COMPARISON OF CONVENTIONAL ONSITE RECORDERS AND SATELLITE TELEMETRY FOR SURFACE-WATER DATA COLLECTION BY THE U.S. GEOLOGICAL SURVEY

By Charles Parrett and E.F. Hubbard, Jr.

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Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.028317	cubic meter per second
mile	1.609	kilometer

Water-year definition: A water year is the 12-month period October 1 through September 30. It is designated by the calendar year in which it ends.

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ABSTRACT

A study was conducted using water year 1989 data to compare conventional onsite recorders and satellite telemetry, describe differences in operating procedures, and identify unmeasured benefits and problems concerning satellite telemetry. State offices of the U.S. Geological Survey having broad automated digital recorder (ADR) experience but limited data-collection platform (DCP) experience--Idaho, Louisiana, Mid-Atlantic (Maryland and Virginia), and Montana--were initially chosen for study. The study was expanded to include offices in Arizona, Arkansas, Colorado, and New York--offices having moderate experience using DCP's as primary recorders.

In offices having broad ADR but limited DCP experience, the number of regularly scheduled site visits was about the same for both groups of stations (range of 7.4 to 10.6 for ADR stations and 8.0 to 11.2 for DCP stations) during water year 1989. The median total office time was greater for DCP stations than for ADR, but the difference was not statistically significant. The median length of missing record and the time to estimate missing record were greater at DCP than at ADR stations. The differences in medians for length of missing record (0 days per station for ADR's, 16.0 days per station for DCP's) and time to estimate missing record (0 days per station for ADR's, 0.5 day per station for DCP's) were statistically significant. In offices having moderate and limited DCP experience, differences in these variables at DCP stations were not statistically significant.

Supplemental information indicated that the biggest difference in operating procedures between ADR's and DCP's was the near-real-time monitoring of site conditions with DCP's. The near-real-time knowledge about site conditions at DCP stations was cited as their major unmeasured benefit. A common problem with DCP stations was the occurrence of gaps in data received by office computers.

INTRODUCTION

Within the U.S. Geological Survey (USGS), the use of satellite telemetry to collect and process streamflow records has rapidly expanded during the past 10 years. As of 1991, about 2,600 gaging stations--about 36 percent of the total operated--are equipped with satellite data-collection telemetry. The primary benefit of satellite telemetry is that streamflow records generally are available for use in about 4 hours or less after the data are collected. Under conditions of rapidly changing streamflow, this near-real-time aspect of satellite-telemetry data can be of substantial benefit to water-management agencies that cooperate with the USGS for streamflow data collection. In other instances, cooperating agencies may not require data on a near-real-time basis, and the decision of whether to utilize satellite telemetry would be made solely by data-network managers within the USGS and would be based on other factors. This study focuses on those other factors and compares conventional and satellite-telemetry data collection solely from the perspective of a data-network manager.

To a data-network manager, perhaps the greatest benefit of satellite telemetry is that it enables one to monitor hydrologic conditions and the operational condition of gages without making onsite visits. This benefit indicates that satellite telemetry may offer increased accuracy and efficiency in the operation of data networks, because visits can be made as needed rather than on a fixed schedule.

Data-network managers need to weigh the recognized benefit of increased site knowledge through satellite telemetry versus the present additional costs of satellite-telemetry instrumentation when considering conversion from conventional onsite data collection to satellite telemetry.

To obtain more information about the present use of satellite telemetry, a comparison study involving selected State offices[1] was developed by the USGS Office of Surface Water in Reston, Va. The results would be helpful to managers in making informed decisions about possible network changes. Because costs for all forms of electronic data-collection equipment are volatile, the study focused on the time required to operate a gaging station and to compute the streamflow record. This "time of operation" was thus used as a surrogate for cost. Likewise, because efficiency and accuracy of gaging-station network operations are difficult to define and measure, the quantity of missing record and the time required to estimate missing record were taken as measures of efficiency and accuracy.

Purpose and Scope

This report presents the results of the comparison study described above. Specific purposes of this report are to:

1. Compare conventional onsite recorders and satellite telemetry for surface-water data collection in terms of number of site visits, field time, office time, and missing record.

2. Describe differences in operating procedures and identify unmeasured benefits and problems concerning satellite telemetry that were supplemental to the established study design.

The study was conducted using data provided by eight State offices for October 1, 1988, to about April 1, 1990--the time required to collect and process streamflow data for 1 complete water year (October 1, 1988, through September 30, 1989). Data were obtained for the time required to perform various aspects of gaging-station operation and streamflow-record computation and for the quantity of missing record and the time required to estimate missing record. Data from all eight offices were compiled for presentation in this report. In addition, study leaders in each State office were requested to provide supplemental information about operating procedures for the two kinds of stations and information about the benefits and problems concerning satellite telemetry.

Acknowledgment

Study leaders in the State offices (excluding Montana where the senior author served as study leader) were William A. Harenberg, Idaho; Darrell D. Carlson and George Arcement, Louisiana; Donald C. Hayes, Mid-Atlantic; Fred C. Boner and Bobby L. Wallace, Arizona; Rodney E. Southard, Arkansas; Dannie L. Collins, Colorado; and James B. Campbell and Carolyn O. Szabo, New York. These individuals managed and reviewed data collection for the study, furnished anecdotal information about station operation, and provided advice and assistance to the senior author on many occasions. Their crucial contributions to the study are gratefully acknowledged.

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[1] A State office is the office that coordinates water-resources activities of the U.S. Geological Survey in a geographic area--normally a State. At the time of this study, the Mid-Atlantic office coordinated activities in Delaware, Maryland, and Virginia; however, only activities in Maryland and Virginia were considered in this study.

Station Operation and Record Computation

Understanding the basic principles of gaging-station operation and streamflow-record computation was essential to the study design and results. Accordingly, this section is devoted to explaining those principles and describing the basic differences between stations equipped with conventional onsite recorders and those equipped with satellite telemetry.

A gaging station is a site on a stream where records of water level (stage) are used to compute discharge, which is the rate of streamflow. For most stations, streamflow is reported as daily mean discharge. For example, the streamflow at a station might be reported as 150 ft^3/s for a given day. This figure would represent the time-averaged discharge for that day; the actual streamflow may have varied significantly from 150 ft^3/s at various times during the day.

The data collected at gaging stations consist of records of stage, measurements of discharge, and general information to supplement stage and discharge measurements in determining the daily discharge. Almost all stations have a gage house where stage is gaged and recorded by automatic instruments on a continuous basis. Discharge is measured by a hydrographer using a current meter during periodic visits to the station. From measurements of discharge and concurrent stages, a mathematical stage-discharge relation is developed that gives the discharge for any stage. The application of the stage, recorded at frequent intervals during a day, to a stage-discharge relation, usually in the form of a rating table, allows the determination of a series of discharges from which daily discharge may be computed. More information on determining the flow of streams can be obtained in the report of Rantz and others (1982).

Although stage is recorded by automatic equipment, hydrographers visit the station from time to time to maintain the equipment--stage gage or sensor, gage structure and accessories, and recording apparatus. Hydrographers also visit the station to verify or update the stage-discharge relation by measuring discharge and observing channel conditions.

Over the years, the objectives of operating gaging stations were to define hydrologic relations and to provide data for use in project planning, design, and operation. These objectives can generally be met satisfactorily by publication of the data (U.S. Geological Survey, issued annually). Annual data reports continue to be the most visible product of the gaging-station program.

In keeping with the need to provide daily discharge data only annually, recorded stage data are retrieved periodically and taken to an office for processing. Then, usually at the end of the year, the computed daily discharge data are finalized for publication.

The recorders at gaging stations can be graphical, digital, or electronic. The most commonly used recorder, the automated digital recorder (ADR), punches digital stage information onto paper tape that can be electronically read and subsequently processed by computer. Gaging stations wherein the primary recorders are automated digital recorders are herein referred to as ADR stations. At some sites, more than one recorder is operated to provide backup in case of equipment failure or to provide displays that are convenient to inspect. Recorders that store the stage data used for streamflow-record computation are referred to as primary recorders; those used for backup or other purposes are referred to as backup recorders.

Gaging stations are generally visited at regular intervals ranging from monthly to bimonthly. Six weeks between visits is typical. Discharge is measured and gaging equipment is serviced during these site visits. Additional visits are sometimes scheduled if equipment needs repair or if a discharge measurement is needed to improve the stage-discharge relation.

Recently, demand for real-time streamflow data has made the wait until a stage record could be retrieved and processed unacceptable for many key gaging stations. Thus, during the past decade or so, many stations have been equipped with radio transmitters, or data-collection platforms (DCP's), which transmit the stage data by means of satellite telemetry to computers for near-real-time processing. Although DCP's are not recorders in the true sense of the word, they serve the same purpose. Gaging stations wherein the primary recorders are data-collection platforms are herein referred to as DCP stations. Hydrographers need not visit a station to retrieve stage records when a DCP is used, but still need to maintain equipment and measure discharge to verify, update, or develop the rating table.

Use of a DCP changes somewhat the operational procedures for a gaging station. During a site visit, there is little difference in servicing a station equipped with a DCP as compared to one with an ADR. No record is retrieved from a DCP, because the data have been transmitted to the computer for processing. The use of a DCP provides the hydrographer in the office with additional knowledge about site conditions that can be used to schedule extra visits at opportune times--when equipment repair is necessary or when a discharge measurement might help to improve the stage-discharge relation.

In the office, differences in procedures for processing data from conventional recorders and satellite telemetry are more pronounced. With the conventional recorder, stage data, usually in the form of a punched paper tape, are read into a computer. This handling of the tape might take from a few minutes to, perhaps, an hour if there are problems. With satellite telemetry, the data are automatically stored in a computer. Stage data collected and transmitted by a DCP have to be inspected, however, to determine if they are complete. Because of electronic transmission, communication, or computer problems, the record often has short lapses--on the order of a few hours--that must be filled in by estimation or by substitution of data from a backup recorder. These processes can be time consuming.

Prudent day-to-day operation calls for periodic scanning of the data being received from a DCP to recognize equipment malfunctions and to monitor fluctuations in stage. Periodic scanning, which might be done daily, is also somewhat time consuming.

Once the data are in a computer, processing is identical. The stage data are used together with the rating table to compute provisional daily discharges. At an appropriate time, usually after the end of the water year, the record is analyzed, using all available information to make any needed corrections or adjustments before subsequent publication and permanent storage. In making this final analysis, streamflow is estimated for periods of missing record. These are periods longer than a few hours of missing transmission record. In most offices, a daily discharge is considered to be missing if 12 or more hours of record for that day are missing. The missing daily discharges can be estimated from stage observations (obtained from a backup recorder or by other means), from records at nearby stations, from weather information, from discharge measurements, or from some combination of these data. Data estimation can be somewhat time consuming; thus, if much record is missing, the time can become substantial.

An advantage of DCP equipment is that malfunctions can be detected and plans made to correct the problems shortly after the occurrence. At times, however, economic or logistic considerations may dictate that a malfunctioning DCP station not be fixed until the next regularly scheduled visit. A station in a remote area where streamflow is normally relatively constant, for example, might not require a special trip for DCP repair purposes--especially if the next regularly scheduled visit will be relatively soon. In addition, a DCP is considerably more complex than a conventional onsite recorder, so malfunctions may occur more frequently. Thus, whether the quantity of missing record to be estimated for a DCP station will be more or less than for an ADR station is unknown.

COMPARISON OF CONVENTIONAL ONSITE RECORDERS AND SATELLITE TELEMETRY

To compare the use of conventional onsite recorders with satellite telemetry, the study involved compilation of data collected in eight State offices. Data were collected from 36 sites having conventional recorders and 74 sites having satellite telemetry.

Study Design

To make the study results as widely applicable as possible, information was obtained from State offices in each of four administrative regions nationwide. Initially, one State office from each region was selected for the study. These offices--Idaho, Louisiana, Mid-Atlantic, and Montana--were chosen because of the broad experience of personnel with ADR's and because each office had several gaging stations equipped with DCP's that were not being used as the primary recorders when the study began. Personnel in these four offices thus were not advocating the use of DCP's or using the near-real-time operational benefits of DCP's. Consequently, these offices were considered to be representative of offices having little bias toward DCP's and little experience in their operation. The comparison study was initially designed to utilize information collected only from these four offices.

