AUTOMATED COLLECTION OF WATER-QUALITY AND DISCHARGE DATA ON STREAMS

By

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INTRODUCTION

The advent of electronic data loggers and computer-compatible portable data collectors is revolutionizing the manner in which data are collected and handled in natural resource investigations. Electronic-based systems promise significant cost savings in reducing and tabulating data formerly recorded on charts, and allow collection of some types of data that heretofore have not been practical. The new technology is certainly applicable to hydrologic investigations.

We describe a system that automates collection of data about water stage, conductivity, pH, and temperature, and air temperature. Data are stored in a reuseable memory pack that is periodically removed to the office. There, data are downloaded into a personal computer (PC) where they can be edited, processed, and archived onto a floppy disk for permanent storage.

HISTORIC DATA COLLECTION PROCEDURES

Hydrologic investigations have been conducted at the Stratton Sagebrush Hydrology Study Area in southcentral Wyoming for two decades. Water discharge was measured at stream gages equipped with a 120° V-notch weir and stilling pond. Water depth information was recorded on a strip chart using a Stephens A-35[2] water level recorder sensitive to changes of ±0.03 cm in water level. Manual readings of pond water elevation were made using a hook gage to set the recorder and to check the accuracy of the pen trace. Stage and time information were digitized from the strip chart after correcting for errors in the pen trace. Digitized data values were stored on magnetic tape for further processing.

A water sample was collected on service visits to stream gages, and the sample was refrigerated and stored until conductivity was measured in the laboratory. Unlike conductivity, pH is unstable even if samples are refrigerated; pH must be measured when water is collected to be representative of stream conditions. Field pH measurements were not made at the Stratton site.

Water and air temperature data at stream gages were collected by a dual-pen thermograph operated on a 33-day drum rotation. Each day's maximum and minimum air and water temperature were read from the chart with a digitizer. Daily data were hand entered into a yearly summary program, which printed daily temperature data and calculated average monthly values.

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[2] The use of trade, firm or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Dept. of Agriculture of any service or product to the exclusion of others that may be suitable.

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AUTOMATED DATA COLLECTION EQUIPMENT AND PROCEDURES

Data logger--Collection of field data is controlled by a battery-powered Omni Data Easy Logger field unit[2/]. The field unit interrogates sensors (Fig. 1) at programmed intervals, reads incoming voltage signals, and processes signal information into engineering units. Information is transferred to a reusable EPROM (Erasable Programmable Read Only Memory) data storage pack at the conclusion of a report period. Memory packs with a capacity up to 128 kilobytes (K) are available, but one with a memory capacity of 64 K was used on our data loggers. Each day 128 data values were collected, which required changing the data storage pack every 37 days.

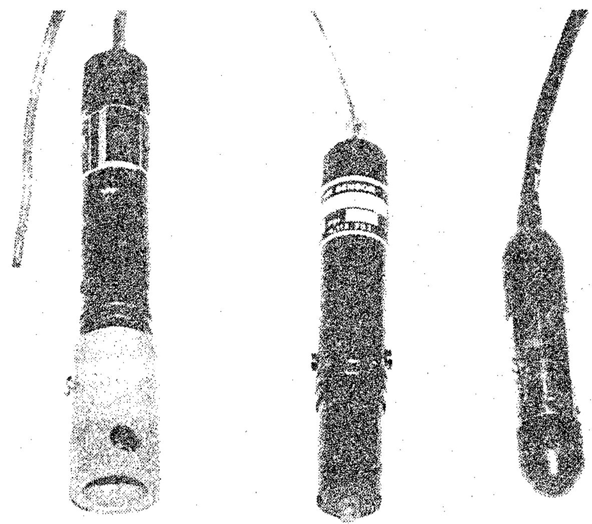

Figure 1: Sensors used with data logger system were from left to right: thermistor probe for measuring air and water temperature, conductivity probe with protective sensor guard inplace, pH probe with guard removed, and pressure transducer. The conductivity and pH probes are about 17 cm long and 2 cm in diameter.

