TECHNICAL MEMORANDUM

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GUIDEBOOK TO THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT'S GEOPHYSICAL LOGGING AND DIGITIZED DATA PROCESSING TECHNIQUES

by

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All work was completed under the supervision of Abe Kreitman, Director, Groundwater Division, Resource Planning Department, South Florida Water Management District.

INTRODUCTION

In 1976 the South Florida Water Management District acquired a Gearhart-Owen "Widco" model 3500 portable geophysical logging system. The 3500 model operates on 120 volts A/C, 2000 watts at 50 to 60 Hertz. The unit was purchased with the following capabilities which comply with Nuclear Instrument Modules Specifications (NIMS): 16 and 64 inch Short and Long Normal Resistivity, 6 foot Lateral Resistivity, Spontaneous Potential, Flowmeter, Fluid Resistivity, Fluid Temperature, Differential Temperature, Natural Gamma Ray, Casing Collar Locator, Neutron Porosity, 36 inch Caliper, Gamma Gamma Density and a Fluid Point Sampler. In 1978 an Acoustic Logging system (probe, module) was purchased from SIMPLEC, Inc. A Tektronix T922R Oscilloscope, purchased with the original equipment, was incorporated with the Acoustic system. All tools were specified to be calibrated to some standard units (e.g., Natural Gamma Ray to API units, etc.). The equipment was mounted in a 4-wheel drive Chevrolet Suburban and was powered by a Honda 2500 model generator (later replaced by a Honda model 3500).

In 1978 the need to have a field digitizer was dictated by the expense of manually digitizing survey data. The definition and use of digitized survey data is presented in the Data Capture and Storage Chapter. An SIE Data Acquisition System (DAS) was subsequently purchased, giving the District capabilities of recording all survey data in the field both in analog and digital formats.

The operation, maintenance and calibration of uphole and downhole equipment are fully described in literature available from the suppliers, and will not be addressed in this report. Specifically, descriptive literature is available for the following:

(a) Gearhart-Owen Industries (GOI) Elm 202 Module, 1975.

(b) Model 3200/3500 P.L.S., 1975.

(c) Gamma/Neutron System, 1977.

(d) MRP 501 Modular Recorder, 1975.

(e) Tektronix, T922 R Oscilloscope, 1975.

The reader is also referred to the publication by Brown and Anderson (1979) for information on Natural Gamma Ray/Neutron Porosity logging.

Purpose and Scope

The purpose of this report is to provide a user's manual to guide District personnel step by step through the available geophysical logging processes for digitized borehole data. It is a description of the South Florida Water Management District's geophysical logging equipment and capabilities for use in groundwater resources investigations. Methods for computerized capture, storage, manipulation and retrieval of geophysical data and case histories describing some applications of borehole geophysical logging data and techniques specific to groundwater problems are discussed. These processes and techniques are general enough to be suitably applicable to other systems.

It should be emphasized that this report does not cover all borehole geophysical surveys applicable to groundwater investigations, and as such is not a substitute for general texts which are intended to do this. For example, the commonly used Single Point Resistivity survey is omitted because, although it is a qualitative survey useful for lithologic correction and other semiquantitative interpretations, the information it yields is similar but not as useful as the generally run 16 inch Normal Resistivity Survey. Other surveys which are outside the capability of the present system may be quite valuable to the hydrogeologist. However, these surveys may be more costly, more difficult to obtain, or not generally available to the hydrogeologist. In addition this report does not purport to be a complete formation evaluation textbook. While common applications in the SFWMD lithologic environments are mentioned, the reader must consult other texts for details of many of the applications. Finally, although the effects of various extraneous factors on the log responses are mentioned, it is not intended to give the impression that these are the only factors which may affect the logs. These effects are, however, considered to be the most likely ones encountered in this area. The Selected Bibliography given at the end of the report is intended to assist the reader in obtaining further details of borehole geophysical methods.

Applications

A well log is defined by Sheriff (1973) as a record of one or more physical measurements as a function of depth in a borehole. Geophysical well logging, also called borehole logging, includes techniques of recording borehole measurements by means of sondes carrying sensors which are lowered into the borehole by a cable.

Geophysical logs are useful in groundwater resource investigations in that they help quantify the properties of the rock and borehole fluid. This information assists hydrogeologists in their decisions on stratification and associated rock properties, as well as water quality and availability. In addition, correlations of rock units can be made based on similar responses from logs in different wells. Table 1 is a generalized summary of the major hydrogeologic applications of the geophysical surveys available at the SFWMD. It should be emphasized, however, that this is a general guide only. Most interpretations require combinations of different logs, or additional data. The particular hydrogeologic situation will, to a large extent, determine what interpretations can be made and how these are done.

The advantage of geophysical logs is that a continuous borehole record with depth is available at reasonable cost. For example, if a hole is entirely cored with 100 percent recovery, laboratory analysis of the core involves the selection of point samples. Continuous coring and subsequent

	LITHOLOGIC CORRELATION	LITHOLOGY	ROCK DENSITY	FRACTURING AND SOLUTION CAVITIES	POROSITY	PERMEABILITY	TRANSMISSIVITY	GROUNDWATER FLOW	WATER LEVEL	WATER QUALITY	TEMPERATURE GRADIENT	HOLE DIAMETER	LOCATION OF CASING	CONDITION OF CASING	LOCATION OF SCREENED INTERVAL	LOCATION AND BONDING OF CEMENT	PRODUCING ZONES	REMARKS
16" NORMAL RES.	A	A	C	B	B	B	B		A	B			B	C	A		B	
64" NORMAL RES.	A	A	C	B	B	B	B		A	B			B	C	B		B	
SPONTANEOUS POT.	A	B			B	C		A	C	B			B		C		B	
6' LATERAL RES.	A	A	C	B		B			A	B			B	C	B		B	
FLUID RESISTIVITY								B		A							B	
FLOWMETER				C		B	B	A					B				A	USED TO CORRECT OTHER LOGS FOR RESISTIVITY OF BOREHOL[illegible] FLUID
TEMPERATURE				C			B	B			A					A	A	
DIF. TEMPERATURE				C			B	B								A	A	
CALIPER	B	B	C	A		C	C					A	A	B			B	USED TO CORRECT OTHER LOGS FOR INFLUENCE OF HOLE DIAMETER
CASING COLLAR LOCATOR		C											A	B				
NATURAL GAMMA	A	B			C	C	C										C	
NEUTRON POROSITY	A	B	B	B	A	B	C		A				C				B	
GAMMA-GAMMA DENSITY	A	B	A	B	B				C				C			B	C	
SONIC ACOUSTIC	A	A	A	A	B	C							B			A	C	

Note: A - Most Direct or Usual Application May Require Some Additional Information For Interpretation of The Logs.
B - Requires Other Logs or Prior Geological or Hydrological Information For Proper Interpretation of The Logs.
C - Used Mainly For Confirmation of Conclusions From Other Data, or Rarely Used For This Purpose or Requires Considerable Additional Information For Proper Interpretation.

TABLE 1 - Major applications of borehole geophysical surveys available at the South Florida Water Management District

analysis of enough samples to be statistically meaningful is extremely costly.

The first borehole geophysical log made in the United States was obtained by W. B. Halloch in 1897 by plotting temperature measurements with depth (Halloch, 1897). The first Resistivity surveys were run in 1927 in an oil field in France by the Schlumberger brothers (Schlumberger, et al., 1929, Schlumberger, et al., 1934). These logs were made by manually plotting the deflections of a galvanometer that responded to the resistivity of the rocks and their in situ fluid. The first comprehensive description of "Subsurface Geophysical Methods in Groundwater Hydrology" was written by P. H. Jones and H. E. Skibitzke in 1956.

DESCRIPTION OF EQUIPMENT

The geophysical logging system consists of surface instrumentation and electronics and downhole probes (see Figure 1). The surface equipment performs the functions of lowering and raising the sondes as well as receiving, processing and recording the downhole signals. The downhole equipment may transmit to and/or receive impulses from the borehole fluid, rock and interstitial fluid. The impulses received by the sensing elements are converted into electrical signals which are transmitted to the surface via conducting wires in the cable connecting the tools to the surface equipment.

The major components of the surface equipment are:

(a) Surface electronics - This consists of the basic Instrument Modules and bin assembly (basic frame and low voltage supply for all modules), power module assembly and a number of other modules. Available modules include shooting power, ratemeters, line power control, differential temperature system, E-log (modules 202 and 204), acoustic system, flowmeter and the oscilloscope.

(b) Draw Works - This system includes a winch with 3500 ft. of 4 conductor 3/16 inch cable, line speed control, 5 speed transmission, slip ring assembly, level wind, manual and optical encoders.

(c) Recorders - Two types of recorders are used, a three channel strip chart recorder and a digital magnetic tape Data Acquisition System.

Specifications for all equipment except the Data Acquisition System (DAS) are available in GOI Products Catalog, 1978, and will not be discussed in

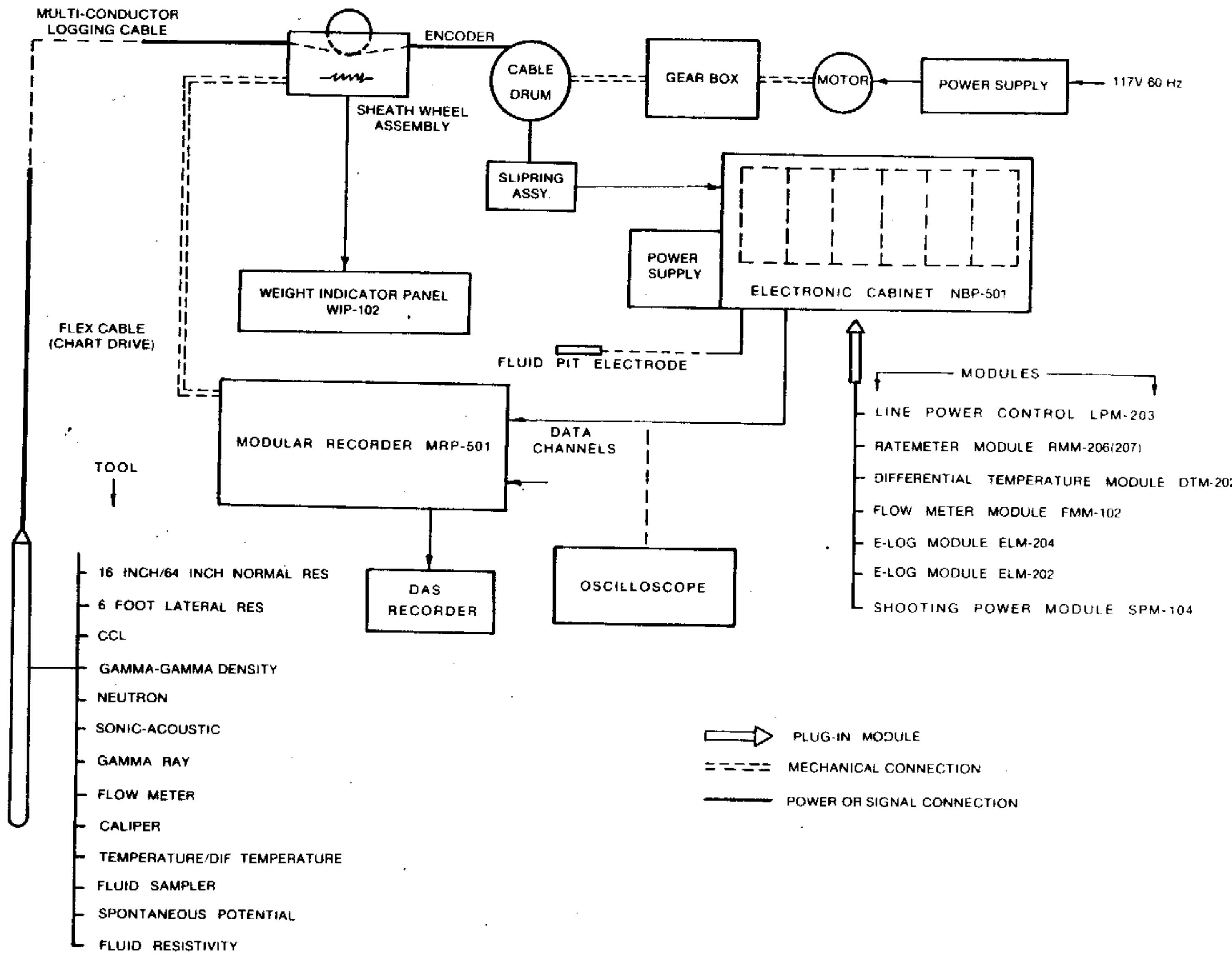

FIGURE 1 - G.O.I. 3500 Portable Logger System block diagram (Modified from G.O.I., 1977)

detail in this report. However, a short discussion of the DAS is appropriate with details available in the SIE design specifications manual.

The SIE Data Acquisition System records simultaneously with the strip chart recorder. Both units process the same input signal as millivolts and consequently calibrate identically. Five channels, one depth and four amplitude, can be recorded on the DAS at any one time; up to five digits for depth and four digits for amplitude can be recorded. A standard Phillips type digital cassette with clear leader and begin end of tape (BEOT) hole is used in the memodyne digitizer, a component of the DAS. Depth measurements are recorded through an optical encoder attached to the sheath wheel assembly. Sampling can occur at .1 foot, .5 foot and 1 foot intervals and are controlled by the logging line speed. All circuitry is contained in a 19 inch dustproof rugged shock-mounted bin installed in the geophysical logging vehicle.

The downhole tools available on the SFWMD research system at the present time are: 16 and 64 inch Normal Resistivities, 6 foot Lateral Resistivity, Spontaneous Potential, Flowmeter, Borehole Fluid Resistivity, Borehole Fluid Temperature and Differential Temperature, Caliper, Neutron Porosity, Natural Gamma Ray, Casing Collar Locator, Gamma Gamma Density, Acoustic Velocity, and Fluid Sampler.

DESCRIPTION OF SURVEYS

This section gives a brief description of the surveys available on the present SFWMD geophysical logging system. Included are theory, principle of operation, types of calibration, restrictions on use and information necessary for interpretation of the survey. As pointed out previously, the reader may want to consult relevant references for a more detailed description.

Resistivity Surveys - 16 and 64 inch Normal:

Resistivity logging devices measure the electrical resistivity of a volume of the earth's materials under direct application of an electric current. The mathematical relationship which defines resistivity is derived from Ohm's Law and may be stated as follows:

$$P = \frac{\Delta V}{I} \cdot \frac{A}{L} \qquad (1)$$

Where,

P = constant of proportionality (Resistivity) in ohm m^2/m

ΔV = potential difference across the element in volts

I = electric current in amperes

A = cross sectional area of element in $meters^2$

L = length of element, in meters

In resistivity measurements, the term $\frac{A}{L}$ is dependent on the electrode arrangement, while I is kept constant. The potential difference ΔV is measured by the probe and converted to resistivity values (P) in units of ohm $meters^2/meter$.

Within the borehole the element of earth material surrounding the probe is a sphere with volume $4 \pi \gamma$. The potential V at a point γ distant from the electrode is given by:

$$\frac{dV}{d\gamma} = \frac{IP}{4\pi\gamma^2} \quad (2)$$

Integrating,

$$V = \frac{-IP}{4\pi\gamma} \int \frac{1}{\gamma^2}\, d\gamma \quad (3)$$

Or,

$$V = \frac{IP}{4\pi\gamma} \quad (4)$$

Normal Resistivity devices utilize two current electrodes (A and B) and two potential electrodes (M and N) (Figure 2). As shown in Figure 2 electrodes A and M are relatively close together, while electrodes B and N are relatively distant from each other and from electrodes A and M. Thus, the potential transmitted between A and M is the major component measured. This potential is measured at the mid point between A and M during logging (Pirson, S. J., 1963). The resistivity values recorded for the normal survey is given by the equation (Pirson, S. J., 1963).

$$P = \frac{4\pi \Delta V AM}{I} \quad (5)$$

Where,

AM is the "geometric factor" equal to 16 inches for the 16 inch Normal survey and 64 inches for the 64 inch Normal survey.

The equipment is, however, generally calibrated to give P in ohm $meters^2/meter$.

For the Lateral log, the above equation becomes (see Figure 5) (Pirson, S. J., 1963).

$$P = \frac{4\pi \Delta V}{I} \left(\frac{1}{AM} - \frac{1}{AN}\right) \quad (6)$$

The reference level for the Lateral log is midway between electrodes M and N.

Electrical conduction in solid particles is by two mechanisms, intrinsic or extrinsic. In porous media, three components of electrical conduction

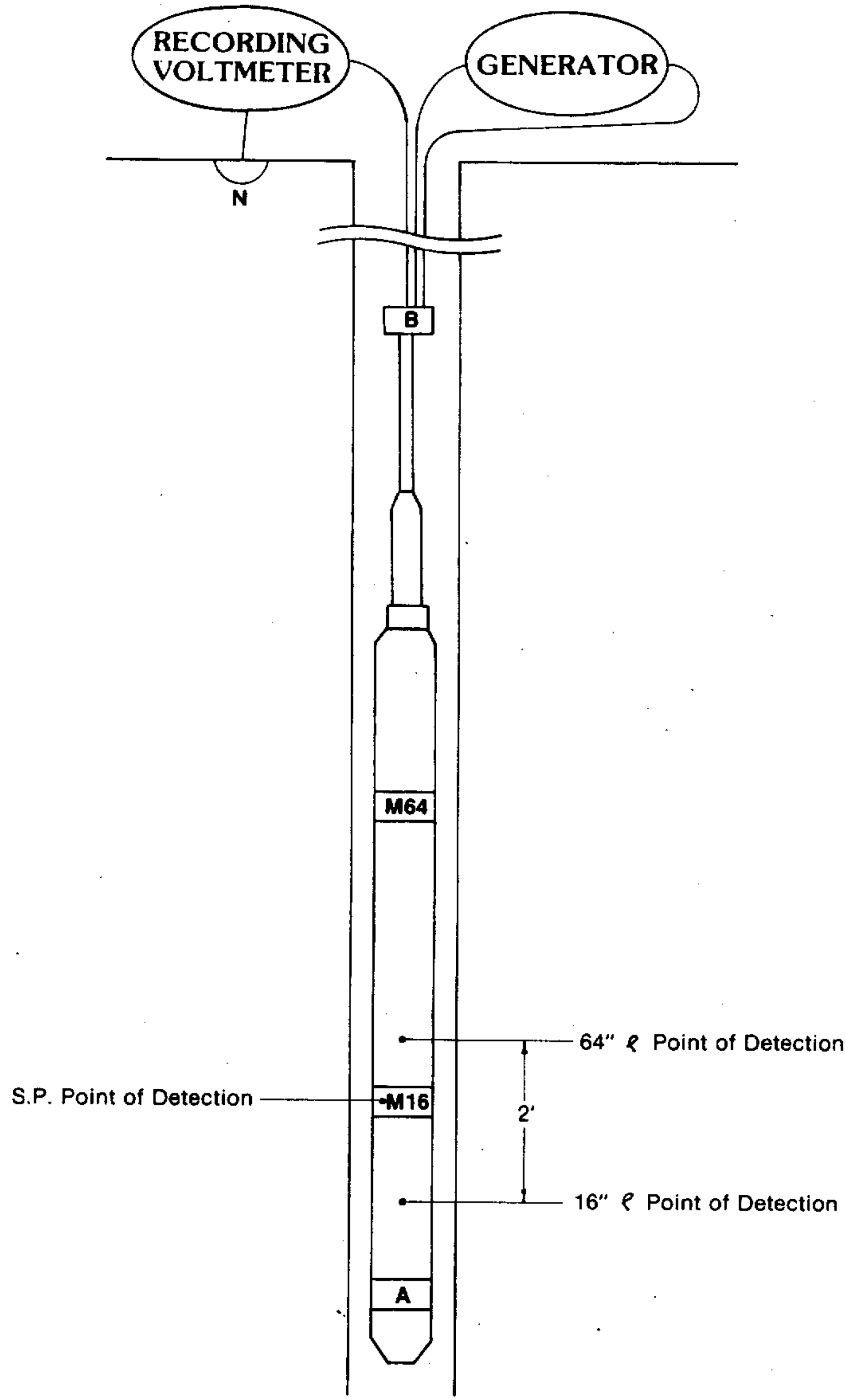

FIGURE 2 - Electrode configuration and circuitry of the Normal Resistivity tool

are recognized: (a) conductance along the solid matrix, (b) sonic conduction by the electrolytic solution, and (c) ionic surface conduction. In general, electrical properties of saturated rocks are controlled by pore geometry, through ionic and surface conduction. Assuming constant borehole fluid resistivity and borehole diameter, the variations noted on the log are directly correlatable with variations in resistivity of the rock and interstitial fluid.

The log responses are sensitive to changes in borehole diameter and borehole fluid conductivity. Large borehole diameter, coupled with highly conductive borehole fluid may result in a large current flow being restricted to the borehole fluid, giving anomalous results on the logs.

Normal Resistivity surveys tend to minimize the effect of borehole fluid. The 16 inch Short Normal device measures principally the resistivity of the zone invaded by the drilling mud, while the 64 inch Long Normal device measures the average resistivity beyond the invaded zone for a radius of approximately twice the AM spacing.

The Normal Resistivity surveys are most useful in quantitatively determining true formation resistivity, invaded zone resistivity, depth of invasion, and for estimating water quality and permeability in clastic rocks. Lithologic correlations and lithology determinations, water levels, and casing conditions and locations can also be made utilizing the Resistivity surveys.

Although there are numerous corrections for reliable saturated formational resistivities (bed thickness, invasion, etc.), the most basic correction is for borehole fluid resistivity and hole size. Figures 3 and 4 taken from Formation Evaluation Data Handbook, G.O.I., 1977, give correction factors for these borehole conditions both for the 16 and 64 inch Normal

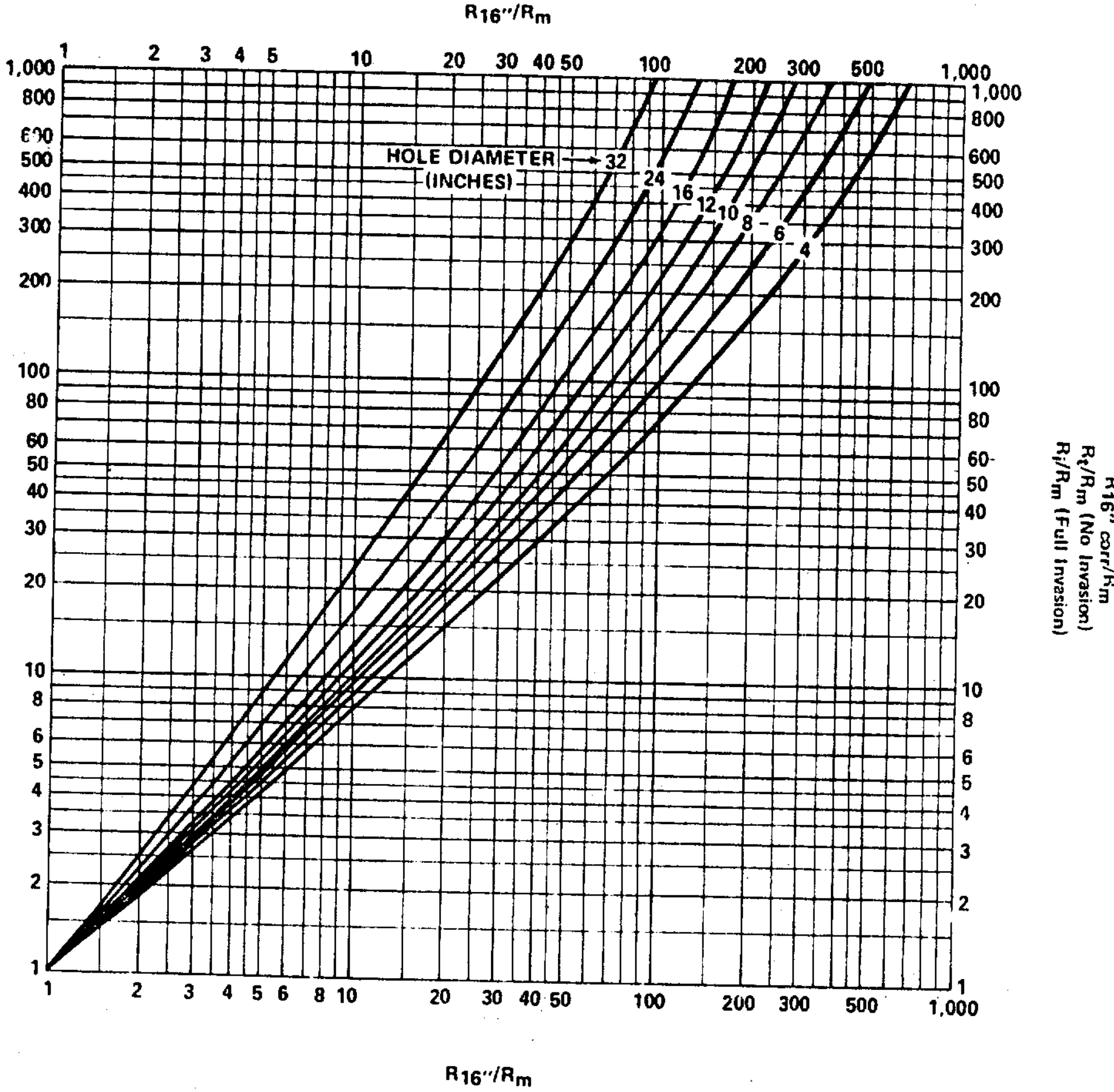

FIGURE 3 - Borehole correction chart for 16 inch Normal Resistivity readings in thick beds having no invasion or full invasion (taken from G.O.I., 1977)

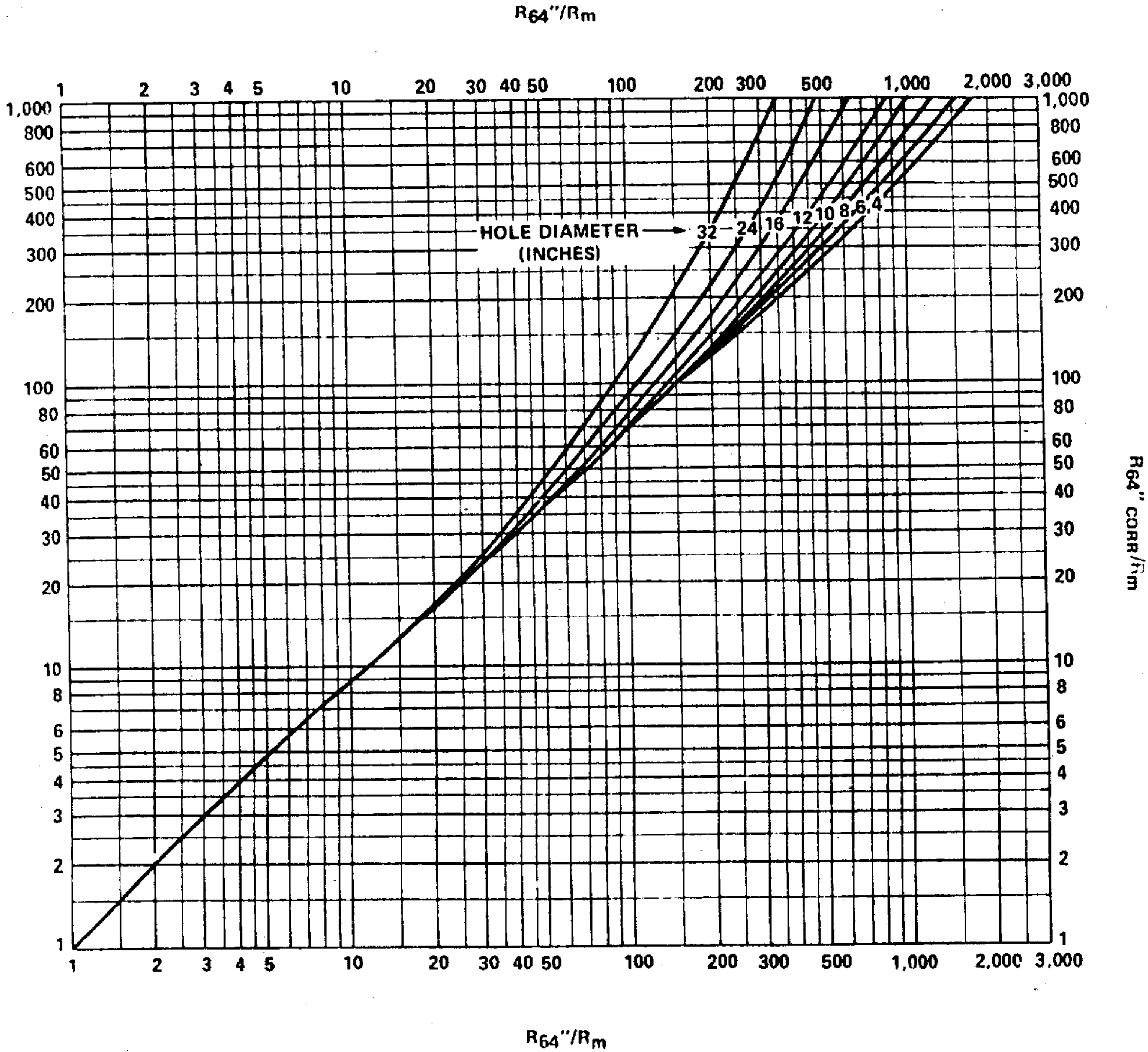

FIGURE 4 - Borehole correction chart for 64 inch Normal Resistivity readings in thick beds having no invasion or full invasion (taken from G.O.I., 1977)

Resistivity logs. For more detailed corrections for the varying formation environments, see log interpretation charts, Schlumberger, 1972.

Useful Resistivity logs can only be obtained in fluid filled holes, or in fluid filled portions of a well. The well must be uncased and unscreened although some success in logging wells with plastic screening has been reported (Keys and MacCary, 1971). Ideally, the borehole fluid should be much more resistant than the beds to be logged. Two other important limitations of the Resistivity logs are their susceptibility to noise and the effect of bed thickness on Normal logs. A thin, highly resistive bed may result in a reversal of the Normal log, giving the indication of a more conductive bed.

The District's electric logging probe is a 2 inch OD rubber-coated probe 7.2 feet in length. It records 16 inch, 64 inch Normal Resistivity and Spontaneous Potential surveys simultaneously. Units recorded are in ohm meter^2/meter for Resistivity and millivolts for Spontaneous Potential. The probe is used in conjunction with the ELM 202.

The District's Resistivity equipment is calibrated in two major steps. The first step is to run a continuity check on the cable, slip ring assembly, and the cablehead assembly. This step will eliminate any shorted or disconnected wires. In the second step the scales are adjusted, using the "short and long normal test box 02-9813-15" or the internal calibration standard. Further details are given in the section on quality control.

6 Foot Lateral Resistivity Survey

The principles of operation and application of the 6 foot Lateral Resistivity survey are similar to those for the 16 inch and 64 inch Resistivity surveys, the major difference being that the wider electrode spacing gives deeper penetration of the electric current. The electrode arrangement for the 6 foot Lateral survey is shown in Figure 5. The Lateral device consists of three effective electrodes, potential electrodes M and N below the current electrode A. The Lateral log supplements the Normal Resistivity logs because of the greater depth of penetration and the lesser influence of borehole fluids. The Lateral survey measures the formation resistivity in ohm meter^2/meter beyond the invaded zone, thus measuring true formation resistivities. Due to its large electrode spacing (6 feet), the Lateral survey has its best response in beds that are more than twice the thickness of the distance between the midpoint of the potential electrodes and the first current electrode (Keys and MacCary, 1971).

Since the 6 foot Lateral log has deeper penetration, it is less influenced by borehole conditions, and is the survey to be used in determining true formational resistivities in thick beds. Other applications and uses of the 6 foot Lateral log are the same as for the Normal Resistivity log. There are no available correction charts for the 6 foot Lateral log for borehole conditions, although for general use, correction charts are not necessary.

The District's 6 foot Lateral Resistivity tool is a 2 inch O.D., 8.3 foot long tool operated with the ELM 204. Operation of the tool is identical to the Normal Resistivity tools. The Lateral log should not be confused with the Laterolog which is a focussed-type Resistivity log.

Spontaneous Potential Survey

The Spontaneous Potential log (or SP log) is a record of variations in natural potentials developed between the borehole fluid and surrounding

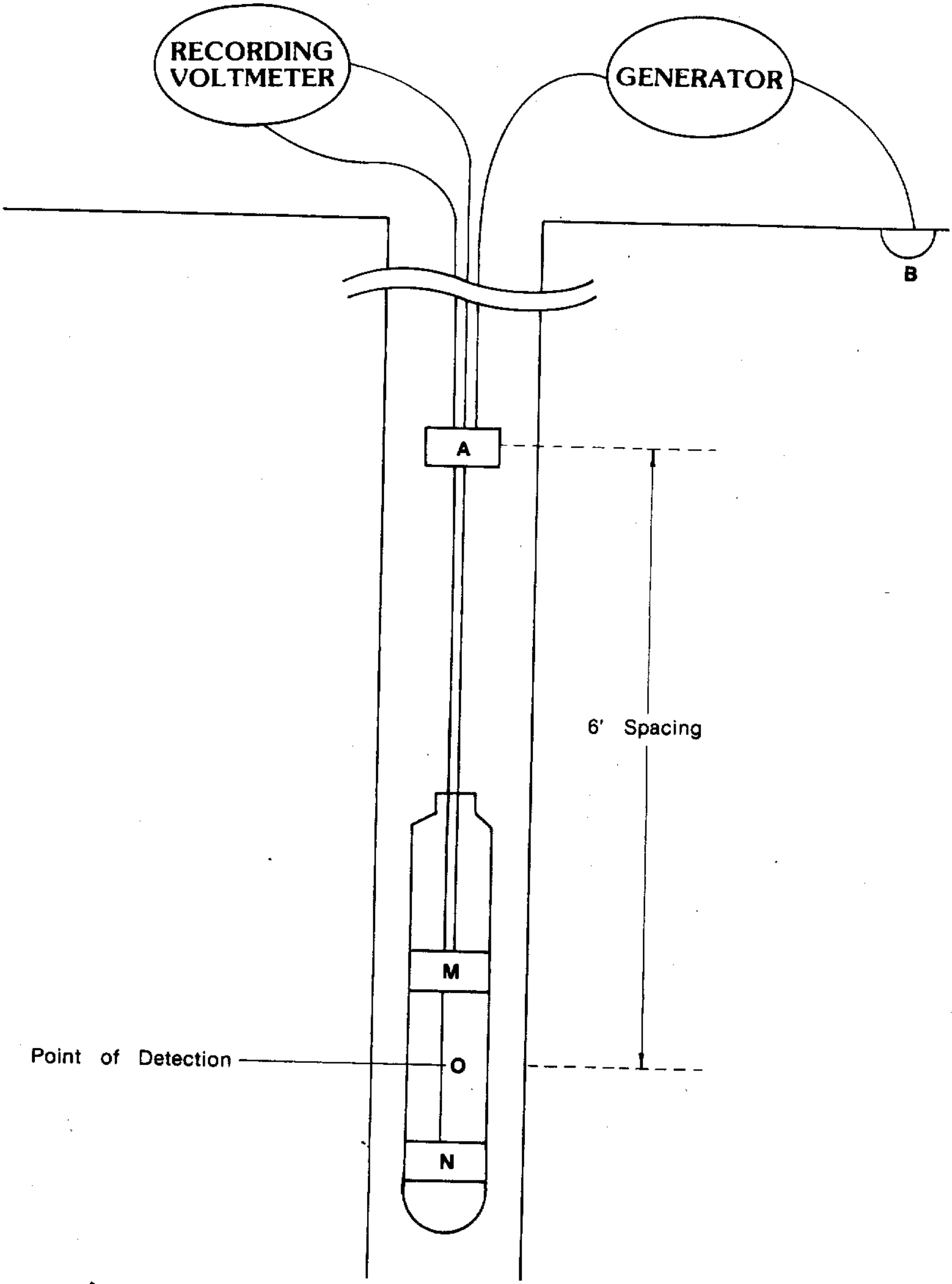

FIGURE 5 - Electrode configuration and circuitry of the 6 foot Lateral Resistivity tool

materials. These potentials may be "streaming potentials" resulting from movement of an electrolyte (borehole fluid or formation fluid) through porous media, or "membrane" or "liquid junction" potentials developed at the junction of dissimilar material in or adjacent to the borehole. The potential arising from these junctions (the more important component of the SP log) cause a current to flow in the mud column in the borehole near a semi-permeable/permeable boundary.

