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PERFORMANCE OF THE LANDSAT-DATA COLLECTION SYSTEM IN A TOTAL SYSTEM CONTEXT*

(E76-10098) PERFORMANCE OF THE LANDSAT-DATA COLLECTION SYSTEM IN A TOTAL SYSTEM CONTEXT Final Report (Geological Survey, Reston, Va.) 29 p HC $4.00 CSCL 05B G3/43 N76-16521 Unclas 00098

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A Final Report
To Be Submitted To The
National Aeronautics and Space Administration

1210A

RECEIVED
NOV 26 1975
SIS/902.6

*Approved for publication by the Director, Geological Survey

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle PERFORMANCE OF THE LANDSAT DATA COLLECTION IN A TOTAL SYSTEM CONTEXT (MMC-1210A)		5. Report Date November 1975 6. Performing Organization Code
7. Author(s) Richard W. Paulson and Charles F. Merk (IN 016)		8. Performing Organization Report No.
9. Performing Organization Name and Address U.S. Geological Survey National Center Reston, Virginia 22092		10. Work Unit No. 11. Contract or Grant No. S-70243AG
12. Sponsoring Agency Name and Address Joseph J. Gentilini NASA, Goddard Space Flight Center Greenbelt, Maryland 20771		13. Type of Report and Period Covered Type III, Final Report 1975 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

An experimental integration of the LANDSAT-Data Collection System (DCS) with the Geological Survey's networks for hydrologic data collection and data processing was performed. The objective of this experiment was to simulate an operational system for collecting, relaying, processing, and disseminating hydrologic data. The integration of the system was successfully performed, and is being used to introduce satellite data relay technology to Geological Survey project and District offices. Although the LANDSAT-DCS has worked very well there are significant modifications to the experimental LANDSAT-DCS that would be necessary to convert the system to an operational tool.

17. Key Words Suggested by Author	18. Distribution Statement
Telemetry, Satellite, Hydrologic Data	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
		24	

Figure 2A. Technical Report Standard Title Page. This page provides the data elements required by DoD Form DD-1473, HEW Form OE-6000 (ERIC), and similar forms.

INT-2097-72

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II Distribution of DCO's by ID, to 25 WRD Districts as of July 31, 1975

INTRODUCTION

The LANDSAT-1 Experiment No. 210, Performance of the LANDSAT-Data Collection System in a Total System Context, was an attempt to integrate the LANDSAT-1 DCS with existing networks of remote site hydrologic instruments and computers. The objective was to evaluate the LANDSAT-DCS in the context of an operational data collection and processing system. The simulation was successfully performed and is continuing to provide Geological Survey personnel with an operational introduction to satellite Data Collection System technology.

BACKGROUND

The Geological Survey Water Resources Division (WRD) operates a network of over 10,000 hydrologic instruments that continuously monitor a wide variety of hydrologic variables. Most of the instruments are operated by WRD Districts in cooperation with local, State and Federal agencies. This cooperative program includes agreements with approximately 500 agencies wherein the Geological Survey jointly funds the collection of hydrologic basic data and performs a variety of hydrologic studies. The most commonly operated instruments monitor water stage, water temperature, dissolved oxygen concentration, pH, turbidity and specific conductance at 25°C. Table 1 is a compilation of the number of sites where water-stage, and/or water quality data are collected by WRD Districts. In general, these are high potential sites where a telemetered data retrieval system could be used. Other sites, where other hydrologic data are collected, such as precipitation, ground-water levels, and tidal stage also could be included. Table 1 was made using the Survey's Management Information System (MIS), a computer-based system for storing and retrieving management information of the Survey.

The primary purpose of the network of hydrologic instruments is the collection of basic data for planning and managing water resources programs, which is part of WRD's mission as indicated in figure 1.

At a stream gaging station, where water stage is monitored as an indirect measure of stream discharge, data normally are recorded with a device known as an Analog to Digital Recorder (ADR). The ADR continuously monitors the level, or stage, of river water via a float in a stilling well or a servo manometer with a gas purge system. The stilling well is designed to have free exchange with the river or stream being monitored, and the float is connected to the ADR by a pulley and counter weight. Periodically, generally every 15 or 30 minutes, the ADR punches current water stage on a 16-channel paper tape. The ADR and the clock that initiates the punch cycle, are battery operated and can be left unattended for several months.

Table I

MIS Compilation of the Number of U.S. Geological Survey Stations Where Water Data Are Collected Continuously

Types of Data Collected	No. of Stations
Water Stage or Discharge	8389
Water Stage/Discharge and Water Quality	614
Water Quality	135

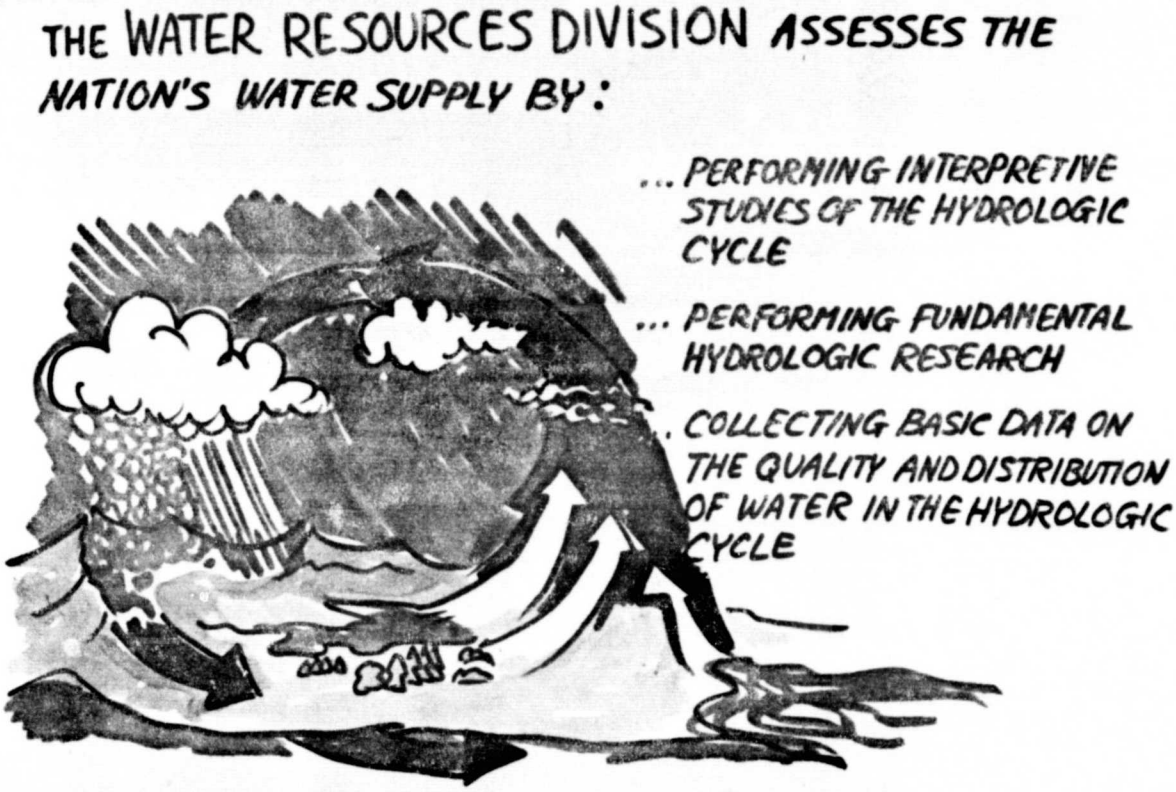

Figure 1: The Water Resources Division assesses the Nation's Water Supply

At a water-quality station, sensors that are continuously bathed by a pumped sample of river water provide output voltages that are related to the variables being monitored. These data are either continuously recorded on an analog strip, or are periodically recorded by an ARD. In the latter case, a servo-mechanism provides a null voltage that positions the coding mechanism of the ADR. Periodically, generally every 30 or 60 minutes, the ADR sequentially punches the water-quality voltages on the 16-channel tape. Water-quality monitors normally require line power and are left unattended for periods of up to a few weeks. Schematic sketches of stations that monitor water stage and water quality are shown in figure 2.

