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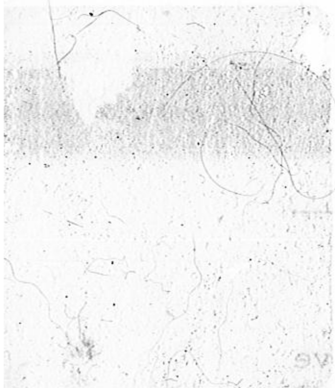
HYDROGEOLOGIC REPORT

EVALUATION OF WELL FIELD FACILITIES



Prepared for

VILLAGE OF PALM SPRINGS
PALM BEACH COUNTY, FLORIDA

Prepared by

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June 1983

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HYDROGEOLOGIC REPORT

EVALUATION OF WELL FIELD FACILITIES

For the

Village of Palm Springs, Florida

VILLAGE COUNCIL

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Charles H. Helm	Vice-Mayor
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VILLAGE MANAGER

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DIRECTOR OF UTILITIES

Robert L. Pratt

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June 1983

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ACKNOWLEDGEMENTS

This report summarizes the results of an investigation of well field facilities for the Village of Palm Springs, Florida. The project was initiated in August 1982 and was completed only with the assistance of a number of individuals. The assistance and support of Mr. Robert L. Pratt, Director of Utilities, was most valuable in keeping project objectives in focus. Also, valuable assistance with data collection and site orientation was provided by Mr. Don Miller, plant supervisor.

Thanks are due to the water plant operators, Mr. Rick Gift, Mr. Phil Rayla, and Mr. Donald Ray, for their patient assistance and guidance during flow rate studies at the Main Water Treatment Plant.

Many thanks are also extended to Mr. Lew Devillon of the Florida Department of Environmental Regulation for help in the timely issuance of well construction permits.

The writer is indebted to Ms. Marcia Olson, Ms. Marie Zwicker, Mr. Rick Bower, Mr. Luc Del Haes, and Mr. Steve Cullinan of the South Florida Water Management District for their assistance during the Aquifer Performance Test. Further thanks are offered to Ms. Olson for her assistance throughout this investigation.

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Chapter 1
INTRODUCTION

In August of 1982, the Village of Palm Springs authorized CH2M HILL to begin studies of their well field facilities.

The Village, located on Florida's southeast coastal strip, currently supplies water to customers from 10 wells located near the Main Water Treatment Plant (Main WTP) on Davis Road. These facilities, constructed in 1957, serve not only the Village of Palm Springs but also a much larger area with approximately 24,000 inhabitants at this time. Part of the current service area also includes a community known as Forest Hill Village, which at one time received its water supply from 4 wells located within the development off Kudza Road. This service area and the associated water supply facilities were obtained by the Village in 1966. Studies conducted by CH2M HILL as part of this effort address the well fields at the Main WTP and the well field at the Forest Hill Village Site (herein referred to as Forest Hill WF).

At this time, only the Main Well Field (WF) is permitted for operation by the Florida Department of Environmental Regulation (FDER) and the South Florida Water Management District (SFWMD).

The current permitted annual allocation for the Village of Palm Springs is 1,265 million gallons or 3.47 million gallons per day (mgd), average daily demand. The permit, included in Appendix A, also states that the maximum day withdrawal shall not exceed 5.544 mgd. This permit (No. 50-00036-W) issued by SFWMD October 11, 1979, expires October 11, 1989. Currently, the Forest Hill WF is not permitted for operation.

PURPOSE AND SCOPE

The purpose of this investigation is twofold:

1. To evaluate the Forest Hill Village site as to its suitability to supply water for public consumption. This evaluation includes inspection and rehabilitation of existing wells, construction of new well(s), and hydrogeologic investigations designed to determine site conditions pertaining to groundwater development.

2. To collect data for the purpose of developing programs to comply with the special conditions of the SFWMD water use permit. These programs include a well field operating and monitoring program.

The ultimate goal of this investigation is to provide hydrogeologic and water use demand data in support of a request to SFWMD for an increase in the permitted annual water use allocation.

The scope of work for this effort was divided into two parts: Part 1, referred to as Forest Hill Village site evaluation, and Part 2, referred to as Water Use Permit (WUP) compliance and assessment of potential for increased permit allocation.

Part 1--Forest Hill Village Site Evaluation--The scope of work included the following tasks:

1. Village of Palm Springs and/or a designated contractor will clear vegetation and fencing around the four wells for access.

2. CH2M HILL will prepare a set of letter specifications for pump removal, well development, and possible well construction. This set of specifications will be reviewed by the Village and sent to selected well drilling contractors capable of handling all phases of this project.

3. CH2M HILL will select the drilling contractor, subject to Village approval, and subcontract directly with him for this work.

4. The drilling contractor, under the direction of a CH2M HILL hydrogeologist, will perform the following tasks:

   A. Assess the condition of each pump as to the feasibility of using it for testing each well. If a pump can be used to test pump the well, the wellhead and discharge piping will be modified so that water levels can be measured during testing and geophysical logs (to be discussed below) can be run. If the pump cannot be used for testing, it will be removed and set aside by the contractor. The driller will then provide a test pump consisting of pump, column, engine (if needed), and discharge line, all capable of a rate of 400 to 500 gpm.

   B. The driller/CH2M HILL will sound the wells after the pump has been modified or removed and conditions such as hard or soft bottom, depth, etc., will be determined and compared with original drilling data, if possible.

C. The driller will assist and CH2M HILL will run a series of geophysical logs on each well. These logs include: natural gamma ray log to identify geologic strata; caliper log to determine well construction details, such as screen setting (if any), casing depths, and inside diameter of the bore hole (if open hole).

D. Once access to all the wells has been completed by either modification or removal of pumps and geophysical logging has been completed, short-duration (4-hour) specific capacity tests will be conducted on three of the four wells. Well No. 4 which is abandoned, will be used as an observation well but will not be tested.

During the testing, water levels will be measured by CH2M HILL in the pumping well and the other wells to determine short-term drawdown effects. Water quality samples will be taken by CH2M HILL at selected pumping rates and intervals. The wells will be sampled by thief sampler at selected depths under static and pumped conditions to determine chemical constituents and biological activity profiles. These data will be used to assess the condition of each well and determine the procedure to be followed at each well. A decision will be made by a CH2M HILL hydrogeologist as to the condition of the well. If the well is not usable it will be capped and abandoned. If it is usable it will be redeveloped.

E. Abandoned wells will be equipped with a steel cap welded to the top of the casing and will include a 3-inch-diameter pipe coupling and plug in the center of the cap. This will allow future access to the well as a monitoring point.

F. Wells which are usable will be redeveloped; the exact procedure will depend on well construction. In general, if the well is open hole it will be pressure tested to assess the casing seal, acidized with metal inhibited hydrochloric acid, and superchlorinated. This procedure will increase well efficiency by dissolving limestone and iron bacteria slime (acid) and killing any iron bacteria in the well (superchlorination). The well will then be developed by air surge, chlorinated, and capped as above. If the wells are screened they will be acidized, superchlorinated (as above), and treated with sodium hexametaphosphate. This procedure will increase the well efficiency as above; in addition any residual clay materials behind the screen will be dispersed and removed (sodium hexametaphosphate). Development will then be accomplished by horizontal jetting and air surge, after which the wells will be capped as above.

G. Wells which have been redeveloped will be retested for specific capacity as above.

5. CH2M HILL will sample adjacent canals at designated localities and depths for chemical and geological constituent profiles. This will be necessary to assess the quality of recharge water to the site.

6. CH2M HILL will compile all data collected during this effort thus far, including water quality results, test pumping data, and redevelopment information in order to make a determination of the need for additional data. Should three of the four wells be usable and no new wells were to be constructed, the need for additional data would be minimal. However, if new well sites are to be selected and wells installed at different (higher) pumping rates than the existing wells could produce, more detailed hydrogeologic data would be required. This data would be used as needed to determine well spacing, interference effects, and final pumping rates. The Village of Palm Springs would be consulted at this time, presented the data, and requested to decide the course of action to follow.

   Based on preliminary discussion with the Village, it is assumed that at least one new well would be constructed at this site. We, therefore, would proceed with data collection and the driller, under CH2M HILL direction, would perform the following tasks:

   A. A test pump will be set at one well, centrally located, for the purpose of conducting a long-term (3- to 5-day) aquifer performance test. The well will be pumped at a constant rate (between 400-500 gpm) for the duration of the test. CH2M HILL will make periodic water level measurements based on a logarithmic scale by steel surveyor tape in the pumped well. Stevens Type F continuous water level recorders will be installed by CH2M HILL on the other three wells and used to collect drawdown versus time data during this test (including recovery).

B. The driller will maintain the pump during the test, remove the pump after the test, rechlorinate the well, and reinstall the well cap.

7. Data collected during the long-term aquifer performance test will be plotted and analyzed to determine aquifer hydrogeologic characteristics. This information will in turn be used to assess the development potential of the site (total safe sustained yield), well spacing, individual well withdrawal rates, interference effects, etc. From this data one or more sites will be selected for construction of new well(s). The drilling contractor would then proceed with drilling and testing of these wells (if decided by the Village). CH2M HILL would provide hydrogeologic and construction inspection support for this effort. At this time it is not known if any, or all, existing wells could be salvaged. However, for estimating purposes it is assumed at this time that one new well would be required and two existing wells could be salvaged. To construct a new well the driller, under CH2M HILL direction, would be required to perform the following tasks:

   A. Drill and log a 4-inch pilot hole to the base of the aquifer (approximately 170 feet).

   B. Maintain open hole while CH2M HILL conducts geophysical logs (gamma ray, electric, and caliper logs).

   C. Ream pilot hole to a size 4 inches greater in diameter than the casing (size of casing will be determined from hydrogeologic data evaluation above). The depth of the reamed hole will be determined from the geologic and geophysical logs.

   D. Furnish, set, and cement casing in place.

   E. Complete the well open hole to a depth selected from the geologic and geophysical logs.

F. Determine if screen is necessary. If not, develop the well by acidization, superchlorination, and air surge. If a screen is needed install screen and develop by acidization, sodium hexametaphosphate, superchlorination, horizontal jetting, and air surge.

G. Set a pump and conduct 12-hour pumping test.

H. Remove pump and cap well as above.

8. CH2M HILL will coordinate all phases of this effort with the Village and SFWMD to ensure timely completion of this project.

9. CH2M HILL will prepare a final report which will include data collected, analysis of data, lab analysis results, hydrogeologic evaluation of the site, conclusions, and recommendations.

<u>Part 2--Water Use Permit Compliance and Assessment of Potential for Increased Permit Allocation.</u> The WUP issued on October 11, 1979, to the Village of Palm Springs by SFWMD allows for the annual withdrawal of 1,265 million gallons of groundwater.

The Village is permitted for a 3.47-mgd average day withdrawal and a 5.544-mgd maximum day withdrawal from the Main WF. The permit was issued subject to 22 special conditions, most of which are statements of regulation requiring no response from the Village. Six of the special conditions of this permit require a response (report) to SFWMD. Those special conditions and their current status are as follows:

1. Special Condition No. 4 requires that monthly treatment plant reports be sent to the District. This is currently being done by the Village.

2. Special Condition No. 6 requires the Village to submit a proposal for a report entitled "Water Shortage Conservation Program." This has been completed by the Village.

3. Special Condition No. 14 requires the Village to develop and implement a Well Field Operating Program. This has not yet been completed.

4. Special Condition No. 19 requires the Village to determine unaccounted-for distribution system losses. This is an ongoing effort at the Village.

5. Special Condition No. 21 requires the Village to install, maintain, and operate an automatic water

level recording device in an observation well at a location and depth acceptable to the District. The Village has had a device installed at one of the abandoned production wells at the water treatment plant. The District would prefer that the device be located further east.

- Special Condition No. 22 requires the Village not to withdraw water from well fields in the added service areas (Forest Hill Village, Englewood Manor, and Town of Lake Clarke Shores).

The Part 2 scope of work includes the following tasks:

1. Assess hydrologic conditions in the existing well field based on the following subtasks:

    A. Assemble existing water level recorder data obtained from the current monitoring well, recent water level, and pumping data (rate, duration) from existing wells. Plot data and assess trends and compare to original data collected at the time wells were drilled and tested.

    B. Evaluate data and develop recommendations for additional data collection.

    C. Perform field inspection of each well to determine accessibility for measuring water level and for installing necessary flow measuring devices and pressure gauges in order to determine specific capacities and pump performance.

    D. Conduct, with Village personnel support, specific capacity tests on all wells in service.

2. Integrate data collected from existing well field with the hydrogeologic assessment of the Forest Hill WF and prepare a Well Field Operating Program. This program will address pumping schedules for wells, rotation schedules, and will probably result in shifting some of the withdrawal from the existing well field to Forest Hill Village site.

3. Prepare a groundwater monitoring program for both well fields. This task will address well location and data type and collection frequency.

4. Initiate discussions with SFWMD regarding the specific aspects of the Well Field Operating Program and monitoring program requiring District input such as location of well(s), depth of well(s), shifting of some withdrawal from the existing well field to the Forest Hill Village site, etc. These discussions will also address the issue of increasing the total permitted allocation. The actual amount of the increase requested will be determined as part of the hydrogeologic studies above combined with an assessment of current water demand data provided by the Village.

5. Prepare plans and specifications for the construction of monitor well(s). This can be handled as an addition to the drilling contract at the Forest Hill Village site, if approved by the Village.

6. Provide hydrogeologic and construction inspection services during the installation of monitoring well(s).

7. Prepare reports to the District addressing Special Conditions No. 14 and 21. Prepare a report justifying an increased permit allocation and amendment to Special Condition No. 22.

This report describes existing well field facilities, presents the data collected, and outlines conclusions and recommendations pertinent to this investigation.

PROJECT LOCATION

The Village of Palm Springs is located on Florida's east coast, approximately 2 miles south of Palm Beach International Airport in Palm Beach County (see Figure 1-1). The Village is located within an area bounded (approximately) by the Lake Worth Drainage District (LWDD) canal No. 8 on the north, Military Trail on the west, Florida Mango Road on the east, and Lake Worth Road on the south. Figure 1-2 illustrates the Village limits, the service area limits, and the locations of the two well field sites upon which this investigation focused.

Part 1 of this investigation concentrated on the Forest Hill WF. This facility is located approximately 2 miles west and one-half mile north of the Main WF; the site consists of approximately 6.8 acres located at the end of Basil Drive in Township 44 South, Range 42 East, Section 14 in the community of Forest Hill Village (see Figure 1-2). The well field is located 2.75 miles east of the Sunshine State Parkway.

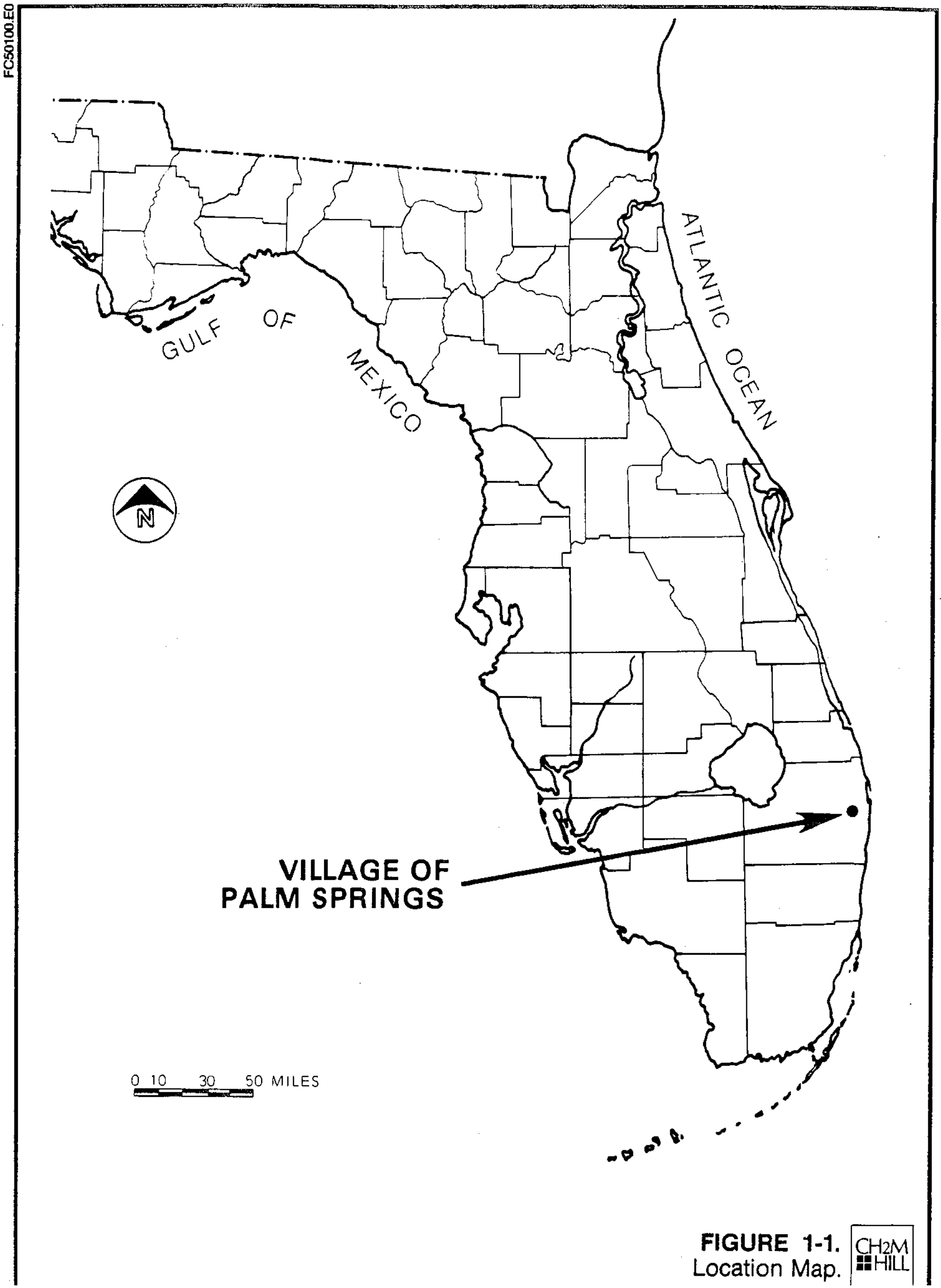

FIGURE 1-1.
Location Map.

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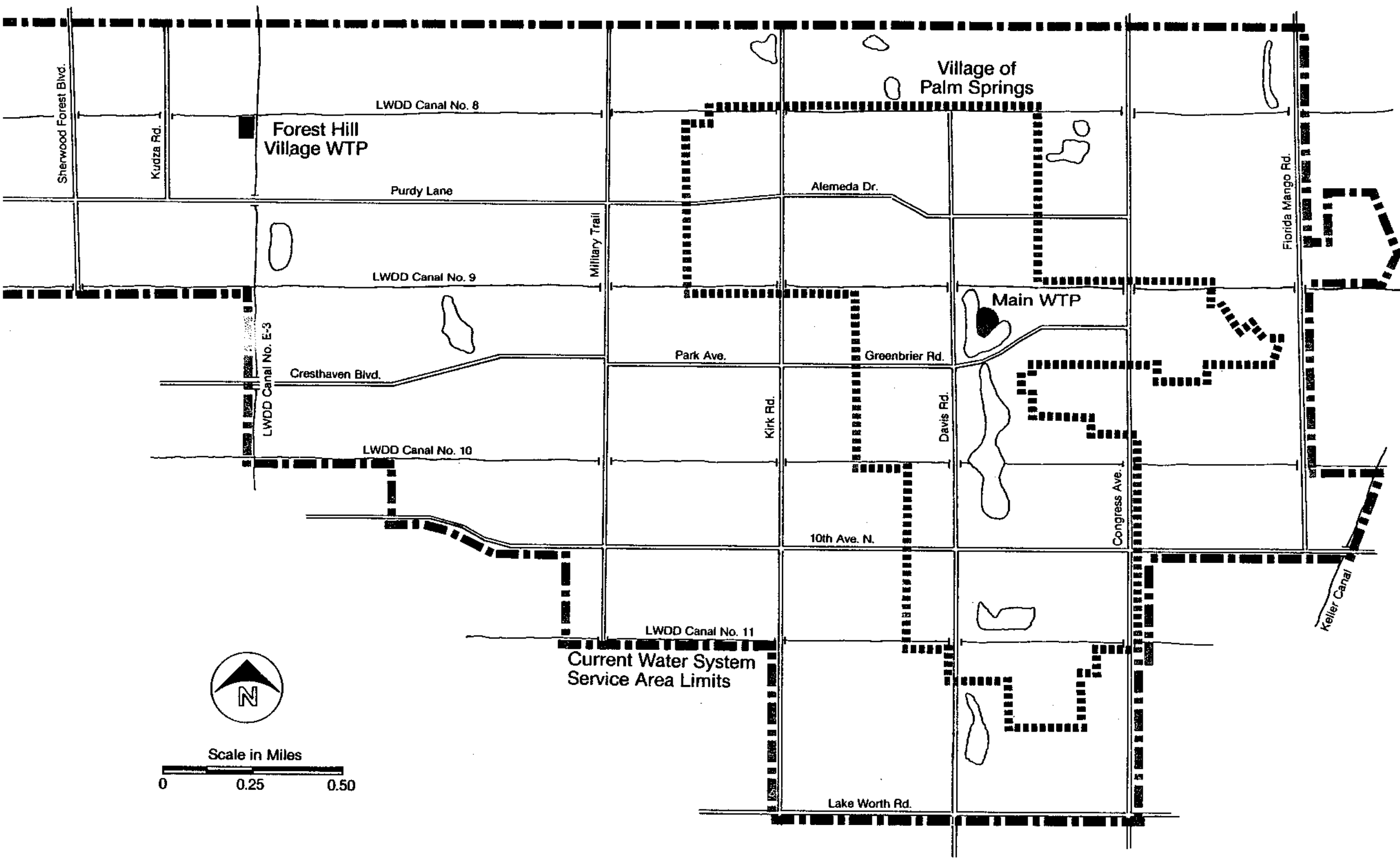

FIGURE 1-2.
Service Area of Village of Palm Springs Water System.

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Part 2 of this study included data collection at the Forest Hill WF and also the Main WF. The Main WF is located 2.84 miles west of the Intracoastal Waterway and 1.65 miles west of Interstate Highway 95 in the heart of the Village of Palm Springs near City Hall. The Main WF is divided into 3 "well fields," from an operations standpoint, which are designated Well Fields No. 1, 2, and 3 by water plant operators. Well Field No. 1 consists of 4 wells (one abandoned) located at the Main WTP on Davis Road. Well Field No. 2 consists of 4 wells located behind City Hall within the Village recreation area on Cypress Lane. Well Field No. 3 consists of 3 wells located along the bank of Canal No. 8 just east of Kirk Road. All of the wells are located within Township 44 South, Range 43 East, Section 18.

CLIMATE

The climate in the study area is humid subtropical, with proximity to the Atlantic Ocean the primary reason for high humidity. Average monthly temperatures for January and August are 60°F and 82°F, respectfully. The average annual temperature is 75°F.

Rainfall in the vicinity averages 60 inches per year. The area experienced a drought in 1981, when only 49 inches fell, but currently the area is receiving an overabundance of rainfall, already 27 inches prior to the beginning of the summer rainy season. Normally, 70 percent of the annual average rainfall (42 inches) falls during the period May through October. Should this area receive 42 inches of rainfall during this period, the total rainfall for the year could exceed 70 inches.

The normal water surplus, i.e., the difference between average annual rainfall and evapotranspiration, is estimated to be 12 inches per year, part of which infiltrates to the groundwater system and part of which discharges as runoff to the ocean via a series of drainage canals crisscrossing the area.

PHYSIOGRAPHY

The study area, located in eastern Palm Beach County, occurs entirely within the Sandy Flatlands physiographic subdivision (see Figure 1-3).

This province is bounded by the Coastal Ridge on the east and the Everglades on the west. Elevations within the flatlands range from 10 to 15 feet above mean sea level (msl). Land surface elevation at the main WF is approximately 15 ft-msl. This site is located at the approximate boundary between the Sandy Flatlands and Coastal Ridge physiographic

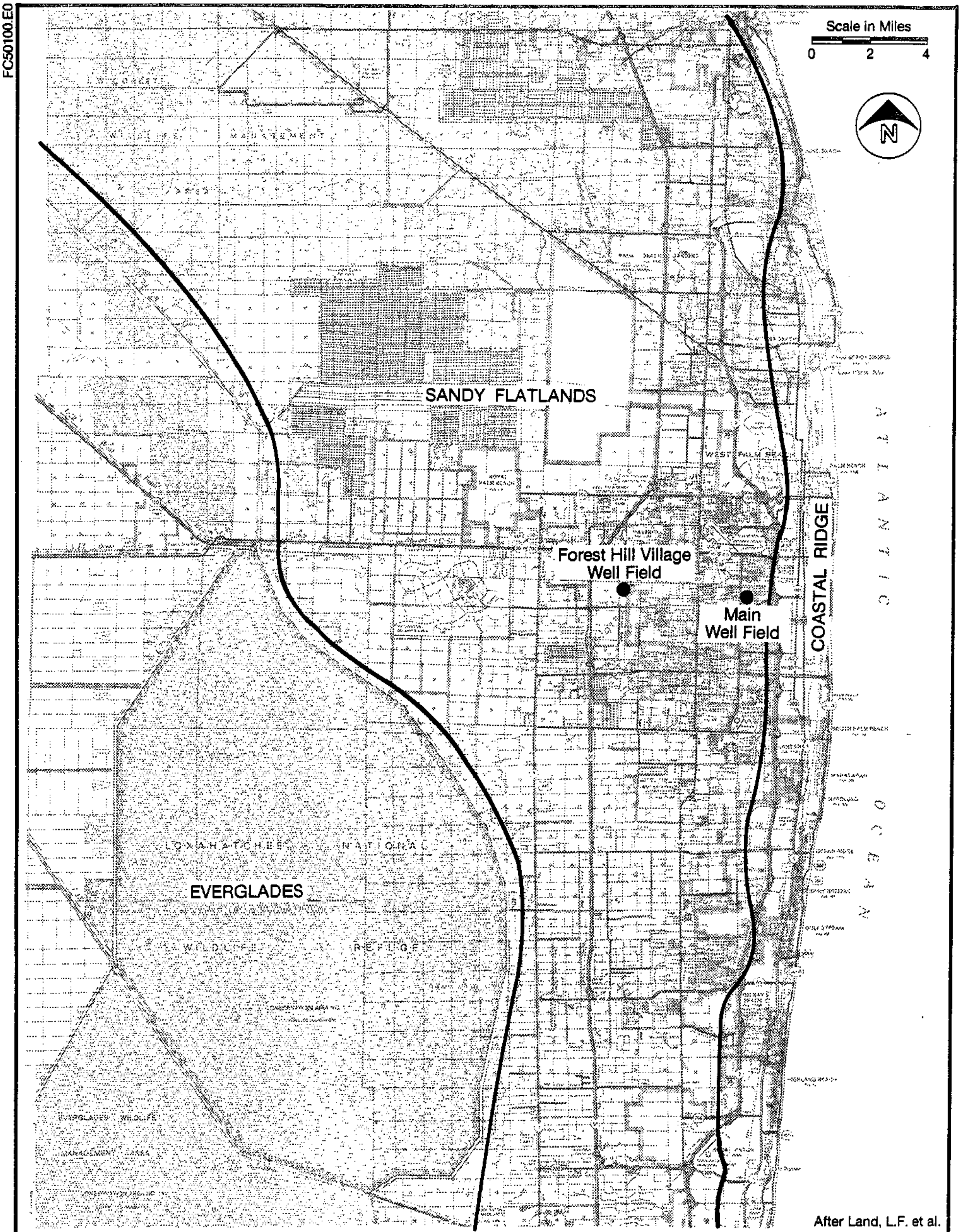

FIGURE 1-3.
Physiographic Subdivisions.

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subdivisions. Elevations at the Forest Hill WF are approximately 12 to 14 ft-msl.

GEOLOGIC SETTING

The study area occurs at the approximate eastern edge of peninsular Florida, which is actually the uppermost, exposed (above sea level) portion of a much larger extension of the North American continental mass. This geologic feature, sometimes called the Florida Plateau, has a core of igneous and metamorphic crystalline rocks similar to those underlying the Piedmont Region of the eastern United States. This core of hard, crystalline rock is covered by successive layers of soft, sedimentary rock of marine origin that is approximately 15,000 feet thick in eastern Palm Beach County. The marine deposits of Tertiary and Quaternary age are shaped into a broad, elongated dome or anticline which trends southeast. The dome has its highest elevation in Citrus County, just west of Ocala where the limestone units of marine origin outcrop at the surface. The marine deposits slope in all directions downward away from this crest.

In eastern Palm Beach County the marine deposits slope to the east at approximately 3 feet per mile, and to the south at 5 feet per mile.

Hydrologically, formations in eastern Palm Beach County can be grouped into three distinct units. The upper unit consists of formations, of Pliocene and Pleistocene age, within which the shallow aquifer occurs. The lower unit occurs within the limestone units, of Miocene, Oligocene,and Eocene age, within which the deep, artesian Floridan aquifer occurs. The middle unit consists of the Miocene age impermeable units which form the confining beds for the deep artesian aquifer and effectively separate the shallow from the Floridan aquifer.

Table 1-1 lists the geologic formations which occur in the study area and the physical and water-bearing characteristics. Figure 1-4 is a geologic map showing the areal occurrence of geologic formations exclusive of surficial sands and soils. Figure 1-5 illustrates a generalized east-west geologic cross section of the study area.

The Village of Palm Springs develops its water supply from the shallow aquifer within a permeable section of the Anastasia Formation. Wells located at the Forest Hill Village site produce water from an extremely permeable section of this formation. This section has been recognized in Palm Beach County and Broward County and has been referred to as the "Turnpike Aquifer." There are no wells

Table 1-1
GEOLOGIC FORMATIONS AND CHARACTERISTICS
IN PALM BEACH COUNTY

Series	Formation	Physical Characteristics	Water-Bearing Characteristics
Recent	Pamlico Sand	Very fine to coarse, white to black or red quartz sand. Mantles, sandy flatlands, and coastal ridge.	Small yields to domestic wells
Pleistocene	Anastasia Formation	Coquina, sand, calcareous sandstone and shell marl. Some zones contain old mangrove-swamp or salt-marsh deposits composed of fine sand, silt, clay, and organic material.	Important shallow aquifer. Fair to good yields.
	Miami Oolite	White to yellow, soft limestone. Solution riddled.	Shallow aquifer. Good yields.
	Fort Thompson Formation	Alternating marine, brackish and freshwater marls, limestones and sandstones.	Shallow aquifer. Fair yields.
Pliocene	Caloosahatchee Marl	Sandy marl, clay, silt, sand and shell beds.	Shallow aquifer. Fair yields.
	Tamiami Formation	Creamy-white limestone, and greenish-gray clay and marl.	Occasional fair yields in upper few feet. Remainder forms upper part of aquiclude.
Miocene	Hawthorn Formation	Sandy, phosphatic marl, interbedded with clay, shell, marl, silt, and sand.	Major part of aquiclude. Limited artesian water.
	Tampa Limestone	White to tan, soft to hard limestone.	Yields some artestian water. Generally top of Floridan aquifer.
Oligocene	Suwannee Limestone	Creamy, soft to hard limestone.	Part of Floridan aquifer.
	Ocala Group	White to cream, porus and cavernous to dense limestone.	Major formation in Floridan aquifer.
Eocene	Avon Park	White to cream foraminiferal limestone.	Major formation in Floridan aquifer.

Source: After L.F. Land et al.

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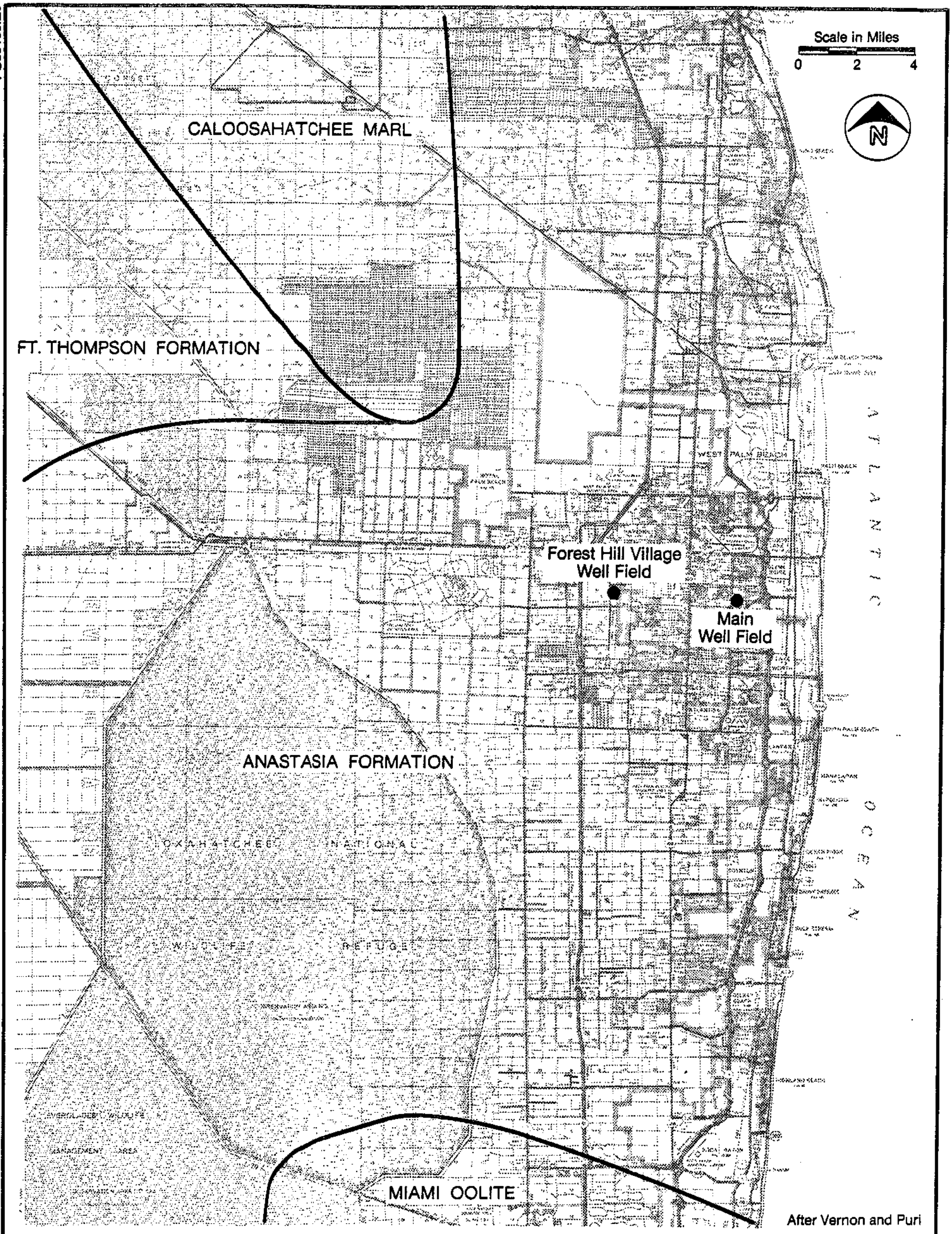

FIGURE 1-4.
Geologic Map.

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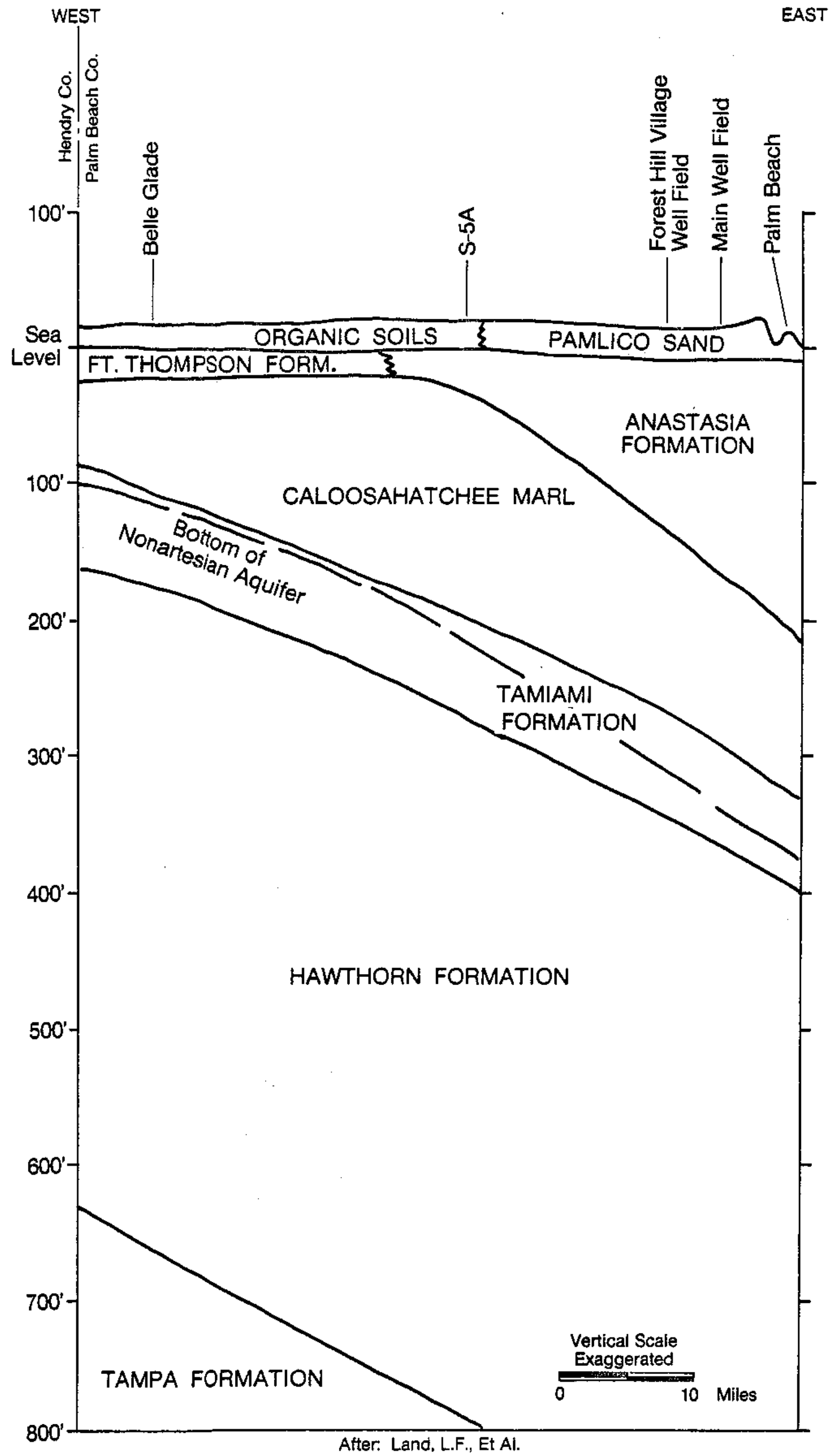

FIGURE 1-5.
Generalized Geologic Cross-Section.

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which produce potable water from the Floridan aquifer in Palm Beach County. This aquifer, an important source of freshwater in other parts of the state, is too highly mineralized (without special treatment) for public water supply in the study area. However, wells do produce water from the Floridan aquifer for irrigation and for desalination make-up.

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Chapter 2
EXISTING FACILITIES AND CURRENT OPERATING PROGRAM

MAIN WELL FIELD

The Main WF is divided for operating purposes into three individual well fields. Figure 2-1 illustrates the overall well field and the locations of the various wells.

Well Field No. 1

WF No. 1 consists of four wells completed in the shallow aquifer at the Main WTP. The wells were constructed between 1957 and 1967 and are equipped with stainless well screens. One of the wells, No. 2, constructed in 1957, has been abandoned due to bacteriologic contamination. This well, along with Well No. 1, was part of the original well field facility installed in 1957 by a then-private utility company. Under the ownership of the private utility one additional well, No. 3, was constructed at the Main WTP. In 1966, The Village of Palm Springs bought the well field and treatment facilities from the private company and in 1967 completed WF No. 1 with the installation of Well No. 4.

All of the active wells in WF No. 1 are equipped with vertical turbine, Peerless pumps set on above-grade pump bases. Initial testing indicates that Wells No. 1, 3, and 4 should produce 400, 400, and 500 gpm, respectively.

Well Field No. 2

The wells in WF No. 2 were constructed between 1969 and 1974 and are located behind City Hall within the Village recreation area. These wells, No. 5, 6, 7, and 8, are also screened wells completed in the shallow aquifer. Wells No. 5 and 6, are equipped with Deming vertical turbine pumps and are installed in below-grade pump pits. Well No. 7 is also installed in a below-grade pit and equipped with a Johnston vertical turbine pump. The reported yields for these three wells are 500 gpm each. Well No. 8 is equipped with a Courbin vertical turbine pump and is also installed in a below-grade pit, somewhat larger than the pits in which Wells No. 5, 6, and 7 are located. Well No. 8 reportedly yields 600 gpm.

Well Field No. 3

WF No. 3 consists of three wells constructed in 1977. These wells, located along the bank of LWDD canal No. 8, are completed in the shallow aquifer. Wells No. 9 and 10 are completed open-hole, whereas Well No. 11 has a well screen. All three wells are equipped with Johnson vertical turbine pumps and are installed in below-grade pump pits. Reported

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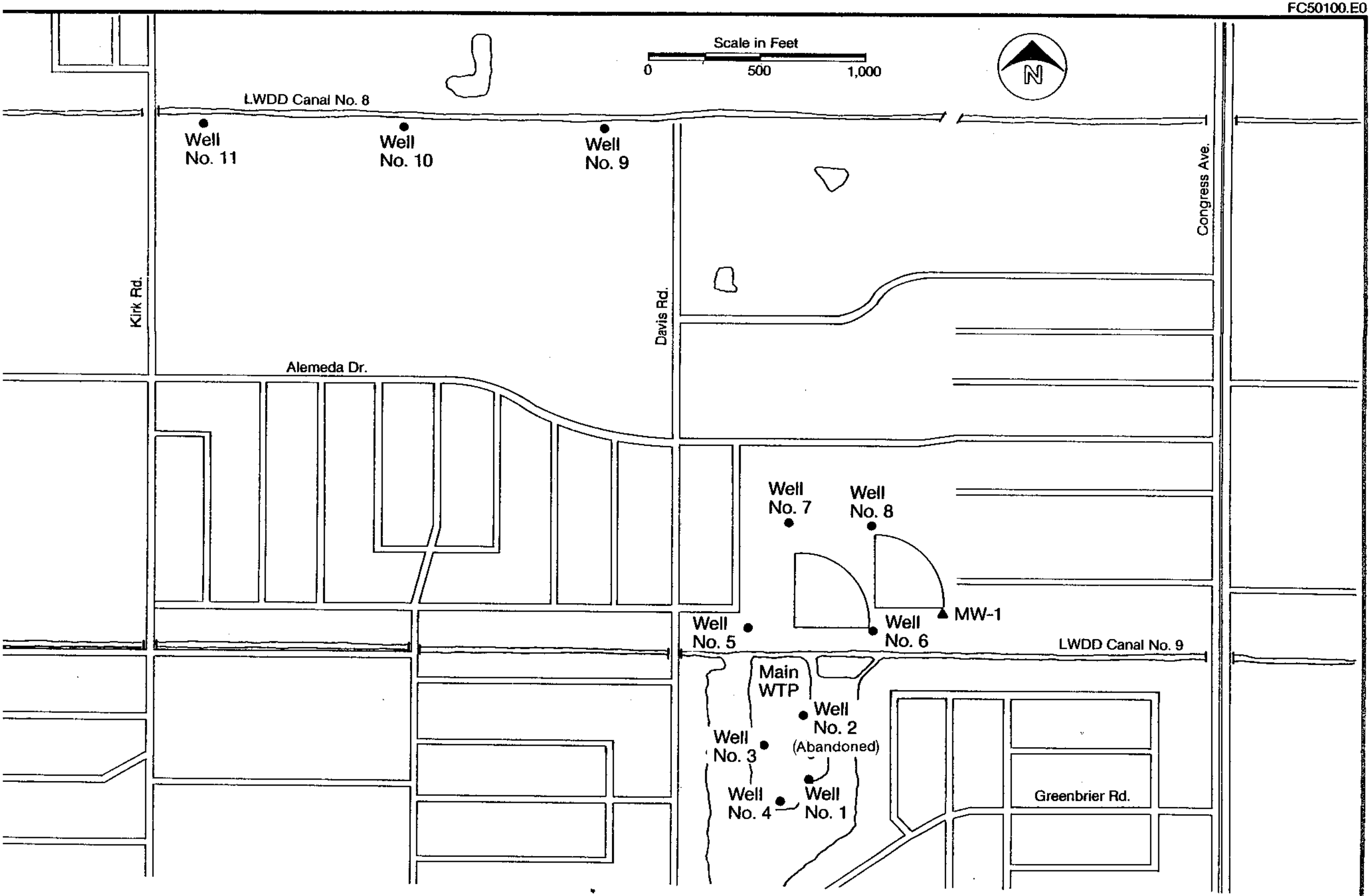

FIGURE 2-1.
Main Well Field—Well Location Map.

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yields of Wells No. 9, 10, 11 are 700 gpm each. Appendix E includes well completion reports for Wells No. 1 through 11--Main WF.

Forest Hill Well Field

The Forest Hill WF, located approximately 2 miles west of the Main WF, consists of four wells constructed in 1959 by a private utility company (see Figure 2-2). This facility, bought by the Village of Palm Springs in 1978, was decommissioned and service to the area has since been provided by the Main WF. Wells No. 1, 2, and 3 are 8-inch diameter steel-cased wells equipped with a louver-style telescoping well screen. Well No. 4 does not appear to have a screen. Geophysical logs run on this well seem to indicate that there are 90 feet of 8-inch casing and 3 feet of open hole. However, since Wells No. 1, 2, and 3, all constructed at the same time, were equipped with screens it is reasonable to assume that Well No. 4 originally had a screen. The screen could have dropped out the end of the casing if the hole were over-drilled during construction or if a cavity was encountered below the screen.

Table 2-1 provides a summary of data for existing wells at both the Main WF and Forest Hill WF. At the beginning of this project all of the Forest Hill WF wells were equipped with vertical turbine pumps, which have since been removed.

