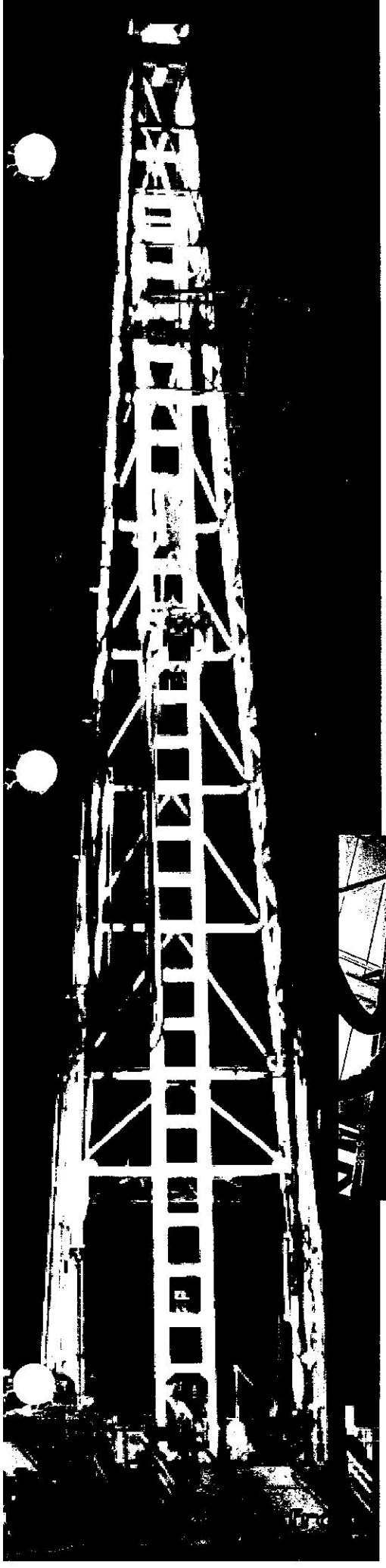
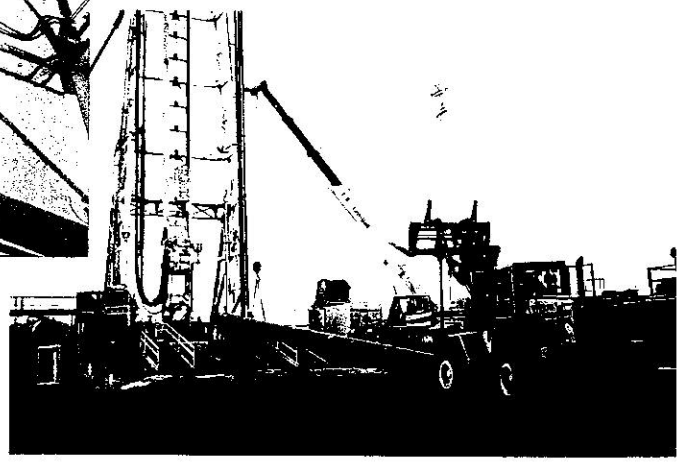


Lee County Utilities
Fort Myers Beach WWTP
Deep Injection Well
Engineering Report

Volume 1
Appendices A - K



Prepared by

JOHNSON ENGINEERING, INC.

