CHAPTER 5

WATER CONTROL DATA SYSTEMS

5-1. General

a. Purpose. This chapter will summarize the technical aspects required for the planning, design, operation, and coordination required for water control data systems. The information presented is arranged by three major components: (1) data observation and collection at field stations, (2) transmission of data and (3) data management and processing in a database. The presentation will address the mechanisms and equipment associated with each of these components.

b. Basic Requirements

(1) The effective management of water control systems is dependent in part upon knowledge of current project and hydrologic conditions, project capabilities and restraints and water control elements in the river system that affect streamflow, water level, and water quality.

(2) The water control data system must be designed to meet the specific needs of the water control manager. The data system must include facilities to perform the following functions:

- observation and storage of data at field stations
- transmission of data from field stations
- decoding and validation of transmitted data
- storage and retrieval of data in a database
- management of a water control database
- providing graphical and tabular data displays
- exchanging data with other users

(3) ER 1110-2-249 establishes requirements for management of water control data systems.

c. Master Plans

(1) Master plans for water control data systems are prepared in conformance with ER 1110-2-240. In general, master plans include all the essential information that set the requirements, justification, scope, and recommended procedures for implementing water control data systems. Accordingly, they:

- outline the system performance requirements, including those resulting from any expected expansions of Corps missions

- describe the extent to which existing facilities fulfill performance requirements

- describe alternative approaches that will upgrade the system to meet requirements not fulfilled by existing facilities, or are more cost effective than the existing system

- justify and recommend a system considering timeliness, reliability, economics and other factors deemed important

- delineate system scope, implementation schedules, proposed annual capital expenditures by district, total costs, and sources of funding

(2) ER 1110-2-240 describes the administrative procedures for preparing and updating master plans for water control data systems. It sets forth the responsibilities associated with developing the water control plan, coordinating its approval, making funding requests for the costs of the proposed facilities, and updating plans as needed on an annual basis. Guidance for the management of dedicated water control data systems including that equipment and software used for acquisition, transmission, and processing of real-time data for regulating Corps projects is prescribed in ER 1110-2-249.

(3) The master plan is prepared by Division water control managers based on detailed studies of communication alternatives as well as all other aspects of the overall water control data system requirements. Because of the rapidly advancing technology, there is no one established method or standardization of design for a water control data communication system. Each existing system has been developed on the basis of design conditions for that particular system. However, considerable experience has been gained to date by Division and District offices in developing these automated networks. Information of these various systems are disseminated through technical conferences and/or workshops on water control management conducted or coordinated by HQUSACE.

5-2. Data Observation and Storage at Field Sites

a. General. A majority of the data input into the water control data collection system are time-variable data. They represent observations of the conditions of water regulation at various projects, water levels and water quality in the river system, and those hydrometeorological elements that affect any of these conditions or elements. Although non-variable data may be included in the data processing system (such as project characteristics related to reservoir capacities, outflow limitations, etc., or hydrologic parameters that define the runoff characteristics of the river system), the data gathering system is designed primarily to observe, process and transmit time-variable data. The time-variable data observed and collected may be classified in three broad categories:

- Hydrometeorological data

- Project data

- Water quality data

b. Hydrometeorological Data

(1) The function of hydrometeorological data is to provide current information by direct observation on all significant elements that affect runoff within a drainage basin or river system.

(2) Some of the hydrometeorological elements that may be observed are:

- water levels in rivers, lakes, and reservoirs

- precipitation as measured at ground stations or as estimated by radar, satellites, or other sensors

- air temperature as measured at ground stations or by upper air atmospheric soundings

- pan evaporation as measured at project sites

- snow sensors or snow courses which measure the depth and water equivalent of the incremental snow accumulation, and/or the total accumulation of snow in the snowpack, as determined from ground measurements or remote sensors

- snow covered area, as determined from aerial or ground reconnaissance, or by remote sensors from satellites or aircraft

- conditions of river ice, as measured at key locations to determine ice thickness and locations of ice jams

(3) In addition to these hydrometeorological elements, observations may also include measurements of soil moisture, soil temperature, and ground water. They may also include atmospheric measurements of humidity, wind speed, wind direction, and solar radiation.

(4) The design of a data network must be based on many factors, including consideration of the hydroclimatic regime, project regulation and forecasting requirements. The principal difficulty in defining the specific coverage and number of data stations is that of striking a practical balance between a theoretically complete coverage and the practical limitations imposed in obtaining and processing the data collected. The judgements to be made as to the amount of coverage that are justified for a particular river system must be based on hydrologic analysis, estimates of cost and benefits for incremental increases of coverage, and a general knowledge of the reservoir regulation and forecasting problems for the subject river system.