As Table 2-1 indicates, some of the older wells in the Main WF appear to be experiencing excessive drawdown. These wells, Wells No. 3, 4, and 7, also have a decreased specific capacity. Well No. 5 also experiences excessive drawdown; however, the well yield has not decreased significantly over the years. These wells appear to be good candidates for rehabilitation using a combination of chemical treatment and horizontal jetting along with air surging similar to that described in Chapter 5. The procedure used to redevelop the Forest Hill wells, along with geophysical logging, testing, and possibly borehole TV inspection, should be initiated on these wells.

CURRENT OPERATING PROCEDURE

Currently, the Main WF provides all water supply to the Village of Palm Springs service area. The Forest Hill WF is still inactive. Operation of the Main WF is as follows:

WF No. 1	On most of the time
WF No. 2	Wells rotated on such that 1 or 2 wells are on most of the time

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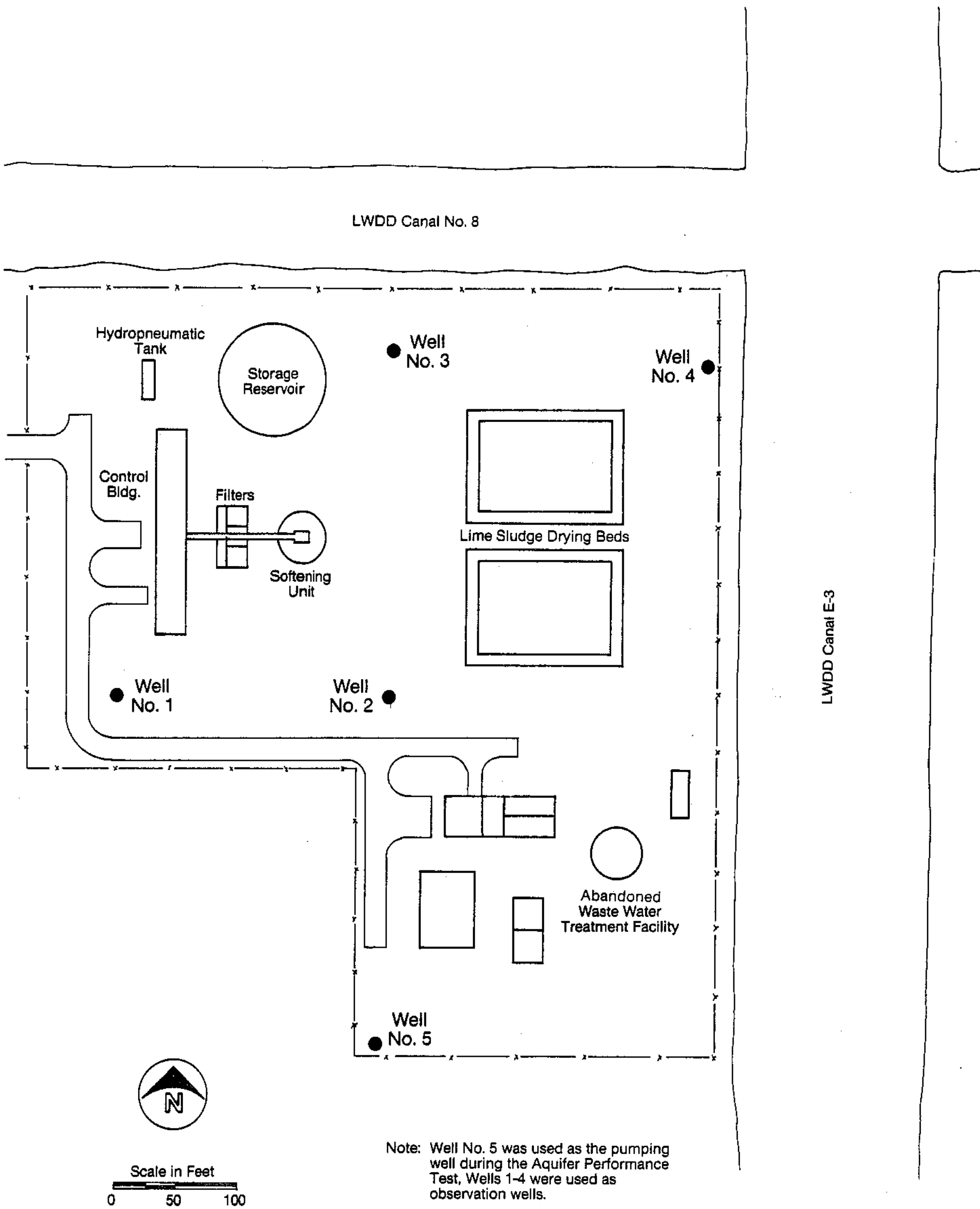

Note: Well No. 5 was used as the pumping well during the Aquifer Performance Test, Wells 1-4 were used as observation wells.

FIGURE 2-2.
Forest Hill Village Well Field—Well Location Map.

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Table 2-1
SUMMARY OF WELL DATA

	Main Well Field														
	Well Field No. 1			Well Field No. 2				Well Field No. 3			Forest Hill Well Field				
	Well No.														
Parameters	1	3[a]	4	5	6	7	8	9	10	11	1	2	3	4	5[b]
Construction Date	1957	1964	1967	1969	1969	1971	1974	1977	1977	1977	1959	1959	1959	1959	1983
Total Depth, ft	150	222	150	222	205	200	200	210	210	210	135	141	135	93[e]	170
Casing: Diameter, in	8	10	10	12	12	12	12	12	12	12	8	8	8	8	14
Depth, ft	140	182	110	183	165	161	160	104	102	104	100	113	109	90	115
Screen: Material	None	Everdur	Everdur	Everdur	Stainless	Stainless	Stainless	Open Hole	Open Hole	Stainless	Unk	Unk	Unk	Unk	Stainless
Size, Slot	—	--	40	--	--	35	40	--	--	40	Unk	Unk	Unk	Unk	80
Depth, ft	--	182	110	182	165	161	160	170	170	170	100-135	113-141	109-135	--	
Pump: Manufacturer	Peerless	Peerless	Peerless	Deming	Deming	Johnston	Courbin	Johnston	Johnston	Johnston	None	None	None	None	None
Model	8MA	10L8	10MA	15M8E1	20M8E1	GD3620	20M8E1	10DS	10DS	10DS	--	--	--	--	--
Well Yield, gpm	400	400	500	500	500	500	600	700	700	700	500	500	400	--	1,400
Static Water Level/ Date	8.4/1-83	10.0/1-83	7.3/1-83	14.5/1-83	5.3/1-83	7.2/1-83	6.2/1-83	8.0/1-83[c]	10.3/1-83	8.7/1-83	5.35/1-83	6.92/12-82	8.65/12-82	--	5.05/4-83
Pumped Water Level/ Date	27.2/1-83	40.0/1-83	34.6/1-83	41.3/1-83	22.7/1-83	42.1/1-83	28.2/1-83	10.6/1-83	17.9/1-83	18.2/1-83	14.15/1-83	10.67/12-82	11.58/12-82	--	16.96/4-83
Maximum Drawdown, ft	18.8	30.0	27.3	26.8	17.4	34.9	22.1	2.6	7.6	9.5	8.80	3.75	2.93	--	11.91
Flow Rate, gpm	325	360	480	675	585	75	715	700	700	700	620	500	400	--	1,600
Specific Capacity, gpm/ft	17	12	18(20)[d]	25(16)[d]	34(42)[d]	2	32(42)[d]	269	92(110)[d]	74	70	133	137	--	134

[a]Well No. 2, drilled in 1964, was abandoned in 1974, used as monitoring well with recorder 1980 to 1983.

[b]Well No. 5 is recently constructed Test Production Well, TPW-1.

[c]Static water level above the base of below-grade pump pit.

[d]Number in parenthesis is original specific capacity given where data available.

[e]Well logged to 93 feet, however, postulated to be deeper (see Figure 5-4). This well will be abandoned.

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WF No. 3	Used sparingly for peaking purposes, one well rotated on briefly during peak demand

The treatment plant at the Main WF includes three 2-mgd Spiractor softening units. The plant's operation requires that a 1,400-gpm flow through each Spiractor be maintained for proper operation. Too low flow will not lift the sand bed and too high flow will over-top the unit.

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The data collection effort at the Main WF was conducted to determine operating conditions at each well. To obtain this information, a time period when water demand would be low was selected. This allowed for the manipulation of pumping schedules such that approximate flow rates could be determined.

YIELD DETERMINATION

The Main WF was divided into three smaller well fields for data collection purposes. On January 12 at 12:00 noon, Wells No. 1, 3, and 4 (WF No. 1), having been discharging since approximately 5:00 that morning, were measured for pumped water level. Measurement was made using steel tape, the reference being the top of the above-grade pump base (approximately 2 feet above land surface). The measurements were taken through a small access hole which acts as a casing vent. Measurements made using this procedure represent normal operation of WF No. 1. The measured pumped water level represents the drawdown associated with each individual well plus the interference effects from the other wells. During this time, all of the remaining wells in WF No. 2 and 3 were off.

After the pumped water levels in Wells No. 1, 3, and 4 were measured, these wells were turned off for approximately 2-1/2 hours. Well No. 2, in which a Stevens Type F water level recorder had been installed tracked the operation of WF No. 1 and was checked to confirm that static water level had been reached. Water levels in Wells No. 1, 3, and 4 were then measured using the same method as above to determine static water levels. Using these two measurements, the drawdown, i.e., the difference between static and pumped water levels, was calculated for each well.

Static and pumped water levels were measured in WF No. 2 and 3 using similar techniques. Measurements were made in WF No. 2 with WF No. 1 on and off. WF No. 3 neither influences nor is influenced by WF No. 1 and 2.

None of the wells at the Main WF are equipped with individual flow measuring devices. The Main WTP is equipped with two Venturi-type measuring devices which measure flow into the plant, but these devices are not very accurate in the flow range produced by one well. In order to approximate flow rates from individual wells, various combinations of wells were turned on and the flows recorded. Table 3-1 lists the flow rate combinations used to determine individual well discharge.

Table 3-1
FLOW RATE ESTIMATION SUMMARY

Well(s) off	Well(s) on	Measured[a] Rate (gpm)	Calculated[b] Rate (gpm)
WF No. 1			
1	3,4	810	405
3	1,4	810	405
4	1,3	700	350
		Total Flow	1,160
3,4	1	325	325
1,4	3	360	360
1,3	4	480	490
		Total Flow	1,165
--	1,3,4	1,000	333
		Total Flow	1,000
WF No. 2			
6,7,8	5	400	400
5,7,8	6	570	570
5,6,8	7	0	0
5,6,7	8	250	250
		Total Flow	1,220
5	6,7,8	1,250	417
6	5,7,8	1,340	447
7	5,6,8	1,850	617
5,6	7,8	700	350
		Total Flow	1,831
--	5,6,7,8	1,925	481
		Total Flow	1,925
WF No. 3			
10,11	9	900	900
9,11	10	910	910
9,10	11	910	910
		Total Flow	2,720

Table 3-1--continued

Well(s) off	Well(s) on	Measured[a] Rate (gpm)	Calculated[b] Rate (gpm)
WF No. 3			
9	10,11	1,440	720
10	9,11	1,390	695
11	9,10	1,360	680
		Total Flow	2,095

[a]Rate measured at the control console of Main WTP.

[b]Calculated rate is flow rate per well determined by dividing the measured rate by the number of wells on.

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Table 3-1 reveals some inconsistencies in the individual flow rates for various combinations of wells on or off, due primarily to the fact that pumps operate differently depending on the head against which they must pump. In general, when more wells are on, the pipeline is under a greater pressure and each individual well pump must "work" harder to pump against that pressure. For example, note the difference between total flow calculated for WF No. 3 based on one well pumping versus total flow when two wells were on (2,720 versus 2,095 gpm). In view of such discrepancies, the analysis of flow rate per individual well must be considered an approximation rather than an accurate determination. It does, however, represent the best available data on flow rate for each well at the Main WF.

Table 3-2 presents the pertinent data which resulted from the data collection efforts at the Main WF regarding static and pumped water levels and flow rate. Also presented in Table 3-2 are original specific capacities of those wells for which this data was available.

WATER QUALITY DATA

In addition to the quantification studies described above, data collection also focused on water quality at the Main WF. During November of 1982, water samples were collected from all production wells. In addition, a composite sample of raw water was collected at the plant influent and at selected points in the finished water distribution system. Table 3-3 lists the analytical results from the production wells for temperature, pH, total dissolved solids, total hardness, iron, chloride, color, nitrate, calcium, and magnesium. Table 3-4 presents the analytical results from the raw water composite (from WF No. 1, 2, and 3) and the finished water distribution system with regard to primary drinking water standards for organics and inorganics. Table 3-5 presents the analytical results from the raw water composite and the finished water distribution system with regard to secondary drinking water standards for inorganics. Table 3-6 presents the analytical results from selected points in the finished water distribution system for trihalomethanes (THM).

Historical water quality data were also assembled as part of this data collection effort. Table 3-7 summarizes historical water quality data for each well at the Main WF. Table 3-8 lists the results of initial test pumping of Wells No. 1, 2, and 3 at Forest Hill WF.

OTHER DATA COLLECTION

Geophysical logs, including gamma ray and caliper, were run on all four wells upon completion of the initial tests. The

Table 3-2
SUMMARY OF MAIN WF DATA COLLECTION

Well No.	Flow Rate (gpm)	Static Water Level (ft)	Pumped Water Level (ft)	Maximum Drawdown (ft)	Specific Capacity 1983 (gpm/ft)	Specific Capacity Original (gpm/ft)
1	325	8.4	27.2	18.8	17	
3	360	10.0	40.0	30.0	12	
4	480	7.3	34.6	27.3	18	20(1967)
5	675	14.5	41.3	26.8	25	16(1969)
6	585	5.3	22.7	17.4	34	42(1969)
7	75	7.2	42.1	34.9	2	
8	715	6.2	28.3	22.1	32	42(1974)
9	700	8.0	10.6	2.6	269	
10	700	10.3	17.9	7.6	92	110(1977)
11	700	8.7	18.2	9.5	74	

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Table 3-3
SUMMARY OF WATER QUALITY ANALYSIS FOR MAIN WF WELLS, RAW WATER COMPOSITE, AND DISTRIBUTION SYSTEM

	Well 1	Well 3	Well 4	Well 5	Well 6	Well 7	Well 8	Well 9	Well 10	Well 11	Raw. Comp.	Distribution
Time of Collection	09:50	09:40	09:45	10:30	10:40	11:04	09:30	10:00	10:10	10:20	09:22	11:15
Temperature, °C	25	25.3	25	25	25	25	26	26	25	25	25	26
pH (field)	7.2	7.3	7.3	7.30	7.25	5.8	7.05	7.1	7.25	7.35	6.95	8.25
Total Dissolved Solids, mg/l	304	378	305	404	329	391	419	398	395	360	363	238
Total Hardness, mg/l as $CaCO_3$	164	247	188	257	203	268	280	216	261	232	227	67
Iron, mg/l	0.07	0.03	0.05	0.1	0.02	0.06	0.02	0.05	0.06	0.05	0.05	0.06
Chloride, mg/l	58	52	48	60	53	38	50	78	54	53	55	66
Color, APHA units	35	30	35	30	35	40	30	45	30	35	30	10
Nitrate, mg/l as N	<0.1	<0.1	<0.1	0.14	0.45	<0.1	0.34	<0.1	<0.1	<0.1	<0.1	<0.1
Calcium, mg/l	62	93	73	101	76	104	108	82	100	88	86	22
Magnesium, mg/l	2.2	3.5	1.1	3.2	1.9	2.4	2.7	2.7	2.7	2.9	2.9	2.9

Note: Samples collected November 18, 1982, November 30, 1982. Analysis performed by Paul R. McGinnes and Associates.

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Table 3-4
ANALYSIS OF PRIMARY ORGANICS AND INORGANICS
AT MAIN WF AND DISTRIBUTION SYSTEM

	Raw Composite	Distribution
Nitrate, mg/l as N	<0.1	<0.1
Fluoride, mg/l	0.23	0.17
Arsenic, mg/l	<0.001	<0.001
Barium, mg/l	<0.05	<0.05
Cadmium, mg/l	<0.002	<0.002
Chromium, mg/l	<0.01	<0.01
Lead, mg/l	<0.02	<0.02
Selenium, mg/l	<0.005	<0.005
Silver, mg/l	<0.001	<0.001
Mercury, mg/l	<0.00001	<0.00001
Endrin, mg/l	<0.00005	<0.00005
Lindane, mg/l	<0.000002	<0.000002
Methoxychlor, mg/l	<0.001	<0.001
Toxaphene, mg/l	<0.0005	<0.0005
2,4-D, mg/l	<0.00001	<0.0001
2,4,5-TP Silvex, mg/l	<0.0001	<0.0001

Note: Samples collected November 18, 1982.
Analysis performed by Paul R. McGinnes and Associates

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Table 3-5
ANALYSIS OF SECONDARY INORGANICS
AT MAIN WF AND DISTRIBUTION SYSTEM

	Raw Composite	Distribution
Time of Collection	09:22	11:15
Temperature, °C	25	26
pH (laboratory)	6.8	8.9
pHs (calculated)	7.2	8.2
Corrosivity	-0.4	0.7
Total Dissolved Solids, mg/l	363	238
Iron, mg/l	0.05	0.06
Sulfate, mg/l (SO_4)	13	13
Sulfides, mg/l	--	--
Hydrogen Sulfide, mg/l	0.46	<0.05
Chloride, mg/l	55	66
Sodium, mg/l	28.4	39.3
Copper, mg/l	0.006	0.028
Zinc, mg/l	0.025	0.025
Manganese, mg/l	0.009	0.004
Foaming Agents, mg/l (MBAS)	0.06	0.04
Turbidity, N.T.U.	1.9	1.2
Total Alkalinity, mg/l as $CaCO_3$	198	44

Note: Samples collected November 18, 1982. Analysis performed by Paul R. McGinnes and Associates.

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Table 3-6
ANALYSIS OF TRIHALOMETHANES AT SELECTED POINTS
IN THE DISTRIBUTION SYSTEM

Identification	Analysis Date	THM's (μg/l)	Chloroform (μg/l)	Bromodichloromethane (μg/l)	Dibromochloromethane (μg/l)	Bromoform (μg/l)
Forest Hill WF	12-1-82	367	296	57	14	<1
Lake Arbor	12-1-82	170	139	22	5	4
Cresthaven	12-1-82	387	313	61	13	<1
Pub	12-1-82	372	308	52	12	<1

Note: Sample collected November 11, 1982. Analysis performed by Paul R. McGinnes and Associates.

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Table 3-7
HISTORICAL WATER QUALITY SUMMARY--MAIN WELL FIELD

Date	TDS (mg/l)	Hardness $CaCO_3$ (mg/l)	Iron (mg/l)	Sulfate (mg/l)	Chloride (mg/l)	H_2S (mg/l)
Well No. 1						
6-22-66	488	214	0.08	180	140	--
7-25-66	868	216	0.20	12	43	--
9-21-70	352	286	0.28	10	51	0.50
8-22-72	370	246	0.27	15	38	1.00
4-12-73	422	244	0.12	17	35	0.50
8-23-73	348	216	0.18	18	31	0.50
3-22-74	342	246	0.04	8	34	0.30
8-12-75	338	232	0.02	10.5	38	0.30
8-30-74	308	240	0.07	23	37	0.40
3-25-76	276	202	0.05	14	42	0.50
11-18-82	304	164	0.07	--	58	--
Well No. 2						
7-25-66	398	286	0.08	16	48	--
9-21-70	344	334	0.08	20	45	1.0
8-22-72	416	262	0.17	12	38	0.5
4-12-73	438	270	0.18	17	42	1.0
8-23-73	310	164	0.12	16	48	0.2
3-22-74	408	250	0.08	10	39	3.0
8-30-74	184	184	0.39	17	53	0.1
Well No. 3						
7-25-66	440	294	0.42	13	65	--
8-22-72	420	260	0.47	4	53	0.1
4-12-73	456	286	0.07	2	53	0.3
8-23-73	446	296	0.16	11	56	0.2
3-22-74	462	296	0.08	0	54	0.3
8-30-74	378	290	0.49	28	43	0.3
8-12-75	350	246	0.02	18.5	48	0.2
3-25-76	208	106	0.44	13	15	0.3
11-18-82	378	247	0.03	--	52	--

Table 3-7--Continued

Date	TDS (mg/l)	Hardness $CaCO_3$ (mg/l)	Iron (mg/l)	Sulfate (mg/l)	Chloride (mg/l)	H_2S (mg/l)
Well No. 4						
8-22-72	374	234	0.11	13	32	1.0
4-12-73	412	236	0.07	15	34	1.0
8-23-73	324	220	0.09	8	35	0.5
3-22-74	354	232	0.04	10	32	0.5
8-30-74	306	238	0.11	18	33	2.0
8-12-75	308	232	0.02	8	35	0.4
3-25-76	280	218	0.07	10	32	0.4
11-18-82	305	188	0.05	--	48	--
Well No. 5						
9-21-70	376	322	0.11	2	120	0.1
8-22-72	484	288	0.31	2	120	0.1
4-12-73	472	288	0.13	5	50	1.0
8-23-73	428	296	0.09	7	53	0.5
3-22-74	462	282	0.06	5	49	0.3
3-22-74	462	282	0.06	5	49	0.3
8-30-74	420	276	0.05	10	55	0.4
8-12-75	400	286	0.09	3.5	55	0.3
3-25-76	380	284	0.05	7.0	53	0.4
11-18-82	404	257	0.01	--	60	--
Well No. 6						
9-21-70	342	294	0.04	2	57	0.5
8-22-72	402	262	0.07	10	41	0.1
4-12-73	394	246	0.04	7	53	0.1
8-23-73	362	242	0.08	9	44	0.4
3-22-74	428	242	0.10	6	42	0.3
8-30-74	360	248	0.03	15	40	0.4
8-12-75	352	244	<0.01	9	44	0.3
3-25-76	312	238	0.31	12	52	0.3
11-18-82	329	203	0.02	--	53	--

Table 3-7--Continued

Date	TDS (mg/l)	Hardness $CaCO_3$ (mg/l)	Iron (mg/l)	Sulfate (mg/l)	Chloride (mg/l)	H_2S (mg/l)
Well No. 7						
8-22-72	534	318	0.13	23	48	0.1
4-12-73	286	278	0.10	18	46	0.3
8-23-73	452	306	0.42	22	39	0.4
3-22-74	452	302	0.22	13	36	0.5
8-30-74	412	300	0.20	33	38	0.1
8-12-75	356	266	<0.01	13.5	27	0.3
3-25-76	332	266	0.03	18	24	0.3
11-18-82	391	268	0.06	--	38	--
Well No. 8						
8-12-75	408	290	0.09	14.5	36	2.0
3-25-76	400	284	0.13	12	38	0.4
11-30-82	419	280	0.02	--	50	--
Well No. 9						
11-18-82	398	216	0.05	--	78	--
Well No. 10						
11-18-82	395	261	0.06	--	54	--
Well No. 11						
11-18-82	360	232	0.05	--	53	--

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Table 3-8
SUMMARY OF INITIAL TEST PUMPING RESULTS
FOREST HILL WF

Well No.	Static Water Level (ft)	Pumped Water Level (ft)	Pumping Rate (gpm)	Maximum Drawdown (ft)	Initial Specific Capacity (gpm/ft)
1	5.8	12.85	500	7.05	71
2	6.1	28.5	450	22.4	20
3	6.5	28.0	500	21.5	23
4	-- Well No. 4 was not test pumped --				

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gamma ray log, which measures natural background gamma ray activity, was run to aid in geologic correlation among the four existing wells and any new production well(s). Caliper logs, which measure the inside diameter of the well and screen, were run to confirm well construction details. (Results of the geophysical logging effort are presented in Chapter 5).

Wells No. 1, 2, and 3 were then redeveloped using chemicals, horizontal jetting, and air surging, as discussed in detail in Chapter 5.

Once the wells were redeveloped, a borehole TV survey was conducted on Wells No. 1, 2, and 3 by Deep Venture Diving Inc. The wells were inspected onsite and a video tape was made of each well for future reference.

Finally, Wells No. 1, 2, and 3 were test pumped once again to determine the effects of redevelopment. Table 3-9 presents a summary of retest results, and Table 3-10 provides a comparison of initial versus retested specific capacities.

Hydrogeologic data collection efforts at the Forest Hill WF focused on the four existing wells (Wells No. 1-4) and one new production well (Well No. 5 initially referred to as TPW-1). The four existing wells were equipped with vertical turbine pumps at the beginning of this project. These pumps were removed by the Contractor (Drilling Services, Inc.) and discarded. The wells were sounded for total depth by the Contractor after the pumps were removed.

Once the pumps were removed, a test pump was set up at Wells No. 1, 2, and 3 in turn and a short duration (2- to 4-hour) specific capacity test was conducted on each well. Well No. 4 was not tested. Water samples were collected for analysis to identify major constituents of the groundwater at the site. Table 3-11 lists analytical results for the existing wells at Forest Hill Village WF. Appendix B includes laboratory water analysis reports for these wells.

The new well constructed at Forest Hill Village WF (Well No. 5) was the prime focus of a detailed data collection effort. The well was drilled to a depth of 265 feet below land surface, was logged (geologic and geophysical), and was the site of the Aquifer Performance Test (APT). The information collected at Well No. 5 as part of the APT formed the basis of the hydrogeologic evaluation of the Forest Hill Village site. A more complete description of the data collection methods and analysis is presented in Chapter 6.

Table 3-9
SUMMARY OF TEST PUMPING RESULTS AFTER REDEVELOPMENT
FOREST HILL WF

Well No.	Static Water Level (ft)	Pumped Water Level (ft)	Pumping Rate (gpm)	Maximum Drawdown (ft)	Initial Specific Capacity (gpm/ft)
1	5.4	11.2	495	5.8	85
2	6.9	10.7	500	3.8	132
3	8.7	11.6	402	2.9	139
4	-- Well No. 4 was not test pumped --				

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Table 3-10
COMPARISON OF INITIAL VERSUS REDEVELOPED SPECIFIC CAPACITIES
FOREST HILL WF

Well No.	Initial Specific Capacity (gpm/ft)	Redeveloped Specific Capacity (gpm/ft)	Percent Improvement
1	71	85	120
2	20	132	660
3	23	139	604

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Table 3-11
WATER QUALITY OF EXISTING WELLS
FOREST HILL WF

Parameter	Average Value	Range
Chloride	41	35-46
Fluoride	0.19	0.17-0.20
Color, APHA Units	55	45-65
Iron	0.51	0.07-0.95
Odor, threshold odor number	N.O.O.	N.O.O.
Sodium	27	24-29
Sulfate	7.2	4.6-9.8
Turbidity, NTU	3.7	0.7-6.7
Alkalinity, Phenolphthalein	0	0
Alkalinity, Total	227	224-230
Carbon Dioxide, Free	112	16-208
Bicarbonates	252	230-273
Carbonates	0.25	0.1-0.4
Hydroxides	<0.1	<0.1
Calcium	220	214-225
Magnesium	15	12-18
Total Hardness	235	232-237
Carbonate Hardness	227	224-230
Noncarbonate Hardness	7.5	7-8
Conductivity, µmhos/cm	540	522-558
pH (lab)	7.08	6.70-7.45
pH_s @ 25°C	7.15	7.13-7.17
Stability Index (2 pH_s-pH)	7.22	6.89-7.55

Table 3-11--Continued

Parameter	Average Value	Range
Saturation Index ($pH-pH_s$)	-0.08	-0.43-0.28
Aggressive Index (pH + log AH)	11.77	11.41-12.13
Total Dissolved Solids	302	293-310
Hydrogen Sulfide	0.37	0.21-0.52

Note: Values expressed as mg/l unless noted otherwise.

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At the end of the APT, a water sample was collected from Well No. 5 for analysis of primary and secondary drinking water standards. Results are presented in Table 3-12. Appendix B includes the water analysis report for Well No. 5.

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Table 3-12
WATER QUALITY ANALYSIS FROM WELL NO. 5
FOREST HILL WF

Parameter	Value
Arsenic	<0.002
Barium	<0.10
Cadmium	0.0002
Chloride	44
Chromium	0.003
Color, APHA units	40
Copper	0.010
Fluoride	0.22
Foaming Agents (MBAS)	<0.02
Iron	0.08
Lead	0.009
Manganese	0.007
Mercury	<0.0002
Nitrate as N	<0.02
Odor, threshold odor number	N.O.O.
Selenium	<0.002
Silver	<0.0005
Sodium	28
Sulfate (SO_4)	5.5
Total Dissolved Solids @ 180°C	256
Turbidity, NTU	0.2
Zinc	0.06
Alkalinity, Phenolphthalein	0.0

Table 3-12--Continued

Parameter	Value
Alkalinity, Total	225
Carbon Dioxide, Free	644
Bicarbonates	225
Carbonates	<0.1
Hydroxides	<0.1
Calcium	215
Magnesium	16
Total Hardness	231
Carbonate Hardness	225
Noncarbonate Hardness	6.0
Conductivity μmhos/cm	565
Oxygen, Dissolved (field)	mg/l O_2
pH (lab)	6.20
pH_s @ 25°C	7.16
Stability Index (2 pH_s-pH)	8.11
Saturation Index (pH-pH_s)	-0.96
Aggressive Index (pH + log AH)	10.49
Sulfide	0.22

Note: All values expressed as mg/l unless noted otherwise.

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Chapter 4
POPULATION PROJECTIONS AND WATER DEMAND

The Village of Palm Springs water service area encompasses about 3,900 acres, of which only 860 are within the Village limits. Inside the Village limits, development is nearing saturation, and the population is approaching the maximum of 12,100 persons as established in the Village Master Plan. Thus, the majority of growth in the service area will occur outside the Village limits in currently undeveloped tracts.

Between 1970 and 1980, the population of the Village proper increased 88 percent, from 4,340 to 8,166 persons, while Palm Beach County increased 64 percent. Housing units in the Village increased from about 1,300 to 4,000, or about 20 percent per year. The population per dwelling unit decreased from 3.35 in 1970 to 2.01 in 1980. In the County, that value fell from 2.47 in 1970 to 1.75 in 1980.

Two primary factors contributed to the decrease in occupancy rate: (1) during the 1970's, construction outstripped population growth; and (2) a shift in demographics to older households with generally smaller families.

The 1980 census indicates a significant change in County demographics since 1960. As a percentage of County population, the under-14 age group has decreased from 27.7 percent in 1960 to only 17.0 percent in 1980, while the over-65 age group has increased from 12.7 percent to over 23 percent. Other categories have shown little change.

EXISTING POPULATION

The 1980 census shows the Village proper to have a population of 8,166, an increase of 88 percent since 1970. Research at the University of Florida, Bureau of Economic and Business Research (BEBR) (February 1983) estimated the Village population as of April 1982 to be about 9,146, indicating a 6 percent annual growth rate. Figure 4-1 shows an approximation of the population of the Village of Palm Springs since 1970 and a projection of growth to saturation between 1986 and 1988. From this graph, the population of the Village in 1983 is estimated to be about 9,700 people.

There is no information available on the population of the outlying service area, other than projections for Palm Beach County as a whole.

The Village maintains historical water billing records detailing water consumption by user category. March 1983 records show 6,247 residential (single- and multi-family) water accounts and 11,931 actual residential units. A comparison of water consumption inside and outside the

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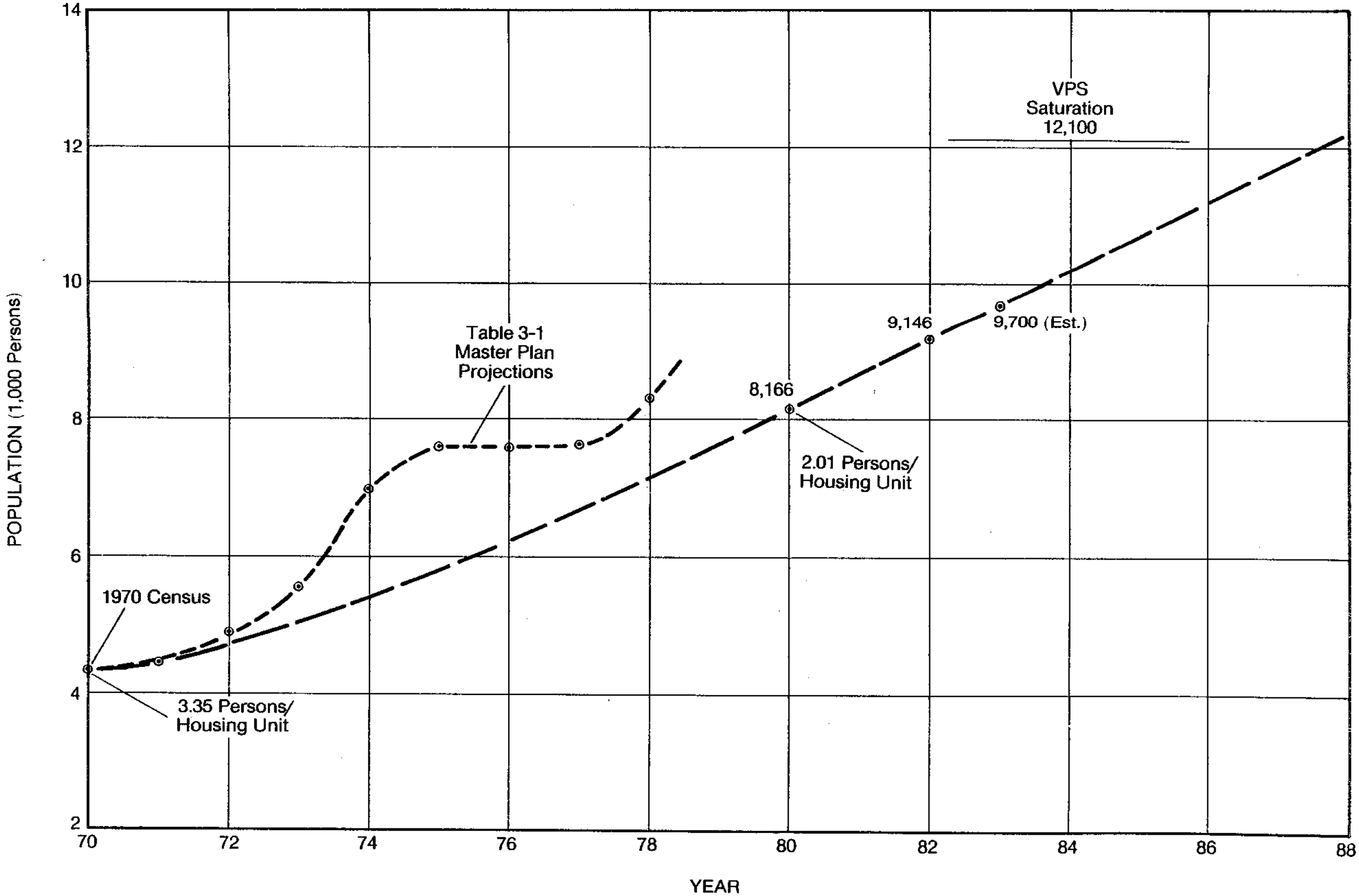

FIGURE 4-1.
Population within Village of Palm Springs.

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Village proper shows that water consumption per residential unit inside the Village was 155 gallons per day (gpd) compared to 144 gpd outside the Village limits. If it is assumed that an individual uses water at a rate of 75 gallons per capita per day (gpcd), then there are 2.07 persons per residential unit inside the Village limits (this compares well to the 1980 census datum of 2.01 persons per unit) and 1.92 persons per unit outside the Village limits. Multiplying the number of persons per unit by the number of residential units results in an estimated population of 9,460 inside the Village proper and 14,130 outside the Village limits. A comparison of the Village population from census projections (9,700) and estimates based on water use (9,460) shows a difference of only 3 percent.

The total service area population in 1983, using the census projections, is 23,830. Table 4-1 shows the development of these projections.

POPULATION PROJECTIONS

Population projections for the Village of Palm Springs service area are not available. The Village has projected that the number of water accounts will increase at a rate of about 5 percent per year through 1987, which is approximately 1,100-1,200 persons per year. Projecting this rate for a 10-year period results in a 1993 population of about 35,000 to 36,000.

The University of Florida, BEBR (February 1983) has shown that the Village proper was grown 6 percent per year since 1980. As the Village approaches saturation, this growth rate should decrease. Based on an extrapolation of the census data, the Village will reach saturation in about 1988, growing about 490 persons per year, a rate of 5 percent per year.

The rate of growth outside the Village limits is a factor of economic conditions and available utility service. The University of Florida BEBR (July 1982) projects countywide growth to range from 2 to 4 percent per year, through 1990, decreasing slightly through 1995. It is expected that the Village of Palm Springs service area will grow slightly faster than the County as a whole. Two growth rates are used in this report. Table 4-2 projects population based on a 5 percent growth rate (700 persons per year). This rate is slightly above the growth rate for the County. Table 4-3 uses an 8 percent rate (1,130 persons per year), which approximates the growth of the Village itself between the years 1970 to 1980. These rates result in a service area 1993 population ranging from 33,230 to 37,530 persons. Figure 4-2 is a graph of projected populations.

Table 4-1
1983 POPULATION ESTIMATES

	Inside Village	Outside Village	Service Area
No. Accounts:			
Single-Family	2,287	2,626	4,913
Multi-Family	1,119	215	1,334
Total	3,406	2,841	6,247
No. Residents:			
Single-Family	2,287	2,626	4,913
Multi-Family	2,284	4,734	7.018
Total	4,571	7,360	11,931
Water Consumption (million gal/month)	22.041	32.862	54.903
Consumption/Unit (gpd/unit)	155	144	
$\frac{gpd}{Unit} \div 75$ gpcd	2.07	1.92	
Est. Population	9,460	14,130	
Census Projection	9,700	14,130	23,830

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Table 4-2
POPULATION AND WATER CONSUMPTION PROJECTIONS--5% GROWTH RATE

Year	Population			Units	
	Village	Outside	Service Area	Resid.	Comm.
1983	9,700	14,130	29,830	11,348	567
1984	10,190	14,830	25,010	11,914	596
1985	10,680	15,530	26,210	12,480	624
1986	11,170	16,230	27,400	13,048	652
1987	11,660	16,930	28,590	13,614	681
1988	12,100	17,630	29,730	14,157	708
1989	12,100	18,330	30,430	14,390	725
1990	12,100	19,030	31,130	14,824	741
1991	12,100	19,730	31,830	15,157	758
1992	12,100	20,430	32,530	15,490	775
1993	12,100	21,130	33,230	15,824	791

Year	Residential (75/gpcd)	Commercial (1,800 gpd/conn)	Total (mgd)
1983	1.787	1.021	2.808
1984	1.877	1.073	2.949
1985	1.966	1.123	3.089
1986	2.055	1.174	3.229
1987	2.144	1.226	3.370
1988	2.230	1.274	3.504
1989	2.282	1.305	3.587
1990	2.335	1.334	3.669
1991	2.387	1.364	3.752
1992	2.440	1.395	3.835
1993	2.492	1.424	3.916

Assumptions

1. Population growth inside Village - 490 person/year (5%).

2. Population growth outside Village - 700 persons/year (5%).

3. Residential units = Pop ÷ 2.1 persons/unit.

4. Number of commercial connections = residential units x .05.

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Table 4-3
POPULATION AND WATER CONSUMPTION PROJECTIONS--8% GROWTH RATE

Year	Population			Units-Conn	
	Village	Outside	Area	Resid.	Comm.
1983	9,700	14,130	23,830	11,348	567
1984	10,190	15,260	25,450	12,119	606
1985	10,680	16,390	27,070	12,890	645
1986	11,170	17,520	28,690	13,662	683
1987	11,660	18,650	30,310	14,433	722
1988	12,100	19,780	31,880	15,181	759
1989	12,100	20,910	33,010	15,719	786
1990	12,100	22,040	34,140	16,257	813
1991	12,100	23,170	35,270	16,795	840
1992	12,100	24,300	36,400	17,333	867
1993	12,100	25,430	37,530	17,871	894

Year	Residential (75/gpcd)	Commercial (1,800 gpd/conn)	Total (mgd)
1983	1.787	1.021	2.808
1984	1.909	1.091	3.000
1985	2.030	1.161	3.191
1986	2.152	1.229	3.381
1987	2.273	1.300	3.573
1988	2.391	1.366	3.757
1989	2.476	1.415	3.891
1990	2.561	1.463	4.024
1991	2.645	1.512	4.157
1992	2.730	1.561	4.291
1993	2.815	1.609	4.424

Assumptions

1. Population growth inside Village - 490 person/year (5%).

2. Population growth ouside Village - 1,130 persons/year (8%).

3. Residential units = Pop ÷ 2.1 persons/unit.

4. Number of commercial connections = residential units x .05.

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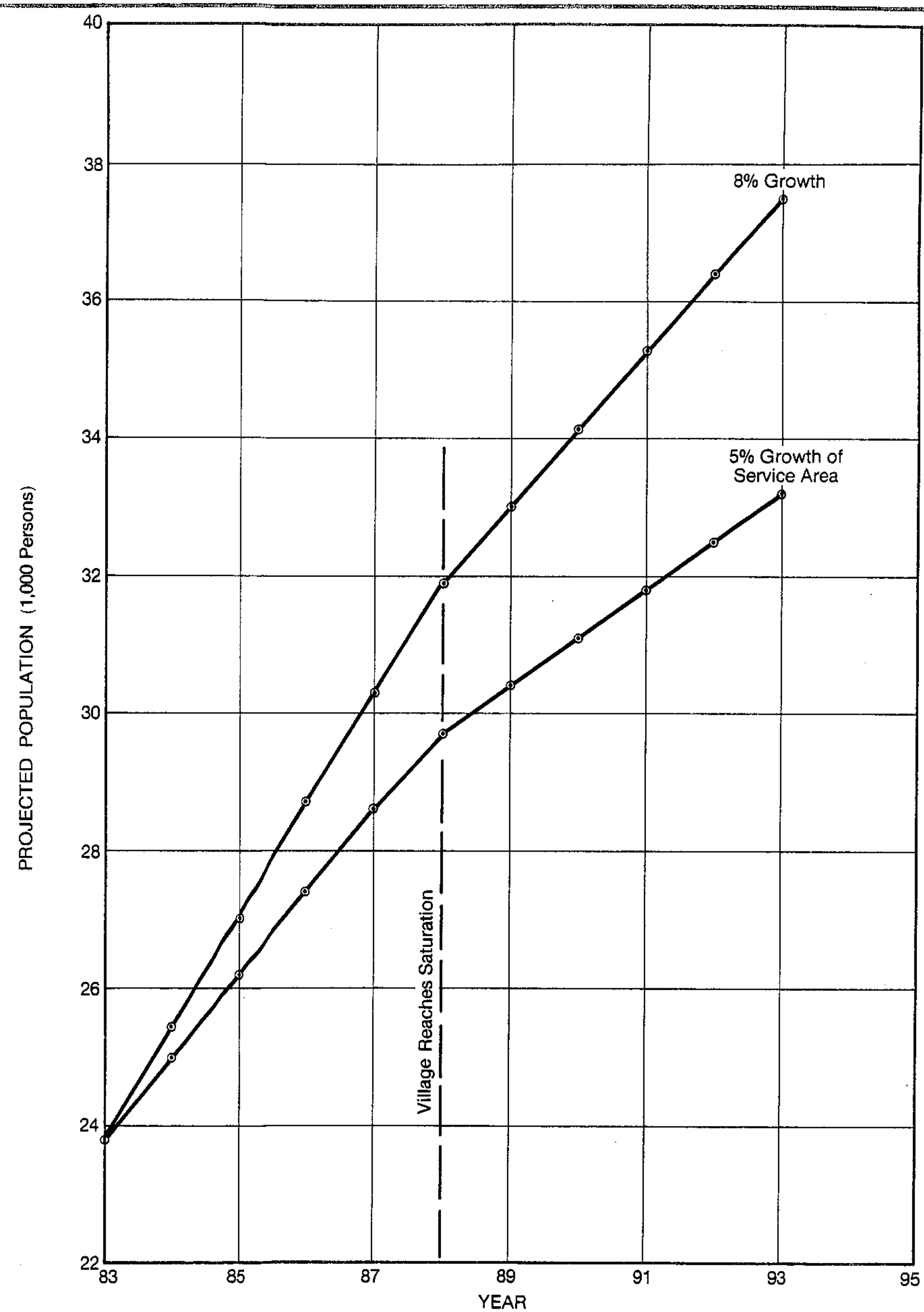

FIGURE 4-2.
Projected Population in Service Area.

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EXISTING WATER DEMAND

Water use in the service area has decreased since 1980 in spite of an increase in the number of water connections. Water use has declined 11.6 percent, from 3 mgd in 1980 to 2.7 mgd in 1982, while the number of water connections has increased from 5,369 to 6,116. Much of the decrease is due to the increase in rainfall since 1980. Adequate rainfall decreased the need for excessive lawn watering and heavy use of water.

Billing records for 1977 and 1978 were examined in reference to a previous study for the Village. Commercial users comprised about 5 percent of the total number of connections and used an average of 1,900 gpd per connection. Single-family and multi-family residential connections used about 345 and 910 gpd, respectively.

March 1983 billing data were compared to earlier data to evaluate any shifts in water use. Commercial accounts still comprised about 5 percent of all water connections and used 1,736 gallons of water per day per connection, down from 1,900 gpd. Single-family and multi-family connections used only 212 and 564 gpd, respectively. System-wide water consumption on a per connection basis was down approximately 35 percent from 1977-1978.

Table 4-4 summarizes raw water quantity data for the Main WF since 1978. Since 1979, after the Forest Hill Village service area was added to the system, an average of 2.9 mgd of raw water has been pumped from the Main WF, reaching a maximum of 3.1 mgd in 1981. Water pumpage decreased slightly in 1982, primarily as a result of increased rainfall.

PROJECTED WATER DEMAND

Residential water consumption has been projected based on a per capita demand of 75 gpd. By the year 1993 residential consumption is expected to have increased from 1.8 to between 2.5 and 2.8 mgd, as shown on Tables 4-2 and 4-3. Commercial demand has been projected using a rate of 1,800 gpd per connection. This rate was obtained from data collected as part of previous studies completed by CH2M HILL for the Village of Palm Springs (Village of Palm Springs Water Supply and Treatment Master Plan). The number of commercial connections is estimated to be 5 percent of the total number of residential accounts. On this basis, commercial demand should range between 1.4 and 1.6 mgd.