Within the area of operation of each of the four State offices, 10 pairs of gaging stations were selected for analysis. One of each pair of stations was equipped with a DCP that, for the study period, was considered to be the primary recorder, and the other was equipped with an ADR as the primary recorder. The paired stations were chosen such that the two streams monitored by each pair were as hydrologically similar as possible. Achieving a maximum degree of hydrologic similarity between paired sites was intended to minimize operational differences between sites because of differing climatic and hydrologic conditions. To minimize operational differences due to human bias, the same hydrographer operated each station in a pair where feasible. Because all gaging stations used in the study were existing stations having various operational purposes and network constraints, it was impossible to treat the DCP stations as true, near-real-time stations where the number of fixed-schedule visits could be minimized. Accordingly, hydrographers from each office visited each station of each test pair according to the fixed schedule of visits currently used for conventional gaging stations.

Each hydrographer was instructed to keep careful and accurate records of time spent in the various prescribed aspects of gaging-station operation for each site included in the study. A form for recording time spent on field and office activities was designed for this purpose (fig. 1). The time of operation was measured for the following field activities (fig. 1):

1. Gage servicing (including primary and backup recorders),
2. Streamflow measurement, and
3. General gage-house maintenance.

To ensure that measured times would be comparable for each gage, no matter what its location in relation to the office, travel time was not measured. However, distance from the main office to each gage was measured and recorded in a file of information about each station so that travel time could later be reconstructed if necessary. The time of operation was measured for the following categories of office work (fig. 1):

1. Data entry and editing (including retrieval and review of data transmitted by satellite),
2. Computation and analysis, and
3. Recorder preparation and equipment check.

A form was also devised for recording periods of missing record at the primary recorder, the reason for the missing record, the method used to estimate the missing record, and the time required to estimate the missing record (fig. 2). If record was missing for just part of a day, study leaders in each office decided whether to count that day as a complete missing-record day. In general, at least 4 hours of record had to be missing from any day before that day was counted as a missing-record day. For relatively stable flow periods, some offices used a minimum of 12 hours of missing record. Specifying the method used to estimate periods of missing record was included because of the differing time requirements and accuracies associated with the different estimation methods. For example, using a backup recorder to estimate missing record would probably result in no loss of record accuracy, whereas using hydrographic comparison techniques would be time consuming and result in data having lesser accuracy than that of the recorded data.

STATION ____________________

DATE	HYDROGRAPHER GRADE (GS-)	FIELD				OFFICE		
		PURPOSE OF VISIT	TIME (hr + min)			TIME (hr + min)		
			GAGE SERVICING	MEAS	GAGE MAINTENANCE	DATA ENTRY AND EDIT	COMPUTATION AND ANALYSIS	RECORDER PREP.

PURPOSE OF VISIT: Designate one of the following-
(1) Regularly scheduled
(2) Extreme measurement--determined by DCP
(3) Extreme measurement--determined from other source
(4) Equipment failure--DCP related
(5) Equipment failure--other source
(6) Gage maintenance (includes levels)
(7) Water-quality considerations (includes sediment)
(8) Other (specify)______________________________

Gage servicing - Service primary and backup recorders and manometers, flush intakes, inspect equipment, program DCP's.

Meas - Starting set up to equipment storage and measurement computation.

Gage maintenance - Paint, run levels, clear brush, repair cables and structures.

Data entry and edit - Review satellite data, run and edit tapes from primary and backup recorders.

Computation and analysis - Analyze and enter shifts, compute and check discharge, prepare station analysis, and review record.

Recorder prep - Repair or bench-test recorders, trouble shoot or preprogram DCP's.

Figure 1.--Example of time-keeping form.

During the study, the scope was expanded to include information from State offices having moderate experience in the operation of gaging stations with DCP's as the primary recorders. The purpose of the expansion was to ensure that study results would be applicable to as wide a range of abilities and experience as possible. Thus, participating offices would have not only a wide range of hydrologic regimes, but also a wide range of experience with the use of DCP's as primary recorders. Accordingly, the Arizona, Arkansas, Colorado, and New York offices were added to the study. Each added office had a fairly extensive network of stations equipped with DCP's and relatively more experience with their operation than did the four initial offices. Each added office selected 10 gaging stations, all equipped with DCP's as the primary recorder. The 10 stations monitored by each office were selected essentially randomly from the total number of stations having DCP's. The same forms initially used in the study to record time of operation (fig. 1) and missing-record information (fig. 2) were also used by the added offices.

Copies of the time-keeping and missing-record forms were distributed to all hydrographers participating in the study, and the forms were periodically collected by the study leaders in each office. The information on the forms was entered into time-of-operation and missing-record computer files that were automatically forwarded to the senior author each time the files were updated. In addition, all

STATION______________

HYDROGRAPHER GRADE (GS-)	DATES OF MISSING RECORD	NO. OF CONSECUTIVE MISSING DAYS	REASON FOR MISSING RECORD	ESTIMATING METHOD	TIME REQUIRED FOR ESTIMATION

REASON FOR MISSING RECORD: Designate one-

(1) Recorder malfunction
(2) Power failure
(3) Timer/clock problem
(4) Input system (tape,float,bubbler,and so forth)
(5) Well or orifice silted or frozen
(6) Vandalism
(7) Ice-affected stage record
(8) Hydrographer mistake
(9) DCP malfunction
(10) Encoder malfunction
(11) Interface problem
(12) Antenna problem
(13) Downlink malfunction
(14) Computer malfunction
(15) Other (specify)______________________________

ESTIMATING METHOD: Designate one-

(1) Backup recorder
(2) Supporting data (cooperator gage, and so forth)
(3) Hydrographic comparison
(4) Climatological analysis
(5) Interpolation
(6) Statistical estimate (correlation/regression)
(7) Other (specify)____________________________

Figure 2.--Example of missing-record form.

pertinent information about the gaging stations used in the study was entered into a station-information computer file. Included in the station-information file were the following:

1. State office,
2. Station number,
3. Type of primary recorder,
4. Brand of primary recorder,
5. Brand of backup recorder,
6. Purpose of station,
7. Recorder ownership,
8. Agency responsible for recorder maintenance,
9. Type of stage sensor (gage) for the primary recorder,
10. Length of record,
11. Distance from office to station,
12. Distance from regular station route (only if a remote station was not visited on the same schedule as other stations),
13. Station number of the gage being used as a paired study site.

If a DCP was the primary recorder at a site, the following additional information was entered into the station information file:

1. Type of data encoder (a device for converting stage data to an electronic signal for transmission),
2. Brand of encoder,
3. Purpose of DCP recorder,
4. Data-transmission interval (time between transmissions of data to the satellite), and
5. Data-redundancy level (number of times each data reading is transmitted).

Descriptive station data are summarized in table 1 (all tables are at the back of the report). The station data are based on records from 10 ADR or DCP stations in each office except Idaho, Louisiana, and New York. In Idaho, summaries are based on nine stations of each type. One station had uniqué vandalism problems that resulted in a long period of missing record. That station and its paired station were also excluded from the analyses. In Louisiana, summaries are based on seven stations of each type. Three sets of paired stations were discontinued before the study started because of State budget reductions. In New York, the summaries are based on eight stations. Two stations were excluded because they had unique equipment malfunctions, unrelated to gaging-station type, that resulted in long periods of missing record.

Information about data-transmission interval and data-redundancy level, the number of visits to each station, the total time spent in each of the six categories of time of operation described earlier, and the total missing record are summarized in table 2. The complete records of time of operation and missing record for all offices are available as computer files in the State office in Helena, Mont. The individual time-of-operation and missing-record forms used by the hydrographers are in the individual State offices where the study was conducted.

Study Results

The results of study are presented in terms of site visits and field time, office time, and missing record. Within each category, the data are described in terms of offices having broad experience with ADR stations, offices having limited experience with DCP stations, and offices having moderate experience with DCP stations.

Site Visits and Field Time

Although the study focused on the collection of data for time of operation and missing record, a more useful measure of field work differences is the number of site visits. Additional unscheduled site visits required for some DCP stations might be balanced by limiting the number of regularly scheduled site visits. Limiting regularly scheduled site visits is a policy decision that may need to be based on factors other than the type of gage, however. In this study, Arkansas was the only office that decreased the number of regularly scheduled visits to DCP stations.

Data on the number of site visits and the time requirements are summarized according to three reasons for the visits in tables 3-5. Because the focus is on differences between ADR and DCP stations, visits for purposes that would be common to both kinds of stations--general gaging-station maintenance, for example--are not included. Site visits that were required for purposes completely unrelated to the type of gage--water-quality sampling, for example--are also not included.

The number of regularly scheduled visits and the average time to service the gage and measure discharge are given in table 3. The average number of visits per station in the Mid-Atlantic and Colorado offices were about once every month. In all other offices except Arkansas, each station was visited about eight times per year. Only 2.4 regularly scheduled visits were made per year to DCP stations in Arkansas.

The average times to service gages and measure discharge on regularly scheduled visits are remarkably similar from office to office and for ADR and DCP stations within the area served by the same office. As indicated in table 3, the average times to service a gage and measure discharge are about 0.5 and 1 hour, respectively. Discharge-measurement times are somewhat greater in Louisiana--about 1.5 hours--presumably because the average stream size is somewhat larger in Louisiana than in the other States. For offices where gage-service and discharge-measurement times were measured for both ADR and DCP stations, similar times on regularly scheduled visits help confirm that no bias existed in the station-selection process. This situation is particularly true for discharge-measurement times, which are completely unrelated to the type of gage used to record stage.

The number of visits and the average time to service the gage and measure discharge are given in table 4 for the situation where the data from DCP's indicated stages for which discharge measurements would likely improve stage-discharge relations. Improved stage-discharge relations ultimately result in improved streamflow records; thus, the additional visits and time required for discharge measurements at particular stages constitute positive measures of DCP performance rather than negative measures.

In this regard, table 4 indicates that hydrographers in Louisiana made the best use of DCP's for improving stage-discharge relations with an average of 2.3 additional visits per station per year for discharge measurements at particular stages. Hydrographers in the Louisiana office used information from DCP stations to make almost as many discharge measurements at ADR stations--1.7 visits per station per year. Hydrographers in Idaho and Montana also used the additional information available from DCP stations to measure discharge at particular stages at ADR stations. Thus, the results in table 4 illustrate that DCP's can be used to improve stage-discharge relations (hence, streamflow records) throughout a station network and not just at DCP stations.

The number of visits and the average time to service the gage due to DCP-equipment failure are given in table 5. Although these additional visits and service times are not required for ADR stations, they might, to the extent that they prevent missing record, be positive measures of DCP performance rather than negative measures. Because discharge is rarely measured during site visits for equipment repair, no discharge measurement times are given in table 5.

The data in table 5 indicate that, overall, only one or two extra visits per year were made to stations to repair DCP equipment. Hydrographers in Arkansas made the most visits for DCP repair--an average of 2.4 trips per station per year. Hydrographers in Arizona made the fewest--an average of 0.1 trip per station per year. The time to repair the gage averaged about 2 hours overall. Colorado personnel spent the most time--3.2 hours per station per visit. Arizona personnel spent the least time--0.5 hour per station per visit. No substantial difference in the number of trips or in the time to repair the gages was evident between the offices having limited DCP experience and those having moderate experience.

Office Time

The average and median times required for office activities per station are given in table 6. Both average and median values are given because, in several instances, the averages were greatly affected by one or two large values. For example, for DCP stations in Arizona, the average time for data entry was 6.1 hours, whereas the median time was only 2.4 hours. An examination of the time for data entry for individual stations in Arizona (table 2) indicates that one station required 30.4 hours for data entry, yet half the stations required less than 2 hours. In such instances, the median is a fairer measure of the central tendency of the data than is the average. Accordingly, office-time results are described in terms of median rather than average values. For most office-time categories for most offices, the average and median values are similar.

In offices having broad experience with ADR equipment, the median time for data entry at ADR stations ranged from 3.5 hours per station in Montana to 4.1 hours in Idaho and Louisiana. In offices having limited DCP experience, median time for data entry at DCP stations ranged from 3.6 hours per station in Louisiana to 7.2 hours in Montana. The range in median time for data entry at DCP stations in offices having moderate DCP experience was about the same, ranging from 2.4 hours per station in Arizona to 8.0 hours in Arkansas.