(5) The streamflow and rainfall reporting networks are developed in cooperation with the U.S. Geological Survey and the National Weather Service. These cooperative programs largely define the scope of coverage of the hydrometeorological networks. In some areas, the cooperative network and stations owned and operated by the Corps supplement each other. Section 5-6 describes the coordination of data collection programs in greater detail.

(6) The design of sensors, equipment, and facilities required in the construction of reporting stations is preferably performed in the project design phase and documented in an appropriate design memorandum. It is not within the scope of this manual to present specific design information or alternatives.

c. Project Data. Time-variable project data are essential for project regulation. Hydrologic data, for observing and interpreting water control functions at the project, is part of the hydrometeorological network discussed in Paragraph 5-2b. Other types of data, while not strictly of a hydrologic nature, may also be required to monitor project regulation. These include spillway and outlet gate positions, power unit status, hourly power generation, navigation lockages, fish counts, and other water control parameters that are involved in daily project regulation.

d. Water Quality Data

(1) Water quality data is essential for real-time water control management. Data collection programs are tailored to individual projects to meet water quality management objectives. Typically, data is needed for inflow, in-lake, discharge and tailwater stations to develop an understanding of cause and effect relationships. This in turn provides needed information for integrating water quality consideration into real-time water control management decisions.

(2) Water quality data collection involves field sampling and analysis, laboratory analysis and in-situ monitoring. Temperature, conductivity, dissolved oxygen, pH, turbidity and some parameters with very short sample holding times are measured in the field, and this data is immediately available for use in the water control process. Laboratory analyses for other parameters provide data that, once evaluated, are available for support of real-time water control management. In-situ monitors are used at projects requiring frequent water quality data for making operating decisions or to monitor their effects in terms of meeting operating objectives. Typical applications involve thermistor strings for measuring temperature stratification in a reservoir, an inflow monitor to detect acid slugs entering a lake and a discharge monitor for gaging results of operations. Monitors integrated into the Geostationary Operational Environmental Satellites (GOES) data collection network greatly enhance the ability to fine tune reservoir regulation to meet operational objectives.

e. Manual Data Observation

(1) Historically, manual observations of water control parameters represented the backbone of hydrometeorological systems. Even with more advanced systems, there may still be a need to incorporate manual observations into the networks. They may serve as backup to the automated systems and may also be necessary for observing hydrologic, project, or water quality parameters that cannot be feasibly automated. For some projects, it may not be economically feasible or desirable to construct, operate, and maintain an automated system. The Cooperative Reporting Network of the National Weather Service (NWS) has historically relied largely on manually observed and reported precipitation and water level amounts. This is particularly true for those observations by cooperative observers that report only when certain criteria of event magnitude are met. A goal of the NWS is to automate their cooperative network as quickly as resources will permit.

(2) Observers for field stations should be selected on the basis of reliability, and they should be properly trained to meet reporting requirements. For those projects that are staffed 24 hours per day, operating personnel are a source of reliable and current data. Specialized parameters related to water quality, fish movement, aquatic life, or other unusual parameters may require observations by technical experts specifically trained to make these observations.

(3) Manually derived data may be stored briefly in digital form in preparation for its subsequent transmission. This may be accomplished by data entry through local computer terminals, Personal Computers, or other digital data entry devices.

f. Automated Data Observation and Storage

(1) The first automated observation and storage capabilities at field sites used analog methods. At a water stage station this typically included a float system to drive a pen recorder. Such a system produced an automatic analog record of water levels. With the availability of digital technology the same sensing system was adapted to drive a punched paper tape to produce an automatic digital record. Other enhancements now commonly use the same float system to drive a digital shaft encoder whose output is stored in memory of a local microprocessor at the gaging site.

(2) Any mix of analog and digital sensor outputs may be stored at specified times to produce a history of past and current digital data at the site.

g. Installation and Maintenance of Data Collection Equipment

(1) Installation of Field Data Collection Equipment. Site selection is generally based on the location of existing USGS or other gages. The site should have a structure which can be used to house the monitoring equipment and the data collection platform (DCP). A DCP may include telephone equipment or a transmitter for communication via satellite, or both. The site should have commercial power or a solar panel as backup to the battery power. The total installation needs to be waterproof.

(2) Maintenance of Field Data Collection Equipment. The data form each site should be reviewed daily to determine if the data is correct and the DCP is transmitting. Each site should be on regular scheduled maintenance so that all equipment can be checked and

properly maintained. Each district should set up regular maintenance schedules. The following is a partial list of items which may be checked daily for each DCP.

