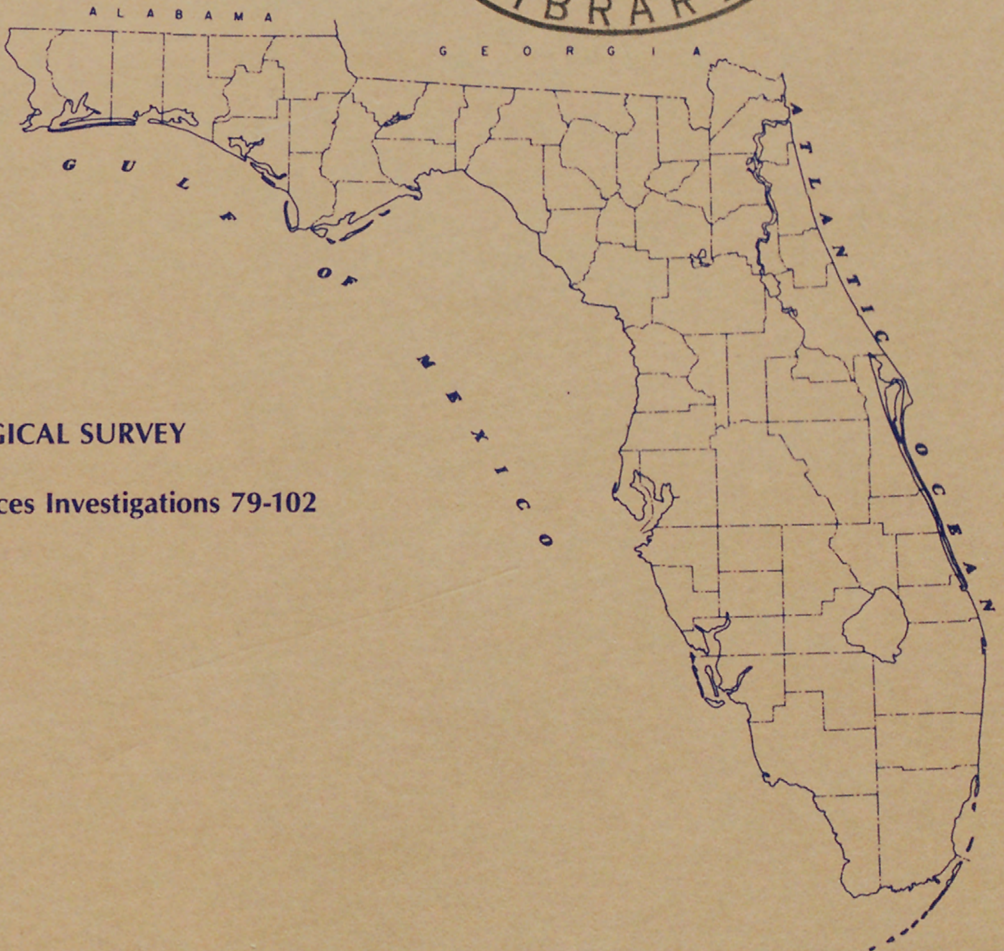
EVALUATION OF REMOTE HYDROLOGIC DATA-ACQUISITION SYSTEMS, WEST-CENTRAL FLORIDA



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Prepared in cooperation with
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This study provides an evaluation of the hydrologic applications of a land-line and two satellite data-relay systems operated during 1977-78 in the Southwest Florida Water Management District. These systems were tested to evaluate operational and reliability characteristics. Telephone lines were used to relay data in the land-line system, and the Geostationary Operational Environmental Satellite (GOES) and Land satellite (Landsat) were used in the satellite system. The land-line system was tested for a period of 15 months at a streamflow site. Accurate data were obtained 94 percent of the time during the test period. Data losses were attributed to telephone-line interference, low-battery voltage, and vandalism. The GOES system was tested at a rainfall site for a 17-month period. During this period, 79 percent of all Convertible Data Collection Platform (CDCP) transmissions from the station were relayed by the GOES system to the U.S. Geological Survey computer, resulting in successful processing of 88 percent of all possible rainfall observations. On the average, seven data transmissions were completed each day. The Landsat system was tested at a rainfall site for about 17 months and for about 8 months at a streamflow site. During these periods of operation, only about 2 percent of all data observations for the stations were successfully relayed by the Landsat system to the U.S. Geological Survey computer. An average of about three data transmissions was completed each day for each site.

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CONVERSION FACTORS

For use of those readers who may prefer to use metric (SI) units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric (SI) unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
inch per hour (in/h)	2.540	centimeter per hour (cm/h)
foot per mile (ft/mi)	0.1895	meter per kilometer (m/km)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

NOTE: The use of brand names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

EVALUATION OF REMOTE HYDROLOGIC DATA-ACQUISITION SYSTEMS, WEST-CENTRAL FLORIDA

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ABSTRACT

This study provides an evaluation of the hydrologic applications of a land-line and two satellite data-relay systems operated during 1977-78 in the Southwest Florida Water Management District. These systems were tested to evaluate operational and reliability characteristics. Telephone lines were used to relay data in the land-line system, and the Geostationary Operational Environmental Satellite (GOES) and Land satellite (Landsat) were used in the satellite system.

The land-line system was tested for a period of 15 months at a streamflow site. Accurate data were obtained 94 percent of the time during the test period. Data losses are attributed to telephone-line interference, low-battery voltage, and vandalism.

The GOES system was tested at a rainfall site for a 17-month period. During this period, 79 percent of all Convertible Data Collection Platform (CDCP) transmissions from the station were relayed by the GOES system to the U.S. Geological Survey computer, resulting in successful processing of 88 percent of all possible rainfall observations. On the average, seven data transmissions were completed each day. Ninety-six percent of the time, at least one data transmission was completed each day, and 80 percent of the time, an average of more than seven transmissions was completed each day. Data were available within about 8 hours after recording at the field site. Uncompleted transmissions were caused chiefly by hardware malfunctions at ground-receiving stations.

The Landsat system was tested at a rainfall site for about 17 months and for about 8 months at a streamflow site. During these periods of operation, only about 2 percent of all data observations for the stations were successfully relayed by the Landsat system to the U.S. Geological Survey computer. An average of about three data transmissions was completed each day for each site. Eighty-eight percent of the time, at least one transmission from each site was completed each day, and 80 percent of the time, an average of more than four transmissions was completed each day for each site. Data were available within about 12 hours after recording at field sites. Uncompleted transmissions are attributed to satellite orbit, hardware malfunction at ground-receiving stations, overloading of recording devices at the U.S. Geological Survey computer center, testing of equipment, battery failure, and vandalism.

INTRODUCTION

Remote data-acquisition systems capable of sensing, recording, and transmitting hydrologic data nearly instantaneously from practically any site to any user are possible with current technology. Principal components of a typical remote data-acquisition system include observation site equipment such as, a data sensor, an analog-to-digital recorder (ADR) and telemeter, a communication relay facility, and a computer system for processing, formatting, and distribution of data to users.

Remote site telemetry units used in this study were interfaced with ADR's. Telemetry units vary in design, function, and capability. Some units operate with telephone lines, while others operate with orbiting or stationary satellites for communication relay links.

In the past, tone-audible, land-line telemeters have been used by the U.S. Geological Survey to obtain real-time data. As the need for real-time data has grown and the capability of digital computers to operate telemetry systems has developed, data-collection agencies have begun to utilize computer-based telemetry systems. In 1972, the Geological Survey began experimenting with satellite telemetry in its data-collection programs. Results of this experimentation indicate that a substantial manpower savings may be realized by using satellite-relay systems to operate large data-collection networks and automatically process the data. However, some experience needs to be gained concerning the dependability of this transmission system. This experience can be gained by applying satellite telemetry to data networks and examining the data for completeness of record and ease of reduction to useful forms.

PURPOSE AND SCOPE

The purpose of this report is to provide an evaluation of remote data-acquisition systems operated in the west-central Florida area during 1977-78. These systems consist of telemeter units operated by (1) land-line relay with data processing at field office using a programmable calculator and (2) satellite relay with central computer processing and storage. A description and an evaluation of the capability and reliability of each system is provided.

These systems were used to remotely obtain hydrologic data at stations in the Anclote, Hillsborough, and Alafia River basins. Data obtained were compared with routinely processed ADR records from the same stations. In making the comparisons, the reliability of the data-acquisition systems was evaluated with emphasis on quality of data received and the percentage of record lost due to malfunctions in various components of the systems. The procedures used to format, process, store, and retrieve data from the satellite-relay systems are described in a supplement to this report.

DESCRIPTION OF DATA-ACQUISITION SYSTEMS

Three telemetry systems were tested in field environments as part of this study. The first is a land-line system and the second and third are satellite-relay systems. The land-line system was used in the operation of a telemeter referred to as a Device for Automatic Remote Data Collection (DARDC). The DARDC has limited memory that retains only the most current data value. The DARDC can transmit data over telephone lines to a programmable calculator or digital decode-display unit upon interrogation.

The second is the (GOES) relay system used in the operation of a convertible, data-collection platform (CDCP). The CDCP has memory that is controlled by user-selected parameters, specifying data transmission interval, sensor update interval, platform identification number, and storage of data. Current data are routinely entered into memory and subsequently transmitted to the GOES and relayed to ground-receiving stations on a 3-hour schedule.

The third is the Landsat relay system used in the operation of a data-collection platform (DCP). The DCP has memory which retains only the last data value. The data value is transmitted to the Landsat about every 3 minutes. The Landsat receives and simultaneously relays data when ground-receiving stations and field-telemeter sites are in alinement with the satellite. The CDCP can also be used with the Landsat relay system but this use was not tested in this study.

Land Line

Field site equipment include the DARDC telemeter interfaced to an ADR and associated sensing apparatus, a telephone set, and an acoustic coupler. The DARDC is connected between the ADR and the acoustic coupler. As hydrologic data are sensed, they are punched on paper tape by the ADR. The last data value is retained in the ADR and is available to the DARDC by interconnecting cable.

A programmable calculator, located at the U.S. Geological Survey Tampa office, is used to interrogate the DARDC (fig. 1). The calculator is connected to telephone lines with a type-500 telephone set and acoustic coupler. A digital decode-display unit, equipped with a suction cup-type telephone pickup, may be used for manual readout.

Interrogation of the DARDC begins by manually dialing its telephone number. At the remote site, the telephone coupler detects the telephone ring and relays the incoming signal to the DARDC, which goes into the operate mode. The DARDC initiates a "pick-up signal" to the acoustic coupler and obtains current data from one to four sensors. The DARDC then generates the station identification number, translates the number and current data value into American Standard Code for Information Interchange

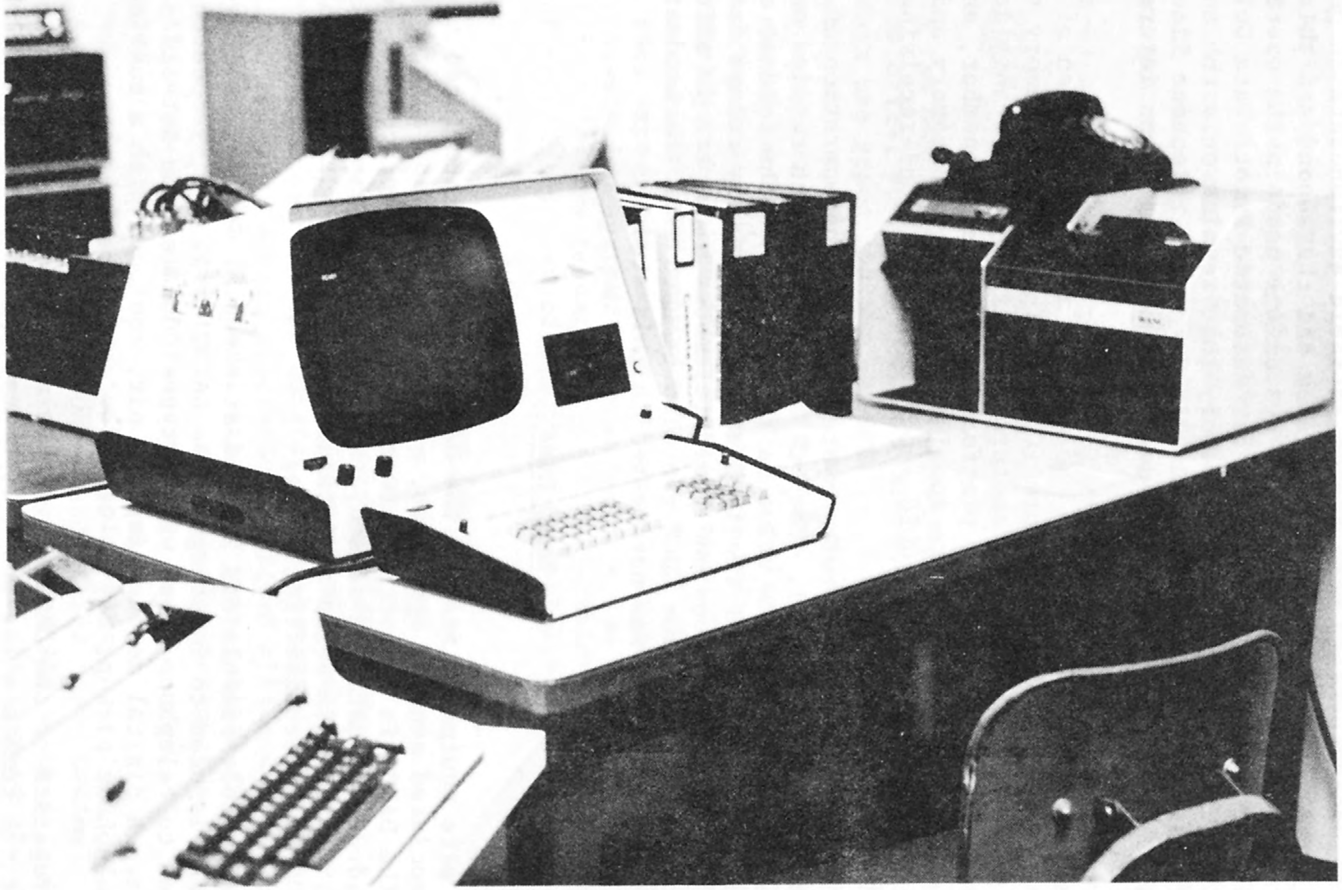

Figure 1.--Programmable calculator used to interrogate DARDC telemeter.

(ASCII) format, and transmits the information to the calculator or digital decode-display device. After the transmission is completed, the DARDC initiates a signal that returns the acoustic coupler and the telemeter to a standby mode.

When the digital decode-display device is used, data from the remote site are received in digital form in proper engineering units. When the calculator is used, data from the remote site are decoded and formatted into engineering units for immediate use or storage on a magnetic device. Basic components of the land-line system are shown in figures 2 and 3.

Satellite Relay

The satellite systems use orbiting and geostationary satellites (fig. 4) to relay data from field sites to ground-receiving stations where data undergo reduction and computer processing. Data are subsequently relayed to a central computer system for final processing, storage, and dissemination. Computer terminals in field offices are used with the commercial telephone system to obtain data from the central computer system for local use.

GOES

In the GOES system, a CDCP transmits data from a field site to the GOES, which in turn relays the data to a ground receiver at Wallops Island, Va. Components and functions of the GOES relay system are listed in table 1.

The GOES is in a nearly stationary orbit that parallels the equator about 22,000 miles above the Earth. The satellite remains in view of the same geographical area at all times.

The CDCP is battery powered and accepts analog or digital data from a wide range of data sensors. An external CDCP power supply consists of a 12-volt, lead-acid battery and a solar panel. Power loss to CDCP will deactivate sensors and result in loss of data. Internal batteries provide continued power to CDCP memory so that the most recent data will be retained if external power is lost. The CDCP can obtain data from as many as four digital and eight analog recorders.

Sensor data are punched on paper tape by an ADR every 6 or 15 minutes, or multiples thereof, for backup record. The CDCP accepts sensor data at these time intervals and formats and stores current values while retaining some preceeding values. The CDCP can be programmed for as many as 255 intervals between updates. Updates occur as new data are sensed, punched on paper tape, and stored sequentially in the CDCP memory. Update and storage of current data occurs prior to transmission to the GOES.