Median time for record computation had even more variation than time for data entry. The median time for record computation at ADR stations ranged from 5.1 hours per station in the Mid-Atlantic office to 37.2 hours in Louisiana. Louisiana was the only office where the median time for record computation at DCP stations was less than that at ADR stations. In offices having limited DCP experience, the median time for DCP stations ranged from 12.3 hours in Idaho to 31.5 hours in

Montana. In offices having moderate DCP experience, the median time for DCP stations ranged from 14.9 hours in Colorado to 44.9 hours in Arkansas.

The median time for recorder preparation was zero in all Districts except Idaho, where the median time for DCP stations was 0.3 hour. Overall, time for recorder preparation is insignificant compared to the time required for other office activities and is not discussed further.

The median total office time, which is the sum of the times for data entry, record computation, and recorder preparation, generally was similar to the time for record computation, its largest component. Thus, the median total office time for ADR stations ranged from 10.0 hours per station in the Mid-Atlantic office to 40.6 hours in Louisiana. In offices having limited DCP experience, the median total office time for DCP's ranged from 18.2 hours in the Mid-Atlantic office to 43.7 hours in Montana. Louisiana was the only District where the median total office time for DCP stations was less than that for ADR stations. In offices having moderate DCP experience, the median total office time ranged from 18.4 hours in Colorado to 56.5 hours in Arizona.

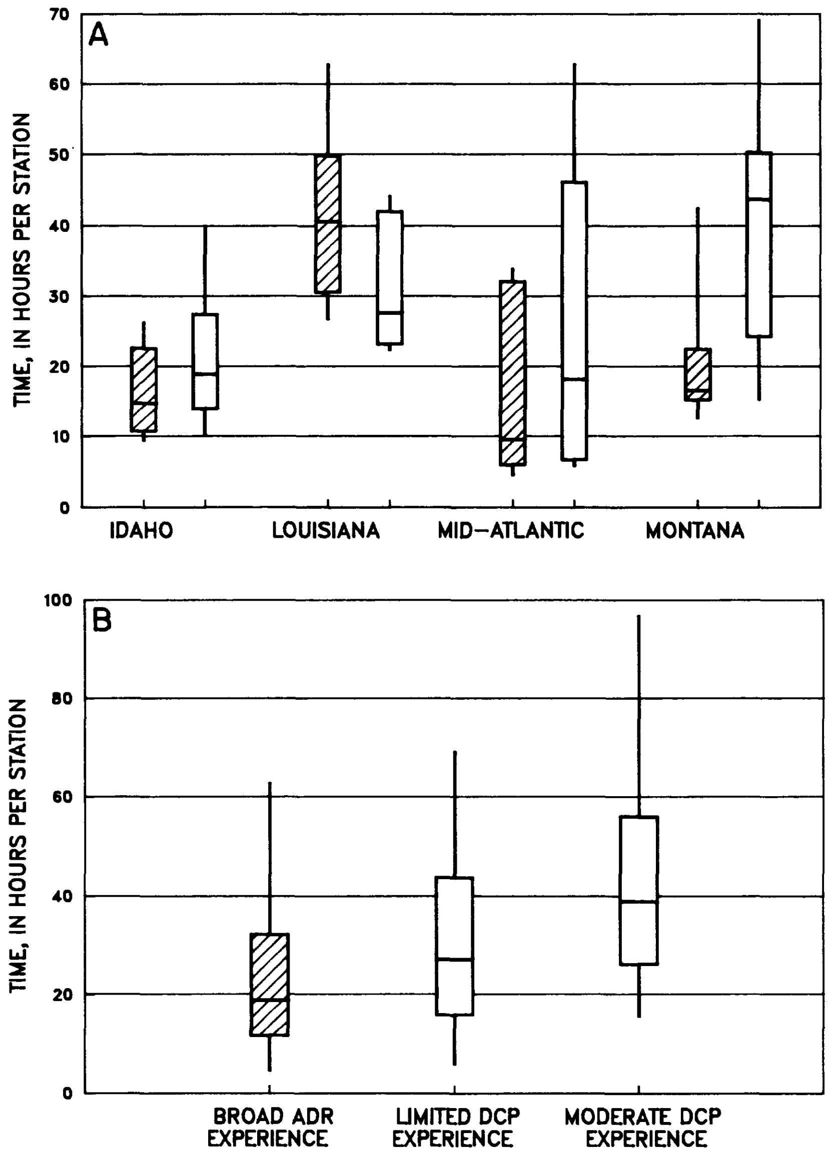
The mixed results for office time (table 6) are difficult to interpret. In some offices, particularly Louisiana and Arizona, more time may have been required because of generally unstable stage-discharge relations at some sites. Likewise, hydrographers in Louisiana and Arizona were somewhat more inexperienced than those in other offices and may thus have required more time for record computation. For the same type of gaging station, the apparent large differences in measured times between the different offices might be due largely to differences in interpretation of the study instructions or in the way the study was conducted in each office. Hydrographers from one office, for example, may have counted time spent inspecting daily stage data from a DCP as data entry, whereas hydrographers from a different office may have counted the same time as record computation. Comparisons between offices thus may be misleading.

In this regard, time for record checking and review was not included as record computation by hydrographers in Arkansas, New York, and Idaho. Consequently, the average time for record checking and review was estimated by study leaders in those offices after the end of the data-collection period; the time was added to the time for record computation for each station to produce the total time for record computation given in table 2. Statistics given in table 6 are based on the adjusted data in table 2.

In offices having broad ADR experience but limited DCP experience, comparisons between ADR and DCP stations are probably valid, because the same hydrographers generally operated both stations of each pair. Results from three of the four offices show an apparent advantage in total office time for ADR stations. In Louisiana, however, the apparent time advantage is for DCP stations.

At least part of the reason that ADR's have an apparent advantage over DCP's in Idaho and Montana is that DCP data were not transmitted redundantly in those offices. Redundant data transmission means that each data item is transmitted at least twice from the station to the satellite. Because of poor radio reception or other problems, some small fraction of all transmissions is not properly received at the office computer. If redundant transmissions are made, any lost data are likely to be filled in on subsequent transmissions. Without redundant data transmission, however, any gaps in the data will remain unfilled. The missing data in these gaps need to be estimated, usually by interpolating between recorded data, and the process is time consuming. In Louisiana, 5 of the 7 DCP stations had redundant data transmissions, and in the Mid-Atlantic office, 7 of the 10 DCP stations had redundant data transmissions. All offices having moderate DCP experience used redundant data transmission at all stations.

Offices do not necessarily control whether data are transmitted redundantly. In many State offices, the DCP's are owned by other agencies, such as the U.S. Army Corps of Engineers or the U.S. Bureau of Reclamation. Those agencies usually do not require nor even allow redundant data transmission. In any event, redundant data transmission is evidently an important factor in the decrease of DCP office time and needs to be considered by offices where feasible.



EXPLANATION

PERCENTILE--Percentage of analyses equal to or less than indicated values. Patterned boxplot represents automated digital recorder (ADR) data. Open boxplot represents data-collection platform (DCP) data

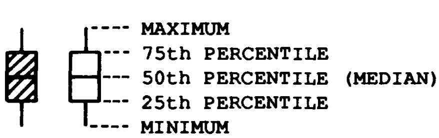


Figure 3.--Total office time. A, For ADR and DCP stations in offices having broad ADR experience but limited DCP experience. B, For various groups of offices.

To determine whether some of the apparent large differences in median office time in table 6 were statistically significant, the nonparametric Mann-Whitney rank-sum test for differences in medians (Minitab, Inc., 1986, p. 128) was applied to total office time for the various groups of offices. Significance tests were not made for data from individual offices because of the small number of data points (between 7 and 10) and because office-to-office comparisons might not, for reasons discussed previously, be valid.

At the 95-percent level of confidence, the statistical tests showed no significant difference ($p = 0.088$) in the median total office time between ADR and DCP stations. The difference in median total office time for DCP stations between offices having limited DCP experience and those having moderate experience, however, was significant. Ironically, the offices having limited DCP experience spent less time than those having moderate experience, and the difference was significant at the 99-percent level of confidence ($p = 0.012$). Although this result indicates that offices having limited DCP experience were somehow more efficient than those having moderate experience, a more likely interpretation is that offices having limited experience did not monitor the operation of DCP stations as closely as those having moderate experience.

Selected data on total office time are displayed graphically in figure 3. Boxplots are used to display the data, because they show the minimum, maximum, and spread of the data in addition to the median. Data for offices having broad ADR experience but limited DCP experience are shown in figure 3A. Data for offices having broad ADR experience, limited DCP experience, and moderate DCP experience are shown by group in figure 3B. Comparisons of data between offices (fig. 3A) may not be valid, for the reason described previously, but comparisons between gage type are considered to be valid. Comparisons of data between groups of offices (fig. 3B) are also considered to be valid.

Missing Record

The length of missing record per station and the time to estimate missing record per station are summarized in table 7. Missing record due to the effects of ice is excluded from the summary to permit more meaningful comparisons between offices in warm and cold climates. As with total office time, comparisons of length of missing record and time to estimate missing record are based on median values.

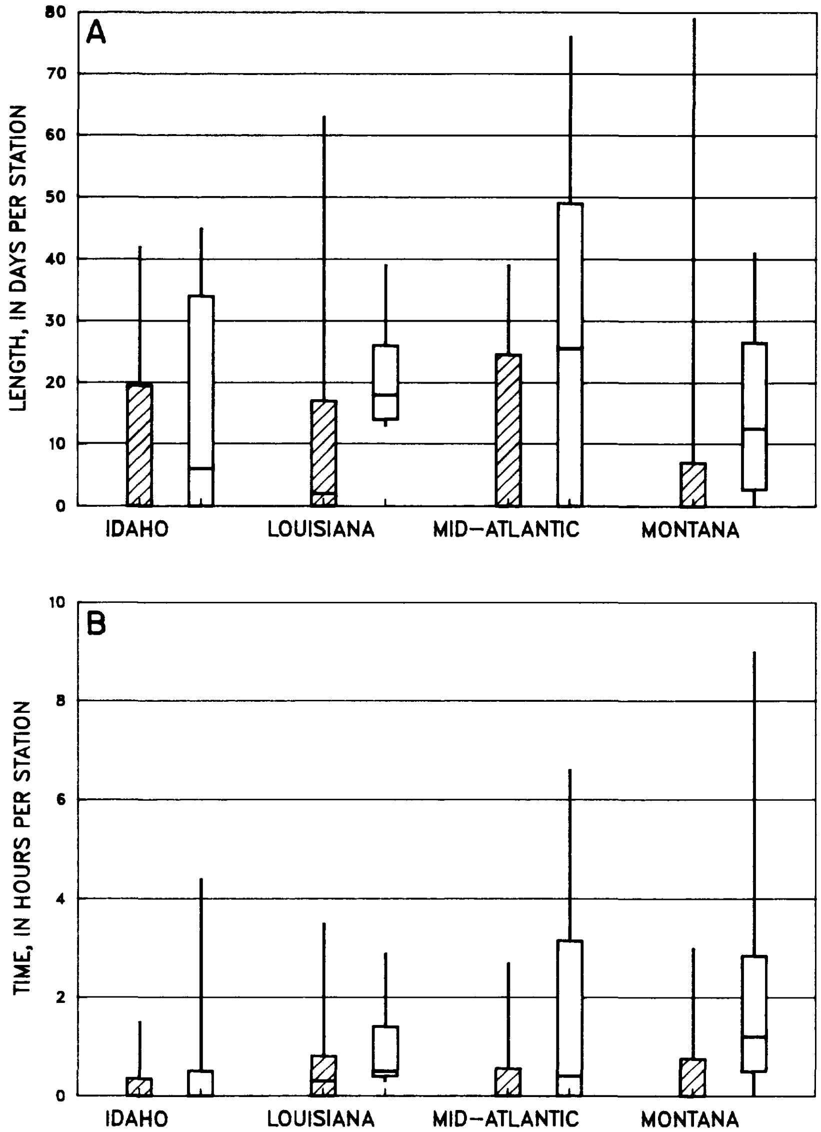
In all four offices that had broad ADR experience but limited DCP experience, the median length of missing record at ADR stations was less than that at DCP stations. In three of the four offices, the median was 0 days; in Louisiana, the median was 2.0 days. The median time to estimate the missing record at ADR stations likewise was less than that at DCP stations. The range was 0 hours for three offices to 0.3 hour in Louisiana. In offices having limited DCP experience, the median length of missing record at DCP stations ranged from 6.0 days per station in Idaho to 25.5 days in the Mid-Atlantic office. The median time required to estimate missing record at DCP stations ranged from 0 hours per station in Idaho to 1.2 hours in Montana. In offices having moderate DCP experience, the median length of missing record at DCP stations ranged from 4.0 days per station in New York to 45.5 days in Arkansas. The median time to estimate missing record at DCP stations in these offices ranged from 0.3 hour per station in Colorado to 4.1 hours in Arkansas.