- correct channel
- correct time slot
- battery voltage
- DCP transmit power
- modulation index
- signal to noise ratio
- limits within time slot
- error messages
- correct identifier
- valid data

These items can be checked from the review of error message reports prepared by the central receiving site operator.

5-3. Data Transmission

a. General. Single project river development systems, or multiproject systems which are relatively small and involve only Corps projects, require much less complicated communication and data handling facilities than large, complex river developments. Manually based and semi-automatic data handling systems may be entirely adequate for the small river systems, but handling data in this manner is generally cumbersome and inadequate for larger systems. The many repetitive transmissions from the data source to the data users, the time required for transmission, the chance of errors in repeated handling of data, and the inability to physically process the vast amounts of data from many different sources usually dictate the installation of an automatic data handling system. However, even with the installation of automated systems, there may still be a need for manual or semi-automatic data interrogation equipment to backup the automated systems and to provide an alternate method for users with less sophisticated needs to obtain basic river data. In this section, the means of transmitting data from field gaging sites (manual, semi-automatic and automatic) will be discussed.

b. Manual Data Transmission Systems. Current manually observed data are usually transmitted to water control managers by commercial telephone or by government operated radio or microwave voice systems. In a large river basin, the network may consist of several sub-systems, and data stations within a sub-system may be transmitted to data collection facilities at a project, sub-system field office, or local Weather Service Office. These offices, in turn, transmit the data to Corps of Engineers District Offices, Weather Service River Forecast Centers, or Weather Service River District Offices. The data may then be sent to the Reservoir/Water Control Centers or other water management element, by telephone. Hydrologic data from other federal government or state agencies may be similarly disseminated.

c. Semi-Automatic Data Transmission Systems

(1) Semi-automatic transmission systems are those systems that have automated part of the data collection function, but still require an individual to be present for complete functioning. An example of a semi-automatic transmission system still in use is the Telemark.

(2) Reporting hydrologic elements remotely by means of Telemarks was the first step in automating hydrologic reporting data networks. A Telemark is a piece of equipment that provides the means for interrogating a hydrologic station remotely without the need for direct observation by an observer. Interrogations are usually performed manually via telephone by someone at a data center, field office, project office, or river forecast center. While such systems depend upon individual interrogations, these may be made at regular intervals as required for routine operation. They can also be made at any time it is desired to monitor hydrologic conditions during floods or other emergencies. The Telemark equipment may be owned and operated by the Corps of Engineers, other federal agencies such as the Bureau of Reclamation, National Weather Service, and power marketing agencies, or state and local water divisions or bureaus. The use of the equipment and its interrogation by others is controlled by the agency who owns the equipment. Many radio based systems report data when they are interrogated.

(3) Retrieval of field station data using Telemarks is by land line equipment and normally through the existing commercial telephone service. Government operated communications systems can also be used when available. Telemarks that are connected to commercial telephone systems utilize a telephone coupling device (Codaphone), which permits automatic answering of incoming calls. Each field station or telemark is assigned a telephone number (often unlisted), which can

be called from any telephone set connected to the commercial telephone system. The manual interrogation of a telemark is interpreted by counting the audio "beeps" corresponding to the digital values of the measured element. Manual interrogation requires about 20 to 30 seconds for a 4-digit reading.

(4) Manual telephone interrogation of telemarks provides direct access to data from individual field stations, thereby avoiding the need to access a central database. For some users such as navigation companies, recreational boaters, irrigation operators, etc., this is particularly useful since they are generally interested in conditions only at a given site or limited reach of the river, as opposed to those responsible for river regulation who need ready access to information on the entire river system. Also, telemarks are easily accessed whereas access to central databases often requires some type of computer terminal. Interrogations by others must be controlled to prevent battery drain on battery operated telemarks and call overloading, which would affect normal operation of the equipment.

(5) Call up of Telemarks by data collection centers is now generally performed through use of computer terminals. These terminals can be programmed to automatically "dial up" the telemarks at preprogrammed times and in any desired sequence. They may also be used to interrogate individual telemarks on call if desired.

d. Automatic Data Transmission Systems

(1) General. In recent years, full automation of field station reporting has replaced manual and semi-automatic transmission equipment in many areas. Data transmission media that are available and being used are:

- ground based VHF radio
- environmental or general purpose communication satellites
- meteor-burst communication systems
- land line equipment utilizing hard wire or switched commercial telephone circuits
- general purpose microwave communication systems

In general, any or all of these types of transmission media may be used either singularly or in combination. Planning and design of a particular system must consider each of these alternatives prior to selecting the one or combination of them that best meets the overall requirements of the water control data system being designed.

Information on these transmission media and things to consider when designing a system using them follows.