The SP device consists essentially of a lead electrode which is lowered into the well on a shielded conducting cable, and a ground electrode which is usually placed in the mud pit. Changes in potential as reference to the constant potential of the ground electrode are recorded to produce this log.

The magnitude and direction of the current flow, and hence the magnitude and direction of the SP log deflections are controlled by the relative salinities (resistivity contrast) of the borehole fluid (drilling mud) and formation water. Ideally, the log follows a "shale line" when the sonde is adjacent to impermeable, shaley beds, and deviates (to the right or left depending on resistivity contrast) in more permeable beds (sands). In south Florida, however, most of the logs do not show a well defined shale base line. For most groundwater work, permeable beds typically deflect the SP curve to the left, whereas impermeable beds deflect the curve to the right. Hence the maximum deflection to the right in shale-sandstone and shale-carbonate sequences occurs adjacent to the shale beds, while a left or more negative deflection occurs opposite porous and permeable sands and limestone.

The most usual applications of the SP log are for geologic correlation, determination of bed thickness, and separating porous from non-porous rocks in shale-sandstone and shale-carbonate sequences. In sand/shale sequences, the relative proportions of sand and shale may be estimated, based on the magnitude of the deflections, if the ionic concentrations of the borehole fluid and aquifer water are constant throughout. Under certain conditions the SP log may also be used to determine water quality.

The SP log, like the Resistivity log, must be run in fluid filled holes. The logs give poor resolution in some sequences and are susceptible to "noise" from a variety of sources.

In the SFWMD system, the SP survey is run simultaneously with the 16 and 64 inch Normal Resistivity surveys, using a combination tool, with the 16 inch potential electrode being the point of measurement, or with the 6 foot Lateral survey. Units of measurement are in millivolts.

The Spontaneous Potential equipment is calibrated at the same time and in the same manner as the Resistivity devices, using a test box or the internal calibration standard, and the test well.

Borehole Fluid Resistivity Survey

Fluid Resistivity surveys measure the resistivity of a volume of borehole fluid to a constant electrical current. This is accomplished by ring type gold or other suitable electrodes spaced a fixed distance apart installed inside an aluminum tube through which the borehole fluid passes as the probe is lowered. The resistivity of a known column of fluid within the tube is measured continuously as the AC-voltage drops across the electrodes. Units of measurement are ohm-meter^2/meter. The resistivity values measured and recorded on the log are dependent on the ionic concentration of the borehole fluid and the temperature of the fluid. The readings can be converted to a fixed temperature, usually 25^{o}C by the equation

$$P_u \cdot (.02) \cdot (^{o}C) + 1.5 - P_u = P_c \qquad (7)$$

Where,

P_u = resistivity uncorrected in ohm-meter^2/m

P_c = resistivity corrected to 25^{o}C

^{o}C = temperature of water in degrees centigrade

The most basic use of borehole Fluid Resistivity logs is to determine chemical quality stratification in the borehole. Resistivity values can be converted to specific conductance values with units of micromhos/cm at 25^{o}C by dividing the corrected values of resistivity into 10,000. The total electrically equivalent NaCl in milligrams per liter can then be approximated using empirical relationships. If the ratio of ions present in the water is known or can be inferred from previous analyses, the Fluid Resistivity logs can be used to approximate the concentrations of these ions.

The Fluid Resistivity profile in the well may be related to the source and movement of groundwater; however, care should be exercised in drawing conclusions from the logs as conductivity changes in the well bore might not be at the same depth as a similar interface in the aquifer due to differentials in temperature, density or potentiometric heads.

Borehole Fluid Resistivity logs may be used to locate the source of water producing zones, or to locate the most permeable zones under injection tests. It must be remembered that there must exist a contrast in fluid resistivities between producing zone waters and injection water respectively for the above techniques to be applicable. Resistivity logs also provide a basis for selecting depths for the collection of water samples via point sampling.

In Fluid Resistivity logging of non-flowing wells there are two basic types of conditions which may exist. In practice, the first log is run under "static" conditions (well not discharging), the well having been left undisturbed for an adequate time to allow for borehole water equilibrium conditions to exist. After this run a log can be made under "dynamic" conditions (discharge via pump or air lift) by discharging the well. A comparison of these logs gives valuable information concerning interborehole circulation, flow, and the location of producing zones.

A very important use of Fluid Resistivity logs is in correcting or aiding in the interpretation of standard electric logs (SP, 16 and 64 inch Normal Resistivity logs).

The District's Borehole Fluid Resistivity probe is a 1 3/8 inch O.D., 3.6 foot long tool. It is a 4-conductor type utilizing 4 gold rings 1 inch apart, which function as two current and two potential electrodes. The resistivity survey is made simultaneously with the Borehole Fluid Temperature, Differential Temperature, and Casing Collar Locator surveys. Downhole current and uphole processing is via the ELM 202.

Calibration of the Borehole Fluid Resistivity survey is done using standard solutions. Calibration or standardization should be checked before and after each logging run to verify the stability of both the surface and downhole electronics.

Flowmeter Survey

Flowmeter surveys measure and record fluid flow within the borehole. The most common type of equipment utilizes an impeller flowmeter consisting of a protective basket assembly enclosing a low inertia impeller. The impeller rotates in response to fluid flow. The equipment is designed so that each rotation of the impeller generates one or more electrical pulses. The pulse count is continuously integrated to give values of counts per unit time. The probe may also be held stationary in the borehole to determine total volume of flow at preselected levels. To accurately relate count rate to actual flow rate, the basket assembly should be as close to the diameter of the borehole as possible.

The Flowmeter survey is used to measure fluid flow within cased or uncased wells. In a discharging well, or a well close to a discharging well, a continuous flow profile may be obtained by running the probe into or out of the well at a constant speed. Vertical flow profiles in wells open to a multiaquifer system may be used to indicate possible transfer of pollutants between the aquifers and to determine the validity of pump test data, water quality depth samples, or Resistivity and Temperature logs.

The Flowmeter log is affected by varying borehole diameters. This may be corrected for, using the equation:

$$Q = \tfrac{1}{4}\pi\, d^2 \cdot v \qquad (8)$$

Where,

Q = flow in counts per second (cps) inches^2

d = diameter in inches

v = velocity in cps

It should be noted that where vertical flow exists in the borehole, the downhole will differ from the uphole log. The logs may also be affected by changes in logging speed or by contact between the probe and the wall of the well. The speed of revolution of the impeller and consequently the magnitude of the log response is a function of the difference between the logging speed and the vertical movement of the water in the borehole. If vertical movement of water is downwards, a log made while the probe is being lowered will indicate less than the "true" velocity of movement, or may indicate no vertical movement at all if the flow rate equals the rate at which the probe is lowered. On the other hand, a log made under the same borehole conditions while the probe is being raised will indicate more than the "true" velocity. The opposite will be true if vertical flow in the borehole is upwards. Consequently it is good practice to run both an uphole and a downhole log in each well.

The District's Flowmeter probe is a 1 7/16 inch O.D., 3 foot long tool having a suite of basket and impeller assemblies ranging from 1 7/16 inch to 4 3/8 inch O.D. The Flowmeter tool contains a low inertia impeller to measure the movement of borehole fluids as they pass through the basket assembly. Movement of the impeller blade rotates a small magnet that actuates four magnetic switches. Closure of the magnet switches completes an electrical circuit, generating a square wave pulse at a frequency proportional to the number of impeller revolutions. There are 4 cycles per second (cps) per revolution since there are four magnetic switches. Power is supplied to the tool from the Flowmeter module (FMM 101). This module also acts as an interface to couple the signal into the Ratemeter module (RMM 202) which processes the uphole signal for the recorder.

The unit of measurement that is recorded in the field is counts per second (cps). There are four counts per revolution as previously discussed. An increase in cps reflects a linear increase in velocity. To convert cps to flow rate in feet per minute (ft./min.) for any well in which a Flowmeter log was made, the Flowmeter should be calibrated before and after the well was logged. To calibrate the Flowmeter survey, a log is made in a static well by running the probe down the water filled well at different line speeds simulating flowing conditions. While running the tool down the well the recorder is put on time drive so that an average of the cps recorded during the time the probe is moving can be taken. This is done at a minimum of four known line speeds. Ideally the line speeds should be in the working range expected in the field. The conversion to ft./min. is useful for quantitative work.

For the conversion from ft./min. into volumetric units it is necessary to relate the velocity of fluid flow in the borehole to the cross sectional area:

$$Q = V \cdot A \quad (9)$$

Where,

Q = flow in volumetric units

V = velocity

A = cross sectional area of borehole

If the conversion to feet/minute from cps is known, the above formula can be used. The cross sectional area of the borehole is calculated from the Caliper log assuming a spherical borehole.

Where,

$$A = \frac{1}{4} \pi d^2 \quad (10)$$

And,

d = diameter in inches or feet.

This method to calculate flow does not correct for the following factors:

(1) Displacement of water (volume) by the probe.

(2) Differential velocities in the borehole due to friction.

For a Flowmeter log run in a straight hole with uniform diameter, a conversion to flow (volumetric units) is as follows. Determine the yield of the well during the discharging stage at the wellhead as a result of pumping or the natural discharge of the well with the tool in the well above all flow zones. The deflection found above the flow zones or in casing above the open hole corresponds to the total yield. The amount of water flowing upward at a certain depth can be calculated by linear interpolation as the impeller of the flowmeter has an almost linear response.

Borehole Fluid Temperature Survey

Borehole Fluid Temperature logs are graphic representations of the temperature of the environment immediately surrounding a sensor in the borehole. The sensor is generally a thermistor which consists of a semi-conductor element having a negative temperature coefficient of resistance. Temperature changes in the borehole fluid cause changes in the resistance of this element and these resistances are measured by feeding a small current through the element. Differential temperatures may be logged separately, using a system which continuously detects and records the difference in temperature over a predetermined time interval (interval of depth). Differential Temperature logs accentuate the temperature changes and thus aid in interpretation.

Temperature logs may be used to determine geothermal gradients, provide information on the source and movement of water, and to identify producing zones. The logs may also be used in quantitative analyses of equilibrium temperatures in wells to determine aquifer coefficients such as transmissivity and leakance, and to determine seasonal recharge to groundwater. The Temperature log is very valuable in correcting and analyzing Resistivity logs.

Other uses of the Temperature log include identification of recharge water or liquid wastes and the location of grout outside the casing after cementing a well.

The main limitation of Borehole Temperature surveys is that an undisturbed environment ("equilibrium conditions") is generally necessary for accurate representation of the natural conditions. This is generally difficult to achieve as disturbances caused by pumping, drilling, cementing, casing, sampling, or other activities may take weeks or years to dissipate. In many holes, Temperature logs do not repeat well, giving the operator only a single opportunity to obtain a good log. With a single sensor Differential Temperature probe, logging speed must be kept constant. In addition, instrumental effects such as thermal lag, self heating, or electronic drift may introduce inaccuracies.

The District's Borehole Fluid Temperature logging system uses a 1 7/16 inch O.D. probe, 2.4 feet in length. A nickel-iron sensing element (thermistor) in the probe measures temperature changes in the borehole fluid. These measurements are related to actual temperatures through calibration of the system. By using the probe in conjunction with the Differential Temperature module (DTM 203) it is possible to obtain a differential temperature curve. Time increments (ΔT) may be varied from 1 to 10 seconds. The signal is transmitted from the probe as pulses which are processed through the ratemeter module which furnishes a signal to the DTM 203. Downhole power is generated from the Line Power module. The Temperature and Delta Temperature surveys are usually run simultaneously with Casing Collar Locator and Borehole Fluid Resistivity surveys. The unit of measurement is ^{o}F although ^{o}C units can be used with proper calibration.

The system is calibrated using an accurate thermometer in a water bath at a constant temperature.

Casing Collar Locator Survey

The GOI Casing Collar Locator (CCL) is a supplementary assembly that can be run with the Natural Gamma Ray, Neutron Porosity, or the Fluid Resistivity Temperature tool, which are pulse logging types. The CCL assembly is essentially a sensing coil which is positioned between two bar magnets. Most of the magnetic flux lines pass within the coil. A change or contrast in magnetic susceptibility of the materials surrounding the tool will cause an increase or decrease of the magnetic lines through the coil. This generates a current pulse in the coil which is sent to the surface. A CCL log can be made either running down or up the hole.

Casing Collar logs are used to locate collars, pipe, zones without pipe, magnetic minerals or debris. Also, when run in combination with the above mentioned survey, the CCL log "ties" the casing collars to lithology. The formation depths are then permanently referenced to casing collar "bench marks."

Caliper Survey

The Caliper log gives an estimate of the diameter of a borehole. The most common type of Caliper equipment gives a record of the extent to which one or more hinged arms or feelers can be extended in a horizontal direction away from the axis of the probe as the probe moves vertically in the borehole.

The Caliper survey operates on the principle that the degree of extension of arms, which are spring loaded to follow the wall of the borehole, are converted into electrical pulses which are processed with the output signal activating the recorder system. The tool is usually run into the hole with the feelers "closed" and a system is provided to release the arms at the bottom of the hole for uphole logging.

Variations on the Caliper log are usually interpreted as variations in the average diameter of the borehole. This information may be correlatable with lithology, stratigraphy, or the presence of fractures and solution openings. However, it should be pointed out that unintentional hole size variations may be the result of drilling techniques such as weight and straightness of the drill stem, volume, pressure and type of fluid circulated, drilling rate or development of the well. Lithologic factors which affect hole size may include competence of the beds, porosity and permeability, bed thickness, size, spacing and orientation of fractures, and swelling of clays.

A very important use of the Caliper logs is in the completion and equiping of wells. Here Caliper logs may be used to calculate gravel pack volume, grout volume, size of casing and screen, and the design of packers.

Caliper logs are also very important in the interpretation of other geophysical logs which may show the effect of hole size. These include Neutron Porosity logs and Flowmeter as well as Resistivity logs. A Caliper log should always be run prior to running any Nuclear log to minimize the possibility of losing the nuclear probe in the hole.

The main limitation of the Caliper survey is that the maximum hole diameter which can be measured is limited by the maximum extension of the arms. In some cases this may be inadequate to calculate accurate borehole volume. With the hinged arm type of caliper, some small depth and/or diameter inaccuracies may result due to the difference in height of the tips when the arms are extended compared to when they are closed, and the fact that where a rapid constriction of the borehole occurs, the arms may begin to close before the tips have reached the level of the constriction.

The District's Caliper tool is a 3 arm type and has a maximum measuring diameter of 36 inches, although for accurate measurements in small diameter holes, shorter arms are available for measuring wells up to 18 inches. The outside diameter of the tool (O.D.) is 1 1/4 inches and its length is 6.2 feet. The arms are opened and closed by switching the polarity of a servomotor. The unit of measurement is in inches. Downhole power is supplied by the LPM 203, although when opening and closing the arms, the shooting power module SPM 301 is used. Uphole voltage, as pulses generated via a pulse type generator (telemetry circuit) in the probe, is processed through the Ratemeter module, RMM 205. Field calibration is performed before and after every run in the hole by placing a calibration board with small diameter holes between the arms and the body of the tool. The holes are spaced to simulate hole diameters over a range of 36 inches at 2 inch increments.

Natural Gamma Ray Survey

The Natural Gamma Ray survey measures the amount of natural gamma radiation emitted by material adjacent to the probe as it is lowered or raised in the borehole. The deflections on the log are a reflection of the abundance of gamma emitting radioisotopes (normally potassium-40 and daughter products of the uranium and thorium decay series) in the rocks.

The Natural Gamma probe consists of a scintillation counter, utilizing thalium-activated sodium iodide crystals, to detect radiation. The electronics consist basically of a high-voltage supply and pulse amplification and shaping circuits. Surface controls consist of a time constant or pulse averaging circuit, logging speed control, recorder sensitivity span, and zero positioning or basing.

The main application of Natural Gamma logs is for identification of lithology and stratigraphic correlation. In general, natural gamma radiation is highest in potash beds and progressively less in shales, sandstone, limestone, dolomite, coal, and anhydrite beds. The logs are also used as an index to permeability in clay formations and in monitoring plugging in well screens.

Natural Gamma Ray logs may be obtained in open or cased, liquid or air filled holes. The logs are not affected by borehole conditions as greatly as other nuclear logs. The borehole diameter generally has little effect unless the diameter is very large, generally over 12 inches in diameter. The nature of the drilling fluid may affect the logs to a greater extent, especially if a barite weighted mud is used. Figure 6 shows a chart for calculating gamma ray correction factors for borehole size and mud density (Gearhart-Owen, Industries, 1977). The chart is applicable to a 1-11/16 inch O.D. cross count probe; however, the authors (GOI) state "it is not considered to be universally applicable. However, its use is preferred to the alternative of making no correction" (GOI, 1977, pg. 175).

The following information on description and calibration of the equipment is taken from a Memorandum Report by Brown and Anderson, 1979.

> "The SFWMD Groundwater Division's Research Geophysical Logger utilizes a Gearhart-Owen 1-11/16 inch O.D., Gamma Ray, Casing Collar Locator (CCL), Neutron Porosity tool. The electronics are all solid state and most of the circuit functions are performed by high temperature rated integrated circuits mounted in field replaceable modules. The detector is a high sensitivity scintillation type with a sodium iodide crystal emitting light pulses optically coupled to a photomultiplier tube where a pulse of electrical current amplified about 1 X 10^6 times, is produced. This pulse is sent to the surface equipment (Ratemeter module) where the pulses are integrated over a preset time constant and a DC-voltage

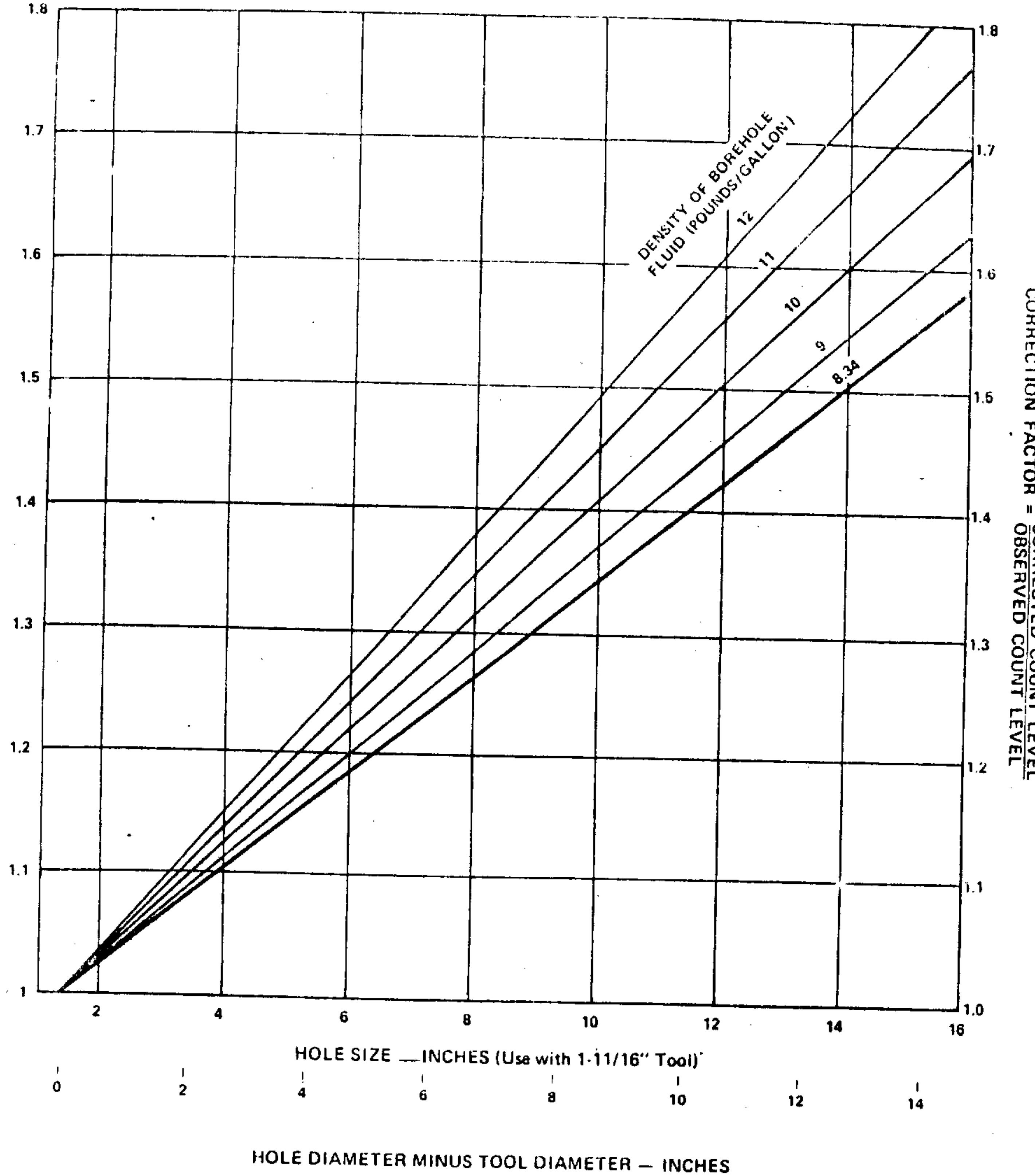

FIGURE 6 - Natural Gamma Ray correction factors to remove the effects of hole size and borehole fluids in uncased holes (taken from G.O.I., 1977)

output is used to drive the recorder pen to reflect the formation's natural gamma radiation intensity in counts per second (cps).

The purpose of calibration is simply to adjust the recorded tool response (counts per second) in terms of "API Gamma Ray Units." The API Gamma Ray unit is an industry standard, which has been set up in order to standardize logs obtained by different logging instruments, relating the logs to a standard environment. The standard environment is the gamma ray test pit at the University of Houston.

Field calibration of the Gamma Ray tool is accomplished by the use of a Gearhart-Owen Gamma Ray calibrator, factory adjusted, to give a response equivalent to 100 API units. The Gamma Ray Calibrator provides a spacing of 48 inches between a Cs^{137} 100 microcurie source and the detector which increases the count rate by 100 API units. Recorded with all Gamma Ray logs for calibration purposes is gamma background (detector 20 ft. from any source and 5 ft. above land surface on time drive) and background plus source standard. The difference between background and background plus source standard equals 100 API gamma ray units."

Neutron Porosity Survey

The Neutron Porosity survey measures the effect of the borehole environment upon introduced neutrons as the probe is lowered and raised in the borehole. The tool consists essentially of a neutron source and a radiation detector. As the neutrons from the source bombard the environment they lose energy by colliding with nuclei of borehole and formation elements. A neutron loses some of its total kinetic energy each time it is involved in either an elastic or inelastic collision. Energy losses are a function of the angle of collision and the relative mass of the struck nucleus. Since hydrogen atoms are both relatively abundant and nearly equal in mass to the neutron, they are primarily responsible for reducing the energy of the neutron. Neutron logs record parameters which are related to the energy reduction of the neutron and are therefore indices of the "hydrogen richness" of the formation. If all of the formation's hydrogen is contained in the form of water, and if these liquids completely occupy the total pore space volume, hydrogen richness is an index of porosity. Neutron penetration depths are thus controlled by both the porosity and the hydrogeneous nature of the substances in the pore spaces (Brown and Anderson, 1979).

Borehole environments with varying hole diameter, mud density and type, and presence of casing, influence to some degree Neutron Porosity survey results. In large liquid filled boreholes, many neutrons are captured near the source causing generally low count rates. Also, Neutron Porosity survey results lose their resolution in boreholes greater than 10 inches. Anomalous hole enlargements give rise to possibly false high porosity indications and interpretations.

Mud densities of drilling fluids can cause an increase in neutron count rates because the addition of common weighting materials to fresh muds serve to displace some water. The presence of steel casing has a lesser effect on the Neutron survey than PVC casing which is an efficient neutron absorber.

The primary applications of the Neutron Porosity log are for: (1) lithologic identification and stratigraphic correlation; (2) bulk porosity or total water content of the formation, which may include pore water between mineral grains and bound or absorbed water in clays, or even crystallization water in gypsum. Further discussion on the use of the Neutron Porosity survey will be presented in the Case History Section.

The District's Neutron Porosity Tool consists of a 3 curie americium 24/beryllium source with a neutron emission of about 10 X 10^6 neutrons per second at 4.5 Mev. The detector is spaced 13.0 inches from the source, and is a Helium-3 filled type which responds only to thermal neutrons and is relatively insensitive to gamma radiation. As with the Gamma Ray tool, the pulses are sent to the surface equipment where they are integrated over a pre-set time constant. The DC voltage output is used to drive the recorder pen to give a trace which reflects the formation porosity. The actual uncorrected porosity of the formation is given by the relationship:

$$\text{Uncorrected porosity} \propto \frac{1}{\text{intensity (cps)}} \quad \text{.........................(11)}$$

The District's Neutron tool is calibrated in the field with a secondary standard which was calibrated against the tool response in the API neutron calibration test pit, University of Houston. The neutron field calibrator consists of a laminated plastic sleeve 26 inches long having an 8.5 inch O.D. and a 5.5 inch I.D. The field calibrator is placed over the tool to provide a known response equivalent to 1000 API neutron units at 19% limestone porosity. On all Neutron logs, calibration curves are provided with the 1000 API neutron unit response and zero API response. A linear function is assumed in this procedure.

The Neutron Porosity calibration procedures are similar to the Gamma Ray calibration. API units have been adopted by the industry to calibrate the Neutron tool. As discussed previously, API calibration is based on the tool response in a controlled logging environment at the neutron calibration test pit maintained by the University of Houston, Houston, Texas.

Gamma Gamma Density Survey

The Gamma Gamma Density survey measures the intensity of gamma radiation from a source in the probe after the radiation is back-scattered and attenuated within the borehole and surrounding rock. The tool consists of a source of radiation (cobalt-60, radium 226, or cesium 137) which is shielded from the detector (usually a scintillation counter). The gamma photons from the source penetrate and are scattered by the fluid, casing and formation. The detector measures the changes in the intensity of the gamma radiation at a fixed distance from the source. The measured intensity is related to physical properties of the environment.

Basically, there are three modes of gamma ray interaction that contribute to the response measured by the detector: (1) compton scattering, (2) photoelectric effect, and (3) pair production. These processes all involve the interaction of the incident photon (a quantum of electromagnetic energy) with an electron in the surrounding material, and are dependent on the bulk density of the material. Measurements of the intensity of return radiation after scattering are therefore inversely proportional to the electron density which is generally equal to the bulk density of the material.

The main uses of Gamma Gamma Density logs are the lithologic identification and bulk density and porosity determinations. The logs may also be used to locate cavities and cement outside the well casing.

Gamma Gamma logs can be obtained in cased or uncased, fluid or air filled holes. The logs are affected by borehole rugosity, mud cake, casing, collars and grout.

The District's Gamma Gamma logging equipment consists of a 1 1/16 inch O.D., 7 foot long tool, having a 2 curie cesium 137 source which emits radiation at an energy level of approximately .66 Mev. The detector is the same as for Natural Gamma logging. It is an uncompensated, single detector tool, using an adjustable bowspring decentralizer. It is powered by the LPM 203, with uphole signal processed by the RMM 202. The units of measurement are counts per second (cps).

Gamma Gamma logging equipment can be calibrated in the API limestone pits; however, for quantitative work, more extensive calibration is necessary. The Gamma Gamma surveys have not been used extensively in the District's groundwater investigations and consequently the authors have limited first hand experience with this survey.

It is of importance to point out that since a radioactive source is used, all precautions necessary for handling radioactive material must be taken by the operator. In addition, great care must be taken not to damage or lose the source in the borehole.

Acoustic Velocity Survey

The Acoustic Velocity survey is a record of the transit time of an acoustic pulse generated from a transmitter with interval transit time recorded between two receivers of known distance. The probe consists basically of one or more transmitters which convert electrical energy to acoustic energy, which is then transmitted through the borehole environment as an acoustic wave. The tool is constructed so that the acoustic wave follows the shortest path through the material surrounding the probe and is refracted along the borehole wall. One or more receivers receive and reconvert the acoustic signal to electrical energy for transmission via the conductor cable to the surface. The measurement recorded by the acoustic log is interval travel time, which is the reciprocal of interval velocity. The unit of measurement is microseconds/foot. The following formula can be used to convert acoustic travel time to velocity.

$$\Delta t = \frac{10^6}{V} \qquad (12)$$

Where,

V = velocity in feet/second

Δt = acoustic travel time in microseconds/foot.

The Acoustic Velocity log is very applicable to the investigation of secondary porosity in carbonate rocks of south Florida. Experimental work and field experience indicate that acoustic wave velocities are influenced only slightly, if at all, by irregular and fracture porosity (Dresser Atlas, 1974). For this reason, the Acoustic Velocity log may be run for the determination of primary or intergranular porosity with the result compared to porosity values derived from the Neutron Porosity log which indicates gross (bulk) porosity. The difference is an approximation of the secondary or fracture porosity.

Acoustic velocity in porous media is dependent on such lithologic factors as the type of matrix, the density, size, distribution, and type of grains and pore spaces, and the degree of cementation, and upon the elastic characteristics and properties of the interstitial fluids (Jenkins, 1967).

Acoustic travel time measurements of subsurface formations can be interpreted in terms of formation porosity. A relationship defining a uniform intergranular porosity in terms of the total formation velocity, rock matrix velocity, and fluid velocity was proposed by Wyllie, et. al. (1956). The relationship is expressed in the following equation and is usually referred to as Wyllie's "time average formula."

$$\frac{1}{V} = \frac{\phi}{V_f} + \frac{(1-\phi)}{V_{ma}} \quad \text{..........} (13)$$

Where,

ϕ = fractional porosity of the rock

V_f = velocity in interstitial fluids in feet/second

V_{ma} = velocity in the rock matrix in feet/second

V = total formation velocity

To convert the above equation in terms of acoustic interval travel time the following equation can be used:

$$\Delta t = \phi \Delta t_f + (1-\phi)\ \Delta t_{ma} \qquad (14)$$

Where,

Δt = travel time measured in microseconds/foot

ϕ = fractional porosity of the rock

Δt_f = travel time in interstitial fluid in microseconds/foot

Δt_{ma} = travel time in the rock matrix in microseconds/foot

Before the above equations can be used, values for acoustic properties of the rock matrix and the formation fluids are needed. Table 2 taken from Dresser Atlas, 1974, presents average matrix velocities for different formations.

The District's Acoustic Velocity system is a self-contained unit manufactured by Simplex, Inc., and is comprised of three receivers, a single transmitter, downhole probe and a surface module, meeting NIMS specifications. The surface module powers the probe and processes uphole data. The transmitter (transducer) emits a frequency of about 20,000 hertz. The Acoustic Velocity log (also called a Sonic log) is a continuous record of depth versus the specific time required for a compressional wave to traverse a predescribed distance of one, two or three feet of formation.

Although the logging probe has three receivers, only two can be used at one time, giving it dual receiver capabilities. This system (employing one transmitter and two receivers) can, in effect, measure only the travel time of the signal in the borehole formation.

No convenient field system for checking the response of the total Acoustic Velocity logging system is available; however, the logs can be calibrated by recording the interval transit time from the oscilloscope, on the trace, while the probe is stationary in the hole. Built-in calibration signals may also be recorded on the log to check the stability of the electronics.

TABLE 2

AVERAGE FORMATIONAL MATRIX VELOCITIES

FORMATION	V_{ma} ft./sec.	Δt_{ma} μ sec./ft.
Sandstone:		
Unconsolidated	17,000 or less	58.8 or more
Semiconsolidated	18,000	55.6
Consolidated	19,000	52.6
Limestone	21,000	47.6
Dolomite	23,000	43.5
Shale	6,000 to 16,000	167.0 to 62.5
Calcite	22,000	45.5
Anhydrite	20,000	50.0
Granite	20,000	50.0
Gypsum	19,000	52.6
Quartz	18,000	55.6
Salt	15,000	66.7

QUALITY CONTROL

Quality control of well log data is important for proper well log interpretation and gives the user confidence that the data collected at a well site is accurate and representative of subsurface conditions in the borehole. All logging systems incorporate some quality control checks which can be performed either at the well site or off site, before and/or after a well is logged. The District's logger incorporates a check of internal electronics and recording system by means of test pulses sent through the electronic and recording system. For example, the Resistivity and SP systems are calibrated by connecting a "test box" to the cablehead cannon plug and to the cannon plug on the front of the Nims Bin Panel labeled "Cable", and plugging the ground plug into the ELM 202. This operation will complete the circuit through the logging lines. A known signal is sent from the test box through the circuit and the recorder pens are set for the desired deflection for that signal. The 64 inch Normal pen deflection should be four times greater than the 16 inch Normal pen deflection. There is also an internal Resistivity calibration within the ELM 202 which has a signal equal to 100 ohms for calibrating the recording equipment in the field. Calibration using this internal signal is done by connecting the probe to the cablehead and lowering it into the borehole fluid below the surface casing. In addition, regular checks of the physical response of the District's logging system are made by recording the response of the tools under known, representative logging conditions. At the beginning of each week, in preparation for production logging, a quality control log is made in a test well constructed for this purpose. The test well designated "SFWMD test well #1" is logged with a four conductor type tool, typically the 16 and 64 inch Normal Resistivity tool, followed by runs with other tools as required, and compared to logs previously run, to assure accuracy and repeatability under field conditions.

Well construction and lithology for test well #1, as well as a suite of surveys designated as the "type surveys" used to cross check weekly test runs, are filed with the geophysical logging program manager. This well has also been logged by the U. S. Geological Survey's research logger and the resulting surveys placed on file at the District.

Quality control also includes methodology for detecting operator errors including inaccurate depths or scales, and incorrect descriptive header information. This type of control is achieved through review of each log by the geophysical logging program manager. In addition, at each step in data transfer or manipulation, careful checks are made against permanently stored field traces to eliminate clerical and machine errors. This aspect of quality control is more fully dealt with in the next section.

CAPTURE AND STORAGE OF BOREHOLE GEOPHYSICAL DATA

The District's Geophysical Logging System employs two formats for primary data capture: (1) analog trace, and (2) digitized format. These two methods are generally employed concurrently. The analog trace is produced by the pen recorder supplied with the equipment. The digitized record is produced by the Data Acquisition System (DAS) in the form of a magnetic tape record. A memodyne reader is used to interpret the tapes.

Storage is achieved in two ways. First, the field analog traces are permanently filed for future reference. Secondly, digitized data is stored on computer for retrieval and manipulation. In cases where simultaneous digitization has not been carried out during logging, the analog trace may be manually digitized using a flat bed digitizer or other methods. Input to the computer may therefore be in the form of: (1) magnetic tape from the DAS system, (2) paper tape from the flat bed digitizer, or (3) computer cards from other manual digitizing.