The results in table 7 apparently indicate that, in offices having broad ADR experience but limited DCP experience, the DCP stations produced more missing record that required more time to estimate than did the ADR stations. To the extent that length of missing record and time to estimate missing record can be considered as indicators of record accuracy, and to the degree that missing record is comparable for the two types of stations, the DCP stations in the study clearly did not produce more accurate records than did the ADR stations. Periods of missing record occurred more frequently at DCP stations than at ADR stations, presumably because of the greater complexity of DCP equipment and the need to transmit data to and from a satellite and because data managers and hydrographers have relatively less experience with DCP stations. The frequent short-term gaps in DCP records that occurred in some offices as a result of missed radio transmissions did not contribute to periods of missing record, however, unless the gaps exceeded 4 hours. Thus, the length of missing record at DCP stations is probably directly comparable to the length at ADR stations, even though the missing record at the two types of stations may be due to entirely different causes. The length of missing record is an imperfect measure of record accuracy, because other factors, such as improved stage-discharge relations resulting from discharge measurements at appropriate stages, are not considered.

Methods used most frequently to estimate missing record, excluding ice-affected missing record, were backup recorders (54 percent of missing record) and hydrographic comparison (38 percent of missing record). Surprisingly, perhaps, more time per day was required to estimate missing record from backup recorders than from hydrographic comparison, although the difference was not substantial.

Another observation of the study is that the office (Arkansas) visiting DCP stations only on an as-needed basis also had the most missing record and required the most time per station to estimate missing record. According to the study leader in Arkansas, this apparent anomaly is probably due to two factors: (1) the DCP equipment in Arkansas was old and prone to failure, and (2) site visits for repair commonly were ineffective, because hydrographers did not have adequate equipment or training to perform effective troubleshooting.

To determine whether the differences in missing record and estimation time given in table 7 were statistically significant, the Mann-Whitney rank-sum test was



EXPLANATION

PERCENTILE--Percentage of analyses equal to or less than indicated values. Patterned boxplot represents automated digital recorder (ADR) data. Open boxplot represents data-collection platform (DCP) data

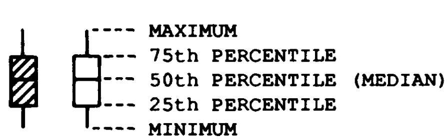


Figure 4.--Missing record for ADR and DCP stations in offices having limited DCP experience. A, Length of missing record. B, Time to estimate missing record.

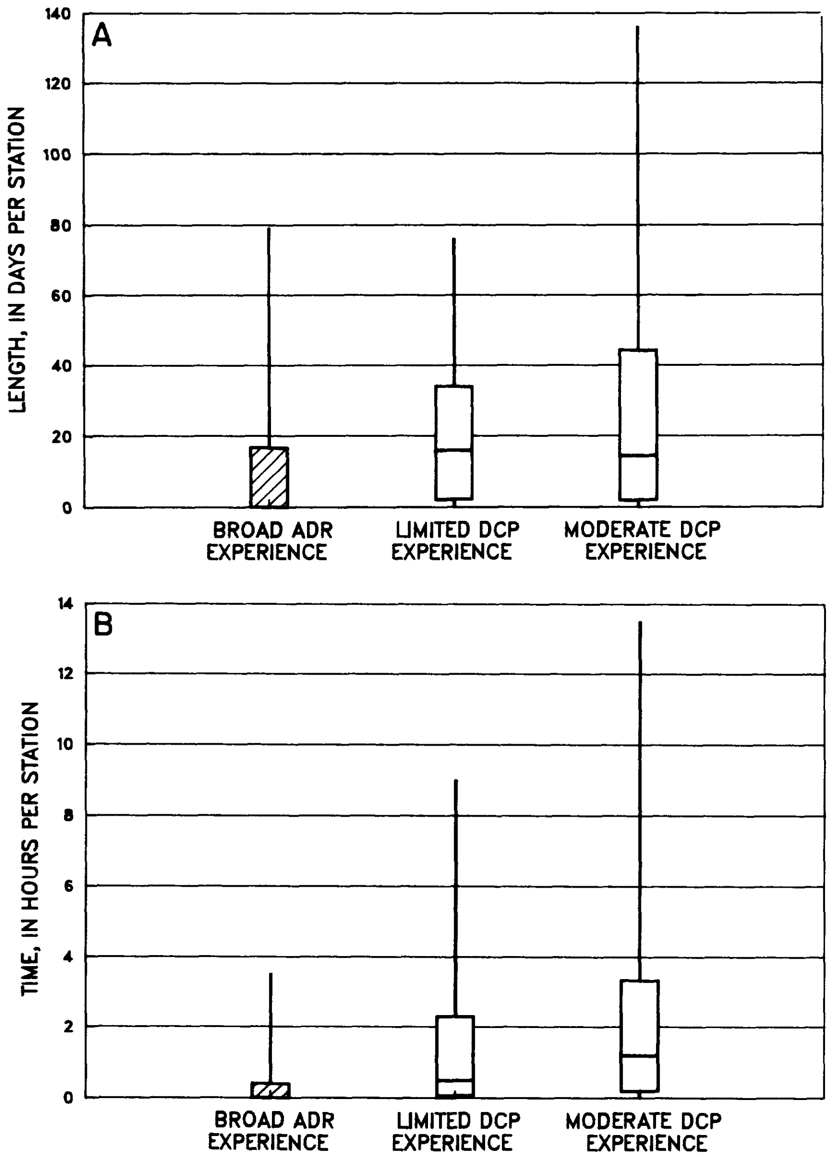
applied to the missing-record and estimation-time data for the various groups of offices. As was true for total office-time data, no significance tests were applied to data from individual offices.

In offices having broad ADR experience but limited DCP experience, the difference in median values for missing record between ADR and DCP stations was significant at the 99-percent confidence level (p = 0.003). Likewise, the difference in median time for estimation between ADR and DCP stations was significant at the 99-percent confidence level (p = 0.001). No significant difference was found in median length of missing record for DCP stations between offices having limited DCP experience and those having moderate DCP experience (p = 0.684). Likewise, no significant difference (p = 0.175) was observed in median time for estimation at DCP stations between these two groups of offices.

Selected data on the length of missing record and the time to estimate missing record are shown as boxplots in figures 4 and 5. Data for offices having broad ADR experience but limited DCP experience are shown in figure 4. Data for offices having broad ADR experience, limited DCP experience, and moderate DCP experience are shown by group in figure 5.

SUPPLEMENTAL STUDY RESULTS

Although the comparison study was designed to provide data on time of operation and missing record for ADR and DCP stations, interpretation of the data required additional information. Accordingly, one purpose of the study was to obtain supplemental information about differences in operating procedures between ADR and DCP stations and unmeasured



EXPLANATION

PERCENTILE--Percentage of analyses equal to or less than indicated values. Patterned boxplot represents automated digital recorder (ADR) data. Open boxplot represents data-collection platform (DCP) data

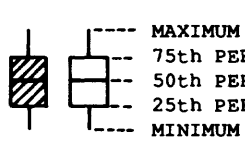


Figure 5.--Missing record for various groups of offices. A, Length of missing record. B, Time to estimate missing record.

benefits and problems concerning satellite telemetry. In addition, the comparison study had some limitations that may affect the interpretation of study results. These limitations are also presented as supplemental information.

Differences in Operating Procedures

At least some of the differences in measured time of operation and in missing record in the study were expected to be the result of differences in operating procedures in the eight offices. Documentation of those procedural differences thus would help in the interpretation of the measured differences in time of operation and missing record. Perhaps more importantly, documentation of those procedural differences might assist in more efficient utilization of and conversion to DCP stations. Accordingly, the study leaders in each office were asked to provide supplemental information about the procedural differences between ADR and DCP gaging stations in their offices.

The most frequently cited difference in procedures between the two types of gaging stations was that unscheduled site visits were made much more frequently to the DCP stations than to the ADR stations. These unscheduled visits were made when the DCP record indicated an equipment problem or a particular stage where a discharge measurement would improve the stage-discharge relation. In most instances, an equipment problem was attended to relatively quickly; in some instances, the repair visit was not made until the next regularly scheduled visit.

In all offices, the biggest difference in office operations between the two types of stations was the near-real-time monitoring of site conditions at the DCP stations. Some form of computer monitoring was used to check the operational status and current stage of each DCP station almost daily. In offices having moderate experience in the operation of DCP's as primary recorders, computer programs were also used to plot current hydrographs at DCP stations. The plots enabled hydrographers to readily determine the current hydrologic conditions, which fostered interest in the near-real-time capabilities of the DCP stations.

Streamflow-record computations were generally kept more current for DCP stations than for ADR stations, especially in offices having moderate DCP experience. Supplemental information obtained from study leaders indicated that hydrographers in these offices were more apt to use computer techniques to automatically update the rating table between discharge measurements (stage-shifting) than were hydrographers in other offices. These automatic updates ensured that the computed daily discharge record, although still provisional, would require little final adjustment. At the ADR stations, streamflow records could be kept only as current as the date of the last record (generally punched tape) retrieval.

Unmeasured Benefits and Problems Concerning Satellite Telemetry

Many benefits of DCP stations may be difficult to measure; consequently, study leaders in the participating offices were asked to provide supplemental information about the unmeasured benefits. Likewise, because DCP stations may have problems that were not measured in the study, supplemental information about problems was also solicited.

Although the analyses for time-of-operation and missing-record data indicate no advantage for DCP stations compared with ADR stations, the data provide only narrow measures of overall gage performance and not other aspects of stream-gaging operation. Even though DCP stations evidently do not save time in office operations, for example, they do provide data managers with additional knowledge about hydrologic conditions at all nearby stations. This additional knowledge can lead to improvement in streamflow records at all nearby stations as well as at the DCP stations. This benefit, although it may far outweigh any additional office time that DCP stations require, is difficult to measure.

The major unmeasured benefit of DCP stations mentioned by all study participants was the near-real-time knowledge about site conditions. This knowledge was used, to some degree, in all participating offices to schedule site visits to both DCP and ADR stations for special repairs or extreme-stage discharge measurements. As noted by the study leader in Arizona, special visits made as a result of additional information from DCP stations may be more effective than regularly scheduled visits, because the streamflow conditions, and thus the proper equipment needed for measurement or repair, are known beforehand. Study results in Arkansas, however, showed that special visits made to repair DCP equipment may be unproductive if personnel do not have the equipment or training needed to make the repairs efficiently.

Another benefit of DCP stations cited by study leaders in Arizona and Colorado is that the near-real-time aspects of data collection can result in improved relations with cooperating agencies. These improved relations, in turn, may result in more efficiently designed data networks and expanded cooperative programs. This study did not attempt to evaluate the benefits of near-real-time data to the many cooperating agencies that support the streamflow-gaging program of the USGS.

Because data from DCP stations are automatically stored in office computers, the need for handling, processing, and storing ADR tapes or graphical recorder charts is eliminated. Although this elimination was a cited benefit of DCP stations in several offices, the lack of an archivable, "hard copy" record of collected data also was cited as a problem with DCP stations. An archivable record is necessary for strict accountability of the data-collection process, but the question of what constitutes an archivable record for DCP stations had not been fully addressed at the time of the comparison study. Until that question is resolved, automatic computer storage of DCP data creates both benefits and problems.