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December 1998
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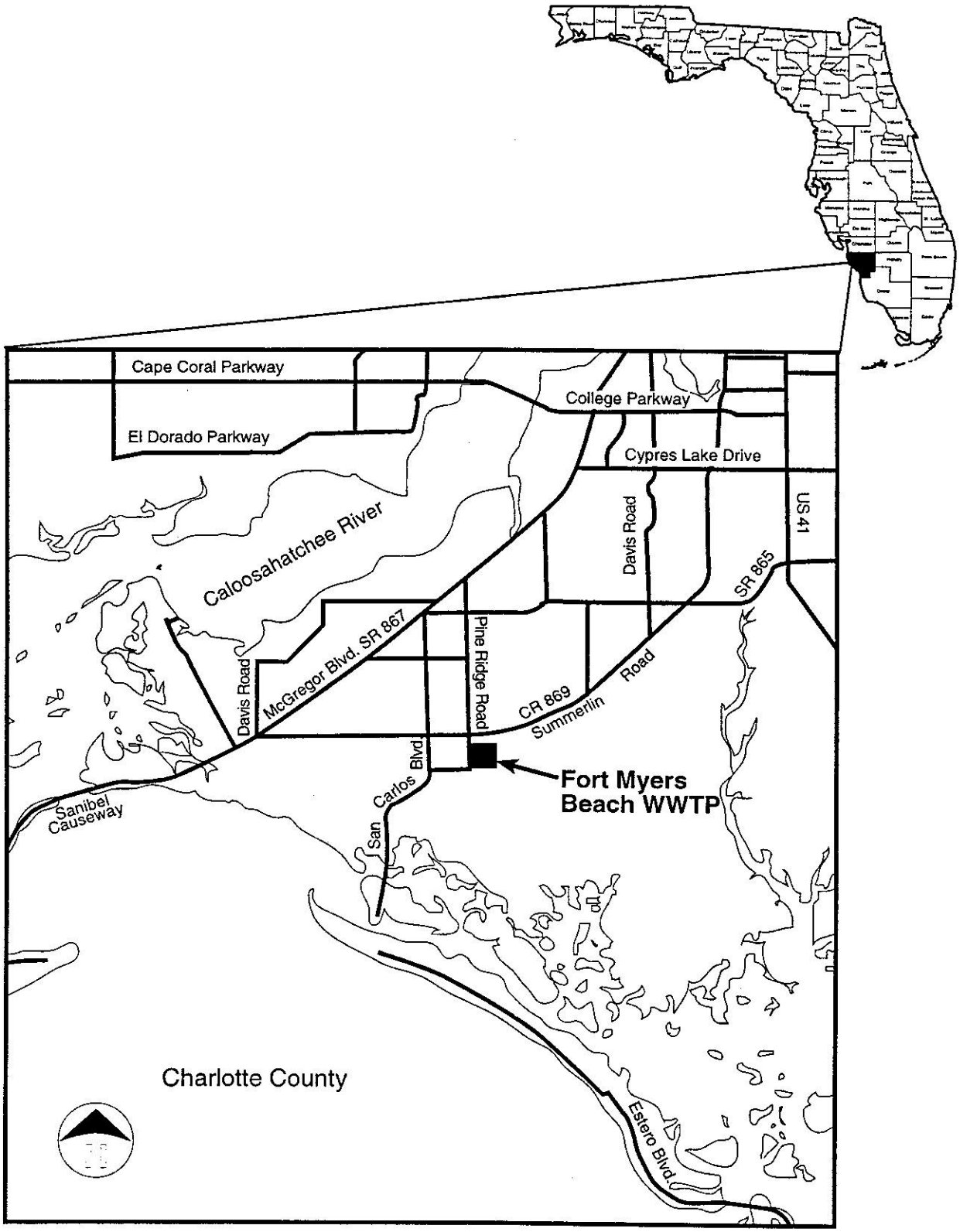

