	3.4
sand bed channel	9.3	extreme hor. angles	2.9
rapid stage changes	8.6	high sediment load	1.5
high turbulence	7.2	air line/wet line	1.5

Not surprisingly, all the respondents make discharge measurements by wading, and most everyone makes measurements from bridges. Measurements in ice and from boats are made by approximately one-half of the respondents, and three-quarters of the respondents make measurements from cableways.

Computer data base

Retrievals of 1990 water year discharge measurements from the USGS Automated Data Processing System(ADAPS) computer data base or photocopies of written discharge measurement notes were submitted for each state. The retrieved files contain mean velocity, discharge, width, area, measurement-type, and measurement-rating. Measurement type refers to whether the measurement is made by wading or from ice cover, bridge, cableways, or boat. Measurement rating is an estimate of measurement accuracy. The photocopies do not contain data for measurement type.

Data was checked for inconsistencies and obvious errors before being analyzed. The data was analyzed using P-STAT (1989), a statistical analysis computer program. The resulting data files contain data from 6,199 continuous-discharge measurement sites and 53,799 measurements. Summary statistics and counts (number of measurements) for area, discharge, velocity, depth, and width are listed in table 2. Other statistics include velocity and depth distributions compiled for all the discharge measurements, grouped by measurement type and by measurement rating.

Distributions of velocity and depth are shown in figure 2a and 2b. For most measurements in the data files, mean velocities are less than 2.0 feet per second and meandepths are less than 2.0 feet. Almost half the discharge measurements are made in mean depths of less than 1.25 feet.

Table 2. -- Summary statistics for discharge measurements made in water year 1990. Negative discharge is for sites with flow reversals.

	Mean	Standard Deviation	Low	High	Count
Width (ft)	105.4	234	0.1	13675	51543
Area (ft^2)	663.2	3328	0	149000	51117
Velocity (ft/sec)	1.52	1.09	0	12.66	51076
Discharge (ft^3/sec)	1960	13557	-836	679800.	53188
Depth (ft)	2.3	3.4	0	51.5	51069

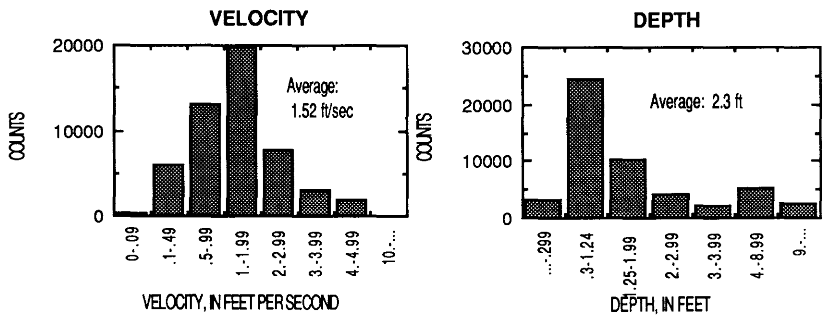

Figure 2.--Distribution of : (a) mean velocity. (b) mean depth.

Figure 3a is the percentage of discharge measurements made by each measurement type; bridge, wading, cableway, ice and boat. Measurement type data was not available for Maine, Virginia, Ohio and Alaska. For data available, approximately three of every four discharge measurements are waded. Bridge measurements are the second most common with 15.57% of the measurements. The percentage of discharge measurements rated as excellent, good, fair and poor, are presented in figure 3b. For any twelve measurements, approximately seven are rated good, and 4 are rated fair. The remaining measurement is usually rated poor. Less than 1 percent of measurements are rated excellent.

Figures 4 and 5 are the mean velocity distributions for each measurement type and for each measurement rating. The highest mean velocities are for cableway measurements and the lowest mean velocity is for ice measurements. Velocity distributions for each rating type are similar to the distribution for the entire data set except for the poor ratings. The velocity distribution for poor ratings are skewed to velocities less than 2 feet per second.

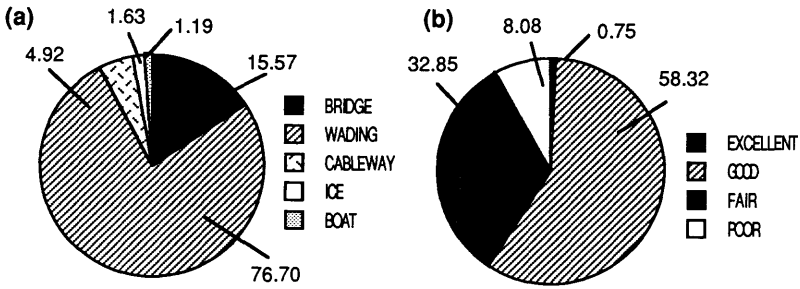

Figure 3.--(a) Percentage of discharge measurement made by measurement type. (b) Percentage of discharge measurements assigned each rating.