(2) Ground Based VHF Radio

(a) VHF radio communication systems have been developed over a period of many years for automatic reporting hydrologic data stations. On site equipment for land based radio systems consists primarily of a radio transmitter and a receiver packaged in a container. The electronic equipment may also have some local intelligence and some storage memory. The receiver is designed to listen for messages/commands from a Data Acquisition Controller (DAC) and to respond accordingly by using the on site transmitter. Thus, either current sensor readings or data stored since the last transmission is sent to the DAC. DAC's are generally located at the project office responsible for data collection from a given sub-system.

(b) Radio frequency allocations for governmental use in reporting hydrologic observations are made in four bands in the 169- to 172-megahertz range and use of certain frequencies in the 406- and 412-megahertz bands. The use of these frequencies requires nearly a direct line-of-sight for transmissions between sending and receiving stations. For this reason, it is usually necessary to incorporate repeaters between the sending and receiving stations, particularly in mountainous regions. Repeaters are generally located on prominent high points in order to meet the line-of-sight requirements. Electrical power is required to operate this equipment. Power may be supplied from commercially available power lines if available, but frequently, these stations are located in areas not served by commercial power, and battery operated equipment must be used. Batteries used for this purpose may be recharged by solar cells, wind chargers, or automatically controlled small electrical generators.

(3) Satellite Communication Systems

(a) Satellites are currently in use to relay ground signals emanating from field hydrologic data gaging stations to a satellite central receiving site facility. Initial experiments were conducted in the New England Division using the LANDSAT polar orbiting satellites. When the Geostationary Operational Environmental Satellites (GOES) were launched in the mid-1970's, the Corps (Lower Mississippi Valley Division) started to use the Data Collection System (DCS) to perform this relay function. This has proven to be so successful and such a reliable means of obtaining data during severe weather conditions that the Corps has shifted dramatically to this system and is now the largest single user of the GOES DCS.

(b) The GOES satellites are operated by the National Earth Satellite, Dissemination and Information Service (NESDIS) of the National Oceanic and Atmospheric Administration (NOAA). This system is available to the Corps for transmitting environmental data. The major components of the DCS are the field gaging sites, the satellite, and direct readout ground stations (sometimes referred to as downlinks) located at central receiving sites for data retrieval.

(c) NESDIS operates three GOES satellites: the eastern satellite positioned at 75 degrees west longitude, the western satellite positioned at 135 degrees west longitude, and a spare satellite positioned at 105 degrees west longitude to serve as a backup for both the east and west satellites. The equipment located at the gaging station site necessary for the use of the GOES DCS is referred to as a Data Collection Platform (DCP). DCP's can either be of the interrogable type, where the DCP (site/gage) can be interrogated at any time, the periodic reporting type, where the DCP reports at regular intervals and specified times (self-timed type), or the randomly reporting type, where the DCP reports randomly within a specific time period that can be decreased by an algorithm programmed in the DCP as various thresholds are met or exceeded. An example of the random reporting system printout is shown on Table 5-1. Column 6 of the table shows the random time interval between transmissions. Dual channel DCP's can also be purchased where one channel is used in the self timed mode and the other channel in the random reporting mode. The majority of the DCP's purchased by the Corps since the advent of this option are the dual channel type.

(d) Several direct readout ground stations (central receiving sites) have been acquired by the Corps to receive Corps and other agency data. These are dispersed around the country in various District/Division offices. They are operated by Corps personnel or by others either through cooperative agreements or by contract. As the Corps system grows, additional central receiving sites will undoubtedly be acquired. In addition to the Corps central receiving sites, GOES data can also be retrieved from NESDIS or through other cooperative Federal or state owned central receiving site facilities.

(4) <u>Meteor-Burst Communication Systems</u>

(a) Meteor-burst communication systems use meteor trails in the ionosphere to reflect radio signals emanating from field gaging sites to a ground based receiving station. One rarely gets an immediate communications link when interrogating a field station or when a field station, through self timed response, is attempting to send its data to the central receiving station. A communication link

Table 5-1

Example Random Reporting System Printout (NED)

GOES RRDCS READINGS DATE: 5/31/84 TIME 11:23
(1) (1)