Capture and storage techniques for well identification and survey data, as well as quality control and correction procedures, are discussed in the following section. Also discussed are the storage, retrieval and manipulation of the geophysical logging data through electronic data processing techniques, which comprise the Well Log Analysis System (WLAS).

Descriptive Information

Descriptive information (header data) for each well to be geophysically logged is attained from the project manager and recorded by the logging operator on the two page well station identification form (Figures 7a and 7b). In addition, a well survey report (Figure 8) is filled in each time a well is logged. A station I.D. is assigned to each well by the geophysical logging project manager and remains with the well regardless of the number of times the well is logged.

Should conditions at a well site change between logging operations (e.g., well drilled deeper, casing installed, etc.) an additional well survey identification form must be completed.

It should be noted that the well station identification form and the well survey report are designed so that all information they contain can be transferred directly onto 80 column computer cards without further adjustments. Once this step is completed, the cards are filed in numeric order by station I.D. and date in a computer card filing cabinet to be used in well identification and information programs. The original forms are stored in a file with the original geophysical survey logs.

Survey Data

Borehole geophysical survey data can be captured into machine readable format by any of the following techniques:

(1) Manually, by reading X, Y breakpoint coordinates from the borehole log, entering them on a well survey data form, keypunching the data, and processing the keypunched cards as input to system programs.

(2) Semi-manually by reading the survey breakpoints with an electronic flatbed type digitizer, producing a paper tape record for each breakpoint, and processing the paper tape as input to system programs.

WELL STATION IDENTIFICATION

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PAGE 1 OF 2

(COMPLETE THIS FORM ONLY FOR THE INITIAL SURVEY OF EACH WELL)

WELL LOCATION CARD ONE

1	10	16		20	37	54	57	59	63	66	68-71
STATION I.D.	SURVEY DATE	A C	CARD	WELL NO.	COUNTY	LAT DEG	LAT MIN	LAT SEC	LON DEG	LON MIN	LON SEC
			W11								

WELL LOCATION CARD TWO

1		17	20	37	39	42	45-61
STATION I.D.	SURVEY DATE AC	CARD	QUARTERSECTIONS	SEC	TOWN-SHIP	RANGE	WATER MANAGEMENT DISTRICT PLANNING AREA
		W12	1/4; 1/4; 1/4				

WELL DATUM CARD

1		17	20	26	32	38	44-59
STATION I.D.	SURVEY DATE AC	CARD	KELLY BUSHING (FEET)	LAND SURFACE (FT)	TOP OF CASING (FT)	OTHER (FT) (SEE NOTES)	DATUM (CHECK ONE)
		W21					MSL- ;LS- ;TOC-

WELL OWNERSHIP CARD

1		17	20	37	54	57	64-80
STATION I.D.	SURVEY DATE AC	CARD	NAME OF OWNER	GROVE/PROPERTY NAME	AREA CODE	TELEPHONE	WELL USE
		W31					

WELL ORIGIN CARD

1		17	20	37	54	71-76
STATION I.D.	SURVEY DATE AC	CARD	DRILLER/ DRILLING COMPANY	OFFICE OF DRILLER (CITY)	DRILLING METHOD	DATE COMPLETED
		W41				

NOTES: COLUMNS 1-16 ARE DUPLICATED IN EACH CARD.
COLUMN 16 IS AN ACTION CODE WITH THE FOLLOWING PERMISSABLE STATES - 1 (CREATE NEW RECORD). 2 (CHANGE ALL VALUES). OR 9 (DELETE OLD RECORD).

FIGURE 7a - Well Station Identification form page 1 of 2

WELL STATION IDENTIFICATION

PAGE 2 OF 2

FORM RP-38 - Rev. 10/78

(COMPLETE THIS FORM ONLY FOR THE INITIAL SURVEY OF EACH WELL

WELL DESCRIPTION - CONSTRUCTION CARD ONE

1	10	16		20	27	34	41	48	54	59 68
STATION I.D.	SURVEY DATE	A C	CARD	TOTAL DEPTH -DRILLER (FT)	TOTAL DEPTH -LOGGER (FT)	CASING DEPTH -DRILLER (FT)	CASING DEPTH -LOGGER (FT)	CASING I.D. (INCHES)	BIT SIZE (INCHES)	DRILLER LOG AVAIL.
			W51							YES- ;NO-

WELL DESCRIPTION - CONSTRUCTION CARD TWO

1		17	20	37	54	59	64	69 73
STATION I.D.	SURVEY DATE	A C	CARD	TYPE OF SCREEN	TYPE OF PACKING	DIA. OF SCREEN	SLOT SIZE (INCHES)	SCREEN BEGINS	SCREEN ENDS (FT)
			W52						

WELL DESCRIPTION - CONFIGURATION CARD. SECTION ONE (TOP)

1		17	20	22	39	44	49	54	59 75
STATION I.D.	SURVEY DATE	A C	CARD	SEC	TYPE OF CASING	NOM. DIA. (INCHES)	BEGIN DEPTH	END DEPTH (FEET)	THICKNESS (INCHES)	TYPE OF ANNULUS FILL
			W61	0						

WELL DESCRIPTION - CONFIGURATION CARD. SECTION TWO

1		17	20	22	39	44	49	54	59 75
STATION I.D.	SURVEY DATE	A C	CARD	SEC	TYPE OF CASING	NOM. DIA. (INCHES)	BEGIN DEPTH	END DEPTH (FEET)	THICKNESS (INCHES)	TYPE OF ANNULUS FILL
			W62	02						

WELL DESCRIPTION - CONFIGURATION CARD. SECTION THREE

1		17	20	22	39	44	49	54	59 75
STATION I.D.	SURVEY DATE	A C	CARD	SEC	TYPE OF CASING	NOM. DIA. (INCHES)	BEGIN DEPTH	END DEPTH (FEET)	THICKNESS (INCHES)	TYPE OF ANNULUS FILL
			W63	03						

NOTES: COLUMNS 1-16 ARE DUPLICATED IN EACH CARD.
COLUMN 16 IS AN ACTION CODE WITH THE FOLLOWING PERMISSABLE STATES - 1 (CREATE NEW RECORD).
2 (CHANGE ALL VALUES). OR 9 (DELETE OLD RECORD).
CARD TYPES <W64>. <W65>. ...., <W69> MAY ALSO BE USED TO PROVIDE DATA FOR A TOTAL OF NINE SECTIONS.

FIGURE 7b - Well Station Identification form page 2 of 2

W E L L   S U R V E Y   R E P O R T

FORM RP-39
Rev. 12/79
(USE ONE FORM/DAY/WELL)

SURVEY CARD

1 STATION I. D.	10 SURVEY DATE	16 AC	CARD	20 LOGGED BY	37 WITNESSED BY	54 * A	* B	56 * C	* D	58 * E	* F	60 * G	* H	62 * I	* J	64 * K	* L	66 * M	* N	68 * O	* P	70 * Q	* R	72 * S	* T
			W71																						

*INSERT AN <X> IN EACH COLUMN FOR WHICH A SURVEY WAS CONDUCTED. SURVEY CODES ARE LISTED BELOW:

A = CALIPER	F = NATURAL GAMMA	K = TEMPERATURE GRADIENT
B = FLOWMETER	G = FLUID RESISTIVITY	L = DELTA TEMPERATURE
C = 16-INCH NORMAL RESISTIVITY	H = GAMMA GAMMA DENSITY	M = SPONTANEOUS POTENTIAL
D = 64-INCH NORMAL RESISTIVITY	I = CASING COLLAR LOCATOR	N = POINT RESISTANCE
E = NEUTRON POROSITY	J = FLUID SAMPLER	O = 6-FOOT LATERAL RESISTIVITY

FLUID QUALITY CARD ONE

1 STATION I. D.	SURVEY DATE	AC	17 CARD	20 SAMPLE SOURCE (WELLHEAD, ETC.)	37 TYPE FLUID	54 DATE SAMPLED	60 TIME SAMPLED 63
			W81				

FLUID QUALITY CARD TWO

1 STATION I. D.	SURVEY DATE	AC	17 CARD	20 TEMP. OF SAMPLE	25 CF	FIELD SP. GRAVITY	32 FIELD PH	35 CHLORIDE (MG/L)	41 DISSOLVED SOLIDS	47 SPEC. COND. (U-MHO/CM)	53 STATIC WATER LEVEL (FEET)	60 W/L REF FROM	64 FLOW RATE (GAL/MIN)	70 PUMP RATE (GAL/MIN) 75
			W82											

COMMENT CARDS

1 STATION I. D.	SURVEY DATE	AC	17 CARD	20 COMMENTS - LINE 1	40 COMMENTS - LINE 2	60 COMMENTS - LINE 3 76
			W91			

1 STATION I. D.	SURVEY DATE	AC	17 CARD	20 COMMENTS - LINE 4	40 COMMENTS - LINE 5	60 COMMENTS - LINE 6 76
			W92			

NOTES: COLUMNS 1-16 ARE DUPLICATED IN EACH CARD.
COLUMN 16 IS AN ACTION CODE WITH THE FOLLOWING PERMISSABLE STATES - 1 (CREATE NEW RECORD), 2 (CHANGE ALL VALUES), OR 9 (DELETE OLD RECORD).
CARD TYPES <W93>, <W94>, ..., <W99> MAY ALSO BE USED TO PROVIDE UP TO A TOTAL OF TWENTY-SEVEN COMMENT LINES.

FIGURE 8 - Well Survey Report form

(3) Machine digitizing through use of the Data Acquisition System (DAS) which converts electrical recorder inpulses into digital format on certified digital 2-track cassette tapes at designated intervals at the time of logging. The cassettes can then be processed as input to the WLAS programs.

Manually Digitized Data

Manually digitized data is that data in which the X and Y breakpoint coordinates are picked from a copy of an original geophysical survey and entered on a well survey data form (Figure 9). The combination county code (card columns 1-3) and well I.D. (card columns 4-9) make up the station I.D. assigned to the well by the geophysical logging project manager.

Data values, depth and Y-amplitude, can either be right justified in their respective fields without a decimal point or anywhere in their field if a decimal point is present. The well survey data form is then submitted to data entry for keypunching and verification.

The keypunched cards with an appropriate requisition for computer work (Appendix II, Page 8) are submitted to Data Processing. Program E209 produces a magnetic tape of the card images in the WLAS format and a printed listing of the data. Program E209 sorts the cards from major to minor on county code, well number, survey year, survey month, survey day, survey type, and depth, and then copies them onto magnetic tape.

Quality control of these data before entry into the master file is completed in part through program E213, a plot program which plots Y amplitudes against depth at any predescribed scale. A plot is generated at the same scale as the original and is used as an overlay to a true

W E L L   S U R V E Y   D A T A

INTERIM WELL LOG ANALYSIS SYSTEM - PROGRAM E209

1 CNTY CODE	4 WELL I.D. NO.	10 SVY MO.	12 SVY DAY	14 SVY YR.	16 *** SVY		21 DEPTH-VALUE (FEET) (USE DECIMAL)	31 SURVEY-VALUE (USE DECIMAL) 40

***SURVEY TYPES -

01 = CALIPER
02 = FLOWMETER
03 = 16-INCH NORMAL RESISTIVITY
04 = 64-INCH NORMAL RESISTIVITY
05 = NEUTRON POROSITY
06 = NATURAL GAMMA
07 = FLUID RESISTIVITY
08 = GAMMA GAMMA DENSITY
09 = CASING COLLAR LOCATOR
10 = FLUID SAMPLER
11 = TEMPERATURE GRADIENT
12 = DELTA TEMPERATURE
13 = SPONTANEOUS POTENTIAL
14 = POINT RESISTANCE
15 = 6-FOOT LATERAL RESISTIVITY
16 = SONIC TRAVEL TIME
17 = ACOUSTIC AMPLITUDE

FIGURE 9 - Well Survey Data form for manually digitized data

copy of the original log for quality controlling the breakpoint data. If the plot matches the trace to the prescribed quality control standards and all scales are correct the data can then be merged into the master survey data file. If there is a correction to be made the card or cards containing the incorrect value or values are removed and replaced with corrected card(s). The procedures for running program E209, or E213, for quality control and correction are repeated until the data meet satisfactory quality control standards and at that time are merged with data on the master tape file with program E210. Program E210 merges a raw data tape, produced by E209 or E200, with the old master file tape to produce a new master file tape.

Semi-Manually Digitized Data

Semi-manually digitized data is that data in which the X and Y breakpoint coordinates are captured on paper tape via an electronic flatbed chart digitizer.

Blue line copies of original geophysical logs are processed for digitizing by marking them with beginning and ending depths and scales for each survey. Station I.D., date, and survey type are then transcribed to a transmittal form (Figures 10a and 10b) designed for efficient transfer of chart data to the digitizer keyboard operator. Data for all charts except Caliper are transmitted on Figure 10a. Caliper survey information is transmitted on Figure 10b. The extra form is to handle the non-linear nature of the Caliper log and requires that all Y scale values be recorded. The transmittal sheet and its associated charts are forwarded to the Data Management Division, Technical Services Department, for digitizing.

Prepared By: Date BATCH NO.

Chart	Well	Station I.D.		Survey Date			No.	Digitized By:
No.	I.D.	County	Well No.	Mo.	Da.	Yr.	Type	
								0000101E/R

Start Depth	00500	=X	=X	=X	
Scale Left	00100	=Y	=Y	=Y	
Scale Right		=Y	=Y	=Y	
Close		=X	=X		End Depth

Chart	Well	Station I.D.		Survey Date			No.	Digitized By:
No.	I.D.	County	Well No.	Mo.	Da.	Yr.	Type	
								0000101E/R

Start Depth	00500	=X	=X	=X	
Scale Left	00100	=Y	=Y	=Y	
Scale Right		=Y	=Y	=Y	
Close		=X	=X		End Depth

Chart	Well	Station I.D.		Survey Date			No.	Digitized By:
No.	I.D.	County	Well No.	Mo.	Da.	Yr.	Type	
								0000101E/R

Start Depth	00500	=X	=X	=X	
Scale Left	00100	=Y	=Y	=Y	
Scale Right		=Y	=Y	=Y	
Close					End Depth

Chart	Well	Station I.D.		Survey Date			No.	Digitized By:
No.	I.D.	County	Well No.	Mo.	Da.	Yr.	Type	
								0000101E/R

Start Depth	00500	=X	=X	=X	
Scale Left	00100	=Y	=Y	=Y	
Scale Right		=Y	=Y	=Y	
Close					End Depth

Chart	Well	Station I.D.		Survey Date			No.	Digitized By:
No.	I.D.	County	Well No.	Mo.	Da.	Yr.	Type	
								0000101E/R

Start Depth	00500	=X	=X	=X	
Scale Left	00100	=Y	=Y	=Y	
Scale Right		=Y	=Y	=Y	
Close					End Depth

FIGURE 10a - Transmittal form for semi-manually digitized data page 1 of 2

Chart No.	Well I.D.	Station I.D. County	Station I.D. Well No.	Survey Date Mo.	Da.	Yr.	Survey No. Type	Digitized By:
								0000101E/R

Start Depth		00500
Left Scale		00100
Y=		

Y= Y= Y= Y= Y= Y= Y= Y= Y= Y= Y= Y= Y= Y= Y= X= X= X= Closing Depth

Chart No.	Well I.D.	Station I.D. County	Station I.D. Well No.	Survey Date Mo.	Da.	Yr.	Survey No. Type	Digitized By:
								0000101E/R

Start Depth		00500
Left Scale		00100
Y=		

Y= Y= Y= Y= Y= Y= Y= Y= Y= Y= Y= Y= Y= Y= Y= X= X= X= Closing Depth

DATE RETURNED TO GROUNDWATER	Q.C. BY	DATE	APPROVED?

DATA STATUS	PROGRAM USED	TAPE NO.	TAPE NAME	RUN SEQ.	RUN DATE	RUN TIME
DIGITIZED	PLTPT		DIGITIZED-BATCH-			
CONVERTED	E200		E200-BATCH-			
MERGED	MERGTAPE		E200-CUMUL-BATCH-			
UPDATED	E201		WELL-SURVEY-MASTER-			

First Run	Received	OK	COMMENTS
To Corr.	Received	OK	

DATE RECEIVED ____________ SENT TO GROUNDWATER ____________

FIGURE 10b - Transmittal form for semi-manually digitized data page 2 of 2

Data Management enters header information-Station I.D., survey date, and survey type on the strip chart digitizer keyboard, followed by beginning depth of the survey, the appropriate Y amplitude scale or scales and the respective digitizer values for each. The survey is then digitized according to normal operating procedures. Ending depth and corresponding digitizer values are again keyed after the log is digitized. This process is repeated until all surveys for a given batch have been completed.

Data Management submits each paper tape and a "Requisition for Computer Work" to Data Processing to be run as input to program E200. Program E200 is the initial program of the WLAS and will accept paper tapes bearing digitized data describing the analog output of a strip chart recorder to produce:

(1) An edited listing of the input paper tape records, with any format errors flagged.

(2) An edited listing of any correction cards designed to eliminate errors found under (1) above, with any errors flagged.

(3) A listing of the digitized values converted from digitizer units to survey units.

(4) A plot of the corrected digitized data for quality control purposes.

(5) A tape file of survey units data for further processing.

The magnetic tapes created by Program E200 are assigned by Data Processing, noted on the return copy of the "Requisition for Computer Work," and the tape numbers transcribed by Data Management onto the transmittal sheet in the appropriate space provided.

If no format errors occurred in the creation of the paper tapes, a set of quality control plots will be produced by Data Processing and sent to Data Management. Should format errors be detected in the paper tape records by program E200; they will be flagged on the digitized data survey listing. When format errors are detected, no further processing is performed and E200 must be rerun with the optional correction card input. Three types of record correction options are available: (1) deletion, (2) replacement, or (3) insertion (for details see Appendix III, Page 6). When all format errors have been eliminated, program E200 will produce plots of the digitized charts showing the data trace with X and Y scales (depth and amplitude) at the same scales as the original log. Once the quality control plots are obtained, the trace and scales are checked for accuracy by overlaying the plot onto the original. Should there be errors in either direction (X or Y) a record correction card must once again be created and E200 rerun until an error free set of plots is produced. The package of plots, charts, printout, and transmittal sheets is returned to the Groundwater Division for a final quality control check. If the digitizing is approved, the Groundwater Division incorporates this new data into the cumulative master file through program E210.

Machine Digitized Data

Machine digitizing of data is accomplished with the Data Acquisition System (DAS), a field digitizing unit which converts electrical recorder impulses into digital format and records them on 2-track Phillips-type cassette tapes. With this equipment, four channels of data along with depth can be recorded concurrently. The cassette tape with digitized data is read on a memodyne reader linked to the computer system, and the data copied to magnetic tape.

The Program E200 options form (Figure 11) is filled out in the field. Log number, survey numbers, station I.D., date, survey type, and the number are recorded as the various surveys are run. The depth offset is used when probes with multiple sensors at different points along the length of the tool are utilized so that a correct depth point for all values surveyed can be established. Intercept and slope values are used to convert from relative units (e.g., cps) to physical units (e.g., volts). All values are recorded without decimal points. If decimal places are required, input of the decimal points can be obtained by designating the number of significant decimal places in Column 46 (Figure 11). Plot scales (columns 62-75) are used for the E200 quality control plots and must be at the same scale as the original for a quality control overlay. Plot scales must be right justified or with decimal points. Variable scale survey options are used to establish accurate scales on the non-linear Caliper log and to output temperature values in the desired units.

The magnetic tape and the proper E200 option cards are then run through program E200. Program E200 flags errors in the cassette data on the printout and records only the correct records onto a magnetic tape in the WLAS format. To input correct values for the records discarded by the E200 program, correction cards can be created (Figure 12) for that data and rerun with E200. As in the semi-manual data, a plot tape is generated for the data values. The plot is then overlayed on the original strip chart log for accuracy checks. Should there be errors, correction cards must be created and E200 rerun with the corrected data. This process continues until the

PROGRAM E200 - OPTIONS

(CASSETTE INPUT ONLY)

LABEL	TAPE
E200-INPUT-BATCH- _ _ _ _	= NO. _ _ _ _
E200-OUTPUT-BATCH- _ _ _ _	= NO. _ _ _ _

FIRST CARD (REQUIRED)

*E200,CASSETTE,BATCH= _ _ _ _

FOR EACH LOG (ONE REQUIRED)

1 7 13 19 28 30 32 34 36 39 46 54 62 69 75

L	LOG NO.	SV	BEGIN REC. NO.	END REC. NO.	STATION I.D.	MO.	DAY	YR.	SVY TYP	RUN NO.	DEPTH OFFSET (FEET)	DP	CONVERSION* INTERCEPT(A)	CONVERSION* SLOPE(B)	PLOT X-SCALE (FEET/INCH)	PLOT Y-SCALE (VALUE/INCH)
L																
L																
L																
L																
L																
L																
L																
L																
L																
L																
L																
L																
L																

SV = SURVEY POSITION NO. (IN DATA RECORD); 1, 2, 3, OR 4

DP = DECIMAL POSITION (NO. DIGITS FROM RIGHT)

*CONVERSION: YPRIME = A + (B * Y)

FOR EACH VARIABLE-SCALE SURVEY (OPTIONAL)

1 7 13 19 23 31 35 43 47 55 59 67 71 77

S	LOG NO.	SV	BEGIN REC. NO.	END REC. NO.	RECORD VALUE	ACTUAL VALUE	RECORD VALUE	ACTUAL VALUE	RECORD VALUE	ACTUAL VALUE	RECORD VALUE	ACTUAL VALUE	RECORD VALUE	ACTUAL VALUE
S														
S														

SV = SURVEY POSITION NO. (IN DATA RECORD); 1, 2, 3, OR 4

FIGURE 11 - Program E200 options form for DAS cassette data

PROGRAM E200 - CORRECTIONS

(CASSETTE INPUT ONLY)

SINGLE RECORD CORRECTIONS (OPTIONAL)

1 7 14 20 26 32 35

*A	RECORD NO.	DEPTH VALUE	VALUE - SRVY 1	VALUE - SRVY 2	VALUE - SRVY 3	VALUE - SRVY 4

*A = ACTION CODE (D=DELETE, R=REPLACE, I=INSERT AFTER)

MULTIPLE RECORD DELETIONS (OPTIONAL)

1 7 9 13

	RECORD NO.		RECORD NO.
D		TO	
D		TO	
D		TO	
D		TO	
D		TO	
D		TO	
D		TO	

FIGURE 12 - Program E200 correction card form for DAS cassette tape

plotted data meet quality control standards and can be merged into the master file by program E210.

Master File

The master file is a compilation of digitized well log survey records in the WLAS format (see Appendix II, Page 2).

The master file records are sorted from major to minor on county code, well number, survey date-year, survey date-month, survey date-day, survey type, and depth.

The master file was originally created and is continually updated by merging raw breakpoint data tapes created by programs E200 and E209 with the data on the master file.

This task is accomplished with WLAS program E210. Program E210 sorts the raw data tape on the same fields as the master file. Then the old master tape records are read and merged with the sorted raw data tape records onto a new master tape file. In addition to the new master file magnetic tape, a listing of the Station I.D.'s (county code through survey type) for all surveys on the tape is printed.

Should a duplicate record appear during the merge, an error message will appear and only the record from the old master file will be retained on tape. A duplicate record is an additional Y amplitude value for any well where the county code through depth values are identical. This indicates that either there is an error in the header information for that survey or that a particular survey has been digitized more than once. It is the data managers job to decide which of these conditions exist and to rectify the situation. Corrections to the header and elimination of duplicate data can be most easily accomplished with the use of program

E208. Program E208 is a general purpose utility program for listing and/or copying selected tape records with the WLAS format. There is also an option of changing records for the purpose of correction. Program E208 will be discussed in greater detail within the retrieval techniques section of this report.

RETRIEVAL OF DIGITIZED BOREHOLE GEOPHYSICAL DATA

Two types of data are manipulated and retrieved by the District's WLAS, they are (1) descriptive header data, and (2) digitized analog values.

There are two non-production programs that currently list selected data from the descriptive data header cards. In addition there are six (6) production programs for manipulation and extraction of digitized geophysical survey data.

Information and instructions in the use of the above mentioned programs and examples of their output are described in this section.

Descriptive Information

At the present time there are two non-production interim programs to print selected data from the well station identification and well survey report forms. Examples of the output from these programs are shown in Figures 13 and 14. Figure 13 shows well locations and descriptive data. This information is recalled using cards numbered "11", "21", "31", "51", and "61" from the well station identification form (card numbers are found in card columns 17-19 of the keypunched data cards). The above named cards for each well must be together but do not have to be in numerical sequence.

Figure 14 lists the well location and survey names for the geophysical surveys logged for a well. This program utilizes the "11" and "12" cards from the well station identification form and the "71" card from the well survey report. Again all cards for any given well must be together but do not have to be in numerical order.

WELL NUMBER	LATITUDE	LONGITUDE	OWNER	WELL USE	LAND SURFACE (FEET)	TOP OF CASING (FEET)	M S L	L S	T O C	I.D. (IN.)	TOTAL DEPTH (FT. LS)	CASING DEPTH (FT. LS)
MF-20	027 09 30.00	080 36 20.00	BOBS GROVE	IRRIGATION	.	1.00		X		8.00	1200	439

FIGURE 13 - Selected information retrieved from the Well Station Identification form

WELL NUMBER	COUNTY	LATITUDE	LONGITUDE	SEC.	TWP.	RGE.	DATE	SURVEY NAME
MF-20	MARTIN	027:09:30.00	080:36:20.00	22	38S	37E	05/16/79	CALIPER
							05/16/79	FLOWMETER
							05/16/79	16-IN NORMAL RES
							05/16/79	64-IN NORMAL RES
							05/16/79	NEUTRON POROSITY
							05/16/79	NATURAL GAMMA
							05/16/79	CASING COLLAR
							05/16/79	TEMP GRADIENT
							05/16/79	DELTA TEMP
							05/16/79	SPONTANEOUS POT

FIGURE 14 - Selected information retrieved from the Well Station Identification form and Well Survey Report form

Continued development of a master file for the descriptive data, along with capabilities of a generalized extraction program, are essential to the efficient quality control of the descriptive data and retrieval of desired parameters.

Digitized Geophysical Survey Data

Once geophysical survey data have been digitized and stored by one of the methods previously discussed, manipulation and presentation of that data are the next steps in utilization of the data. The following is a brief discussion of the extraction programs.

(1) Program E208 provides a general purpose utility program to list, copy, and/or correct any tape in the WLAS format.

(2) Program E211 will convert one or more sets of breakpoint well survey data to equal depth value (common depth point) data.

(3) Program E212 will synthesize a new set of survey data from one or more common depth point surveys.

(4) Program E213 will plot surveys from any WLAS magnetic tape.

(5) Program E214 will plot multiple surveys on a single depth axis.

(6) Program E215 will plot the values of two surveys for a series of common depth points against each other.

Program E208

This program is used as a general purpose utility program using option cards to control the listing of data, copying of data to a new tape, the format for displaying the data, and the selection or correction of specific data from any tape in the well log analysis system format. The basic options are list, copy, select, reject, and modify. A complete explanation of the "Select Procedure" is contained within the Management Information System (MIS) documentation.

During the processing E208 reads, prints, and edits all option cards flagging any errors. If no errors are found, the program then reads each record from the input tape, checks it against the selection criteria, and displays and/or copies it based upon option card requirements.

An example of the "Select Procedure" set up criteria is shown in Figure 15. The subsequent printout from that criteria is shown in Figures 16 and 17. A magnetic tape was created with the selected data, and additional well log analysis procedures can be carried out using that tape. A sample requisition for computer work along with option card selections are available in Appendix II, pages 7a and 7b.

<u>Program E211</u>

Program E211 will convert one or more sets of breakpoint well survey data to common depth point data. Program E211 requires an input tape in the WLAS format and a set of option cards. The option card format sheet (Figure 18) is filled out, one line for each survey being manipulated. The county code and well I.D. number in Columns 1-9 are the same as the station I.D. assigned by the geophysical logging project manager. The month, day, and year the survey was made, along with the survey type (codes on form), are filled in Columns 10-17. The depth at which the common depth interval data is to begin is inserted in Columns 41-50, while the depth at which the common depth point is to end is inserted in Columns 51-60. Finally, the desired interval for the common depth point data is indicated in Columns 61-70. The example shown for the option cards on Figure 18 will

```
E 2 0 8                          T A P E   F I L E   U T I L I T Y   P R O G R A M                         PAGE     1
01/07/81                               INTERIM WELL LOG ANALYSIS SYSTEM                            INPUT TAPE:  NONE
19:08:20                            SOUTH FLORIDA WATER MANAGEMENT DISTRICT                        OUTPUT TAPE:  NONE

                      I N P U T   T A P E   R E C O R D              ********         M O D I F I E D   R E C O R D
INPUT    -----------------------------------------------------------  *      *  -----------------------------------------------------------
TAPE     STATION ID  SURVEY  SURVEY      C                            *ACTION*  STATION ID  SURVEY  SURVEY      C
RECORD   ----------   DATE    TYPE  RUN 0 2   DEPTH      SURVEY       *      *  ----------   DATE    TYPE  RUN 0 2   DEPTH      SURVEY
NO(S).   CO.  WELL  MM/DD/YY  CODE  NO. L O   (FEET)     VALUE        ********  CO.  WELL  MM/DD/YY  CODE  NO. L O   (FEET)     VALUE
------   --- -----  -------- ------ --- --- ---------- ----------     --------  --- -----  -------- ------ --- --- ---------- ----------

OPTION CARD LISTING - PROGRAM E208.

OPTION CARD LISTING - PROGRAM E208.
*E208, COPY, SELECTED
*E208, LIST, SELECTED
*SELECT
*MATCH
085000044
*REJECT
*MATCH
               11
*ENDSEL


BEGIN FILE LISTING/UPDATE.
```

FIGURE 15 - Selection options from Program E208

E 2 0 8
01/07/81
19:08:20

TAPE FILE UTILITY PROGRAM
INTERIM WELL LOG ANALYSIS SYSTEM
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PAGE 2
INPUT TAPE: 1174
OUTPUT TAPE: 1787

INPUT TAPE RECORD NO(S).	INPUT TAPE RECORD: STATION ID CO.	WELL	SURVEY DATE MM/DD/YY	SURVEY TYPE CODE	RUN NO.	C O L	2 0	DEPTH (FEET)	SURVEY VALUE	*ACTION*	MODIFIED RECORD: STATION ID CO.	WELL	SURVEY DATE MM/DD/YY	SURVEY TYPE CODE	RUN NO.	C O L	2 0	DEPTH (FEET)	SURVEY VALUE
	085	000044	05/16/79	01	00	0				SELECTED									
	085	000044	05/16/79	02	00	0				SELECTED									
	085	000044	05/16/79	03	00	0				SELECTED									
	085	000044	05/16/79	04	00	0				SELECTED									
	085	000044	05/16/79	05	00	0				SELECTED									
	085	000044	05/16/79	06	00	0				SELECTED									
	085	000044	05/16/79	13	00	0				SELECTED									

FIGURE 16 - Selected data requested from Program E208

```
E 2 0 8                        T A P E   F I L E   U T I L I T Y   P R O G R A M                              PAGE    3
01/07/81                            INTERIM WELL LOG ANALYSIS SYSTEM                                INPUT TAPE:  1174,1221
19:08:20                          SOUTH FLORIDA WATER MANAGEMENT DISTRICT                              OUTPUT TAPE:  1787

                      I N P U T   T A P E   R E C O R D            ********               M O D I F I E D   R E C O R D
INPUT    ----------------------------------------------------------- *      *   ---------------------------------------------------------------
TAPE     STATION ID  SURVEY  SURVEY      C                            *ACTION*   STATION ID  SURVEY  SURVEY      C
RECORD   ----------   DATE    TYPE  RUN O 2   DEPTH       SURVEY      *      *   ----------   DATE    TYPE  RUN O 2   DEPTH       SURVEY
NO(S).   CO.  WELL  MM/DD/YY  CODE  NO. L O   (FEET)      VALUE       ********   CO.  WELL  MM/DD/YY  CODE  NO. L O   (FEET)      VALUE
------   --- ------ -------- ------ --- --- ---------- ----------     --------   --- ------ -------- ------ --- --- ---------- ----------

END FILE LISTING/UPDATE.


RECORDS INPUT:      324,053,          RECORDS OUTPUT:        4,230.


NORMAL TERMINATION OF PROGRAM E208.
```

FIGURE 17 - Termination page Program E208

E 2 1 1 (EX-NUINTRVL) OPTION CARDS

INTERIM WELL LOG ANALYSIS SYSTEM

CNTY CODE (1)	WELL I.D. NO. (4)	SVY MO. (10)	SVY DAY (12)	SVY YR. (14)	*** SVY (16)		BEGIN DEPTH (FEET) (USE DECIMAL) (41)	END DEPTH (FEET) (USE DECIMAL) (51)	INTERVAL (FEET) (USE DECIMAL) (61–70)
085	000044	05	16	79	01		0	1200	2
085	000044	05	16	79	02		0	1200	2

***SURVEY TYPES -

01 = CALIPER
02 = FLOWMETER
03 = 16-INCH NORMAL RESISTIVITY
04 = 64-INCH NORMAL RESISTIVITY
05 = NEUTRON POROSITY
06 = NATURAL GAMMA
07 = FLUID RESISTIVITY
08 = GAMMA GAMMA DENSITY
09 = CASING COLLAR LOCATOR
10 = FLUID SAMPLER
11 = TEMPERATURE GRADIENT
12 = DELTA TEMPERATURE
13 = SPONTANEOUS POTENTIAL
14 = POINT RESISTANCE
15 = 6-FOOT LATERAL RESISTIVITY
16 = SONIC TRAVEL TIME
17 = ACOUSTIC AMPLITUDE

FIGURE 18 - Program E211 - option card form

take data for MF-20 (Station I.D. - 085000044), the Caliper (01) and Flowmeter (02) surveys and create new Y-amplitude values every 2 feet.

After keypunching and submittal to the computer, processing commences with the reading of all depth conversion option cards. Each survey on the input tape is screened against the option cards to see if depth conversion is required. New data point values are created by a linear interpolation between the two adjoining breakpoint data points. The new data points (depth and values) are output to magnetic tape. A listing for each survey processed, showing the original breakpoint data and the equal interval data points generated, is created in addition to the magnetic tape. A sample page of this output is shown in Figure 19. Limitations to this process and a sample requisition for computer work are outlined in Appendix II, page 11.