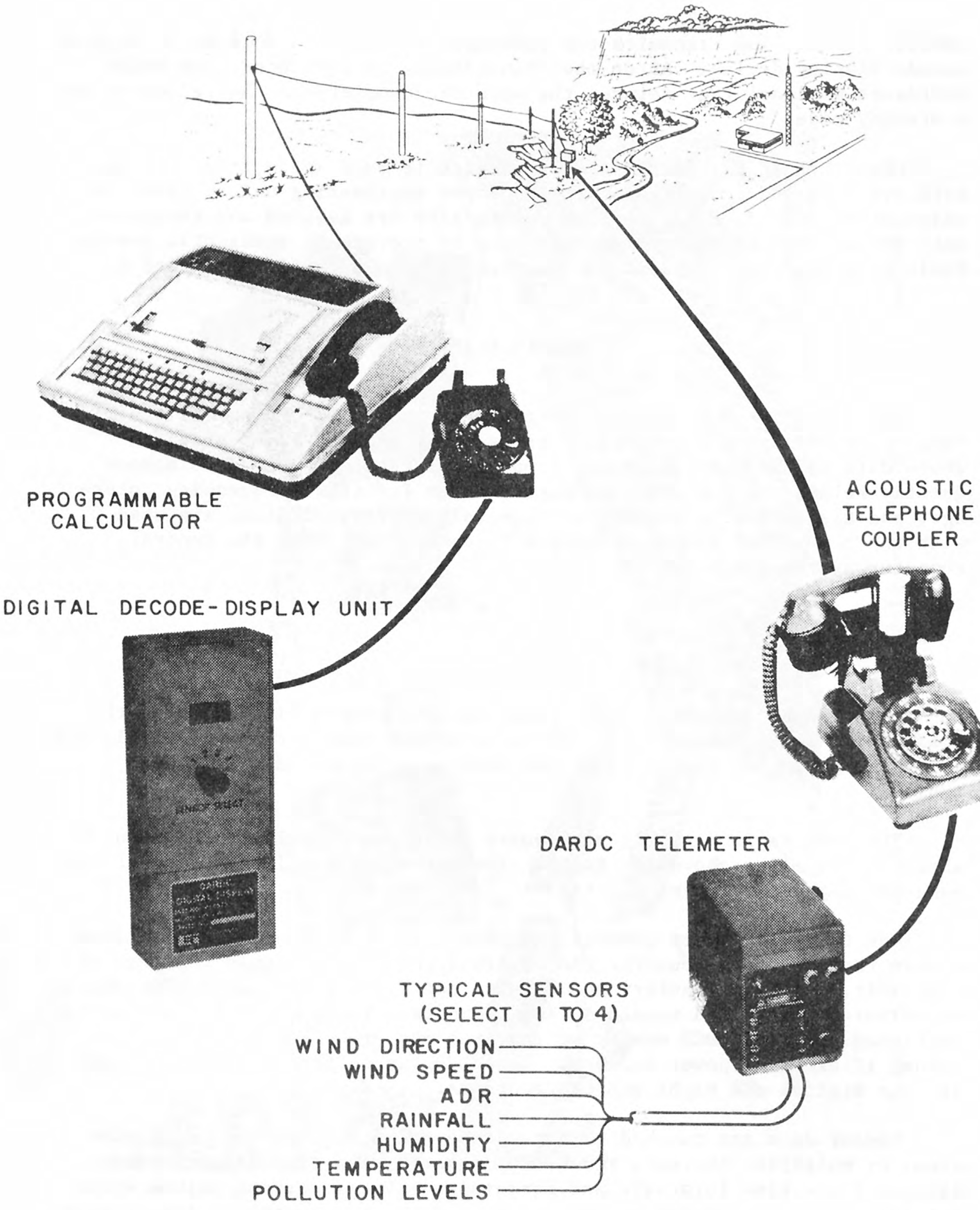

Figure 2.--Schematic of land-line system (modified from LaBarge Inc. catalog of meterological products).

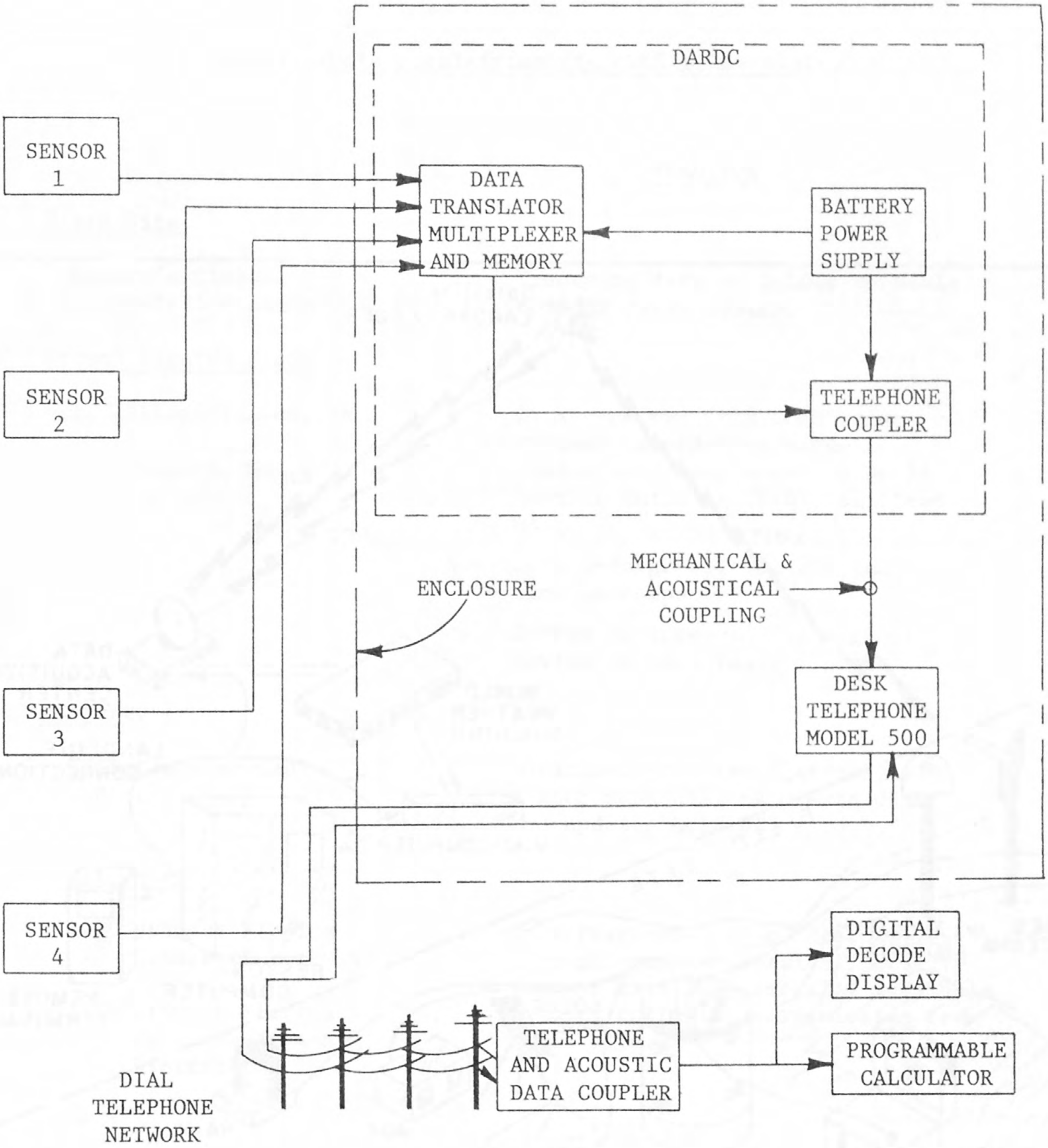

Figure 3.--Schematic showing multisensor configuration for DARDC (modified from LaBarge Inc. Instruction Manual for DARDC).

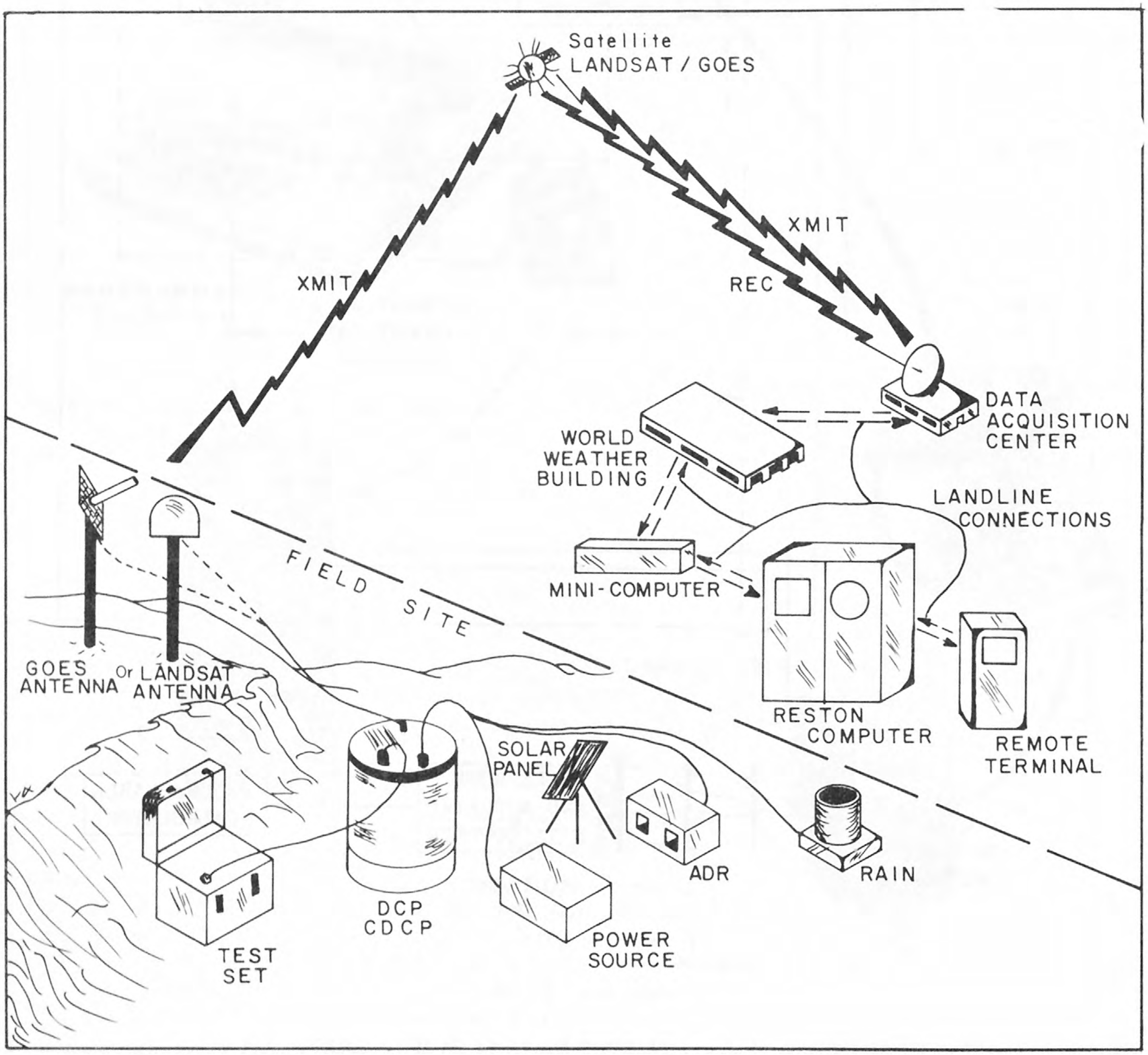

Figure 4.--Generalized schematic showing components of the GOES and Landsat relay systems (modified from LaBarge Inc. Instruction Manual for Convertible Data Collection Platforms).

Table 1.--Data acquisition via GOES relay system

	FUNCTION
Field Site	
Nature's Classroom rainfall station[1/]	a. Transmits data on 3-hour schedule to GOES relay system.
Ground Receive Sites	
1. Wallops Island, Va. 2. Suitland, Md.	a. Data received from GOES relay system, recorded on magnetic device and transferred to World Weather Building (WWB), Suitland, Md.;
	b. Data undergo editing and reduction by computer;
	c. Stored on intermediate magnetic device in card image format.
Computer	
USGS Computer Center Reston, Va.	a. Minicomputer interrogates file on 6-hour schedule, reformats data and updates GOES DCS file.
Local Users	
1. Southwest Florida Subdistrict (USGS) 2. Southwest Florida Water Management District	a. Interrogate DCS file, Reston, Va., through computer terminal facility. Current data are generally available 8 hours following transmission from field site.

NOTE: Field offices having time-share computer capacity, may be able to interrogate WWB directly to obtain data on 3-hour basis.

1/ Site 2, table 3 and figure 6.

Data in the CDCP memory are stored in a "pushdown list" configuration. That is, when memory becomes filled, space for storing new data is provided by eliminating the oldest data in storage. Data from previous transmissions (depending on update frequency and number of sensors) can be stored for future transmissions. Transmissions containing redundant or overlapping data increase system reliability.

In this study, the CDCP's were precisely timed to transmit to the GOES every 3 hours. Radio signals are emitted from a cylindrical antenna at the field sites. Transmissions last about 28 seconds and are scheduled to occur within about 30 seconds of an assigned time to avoid interfering with transmissions from other CDCP units that transmit on the same frequency. Following each data transmission, the CDCP returns to standby conditions for minimum power consumption.

The CDCP operates under control of a built-in precision timer that is accurate to 30 seconds per year. Time intervals for recorder updates and transmissions are selected prior to placing the CDCP in operation.

Data transmissions from the CDCP to the satellite include stored data for each parameter and the CDCP identification number. Data reference time is determined from the prescribed recording and transmission schedules and a log of completed transmissions. Data reference times are determined and stored with sensor data in computer files maintained at the U.S. Geological Survey computer center, Reston, Va.

Landsat

In the Landsat system, a DCP transmits data from field sites to Landsat (formerly known as ERTS, Earth Resources Technological Satellite) for instantaneous relay to ground-receiving stations at Greenbelt, Md., or Goldstone, Calif. Table 2 lists components and functions of the system.

Landsat is at an altitude of about 570 miles above the Earth's surface and in a nearly polar orbit, circling the Earth about every 103 minutes. Each orbital path of the satellite shifts about 1,800 miles to the west due to the Earth's rotation (fig. 5). The orbit of the Landsat limits use of the system for data relay in west-central Florida because transmission and subsequent relay of radio signals by the satellite can only be accomplished when the DCP and ground-receiving stations are mutually visible to the satellite. The satellite can receive DCP transmissions from stations as far as 1,200 miles normal to its orbit. Data transmissions and relay are accomplished generally during two to three daylight orbits and two to three nighttime orbits, therefore, possible data transmissions are limited by two-thirds for this area.

DCP at field sites are battery powered and operate with ADR or analog voltage sources and signals from a wide range of hydrologic data sensors. In this study, the DCP was connected to the ADR only. The DCP will accept data input from as many as four ADR or eight analog recorders (voltage sources).

Table 2.--Data acquisition via Landsat relay system

	FUNCTION
Field Site	
1. Anclote River near Elfers streamflow station[1]	a. Transmits data at 3-minute intervals to Landsat relay system when mutual visibility exists.
2. Eisenhower Boulevard rainfall station[2]	
Ground Receive Sites	
1. Beltsville, Md.	a. Data received from Landsat relay system and recorded on magnetic devices;
2. Goldstone, Calif.	
	b. Data undergo editing, reduction, formatting, and relay to Reston, Va., on continuous basis.
Computer	
USGS Computer Center Reston, Va.	a. Data recorded on intermediate magnetic tape;
	b. DCS file updated at 1700 hours each day.
Local Users	
1. Southwest Florida Subdistrict (USGS)	a. Interrogate DCS file through local terminal facility. Current data are generally available 12 hours following transmission from field site.
2. Southwest Florida Water Management District	

[1] Site 4, table 3 and figure 6.
[2] Site 3, table 3 and figure 6.