U.S. Geological Survey field personnel usually visit water-stage stations every 4-6 weeks, and water-quality stations as frequently as once a week. During the station visit the data record is removed, equipment maintenance and calibration are performed, and supplementary hydrologic measurements are taken. During a period of one or several days a technician or engineer may visit several stations in a prearranged sequence before returning to his field or District office. When the data are returned to the field office they are reviewed and prepared for computer processing.

The Geological Survey operates a national telecomputing network, as shown in figure 3 that includes major computer centers in Washington, D.C. and Reston, Virginia, and a network of over 150 remote computer terminals across the United States. The telecomputing network is extensively used by WRD Districts for communicating, processing, storing, and disseminating the station data discussed above. There are two methods normally used for entering field data into the telecomputing network. In the first method the 16-channel punched paper types are read by a tape reader in the field office. The reader is connected to a modem on a telephone dial-up-line to a modem and magnetic tape recorder in the computer center in Reston, Virginia. During the course of a day, the typical field office will dial into a tape recorder and transmit several station data records, each one containing 4-6 weeks of data. After the raw data have been translated from paper tape in the field office to the magnetic tape recorder the tape is removed from the tape recorder and stored in the tape library of the computer center. A job then can be entered into the computer from the field office remote terminal that instructs the computer operator to mount the appropriate magnetic tape on the computer. The raw data then are merged with other computer resources, and the data processed and stored on line in the computer center.

In a second method data are punched on computer cards and entered directly into the computer from the remote computer terminal in the field offices. In any event, the largest portion of data collected by the network of field instruments eventually are entered into the Reston computer where a set of computer programs and data files, known as the National Water Data Storage and Retrieval System (WATSTORE), are available to process the data. Once the data have been entered into WATSTORE they are available for retrieval or analysis, as shown in figures 4 and 5.

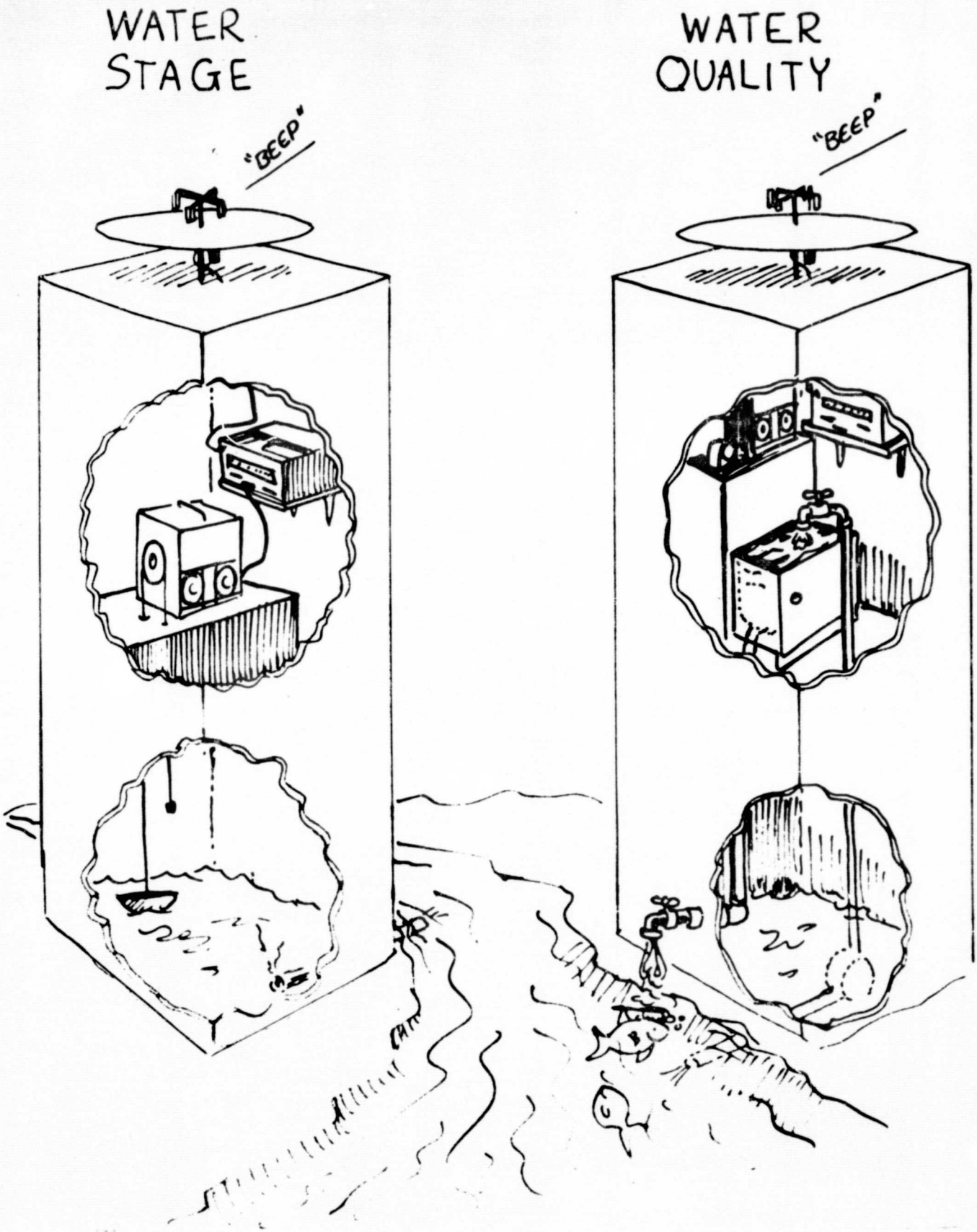

Figure 2: DCP Equipped Water-Stage and Water-Quality Monitoring Stations.