Program E212

Program E212 synthesizes a new set of survey data for one to four common depth point surveys. Single survey calculations do not have to have common depth intervals. Figure 20 is the option card format form for this program. The survey type for survey A is the same survey type as the synthesized output data. A maximum of 300 option cards are allowed per run with a total maximum survey count of 600. Columns 79-80 are for the index number of the calculation to be used to synthesize the data from the surveys indicated. In processing, all option cards are read first, then the surveys used in the calculations are copied from the tape to a work disk. Each new survey is then synthesized and the data points created are written onto the output tape. A listing is generated for each survey created, showing at each common depth interval the first and last 10 values for the input surveys and the value calculated. Zero

01/07/81 (20.23.10) <TAPES USED - INPUT = 1174, OUTPUT = 6793> (EX-NUINTRVL) E211

STATION I.D.: 085000044 SURVEY DATE: 05/16/79 SURVEY TYPE (NO.): 01 PAGE 1

SCALE-CHANGE: BEGINNING DEPTH = 0.0 ENDING DEPTH = 1200.0 INTERVAL = 2.0

ORIGINAL SURVEY DATA

POINT NO.	DEPTH, IN FT. (X)	AMPLITUDE (Y)
1	8.00	8.05
2	48.65	8.05

SURVEY DATA WITH SCALE-CHANGE APPLIED

POINT NO.	DEPTH, IN FT. (X)	AMPLITUDE (Y)
1	8.00	8.05
2	10.00	8.05
3	12.00	8.05
4	14.00	8.05
5	16.00	8.05
6	18.00	8.05
7	20.00	8.05
8	22.00	8.05
9	24.00	8.05
10	26.00	8.05
11	28.00	8.05
12	30.00	8.05
13	32.00	8.05
14	34.00	8.05
15	36.00	8.05
16	38.00	8.05
17	40.00	8.05
18	42.00	8.05
19	44.00	8.05
20	46.00	8.05
21	48.00	8.05
22	50.00	8.05
23	52.00	8.05
24	54.00	8.05
25	56.00	8.05
26	58.00	8.04
27	60.00	8.04
28	62.00	8.04
29	64.00	8.04
30	66.00	8.04
31	68.00	8.04
32	70.00	8.04
33	72.00	8.04
34	74.00	8.03
35	76.00	8.03
36	78.00	8.03
37	80.00	8.03
38	82.00	8.03
39	84.00	8.03
40	86.00	8.03
41	88.00	8.02
42	90.00	8.02
43	92.00	8.02
44	94.00	8.02

FIGURE 19 - Common Depth Point data from Program E211

E 2 1 2 (EX-NUSURVEY) O P T I O N C A R D S

INTERIM WELL LOG ANALYSIS SYSTEM

1 -A- CNTY	4 -A- WELL ID NO	10 -A- MO.	12 -A- DAY	14 -A- YR.	16 *** SVY	21 -B- CNTY	24 -B- WELL ID NO	30 -B- MO.	32 -B- DAY	34 -B- YR.	36 *** SVY	41 -C- CNTY	44 -C- WELL ID NO	50 -C- MO.	52 -C- DAY	54 -C- YR.	56 *** SVY	61 -D- CNTY	64 -D- WELL ID NO	70 -D- MO.	72 -D- DAY	74 -D- YR.	76 *** SVY	79 ** CLC
085	000044	05	16	79	02	085	000044	05	16	79	01													01

***SURVEY TYPES -

01 = CALIPER
02 = FLOWMETER
03 = 16-INCH NORMAL RESISTIVITY
04 = 64-INCH NORMAL RESISTIVITY
05 = NEUTRON POROSITY
06 = NATURAL GAMMA
07 = FLUID RESISTIVITY
08 = GAMMA GAMMA DENSITY
09 = CASING COLLAR LOCATOR
10 = FLUID SAMPLER
11 = TEMPERATURE GRADIENT
12 = DELTA TEMPERATURE
13 = SPONTANEOUS POTENTIAL
14 = POINT RESISTANCE
15 = 6-FOOT LATERAL RESISTIVITY
16 = SONIC TRAVEL TIME
17 = ACOUSTIC AMPLITUDE

**CALCULATION TYPES -

01 = CORRECTED FLOW LOG
02 = CORRECTED RESISTIVITY (FAHRENHEIT)
03 = CONDUCTIVITY
04 = CORRECTED RESISTIVITY (CENTIGRADE)

FIGURE 20 - Program E212 - option card form

data values are treated as missing data and no new value is calculated for that depth nor is that data printed. Only depth intervals with data for all surveys used in the calculation are synthesized. Current calculations available are shown in Table 3. Figure 21 is an example of the E212 listing output as a result of the options selected on the option card form (Figure 20). The common depth point of every 2 feet is used for the Flowmeter and Caliper surveys to obtain a Flowmeter log corrected for borehole diameter. These data can then be plotted or used in any other WLAS programs.

Program E213

This program will plot survey data stored on magnetic tape in the WLAS format. The E213 option card format is shown on Figure 22. The survey I.D., county code through survey type, and the X and Y scale ratios must be specified for each plot. The minimum and maximum X and Y values are optional. During processing, all survey scale cards are read first. Next, the input tape is read and each survey requested is output to a plot tape. The plot tape is processed by an off-line plotter. The survey data plot shown in Figure 23 is the result of the options selected on the option card form in Figure 22.

There is no output listing for E213, simply one line with the words "plot generation completed."

Program E214

Program E214 is designed to plot multiple surveys for a single depth axis. It allows the user to control axes sizing, labelling and coloring.

TABLE 3

E212 CALCULATIONS CURRENTLY IN THE WLAS

Calculation Number	Calculation Description
01	Corrected Flowmeter (((B/2.0) ** 2.0) * 3.14159) * A
02	Corrected Resistivity (Farenheit) 1.5 - (.02) * (5/9 (A - 32)) * 10000/B
03	Conductivity 10000/A
04	Corrected Resistivity (Centigrade) 1.5 - (.02) * A * 10000/B
05	A = no calculation (copy as is)
06	Temperature (degrees F to degrees C) (A-32) * (5/9)
07	Temperature (degrees C to degrees F) ((A * 9) / 5) + 32
08	Conversion from CPS to API - some neutron logs A * 1.92
09	LOGE (A)
10	LOG10 (A)

01/07/81 (20.31.40) <TAPES USED - INPUT = 6793, OUTPUT = 6796> (EX-NUSURVEY) E212

STATION I.D. = 085000044 SURVEY DATE = 05/16/79 SURVEY TYPE = FLOWMETER PAGE 1

CALCULATION OF RESULT = (((B/2.0)**2.0)*3.14159)*A

-DEPTH (FT)-	-A-	-B-	-C-	-D-	-RESULT-
STATION I.D.	085000044	085000044			085000044
SURVEY DATE	05/16/79	05/16/79			05/16/79
SURVEY	FLOWMETER	CALIPER			FLOWMETER
20.00	18.53	8.05			943.10
22.00	25.72	8.05			1309.04
24.00	27.22	8.05			1385.38
26.00	26.35	8.05			1341.10
28.00	26.62	8.05			1354.84
30.00	26.30	8.05			1338.56
32.00	26.52	8.05			1349.75
34.00	26.24	8.05			1335.50
36.00	26.85	8.05			1366.55
38.00	26.68	8.05			1357.90
. . . ONLY FIRST AND LAST TEN RECORDS PRINTED TO SAVE PAPER . . .					
1182.00	3.56	7.70			165.78
1184.00	3.61	7.70			168.10
1186.00	3.61	7.70			168.10
1188.00	3.80	7.70			176.95
1190.00	3.37	7.70			156.93
1192.00	3.80	7.70			176.95
1194.00	3.49	7.70			162.52
1196.00	4.10	7.69			190.43
1198.00	2.47	7.52			109.70
1200.00	3.07	7.19			124.65

FIGURE 21 - New Survey data from Program E212

E 2 1 3 (EX-LOGPLOT) OPTION CARDS

INTERIM WELL LOG ANALYSIS SYSTEM

1 CNTY CODE	4 WELL I.D. NO.	10 SVY MO.	12 SVY DAY	14 SVY YR.	16 *** SVY		21 X-SCALE RATIO (FEET / INCH) **	31 Y-SCALE RATIO (Y-UNITS / INCH)**	41 MINIMUM X-VALUE (DEPTH IN FEET) **	51 MAXIMUM X-VALUE (DEPTH IN FEET) **	61 MINIMUM Y-VALUE (IN Y-UNITS) **	71 MAXIMUM Y-VALUE (IN Y-UNITS) ** 80
085	000044	05	16	79	02		10	50	0	120	0	250

**USE DECIMAL POINT OR RIGHT-JUSTIFY VALUE

***SURVEY TYPES -

01 = CALIPER
02 = FLOWMETER
03 = 16-INCH NORMAL RESISTIVITY
04 = 64-INCH NORMAL RESISTIVITY
05 = NEUTRON POROSITY
06 = NATURAL GAMMA
07 = FLUID RESISTIVITY
08 = GAMMA GAMMA DENSITY
09 = CASING COLLAR LOCATOR
10 = FLUID SAMPLER
11 = TEMPERATURE GRADIENT
12 = DELTA TEMPERATURE
13 = SPONTANEOUS POTENTIAL
14 = POINT RESISTANCE
15 = 6-FOOT LATERAL RESISTIVITY
16 = SONIC TRAVEL TIME
17 = ACOUSTIC AMPLITUDE

FIGURE 22 - Program E213 - option card form

01/05/81 (19.16.20) <INPUT TAPE USED =6796 > (EX-LOGPLOT) E213

WELL I.D. = 085C00044. SURVEY DATE = 05/16/79. SURVEY TYPE = 02

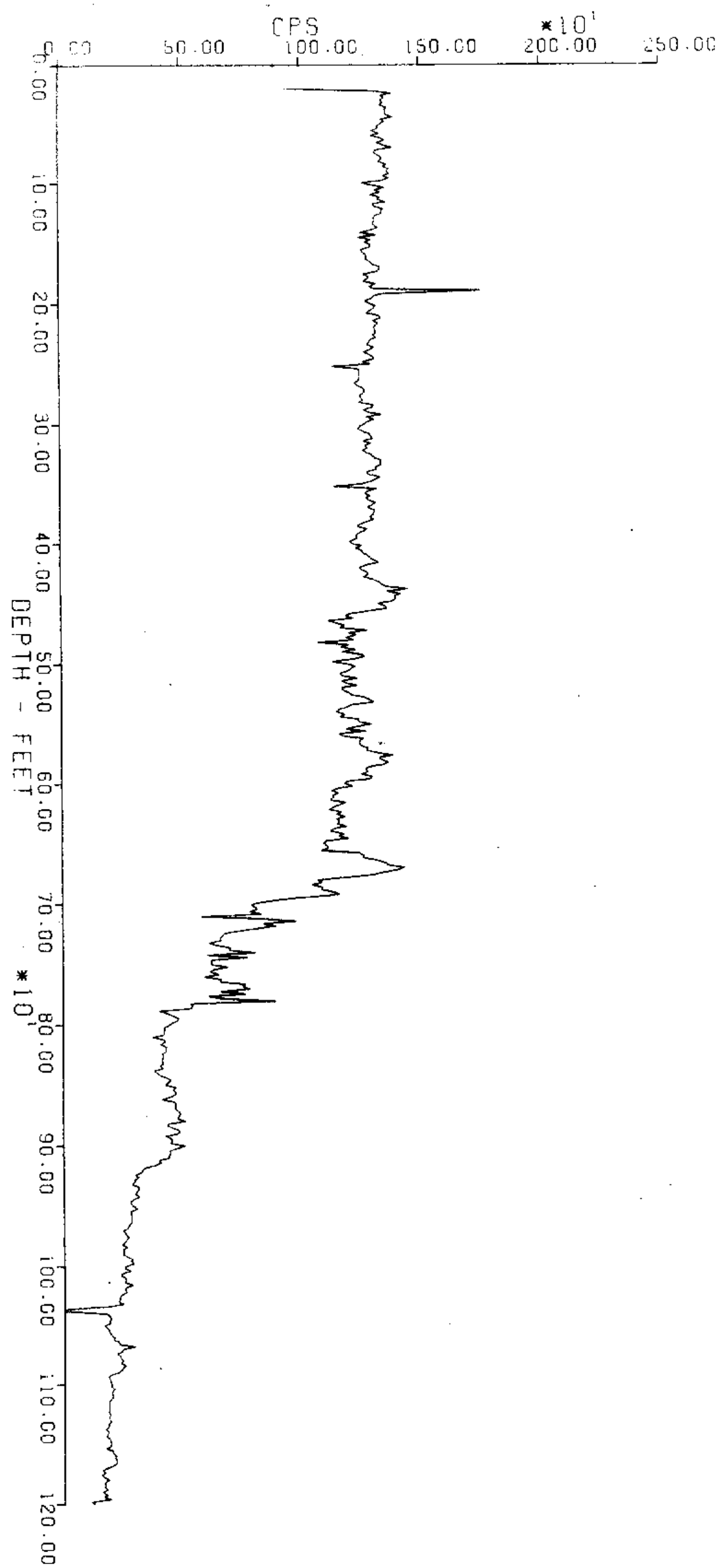

FIGURE 23 - Output plot from Program E213 (plot reduced photographically for printing)

The formats for the option cards are shown in Figure 24. The option card form is self-explanatory with options for most codes explained under the card type. A detailed options list is shown in Table 4.

In processing, all input option cards are read, printed, and edited with any errors flagged beneath the card image (Figure 25). Surveys required are then copied from the input tape to a work file disk. Default values are supplied for options that were omitted and a sorted list of all plot options is printed (Figure 26). The program then produces the requested plots on a plot tape and, if requested, a list of all input data records can be produced. The plot tape is processed by an off-line plotter.

The plot seen in Figure 27 is the result of the options selected on the example E214 option card form in Figure 25. The multiple-survey plot program printout (Figures 25 and 26) accompany this plot.

Program E215

This program plots two surveys at common depth intervals against one another. The horizontal axis (abscissa) will show the survey values for the independent variable, X, in the following equation:

$$Y = f(X)$$

The vertical axis (ordinate) will show the corresponding values of the dependent variable, Y.

The data points are plotted in descending depth order and may be optionally annotated as to the sequence in which they are plotted Program E215 allows the user to control the axes sizing, labelling, and coloring. The representation of data points may be controlled through a choice of the plotted symbol, its size and its color.

E 2 1 4 (MULTIPLE SURVEYS/PLOT) O P T I O N C A R D S

INTERIM WELL LOG ANALYSIS SYSTEM

P R O G R A M I . D . C A R D (REQUIRED: 1/RUN)

1	6	80
I.D.	F R E E - F O R M O P T I O N S (SEE DESCRIPTIONS BELOW)	NOT AVAILABLE FOR USE
*E214		

OPTIONS - [.AXES] = PLOTS DEPTH AXES FOR ALL SURVEYS [.LIST] = LISTS ALL DATA RECORDS USED IN PLOTTING
[.DUMP] = FOR PROGRAMMER USE ONLY (LOAD MAP AND DUMP)

P L O T T I T L E C A R D (OPTIONAL: 0-9 CARDS/PLOT)

1	4	9		41	72	75	80
PLOT NO.	I.D.	LN	T I T L E (LEFT-SIDE OF CENTER)	T I T L E (RIGHT-SIDE OF CENTER)	LTR SIZE	PEN COLOR	TL
	TITLE						
	TITLE						

LN = LINE NO. OF TITLE
TL = TITLE LOCATION (L=LEFT-JUSTIFIED, R=RIGHT-JUSTIFIED)
LTR SIZE = LETTER SIZE (IN INCHES)

D E P T H A X I S C A R D (REQUIRED: 1/PLOT)

1	4	9	16	22	28	34	37	80
PLOT NO.	I.D.	DEPTH SCALE - FEET/INCH	DEPTH RANGE - BEGINNING	DEPTH RANGE - ENDING	DEPTH RANGE - TIC-MARK	LTR SIZE	PEN COLOR	NOT AVAILABLE FOR USE
	DEPTH							

LTR SIZE = LETTER SIZE (IN INCHES)

S U R V E Y P L O T C A R D (REQUIRED: 1 OR MORE/PLOT)

1	4	13	15	17	19	21	23	28	33	39	42	47	52	57	60	65	68		74	80
PLOT NO.	STATION I.D. NO.	SVY NO.	SVY DAY	SVY YR.	SVY TYP	RUN NO.	X-OFFSET - INCHES	Y-OFFSET - INCHES	Y-SCALE - UNITS/INCH	UNITS CODE	SCALE - BEGINNING	SCALE - ENDING	SCALE - TIC-MARK	LTR SIZE	PEN COLOR	SYMBL CODE	HL	HDG LINES W D S R U	HDG/SCALE X-OFFSET	NOT USE

UNITS CODE = SEE IWLAS WRITE-UP (WILL DEFAULT TO SURVEY TYPE) LTR SIZE = LETTER SIZE (IN INCHES)
SYMBL CODE = SYMBOL CODE (SEE APPENDIX 6 OF WMD MANUAL; IF NEGATIVE, NO LINE WILL CONNECT POINTS)
HL = HEADING LOCATION (L=LEFT-JUSTIFIED, R=RIGHT-JUSTIFIED)
HDG LINES = HEADING LINES (W=WELL NO., D=DATE, S=SURVEY, R=RUN, U=UNITS); ENTER <1> TO PRINT W/D/R, <0> TO OMIT S/U
HDG/SCALE X-OFFSET = VERTICAL OFFSET OF BOTTOM OF Y-AXIS (NEGATIVE IS UPWARD FROM BEGINNING DEPTH; POSITIVE IS DOWNWARD)

FIGURE 24 - Program E214 - option card form

TABLE 4

E214 OPTION CARD OPTIONS

E214 Card:

Field	Req./Opt.	Explanation
*E214	Required	Card Identifier (1st field)
,AXES	Optional	Plot depth (X-scale) axis for each survey, in addition to master depth axis.
,LIST	Optional	List values for plotted records.
,DUMP	Optional	Provides map and dump of program variables.

Master Depth Axis Card:

Card Column	Description of Field
1-3	Plot Number
4-8	<DEPTH>
9-15	Depth scale, in feet/inches (required)
16-21	Beginning depth in feet (optional: program computes if omitted)
22-27	Ending depth in feet (optional: program computes if omitted).
28-33	Tic mark interval (optional: program computes if omitted).
34-36	Letter size, in hundredths of inches (optional: Default is 0.10 inch).
37-41	Pen color (<BLACK>, <RED>, <BLUE>, <GREEN>), (Optional: default is <BLACK>).
42-80	Unused.

....TABLE 4 (Continued)

Plot Title Card (one per title line, 0-9 title lines per plot):

Card Column	Description of Field
1-3	Plot number.
4-8	<TITLE>
9	Title line number (1-9).
10-40	Left hand side of title line.
41-71	Right hand side of title line.

NOTE: The following fields are taken from the first title line card only.

72-74	Letter size, to two decimal places.
75-79	Pen color (for title only). <BLACK> is the default; <RED>, <BLUE>, or <GREEN> may also be specified.
80	Title location (<C> for centered, <R> for right justified, <L> for left justified, default is <C>).

Survey Card (one per survey per plot):

Card Column	Description of Field
1-3	Plot number.
4-12	Station I.D. number.
13-14	Survey date - month.
15-16	Survey date - day.
17-18	Survey date - year.
19-20	Survey type code.
21-22	Run number.
23-27	X-offset, in inches of relative origin of plot from relative origin of depth axis (negative offset = shift up).
28-32	Y-offset, in inches of relative origin of plot from relative origin of X axis (positive offset = shift right).

....TABLE 4 (Continued)

Card Column	Description of Field
33-38	Y scale, in units/inch (required).
39-41	Units code number. Two digit unit codes correspond to the survey type code numbers and are the defaults in this field if blank. Three digit units codes are used to change the standard (default) units to new units; the acceptable values are: 101 = counts/second 102 = velocity (feet/second) 103 = API 104 = degrees centigrade 105 = ohm m^2/m
42-47	Beginning Y-scale values, in survey units (optional: program computes if omitted).
48-53	Ending Y-scale value, in survey units (optional: program computes if omitted).
54-59	Tic mark interval value, in survey units (optional: program computes if omitted).
60-62	Letter size, in hundredths of inches (optional: default is 0.10 inch).
63-67	Pen color, left justified chosen among the following: <BLACK>, <RED>, <BLUE>, or <GREEN>. <BLACK> is the default.
68-70	Data Point symbol code, selected from the list in appendix six of the SFWMD computer system manual, if code is blank or zero, no symbol will be plotted at each data point; if the code is negative no line will connect the data point symbols.
71	Heading location code (optional) L = left justify R = right justify C = center (default value)
72	Heading print control well number (1=print line, 0=do not print line, default: line does not print).

....TABLE 4 (Continued)

Card Column	Description of Field
73	Heading print control - survey date (1=print line, 0=do not print line, default: line does not print).
74	Heading print control - survey type (1=print line, 0=do not print line, default: line prints).
75	Heading print control - survey run number (1=print line 0=do not print line, default: line does not print).
76	Heading print control - survey units (1=print line, 0=do not print line, default: line prints).
77-78	Unused.
79-80	Not used on input, reserved for use by the program.

```
E 2 1 4                          M U L T I P L E - S U R V E Y   P L O T   P R O G R A M              PAGE    1
01/07/81                         -------------------------------------------------------
20:18:00                                    INTERIM WELL LOG ANALYSIS SYSTEM                  INPUT TAPE = XXXX

 *E214
 002TITLE1                                                          025BLACKL
 002TITLE2
 002TITLE3
 002TITLE4
 002TITLE5
 002TITLE6
 002TITLE7
 002TITLE8 MF - 20
 002TITLE9 5/16/79
 002DEPTH  100.0    0.01200.0 100.0009BLACK
 00208500004405167901000  000  500    4       7   13    3   RED              000
 00208500004405167902000  000  625   20       0   40   20   BLUE            -125
 00208500004405167903000  000  115  100       0   70   70   RED              250
 00208500004405167904000  000  165  100       0   60   60   BLUE     R       175
 00208500004405167905000  000  354  750       0 1000  500   BLACK           -075
 00208500004405167906000  000  233  133       0  300  100   GREEN            000
 00208500004405167911000  000  825     2104  27   29    2   GREEN            075
 00208500004405167913000  000  050  100       0  100  100   BLACK    L       325
```

FIGURE 25 - Option selections Program E214

E 2 1 4
01/07/81
20:18:00

MULTIPLE-SURVEY PLOT PROGRAM

INTERIM WELL LOG ANALYSIS SYSTEM

INPUT TAPE = 1775

PLOT NO. 2

TITLE LINE 1 = / /, LETTER SIZE = 0.25 IN., COLOR = BLACK, LEFT-JUSTIFIED
TITLE LINE 2 = / /
TITLE LINE 3 = / /
TITLE LINE 4 = / /
TITLE LINE 5 = / /
TITLE LINE 6 = / /
TITLE LINE 7 = / /
TITLE LINE 8 = / MF - 20 /
TITLE LINE 9 = / 5/16/79 /

DEPTH AXIS SCALE = 100.0 FEET/INCH
LETTER SIZE = 0.09 INCHES
COLOR = BLACK

DEPTH AXIS RANGE: BEGINNING DEPTH = 0.0 FEET
ENDING DEPTH = 1200.0 FEET
TIC-MARK INTERVAL = 100.0 FEET

SURVEY IDENTIFICATION					DEPTH ORIGIN OFFSETS (IN.)		Y-AXIS SCALE (UNITS /INCH)	Y-AXIS SCALE (UNITS SHOWN UNDERNEATH)			PLOT CONTROLS					
STATION I. D.	SURVEY DATE	SURVEY TYPE	(CODE	RUN NO.	X	Y		BEGIN	END	TIC-MARK	LETTER SIZE	PEN COLOR	SYM. CODE	HDG LOC	HDG LINES	HDG OFFSET
085000044	05/16/79	CALIPER	(01)	00	0.00	5.00	4	7	13	3	0.10	RED	000	C	S U	0.00
								(HOLE DIAMETER (INCHES))								
085000044	05/16/79	FLOWMETER	(02)	00	0.00	6.25	20	0	40	20	0.10	BLUE	000	C	S U	-1.25
								(COUNTS/SECOND)								
085000044	05/16/79	16-IN NORMAL RES	(03)	00	0.00	1.15	100	0	70	70	0.10	RED	000	C	S U	2.50
								(OHM-METERS)								
085000044	05/16/79	64-IN NORMAL RES	(04)	00	0.00	1.65	100	0	60	60	0.10	BLUE	000	R	S U	1.75
								(OHM-METERS)								
085000044	05/16/79	NEUTRON POROSITY	(05)	00	0.00	3.54	750	0	1000	500	0.10	BLACK	000	C	S U	-0.75
								(API)								
085000044	05/16/79	NATURAL GAMMA	(06)	00	0.00	2.33	133	0	300	100	0.10	GREEN	000	C	S U	0.00
								(API)								
085000044	05/16/79	TEMP GRADIENT	(11)	00	0.00	8.25	2	27	29	2	0.10	GREEN	000	C	S U	0.75
								(DEGREES CENTIGRADE)								
085000044	05/16/79	SPONTANEOUS POT	(13)	00	0.00	0.50	100	0	100	100	0.10	BLACK	000	L	S U	3.25
								(MV)								

FIGURE 26 - Sorted List of plot options Program E214

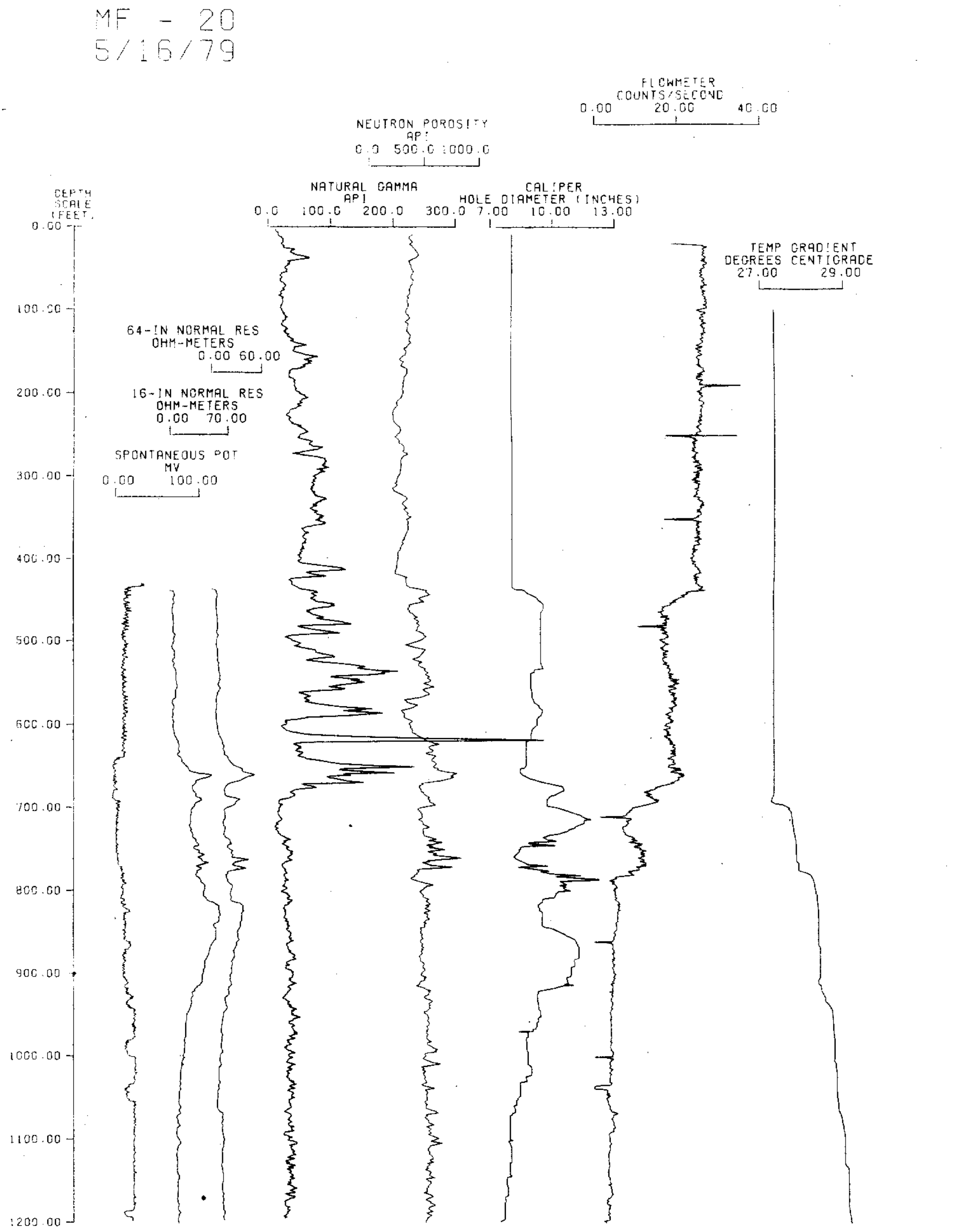

FIGURE 27 - Output plot - Program E214 (Plot reduced photographically for printing)

The formats for the E215 option cards are shown in Figure 28. Each format and field has some option selections beneath it. For a complete list of options and defaults for program E215 see Table 5. A sample "Requisition for Computer work" is shown in Appendix II, page 16C.

In processing, all input cards are sequentially read, printed and edited, with any errors flagged immediately beneath the card images. If there are no errors, the required surveys are then copied from the input tape to a work disk file. Defaults for any omitted options are then supplied by the program and a printed listing of all plots and associated options is produced in plot number sequence. A listing of the plotted points is available if requested. A plot tape is also created to be processed by an off-line plotter.

An example of the options selected from the options form in Figure 28 is shown in the printout (Figures 29 and 30) and a plot of the survey data in Figure 31.

Linked Jobs

A full data analysis may be produced in one job by assembling a deck made up of program I.D. cards and their appropriate option cards. Linked jobs may start with Program E209 and run through E211, E212, and E213 consecutively, or they may start and stop anywhere along that chain, with jobs being omitted in the middle. Examples of linked jobs and the appropriate option cards and requisitions for submittal are shown in Appendix II, pages 17-19.

E 2 1 5 (SURVEY AGAINST SURVEY PLOTS) OPTION CARDS

INTERIM WELL LOG ANALYSIS SYSTEM

PROGRAM I.D. CARD (REQUIRED: 1/RUN)

1	6	80
I.D.	FREE-FORM OPTIONS (SEE DESCRIPTIONS BELOW)	NOT AVAILABLE FOR USE
*E215		

OPTIONS - [,DUMP] = FOR PROGRAMMER USE ONLY (LOAD MAP AND DUMP)   [,LIST] = LISTS ALL DATA RECORDS USED IN PLOTTING

PLOT TITLE CARD (OPTIONAL: 0-9 CARDS/PLOT)

1	4	9		41	72	75	80
PLOT NO.	I.D.	LN	TITLE (LEFT-SIDE OF CENTER)	TITLE (RIGHT-SIDE OF CENTER)	LTR SIZE	PEN COLOR	TL
	TITLE						
	TITLE						
	TITLE						

LN = LINE NO. OF TITLE   LTR SIZE = LETTER SIZE (IN INCHES)
TL = TITLE LOCATION (L=LEFT-JUSTIFIED, R=RIGHT-JUSTIFIED)

PLOT CONTROL CARD (OPTIONAL: 1/PLOT)

1	4	9		13	16	21	27	33	80
PLOT NO.	I.D.	A	SYMBL CODE	LTR SIZE	PEN COLOR	DEPTH RANGE - BEGINNING	DEPTH RANGE - ENDING	DEPTH RANGE - INTERVAL	NOT USE
	DEPTH								

A = ANNOTATION CODE (IF NON-BLANK, POINTS WILL BE NUMBERED)   LTR SIZE = LETTER SIZE (IN INCHES)
SYMBL CODE = SYMBOL CODE (SEE APPENDIX 6 OF WMD MANUAL; IF NEGATIVE, LINE WILL CONNECT POINTS IN DEPTH ORDER)

X - AXIS (ABSCISSA) PLOT CARD (REQUIRED: 1/PLOT)

1	4		14	16	18	20	22	24	30	33	39	45	51	54	59		80
PLOT NO.	X	STATION I.D. NO.	SVY MO.	SVY DAY	SVY YR.	SVY TYP	RUN NO.	Y-SCALE - UNITS/INCH	UNITS CODE	SCALE RANGE - BEGINNING	SCALE RANGE - ENDING	SCALE RANGE - TIC-MARK	LTR SIZE	PEN COLOR	HL	HDG LINES W D S R U	NOT USE
	X																

Y - AXIS (ORDINATE) PLOT CARD (REQUIRED: 1/PLOT)

1	4		14	16	18	20	22	24	30	33	39	45	51	54	59		80
PLOT NO.	Y	STATION I.D. NO.	SVY MO.	SVY DAY	SVY YR.	SVY TYP	RUN NO.	Y-SCALE - UNITS/INCH	UNITS CODE	SCALE RANGE - BEGINNING	SCALE RANGE - ENDING	SCALE RANGE - TIC-MARK	LTR SIZE	PEN COLOR	HL	HDG LINES W D S R U	NOT USE
	Y																

UNITS CODE = SEE IWLAS WRITE-UP (WILL DEFAULT TO SURVEY TYPE)   LTR SIZE = LETTER SIZE (IN INCHES)
HL = HEADING LOCATION (L=LEFT-JUSTIFIED, R=RIGHT-JUSTIFIED)
HDG LINES = HEADING LINES (W=WELL NO., D=DATE, S=SURVEY, R=RUN, U=UNITS), ENTER <1> TO PRINT W/D/R, <0> TO OMIT S/U

FIGURE 28 - Program E215 - option card form

TABLE 5

E215 OPTION CARD OPTIONS

*E215 Card:

Field	Req./Opt.	Explanation
<*E215>	Required	Card identifier (first field)
<,LIST>	Optional	List values of plotted records.
<,DUMP>	Optional	Provide map and dump of program variables.

Plot Control Card

Card Column	Description of Field
1-3	Plot number.
4-8	<DEPTH>
9	Annotation code (if non-blank, points will be numbered in sequence plotted).
10-12	Symbol code used to represent points plotted; see appendix six of SFWMD computer system manual for valid code numbers (if code is negative, a line will connect points in order plotted).
13-15	Letter size, in hundredths of inches (optional default is 0.10 inch).
16-20	Pen color (for plotted points only, axes colors may be selected independently. <BLACK> is the default, <RED>, <BLUE> or <GREEN> may also be selected.
21-26	Beginning depth, in feet (optional: program computes if omitted).
27-32	Ending depth, in feet (optional: program computes if omitted).
33-38	Depth interval, in feet (optional: program computes if omitted).
39-80	Unused.

Plot Title Card (one per title line, 0-9 title lines per plot)

Card Column	Description
1-3	Plot number.
4-8	<TITLE>

....TABLE 5 (Continued)

Card Column	Description
9	Title line number (1-9)
10-40	Left hand side of title line.
41-71	Right hand side of title line.

NOTE: The following fields are taken from the first title card only.

72-74	Letter size, to two decimal places.
75-79	Pen color for title. <BLACK> is the default. <RED>, <BLUE> or <GREEN> may be specified.
80	Title location (blank or <C> for centered; <L> for left justified; <R> for right justified).

X-Axis (abscissa) Plot Card (one/plot)

Card Column	Description of Field
1-3	Plot number.
4	the letter <X>
5-13	Station ID number.
14-15	Survey date - month.
16-17	Survey date - day.
18-19	Survey date - year.
20-21	Survey type code.
22-23	Survey run number.
24-29	Y-scale, in units/inch.
30-32	Survey units code, from the following list: two digit units code corresponds to the survey type code number and are the defaults if this field is blank. Three digit units codes are used to change the standard (default) units to new units: the acceptable values are: 101 = counts/second. 102 = velocity (feet/second) 103 = API 104 = degrees centigrade 105 = ohm m^2/m

Card Column	Description of Field
33-38	Beginning Y-scale value, in survey units (optional, program computes if omitted).
39-44	Ending Y-scale value, in survey units (optional, program computes if omitted).
45-50	Tic mark interval, in survey units (optional, program computes if omitted).
51-53	Letter size, in hundredths of inches (optional, default is 0.10 inch).
54-58	Pen color (<BLACK>, <RED>, <BLUE>, <GREEN>) (Optional, default is <BLACK>).
59	Heading location code (optional) L = left - justify R = right - justify C = center (default for a blank field)
60	Heading print control - well number (1=print line, 0=do not print line, default - line does not print).
61	Heading print control - survey date (1=print line, 0=do not print line, default - line does not print).
62	Heading print control - survey type (1=print line, 0=do not print line, default - line prints).
63	Heading print control - survey run number (1=print line, 0=do not print line, default - line does not print).
64	Heading print control - survey units (1=print line, 0=do not print line, default - line prints).
65-78	Unused.
79-80	Not used on input, reserved for use by program.