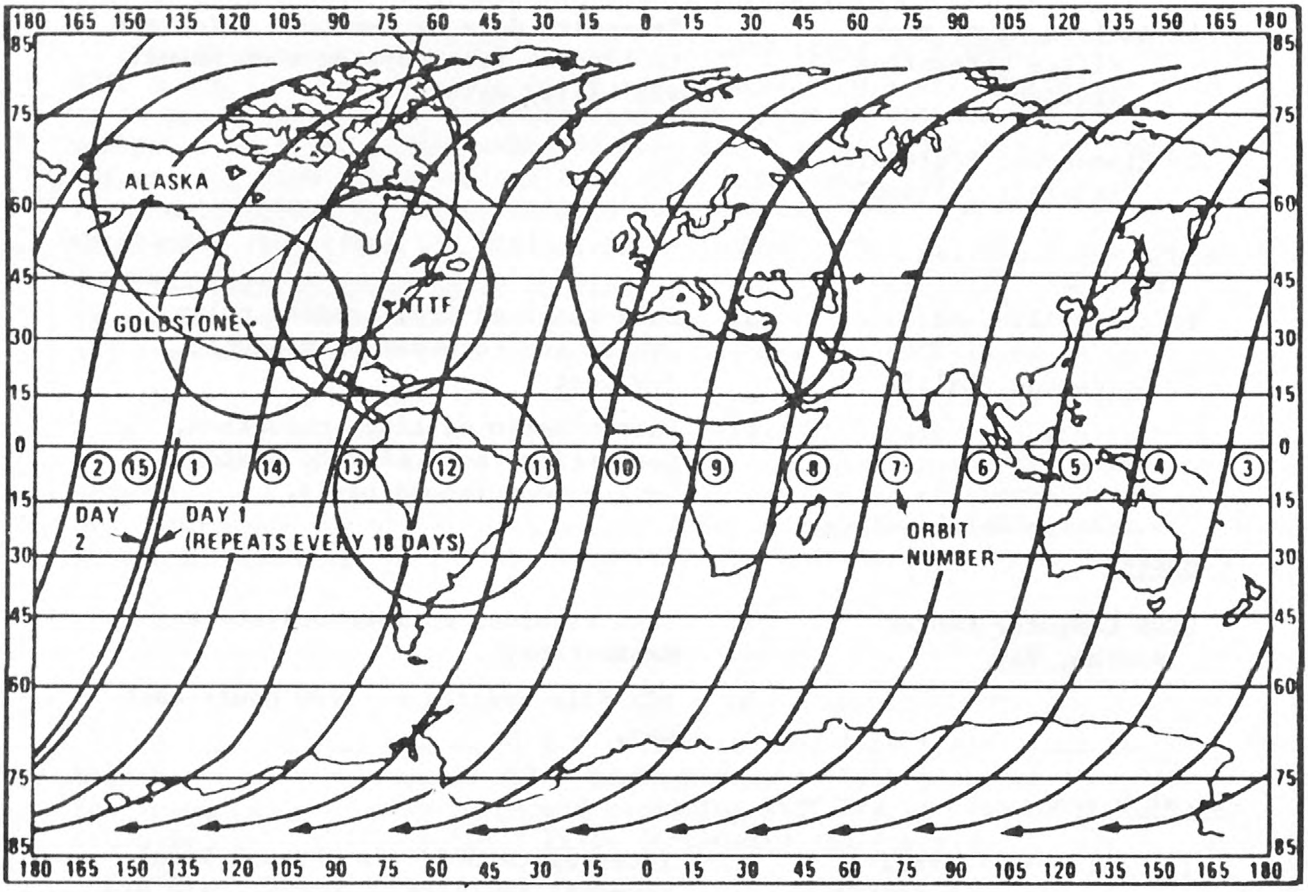

Figure 5.--Typical daylight orbital transits for the Landsat satellite (after National Aeronautics and Space Administration handbook).

Current data are punched on paper tape by an ADR at selected time intervals from 5 to 60 minutes. This function is controlled by a timer independent of the DCP. During the recording cycle, a new data value is stored by magnetic switches inside the ADR. The DCP interrogates the switches before each data transmission and transmits data as two 8-bit digital words.

All DCP transmit on the same frequency to Landsat using omnidirectional antennas. Radio transmissions occur continuously at intervals of approximately 1-1/2 or 3 minutes and are completed in about 38 milliseconds. The antenna emission is in the form of an inverted 140° cone. Transmissions include the stored data and the DCP identification. The DCP transmits on random time schedules but interference from other DCP does occur. The chance of at least one successful DCP transmission every 12 hours is about 95 percent.

HYDROLOGIC APPLICATIONS

Remote data-acquisition systems were tested at several data-collection sites in the Southwest Florida Water Management District during 1977-78. Data sites selected, type of telemeter used, and hydrologic data monitored are summarized in table 3. Sites proposed for instrumentation during 1978 are also listed. Locations of telemeter sites are shown in figure 6. River stage, used for computation of daily streamflow records, was obtained at one network site, and rainfall was obtained at one network site and one test site. River stage, rainfall, and groundwater level sites are included in telemetry installations proposed for 1978.

River Stage, Alafia River at Lithia

The land-line system was used in the operation of the DARDC located at the Alafia River at Lithia streamflow station (site 1, fig. 6). The station is at State Highway 640 about 10 miles southeast of Tampa. Equipment at the station include an ADR and water-level sensing device, the DARDC, and telephone related devices. The equipment is housed in a small shelter over a stilling well attached to the downstream side of the bridge. Water levels in the stilling well are maintained at stream level through intake pipes extending from the stilling well into the stream. Stream stages are punched on paper tape by the ADR at hourly intervals.

The DARDC may be interrogated as often as desired for purposes of hydrographing or tabulating the river stage. If desired, stage could be obtained at sufficient time intervals to define the daily mean and extremes. Stored values are changed as often as the ADR punch interval. Any new data are available 10 seconds following completion of the ADR punch cycle. Doubtful readings can be verified by reinterrogation, hydrographic comparison, or later by comparison with the ADR tape. Validity of the data is discussed later in the section on systems reliability.

Table 3.--Summary of existing and proposed remote data-acquisition sites in southwest Florida

Site number 1/	Station name	Location	Type of unit	Type of data monitored
1	Alafia River at Lithia.	At State Highway 640, Hillsborough County.	DARDC	Stream stage.
2	Nature's Classroom rainfall near Thonotosassa.	Hillsborough River 6.4 mi downstream from Flint Creek, Hillsborough County.	CDCP	Rainfall.
3	Rainfall at Eisenhower Blvd. near Tampa.	4710 Eisenhower Blvd., Tampa.	DCP	Rainfall.
4	Anclote River near Elfers.	At State Highway 54, Pasco County.	DCP	Stream stage.
5	Rock Ridge rainfall near Providence.	Rock Ridge in northern Polk County.	CDCP	Rainfall.
6	Brooker Creek near Tarpon Springs.	Tarpon Woods in Pinellas County.	CDCP	Stream stage.
7	Flint Creek near Thonotosassa.	At Lake Thonotosassa in Hillsborough County.	CDCP	Stream stage.
8	Pebbledale Road Deep Well near Pierce.	Near Pierce in Polk County.	CDCP	Water level.
9	Romp 50 Deep Well near Wimauma.	Sun City Center in Hillsborough County.	CDCP	Water level.

Sites 1-4 currently in operation.
Sites 5-9 installed 1978.

DARDC - Device for automatic remote data collection operated with existing telephone lines.
DCP - Data collection platform operated with Landsat orbiting satellite.
CDCP - Convertible data collection platform that can be operated with either Landsat or GOES systems.

1/ Site number refers to station locations shown on figure 6.

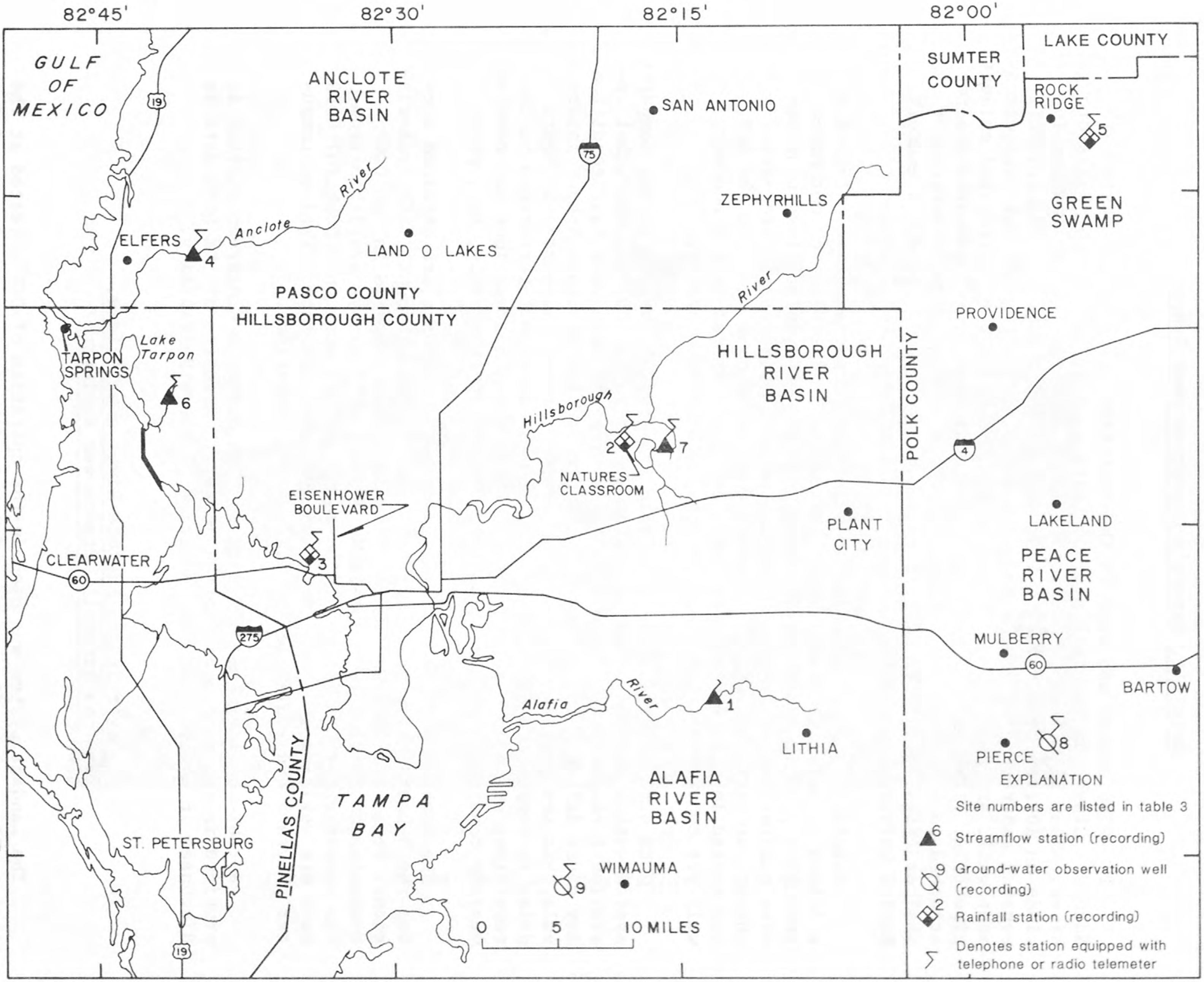

Figure 6.--Location of telemetry instruments.

Rainfall, Nature's Classroom near Tampa

The GOES system was used in the operation of the CDCP located at Nature's Classroom rainfall station (site 2, fig. 6) near the Hillsborough River, about 11 miles northeast of Tampa. Equipment at the station include an ADR, rainfall sensing instruments, and the CDCP. The rainfall sensing and recording equipment, with attached 3-inch diameter pipe catchment well, are housed in a small shelter supported by a corrugated culvert pipe (fig. 7). The CDCP and associated equipment are in a nearby shelter attached to a concrete floor, about 12 feet from the rainfall recorder shelter (figs. 8 and 9). Interface cables are routed through a conduit buried between the shelters.

Rainfall is measured using an 8-inch circular catchment attached to a 3-inch diameter receiving well. Rainwater drains from the catchment through a plastic tube to the receiving well. The rainfall sensing device monitors water-level changes in the receiving well. Water-level changes are sensed every 15 minutes, punched on paper tape by the ADR, and stored in the CDCP. Water-level changes measured in the recovery well are converted to inches of rainfall later by computer.

GOES data are generally available from the Geological Survey computer system within about 8 hours following transmission from the CDCP, but operational constraints of the computer system and telephone line condition may cause delays. The computer files are updated at about 6-hour intervals, but the current workload on the computer may cause several hours delay in completing data retrievals. Telephone line interference is intermittent and occurs as the result of equipment malfunctions and adverse weather conditions from west-central Florida to the Reston, Va., area.

The most current data available from the computer are obtained during the 3-hour period prior to the latest (or most recent) CDCP transmission. Because of overlapping or redundant data imbedded in the CDCP transmission, virtually complete data are nearly always available from the computer for the Nature's Classroom rainfall station. Doubtful GOES data are verified by graphical comparison with ADR tape. Various computer programs are available for making this comparison.

A table summarizing GOES data for the Nature's Classroom station is provided in the supplement to this report. Accuracy of the GOES data is discussed in a later section, entitled "Systems Reliability."

River Stage, Anclote River near Elfers, and Rainfall, Eisenhower Boulevard

The Landsat system was used in the operation of DCP's tested at the Anclote River streamflow station (site 4, fig. 6) in Pasco County, 3.5 miles east of Elfers, and at a rainfall station at the Geological Survey Tampa office on Eisenhower Boulevard (site 3, fig. 6).

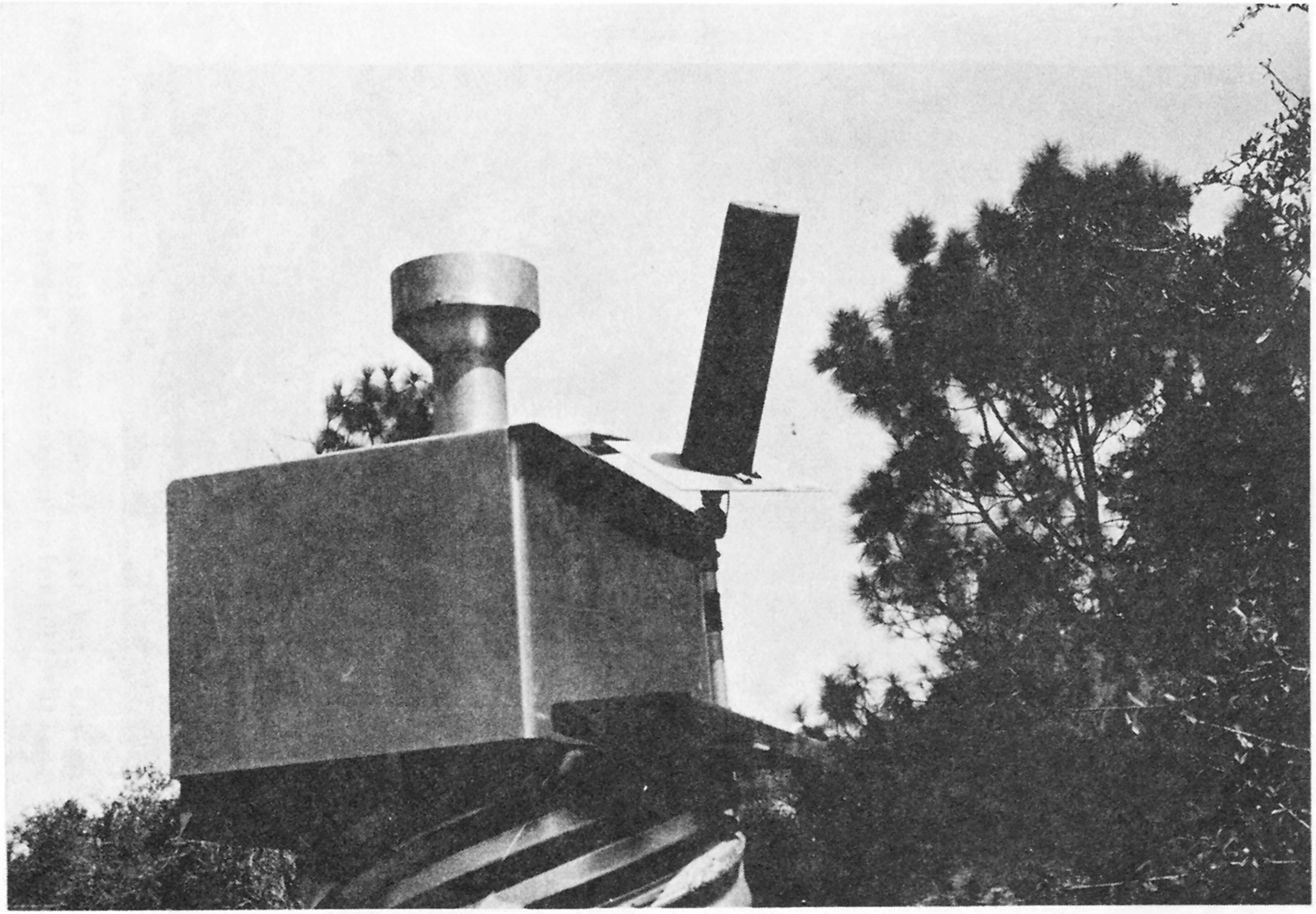

Figure 7.--Nature's Classroom rainfall station.