Total water demand, projected to the year 1993, is between 3.9 and 4.4 mgd. These projections, however, are dependent upon economic and climatological conditions. A significant

Table 4-4
TOTAL WELL FIELD PRODUCTION--MAIN WF
(gal x 1,000)

Date	Max.	Min.	Average	Date	Max.	Min.	Average
Jan 1978	2,182	1,489	1,850	Jan 1980	3,324	2,409	2,786
Feb	2,444	1,658	1,970	Feb	3,332	2,128	2,693
Mar	2,529	1,640	2,052	Mar	4,037	2,365	3,236
Apr	2,900	1,646	2,360	Apr	3,658	2,171	2,800
May	2,929	1,619	2,087	May	4,571	2,392	3,331
Jun	2,674	1,480	1,913	Jun	4,423	2,300	3,290
Jul	2,600	1,502	2,044	Jul	3,900	2,330	2,784
Aug	2,887	1,559	2,149	Aug	4,145	2,324	2,892
Sept	2,650	1,585	2,063	Sept	3,269	2,008	2,453
Oct	2,748	1,674	2,014	Oct	3,290	2,081	2,619
Nov	3,084	2,018	2,437	Nov	3,530	2,338	2,883
Dec	2,989	1,977	2,487	Dec	3,483	2,430	2,920
Average			2,101	Average			2,891
Jan 1979	2,641	2,024	2,381	Jan 1981	3,605	2,511	3,281
Feb	3,666	2,331	2,865	Feb	3,650	2,592	3,139
Mar	3,730	2,439	3,097	Mar	4,235	2,763	3,468
Apr	4,528	2,224	3,477	Apr	4,529	2,629	3,916
May	3,092	2,071	2,488	May	4,179	2,181	3,038
Jun	4,056	2,250	2,919	Jun	3,282	2,173	2,850
Jul	4,110	2,450	3,242	Jul	Missing		
Aug	3,547	2,295	2,819	Aug	3,530	2,113	2,623
Sept	2,993	1,710	2,400	Sept	3,125	2,318	2,598
Oct	3,385	2,073	2,665	Oct	3,529	2,421	2,965
Nov	2,892	2,004	2,530	Nov	2,583	2,365	2,994
Dec	3,084	2,144	2,658	Dec	3,551	2,697	3,090
Average			2,795	Average			3,088

Table 4-4--Continued

Date	Max.	Min.	Average	Date	Max.	Min.	Average
Jan 1982	3,555	2,490	2,979	Jan 1983	2,898	2,198	2,447
Feb	3,717	2,525	2,994	Feb	3,035	2,205	2,549
Mar	3,447	2,326	2,850	Mar	3,065	2,441	2,599
Apr	3,714	2,317	2,949				
May	3,248	2,230	2,618				
Jun	3,146	1,966	2,625				
Jul	4,365	2,476	3,338				
Aug	3,936	2,721	3,098				
Sept	3,372	2,722	2,997				
Oct	3,215	2,450	2,828				
Nov	2,854	2,031	2,549				
Dec	2,786	2,267	2,688				
Average			2,876				

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upturn in the economy coupled with a return of recent drought conditions could increase demand well beyond current projections.

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Chapter 5
WELL REHABILITATION AND CONSTRUCTION

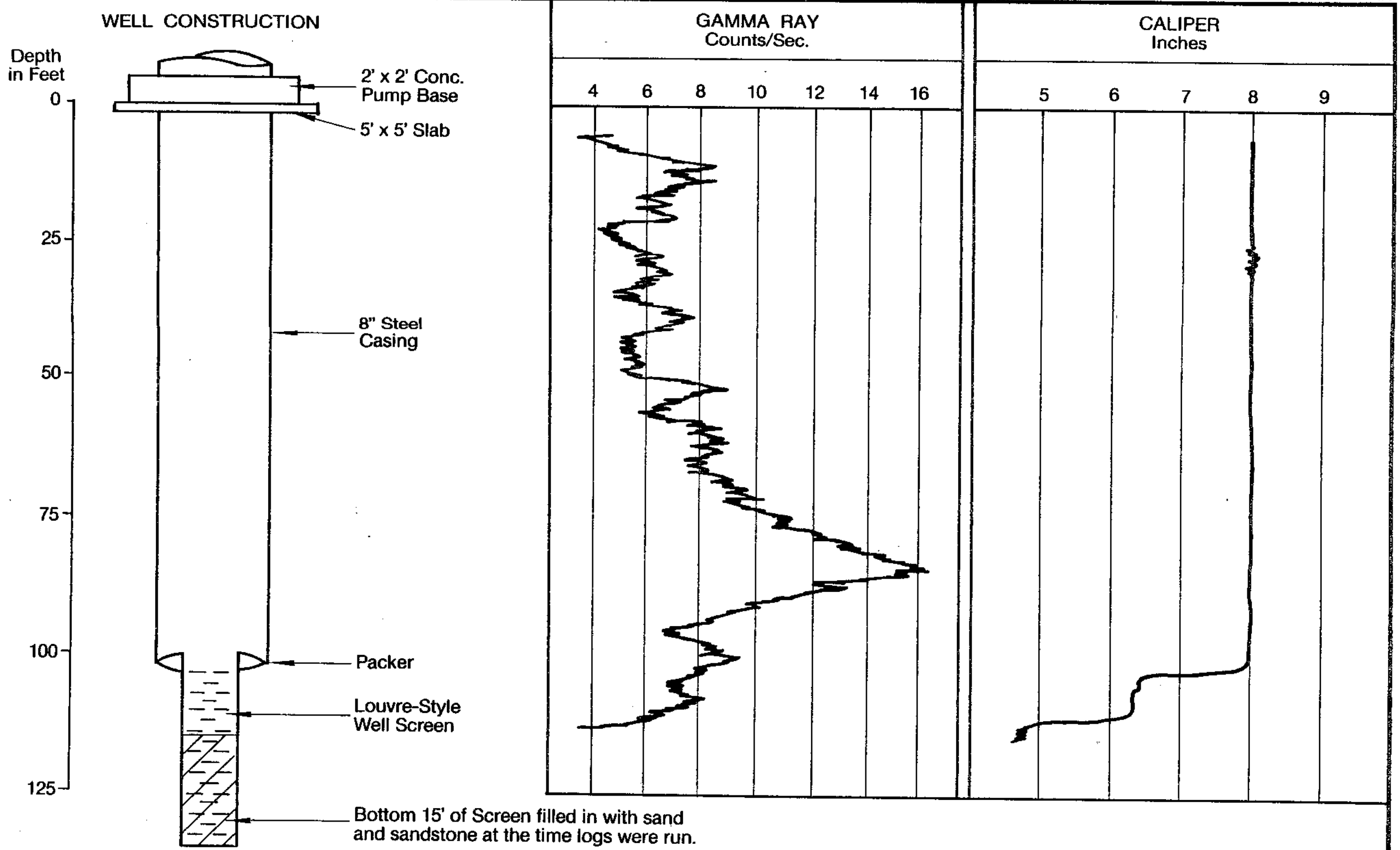
Three of the four existing wells at the Forest Hill Village site appeared to be candidates for rehabilitation. The fourth, Well No. 4, was abandoned. Figures 5-1 through 5-4 illustrate the results of geophysical logging of the existing wells. This information plus the borehole TV survey formed the basis for the determination of construction details and the decision to rehabilitate or abandon each well.

WELL REHABILITATION

Well rehabilitation consisted of chemical treatment with a 100-pound (dry weight) dose of sodium hexametaphosphate, also known as polyphosphate. Polyphosphates work in much the same way as detergents in accomplishing a cleaning action except that the solution does not foam or form suds. Foaming is not desired in well cleaning because it interferes with development. Polyphosphates also act as a dispersing agent for very fine-grained (clay, silt) materials that would otherwise bind together, held by molecular attraction. The large, monovalent (single ionic charge) sodium ion in solution tends to replace smaller, divalent ions (such as calcium) and thus split apart the individual grains so they can be developed out of the formation by mechanical agitation. As the quantity of fine grained material removed from the vicinity of the well bore increases, the material becomes more permeable and the well becomes more efficient.

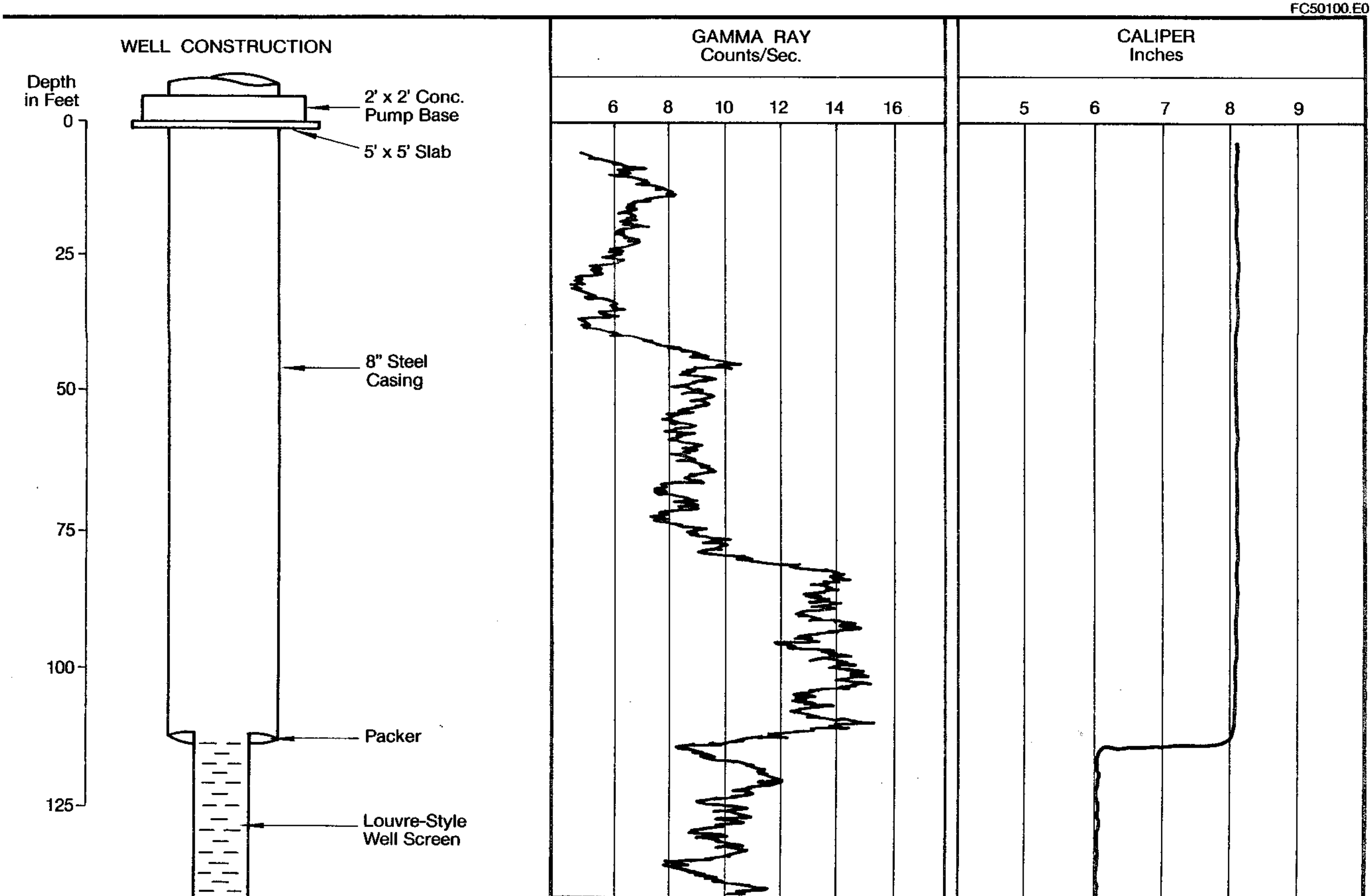
This chemical treatment is achieved by mixing 100 pounds (dry weight) of sodium hexametaphosphate with 600 gallons of freshwater and pumping into the screened section of the well with a horizontal jetting tool (described below). The solution was allowed to remain in the well overnight (at least 14 hours) and was developed out by airlifting. This treatment was repeated twice for each well during the development procedure.

The existing wells, all of which are screened, were redeveloped using a horizontal jetting tool in combination with air surging. The jetting tool consisted of a device with small diameter (approximately 1/8-inch) holes drilled around a short, 1-1/2-foot-long piece of pipe, slightly smaller in outside diameter than the inside diameter of the well screen. This tool was attached to 2-inch threaded pipe and connected to a moveable rotary overhead motor. This allowed the tool to be rotated continuously and moved up and down in the screen section. Jetting was accomplished by pumping clear water from a tank, using two high service diaphragm pumps, through the 2-inch pipe to the jetting tool. The



Note: Unable to determine if wells were drilled rotary or cable tool.

FIGURE 5-1.
Well No. 1 Geophysical Logs and Construction Details.



Note: Unable to determine if wells were drilled rotary or cable tool.

FIGURE 5-2.
Well No. 2 Geophysical Logs and Construction Details.

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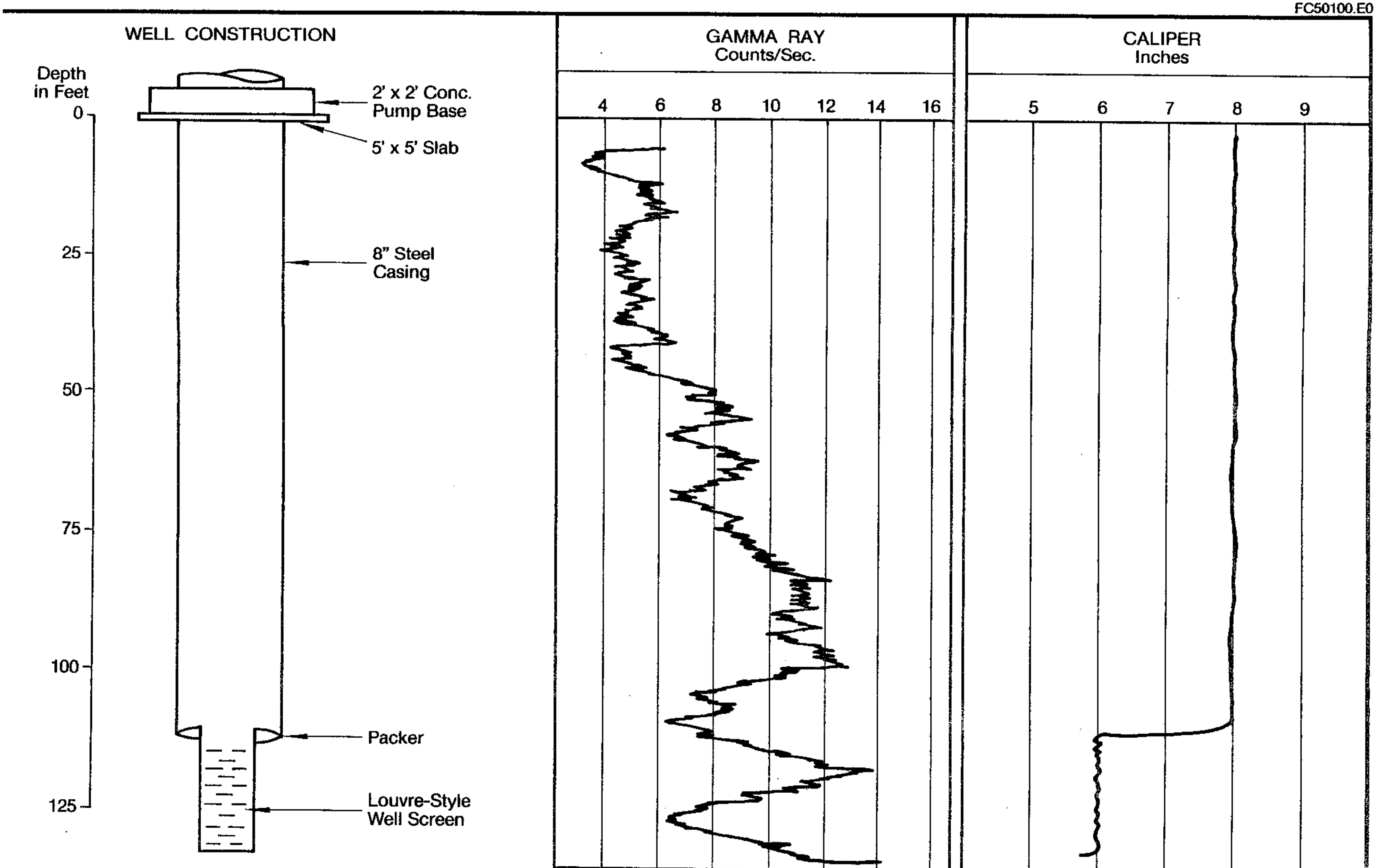

Note: Unable to determine if wells were drilled rotary or cable tool.

FIGURE 5-3.
Well No. 3 Geophysical Logs and Construction Details.

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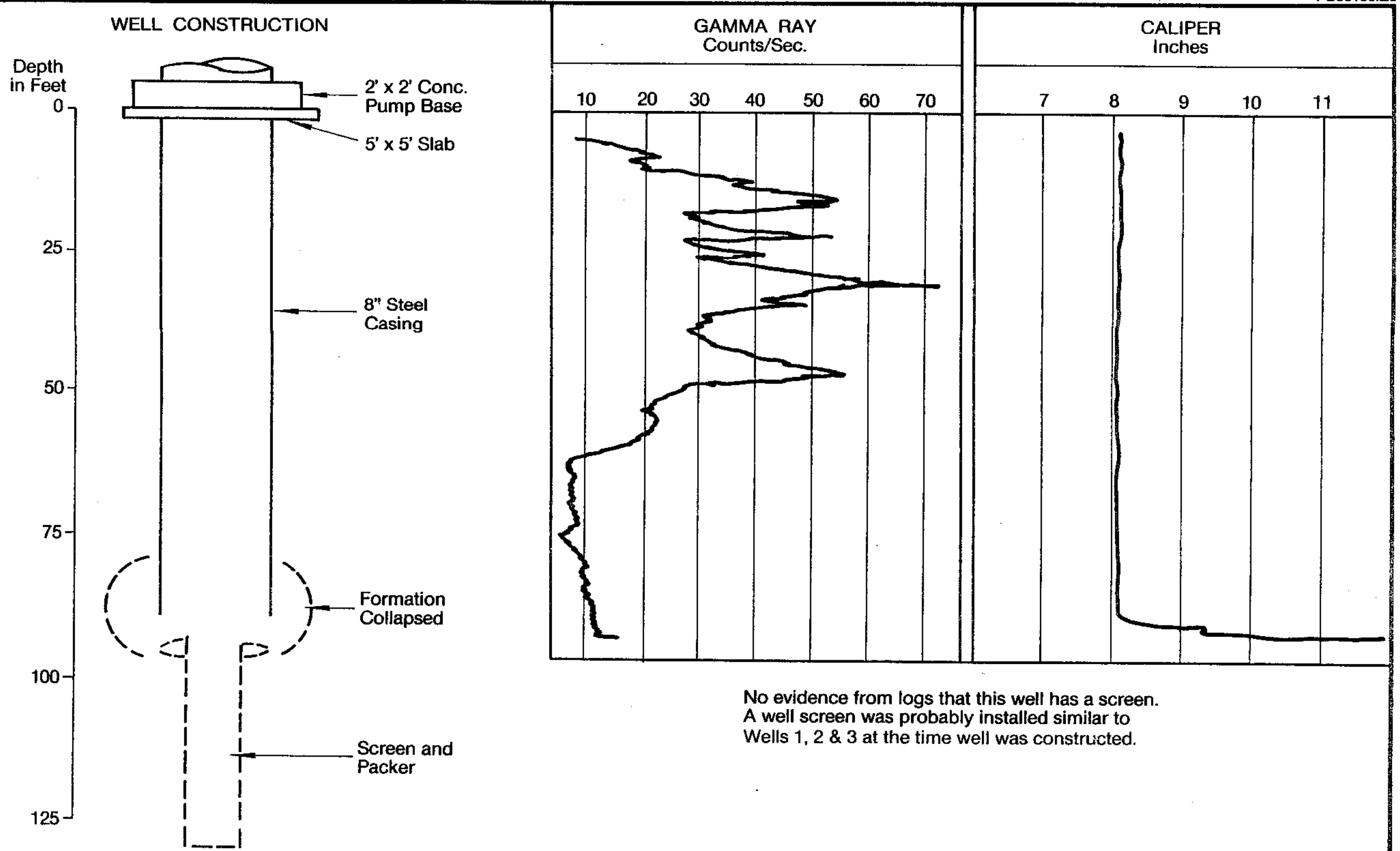

Note: Unable to determine if wells were drilled rotary or cable tool.

No evidence from logs that this well has a screen. A well screen was probably installed similar to Wells 1, 2 & 3 at the time well was constructed.

FIGURE 5-4.
Well No. 4 Geophysical Logs and Construction Details.

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tool was then slowly rotated and slowly moved up then back down in the screen section.

Concurrently with jetting, the well was airlifted (pumped with compressed air). Air lifting was accomplished with a 200-cfm air compressor which was used to surge the well during development.

Each well was also developed by air surging alone. This was accomplished by removing the jetting tool from the 2-inch line and disconnecting the diaphragm pumps. The 2-inch line was then connected to the air compressor and the well surged with air. The end of the 2-inch pipe was raised up and down in the screen section while surging. This combination of development techniques was used to break up and remove encrustation from the screen and to remove any "fines" from the formation surrounding the well bore. As discussed in Chapter 3, specific capacity tests were conducted on Wells 1, 2, and 3 prior to and after redevelopment.

This was done not only to assess the original condition of each well and to provide design criteria for pump selection, but also to determine the effectiveness of well rehabilitation. After the rehabilitation, Wells 1, 2, and 3 were chlorinated and all four wells were equipped with threaded 8-inch cast iron caps.

WELL CONSTRUCTION

Along with well rehabilitation, two wells were constructed during this project. One well (MW-1), was constructed opposite the Village maintenance building behind City Hall (see Figure 2-1). This well was constructed as a monitoring well and was equipped with a Stevens Type F continuous water level recorder (required as special condition No. 21 of Water Use Permit No. 50-00036-W issued by SFWMD). The other well constructed during this project was a test production well (Well No. 5) installed at the Forest Hill Village site.

MW-1 Construction and Testing

Monitoring Well No. 1 (MW-1) was constructed to provide SFWMD with data on production zone water level decline in the vicinity of the Main WF. When the WUP was issued in 1979, one of the abandoned production wells (Well No. 2) at the Main WTP was converted to a monitoring well and equipped with a Stevens recorder to satisfy Special Condition No. 21. Data obtained from this installation, however, proved to be difficult if not impossible to interpret, due to interference from the other production wells. The recorder chart provided a record of well field use rather than the data required on water level trends in the production zone. MW-1 was sited at the east side of the well field and as far as practical from other production wells. This location also puts the monitoring well between the saltwater to the east and the well field, although the primary function of the well is to track water level fluctuations.

MW-1 was constructed by drilling a 4-inch pilot hole to a depth of 195 feet bls using mud-rotary drilling techniques. Construction was advanced by drilling 5 feet and circulating drilling fluid until the hole was cleared of cuttings. A formation sample was collected and retained. The hole was advanced in 5 foot increments to the total depth. Once the pilot hole was completed and the drilling tools removed from the well, a series of geophysical logs were run to aid in the final design of the well. A caliper log, which measures the inside diameter of the borehole, was run to identify any cavernous zones or places where excessive "wash out" of the unconsolidated formation occurred. The log was featureless, showing that the hole was drilled to gauge and remained that way during logging.

A gamma ray log, which measures the natural emission of gamma rays from formation materials (similar to a geiger counter), was run to aid in the identification of geologic strata and for possible correlation among wells. This log indicated different gamma ray activity for each stratum and showed a particularly high peak at approximately 125 feet bls.

High gamma ray activity is usually associated with fine-grained materials (clays and silts) which in turn are associated with low permeability. Therefore, in general, low gamma ray activity (low count rate) is usually associated with higher permeability.

Electric logs, both self-potential (SP) and resistivity, were also run on the mud-filled open borehole. The SP log measures the electrical potential between the moving electrode in the borehole and the ground electrode placed at the surface. The resistivity log measures the electrical resistivity of the fluid in the vicinity of the moving tool. In general, higher resistivity is associated with freshwater-filled, permeable strata.

Upon completion of geophysical logging, the results were compared to the formation samples and both were used to complete the final well design. The well was completed by reaming the 5-inch hole to 11 inches to a depth of 162 feet bls. Six-inch diameter steel casing was then installed to a depth of 162 feet with 3 feet above land surface (162 feet bls + 3 feet bls = 165 feet total). The casing was then cemented in place by pumping neat cement through a 2-inch pipe installed inside the 6-inch casing through a Dresser coupling to a depth of 160 feet bls. The cement was allowed to cure for 24 hours and the well was completed open hole by drilling out the cement plug in the bottom and continuing a nominal 6-inch hole to a depth of 195 feet bls.

The well was developed for 4 hours by air lifting and a 4-hour specific capacity test was completed; the well was then capped. A one-half inch steel plate and an aluminum housing were installed on the well and the Stevens recorder was transferred from Well No. 2 to MW-1. Figure 5-5 illustrates the well construction details, geologic and geophysical logs, and other pertinent data obtained from MW-1.

Well No. 5 Construction and Testing

The test-production well installed at the Forest Hill Village site was constructed using a technique similar to the one described above. The well, drilled mud rotary, was preceded by a 5-inch pilot hole drilled to 260 feet bls in 5-foot intervals. The borehole was maintained with mud and geophysical logs run (electric and gamma ray). The 5-inch hole was reamed to 115 feet bls to a diameter of 20 inches, after a 24-inch pit casing was set to a depth of 20 feet. A 14-inch steel casing was set to a depth of 115 ft bls (1-1/2 feet above land surface) and cemented in place as described above. The cement was allowed to cure for 24 hours and the hole completed to a depth of 170 ft bls. It was hoped that this well could be completed open hole. Therefore after the nominal 14-inch hole was drilled to 170 ft bls, an attempt was made to develop the open hole section by air surging. However, the open hole could not be maintained and plans were made to install a screen and gravel pack to complete the well. The well was finished by installing an 8-inch telescoping Johnson stainless steel well screen (80 slot) centered inside the 14-inch casing. The screened intervals selected from the logs were 123-133 and 140-170 feet bls. The well was developed using chemical treatment (sodium hexametaphosphate - 2 times) and a combination of horizontal jetting and air surge similar to the procedure used on Forest Hill Wells No. 1, 2, and 3. Figure 5-6 illustrates the well construction details and geophysical logs for Well No. 5.

Once the development was completed, this well was used as the pumping well in conducting a detailed Aquifer Performance Test (APT) which is the basis for the hydrogeologic evaluation of this site (details given in Chapter 6).

After testing, Well No. 5 was chlorinated and capped for future use.

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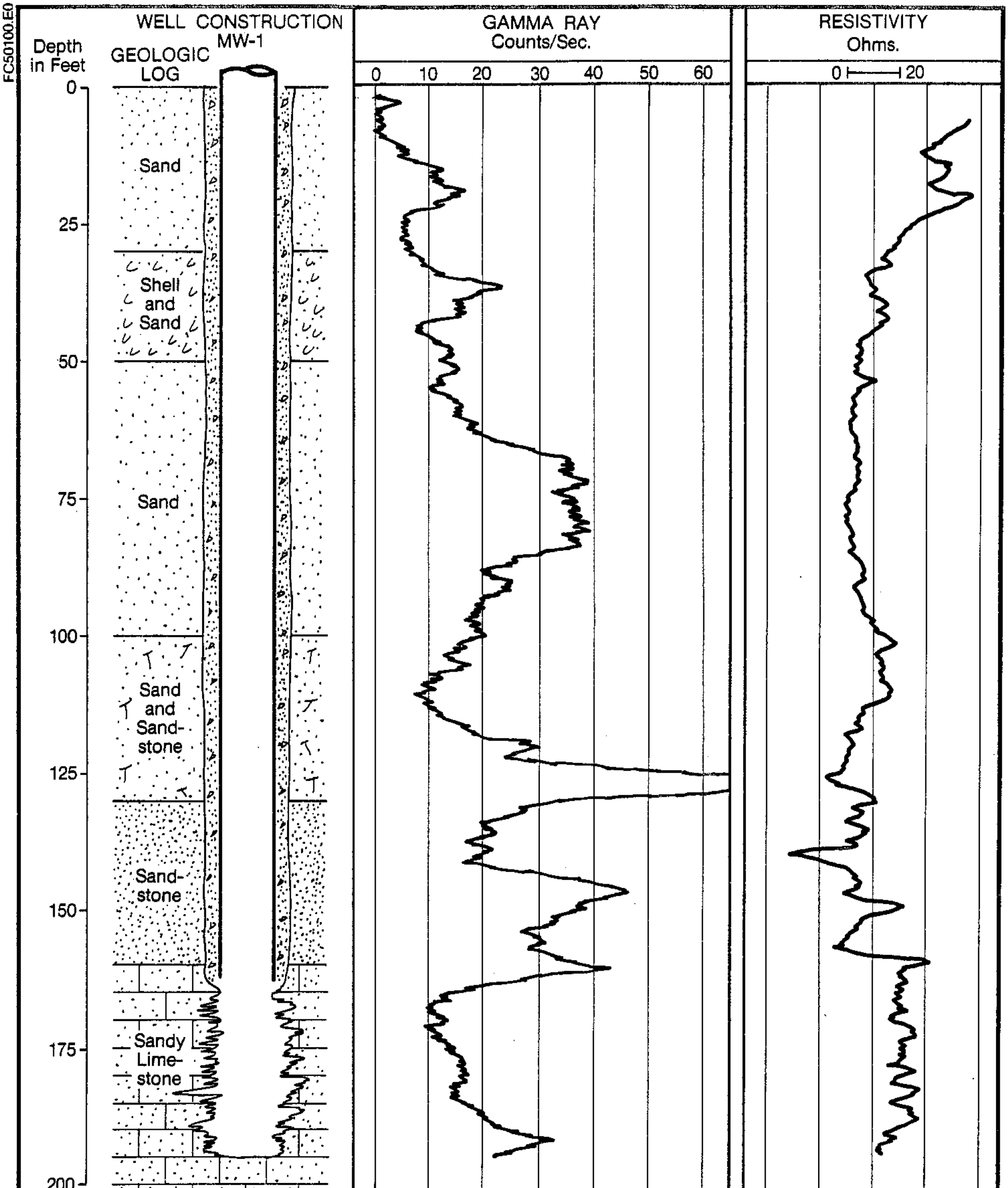

Well No. MW-1
Date Completed 12/20/82
Casing Diameter 6 in.
Casing Depth 162 ft.
Open Hole 162-195 ft.

Final Pumping Test 12/20/82
Duration 2 hr
Pumping Rate 75 gpm
Static Water Level 15.75 ft
Maximum Drawdown 6.35 ft
Specific Capacity 12 gpm/ft

FIGURE 5-5.
Well Completion Report—MW-1.

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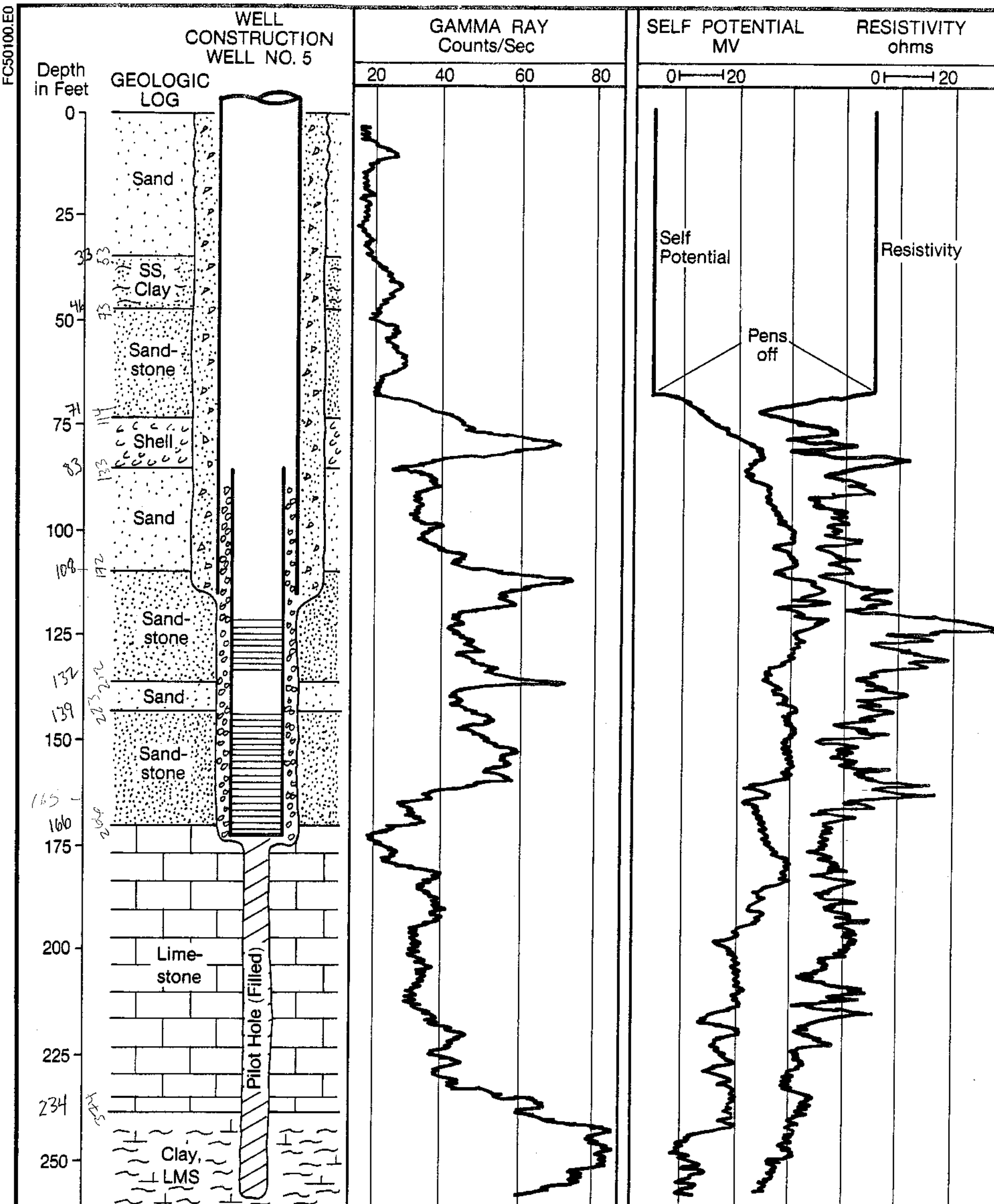

Well No. 5	Screen Diameter 8 in TS	Pumping Rate 1,600 gpm
Date Completed 3/25/83	Screen Slot Size 80	Static Water Level 5.05 ft
Casing Diameter 14 in	Gravel Pack Size ⅛ in x ¼ in	Maximum Drawdown 11.92 ft
Casing Depth 115 ft	Final Pumping Test 4/13 to 4/15, 1983	Specific Capacity 134 gpm/ft
Screen Section 123-133; 140-170	Duration 48 hr	

Note: SS is Sandstone.

FIGURE 5-6.
Well Completion Report—Well No. 5

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Chapter 6
HYDROGEOLOGY

Three major aquifers occur within Palm Beach County which are of significance to groundwater development. The deepest, the Floridan aquifer, occurs under artesian conditions and is developed within the limestones and dolomitic limestones of Eocene age. The top of the Floridan aquifer occurs at a depth of 900 to 1,100 feet bls in eastern Palm Beach County. The Floridan aquifer, though an important source of potable water throughout much of Florida, contains water too highly mineralized for most purposes in Palm Beach County. The upper Floridan aquifer is tapped in some places as a source of citrus irrigation water and desalination feed water for potable use. In addition, the highly transmissive lower Floridan aquifer, which contains water with salinity equal to or greater than that of seawater, is used for municipal sewage and chemical waste disposal via injection wells in Palm Beach County.

In the extreme southern part of the County, the highly transmissive Biscayne aquifer terminates in the vicinity of Boca Raton. This aquifer, occurring under unconfined conditions, supplies most of the potable water to the metropolitan south Florida area. The aquifer extends from the shallow, surficial sands to a depth of approximately 400 feet bls. Most of the large, municipal well fields in south Florida, including those serving Miami, Fort Lauderdale, Pompano Beach, Deerfield Beach, and Boca Raton, develop potable water supplies from the Biscayne aquifer.

Throughout most of eastern Palm Beach County, the shallow non-artesian aquifer provides most of the potable water. This aquifer, occurring under unconfined conditions, is developed within shallow sand, sandstone, and shell of the Anastasia Formation and the Caloosahatchee marl (see Figures 1-4 and 1-5). The aquifer is estimated to be at least 250 feet thick near the coast, thinning to less than 100 feet near the center and then terminating in the western part of the County. The water-producing formations have been described as solution-riddled strata with cavities which subsequently became filled with sand.

The principal source of recharge to this aquifer is local rainfall. Various freshwater canals which transmit stored water from conservation areas in the western part of the County are an important recharge mechanism in Palm Beach County. Since the aquifer generally occurs under unconfined conditions, water level fluctuations in response to climatologic changes are common.

Until recently, it was thought that the shallow, non-artesian aquifer became thinner and less productive moving from south to north and from east to west. Previous investigations indicated that aquifer transmissivity within the County ranged from a high at Boca Raton of 51,000 ft^2/day to 19,000 ft^2/day at Delray Beach, to 1,300 ft^2/day at Riviera Beach. Storage coefficients ranged from 0.04 to 0.36 from Boca Raton to West Palm Beach, respectively. Limited data from previous studies indicated that at the center of the County, near the terminus of the Anastasia Formation, transmissivity was approximately 13,300 ft^2/day and storage coefficient reportedly 0.0013.

As development continued in Palm Beach County, population centers began to move west, and the rapidly increasing population put a strain on existing well fields located close to the freshwater/saltwater interface. As development moved west, so also did water supply facilities. As more data were obtained, it became clear that the general statement that aquifer transmissivity decreased from east to west was not precisely true. In fact, a highly permeable section of the Anastasia Formation was identified in the mid-1970's and is located generally in the vicinity of the Sunshine State Parkway, known by some as the Florida Turnpike. Because of first indications that this permeable section occurred over a fairly wide area extending from Broward through Palm Beach Counties and roughly parallel to the turnpike, it was identified as the Turnpike aquifer.

Village of Palm Springs well fields produce water from the Turnpike aquifer as well as less productive sections of the Anastasia Formation. A primary intent of this investigation is to provide a detailed hydrogeologic study of the Forest Hill Village well field and the emphasis of this chapter will focus on this site.

FOREST HILL VILLAGE HYDROGEOLOGIC INVESTIGATION

Within the Main WF, Well Fields No. 1 and 2 develop water from what may be called typical eastern Palm Beach County Anastasia Formation. Wells range in specific capacity from 12 to 72 gpm/ft, which roughly translates to an aquifer transmissivity of 3,200 to 19,000 ft^2/day. This corresponds well with previous reports on aquifer transmissivity in the West Palm Beach area.

WF No. 3, located west of Well Fields No. 1 and 2, has wells with specific capacities ranging from 74 to 269 gpm/ft. Pumping tests conducted in WF No. 3 indicate that transmissivity is approximately 40,000 ft^2/day and may be as high as 72,000 ft^2/day--somewhat higher than might have been predicted. WF No. 3 probably represents the easternmost extent of the Turnpike aquifer.

The Forest Hill WF, located approximately 2 miles west of WF No. 3, clearly develops water from the Turnpike aquifer. This highly permeable section of the Anastasia Formation probably extends from WF No. 3 westward through the Forest Hill Village site, terminating in the vicinity of the Florida Turnpike.

Aquifer Performance Test

During the rehabilitation of Forest Hill Village Wells No. 1, 2, and 3, it became clear that the well yields at this site were quite high (70 to 137 gpm/ft). Following the rehabilitation of these existing wells, a new well was constructed to complete the well field facility. This well, identified as Well No. 5, was used as the pumping well during a 48-hour APT conducted April 13 to April 15, 1983.

In order to conduct the test, a 12-inch vertical turbine pump with diesel engine was installed in Well No. 5. A total of 350 feet of 10-inch PVC pipe was laid from the well eastward to LWDD Canal E-3 (see Figure 2-2).

A Stevens Type F continuous water level recorder was installed at Well No. 2 one day prior to the planned start of the test to collect background water level data. However, the pen malfunctioned and no record was produced. On April 12, 1983, Stevens recorders were installed at Wells No. 2, 3, and 4 and gear ratios were set to run 4 hours at full time scale using a 1:1 gauge scale ratio. Static water levels in Wells No. 1 through 5 were measured, as was the "static" water level in Canal E-3 adjacent to Well No. 4. The test was officially started at 1446 hours at a withdrawal rate of 1,800 gpm. Approximately 30 minutes into the test, a "familiar" pattern was observed on the water level recorder charts. This pattern indicated that the pump was cavitating and the resulting water level response was a series of rapid, cyclic fluctuations. The test was terminated and rescheduled for the next day after determining a more suitable withdrawal rate (1,600 gpm).

The APT was restarted on April 13, 1983, at 0917 at the rate of 1,600 gpm. Figure 6-1 illustrates the background water level response at Well No. 2 (300 feet north of Well No. 5) just prior to the start of the test.

Data collection during the test was accomplished with Stevens recorders (Wells No. 2, 3, and 4) and chalked, steel tape (Wells No. 1, 5 and the canal). At the start of the test each well, the flow measuring device, and the engine were manned. The start of the test was signaled at the pumped well just after static water levels were measured (all wells and canal). Simultaneously, stop watches were started at all wells. The pumping rate quickly stabilized

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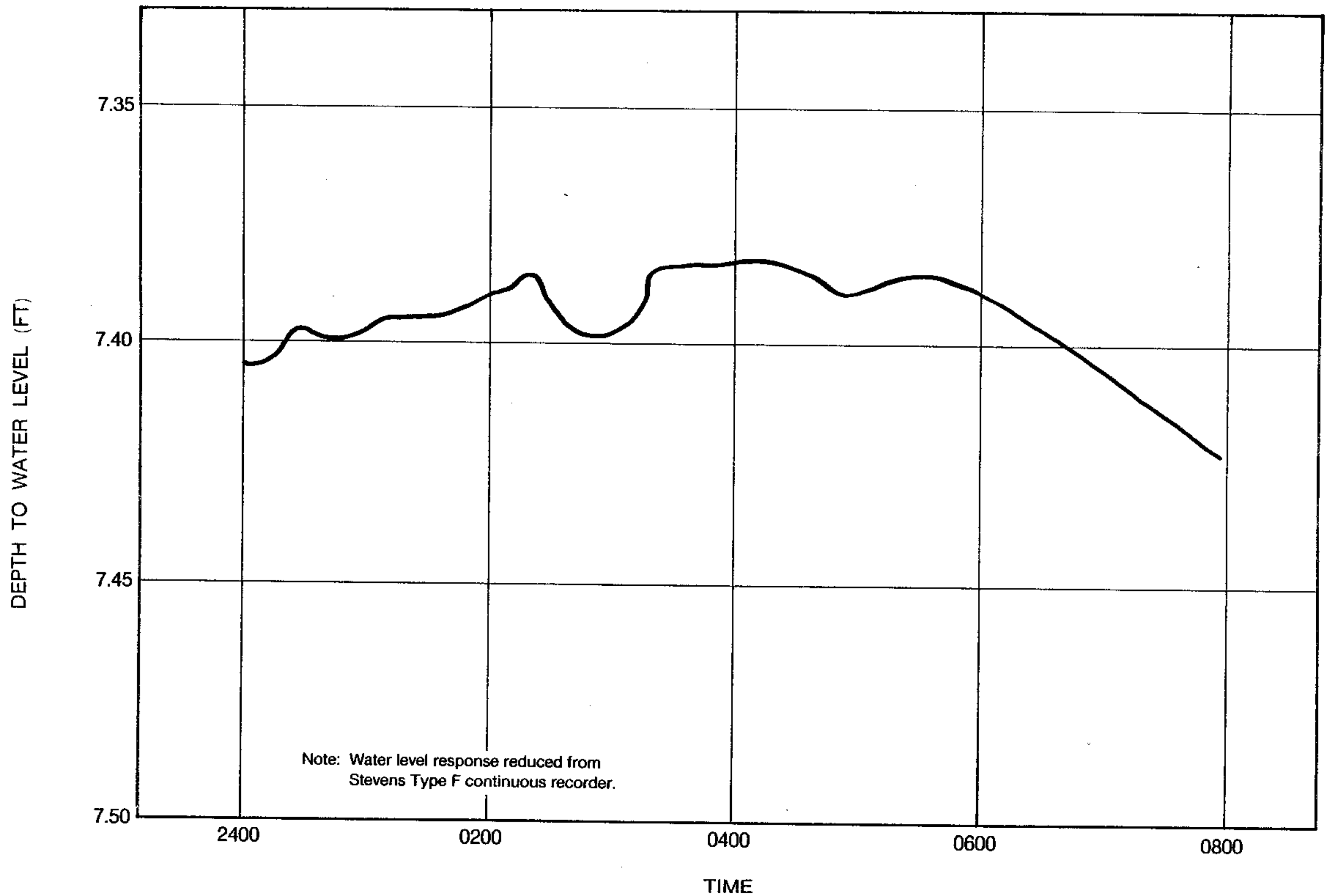

FIGURE 6-1.
Background Water Level Response at Well No. 2 (4/12/83).