Y-Axis (ordinate) Plot Card (one/plot)

Same options as the X-axis plot card except Card Column 4 would contain the letter <Y> instead of <X>.

```
E 2 1.5                 S U R V E Y   V S .   S U R V E Y   P L O T   P R O G R A M                PAGE   1
01/07/81                -----------------------------------------------------------
20:49:50                          INTERIM WELL LOG ANALYSIS SYSTEM                          INPUT TAPE = 7665

 *E215
 002TITLE8MF - 20  (5/16/79)                                    025BLACKL
 002TITLE9CALIPER VS. FLOWMETER
 002DEPTHA  3   BLACK  2C.C1200.0    20
 002X085000044051679010O     2        7    13     2   BLACK
 002Y08500004405167902OC    10                        BLACK 10100
```

FIGURE 29 - Selection options - Program E215

E 2 1 5
01/07/81
20:49:50

SURVEY VS. SURVEY PLOT PROGRAM

INTERIM WELL LOG ANALYSIS SYSTEM

PLOT NO. 2

INPUT TAPE = 7665

TITLE LINE 8 = /MF - 20 (5/16/79) /, LETTER SIZE = 0.25 IN., COLOR = BLACK, LEFT-JUSTIFIED
TITLE LINE 9 = /CALIPER VS. FLOWMETER /

SYMBOL NO. = 3 (ANNOTATED POINTS)
LETTER SIZE = 0.10 INCHES
COLOR = BLACK

DEPTH AXIS RANGE: BEGINNING DEPTH = 20.0 FEET
ENDING DEPTH = 1200.0 FEET
TIC-MARK INTERVAL = 20 FEET

	SURVEY IDENTIFICATION					AXIS SCALE	SCALE RANGE (UNITS SHOWN UNDERNEATH)			PLOT CONTROLS			
AXIS	STATION I. D.	SURVEY DATE	SURVEY TYPE	(CODE)	RUN NO.	(UNITS /INCH)	BEGIN	END	TIC-MARK	LETTER SIZE	PEN COLOR	HDG. LOC.	HDG. LINES
X (ABSCISSA)	085000044	05/16/79	CALIPER	(01)	00	2	7	13	2	0.10	BLACK	CENTER	S U
							(HOLE DIAMETER (INCHES))						
Y (ORDINATE)	085000044	05/16/79	FLOWMETER	(02)	00	10	0000.0	0030.0	0005.0	0.10	BLACK	CENTER	W S
							(COUNTS/SECOND)						

FIGURE 30 - Sorted list of plot options - Program E215

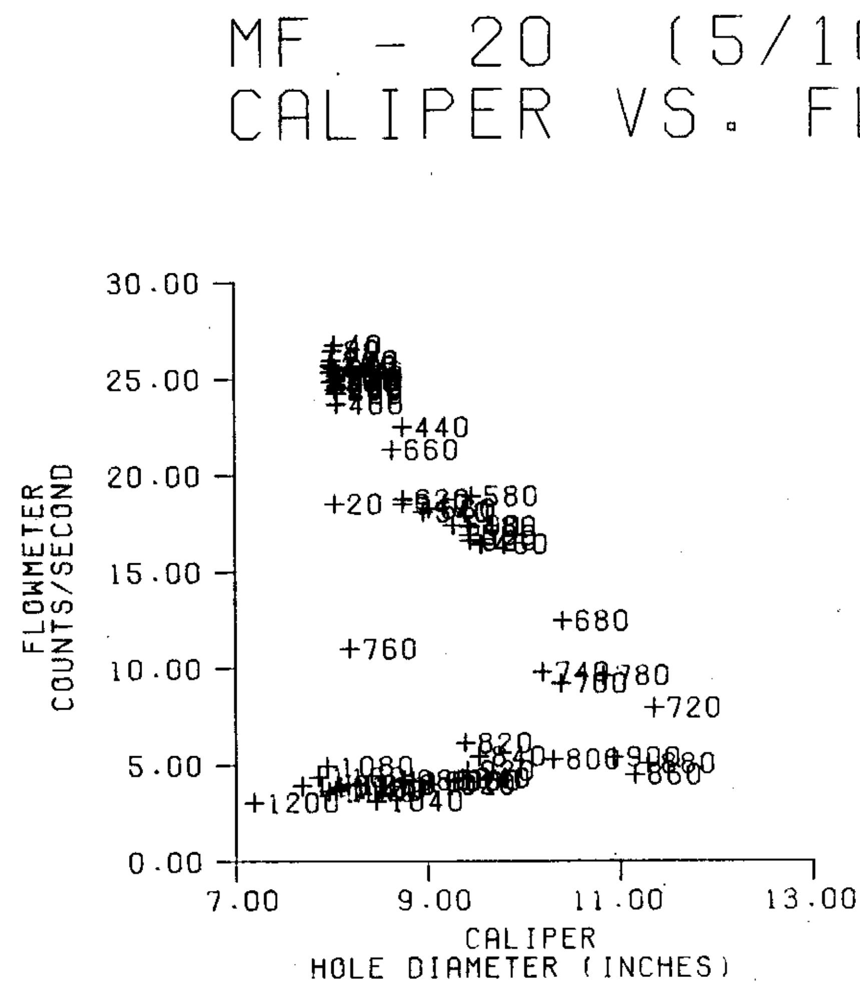

FIGURE 31 - Output plot - Program E215

INTERPRETATIVE TECHNIQUES AND CASE HISTORIES - SOUTH FLORIDA HYDROGEOLOGY

The stratigraphy and hydrogeology of south Florida offer many good opportunities for application of geophysical borehole logging techniques to groundwater investigations. The absence of surface exposures of most of the rock units, the complex stratification, the presence of usable groundwater supplies in deep strata, vertical and lateral variations in groundwater quality and temperature, and the development of secondary permeability through fractures and solution openings are some of the features which make these techniques especially applicable.

Basically the subsurface units encountered in boreholes in this area consist of sands, clays, shell beds, sandstone, marls, limestones, and dolomite. The near-surface rocks comprise the "Shallow aquifer" system, consisting of interbedded sands, clays, shell beds, sandstones, marls, and silt, and are characterized by complex facies changes. Saline water occurs in some parts of this system. This system is separated from the deeper "Floridan aquifer" by a thick (up to 500 ft.) layer of phosphatic marl interbedded with clay, shell, marl, silt, and sand. The Floridan aquifer consists of porous and cavernous limestones and dolomites characterized by development of vertically isolated high permeability zones. Waters of varying salinities and temperatures occur in this aquifer system (Parker, et. al., 1955).

The following case histories illustrate the use of single or multiple survey data in the investigation of some properties of these aquifers.

Case History No. 1 - Borehole Geophysical Survey Signatures of Different Lithologies Comprising the Upper Floridan Aquifer System in the Upper East Coast Planning Area

The Floridan aquifer, first defined by Parker, includes, "parts or all of the Middle Eocene (Ocala Limestone), Oligocene (Suwannee Limestone), and Miocene (Tampa Limestone) and permeable parts of the Hawthorn formation that are in hydrologic contact with the rest of the aquifer" (Parker, et al., 1955). In the Upper East Coast Planning Area (UECPA) the Floridan aquifer system consists of a number of producing zones of different hydrologic properties separated by semi-permeable zones in a sequence of lower Oligocene (unknown, possible Suwannee Limestone), and Upper and Middle Eocene (Ocala Limestone and Upper Avon Park formation) carbonate sediments (Brown and Reece, 1979).

Borehole geophysical surveys including Borehole Fluid Resistivity, Temperature, corrected Flow Meter, Natural Gamma Ray, Neutron Porosity, and electric logs were used in a regional investigation of this area. Logs were obtained in 23 wells.

The objective of this study was to identify the top and base of the Floridan aquifer system and to locate zones of high permeability (producing zones) within the system. The methodology used was to identify and correlate geophysical signatures which correspond to specific marker beds of known geology, based on detailed lithologic and paleontologic study of the well cuttings and to correlate these "type logs" with logs from wells at other locations within the area.

Figure 32 shows the lithology and a suite of logs from the selected "type well" in the UECPA. Based on lithology, the top of the Floridan aquifer is placed at the top of a tan to white sandy fossiliferous limestone

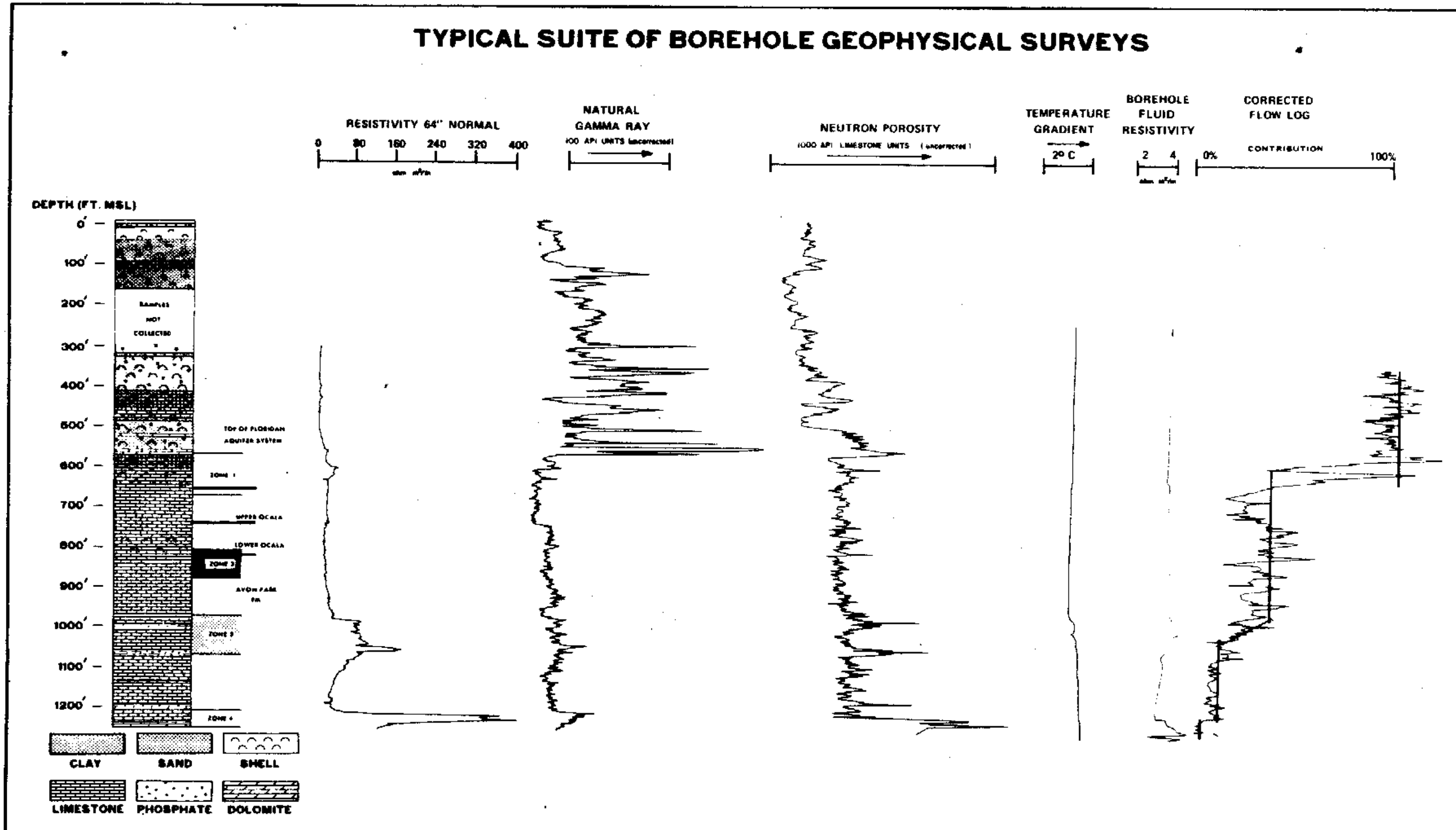

FIGURE 32 - Typical suite of borehole geophysical surveys, geologic section, and computed corrected flow log for a well in the Upper East Coast Planning Area

containing silt size phosphorite. Geophysical signatures at this depth are:

(1) A change from high to low gamma radiation with considerable damping of fluctuations on the log. High gamma radiation is typical of the Hawthorn formation which is clayey and contains phosphorite.

(2) A marked increase in electrical resistivity, due to the change from less resistive clayey beds to a limestone.

(3) An increase in the neutron log correlatable with transition from the highly porous clay to the limestone.

In addition the corrected flow log indicates a marked contribution to the artesian flow of the well just below this interface, indicating a producing zone. This zone is designated Producing Zone 1.

Producing Zone 2 is marked by a decrease in the gamma ray intensity and a small flow contribution indicated on the flow log. The top of this zone is correlated with the interface between a white, very clean, microfossiliferous limestone above, and a less pure, chalky limestone with few fossils below. Producing Zone 2 grades into a light gray to tan, hard, well cemented, subcrystalline limestone or dolostone. A decrease in neutron counts is observed at this transition.

Producing Zones 2 and 3 were identified in relatively thick, discrete beds of gray to blue crystalline dolomite within massive limestone beds. Within this bed, a significant increase both in resistivity and natural gamma radiation is observed on the logs, along with a marked decrease in neutron log response.

Based on these identifications a table was prepared, linking formation name, series, faunal assemblages, and geophysical signatures with the hydrogeologic units (Figure 33). The chart was then used, along with

GENERAL HYDROGEOLOGY — UPPER EAST COAST PLANNING AREA

APPROXIMATE THICKNESS	*SERIES	*FORMATION	GENERAL LITHOLOGY	GEOPHYSICAL SURVEY CHARACTERIZATION	AQUIFER	CHARACTERISTIC FAUNAL ASSEMBLAGES
50' – 250'	Plio-Pleistocene	Undifferentiated Pamlico Terrace Anastasia Fm.	Unconsolidated quartz sand; calcareous sandstone, shell beds.	Low natural gamma radiation higher in phosphatic shell beds; high neutron porosity, high resistivity (freshwater).	Shallow Aquifer System	————
200' – 800'	Upper Miocene	Tamiami Formation	Gray sandy clay, calcareous, phosphatic.	High natural gamma radiation, "hot spots" due to high accumulations of pebble phosphate; high neutron porosity becoming lower at bottom of section; low apparent resistivity. High natural gamma kick at base of Miocene sediments.	Confining Zone Possible low yielding secondary artesian aquifers(s)	————
	Middle Miocene	Hawthorn Formation	Gray to olive green plastic clay, phosphatic, sandy, shelly.			
10' – ≃50'	Oligocene?	Undifferentiated	White limestone, calcilutite, silt size phosphate particles.	High natural gamma radiation (lower than above), increasing resistivity.	Top of Floridan Aquifer System Producing Zone 1	Halimeda sp. Bryozoan sp.
50' – 125'	Upper Eocene	Ocala Limestone UPPER	White limestone, biocalcilutite, fossiliferous (foram. coquina).	Extremely low natural gamma radiation; low neutron porosity; apparent resistivity lower than the Oligocene, higher than the Miocene.	Semi-Permeable Zone	Lepidocyclina sp. (large foram.)
		Ocala Limestone LOWER	White limestone (grapestone) biocalcarenite	Natural gamma radiation increases in lower Ocala.	Producing Zone 2	Heterostegina sp. Camerina sp. (small foram.) Operculinoides sp.
Total thickness not penetrated	Upper Middle Eocene	Avon Park Formation	Tan, light gray, brown limestone, dolomitic sub-crystalline to sucrosic texture; interbedded dolomites, crystalline, gray to brown.	Low natural gamma radiation, higher in dolomite beds; low neutron porosity, extremely low in dolomite; increase in apparent resistivity extremely high in dolomite.	Semi-Permeable Zone Producing Zone (s) 3 & 4 in massive dolomite beds	Dictyoconus Cookei Coskinolina sp. Fibularia sp.

*Classification and nomenclature of the geologic units conform to the usage of the Florida Bureau of Geology.

FIGURE 33 - General Hydrogeology - Upper East Coast Planning Area

geophysical and geologic logs from other wells to produce a regional picture of the hydrogeologic units.

Case History No. 2 - Borehole Geophysical Methods In Defining Major Water Producing Zones and Accompanying Water Quality Within the Floridan Aquifer System, Upper East Coast Planning Area

This case history is an extension of the studies detailed in Case History No. 1. The objective of this study is to further define the hydrogeologic properties of the Producing Zones as follows:

(1) Further delineate the Producing Zones, using continuous borehole temperature data, based on observed differential temperatures as great as 0.44^{o}C across these zones, as well as Fluid Resistivity logs.

(2) Calculate quantities of water entering the borehole from each of the Producing Zones, using Continuous Borehole Flowmeter Surveys made while the well was discharging under artesian pressure, along with Caliper logs.

(3) Calculate chemical parameters of the water from each producing zone using Borehole Fluid Resistivity and Temperature surveys.

Figure 34 shows Temperature and Fluid Resistivity Logs of the interval previously identified as containing producing zones in Case History 1. The tops and bottoms of the Producing Zones are correlated with gradient changes in the logs. These changes are caused by inflow of waters of different temperatures and chemical composition. A mass balance technique requiring borehole flow and borehole water quality above and below a producing zone was used to estimate total dissolved solids content (TDS) of the water in each producing zone. Water quality observed at the wellhead

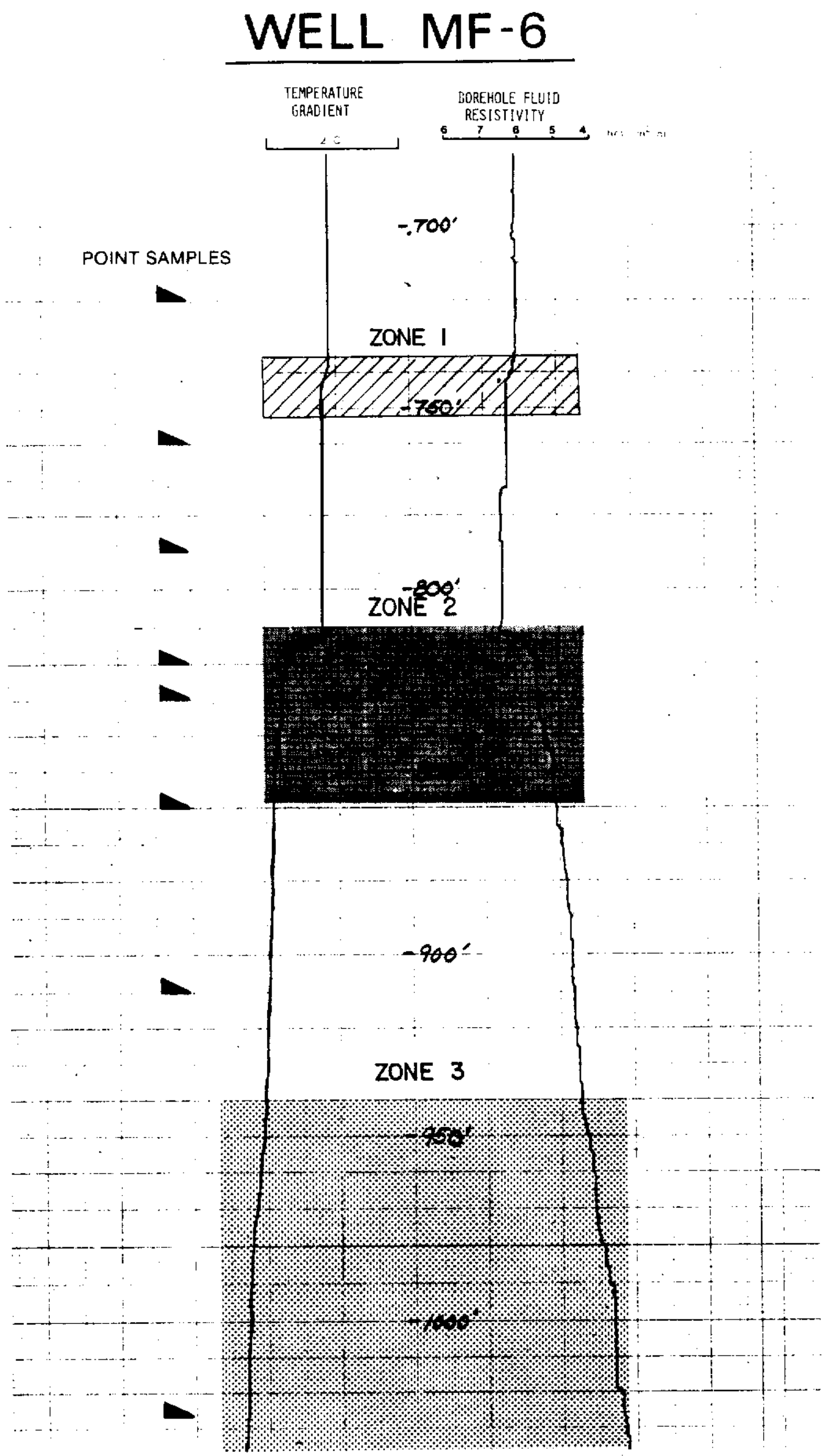

FIGURE 34 - Borehole Fluid Resistivity and Temperature surveys used to locate water producing zones for point sampling

of a Floridan well in the Upper East Coast Planning Area is a composite of the formational water quality of the various producing zones penetrated by the open portion of the borehole. Relative borehole flow at any point in the well was calculated from the Flowmeter log and the Caliper log in the following manner:

$$Q = A \cdot v \quad \ldots\ldots (15)$$

Where,

Q = flow (in relative units of cps-in^2) in the borehole.

A = area (in^2) of the borehole assuming a circular borehole.

v = velocity (cps) of the borehole fluid.

Corrected Flowmeter logs were computed at constant depth intervals of two feet. A typical Caliper log, Flowmeter log and computed corrected Flowmeter log are shown in Figure 35. A best fit line is drawn through constant flow portions of the Flowmeter log. Where a producing zone contributes water, flow increases, reflecting the cumulative flow of all producing zones below the point of measurement. The relative flow contribution of each producing zone is the ratio of the difference in flow across the producing zone to the total flow of the well.

Fluid Resistivity logs were used to estimate borehole water quality for most wells. Fluid Resistivity is related to specific conductance by the following equation:

$$C = \frac{10,000}{R} \quad \ldots\ldots (16)$$

Where,

C = specific conductance in micromhos/cm

R = fluid resistivity in ohm-meters

Fluid Resistivity data used in this study were compensated for fluid temperature and corrected to a constant temperature of 25°C. Wellhead

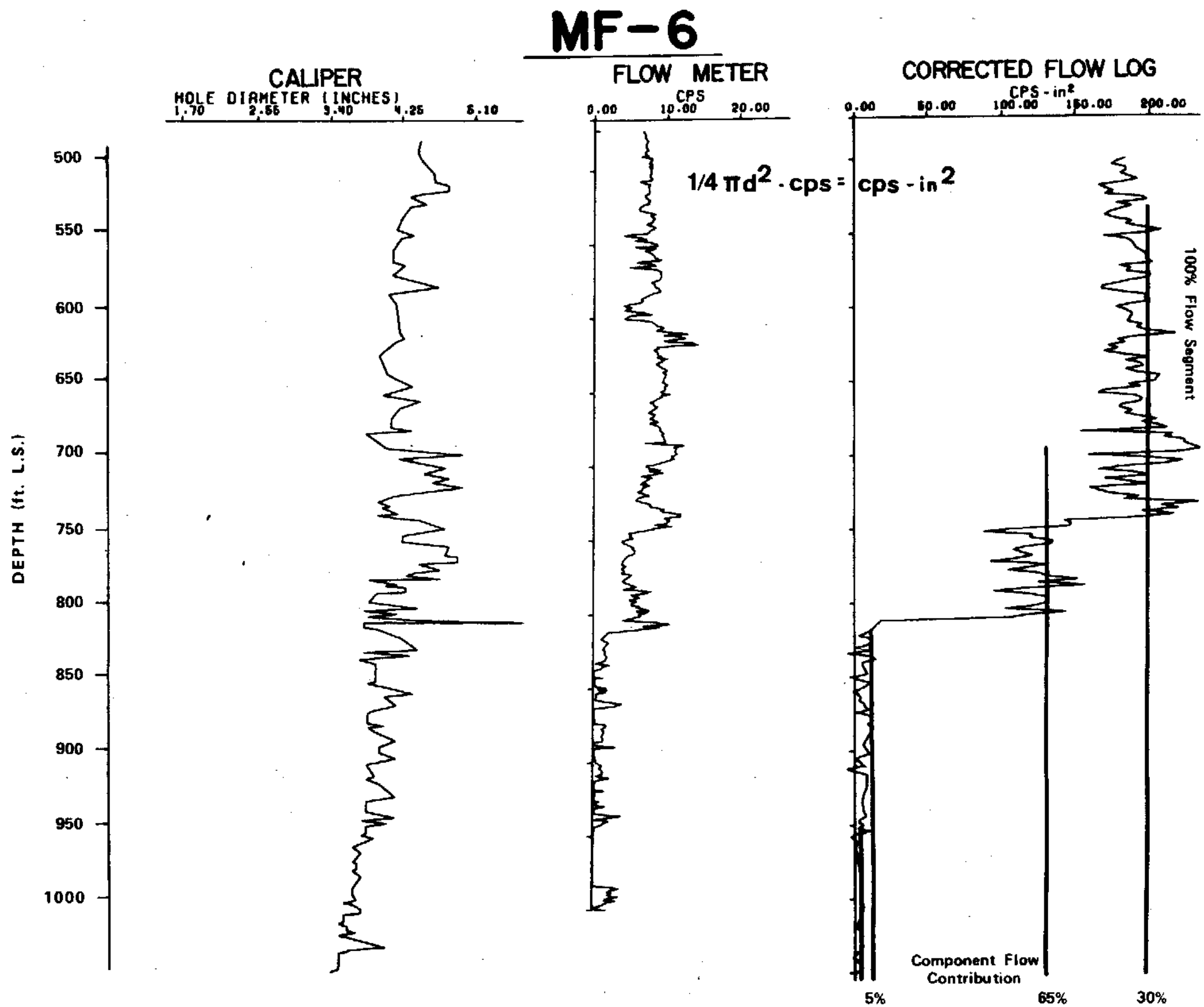

FIGURE 35 - Caliper log, Flowmeter log and computed corrected Flowmeter log

water sample analyses from all monitoring wells were used to calculate the following regression equation for TDS and specific conductance:

$$TDS = .631 \times C + 57.5 \quad \text{.....(17)}$$

Where,

TDS = total dissolved solids in mg/l

C = conductivity in micromhos/cm

A linear correlation coefficient of 0.92 was found for TDS and specific conductance.

The following mass balance equation was used to estimate TDS values for the water of each producing zone:

$$TDS_{zone} = \frac{Q_A TDS_A - Q_B TDS_B}{(Q_A - Q_B)} \quad \text{.....(18)}$$

Where,

Q_A, TDS_A = the borehole flow and borehole fluid TDS values, respectively, above the producing zone.

Q_B, TDS_B = the borehole flow and borehole fluid TDS value, respectively, below the producing zone.

Generally, only one significant flow contribution was found within a single producing zone of a well. All flow contributions within a single producing zone were integrated to give a single TDS value for that producing zone. More than one flow contribution was detected within a single producing zone in only a few cases.

Five wells in the UECPA were sampled at different depths to determine the reliability of the above technique. Depths at which samples were collected by the downhole point sampler were determined from the Borehole Fluid Resistivity and Temperature surveys. Samples were collected above and below each producing zone away from any possible mixing (Figure 34).

The chemical characteristics of the water entering the borehole at each water producing zone were determined using the above mass balance technique.

Figures 36 and 37 show a hydrogeologic section reflecting both calculated water quality and chemical analysis results of the samples collected and the geographic location of the cross-section.

Case History No. 3 - Neutron Log Responses in Boreholes with Varying Hole Diameter

Neutron surveys in irregular boreholes require special interpretative techniques. In large liquid-filled boreholes, many neutrons are captured near the source, resulting in generally low count rates. Variations in the log due to hole enlargement may therefore be erroneously interpreted as high formation porosities. Also, Neutron surveys lose their resolution in boreholes with diameters greater than about 10 inches and should not be used quantitatively.

Figure 38 shows Neutron and Caliper surveys for a well with varying hole diameter. The correlation between hole diameter, at the washout zones as shown on the Caliper log, and the apparent porosity as shown on the Neutron log may be controlled by three factors: (1) the hole size which results in greater volumes of water adjacent to the probe, (2) a possible higher formation porosity in this zone, (3) a combination of 1 and 2 above. Lithologic and stratigraphic studies indicated that washout zone 1 is within the Ocala Group, which is a white, foraminifera-coquina biocalcilutite, having a very high vuggy porosity. Washout zones 2 and 3 are in the Avon Park formation, which is a light tan to light gray limestone with sucrosic texture, interbedded with dolomites. The dolomites, which behave competently, do not wash out like the limestone, and also have lower bulk porosity.

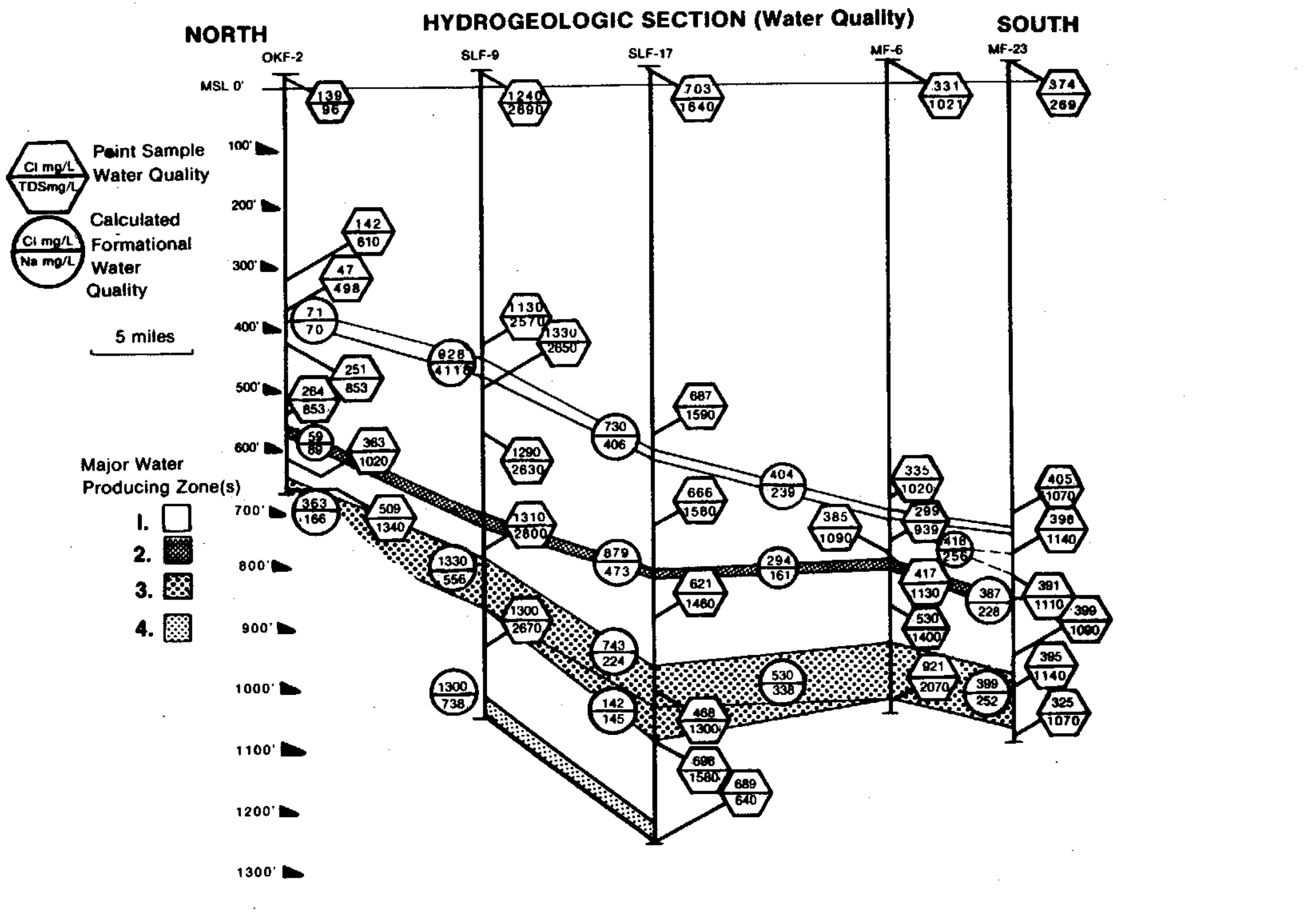

FIGURE 36 - Hydrogeologic cross section reflecting calculated water quality and chemical analyses

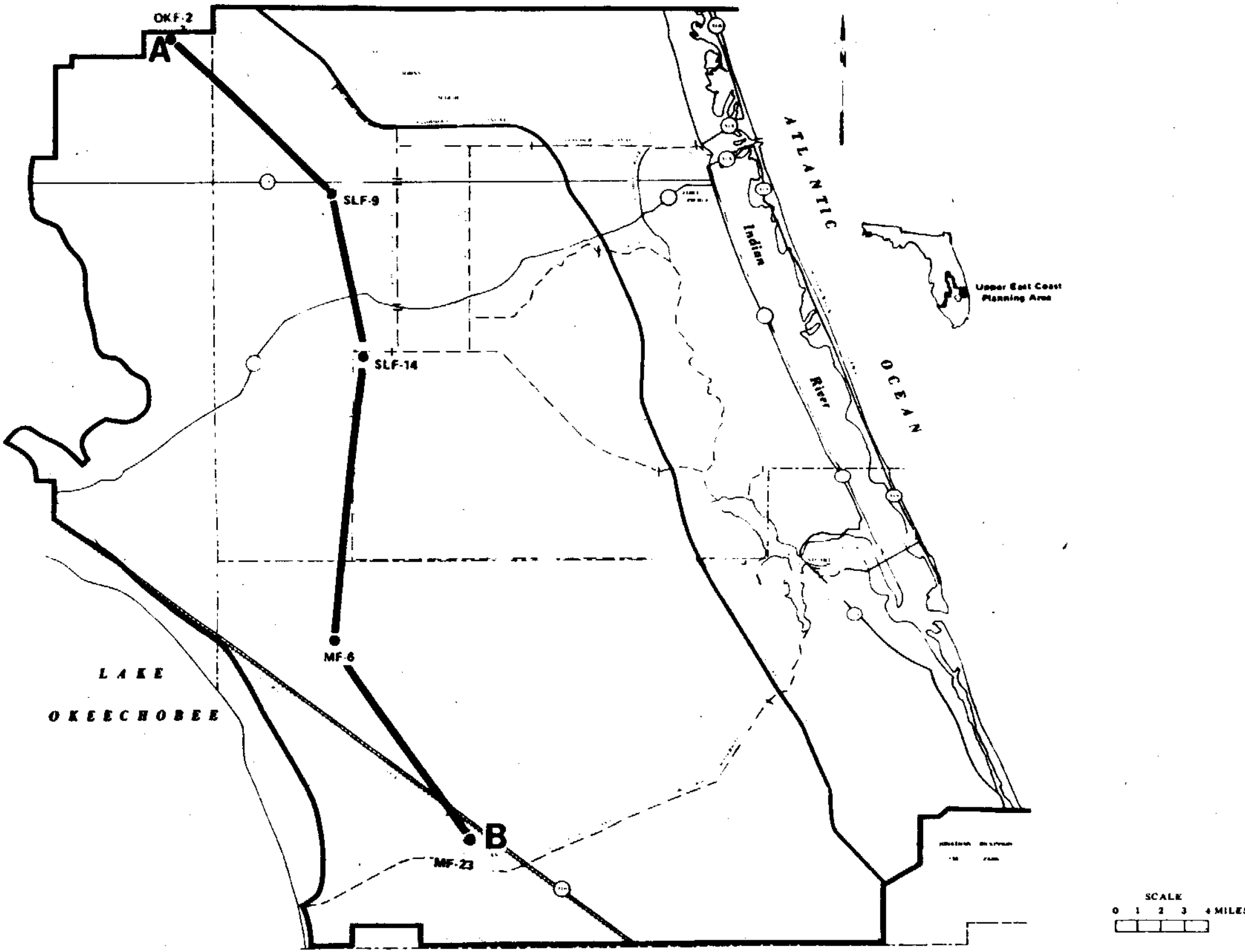

FIGURE 37 - Geographic location of hydrogeologic cross section

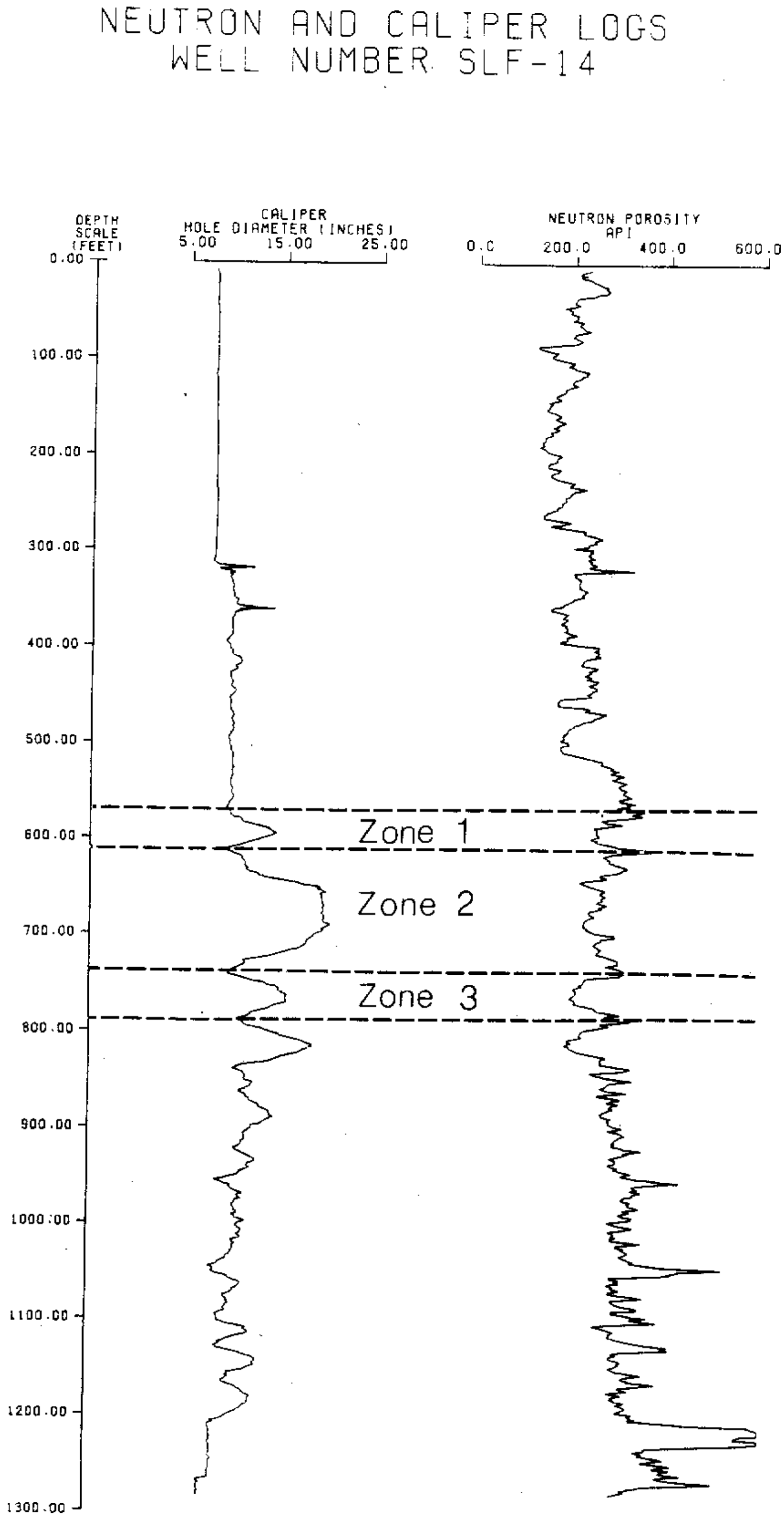

FIGURE 38 - Neutron and Caliper logs for a well with varying hole diameter

Although the variations on the Neutron logs seem to be affected by hole diameter, it is this author's interpretation that it is the bulk porosity of the rock that is the major controlling factor in the variations on the Neutron log, in spite of the significant hole size variations in the uncased portion of the hole.