Figure 8.--Antenna, solar panel, and instrument shelter for GOES telemeter (CDCP) at Nature's Classroom rainfall station.

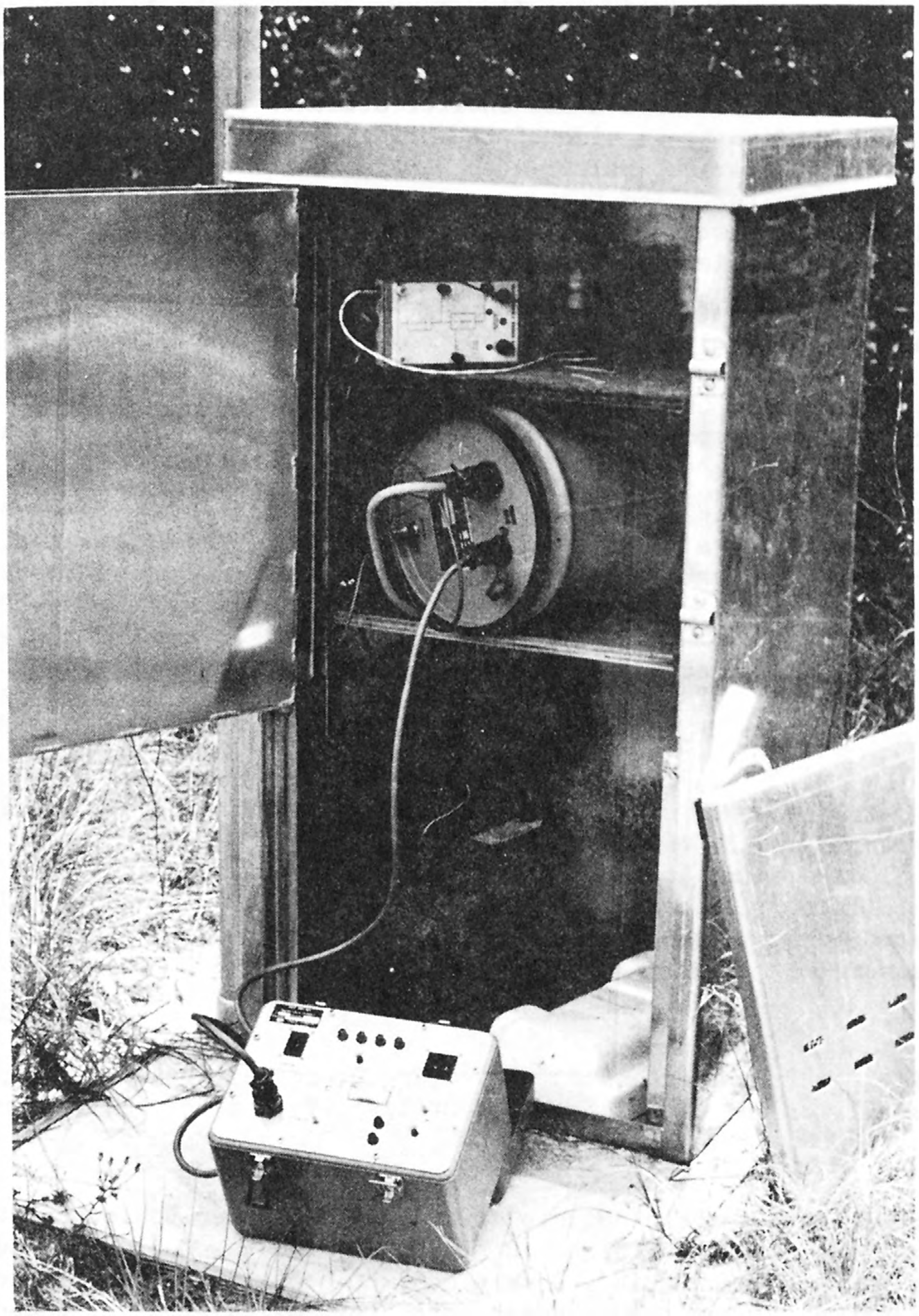

Figure 9.--GOES telemeter (CDCP), test set, and related instrumentation at Nature's Classroom rainfall station.

Hydrologic sensing and recording instruments at the Anclote River station are the same general type as that used at the Alafia River streamflow station discussed in a preceeding section. Hydrologic instruments and the DCP are housed in a small shelter attached to the top of a stilling well on the downstream side of the bridge. Batteries used for power supply are in a separate shelter attached to a walkway about 8 feet from the equipment shelter. The DCP antenna and related support members are attached to the walkway about 5 feet from the equipment shelter. Antenna and power supply cables connecting to the DCP are protected by conduit.

The satellite relayed stages are converted to discharge by computer through a stage-discharge rating. Stream stages, recorded hourly at the station, are punched on paper tape by the ADR and are processed at the Geological Survey Tampa office to evaluate accuracy of relayed data.

Rainfall sensing and recording instruments located at the Eisenhower rainfall station are similar to those described previously for the Nature's Classroom rainfall station. Rainfall sensors, ADR, and the DCP are housed in a small shelter mounted over a receiving well (fig. 10). The DCP antenna is supported by an aluminum pipe attached to an office building (fig. 11). Power is provided by several wet-cell batteries located in a nearby shelter (fig. 12). Battery cables between shelters are protected by plastic tubing.

The Eisenhower rainfall station is equipped with an additional rainfall measuring device referred to as a "tipping-bucket gage". The device uses an electronic digital counter that is advanced one count each time a pivoted collector is dumped by the accumulation of 0.01 inch of rainfall. Accumulated count is continuously available to the DCP. Rainfall, after being measured by the tipping-bucket gage, is drained to the receiving well.

ADR tapes from the Landsat system are processed locally on a programmable calculator and used to evaluate reliability of the DCP-transmitted data.

Landsat data for the Anclote River and Eisenhower Boulevard stations are normally available within about 12 hours from the Geological Survey computer system. Data that are relayed by Landsat after 5 p.m. each day are not available from the computer until the following day. Because Landsat has limited relay capability for this area of west-central Florida, only about 2 percent of all DCP transmissions are relayed successfully. Because of this limitation, Landsat data may not be useful in determining accurate daily means or extremes for river stage, discharge, or rainfall. Landsat data are verified with ADR tape record. A table of data relating to the Anclote River station is provided in the supplement to this report. Accuracy of Landsat data for both the Anclote River and Eisenhower Boulevard station is discussed in a subsequent section of the report, entitled "Systems Reliability."

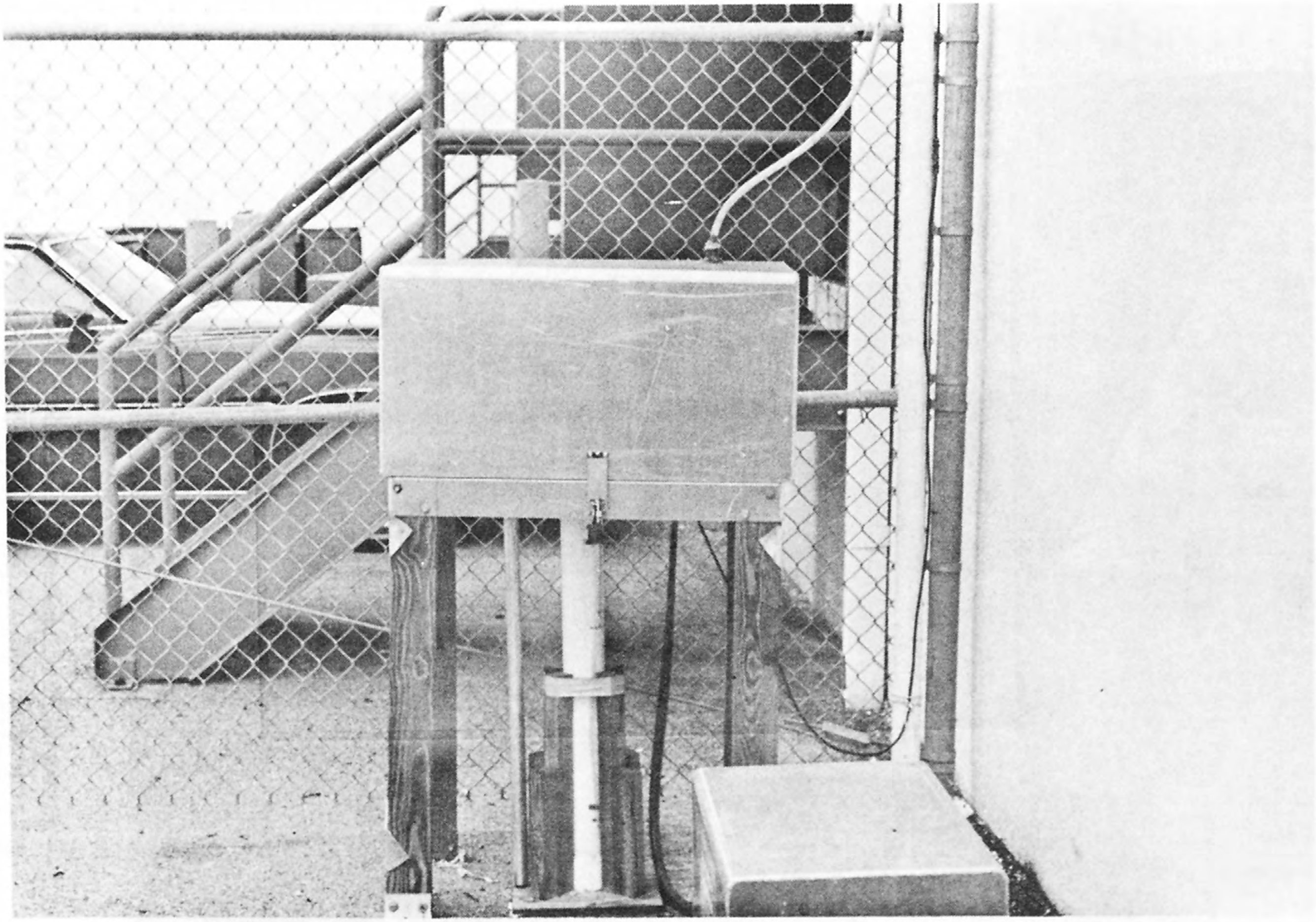

Figure 10.--Instrument shelters for Landsat telemeter (DCP) at Eisenhower Boulevard rainfall station.

Figure 11.--Antenna for Landsat telemeter (DCP) and rainfall catchment device at Eisenhower Boulevard rainfall station.

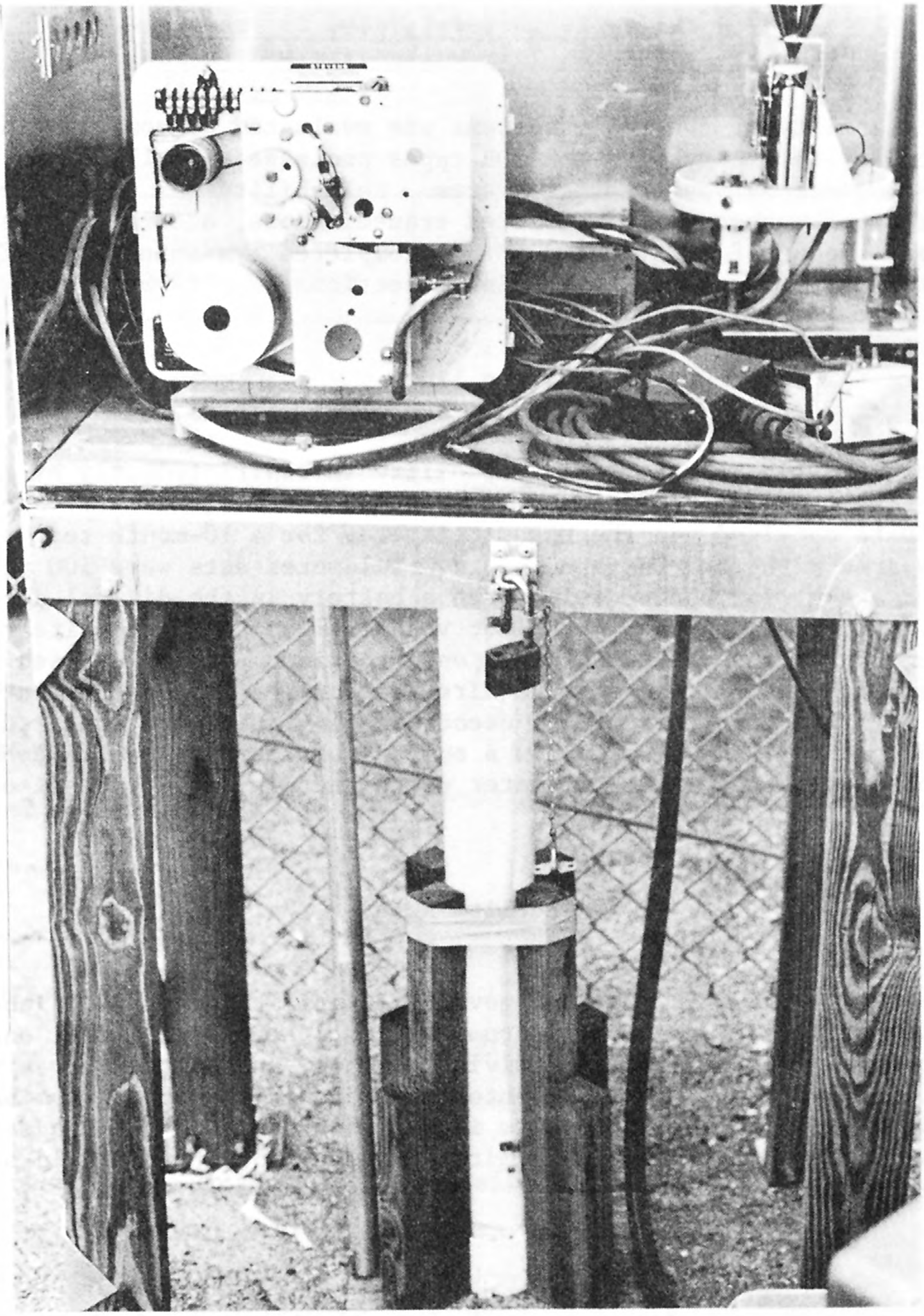

Figure 12.--ADR, Landsat telemeter (DCP), and tipping-bucket rain gage at Eisenhower Boulevard rainfall station.

SYSTEMS RELIABILITY

Reliability of the relay systems was evaluated by comparing data collected by telemetry with the ADR tapes processed locally or in the U.S. Geological Survey computer system. Reliability was determined as percentage of successfully completed transmissions, accuracy of relayed data, and amount of data lost due to uncompleted transmissions. The evaluations are discussed in remaining sections of this report.

Land Line

The land-line system relay capability is restricted only by recorder update frequency and condition of the telephone-line and interface equipment. Data obtained via the DARDC telemeter for a 10-month test period was compared with the ADR tape record. Telemeter data were 100 percent accurate except for one occasion when a battery in the digital decode-display unit was inoperative. Minor vandalism at the field site required reconnection of interface cables on one occasion. Batteries used for power supply at the field site required recharging at about 4-month intervals. Batteries for the digital decode-display unit were replaced about every 3 months. Table 4 provides a summary of responses to telephone interrogation of the DARDC telemeter using the digital decode-display unit.

Satellite Relay

There are many factors that govern reliability of the GOES and Landsat relay systems, including instrumentation of the field site, onboard the satellite, at the ground-receiving station, and at the Survey computer system. In addition, the GOES system has a rapid time-of-transmission criteria that occasionally results in malfunctions, and the Landsat system is in a near polar orbit which limits mutual visibility of field site and ground-receiving station.