FIGURE 1-1
Project Location Map

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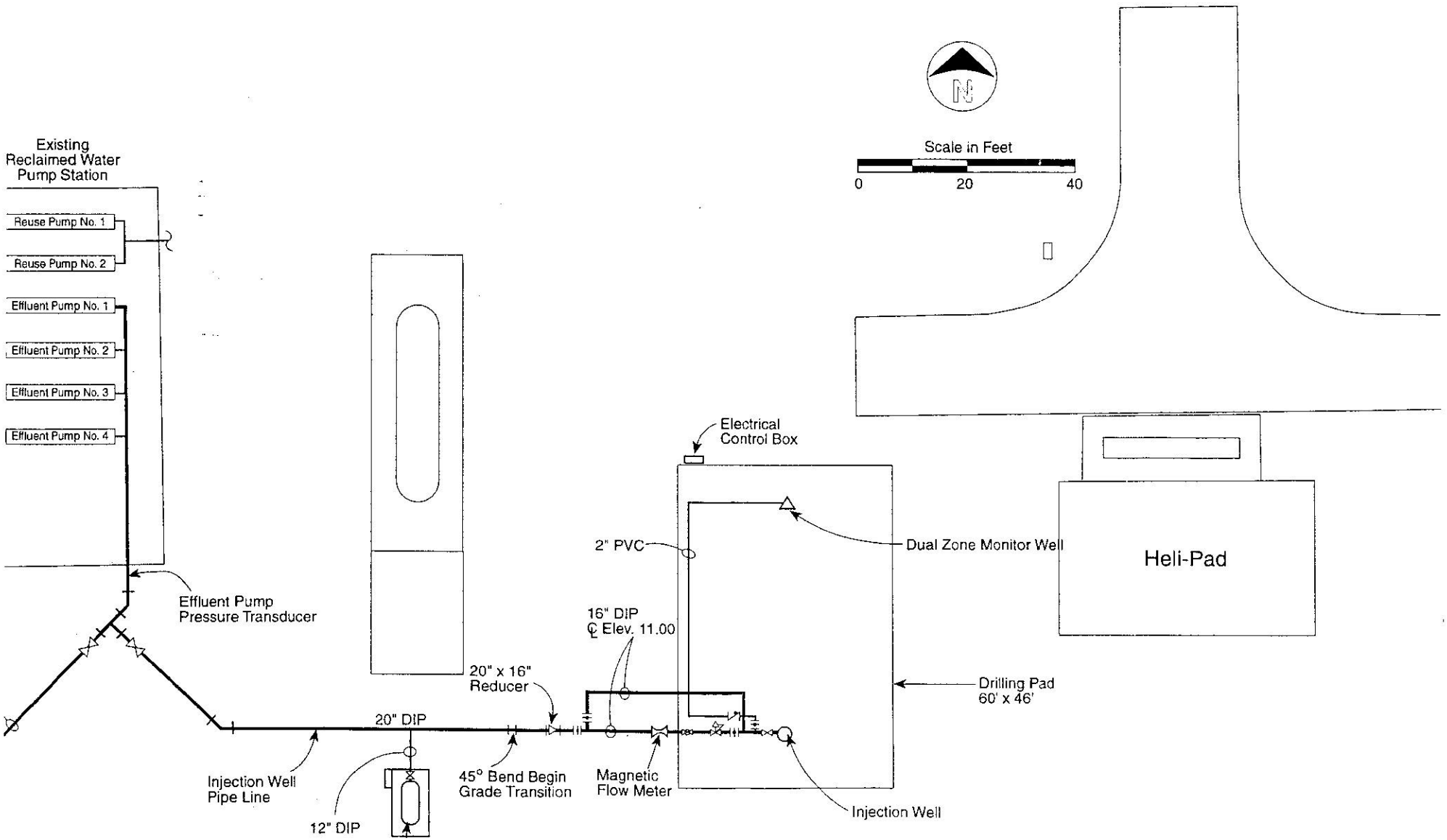
Existing
Reclaimed Water
Pump Station
Reuse Pump No. 1
Reuse Pump No. 2
Effluent Pump No. 1
Effluent Pump No. 2
Effluent Pump No. 3
Effluent Pump No. 4
Effluent Pump
Pressure Transducer
Scale in Feet
0
20
40
Electrical
Control Box
2" PVC
Dual Zone Monitor Well
Heli-Pad
16" DIP
℄ Elev. 11.00
20" x 16"
Reducer
Drilling Pad
60' x 46'
20" DIP
Injection Well
Pipe Line
12" DIP
45° Bend Begin
Grade Transition
Magnetic
Flow Meter
Injection Well

SECTION 2

Construction

This section describes the construction, drilling, and testing details associated with the construction of IW-1 and dual-zone monitoring well MW-1.

Before beginning drilling activities, a temporary drilling pad was installed, which contained both the drilling rig and cutting's tank. This pad was later modified to a permanent pad. Construction of the injection well system included construction of the pad, four surficial monitoring wells, a deep injection well, and a dual-zone monitoring well. Figures 2-1 and 2-2 provide diagrams of the temporary drilling pad and the permanent drilling pad, respectively.

Surficial Monitoring Wells

As required by the construction permit, four surficial monitoring wells were installed and sampled before the start of construction at IW-1. Surficial monitoring wells were installed at each corner of the drilling pad to monitor for groundwater contamination during construction. Following installation of the surficial monitoring wells, samples were collected from each well and analyzed to establish background water quality data. Figure 2-3 presents a typical surficial monitoring well diagram. Water quality data from the surficial monitoring wells is discussed in Section 4 of this report.