NO.	NAME	D.A. SQ MI	M/D	TIME HR:MIN	DT HRS	STAGE FT	+/- FT/HR	Q CFS	+/- Q/HR	CSM Q/DA	STORM PREC.	NOTE
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
38	WELLS RIVER	2644	5/31	4:55	7.3	13.73	.27	42574.	1020.	16.1		
36	WEST HARTFORD	690	5/31	7:39	1.1	11.23	.02	12894.	50.	18.7	4.34	WARN
35	WEST LEBANON	4092	5/31	6:00	3.3	20.21	.05	55166.	252.	13.5		WARN
37	NORTH WALPOLE	5493	5/31	7:36	.7	27.54	.10	82900.	468.	15.1		WARN
6	MONTAGUE CITY	7865	5/31	8:08	1.9	37.18	.13	135260	877.	17.2		FLOOD
5	GIBBS CROSSING	199	5/31	11:05	3.8	7.56	.05	4616	53.	23.2	9.00	FLOOD

EXPLANATION OF COLUMN HEADINGS

(1) Date and time of the creation of this listing.
(2) "NO." and "NAME" are data collection platform identifiers.
(3) D.A. -- Drainage area at the data collection platform (square miles).
(4) "M/D" stands for the month and day of the month of the latest message received. This item and item 5 comprise the time tag.
(5) "TIME" is the hour and minute of the latest message (standard time).
(6) "DT HOURS" is the time difference between the next-to-last and the last messages received -- used in the calculation of rates of change.
(7) "STAGE FT" is the water level (pool or river stage).
(8) "+/- FT/HR" is the rate of change of stage in feet per hour.
(9) "Q CFS" is the discharge in cubic feet per second associated with the stage reported in the last message.
(10) "+/- Q/HR" is the rate of change of discharge in cubic feet per second per hour.
(11) "CSM Q/DA" is the discharge in cubic feet per second per square mile, otherwise known as 'csm'.
(12) "STORM PREC." stands for inches of accumulated rainfall in the most recent storm.
(13) "NOTE" heads a column reserved for comments regarding each message, such as nonvalid messages, flood stage, warning stage, or low battery.

is established only when the signal being transmitted has the proper reflection angle from the meteor trail to be picked up by the receiving station. This usually takes less than 2 or 3 minutes to occur.

(b) A meteor-burst communication system is used by the U.S. Soil Conservation Service, who operate the "SNOTEL" system used for transmitting snowpack and other hydrologic data from remote mountain locations in the western United States. Another meteor-burst communication system is used operationally by the Alaska District of the Corps of Engineers, together with other federal agencies operating in the State of Alaska, for obtaining hydrologic data from remote field stations.

(5) Land Line Data Transmission

(a) Land lines can provide a path for data transmission. They may be used for backup to critical sites that also transmit via GOES or other radio based system. In some geographic areas land lines may be subject to outage during hurricanes or other major meteorological events. Unfortunately, it is during such events that data transmission is most critical. Land line outages are being reduced and performance improved as wires are replaced by fiber optics and as lines are placed in conduits beneath the ground.

(b) The choice between a dedicated line or the use of switched public service should be based on the frequency of use, volume of use, cost and availability. Even if reliable public switched service may be functional during a flood emergency, the service may become overloaded by other users.

(c) In establishing land line communications consideration must be given to: transmission rate (110-9600 baud), mode (synchronous or asynchronous), protocol, error detection/correction and other issues. Different communications approaches may be appropriate when transmitting data from a field site to a host system, than would be used between two host systems.

(d) An automated data collection system now in operational use for hydrologic reporting networks by the National Weather Service is termed the Device for Automatic Remote Data Collection (DARDC). The remote station equipment produces serial ASCII code to represent in engineering units various hydrologic parameters, with 4 character identification and 4-decimal digit representation of each measured element. The field station equipment can be used in conjunction with the GOES DCS, with land line (or VHF radio communication) systems through which interrogations are made from a sub-system DAC. A more recent system now being developed by the NWS and TVA is termed the

Limited Automatic Remote Collector (LARC), which performs the same functions as the DARDC field equipment, but with added capability. The LARC system includes computer memory at the field station for storing current data, for the purpose of providing trends over recent time. The LARC equipment also provides both audio interrogation and computerized ASCII code.

(6) Microwave Communication Systems. Microwave communication systems provide a high capacity, line of sight, point to point, transmission path. Where microwave links have been established for other communications purposes, it may be possible to add real-time data communication at little additional cost. However, these communication systems are subject to outages during electrical storms and are generally considered less reliable than the more conventional means of water control data transmission.

(7) Communications Regulations. There are two regulations pertinent to the design and operation of the hydrologic data transmission systems that use the electromagnetic spectrum. ER 1125-2-308 describes requirements for the management of call signs and radio frequencies for data communication systems. ER 1110-2-248 deals specifically with data transmission via the GOES DCS.