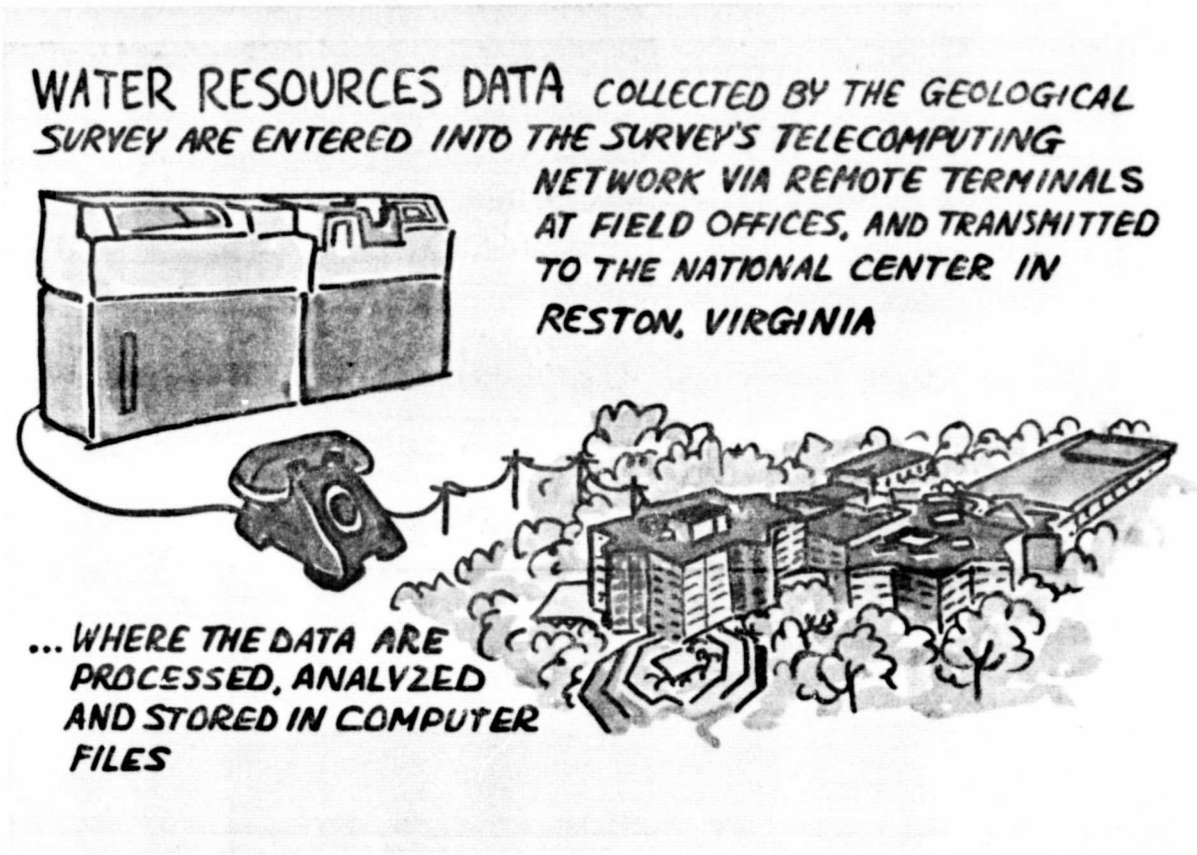

Figure 3: Where Water Resources Data Are Processed, Analyzed, and Stored.