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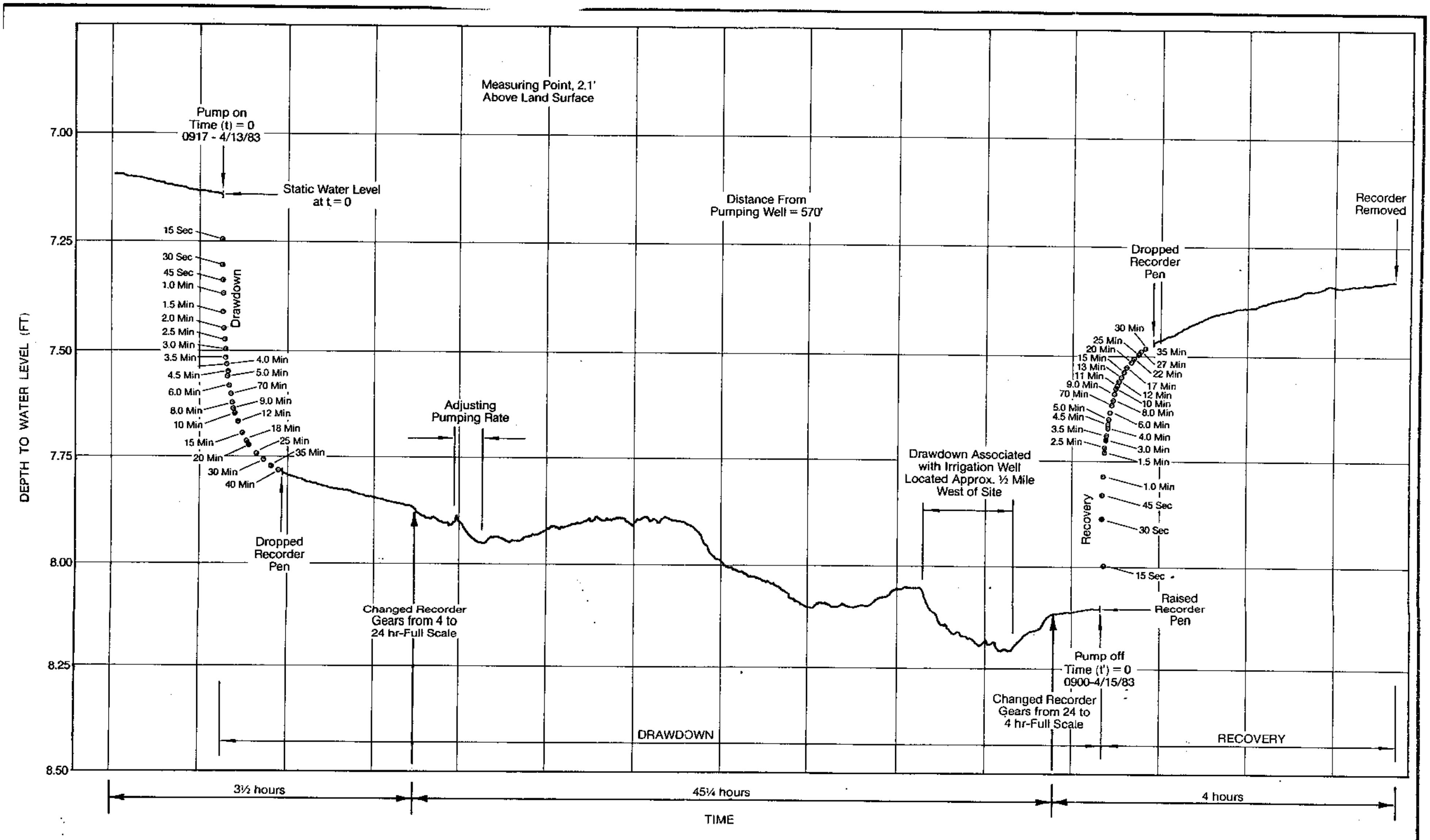
at 1,600 gpm. Flow was measured by an 8-inch orifice plate attached to 10-inch pipe and piezometer.

Water levels in Wells No. 1 and 5 were measured using a chalked, steel tape at regular (logarithmic) intervals. Appendix C lists time-drawdown values obtained during the test. At Wells No. 2, 3, and 4, equipped with Stevens recorders, a different technique was used. Here, at time, t = 0, the recorder pen was lifted off the chart. The pen was subsequently dropped and lifted at t = 15, 30, 45, and 60 seconds. As the test proceeded, the pen was dropped at 1½, 2, 2½, 3, 4, etc., minutes for every minute until 10 minutes into the test. After marking 12, 15, and 17 minutes, the pen was dropped and raised every 5 minutes until 40 minutes into the test, at which time the pen was dropped and allowed to track a continuous record. At approximately 4 hours into the test, recorder charts were replaced and time scales changed to 24-hour, full scale. Figure 6-2 illustrates the type of data this method produces. During the initial portion of the test, when water levels are dropping (or recovering) rapidly, a single point at a known time is made. The drawdown can be accurately scaled from the 1:1 chart, and the method results in very accurate early time-drawdown/recovery data. Later in the test, as water levels change less rapidly, the pen can be dropped to produce a continuous record requiring only periodic checking rather than continuous staffing. For recovery, the reverse procedure is used, i.e., 24-hour recorder gears are replaced with 4-hour gears, and the pen dropping maneuver is employed at the cessation of pumping.

Throughout the test, recorders were checked at regular intervals and the water levels in the pumped well, Well No. 1, and the canal were measured. Also, flow rate from the pumped well was checked periodically. The withdrawal portion of the APT lasted approximately 48 hours, and recovery was tracked for 4 hours. Appendix C also includes time-recovery data from the pumped well and observation wells.

There are several pertinent observations that can be made regarding the APT based on a review of the continuous water level record at Well No. 3 (see Figure 6-2). These are as follows:

1. The initial segment of the water level record (just prior to the start of the test) traces a slow, steady decline. This decline represents the aquifer response to evapotranspiration. Although no rainfall occurred during the test, approximately 2 inches fell the previous week. Since the shallow aquifer in eastern Palm Beach County is recharged directly by rainfall, continuous water level records plot the rise of



Note: This illustration was copied from a photographic reduction of the Stevens Recorder Charts used during the test.

FIGURE 6-2.
Typical Water Level Record from Observation Well (Well No. 3).

the aquifer water levels after rainfall (and the decline when no rain falls).

Extending the pre-test water level decline to the end of the test results in the projection of a 0.5-foot decline in water level over 24 hours, using the same slope as the initial segment. This would be valid except that the water level decline is influenced by other factors including barometric pressure. Changes in barometric pressure cause a water level response in aquifers. Increases in pressure result in water level decline. The amount of water level decline attributed to barometric pressure changes can be estimated by comparing the static water level at the beginning and end of the test. Since the test was started and stopped at approximately the same time, it can be assumed that the daily barometric cycles were approximately equal at the beginning and end of the test. Then, comparing the static water levels at the beginning and end of the test, there is approximately a 0.25-foot difference in water level. Comparing this number to the projected slope of the plot on the initial segment suggests that half of the decline is therefore attributable to daily cyclic barometric pressure change and that the other half is attributable to aquifer response due to lack of rainfall.

2. At a point approximately 8 hours into the test, the piezometer attached to the orifice which was used to measure flow slipped down approximately 2 inches. This resulted in the appearance that the flow rate had increased by approximately 100 gpm and therefore the engine was throttled back. This error was quickly discovered and the piezometer and flow rate subsequently adjusted to the proper position. The result can be seen on the continuous water level plot. There is a slight recovery of the water level as the engine (and therefore pumping rate) was throttled back and a return to a steady-state drawdown condition as the situation was corrected.

3. Approximately midway through the test, water levels began to stabilize and even recover slightly. This is due to the fact that at this point, the cone of depression had stabilized and discharge was balanced by recharge and inflow in the production zone. Therefore, the plot represents a "static" water level response although at a lower elevation (approximately 1 foot lower). During this time segment, the

water level decline due to evapotranspiration is balanced by the effects of cyclic barometer pressure changes.

4. The water level plot has two "peaks," one at the approximate midpoint of the graph, the other approximately 24 hours later. If a line is drawn connecting the crest of these two "peaks," the scope of that line has the same slope as the initial segment of the plot just prior to starting the test. Again this suggests that pumping has been balanced by recharge and inflow and that the plot represents aquifer "static" response.

5. At approximately 40 hours into the test, a water level decline was observed at all observation wells. After checking the flow rate, it was determined that another well must have been turned on. A thorough search of the area was made and a 6-inch irrigation well used to water grass and shrubs was located. The well was pumping at approximately 300 gpm and was located more than 3,000 feet from Well No. 5. This well caused approximately 0.12 foot of drawdown at Well No. 5. The irrigation well discharged for approximately 3 hours, after which water levels at the Forest Hill Village site recovered.

   This drawdown-recovery due to the irrigation well affected all of the observation wells, and therefore all subsequent data plots of time vs. water level will depict this response. This can be seen clearly at the end of the data plots illustrated in this report.

Figure 2-2 illustrates the areal relationships among the pumped well, the four observation wells, and canals at the APT site. Figure 6-3 illustrates the vertical relationship of the wells and canal at the site.

DATA ANALYSIS

Time vs. water level data from the pumped well and observation wells were tabulated (Appendix C) and plotted on 3x5 cycle log/log and 5 cycle semi-log graph paper. Both time/drawdown and time/recovery data were plotted. In addition, distance/drawdown data at specific times were also plotted on 5 cycle semi-log graph paper.

Figure 6-4 illustrates the plot of drawdown versus distance from the pumped well at times of 100, 200, and 400 minutes after the start of the test.

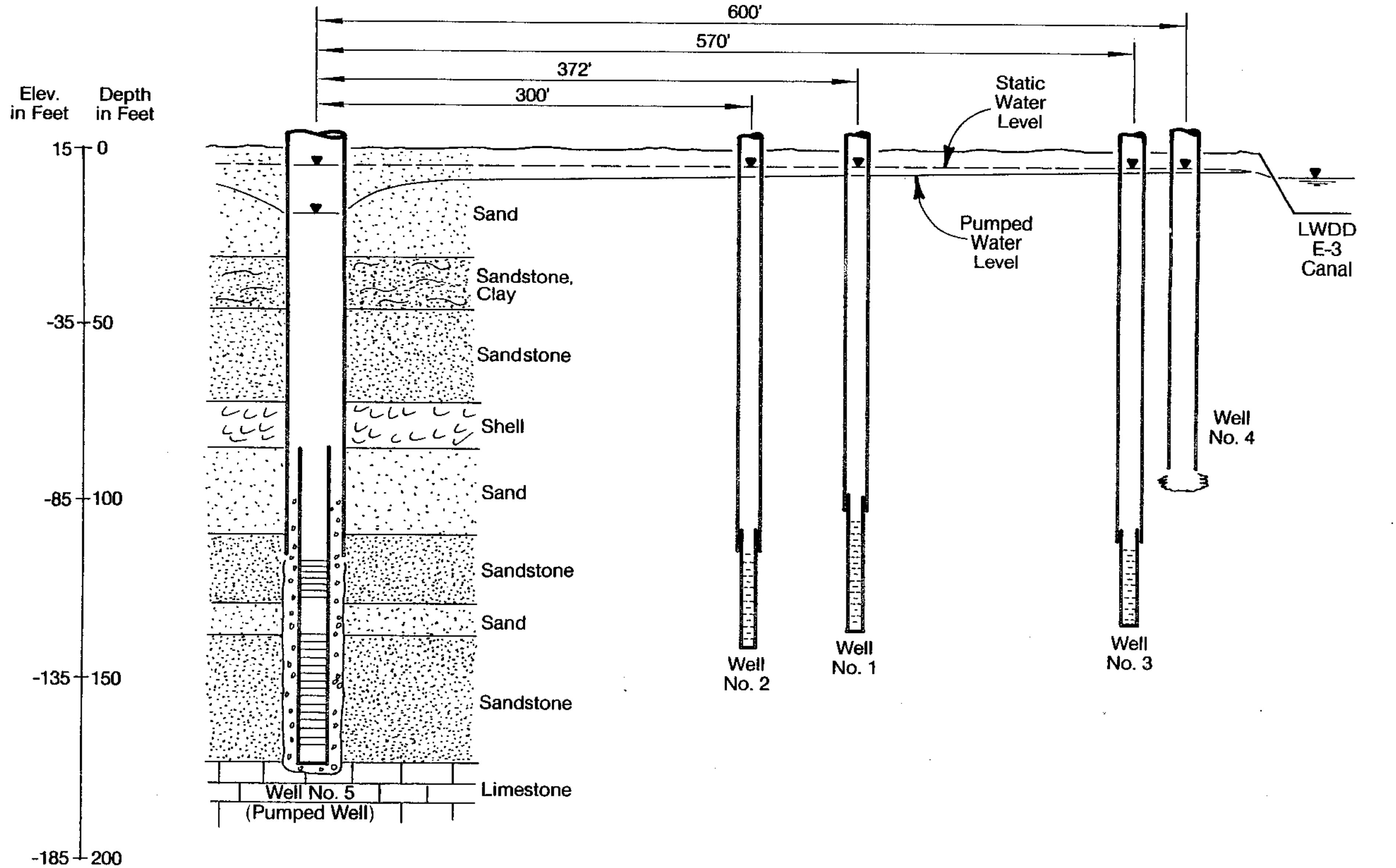


FIGURE 6-3.
Aquifer Performance Test, Pumped—Observation Well Relationships.

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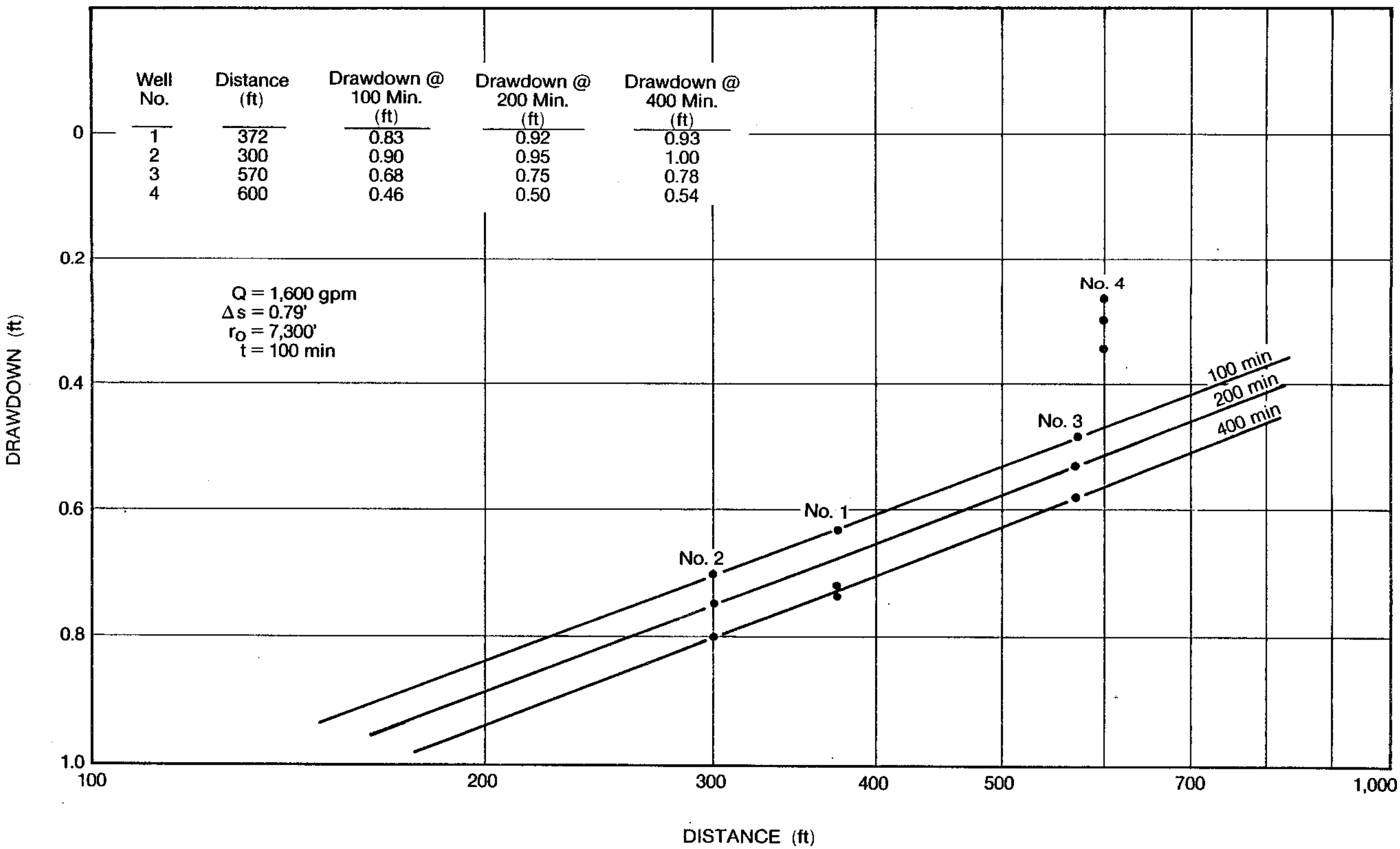

Well No.	Distance (ft)	Drawdown @ 100 Min. (ft)	Drawdown @ 200 Min. (ft)	Drawdown @ 400 Min. (ft)
1	372	0.83	0.92	0.93
2	300	0.90	0.95	1.00
3	570	0.68	0.75	0.78
4	600	0.46	0.50	0.54

FIGURE 6-4.
Distance-Drawdown Graphs.

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Only the observation wells were plotted at this scale and aquifer transmissivity was calculated using the non-equilibrium formula developed by Jacob. Transmissivity was determined using Equation No. 1:

$$T = \frac{528\ Q}{\Delta s} \qquad (1)$$

where

T = Transmissivity (gpd/ft)

Q = Pumping rate (gpm)

Δs = Slope of the distance-drawdown graph expressed as the change in drawdown per log cycle (ft)

From Figure 6-4, transmissivity was calculated as follows:

$$T = \frac{528\ (1,600\ \text{gpm})}{0.79\ \text{ft}}$$

Nicey conversion factor B.P.

$$T = 1,070,000\ \text{gpd/ft or } 227,270\ \text{ft}^2\text{/day}$$

Therefore, from the slope of the distance-drawdown graph, transmissivity is calculated to be 227,270 ft^2/day.

In reviewing the distance-drawdown plots on Figure 6-4 two major facts should be noted: first, drawdown at Well No. 4 was considerably less than would be expected based on the plotted curves using Wells No. 1, 2, and 3. This could be due to its proximity to the canal (~50 feet) and distance from the pumping well (600 feet). However, it is more likely a function of well construction. Recalling Figure 5-4, Well No. 4 apparently has no screen and what appears to be 1 or 2 feet of open hole. This results in a very poor, inefficient hydraulic connection to the aquifer which in turn results in a poor transmission of aquifer water level change to the well. Due to this fact, distance and time drawdown data obtained from Well No. 4 were not used to formulate conclusions regarding aquifer characteristics.

The second observation made from review of Figure 6-4 is that distance from the canals, a line source of recharge, was found to have no greater effect on those wells in close proximity than on those located farther away. Wells No. 2 and 3 were parallel to Canal E-3 but perpendicular to Canal No. 8 (see Figure 2-2). Well No. 1 was located the furthest from either canal.

Since the hydraulic gradient observed from drawdown measurements made at Wells No. 1, 2, and 3 were approximately equal in all directions, time versus drawdown plots were prepared for the pumped well and observation wells (including Well No. 4). Data were plotted on both log/log and semi-log graph paper and used to calculate aquifer characteristics using two different methods.

Semi-log graphical plots were used to calculate transmissivity and aquifer storage using non-equilibrium equations derived by Jacob. Equation No. 2 was used to calculate transmissivity and Equation No. 3 was used to calculate storage, as follows:

$$T = \frac{264\ Q}{\Delta s} \qquad (2)$$

where

T = Transmissivity (gpd/ft)

Q = Pumping rate (gpm)

Δs = Slope of the distance-drawdown graph expressed as the change in drawdown per log cycle (ft)

and

$$S = \frac{0.3\ T\ t_o}{r^2} \qquad (3)$$

where

S = Storage coefficient (dimensionless)

T = Transmissivity (gpd/ft)

t_o = Intercept of the straight line at zero drawdown (days)

r = Distance from pumped well to the observation well where drawdown measurements were made (ft)

Log/log plots were used to calculate aquifer characteristics using graphical methods described by Hantush, Jacob, and others. Equation 4 was used to calculate transmissivity, Equation 5 to calculate storage, and Equation 6 to calculate leakance, as follows:

$$T = \frac{Q}{4 \pi s} L(u,v) \qquad (4)$$

where

T = Transmissivity (ft^2/day)

Q = Pumping rate (gpm)

s = Drawdown at match point (ft)

$L(u,v)$ = Leakance function of u,v; values obtained from match point on the type curve (dimensionless)

and

$$S = 4T \frac{t/r^2}{1/u} \qquad (5)$$

where

S = Storage coefficient (dimensionless)

T = Transmissivity (ft^2/day)

t = Time from match point (days)

r = Distance from pumped well to the observation well where drawdown measurements were made (feet)

$1/u$ = Values obtained from match point on the type curve (dimensionless)

and

$$k'/b' = 4T \frac{v^2}{r^2} \qquad (6)$$

where

k'/b' = Leakance (day^{-1})

T = Transmissivity (ft^2/day)

v = Values obtained from curve matrix to type curve (dimensionless)

r = Distance from pumped well to the observation well where drawdown measurements were made (feet)

Figure 6-5 illustrates the time-drawdown plot from data collected at the pumped well (No. 5). Although the pumped well data is not the most appropriate application for the above formulas, transmissivity can be calculated using Equation No. 1. From this plot, there appear to be two distinct trends to the points plotted. A best-fit line has been drawn approximating the trend of both sets of points and the slope per log cycle measured. The general shape of the data points and the best-fit lines seems to indicate that a recharge boundary has been reached by the expanding cone of depression. This data plot, or at least the best-fit lines through the points, resemble a typical recharge boundary condition. That is, during the early time (0 to 12 minutes) water is derived from the production zone only, and the slope of this portion of the curve reflects aquifer hydraulic characteristics accurately. After approximately 12 minutes, the cone of depression created by the pumping well begins to become distorted, expanding at a much slower rate due to recharge. This recharge, either from a line source (canal) or from induced infiltration, results in the drawdown being less than it would otherwise be and thus the later time sections of the curve have a much flatter slope than the earlier segments. Since the later time segment does not accurately reflect aquifer hydraulic conditions alone, only the early time segment can be used to determine aquifer characteristics. Table 6-1 lists aquifer characteristics calculated from the data plot of time/drawdown for Well No. 5 (Figure 6-5).

Figure 6-6 illustrates the time/drawdown plot from data collected at Well No. 2. Again, aquifer characteristics were calculated using Equation 1. The storage coefficient can also be calculated from observation well data, whereas it cannot be calculated from pumped well data. Equation 2 was used to determine storage, and the results are listed in Table 6-1.

Figure 6-7 illustrates the time/recovery plot for Well No. 2. In comparing the two curves, the time/drawdown curve again results in a change in slope at approximately 12 minutes into the test, indicating a recharge boundary condition. The time/recovery curve appears to be a smooth plot, with the best-fit line having the same slope throughout.

Figure 6-8 illustrates the time/drawdown data plotted on a log/log scale water level response collected at Well No. 2. These data, when matched to the type curves developed by

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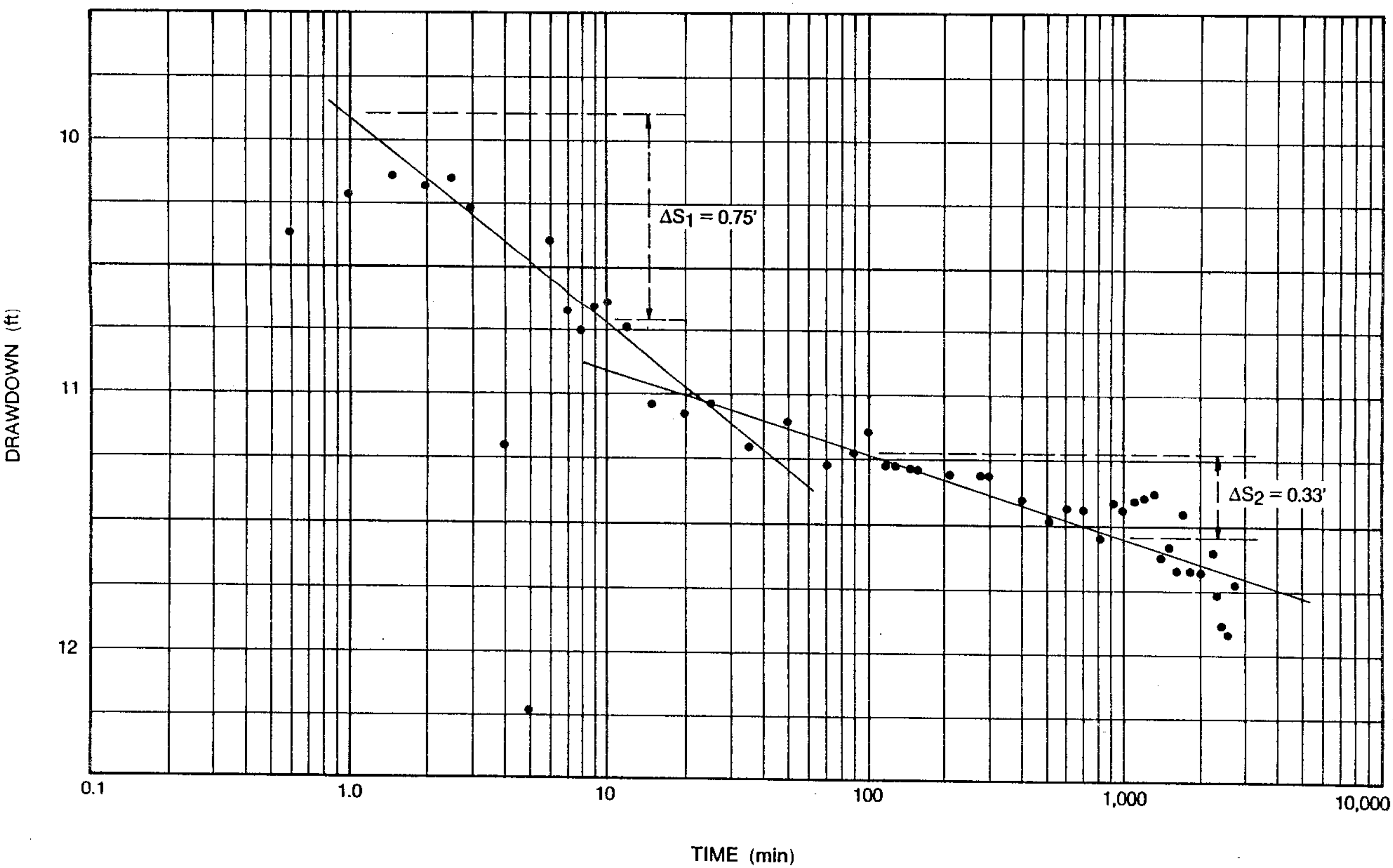

FIGURE 6-5.
Drawdown at the Pumped Well, Well No. 5.

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Table 6-1
SUMMARY OF AQUIFER CHARACTERISTICS

Pumped Well No.	Observation Well No.	Distance[a] (ft)	ΔS/Log Cycle[b]	t_o[c] (days)	Match Point Values[d] s, t, 1/u, L(u,v), v	Method	Transmissivity ft^2/day	Storage	Leakance day^{-1}
5	5	0.6	$\Delta s_1 = 0.75$ $\Delta s_2 = 0.33$	--	--	Jacob, DD	75,300 171,100	--	--
5	1	372	$\Delta s_1 = 0.24$ $\Delta s_2 = 0.10$	5×10^{-6}	--	Jacob, DD	235,300 564,700	2×10^{-5}	--
5	1	372	--	--	1.9, 12, 10, 10, 0.8	Jacob-Hantush, DD	129,000	3×10^{-3}	2.3×10^{-2}
5	1	372	$\Delta s' = 0.22$	9.7×10^{-6}	--	Jacob, Recov	265,700	6×10^{-6}	--
5	1	372	--	--	1.0, 0.16, 10, 10, 0.02	Jacob-Hantush, Recov	245,100	7.9×10^{-5}	2.8×10^{-3}
5	2	300	$\Delta s_1 = 0.30$ $\Delta s_2 = 0.16$	3.3×10^{-5}	--	Jacob, DD	188,200 352,900	2×10^{-4}	--
5	2	300	--	--	1.5, 0.43, 10, 10, 0.02	Jacob-Hantush, DD	163,400	2×10^{-4}	3×10^{-3}
5	2	300	$\Delta s' = 0.2$	2.0×10^{-6}	--	Jacob, Recov	282,400	1×10^{-5}	--
5	2	300	--	--	1.04, 0.44, 100, 10, 0.005	Jacob-Hantush, Recov	176,300	2.4×10^{-5}	--
5	3	300	$\Delta s'_1 = 0.27$ $\Delta s'_2 = 0.18$	1×10^{-4}	--	Jacob, DD	209,200 313,700	5×10^{-5}	--
5	3	570	--	--	1.05,0.70, 10, 10, 0.02	Jacob-Hantush, DD	174,600	1×10^{-4}	9×10^{-4}
5	3	570	$\Delta s'_1 = 0.22$ $\Delta s'_2 = 0.18$	4×10^{-5}	--	Jacob, DD	256,700 313,700	7×10^{-5}	--
5	3	570	--	--	1.2, 0.70, 10, 10, 0.02	Jacob-Hantush, Recov	152,800	9×10^{-5}	9×10^{-4}
5	4	600	$\Delta s_1 = 0.22$ $\Delta s_2 = 0.13$	4×10^{-4}	--	Jacob, DD	256,700 434,400	6×10^{-4}	--
5	4	600	--	--	0.13, 0.33, 1, 1, 0.05	Jacob-Hantush, DD	188,600	5×10^{-4}	5×10^{-3}

[a]Distance from pumped well to the observation well where drawdown measurements were made.

[b]Slope of the time-drawdown graph expressed as change in drawdown per log cycle.

[c]Intercept of the straight line at zero drawdown.

[d]Values obtained from matching the log/log time/drawdown-recovery data to the type curve.

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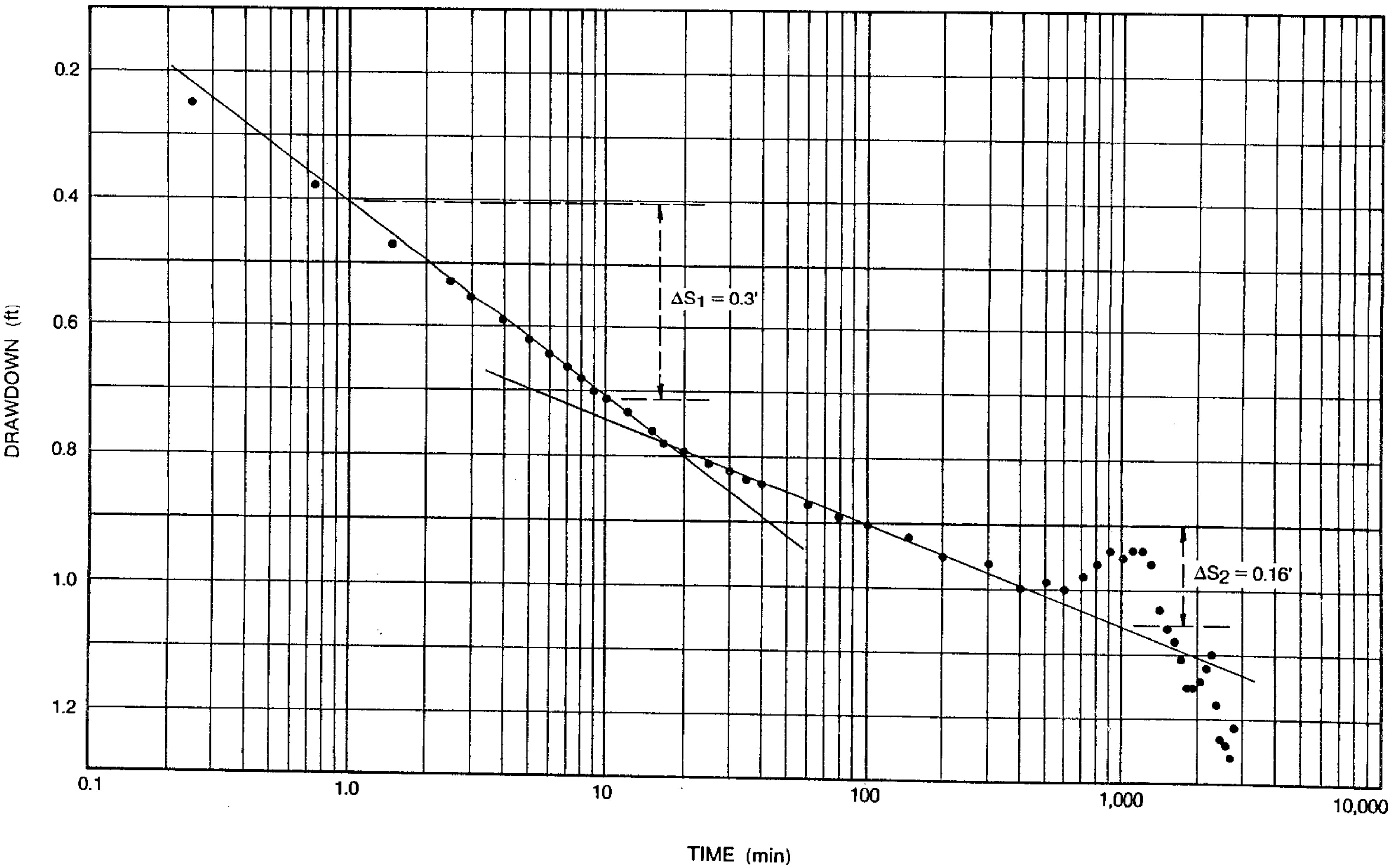

FIGURE 6-6.
Pumping Test at Well No. 5, Drawdown at Well No. 2.

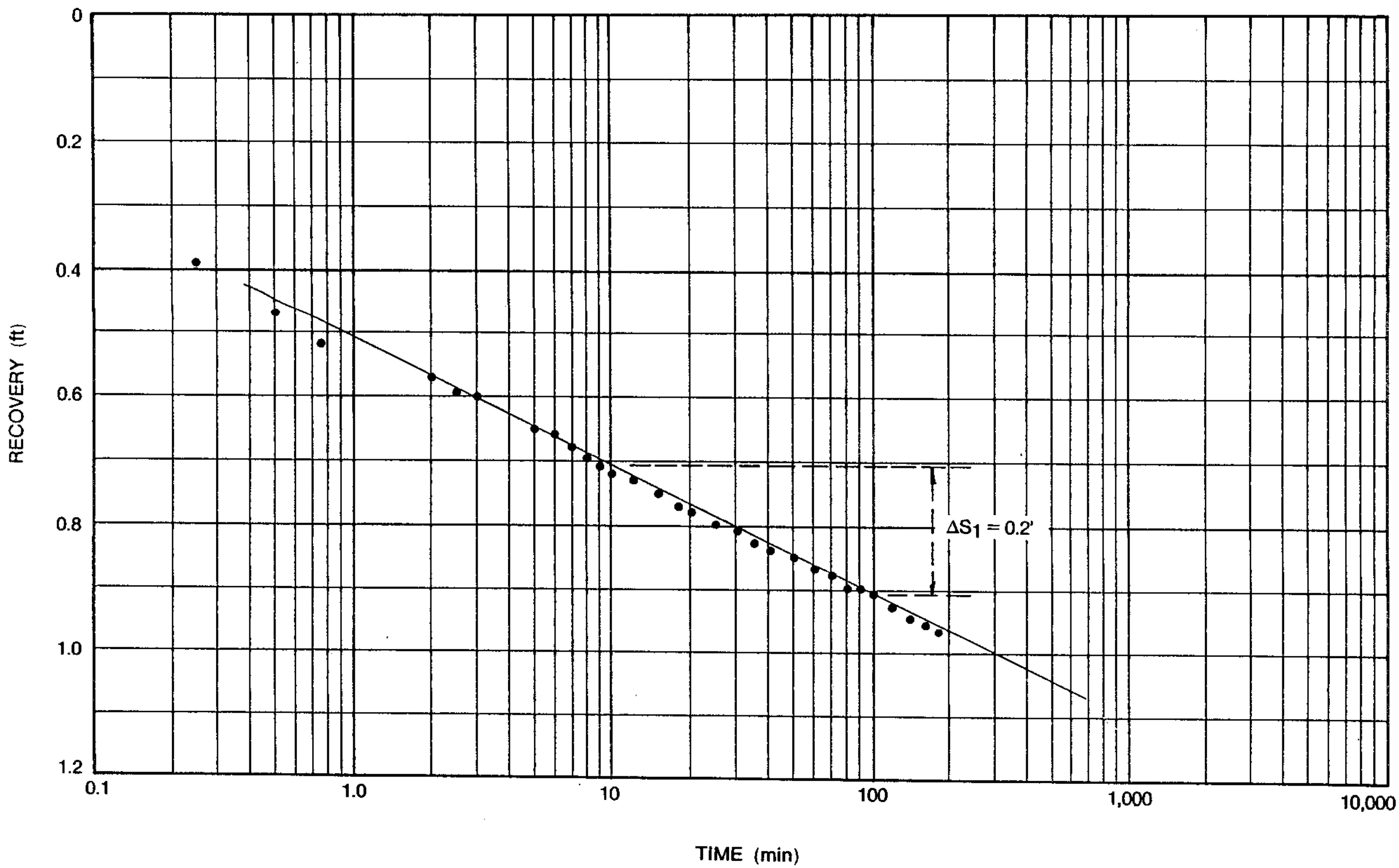

FIGURE 6-7.
Pumping Test at Well No. 5, Recovery at Well No. 2.

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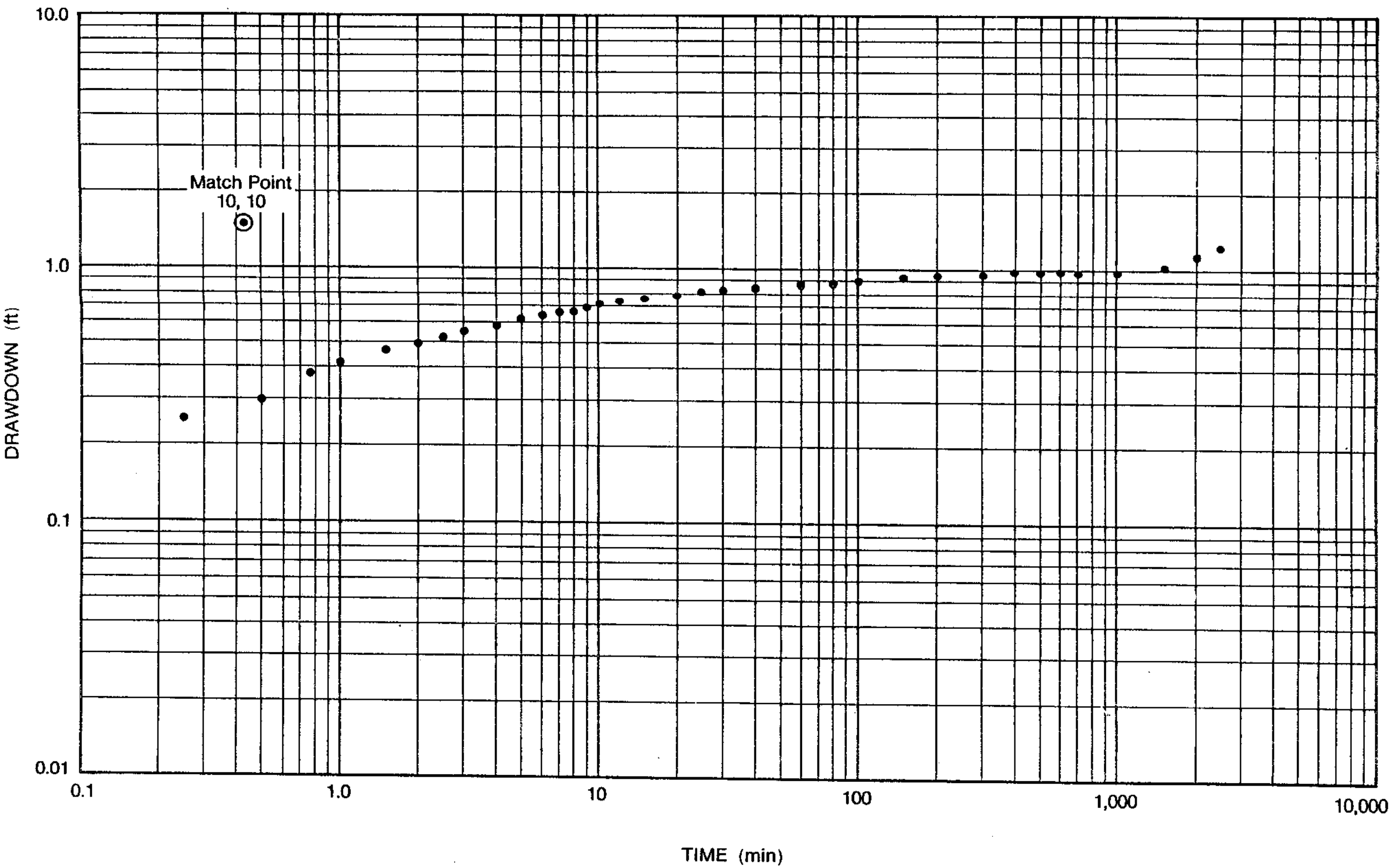

FIGURE 6-8.
Pumping Test at Well No. 5, Drawdown at Well No. 2.

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Cooper, were used to calculate aquifer characteristics using Equations 3, 4, and 5.

Similarly, time/recovery data were also plotted on a log/log scale and matched to the type curve; aquifer characteristics were then calculated (see Figure 6-9). Table 6-1 lists the results of these calculations.

Using this methodology, aquifer characteristics were determined based on data collected from all the observation wells used during the APT. Data plots for Wells No. 1, 3, and 4 are included in Appendix D.

Table 6-1 summarizes the results of these time/drawdown recovery calculations.

Aquifer characteristics determined from time/drawdown-recovery calculations were averaged, resulting in the following approximation:

$$T = 215{,}000 \text{ ft}^2/\text{day}$$

$$S = 1.5 \times 10^{-4}$$

$$k'/b' = 2 \times 10^{-3} \text{day}^{-1}$$

Values obtained from distance/drawdown plots were:

$$T = 143{,}000 \text{ ft}^2/\text{day}$$

$$S = 4 \times 10^{-4}$$

The results using the average values calculated from time/drawdown recovery rate do not compare well with distance/drawdown values.

Comparing the average values for transmissivity for each observation well regardless of the method used results in the following:

T_{ave} @ Well No. 1 = 218,775 ft²/day

T_{ave} @ Well No. 2 = 202,575 ft²/day

T_{ave} @ Well No. 3 = 198,325 ft²/day

Comparing the average values for transmissivity for each observation well for both log/log and semi-log methods results in the following:

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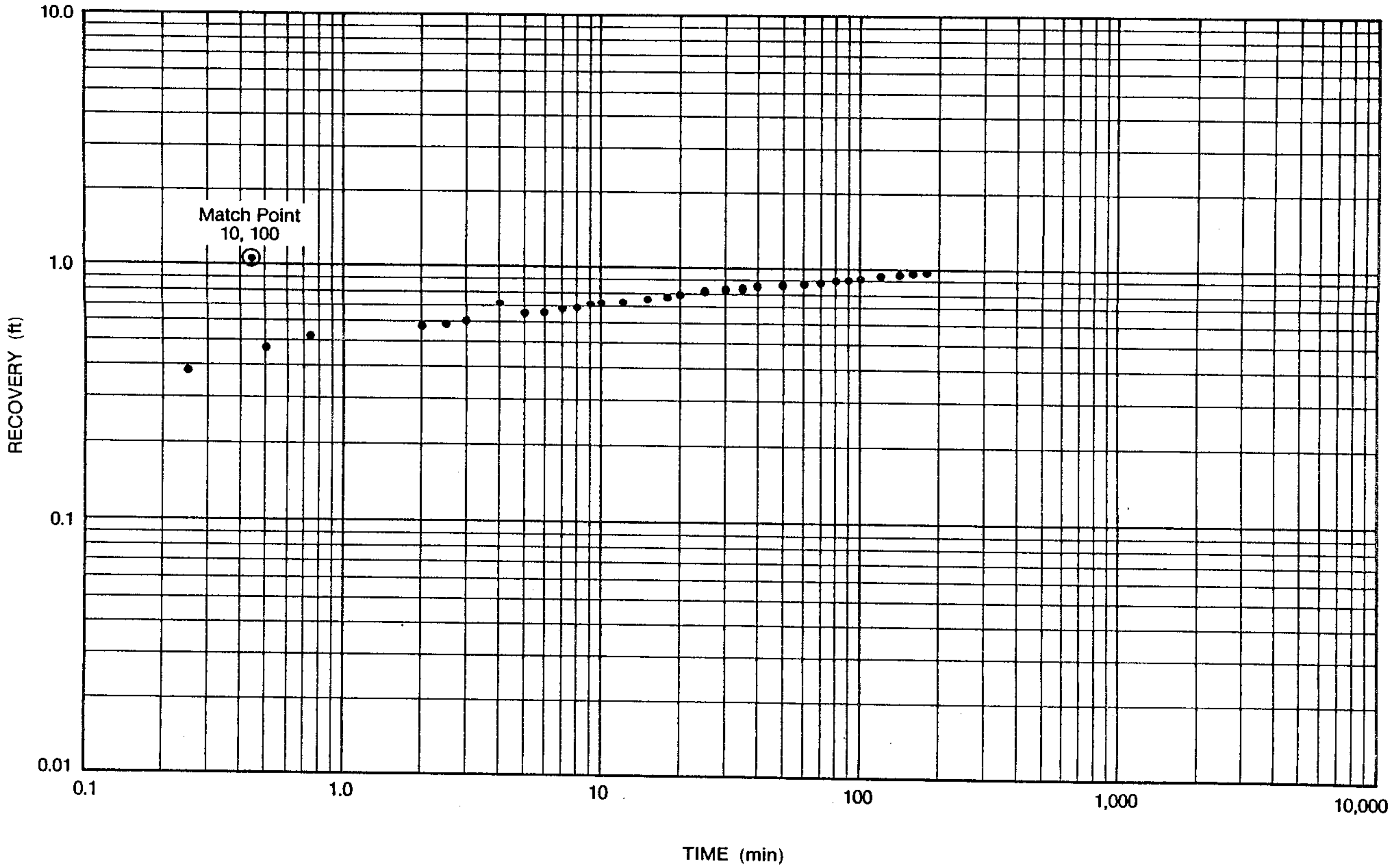

FIGURE 6-9.
Pumping Test at Well No. 5, Recovery at Well No. 2.