5-4. Decoding and Validating Transmitted Data

a. Information received from a data collection system must be decoded from the transmitted format. This operation may be different for each possible source from which data is received. After decoding into a standard form the data must be verified. Data received in a host system may contain errors introduced at any step from the sensing of the parameter to its receipt by the host equipment. Most common errors are associated with a failure of the sensing of the element. Water stage floats may hang up, precipitation gages may become fouled with foreign material, or maintenance personnel may reset a datum. Data transmission functions may introduce occasional random errors.

b. All received data should be validated before it is used to make water control decisions. Validation should include a range of possible checks. Simple checks should test data against an allowable range of values. Extended checks should test data against allowable rates of change for that parameter. Complex checks should test data by correlations with other stations and parameters. Where data fails to meet a validity check it should be marked as such, and if appropriate, a new value should be estimated. All actions must be clearly logged so the water control manager can accept or reject invalid, missing or estimated data.

5-5. Water Control Data Management and Processing

a. Data Storage and Retrieval

(1) A database is essential for the storage and retrieval of water control data. The database must provide for the storage of a variety of stations, parameters, and data versions, over various time intervals. New data received from the data collection network should be stored in the database. The database should also include forecast and project operation data.

(2) The database must be simultaneously accessible by multiple functions. Report generation, analysis tools and other routines must be able to retrieve data of both historical and real-time interest. Text products and non-numeric data must be included in a database for orderly storage and retrieval. This includes locally generated text reports, as well as reports received from other sources.

b. Water Control Database Management. Provision must be made for the management of the water control database. The water control manager must be able to control the amount of data that is available in the database. This includes the particular stations, parameters, time intervals and time duration. Data must be removed from the database on an established periodic basis. Removed data should be stored in an archive format which will allow its restoration many years in the future, if needed. The database must be capable of being edited to alter, add, and delete data values or entire data sets.

c. Data Interpretation and Displays. The data system must be capable of providing both graphical and tabular displays of information in the database. This includes any data received from the data collection system, or any data generated in the analysis of received data. The system should allow displays to appear on terminal screens, large screen display systems that may be utilized in briefing rooms or hardcopy device at user request. Text products must be displayable on these same devices as required.

d. Data Processing

(1) General. With the advent of real-time data collection, increasing water control management responsibilities, and decreasing manpower resources, computers are essential for data handling, manipulation and analyzing various project regulation schemes to accomplish the many tasks required of todays water control manager. These computers are generally located in District and Division

offices or maybe in a commercially available time sharing computer facility. The functional requirements for the computer can be such that they act as both a Data Acquisition Controller (DAC) and a data processor. These functions may also be divided either fully or partially between separate computers.

(2) Hardware and Software Requirements

(a) Hardware. The selection of the data processor used will depend upon the requirements that the processor must meet. Once the functions to be performed have been decided, the computer or computers chosen must be large enough and have sufficient data handling and analysis speeds to meet system requirements and the needs of the water control manager. The computer that performs the data handling functions must be a highly reliable system that is continuously on line to assure the dependable receipt and control of data inflow to the system. The computer that performs the data processing and analysis computations must provide the water control manager with answers in sufficient time to make real-time water control decisions.

(b) Loss of Commercial Power. Water control managers need to recognize the impacts and problems when the loss of commercial power affects communications and data collection activities. The need to install or develop emergency power facilities and uninterruptable power supply systems should be considered.

(c) Software. Development of system software must be designed knowing the type or types of hardware on which it will be required to run. The DAC must include appropriate software for data processing, storage and retrieval. The software design is highly dependent on the data system and processing requirements. Figure 5-1 is a schematic of an example water control data system showing acquisition, application and management software 2/. Water control data and application management software has been developed by the Hydrologic Engineering Center for Corps-wide use. (See References 3 through 6).

5-6. Coordination of Data Collection and Exchange

a. Interagency Cooperation

(1) Nearly all water control data systems require coordination with other agencies to collect the hydrologic data necessary for water control management. In addition to the Corps of Engineers