Injection Well IW-1

Drilling of injection well IW-1 began on January 12, 1998. Mud rotary drilling techniques were used to drill through the surficial aquifer and the clay intervals that make up the Hawthorn Group. Reverse air drilling techniques were used during subsequent drilling to a total depth of 3,036 feet below pad level (bpl) to remove drill cuttings from the borehole and to collect water samples at 30-foot intervals. A closed circulation system was used during reverse air drilling.

The drilling schedule and casing-setting depths were designed to conform to the hydrogeological features observed at the site, as well as to various regulatory agency requirements. Geologic formation samples were collected and described at 10-foot intervals during the drilling of the pilot hole. Data from the pilot hole interval (formation samples [cuttings], cores, water samples, air-lift specific capacity tests, packer tests, an injection test, and geophysical logs) were evaluated to assist in selection of the casing setting depths, and to interpret the site lithology and hydrogeology.

Three concentric steel casings were used to construct IW-1 (34-inch, 26-inch, and 16-inch outside diameters). Appendix D contains copies of casing mill certificates for each of the casings used during construction of IW-1. Immediately upon installation, the annular space around each casing string was cemented from the bottom of casing to land surface. The cementing program was specifically tailored for each casing installed. Table 2-1 provides a

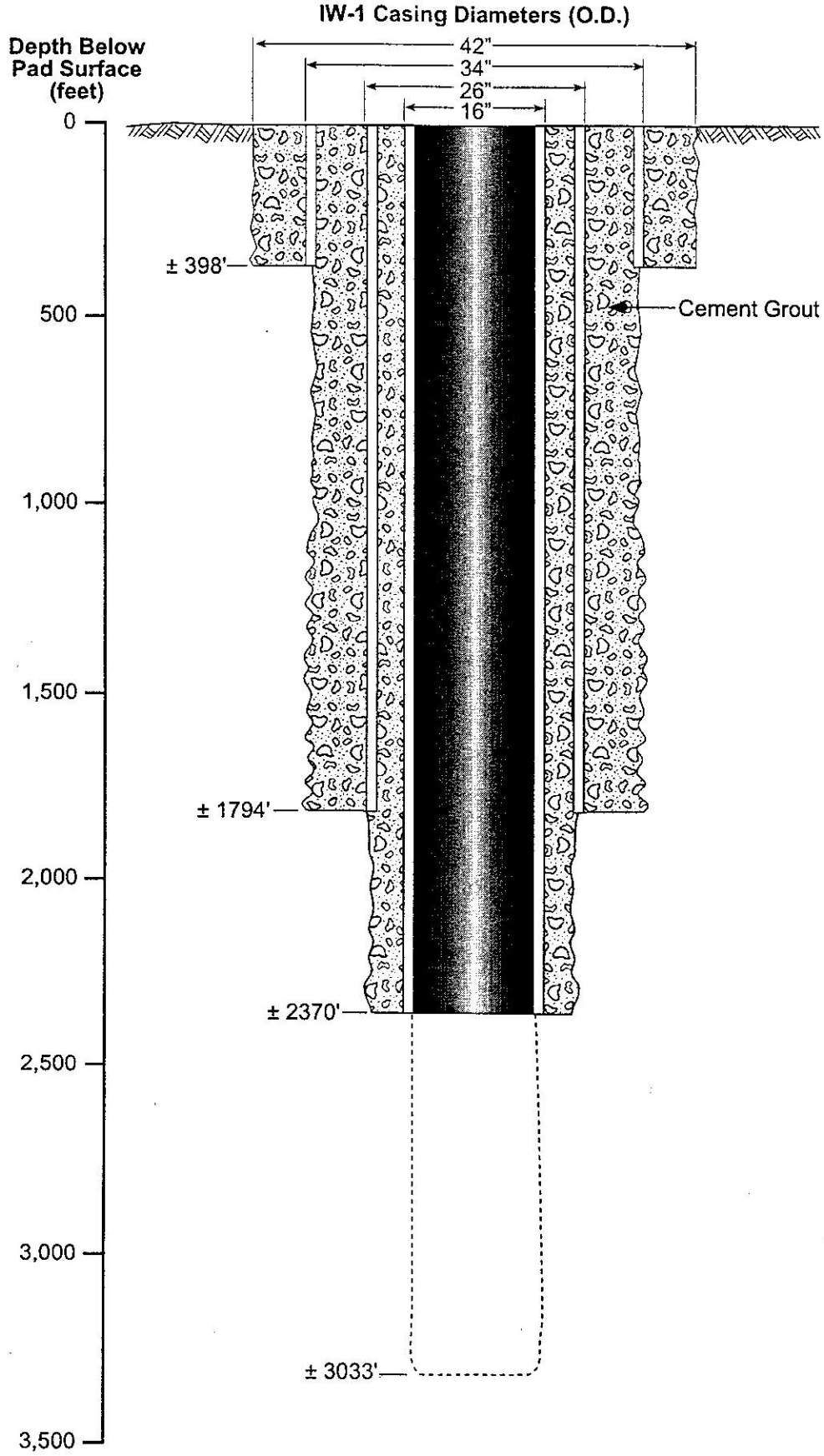

FIGURE 2-4
Injection Well Completion Diagram

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Table 2-1

Fort Myers Beach Wastewater Treatment Plant
Injection Well IW-1
Summary of Casing Setting Depths and Cement Quantities

Casing	Casing Material	Outside Diameter (inches)	Inside Diameter (inches)	Casing Thickness (inches)	Casing Depth (feet bpl)	Date	Cement Stage	Type of Cement	Quantity of Cement (sacks)	Remarks
Shallow	Steel	34.00	33.00	0.500	398	1/16/98	#1	Neat	338	Pressure grout from bottom of casing
								4% bentonite	517	
Intermediate	Steel	26.00	25.00	0.500	1794	2/26/98	#1	Neat	789	Pressure grout from bottom of casing
								6% bentonite	478	
						2/26/98	#2	6% bentonite	1264	Tremied into annulus from 1,606 feet bpl
						2/27/98	#3	6% bentonite	1457	Tremied into annulus from 1,190 feet bpl
						2/27/98	#4	6% bentonite	1434	Tremied into annulus from 895 feet bpl
						2/28/98	#5	12% bentonite	928	Tremied into annulus from 625 feet bpl