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T_{ave} @ Well No. 1 = 250,500 ft^2/day (semi-log)

T_{ave} @ Well No. 1 = 245,100 ft^2/day (log/log)

T_{ave} @ Well No. 2 = 235,400 ft^2/day (semi-log)

T_{ave} @ Well No. 2 = 169,850 ft^2/day (log/log)

T_{ave} @ Well No. 3 = 232,950 ft^2/day (semi-log)

T_{ave} @ Well No. 3 = 163,700 ft^2/day (log/log)

Some observations can be made from these comparisons. In general, a higher transmissivity is obtained using the semi-log data plots and Jacob non-equilibrium equations. Also, there appears to be little difference in transmissivity when calculated from data taken at Wells No. 2 and 3. Distance versus drawdown calculated transmissivity (143,000 ft^2/day) appears to compare well to the log/log calculated values from data at Wells No. 2 and 3 (average = 166,800 ft^2/day).

Comparing time-drawdown to distance-drawdown observations, it appears that the transmissivity obtained from the average value of log/log data plots is a reasonably good approximation. However, the storage coefficient determination using this method is not accurate because of the effects of recharge. Walton describes a procedure for calculating the effect of a recharge boundary groundwater withdrawal. Walton's method assumes that no drawdown occurs along an effective line of recharge. Under this boundary condition, water levels will drawdown at an initial rate under the influence of the pumping well only. When the recharge boundary begins to affect the production well, the time rate of drawdown will change, continually decreasing until equilibrium is reached. The APT site is bounded by two partially penetrating recharge boundaries, and therefore Walton's method may be somewhat inappropriate for this site. To apply this method to the Forest Hill Village site, these two partially penetrating recharge boundaries (Canal E-3 and 8 are approximately 6 feet deep) are theoretically replaced by one single, fully penetrating boundary which would produce the same effect on the site.

Applying Walton's method, a determination of storage coefficient can be made and the results checked by trial and error against actual data. For this analysis, observed drawdown (stabilized) data for Wells No. 1, 2, and 3 were substituted into Equation No. 7 to calculate a value for the distance (a) from the pumped well to the effective recharge boundary as follows:

$$s = \frac{528\ Q\ \text{Log}\ \frac{\sqrt{4a^2 + r^2}}{r}}{T} \qquad (7)$$

where

a = Distance to effective recharge boundary (ft)

r = Distance from observation well to pumped well (ft)

Q = Pumping rate (gpm)

T = Transmissivity (gpd/ft)

The results of these calculations were as follows:

Well No.	Distance (ft)	Drawdown (ft)	a (ft)
1	372	1.14	8,975
2	300	1.21	9,184
3	570	0.96	7,453
		Average a =	8,537

Once a value is known for the distance to the effective recharge boundary (a), the storage coefficient can be determined by substitution using Equations No. 8, 9, 10, 11, and 12.

$$s_r = s - s_i = \frac{114.6\ Q}{T}\ [W(u)-W(u_i)] \qquad (8)$$

where

$$u = \frac{1.87\ r^2\ S}{Tt} \qquad (9)$$

and

$$u_i = \frac{1.87\ ri^2\ S}{Tt} \qquad (10)$$

and

$$W(u) = -0.5772 - \text{Ln } u \quad (11)$$

and

$$W(u_i) = -0.5772 - \text{Ln } u_i \quad (12)$$

where

S_r = Drawdown in observation well (ft)

s = Drawdown due to pumped well (ft)

S_i = Build-up to image well (ft)

Q = Pumping rate (gpm)

T = Transmissivity (gpd/ft)

S = Storage coefficient

r = Distance from observation well to pumped well (ft)

r_i = Distance from observation well to image well (ft)

Using this method, a storage coefficient of 1×10^{-3} was calculated using Wells 1, 2, and 3 (see Table 6-2).

Once aquifer characteristics are known, the percentage of water being diverted from a source of recharge can be calculated using Equation No. 13 together with Figure 6-10 as follows:

$$F_f = \frac{1.87\ a^2\ S}{Tt} \quad (13)$$

where

a = Distance to effective recharge boundary (ft)

S = Storage coefficient

T = Transmissivity (gpd/ft)

t = Time (days)

Table 6-2
SUMMARY OF STORAGE COEFFICIENT DETERMINATIONS

Well No.	r (ft)	u	ui	w(u)	w(ui)	Drawdown (Calculated) (ft)	Drawdown (Actual) (ft)
1	370	7.4×10^{-4}	1.5	6.62	0.10	0.96	0.95
2	300	4.85×10^{-4}	1.5	7.08	0.10	1.02	1.00
3	570	1.75×10^{-3}	1.5	5.783	0.10	0.83	0.78

Note: r_i = 17,074 feet

$S = 1 \times 10^{-3}$

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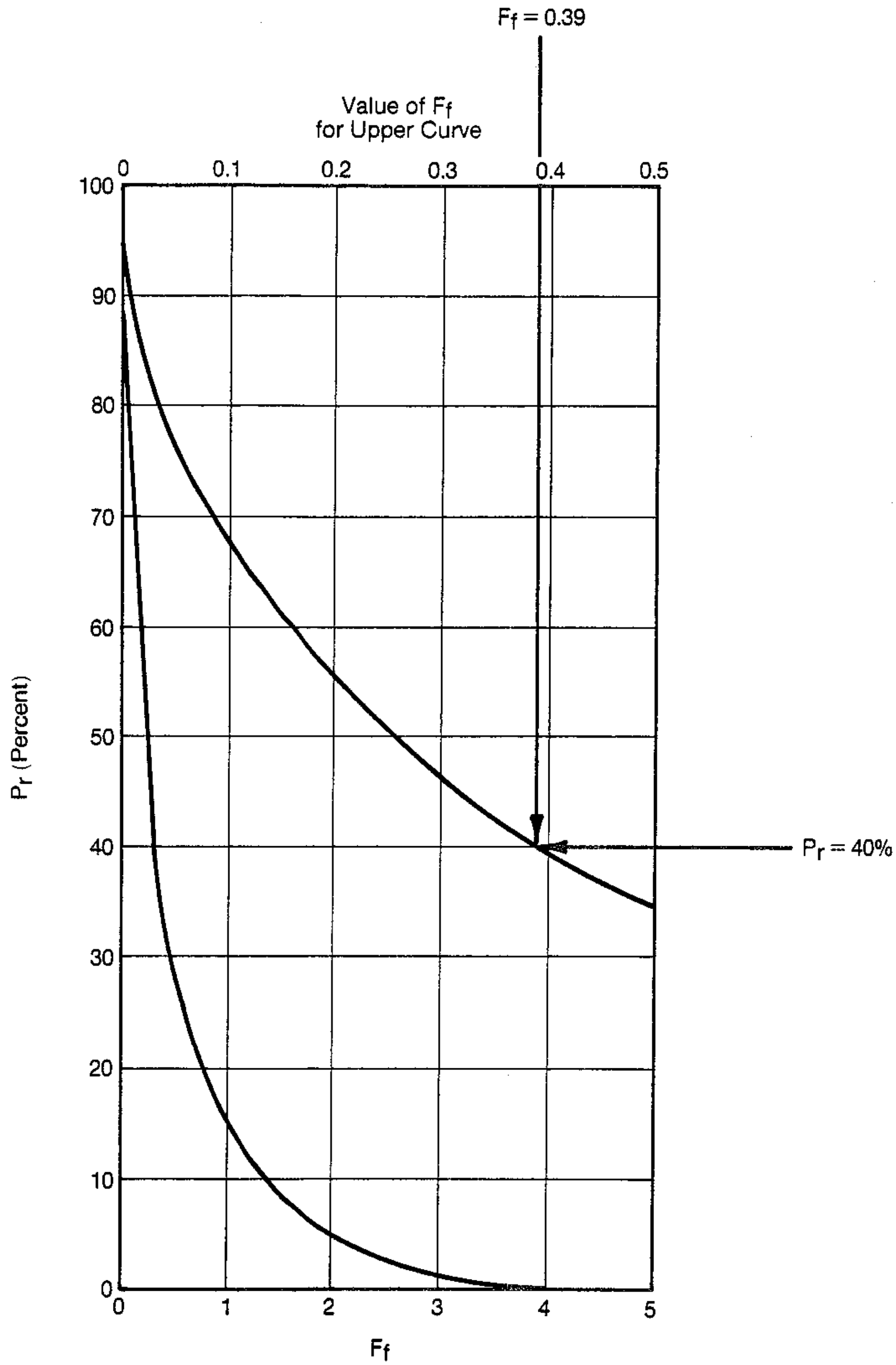

Note: Graph for determination of percentage of pumped water being diverted from a source of recharge. (From Theis, 1941.)

FIGURE 6-10.
Percentage of Pumped Water Derived from Recharge.

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therefore

$$F_f = \frac{1.87\ (8,537)^2\ 1 \times 10^{-3}}{1,247,664\ (0.278)}$$

$$= 0.39$$

From Figure 6-10:

P_r = 40%

where

P_r = % of water diverted from a source of recharge

The sources of recharge are induced infiltration from the overlying permeable sediments and leakance from the canal. Since the canal is not fully penetrating, it recharges the upper water table, which in turn recharges the production zone.

No attempt was made to rigorously determine the actual amount of recharge contributed by the canal. In other parts of the County where transmissivity of the Anastasia Formation is much lower, a pumping well (or well field) will cause a greater head differential between the canal and the producing zone than was experienced at the Forest Hill Village site. The head differential caused by the pumping well (Well No. 5) during the APT at the closest canal was less than 1 foot (see Figure 6-11). The reason for this is that the producing zone at this site has much higher transmissivity than is common for the Anastasia Formation.

A very rough approximation can be made regarding how much water is obtained from canal recharge at the Forest Hill Village. If we assume a very simple model, the site can be replaced by a square having a discharge point at the center to simulate the well field center of pumping. The square is bounded on two adjacent sides by a line source of recharge (LWDD canals 8 and E-3) which are considered fully penetrating for this discussion. Then, if 40 percent of the water produced at the center comes from a recharge source, approximately half would come from the canal. Since the model described above does not exactly fit conditions at the site, a reasonable assumption as to amount of water recharged by both canals is 15 to 25 percent.

Having established a value for aquifer transmissivity, storage, and leakance, a series of theoretical distance-drawdown curves were constructed using steady-state leaky artesian formulas. Figure 6-11 illustrates this series of curves for various pumping rates including the rate used during the APT.

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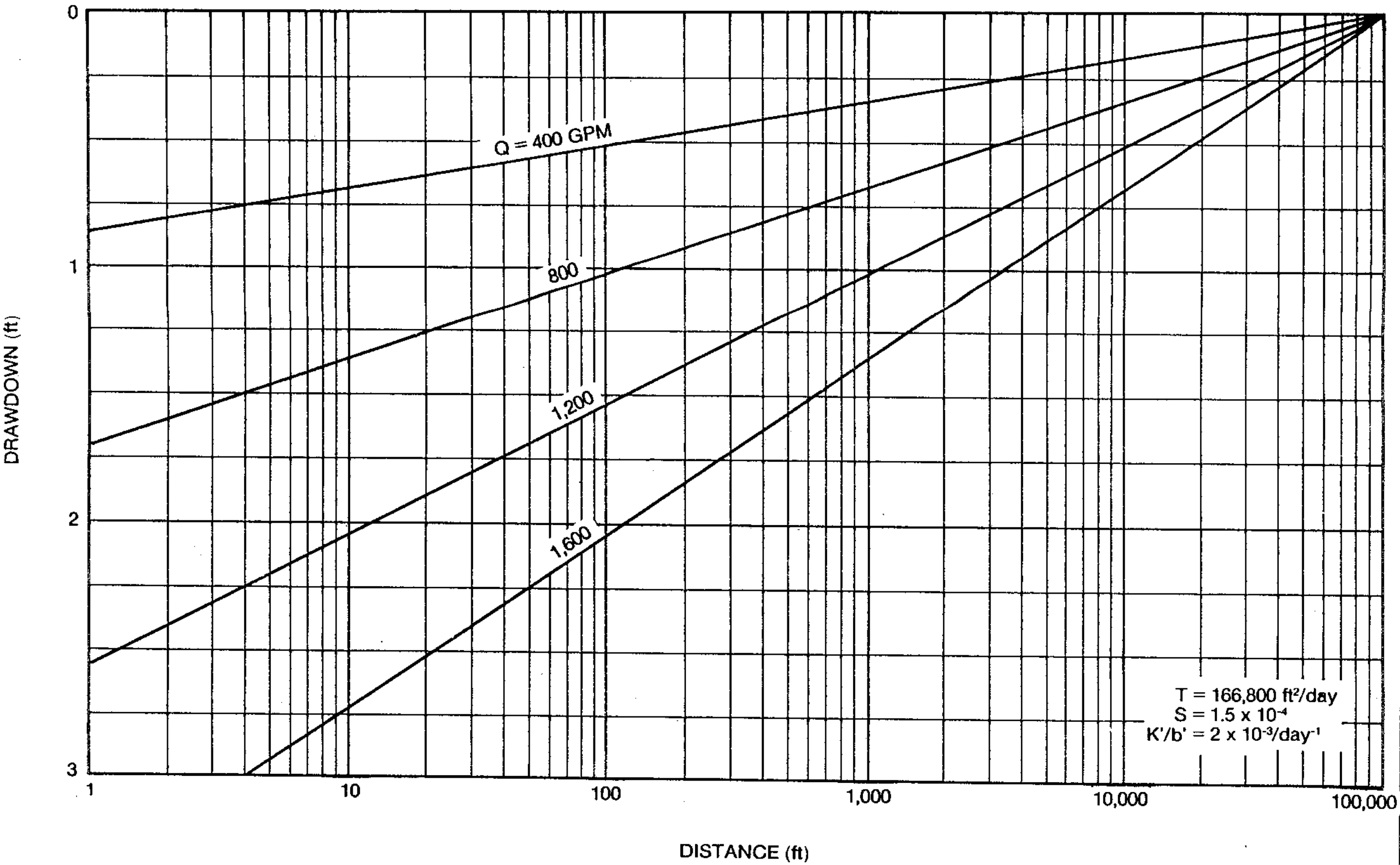

FIGURE 6-11.
Theoretical Distance-Drawdown Curves.

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Values used to calculate theoretical distance-drawdown curves were:

$$T = 166,800 \text{ ft}^2/\text{day}$$

$$S = 1 \times 10^{-3}$$

$$k'/b' = 2 \times 10^{-3} \text{day}^{-1}$$

Theoretical curves, if based on appropriate aquifer characteristics, should predict aquifer response to pumping. A comparison of theoretical versus actual distance-drawdown relationships was made to determine if the aquifer characteristics arrived at were reasonable. Figure 6-12 illustrates the plot of the actual, stabilized distance-drawdown relationship observed during the APT (the solid line). The theoretical distance-drawdown curve (the dashed line), calculated from the steady-state leaky artesian formula at 1,600 gpm, plots almost directly over the actual curve constructed after 48 hours of pumping.

It appears, therefore, that the aquifer characteristics established for the Forest Hill Village site are reasonable and that theoretical curves can be used to predict aquifer response to pumping. Having developed these curves, it is now possible to design a well field for the site. Had wells not already been constructed on the site, the design would focus on well spacing (location) and withdrawal rates which would efficiently develop groundwater within the site boundaries. However, since production wells have already been located, well field design efforts will be directed toward the establishment of withdrawal rates for the wells.

In selecting the pumping rate for a particular well, several factors must be considered, including:

- Aquifer characteristics
- Available drawdown
- Casing size
- Screen conditions
- Proximity to recharge boundary
- Well efficiency/specific capacity
- Need for water

Aquifer characteristics determine the interference effects among wells in the well field, which in turn affect well spacing. Since well spacing has already been established, interference effects can be mitigated only by adjustments to the individual well pumping rate.

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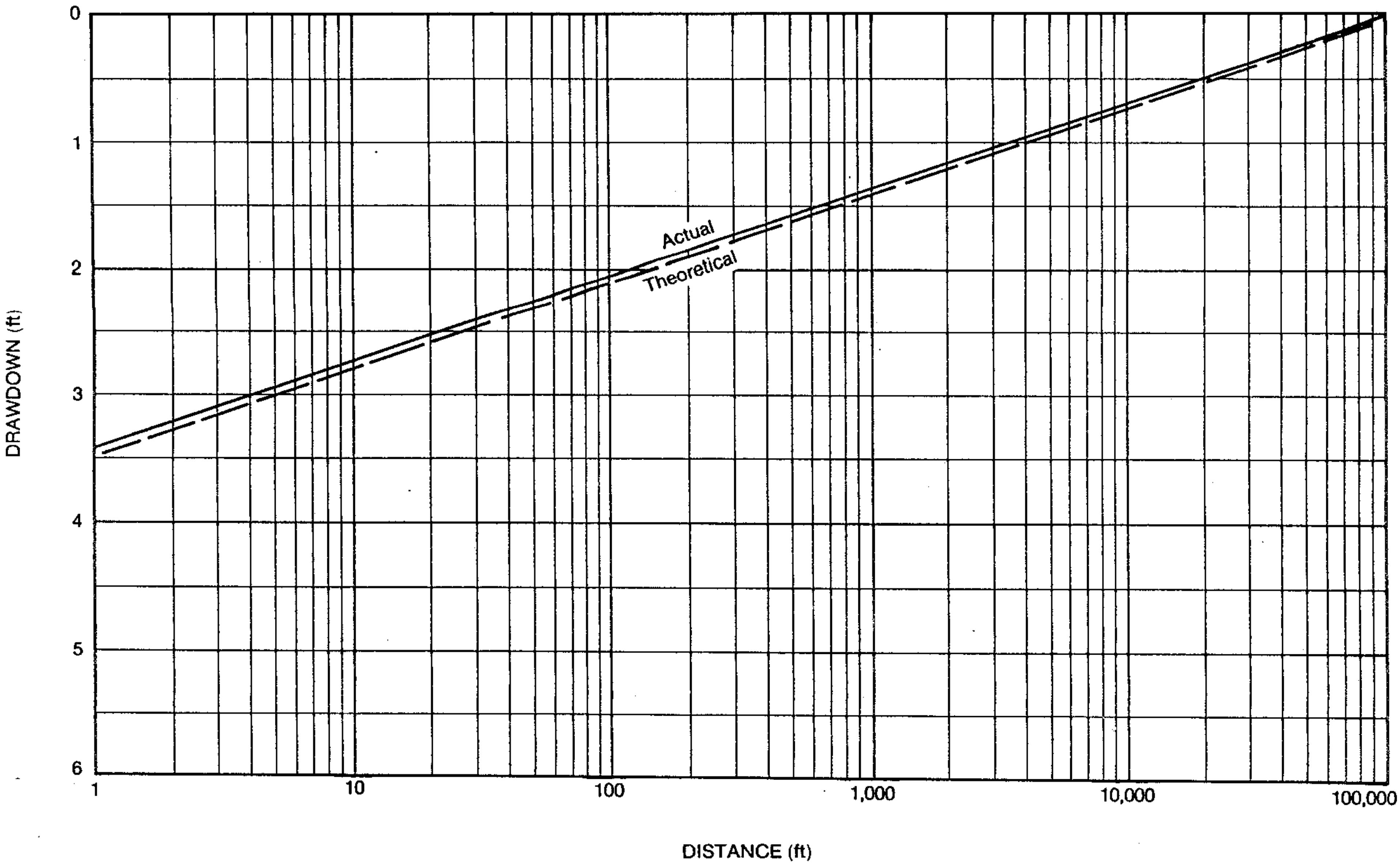

FIGURE 6-12.
Distance-Drawdown Relationship at 1,600 GPM—Actual Versus Theoretical.

Available drawdown limits the water level to which individual wells can be reduced by pumping. In screened wells, the maximum design pumping level including interference effects is 10 to 15 feet above the top of the screen.

Casing size limits the size pump which can be installed in a particular well, which therefore limits the pumping rate.

Screen condition, which depends primarily upon the age, type, and installation method, may limit the rate of withdrawal. The higher the pumping rate, the higher the likelihood that the well will pump sand if the screen is in poor condition, improperly designed, etc.

Proximity to a recharge boundary might result in a well being rated higher than wells remote from the boundary, because induced recharge from a recharge source would reduce the effects of pumping.

Well efficiency/specific capacity, which is a measure of individual well performance, is a function of construction and development rather than aquifer characteristics. Therefore, a well having a low efficiency and/or specific capacity would be rated lower than perhaps might be possible given the aquifer characteristics.

Finally, after considering all of the above factors, the actual water needed from a particular site must be considered.

As discussed above, aquifer characteristics determined for this site are:

Transmissivity	=	166,800 ft^2/day
Storage	=	1×10^{-3}
Leakance	=	2×10^{-3} day^{-1}

Again referring to the theoretical distance-drawdown curves constructed on the basis of aquifer characteristics (Figure 6-11), interference effects can be determined for various pumping rates. Recalling that well spacing has already been established, the determination of recommended withdrawal rates then becomes an iterative process of assigning pumping rates to each well and evaluating interference effects using the theoretical distance-drawdown curves. As an example, if Well No. 5 is assigned a rate of 1,600 gpm, then theoretically (from Figure 6-11) the drawdown at that well would be approximately 2-1/2 feet, assuming that no other wells were in use and that Well No. 5 were 100 percent efficient.

If Well No. 2 were also pumping at 1,600 gpm, then the interference effect at Well No. 5 would be 1 foot; thus the total drawdown at Well No. 5, would be 3-1/2 feet. Should Wells No. 1, 2, and 3 all be pumping at 1,600 gpm along with Well No. 5, the total drawdown at Well No. 5 would be approximately 4-1/2 feet. This assumes that the wells were 100 percent efficient and that nothing need be considered except aquifer characteristics. However, this is not the case. It is very important to note that this site is not limited in its development by aquifer conditions. As an illustration of this fact, in the above example four wells pumping 1,600 gpm each for a total withdrawal of 4.44 mgd results in a total theoretical drawdown of only 5-1/2 feet in each well and less than 1 foot at a distance of 1,000 feet from any pumping well.

Available drawdown is the difference between the static water level and some limiting factor. The static water level used as a reference should be one which is representative of average conditions--not extremely high or low. During the APT, static water levels were several feet higher than normal due to higher than normal rainfall. The static water levels measured at all wells at the site averaged 5.42 feet bls, ranging from 3.73 to 5.13 feet bls. Assuming that water levels were 2 to 3 feet higher than normal, 8 feet bls was selected as the design static water level.

The limiting factor with regard to drawdown in coastal aquifers is often selected as sea level to ensure that saltwater intrusion does not occur. This site is located several miles from a source of saltwater contamination and therefore the limiting factor is related to well construction.

It is not desirable to pump below the top of the well screen and therefore screen setting with some factor of safety (10 to 15 feet) should be the limiting factor. Therefore, assuming a 15-foot factor of safety, available drawdowns at Wells No. 1, 2, 3, and 5 are listed below:

Well No.	Available Drawdown (ft)
1	77
2	90
3	86
5	92

The above example assigned a pumping rate of 1,600 gpm to all four production wells. However, Wells No. 1, 2, and 3 have 8-inch casings limiting the size pump which can be installed to 6 inches. Well No. 5 has a 14-inch casing, limiting the pump size to 12-inch maximum. Therefore, Wells No. 1, 2, and 3 would be limited to a maximum withdrawal of 600 gpm and Well No. 5 limited to 2,500 gpm due to pump size limitations.

In view of the fact that Wells No. 1, 2, and 3 were constructed in 1959, screen condition is an important consideration in assigning a pumping rate. The only guidance available for making this judgement would be observation during pumping tests, review of borehole TV surveys, and geophysical logging surveys. Very small amounts of sand were observed during pumping tests at Wells No. 1, 2, and 3. The TV surveys indicate that screens are of the louver type and probably are not stainless steel. Geophysical logs indicate that the screens are the telescoping type , are smaller in diameter than the casing, and therefore could possibly be replaced if necessary. These data suggest that, in the interest of safety, Wells No. 1, 2, and 3 should not be pumped at full capacity. Well No. 5 being recently constructed, using Johnson continuous wrap stainless steel would not be limited by screen condition.

The recharge source of most significance to groundwater development at this site is induced recharge from the overlying, saturated sediments. As discussed above, approximately 40 percent of the water withdrawn from this site will come from a recharge source. Of this total recharge, approximately half is developed from the two canals bordering the site on the north and east. As further support for this conclusion, theoretical distance-drawdown curves indicate that the difference in head caused by pumping Well No. 5 at 1,600 gpm at the nearest canal is only 1 foot in the production zone. Although no shallow water table observation wells were installed during this test, the actual head difference experienced at the canal bottom ($\sim$15 to 20 feet bls) was, in all likelihood, considerably less than 1 foot. The conclusion, therefore, would be that most of the recharge comes from induced infiltration developed around the pumping well from overlying saturated sediments. These sediments probably did receive some recharge from the canal(s). Therefore, since recharge is primarily induced infiltration, no special consideration need be given wells located closer to surface-water canals.

Well efficiencies were determined for Well No. 1 by performing a step-drawdown pumping test and for Well No. 5 by constructing distance-drawdown graphical plots. Well No. 1 had an efficiency of 50 percent at a rate of 500 gpm.

Figure 6-13 illustrates a plot of distance versus drawdown at time = 1,600 minutes during the APT. Drawing a best-fit line through values obtained from Wells No. 1, 2, and 3 results in a graphical distance-drawdown plot. Dividing the theoretical drawdown at the pumping well by the actual measured drawdown and multiplying the results by 100 gives well efficiency as a percentage. For example, theoretical drawdown at Well No. 5, from Figure 6-13, at a distance of 0.58 feet (well radius) is 3.9 feet. Actual drawdown at Well No. 5 after 1,600 minutes of pumping at 1,600 gpm was 11.7 feet, making the efficiency of Well No. 5 approximately 33 percent. Specific capacity of Well No. 5 at 1,600 gpm was 134 gpm/ft. Although 33 percent is not a particularly high well efficiency, and assuming that at higher rates specific capacity decreases, Well No. 5 could be pumped at greater than 3,000 gpm and the resulting drawdown would be less than 30 feet, where there are no other considerations.

Finally, the consideration of need for the water must be discussed. As pointed out in Chapter 4, the projected 1993 water demand is between 3.9 and 4.4 mgd. Due to the design of the proposed treatment unit at the Forest Hill WF, 2 mgd is required from the well field. This would produce a corresponding reduction in the demand on the Main WF.

Assuming that 2 mgd will be developed from the Forest Hill WF, and in view of the limiting factors discussed above, the recommended withdrawal rates at Forest Hill WF are as follows:

Well No.	Withdrawal Rate (gpm)	Approximate Drawdown (ft)	Approximate[a] Pumping Level (ft-bls)
1	400	6	14
2	500	4	12
3	500	4	12
4	0	0	8
5	1,400	11	19

[a]Assuming an 8-foot-bls static water level.

This results in an installed capacity of slightly over 4 mgd. However, since the treatment unit can handle only 2 mgd, all wells will not be pumping at once. Chapter 7 describes the recommended operation of the Forest Hill WF.

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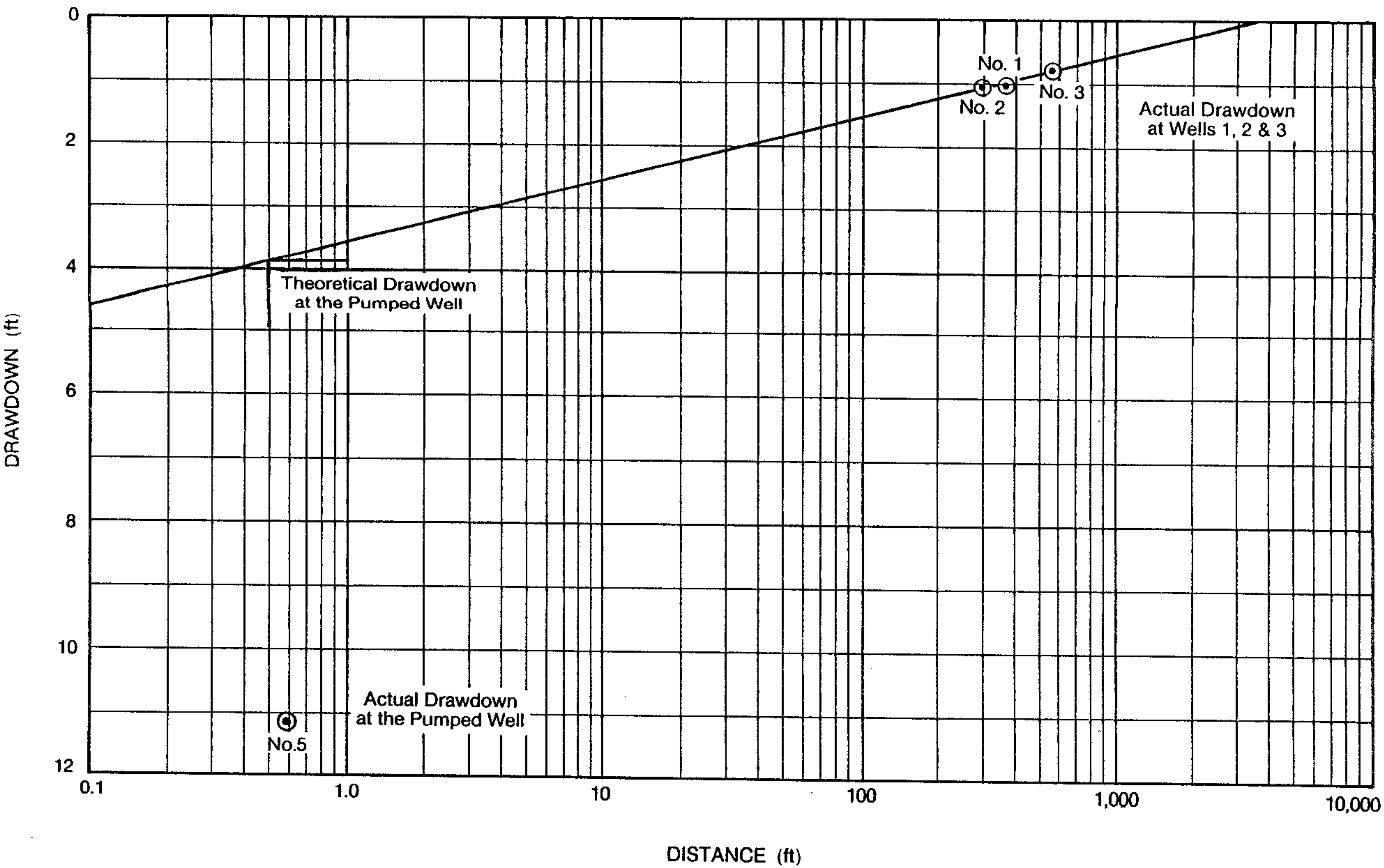


FIGURE 6-13.
Distance-Drawdown at t = 1,600 Minutes.

Chapter 7
WELL FIELD OPERATING PROGRAM

The Village of Palm Springs currently develops its groundwater supply from the Main WF. However, at some time in the future the Village will also have the option of groundwater development from the Forest Hill WF. The Well Field Operating Program proposed herein to meet Special Condition No. 14 of the Water Use Permit will address the immediate situation, or "case" in detail (Case I), that is, the Main WF. Case II, assuming future groundwater development from the Forest Hill Village site, will be covered only in general terms at this time, since this well field would not be put into service for approximately 2 years.

CASE I--MAIN WF ONLY

Wells No. 1, 3, and 4 account for most of the average day withdrawals, Wells No. 5, 6, 7, and 8 are rotated on-line as demand requires, and Wells No. 9, 10, and 11 are used only sparingly to meet peak demands.

At this time, average daily flow for the service area is approximately 2.7 mgd, or 1,875 gpm. This compares very closely with the flow rates determined for Wells No. 1, 3, 4, and 5. (Well No. 5 is part of WF No. 2 but is operated as if part of WF No. 1.) This total flow rate (from Table 3-2) is 1,840 gpm.

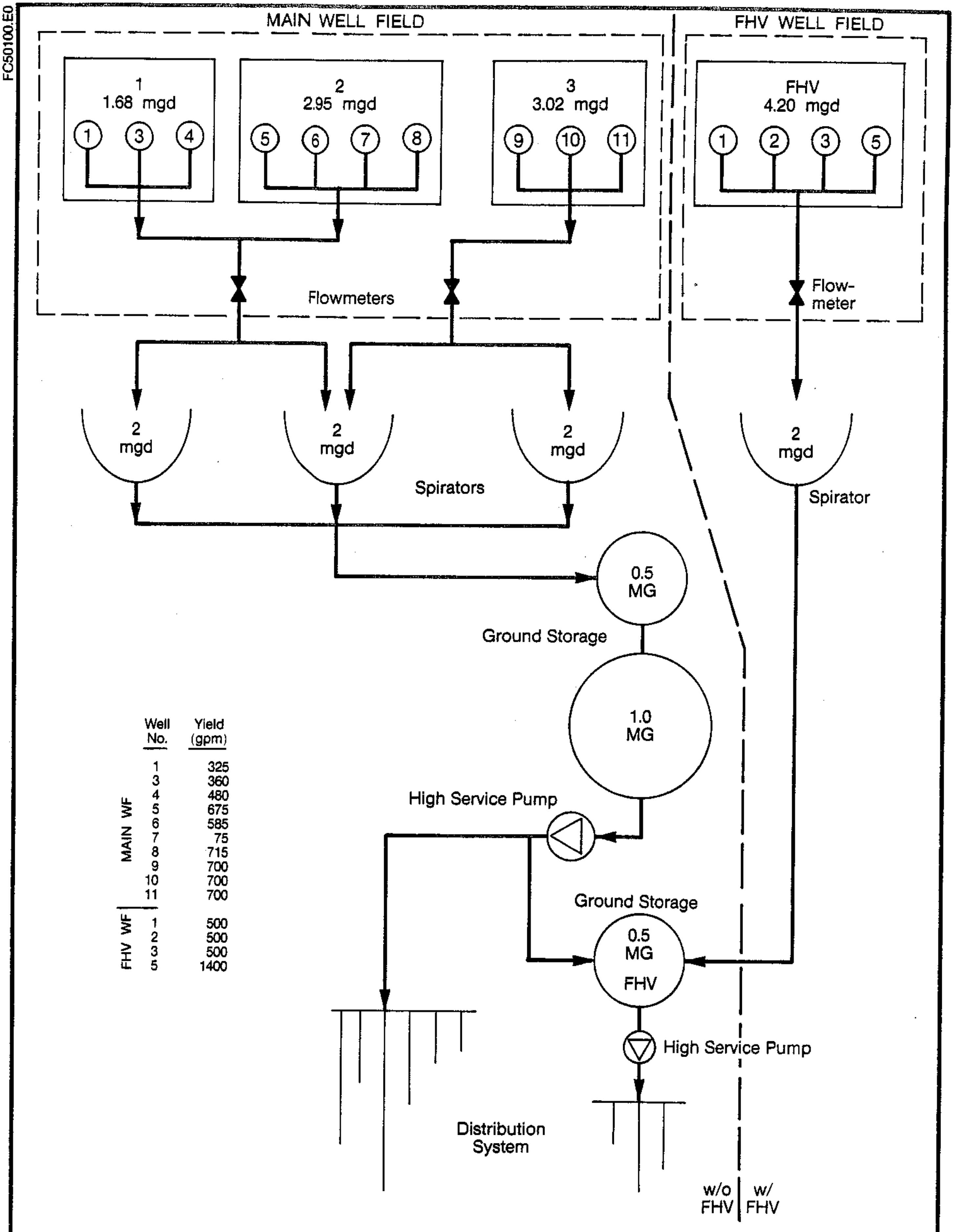
Further review of Table 3-2 reveals that, with the exception of Well No. 7, Wells No. 1, 3, and 4 yield the least amount of water and are the oldest wells in the system.

Water quality data from each of the wells is presented in Table 3-3. Wells No. 1, 3, and 4 have the lowest overall concentrations of the constituents tested, including total dissolved solids, total hardness, iron, chloride, nitrate, calcium, and magnesium. This is primarily because these wells, surrounded by surface water, develop water from this recharge source.

Figure 7-1 is a schematic of the Village of Palm Springs water system. From this drawing it can be seen how WF's No. 1, 2, and 3 interact to produce the total flow to the distribution system.

It is desirable from a hydrogeologic standpoint to rotate pumping and therefore aquifer stress around the well field. The current method of operation places all the stress on WF No. 1, with minimal stress on WF No. 3.

Because each Spiractor treatment unit must receive a flow of 1,400 gpm to operate properly, the pumps must be rotated not only to match demand and meet system operational requirements,



	Well No.	Yield (gpm)
MAIN WF	1	325
	3	360
	4	480
	5	675
	6	585
	7	75
	8	715
	9	700
	10	700
	11	700
FHV WF	1	500
	2	500
	3	500
	5	1400

FIGURE 7-1.
Water System Schematic.

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but also to achieve the goal of rotating aquifer stress around the well field.

Probably the simplest way to achieve the goal of rotating aquifer stress would be to set up a weekly operation schedule which alternately shuts down WF No. 1 and 2. Currently WF No. 1 yields approximately 1,840 gpm, WF No. 2 yields 2,050 gpm, and WF No. 3 yields 2,100 gpm. Since all 3 well fields yield approximately the same amount of water (∿2,000 gpm average), then a weekly schedule could be established which designates one well field as primary and the other two as secondary. For example, during Week No. 1 WF No. 1 would supply most of the demand, WF No. 3 would supply the remainder, and WF No. 2 would hardly be used at all. During Week 2, WF No. 2 would provide most of the demand, WF No. 3 would provide the remainder, and WF No. 1 would hardly be used at all. During Week 3, WF No. 3 would meet most of the demand and WF No. 1 would supply the remainder.

The schedule should be such that WF's No. 1 and 2 are not primary and immediate secondary at the same time. In other words, WF No. 3 should be used more than 1 and 2. This is because WF No. 3, completed in a highly permeable section of the Anastasia Formation referred to as the Turnpike Aquifer, is not in any danger of overstress due to withdrawal from Wells No. 9, 10, and 11.

CASE II--MAIN WF AND FOREST HILL WF

Once the Forest Hill WF is operational, demand at the Main WF will be reduced by approximately 2 mgd. Figure 7-1 illustrates the relationship between the two WF's. Like the Main WF, the Forest Hill WF will have a 2-mgd Spiractor treatment unit which must receive 1,400 gpm to operate properly. Operation of the Main WF should be as described above, i.e., weekly rotation of pumping around the well field. The schedule would remain the same with the reduced demand but individual wells, even in the well field designated as primary, would be off some of the time during periods of low demand.

At the Forest Hill WF, rotation of pumping should also be standard operational practice. Rotation could also be on a weekly basis, with Wells No. 1, 2, and 3 meeting demand one week and Well No. 5 the next.

Since the Main WF and Forest Hill WF will be interconnected, any excessive demands could be met from any of the four well fields.

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Chapter 8
MONITORING PROGRAM

For a monitoring program to be valuable, the data must be properly obtained and must be utilized effectively in an orderly decision-making process. The goal of this monitoring program is to provide guidance for the collection of useful information, which in turn will become the basis for water system management for the Village of Palm Springs.

As discussed previously in this report, the Village water system consists of two separate well field and treatment facilities. Since only one of the facilities is currently in use, the monitoring program(s) described below will address two separate cases. The Case I Monitoring Program is based on the assumption that groundwater is withdrawn from the Main WF only. The Case II Monitoring Program is based on the assumption that both the Main WF and the Forest Hill WF provide water to the system.

CASE I--MAIN WF ONLY

The Main WF consists of three small well fields constructed at different times as demand increased over the years in the Village service area. WF's No. 1 and 2 are separate only from an operational standpoint. Hydrogeologically, these two well fields can be considered as one. WF No. 3, consisting of 3 wells installed along the bank of LWDD Canal No. 8, is far enough away from WF's No. 1 and 2 that there are no interference effects transmitted between the two sites.

The monitoring program recommended for the Main WF can be divided into three separate functions. These are:

- Operation
- Water Quality
- Water Availability

Operational Monitoring

As the term implies, well field operational monitoring is intended to provide information on the performance of the system. In general, the Village water system consists of wells, a raw water collection system, in-flow metering devices, treatment facilities, storage, and distribution.

Well performance should be monitored on an annual basis. Once per year each well should be inspected (visually) for leaks, check-valve operation, and general condition. Any deficiencies should be corrected and a record kept on file for each well. Depth to water level should be measured annually, preferably in May (the end of the dry season) in each well. This procedure should include both a static depth to water level (pumps off for at least 2 hours) and a pumped water level measurement (pumps on for at least 1 hour). The difference between these two measurements should then be calculated (drawdown) and all three values recorded for each well.

It should be noted that at this time it is somewhat difficult to obtain water level measurements in the Main WF wells, particularly those in WF's No. 2 and 3. In WF No. 1, wells are above grade, and measurements can be made with a chalked steel tape through a small access hole (~1/8-inch diameter) where an air line water measuring device was once installed. However, in WF's No. 2 and 3, wells are housed in below grade pump pits and access is obtained by disconnecting casing vent lines and/or air release valves, a somewhat laborious task. In the future, as maintenance on each well is accomplished, it is suggested that piping be modified to allow for easier access to each well.

On the same day that water level measurements are being recorded, flow rates for each well should be determined using the approach described in Chapter 3. This information should be recorded and the specific capacity calculated for each well. Specific capacity is the pumping rate, in gallons per minute, divided by the drawdown, measured in feet. The purpose of this calculation is to provide information on well performance. Yearly measurements become valuable when compared to original values in determining appropriate rehabilitation schedules for individual wells. Further, over the years, trends for individual wells can be determined and a regular maintenance/rehabilitation schedule can be outlined for each well.

Water lost through the raw water collection system would invalidate the determination of flow for individual wells described above, since flow is not measured at the well head. The quantity of water lost through the raw water collection system should be determined periodically to ensure that large leaks are not occurring in the system. This could be accomplished by pressure testing lines or measuring flow at individual wells and comparing those rates measured at the treatment plant influent flow meter. A reasonable frequency for this effort might be once every 5 years.

Raw water inflow to the Main WTP is measured by two Venturi type flow meters. The flow rate is then recorded on a circular chart as a permanent record of total Main WF water production. To ensure that the records are accurate, these devices should be checked and calibrated once per year by qualified personnel. Calibration of the flow meters is not only important to ensure accurate withdrawal/water use data but also to minimize the source of error in determining flow rates from individual wells as discussed above. This calibration then should be accomplished just prior to the well performance evaluation described above.

The scope of this monitoring program focuses primarily on the well field. Operational monitoring of the treatment facilities, storage facilities, and distribution system should be an on-going effort for any water utility. The exact details of operational monitoring of the system beyond the flow measuring devices is part of this effort. It should be noted that the Village of Palm Springs is currently performing some of the tasks described above.

Water Quality Monitoring

Well field water quality monitoring is intended to provide data on individual well, raw water composite, and distribution system water quality trends.

Individual wells should be sampled annually and tested for the following parameters:

Temperature
pH (field)
Total dissolved solids
Total hardness
Iron
Chloride
Color
Nitrate
Calcium
Magnesium

A raw water composite sample (composite from all Main WF wells) should be collected every 2 years. In addition, a distribution system sample (composite at several different points) should be collected every 2 years. These two composite samples should be analyzed for the following parameters:

Nitrate	Mercury
Fluoride	Endrin
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Toxaphene
Chromium	2, 4-D
Lead	2,4,5 -TP silvex
Selenium	Total dissolved solids

Silver	Iron
pH (lab)	Chloride
pHs	Sodium
Corrosivity	Copper
Sulfate	Zinc
Sulfides	Turbidity
Hydrogen Sulfide	Foaming Agents
Manganese	Total Alkalinity

Should results for any of the above parameters be higher than maximum allowable contaminant levels (where standards exist) or show any marked increase in concentration from previous years (where no standards exist), individual wells should be sampled and analyzed for that particular constituent.

Water samples should be taken at selected points in the distribution system including some dead end lines and points farthest from the Main WTP (a minimum of 4 locations) once every 2 years. These samples should be analyzed for the following parameters:

Total Trihalomethanes
Chloroform
Bromodichloromethane
Dibromochloromethane
Bromoform

Water Availability Monitoring

Water availability monitoring is intended to provide data on aquifer production zone water level trends and response to rainfall. Well field performance is directly affected by declines in water level due to drought conditions. Adjustments to pumping rates and/or schedules may need to be made in response to declining water levels to prevent damage to wells (drawdown below screen), pumps (cavitation), and lateral intrusion of saltwater (overstressing the aquifer).

Rainfall is the source of all recharge to the Village of Palm Springs Main WF. The actual recharge mechanism is induced infiltration from the overlying water table and leakance from canals. The relationship between rainfall and recharge is direct and of importance to the long-term monitoring of the Main WF.

Water level trends in the vicinity of the Main WF can be monitored by the compilation of static water levels measured at the end of the dry season (May) in each production well as discussed in Chapter 3. These data are most helpful when plotted on a graph such that water level trends can be quickly visualized.

A much better record of water trends will be obtained from the continuous water level recorder installed at Well MW-1 (see Figure 2-1 for location). The continuous record produced at this well would likewise be most helpful if plotted on a graph in which data covering at least 1 entire year could be visualized.

Since recharge is direct from rainfall, a simple rain gauge could be installed at the Main WTP and read by water plant operators on duty at the time. These data, likewise, should be plotted on a graph. Rainfall data would be most useful if it were plotted on the same graph as the continuous water level record. Using this approach, quick visual inspection could be made to assess the water level trends and aquifer response to rainfall.

All data collected as part of this monitoring program should be kept in an organized, easily understandable format. Water system management decisions could then be made with a minimum of effort by quick visual inspection of monitoring data.

CASE II--MAIN WF AND FOREST HILL WF

This monitoring program can be divided into the same three functions as Case I: Operation, Water Quality, and Water Availability. The program described in Case I should be followed at the Main WF. In addition, since the Forest Hill WF will also provide water to the system, monitoring at this site should be included in the Case II program.

Well performance at the Forest Hill WF should be determined annually, using the same procedures as in Case I, i.e., measurement of static and pumped water levels, calculation of drawdown, measurement of flow rate, and calculation of specific capacity. It is assumed that this task would be much easier at the Forest Hill WF since wells are above grade. Final design of the well head should include provisions for measuring water level and flow rate at each well (1, 2, 3, and 5). As with Case I, this effort should be performed in May, the end of the dry season.

