Computer Aids Groundwater Resources Research Project

*by W. G. Matlock and P. R. Davis**

Digital computer programs have been written to meet the requirements of the groundwater resources research project in the Agricultural Engineering Department. The computer speeds data storage and retrieval for project personnel as well as more easily satisfying the needs of the users of groundwater data. Mapping of groundwater contours is also expedited by the computer. The programs are adaptable to similar propjects in other areas, and inquiries from interested persons may be directed to the authors.

Groundwater research in the Agricultural Engineering Department of The University of Arizona began in the early 1900's with Dr. G. E. P. Smith, Professor Emeritus and former Head of the Department of Agricultural Engineering. The project has been continued since that time under the leadership of Dr. Smith and later Harold C. Schwalen, also Professor Emeritus and former Department Head. Richard J. Shaw, who recently retired, joined the project in 1947 to organize a more intensive water level measurement program. These men recognized the importance of groundwater to Arizona particularly in the Tucson area where perennial surface supplies are unavailable.

Project activities are focused on the collection of basic groundwater data. The depth to water is measured in hundreds of wells one or more times annually with a steel tape or electric sounder. Total yearly water pumpage from the groundwater reservoir is obtained by adding the quantities used for various purposes. Consumptive use by irrigation is computed from a crop survey. Domestic and industrial use are measured or estimated. Water samples are collected for chemical analysis and temperature measurement. A file of drillers' logs of wells is maintained. Other specialized studies are also conducted.

The Santa Cruz Valley from the International Boundary near Nogales to Picacho Peak is the most intensively studied. Other project areas include the Avra-Altar Valleys, west of Tucson, and the Little Chino Valley, north of Prescott. Several other areas have been studied in the past.

The records from seventy years' field work fill several filing cabinets. Much effort has gone into the transfer of field data onto permanent record cards. Most of the copying was and is done by students working part time (Figure 1).

Data analysis requires further handling of the records. Groundwater contour maps and water level change maps are prepared each year. Measured water levels are subtracted from ground surface elevations or from previous measurements to obtain plotting values. The maps are prepared by plotting these values in the proper

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Figure 1. Linda Grabowski, left, of Tucson and Bob Mohammed, Glendale, are students in Agricultural Engineering. Here they are working on transcribing groundwater data.

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location and drawing contour lines of equal elevation or water level change.

In the past several months were required each year for making computations, plotting and drawing the maps. Project operations have been simplified and expedited by utilizing the capabilities of The University's CDC-6400 computer. First the data had to be prepared in a form for direct input into the computer. Several types of input are acceptable; for this project the most practical was the punch cards since it also provides a permanent record for office use. An additional benefit is realized in the reduction of space required for record storage (Figure 2). Data printed on the cards includes an identifying number, the location of the well by legal description and by latitude and longitude, the elevation of the well measuring point above sea level and the depth to water measured approximately at the same time for all years of measurement.

The first computer program was written to print out the punch card data in a form convenient for office use. A second program prints out a brief history of each well including number, location, measuring point elevation, current depth to water and changes in water level in the past 5 years and since the base year for the measuring program in the particular area (Figure 3). These data are very useful in answering the daily requests for well information received by telephone.

Other computer programs were written to plot hydrographs and summarize the crop survey data. Hydrographs, or graphs of water level versus time, are used in the project principally to detect trends in the elevation of the water surface and to estimate missing records for those years when no measurement was made. Computerizing the crop survey data used in computing water use virtually eliminates arithmetic errors and allows much faster analysis of the field data.

Figure 2. Linda with complete punch card file of the Tucson Basin groundwater data. This drawer contains records formerly filling three file cabinets.

As noted, manual contour mapping is time consuming and laborious. Computer programs for plotting contour points in use on similar projects around the country were first investigated, but none were suitable. A new contour mapping program was then written in three parts. The first verifies the well locations on the latitude and longitude coordinate grid by printing them on a map; the next two compute and plot contour points.

From the input data, the contour program calculates contour points by linear interpolation along preselected lines between wells. When the elevation of a contour point is determined, the latitude and longitude of that point are calculated. In addition to points representing water surface elevation, with a slight variation the program will also calculate contour points for depth to water or change in water level. Any contour interval can be used. When all contour points are calculated, they are placed in order of decreasing latitude (from north to south) on a magnetic tape file to be used as input for the mapping program.

In addition to the coordinates of the contour points, input for the mapping program includes latitude and longitude boundaries of a rectangle containing the area of interest and the incremental change in latitude and longitude for one line and one space on the computer output printer. The output is printed on 12-inch wide strips which are placed together to form a complete map of the area.

Each contour value is assigned a letter of the alphabet. Contours are then drawn in by connecting all like letters. Judgment is still required in smoothing and finishing the contour map which is ultimately transferred to a base map of the area for reproduction. Figure 4 is an example of the computer output with the contours drawn in by hand.

The use of the digital computer in the groundwater resources research project has already saved appreciable time. As project personnel become more familiar with the system, greater

Figure 3. Sample printout of water level program.