Final	Steel	16.00	15.00	0.500	2370	4/28/98	#1	Neat	518	Pressure grout from bottom of casing
								6% bentonite	501	
						4/29/98	#2	Neat	195	Tremied into annulus from 2,132 feet bpl
						4/29/98		Gravel	15 yards	Tremied into annulus from 2,126 feet bpl
						4/29/98	#3	6% bentonite	498	Tremied into annulus from 2,110 feet bpl
						4/30/98		Gravel	10 yards	Tremied into annulus from 2,105 feet bpl
						4/30/98	#4	Neat	95	Tremied into annulus from 2,089 feet bpl
						5/1/98		Gravel	10 yards	Tremied into annulus from 2,080 feet bpl
						5/1/98	#5	Neat	106	Tremied into annulus from 2,050 feet bpl
						5/1/98	#6	6% bentonite	913	Tremied into annulus from 2,010 feet bpl
						5/2/98	#7	12% bentonite	1211	Tremied into annulus from 1,520 feet bpl
						5/25/98	#8	12% bentonite	189	Tremied into annulus from 230 feet bpl
								Total Sacks Neat:	**4354**	
								Total Sacks 4%:	**8992**	

bpl = below pad level

summary of casing depths and the types and quantities of cement used during the construction of IW-1. Figure 2-4 presents a cross-sectional view depicting the completion diagram of IW-1.

Construction of IW-1 began with the mud-rotary drilling of a nominal 12.25-inch-diameter pilot hole to a depth of 473 feet bpl. The pilot hole was then geophysically logged (caliper, gamma ray, spontaneous potential, and dual induction logs). Upon examination of the logs, the casing depth was targeted at 398 feet and the borehole was reamed to a nominal 40-inch-diameter to a depth of 405 feet bpl. A caliper log was then performed on the reamed hole and the 34-inch-diameter casing was installed and cemented through the surficial and intermediate aquifers to a depth of 398 feet bpl.

After allowing for a 24-hour cement cure time, the pilot hole was advanced with reverse air drilling techniques to a depth of 1,900 feet bpl. Three 4-inch-diameter cores were collected from the interval of 1,444 to 1,684 feet bpl during this phase of pilot hole drilling. Core analyses and descriptions are discussed in Section 4 of this report. Caliper, gamma ray, spontaneous potential, dual induction, borehole compensated sonic, temperature, fluid conductivity, and flowmeter logs were then conducted on the open hole interval. Five straddle packer tests were performed between the interval of 1,220 and 1,844 feet bpl in order to identify the base of the Underground Source of Drinking Water (USDW) and provide confining characteristics of the tested intervals. The results of the packer tests are presented and discussed in Section 4.