As seen on the Caliper log, hole diameter below the casing is never less than 7 inches, with washout zones having diameters greater than 17 inches. Quantitative log interpretation in this hole would probably not yield useful information although corrections for large hole size changes may be helpful in general qualitative lithologic and stratigraphic interpretations.

Case History No. 4 - Use of Fluid Resistivity and Temperature Logs to Detect Groundwater Circulation in Non-Flowing Wells

A technique for investigating interborehole circulation, flow, and location of producing zones involves the use of logs run under "static" and "dynamic" conditions. In practice, the first log is made with the borehole "static" or not discharging and in equilibrium with the surrounding formations. The well is then allowed to discharge and a second set of logs run.

Figure 39 shows two sets of logs run under these conditions. The obvious differences between these logs may be interpreted in terms of the induced flow of groundwater into and up the borehole.

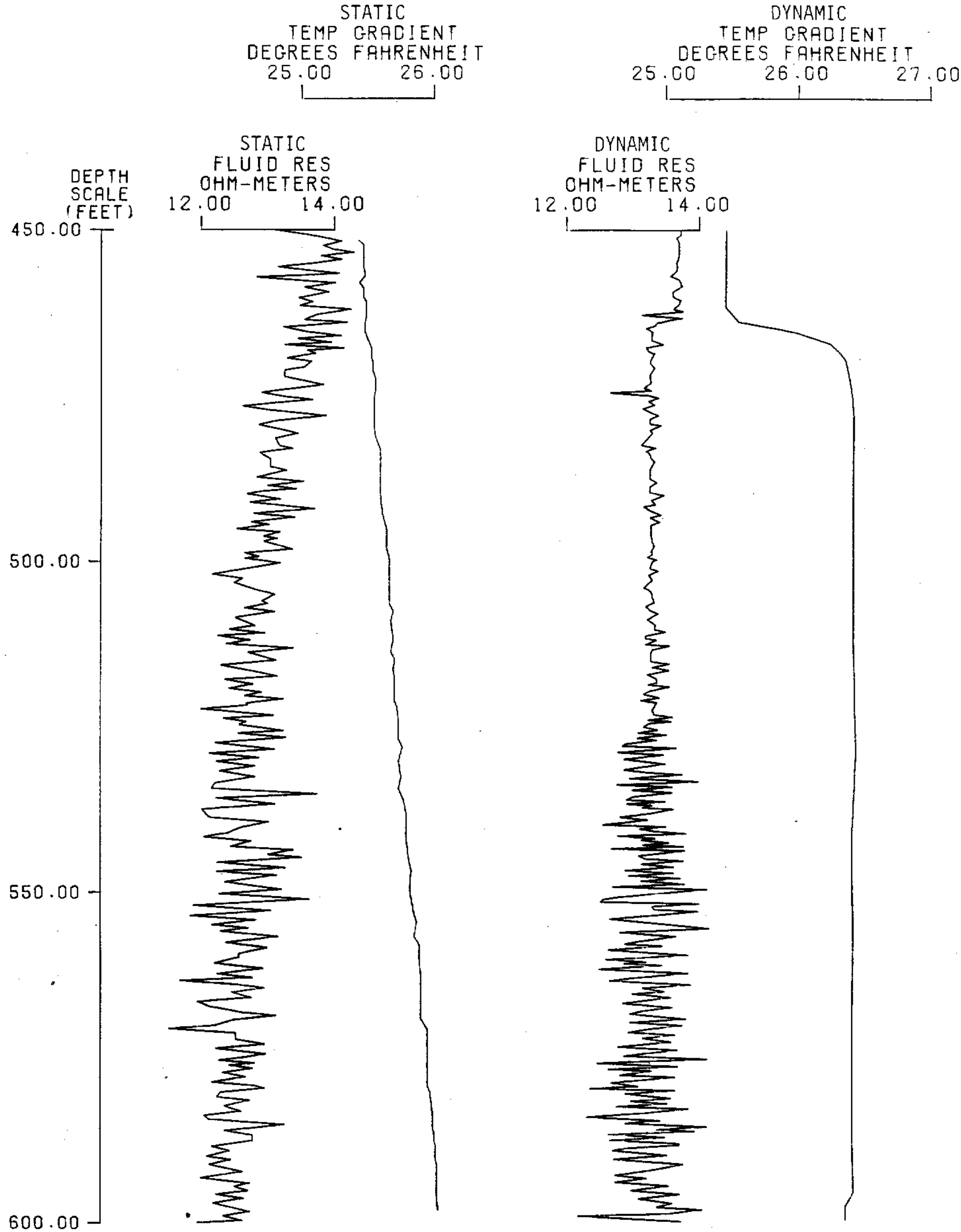

FIGURE 39 - Fluid Resistivity and Temperature Surveys made under "static" and "dynamic" borehole conditions

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APPENDIX I

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APPENDIX II

INTERIM WELL LOG ANALYSIS SYSTEM

Data Processing Documentation

Prepared for

Groundwater Division
Department of Resource Planning
South Florida Water Management District

Prepared by

Data Processing Division
Department of Technical Services
South Florida Water Management District

June 15, 1979
Revised: February 13, 1981

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INTERIM WELL LOG ANALYSIS SYSTEM

GENERAL

The Interim Well Log Analysis System (IWLAS) provides a semi-integrated methodology for examining the borehole geophysical logs. Data for individual surveys (e.g., fluid resistivity, lateral resistivity) are extracted from the analog borehole logs and stored on magnetic tape as a series of digital, breakpoint values. The resulting magnetic tapes are merged to maintain a single Master Tape as survey data is accumulated. Data for one or more surveys may be converted from breakpoint values to common depth (CDP) values. The CDP-value surveys may be further processed to synthesize new or adjusted surveys for analyses.

Survey data may be plotted and/or displayed in tabular form regardless of its nature, breakpoint or CDP, or its origin, raw or synthesized. The plots may be sequential (i.e., on separate depth axes) or may share a common depth axis. When data for two surveys are available at common depth (CDP) values, a cross-plot showing the values for each depth point may be produced to study survey relationships.

MAGNETIC TAPE FORMAT

All input and output magnetic tapes within the IWLAS are identical in format. They are labeled and written at 800 BPI density in BCD mode. Each logical record is twenty (20) words long (80 BCD characters). Sixteen (16) logical records are contained in a physical record or block. The record format is shown below:

BCD Characters	Field Description	
1-3	USGS County Code	Station I.D.
4-9	Well I.D. No.	Station I.D.
10-11	Survey date - month	
12-13	Survey date - day	
14-15	Survey date - year	
16-17	Survey type, where 01 = Caliper 02 = Flowmeter 03 = 16-inch normal resistivity 04 = 64-inch normal resistivity 05 = Neutron porosity 06 = Natural gamma 07 = Fluid resistivity 08 = Gamma gamma density 09 = Casing collar locator 10 = Fluid sampler 11 = Temperature gradient 12 = Delta temperature 13 = Spontaneous potential 14 = Point resistance 15 = 6-foot lateral resistivity 16 = Sonic travel time 17 = Acoustic amplitude	
18-19	Run No.	
20	unused (blank)	
21-30	X-value (depth)	
31-40	Y-value (amplitude)	
41-80	unused (blank)	

DATA CAPTURE AND STORAGE

Digital, breakpoint data for each of the surveys on a borehole log may be captured in any of three ways:

1. Manually, by reading the X, Y breakpoint coordinates from the borehole log, entering them on a keypunch form in the same format as the magnetic tapes, and processing the keypunched cards as input to Program E209 (ex-CRDTOTAP).

2. Semi-manually, by reading the survey breakpoints with a digitizer, producing a paper tape record for each breakpoint, and processing the resulting paper tape(s) as input to Program E200.

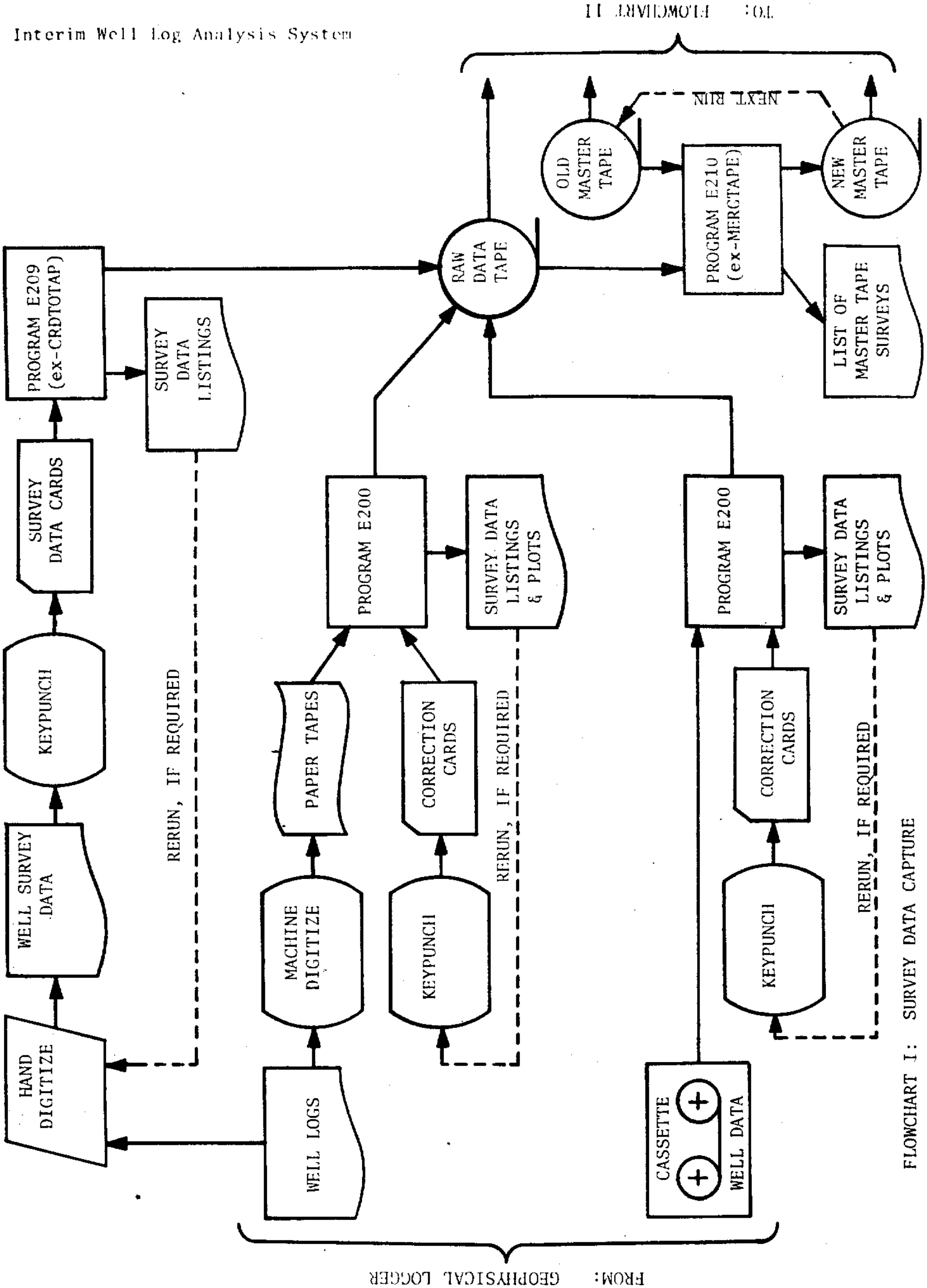
3. Automatically, by producing a cassette tape record showing digital values of survey data at specific depths and by processing the resulting cassette as input to Program E200.

Both programs, E200 and E209, will produce a Raw Data Tape in the standard IWLAS format. Depending upon the amount of input data available at run time, one or more surveys will be stored on the magnetic tape.

Program E210 (ex-MERGTAPE) is used to combine a new Raw Data Tape with the previous (or Old) Master Tape to create a current (or New) Master Tape. Program E210 will sort the data records into ascending order by County Code, Well No., Year, Month, Day, Survey Type and Depth.

The current Master Tape produced by Program E210 will normally be used as input when beginning any analyses, since it will contain all available breakpoint survey data.

A pictorial representation of the preceding data capture and storage process is shown as Flowchart I.



FLOWCHART I: SURVEY DATA CAPTURE

DATA ANALYSIS

A full data analysis, shown in Flowchart II, will normally include:

1. Conversion of survey data from breakpoint values to CDP-values;

2. Synthesis of a new set of survey CDP-values based upon some fixed equation; and

3. Plotting of the synthesized survey.

These steps of a full data analysis are performed using, consecutively, Programs E211 (ex-NUINTRVL), E212 (ex-NUSURVEY) and E213 (ex-LOGPLOT). The programs are automatically linked to one another in the previously described sequence, so that only one job need be submitted on a Requisition for Computer Work (Form DP-1). The subsequent jobs will be executed provided the prior program completed successfully and option cards are present for the next program. The intermediate magnetic tapes produced as output from one program to be input to the next program are all in the IWLAS format and may be designated, at the user's discretion, as scratch tapes or as output tapes to be saved.

Saving the output tape created by Program E211 would enable the user, at a later date, to perform additional syntheses of new sets of CDP-values and subsequently plot them. This would be accomplished by executing Program E212 (ex-NUSURVEY) which in turn would link to execute Program E213 (ex-LOGPLOT).

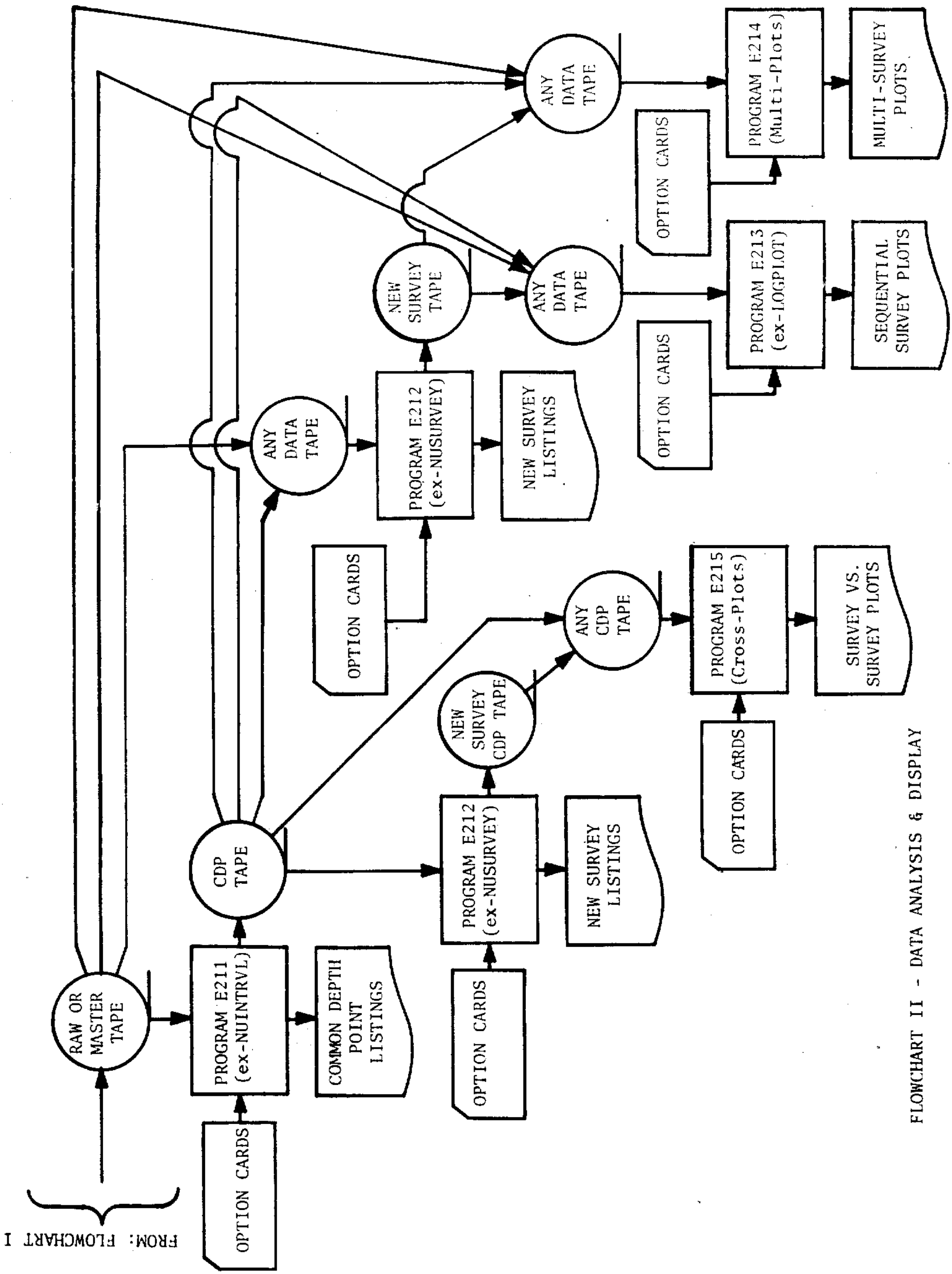
Program E213 (ex-LOGPLOT) may be individually executed with any magnetic tape in the standard IWLAS format. Thus, plots may be obtained of:

1. Raw, breakpoint survey data (using output tapes produced by Programs E200, E209 and/or E210);

2. Common depth point (CDP) survey data (using output tapes produced by Program E211); or

3. Synthesized survey data (using output tapes produced by Program E212).

More formal presentations of data analyses, suitable for inclusion in reports, may be created through the use of Program E214 (not shown in Flowchart II). Program E214 may be run using any IWLAS-format magnetic tape, as discussed above for Program E213. Program E214 plots one or more surveys using a single depth axis. It may be used to plot all or selected surveys for one well in one plot for viewing together. It may also be used to plot similar surveys for differing wells on the same plot. The user can control the vertical and horizontal placement of the surveys to indicate differences in datums between wells (vertical displacements) or to show relative locations on a cross-sectional view of some geographical area (horizontal displacements). Program E214 may also be used in place of Program E213, though somewhat more complicated input options are required.



FLOWCHART II - DATA ANALYSIS & DISPLAY

DATA ANALYSIS (continued)

Another type of data analysis is the plotting of values of one survey against those of another survey for corresponding depth points. This is accomplished by the use of Program E215. The input tape used by E215 must have been processed by Program E211 at some point prior to the use of E215 to insure that common depth points exist for both surveys.

SAMPLE SINGLE JOB SET-UPS

E200 - Capturing Machine-Digitized Data

This program is a part of the final Well Log Analysis System and is documented as a separate production program. Copies of the documentation may be found in the Data Processing Production Library.

PROGRAM E208 - Well Log Data Retrieval and Correction Program

This program permits the selective listing and/or copying of any IWLAS-format tape data records. Corrections may also be made in individual records or record-fields at the time of the run.

The program has four main categories of options available for user control:

a) a LIST option (specifying which types of records are to be listed: Selected, Rejected, Modified or All records);

b) a COPY option (specifying which types of records are to be copied to a new IWLAS-format tape: Selected, Rejected, Modified or All records);

c) a DISPLAY option (permitting the display, on the listing, of complete data for each record of listed surveys; the normal, default DISPLAY option only shows the 20-character survey ID, while the complete data also includes all depth and corresponding survey values); and

d) a comprehensive SELECT option which permits selection or rejection of records by specific values or ranges of values for any of the individual fields within a record (Station ID, Survey Date, Survey Type, Run No., Depth Value or Survey Value); this option also includes provisions for modifying any or all of these fields prior to listing or copying the record selected.

The first three options above are each controlled by a separate input card and the SELECT option is controlled by a set or group of input cards. The input card options are shown on the following page. The Requisition for Computer Work (form DP-1) for Program E208 would be completed as shown below and submitted with the option cards and label:

REQUISITION FOR COMPUTER WORK

SUBMITTED BY: Fran Fixitt	TEL. NO.: 227	LOCATION: 201	I. D. ACCOUNT CODE: 8216-306	PRIORITY EST. TIME (MIN.): 30
CATEGORY: [ ] SYSTEM or R/T	[ ] PROGRAM DEVELOPMENT [X] PRODUCTION RUN		JOB RUN NO.: E208	SEQ. NO.
INPUT TAPES (RING OUT): 01 = 2409		OUTPUT TAPES (RING IN): 02 = (if COPY used)		TIME IN
SCRATCH TAPES (RING IN)		DISKS: 3001,3006,3997,6501		TIME OUT
[X] PRINT	[ ] PUNCH	[ ] PLOT	[ ] PAPER TAPE	

REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)

Output tape label attached
(if COPY used)

HR.	MIN.	SEC.

MACH.	INITIALS

FORM DP-1
Rev. 1-79
(Use BALL POINT PEN or PENCIL)

E208 OPTION CARDS

Control Cards (One required; both permitted)

*E208 ,LIST	,SELECTED (default) ,REJECTED ,MODIFIED ,ALL
*E208 ,COPY	,SELECTED (default) ,REJECTED ,MODIFIED ,ALL

Listing Format Card (Optional; if missing, listing defaults to SURVEY)

*E208 ,DISPLAY	,SURVEY (default) ,RECORD

Select Procedure Cards (Optional; default is all records)

*SELECT	(required)
*REJECT	(optional)
*MATCH	(optional, if *RANGE not used)
(match data card)	(required if *MATCH used)
*RANGE	(optional, if *MATCH not used)
(range data cards)	(required if *RANGE used)
*MODIFY	(optional)
(modify data card)	(required if *MODIFY used)
*ENDSEL	(required)

(See M.I.S. documentation for a fuller discussion of Select procedure usage.)

E209 - Capturing Manually-Digitized Data

The card format for manually-digitized data is shown in Figure 1. All survey data values, depth and amplitude, may be entered either right-justified without a decimal point or may be placed anywhere in their respective fields as long as a decimal point is present. The Requisition for Computer Work (Form DP-1) for Program E209 (ex-CRDTOTAP) would be completed as shown below and submitted with the keypunched cards and an appropriate magnetic tape label:

REQUISITION FOR COMPUTER WORK				PRIORITY
SUBMITTED BY GARY GROUNDWATER	TEL. NO. 360	LOCATION 221	I. D. ACCOUNT CODE 8216-306	EST. TIME (MIN.) 10
CATEGORY ☐ SYSTEM or R/T	☐ PROGRAM DEVELOPMENT ☒ PRODUCTION RUN		JOB RUN NO. E209	SEQ. NO.
INPUT TAPES (RING OUT)		OUTPUT TAPES (RING IN) 01=		TIME IN
SCRATCH TAPES (RING IN)		DISKS 6501, 3006		TIME OUT
☒ PRINT	☐ PUNCH	☐ PLOT	☐ PAPER TAPE	
				HR. / MIN. / SEC.
REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR) OUTPUT TAPE LABEL ATTACHED			FORM DP-1 Rev. 1-79 (Use BALL POINT PEN or PENCIL)	MACH. / INITIALS

Program E209 produces a listing of the survey data values copied to magnetic tape.

W E L L   S U R V E Y   D A T A

INTERIM WELL LOG ANALYSIS SYSTEM   PROGRAM [illegible]

1–4	4–10	10–12	12–14	14–16	16		21–31	31–40
CNTY CODE	WELL I.D. NO.	SVY MO.	SVY DAY	SVY YR.	*** SVY		DEPTH-VALUE (FEET) (USE DECIMAL)	SURVEY-VALUE (USE DECIMAL)

***SURVEY TYPES -

01 = CALIPER
02 = FLOWMETER
03 = 16-INCH NORMAL RESISTIVITY
04 = 64-INCH NORMAL RESISTIVITY
05 = NEUTRON POROSITY
06 = NATURAL GAMMA
07 = FLUID RESISTIVITY
08 = GAMMA GAMMA DENSITY
09 = CASING COLLAR LOCATOR
10 = FLUID SAMPLER
11 = TEMPERATURE GRADIENT
12 = DELTA TEMPERATURE
13 = SPONTANEOUS POTENTIAL
14 = POINT RESISTANCE
15 = 6-FOOT LATERAL RESISTIVITY
16 = SONIC TRAVEL TIME
17 = ACOUSTIC AMPLITUDE

06/15/79:ets

Figure 1

E210 - Merging Raw Data Tapes

The Raw (breakpoint) Data Tapes produced by Programs E200 and E209 may be merged with the Old Master Tape to create a New Master Tape. This is performed by Program E210 (ex-MERGTAPE) and the Requisition for Computer Work (Form DP-1) would be completed as shown below and submitted with an appropriate magnetic tape label:

REQUISITION FOR COMPUTER WORK

SUBMITTED BY: HARRY HYDROLOGIST	TEL. NO.: 350	LOCATION: 223	I. D. ACCOUNT CODE: 8216 - 306	PRIORITY
CATEGORY: ☐ SYSTEM or R/T	☐ PROGRAM DEVELOPMENT ☒ PRODUCTION RUN		JOB RUN NO.: E210	EST. TIME (MIN.): 15
INPUT TAPES (RING OUT): 01=1234, 02=5678		OUTPUT TAPES (RING IN): 03=		SEQ. NO.
SCRATCH TAPES (RING IN)		DISKS: 6501, 3006		TIME IN
☒ PRINT	☐ PUNCH	☐ PLOT	☐ PAPER TAPE	TIME OUT

REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)

OUTPUT TAPE LABEL ATTACHED

HR.	MIN.	SEC.

MACH.	INITIALS

FORM DP-1
Rev. 1-79
(Use BALL POINT PEN or PENCIL)

Program E210 produces a listing of the surveys for which data are available on the New (output) Master Tape.

Note: The Raw Data Tape is input on Logical Unit 01; the Old Master Tape is input on Logical Unit 02; and the New Master Tape is output on Logical Unit 03.

E211 - Creation of Common Depth (CDP) Data Values

Program E211 (ex-NUINTRVL) will create a new set of data values for a survey specified on an input card. The input card also specifies beginning and ending depth values and a depth interval. The current Master Tape is normally used as input, but any IWLAS-format magnetic tape may be used. The Requisition for Computer Work (Form DP-1) shown below is submitted along with the input cards and an appropriate magnetic tape label:

REQUISITION FOR COMPUTER WORK

SUBMITTED BY: WALLY WATERMAN	TEL. NO.: 370	LOCATION: 216	I. D. ACCOUNT CODE: 8216-306	PRIORITY / EST. TIME (MIN.): 15
CATEGORY: ☐ SYSTEM or R/T; ☐ PROGRAM DEVELOPMENT; ☒ PRODUCTION RUN			JOB RUN NO.: E211	SEQ. NO.
INPUT TAPES (RING OUT): 10 = 9876		OUTPUT TAPES (RING IN): 11 =		TIME IN
SCRATCH TAPES (RING IN)		DISKS: 6501		TIME OUT
☒ PRINT	☐ PUNCH	☐ PLOT	☐ PAPER TAPE	
REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR): OUTPUT TAPE LABEL ATTACHED				HR. / MIN. / SEC.
FORM DP-1 Rev. 1-79 (Use BALL POINT PEN or PENCIL)				MACH. / INITIALS

The format for the input cards for Program E211 is shown in Figure 2. The data values for beginning and ending depths and for intervals may be entered either right-justified without a decimal point or may be placed anywhere in their respective fields as long as a decimal point is present.

Program E211 (ex-NUINTRVL) produces a listing for each CDP survey showing the breakpoint data values and their associated depths on the left-hand side of the page and the intervening CDP depths and interpolated values on the right-hand side of the page.

E 2 1 1 (EX-NUINTRVL) OPTION CARDS

INTERIM WELL LOG ANALYSIS SYSTEM

1 ENTY CODE	4 WELL I.D. NO.	10 SVY MO.	12 SVY DAY	14 SVY YR.	16 *** SVY		41 BEGIN DEPTH (FEET) (USE DECIMAL)	51 END DEPTH (FEET) (USE DECIMAL)	61 INTERVAL (FEET) (USE DECIMAL) 70

***SURVEY TYPES -

01 = CALIPER
02 = FLOWMETER
03 = 16-INCH NORMAL RESISTIVITY
04 = 64-INCH NORMAL RESISTIVITY
05 = NEUTRON POROSITY
06 = NATURAL GAMMA
07 = FLUID RESISTIVITY
08 = GAMMA GAMMA DENSITY
09 = CASING COLLAR LOCATOR
10 = FLUID SAMPLER
11 = TEMPERATURE GRADIENT
12 = DELTA TEMPERATURE
13 = SPONTANEOUS POTENTIAL
14 = POINT RESISTANCE
15 = 6-FOOT LATERAL RESISTIVITY
16 = SONIC TRAVEL TIME
17 = ACOUSTIC AMPLITUDE

06/15/79:ets

Figure 2

E212 - Synthesis of New Survey Data Values

Program E212 (ex-NUSURVEY) will create a new set of survey data values from one, two, three or four common depth point (CDP) surveys based upon standard calculations stored within the program logic. Calculations with multiple CDP surveys must have data values at matching depths (e.g., 100 feet, 105 feet, 110 feet), thus permitting only IWLAS-format tapes created by Program E211 (ex-NUINTRVL) to be used as input magnetic tapes. Synthesized survey data values will not be created at a specific depth if one or more of the CDP surveys does not have data at that depth (i.e., beginning or ending depths that do not coincide among the surveys will not produce new survey data points).

The format for the input cards for Program E212 is shown in Figure 3. A valid calculation number must be entered in columns 79-80. A list of valid calculations is shown in Appendix A. An appropriate set of survey I.D.'s, county code through survey type, must be entered on the remainder of the card line. This set of survey I.D.'s must agree in number, type and order with the calculation requirements shown in Appendix A.

The Requisition for Computer Work (Form DP-1) shown below is submitted along with the keypunched cards and an appropriate magnetic tape label for the output tape:

REQUISITION FOR COMPUTER WORK

SUBMITTED BY	TEL. NO.	LOCATION	I. D. ACCOUNT CODE	PRIORITY
LARRY LOGGER	385	247	8216 - 306	EST. TIME (MIN.) 20
CATEGORY [ ] SYSTEM or R/T [X] PRODUCTION RUN [ ] PROGRAM DEVELOPMENT			JOB RUN NO. E212	SEQ. NO.
INPUT TAPES (RING OUT) 11 = 5432		OUTPUT TAPES (RING IN) 12 =		TIME IN
SCRATCH TAPES (RING IN)		DISKS 6501, 3006		TIME OUT
[X] PRINT	[ ] PUNCH	[ ] PLOT	[ ] PAPER TAPE	
REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR) OUTPUT TAPE LABEL ATTACHED			FORM DP-1 Rev. 1-79 (Use BALL POINT PEN or PENCIL)	HR / MIN. / SEC.; MACH. / INITIALS

A listing is produced by Program E212 showing each input survey value for a given depth and the resultant value calculated for the new, output survey. The output survey I.D., county code through survey type, is the same as that of the first, or "A" survey; this means that syntheses which will produce identical survey I.D.'s must be processed in separate runs.

