THE ROLE OF MICROCOMPUTERS IN DATA ACQUISITION AND ANALYSIS AT THE SALT RIVER PROJECT

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INTRODUCTION

A microcomputer is being used to gather and preprocess data for a computerized data management system developed at the Salt River Project (SRP). The purpose of the system is to collect, process, and store hydrologic and meteorologic data for the Salt and Verde watersheds. The following topics will be discussed to demonstrate the role of the microcomputer in data acquisition and analysis at SRP:

- Reservoir operations and watershed monitoring at SRP.
- Components of the Hydromet Data Management System.
- Development of an automated data collection component using a microcomputer.
- Functions of the automated data collection component.
- Benefits of the microcomputer automated data collection component.

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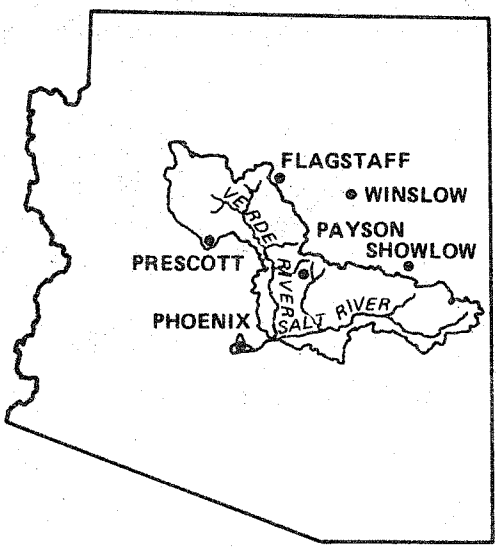
BACKGROUND

The Salt River Project, a water and power utility serving the greater Phoenix area, operates a system of six water storage reservoirs on the Salt and Verde Rivers in central Arizona. SRP is the nation's oldest multipurpose reclamation project. Since its creation in 1904, SRP has been involved in making water management and policy decisions which affect the lives of many residents of central Arizona. Historically, the traditional method of reservoir operation was the "fill and spill" procedure (Phillips, Jordan, 1986). Runoff from the 33,670 km2 (13,000 mi2) watershed was stored up to the 2,466,978,000 m3 (2,000,000 af) capacity of the system to provide water for agricultural, municipal, and industrial uses within the 101,172 ha (250,000 ac) project service area. Excess flows which could not be stored were allowed to flow harmlessly downstream through the Phoenix area in the normally dry Salt River channel.



THE SALT AND VERDE RIVER WATERSHEDS OF CENTRAL ARIZONA. THE VERDE JOINS THE SALT UPSTREAM FROM PHOENIX AND BELOW THE RESERVOIR SYSTEM OPERATED BY SRP

In the last 30 years, a growing urban population has resulted in decreased flexibility for reservoir operations. This rapid growth has resulted in increased property values along with the encroachment of residential and commercial building into the Salt River flood plain. Because the 6-reservoir system was originally designed for water conservation only, no flood control space exists. The need to maximize water storage must now be measured against the need to minimize flood damage. The flooding potential is real; recurring wet winter seasons since 1978 have resulted in numerous major flood events. In addition, updated hydrometeorological studies of the watershed indicate that reservoir capacities and dam outlet works are inadequate for controlling the revised maximum probable flood (U.S. Bureau of Reclamation, 1981). Water management decisions have become complex and are requiring more timely data as well as more sophisticated analytical tools.

NEW DEVELOPMENTS

Agencies responsible for water resource management have significantly increased their monitoring activities throughout the state. The increased activity has been in response to the rapid population growth in the Salt River Valley, the extended drought of the mid-1970's, and the major flooding events at the close of that decade. Of particular interest to the SRP was the completion of the Soil Conservation Service's SNOTEL system in 1978. SRP retrieves snow water equivalent (SWE), rainfall, and temperature data daily from 18 SNOTEL sites of which 14 are within the Project watershed. In 1981, six agencies including the Arizona Department of Water Resources, Maricopa County Flood Control District, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, U.S. Geological Survey, and the Salt River Project cooperatively purchased a Direct Readout Ground Station (DRGS). This system greatly expanded the cooperating agencies' ability to collect real-time data through the GOES (Geostationary Operational Earth Satellite) system. Currently, SRP collects streamflow and precipitation data from 35 sites from the DRGS.