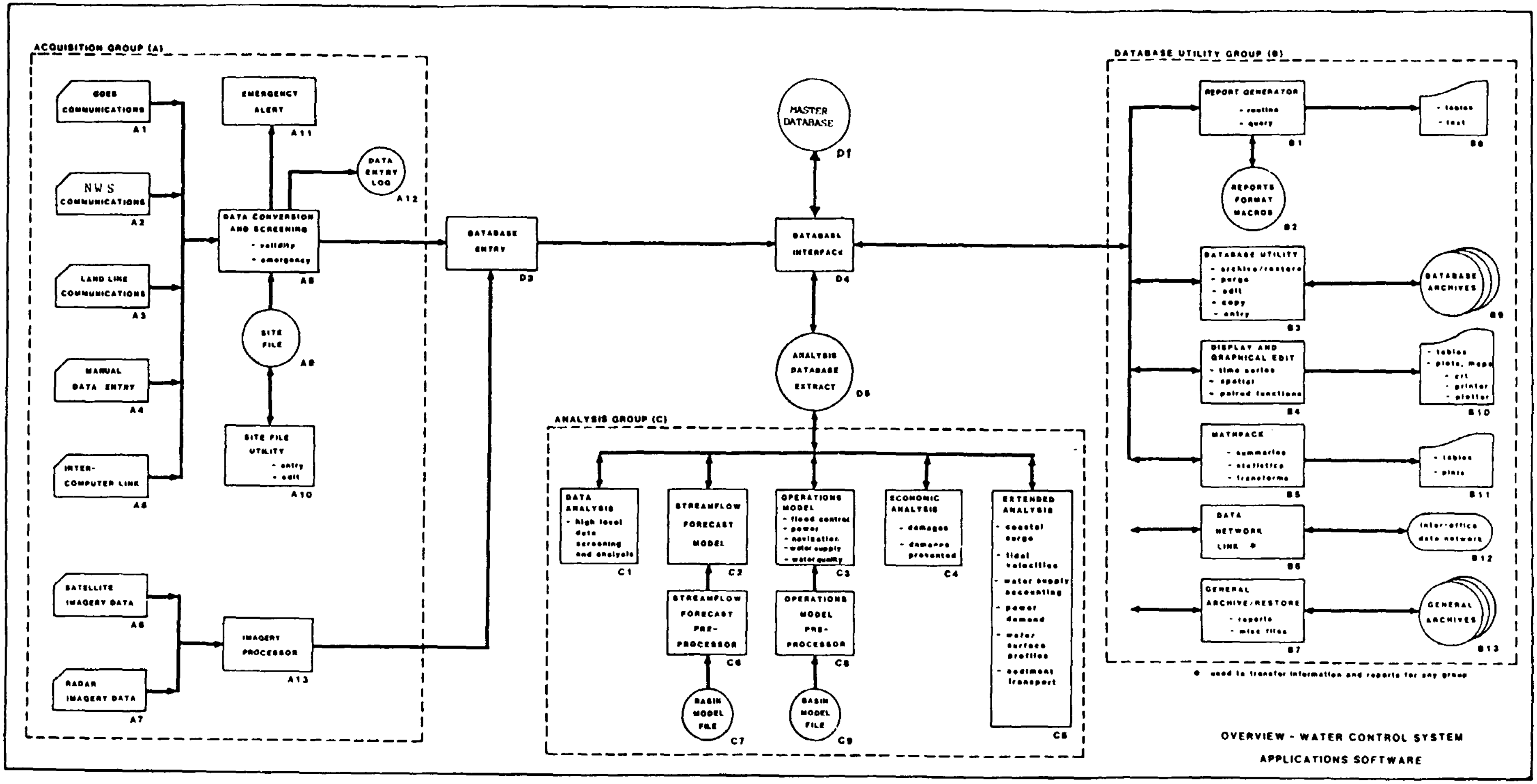
ACQUISITION GROUP (A)
GOES COMMUNICATIONS
A1
NWS COMMUNICATIONS
A2
LAND LINE COMMUNICATIONS
A3
MANUAL DATA ENTRY
A4
INTER-COMPUTER LINK
A5
SATELLITE IMAGERY DATA
A6
RADAR IMAGERY DATA
A7
DATA CONVERSION AND SCREENING
- validity
- emergency
A8
SITE FILE
A9
SITE FILE UTILITY
- entry
- edit
A10
EMERGENCY ALERT
A11
DATA ENTRY LOG
A12
IMAGERY PROCESSOR
A13
DATABASE ENTRY
D3
MASTER DATABASE
D1
DATABASE INTERFACE
D4
ANALYSIS DATABASE EXTRACT
D5
ANALYSIS GROUP (C)
DATA ANALYSIS
- high level data screening and analysis
C1
STREAMFLOW FORECAST MODEL
C2
OPERATIONS MODEL
- flood control
- power
- navigation
- water supply
- water quality
C3
ECONOMIC ANALYSIS
- damages
- damages prevented
C4
EXTENDED ANALYSIS
- coastal surge
- tidal velocities
- water supply accounting
- power demand
- water surface profiles
- sediment transport
C5
STREAMFLOW FORECAST PRE-PROCESSOR
C6
BASIN MODEL FILE
C7
OPERATIONS MODEL PRE-PROCESSOR
C8
BASIN MODEL FILE
C9
DATABASE UTILITY GROUP (B)
REPORT GENERATOR
- routine
- query
B1
REPORTS FORMAT MACROS
B2
DATABASE UTILITY
- archive/restore
- purge
- edit
- copy
- entry
B3
DISPLAY AND GRAPHICAL EDIT
- time series
- spatial
- paired functions
B4
MATHPACK
- summaries
- statistics
- transforms
B5
DATA NETWORK LINK *
B6
GENERAL ARCHIVE/RESTORE
- reports
- misc files
B7
- tables
- text
B8
DATABASE ARCHIVES
B9
- tables
- plots, maps
- crt
- printer
- plotter
B10
- tables
- plots
B11
inter-office data network
B12
GENERAL ARCHIVES
B13
* used to transfer information and reports for any group
OVERVIEW - WATER CONTROL SYSTEM
APPLICATIONS SOFTWARE