GOES

The CDCP at Nature's Classroom rainfall station was tested for about 17 months, from October 1976 through February 1978. An analysis of GOES test data for the Nature's Classroom rainfall station is provided in table 5. These data are as follows: maximum number of rainfall observations possible each month; the number of monthly observations recorded by the ADR; the number of observations transmitted by the CDCP and the number received at the Survey computer; and the number of observations processed as rainfall data each month, including replacement of missing observations by previously transmitted observations (redundancy feature of CDCP). Also

Table 4.--Summary of DARDC interrogations for Alafia River at Lithia streamflow station, April 1977 through January 1978

Date	Number of interrogations	Number of responses	Number of interrogations resulting in data with 100 percent accuracy
1977			
April	3	1/ 2	1/ 2
May	6	6	6
June	19	19	19
July	4	4	4
August	12	2/ 11	2/ 11
September	4	4	4
October	8	8	8
November	4	4	4
December	4	4	4
1978			
January	4	3/ 3	4/ 2

1/ No response once owing to remote site battery failure.

2/ No response once owing to vandalism.

3/ Telephone line problems.

4/ Weak digital decode-display unit batteries once.

Table 5.--Analysis of GOES data for Nature's Classroom rainfall station, October 4, 1976, through February 28, 1978

Month	Number of 15-minute rainfall observations					Percent of transmitted observations that were received (4÷3) x 100 (6)	Percent of possible observations processed (5÷1) x 100 (7)
	Maximum possible (1)	Recorded in field (ADR) (2)	Transmitted from CDCP (including redundant observations) (3)	Received at USGS computer (including redundant observations) (4)	Processed (including redundant observations used for missing data) (5)		
1976							
Oct.	2,628	2,628	10,512	8,064	2,484	76.7	94.5
Nov.	2,880	2,880	11,520	7,488	1/ 2,328	65.0	80.8
Dec.	2,976	2,976	11,904	9,456	2,532	79.4	85.1
1977							
Jan.	2,976	2,976	11,904	6,144	2/ 1,992	51.6	66.9
Feb.	2,688	2,688	10,752	7,920	2,436	73.7	90.6
Mar.	2,976	2,976	11,904	6,288	2,364	52.8	79.4
Apr.	2,880	2,880	11,520	7,680	3/ 2,328	66.7	80.8
May	2,976	2,976	11,904	7,296	4/ 2,244	61.3	75.4
June	2,880	2,880	11,520	7,152	5/ 2,052	62.1	71.2
July	2,976	6/ 1,344	11,904	10,512	2,664	88.3	89.5
Aug.	2,976	2,976	11,904	11,184	2,928	94.0	98.4
Sept.	2,880	2,880	11,520	10,896	2,868	94.6	99.6
Oct.	2,976	2,976	11,904	11,520	2,976	96.8	100
Nov.	2,880	2,880	11,520	11,040	2,880	95.8	100
Dec.	2,976	7/ 2,976	11,904	11,040	2,784	92.7	93.5
1978							
Jan.	2,976	7/ 2,976	11,904	11,424	2,964	96.0	99.6
Feb.	2,688	2,688	10,752	10,608	2,688	98.7	100

NOTE.--Redundancy in this study refers to previously transmitted observations that appear in up to four sequential CDCP transmissions.

1/ No transmissions processed for 2 days in November 1976.
2/ No transmissions processed for 5 days in January 1977.
3/ No transmissions processed for 2 days in April 1977.
4/ No transmissions processed for 4 days in May 1977.
5/ No transmissions processed for 6 days in June 1977.
6/ ADR stopped July 8-21, 24-27, 1977, CDCP continued to function properly.
7/ Maximum useable readings - ADR malfunctioned and punched 50 percent too many times, CDCP continued to function properly.

shown, for each month, is the percentage of CDCP transmissions received each month at the Geological Survey computer and the percentage of all possible observations processed each month as rainfall data.

These data show that the GOES system relayed an average of 79 percent of all CDCP transmissions from the Nature's Classroom rainfall station during the test period. Monthly transmissions received varied from 51 to 88 percent (table 5, col. 6). Because of the CDCP data redundancy feature of repeating observations in from two to four sequential transmissions, 88 percent of all possible rainfall observations for the test period were processed as rainfall data; monthly observations received (table 5, col. 7) varied from 67 to 100 percent.

During the test period, an average of seven data transmissions was completed each day. Ninety-six percent of the time, at least one data transmission was completed each day, and 80 percent of the time, an average of 7.36 transmissions was completed each day (92 percent of the maximum number possible, fig. 13). A cumulative frequency distribution of successfully relayed data transmissions by the GOES system is shown in figure 13.

Accuracy of GOES data received, edited, and stored in the U.S. Geological Survey computer file was 100 percent. About 5 to 10 percent of the GOES data entered in the files were deleted because of processing and translation errors.

During the 17-month test period, there were 19 days having no completed CDCP transmissions. CDCP transmissions were not completed during these days because of satellite being turned off temporarily due to solar eclipse and equipment malfunction at the ground-receiving site. CDCP transmissions were also not completed during periods of other satellite launch and testing. On several occasions, the ADR malfunctioned for short periods of time and failed to update CDCP memory. The CDCP operated properly during these times. One CDCP malfunction occurred when an internal transmit interval counter failed to register properly and shifted the assigned transmit time. The cause of the malfunction was not determined; however, the CDCP operated satisfactorily when restarted.

The automotive battery that supplied power to the CDCP during the test period was maintained satisfactorily by a solar panel.

Examples of primary computation and formatting of GOES data are provided in the supplement to this report. The supplement also provides documentation required for retrieval and processing of GOES data.

Landsat

Two Landsat DCP's were tested, one for about 17 months and the other for about 8 months. Comparison with ADR tape data indicated that data

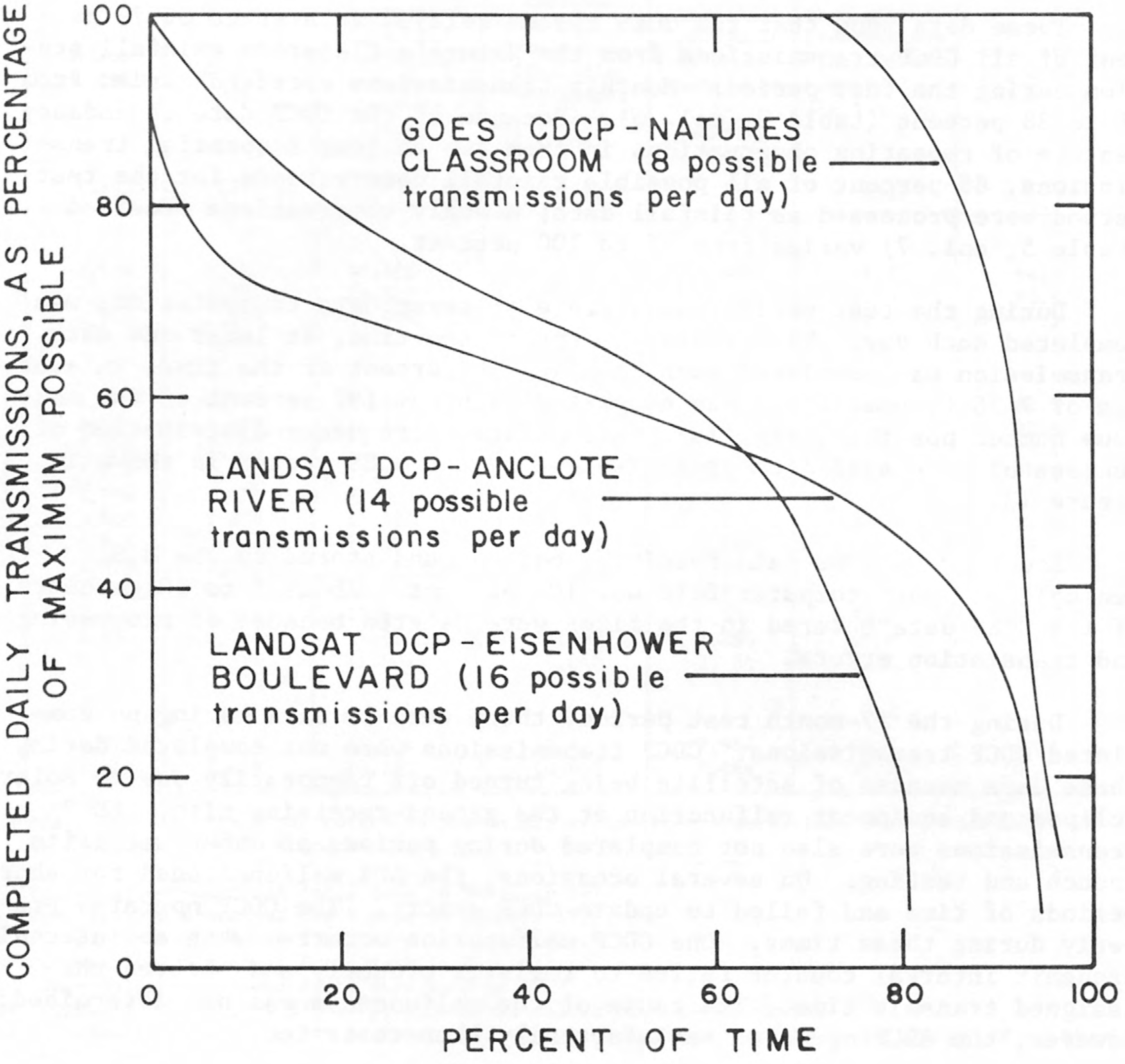

Figure 13.--Cumulative frequency distribution of successfully relayed data transmissions by GOES and Landsat systems.

transmissions relayed, edited, and stored in U.S. Geological Survey computer files were 100 percent accurate except for several short periods when the DCP malfunctioned.

Results of a detailed analysis of Landsat data for the Eisenhower Boulevard rainfall station and the Anclote River near Elfers streamflow station are summarized in tables 6 and 7. This analysis indicates that the Landsat system relayed, on the average, only 1.9 percent (tables 6 and 7, col. 9) of all DCP transmissions from the two sites during the test period, but that 57 percent (tables 6 and 7, col. 10) of transmissions possible during times of mutual visibility were successfully relayed. Monthly percentages for periods of mutual visibility vary from 8.3 to 75 percent.

During the test periods, an average of three data transmissions was completed each day for each site. Cumulative frequency distributions of successfully relayed data transmissions by the Landsat relay system are shown in figure 13 for the Eisenhower Boulevard and Anclote River sites. Eighty-eight percent of the time, at least one data transmission from each site was completed each day, and 80 percent of the time, an average of 4.34 transmissions was completed each day (31 percent of the maximum number possible, fig. 13).

During the test periods, there were a total of 77 days having no completed transmissions for the two sites. Data losses occurred because of system hardware malfunction at ground-receiving site, interference from other DCP's, and recording device overruns at the U.S. Geological Survey computer system. DCP's were inoperative for short periods because of battery failure, loss of antenna cable by vandalism, or for testing and replacement of components. Percentages of transmission receipt were not computed for periods when the local DCP was not operative or when data were not retrieved from the DCS file for short periods.

Automotive-type, lead-acid batteries used for DCP power supplies required recharging at about 10-month intervals. Equipment replaced during the test period included a battery, antenna cable, and a "plug-in" unit for the DCP located at the Anclote River near Elfers station.

Data retrieval with the local computer terminal allows monitoring of station status and need for service. Nonroutine service was required three times for the Eisenhower Boulevard station and once for the Anclote River station.

Examples of Landsat data and engineering unit tables used in compilation and computer program documentation for data retrievals are provided in the supplement to this report.

Table 6.--Analysis of Landsat data for Eisenhower Boulevard rainfall station, September 29, 1976, through February 28, 1979

Month or beginning and ending dates	Number of 15-minute rainfall observations								Percent of all DCP transmissions relayed (5÷3) x 100	Percent of all observations received (during mutual visibility (8÷4) x 100
			Transmitted by DCP		Received					
	Maximum possible (1)	Recorded in field (ADR) (2)	Total 1/ (3)	During periods of mutual visibility 2/ (4)	Site N (5)	Site G (6)	Both (7)	Total (8)	(9)	(10)
1976										
Sept. 29, 30	192	192	960	32	11	8	0	19	2.0	59
Oct. 1-13	1,248	1,248	6,240	208	82	19	5	4/ 96	1.5	46
Oct. 14-31	1,728	1,728	8,640	(3)	-	-	-	-	-	-
Nov. 1-17, 27-30	2,016	2,016	10,080	336	175	58	11	192	1.9	57
Nov. 18-26	864	864	4,320	(3)	-	-	-	-	-	-
Dec. 1-14, 18-31	2,688	2,688	13,440	448	204	104	25	283	2.1	63
Dec. 15-17	288	288	1,440	(3)	-	-	-	(5)	-	-
1977										
Jan.	2,976	2,976	14,880	496	29	14	2	6/ 41	0.3	8.3
Feb.	2,688	2,688	13,440	448	92	36	7	7/ 121	0.9	27
Mar.	2,976	2,976	14,880	496	-	-	-	(8)	-	-
Apr. 1-28	2,688	2,688	13,440	448	-	-	-	(9)	-	-
Apr. 29, 30	192	192	960	32	14	8	1	21	2.2	66
May	2,976	2,976	14,880	496	207	76	15	10/ 268	1.8	54
June	2,880	2,880	14,400	480	231	84	15	11/ 300	2.1	62
July 1-7, 21-31	1,728	1,728	8,640	288	130	55	11	12/ 174	2.0	60
July 8-20	1,248	0	6,240	208	-	-	-	(13)	-	-
Aug.	2,976	2,976	14,880	496	265	95	15	14/ 345	2.3	70
Sept. 1-19, 28-30	2,112	2,112	10,560	352	184	58	11	231	2.2	66
Sept. 20-27	768	768	3,840	128	-	-	-	(15)	-	-
Oct. 1-28, 31	2,784	2,592	13,920	464	223	103	21	305	2.2	66
Oct. 29, 30	192	0	960	32	-	-	-	(16)	-	-
Nov.	2,880	2,688	14,400	480	238	86	17	16/ 307	2.1	64
Dec. 1-21	2,016	2,016	10,080	336	133	51	11	173	1.7	52
Dec. 22-31	960	960	4,800	160	-	-	-	(17)	-	-
1978										
Jan. 1-11	1,056	1,056	5,280	176	-	-	-	(17)	-	-
Jan. 12-31	1,920	1,920	9,600	320	153	71	10	214	2.2	67
Feb.	2,688	2,688	13,440	448	179	67	15	18/ 231	1.7	52

N - National Training and Testing Facility, Greenbelt, Md.
G - Goldstone, Calif.

1/ 15-minute observations may be repeated in up to four DCP transmissions.

2/ In this study, a maximum of 16 transmissions were received during 6 possible periods of mutual visibility on any day.

3/ Data not obtained from DCS file.

4/ Landsat data lost all or part of each day, October 7, 8, 9-12, 22-26. No transmissions processed for 4 days.

5/ Landsat data lost all or part of each day, December 14-16.

6/ Landsat data lost all or part of each day, January 2, 3, 13-31. No transmissions processed for 5 days.

7/ Landsat data lost part of each day February 1-15, 28. No transmissions processed for 17 days.

8/ DCP inoperative. Landsat data lost all or part of each day, March 26-28.

9/ DCP inoperative. Landsat data lost part of each day, April 6, 7.

10/ Landsat data lost part of each day, May 8-11, 17, 25-26. No transmissions processed for 2 days.

11/ Landsat data lost all or part of each day, June 1, 2, 5, 6, 17-20, 22, 23, 30. No transmissions processed for 4 days.

12/ Landsat data lost all or part of each day, July 1-5. No transmissions processed for 3 days.

13/ DCP inoperative (ADR removed) July 8-19.

14/ Landsat data lost all or part of each day, August 7-9, 28, 29.

15/ Landsat data lost all or part of each day, September 5, 6, 11, 12. No transmissions processed for 8 days. Data set at Goddard Space Center malfunctioned September 19-28.

16/ Landsat data lost all or part of each day, October 28-31. No transmissions processed for 2 days. ADR stopped October 28 to November 2.

17/ DCP battery failed December 22 to January 11.

18/ No transmissions processed for 2 days.