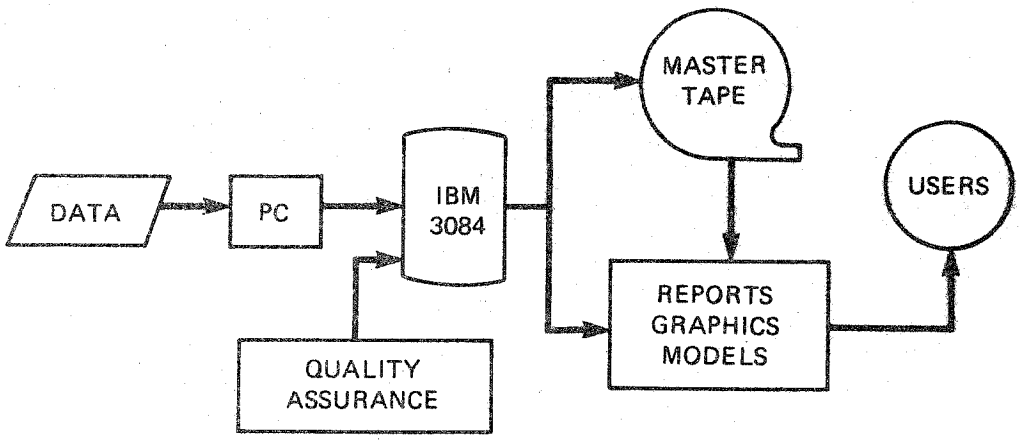
Additionally, in 1985 SRP upgraded its own River Gauge System (RGS) on the mainstem of the Salt and Verde Rivers and Tonto Creek. Six out of seven of these gauges are redundant to the already existing U.S.G.S. gauges. This redundancy provides a backup system for vital streamflow data. The RGS data is transmitted via SRP's telemetry system and can be accessed at predetermined intervals or by a manually initiated request.

The tremendous increase in the volume of data available to water resource managers along with the increasing number of complex models, equations, and graphics for which the data are used has prompted the development of the Hydromet Data Management System.

THE HYDROMET DATA MANAGEMENT SYSTEM

The Hydromet Data Management System is a database and data processing tool designed to collect, process, and store the real-time hydrological and meteorological data required to monitor conditions on the watershed. In addition, the system manages historical records used in forecast models and studies concerning the watershed.

HYDROMET DATA MANAGEMENT SYSTEM



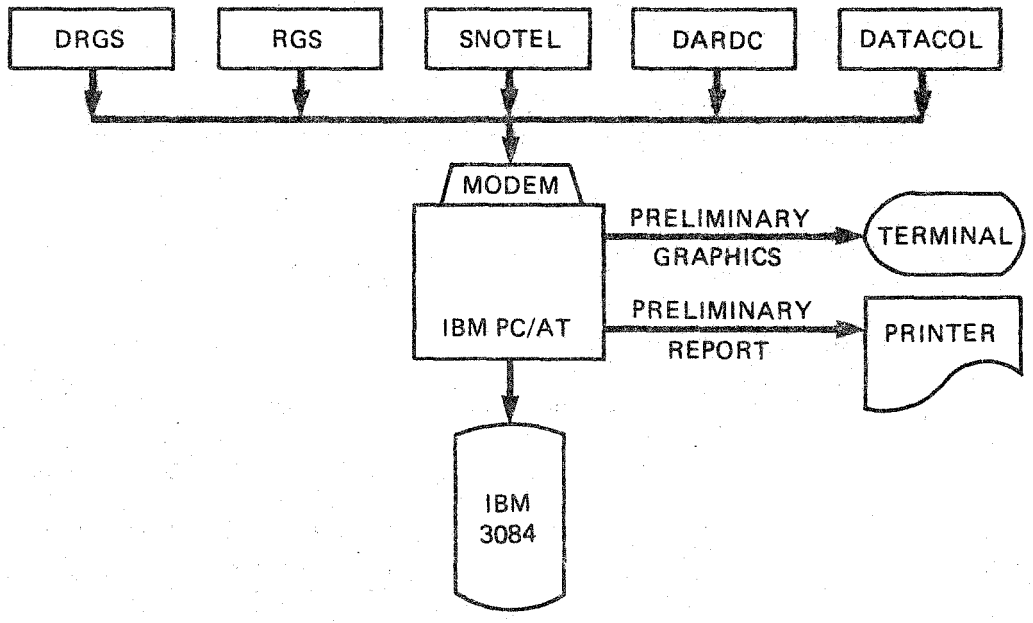
The Hydromet Data Management System resides on an IBM 3084 mainframe where it has several different functions. Meteorologists and hydrologists provide quality assurance by editing the incoming data. Analysts performing reservoir operation studies and making runoff forecasts, run models against the database files. Sophisticated graphics and a report distribution system are regularly available to all levels of decision-makers in the company. Finally, historical data analyses are initiated at the request of SRP analysts and outside agencies.