Pressure transducer--The water stage sensor (Druck, Inc.)[2/] employees a strain gage bridge to sense pressure. The sensor puts out a voltage signal proportional to water depth. We used a transducer with a measurement range of 76 cm of water. Accuracy of this transducer is stated by the manufacturer as ±0.075 cm of water level change.

Conductivity and pH--The conductivity and pH sensors (TBI - Balley Controls Company)[2/] connect to a transmitter which serves as an interface between the sensor and data logger. Sensitive potentiometers are used to calibrate transmitters so that current flow is regulated between 4 and 20 milliamps. Current from the transmitter is routed through a 10 ohm precision wire-wound resistor, and the resulting voltage is measured by the data logger.

Temperature--The temperature sensor is a thermistor (Omni Data Corporation)[2/] made from a metal oxide whose resistance changes rapidly with minor changes of temperature. This property allows voltage signals from the sensor to be related to temperature.

FIELD OPERATION OF DATA LOGGER

Data logger functions are programmed through the field terminal. Important programming functions include setting an internal clock, specifying how often sensors are scanned, how often scanned data values are transferred to the data storage pack, and the type of information from each sensor that is recorded (e.g., maximum, minimum, instantaneous values). A relationship to convert sensor voltage signals into engineering units is another programmable function, as are abilities to turn on sensors before each scan for a specified length of time, and to specify operating voltages supplied to sensors.

A number of other functions are performed with the field terminal. The formats of data output and column labels are specified through the field terminal. Sensors can be tested to see that they operate properly. Data residing in the storage pack can be viewed on the field terminal and the current memory status of the pack can be checked, as can battery voltage. The batteries and the data storage pack can be changed without interrupting collection of data if performed between sensor scans as indicated on the field terminal.

DATA TRANSFER TO A PERSONAL COMPUTER

The data storage pack plugs into an Easy Logger Reader[2/] (ELR) which serves as the interface between the pack and a PC. The ELR converts information in the storage pack to a serial ASCII code for input to the computer via its RS-232 communication port. The ELR configures itself to automatically match important communication parameters set on the PC. Data transfer is facilitated by use of a communication program such as PROCOM[2/] that allows the PC to control operation of the ELR. Information loaded into the PC can be immediately stored on a disk to preserve a permanent record of raw data. An editing program such as BRIEF[2/] is used to edit data before they are saved in a spread sheet program such as LOTUS[2/]. Information stored in the data storage pack is erased by exposure to ultraviolet rays, allowing reuse of the storage pack.

COMPUTER PROCESSING OF DATA

Data loggers can easily collect far more information than required to meet a specific data need. The programming capability within the logger allows selective editing before information is stored in the data storage pack. Sensors were scanned at 5-minute intervals in our study. Maximum, minimum, and instantaneous water stage values collected over a 15-minute period were placed in one report along with water conductivity and pH values (Table 1). Maximum, minimum, and average water and air temperature values for each day were placed in a second report (Table 1).

Programming instructions within the spread sheet program can be used to further edit water stage and water quality information. Only water stage data values associated with a given percentage change in discharge need be retained in the final data set. Programming instructions also allow retention of maximum and minimum daily stage values if desired. The streamlined data set is archived to disk storage. Once streamflow data are reduced to this point, further processing to calculate daily, monthly, and yearly discharge is identical to procedures utilized for chart-derived information.

INSTRUMENTATION COSTS

The price of sensors and components at one gaging system was $4,403.76 distributed as follows:

Omni Data:	
Data logger	$1,850.00
64K data storage packs (2)	339.80
Temperature probes (2)	91.80
Druck:	
pressure transducer	820.16
TBI:	
Conductivity sensor	$ 80.00
pH sensor	162.00
Conductivity transmitter	585.00
pH transmitter	475.00

In addition to field equipment, a reader ($600.00), eraser ($259.90) for data storage packs, and field terminal ($500.00) are required. These items (Omni Data Corporation)[2/] can be shared across a number of gaging stations. The total instrumentation cost for one gaging station including shared items was $5,763.66.