Table 7.--Analysis of Landsat data for Anclote River near Elfers streamflow station, July 3, 1977, through February 28, 1979

Month or beginning and ending dates	Number of 15-minute stage observations								Percent of all DCP transmissions relayed (8÷3) x 100	Percent of all observations received (during mutual visibility (8÷4) x 100
			Transmitted by DCP		Received					
	Maximum possible (1)	Recorded in field (ADR) (2)	Total[1] (3)	During periods of mutual visibility[2] (4)	Site N (5)	Site G (6)	Both (7)	Total (8)	(9)	(10)
1977										
July 8-31	2,208	2,208	11,040	322	204	44	7	241	2.2	75
Aug.	2,976	2,976	14,880	434	245	51	15	[3]281	1.9	65
Sept. 1-19, 28-30	2,112	2,112	10,560	308	168	31	7	[4]192	1.8	62
Sept. 20-27	768	768	3,840	112	-	-	-	(5)	-	-
Oct. 1-28, 31	2,784	2,784	13,920	434	218	62	12	268	1.9	62
Oct. 29, 30	192	192	960	28	-	-	-	(6)	-	-
Nov.	2,880	2,880	14,400	420	232	40	11	[7]261	1.8	62
Dec.	2,976	[8]2,304	11,520	434	215	42	10	[7]247	2.1	57
1978										
Jan.	2,976	[8]2,496	12,480	434	241	61	17	[7]285	2.3	66
Feb. 1, 2, 6-28	2,400	2,400	12,000	350	157	37	5	[7]189	1.6	54
Feb. 3-5	288	288	1,440	42	-	-	-	(9)	-	-

N - National Training and Testing Facility, Greenbelt, Md.
G - Goldstone, Calif.

[1] 15-minute observations may be repeated in up to four DCP transmissions.

[2] In this study, a maximum of 14 transmissions were received during 6 possible periods of mutual visibility on any day.

[3] Landsat data lost part of each day, August 7-9, 28, 29.

[4] Landsat data lost all or part of each day, September 5, 6, 11, 12.

[5] Data set at Goddard Space Center malfunctioned, September 19-28. No transmissions processed for 8 days.

[6] Landsat data lost all or part of each day, October 28-31. No transmissions processed for 2 days.

[7] Partial erroneous digital decoding due to malfunction of digital multiplexer in DCP.

[8] ADR stopped December 24 to January 5, DCP continued to function.

[9] Landsat data lost all or part of each day, February 2-6. No transmissions processed for 3 days.

SUMMARY AND CONCLUSIONS

Remote data-acquisition systems operated during 1977-78 in the Southwest Florida Water Management District were evaluated in this study, including a land-line and two satellite systems. The land-line system was operated using a programmable calculator and a digital decode-display unit and telephone lines. The satellite systems were operated in conjunction with GOES and Landsat and the U.S. Geological Survey computer system in Reston, Va.

The land-line system is considered a reliable means of obtaining real-time data from remote stations. The system could be used for the acquisition of data, on a continuous basis, if it were operated under control of a dedicated computer having automatic dialing and internal timing capability.

The land-line system provided data for one streamflow site 94 percent of the time during the test period. Transmitted data were accurate. The system was inoperative for several occasions because of telephone-line interference and battery failure in the decode-display unit. The system required maintenance only for cable re-connection and battery replacement.

The satellite relay systems were tested in remote areas where access is difficult or limited. Satellite systems tested allow nearly direct computer storage of relayed data, which may be important in manpower savings over methods now used for routine collection and processing of hydrologic records from large networks.

The GOES system was tested at a rainfall site for a period of 17 months. During this period, 79 percent of all CDCP transmissions from the site were relayed by the GOES system to the Geological Survey computer system and resulted in successful processing of 88 percent of all possible rainfall observations. On the average, seven data transmissions were completed each day. Ninety-six percent of the time, at least one data transmission was completed each day, and 80 percent of the time, an average of more than seven transmissions was completed each day.

Transmitted data were normally available within about 8 hours after recording at the field site and were virtually as accurate as ADR records processed routinely. Data losses occurred as the result of malfunction of instruments on board the GOES and at the ground-receiving station. Data transmissions were also interrupted while data channels were turned off during occasional periods of satellite launch and testing. Although the GOES system operates on a very rigid time schedule, little data were lost due to off schedule transmissions. Redundancy of the system aids in minimizing data losses. The system requires specialized training for personnel who service the field instruments.

The Landsat system was tested at a streamflow site for about 8 months, and at a rainfall site for about 17 months. During these test periods, an average of 57 percent of all DCP transmissions during periods of mutual visibility was relayed by the Landsat system to the Geological Survey computer system. On the average, three data transmissions were completed each day for each site. Eighty-eight percent of the time, at least one data transmission from each site was completed each day, and 80 percent of the time, an average of more than four transmissions was completed each day for each site.

Data were normally available within about 12 hours after recording at the field sites. Transmitted data were virtually as accurate as ADR records. Occasional data losses occurred as the result of instrument malfunctions. Data losses also occurred during periods of satellite launch and testing. Opportunity for successful data relay is limited by the orbital path of Landsat. Therefore, the system does not provide data required to compute accurate mean daily or extreme values of some hydrologic variables. Except for battery replacement, only one equipment malfunction occurred during the study. Spare "plug-in" electronic units were used for servicing and minor field repairs.

Satellite-relay systems described in this report could be classified as automated systems; and, with some modification, the land-line system could also be used as an automated system. Automated systems provide a useful means for collecting, processing, and disseminating data from a local, regional, or larger area on a near real-time basis. Automated systems also allow maintenance of a high level of reliability and accuracy of data that cannot be easily attained using conventional methods. Operation of data networks with systems evaluated as part of this study is feasible. However, operational characteristics of the various systems described may limit applicability in Florida and other areas of the country. For example, the Landsat system could not provide data at a frequency adequate to define rapid changes, occurring in an hour or less, in flooding of a small stream, or mean daily discharge of a stream when discharge is highly variable. Many improvements in existing data handling procedures, particularly computer hardware and software, will be required for a system to operate in a highly efficient manner and with minimum data loss for large areas.

All systems tested as part of this study are dependent on the telephone system which may become inoperative during severe storms, particularly hurricanes, that occur with some regularity on the southeastern coast of the United States. Under these conditions, near real-time data would not be available for network stations. However, records collected at the field sites would be available to verify and complete records for these periods.

Based on results of this study, five additional GOES sites were instrumented with CDCP's during 1978. No additional sites will be instrumented for Landsat because of limited data receipt experienced with DCP's. Data from this network of eight satellite stations (six GOES and two Landsat) will be used in a final phase study during 1979 to determine cost effectiveness of using satellite relay systems to operate a small hydrologic network in west-central Florida. Network stations will provide monitoring data to the Southwest Florida Water Management District for use in conducting regulatory and water management functions.

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SUPPLEMENT

PROCESSING OF SATELLITE RELAYED DATA BY COMPUTER

Hydrologic data are relayed to the U.S. Geological Survey computer system by the GOES and Landsat systems. Incoming data are encoded telemeter transmissions. These data are stored in two files. Data relayed by the GOES relay system are stored in the GOES DCS File, and data relayed by the Landsat relay system are stored in the WRD Satellite Data Collection System File. Several cataloged procedures are used to access these files to retrieve and convert telemeter data into hydrologic data with proper engineering units, and to complete other desired processing, storage, and dissemination of data.

Cataloged procedures used to process data relayed by the GOES system include GOESRTV and GOESADR. GOESRTV is a procedure used to retrieve encoded telemeter data from the GOES DCS file and output the data in desired formats, such as hard copy, punched cards, or data sets on magnetic devices. The GOESADR procedure consists of programs J200 and E659. Preprocessor program J200 is used to retrieve and convert telemeter data into sensor data and format for input to primary processing program. Input to the primary processing program, E659, is the same format as a punched paper tape from an ADR. The primary computation program, E659, converts sensor records into hydrologic data with appropriate engineering units. Data are output in desired formats.

The ERTSDCP cataloged procedure is used to process data relayed by the Landsat system. The procedure has two subprograms, H291 and H292. Program H291 retrieves and formats encoded telemeter data for input to program H292. Program H292 converts telemeter data into sensor data with proper engineering units. Output from the procedure includes table of hydrologic data in proper engineering units.

A summary of procedures and programs used to process satellite relayed data on the U.S. Geological Survey computer system is presented in table 8.

Each procedure is described in detail in the following sections of this supplement. Special attention is given to information required to execute the procedure and resulting program output. Sufficient information is provided for users to access and process satellite relayed data from a remote terminal.

Much of the information provided in this supplement was summarized or abstracted from the U.S. Geological Survey WATSTORE User's Guide, volume 5, chapter IV, covering processing of satellite-relayed data.

Table 8.--Procedures used for processing GOES and Landsat data

Catalog procedure	Program number	Function	Input	Output	Computer file
GOESRTV	J201	Retrieves encoded telemeter data and formats for special output.	Control cards	Encoded telemeter data as hard copy, punched cards or magnetic tape or disk.	GOES DCS
GOESADR	J200	Retrieves, decodes telemeter data into sensor data and formats for input to primary processing program, E659.	do.	Pseudo punched paper tape from digital recorder.	Do.
	E659	Primary data computation.	do.	Hard copy listing of hydrologic data with appropriate engineering units.	Do.
ERTSDCP	H291	Retrieves encoded telemeter data and formats records for input to translation program.	do.	Telemeter records as temporary data set on magnetic device.	WRD Satellite DCS
	H292	Decode telemeter data into sensor record and converts sensor records to engineering units.	do.	Tables of converted sensor data.	Do.

GOES DCS FILE

Data Retrieval (GOESRTV)

Data from the GOES satellite-relay system are stored in the GOES DCS file maintained in the U.S. Geological Survey computer system, Reston, Va. A cataloged procedure, GOESRTV, is used to retrieve records from the GOES DCS file and output the data in print or punch format, or store the data on magnetic devices. Users may supply their own programs to convert file data to desired engineering units. Retrieved data are identified by eight hexadecimal characters assigned to the CDCP, and a starting and ending date and time.

Control Cards

The retrieval program, J201, requires a control card for each set of data to be retrieved. Each card specifies data to be retrieved and disposition option, including PRINT, PUNCH, or STORE. Any number of control cards may be included in a data retrieval.

If the STORE option is selected, information defining the data set being created is required on the procedure EXEC card, a job control language (JCL) procedure card. This will be explained under "Execution of the Procedure." Preparation of control cards is described as follows:

Column(s)

1-8 CDCP Identifier. -- Enter the eight hexadecimal characters that identify the CDCP.

9-14 Starting Date. -- This field should contain the starting date of the data to be retrieved. Where starting time is not specified, the retrieval will begin with the earliest record of the CDCP. Subfields are coded as follows:

(9-10) Enter the two least significant digits of the starting year.
(11-12) Enter the starting month; "01" for January, "02" for February, and so forth.
(13-14) Enter the starting day; "01" for day 1, "02" for day 2, and so forth.

15-18 Starting Time. -- This field should contain the starting time, Universal Time Coordinated (UTC), of the data to be retrieved. If blank, the retrieval will begin with the first record on the specified date. Subfields are coded as follows:

(15-16) Enter the starting hour (UTC).
(17-18) Enter the starting minute. If blank, the retrieval will begin with the first record of the specified hour and date.

Column(s)

19-24 Ending Date. -- This field should contain the ending date of the data to be retrieved. If blank, the retrieval will end with the most recent record for the specified CDCP. Subfields are coded as follows:

(19-20) Enter the two least significant digits of the ending year.
(21-22) Enter the ending month.
(23-24) Enter the ending day.

25-28 Ending Time. -- This field should contain the ending time (UTC) of the data to be retrieved. If blank, the retrieval will end with the most recent record for the specified date. Subfields are coded as follows:

(25-26) Enter the ending hour (UTC).
(27-28) Enter the ending minute. If blank, the retrieval will end with the most recent record for hour and date specified.

29-33 Output Option. -- To print, punch, or store retrieved card images, enter 'PRINT', 'PUNCH', or 'STORE'.

34-80 Blank.

The following control card is typical for program J201:

```
-----------------------------------CARD IMAGE-----------------------------------
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

16CB731470209               PRINT
```

Data Output

For each set of records retrieved, the program prints the CDCP identifier, option selected, the date and time of the first and last record (transmission), number of records retrieved, number of lines printed, number of card images produced, and number of records deleted. The times printed in this summary are the actual times on the first and last record, and may or may not be the same as the times specified on the control card. An example of this summary is shown in table 9.

Table 9.--Sample program activity summary for the GOES retrieval program

```
                    PROGRAM ACTIVITY SUMMARY FOR THE GOES RETRIEVAL PROGRAM

  DCP                STARTING          ENDING         RECORDS          LINES        CARD IMAGES     RECORDS
 IDENT     OPTION   DATE      TIME   DATE      TIME   PROCESSED        PRINTED     STORED/PUNCHED   DELETED

16CB7314   PRINT   09/02/77 01:15  09/12/77 19:15        79              237              0               0
```

Execution of the Procedure

The following procedure should be used if card images are to be printed or punched, but not stored:

```
-----------------------------------CARD IMAGE-----------------------------------
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

/*RELAY  PUNCH RE2
//         JOB
/*PROCLIB  WRD.PROCLIB
// EXEC    GOESRTV
//SYSIN  DD *
           .
           .
         CONTROL CARDS FOR PROGRAM J201
   (NO CONTROL CARD SHOULD HAVE THE STORE OPTION)
           .
           .
/*
//
```

An example of the card image printout of raw data obtained using the above procedure is shown in table 10. Raw data format and redundancy are illustrated in table 11.

The following procedure should be used if card images are to be stored on a magnetic tape:

```
-----------------------------------CARD IMAGE-----------------------------------
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

/*RELAY  PUNCH RE2
//         JOB
/*PROCLIB  WRD.PROCLIB
/*SETUP    TAPENO/XR
           ¬¬¬¬¬¬ ¬
//       EXEC GOESRTV,NAME1=DATA SET 1,UNIT1=DEVICE1,
                            ¬¬¬¬¬¬¬¬¬¬       ¬¬¬¬¬¬¬
//            VOL1=TAPE1,DISP1=KEEP
                   ¬¬¬¬¬
//SYSIN  DD *
           .
           .
         CONTROL CARDS FOR PROGRAM J201
   (AT LEAST ONE CONTROL CARD SHOULD HAVE THE STORE OPTION)
           .
           .
/*
//
```

Table 10.--Sample of GOES data (raw) for Nature's Classroom rainfall station

DCP ID	DATE YY DDD	TIME HH MM SS	LENGTH OF MEMORY	CONTENTS OF THE MEMORY 1 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
16CB7314	77 245	01:15:11	192	G@E@@@@@G@E@@@@@G@E@@@@@G@E@@@@@G@E@@@@@G@E@@@@@G@E@@@@@H@E@@@@@I@E@@@@@I@E@@@@@ I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@ I@E@@@@@@AE@@@@@@AE@@@@@@AE@@@@@
16CB7314	77 245	04:15:11	192	I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@I@E@@@@@@AE@@@@@ @AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@ @AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@
16CB7314	77 245	07:15:11	192	@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@ @AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@ @AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@
16CB7314	77 245	10:15:12	192	@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@ @AE@@@@@@AE@@@@@@AE@@@@@@AE@@@@@IAE@@@@@BBE@@@@@BBE@@@@@CBE@@@@@CBE@@@@@CBE@@@@@ CBE@@@@@CBE@@@@@CBE@@@@@CBE@@@@@
16CB7314	77 245	16:15:12	192	CBE@@@@@CBE@@@@@CBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@ DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@ DBE@@@@@DBE@@@@@EBE@@@@@EBE@@@@@
16CB7314	77 245	19:15:12	192	DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@ EBE@@@@@EBE@@@@@EBE@@@@@EBE@@@@@EBE@@@@@FBE@@@@@FBE@@@@@FBE@@@@@FBE@@@@@GBE@@@@@ GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@
16CB7314	77 245	22:15:12	192	EBE@@@@@EBE@@@@@EBE@@@@@EBE@@@@@FBE@@@@@FBE@@@@@FBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@ GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@ HBE@@@@@ACE@@@@@ICE@@@@@DDE@@@@@
16CB7314	77 246	01:15:12	192	GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@GBE@@@@@HBE@@@@@ACE@@@@@ ICE@@@@@DDE@@@@@GDE@@@@@HDE@@@@@@EE@@@@@AEE@@@@@BEE@@@@@CEE@@@@@DEE@@@@@EEE@@@@@ EEE@@@@@FEE@@@@@FEE@@@@@GEE@@@@@
16CB7314	77 246	04:15:12	192	GDE@@@@@HDE@@@@@@EE@@@@@AEE@@@@@BEE@@@@@CEE@@@@@DEE@@@@@EEE@@@@@EEE@@@@@FEE@@@@@ FEE@@@@@GEE@@@@@HEE@@@@@HEE@@@@@IEE@@@@@IEE@@@@@@FE@@@@@@FE@@@@@@FE@@@@@AFE@@@@@ AFE@@@@@AFE@@@@@AFE@@@@@BFE@@@@@
16CB7314	77 246	07:15:12	192	HEE@@@@@HEE@@@@@IEE@@@@@IEE@@@@@@FE@@@@@@FE@@@@@@FE@@@@@AFE@@@@@AFE@@@@@AFE@@@@@ AFE@@@@@BFE@@@@@BFE@@@@@BFE@@@@@CFE@@@@@DFE@@@@@EFE@@@@@FFE@@@@@HFE@@@@@@GE@@@@@ AGE@@@@@BGE@@@@@CGE@@@@@DGE@@@@@
16CB7314	77 246	10:15:12	192	BFE@@@@@BFE@@@@@CFE@@@@@DFE@@@@@EFE@@@@@FFE@@@@@HFE@@@@@@GE@@@@@AGE@@@@@BGE@@@@@ CGE@@@@@DGE@@@@@DGE@@@@@DGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@ EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@
16CB7314	77 246	16:15:12	192	EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@ EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@ EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@
16CB7314	77 246	19:15:12	192	EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@ EGE@@@@@EGE@@@@@EGE@@@@@EGE@@@@@FGE@@@@@FGE@@@@@FGE@@@@@FGE@@@@@FGE@@@@@FGE@@@@@ FGE@@@@@FGE@@@@@FGE@@@@@FGE@@@@@