Having the data in place as it is needed insures timely and informed water management decisions. Manual input to the database is no longer feasible because of the quantity of data now being collected on a daily basis. This is especially true during storms when real-time data is vital. Manual data collection would lessen the effectiveness of the analysts and decision-makers.

AUTOMATED DATA COLLECTION

An independent automated data collection and preprocessing system was developed using a microcomputer because manual data collection and entry were not efficient and the mainframe was not suited to the task. The core of the automated data collection component is an IBM PC/AT configured with a modem and printer. The system utilizes a commercial software package to accomplish remote communications with 5 computerized data sources. There is also an internal communications link to the SRP host computer. The integration of several additional commercial software products has produced a system capable of collecting and transferring data to the mainframe independent of human intervention. By the beginning of each work day, over 5,200 pieces of information are collected, preprocessed and transferred to the host. Preliminary reports are printed and graphics are available.

AUTOMATED DATA COLLECTION SYSTEM



The microcomputer plays a unique role in the Hydromet Data Management System. It has been applied to specific functions where it works independently of users and other Hydromet data processing functions.

FUNCTIONS OF THE MICROCOMPUTER SYSTEM

1. Data Acquisition

   Streamflow, precipitation, and snow data are collected to monitor conditions on the Salt and Verde watersheds and to aid in reservoir operating decisions. Five remote computers are accessed automatically each morning by the microcomputer to collect the data. At 6:00am the microcomputer is activated and calls the remote data sources via the modem. Data files are transferred over telephone lines and stored in the PC. User-initiated data collection can be performed at any time throughout the day as well.

   The following is a list of the remote systems that provide data to the Hydromet database:

   - The U.S.G.S. operated DRGS system supplies 15-minute stream gauge and precipitation values for 35 watershed sites.
   - The SRP operated River Gauge System provides the company with backup stream gauge data at 7 crucial sites.
   - The Soil Conservation Service SNOTEL system supplies snow water equivalent, precipitation, and temperature data for 14 watershed and 4 neighboring sites.
   - The National Weather Service DATACOL system provides daily snow depth, precipitation, and temperature data from 49 National Weather Service sites and cooperative observers.
   - The National Weather Service DARDC system supplies precipitation data for 18 National Weather Service automatic rain gauges.

The agencies and data they provide are summarized in Table 1.

TABLE I. AUTOMATED DATA SOURCES

SOURCE	AGENCY	DATA TYPE
DRGS	USGS	STREAM GAUGE HEIGHTS AND PRECIPITATION
RGS	SRP	STREAM GAUGE HEIGHTS
SNOTEL	SCS	SWE, PRECIPITATION, AND TEMPERATURE
DATA COL	NWS	SNOW DEPTH, PRECIPITATION, AND TEMPERATURE
DARDC	NWS	PRECIPITATION

2. Data Preprocessing

Data processing programs have been developed on the microcomputer to prepare the data for preliminary reports and for placement in the Hydromet database files. The data values are reformatted to achieve efficient processing on the mainframe. The new format facilitates merging the values into data files. In addition, out-of-range values are deleted.