E 2 1 2 (EX-NUSURVEY) OPTION CARDS

INTERIM WELL LOG ANALYSIS SYSTEM

1	4	10	12	14	16		21	24	30	32	34	36		41	44	50	52	54	55		61	54	70	72	74	76		79
-A-	-A-	-A	-A-	-A-	***		-B-	-B-	-B-	-B-	-B-	***		-C-	-C-	-C-	-C-	-C-	***		-D-	-D-	-D-	-D-	-D-	***		**
CNTY	WELL ID NO	MO	DAY	YR	SVY		CNTY	WELL ID NO	MO	DAY	YR	SVY		CNTY	WELL ID NO	MO	DAY	YR	SVY		CNTY	WELL ID NO	MO	DAY	YR	SVY		CLC

***SURVEY TYPES -

01 = CALIPER
02 = FLOWMETER
03 = 16-INCH NORMAL RESISTIVITY
04 = 64-INCH NORMAL RESISTIVITY
05 = NEUTRON POROSITY
06 = NATURAL GAMMA
07 = FLUID RESISTIVITY
08 = GAMMA GAMMA DENSITY
09 = CASING COLLAR LOCATOR
10 = FLUID SAMPLER
11 = TEMPERATURE GRADIENT
12 = DELTA TEMPERATURE
13 = SPONTANEOUS POTENTIAL
14 = POINT RESISTANCE
15 = 6-FOOT LATERAL RESISTIVITY
16 = SONIC TRAVEL TIME
17 = ACOUSTIC AMPLITUDE

**CALCULATION TYPES -

01 = CORRECTED FLOW LOG
02 = CORRECTED RESISTIVITY (FAHRENHEIT)
03 = CONDUCTIVITY
04 = CORRECTED RESISTIVITY (CENTIGRADE)

06/15/79:ets

Figure 3

E213 - Plotting of Survey Data Values

Any survey contained on an IWLAS-format magnetic tape may be plotted by use of Program E213 (ex-LOGPLOT). The format of the option cards for controlling the size and scale of the plot are shown in Figure 4. The survey I.D., county code through survey type, and both the X- and Y-scale ratios must be specified for each plot. The other data items, X and Y ranges, are optional. A sample Requisition for Computer Work (Form DP-1) is shown below:

REQUISITION FOR COMPUTER WORK				PRIORITY
SUBMITTED BY: POLLY PLOTTER	TEL. NO.: 492	LOCATION: 232	I. D. ACCOUNT CODE: 8216-306	EST. TIME (MIN.): 20
CATEGORY: ☐ SYSTEM or R/T	☐ PROGRAM DEVELOPMENT ☒ PRODUCTION RUN		JOB RUN NO.: E213	SEQ. NO.
INPUT TAPES (RING OUT): 12 = 2468		OUTPUT TAPES (RING IN)		TIME IN
SCRATCH TAPES (RING IN)		DISKS: 6501		TIME OUT
☒ PRINT	☐ PUNCH	☒ PLOT	☐ PAPER TAPE	
				HR. / MIN. / SEC.
REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)			FORM DP-1 Rev. 1-79 (Use BALL POINT PEN or PENCIL)	MACH. / INITIALS

Each survey may be plotted only once in a single run of E213; multiple runs would be required to plot the same survey at differing scales.

E 2 1 3 (EX-LOGPLOT) OPTION CARDS

INTERIM WELL LOG ANALYSIS SYSTEM

1 CNTY CODE	4 WELL I.D. NO	10 SVY MO	12 SVY DAY	14 SVY YR	16 *** SVY		21 X-SCALE RATIO (FEET / INCH) **	31 Y-SCALE RATIO (Y-UNITS / INCH) **	41 MINIMUM X-VALUE (DEPTH IN FEET) **	51 MAXIMUM X-VALUE (DEPTH IN FEET) **	61 MINIMUM Y-VALUE (IN Y-UNITS) **	71 MAXIMUM Y-VALUE (IN Y-UNITS) ** 80

**USE DECIMAL POINT OR RIGHT-JUSTIFY VALUE

***SURVEY TYPES -

01 = CALIPER
02 = FLOWMETER
03 = 16-INCH NORMAL RESISTIVITY
04 = 64-INCH NORMAL RESISTIVITY
05 = NEUTRON POROSITY
06 = NATURAL GAMMA
07 = FLUID RESISTIVITY
08 = GAMMA GAMMA DENSITY
09 = CASING COLLAR LOCATOR
10 = FLUID SAMPLER
11 = TEMPERATURE GRADIENT
12 = DELTA TEMPERATURE
13 = SPONTANEOUS POTENTIAL
14 = POINT RESISTANCE
15 = 6-FOOT LATERAL RESISTIVITY
16 = SONIC TRAVEL TIME
17 = ACOUSTIC AMPLITUDE

Figure 4

E214 - Plotting of one or More Surveys on a Single Depth Axis

Any single survey contained on an IWLAS-format magnetic tape may be plotted by use of Program E214. The resulting plot will be considerably more presentable than would be a similar plot produced by Program E213. Program E214 allows the user to control axes' sizing, labelling and coloring which are all relatively fixed within E213.

Multiple surveys may also be plotted showing a single depth axis using Program E214.

The formats of the option cards for Program E214 are shown in Figure 5. A sample Requisition for Computer Work (Form DP-1) is shown below:

REQUISITION FOR COMPUTER WORK

SUBMITTED BY MANNY PLOTZ	TEL. NO. 281	LOCATION 236	I. D. ACCOUNT CODE 8216-306	PRIORITY
CATEGORY ☐ SYSTEM or R/T	☐ PROGRAM DEVELOPMENT ☒ PRODUCTION RUN		JOB RUN NO. E214	EST. TIME (MIN.) 20
INPUT TAPES (RING OUT) 12 = 4793		OUTPUT TAPES (RING IN)		SEQ. NO.
SCRATCH TAPES (RING IN)		DISKS 3001, 3006, 6501		TIME IN
☒ PRINT	☐ PUNCH	☒ PLOT	☐ PAPER TAPE	TIME OUT
REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)				HR. / MIN. / SEC.
			FORM DP-1 Rev. 1-79 (Use BALL POINT PEN or PENCIL)	MACH. / INITIALS

Multiple plots, with multiple surveys on each plot may be made in a single run of Program E214. The same survey may also be used in more than one plot within a single run.

E 2 1 4 (MULTIPLE SURVEYS/PLOT) OPTION CARDS

INTERIM WELL LOG ANALYSIS SYSTEM

PROGRAM I.D. CARD (REQUIRED: 1/RUN)

I.D. (1)	FREE-FORM OPTIONS (SEE DESCRIPTIONS BELOW) (6)	NOT AVAILABLE FOR USE (–80)
*E214		

OPTIONS - [,AXES] = PLOTS DEPTH AXES FOR ALL SURVEYS
[,DUMP] = FOR PROGRAMMER USE ONLY (LOAD MAP AND DUMP)
[,LIST] = LISTS ALL DATA RECORDS USED IN PLOTTING

PLOT TITLE CARD (OPTIONAL: 0-9 CARDS/PLOT)

PLOT NO. (1)	I.D. (4)	LN (9)	TITLE (LEFT-SIDE OF CENTER)	TITLE (RIGHT-SIDE OF CENTER) (41)	LTR SIZE (72)	PEN COLOR (75)	TL (80)
	TITLE						
	TITLE						

LN = LINE NO. OF TITLE
TL = TITLE LOCATION (L=LEFT-JUSTIFIED, R=RIGHT-JUSTIFIED)
LTR SIZE = LETTER SIZE (IN INCHES)

DEPTH AXIS CARD (REQUIRED: 1/PLOT)

PLOT NO. (1)	I.D. (4)	DEPTH SCALE - FEET/INCH (9)	DEPTH RANGE - BEGINNING (16)	DEPTH RANGE - ENDING (22)	DEPTH RANGE - TIC-MARK (28)	LTR SIZE (34)	PEN COLOR (37)	NOT AVAILABLE FOR USE (–80)
	DEPTH							

LTR SIZE = LETTER SIZE (IN INCHES)

SURVEY PLOT CARD (REQUIRED. 1 OR MORE/PLOT)

PLOT NO. (1)	STATION I.D. NO. (4)	SVY NO. (13)	SVY DAY (15)	SVY YR. (17)	SVY TYP (19)	RUN NO. (21)	X-OFFSET - INCHES (23)	Y-OFFSET - INCHES (28)	Y-SCALE - UNITS/INCH (33)	UNITS CODE (39)	SCALE - BEGINNING (42)	SCALE - ENDING (47)	SCALE - TIC-MARK (52)	LTR SIZE (57)	PEN COLOR (60)	SYMBL CODE (65)	HL (68)	HDG LINES W D S R U	HDG/SCALE X-OFFSET (74)	NOT USE (80)

UNITS CODE = SEE IWLAS WRITE-UP (WILL DEFAULT TO SURVEY TYPE)
LTR SIZE = LETTER SIZE (IN INCHES)
SYMBL CODE = SYMBOL CODE (SEE APPENDIX 6 OF WMD MANUAL; IF NEGATIVE, NO LINE WILL CONNECT POINTS)
HL = HEADING LOCATION (L=LEFT-JUSTIFIED, R=RIGHT-JUSTIFIED)
HDG LINES = HEADING LINES (W=WELL NO., D=DATE, S=SURVEY, R=RUN, U=UNITS); ENTER <1> TO PRINT W/D/R, <0> TO OMIT S/U
HDG/SCALE X-OFFSET = VERTICAL OFFSET OF BOTTOM OF Y-AXIS (NEGATIVE IS UPWARD FROM BEGINNING DEPTH; POSITIVE IS DOWNWARD)

E215 - Plotting of One Survey Versus Another

Program E215 will plot points showing data values for any two surveys whose depth values are identical. The horizontal axis is the abscissa and will show the survey values for the independent variable, X, in the following equation:

$$Y=f(X)$$

The vertical axis is the ordinate and will show the corresponding values of the dependent variable, Y.

The data points are plotted in descending depth order and may optionally be annotated as to the sequence in which they are plotted. Program E215 allows the user to control the axes' sizing, labelling and coloring. The representation of data points may be controlled through a choice of the plotted symbol, its size and its color.

The format of the option cards for Program E215 are shown in Figure 6. A sample Requisition for Computer Work (Form DP-1) is shown below:

REQUISITION FOR COMPUTER WORK

				PRIORITY
SUBMITTED BY WYANDE HEX	TEL. NO. 377	LOCATION 327	I. D. ACCOUNT CODE 8216-306	EST. TIME (MIN.) 20
CATEGORY ☐ SYSTEM or R/T	☐ PROGRAM DEVELOPMENT ☒ PRODUCTION RUN		JOB RUN NO. E215	SEQ. NO.
INPUT TAPES (RING OUT) 12 = 6341		OUTPUT TAPES (RING IN)		TIME IN
SCRATCH TAPES (RING IN)		DISKS 3001, 3006, 6501		TIME OUT
☒ PRINT	☐ PUNCH	☒ PLOT	☐ PAPER TAPE	

REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)

HR.	MIN.	SEC.

MACH.	INITIALS

FORM DP-1
Rev. 1-79
(Use BALL POINT PEN or PENCIL)

Multiple plots may be made in a single run of Program E215. The same survey may be used in more than one plot within a single run.

E 2 1 5 (SURVEY AGAINST SURVEY PLOTS) OPTION CARDS

INTERIM WELL LOG ANALYSIS SYSTEM

PROGRAM I.D. CARD (REQUIRED: 1/RUN)

I.D. (col. 1)	FREE-FORM OPTIONS (SEE DESCRIPTIONS BELOW) (col. 6)	NOT AVAILABLE FOR USE (to col. 80)
*E215		

OPTIONS = [.DUMP] = FOR PROGRAMMER USE ONLY (LOAD MAP AND DUMP) [.LIST] = LISTS ALL DATA RECORDS USED IN PLOTTING

PLOT TITLE CARD (OPTIONAL: 0-9 CARDS/PLOT)

PLOT NO. (1)	I.D. (4)	LN (9)	TITLE (LEFT-SIDE OF CENTER)	TITLE (RIGHT-SIDE OF CENTER) (41)	LTR SIZE (72)	PEN COLOR (75)	TL (80)
	TITLE						
	TITLE						
	TITLE						

LN = LINE NO. OF TITLE
TL = TITLE LOCATION (L=LEFT-JUSTIFIED, R=RIGHT-JUSTIFIED)
LTR SIZE = LETTER SIZE (IN INCHES)

PLOT CONTROL CARD (OPTIONAL: 1/PLOT)

PLOT NO. (1)	I.D. (4)	A (9)	SYMBL CODE	LTR SIZE (13)	PEN COLOR (16)	DEPTH RANGE - BEGINNING (21)	DEPTH RANGE - ENDING (27)	DEPTH RANGE - INTERVAL (33)	NOT USE (to 80)
	DEPTH								

A = ANNOTATION CODE (IF NON-BLANK, POINTS WILL BE NUMBERED)
SYMBL CODE = SYMBOL CODE (SEE APPENDIX 6 OF WMD MANUAL; IF NEGATIVE, LINE WILL CONNECT POINTS IN DEPTH ORDER)
LTR SIZE = LETTER SIZE (IN INCHES)

X-AXIS (ABSCISSA) PLOT CARD (REQUIRED: 1/PLOT)

PLOT NO. (1)	X (4)	STATION I.D. NO.	SVY MO. (14)	SVY DAY (16)	SVY YR. (18)	SVY TYP (20)	RUN NO. (22)	Y-SCALE - UNITS/INCH (24)	UNITS CODE (30)	SCALE RANGE - BEGINNING (33)	SCALE RANGE - ENDING (39)	SCALE RANGE - TIC-MARK (45)	LTR SIZE (51)	PEN COLOR (54)	HL (59)	HDG LINES W D S R U	NOT USE (to 80)
	X																

Y-AXIS (ORDINATE) PLOT CARD (REQUIRED: 1/PLOT)

PLOT NO. (1)	Y (4)	STATION I.D. NO.	SVY MO. (14)	SVY DAY (16)	SVY YR. (18)	SVY TYP (20)	RUN NO. (22)	Y-SCALE - UNITS/INCH (24)	UNITS CODE (30)	SCALE RANGE - BEGINNING (33)	SCALE RANGE - ENDING (39)	SCALE RANGE - TIC-MARK (45)	LTR SIZE (51)	PEN COLOR (54)	HL (59)	HDG LINES W D S R U	NOT USE (to 80)
	Y																

UNITS CODE = SEE IWLAS WRITE-UP (WILL DEFAULT TO SURVEY TYPE)
HL = HEADING LOCATION (L=LEFT-JUSTIFIED, R=RIGHT-JUSTIFIED)
HDG LINES = HEADING LINES (W=WELL NO., D=DATE, S=SURVEY, R=RUN, U=UNITS); ENTER <1> TO PRINT W/D/R, <0> TO OMIT S/U
LTR SIZE = LETTER SIZE (IN INCHES)

RUNNING LINKED JOBS

A full data analysis, as shown in Flowchart II, may be produced in one job by assembling a deck made up of the following cards and submitting it with the requisition shown below:

1. E211 option cards
2. A card with *E212 in columns 1-5
3. E212 option cards
4. A card with *E213 in columns 1-5
5. E213 option cards

REQUISITION FOR COMPUTER WORK

PRIORITY

SUBMITTED BY: RANDY RUNON
TEL. NO.: 377
LOCATION: 213
I. D. ACCOUNT CODE: 8216-306
EST. TIME (MIN.): 30

CATEGORY
[ ] PROGRAM DEVELOPMENT
[ ] SYSTEM or R/T [X] PRODUCTION RUN
JOB RUN NO.: E211
SEQ. NO.

INPUT TAPES (RING OUT): 10 = 1357
OUTPUT TAPES (RING IN)
TIME IN

SCRATCH TAPES (RING IN): 11 = , 12 =
DISKS: 6501
TIME OUT

[X] PRINT [ ] PUNCH [X] PLOT [ ] PAPER TAPE

HR.	MIN.	SEC.

REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)

MACH.	INITIALS

FORM DP-1
Rev. 1-79
(Use BALL POINT PEN or PENCIL)

If either the CDP tape, Logical Unit 11, or the New Survey Tape, Logical Unit 12, is desired to be saved by the user, it should be shown as an output unit rather than a scratch unit in the example and an appropriate magnetic tape label(s) should be provided with the requisition.

If no plot is desired, only items (1), (2), and (3), above, need be supplied and the requisition would omit Logical Unit 12 and the mark in the "PLOT" box.

If a CDP Tape has already been created by a previous E211 run and has been saved by the user by designating it as an output tape, a different survey calculation may be performed and plotted by submitting the following card deck and requisition:

1. E212 option cards

2. A card with *E213 in columns 1-5

3. E213 option cards

REQUISITION FOR COMPUTER WORK				PRIORITY
SUBMITTED BY SAM SYNTHESIZER	TEL. NO. 277	LOCATION 408	I. D. ACCOUNT CODE 8216-306	EST. TIME 20
CATEGORY ☐ SYSTEM or R/T ☒ PRODUCTION RUN ☐ PROGRAM DEVELOPMENT			JOB RUN NO. E212	SEQ. NO.
INPUT TAPES (RING OUT) 11 = 4967		OUTPUT TAPES (RING IN)		TIME IN
SCRATCH TAPES (RING IN) 12 =		DISKS 6501		TIME OUT
☒ PRINT	☐ PUNCH	☒ PLOT	☐ PAPER TAPE	
REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)			FORM DP-1 Rev 1-79 (Use BALL POINT PEN or PENCIL)	HR. MIN MACH.

Any run of Program E209 (ex-CRDTOTAP) may be linked to Programs E211, E212, and/or E213. The manually digitized data cards for Program E209 are followed by a card with either *E211, *E212, or *E213 in columns 1-5; this card is then followed by the corresponding program's data and/or option cards.

The following card deck and requisition will copy manually-digitized survey data to tape and automatically plot the data:

1. E209 data cards

2. A card with *E213 in columns 1-5

3. E213 option cards

REQUISITION FOR COMPUTER WORK

PRIORITY

SUBMITTED BY	TEL. NO.	LOCATION	I. D. ACCOUNT CODE	EST. TIME (MIN.)
IOLA INPUTTER	350	243	8216-306	20

CATEGORY ☐ SYSTEM or R/T ☐ PROGRAM DEVELOPMENT ☒ PRODUCTION RUN

JOB RUN NO. E209

SEQ. NO.

INPUT TAPES (RING OUT)

OUTPUT TAPES (RING IN) 01 = 12 = ________

SCRATCH TAPES (RING IN)

DISKS

TIME IN

TIME OUT

☒ PRINT ☐ PUNCH ☒ PLOT ☐ PAPER TAPE

HR.	MIN.	SEC.

MACH.	INITIALS

REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)

OUTPUT TAPE LABEL ATTACHED

FORM DP-1
Rev. 1-79
(Use BALL POINT PEN or PENCIL)

CALCULATIONS AVAILABLE FOR PROGRAM E212

CALCULATION NO.	INPUT SURVEY TYPES A	B	C	D	CALCULATION
01	02	01	n/a	n/a	CORRECTED FLOW LOG = A*(((B/2)**2)*3.14159)
02	11	07	n/a	n/a	CORRECTED RESISTIVITY (FAHRENHEIT) = 1.5-(.02)*(5/9(A-32))*10000/B
03	07	n/a	n/a	n/a	CONDUCTIVITY = 10000/A
04	11	07	n/a	n/a	CORRECTED RESISTIVITY (CENTIGRADE) = 1.5-(.02)*A*10000/B
05	Any	n/a	n/a	n/a	COPY SURVEY AS IS
06	11	n/a 1	n/a	n/a	TEMPERATURE CONVERSION (FAHRENHEIT TO CENTIGRADE) = (A-32)*(5/9)
07	11	n/a	n/a	n/a	TEMPERATURE CONVERSION (CENTIGRADE TO FAHRENHEIT) = ((A*9)/5)+32
08	05	n/a	n/a	n/a	CPS TO API = A*1.92
09	Any	n/a	n/a	n/a	$LOG_e = LOG_e(A)$
10	Any	n/a	n/a	n/a	$LOG_{10} = LOG_{10}(A)$

APPENDIX III

WELL SURVEY SYSTEM - PROGRAM E200

Survey Data Conversion and Editting

Programmer

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Data Processing Division
Department of Technical Services

Revised: February 13, 1981

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GENERAL

This initial program of the Well Survey System will accept paper tapes bearing digitized data describing the analog output of a strip-chart recorder and will produce:

1) An edited listing of the input paper tape records, with any errors flagged;

2) An edited listing of any correction cards designed to eliminate errors found under 1), above, with any errors flagged;

3) A listing of the digitized values converted from digitizer units to survey-units;

4) Plots of the corrected digitizer data for Quality Control functions; and

5) A tape file of the survey-units data for processing by the Interim Well Log Analysis System.

Program E200 will also accept cassette recordings of digitized data produced by an analog-to-digital conversion device attached to the well survey instruments. For cassette input, the program output is:

1) An edited listing of the option cards required to identify and define the data contained on the tape, with any input errors flagged;

2) An edited listing of the cassette data tape records, with any errors flagged and any corrections (made by input cards) shown;

3) Plots of the data for each survey for Quality Control functions; and

4) A tape file of the data for processing by the Interim Well Log Analysis System.

PAPER TAPE INPUT

DATA PREPARATION AND INPUT

Groundwater creates analog recordings of survey parameters in the field using a strip-chart recorder. Up to four surveys may be recorded on the same physical chart, depending upon the number of survey tools used simultaneously. A translucent Well Log form (WMD 60) is completed and attached to the top of the appropriate chart and the chart is annotated with the appropriate scale(s). A blue-line copy of each chart is produced and all such copies for a single well are gathered together and recorded on a Well Log Transmittal (Figure 1). The transmittal sheet and its associated charts are forwarded to Data Management for digitizing.

As each survey is digitized, the person performing the digitizing initials the appropriate line on the transmittal sheet. Each paper tape produced during digitizing shall be marked at its beginning with: Chart No., Batch No., Station I.D., Date and Survey (Type) No. The Chart No. should be circled. The paper tapes thus produced, one for each survey, are accumulated until all surveys on the transmittal have been digitized. Data Management then submits the paper tapes, and a Requisition for Computer Work, to Data Processing to be run as input to Program E200. The magnetic tapes created by Data Processing are noted on the returned copy of the Requisition for Computer Work and these are transcribed by Data Management onto the transmittal sheet.

If no format errors have occurred in the creation of the paper tapes, a set of quality control plots for each survey is prepared by Data Processing and returned to Data Management. These plots are then placed over the corresponding survey's charts and discrepancies are noted on the transmittal sheet and on the plot itself.

If no data errors are found through comparision of the plots and surveys, the "Q. C. By" and "DATE" portions of the transmittal sheet are completed by Data Management and the package of plots, charts, printout and transmittal sheet is returned to Groundwater. Data Management retains the paper tapes.

Groundwater records the date the package is returned and performs a final quality control check of the plots and the original charts. If the digitizing is approved, Groundwater runs program MERGTAPE to incorporate the new data onto the Interim Cumulative Master File, noting the new magnetic tape number on the transmittal.

Prepared By: Date BATCH NO.

Chart No.	Well I.D.	Station I.D. County	Station I.D. Well No.	Survey Date Mo.	Da.	Yr.	No. Type	Digitized By:
								0000101E/R

Start Depth Scale Left Scale Right: 00500 / 00100 =X =Y =Y =X =Y =Y =X =Y =Y

Close =X =X End Depth

Chart No.	Well I.D.	Station I.D. County	Station I.D. Well No.	Survey Date Mo.	Da.	Yr.	No. Type	Digitized By:
								0000101E/R

Start Depth Scale Left Scale Right: 00500 / 00100 =X =Y =Y =X =Y =Y =X =Y =Y

Close =X =X End Depth

Chart No.	Well I.D.	Station I.D. County	Station I.D. Well No.	Survey Date Mo.	Da.	Yr.	No. Type	Digitized By:
								0000101E/R

Start Depth Scale Left Scale Right: 00500 / 00100 =X =Y =Y =X =Y =Y =X =Y =Y

Close End Depth

Chart No.	Well I.D.	Station I.D. County	Station I.D. Well No.	Survey Date Mo.	Da.	Yr.	No. Type	Digitized By:
								0000101E/R

Start Depth Scale Left Scale Right: 00500 / 00100 =X =Y =Y =X =Y =Y =X =Y =Y

Close End Depth

Chart No.	Well I.D.	Station I.D. County	Station I.D. Well No.	Survey Date Mo.	Da.	Yr.	No. Type	Digitized By:
								0000101E/R

Start Depth Scale Left Scale Right: 00500 / 00100 =X =Y =Y =X =Y =Y =X =Y =Y

Close End Depth

FIGURE 1. Well Log Transmittal Form

Chart No.	Well I.D.	Station I.D. County	Station I.D. Well No.	Survey Date Mo.	Survey Date Da.	Survey Date Yr.	Survey No. Type	Digitized By:
								0000101E/R

Start Depth 00500
Left Scale 00100

Y=
Y=
Y=
Y=

Y= Y= Y= Y= Y= Y=

Y= Y= Y= X= X= X=

Closing Depth

Chart No.	Well I.D.	Station I.D. County	Station I.D. Well No.	Survey Date Mo.	Survey Date Da.	Survey Date Yr.	Survey No. Type	Digitized By:
								0000101E/R

Start Depth 00500
Left Scale 00100

Y=
Y=
Y=
Y=

Y= Y= Y= Y= Y= Y=

Y= Y= Y= X= X= X=

Closing Depth

DATE RETURNED TO GROUNDWATER	Q.C. BY	DATE	APPROVED?

DATA STATUS	PROGRAM USED	TAPE NO.	TAPE NAME	RUN SEQ.	RUN DATE	RUN TIME
DIGITIZED	PLTPT		DIGITIZED-BATCH-			
CONVERTED	E200		E200-BATCH-			
MERGED	MERGTAPE		E200-CUMUL-BATCH-			
UPDATED	E201		WELL-SURVEY-MASTER-			

			COMMENTS
First Run	Received	OK	
To Corr.	Received	OK	

DATE RECEIVED ____________ SENT TO GROUNDWATER ____________

PAPER TAPE INPUT (continued)

QUALITY CONTROL PROCEDURES

Format errors may be detected in the paper tape records by Program E200; these will be flagged on the Digitized Survey Data listed produced by Program E200. The flags will appear in two places: directly under the incorrect record and underneath the Line No. which appears at the extreme left of the listing. If format errors are detected, no further processing is performed by Program E200 and it must be rerun with the optional correction card input (see "CORRECTION CARDS").

If the correction cards are subsequently found to have format errors, the errors will be flagged immediately beneath the card image shown on the Correction Card Listing produced by Program E200.

(Note: Errors in the no. of scale-box records are flagged with "B"s placed beneath the ninth subsequent record.)

When all format errors have been eliminated from the paper tape and correction card records, Program E200 will produce plots of the digitized charts showing the data trace and X- and Y-scale lines. The plot is to be checked as follows:

1) Align the plotted data trace atop the appropriate chart and circle any incorrect break-points; these must be corrected with correction cards and Program E200 must be rerun.

2) Two vertical dashed-lines are shown on the plot; one for the leftmost X-scale point (which may coincide with the lefthand, or zero, digitizer Y-axis) and one for the rightmost X-scale point. Each vertical scale-line shows a chart X-value immediately beneath it on a line beneath the digitizer X-values. These two X-values must agree with those on the chart at the respective points. If they disagree, the appropriate scale-box records must be corrected by correction cards.

3) Two or more horizontal dashed lines are shown on the plot; these are the Y-scale points and their values will be shown to the left of the digitizer Y-values. (The lowest dashed line may coincide with the digitizer's lower, or zero, X-axis.) As for the X-scale values, the Y-scale values must coincide with those on the original chart; incorrect values must be corrected.

PAPER TAPE INPUT (continued)

RUN OPTION CARD

The Run Option Card must be present to run Program E200; it consists of "*E200" in card columns 1-4 and one or more of the following options in the remainder of the card in any order:

,DIGTZR
,INPUT LIST
,BATCH=nnn
,DUMP

If ",DIGTZR" is not present, Program E200 will process the input paper tape using an ASCII code-conversion table. If ",DIGTZR" is present, the tapes will be processed using the code-conversion table used by the program prior to the availability of ASCII-punched tape.

If ",INPUT LIST" is not present, none will be printed when the run is error-free. If errors occur, the error listing will be printed regardless of options. ",DUMP" should be used only be a programmer; it provides an octal dump of all variables in the program at the end of each program link and will consume excessive amounts of paper if not needed.

The "nnn" of ",BATCH=nnn; should coincide with that on the Well Log Transmittal.

PAPER TAPE INPUT (continued)

CORRECTION CARDS

The optional correction cards are punched in the following format:

Col. 1	Action Code (D=delete, R=replace, I=insert)
Cols. 2-6	Paper Tape Record No.
Cols. 7-31	New or Corrected Paper Tape Record Image

The correction cards must be in sequence on columns 2-6 and are placed immediately behind the *E200 Run Option Card.

If a large number of records are to be deleted, the following format may be used:

Col. 1	Action Code (D=delete)
Cols. 2-6	Beginning Paper Tape Record No.
Cols. 7-8	TO
Cols. 9-13	Ending Paper Tape Record No.

PAPER TAPE INPUT (continued)

REQUISITIONS FOR COMPUTER WORK

The initial Requisition for Computer Work (form DP-1) is completed as shown below. Actual magnetic tape labels may be attached in lieu of the notes in the Remarks section of the form. The computer operator will indicate the magnetic tape assignments in the areas provided on the form.

REQUISITION FOR COMPUTER WORK

PRIORITY

SUBMITTED BY	TEL. NO.	LOCATION	I. D. ACCOUNT CODE	EST. TIME (MIN.)
Wally G. Water	350	108	8216-306	20

CATEGORY: [ ] SYSTEM or R/T; [ ] PROGRAM DEVELOPMENT; [X] PRODUCTION RUN

JOB RUN NO.: E200

SEQ. NO.:

INPUT TAPES (RING OUT):

OUTPUT TAPES (RING IN): 07 =

SCRATCH TAPES (RING IN):

DISKS: 6501, 3001, 3006

TIME IN:

TIME OUT:

[X] PRINT; [ ] PUNCH; [X] PLOT; [X] PAPER TAPE

HR.	MIN.	SEC.

MACH.	INITIALS

REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)
Label Paper Tape Images: Well-Log, Digitized - Batch-7
Label Output Tape: Well-Log, E200 - Batch-7
EDP ONLY

FORM DP-1
Rev. 1-79

If the initial data (i.e., paper tape input only) contains errors, no magnetic tapes will be assigned to the Output Tape (07=) or to the Plot tape. A magnetic tape will be assigned to the Paper Tape images. After the Correction Cards are prepared, the Requisition for the rerun should look like that shown below. Input Tape unit 30 is the tape containing the paper tape images.

REQUISITION FOR COMPUTER WORK

PRIORITY

SUBMITTED BY	TEL. NO.	LOCATION	I. D. ACCOUNT CODE	EST. TIME (MIN.)
Wally G. Water	350	108	8216-306	20

CATEGORY: [ ] SYSTEM or R/T; [ ] PROGRAM DEVELOPMENT; [X] PRODUCTION RUN

JOB RUN NO.: E200

SEQ. NO.:

INPUT TAPES (RING OUT): 30 = 1234

OUTPUT TAPES (RING IN): 07 =

SCRATCH TAPES (RING IN):

DISKS: 6501, 3001, 3006

TIME IN:

TIME OUT:

[X] PRINT; [ ] PUNCH; [X] PLOT; [ ] PAPER TAPE

HR.	MIN.	SEC.

MACH.	INITIALS

REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)
Label output tape: Well-log, E200 - Batch-7
EDP ONLY

FORM DP-1
Rev. 1-79

PAPER TAPE INPUT (continued)

PAPER TAPE RECORDS LAYOUTS

Label/Header Records

One label record per survey, beginning the first paper tape:

Characters	Type	Data Field Contents
1-9	A/N	Station ID
10-11	N	Survey Date - Month
12-13	N	Survey Date - Day
14-15	N	Survey Date - Year
16-17	N	Survey Type/No. (from the list shown below): 01 = Caliper 02 = Flowmeter 03 = 16-inch normal resis. 04 = 64-inch normal resis. 05 = Neutron porosity 06 = Natural gamma 07 = Fluid resistivity 08 = Gamma gamma density 09 = Casing collar locator 10 = Fluid sampler 11 = Temperature gradient 12 = Delta temperature 13 = Spontaneous potential 14 = Point resistance 15 = 6-foot lateral resis. 16 = Sonic travel time 17 = Acoustic amplitude
18	N	No. of decimal points in data values
19-21	Zeroes	Reserved for expansion
22	N	Digitizer scale code for X-axis 0 = 248.60 digitizer units per inch on X-axis 1 = 246.32 digitizer units per inch on X-axis
23-24	N	Paper tape no.
25	\]	End-of-record character

PAPER TAPE INPUT (continued)

PAPER TAPE RECORD LAYOUTS (continued)

Scale Records

Scale records contain pairs of chart values and their corresponding digitizer values. The values may be either four-digits or five-digits in length and either of the following alternative record formats may be used interchangeably (even within an individual survey):

Data Field Contents	Type	Character(s) in Record: 4-Char-Field Format	Character(s) in Record: 5-Char-Field Format
Chart Value	N	1-4	1-5
Slash (Field Separator)	</>	5	6
Digitizer Value Corresponding to the Chart Value	N	6-9	7-11
End-of-Record Character	<]>	10	12

The beginning scale record of each scale-box, defining a fixed set of survey data records, provides the X-values for beginning (leftmost side) of the scale-box. The next scale records before the beginning of the survey data records provide the Y-values for the scale-box. The Y-value scale records are input beginning with the lowermost and ending with the uppermost. If only one Y-scale exists between the lowermost and uppermost points of the survey chart, only two Y-value scale records need be input. If the scale changes between the lowermost and uppermost points, a Y-value scale record must appear for each such scale change point in its relative sequence between the lowermost and uppermost scale change records. A scale change record with X-values for the ending (rightmost side) of the scale-box must immediately follow the survey data records. (See Sample Paper Tape Layout, Page 11.)