QUALITY CONTROL

The data logger eliminates time discrepancies between clock-driven instruments, which used to be a continuing problem when working with charts from several recorders. Field quality control measures are as important for electronically collected data as they are for chart data. Independent measurements of parameters being monitored by a data logger are essential to see that sensors and the data logger operate correctly; the independent measurements also provide a basis for correcting recorded data if that is needed. Water stage is measured with a hook gage on service visits to stream gaging stations. Field measurements of conductivity and pH are also now a routine part of each service visit.

Table 1. Data output from Omni Data Logger for Sane Creek, Stratton Sagebrush Hydrology Study Area. Report 3 (top) contains data collected over a 15-minute interval for water stage, conductivity, and pH. Report 2 (bottom) contains data for water and air temperature collected over a 24-hour interval. The data logger interrogated sensors at 5-minute intervals.

LOCATION: SANE CREEK 1989 SCAN INTERVAL: 5 MINUTES
OPERATOR: KB DLS REPORT INTERVAL: 15 MINUTES
REPORT: 3 START WHEN?: 1355
STOP WHEN?:

		WATER LEVEL FEET INST	WATER LEVEL FEET MAX	WATER LEVEL FEET MIN	COND MMHOS AVG	COND MMHOS MAX	COND MMHOS MIN	pH INST	pH MAX	pH MIN
02/01	14:15	0.154	0.155	0.153	334.	334.	333.	7.69	7.69	7.68
02/01	14:30	0.153	0.154	0.151	294.	333.	216.	7.68	7.69	7.68
02/01	14:45	0.153	0.156	0.153	216.	216.	215.	7.69	7.69	7.69
02/01	15:00	0.153	0.156	0.153	215.	216.	215.	7.69	7.69	7.69
02/01	15:15	0.154	0.154	0.151	284.	284.	284.	7.69	7.69	7.67
02/01	15:30	0.153	0.155	0.152	314.	328.	285.	7.69	7.69	7.69
02/01	15:45	0.158	0.158	0.157	328.	328.	328.	7.69	7.69	7.67
02/01	16:00	0.158	0.158	0.158	330.	330.	329.	7.68	7.69	7.68
02/01	16:15	0.158	0.158	0.158	329.	329.	329.	7.68	7.68	7.68
02/01	16:30	0.158	0.158	0.158	330.	331.	330.	7.69	7.69	7.68
02/01	16:45	0.157	0.158	0.158	330.	331.	330.	7.68	7.69	7.68
02/01	17:00	0.158	0.158	0.157	331.	331.	331.	7.68	7.68	7.68

LOCATION: SANE CREEK 1989 SCAN INTERVAL: 5 MINUTES
OPERATOR: KB DLS REPORT INTERVAL: 1440 MINUTES
REPORT: 2 START WHEN?: 2400
STOP WHEN?:

		WATER TEMP DEG. C AVG	WATER TEMP DEG. C MAX	WATER TEMP DEG. C MIN	AIR TEMP DEG. C AVG	AIR TEMP DEG. C MAX	AIR TEMP DEG. C MIN
02/16	24:00	5.8	5.8	5.8	-7.0	-1.0	-16.7
02/17	24:00	5.8	5.8	5.8	-5.5	5.3	-15.0
02/18	24:00	5.8	5.8	5.8	-1.3	6.1	-5.1
02/19	24:00	5.8	5.8	5.8	-0.5	8.3	-3.6
02/20	24:00	5.8	5.8	5.8	-3.8	2.4	-7.9
02/21	24:00	5.8	5.8	5.8	-6.6	2.2	-11.9
02/22	24:00	5.8	5.8	5.8	-5.9	0.0	-14.7
02/23	24:00	5.8	5.8	5.8	-1.5	6.2	-6.8
02/24	24:00	5.8	5.8	5.8	-1.6	5.3	-8.0
02/25	24:00	5.8	5.8	5.8	1.0	9.8	-4.4
02/26	24:00	5.8	5.8	5.8	-0.4	5.2	-6.9
02/27	24:00	5.8	5.8	5.8	-7.6	-3.7	-10.2