The most common problem with DCP stations was the large number of gaps in data received by office computers. This problem was particularly severe in the offices where data were not transmitted redundantly (Idaho and Montana), which resulted in considerable additional office work to manually input the skipped data. Not surprisingly, hydrographers in those offices seemed to be the most skeptical about the benefits of DCP stations.

Another common problem with DCP stations is that hydrographers require considerably more training to effectively operate and maintain complicated electronic equipment. Without the training, DCP station operation is frustrating and, to some extent, counterproductive as evidenced by some repeated, unsuccessful site visits in Arkansas. On the other hand, the results of the office-time analysis in Louisiana showed a significant difference in favor of DCP stations compared to ADR stations. According to the study leader in Louisiana, at least part of the reason for that difference is that the hydrographers, although not greatly experienced, are well-trained and highly motivated in all aspects of electronic data collection. Hydrographers in that office also expressed a clear preference for DCP stations over ADR stations. As hydrographers in other offices become better trained and more familiar with the electronics, the efficiency of record collection at DCP stations is likely to improve.

As evidenced by the number of trips required for repair and the missing-record analyses, DCP stations presently have more equipment breakdowns and missing record than ADR stations. These problems are evidently due to the greater complexity of the equipment and the fact that the data are moved electronically to several locations before they are stored in a computer. When onsite repair is not possible, equipment is usually sent to the manufacturer or some repair facility. Lengthy turnaround from such facilities was a frustration to several study leaders. However, most study leaders believed that the quality of electronic equipment is improving and that the reliability of DCP's will soon equal that of the ADR's.

Limitations of Comparison Study

A major limitation of the comparison study is that it occurred at a time when the computerized system and data-processing procedures for DCP stations were relatively new. Some of the problems experienced during the study with DCP stations, including missing record and additional office time required, are probably due, in part, to the relative newness of the DCP system and procedures. A related limitation of the comparison study is that hydrographers, even in the offices having moderate DCP experience, are generally more experienced with ADR operation and records processing than with DCP operation and records processing. As hydrographers gain more experience with DCP's and with the newer computerized data-processing systems, the performance of DCP stations in comparison with ADR stations will likely improve. A third limitation of the comparison study is that most field-work schedules presently (1992) are designed for networks consisting mostly of ADR stations. Thus, regularly scheduled site visits are commonly made to both ADR and DCP stations even though they may not always be necessary at DCP stations. As more DCP stations are added to office networks, the frequency of regularly scheduled trips will probably decrease.

SUMMARY AND CONCLUSIONS

The use of satellite telemetry to collect and process streamflow records has rapidly expanded within the USGS during the past 10 years. As a result of this expansion, a study was conducted among eight State offices to compare the use of conventional data-collection methods and satellite telemetry. The study focused on time of operation of a gaging station as a surrogate for cost. Likewise, the quantity of missing record and the time required to estimate missing record were taken as measures of efficiency and accuracy.

State offices, one in each of four administrative regions nationwide, were initially chosen for the study. Hydrographers in the selected offices--Idaho, Louisiana, Mid-Atlantic, and Montana--had no experience with the use of DCP's as primary recorders at gaging stations. Within each office, 10 gaging stations with

ADR's were paired with 10 gaging stations equipped with DCP's. The paired sites were matched as closely as possible in terms of hydrologic and streamflow-measurement characteristics. Forms were devised for recording the time needed to complete various aspects of gaging-station operation and streamflow-record computation and for recording the length of missing record and the time needed to estimate missing record at each station. Hydrographers used the forms to record gaging-station operation, streamflow-data collection, and record processing for water year 1989.

To ensure that study results would be applicable to as wide a range of abilities and experience as possible, the study was expanded to include offices in Arizona, Arkansas, Colorado, and New York. Hydrographers in each of these offices had experience using DCP's as primary data recorders. Study leaders randomly selected 10 DCP stations for inclusion in the study and used the same forms used in the offices initially selected to record time of operation and missing record for water year 1989. In three States, the number of stations included in the study had to be reduced because of various equipment or budgetary problems.

Although the focus of the study was on time of operation and missing record, the number of site visits was considered to be a better measure of differences in field work between the two kinds of gages than the time spent on individual field activities. In each office that tested both ADR's and DCP's, the number of regularly scheduled site visits was about the same for both kinds of stations. In three of the four offices, each ADR and DCP was visited about eight times per year; in the Mid-Atlantic office, each ADR and DCP was visited about once a month. In offices having moderate experience with DCP's, Arkansas decreased the number of regularly scheduled site visits to DCP's to 2.4 per station. The other three offices visited DCP's about 8-12 times per year.

Site visits made to DCP stations to measure discharge, where the data from DCP's indicated stages for which measurements would likely improve stage-discharge ratings, ranged from 0.3 trip per station per year in Idaho and Colorado to 2.3 trips in Louisiana. Three of the four offices that tested both kinds of stations also used information from DCP's to measure discharge at particular stages at ADR stations.

The number of site visits required because of DCP equipment failure ranged from an average of 0.1 trip per station in Arizona to 2.4 trips in Arkansas. Although these additional visits were not required for ADR stations, they might result in less missing record at DCP stations.

Time spent on various office activities associated with gaging-station operation and record computation differed from office to office and between DCP and ADR stations in the same office. Comparisons between offices are probably not valid because of differences in interpretation of study instructions or in the way the study was conducted in each office. Comparisons between ADR and DCP stations in individual offices are probably valid because the same hydrographer, in most instances, operated both stations of each pair.

In offices having broad ADR experience, median total office time for ADR stations ranged from 10.0 hours per station in the Mid-Atlantic office to 40.6 hours in Louisiana. In these same offices, the median total office time for DCP stations ranged from 18.2 hours per station in the Mid-Atlantic office to 43.7 hours in Montana. Only in Louisiana was the median total office time less for DCP stations than for ADR stations. In the offices having moderate DCP experience, the median total office time for DCP stations ranged from 18.4 hours per station in Colorado to 56.5 hours in Arizona.

The Mann-Whitney rank-sum test for differences in medians was applied to total office time for the various groups of offices. The results showed no significant difference between ADR and DCP stations in the group of offices having broad ADR experience. The difference in median total office time for DCP stations was significant at the 99-percent level of confidence ($p = 0.012$) between offices having limited DCP experience and offices having moderate DCP experience. The difference was in favor of the offices having limited DCP experience, perhaps indicating that these offices did not monitor operation of DCP stations as closely as did the offices having moderate DCP experience.

In the offices having broad ADR experience but limited DCP experience, the median length of missing record at ADR stations ranged from 0 days per station in three of the four offices to 2.0 days in Louisiana. The median time to estimate missing record at ADR stations ranged from 0 hours per station in three of the four offices to 0.3 hour in Louisiana. In all four offices that tested both ADR's and DCP's, the median length of missing record was greater at DCP stations than at ADR stations, ranging from 6.0 days in Idaho to 25.5 in the Mid-Atlantic office. Likewise, the median time to estimate missing record at DCP stations was equal to or greater than that at the ADR stations, ranging from 0 hours per station in Idaho to 1.2 hours in Montana.

In the offices having moderate DCP experience, the median length of missing record at DCP stations ranged from 4.0 days per station in New York to 45.5 days in Arkansas. The median time required to estimate missing record at DCP stations in these offices ranged from 0.3 hour per station in Colorado to 4.1 hours in Arkansas.

When data from individual offices were grouped by type of station, statistical tests showed that the differences in median values for length of missing record and time required to estimate missing values between ADR and DCP stations were significant. No significant differences were found in length of missing record or time required to estimate missing record at DCP stations between the group of offices having limited DCP experience and the group having moderate DCP experience.

Supplemental information obtained from study leaders indicated that the biggest difference in operating procedures between ADR's and DCP's was the near-real-time monitoring of site conditions with DCP's. Thus, streamflow-record computations were generally kept more current for DCP stations than for ADR stations. The near-real-time knowledge about site conditions provided by DCP stations was cited as their major unmeasured benefit. Improved relations with cooperating agencies was cited as another benefit of DCP stations. The most common problem with DCP stations was the large number of gaps in data received by office computers. Another problem was the extensive training required for successful operation and maintenance of complicated electronic equipment.

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Table 1.--*Descriptive station-information file*

Primary recorder--ADR, automated digital recorder; DCP, data-collection platform (satellite telemeter).

Type of DCP data encoder--Inc, incremental shaft encoder; Mod, Module A; Oth, other; Tel, Tel-kit.

Brand of DCP data encoder--Han, Handar; HIF, Hydrologic Instrumentation Facility (U.S. Geological Survey); Oth, other; Sut, Sutron; Syn, Synergetics.

Purpose of DCP recorder--DI, used by U.S. Geological Survey for improvement of data accuracy; F, requested by cooperating agency for flood forecasting; M, requested by cooperating agency for streamflow management; OP, used by U.S. Geological Survey for other purposes; PA, used by U.S. Geological Survey because of poor site accessibility.

Brand of primary recorder--Fis, Fisher-Porter; Han, Handar; Ste, Stevens; Sut, Sutron; Syn, Synergetics.

Brand of backup recorder--Fis, Fisher-Porter; Han, Handar; Ste, Stevens; Syn, Synergetics.

Purpose of station, as defined by National Water Data Exchange (Perry and Williams, 1982, p. 71)--AA, areal analysis; B, benchmark; CL, compact or legal; CO, current operation; F, forecasting; LH, long-term hydrologic.

Agency owning primary recorder--BPA, Bonneville Power Administration; USAE, U.S. Army Corps of Engineers; USBR, U.S. Bureau of Reclamation; USGS, U.S. Geological Survey; USWB, National Weather Service.

Agency maintaining primary recorder--USGS, U.S. Geological Survey; USWB, National Weather Service.

Stage sensor--F, float; M, manometer.

Length of record in years; >, greater than.

Distance to station from regular gage route--applies only if gage is not on regular route.

Paired station--U.S. Geological Survey streamflow-gaging-station number of paired station used for comparison (applies only in Idaho, Louisiana, Mid-Atlantic, and Montana offices).

--, no data or not applicable.