3. Preliminary Reports

Reports are generated for each data source at the time of collection. The processed values are presented in a comprehensible format. Daily automated data collection occurs before 7:00am and reports of overnight activity are printed at the Data Collection Center by 8:00am. If additional data values are requested during the day, updated reports are produced during user-initiated data collection.

The raw data collected from the DRGS system is processed to produce an edited file. Fifteen-minute DRGS values, reported in Greenwich Mean Time, are converted to hourly values recorded in Mountain Standard Time. This condensed file is utilized to produce a summary showing the accumulated rainfall, last reported gauge height and corresponding flow rate for each site. The edited data file and summary report are both printed each morning for analysts to examine. An example of this editing process is shown in Table 2.

TABLE II. PRELIMINARY REPORT PRODUCTION
SALT RIVER AT ROOSEVELT DRGS

(a)

SLTR	162A02F4	87/016	4:40:08		3/064	462	0	+42.8	–04.0	076	+17.6	0
STAGE	4:30	0:15	7.12	7.12	7.12	7.12		7.12	7.12	7.12	7.12	
			7.12	7.12	7.12	7.12		7.12	7.12	7.12	7.11	
			7.11	7.11	7.11	7.11		7.11	7.11	7.11	7.12	
			7.12	7.13	7.14	7.16		7.16	7.16	7.17	7.17	
PREC	4:30	0:15	6.95	6.95	6.95	6.95		6.95	6.95	6.95	6.95	
			6.95	6.95	6.95	6.95		6.95	6.95	6.95	6.95	
			6.95	6.96	6.97	6.99		6.99	7.00	7.00	7.03	
			7.04	7.04	7.06	7.10		7.13	7.18	7.22	7.26	
BATVT	4:40	4:00	12.5	12.3								

(b)

14:14:35 F

>> SLTR

1/14/87	2200	7.13	–8.88	1/14/87	2300	7.15	0.00	1/15/87	0	7.15	0.00
1/15/87	100	7.15	0.00	1/15/87	200	7.15	0.00	1/15/87	300	7.15	0.00
1/15/87	400	7.15	0.00	1/15/87	500	7.15	0.00	1/15/87	600	7.14	0.00
1/15/87	700	7.13	0.00	1/15/87	800	7.13	0.00	1/15/87	900	7.12	0.00
1/15/87	1000	7.12	0.00	1/15/87	1100	7.12	0.00	1/15/87	1200	7.12	0.00
1/15/87	1300	7.12	0.00	1/15/87	1400	7.12	0.00	1/15/87	1500	7.12	0.00
1/15/87	1600	7.12	0.00	1/15/87	1700	7.12	0.00	1/15/87	1800	7.11	0.01
1/15/87	1900	7.11	0.04	1/15/87	2000	7.13	0.04	1/15/87	2100	7.16	0.14
1/15/87	2200	7.17	0.13	1/15/87	2300	7.18	0.07	1/16/87	0	7.18	0.02
1/16/87	100	7.18	0.03	1/16/87	200	7.17	0.02	1/16/87	300	7.17	0.00
1/16/87	400	7.17	0.00	1/16/87	500	7.17	0.00				

(a) USGS DOWNLINK DATA FILE
(b) SRP MICROCOMPUTER PROCESSED DATA FILE

continued

(c)

table II. continued

DOWNLINK REPORT
FOR DATA 400 1/15/87 – 700 1/16/87

STATION	PRECIP SINCE 0500 YEST (in)	PRECIP SINCE 0500 TODAY (in)	PRECIP IN LAST 3 HRS (in)	GAUGE HT (ft)	STREAM FLOW (cfs)
NORTH FORK THOMAS CREEK NEAR	0.00	*****	0.00		
BLACK RIVER AT PUMPS	0.00	*****	0.00	2.67	174
BLACK RIVER NEAR FT APACHE	*****	*****	*****	2.72	314
EAST FORK – WHITE RIVER	*****	*****	*****	1.35	56
WHITE RIVER NEAR FT APACHE	0.12	*****	0.00	2.17	76
CARRIZO CREEK	0.00	*****	0.00	1.53	61
SALT RIVER NEAR CHERRY	0.10	*****	0.00	2.13	348
CIBECUE CREEK	0.27	*****	0.02	1.91	11
SALT RIVER @ ROOSEVELT	0.50	*****	0.00	7.17	464
PARKER CREEK NEAR ROOSEVELT	0.00	*****	0.00		

(c) PRELIMINARY REPORT

Hourly gauge heights and associated streamflows from the SRP River Gauge System are displayed for the previous 24-hour day and up to the present hour of the current day.