PAPER TAPE INPUT (continued)

PAPER TAPE RECORD LAYOUTS (continued)

Survey Data Records

One Survey Data Record is punched for each (X, Y) point digitized. As for the Scale Records, the digitizer values may be either four-digit or five-digit fields. The alternative formats for the 18-character Survey Data Records are shown below:

		Character(s) in Record	
Data Field Contents	Type	4-Char-Field Format	5-Char-Field Format
Depth Range (in hundred feet)	N	1-2	1-2
Slash (Field Separator)	</>	3	3
X-Scale Digitizer Value (Depth)	N	4-7	4-8
Slash (Field Separator)	</>	8	9
Y-Scale Digitizer Value (Amplitude)	N	9-12	10-14
Slash (Field Separator)	</>	13	15
Unused (Zeroes)	N	14-17	16-17
End-of-Record Character	<]>	18	18

PAPER TAPE INPUT (continued)

PAPER TAPE RECORD LAYOUTS (continued)

Sample Paper Tape Layout

A well survey system paper tape will contain the following sequence of record types:

Label/Header Record

Scale Record (X-Values, Leftmost Point)
Scale Record (Y-Values, Bottommost Point)
Scale Record (Y-Values, Intermediate Point of Scale Change)
Scale Record (Y-Values, Intermediate Point of Scale Change)
.
.
.
Scale Record (Y-Values, Intermediate Point of Scale Change)
Scale Record (Y-Values, Uppermost Point)
Survey Data Record
Survey Data Record
.
.
.
Survey Data Record
Survey Data Record
Scale Record (X-Values, Rightmost Point)

Scale Record (X-Values, Leftmost Point)
Scale Record (Y-Values, Bottommost Point)
Scale Record (Y-Values, Intermediate Point of Scale Change)
Scale Record (Y-Values, Intermediate Point of Scale Change)
.
.
.
Scale Record (Y-Values, Intermediate Point of Scale Change)
Scale Record (Y-Values, Uppermost Point)
Survey Data Record
Survey Data Record
.
.
.
Survey Data Record
Survey Data Record
Scale Record (X-Values, Rightmost Point)

PAPER TAPE INPUT (continued)

SAMPLE OUTPUTS

Survey Data Listing (Edited Digitizer Values)

E 2 0 0
10/11/78
09:54:48

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WELL SURVEY SYSTEM
D I G I T I Z E D   S U R V E Y   D A T A

BATCH 000 .... PAGE 12
STATION I. D. 093000402
DATE OF SURVEY 12/13/77
SURVEY TYPE 01

SURVEY = 01 (CALIPER)

XXX	RECORD NO. XXX0 OR XXX5	RECORD NO. XXX1 OR XXX6	RECORD NO. XXX2 OR XXX7	RECORD NO. XXX3 OR XXX8	RECORD NO. XXX4 OR XXX9
073	05/3277/0215/0000]	05/3280/0218/0000]	05/3303/0218/0000]	05/3308/0224/0000]	05/3321/0225/0000]
073	05/3333/0242/0000]	05/3337/0242/0000]	05/3346/0217/0000]	05/3412/0217/0000]	05/3419/0225/0000]
074	05/343[illegible]/0233/0000]	05/3439/0233/0000]	05/3443/0212/0000]	05/3452/0204/0000]	05/3462/0214/0000]
074	05/3[illegible]77/[illegible]/0000]	05/3[illegible]95/0217/0000]	05/35[illegible]2/0220/0000]	05/3511/0231/0000]	05/3517/0229/0000]
075	05/3524/[illegible]/0000	05/3534/0215/0000]	05/3545/0215/0000]	05/3550/0220/0000]	05/3566/0218/0000]
075	05/35[illegible]	[illegible]/3596/[illegible]	05/3605/0214/0000]	05/3612/0206/0000]	05/3628/0218/0000]
076	05/3639/021[illegible]/0000]	05/3649/0210/0000]	05/3663/0218/0000]	05/3678/0218/0000]	05/3686/0216/0000]
076 ***	05/37[illegible]/0215/[illegible]	05/3719/0218/0000]	0600/3747]	0600/0000] DDDDDDDDDD	0002/0000]
077 ***	00000131 DDDD[illegible]	0600/0000]	0002/0000]	0004/0155]	0006/0282]
077	0[illegible]/04[illegible]	[illegible]/0515]	0012/0621]	06/0021/0220/0000]	06/0028/0211/0000]
078	06/0036/0208/0000]	06/0046/0216/0000]	06/0068/0216/0000]	06/0079/0213/0000]	06/0094/0214/0000]
078	06/0109/02[illegible]8/0000]	06/0123/0201/0000]	06/0134/0202/0000]	06/0148/0216/0000]	06/0158/0212/0000]
079	06/0163/0209/0000]	06/0173/0210/0000]	06/0185/0210/0000]	06/0199/0206/0000]	06/0219/0209/0000]
079	06/0231/0216/0000]	06/0254/0216/0000]	06/0264/0213/0000]	06/0276/0207/0000]	06/0286/0205/0000]

Correction Card Listing


```
                                                     BATCH 000 .... PAGE   1
                  SOUTH FLORIDA WATER MANAGEMENT DISTRICT
F 2 0 0                    WELL SURVEY SYSTEM
10/11/78          C O R R E C T I O N   C A R D   L I S T I N G
09154:48

REPLACEMENT   R00008   0012/06171
   DELETION   D00010   T000011
   DELETION   D00013   T000016
   DELETION   D00017   T000087
REPLACEMENT   R00089   0300/36031
   DELETION   D00090
  INSERTION   I00089   0300/00001
               *****
   DELETION   D00091
   DELETION   D00099   T000374
   DELETION   D00768
   DELETION   D00770
   DELETION   D00769
               *****
```

SAMPLE OUTPUTS (continued)

Survey Data Listing (Actual & Digitized Values)

E 2 0 0
10/11/78
09154148

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WELL SURVEY SYSTEM
D I G I T I Z E D   S U R V E Y   D A T A

BATCH 000 .... PAGE 13
STATION I. D. 093000502
DATE OF SURVEY 12/13/77
SURVEY TYPE 01

SURVEY = 01 (CALIPER)

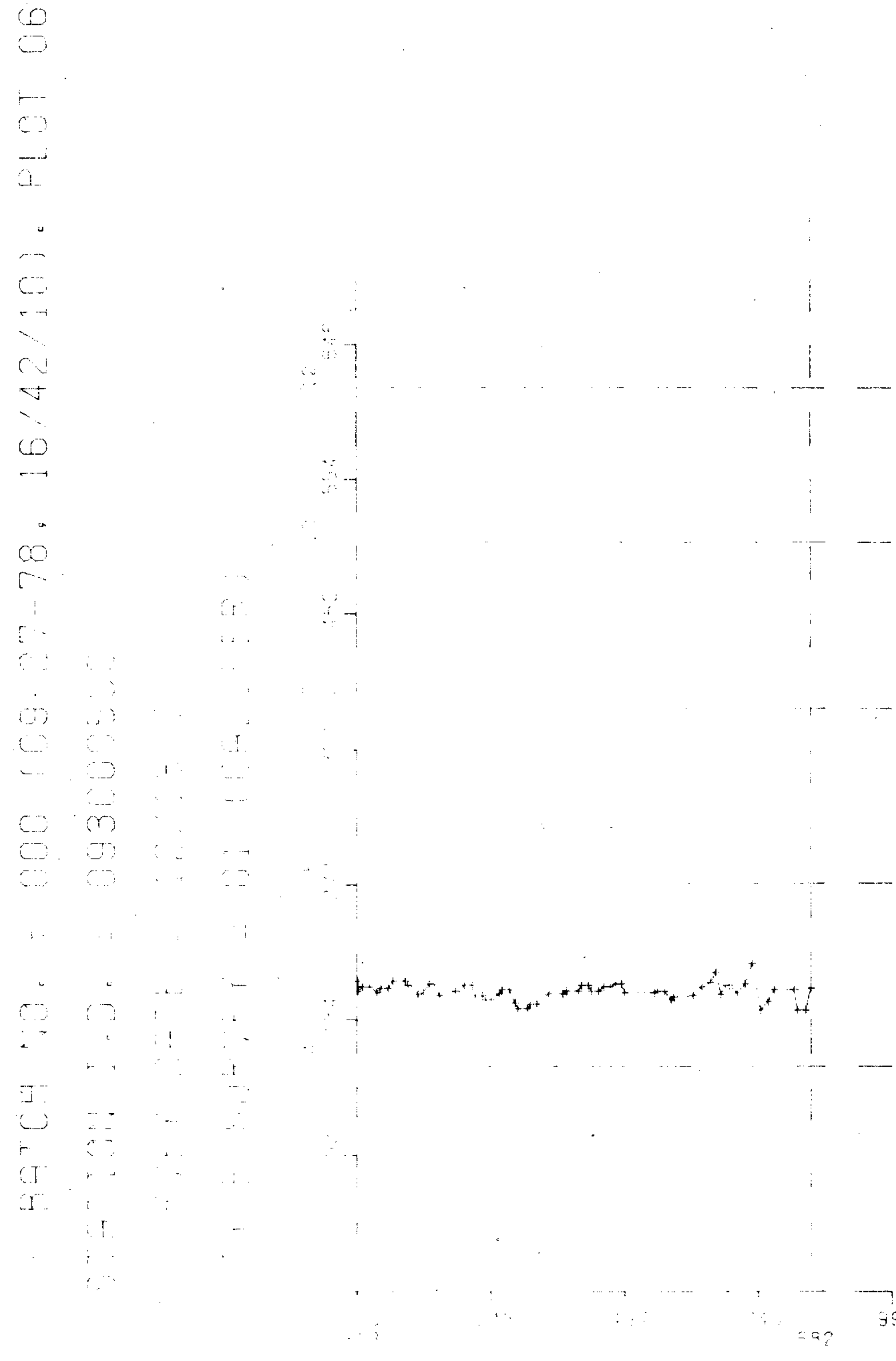
-Y- DEPTH (IN FEET)	-V- SURVEY MEASUREMENT	DIGITIZER VALUES RECORD NO.	X-UNITS	Y-UNITS	CHART VALUE Y-MAX
664.07	4.77	0436	624	201	0000
665.38	4.86	0437	640	207	
666.69	4.91	0438	656	210	
667.51	5.02	0439	666	217	
668.33	4.78	0440	676	202	
669.07	4.88	0441	685	208	
669.64	4.86	0442	692	208	
670.87	4.30	0443	707	203	
672.01	4.20	0444	721	209	
673.68	5.12	0445	734	223	
674.39	4.61	0446	750	191	
675.53	4.70	0447	764	197	
676.43	4.83	0448	775	205	
679.16	4.83	0449	812	205	
679.95	4.61	0450	818	191	
681.18	4.61	0451	833	191	
682.06	4.85	0452	843	206	

PLOT

PAPER TAPE INPUT (continued)

SAMPLE OUTPUTS (continued)

Quality Control Plot



CASSETTE INPUT

RECORD FORMAT AND TYPES

The format of the cassette tape records produced by the recording equipment attached to the geophysical logger is shown below:

Character No(s).	Field/Contents
1-5	Depth (in tenth-feet)
6-7	2 blank characters
8-11	Data Value, Survey No. 1
12-13	2 blank characters
14-17	Data Value, Survey No. 2
18-19	2 blank characters
20-23	Data Value, Survey No. 3
24-25	2 blank characters
26-29	Data Value, Survey No. 4
30	] (end-of-record)

If the first character of a record is a nine (9), this record is interpreted as a LOG CONTROL RECORD. (The LOG CONTROL RECORD is recorded by the logger operator with the equipment in "AUTO" mode and its values are "dialed-in".) Only the first five characters of this record are used and they are interpreted as a five-digit Log No. These Log Nos. should be unique and should be individually-assigned for each traverse of the well.

A Log No. of 99999 must be recorded at the end of data on an individual cassette.

CASSETTE INPUT (continued)

OPTION CARD FORMATS

*E200 Card

The *E200 card (Run Option Card) is similar to that used for processing digitized paper tapes. It must begin with "*E200" in columns 1-4. The option ",CASSETTE" must also be included to identify the type of input data to be processed. The option ",BATCH=nnn", where nnn represents a three-digit Batch No., should also be included. A sample Run Option Card might be:

*E200,CASSETTE,BATCH=521

The ",DUMP" option described under PAPER TAPE INPUT is also available, but should only be used by a programmer for debugging purposes. (The two other paper tape options, ",DIGTZER" and ",INPUT LIST", are not utilized for cassette tape processing.)

This card format and those of the Log-Survey and Variable-Scale cards are shown on the Program E200 - Options (Cassette Input Only) form on the following page.

PROGRAM E200 - OPTIONS
(CASSETTE INPUT ONLY)

LABEL	TAPE
E200-INPUT-BATCH-	= NO.
E200-OUTPUT-BATCH-	= NO.

FIRST CARD (REQUIRED)

•E200.CASSETTE.BATCH=

FOR EACH LOG (ONE REQUIRED)

1		7	13		19	28	30	32	34	36		39	46		54		62	69	75
L	LOG NO.	SV	BEGIN REC. NO.	END REC. NO.	STATION I.D.	MO.	DAY	YR.	SVY TYP	RUN NO.		DEPTH OFFSET (FEET)	DP	CONVERSION• INTERCEPT(A)	CONVERSION• SLOPE(B)		PLOT X-SCALE (FEET/INCH)	PLOT Y SCALE (VALUE/INCH)

SV = SURVEY POSITION NO. (IN DATA RECORD): 1, 2, 3, OR 4 DP = DECIMAL POSITION (NO. DIGITS FROM RIGHT)
•CONVERSION: Y'PRIME = A + (B • Y)

SURVEY TYPES
01=caliper
02=flowmeter
03=16" norm. resis.
04=64" norm. resis.
05=neutron
06=natural gamma
07=fluid resis.
08=gamma gamma
09=casing collar
10=fluid sampler
11=temp. gradient
12=delta temp.
13=spon. pot.
14=point resis.
15=6' lateral
16=sonic trvl.
17=acoustic ampl.

FOR EACH VARIABLE-SCALE SURVEY (OPTIONAL)

1	7		13	19	23	31	35	43	47	55	59	67	71	77
LOG NO.	SV	BEGIN REC. NO.	END REC. NO.	RECORD VALUE	ACTUAL VALUE	RECORD VALUE	ACTUAL VALUE	RECORD VALUE	ACTUAL VALUE	RECORD VALUE	ACTUAL VALUE	RECORD VALUE	ACTUAL VALUE	
S														
S														

SV = SURVEY POSITION NO. (IN DATA RECORD): 1, 2, 3, OR 4

CASSETTE INPUT (continued)

OPTION CARD FORMATS (continued)

Log-Survey Card

At least one Log-Survey Card is required for each Log Control Record on the cassette tape. If more than one survey is recorded for a log (or traverse of the well), one Log-Survey Card is required for each survey.

The Log Nos. should correspond with those recorded on the cassette in Log Control Records. The Survey Position No. (card column 7) is a value from one to four (1-4) indicating the location of the survey values in the data record. The Survey Identification is entered in card columns 19-37. The Depth Offset of the sensor from the top of the tool or probe is entered in card columns 39-45, either with a decimal point included or right-justified.

Survey data values may be adjusted by three conversion methods:

1. the decimal point, assumed to be after the right-most digit of the data value, may be shifted up to nine positions to the left by the use of card column 46;

2. the data values may be subjected to a linear conversion by specifying the intercept and slope of the straight-line equation; and

3. the data values may be subjected to non-linear conversion by the use of Variable-Scale Survey Cards (see next section).

The Log-Survey Card also contains a provision for specifying the scale for quality control plots (card columns 62-75). If scales are not specified, no plot will be produced for that survey.

If the values of the recording parameters change during the course of a single traverse or log, card columns 8-17 may be used to differentiate the changes by record numbers within a survey.

CASSETTE INPUT (continued)

OPTION CARD FORMATS (continued)

Variable-Scale Survey Cards

Non-linear conversion of survey data values must be accomplished by the use of Variable-Scale Survey Cards. The format for these cards is shown at the bottom of the Program E200 - Options (Cassette Input Only) form on Page 18. Multiple cards may be created for a single log-survey combination. These cards are placed together in a group behind the Log-Survey Cards in the input deck.

The Log No., Survey Position No., and Beginning and Ending Record No. fields are defined the same as for the Log-Survey Cards. At least two pairs of Record Actual Values must be present. The Record Value is the four-digit value created by the recording equipment, without any conversion. The Actual Value must either contain a decimal point or be right-justified.

CASSETTE INPUT (continued)

OPTION CARD FORMATS (continued)

Correction Cards

The formats for Correction Cards is shown on the Program E200 - Corrections (Cassette Input Only) form on the following page.

An Action Code (D = delete; R = replace; or I = insert after) is entered in card column 1. The appropriate Record No. is entered in card columns 2-6. Values for the corrected Depth and Survey Data are entered as shown, without any conversions (i.e., as they would have been recorded by the logging equipment).

Deletion of a range of records may be accomplished by use of the format shown at the bottom of the form.

1 7 35

RECORD

NO

I=INSERT

RECORD

NO

CASSETTE INPUT (continued)

INPUT DECK MAKE-UP

The cards punched from the two forms shown on Pages 18 and 22 are assembled into in input deck in the order shown below:

1. *E200 Card - this must be the first card

2. Log-Survey (or "L") Cards - these may be in any order, but must be grouped together

3. Variable-Scale Survey (or "S") Cards - these may be in any log-survey order, but must be in ascending order by Record Values if multiple cards are present for an individual log-survey.

4. Correction Cards - these may be in any order

CASSETTE INPUT (continued)

JOB SUBMISSION

The initial Requisition for Computer Work (form DP-1) is to be completed as shown below. Actual magnetic tape labels may be attached in lieu of the notes in the Remarks section of the form. The computer operator will indicate the magnetic tape assignments in the areas provided for output tapes (i.e., output, plot and cassette tapes). The requisition is to be submitted to Data Processing Operations along with the input card deck and the cassette.

REQUISITION FOR COMPUTER WORK

PRIORITY

SUBMITTED BY	TEL. NO.	LOCATION	I. D. ACCOUNT CODE	EST. TIME (MIN.)
Casey Cassette	516	219	8216-306	20

CATEGORY
[ ] SYSTEM or R/T [ ] PROGRAM DEVELOPMENT [X] PRODUCTION RUN

JOB RUN NO. E200

SEQ. NO.

INPUT TAPES (RING OUT)

OUTPUT TAPES (RING IN) 07 =

SCRATCH TAPES (RING IN)

DISKS 3001, 3006, 6501

TIME IN

TIME OUT

[ ] PRINT [ ] PUNCH [X] PLOT [X] ~~PAPER TAPE~~ CASSETTE

HR.	MIN.	SEC.

MACH.	INITIALS

REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)
Label cassette tape: Well Log, Cassette - Batch 521
Label output tape: Well Log, E200 - Batch 521
Load side A only; 12" plot; black pen

FORM DP-1
Rev. 1-79
(Use BALL POINT PEN or PENCIL)

CASSETTE INPUT (continued)

JOB SUBMISSION (continued)

If the initial run shows data errors or if it was necessary to determine a correspondence between survey depth and record nos., a second run will be necessary. This second run will not require a reloading of the cassette records onto a standard (reel-type) magnetic tape. Input Tape 30 becomes the cassette image tape for the second run, as shown on the requisition below.

REQUISITION FOR COMPUTER WORK

SUBMITTED BY: Randy Redeux	TEL. NO.: 516	LOCATION: 219	I. D. ACCOUNT CODE: 8216-306	PRIORITY
				EST. TIME (MIN.): 20
CATEGORY: ☐ SYSTEM or R/T	☐ PROGRAM DEVELOPMENT [X] PRODUCTION RUN		JOB RUN NO.: E200	SEQ. NO.
INPUT TAPES (RING OUT): 30 = 5678		OUTPUT TAPES (RING IN): 07 =		TIME IN
SCRATCH TAPES (RING IN)		DISKS: 3001, 3006, 6501		TIME OUT
☐ PRINT	☐ PUNCH	[X] PLOT	☐ PAPER TAPE	

REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)
Label output tape: Well Log, E200 - Batch 521
12" Plot; black pen

HR.	MIN.	SEC.

MACH.	INITIALS

FORM DP-1
Rev. 1-79
(Use BALL POINT PEN or PENCIL)

CASSETTE INPUT (continued)

SAMPLE OUTPUTS

General

Samples of the printed output from Program E200 are shown on pages 27-30. The quality control plot would be similar to that produced for paper tape input (page 15), but would not include the dashed lines; the axes would be labelled in actual values, rather than in digitizer values.

The Option Card Listing (page 27) shows all Log-Survey ("L") cards in ascending sequence by Log No. and Survey Position No. The warning messages at the bottom of the sample merely indicate logs which do not have survey data indicated for consecutive Survey Position Nos. beginning with one (1).

The Variable-Scale Card Listing (page 28) will be printed if any "S" cards are submitted for the run. They will be printed in ascending sequence by Log No. and Survey Position No. If multiple cards are submitted for an individual log-survey, they will be shown in the sequence submitted.

The Data Listing (page 29) shows two surveys for Log No. 91278 in Survey Position Nos. 2 and 3. Several errors are shown in the right-hand column and their corresponding records are printed on the same line in-between the brackets (< and >).

The List of Survey Segments Plotted (page 30) shows all plots produced during a run. If no plot scales are input on a Log-Survey card, no plot will be produced.

CASSETTE DATA (continued)

SAMPLE OUTPUTS (continued)

Option Card Listing

E 2 0 0
03/05/81
19:00:53

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WELL SURVEY SYSTEM
C A S S E T T E - R E C O R D E D   S U R V E Y   D A T A

BATCH 540 .... PAGE 1
O P T I O N S

W E L L   L O G   O P T I O N   C A R D   L I S T I N G

RECORDING DATA				SURVEY IDENTIFICATION					ADJUSTMENTS TO RECORDED DATA				PLOT CONTROL	
LOG NO.	SVY	RECORD NOS. BEGIN	END	STATION I. D.	SURVEY DATE	SURVEY TYPE	(CODE)	RUN NO.	X-DEPTH OFFSET (FEET)	Y-DECIMAL POSITION (DIGITS)	Y-CONVERSION INTERCEPT	Y-CONVERSION SLOPE	X-DEPTH (FEET/INCH)	Y-SCALE (VALUE/INCH)
91270-3				021000043	02/11/81	6-FT LATERAL RES	(15)	01	0.0				10	20
91271-2				021000043	02/11/81	TEMP GRADIENT	(11)	01	0.0				10	2
91271-3				021000043	02/11/81	DELTA TEMP	(12)	01	0.0				10	10
91272-3				021000043	02/11/81	FLOWMETER	(02)	01	0.0				10	10
91273-3				021000043	02/11/81	FLOWMETER	(02)	02	0.0				10	10
91274-3				021000043	02/11/81	FLOWMETER	(02)	03	0.0				10	10
91275-3				021000043	02/11/81	CALIPER	(01)	01	0.0	1			10	71
91276-3				021000043	02/11/81	FLUID RESISTVTY	(07)	01	0.0				10	2
91277-1				021000043	02/11/81	64-IN NORMAL RES	(04)	01	-2.0				10	20
91277-2				021000043	02/11/81	SPONTANEOUS POT	(13)	01	-0.6				10	20
91277-3				021000043	02/11/81	16-IN NORMAL RES	(03)	01	0.0				10	20
91278-2				021000043	02/11/81	NATURAL GAMMA	(06)	01	-5.0				10	40
91278-3				021000043	02/11/81	NEUTRON POROSITY	(05)	01	0.0				10	80

* * * * *   W A R N I N G   * * * * *   MISSING SURVEY POSITION NO. (NOS. SHOULD BE CHECKED CAREFULLY, AS PROCESSING WILL CONTINUE).
L912703

* * * * *   W A R N I N G   * * * * *   MISSING SURVEY POSITION NO. (NOS. SHOULD BE CHECKED CAREFULLY, AS PROCESSING WILL CONTINUE).
L912713

* * * * *   W A R N I N G   * * * * *   MISSING SURVEY POSITION NO. (NOS. SHOULD BE CHECKED CAREFULLY, AS PROCESSING WILL CONTINUE).
L912723

* * * * *   W A R N I N G   * * * * *   MISSING SURVEY POSITION NO. (NOS. SHOULD BE CHECKED CAREFULLY, AS PROCESSING WILL CONTINUE).
L912733

* * * * *   W A R N I N G   * * * * *   MISSING SURVEY POSITION NO. (NOS. SHOULD BE CHECKED CAREFULLY, AS PROCESSING WILL CONTINUE).
L912743

* * * * *   W A R N I N G   * * * * *   MISSING SURVEY POSITION NO. (NOS. SHOULD BE CHECKED CAREFULLY, AS PROCESSING WILL CONTINUE).
L912753

* * * * *   W A R N I N G   * * * * *   MISSING SURVEY POSITION NO. (NOS. SHOULD BE CHECKED CAREFULLY, AS PROCESSING WILL CONTINUE).
L912763

* * * * *   W A R N I N G   * * * * *   MISSING SURVEY POSITION NO. (NOS. SHOULD BE CHECKED CAREFULLY, AS PROCESSING WILL CONTINUE).
L912782

SAMPLE OUTPUTS (continued)

Variable-Scale Card Listing

E 2 0 0
03/05/81
19:00:50

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WELL SURVEY SYSTEM
C A S S E T T E - R E C O R D E D S U R V E Y D A T A

BATCH 540 .... PAGE 2
O P T I O N S

W E L L L O G V A R I A B L E - S C A L E C A R D L I S T I N G

LOG NO.	S V Y	RECORD NOS. BEGIN	RECORD NOS. END	SCALE POINT NO. 1 Y READING	SCALE POINT NO. 1 ACTUAL VALUE	SCALE POINT NO. 2 Y READING	SCALE POINT NO. 2 ACTUAL VALUE	SCALE POINT NO. 3 Y READING	SCALE POINT NO. 3 ACTUAL VALUE	SCALE POINT NO. 4 Y READING	SCALE POINT NO. 4 ACTUAL VALUE	SCALE POINT NO. 5 Y READING	SCALE POINT NO. 5 ACTUAL VALUE
91271	2			0	80.0	10	82.0	20	84.0	30	86.0	40	88.0
91275	2			815	2.0	909	4.0	977	6.0	1045	8.0	1108	10.0
91275	3			1147	12.0	1236	14.0						

SAMPLE OUTPUTS (continued)

Data Listing

```
E 7 0 0                        SOUTH FLORIDA WATER MANAGEMENT DISTRICT                    BATCH 540 .... PAGE  93
03/05/81                                  WELL SURVEY SYSTEM                                            D A T A
19:00:50                 C A S S E T T E - R E C O R D E D   S U R V E Y   D A T A          WELL LOG NO. 91278

                                          D A T A   L I S T I N G
                                          -----------------------

                                     NATURAL GAMMA          NEUTRON POROSITY
                                  (SURVEY TYPE = 06)       (SURVEY TYPE = 05)
        RECORD                   --------------------     --------------------
RECORD  DEPTH                    ADJ    ORIG   ADJ         ADJ    ORIG   ADJ         CORRECTION/ERROR MESSAGE
  NO.   (FEET)                   DEPTH  SURVEY SURVEY      DEPTH  SURVEY SURVEY      ------------------------
------  ------                   ------ ------ ------      ------ ------ ------

03748   91278-LOG NO.

037[illegible]**ERROR**<000 03  0563  0376  0000]                                   >INVALID RECORD SIZE.
                 ++++++++++++++++++++++++++++++
03750    800.0                   0795.0 0665   665.       0800.0 0377   377.
03751    799.0                   0794.0 0506   506.       0799.0 0389   389.
[illegible] [illegible]          0793.0 0432   432.       0798.0 0392   392.
[illegible] [illegible]          0792.0 0479   479.       0797.0 0413   413.
03754    796.0                   0791.0 0633   633.       0796.0 0429   429.
03755    795.0                   0790.0 0493   493.       0795.0 0500   500.
03756    794.0                   0789.0 0373   373.       0794.0 0497   497.
03757    793.0                   0788.0 0349   348.       0793.0 0494   494.
03758    792.0                   0787.0 0240   240.       0792.0 0451   451.
03759    791.0                   0786.0 0194   194.       0791.0 0424   424.
[illegible] 790.0                0785.0 0168   168.       0790.0 0434   434.
03761**ERROR**<91279  0063  0678  0383  000]                                        >INVALID RECORD SIZE.
                 ++++++++++++++++++++++++++++++
03762**ERROR**<91279  0062  0677  0385  0000]                                       >INVALID LOG - NO CARD(S).
03763**ERROR**<07990  0063  0480  0405  0000]                                       >DIRECTION CHANGE ERROR.
03764**ERROR**<07980  0062  0420  0408  0000]                                       >DIRECTION CHANGE ERROR.
03765**ERROR**<07970  0062  0468  0416  0000]                                       >DIRECTION CHANGE ERROR.
03766**ERROR**<07960  0063  0655  0433  0000]                                       >DIRECTION CHANGE ERROR.
03767**ERROR**<07950  0062  0486  0506  0000]                                       >DIRECTION CHANGE ERROR.
03768**ERROR**<07940  0062  0388  0505  0000]                                       >DIRECTION CHANGE ERROR.
03769**ERROR**<07930  0062  0356  0493  0000]                                       >DIRECTION CHANGE ERROR.
03770**ERROR**<07920  0062  0253  0447  0000]                                       >DIRECTION CHANGE ERROR.
03771**ERROR**<07910  0062  0196  0422  0000]                                       >DIRECTION CHANGE ERROR.
03772**ERROR**<07900  0062  0175  0434  0000]                                       >DIRECTION CHANGE ERROR.
03773    789.0                   0784.0 0167   167.       0789.0 0392   392.
03774    788.0                   0783.0 0174   174.       0788.0 0373   373.
03775    787.0                   0782.0 0170   170.       0787.0 0364   364.
03776    786.0                   0781.0 0181   181.       0786.0 0307   307.
03777    785.0                   0780.0 0197   197.       0785.0 0277   277.
03778    784.0                   0779.0 0274   274.       0784.0 0245   245.
03779    783.0                   0778.0 0315   315.       0783.0 0236   236.
03780    782.0                   0777.0 0266   266.       0782.0 0250   250.
03781    781.0                   0776.0 0350   350.       0781.0 0248   248.
03782    780.0                   0775.0 0515   515.       0780.0 0269   269.
03783    779.0                   0774.0 0458   458.       0779.0 0284   284.
03784    778.0                   0773.0 0354   354.       0778.0 0292   292.
03785    777.0                   0772.0 0266   266.       0777.0 0343   343.
03786    776.0                   0771.0 0215   215.       0776.0 0384   384.
03787    775.0                   0770.0 0185   185.       0775.0 0348   348.
03788    774.0                   0769.0 0191   191.       0774.0 0344   344.
03789    773.0                   0768.0 0189   189.       0773.0 0369   369.
```

SAMPLE OUTPUTS (continued)

List of Survey Segments Plotted

F 2 0 0
03/05/81
19:00:50

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WELL SURVEY SYSTEM
C A S S E T T E - R E C O R D E D   S U R V E Y   D A T A

BATCH 540 .... PAGE 111
P L O T S
OUTPUT TAPE NO. 0627

L I S T   O F   S U R V E Y   S E G M E N T S   P L O T T E D

	SURVEY IDENTIFICATION					DEPTH RANGE (FEET)	
PLOT NO.	STATION I. D.	SURVEY DATE	SURVEY TYPE	(CODE)	RUN NO.	MINIMUM	MAXIMUM
1	021000043	02/11/81	6-FT LATERAL RES	(15)	01	434.00	798.00
2	021000043	02/11/81	TEMP GRADIENT	(11)	01	302.00	799.00
3	021000043	02/11/81	DELTA TEMP	(12)	01	302.00	799.00
4	021000043	02/11/81	FLOWMETER	(02)	01	300.00	742.00
5	021000043	02/11/81	FLOWMETER	(02)	02	400.00	798.00
6	021000043	02/11/81	FLOWMETER	(02)	03	383.00	798.00
7	021000043	02/11/81	CALIPER	(01)	01	8.00	797.00
8	021000043	02/11/81	FLUID RESISTVTY	(07)	01	401.00	797.00
9	021000043	02/11/81	64-IN NORMAL RES	(04)	01	429.00	797.00
10	021000043	02/11/81	SPONTANEOUS POT	(13)	01	430.20	798.20
11	021000043	02/11/81	16-IN NORMAL RES	(03)	01	431.00	799.00
12	021000043	02/11/81	NATURAL GAMMA	(06)	01	7.00	795.00
13	021000043	02/11/81	NEUTRON POROSITY	(05)	01	12.00	800.00

FORM DP-2
REV. 1/80

USER DOCUMENTATION

SYSTEM	Well Log	DATE	6/30/78
PROGRAM	E200	REVISED	2/13/81
AUTHOR	Dick Hazlett	MAX. EST. TIME	60 Minutes

SCOPE / PURPOSE: Captures geophysical well log data produced by either:

1. machine digitizing of break-point data onto paper tapes or
2. fixed-interval recording of digital values onto cassette (magnetic) tape.

INPUT:

PAPER TAPE OPTION - Paper Tape(s) (Required); *E200 Option Card (Required); Correction Card(s) (Optional)

CASSETTE TAPE OPTION - Cassette Tape (Required); *E200 Option Card (Required); Log-Survey Card(s) (1 Required); Variable-Scale Survey Card(s) (Optional); Correction Card(s) (Optional)

PROCESSING:

1. Reads and edits raw data records.
2. Converts raw data values to actual values.
3. Creates quality control plots.
4. Creates output tape in IWLAS - format (Interim Well Log Analysis System)
5. Provides correction of raw data values when required.

OUTPUT:

1. Corrected and edited listing of raw data values.
2. Listing of converted survey values.
3. Quality control plots.
4. IWLAS - format magnetic tape of converted (actual) survey values.

ERROR MESSAGES AND ACTION:

Errors are generally self-descriptive and preceded by a Severity Code (I = informative, processing continues; D = destructive, processing ceases). Fields in error are flagged immediately beneath the field image.

SAMPLE REQUISTION: (See additional documentation for 4 samples.)

REQUISITION FOR COMPUTER WORK				PRIORITY
SUBMITTED BY	TEL. NO.	LOCATION	I. D. ACCOUNT CODE	EST. TIME (MIN.)
CATEGORY ☐ SYSTEM or R/T	☐ PROGRAM DEVELOPMENT ☐ PRODUCTION RUN		JOB RUN NO.	SEQ. NO.
INPUT TAPES (RING OUT)		OUTPUT TAPES (RING IN)		TIME IN
SCRATCH TAPES (RING IN)		DISKS		
☐ PRINT	☐ PUNCH	☐ PLOT	☐ PAPER TAPE	TIME OUT
REMARKS (SPECIAL INSTRUCTIONS FOR OPERATOR)				HR. | MIN. | SEC.
FORM DP-1 Rev. 1-79 (Use BALL POINT PEN or PENCIL)				MACH. | INITIALS

RECOVERY PROCEDURE:

Rerun with no changes.

RESTRICTIONS:

Restricted to Data Management, Groundwater and Data Processing personnel.

02/13/81:pc

PROGRAM E200 PROGRAMMER: Dick Hazlett

RESTRICTION:	Data Management, Groundwater or Data Processing personnel only
PURPOSE:	To edit Well Log data
DISKS:	6501, 3001, 3006
TAPES:	LUN 30 - Paper Tape or Cassette Tape Images (Input) LUN 07 - Well Log Data Tape (Output) LUN 13 - Plot Tape (Optional Output)
CONTROL CARDS:	$JOB,S216-306,E200-RUN,60,30000,, E200 $CTO,PROGRAM USES NO MORE THAN 2 TAPES AT ONE TIME $RONL,854/6501 $RRAT,854/6501 $FET,WELL-LOG,WELL-SURVEY-PAPER-TAPE,1280 $RELEASE ALL $ALLOCATE,B1000,991231 $FET,WELL-LOG,MAINSUB-AUX $OPEN,25 $AUX,25 $E200A
CARD INPUT:	Batch control card (Required) Log-Survey Cards (Optional) Variable-Scale Survey Cards (Optional) Correction cards (Optional)
OPERATING INSTRUCTIONS:	Run as a normal job.
RECOVERY PROCEDURES:	Rerun as needed.
TIMING:	Approximately 30 minutes for large batch.
OUTPUT:	50,000 lines for a large batch.

02/13/81:pc (previous 07/24/79)