Table 1.--*Descriptive station-information file*--Continued

State office	Station number	Primary recorder	Type of DCP data encoder	Brand of DCP data encoder	Purpose of DCP recorder	Brand of primary recorder	Brand of backup recorder	Purpose of station	Agency owning primary recorder	Agency maintaining primary recorder	Stage sensor	Length of record (years)	Distance to station, in miles: From servicing office	From regular route	Paired station
Offices having broad experience with ADR stations															
Idaho	13055000	ADR	--	--	--	Ste	--	CO	USGS	USGS	F	>10	033	000	13052200
	13055340	ADR	--	--	--	Ste	Ste	CO	USGS	USGS	M	5-10	022	000	13055198
	13058520	ADR	--	--	--	Ste	--	CO	USGS	USGS	F	2-5	010	000	13058549
	13075910	ADR	--	--	--	Fis	Ste	AA	USGS	USGS	M	2-5	053	000	13075500
	13076200	ADR	--	--	--	Fis	Ste	AA	USGS	USGS	M	2-5	061	000	13075983
	13296500	ADR	--	--	--	Fis	--	AA	USGS	USGS	F	>10	145	000	13302500
	13337000	ADR	--	--	--	Ste	Syn	F	USGS	USGS	F	>10	250	000	13336500
	13340000	ADR	--	--	--	Ste	Ste	F	USGS	USGS	M	>10	255	000	13338500
	13342500	ADR	--	--	--	Ste	Ste	F	USGS	USGS	M	>10	260	000	13334300
Louisiana	07375000	ADR	--	--	--	Fis	--	AA	USGS	USGS	F	>10	081	000	07375500
	07376500	ADR	--	--	--	Fis	--	AA	USGS	USGS	F	>10	044	000	07376000
	07377500	ADR	--	--	--	Fis	--	AA	USGS	USGS	F	>10	030	000	07377000
	07378000	ADR	--	--	--	Fis	--	AA	USGS	USGS	F	>10	007	000	07378500
	07380120	ADR	--	--	--	Ste	Han	AA	USGS	USGS	F	5-10	028	000	08012470
	07386980	ADR	--	--	--	Ste	--	AA	USGS	USGS	F	5-10	105	000	07386880
	08013000	ADR	--	--	--	Fis	--	AA	USGS	USGS	F	>10	187	000	08013500
Mid-Atlantic[1]	01595000	ADR	--	--	--	Fis	--	CO	USGS	USGS	M	>10	046	000	01596500
	01614500	ADR	--	--	--	Fis	Ste	CO	USGS	USGS	F	>10	063	000	01598500
	01618000	ADR	--	--	--	Fis	--	CO	USGS	USGS	F	>10	084	000	01613000
	01619500	ADR	--	--	--	Fis	Ste	CO	USGS	USGS	F	>10	080	000	01601500
	01631000	ADR	--	--	--	Fis	--	LH	USGS	USGS	F	>10	080	000	02060500
	02075500	ADR	--	--	--	Fis	Syn	CO	USGS	USGS	F	>10	125	000	02075000
	03075500	ADR	--	--	--	Fis	--	CO	USGS	USGS	F	>10	057	000	01597500
	03473000	ADR	--	--	--	Fis	--	CO	USGS	USGS	F	>10	038	000	03207800
	03524000	ADR	--	--	--	Fis	--	CO	USGS	USGS	F	>10	060	000	03208500
	03531500	ADR	--	--	--	Fis	--	LH	USGS	USGS	F	>10	121	000	03208950
Montana	06207500	ADR	--	--	--	Fis	Ste	LH	USGS	USGS	M	>10	060	000	06214500
	06295000	ADR	--	--	--	Fis	Ste	LH	USGS	USGS	M	>10	100	000	06309000
	06307500	ADR	--	--	--	Fis	Ste	LH	USGS	USGS	F	>10	140	000	06287000
	06307616	ADR	--	--	--	Fis	--	AA	USGS	USGS	F	>10	130	000	06308500
	06324500	ADR	--	--	--	Fis	Ste	AA	USGS	USGS	F	>10	210	000	06326500
	12301933	ADR	--	--	--	Ste	Ste	CO	USGS	USGS	F	>10	090	000	12362500
	12303000	ADR	--	--	--	Fis	Ste	CO	USGS	USGS	F	>10	090	000	12363000
	12304500	ADR	--	--	--	Ste	Ste	LH	USGS	USGS	F	>10	125	000	12355500
	12370000	ADR	--	--	--	Ste	Ste	LH	USGS	USGS	F	>10	030	000	12358500
	12389000	ADR	--	--	--	Fis	Ste	LH	USGS	USGS	F	>10	100	000	12354500
Offices having limited experience with DCP stations															
Idaho	13052200	DCP	Mod	HIF	M	Ste	--	CO	USGS	USGS	F	>10	066	000	13055000
	13055198	DCP	Mod	HIF	M	Ste	Ste	CO	USGS	USGS	M	>10	036	000	13055340
	13058549	DCP	Mod	HIF	M	Ste	--	CO	USGS	USGS	F	2-5	006	000	13058520
	13075500	DCP	Mod	HIF	M	Ste	Ste	CO	USGS	USGS	M	>10	056	000	13075910
	13075983	DCP	Mod	HIF	M	Ste	Ste	CO	USGS	USGS	M	5-10	045	000	13076200
	13302500	DCP	Mod	HIF	OP	Fis	Ste	AA	USGS	USGS	F	>10	250	000	13296500
	13334300	DCP	Inc	Syn	F	Syn	Ste	F	USGS	USGS	M	>10	300	000	13342500
	13336500	DCP	Mod	Oth	F	Syn	Ste	F	USGS	USGS	F	>10	260	000	13337000
	13338500	DCP	Mod	Oth	F	Syn	Ste	F	USGS	USGS	F	>10	225	000	13340000
Louisiana	07375500	DCP	Inc	Han	M	Han	Fis	AA	USGS	USGS	F	>10	049	000	07375000
	07376000	DCP	Inc	Han	M	Han	Fis	AA	USGS	USGS	F	>10	029	000	07376500
	07377000	DCP	Inc	Han	OP	Han	Fis	LH	USGS	USGS	F	>10	050	000	07377500
	07378500	DCP	Inc	Han	F	Han	Fis	LH	USGS	USGS	F	>10	000	001	07378000
	07386880	DCP	Inc	Han	DI	Han	Ste	AA	USGS	USGS	F	>10	068	000	07386980
	08012470	DCP	Inc	Han	DI	Han	Ste	AA	USGS	USGS	F	>10	130	000	07380120
	08013500	DCP	Inc	Han	DI	Han	Fis	AA	USGS	USGS	F	>10	156	000	08013000
Mid-Atlantic[1]	01596500	DCP	Inc	Syn	F	Fis	Ste	F	USGS	USGS	F	>10	037	000	01595000
	01597500	DCP	Inc	Syn	F	Fis	Ste	CO	USGS	USGS	F	>10	030	000	03075500
	01598500	DCP	Inc	Syn	F	Fis	Ste	CO	USGS	USGS	F	>10	026	000	01614500
	01601500	DCP	Inc	Syn	F	Fis	--	CO	USGS	USGS	F	>10	002	000	01619500
	01613000	DCP	Inc	Syn	F	Fis	Ste	CO	USGS	USGS	F	>10	043	000	01618000
	02060500	DCP	Tel	Oth	M	Fis	Fis	LH	USGS	USGS	F	>10	105	000	01631000
	02075000	DCP	Tel	Oth	F	Syn	Fis	CO	USGS	USGS	F	>10	146	000	02075500
	03207800	DCP	Inc	Han	M	Han	Ste	CO	USGS	USGS	F	>10	123	000	03473000
	03208500	DCP	Inc	Han	M	Han	Fis	CO	USGS	USGS	F	>10	099	000	03524000
	03208950	DCP	Inc	Han	M	Han	Fis	CO	USGS	USGS	F	>10	096	000	03531500

Table 1.--*Descriptive station-information file*--Continued

State office	Station number	Primary recorder	Type of DCP data encoder	Brand of DCP data encoder	Purpose of DCP recorde	Brand of primary recorder	Brand of backup recorder	Purpose of station	Agency owning primary rercorder	Agency maintaining primary recorder	Stage sensor	Length of record (years)	Distance to station, in miles: From servicing office	Distance to station, in miles: From regular route	Paired station
				Offices having limited experience with DCP stations--Continued											
Montana	06214500	DCP	Inc	Sut	M	Sut	Fis	LH	USAE	USGS	M	>10	005	000	06207500
	06287000	DCP	Inc	Sut	M	Sut	Fis	LH	USBR	USGS	F	>10	090	000	06307500
	06308500	DCP	Inc	Sut	M	Sut	Fis	LH	USAE	USGS	M	>10	140	000	06307616
	06309000	DCP	Inc	Sut	M	Sut	Fis	LH	USAE	USGS	M	>10	135	000	06295000
	06326500	DCP	Inc	Sut	M	Sut	Fis	LH	USAE	USGS	M	>10	180	000	06324500
	12354500	DCP	Inc	Sut	M	Sut	Ste	LH	BPA	USGS	F	>10	120	000	12389000
	12355500	DCP	Inc	Sut	M	Sut	Ste	LH	USBR	USGS	M	>10	035	000	12304500
	12358500	DCP	Inc	Sut	M	Sut	Ste	LH	USBR	USGS	F	>10	035	000	12370000
	12362500	DCP	Inc	Sut	M	Sut	Fis	LH	USBR	USGS	F	>10	020	000	12301933
	12363000	DCP	Inc	Sut	M	Sut	Ste	CO	USBR	USGS	F	>10	020	000	12303000
				Offices having moderate experience with DCP stations											
Arizona	09398500	DCP	Inc	Han	F	Han	Ste	LH	USGS	USGS	F	>10	090	007	--
	09472000	DCP	Inc	Han	F	Han	Ste	LH	USGS	USGS	F	>10	073	030	--
	09480000	DCP	Inc	Han	DI	Han	Fis	LH	USGS	USGS	F	>10	083	024	--
	09480500	DCP	Inc	Han	F	Han	Ste	LH	USGS	USGS	M	>10	077	006	--
	09486100	DCP	Inc	Han	DI	Han	Fis	AA	USGS	USGS	F	2-5	027	007	--
	09490500	DCP	Oth	Oth	F	Han	Ste	LH	USGS	USGS	F	>10	171	012	--
	09492400	DCP	Inc	Han	F	Han	Ste	LH	USGS	USGS	F	>10	185	012	--
	09494000	DCP	Inc	Han	F	Han	Ste	LH	USGS	USGS	F	>10	171	006	--
	09496500	DCP	Inc	Han	F	Han	Ste	LH	USGS	USGS	M	>10	146	001	--
	09505350	DCP	Inc	Han	F	Han	Ste	AA	USGS	USGS	F	>10	042	000	--
Arkansas	07056000	DCP	Inc	Syn	M	Syn	Ste	CO	USAE	USGS	F	>10	120	999	--
	07060500	DCP	Inc	Syn	M	Syn	Ste	CO	USGS	USGS	F	>10	135	999	--
	07060710	DCP	Inc	Syn	OP	Syn	Ste	B	USGS	USGS	M	>10	135	000	--
	07061000	DCP	Inc	Syn	M	Syn	Fis	CO	USAE	USGS	F	>10	100	000	--
	07069500	DCP	Inc	Syn	M	Syn	Ste	LH	USGS	USGS	F	>10	145	000	--
	07072000	DCP	Inc	Syn	M	Syn	Ste	CO	USGS	USGS	M	>10	152	000	--
	07072500	DCP	Inc	Syn	M	Syn	Ste	CO	USAE	USGS	M	>10	130	000	--
	07074000	DCP	Inc	Syn	M	Syn	Ste	CO	USAE	USGS	M	>10	125	000	--
	07075300	DCP	Inc	Syn	M	Syn	Ste	CO	USAE	USGS	M	>10	070	000	--
	07077380	DCP	Inc	Syn	OP	Syn	Fis	AA	USGS	USGS	F	>10	120	000	--
Colorado	09059500	DCP	Inc	Syn	PA	Syn	Ste	LH	USGS	USGS	M	>10	149	010	--
	09063000	DCP	Inc	Syn	F	Syn	Fis	CO	USWB	USWB	M	>10	157	001	--
	09081600	DCP	Inc	Syn	F	Syn	Ste	CL	USWB	USWB	F	>10	116	000	--
	09085000	DCP	Inc	Syn	DI	Syn	Ste	CO	USGS	USGS	F	>10	090	001	--
	09112500	DCP	Inc	Syn	F	Syn	Ste	CL	USWB	USWB	F	>10	137	000	--
	09144250	DCP	Inc	Syn	F	Syn	Ste	CO	USWB	USWB	M	>10	040	000	--
	09172500	DCP	Inc	Syn	F	Syn	Ste	CL	USWB	USWB	M	>10	126	000	--
	09260050	DCP	Inc	Han	M	Han	Fis	CO	USGS	USGS	M	5-10	090	034	--
	09306290	DCP	Inc	Syn	M	Syn	Ste	CO	USGS	USGS	M	5-10	044	026	--
	09342500	DCP	Inc	Syn	F	Syn	Ste	CL	USWB	USWB	M	>10	060	000	--
New York	01515000	DCP	Inc	Syn	M	Syn	Fis	LH	USAE	USGS	F	>10	040	000	--
	01520500	DCP	Inc	Syn	M	Syn	Fis	LH	USAE	USGS	F	>10	057	000	--
	01521500	DCP	Inc	Syn	F	Syn	Fis	LH	USAE	USGS	F	>10	091	000	--
	01523500	DCP	Inc	Syn	M	Syn	Fis	LH	USAE	USGS	F	>10	092	000	--
	01529500	DCP	Inc	Syn	M	Syn	Fis	LH	USAE	USGS	F	>10	055	000	--
	01529950	DCP	Inc	Syn	M	Syn	Fis	LH	USAE	USGS	F	>10	044	000	--
	01531000	DCP	Inc	Syn	M	Syn	Fis	LH	USAE	USGS	F	>10	042	000	--
	04221000	DCP	Inc	Syn	M	Syn	Fis	LH	USAE	USGS	F	>10	101	000	--

[1] Maryland and Virginia.