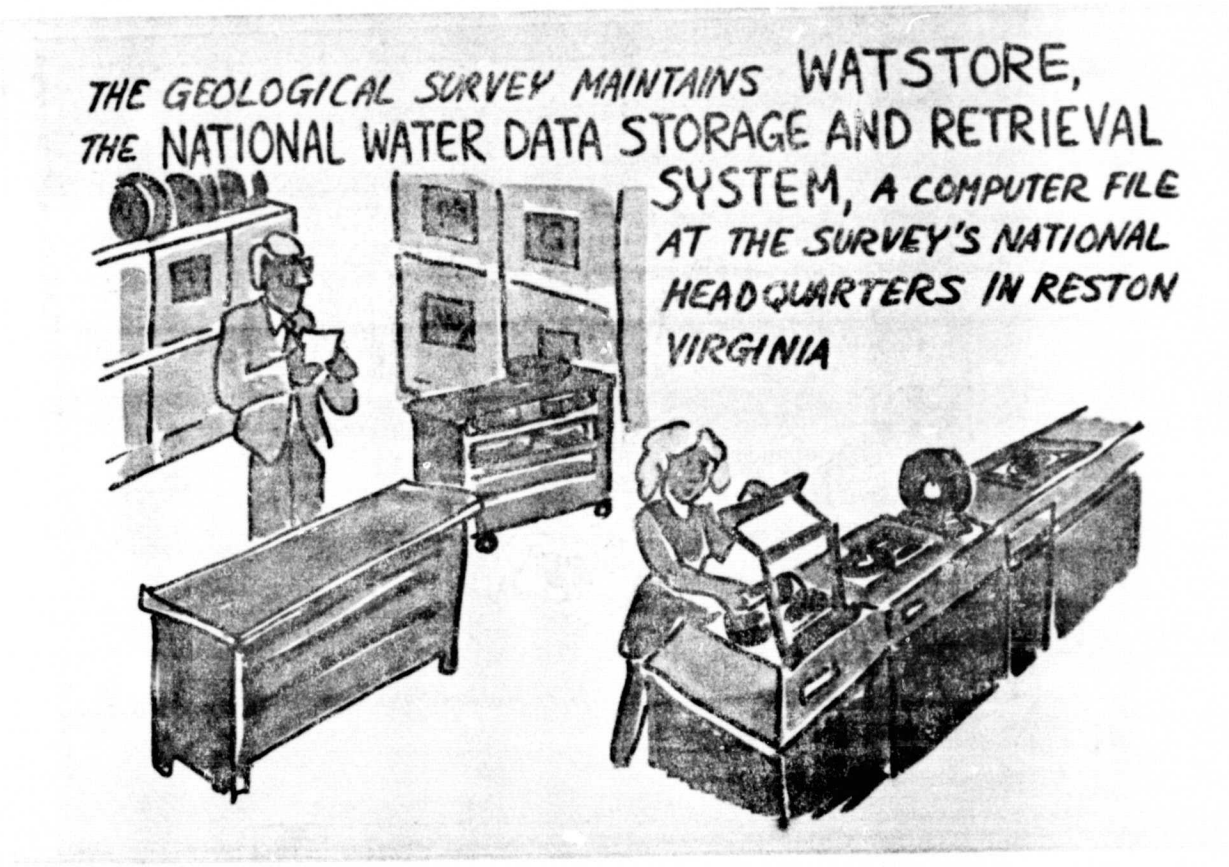

Figure 4: The Geological Survey's WATSTORE System

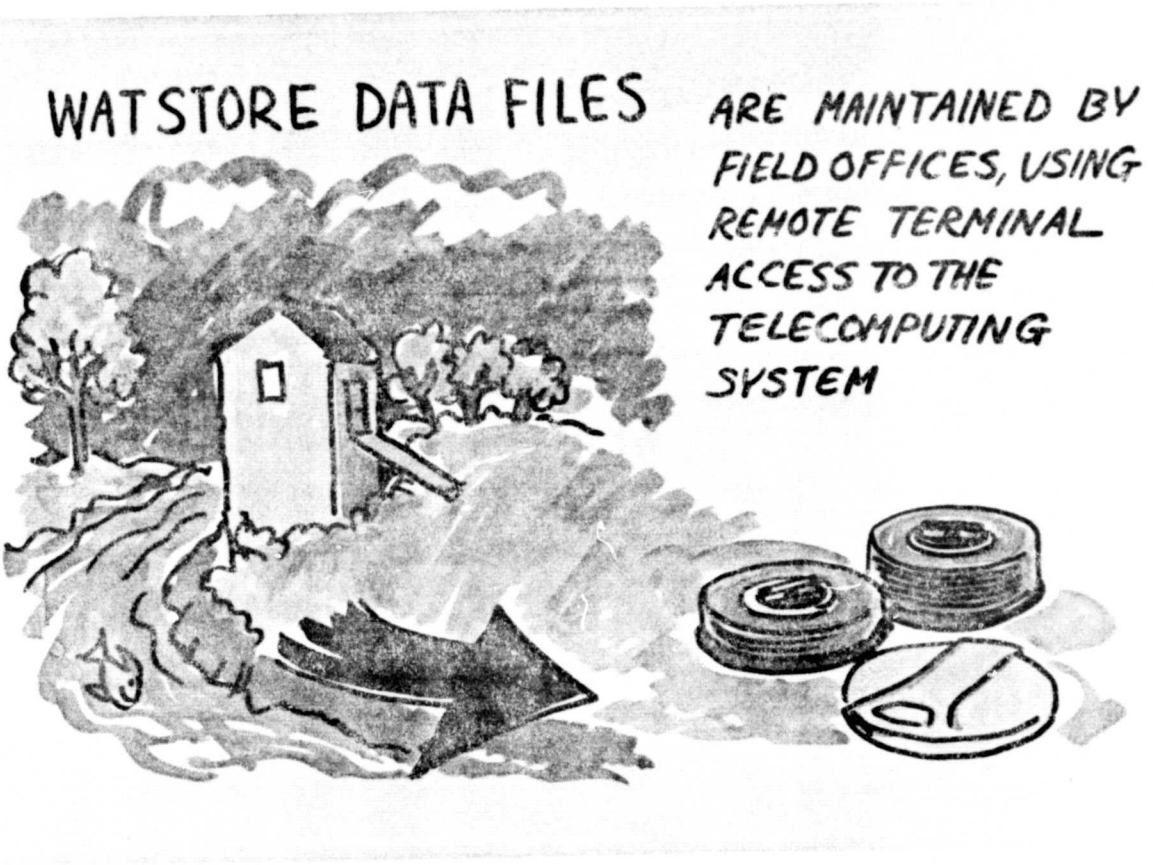

Figure 5: WATSTORE Data Files

In summary, as shown in figure 6, the WRD operates a large network of hydrologic instruments that records data that must be manually retrieved, processed, and entered into the Survey's telecomputing network. Large manpower and travel resources are required to operate and maintain the stations and retrieve the data. If a low cost, reliable telemetry system was available to collect the field data directly on a daily basis, it is possible that a significant number of station visits may be eliminated, therein increasing the efficiency of the system. This LANDSAT experiment was designed to assess satellite Data Collection System technology as a potential operational tool for direct hydrologic data collection.

LANDSAT-DCS

No significant description of the functional characteristics of the LANDSAT-DCS is presented herein because the reader is presumed to be familiar with the basic design and operation of the system; if not, this information is available from NASA publications (NASA 1971, NASA 1972). A description follows on the special data handling procedures that were established by the U.S. Geological Survey (USGS) and National Aeronautics and Space Administraiton (NASA) that facilitated the timely exchange of DCS data from NASA to the USGS.

In response to requests by the Geological Survey, NASA established a teletype distribution system for DCS data link to the Geological Survey offices in Harrisburg, Pennsylvania; Miami, Florida; and Menlo Park, California. These three locations were supplied with near real-time data to support large-user DCS test sites. These test sites have been discussed by Paulson (1974), Higer and others (1974), and Ward and others (1974). Of the three test sites, only the one in Pennsylvania was closely integrated with the Survey's telecomputing network (Paulson, 1975).

Initially, the Pennsylvania experiment used a remote computer terminal access to the Geological Survey's computer programs for processing DCS data. After the initial phase of the experiment, a set of computer programs was stored on-line in the computer, and executed daily to process Pennsylvania test site data. It is possible to enter a computer job from one remote terminal and route the output to any other remote terminal in the telecomputing network. It becomes possible to simulate an operational data collection and processing system for small scale Geological survey DCS users by acquiring other user data from the NASA teletype distribution system and process and disseminate the data with the Survey's network.

Although most of the Water Resources Divisions' Data Collection Platforms (DCP's) were concentrated in the Florida, Pennsylvania, and Arizona Districts, a modest number initially were available to be tested by other Districts on a one to four DCP per District basis. The small scale users, including Arizona which only had seven DCP's, did not warrant inclusion in

U.S. Geological Survey

Hydrologic Data Collection and Processing

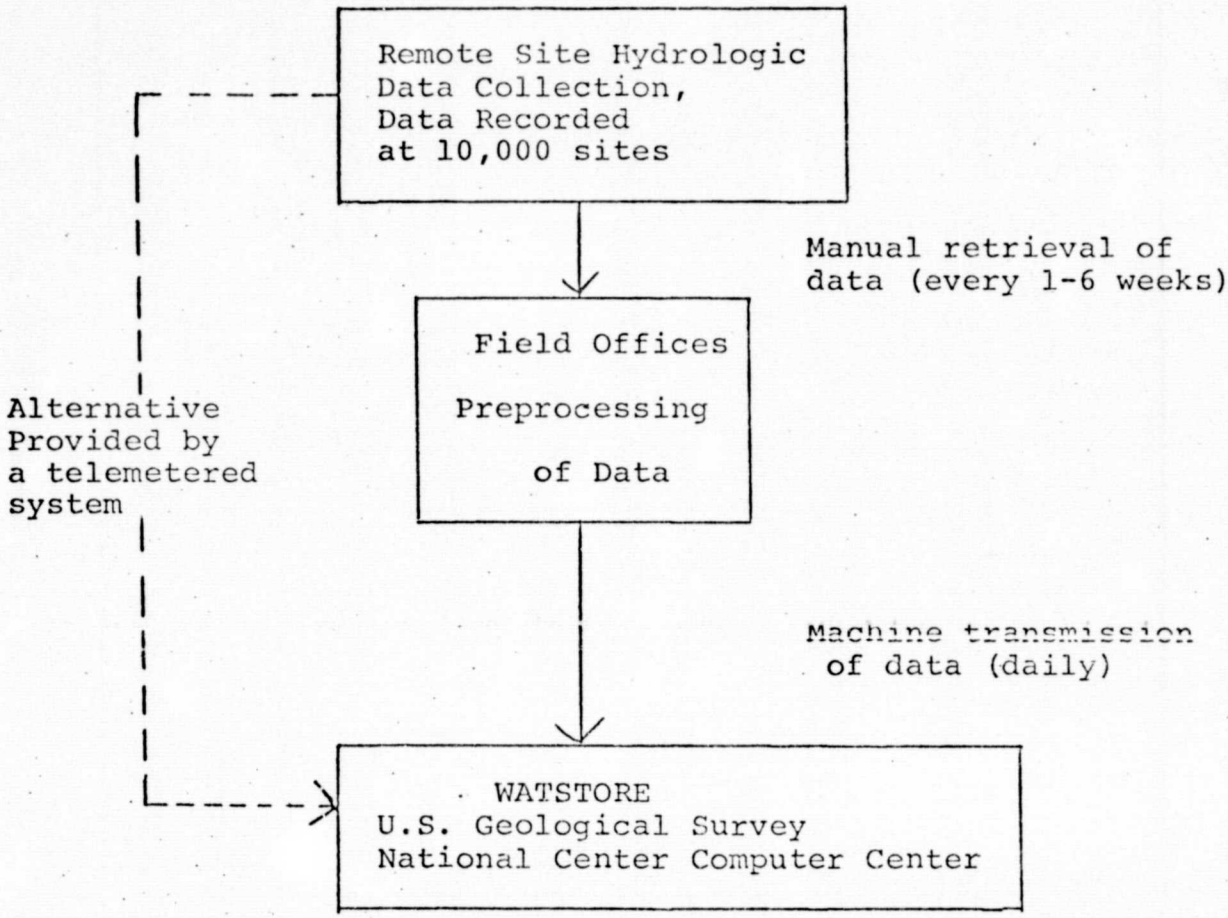

Figure 6: Existing flow of WRD hydrologic data

the NASA teletype system. During the period from the LANDSAT-1 launch in 1972 to the spring of 1975 the WRD DCP's where distributed to 25 WRD Districts as shown in Table II. Most of the Pennsylvania DCP's were redistributed to other Districts after the original Pennsylvania experiment was completed.

SIMULATION OF AN OPERATIONAL DATA COLLECTION AND PROCESSING SYSTEM

The practical objective of simulating an operational data collection and processing system was to provide WRD users who were unskilled in DCS technology with resources to acquire remote site hydrologic data in a familiar format. Functionally, a new user of the system should be able to interface a DCP with standard WRD field instrumention and, in a day or two, be able to enter a simple computer job into his terminal to retrieve his data in engineering units. The role of this experiment was to provide the computer software and files, and technical guidance to use the integrated NASA and Geological Survey systems.