Table 11.--GOES data format

CDCP ID	Julian date YR DAY	Time (UTC)*	Memory size set in CDCP	Partial Data Set (These data were punched on ADR and placed in CDCP memory during the time period 10:30 to 13:15 (UTC), but were not received on 13:15 transmission.)
16CB7314	77 245 Calendar date 9-2-77	16:15:12	192	10:30 10:45 11:00 11:15 11:30 11:45 12:00 12:15 12:30 12:45 CBE@@@@@CBE@@@@@CBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@ DBE@@@@@DBE@@@@@ 13:00 13:15
16CB7314	77 245	16:15:12	192	13:30 13:45 14:00 14:15 14:30 14:45 15:00 15:15 DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@ DBE@@@@@DBE@@@@@EBE@@@@@EBE@@@@@ 15:30 15:45 16:00 16:15 [These data transmitted at 16:15 represent data punched on ADR and placed in CDCP memory from 13:30 to 16:15. The 16:15 transmission included data from the previous three hours (10:30 to 13:15).]
				Total Data Set
16CB7314	77 245	16:15:12	192 4 characters per parm 2 parms 4 punches per hour 6 hours (4x2x4x6)= 192 characters	CBE@@@@@CBE@@@@@CBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@ DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@DBE@@@@@ DBE@@@@@DBE@@@@@EBE@@@@@EBE@@@@@ ADR data (latest data placed in memory at 19:15 hours) | ADR dummy 4250 | 0000 (digital conversion) 05.24 | 0.00 (inverted) (converted to decimal form see table 21)

*UTC: Universal Time Coordinated (formerly GMT); subtract 5 hours for EST.
Data is represented by ASCII character set.

where TAPEN0	Volume serial number of the output magnetic tape;
X	Use 7 if 7-track tape or 9 if 9-track tape;
DATASET1	Data set name (DSNAME) of the output tape;
DEVICE1	Device identifier of the output tape, for example, TAPE7 for 7-track tape, TAPE9 for a 9-track tape;
TAPE1	Volume serial number of the output magnetic tape.

Card images may be stored on disk as temporary or permanent data sets. If the card images are to be stored as a temporary data set for use in another program, named XXXX, then the following procedure should be used:

```
-----------------------------------CARD IMAGE-----------------------------------
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

/*PELAY  PUNCH RE2
//         JOB
/*PROCLIB  WRD.PROCLIB
//       EXEC GOESRTV.SP1=SPACE1
                          ¬¬¬¬¬¬
//SYSIN  DD *
           .
           .
         CONTROL CARDS FOR PROGRAM J201
   (AT LEAST ONE CONTROL CARD SHOULD HAVE THE STORE OPTION)
           .
           .
/*
//       EXEC PGM=XXXX
//STEP.INPUTFILENAME DD DSN=&&GOESDATA,DISP=(OLD,DELETE)
  ¬¬¬¬ ¬¬¬¬¬¬¬¬¬¬¬¬¬
/*
//
```

where SPACE1	Number of tracks allocated for the output data set (default value = 10);
STEP	Step name in which the passed data set is to be used;
INPUTFILENAME	Input file of the program using the passed data set.

If the card images are to be permanently stored on a private disk, the following procedure should be used:

```
-------------------------------------CARD IMAGE-----------------------------------
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

/*RELAY  PUNCH RE2
//         JOB
/*PROCLIB  WRD.PROCLIB
/*SETUP  DISKNO/DISK
         ¬¬¬¬¬¬
//       EXEC GOESRTV.NAME1=DATA SET 1,UNIT1=DEVICE1,
                            ¬¬¬¬¬¬¬¬¬¬       ¬¬¬¬¬¬¬
//            VOL1=DISK1.SP1=SPACE1,DISP1=KEEP
                   ¬¬¬¬¬     ¬¬¬¬¬¬
//SYSIN  DD *
           .
           .
         CONTROL CARDS FOR PROGRAM J201
   (AT LEAST ONE CONTROL CARD SHOULD HAVE THE STORE OPTION)
           .
           .
/*
//
```

where	DISKNO	Volume serial number of the output disk;
	DISK1	Volume serial number of the output disk;
	DATASET1	Name of the data set to be created;
	DEVICE1	Device identifier of the disk, code UNIT1=2314 or UNIT1=3330, or UNIT1=ONLINE, and so forth;
	SPACE1	Number of tracks allocated for the data set (default value = 10).

Processing GOES Data (GOESADR)

The GOESADR procedure is used for primary processing of data in the GOES DCS file. The procedure has a preprocessor that retrieves, interprets, and formats records for input to program E659. Record format is the same as that of an ADR punched paper tape. Program E659 is used for primary records computation. An example of primary computations for rainfall data for the Nature's Classroom station is shown in table 12.

The preprocessor formats data into STAGE or NONSTAGE records. STAGE records are used for processing of streamflow data. STAGE records are the first data recorded by the CDCP on each acquisition cycle. The STAGE records are processed by the E659 subprogram, XPRIME.

Table 12.--Sample of GOES data computation for Nature's Classroom rainfall station

```
                  UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION                  DIST 12
                                  PRIMARY COMPUTATIONS OF QUALITY OF WATER DIGITAL MONITOR RECORDS
280510082200000                                           DATA PROCESSED 09-13-77                              RT NO  1  TEST DIFF 10
     10H RAINFALL AT NATURE CLASS NR THONOTOSASSA,FLA
     ACCUMULATED RAINFALL (IN.)                                    PARAMETER CODE 00045     STORE STATISTICS        ,        ,

     PROVISIONAL DATA FOR WATER YEAR ENDING SEPT. 30, 1977
                                                                   VALUES AT INDICATED HOURS
S  DATE       MAX      MIN   TOTAL        1       2       3       4       5       6       7       8       9      10      11      12

   8-31       .01              .01* AM
                                    PM                                                                  501     501     502     502

   9-01       .02              .08  AM   502     502     502     502     502     502     502     502     502     502     502     502
                                    PM   502     507     507     508     509     509     509     510     510     510     510     510
   9-02       .09              .54  AM   510     510     522     523     523     524     524     524     524     524     525     526
                                    PM   527     527     527     527     544     551     555     557     559     561     562     564
A  9-03       .44             1.37  AM   570     574     575     575     575     575     575     575     575     575     575     576
                                    PM   576     576     576     576     576     659     696     699     701     701     701     701
   9-04       .08              .13  AM   701     701     701     701     701     701     701     701     701     701     701     701
                                    PM   701     701     701     712     713     713     714     714     714     714     714     714
   9-05                             AM   714     714     714     714     714     714     714     714     714     714     714     714
                                    PM   714     714     714     714     714     714     714     714     714     714     714     714

   9-06       .01              .01  AM   714     714     714     714     714     714     714     714     714     714     714     714
                                    PM   714     714     714     714     715     715     715     715     715     715     715     715
   9-07                             AM   715     715     715     715     715     715     715     715     715     715     715     715
                                    PM   715     715     715     715     715     715     715     715     715     715     715     715
   9-08                             AM   715     715     715     715     715     715     715     715     715     715     715     715
                                    PM   715     715     715     715     715     715     715     715     715     715     715     715
   9-09                             AM   715     715     715     715     715     715     715     715     715     715     715     715
                                    PM   715     715     715     715     715     715     715     715     715     715     715     715
   9-10                             AM   715     715     715     715     715     715     715     715     715     715     715     715
                                    PM   715     715     715     715     715     715     715     715     715     715     715     715

   9-11                             AM   715     715     715     715     715     715     715     715     715     715     715     715
                                    PM   715     715     715     715     715     715     715     715     715     715     715     715
   9-12                             AM   715     715     715     715     715     715     715     715     715     715     715     715
                                    PM   715     715     715     715     715     715     715     715     715     715     715     715
   9-13                             AM   715     715     715     715     715     715     715     715
                                    PM

NOTE.-     SYMBOLS USED ABOVE HAVE THE FOLLOWING MEANINGS
           A - SUCCESSIVE RECORDED PUNCH READINGS DIFFER BY MORE THAN THE SPECIFIED ALLOWABLE TEST DIFFERENCE
           R - ONE OR MORE INPUT VALUE IS OUTSIDE THE RANGE OF THE CONVERSION TABLE FOR THAT ITEM
           * - DAILY SUMMARY IS FOR AN INCOMPLETE DAY
           % - UNIT VALUES RECORD WRITTEN
```

The NONSTAGE records are the remaining data recorded during the CDCP data-acquisition cycle. The NONSTAGE records can be processed by any of the E659 subprograms including: XGWLEV, for ground-water level data; XQWMON, for digital-monitor data; and XTIDE, for tide-stage data.

Control Cards

Two sets of control cards are required for the GOESADR procedure; one set is for the preprocessor and the other is for program E659. Control cards for the preprocessor are described in this section. Control cards for program E659 are described in the WATSTORE User's Guide, volume 5, chapter 1, "Instructions for Processing Digital Recorder Records."

The preprocessor may require two types of control cards, including specifications (SPEC) and voltage (VOLT). A SPEC card defines a set of data to be retrieved, including types of data, number of ADR and analog records obtained each CDCP data-acquisition cycle, and the type(s) of record formatting to be accomplished by E659. At least one SPEC card must be provided for each job. VOLT cards are used to rescale (linearly) recorded analog voltages. Upper and lower limits for rescaled data must be provided as four-digit integers. VOLT cards are optional; and, if omitted, lower and upper limits of default, 1000 and 1999, are used. If default limits are used, a recorded value of 1000 represents 0 volts and a value of 1999 represents 5 volts.

Formats for SPEC and VOLT cards are described in the following section.

<u>Specifications (SPEC) Card</u>. -- Format of the SPEC card is as follows:

<u>Column(s)</u>	
1-4	<u>Type Card</u>. -- Enter SPEC;
5-12	<u>Station Number</u>. -- Enter standard downstream order number or the last 8 digits of 15-digit latitude-longitude number;
13-20	<u>CDCP Identification Number</u>. -- Enter the eight hexadecimal characters used to identify the CDCP;
21-23	<u>Daily Recording Cycle</u>. -- Enter the number of data-acquisition cycles per day; this number must be either 024, 048, or 096;
24-25	<u>Time Zone</u>. -- Enter the time zone in which the CDCP is operating. '04' = EDT '05' = EST, and so forth.

Column(s)

26-31 Starting Date. -- Enter starting date of the data to be processed; if blank, processing will begin with earliest data in the file. Subfields are coded as follows:

(26-27) Enter the two least significant digits of the starting year.
(28-29) Enter the starting month.
(30-31) Enter the starting day.

32-35 Starting Time. -- Enter starting time of the data to be processed; if blank, processing will begin at hour 24, minute 0 of the day preceding the specified day. Subfields are coded as follows:

(32-33) Enter the starting hour.
(34-35) Enter the starting minute; if blank, default is minute 0.

36-41 Ending Date. -- Enter ending date of the data to be processed; if blank, processing will continue until the most recent data have been processed. The subfields are coded as follows:

(36-37) Enter the ending year (two least significant digits).
(38-39) Enter the ending month.
(40-41) Ender the ending day.

42-45 Ending Time. -- Enter ending time of the data to be retrieved; if blank, the time will default to hour 24, minute 0. The subfields are coded as follows:

(42-43) Enter the ending hour.
(44-45) Enter the ending minute; if blank, the minute defaults to 59.

46-47 Data Types. -- Enter the number of records that entered memory during each data-acquisition cycle. This information is used by the preprocessor to determine number of four-bit records entered during a data-acquisition cycle and how these messages are to be interpreted, whether an ADR record or an analog record. Subfields are coded as follows:

(46) ADR Records. -- Enter the number of ADR records entered into the memory during a data-acquisition cycle. Valid values are 0, 1, 2, 3, and 4.
(47) Analog Records. -- Enter the number of analog records entered into memory during an acquisition cycle. Valid values are 0, 1, 2, 3, 4, 5, 6, 7, and 8.

Column(s)	
48	Stage Code. -- Enter 'S' if STAGE records are to be created (first ADR value for each data acquisition cycle). If left blank, only NONSTAGE records will be created using all the records entered each acquisition cycle.
49-80	Blank.

Voltage (VOLT) Card. -- Format of the VOLT card is as follows:

Column(s)	
1-4	Type Card. -- Enter VOLT.
5	Blank.
6	Sequence Number. -- Enter the sequence number, relative to the entry of analog records to be rescaled. Valid values are 1, 2, ..., n, where n is the number of analog readings entered during a data-acquisition cycle.
8-11	Lower Limit. -- Enter a four-digit number corresponding to a digital recorder equivalent of 0 volts.
12	Blank.
13-16	Upper Limit. -- Enter a four-digit number corresponding to a digital recorder equivalent of 5 volts.
17-18	Blank.

Example SPEC and VOLT cards are shown below:

```
-----------------------------------CARD IMAGE-----------------------------------
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

VOLT 1 0004 1024
SPEC0230111116CB731402405                    22
```

The preprocessor reads control cards by data sets for each CDCP record being processed. Each set consists of a SPEC card followed by VOLT cards as required. A VOLT card may be used for each analog record obtained during each data-acquisition cycle for the CDCP specified on the SPEC card. Any number of sets may be included during a job.

JCL cards for program E659 should be organized in the manner described in the WATSTORE User's Guide. However, it must be remembered that the XPRIME subprogram can only be used if STAGE records are created, and the other subprograms can only be used if NONSTAGE records are created.

Since the preprocessor sorts the control cards into the two sets, it does not matter whether the XPRIME control cards precede or follow control cards for other subprograms. An example, showing sequence of control cards for a typical application, is as follows:

```
-----------------------------------CARD IMAGE-----------------------------------
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

XQWMON
2       02301111                                 00065
7       02301111 0100065760801   0001.01     999999.99
2       02301111                                 00010
7       02301111 0200010760801   0001.01     999999.99
2       02301111                                 00045
7       02301111 0300045760801   0004.00     102410.24
2       02301111                                 00020
7       02301111 0400020760801   0001.01     999999.99
```

For card type 2, it is important to note: (1) blank columns, 29-49, to avoid storage of input data in Daily Values File, and (2) blank columns, 55-69, to avoid storage of computed data in Daily Values File.

Data Summaries

Output from the preprocessor includes a summary of control information and a summary of records created for input to program E659. Other output occurs when certain errors occur.

The summary of control information includes all information supplied to the preprocessor by the control cards. Error messages result when errors are detected in this information. An example of the control information summary is shown in table 13.

The summary of records created for input to program E659 includes, for each record formatted, the sequence number of the record in the created data set; the record type, STAGE or NONSTAGE; the starting and ending date and time of the data on the record; the number of sets of data on the record; the number of values in each set; and the total number of values on the record. Error messages are also printed when invalid ADR values are detected during record formatting. An example of this summary is shown in table 14.