Table 2.--*Station operation and missing-record data*

Primary recorder--ADR, automated digital recorder; DCP, data-collection platform (satellite telemeter).

Redundancy level--1, data transmitted once; 2, data transmitted twice.

Type of backup recorder--ADR, automated digital recorder; DCP, data-collection platform; G, graphical; N, none.

Average, average value for group.

Std err of average, standard error of the average.

-- or -, no data or not applicable.

State office	Station number	Primary recorder	Transmission interval (hours)	Redundancy level	Type of backup recorder	Number of visits	Field time, in hours: Gage service	Field time, in hours: Discharge measurement	Field time, in hours: Maintenance	Office time, in hours: Data entry	Office time, in hours: Record computation	Office time, in hours: Recorder preparation	Missing record: Length (days per station)	Missing record: Time to estimate (hours)
Offices having broad experience with ADR stations														
Idaho	13055000	ADR	-	-	N	9	4.9	7.0	0	3.2	[1]11.5	0	0	0
	13055340	ADR	-	-	G	13	7.8	7.2	0	4.3	[1]18.7	0	16	.3
	13058520	ADR	-	-	N	11	5.0	3.5	0	6.6	[1]14.7	0	0	0
	13075910	ADR	-	-	G	20	9.0	11.9	4.8	5.5	[1]20.8	0	0	0
	13076200	ADR	-	-	G	30	8.4	11.8	0	2.6	[1]9.0	0	23	.4
	13296500	ADR	-	-	N	9	2.4	11.6	.7	.7	[1]10.6	0	0	0
	13337000	ADR	-	-	DCP	9	3.2	15.6	.3	3.4	[1]6.0	0	0	0
	13340000	ADR	-	-	G	12	9.2	13.5	.6	9.9	[1]12.3	0	42	1.5
	13342500	ADR	-	-	G	8	4.6	7.1	.3	4.1	[1]6.1	0	0	0
Average		--	-	-	--	13.4	6.0	9.9	.7	4.5	12.2	0	9.0	.2
Std err of average		--	-	-	--	2.4	.9	1.3	.5	.9	1.7	0	5.0	.2
Louisiana	07375000	ADR	-	-	N	8	3.4	18.2	.8	1.6	25.1	0	2	.3
	07376500	ADR	-	-	N	10	8.5	21.4	1.3	25.6	37.2	0	0	0
	07377500	ADR	-	-	N	11	5.4	16.5	2.8	4.1	32.2	0	63	3.5
	07378000	ADR	-	-	N	15	5.2	23.4	3.4	3.7	42.3	0	0	0
	07380120	ADR	-	-	DCP	17	9.4	23.4	5.0	7.5	42.3	0	4	.8
	07386980	ADR	-	-	N	16	7.1	7.3	3.3	6.3	24.3	0	17	.5
	08013000	ADR	-	-	N	12	3.2	18.6	2.5	2.5	38.1	0	0	0
Average		--	-	-	--	12.7	6.0	18.4	2.7	7.3	34.5	0	12.3	.7
Std err of average		--	-	-	--	1.3	.9	2.1	.5	3.1	2.8	0	8.8	.5
Mid-Atlantic[2]	01595000	ADR	-	-	N	16	5.0	7.6	2.1	3.0	3.9	0	8	.3
	01614500	ADR	-	-	G	13	3.4	6.4	1.9	2.8	3.5	0	0	0
	01618000	ADR	-	-	N	14	3.5	7.3	1.5	2.4	2.8	0	0	0
	01619500	ADR	-	-	G	14	3.6	5.5	1.5	2.1	2.4	0	0	0
	01631000	ADR	-	-	N	11	5.5	11.8	2.8	5.7	6.0	0	0	0
	02075500	ADR	-	-	DCP	10	7.5	7.8	4.0	6.4	26.5	1.0	39	2.7
	03075500	ADR	-	-	N	13	4.7	3.6	2.2	3.2	4.2	0	20	.4
	03473000	ADR	-	-	N	10	4.1	12.6	0	4.9	27.7	0	38	1.0
	03524000	ADR	-	-	N	10	4.3	13.1	0	4.7	26.9	0	0	0
	03531500	ADR	-	-	N	11	4.1	13.7	0	5.1	26.8	0	0	0
Average		--	-	-	--	12.2	4.6	8.9	1.6	4.0	13.1	.1	10.5	.4
Std err of average		--	-	-	--	.7	.4	1.1	.4	.5	3.8	.1	5.1	.3
Montana	06207500	ADR	-	-	G	8	4.3	8.7	1.8	1.8	16.6	0	0	0
	06295000	ADR	-	-	G	13	5.9	17.4	4.0	4.0	28.3	0	0	0
	06307500	ADR	-	-	G	9	3.2	5.5	2.2	2.2	13.2	0	79	3.0
	06307616	ADR	-	-	N	8	3.0	4.0	2.2	4.2	12.2	0	0	0
	06324500	ADR	-	-	G	9	4.0	7.5	3.0	3.0	39.5	0	0	0
	12301933	ADR	-	-	G	14	13.5	3.0	3.8	5.8	13.4	0	0	0
	12303000	ADR	-	-	G	10	4.5	4.0	.9	2.8	13.9	0	0	0
	12304500	ADR	-	-	G	9	4.3	9.0	1.4	3.1	9.5	0	0	0
	12370000	ADR	-	-	G	11	6.5	6.6	3.6	3.9	11.5	0	28	3.0
	12389000	ADR	-	-	G	10	6.6	8.3	.5	4.4	10.3	0	0	0
Average		--	-	-	--	10.1	5.6	7.4	2.3	3.5	16.8	0	10.7	.6
Std err of average		--	-	-	--	.6	1.0	1.3	.4	.4	3.0	0	8.1	.4
Average of group 1		--	-	-	--	12.0	5.5	10.6	1.8	4.6	18.1	0	10.5	.5
Std err of average		--	-	-	--	.7	.4	.9	.3	.7	2.0	0	3.3	.2

Table 2.--*Station operation and missing-record data*--Continued

State office	Station number	Primary recorder	Transmission interval (hours)	Redundancy level	Type of backup recorder	Number of visits	Field time, in hours: Gage service	Field time, in hours: Discharge measurement	Field time, in hours: Maintenance	Office time, in hours: Data entry	Office time, in hours: Record computation	Office time, in hours: Recorder preparation	Missing record: Length (days per station)	Missing record: Time to estimate (hours)
Offices having limited experience with DCP stations														
Idaho	13052200	DCP	4	1	N	10	4.9	11.3	4.5	18.7	[1]21.3	0	45	4.4
	13055198	DCP	4	1	G	10	3.4	5.7	0	5.5	[1]6.5	.3	6	.2
	13058549	DCP	4	1	N	10	4.2	3.1	2.6	2.6	[1]7.3	.3	0	0
	13075500	DCP	4	1	G	16	10.3	10.7	4.4	5.9	[1]20.7	0	34	.5
	13075983	DCP	4	1	G	9	4.3	4.1	0	3.3	[1]13.0	.3	34	.5
	13302500	DCP	4	1	ADR	9	2.8	11.9	.4	2.6	[1]13.0	0	20	.5
	13334300	DCP	4	1	G	6	5.7	6.4	.3	8.6	[1]10.8	0	0	0
	13336500	DCP	4	1	ADR	11	8.2	11.3	.3	12.9	[1]12.3	3.0	0	0
	13338500	DCP	4	1	G	7	3.0	9.7	.3	6.6	[1]9.3	3.0	0	0
Average		--	-	-	--	9.8	5.2	8.2	1.4	7.4	12.7	.8	15.4	.7
Std err of average		--	-	-	--	.9	.8	1.1	.6	1.8	1.8	.4	6.0	.5
Louisiana	07375500	DCP	4	1	ADR	11	4.5	18.4	.8	6.1	38.1	0	26	.5
	07376000	DCP	4	1	ADR	11	5.5	20.8	.8	.8	24.1	0	20	.6
	07377000	DCP	4	2	ADR	11	5.0	25.0	.7	.7	21.6	0	13	.3
	07378500	DCP	4	2	ADR	12	5.0	25.5	3.5	3.8	27.1	0	16	.4
	07386880	DCP	4	2	ADR	9	16.8	11.0	2.6	3.6	35.4	3.0	18	.5
	08012470	DCP	4	2	ADR	23	13.5	20.6	3.9	3.9	19.0	.3	39	2.9
	08013500	DCP	4	2	ADR	12	3.2	25.1	2.2	2.2	25.4	0	14	1.4
Average		--	-	-	--	12.7	7.6	20.9	2.1	3.0	27.2	.5	20.9	.9
Std err of average		--	-	-	--	1.8	2.0	2.0	.5	.7	2.7	.4	3.4	.4
Mid-Atlantic[2]	01596500	DCP	4	2	DCP	15	5.6	6.7	2.9	3.5	4.5	0	4	.3
	01597500	DCP	4	2	G	27	5.5	15.0	1.8	2.8	4.1	0	0	0
	01598500	DCP	4	2	G	21	5.2	18.5	1.8	3.0	4.2	0	0	0
	01601500	DCP	4	2	N	15	3.0	4.9	1.5	2.4	3.4	0	0	0
	01613000	DCP	4	2	G	16	5.6	7.0	1.5	2.4	3.8	0	17	.3
	02060500	DCP	0	2	ADR	10	6.2	16.0	.2	4.1	24.2	0	34	.5
	02075000	DCP	0	2	ADR	15	9.1	13.5	4.5	8.4	24.9	3.0	35	4.8
	03207800	DCP	4	1	ADR	10	4.5	12.6	0	14.0	30.6	0	41	2.6
	03208500	DCP	4	1	ADR	9	9.7	12.3	0	16.4	46.4	0	73	6.6
	03208950	DCP	4	1	ADR	10	7.0	12.4	.5	14.2	35.5	1.0	76	2.4
Average		--	-	-	--	14.8	6.1	11.9	1.5	7.1	18.2	.4	28.0	1.8
Std err of average		--	-	-	--	1.8	.6	1.4	.5	1.7	5.1	.3	9.2	.7
Montana	06214500	DCP	4	1	ADR	30	25.1	18.4	0	15.0	39.0	0	10	1.1
	06287000	DCP	4	1	ADR	9	2.5	12.0	0	5.0	27.2	0	0	0
	06308500	DCP	4	1	ADR	14	21.0	9.0	3.3	13.3	35.7	0	41	2.0
	06309000	DCP	4	1	ADR	14	5.6	15.0	1.8	2.7	40.8	1.5	3	1.0
	06326500	DCP	4	1	ADR	17	9.0	14.0	3.8	5.6	63.5	0	15	1.3
	12354500	DCP	4	1	ADR	11	6.5	8.1	2.0	17.8	24.6	0	37	9.0
	12355500	DCP	4	1	G	12	9.9	10.4	.5	11.7	36.7	0	23	3.0
	12358500	DCP	4	1	G	11	5.5	9.3	.9	8.7	17.7	0	16	2.8
	12362500	DCP	4	1	ADR	11	4.5	2.0	3.6	4.4	10.8	0	2	.5
	12363000	DCP	4	1	ADR	8	3.1	4.5	2.3	5.5	12.3	0	6	.5
Average		--	-	-	--	13.7	9.3	10.3	1.8	9.0	30.8	.2	15.3	2.1
Std err of average		--	-	-	--	2.0	2.4	1.5	.5	1.6	5.0	.2	4.6	.8
Average of group 2		--	-	-	--	12.8	7.1	12.3	1.7	6.9	22.1	.4	19.9	1.4
Std err of average		--	-	-	--	.9	.8	1.0	.3	.9	2.4	.2	3.3	.3