Based on the results of packer testing, coring, geophysical logging, and formation sample analyses, a 26-inch diameter casing setting depth of 1,800 feet bpl was recommended to and approved by the FDEP and TAC. The pilot hole was then back plugged with cement and reamed to a nominal 34-inch-diameter to a depth of 1,805 feet bpl. The reamed hole was then caliper-logged and the 26-inch-diameter intermediate casing was installed below the base of the USDW to a depth of 1,794 feet bpl, and its annular space cemented to land surface.

After the cement cure period, the pilot hole was advanced to a depth of 3,036 feet bpl. Five 4-inch-diameter cores were collected from the interval of 1,965 to 2,524 feet bpl during this phase of pilot hole drilling. Section 4 of this report presents core analyses, including detailed descriptions. Caliper, gamma ray, spontaneous potential, dual induction, borehole compensated sonic, temperature, fluid conductivity, video, and flowmeter logs were then conducted on the open hole interval. A drill stem packer test was performed on the interval from 1,450 to 1,990 feet bpl. Caliper, fluid resistivity, temperature, and flowmeter logs were performed on the test interval during drill stem packer testing. Section 4 of this report discusses the results of drill stem packer testing. Five packer tests were then conducted between the interval of 1,796 and 3,036 feet bpl in order to determine the confining characteristics of the tested intervals.

Based on flow results of packer testing, along with coring, geophysical logging, and formation sample analyses, a 16-inch diameter casing setting depth of 2,370 feet bpl was recommended to and approved by the FDEP and TAC. Before reaming the pilot hole, a bridge plug was installed at a depth of 2,405 feet bpl and the interval from the bridge plug to the 26-inch casing was back plugged with cement. The back plugged pilot hole was then reamed to a nominal (25-inch) diameter to a depth of 2,376 feet bpl and caliper-logged. The final casing (16-inch-diameter) was then installed to a depth of 2,370 feet bpl.