To the user not highly skilled in computer technology, two computer resources were made available, (1) an on-line computer file where his DCP data were stored, and (2) on-line computer programs that he could use to retrieve and process his data. An on-line disk file was established to contain the most-recently-collected 180 transmissions of each DCP in the file. The file, called the WRD Satellite Data Collection System File, contained the 180 DCP transmissions plus ancillary information on the U.S. Geological Survey station name, number, etc. As new data were entered into the file by a computer job initiated at the Harrisburg Computer terminal, new data messages from a DCP replaced the oldest messages for that DCP in the file. The lag time from message reception at the NASA Operation Control Center (OCC) to the entry of a message in the file normally was from 12 to 24 hours. Starting in July 1975, a more timely data transfer procedure between the NASA Operations Control Center (OCC) at the Goddard Space Flight Center in Greenbelt, Maryland, and the Survey Computer Center in Reston, Virginia, was initiated. NASA established a dedicated high speed (9600 bits per second) line to the Reston Center. As DCS data came into the OCC from the NASA receiving stations at Goldstone, California, and Greenbelt, Maryland a duplicate data stream was sent immediatly via the dedicated line to a 9-channel magnetic tape recorder in the Reston Center. After the completion of a LANDSAT pass, the magnetic tape was placed on the computer tape library and a job executed to update the on-line disk file. The lag time was cut significantly to minutes.

By design, the actual path of data flow from a DCP to the Reston computer file was transparent to the average user. Most users had general information on the path but few needed to have detailed knowledge. Of concern to the user was that the data flow from his DCP to the Reston file was accomplished in as short a period as possible.

TABLE II
Distribution of DCP's by ID, to 25 WRD Districts as of July 31, 1975

Alaska

6030
6050

Arizona

6006
6016
6137
6151
6167
6177
6225
6261
6373

Arkansas

6014

California

6230

Colorado

6136

Florida

6000
6001
6003
6024
6031
6033
6051
6055
6112
6121
6122
6125
6141
6152
6157
6131
6214
6235
6236
6252
6256
6303
6313
6321
6362
6364
6077
6015
6002
6244

Idaho

6067
6115
6332

Indiana

6044

Louisiana

6110
6144
6237
6257

Massachusetts

6063
6017

Minnesota

6327

Mississippi

6013
6037
6203

Montana

6266
6301
6367

Nebraska

6116

Nevada

6307

New Jersey

6233
6277

New York

6245

Ohio

6361

Oklahoma

6306

Oregon

6114
6264
6275
6343
6351

Pennsylania

6073
6227
6341
6344
6402

Tennessee

6204
6263

Washington

6046
6215
6322
6324
6371

Wisconsin

6401

Two application computer procedures, called LANDSAT-DCP and LANDSAT-MU were routinely available to WRD users of the LANDSAT-DCS. Routine computer documentation was provided to WRD Districts so that any WRD user could retrieve data from any WRD DCP data file. The user merely provided the DCP identification number for one or more DCP's, the day number range of the messages required, and ancillary information on the way the data are formated in the DCP. The system appeared to be operational to the user (figure 7).

As shown in figure 8, the LANDSAT DCP's have been interfaced with a variety of hydrologic instrument. A small number of DCP's have been interfaced with external memory devices that the Geological Survey procured to increase the efficiency of the LANDSAT-DCS. Figure 9 shows how the external memory was connected to the DCP and figure 10 depicts the data flow within the memory system. The addition of a memory permitted the daily recovery of hourly stage values as explained in more detail later.

Several examples of typical computer printouts that are generated by this procedure are shown in figures 11, 12, 13. Figure 11 shows water-stage data collected at a gaging station in Oregon. The LANDSAT-DCP procedure retrieves the data from the DCP ID from the disk file, sequentially orders the messages by time and converts the data to engineering units. The procedure also retrieves the stage-discharge rating table from an on-line file and uses that table to compute stream discharge from water stage. The relationship between stage and discharge is unique for each stream site. LANDSAT-DCP's in this application transmit gage heights from the station. The rating table, which is a correlation between gage heights and discharge, is maintained by the field office responsible for that station.

Figure 12 contains processed data from a Louisiana station where four water-quality parameters are recorded. Each parameter voltage is provided to the DCP twice, hence the parallel listing of each parameter. User supplied conversion tables for the computation of engineering values from DCP input voltages were used in this application.

Figure 13 contains processed data from a Colorado station where both gage height and four water-quality parameters are measured.

The LANDSAT-DCP is a general purpose program which permits the processing of data from a variety of standard WRD instruments, and moreover permits the user to enter the data into the DCP in any sequence he chooses. For example, gage height can be entered into any two contiguous words in the eight 8-bit words of the DCP and any of the remaining 8-bit words can be used to represent 0 to 5 volt analog inputs. Any of the 8-bit words also can be ignored.

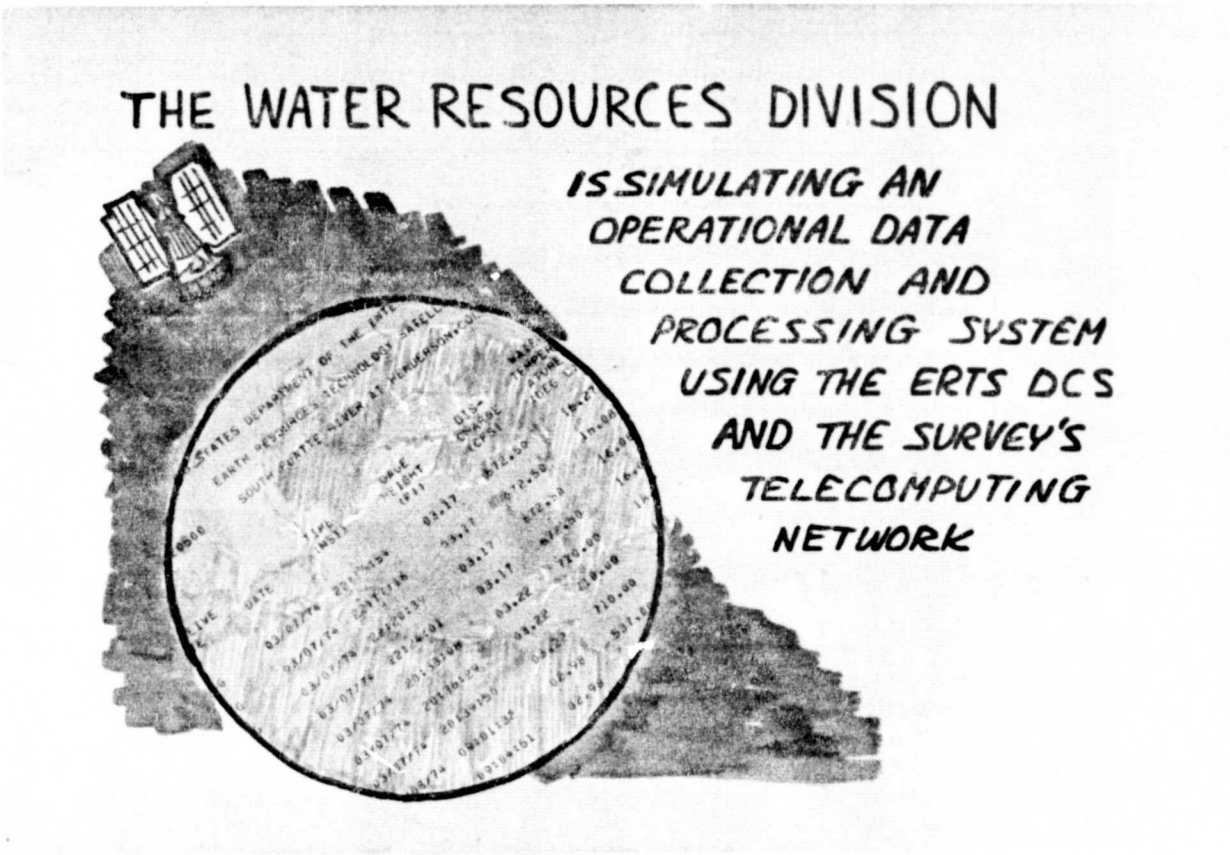

Figure 7: Water Resources Division is Simulating An Operational System.