It is assumed that raw water collection lines will be installed or tested as part of the water treatment plant reactivation. As above, visual inspection of all wells should be made and defects corrected as soon as possible. It is also assumed that a flow meter will be installed at the plant to measure total well field flow. The raw water collection system could then be monitored by comparing flow at the plant with flow from each well.

As in Case I, the plant influent flow meter should be calibrated annually prior to data collection.

Well field water quality monitoring at the Forest Hill WF should involve the same parameters and frequency as listed above for Case I.

Water availability monitoring at the Forest Hill WF should consist primarily of reviewing the information collected as part of the operational monitoring. This would involve reviewing and plotting static water level measurements made at one well (Well No. 2). In addition, the static water level should be measured once in September at Well No. 2. The record of wet-season (September) and dry-season (May) static water levels at the approximate center of pumping (Well No. 2) will provide, over the years, valuable information on water level trends at the Forest Hill WF.

Again, it should be emphasized that monitoring data is only useful if it is easily accessible and becomes part of the decision-making process.

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Chapter 9
CONCLUSIONS AND RECOMMENDATIONS

Based on this investigation, the following conclusions have been reached:

1. The Main WF is in good repair and is capable of providing water of good quality to meet current demand.

2. Wells No. 3, 4, 5, and 7 at the Main WF should respond well to rehabilitation.

3. Total flow potential from the Main WF is approximately 5,300 gpm.

4. Wells No. 1, 2, and 3 at Forest Hill WF improved by 120 to 660 percent after redevelopment.

5. Water quality at the Main WF is good, with TDS less than 400 mg/l.

6. Water quality at the Forest Hill WF is good, with TDS less than 300 mg/l.

7. The current estimated population in the Village service area is 23,830, and the current water use rate is 2.7 mgd.

8. The projected 1993 population for the service area is 33,230 to 37,530 people. Projected water use is 3.9 to 4.4 mgd, average daily flow.

9. The Main WF develops water from the Anastasia Formation, with Wells No. 9, 10, and 11 completed in the highly permeable portion of this formation known as the Turnpike Aquifer.

10. Forest Hill WF develops water from the Turnpike Aquifer.

11. Aquifer characteristics determined at the Forest Hill WF are:

    $T = 166{,}800\ ft^2/day$

    $S = 1 \times 10^{-3}$

    $k'/b' = 2 \times 10^{-3}/day$

12. The Forest Hill Village site is capable of safely producing much more water than is required by the Village.

13. The goal of the Well Field Operating Program should be to rotate pumping and therefore aquifer stress around the well fields.

14. The goal of the monitoring program is to collect useful information that can be effectively utilized in the decision-making process.

Based on this investigation, the following recommendations are submitted:

1. Install and maintain a continuous water level recorder at MW-1.

2. Redevelop Wells No. 3, 4, 5, and 7 in the Main WF.

3. Implement the Well Field Operating Program and monitoring program described in this report.

4. Apply to the South Florida Water Management District for a change in allocation in WUP Permit No. 50-00036-W from 3.47 mgd through 1989 to 4.4 mgd through 1993.

5. Request that SFWMD amend WUP Permit No. 50-00036-W by deleting Special Condition No. 22, which currently disallows groundwater withdrawal from Forest Hill WF.

6. Submit this report to SFWMD as support documentation for permit modification.

GNR61

Appendix A

PERMITS

JOHN R. MALOY, Executive Director

South Florida Water Management District

POST OFFICE BOX "V", WEST PALM BEACH, FLORIDA 334(

TELEPHONE (305) 686-88(

IN REPLY REFER TO:

October 17, 1979

Dear Permittee:

Enclosed is your permit as authorized by the Governing Board of the South Florida Water Management District at its meeting on October 11, 1979.

Some of the special conditions on your permit require reports to be sent in to this District. Please read these conditions and use the forms provided when submitting these reports. If you have any questions, please do not hesitate to call this office.

Sincerely,

Vern Kaiser, Supervisor
Permit Administration Division
Resource Control Department

VK/dr

Enclosures

FORM 680
REV. Nov. 1975

South Florida
Water Management District

WATER USE PERMIT NO. Re-Issue 50-00036-W

(NON-ASSIGNABLE)

DATE ISSUED: October 11, 1979 EXPIRATION DATE October 11, 1989

AUTHORIZING: USE OF GROUNDWATER FROM THE SHALLOW AQUIFER FOR PUBLIC WATER SUPPLY WITH AN ANNUAL ALLOCATION OF 1,265 MILLION GALLONS.

LOCATED IN: PALM BEACH COUNTY, SECTION 18 TWP. 44S RGE. 42, 43E

ISSUED TO: Village of Palm Springs
City Hall
Palm Springs, Florida 33460

This Permit is issued pursuant to Application for Permit No. --- dated ------, 19 -- for the Use of Water as specified above and subject to the Special Conditions set forth below. Said application, including all plans and specifications attached thereto, is by reference made a part hereof.

Upon written notice to the permitee, this permit may be temporarily modified, or restricted under a Declaration of Water Shortage or a Declaration of Emergency due to Water Shortage in accordance with provisions of Ch. 373, Fla. Statutes, 1973 and applicable rules and regulations of the South Florida Water Management District.

This Permit may be permanently or temporarily revoked, in whole or in part, for the violation of the conditions of the permit or for the violation of any provision of the Water Resources Act and regulations thereunder.

This Permit does not convey to permittee any property rights nor any privileges other than those specified herein, nor relieve the permittee from complying with any law, regulation, or requirement affecting the rights of other bodies or agencies.

SPECIAL CONDITIONS ARE AS FOLLOWS:

SEE SHEETS 2, 3, AND 4 OF 4 - 22 GROUNDWATER SPECIAL CONDITIONS.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT, BY ITS GOVERNING BOARD

By [signature]
Assistant Secretary

1. APPLICATION FOR AN ADDITIONAL ALLOCATION OR MODIFICATION MAY BE MADE AT ANY TIME.

2. THIS PERMIT SHALL EXPIRE 10 YEARS FROM THE DATE OF ISSUANCE.

3. MAXIMUM DAY WITHDRAWAL SHALL NOT EXCEED 5.544 MGD.

4. PERMITTEE SHALL SUBMIT TO THE DISTRICT COPIES OF THE MONTHLY D.E.R. WATER TREATMENT PLANT REPORTS.

   THE REPORTS SHALL BE SUBMITTED ON A MONTHLY BASIS FOLLOWING THE MONTH OF RECORD. PERMITTEE SHALL BEGIN SUBMITTING REPORTS IN THE MONTH FOLLOWING THE MONTH OF PERMIT ISSUANCE. REPORTS SHALL BE LEGIBLE, AND THE WATER USE PERMIT NUMBER SHALL BE ATTACHED TO ALL REPORTS.

5. IN THE EVENT OF A DECLARED WATER SHORTAGE, WATER WITHDRAWAL REDUCTIONS SHALL BE MADE AS SPECIFIED BY THE DISTRICT.

6. PERMITTEE SHALL SUBMIT A PROPOSAL FOR A REPORT ENTITLED "WATER SHORTAGE CONSERVATION PROGRAM" TO THE DISTRICT WITHIN 18 MONTHS OF PERMIT ISSUANCE. THIS PROGRAM SHALL DESCRIBE THE MANNER IN WHICH THE PERMITTEE WILL EFFECT CUTBACKS IN WATER USE DURING WATER SHORTAGE CONDITIONS. A FINAL REPORT WHICH MEETS THE APPROVAL OF DISTRICT STAFF SHALL BE SUBMITTED WITHIN 24 MONTHS OF PERMIT ISSUANCE. PERMITTEE SHOULD CONTACT THE DIRECTOR OF THE DISTRICT'S WATER RESOURCE CENTER, P.O. BOX V, W. PALM BEACH, FL 33402 (TELEPHONE NO. 1-800-432-2045) FOR ASSISTANCE IN COMPLYING WITH THIS PROVISION.

7. PERMITTEE SHALL MITIGATE ANY ADVERSE IMPACT CAUSED BY WITHDRAWALS ON LEGAL USES WHICH EXISTED AT THE TIME OF PERMIT APPLICATION. DISTRICT RESERVES THE RIGHT TO CURTAIL FUTURE PUMPAGE RATES IF PUMPAGE CAUSES AN ADVERSE IMPACT ON LEGAL USES OF WATER WHICH EXISTED AT THE TIME OF APPLICATION. ADVERSE IMPACTS ARE EXEMPLIFIED BY BUT NOT LIMITED TO THE FOLLOWING: 1) REDUCTION IN WELL WATER LEVELS RESULTING IN A REDUCTION OF 10% IN THE ABILITY OF AN ADJACENT WELL TO PRODUCE WATER (AN ADJACENT WELL MAY BE A DOMESTIC WELL, LAWN IRRIGATION WELL, PUBLIC WATER SUPPLY WELL, ETC.), 2) SIGNIFICANT REDUCTION IN WATER LEVELS IN AN ADJACENT WATER BODY SUCH AS A LAKE, POND, OR A CANAL SYSTEM, RESULTING IN A SIGNIFICANT IMPAIRMENT OF THE USE OF WATER IN THAT WATER BODY, 3) SALINE WATER INTRUSION OR INDUCTION OF POLLUTANTS INTO THE WATER SUPPLY OF AN ADJACENT WATER USE RESULTING IN A SIGNIFICANT REDUCTION IN WATER QUALITY.

8. PERMITTEE SHALL MITIGATE ANY ADVERSE IMPACT ON OFF-SITE LAND USE WHICH EXISTED AT THE TIME OF APPLICATION, AS A CONSEQUENCE OF WITHDRAWALS PERMITTED HEREIN TO THE SATISFACTION OF THE DISTRICT. THE DISTRICT RESERVES THE RIGHT TO CURTAIL FUTURE PUMPAGE RATES IF INCREASED WITHDRAWALS CAUSE AN ADVERSE IMPACT ON LAND USE WHICH EXISTED AT THE TIME OF APPLICATION. ADVERSE IMPACTS ARE EXEMPLIFIED BY BUT NOT LIMITED TO THE FOLLOWING: 1) SIGNIFICANT REDUCTION IN WATER LEVELS IN AN ADJACENT WATER BODY SUCH AS A LAKE, POND, OR CANAL SYSTEM WHICH IS NOT BEING USED AS A SOURCE OF WATER; 2) LAND COLLAPSE OR SUBSIDENCE CAUSED BY REDUCTION IN WATER LEVELS; 3) DAMAGE TO CROPS AND OTHER TYPES OF VEGETATION, THE ELIMINATION OF WHICH WOULD CAUSE FINANCIAL HARM TO THE LANDOWNER.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT, BY ITS GOVERNING BOARD

By ______________________
Assistant Secretary

9. THE ANNUAL ALLOCATION SPECIFIED HEREIN IS NOT A GUARANTEE EITHER THAT THE WATER IS AVAILABLE OR THAT THE ANNUAL ALLOCATION WILL NOT PRODUCE AN ADVERSE IMPACT, BUT REPRESENTS THE BEST EVALUATION BY THE DISTRICT STAFF OF AVAILABLE DATA. THE ALLOCATION MAY BE SUBJECT TO CHANGE IF THE RESULTS OF MONITORING ACTIVITIES SPECIFIED HEREIN DEMONSTRATE AN ADVERSE IMPACT OR SIGNIFICANT ADVANCE OF THE SALINE WATER INTERFACE.

10. IF THE PERMITTEE WILL NOT SERVE A NEW DEMAND LOCATED WITHIN THE SERVICE AREA FOR WHICH THE ANNUAL ALLOCATION WAS CALCULATED, THE ANNUAL ALLOCATION MAY BE SUBJECT TO MODIFICATION.

11. MODIFICATION OF EXISTING WELLS SHALL BE PERFORMED PER F.A.C. 17-21 AND 17-22. MODIFICATIONS OF EXISTING WELLS SHALL BE UNDER THE DIRECTION AND TH SUPERVISION OF A WATER WELL CONTRACTOR LICENSED BY THE FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION. PERMITTEE SHALL OBTAIN A DER WELL CONSTRUCTIC PERMIT PRIOR TO CONSTRUCTING A WELL.

12. THE DISTRICT AND THE DEPARTMENT OF ENVIRONMENTAL REGULATION SHALL BE NOTIFIED AT LEAST 5 DAYS PRIOR TO THE CONSTRUCTION OF PROPOSED WELLS.

13. A DRILLER'S WELL COMPLETION REPORT FOR MODIFIED WELLS SHALL BE PROVIDED TO THE DISTRICT WITHIN ONE MONTH OF DATE OF WELL CONSTRUCTION OR MODIFICATION.

14. PERMITTEE SHALL DEVELOP AND IMPLEMENT A "WELLFIELD OPERATING PROGRAM (WOP)" WITHIN SIX MONTHS OF DATE OF PERMIT ISSUANCE. THIS PROGRAM SHALL DETAIL WHICH WELLS ARE PRIMARY, STANDBY (RESERVE), WELL ROTATION SCHEDULE THE ORDER OF PREFERENCE IN TURNING-ON WELLS, AND ANY OTHER ASPECTS OF WELLFIELD MANAGEMENT. THE WOP MAY BE SUBMITTED AS A LETTER REPORT.

15. SOURCE CLASSIFICATION IS GROUNDWATER FROM THE SHALLOW AQUIFER.

16. USE CLASSIFICATION IS PUBLIC SUPPLY.

17. THE DIRECTOR OF THE RESOURCE CONTROL DEPARTMENT OR HIS AUTHORIZED REPRESENTATIVES SHALL BE PERMITTED TO ENTER, INSPECT AND OBSERVE THE PUBLIC WATER SYSTEM UPON DISTRICT STAFF IDENTIFICATION IN ORDER TO DETERMINE COMPLIANCE WITH SPECIAL CONDITIONS.

18. PERMITTEE SHALL NOTIFY THE DISTRICT OF ANY CHANGE IN SERVICE TERRITORY OR AREA WITHIH 30 DAYS OF THE CHANGE IN BOUNDARY.

19. PERMITTEE SHALL DETERMINE "UNACCOUNTED FOR" DISTRIBUTION SYSTEM LOSSES IF THE PERMITTEE DISTRIBUTES WATER WITHIN ONE MILE OF SURFACE SALINE WATER. LOSSES SHALL BE DETERMINED FOR THE ENTIRE DISTRIBUTION SYSTEM ON A MONTHLY BASIS. PERMITTEE SHALL DEFINE THE MANNER IN WHICH "UNACCOUNTED FOR" LOSSES ARE CALCULATED. DATA COLLECTION SHALL BEGIN WITHIN SIX MONTHS OF PERMIT ISSUANCE. LOSSES SHALL BE SUBMITTED TO THE DISTRICT ON A YEARLY BASIS FROM THE DATE OF PERMIT ISSUANCE WITH NO DATA SUBMITTED MORE THAN ONE MONTH AFTER EXPIRATION OF THE ONE YEAR PERIOD.

20. IF ANY CONDITIONS OF THIS PERMIT ARE VIOLATED, THE PERMIT SHALL BE SUBJ TO REVIEW AND POSSIBLE REVOCATION AND MODIFICATION, OR ENFORCEMENT ACTI

21. THE PERMITTEE SHALL INSTALL, MAINTAIN AND OPERATE AN AUTOMA..C WATER LEVEL RECORDING DEVICE IN AN OBSERVATION WELL IN THE VILLAGE OF PALM SPRINGS WELLFIELD AT A LOCATION AND DEPTH ACCEPTABLE TO THE DISTRICT. HYDROGRAPHS DERIVED THEREFROM SHALL BE SUBMITTED TO THE DISTRICT ON A QUARTERLY BASIS.

22. PERMITTEE SHALL NOT WITHDRAW WATER FROM WELLFIELDS IN THE ADDED SERVICE AREAS (FOREST HILL VILLAGE, ENGLEWOOD MANOR AND TOWN OF LAKE CLARKE SHORES), EXCEPT FOR AQUIFER EVALUATION APPROVED BY THE DISTRICT.

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

SOUTHEAST FLORIDA DISTRICT

P.O. BOX 3858
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33402-3858

File

BOB GRAHAM
GOVERNOR

VICTORIA J. TSCHINKEL
SECRETARY

ROY M. DUKE
DISTRICT MANAGER

PW - Palm Beach County
Village of Palm Springs
Test/ Production Well #1

January 27, 1983

Patrick D. Miller
Village Manager
Village of Palm Springs
226 Cypress Lane
Palm Springs, Florida 33461

David E. Webb
Vice President
Drilling Services, Inc.
3504 Industrial 33rd Street
Fort Pierce, Florida 33450

Dear Gentlemen:

Enclosed is Permit Number WW 50-63792, to drill test/production well #1 issued pursuant to Section 373.313, Florida Statutes.

Should you object to this permit, including any and all of the conditions contained therein, you may file an appropriate petition for administrative hearing. This petition must be filed within fourteen (14) days of the receipt of this letter. Further, the petition must conform to the requirements of Florida Administrative Code Rule 28-5.201 (see reverse side of this letter). The petition must be filed with the Office of General Counsel, Department of Environmental Regulation, Twin Towers Office Building, 2600 Blair Stone Road, Tallahassee, Florida 32301.

If no petition is filed within the prescribed time, you will be deemed to have accepted this permit and waived your right to request an administrative hearing on this matter.

Acceptance of the permit constitutes notice and agreement that the Department will periodically review this permit for compliance, including site inspections where applicable, and may initiate enforcement action for violation of the conditions and requirements thereof.

Sincerely,

Louis Devillon
Drinking Water Engineer

cc: Tallahassee
Palm Beach County Health Department
CH_2 M-Hill

LD:km/12

Enclosure

DER Form 17-1.201(7)
Effective November 30, 1982

RULES OF THE ADMINISTRATION COMMISSION
MODEL RULES OF PROCEDURE
CHAPTER 28-5
DECISIONS DETERMINING SUBSTANTIAL INTERESTS

PART II
FORMAL PROCEEDINGS

28-5.201 Initiation of Formal Proceedings.

(1) Initiation of formal proceedings shall be made by petition to the agency responsible for rendering final agency action. The term petition as used herein includes any application or other document which expresses a request for formal proceedings. Each petition should be printed, typewritten or otherwise duplicated in legible form on white paper of standard legal size. Unless printed, the impression shall be on one side of the paper only and lines shall be double-spaced and indented.

(2) All petitions filed under these rules should contain:

(a) The name and address of each agency affected and each agency's file or identification number, if known;

(b) The name and address of the petitioner or petitioners, and an explanation of how his/her substantial interests will be affected by the agency determination;

(c) A statement of when and how petitioner received notice of the agency decision or intent to render a decision;

(d) A statement of all disputed issues of material fact. If there are none, the petition must so indicate;

(e) A concise statement of the ultimate facts alleged, as well as the rules and statutes which entitle the petitioner to relief;

(f) A demand for relief to which the petitioner deems himself entitled; and

(g) Other information which the petitioner contends is material.

****

A petition may be denied if the petitioner does not state adequately a material factual allegation, such as a substantial interest in the agency determination, or if the petition is untimely. (Section 28-5.201(3)(a), FAC)

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL REGULATION

SOUTHEAST FLORIDA DISTRICT
P.O. BOX 3858
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33402-3858

BOB GRAHAM
GOVERNOR
VICTORIA J. TSCHINKEL
SECRETARY
ROY M. DUKE
DISTRICT MANAGER

PERMITTEE:
Patrick D. Miller
Village Manager
Village of Palm Springs
226 Cypress Lane
Palm Springs, Florida 33461

David E. Webb
Vice President
Drilling Services, Inc.
3504 Industrial 33rd Street
Fort Pierce, Florida 33450

I.D. NUMBER: 4501058
PERMIT/CERTIFICATION NUMBER: WW 50-63792
DATE OF ISSUE: January 27, 1983
EXPIRATION DATE: July 10, 1983
COUNTY: Palm Beach County
LATITUDE/LONGITUDE: 26°38'18", 80°05'49"
SECTION/TOWNSHIP/RANGE: 19, 44S, 43E
PROJECT: Village of Palm Springs Test/Production Well #1

This permit is issued under the provisions of Chapter 373, Florida Statutes, and Florida Administrative Code Rule 17-21 and 17-22. The above named permittee is hereby authorized to perform the work or operate the facility shown on the application and approved drawing(s), plans, and other documents attached hereto or on file with Department and made a part hereof and specifically described as follows:

TO CONSTRUCT: Test/Production Well #1 by the rotary method with 100± feet of 12 inch casing sealed with neat cement grout to the formation the complete length. A 70± foot deep open hole shall be drilled from the bottom of the casing to a total depth of 170± feet. Well screen may be utilized if necessary.

IN ACCORDANCE WITH: Application on DER Form 17-1.122(11), revised site layout received January 18, 1983 (not attached).

LOCATED AT: Forest Hill Village facility, Basil Drive, Palm Springs, Florida.

TO SERVE: Village of Palm Springs water supply service area.

SUBJECT TO: General Conditions 1-15 and Specific Conditions 1-6.

PERMITTEE:

I.D. Number:
Permit/Certification Number:
Date of Issue:
Expiration Date:

GENERAL CONDITIONS:

1. The terms, conditions, requirements, limitations, and restrictions set forth herein are "Permit Conditions" and a such are binding upon the permittee and enforceable pursuant to the authority of Sections 403.161, 403.727, o 403.859 through 403.861, Florida Statutes. The permittee is hereby placed on notice that the department wil review this permit periodically and may initiate enforcement action for any violation of the "Permit Conditions by the permittee, its agents, employees, servants or representatives.

2. This permit is valid only for the specific processes and operations applied for and indicated in the approve drawings or exhibits. Any unauthorized deviation from the approved drawings, exhibits, specifications, or condi tions of this permit may constitute grounds for revocation and enforcement action by the department.

3. As provided in Subsections 403.087(6) and 403.722(5), Florida Statutes, the issuance of this permit does not con vey any vested rights or any exclusive privileges. Nor does it authorize any injury to public or private propert or any invasion of personal rights, nor any infringement of federal, state or local laws or regulations. Thi permit does not constitute a waiver of or approval of any other department permit that may be required for othe aspects of the total project which are not addressed in the permit.

4. This permit conveys no title to land or water, does not constitute state recognition or acknowledgement of title and does not constitute authority for the use of submerged lands unless herein provided and the necessary title o leasehold interests have been obtained from the state. Only the Trustees of the Internal Improvement Trust Fun may express state opinion as to title.

5. This permit does not relieve the permittee from liability for harm or injury to human health or welfare, animal plant or aquatic life or property and penalties therefor caused by the construction or operation of this permitte source, nor does it allow the permittee to cause pollution in contravention of Florida Statutes and departmen rules, unless specifically authorized by an order from the department.

6. The permittee shall at all times properly operate and maintain the facility and systems of treatment and contro (and related appurtenances) that are installed or used by the permittee to achieve compliance with the condition of this permit, as required by department rules. This provision includes the operation of backup or auxiliar facilities or similar systems when necessary to achieve compliance with the conditions of the permit and when re quired by department rules.

7. The permittee, by accepting this permit, specifically agrees to allow authorized department personnel, upon pre sentation of credentials or other documents as may be required by law, access to the premises, at reasonabl times, where the permitted activity is located or conducted for the purpose of:

   a. Having access to and copying any records that must be kept under the conditions of the permit;

   b. Inspecting the facility, equipment, practices, or operations regulated or required under this permit; and

   c. Sampling or monitoring any substances or parameters at any location reasonably necessary to assure complianc with this permit or department rules.

   Reasonable time may depend on the nature of the concern being investigated.

8. If, for any reason, the permittee does not comply with or will be unable to comply with any condition or limita tion specified in this permit, the permittee shall immediately notify and provide the department with the follow ing information:

   a. a description of and cause of non-compliance; and

PERMITTEE:
Patrick D. Miller, Village Manager

David E. Webb, Vice President

I.D. Number:
Permit/Certification Number: WW 50-63792
Date of Issue: January 27, 1983
Expiration Date: July 10, 1983

SPECIFIC CONDITIONS:

1. This permit is for the purpose of drilling a test or exploratory well(s), which, if the water proves to be acceptable, will serve as a source of raw water for a public water system.

2. A copy of the well completion report shall be mailed to the Department and the South Florida Water Management District at P.O. Box "V", West Palm Beach, Florida 33402.

3. South Florida Water Management District representatives are authorized to monitor your construction operation for compliance with this permit. Notify them of the date you intend to start construction by filling out and mailing the enclosed card. Notification must be received by them five (5) days prior to starting construction.

4. The well (s) shall be cleaned, disinfected and bacteriologically cleared in accordance with Chapter 17-22, F.A.C. The bacteriological clearance data and the well driller's completion report(s) shall be submitted to the County Health Department and a release for use shall be obtained therefrom prior to placing the well(s) in service.

5. A chemical analysis of the raw well water for contaminants listed in the Primary and Secondary standards of Florida Administrative Code Rule 17-22.104(1)(a), (b), (c), and (2) shall be submitted prior to release for use.

6. Appropriate applications, plans, and specifications for associated raw water transmission main, well head, well and pump shall be submitted and Department approval given prior to release of this well for service.

Issued this 27th day of January, 1983

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL REGULATION

Roy M. Duke

ID

Roy M. Duke
District Manager

DER Form 17-1.201(5)
Effective November 30, 1982

Appendix B

WATER ANALYSIS REPORTS

CH2M HILL

ENVIRONMENTAL LABORATORIES
7201 N.W. Eleventh Place
P.O. Drawer 1647
Gainesville, Florida 32602
904/377-2442

Sample No. 19302

Lab ID #82112

WATER ANALYSIS REPORT

Owner: Village of Palm Springs

Project No. FC50100.E0

Attention: Gary Eichler

Received: 1/13/83

Address:

Reported: 1/21/83

SAMPLE LOCATION: Well #3 Pumping Test

SOURCE OF SUPPLY: ☐ Surface, ☒ Ground

TYPE OF SAMPLE: ☐ Composite, ☒ Grab

SAMPLE COLLECTED BY: Gary Eichler

DATE: 12 / 29 / 82 TIME ☐ AM ☐ PM

Substance		MCL (milligrams per liter[1])	present (milligrams per liter[1])
Arsenic	As	0.05	
Barium	Ba	1	
Cadmium	Cd	0.01	
Chloride	Cl^-	250	35
Chromium	Cr	0.05	
Color, APHA color units		15	65
Copper	Cu	1	
Fluoride	F^-	*	0.17
Foaming agents	MBAS	0.5	
Iron	Fe	0.3	0.95
Lead	Pb	0.05	
Manganese	Mn	0.05	
Mercury	Hg	0.002	
Nitrate (as N)	NO_3^-	10	
Odor, threshold odor number		3	NOO
Selenium	Se	0.01	
Silver	Ag	0.05	
Sodium	Na	160	24
Sulfate	$SO_4^=$	250	9.8
Total dissolved solids @ 180° C		500	
Turbidity, NTU		1	6.7
Zinc	Zn	5	

Substance		as substance (milligrams per liter[1])	as $CaCO_3$ (milligrams per liter[1])
Alkalinity, phenolphthalein			0.0
Alkalinity, total			224
Carbon dioxide, free	CO_2	36	16
Bicarbonates	HCO_3^-	223	273
Carbonates	$CO_3^=$	0.6	0.4
Hydroxides	OH^-	<0.1	<0.1
Calcium	Ca	86	214
Magnesium	Mg	4.4	18
Total hardness			232
Carbonate hardness			224
Noncarbonate hardness			8.0

Conductivity 522 µmhos/cm @ 25° C

Oxygen, dissolved (field) mg/L O_2

Temperature (field) ° C

pH (field) [6.5-8.5]

pH (laboratory) 7.45 pH_s @ 25 °C 7.17

Stability index ($2\,pH_s$-pH) 6.89

Saturation index (pH-pH_s) 0.28

Aggressive index (pH + log AH) 12.13

Dissolved Solids (by Σ major ions) 293 mg/l

Sulfide (mg/l) 0.21

THE INFORMATION SHOWN ON THIS SHEET IS TEST DATA ONLY AND NO INTERPRETATION OF THE DATA IS INTENDED OR IMPLIED

1. Except color, odor, pH and turbidity

MCL Maximum contaminant level

* MCL 1.4-2.4—depends upon avg. daily max. air temp.

< means less than detection limits

N.O.O. means no odor observed

Respectfully submitted,

K D Starcher

K. D. Starcher Chemist

CH2M HILL

ENVIRONMENTAL LABORATORIES
7201 N.W. Eleventh Place
P.O. Drawer 1647
Gainesville, Florida 32602
904/377-2442

Sample No. 19395

Lab ID #82112

WATER ANALYSIS REPORT

Owner Village of Palm Springs

Project No. FC50100.E0

Attention Gary Eichler

Received 1/31/83

Address

Reported 2/8/83

SAMPLE LOCATION: Groundwater
3 hr. pump test

SOURCE OF SUPPLY: ☐ Surface, ☒ Ground

TYPE OF SAMPLE: ☐ Composite, ☐ Grab

SAMPLE COLLECTED BY: Gary Eichler DATE: 1 / 27/ 83 TIME ☐ AM ☐ PM

Substance		milligrams per liter MCL	present
Arsenic	As	0.05	
Barium	Ba	1	
Cadmium	Cd	0.01	
Chloride	Cl^-	250	46
Chromium	Cr	0.05	
Color, APHA color units		15	45
Copper	Cu	1	
Fluoride	F^-	*	0.20
Foaming agents	MBAS	0.5	
Iron	Fe	0.3	0.07
Lead	Pb	0.05	
Manganese	Mn	0.05	
Mercury	Hg	0.002	
Nitrate (as N)	NO_3^-	10	
Odor, threshold odor number		3	N.O.O.
Selenium	Se	0.01	
Silver	Ag	0.05	
Sodium	Na	160	29
Sulfate	$SO_4^=$	250	4.6
Total dissolved solids @ 180°C		500	
Turbidity, NTU		1	0.7
Zinc	Zn	5	

Substance		milligrams per liter as substance	as $CaCO_3$
Alkalinity, phenolphthalein			0.0
Alkalinity, total			230
Carbon dioxide, free	CO_2	92	208
Bicarbonates	HCO_3^-	280	230
Carbonates	$CO_3^=$	<0.1	0.1
Hydroxides	OH^-	<0.1	<0.1
Calcium	Ca	90	225
Magnesium	Mg	2.9	12
Total hardness			237
Carbonate hardness			230
Noncarbonate hardness			7.0

Conductivity 558 µmhos/cm @ 25° C

Oxygen, dissolved (field) mg/L O_2

Temperature (field) ° C

pH (field) [6.5-8.5]

pH (laboratory) 6.70 pH_s @ 25 °C 7.13

Stability index ($2 pH_s - pH$) 7.55

Saturation index ($pH - pH_s$) -0.43

Aggressive index (pH + log AH) 11.41

Dissolved Solids (by Σ of major Ions) 310 mg/l

Hydrogen Sulfide (mg/l) 0.52

THE INFORMATION SHOWN ON THIS SHEET IS TEST DATA ONLY AND NO INTERPRETATION OF THE DATA IS INTENDED OR IMPLIED

1. Except color, odor, pH and turbidity
MCL Maximum contaminant level
* MCL 1.4-2.4—depends upon avg. daily max. air temp.
< means less than detection limits
N.O.O. means no odor observed

Respectfully submitted,

K D Starcher

K. D. Starcher Chemist

CH2M HILL

ENVIRONMENTAL LABORATORIES
7201 N.W. Eleventh Place
P.O. Drawer 1647
Gainesville, Florida 32602
904/377-2442

Sample No. 19965

Lab ID #82112

WATER ANALYSIS REPORT

Owner: Village of Palm Springs
Project No. FC50100.E0

Attention: Gary Eichler
Received: 4/18/83

Address:
Reported: 5/17/83

SAMPLE LOCATION: Forest Hill Village - TPW

SOURCE OF SUPPLY: ☐ Surface, ☒ Ground

TYPE OF SAMPLE: ☐ Composite, ☒ Grab

SAMPLE COLLECTED BY: Gary Eichler

DATE: 4 / 15 / 83 TIME 0.710 ☒ AM ☐ PM

Substance		milligrams per liter[1] MCL	present
Arsenic	As	0.05	<0.002
Barium	Ba	1	<0.10
Cadmium	Cd	0.01	0.0002
Chloride	Cl^-	250	44
Chromium	Cr	0.05	0.003
Color, APHA color units		15	40
Copper	Cu	1	0.010
Fluoride	F^-	*	0.22
Foaming agents	MBAS	0.5	<0.02
Iron	Fe	0.3	0.08
Lead	Pb	0.05	0.009
Manganese	Mn	0.05	0.007
Mercury	Hg	0.002	<0.0002
Nitrate (as N)	NO_3^-	10	<0.02
Odor, threshold odor number		3	N.O.O.
Selenium	Se	0.01	<0.002
Silver	Ag	0.05	<0.0005
Sodium AA	Na	160	28
Sulfate	$SO_4^=$	250	5.5
Total dissolved solids @ 180°C		500	256
Turbidity, NTU		1	0.2
Zinc	Zn	5	0.06

Substance		milligrams per liter[1] as substance	as $CaCO_3$
Alkalinity, phenolphthalein			0.0
Alkalinity, total			225
Carbon dioxide, free	CO_2	284	644
Bicarbonates	HCO_3^-	274	225
Carbonates	$CO_3^=$	<0.1	<0.1
Hydroxides	OH^-	<0.1	<0.1
Calcium	Ca	86	215
Magnesium	Mg	3.9	16
Total hardness			231
Carbonate hardness			225
Noncarbonate hardness			6.0
Conductivity 565 µmhos/cm @ 25° C			
Oxygen, dissolved (field)			mg/L O_2
Temperature (field)			°C
pH (field) [6.5-8.5]			
pH (laboratory) 6.20	pH_s @ 25 °C		7.16
Stability index (2 pH_s-pH) 8.11			
Saturation index (pH-pH_s) -0.96			
Aggressive index (pH + log AH) 10.49			
Sulfide (mg/l) 0.22			

THE INFORMATION SHOWN ON THIS SHEET IS TEST DATA ONLY AND NO INTERPRETATION OF THE DATA IS INTENDED OR IMPLIED

1. Except color, odor, pH and turbidity

MCL Maximum contaminant level

* MCL 1.4-2.4—depends upon avg. daily max. air temp.

< means less than detection limits

N.O.O. means no odor observed

Respectfully submitted,

K D Starcher

K. D. Starcher, Chemist

PARAMETER	REFERENCE	METHOD	ANALYST	DATE ANALYZED
Alkalinity	1	310.1	CCP1/47	4-19-83
Arsenic	1	206.2	KDS 33/4	5-13-83
Barium	1	208.1	KDS 33/4	4-28-83
Cadmium	1	213.2	KDS 32/88	4-20-83
Calcium	1	215.1	KDS 32/98	4-25-83
Carbon dioxide	2	406C	KDS	5-16-83
Chloride	1	325.3	CCP 1/48	4-19-83
Chromium	1	218.2	KDS 33/20	5-16-83
Color	1	110.2	CCP 1/49	4-19-83
Conductivity	2	205	CCP 1/49	4-19-83
Copper	1	220.2	KDS 32/84	4-18-83
Corrosivity	2/3	203/II.C.1	KDS	5-16-83
Fluoride	1	340.2	CCP 1/46	4-19-83
Foaming agents	1	425.1	MFB 21/23	4-26-83
Hardness	2	314.A	KDS	5-16-83
Iron	1	236.1	KDS 33/11	5-5-83
Lead	1	239.2	KDS 32/93	4-21-83
Magnesium	1	242.1	KDS 32/99	4-25-83
Mangenese	1	243.2	KDS 32/86	4-18-83
Mercury	1	245.1	KDS 33/10	5-4-83
Nitrate	1	353.2	KDS 32/95	4-21-83
Odor	1	140.1	KDS	4-18-83
Oxygen dissolved	1	360.1		
pH	1	150.1	CCP 1/49	4-19-83
Selenium	1	270.2	KDS 33/18	5-13-83
Silver	1	272.2	KDS 32/90	4-20-83
Sodium	1	273.1	KDS 32/100	4-25-83
Sulfate	1	375.2/.4	CCP 1/63	4-25-83
Temperature	1	170.1		
Total dissolved solids	1	160.1	MFB 21/27	4-28-83
Turbidity	1	180.1	CCP 1/49	4-19-83
Zinc	1	289.1	KDS 33/6	4-28-83

References

1. "Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, 1979
2. "Standard Methods for the Examination of Water and Wastewater," 15th ed., APHA, 1980
3. "AWWA Standard for Asbestos - Cement Pipe, . . .," C400-77, AWWA 1977

PAUL R. MCGINNES AND ASSOCIATES
CONSULTING LABORATORIES, INC.

950 OLD DIXIE HIGHWAY · LAKE PARK, FLORIDA 33403 · (305) 842-2849

In compliance with the laboratory certification program by the State of Florida, all primary and secondary drinking water analyses were conducted by certified laboratories: I. D. #86140 & 86117.

Client: Village of Palm Springs Atten: Richard Gift December 21, 1982

Sample: Collected 11-18-82 Job No: 82-11-18-PS-32

Semi-Annual Water Analysis Requirements - ECR II

	Well 1	Well 3	Well 4	Well 5	Well 6	Well 7
Time of Collection	09:50	09:40	09:45	10:30	10:40	11:04
Temperature, °C	25	25.3	25	25	25	25
pH (field)	7.2	7.3	7.3	7.30	7.25	5.8
Total Dissolved Solids, mg/l	304	378	305	404	329	391
Total Hardness, mg/l as $CaCO_3$	164	247	188	257	203	268
Iron, mg/l Fe	0.07	0.03	0.05	0.01	0.02	0.06
Chloride, mg/l Cl	58	52	48	60	53	38
Color, units	35	30	35	30	35	40
Nitrate, mg/l N	<0.1	<0.1	<0.1	<0.1	0.14	0.45
Calcium, mg/l Ca	62	93	73	101	76	104
Magnesium, mg/l Mg	2.2	3.5	1.1	1.1	3.2	1.9

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In compliance with the laboratory certification program by the State of Florida, all primary and secondary drinking water analyses were conducted by certified laboratories: I. D. #86140 & 86117.

Client: Village of Palm Springs Atten: Richard Gift December 21, 1982

Sample: Collected 11-18-82, 11-30-82* Job No: 82-11-18-PS-32

Semi-Annual Water Analysis Requirements - ECR II

	Well 8*	Well 9	Well 10	Well 11	Raw Comp.	Distribution
Time of Collection	09:30*	10:00	10:10	10:20	09:22	11:15
Temperature, °C	26	26	25	25	25	26
pH (field)	7.05	7.1	7.25	7.35	6.95	8.25
Total Dissolved Solids, mg/l	419	398	395	360	363	238
Total Hardness, mg/l as $CaCO_3$	280	216	261	232	227	67
Iron, mg/l Fe	0.02	0.05	0.06	0.05	0.05	0.06
Chloride, mg/l Cl	50	78	54	53	55	66
Color, units	30	45	30	35	30	10
Nitrate, mg/l N	<0.1	0.34	<0.1	<0.1	<0.1	<0.1
Calcium, mg/l Ca	108	82	100	88	86	22
Magnesium, mg/l Mg	2.4	2.7	2.7	2.9	2.9	2.9

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In compliance with the laboratory certification program by the State of Florida, all primary and secondary drinking water analyses were conducted by certified laboratories: I. D. #86140 & 86117.

Client: Village of Palm Springs Atten: Richard Gift December 21, 1982

Sample: Collected 11-18-82 Job No: 82-11-18-PS-32

Annual Water Analysis Requirements - ECR II

Secondary Inorganics

	Raw Composite	Distribution
Time of Collection	09:22	11:15
Temperature, °C	25	26
pH ~~(field)~~ (laboratory)	6.8	8.9
pHs (calculation)	7.2	8.2
Corrosivity	-0.4	0.7
Total Dissolved Solids, mg/l	363	238
Iron, mg/l Fe	0.05	0.06
Sulfate, mg/l SO_4	13	13
Sulfides, mg/l $S^{=}$	--	--
Hydrogen Sulfide, mg/l $S^{=}$	0.46	<0.05
Chloride, mg/l Cl	55	66
Sodium, mg/l Na	28.4	39.3
Copper, mg/l Cu	0.006	0.028
Zinc, mg/l Zn	0.025	0.025
Manganese, mg/l Mn	0.009	0.004
Foaming Agents, mg/l MBAS	0.06	0.04
Color, units / Odor, threshold	30 / 1	10 / none
Turbidity, N.T.U.	1.9	1.2
Total Alkalinity, mg/l as $CaCO_3$	198	44

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950 OLD DIXIE HIGHWAY · LAKE PARK, FLORIDA 33403 · (305) 842-2849

Client: Village of Palm Springs Atten: Richard Gift December 21, 1982

Sample: Collected 11-18-82 Job No. 82-11-18-PS-32

TRIHALOMETHANES, µg/l

Sample #	Identification	Cl_2 at collection	Analysis Date	Total THM's µg/l	Chloroform µg/l	Bromodichloromethane µg/l	Dibromochloromethane µg/l	Bromoform µg/l
1	Forest Hill W. P.		12-1-82	367	296	57	14	<1
2	Lake Arbor		12-1-82	170	139	22	5	4
3	Cresthaven		12-1-82	387	313	61	13	<1
4	Pub		12-1-82	372	308	52	12	<1

Analysis by Gas Chromatography, Solvent Extraction Method.

Sample dechlorinated at time of collection.

Laboratory I. D. No. 86140

PAUL R. McGINNES AND ASSOCIATES
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In compliance with the laboratory certification program by the State of Florida, all primary and secondary drinking water analyses were conducted by certified laboratories: I. D. #86140 & 86117.

Client: Village of Palm Springs Atten: Richard Gift December 21, 1982

Sample: Collected 11-18-82 Job No: 82-11-18-PS-32

3-Year Water Analysis Requirements - ECR II

Primary Organics & Inorganics

	Raw Composite	Distribution
Nitrate, mg/l N	<0.1	<0.1
Fluoride, mg/l F	0.23	0.17
Arsenic, mg/l As	<0.001	<0.001
Barium, mg/l Ba	<0.05	<0.05
Cadmium, mg/l Cd	<0.002	<0.002
Chromium, mg/l Cr	<0.01	<0.01
Lead, mg/l Pb	<0.02	<0.02
Selenium, mg/l Se	<0.005	<0.005
Silver, mg/l Ag	<0.001	<0.001
Mercury, mg/l Hg	<0.00001	<0.00001
Endrin, mg/l	<0.00005	<0.00005
Lindane, mg/l	<0.000002	<0.000002
Methoxychlor, mg/l	<0.001	<0.001
Toxaphene, mg/l	<0.0005	<0.0005
2,4-D, mg/l	<0.0001	<0.0001
2,4,5-TP Silvex, mg/l	<0.0001	<0.0001

Appendix C

TABULATION OF DRAWDOWN/RECOVERY DATA--APT

Well: TPW--Pumping Well
Type of Data: Drawdown
Pumped Well No: TPW Radius: 7 in.
Pumping Rates: 1599 gpm
How Q Measured: Orifice 10 x 8
How WL's Measured: Steel tape
Distance from Pumped Well: 0

M.P. for WL's: TOC- Slot
Pump On: Date 4/13/83 Time: 0917
Pump Off: Date 4/15/83 Time: 0900
Comments: Mp, Slot at TOC
1' Above LSD
Depth to Static Water Level: 5.05 ft

Time* (Minutes)	Drawdown (Feet)
0	0
.5	10.37
1	10.23
1.5	10.14
2	10.18
2.5	10.15
3	10.27
4	11.20
5	12.23
6	10.40
7	10.67
8	10.75
9	10.65
10	10.64
12	10.74
15	11.04
20	11.07
25	11.04
30	--
35	11.20
50	11.10
71	11.27
90	11.22
100	11.14
120	11.27
130	11.27
150	11.28
160	11.28
210	11.30
280	11.31
300	11.31
400	11.40
520	11.48
600	11.43
714	11.43
807	11.54
907	11.41
997	11.43
1107	11.40
1205	11.39
1300	11.38
1400	11.62
1524	11.57
1600	11.67
1703	11.45
1800	11.67
1900	11.69
2006	11.68
2200	11.60
2300	11.77
2400	11.89
2506	11.92
2602	11.91
2700	11.72
2800	11.83

*Time since pump started.

Well: TPW--Pumping Well
Type of Data: Recovery
Pumped Well No: TPW Radius: 7 in.
Pumping Rates:
How Q Measured:
How WL's Measured: Steel tape
Distance from Pumped Well: 0

M.P. for WL's: TOC- Slot
Pump On: Date 4/13/83 Time:
Pump Off: Date 4/15/83 Time: 0900
Comments: ST

Time* (Minutes)	Drawdown (Feet)
0	0
.50	5.19
.75	12.83
1	12.08
2	11.33
3	11.26
4	11.28
5	11.30
6	11.30
7	11.32
8	11.34
9	11.35
10	11.36
12	11.38
30	11.48

*Time since pumping stopped.

Well: No. 1--Observation Well
Type of Data: Drawdown
Pumped Well No: T2W Radius: 7 in.
Pumping Rates: 1599 gpm
How Q Measured: Orifice 10 x 8
How WL's Measured: Steel tape
Distance from Pumped Well: ______

M.P. for WL's: TOC
Pump On: Date 4/13/83 Time: 0917
Pump Off: Date 4/15/83 Time: 0900
Comments: MP @ TOC; 2.05' above slab; 1" above pump base
Depth to Static Water Level: 6.29 ft

Time* (Minutes)	Drawdown (Feet)
0	0
1	0.19
2	0.50
3	0.61
4	0.65
5	0.66
6	0.67
7	0.70
8	0.73
9	0.76
10	0.76
15	0.77
20	0.80
25	0.81
30	0.83
35	0.86
40	0.87
45	0.87
75	0.82
102	0.83
124	0.88
157	0.91
206	0.92
275	0.92
300	0.91
400	0.95
500	--
520	0.95
600	0.96
710	0.92
805	0.93
906	0.90
993	0.89
1105	0.89
1202	0.89
1290	0.90
1400	0.98
1520	1.05
1602	1.05
1700	1.06
1797	1.10
1902	1.09
2010	1.09
2198	1.06
2344	1.16
2407	1.19
2502	1.22
2605	1.19
2702	1.13
2800	1.14

*Time since pump started.