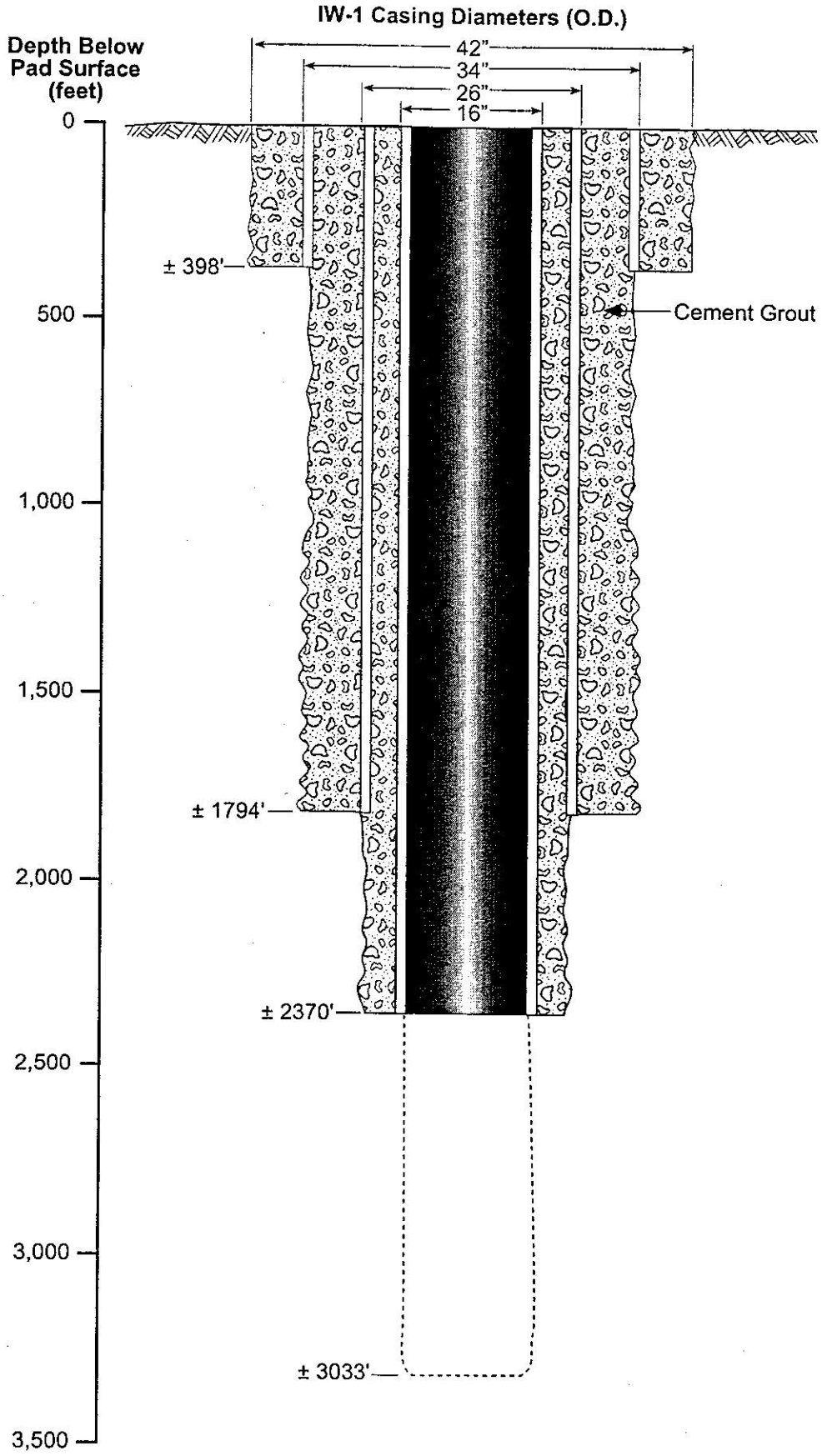

FIGURE 2-4
Injection Well Completion Diagram

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A pressure test was conducted on the final casing string before conducting a cement bond log. The interval below the base of the final casing was then reamed to a nominal (15-inch) diameter to a depth of 3,033 feet bpl before developing the well and collecting a background water quality sample for laboratory analysis. The water quality sample analyses are presented in Section 4.

Caliper, gamma ray, temperature, video, and flowmeter logs were conducted on the well before performing a radioactive tracer survey (RTS) to assess the external mechanical integrity of IW-1. The IW-1 wellhead was then installed and wellhead piping was connected to the WWTP effluent disposal piping. Figure 2-5 presents the completion diagram for the IW-1 wellhead.

Monitoring Well MW-1

Drilling of monitoring well MW-1 began on May 15, 1998, utilizing the same drilling techniques used for the injection well. The upper monitoring zone is constructed in the first permeable zone above the base of the USDW, and is open over the intervals from 1,170 to 1,271 feet bpl. The lower monitoring zone is constructed below the base of the USDW within the first permeable zone above the uppermost portion of the injection zone, and is open over the interval between 1,563 and 1,649 feet bpl.

MW-1 was constructed using three (3) concentric casings (24-inch, 16-inch, and 6-5/8-inch outside diameters). Appendix E contains copies of casing mill certificates for each casing used during construction of MW-1. The cementing program was specifically tailored for each casing installed. Table 2-2 summarizes the casing depths and the types and quantities of cement used for the construction of MW-1. Figure 2-6 presents a cross-section representation of the completed well.

Construction of MW-1 began with the mud-rotary drilling of a nominal 12.25-inch-diameter pilot hole to a depth of 410 feet bpl. The pilot hole was then geophysically logged (caliper, gamma ray, spontaneous potential, and dual induction logs) and reamed to a nominal 28-inch-diameter to a depth of 405 feet bpl. A caliper log was then performed on the reamed hole and a 24-inch-diameter steel casing was installed and cemented to a depth of 400 feet bpl.

After completion of the surface casing, followed by a 24-hour waiting period, the pilot hole was then advanced to a depth of 1,193 feet bpl and geophysically logged. Logs conducted included caliper, gamma ray, spontaneous potential, dual induction, borehole compensated sonic, temperature, fluid conductivity, and flowmeter. After logging, the pilot hole was reamed to a nominal 22-inch diameter to a depth of 1,180 feet. After conducting a caliper log on the reamed hole, the 16-inch casing was installed and cemented to a depth of 1,170 feet bpl.