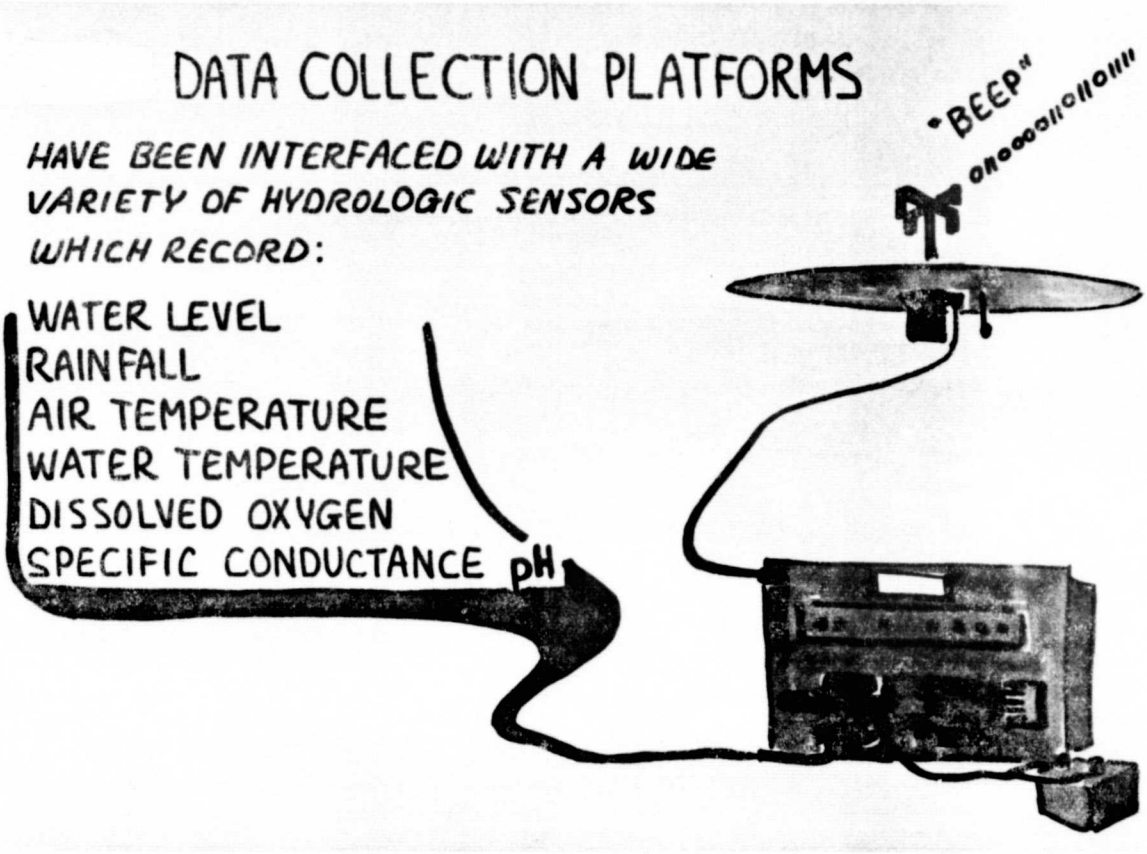

Figure 8: Data Collection Platforms.