Table 2.--*Station operation and missing-record data*--Continued

State office	Station number	Primary recorder	Transmission interval (hours)	Redundancy level	Type of backup recorder	Number of visits	Field time, in hours: Gage service	Field time, in hours: Discharge measurement	Field time, in hours: Maintenance	Office time, in hours: Data entry	Office time, in hours: Record computation	Office time, in hours: Recorder preparation	Missing record: Length (days per station)	Missing record: Time to estimate (hours)
Offices having moderate experience with DCP stations														
Arizona	09398500	DCP	4	2	G	11	17.9	10.3	.4	4.7	59.2	0	14	2.6
	09472000	DCP	4	2	G	15	40.3	8.3	0	8.0	64.5	0	15	1.2
	09480000	DCP	4	2	ADR	10	8.0	4.6	.6	3.6	52.3	0	30	1.0
	09480500	DCP	4	2	G	13	12.3	9.8	1.8	30.4	38.8	0	10	.5
	09486100	DCP	4	2	ADR	10	8.6	3.9	1.3	13.5	43.5	0	0	0
	09490500	DCP	4	2	G	12	3.9	8.6	0	0	30.0	0	36	6.2
	09492400	DCP	4	2	G	12	3.9	6.0	0	0	42.2	0	60	5.1
	09494000	DCP	4	2	G	12	6.3	9.8	0	0	33.9	0	15	2.6
	09496500	DCP	4	2	G	19	4.7	7.8	0	0	30.0	0	17	2.7
	09505350	DCP	4	2	G	14	11.2	5.8	1.0	1.2	95.6	0	11	2.9
Average		--	-	-	--	12.8	11.7	7.5	.5	6.1	49.0	0	20.8	2.5
Std err of average		--	-	-	--	.8	3.5	.7	.2	3.0	6.4	0	5.4	.6
Arkansas	07056000	DCP	4	2	ADR	15	26.1	4.1	.8	9.1	[3]39.8	0	49	10.6
	07060500	DCP	4	2	ADR	8	10.9	1.3	0	8.0	[3]48.0	0	34	8.2
	07060710	DCP	4	2	G	6	5.8	4.4	.5	8.5	[3]41.8	0	16	2.1
	07061000	DCP	4	2	ADR	7	3.7	5.8	.3	8.3	[3]36.5	.5	43	4.2
	07069500	DCP	4	2	ADR	4	.7	10.9	0	8.0	[3]32.0	0	0	0
	07072000	DCP	4	2	ADR	3	1.1	1.5	0	8.0	[3]32.0	0	8	1.6
	07072500	DCP	4	2	ADR	9	8.3	8.4	0	8.0	[3]48.0	0	48	4.6
	07074000	DCP	4	2	ADR	9	5.2	3.6	0	8.0	[3]48.0	0	58	3.0
	07075300	DCP	4	2	ADR	11	7.4	7.0	1.0	9.0	[3]58.0	.8	82	12.1
	07077380	DCP	4	2	ADR	6	10.1	6.0	0	8.0	[3]48.0	0	59	4.0
Average		--	-	-	--	7.8	7.9	5.3	.3	8.3	43.2	.1	39.7	5.0
Std err of average		--	-	-	--	1.1	2.3	.9	.1	.1	2.6	.1	8.1	1.3
Colorado	09059500	DCP	4	2	ADR	13	3.0	5.2	2.4	3.4	15.3	0	2	.2
	09063000	DCP	6	2	ADR	13	3.1	10.5	0	2.9	14.4	.1	13	.5
	09081600	DCP	6	2	ADR	15	4.1	19.3	0	4.0	11.5	0	2	.2
	09085000	DCP	4	2	G	13	14.2	7.7	2.3	4.3	13.0	0	9	.1
	09112500	DCP	6	2	ADR	14	4.7	13.7	.5	4.4	12.7	0	98	1.2
	09144250	DCP	6	2	ADR	10	8.0	20.1	5.8	5.8	12.3	0	0	0
	09172500	DCP	6	2	G	14	14.7	7.3	.5	2.7	23.1	.3	14	.7
	09260050	DCP	4	2	ADR	16	12.7	16.2	7.4	9.7	28.0	1.3	136	13.5
	09306290	DCP	4	2	G	17	6.7	12.1	2.9	3.7	22.5	0	8	.3
	09342500	DCP	6	2	G	12	4.5	9.7	3.6	4.8	19.3	0	0	0
Average		--	-	-	--	13.7	7.6	12.2	2.5	4.6	17.2	.2	28.2	1.7
Std err of average		--	-	-	--	.6	1.5	1.6	.8	.6	1.8	.1	15.2	1.3
New York	01515000	DCP	3	2	ADR	11	6.2	14.2	0	[4]6.2	[5]25.0	0	7	.5
	01520500	DCP	4	2	ADR	7	3.2	5.8	0	[4]6.2	[5]19.0	0	0	0
	01521500	DCP	4	2	ADR	9	3.6	5.4	0	[4]5.8	[5]33.0	0	0	0
	01523500	DCP	4	2	ADR	12	5.5	5.9	0	[4]6.5	[5]29.3	0	88	3.1
	01529500	DCP	4	2	ADR	23	14.9	41.0	0	[4]6.2	[5]33.0	0	19	.9
	01529950	DCP	3	2	ADR	15	11.3	11.9	0	[4]5.7	[5]27.8	0	0	0
	01531000	DCP	3	2	ADR	9	5.2	5.9	0	[4]6.2	[5]25.0	0	31	1.3
	04221000	DCP	4	2	ADR	9	4.4	7.1	0	[4]6.0	[5]21.5	0	1	.2
Average		--	-	-	--	11.9	6.8	12.2	0	6.1	26.7	0	18.2	.8
Std err of average		--	-	-	--	1.8	1.5	4.3	0	.1	1.8	0	10.7	.4
Average of group 3		--	-	-	--	11.6	8.6	9.1	.9	6.3	34.4	.1	27.2	2.6
Std err of average		--	-	-	--	.7	1.2	1.1	.3	.8	2.8	0	5.2	.6

[1] Includes estimated average time for record checking and review of 2.5 hours per station.
[2] Maryland and Virginia.
[3] Includes estimated average time for record checking and review of 24.0 hours per station.
[4] Includes estimated average time for review of daily operation of DCP stations of 5.2 hours per station.
[5] Includes estimated average time for record checking and review of 12.0 hours per station.

Table 3.--*Site visits regularly scheduled*

[ADR, automated digital recorder; DCP, data-collection platform (satellite telemeter)]

State office	Primary recorder	No. of stations	No. of visits per station per year	Average time, in hours per station per visit: Gage service	Average time, in hours per station per visit: Discharge measurement
			Offices having broad experience with ADR stations		
Idaho	ADR	9	7.7	0.5	1.0
Louisiana	ADR	7	7.4	.6	1.4
Mid-Atlantic[1]	ADR	10	10.6	.4	.8
Montana	ADR	10	8.8	.5	.8
			Offices having limited experience with DCP stations		
Idaho	DCP	9	8.0	.5	.9
Louisiana	DCP	7	8.0	.5	1.6
Mid-Atlantic[1]	DCP	10	11.2	.4	.9
Montana	DCP	10	8.4	.5	1.0
			Offices having moderate experience with DCP stations		
Arizona	DCP	10	7.9	1.0	.7
Arkansas	DCP	10	2.4	.6	.9
Colorado	DCP	10	11.2	.4	1.0
New York	DCP	8	7.4	.5	.7

[1]Maryland and Virginia

Table 4.--*Site visits scheduled because information from DCP stations showed stages where discharge measurements would likely improve stage-discharge relations*

[ADR, automated digital recorder; DCP, data-collection platform (satellite telemeter)]

State office	Primary recorder	No. of stations	No. of visits per station per year	Average time, in hours per station per visit	
				Gage service	Discharge measurement
		Offices having broad experience with ADR stations			
Idaho	ADR	9	0.4	0.5	1.2
Louisiana	ADR	7	1.7	.5	1.9
Mid-Atlantic[1]	ADR	10	0	0	0
Montana	ADR	10	.1	.5	2.0
		Offices having limited experience with DCP stations			
Idaho	DCP	9	.3	.2	1.8
Louisiana	DCP	7	2.3	.1	2.8
Mid-Atlantic[1]	DCP	10	.4	.1	1.0
Montana	DCP	10	.5	.7	2.1
		Offices having moderate experience with DCP stations			
Arizona	DCP	10	.4	.8	1.9
Arkansas	DCP	10	.9	0	2.7
Colorado	DCP	10	.3	.3	1.1
New York	DCP	8	1.0	.8	2.1

[1]Maryland and Virginia.

Table 5.--*Site visits scheduled because of DCP-equipment failure*

[DCP, data-collection platform (satellite telemeter)]

State office	Primary recorder	No. of stations	No. of visits per station per year	Average time to service gage, in hours per station per visit
		<u>Offices having limited experience with DCP stations</u>		
Idaho	DCP	9	0.4	1.5
Louisiana	DCP	7	.4	1.5
Mid-Atlantic[1]	DCP	10	.5	2.6
Montana	DCP	10	1.5	1.5
		<u>Offices having moderate experience with DCP stations</u>		
Arizona	DCP	10	.1	.5
Arkansas	DCP	10	2.4	1.5
Colorado	DCP	10	.4	3.2
New York	DCP	8	1.0	.8

[1]Maryland and Virginia.

Table 6.--*Office-time summary*

[ADR, automated digital recorder; DCP, data-collection platform (satellite telemeter). --, not applicable]

State office	Primary recorder	No. of stations	Data entry Average	Data entry Median	Record computation Average	Record computation Median	Recorder preparation Average	Recorder preparation Median	Total Average	Total Median
			Offices having broad experience with ADR stations							
Idaho	ADR	9	4.5	4.1	12.2	11.5	0	0	16.7	14.7
Louisiana	ADR	7	7.3	4.1	34.5	37.2	0	0	41.8	40.6
Mid-Atlantic[1]	ADR	10	4.0	4.0	13.1	5.1	.1	0	17.2	10.0
Montana	ADR	10	3.5	3.5	16.8	13.3	0	0	20.4	16.6
Group total	--	36	4.6	4.0	18.1	13.7	0	0	22.7	18.8
			Offices having limited experience with DCP stations							
Idaho	DCP	9	7.4	5.9	12.7	12.3	.8	.3	20.9	18.9
Louisiana	DCP	7	3.0	3.6	27.2	25.4	.5	0	30.7	27.6
Mid-Atlantic[1]	DCP	10	7.1	3.8	18.2	14.4	.4	0	25.7	18.2
Montana	DCP	10	9.0	7.2	30.8	31.5	.2	0	40.0	43.7
Group total	--	36	6.9	5.3	22.1	21.5	.4	0	29.4	27.1
			Offices having moderate experience with DCP stations							
Arizona	DCP	10	6.1	2.4	49.0	42.9	0	0	55.1	56.5
Arkansas	DCP	10	8.3	8.0	43.2	44.9	.1	0	51.6	53.2
Colorado	DCP	10	4.6	4.2	17.2	14.9	.2	0	22.0	18.4
New York	DCP	8	6.1	6.2	26.7	26.4	0	0	32.8	32.4
Group total	--	38	6.3	6.1	34.4	32.0	.1	0	40.8	38.9

Office time required for specified office activity, in hours per station.

[1]Maryland and Virginia.

Table 7.--*Missing-record summary*

[ADR, automated digital recorder; DCP, data-collection platform (satellite telemeter). --, not applicable]

State office	Primary recorder	No. of stations	Length of missing record, in days per station		Time to estimate missing record, in hours per station	
			Average	Median	Average	Median
			Offices having broad experience with ADR stations			
Idaho	ADR	9	9.0	0	0.2	0
Louisiana	ADR	7	12.3	2.0	.7	.3
Mid-Atlantic[1]	ADR	10	10.5	0	.4	0
Montana	ADR	10	10.7	0	.6	0
Group total	--	36	10.5	0	.5	0
			Offices having limited experience with DCP stations			
Idaho	DCP	9	15.4	6.0	.7	0
Louisiana	DCP	7	20.9	18.0	.9	.5
Mid-Atlantic[1]	DCP	10	28.0	25.5	1.8	.4
Montana	DCP	10	15.3	12.5	2.1	1.2
Group total	--	36	19.9	16.0	1.4	.5
			Offices having moderate experience with DCP stations			
Arizona	DCP	10	20.8	15.0	2.5	2.6
Arkansas	DCP	10	39.7	45.5	5.0	4.1
Colorado	DCP	10	28.2	8.5	1.7	.3
New York	DCP	8	18.2	4.0	.8	.4
Group total	--	38	27.2	14.5	2.6	1.2

[1]Maryland and Virginia.