Well: No. 1--Observation Well
Type of Data: Recovery
Pumped Well No: TPW Radius: 7 in.
Pumping Rates: 1600 gpm
How Q Measured:
How WL's Measured: Steel tape
Distance from Pumped Well:

M.P. for WL's: TOC
Pump On: Date 4/13/83 Time: 0917
Pump Off: Date 4/15/83 Time: 0900
Comments: MP @ TOC; 2.05' above slab; 1" above pump base

Time* (Minutes)	Drawdown (Feet)
0	0
.25	0.41
.50	0.54
.75	0.54
1	0.59
1.5	0.61
2	0.58
2.5	0.54
3	0.58
4	0.68
5	1.21
6	0.62
7	0.63
8	0.65
9	0.66
10	0.66
12	0.70
15	0.71
20	0.71
25	0.77
30	0.78
35	0.81
40	0.81
50	0.81

* NOTE: ______

Well: No. 2--Observation Well
Type of Data: Drawdown
Pumped Well No: TPW Radius: 7 in
Pumping Rates: 1599 gpm
How Q Measured: Orifice 10 x 8
How WL's Measured: Water Level Recorder
Distance from Pumped Well: ______

M.P. for WL's: TOC
Pump On: Date 4/13/83 Time: 0917
Pump Off: Date 4/15/83 Time: 0900
Comments: ______

Depth to Static Water Level: 6.47 ft

Time* (Minutes)	Drawdown (Feet)
.25	0.25
.50	0.30
.75	0.38
1	0.42
1.50	0.47
2	0.50
2.50	0.53
3	0.55
4	0.59
5	0.62
6	0.64
7	0.66
8	0.68
9	0.70
10	0.71
12	0.73
15	0.76
17	0.78
20	0.79
25	0.81
30	0.82
35	0.83
40	0.84
60	0.87
80	0.89
100	0.90
150	0.92
160	0.94
200	0.95
300	0.96
400	1.00
500	0.99
600	1.00
700	0.98
800	0.96
900	0.94
1000	0.95
1100	0.94
1200	0.94
1300	0.96
1400	1.03
1500	1.06
1600	1.09
1700	1.11
1800	1.15
1900	1.15
2000	1.14
2100	1.12
2200	1.10
2300	1.18
2400	1.23
2500	1.24
2600	1.26
2700	1.21

*Time since pump started.

Well: No. 2--Observation Well
Type of Data: Recovery
Pumped Well No: TPW Radius: 7 in.
Pumping Rates:
How Q Measured:
How WL's Measured: Water Level Recorder
Distance from Pumped Well:

M.P. for WL's: TOC
Pump On: Date 4/13/83 Time: 0917
Pump Off: Date 4/15/83 Time: 0900
Comments:

Time* (Minutes)	Drawdown (Feet)
0	0
.25	0.39
.50	0.47
.75	0.52
2	0.57
2.5	0.59
3	0.60
4	0.71
5	0.65
6	0.66
7	0.68
8	0.69
9	0.71
10	0.72
12	0.73
15	0.75
18	0.77
20	0.78
25	0.80
30	0.81
35	0.83
40	0.84
50	0.85
60	0.87
70	0.88
80	0.90
90	0.90
100	0.91
120	0.93
140	0.95
160	0.96
180	0.97

*Time since pumping stopped.

Well: No. 3--Observation Well
Type of Data: Drawdown
Pumped Well No: TPW Radius: 7 in.
Pumping Rates: 1599 gpm
How Q Measured: Orifice 10 x 8
How WL's Measured: Water Level Recorder
Distance from Pumped Well: ______

M.P. for WL's: TOC
Pump On: Date 4/13/83 Time: 0917
Pump Off: Date 4/15/83 Time: 0900
Comments: ______

Depth to Static Water Level: 7.13 ft

Time* (Minutes)	Drawdown (Feet)
.25	0.10
.50	0.16
.75	0.19
1	0.23
1.50	0.27
2	0.31
2.5	0.33
3	0.36
3.5	0.37
4	0.39
5	0.42
6	0.44
7	0.46
8	0.48
9	0.49
10	0.50
12	0.52
15	0.55
18	0.57
20	0.58
25	0.59
30	0.61
40	0.63
50	0.64
60	0.65
80	0.67
100	0.68
120	0.70
200	0.73
300	0.74
400	0.78
500	0.77
600	0.78
700	0.75
800	0.74
900	0.73
1000	0.73
1100	0.72
1200	0.72
1300	0.74
1400	0.81
1500	0.84
1600	0.89
1750	0.94
1900	0.95
2200	0.90
2350	0.99
2500	1.03
2800	0.96

*Time since pump started.

Well: No. 3--Observation Well
Type of Data: Recovery
Pumped Well No: TPW Radius: 7 in.
Pumping Rates:
How Q Measured:
How WL's Measured: Water Level Recorder
Distance from Pumped Well:

M.P. for WL's: TOC
Pump On: Date 4/13/83 Time: 0917
Pump Off: Date 4/15/83 Time: 0900
Comments:

Time* (Minutes)	Drawdown (Feet)
0	0
.25	0.10
.50	0.21
.75	0.26
1.0	0.31
2.0	0.36
2.5	0.37
3.0	0.39
3.5	0.40
4.0	0.42
5.0	0.44
6	0.45
7	0.47
8	0.48
9	0.50
10	0.51
11	0.52
12	0.53
13	0.54
15	0.55
17	0.56
20	0.57
22	0.58
25	0.59
27	0.59
30	0.60
35	0.61
40	0.62
50	0.64
60	0.65
70	0.67
80	0.68
90	0.69
100	0.69
120	0.71
150	0.73
180	0.74
200	0.75

*Time since pumping stopped.

Well: No. 4--Observation Well
Type of Data: Drawdown
Pumped Well No: TPW Radius: 7 in.
Pumping Rates: 1599 gpm
How Q Measured: Orifice 10 x 8
How WL's Measured: Water Level Recorder
Distance from Pumped Well:

M.P. for WL's: TOC
Pump On: Date 4/13/83 Time: 0917
Pump Off: Date 4/15/83 Time: 0900
Comments:

Depth to Static Water Leve: 5.73 ft

Time* (Minutes)	Drawdown (Feet)
1	0.08
1.5	0.11
2	0.14
2.5	0.16
3	0.18
4	0.20
5	0.23
6	0.24
7	0.26
8	0.28
9	0.29
10	0.30
12	0.32
15	0.34
17	0.35
20	0.36
25	0.38
30	0.39
35	0.41
40	0.42
50	0.43
60	0.44
80	0.45
100	0.46
120	0.48
140	0.49
200	0.50
300	0.51
400	0.54
500	0.53
600	0.53
700	0.52
800	0.51
900	0.49
1000	0.49
1100	0.49
1200	0.49
1300	0.50
1400	0.57
1500	0.60
1600	0.62
1700	0.65
1800	0.67
1900	0.68
2000	0.68

NOTE:

Appendix D

TIME/DRAWDOWN-RECOVERY DATA
GRAPHICAL PLOTS FOR WELLS 1, 3, AND 4

FC50100.E0

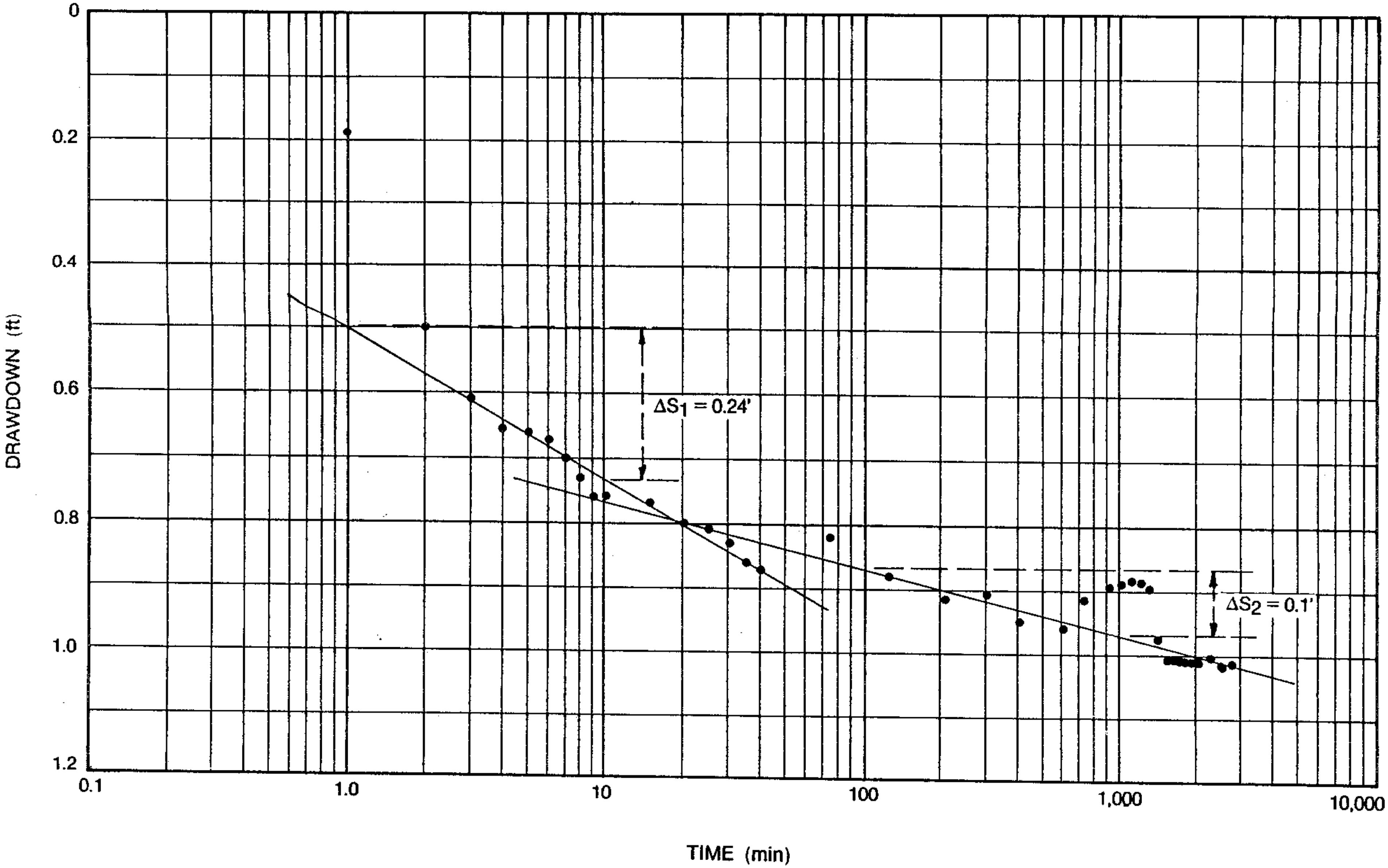

FIGURE D-1. Pumping Test at Well No. 5, Drawdown at Well No. 1.

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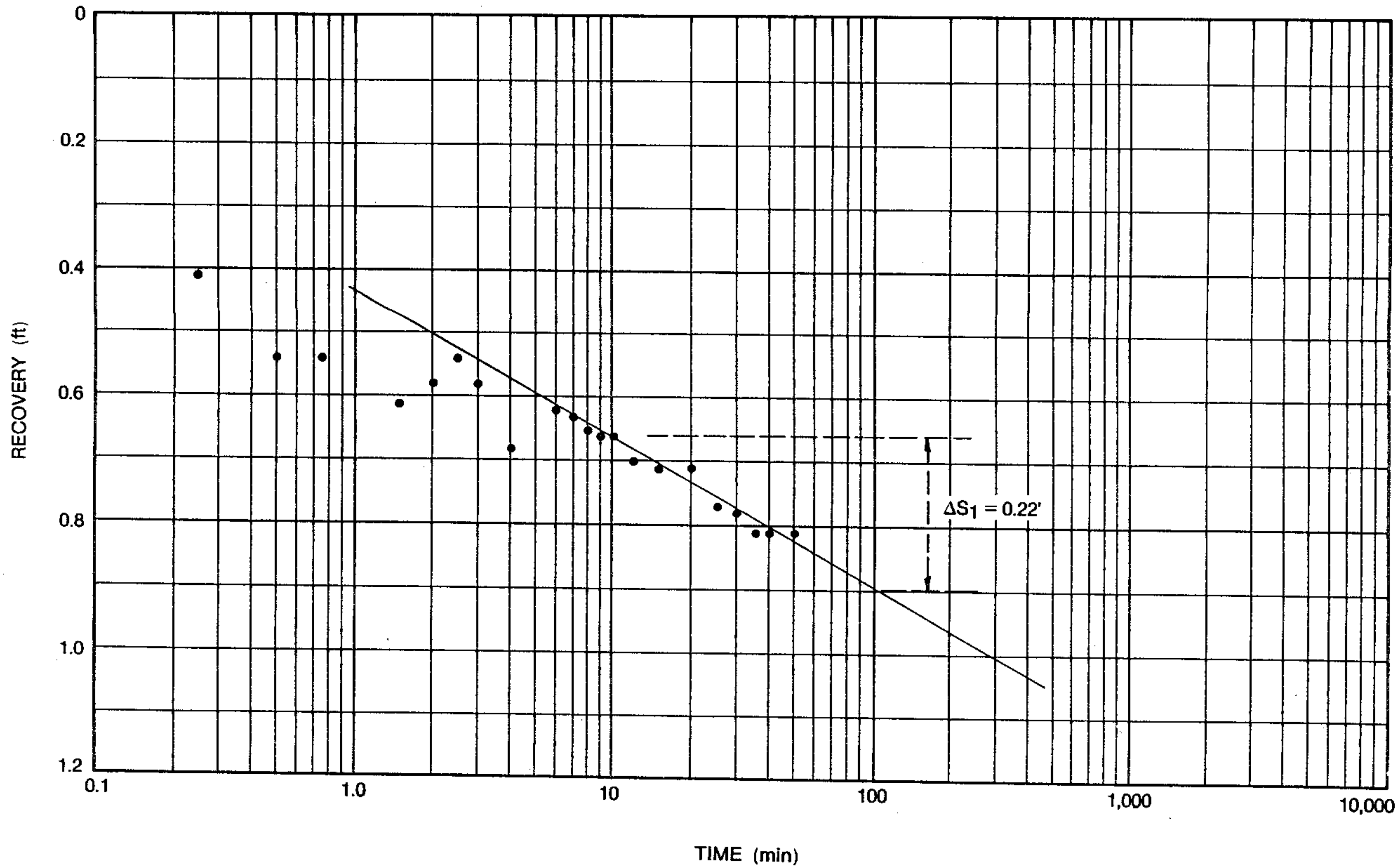

FIGURE D-2.
Pumping Test at Well No. 5, Recovery at Well No. 1.

CH2M HILL

FC50100.E0

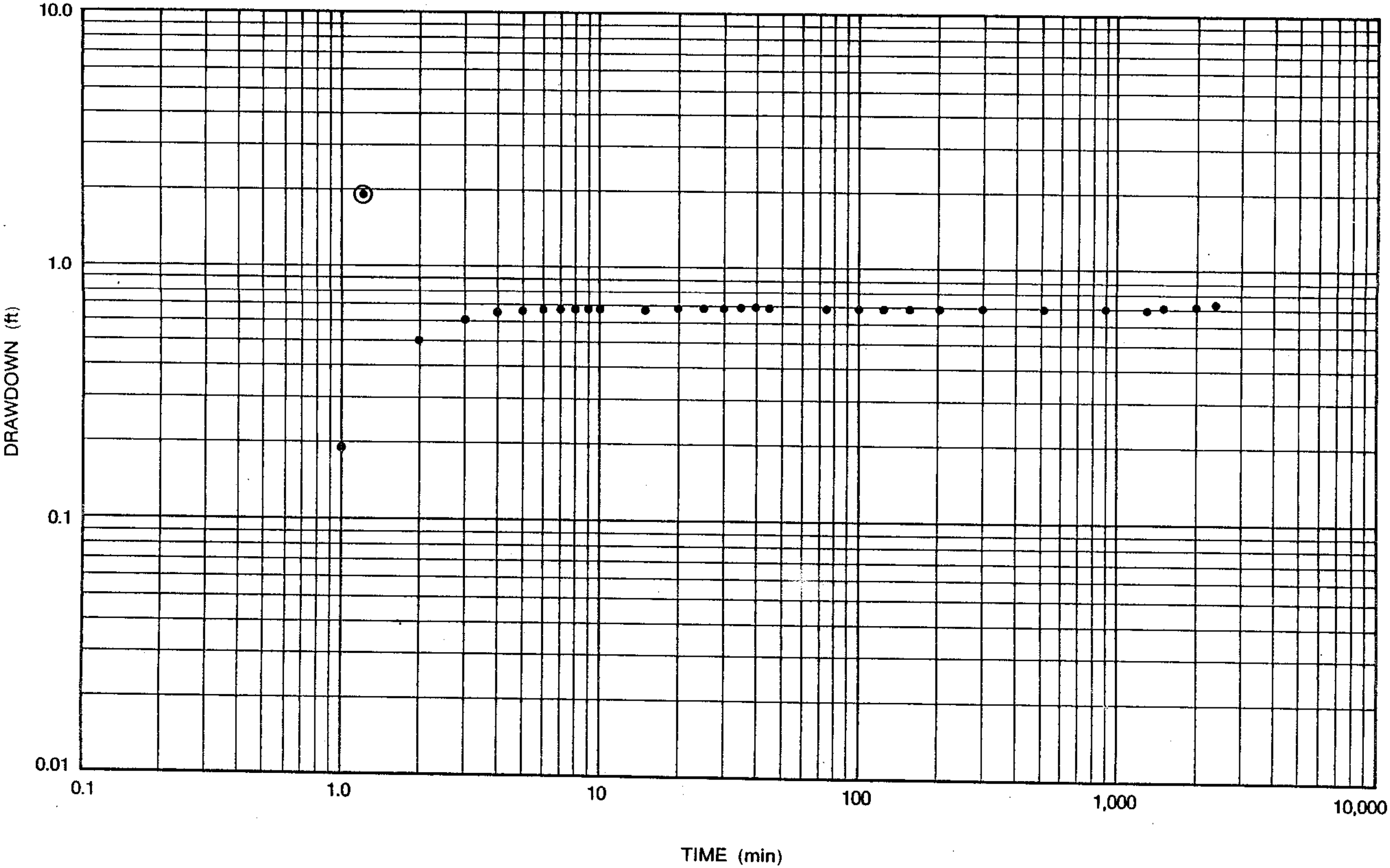

FIGURE D-3.
Pumping Test at Well No. 5, Drawdown at Well No. 1.

CH2M HILL

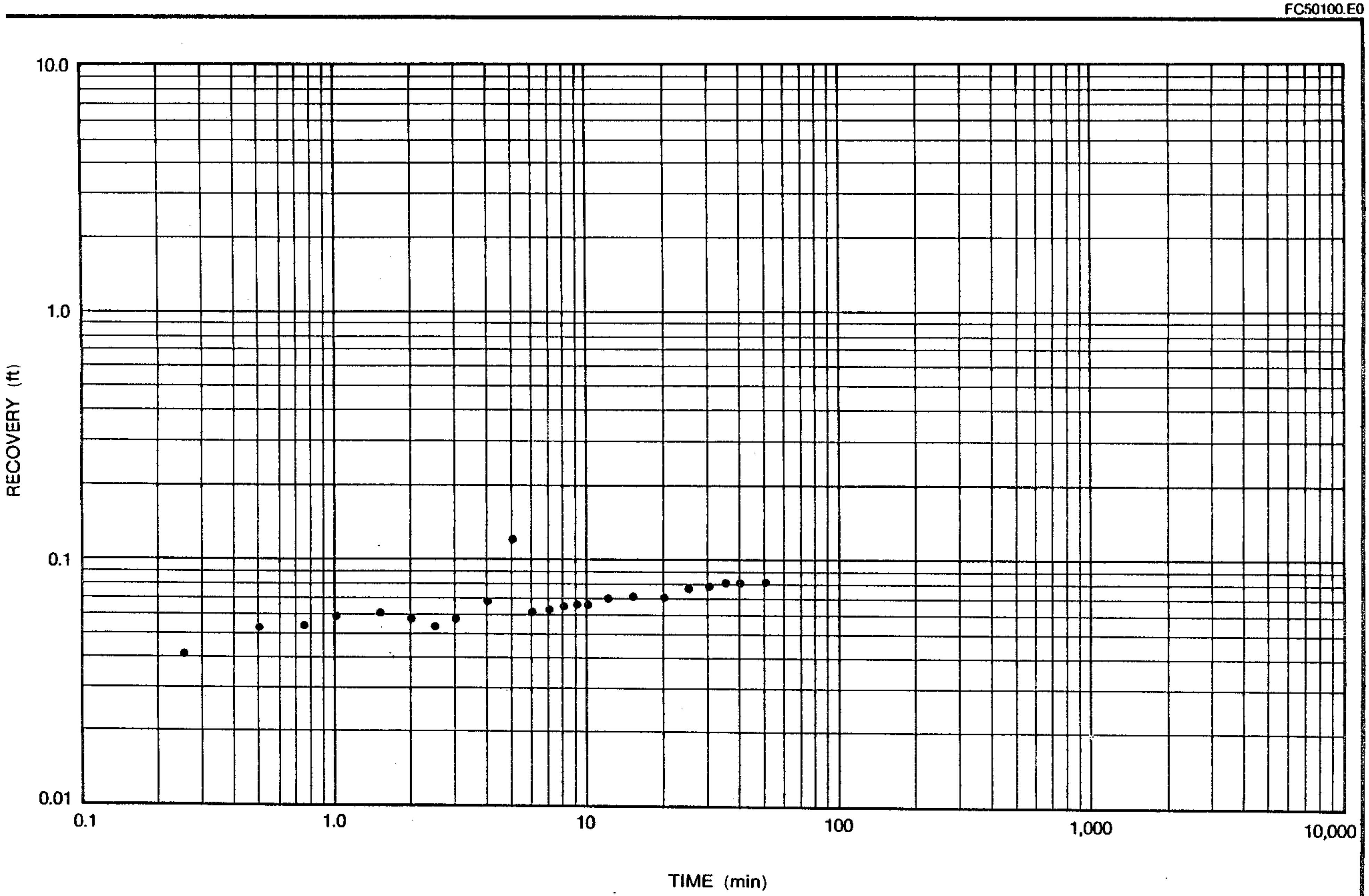

FIGURE D-4.
Pumping Test at Well No. 5, Recovery at Well No. 1.

CH2M HILL

FC50100.E0

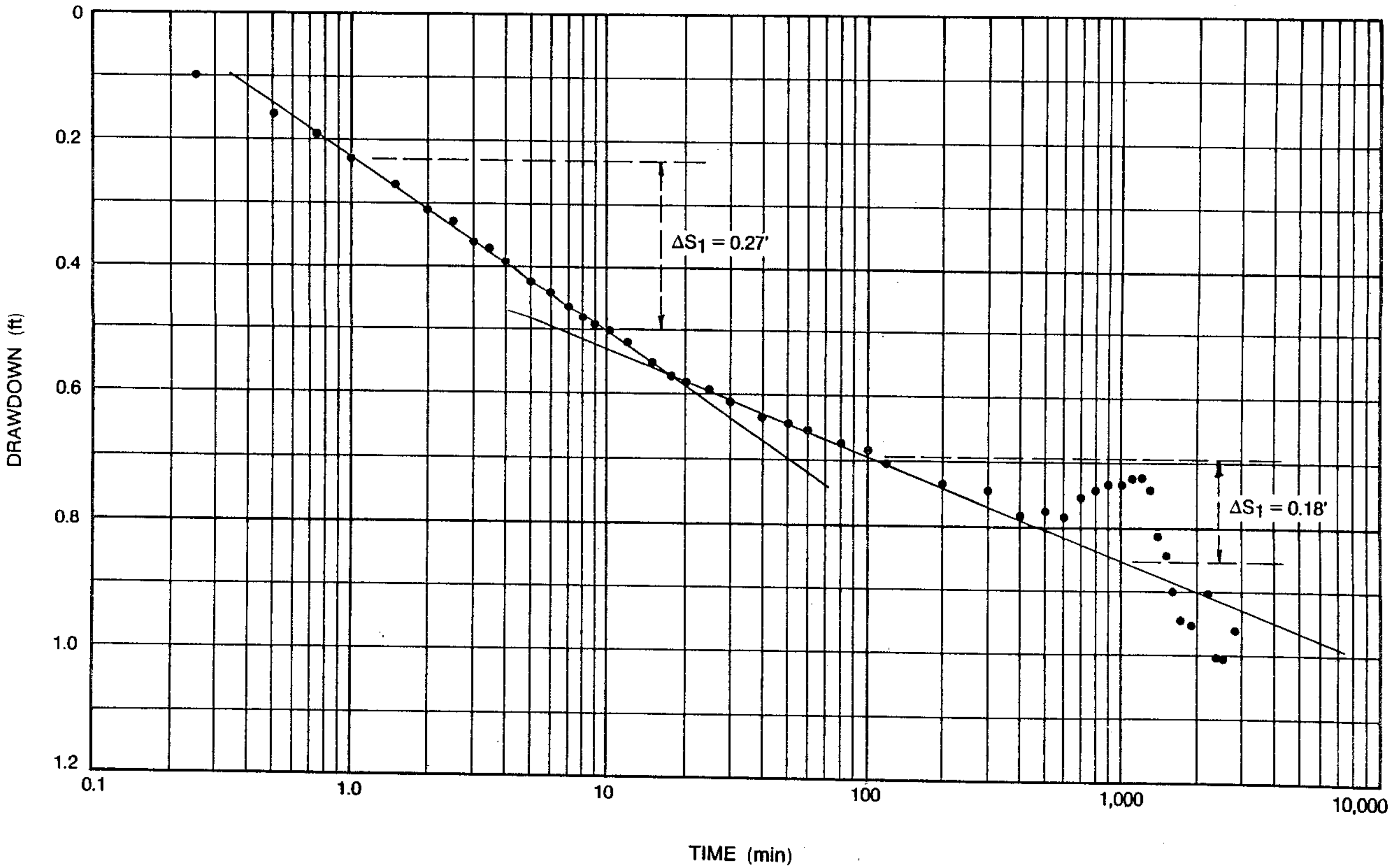

FIGURE D-5.
Pumping Test at Well No. 5, Drawdown at Well No. 3.

CH2M HILL

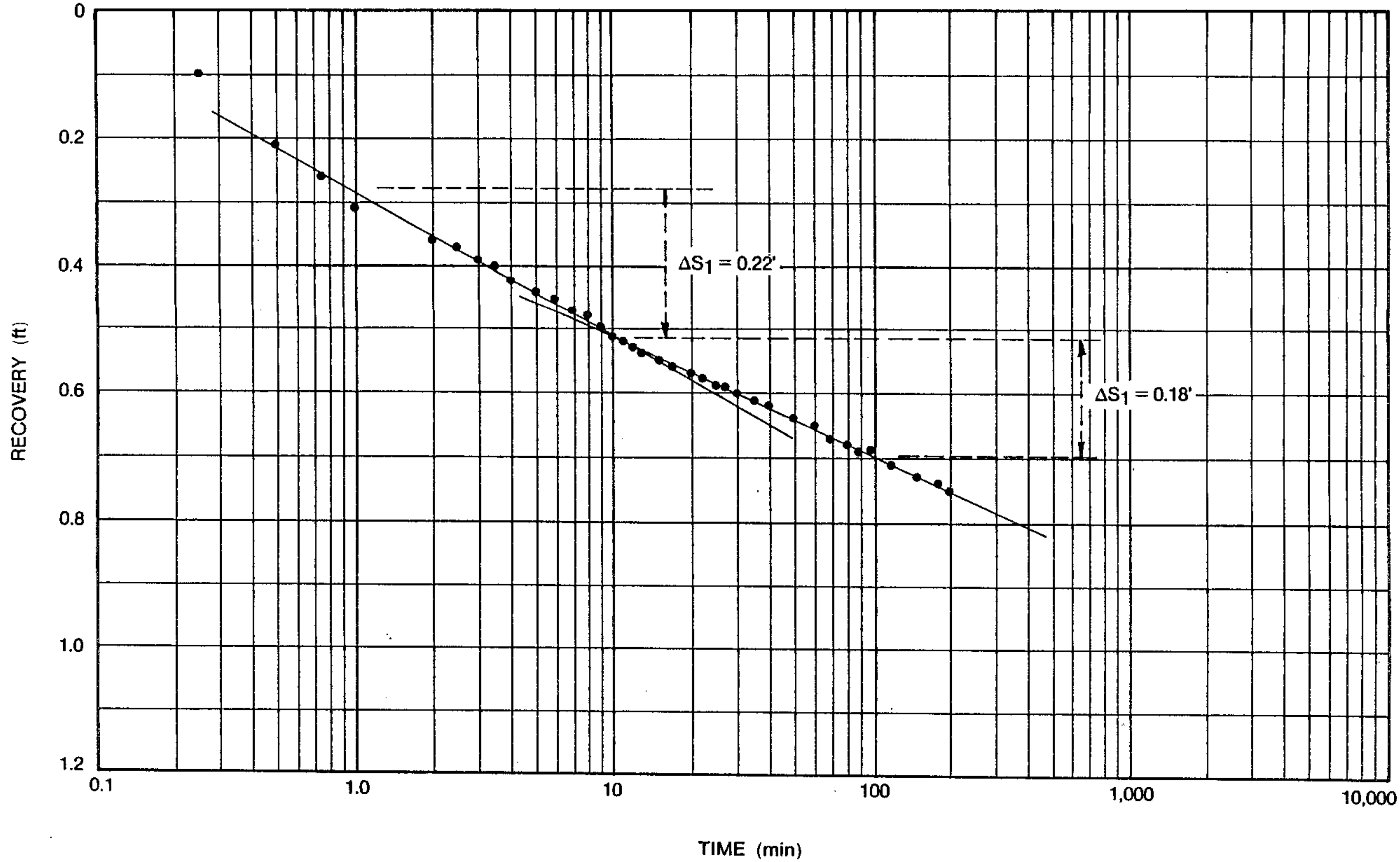

FIGURE D-6.
Pumping Test at Well No. 5, Recovery at Well No. 3.

FC50100.E0

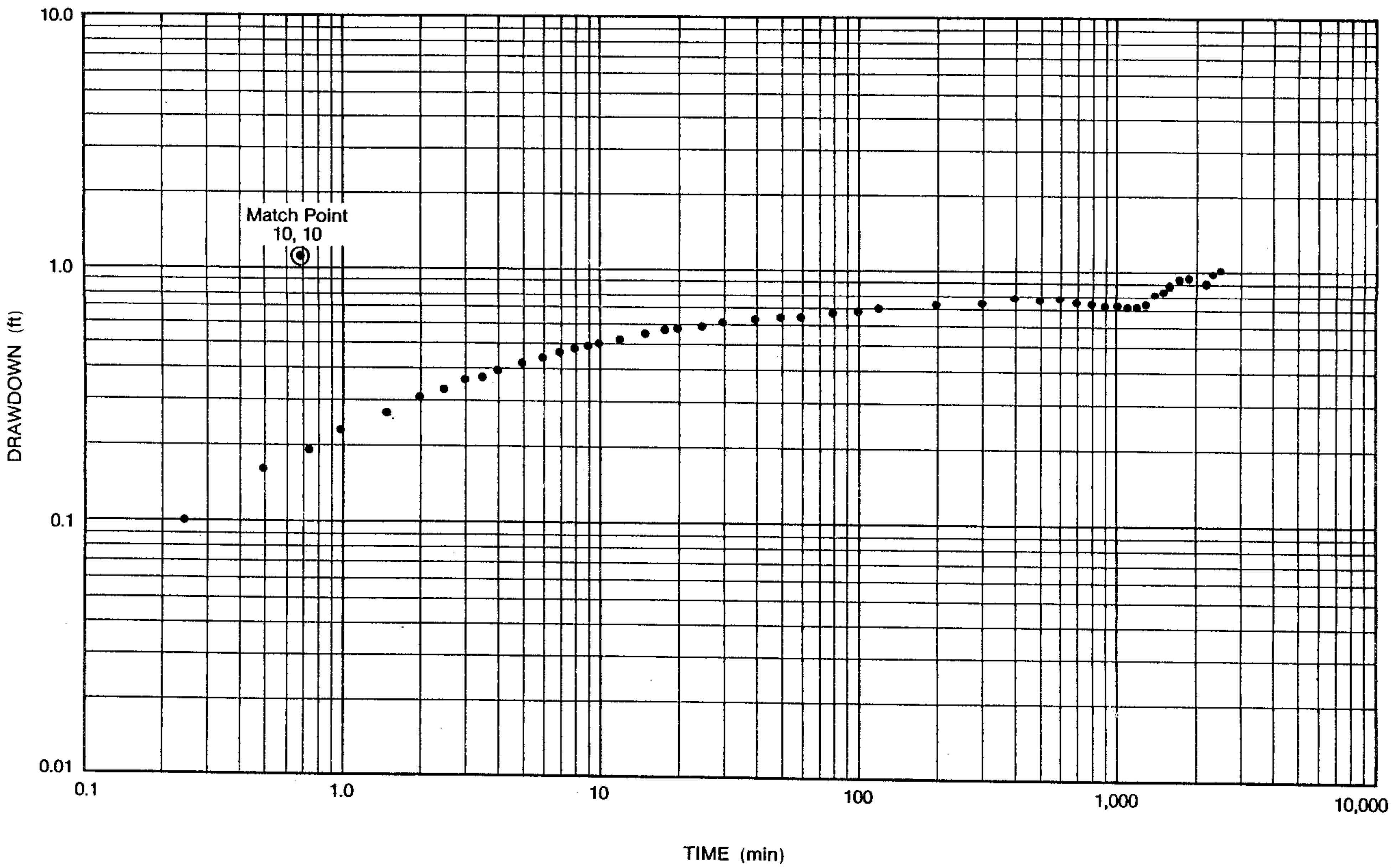

FIGURE D-7.
Pumping Test at Well No. 5, Drawdown at Well No. 3.

CH2M HILL

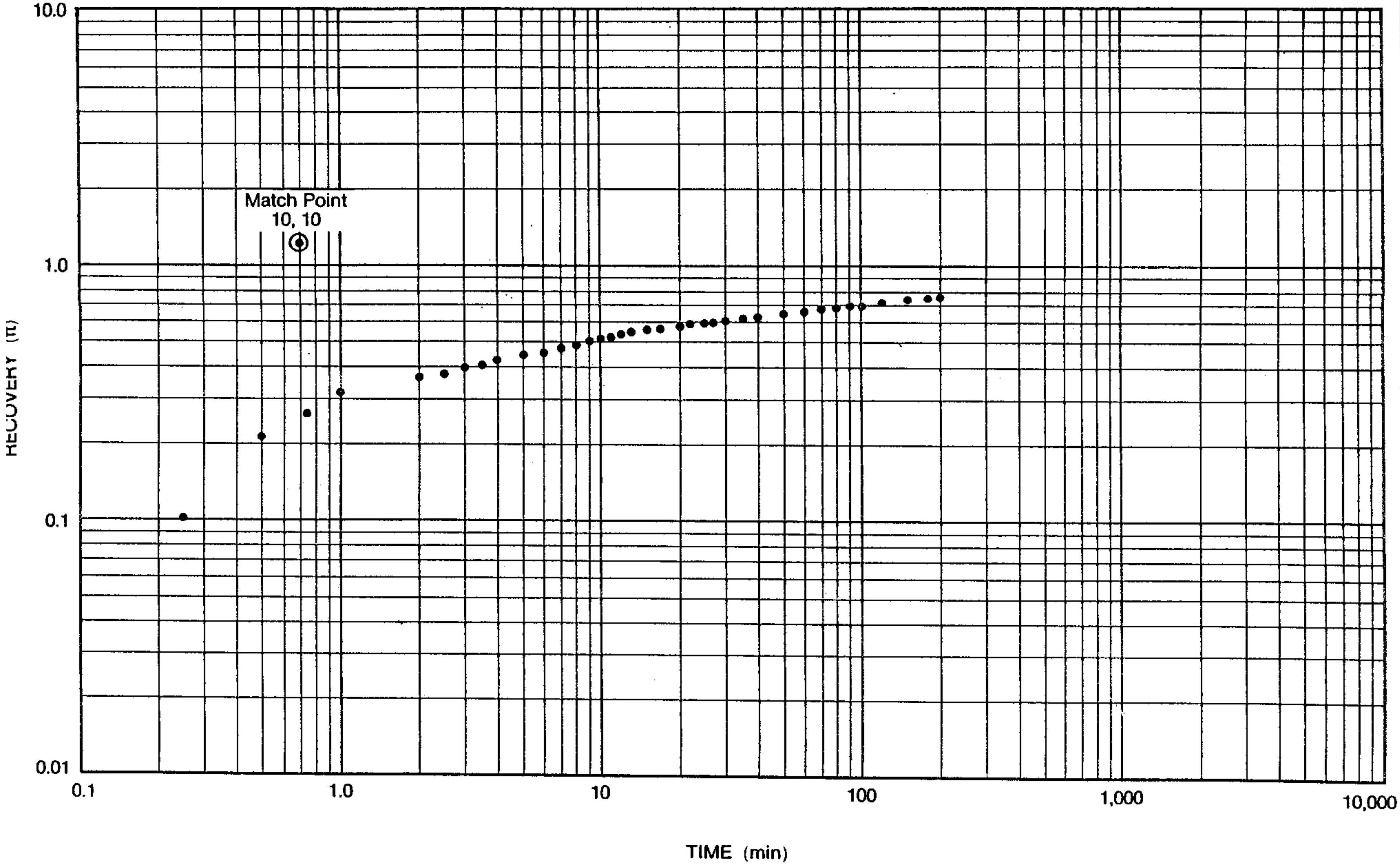

FIGURE D-8.
Pumping Test at Well No. 5, Recovery at Well No. 3.

CH2M HILL

FC50100.E0

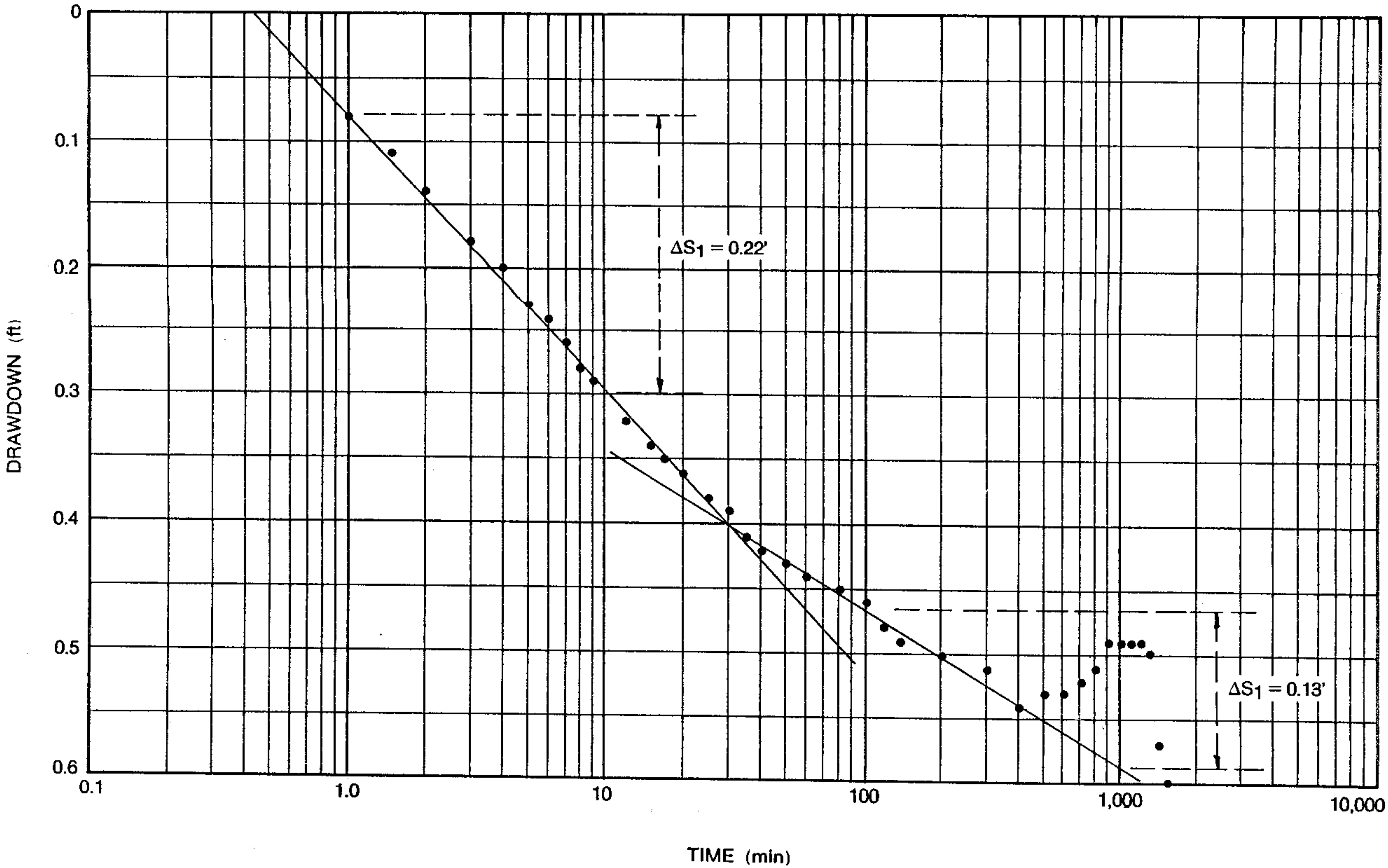

FIGURE D-9.
Pumping Test at Well No. 5, Drawdown at Well No. 4.

CH2M HILL

FC50100.E0

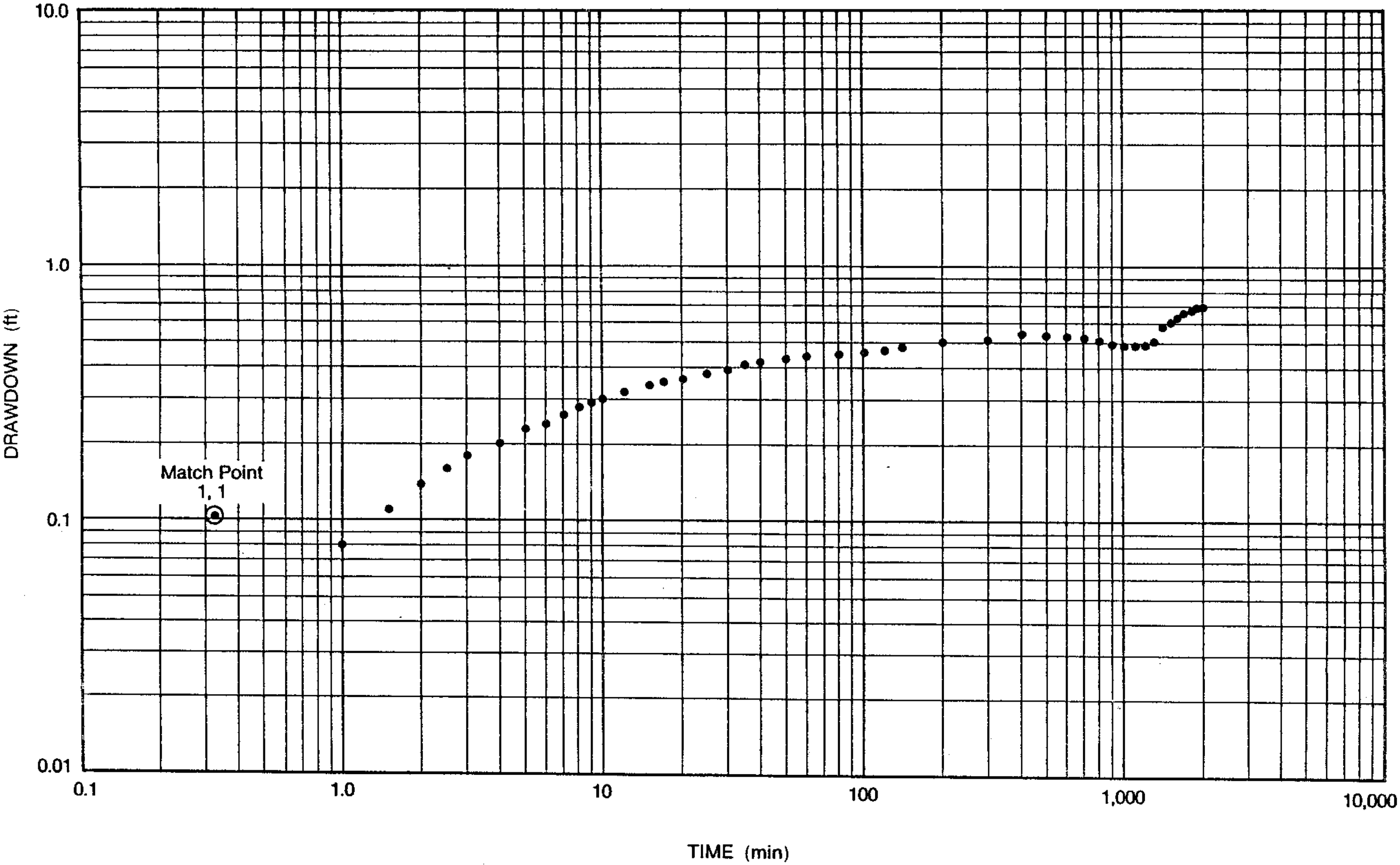

FIGURE D-10.
Pumping Test at Well No. 5, Drawdown at Well No. 4.