The pilot hole was then drilled to a depth of 1,720 feet bpl and geophysically logged. Logs included caliper, gamma ray, spontaneous potential, dual induction, borehole compensated sonic, temperature, fluid conductivity, and flowmeter. After logging, the pilot hole was reamed to a nominal 15-inch diameter to a depth of 1,710 feet bpl and geophysically logged with a caliper tool. Upon completion of the caliper log, the 6-5/8-inch fiberglass-reinforced plastic (FRP) casing was set to a depth of 1,572 feet bpl. The borehole below the base of the

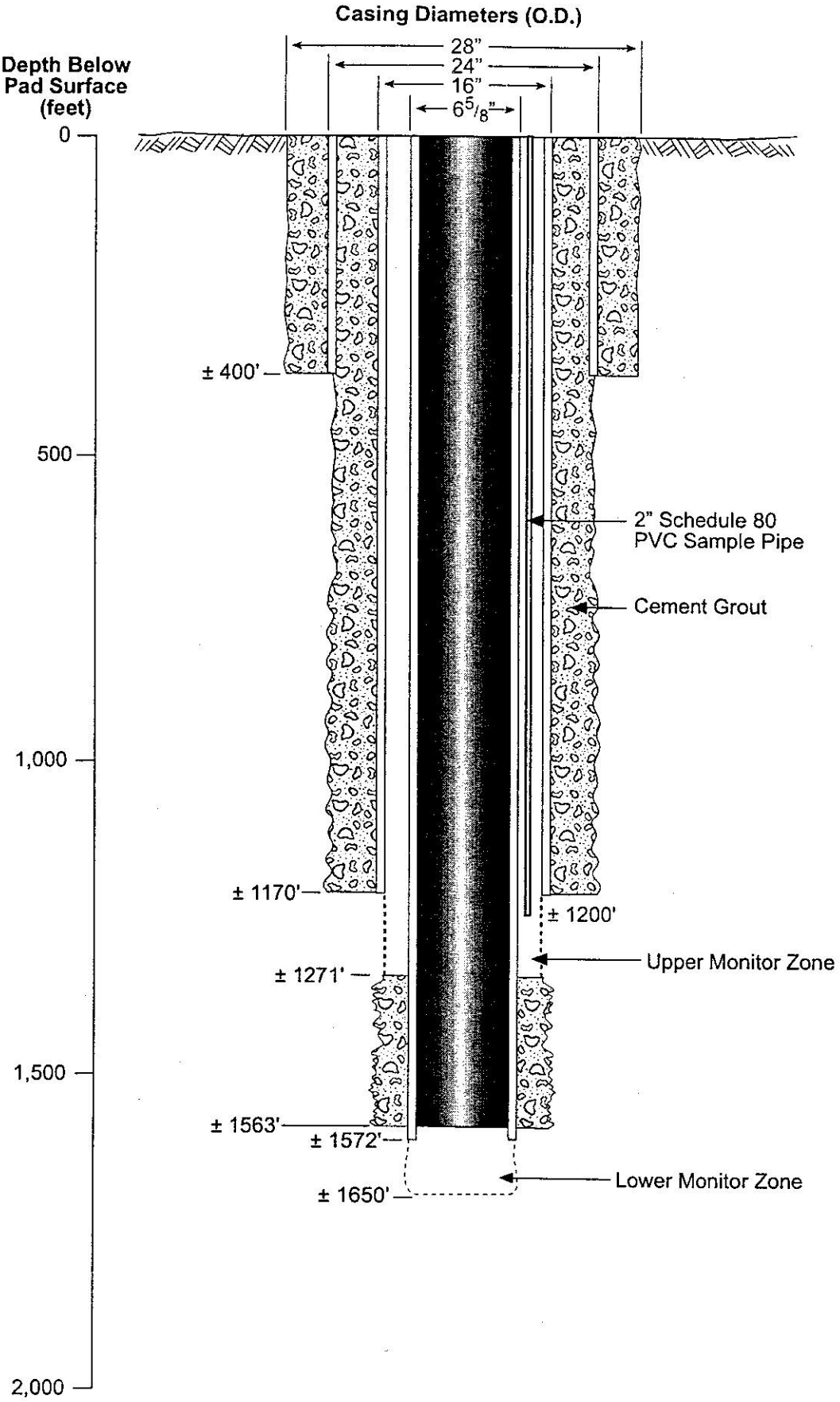

FIGURE 2-6
Dual-Zone Monitor Well Completion Diagram

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