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NM---NO MEASUREMENT

WELL NUMBER	WELL LOCATION	BENCH MARK ELEVATION	CURRENT YEAR DEPTH TO WATER	CURRENT YEAR WATER TABLE ELEVATION	ONE-YEAR CHANGE	FIVE-YEAR CHANGE	CHANGE FROM BASE YEAR 1947
536	121332.322	2320.86	216	2105	-4	-8	-31
548	121336.433	2607.90	NM	NM	NM	NM	NM
549	121403.221	2711.19	9	2702	28	-2	NM
556	121405.343	2625.22	101	2524	-18	14	-1
618	131201.413	2187.20	75	2112	-5	-7	-19

NUMBER OF WELLS PROCESSED IS 5

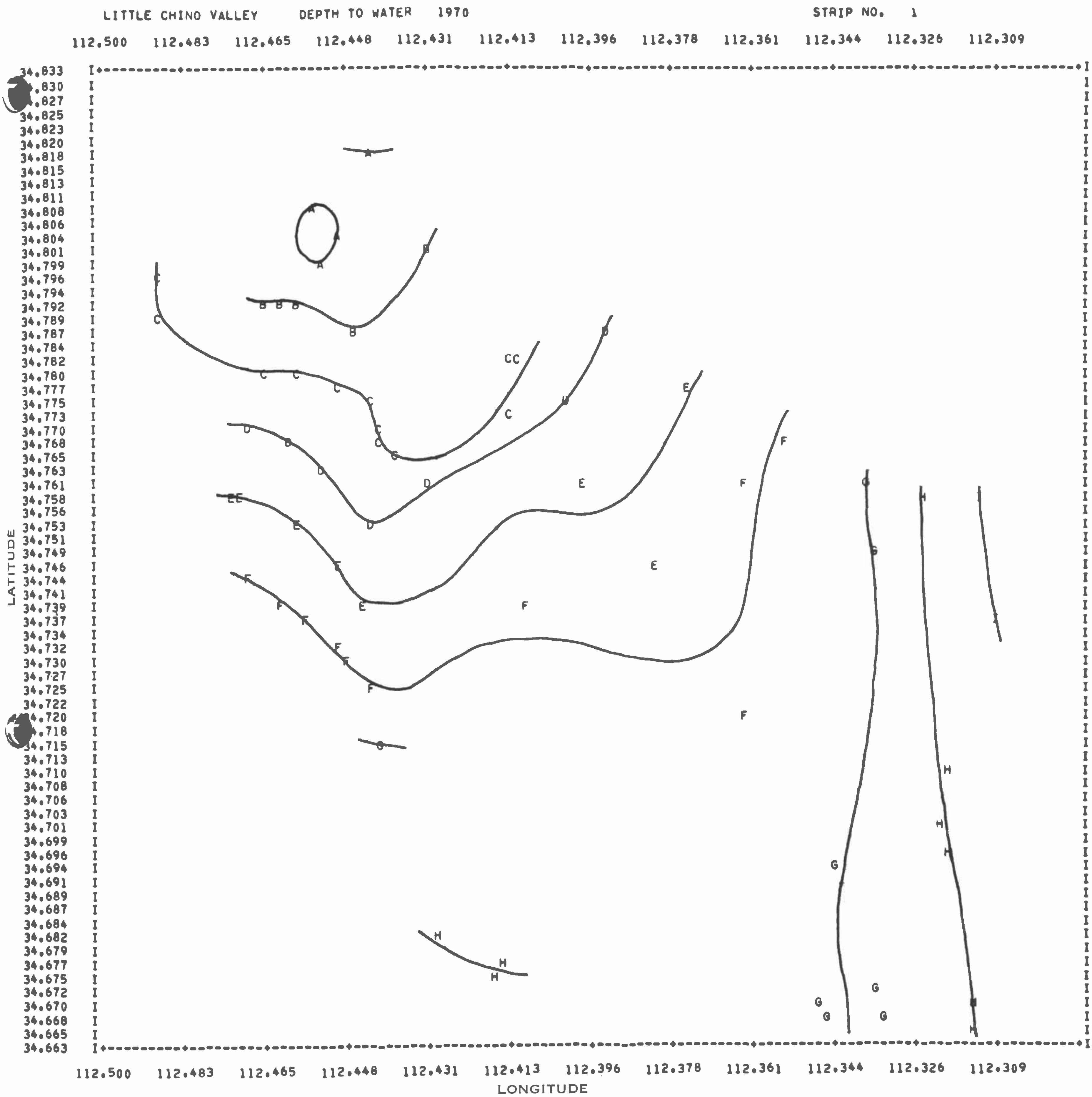

Figure 4. Example of computer plotted contour map.

savings are anticipated. Errors in general have been reduced, but those involved in transcribing the data to punch cards are still a problem and must be carefully avoided.

Because of the time saving, researchers are now able to make analyses as a routine operation that were previously too time-consuming to be considered. Other types of analysis, not even possible in the past, will probably be introduced.

Service to the community is an important project objective. Groundwater information is provided from the department files for many different people and government agencies. Students use it for class projects and graduate theses; consulting engineers and groundwater geologists base their recommendations on it. Real estate agents are frequent users as is the general public.

Although representative data are published about every five years, a need for more detailed information formerly required the user to spend considerable time in studying and copying records. Publications for general distribution will be issued, as in the past, but for those who require information at other times, it will be much more readily available.