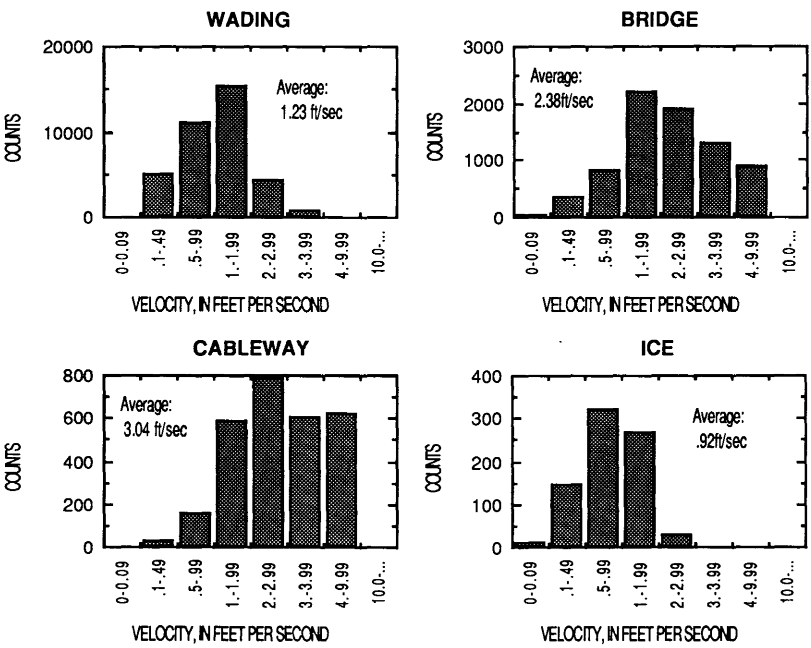

Figure 4.--Mean velocity distributions by measurement types.

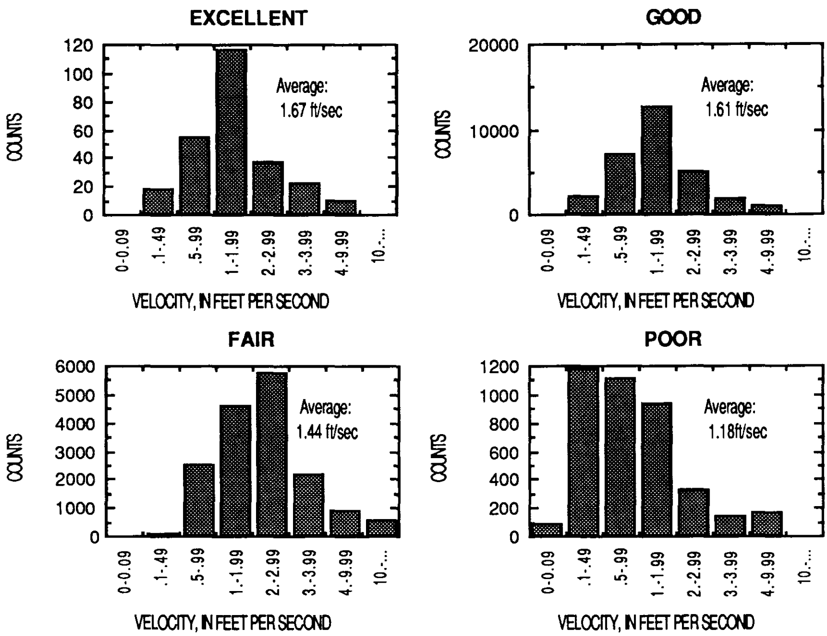

Figure 5.--Mean velocity distributions for each measurement rating.

Conclusions

The survey of current-meter usage and discharge measurement data for water year 1990 provides quantitified data on USGS discharge measurements. The two part survey is composed of a written questionnaire and computer data base retrievals, and has data on measurement conditions, frequency of use of various meter types, depth, area, velocity, and discharge. The survey provides a national summary of the range of flows and conditions in which current meters are expected to operate accurately.

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