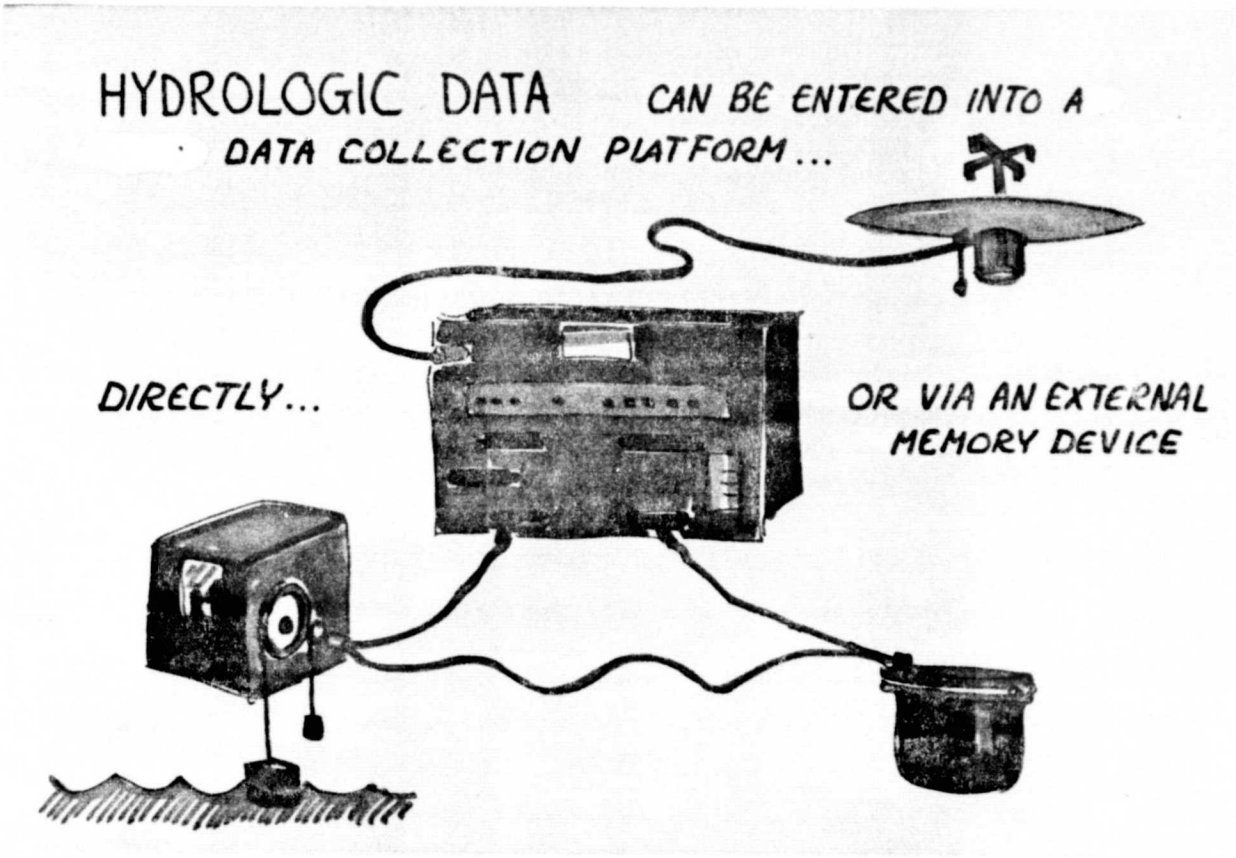

Figure 9: Hydrologic Data

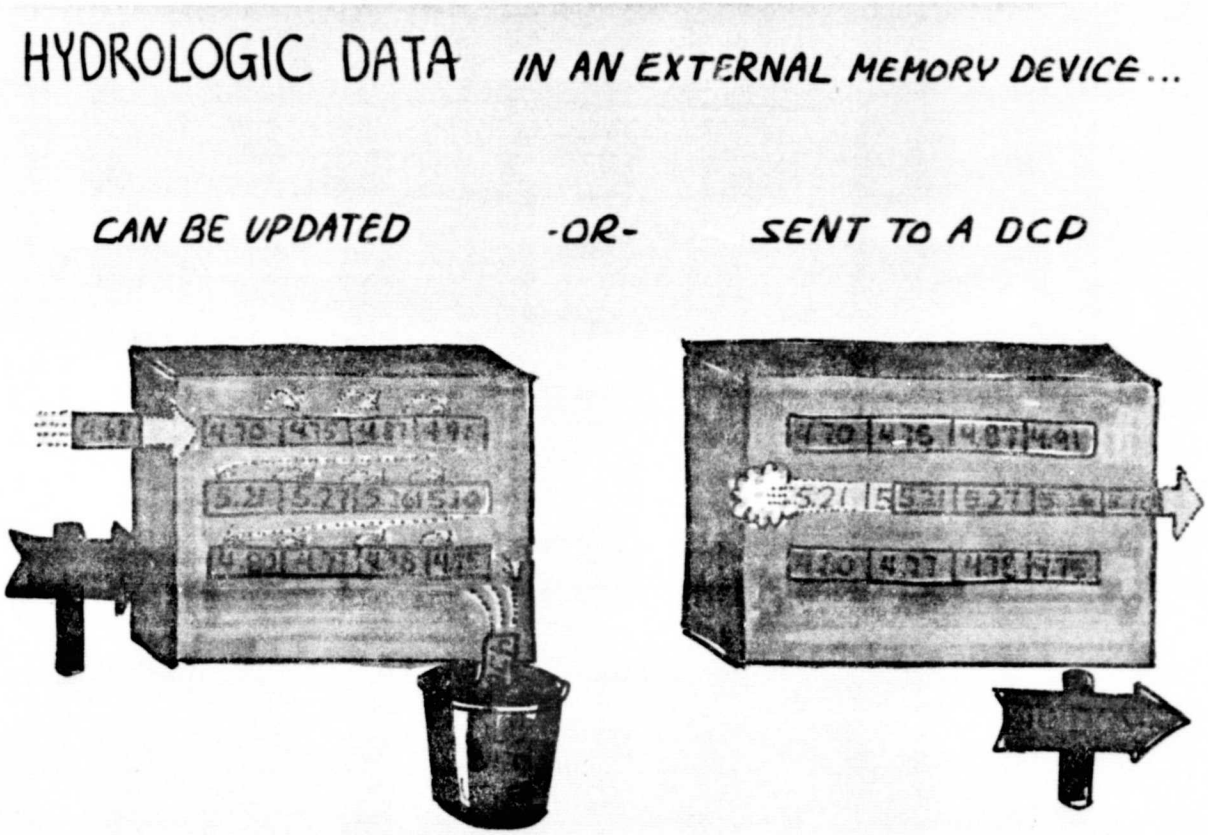

Figure 10: Hydrologic Data In An External Memory Unit

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UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EARTH RESOURCES TECHNOLOGY SATELLITE EXPERIMENT - DATA COLLECTION SYSTEM

14137000 SANDY RIVER NEAR MARMOT, OREG. DCP ID NO. 6264

RECEIVE SITE	DATE	TIME (PST)	GAGE HEIGHT (FT)	DIS-CHARGE (CFS)
G	07/06/74	10:52:53	7.78	1370.00
N	07/06/74	19:09:37	7.72	1310.00
G	08/20/74	21:36:29	6.88	644.00
G	08/20/74	21:39:31	6.88	644.00
G	08/21/74	10:02:16	6.83	614.00
G	08/21/74	10:05:23	6.83	614.00
G	08/21/74	10:08:28	6.83	614.00
G	08/21/74	20:02:23	6.79	590.00
G	08/21/74	21:39:59	6.79	590.00
G	08/21/74	21:42:58	6.79	590.00
G	08/21/74	21:45:57	6.79	590.00
G	08/22/74	10:08:37	6.79	590.00
G	08/22/74	10:11:37	6.79	590.00
G	08/22/74	20:05:52	6.77	578.00
G	08/22/74	20:08:46	6.77	578.00
G	08/22/74	21:45:10	6.77	578.00
G	08/22/74	21:48:07	6.77	578.00
G	08/22/74	21:51:03	6.77	578.00

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Figure 11: Computer Printout From LANDSAT-DCP File of Data From A Stream-Gaging Station in Oregon.

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UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EARTH RESOURCES TECHNOLOGY SATELLITE EXPERIMENT - DATA COLLECTION SYSTEM

07374508 MISSISSIPPI RIVER AT NEW ORLEANS, LA. DCP ID NO. 6237

RECEIVE SITE	DATE	TIME (CST)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	DIS-SOLVED OXYGEN (MG/L)	DIS-SOLVED OXYGEN (MG/L)	AIR TEMPER-ATURE (DEG C)	AIR TEMPER-ATURE (DEG C)	PH (UNITS)	PH (UNITS)
G	08/21/74	21:56:06	419.58	415.67	5.47	5.47	26.08	26.08	7.52	7.52
G	08/21/74	21:59:03	407.81	407.81	5.47	5.47	26.08	26.08	7.47	7.47
G	08/21/74	22:01:59	407.81	407.81	5.47	5.47	26.08	26.08	7.41	7.36
N	08/22/74	08:47:13	415.67	407.81	5.29	5.29	26.08	26.08	7.47	7.47
N	08/22/74	08:50:10	403.91	403.91	5.29	5.29	26.08	26.08	7.47	7.47
N	08/22/74	10:27:06	400.00	403.91	5.29	5.29	26.08	26.08	7.52	7.52
G	08/22/74	10:27:06	400.00	403.91	5.29	5.29	26.08	26.08	7.52	7.52
N	08/22/74	10:30:02	403.91	400.00	5.29	5.35	26.08	26.08	7.58	7.52
G	08/22/74	10:30:02	403.91	400.00	5.29	5.35	26.08	26.08	7.58	7.52
N	08/22/74	10:32:58	403.91	407.81	5.29	5.29	26.08	26.08	7.52	7.52
G	08/22/74	10:32:58	403.91	407.81	5.29	5.29	26.08	26.08	7.52	7.52
G	08/22/74	10:35:54	403.91	411.72	5.35	5.29	26.08	26.08	7.58	7.58
G	08/22/74	12:12:41	400.00	403.91	5.35	5.35	26.08	26.08	7.52	7.52
N	08/22/74	20:22:41	396.04	396.04	5.35	5.35	26.08	26.08	7.41	7.41
G	08/22/74	21:59:49	396.04	403.91	5.35	5.35	26.08	26.08	7.52	7.52
G	08/22/74	22:02:45	403.91	407.81	5.35	5.35	26.08	25.88	7.47	7.47
G	08/22/74	22:05:42	403.91	407.81	5.35	5.35	26.08	25.88	7.52	7.52
N	08/23/74	08:50:44	403.91	407.81	5.23	5.23	25.88	25.88	7.52	7.52
N	08/23/74	08:56:37	403.91	407.81	5.23	5.23	25.88	25.88	7.47	7.47
G	08/23/74	10:43:26	403.91	407.81	5.29	5.23	25.88	25.88	7.58	7.52
G	08/23/74	10:49:17	403.91	407.81	5.29	5.23	25.88	25.88	7.58	7.58
G	08/23/74	10:42:13	396.04	396.04	5.23	5.23	25.88	25.88	7.58	7.63

Figure 12: Computer Printout of LANDSAT-DCS Data From A Water-Quality Monitoring Station.