Eight days of SNOTEL values are analyzed to show the last 24 hours of accumulated precipitation and the corresponding snow water equivalent values.

DARDC precipitation values are converted to 24-hour accumulations.

The DATACOL report is a copy of the summary produced by the National Weather Service. This report is printed without editing.

4. Data Transfer to Mainframe

Using a direct internal communications link, the edited data files are sent to the mainframe IBM computer. Programs that run on the mainframe are automatically invoked from the PC following the transfer process. These jobs place the data in the Hydromet database files and create libraries of graphs that display the current data. Data values collected each morning are in place and available to all SRP users by 8:30am.

BENEFITS OF THE MICROCOMPUTER IN DATA ACQUISITION

The use of a microcomputer to collect, preprocess, report and upload data to the Hydromet database has proven beneficial to the Salt River Project. The quality, quantity, availability, and timeliness of data have greatly improved since implementation of the automated data collection system in early 1986. The major benefits of the system include:

1. Management decision making has become more effective. Managers can make more informed decisions based on summarized data reports and graphics produced from a large quantity of real-time, high quality data. Twenty times more data is available using automated data collection than had been available with manual collection and entry.

2. The data values have become more dependable. When the manual entry of data was replaced with automated uploading, human data entry errors were eliminated. In addition, the microcomputer automatically removes outlying data points which has reduced the impact of instrument failure. Freed from manual collection and data entry, analysts have turned their attention to data verification, which ensures high quality. The most significant improvement that the automated data collection system has made to reservoir operations and watershed management at SRP is dependable, high quality data.

3. Analysts' time has become more productive. They no longer need to spend up to 15 hours per week gathering and processing data from several different sources. Because data verification only takes approximately 2 hours per week, analysts can concentrate on the interpretation and analysis of the data.

4. The concise reporting of current data at the Data Collection Center has been enhanced. After processing the collected data, preliminary data reports are produced. Simple graphics on the microcomputer can be accessed to view the precipitation and stream data at the various DRGS sites. The availability of these reports by 8:30am provides analysts with a quick summary of overnight activity and aids data verification by displaying erroneous data.

5. Company wide data accessibility has increased dramatically. Any computer user in the Project with the proper terminal sign-on can have rapid access to graphic displays of the data or summarized reports. Requests for more complex analyses are sent to analysts who design special programs to access the Hydromet database and produce specially tailored reports.

6. Real-time data is now readily available for analysis and for use in real-time forecasting models. Current data values are in place in the database files every morning and the files may be updated with real-time values throughout the day. Real-time forecast models can be run against the automatically updated database files with increased efficiency and accuracy.

7. Data backup also exists within the microcomputer. The microcomputer retains 7 days of data to preclude the possible loss or inaccessibility of data if the mainframe is down. One week of data backup is sufficient to continue water management operations without major problems.

8. Finally, the microcomputer reduces demand on the mainframe. By reducing our dependence upon the mainframe computer for relatively simple tasks, the mainframe is more responsive when performing its many complex operations.

The Hydromet Data Management System has proven to be a valuable tool at the Salt River Project. The need to make informed and timely water management decisions has increased with the expanding urban population of central Arizona. Monitoring water resources has become more complex while remaining basic to strategic decision making. The microcomputer automated data collection component has increased the efficiency of the Hydromet Data Management System. The use of the microcomputer to collect and preprocess the large quantity of hydrological and meteorological data needed to manage the Salt and Verde watersheds has provided high quality, readily available data to SRP water resource managers. Automating the collection function with a computer and isolating the function to a PC has allowed both the human and mainframe resources at SRP to be more efficient and effective.

REFERENCES

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