Figure 5-1

requirements, other Federal agencies have major missions that require them to also collect hydrologic and water control data. These agencies and the data they collect are listed below.

(a) National Weather Service - Various hydrometeorological data from surface observations and satellite sensors.

(b) U.S. Geological Survey - Water levels, streamflows, and water quality.

(c) U.S. Soil Conservation Service - Snow water equivalent and related hydrologic parameters.

(d) National Aeronautics and Space Administration - Data which expresses the areal extent of hydrologic elements such as snow cover, area of flooding, or soil moisture indexes as determined primarily from satellite measurements.

(e) U.S. Bureau of Reclamation and Bureau of Indian Affairs - Hydrologic and water control data.

(f) U.S. Department of Energy, through their Power Marketing Agencies (PMA's) - Certain types of hydrologic and power operational data needed for hydropower system operation.

(g) Tennessee Valley Authority - Project related hydrologic, water control, and hydropower data.

(2) In addition to these agencies, state, local and private organizations may also obtain water control data needed for the operation of their individual projects. A wide range of water data systems coordination is accomplished through formal and informal operating agreements between agencies, at the national level as well as at regional and local levels. These cooperative programs have been entered into in order to avoid duplication of effort in the installation, operation, maintenance and funding of hydrologic reporting stations that meet both Corps of Engineers water control data requirements and the cooperating agency's needs. As described in Section 5-3, ER 1110-2-248 defines the requirements for coordinating water data transmission using the GOES DCS. Information Service of the National Oceanic and Atmospheric Administration. ER 1110-2-241 stipulates that the owner of this type of project will provide hydrometeorological instrumentation and communication equipment as necessary for real-time project regulation. Operating arrangements for the cooperative exchange of data between the Corps of Engineers and Federal agencies, as well as for state, local, and private entities, are generally made at the local level. Interagency coordination and/or operating agreements needed for the exchange of

water control data with other entities is normally included as part of the Master Plan for Water Control Data Systems.

(3) An example of basin-wide coordination of water control data collection and dissemination among a number of entities (Canadian, Federal and local) is the Columbia River Operational Hydromet Management System (CROHMS). This data system, which was an outgrowth of previous interagency coordination, was developed on an interagency basis, through the principles contained in a Memorandum of Understanding, signed in 1971 by six Federal agencies. The CROHMS data system is also utilized for the exchange of data between the United States and Canada, as required under the Columbia River Development Treaty of 1961. It provides data exchange among a large number of non-federal hydropower projects and a variety of other Federal, state and local interests. A summary of the design and operation of CROHMS is contained in References 7 through 9.

b. Operational Management of Cooperative Data Systems

(1) The operation of a cooperative water data system that includes several agencies and organizations must be managed in a manner which meets the requirements of each agency. While design and procurement of sub-systems is generally the responsibility of each individual agency, the melding of system requirements must be accomplished in a cooperative manner in order to assure the reliable and timely access to the system for each user.

(2) Limits may be placed on access to the system by those not party to the cooperative agreements, as indiscriminate use might overload the system. Problems associated with the design and use of the system as related to interagency activities must be resolved by interagency actions. Formal or informal operating agreements signed by all participating agencies help to resolve these problems as they arise.

c. Data Exchange

(1) Intra-Corps. Data exchange between Corps offices should make use of available data communications within the agency. Real-time data transfers should use dedicated communication circuits between District/Division offices. An economic analysis should be performed to evaluate when separate dedicated circuits would be appropriate compared with shared dedicated or switch (dial-up) circuits.

(2) Inter-Agency. Depending on the volume of data and relative location of each office, dedicated or switched circuits may be used for data transfers to other agencies.

(3) Format. For all intra-Corps and inter-agency transfers, the data should be transferred in an approved standard format. The current adjusted format for such data transfers is the Standard Hydrometeorological Exchange Format (SHEF).