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UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

EARTH RESOURCES TECHNOLOGY SATELLITE EXPERIMENT - DATA COLLECTION SYSTEM

06720500 SOUTH PLATTE RIVER AT HENDERSON, CO. DCP ID NO. 6136

RECEIVE SITE	DATE	TIME (MST)	GAGE HEIGHT (FT)	DIS-CHARGE (CFS)	WATER TEMPER-ATURE (DEG C)	PH (UNITS)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	DIS-SOLVED OXYGEN (MG/L)
N	08/20/74	09:20:15	2.50	260.00	20.98	7.51	345.02	1.57
G	08/20/74	09:20:15	2.50	260.00	20.98	7.51	345.02	1.57
N	08/20/74	09:23:29	2.50	260.00	20.98	7.51	329.39	1.57
G	08/20/74	09:23:29	2.50	260.00	20.98	7.51	329.39	1.57
G	08/20/74	10:56:37	2.43	228.00	22.74	7.47	815.62	1.49
G	08/20/74	10:59:48	2.40	214.50	22.74	7.47	846.97	1.57
G	08/20/74	11:03:00	2.40	214.50	22.74	7.47	509.77	1.65
G	08/20/74	11:06:12	2.40	214.50	22.74	7.47	352.93	1.80
N	08/20/74	19:17:24	2.64	332.50	23.72	7.43	345.02	0.31
G	08/20/74	20:47:07	2.64	332.50	21.96	7.55	313.67	0.31
G	08/20/74	20:50:21	2.64	332.50	21.96	7.55	313.67	0.23
G	08/20/74	20:53:34	2.64	332.50	21.96	7.55	305.86	0.23
G	08/20/74	20:56:48	2.64	332.50	21.96	7.55	321.48	0.23
G	08/20/74	22:34:09	2.61	316.00	20.59	7.59	376.46	0.39
G	08/20/74	22:37:25	2.61	316.00	20.59	7.59	376.46	0.39
G	08/20/74	22:40:41	2.61	316.00	20.59	7.63	360.74	0.39
N	08/21/74	09:21:18	2.36	197.40	18.63	7.67	109.77	1.72
G	08/21/74	09:21:18	2.36	197.40	18.63	7.67	109.77	1.72
N	08/21/74	09:24:35	2.36	197.40	18.63	7.67	109.77	1.65
G	08/21/74	09:24:35	2.36	197.40	18.63	7.67	109.77	1.65
G	08/21/74	09:27:53	2.36	197.40	18.63	7.67	109.77	1.72
G	08/21/74	11:02:44	2.29	168.00	20.98	7.67	109.77	1.80

Figure 13: LANDSAT-DCS Data From A Combined Stream Gaging And Water-Quality Monitoring Station.

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The LANDSAT-MU procedure is a special purpose computer program for processing water stage data that have been entered into a DCP add on memory unit.

The memory unit was designed to increase the efficient use of the LANDSAT-DCS. Prior to the addition of the memory device, a DCP at a gaging station would typically transmit up to 3 messages during a pass of the satellite, all of which contained the same data. Moreover, the capacity of each message was only partially used. Figure 9 shows that four stage readings could be accumulated in each memory set and that several sets could be sequentially passed to a DCP for transmission. Thus, asynchronously, a new reading might be entered to update the memory once an hour, while every 180 seconds a new memory set would be provided to the DCP for transmission. The net result was that hourly values of water stage could be accumulated and transmitted through the DCS. There are operational programs in WATSTORE that process hourly stage values, regardless of whether these hourly values are recorded on site or transmitted via a telemetry system.

Figure 14 is an example of the output of the LANDSAT-MU procedure. The significance of this printout is that it was produced by an operational WRD program for basic data processing. The LANDSAT-MU procedure merely reformats data from an add-on-memory equipped DCP and provides the data to the existing WRD operational data processing system, WATSTORE. It is the only demonstration of the LANDSAT-DCS as an integral part of the WRD's operational basic data procession system where no modification to the pre-LANDSAT computer program was made.

CONCLUSIONS

This experiment has been, and continues to be, an integration of the LANDSAT-DCS with the data collection and processing system of the Geological Survey. Although an experimental demonstration, it was a successful integration of a satellite relay system that is capable of continental data collection, and an existing governmental nationwide operational data processing and distributing networks.

The LANDSAT-DCS is classified as an experimental system, the DCP capacity of the LANDSAT-DCS is small and the data capacity of the individual DCP's is small. Moreover, the Survey's data processing system uses a large general purpose computer with insufficient redundancy for 24-hour a day 7 day a week operation. These are significant, but soluble obstacles to converting the experimental integration of the system to an operational integration.

This DCS experiment has demonstrated a national institutional application of LANDSAT-DCS technology, and has been very useful to demonstrate the potential application of the technology to a community of users who do

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UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION DIST 05

PRIMARY COMPUTATION OF GAGE HEIGHTS AND DISCHARGE

07195000 DATA PROCESSED 10-04-74

OSAGE CREEK NEAR ELM SPRINGS, ARKANSAS USE RT 14

PROVISIONAL DATA FOR WATER YEAR ENDING SEPT. 30, 1974 TEST DIFF 0.1 PUNCH INT 60 MIN STORE

	DATE	MAX GH (TIME)	MIN GH (TIME)	MEAN GH	EQUIV GH	MEAN DISCH	SHIFT AT ADJ	HR	DATUM AT CORR	HR	STAGE, IN HUNDREDTHS OF FEET, AT INDICATED HOURS 1	2	3	4	5	6	7	8	9	10	11	12
	9-26	2.61	2.61	2.61	2.61	128P				AM												
		(2400)	(2400)							PM												261
	9-27	2.62	2.58	2.60	2.60	127				AM	261	260	260	260	260	259	259	258	258	261	262	262
		(1100)	(0800)							PM	262	262	261	261	261	261	261	261	261	260	260	259
A	9-28	2.79	2.57	2.66	2.66	135				AM	259	259	258	258	258	258	258	258	257	257	260	274
		(2100)	(0900)							PM	274	273	272	271	271	270	270	275	279	278	276	274
	9-29	2.73	2.60	2.64	2.64	134				AM	273	272	270	269	268	267	265	264	263	262	262	262
		(0100)	(2200)							PM	262	262	262	261	261	261	261	261	261	260	260	260
	9-30	2.63	2.59	2.61	2.61	128				AM	259	259	259	259	259	259	259	259	259	262	262	263
		(1200)	(0100)							PM	263	262	262	262	262	262	262	262	262	262	260	260
	PERIOD	2.79	2.57																			

NOTE. SYSBOLS USED ABOVE HAVE THE FOLLOWING MEANINGS
A - SUCCESSIVE ADJUSTED PUNCH READINGS DIFFER BY MORE THAN THE SPECIFIED ALLOWABLE TEST DIFFERENCE
P - DAILY SUMMARY IS FOR AN INCOMPLETE DAY
R - ONE OR MORE INPUT VALUE IS OUTSIDE THE RANGE OF THE RATING IN USE
* - SHIFT IS A VALUE WEIGHTED BY DISCHARGE WHERE SHIFT VARYS WITH STAGE DURING THE DAY

Figure 14: Primary Computation Of Gage Heights And Discharge, An Output From A WATSTORE Program Using LANDSAT-DCS Data As Input

not possess in-depth electronics or computer training. The significant contribution of this experiment has been the exposure that has been provided to a large community of potential users of an operational satellite data collection and processing system.

The most signif cant result of this experiment is that the demonstration of an integrated NASA-WRD data collection and processing system was the basis for establishing a WRD Data Relay Project. Several tests of the LANDSAT-DCS that the WRD performed demonstrated that DCS technology is viable. The test described herein demonstrated that it could be operationally integrated with existing systems. The WRD Data Relay Project headquartered at the Survey's National Center in Reston, Virginia is actively pursuing the operational integration of DCS technology with existing WRD operational data collection and data processing systems.

ACKNOWLEDGMENT

The success of this experiment has hinged upon the enthusiastic cooperation of several individuals in the Geological Survey and NASA. The cooperation of J. Earle Painter of the Goddard Space Flight Center has been particularly noteworthy and merits special achnowledgment.

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