An error report is also printed when the preprocessor determines that data have been lost because the time interval between two successive messages is too long. The report includes station number and CDCP identifier, the number of data sets lost, and the time interval when lost data sets were entered into CDCP memory. An example of error report is shown in table 15.

Table 13.--Sample preprocessor information for GOES data generated by program E659

```
                    PREPROCESSOR INFORMATION FROM CONTROL CARD SET          1

                                                                            NUMBER OF READINGS
                                                                            ENTERED DURING A DATA
 STATION           TIME      STARTING          ENDING      NUMBER OF DATA ACQUI-   ACQUISITION CYCLE          STAGE RECORDS ARE
 NUMBER   DCP ID   ZONE   DATE     TIME     DATE    TIME   SITION CYCLES PER DAY    ADR        ANALOG         TO BE CREATED
82200000 16CB7314  EST  08/11/77 24:00      LATEST DATA           096               2           0                NO
```

Table 14.--Sample of GOES data formatting by program E659

```
                          E659 RECORDS CREATED FOR DATA  COLLECTION PLATFORM 16CB7314

                           STARTING         ENDING          NO.          NO. VALUES    TOTAL NO.
RECORD       TYPE        DATE     TIME   DATE     TIME      SETS          PER SET       VALUES

   1     NONSTAGE      08/11/77 24:00  08/28/77 23:00     1629             2           3258*SEE ERROR REPORT FOR INVALID ADR VALUES*
   2     NONSTAGE      08/29/77 05:15  08/31/77 02:00      180             2            360
   3     NONSTAGE      08/31/77 05:15  08/31/77 17:00       48             2             96
   4     NONSTAGE      08/31/77 20:15  09/13/77 08:00     1200             2           2400
```

Table 15.--Sample error report for invalid time interval in GOES data

```
                                           ERROR REPORT
                                               FOR
                                      SETS OF READINGS LOST BECAUSE
                                      THE TIME INTERVAL BETWEEN
                                      TRANSMISSIONS WAS TOO LONG

                                                                            TIME INTERVAL
 STATION                                                          STARTING              ENDING
  NUMBER           DCP ID           SETS LOST                   DATE     TIME         DATE     TIME
 82200000         16CB7314              24                    08/28/77 23:15       08/29/77 05:00
 82200000         16CB7314              12                    08/31/77 02:15       08/31/77 05:00
 82200000         16CB7314              12                    08/31/77 17:15       08/31/77 20:00
```

An error report is also generated when invalid ADR records are found while formatting E659 input record. The error report includes the station number and CDCP identifier, the sequence number and type E659 record being formatted, the number of invalid ADR values, the number of times the preceding ADR value was substituted for the value in error, the maximum number of consecutive substitutions, the number of lost data sets because no preceding value was available for substitution, and the date and time of the first and last invalid ADR record. An example of this summary is shown in table 16.

Execution of GOESADR Procedure

The GOESADR procedure may be executed using the following set of JCL cards:

```
-----------------------------------CARD IMAGE-----------------------------------
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

/*RELAY  PUNCH RE2
//         JOB
/*PROCLIB  WRD.PROCLIB
// EXEC    GOESADR
//STEP1.PREPRO  DD *
           .
           .
    CONTROL CARDS FOR E659 PREPROCESSOR
           .
           .
/*
//STEP1.SYSIN  DD *
           .
           .
       CONTROL CARDS FOR PROGRAM E659
           .
           .
/*
//
```

PROCESSING DATA FROM THE WRD SATELLITE DATA COLLECTION SYSTEM FILE

A cataloged procedure, ERTSDCP, that retrieves, decodes, and lists data transmissions in the WRD Satellite Data File has been stored in the WRD JCL Procedure Library (WRD.PROCLIB). The procedure includes program H291 (ERTS Data Retrieval), a utility sort program, and program H292 (ERTS Data Listing).

Table 16.--Sample error report for ADR errors in GOES data

```
                                                ERROR REPORT
                                                    FOR
                                           INVALID ADR READINGS

                                                                                                              SET CONTAINING
                                      NUMBER OF     NUMBER OF TIMES THE     MAXIMUM NUMBER   NUMBER OF     FIRST INVALID     LAST INVALID
 STATION                RECORD RECORD  INVALID ADR  PRECEEDING ADR VALUE    OF CONSEQUTIVE   SETS OF           VALUE             VALUE
 NUMBER    DCP ID       NUMBER  TYPE   READINGS     WAS SUBSTITUTED         SUBSTITUTIONS    VALUES LOST    DATE      TIME    DATE      TIME
82200000  16CB7314          1 NONSTAGE       5                5                     1              0        08/25/77 14:30  08/27/77 20:30
```

Data Retrieval

The ERTSDCP cataloged procedure requires a retrieval card for each station to be processed. Data for any number of DCP's may be requested in a single retrieval. The format of this card is as follows:

Column(s)	
1	Enter an 'R'.
2-5	DCP identification number (for example, 6362).
6-9	Begin year of period requested (for example, 1978).
10-12	Begin day number (Julian date) of period requested (for example, 025).
13-16	End year of period requested.
17-19	End day number of period requested. If entire period is required, leave columns 6-19 blank. End year and end day number need not be specified.
20-21	Time Zone Code - Difference in hours between UTC and Standard Time Zone in which DCP is located. '04' = EDT '05' = EST, and so forth.

Format of a typical retrieval card for program H291 is as follows:

```
-----------------------------------CARD IMAGE-----------------------------------
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

R60331978025       05
R63621978025       05
```

Output from this program is used as input to an application program, H292, and consists of a temporary data set, sorted by a utility program, in ascending DCP identification number order.

Translation (Program H292)

Program H292 converts telemetry data into sensor data with proper engineering units. Program H292 also receives supplemental input data on cards, including sensor information and conversion (rating) points. An example of program H292 output is shown in tables 17 and 18.

Table 17.--Sample of Landsat data prior to conversion

```
100 7 2490025 51  6362  7  373  355  377  206  377  377  377  377
100 7 2490205 46  6362  7  373  355  377  206  377  377  377  377
100 7 2490208 38  6362  7  373  355  377  206  377  377  377  377
100 7 2490211 31  6362  7  373  355  377  206  377  377  377  377
100 7 2491300 26  6362  7  373  355  377  206  377  377  377  377
100 7 2491439 09  6362  7  373  355  377  206  377  377  377  377
100 7 2491442 02  6362  7  373  355  377  206  377  377  377  377
100 7 2491444 56  6362  7  373  355  377  206  377  377  377  377
100 7 2491622 47  6362  7  373  355  377  206  377  377  377  377
110 7 2491625 39  6362  7  373  355  377  206  377  377  377  377
010 7 2491628 31  6362  7  373  355  377  206  377  377  377  377
010 7 2491631 23  6362  7  373  355  377  206  377  377  377  377
100 7 2500030 28  6362  7  373  356  377  206  377  377  377  377
100 7 2500033 18  6362  7  373  356  377  206  377  377  377  377

100 7 2481618 09  6362  7  373  355  377  206  377  377  377  377
110 7 2481621 02  6362  7  373  355  377  206  377  377  377  377
010 7 2481623 55  6362  7  373  355  377  206  377  377  377  377
010 7 2481626 48  6362  7  373  355  377  206  377  377  377  377

 121 DATA TRANSMISSIONS RETRIEVED FOR DCP# 6362
```

Table 18.--Sample of converted Landsat data for Anclote River near Elfers streamflow station

```
        UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION
              EARTH RESOURCES TECHNOLOGY SATELLITE EXPERIMENT - DATA COLLECTION SYSTEM
    02310000      ANCLOTE RIVER NR ELFERS, FLA.                              DCP ID NO.   6033


RECEIVE                 TIME       GAGE       DIS-
SITE        DATE        (EST)      HEIGHT     CHARGE
                                    (FT)      (CFS)

N         09/08/77    09:51:01     08.41      20.00
N         09/08/77    09:53:57     08.41      20.00
N         09/08/77    09:56:52     08.41      20.00
G         09/08/77    11:41:01     08.41      20.00
N         09/08/77    19:43:46     08.37      19.00
N         09/08/77    19:46:39     08.37      19.00
N         09/08/77    21:25:05     08.35      19.00
N         09/08/77    21:27:59     08.35      19.00
N         09/08/77    21:30:54     08.35      19.00
N         09/09/77    08:15:35     08.25      17.00
N         09/09/77    09:58:38     08.23      17.00
N         09/09/77    10:01:33     08.23      17.00
G         09/09/77    11:42:51     08.23      17.00
N         09/09/77    19:48:12     08.15      15.00
N         09/09/77     9:51:04     08.15      15.00
N         09/09/77    19:53:57     08.15      15.00
N         09/09/77    21:29:26     08.13      15.00
N         09/09/77    21:32:20     08.13      15.00
N         09/09/77    21:35:14     08.13      15.00
N         09/10/77    08:23:18     08.03      13.00
N         09/10/77    10:03:25     08.01      13.00
N         09/10/77    10:06:20     08.01      13.00
```

Sensor Definition Card

A sensor definition card is required as the first card, of the group of cards, for each DCP that is to be processed under program H292. This card identifies the U.S. Geological Survey station identification number, DCP identification number, time zone code, and one parameter code for each sensor. The parameter code, in addition to identifying the parameter sensed, identifies the location of the sensor data in the encoded DCP data transmissions. The format of the sensor definition card is as follows:

Column(s)	
1	Always enter a '2'.
2-16	USGS Station Identification Number. -- If the station number is the WRD eight-digit downstream order number, it is coded as follows:

Column(s)	
2-8	Blank.
9-16	Station Number.

If the number is latitude and longitude, it is coded as follows:

Column(s)	
2-7	Latitude.
8-14	Longitude.
15-16	Sequence number.

17-20	Data Collection Platform ID Code. -- Four digits, always begins with '6' in column 17, for example, 6006.
21-22	Time Zone Code. -- Difference, in hours, between Universal Time Coordinated (UTC) and Standard Time zone in which DCP is located. '04' = EDT '05' = EST
23-24	Blank unless signal inversion is required, as with Leupold and Stevens digital recorders, then use 'Z' in column 24.
25-80	Sensor Parameter Fields. -- Encode a five-digit parameter code and a one-digit sensor type code in eight fields. The parameter codes are entered in columns 25-29, 32-36, 39-43, 46-50, 53-57, 60-64, 67-71, and 74-78. Corresponding sensor type codes are entered in columns 30, 37, 44, 51, 58, 65, 72, and 79.

Code 'A' for analog input.
Code 'D' for ADR input.

Columns 31, 38, 45, 52, 59, 66, 73, and 80 are to be left blank except when daily totals of rainfall are desired, then code 'T' in applicable column. Note that the parameter code, and so forth, for a digital reading must only be coded in the first field of the two fields allocated for those two words, for example, Digital Precipitation sensed in words 5 and 6 - code '00045' in columns 53-57, code 'D' in column 59.

Conversion-Rating Cards

At least one conversion-rating card is required for each parameter (field) coded on the sensor definition card (type-2 card). Each rating card contains up to four points and there is a maximum of 75 points per rating. All rating points are assumed to be rectilinear. The coding format of the rating card is as follows:

Column(s)	
1	Always enter '7'.
2-16	USGS Station Identification Number. -- Same as on sensor definition card.
17	Blank.
18-19	Table Identification. -- Two-digit table identifier.
20-24	Parameter Code. -- See page 79 for five-digit parameter codes used in this application.
25-32	Leave blank.
33-80	Rating Points. -- There are four sets of fields, each containing a five-digit input value (either voltage or dial reading) and a seven-digit output value. In both subfields, code values in whole numbers unless a significant digit is required to the right of the decimal point; otherwise, code the decimal point in the appropriate columns. The input values are coded in columns -37, 45-49, 57-61, and 69-73, and the corresponding output values are coded in columns 38-44, 50-56, 62-68, and 74-80.

Data input to program H292 is listed below for a typical application:

```
----------- ---- ------------------CARD IMAGE-----------------------------------
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

2       02310000603305 700060D
7       02310000 0100060
2275916082325100636205 700065DT              00045AT
7275916082325100 0100065         0001    .01 9999  99.99
7275916082325100 0200045          .01    .0212.00  24.00
```

Organization of Card Input

The supplemental data card for program number H292 should be assembled by ascending Data Collection Platform identification number, which appears in columns 17-20 of the type-2 card, by card type which appears in column 1 of both cards, and by parameter word order.

Parameter Codes

The parameter codes that may be specified on the sensor identification card are as follows:

Parameter Code	Parameter Name
00060	Discharge (cubic feet per second)
00010	Water temperature (degrees Celsius)
00011	Water temperature (degrees Celsius/degrees Fahrenheit)
00020	Air temperature (degrees Celsius)
00021	Air temperature (degrees Celsius/degrees Fahrenheit)
00045	Accumulated rainfall (inches)
00065	River stage (feet)
00070	Turbidity (Jackson Units)
00095	Specific conductance (micromhos per centimeter)
00300	Dissolved oxygen (milligrams per liter)
00400	pH (units)

Miscellaneous Conversion Tables

Conversion tables are provided to aid in interpretation of GOES raw data. Tables 19 and 20 list Julian dates and corresponding dates. Table 21 may be used to convert GOES raw data (ASCII format) hexidecimal equivalents.

Table 19.--Julian dates for regular years

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029		088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31

Table 20.--Julian dates for leap years

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	061	092	122	153	183	214	245	275	306	336	1
2	002	033	062	093	123	154	184	215	246	276	307	337	2
3	003	034	063	094	124	155	185	216	247	277	308	338	3
4	004	035	064	095	125	156	186	217	248	278	309	339	4
5	005	036	065	096	126	157	187	218	249	279	310	340	5
6	006	037	066	097	127	158	188	219	250	280	311	341	6
7	007	038	067	098	128	159	189	220	251	281	312	342	7
8	008	039	068	099	129	160	190	221	252	282	313	343	8
9	009	040	069	100	130	161	191	222	253	283	314	344	9
10	010	041	070	101	131	162	192	223	254	284	315	345	10
11	011	042	071	102	132	163	193	224	255	285	316	346	11
12	012	043	072	103	133	164	194	225	256	286	317	347	12
13	013	044	073	104	134	165	195	226	257	287	318	348	13
14	014	045	074	105	135	166	196	227	258	288	319	349	14
15	015	046	075	106	136	167	197	228	259	289	320	350	15
16	016	047	076	107	137	168	198	229	260	290	321	351	16
17	017	048	077	108	138	169	199	230	261	291	322	352	17
18	018	049	078	109	139	170	200	231	262	292	323	353	18
19	019	050	079	110	140	171	201	232	263	293	324	354	19
20	020	051	080	111	141	172	202	233	264	294	325	355	20
21	021	052	081	112	142	173	203	234	265	295	326	356	21
22	022	053	082	113	143	174	204	235	266	296	327	357	22
23	023	054	083	114	144	175	205	236	267	297	328	358	23
24	024	055	084	115	145	176	206	237	268	298	329	359	24
25	025	056	085	116	146	177	207	238	269	299	330	360	25
26	026	057	086	117	147	178	208	239	270	300	331	361	26
27	027	058	087	118	148	179	209	240	271	301	332	362	27
28	028	059	088	119	149	180	210	241	272	302	333	363	28
29	029	060	089	120	150	181	211	242	273	303	334	364	29
30	030		090	121	151	182	212	243	274	304	335	365	30
31	031		091		152		213	244		305		366	31

Table 21.--Explanation of GOES data conversion

ASCII character		Hexidecimal character
@		0
A		1
B		2
C		3
D		4
E		5
F		6
G		7
H		8
I		9
J	Appearance of	A
K	these characters	B
L	in raw data	C
M	indicate errors	D
N	in ADR	E
O	record	F

NOTE.--Data are transmitted from CDCP to GOES satellite in hexidecimal form and are received at ground-receiving station in ASCII format. Data are later converted to digital form by use of various utility computer programs.

Execution of the ERTSDCP Procedure

The following JCL may be used to execute the ERTSDCP procedure:

```
-----------------------------------CARD IMAGE-----------------------------------
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

/*RELAY  PUNCH RE2
//         JOB
/*PROCLIB  WRD.PROCLIB
//  EXEC    ERTSDCP
//STEP1.SYSIN  DD  *
           .
           .
       DATA CARDS FOR PROGRAM H291
           .
           .
/*
//STEP2.SYSIN  DD  *
           .
           .
       DATA CARDS FOR PROGRAM H292
           .
           .
/*
//
```

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