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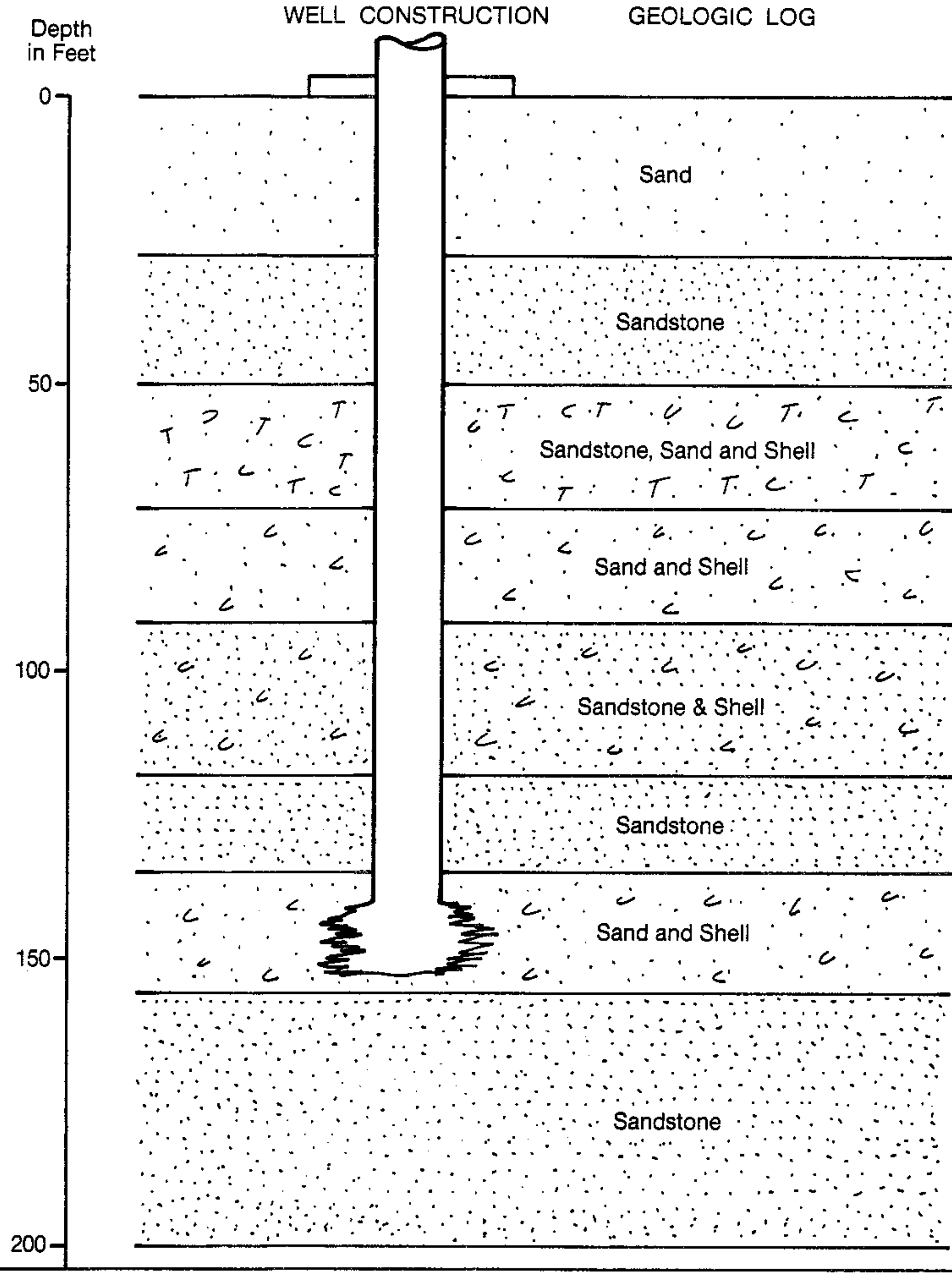
Appendix E

ADDITIONAL WELL COMPLETION REPORTS

FC50100.E0



Well No. 1
Date Completed 1957
Casing Diameter 8 in.
Casing Depth 140 ft.
Open Hole Section 140-150 ft.

Screen Diameter N/A
Screen Slot Size N/A
Gravel Pack Size None
Pumping Test 1/83
Duration 3 hr.

Pumping Rate 325 gpm
Static Water Level 8.4 ft.
Maximum Drawdown 18.8 ft.
Specific Capacity 17 gpm/ft.

Note: Geologic Log Developed from Nearby Wells.

FIGURE E-1.
Well Completion Report—Well No. 1.

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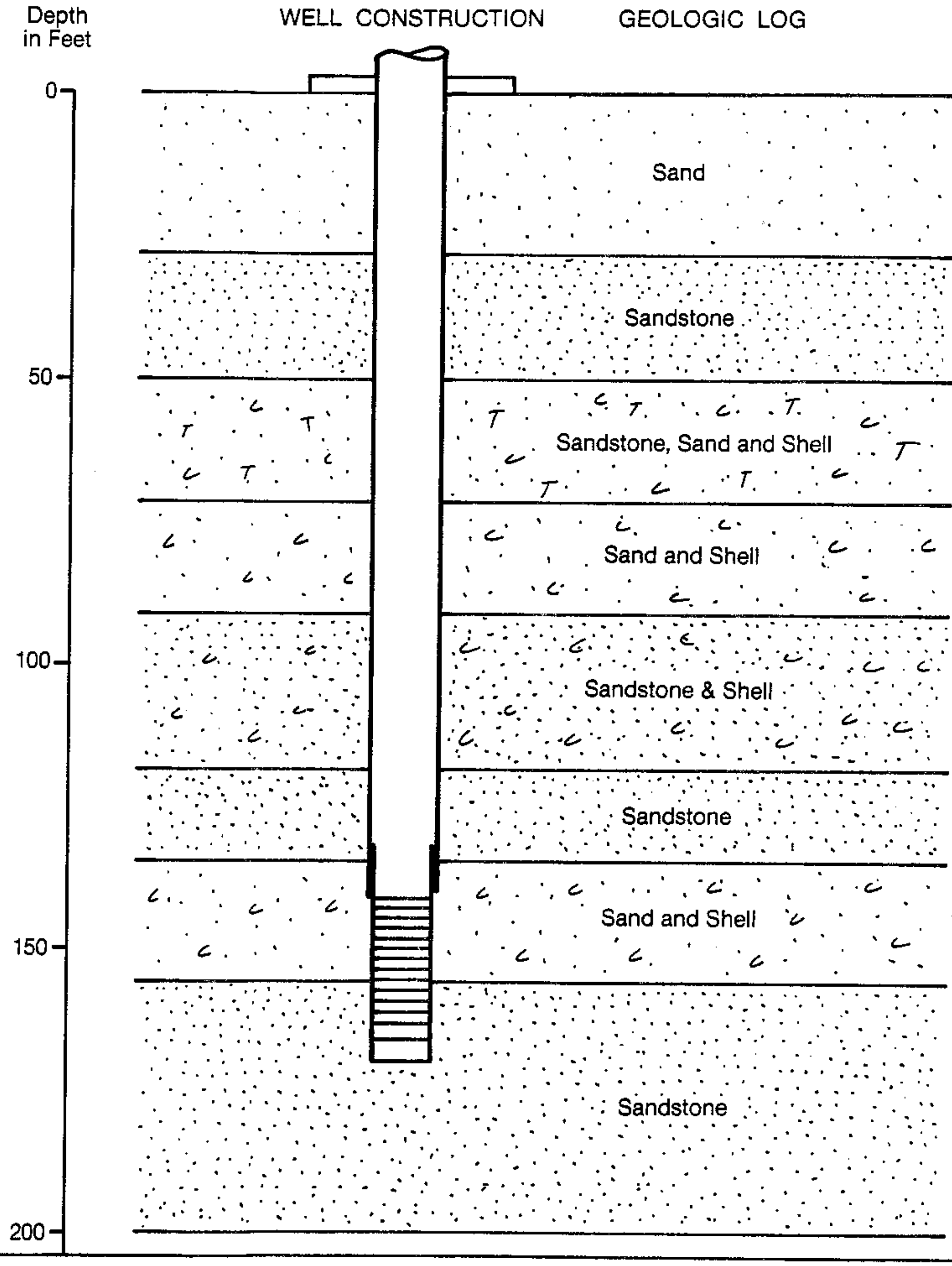
FC50100.E0



Well No. 2
Date Completed 1957
Casing Diameter 8 in.
Casing Depth 140 ft.
Screen Section 140-170 ft.

Screen Diameter 8 in.
Screen Slot Size —
Gravel Pack Size None
Pumping Test —
Duration — hr.

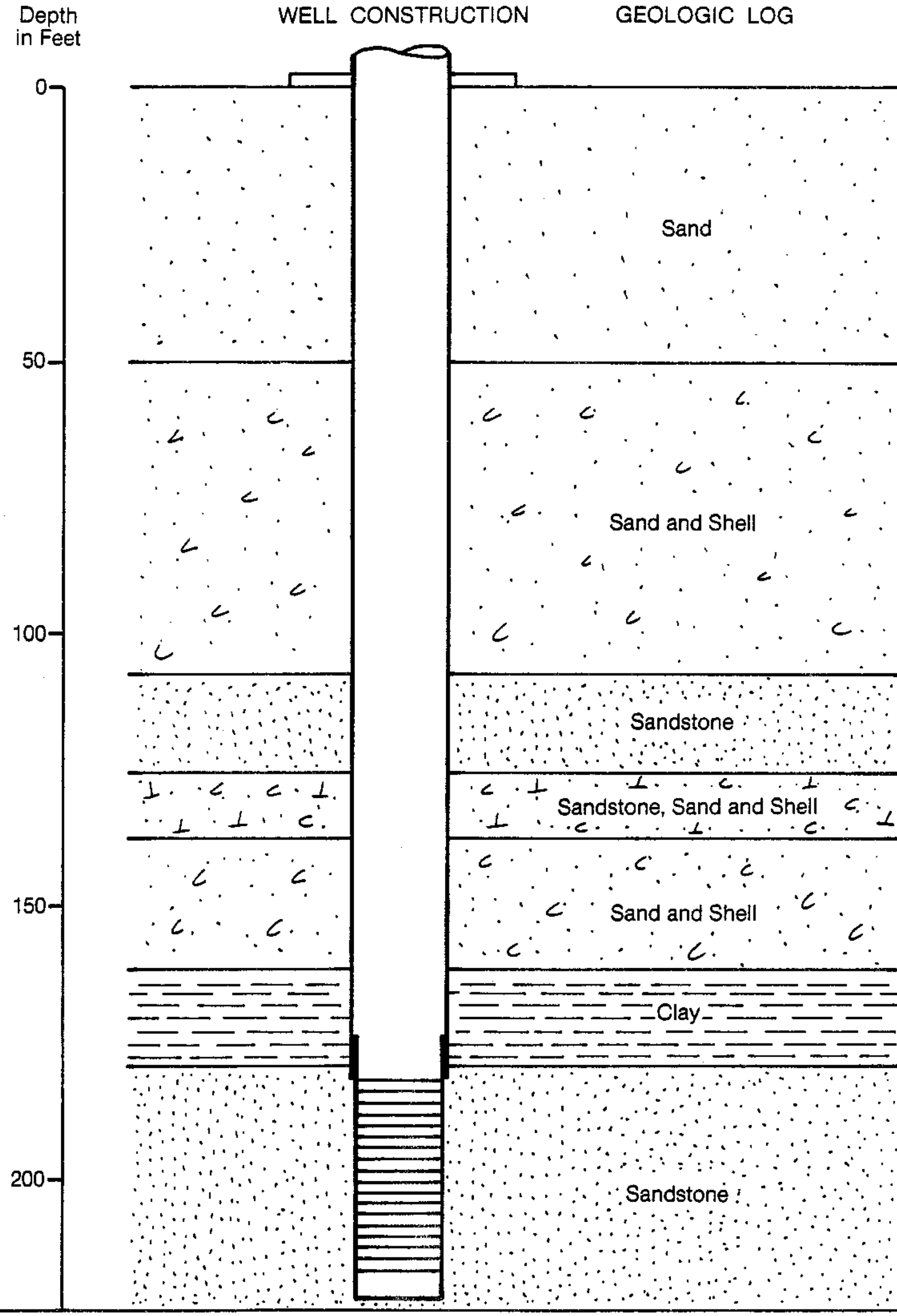
Pumping Rate — gpm
Static Water Level — ft.
Maximum Drawdown — ft.
Specific Capacity — gpm/ft.

Note: Geologic Log Developed from Nearby Wells. This Well is Abandoned.

FIGURE E-2.
Well Completion Report—Well No. 2.

CH2M HILL

FC50100.E0



Well No. 3
Date Completed 1964
Casing Diameter 10 in.
Casing Depth 182 ft.
Screen Section 182-222 ft.

Screen Diameter 10 in.
Screen Slot Size —
Gravel Pack Size None
Pumping Test 1/83
Duration 3 hr.

Pumping Rate 360 gpm
Static Water Level 10.0 ft.
Maximum Drawdown 30.0 ft.
Specific Capacity 12 gpm/ft.

Note: Geologic Log Developed from Nearby Wells.

FIGURE E-3.
Well Completion Report—Well No. 3.

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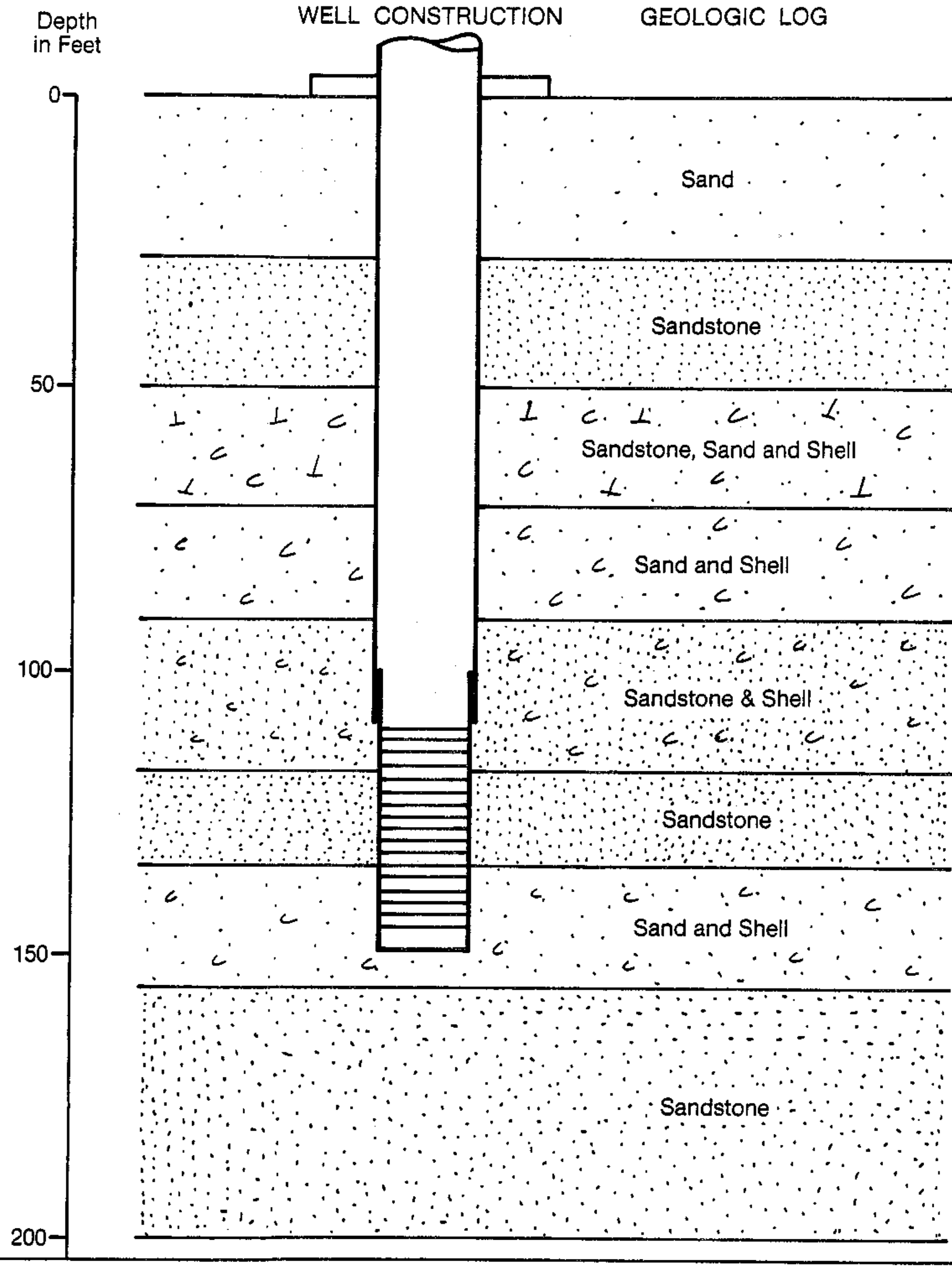
FC50100.E0



Well No. 4
Date Completed 1967
Casing Diameter 10 in.
Casing Depth 110 ft.
Screen Section 110-150 ft.

Screen Diameter 10 in.
Screen Slot Size 35
Gravel Pack Size None
Pumping Test 1/83
Duration 3 hr.

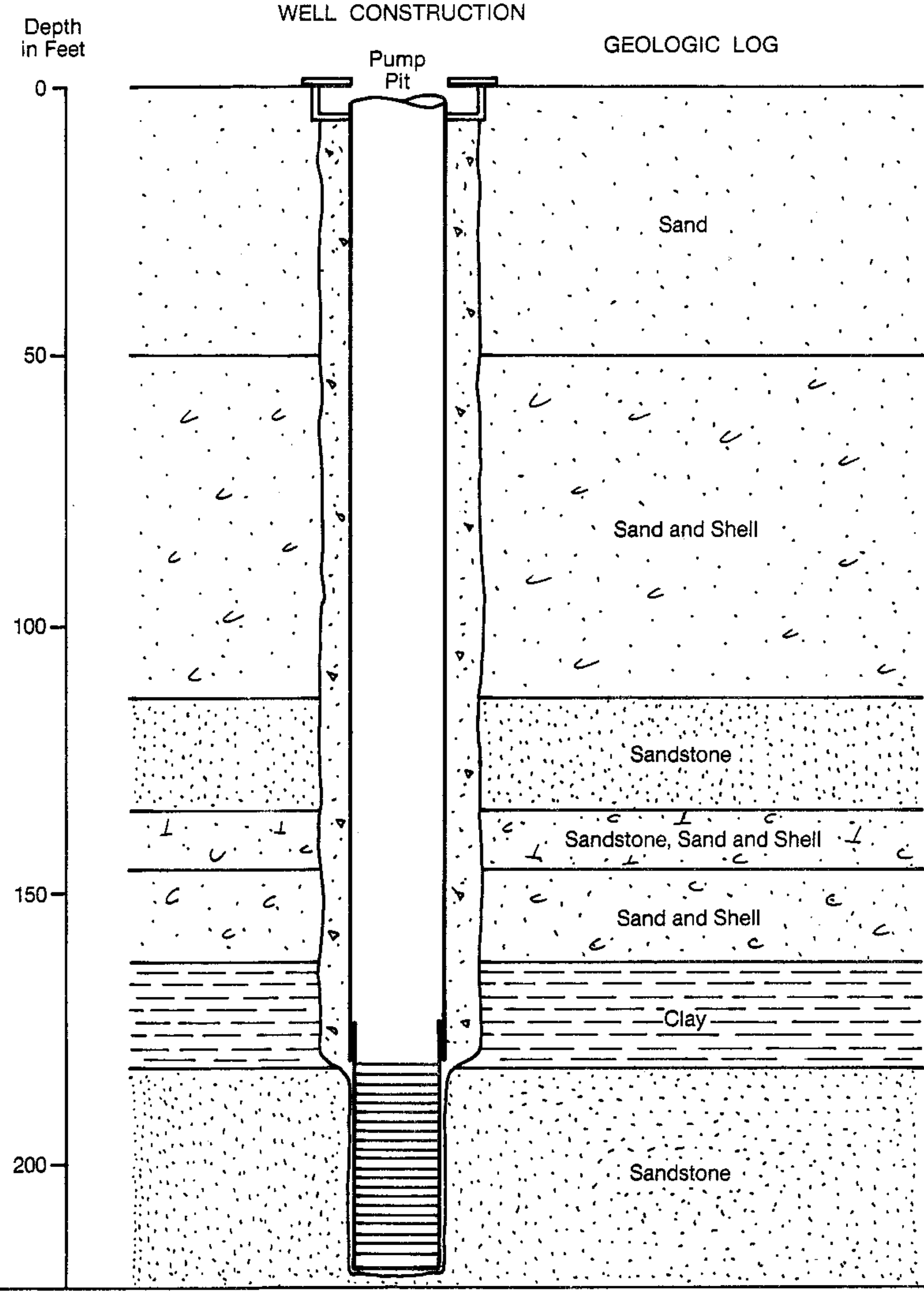
Pumping Rate 480 gpm
Static Water Level 7.3 ft.
Maximum Drawdown 27.3 ft.
Specific Capacity 18 gpm/ft.

Note: Geologic Log Developed from Nearby Wells.

FIGURE E-4.
Well Completion Report—Well No. 4.

CH2M HILL

FC50100.E0



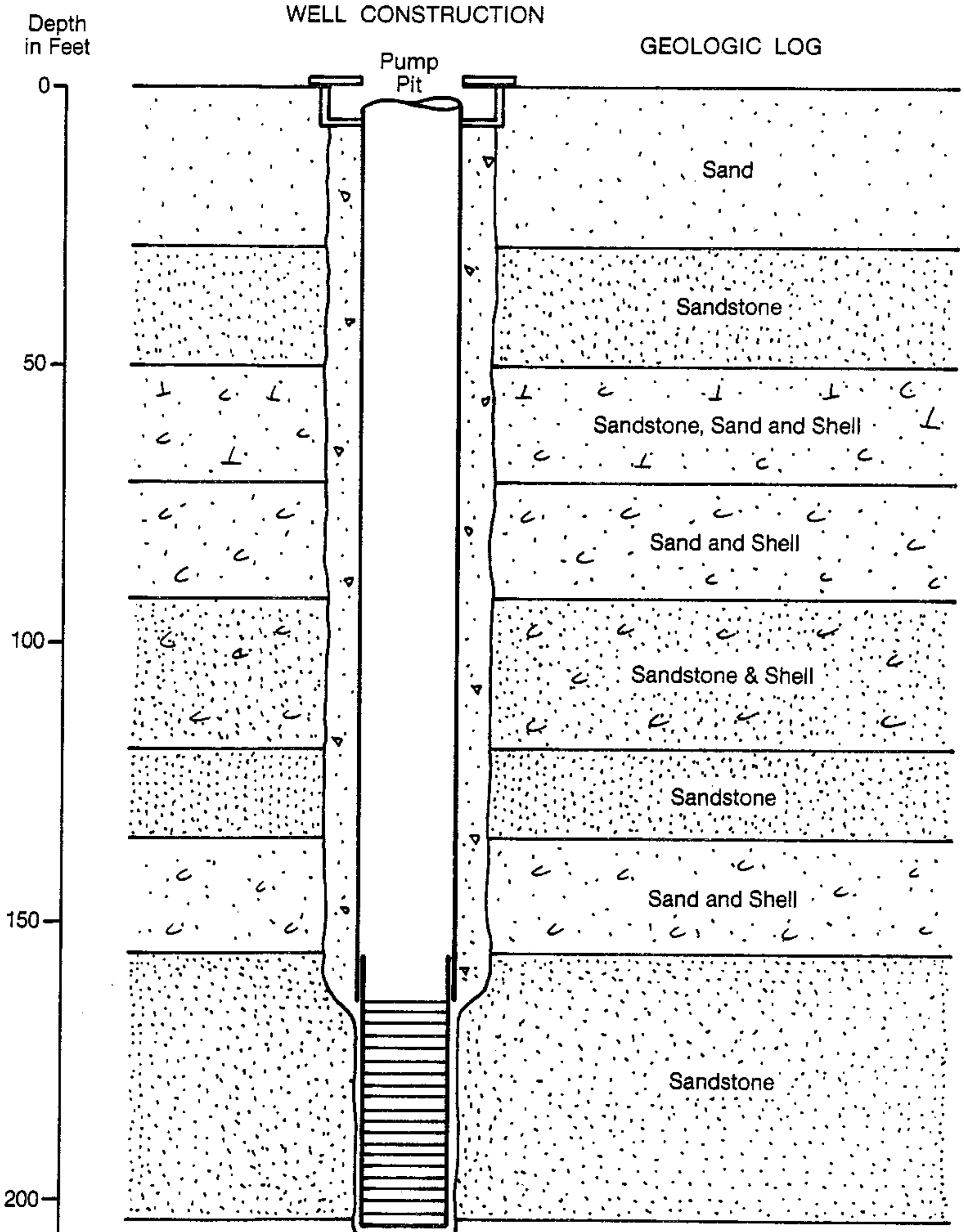
Well No. 5
Date Completed 12/69
Casing Diameter 12 in.
Casing Depth 183 ft.
Screen Section 183-223 ft.

Screen Diameter 12 in.
Screen Slot Size 40
Gravel Pack Size None
Pumping Test 3/70
Duration 2 hr.

Pumping Rate 900 gpm
Static Water Level 7.8 ft.
Maximum Drawdown 55.6 ft.
Specific Capacity 16 gpm/ft.

FIGURE E-5.
Well Completion Report—Well No. 5.

CH2M HILL

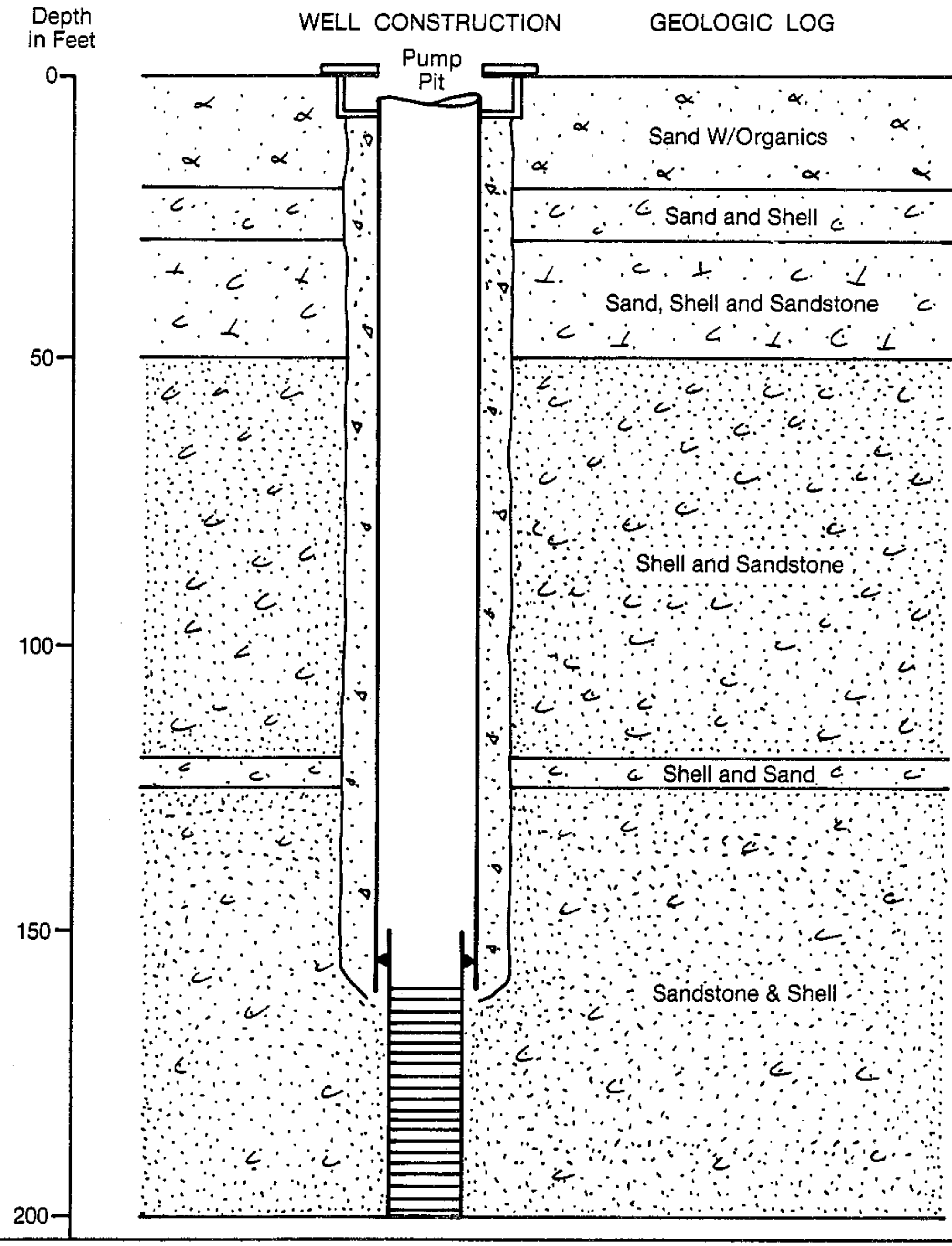


Well No. 6
Date Completed 12/69
Casing Diameter 12 in.
Casing Depth 165 ft.
Screen Section 165-205 ft.

Screen Diameter 12 in. TS
Screen Slot Size 40
Gravel Pack Size None
Pumping Test 12/69
Duration 3 hr.

Pumping Rate 1,000 gpm
Static Water Level 7.8 ft.
Maximum Drawdown 23.8 ft.
Specific Capacity 42 gpm/ft.

FIGURE E-6.
Well Completion Report—Well No. 6.



Well No. 7
Date Completed 8/71
Casing Diameter 12 in.
Casing Depth 161 ft.
Screen Section 161-201 ft.

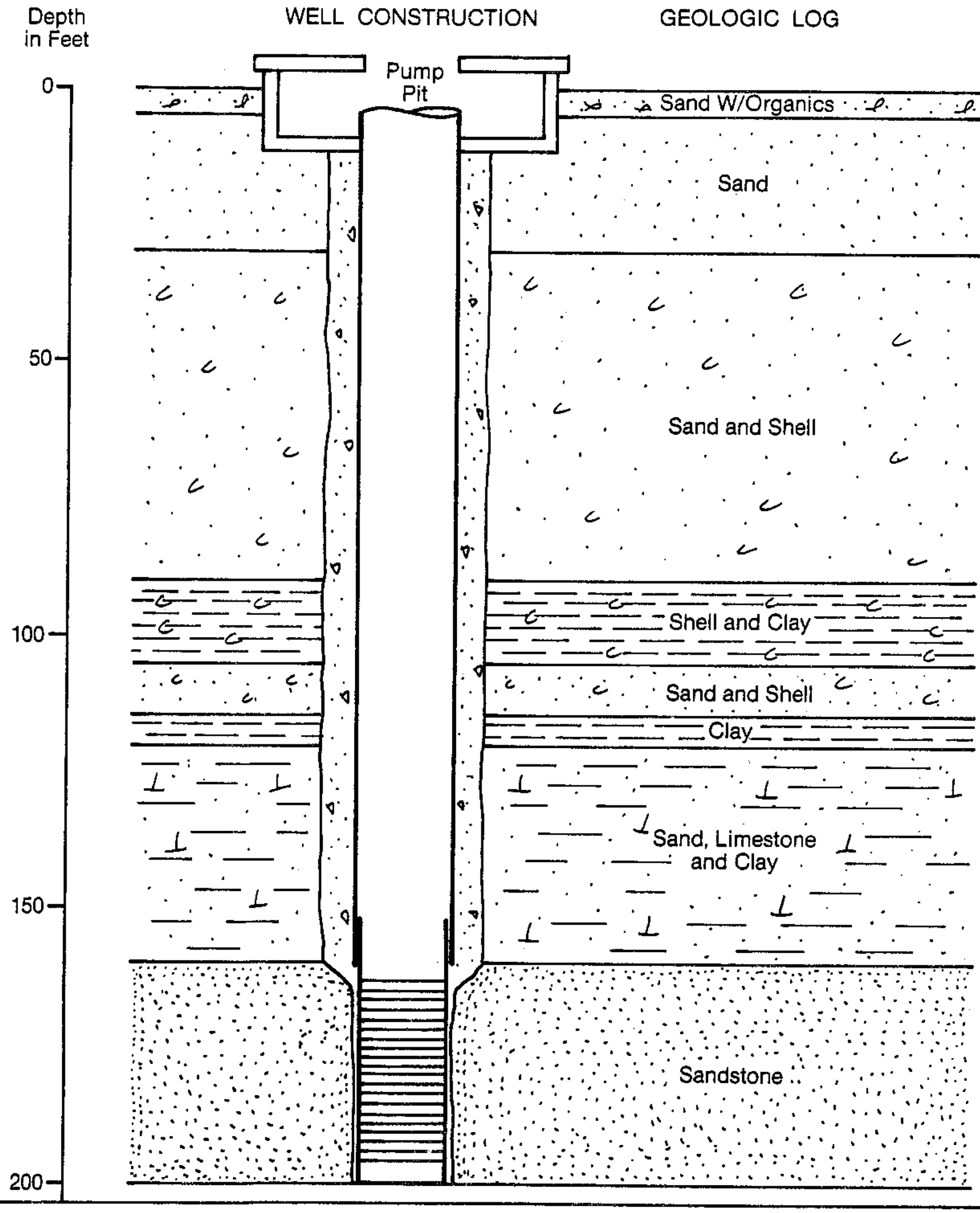
Screen Diameter 10 in. TS
Screen Slot Size 35
Gravel Pack Size None
Pumping Test 1/83
Duration — hr.

Pumping Rate 75 gpm
Static Water Level 7.2 ft.
Maximum Drawdown 34.9 ft.
Specific Capacity 2 gpm/ft.

FIGURE E-7.
Well Completion Report—Well No. 7.

CH2M HILL

FC50100.E0



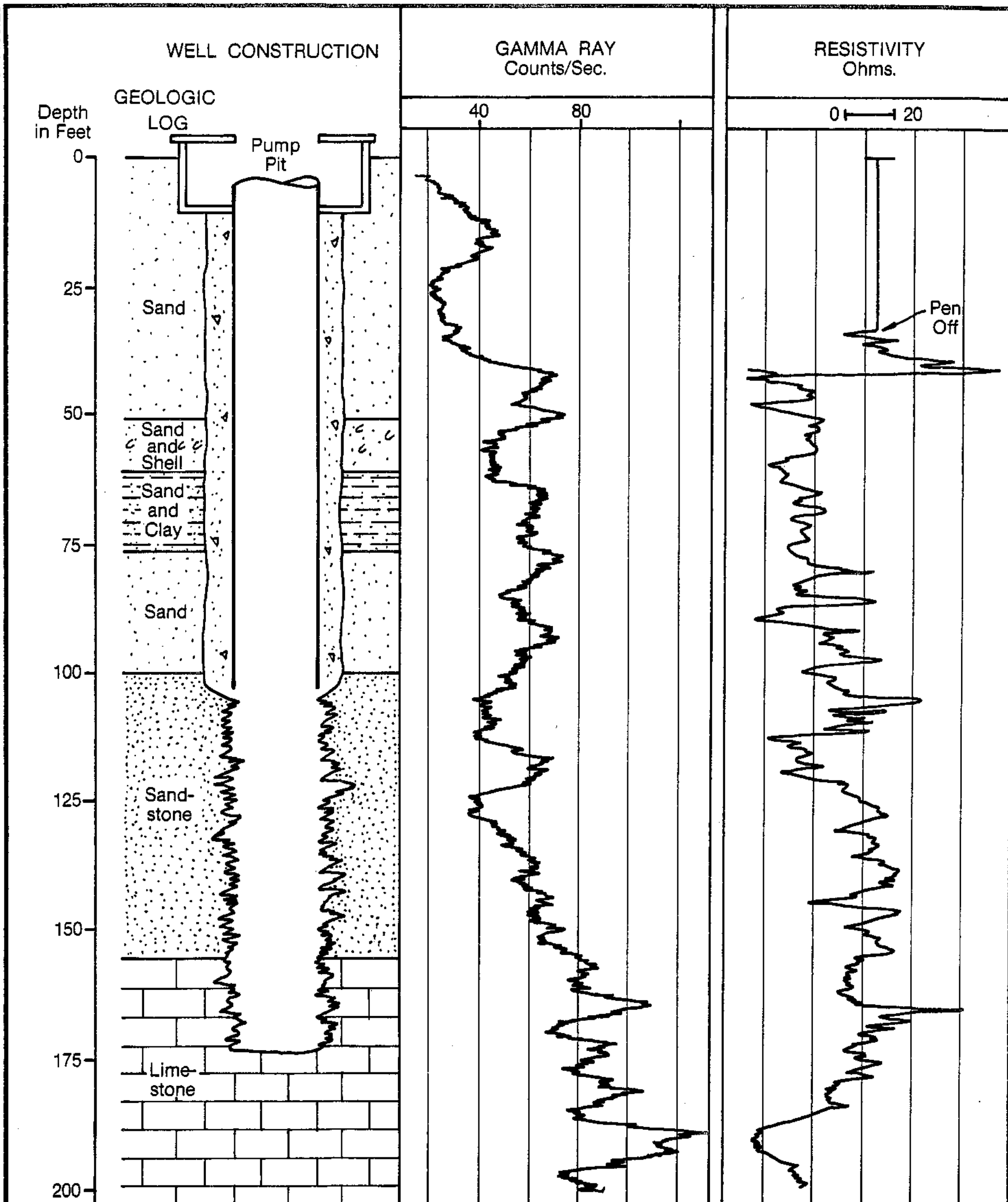
Well No. 8
Date Completed 1974
Casing Diameter 12 in.
Casing Depth 160 ft.
Screen Section 160-200 ft.

Screen Diameter 12 in. TS
Screen Slot Size 40
Gravel Pack Size None
Pumping Test 1/83
Duration 3 hr.

Pumping Rate 715 gpm
Static Water Level 6.2 ft.
Maximum Drawdown 22.1 ft.
Specific Capacity 32 gpm/ft.

FIGURE E-8.
Well Completion Report—Well No. 8.

CH2M HILL



Well No. 9
Date Completed 2/77
Casing Diameter 12 in.
Casing Depth 104 ft.
Open Hole Section 104-170 ft.

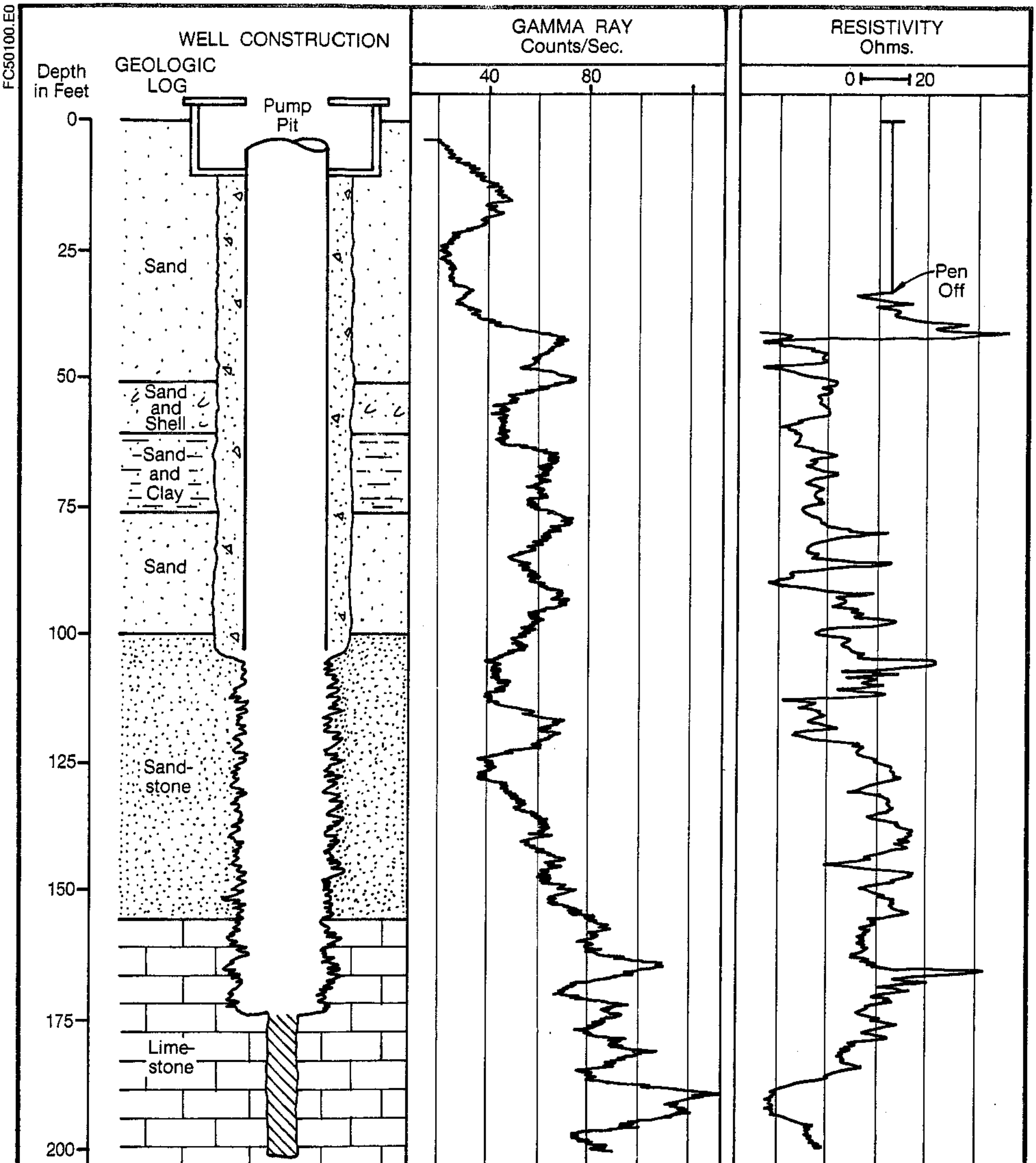
Screen Diameter N/A
Screen Slot Size N/A
Gravel Pack Size N/A
Pumping Test 3/77
Duration 4 hr.

Pumping Rate 1,200 gpm
Static Water Level 8.1 ft.
Maximum Drawdown 10.9 ft.
Specific Capacity 110 gpm/ft.

Note: Geophysical Logs from Well 10.

FIGURE E-9. Well Completion Report—Well No. 9

CH2M HILL



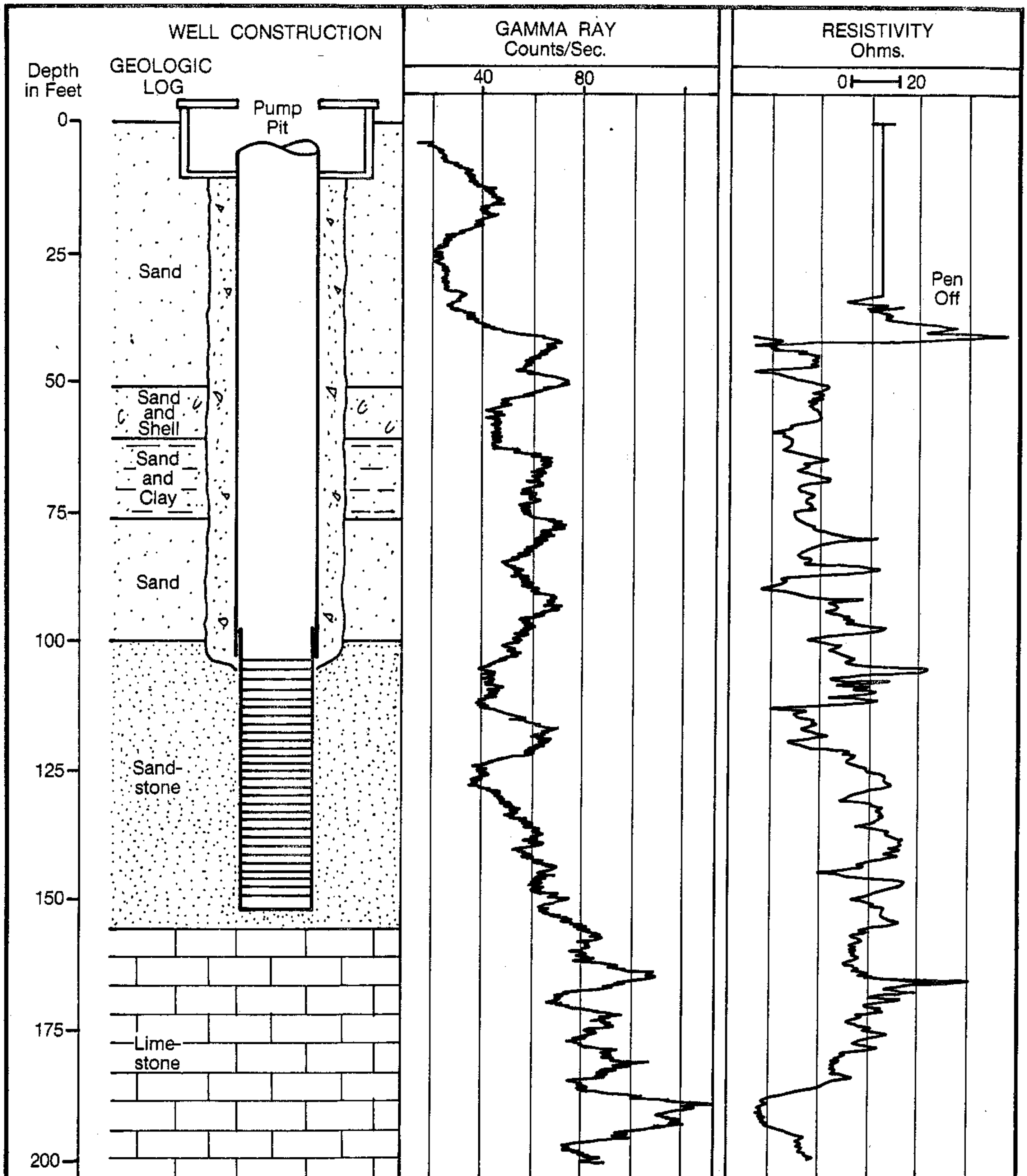
Well No. 10
Date Completed 3/77
Casing Diameter 12 in.
Casing Depth 102 ft.
Open Hole Section 102-170 ft.

Screen Diameter N/A
Screen Slot Size N/A
Gravel Pack Size N/A
Pumping Test 12/76
Duration 23 hr.

Pumping Rate 1,200 gpm
Static Water Level 8.1 ft.
Maximum Drawdown 10.9 ft.
Specific Capacity 110 gpm/ft.

FIGURE E-10.
Well Completion Report—Well No. 10.

CH2M HILL



Well No. 11
Date Completed 4/7/77
Casing Diameter 12 in.
Casing Depth 104 ft.
Screen Section 110-150 ft.

Screen Diameter 8 in. TS
Screen Slot Size 40
Gravel Pack Size None
Pumping Test 4/28/77
Duration 12 hr.

Pumping Rate 1000 gpm
Static Water Level 9.8 ft.
Maximum Drawdown 4.6 ft.
Specific Capacity 217 gpm/ft.

Note: Geophysical Logs from Well 10.

FIGURE E-11.
Well Completion Report—Well No. 11.

CH2M HILL