HYDROGEOLOGIC DATA FROM A TEST WELL AT KATHRYN ABBEY HANNA PARK, CITY OF JACKSONVILLE, FLORIDA

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CONTENTS

ILLUSTRATIONS

TABLES

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ABSTRACT

A 2,026-foot test well was drilled at Kathryn Abbey Hanna Park, City of Jacksonville, Duval County, Florida, to obtain geologic, hydrologic, and water chemistry data. Drill cuttings and water samples were collected, and water-level measurements and lithologic and geophysical logs were made. The well is cased with 6-inch diameter casing from land surface to a depth of 1,892 feet and cement grouted in place. The remainder (1,892 to 2,026 feet) is open hole.

The uppermost 411 feet of material consists of sand, clayey sand, phosphatic sandy clay, coquina, sandy limestone, and dolostone. In the remainder of the hole, the material consists of fragmented and granular limestone and massive to finely crystalline dolostone, which comprise the Floridan aquifer in the area.

Water levels in the completed test well ranged from about 13 to 20 feet above land surface from January to August 1982. Water-level fluctuations are cyclic tidal induced with a maximum daily amplitude of about 1 to 2 feet.

Chloride concentrations of water sampled through the drill stem from a depth of 691 to 1,918 feet ranged from 6.4 to 75 milligrams per liter and then increased steadily to a maximum of 3,300 milligrams per liter at 2,022 feet. After completion of the well, chloride concentration was 3,000 to 3,900 milligrams per liter and dissolved solids concentration was 5,920 to 7,430 milligrams per liter.

INTRODUCTION

Purpose and Scope

Little information is available on the geology, hydrology, and water chemistry of the deeper, saline-water zones of the Floridan aquifer and the interconnection of these zones with the shallower freshwater zones in the Duval County-northeast Florida area. Information on water levels, the location of the freshwater-saltwater interface, and water chemistry, is necessary to determine the relation between withdrawals of water from the upper freshwater zones and saltwater intrusion. The information will aid in properly assessing the availability of potable water from the Floridan aquifer.

The U.S. Geological Survey, in cooperation with the St. Johns River Water Management District and the City of Jacksonville is investigating the hydrogeology and water chemistry of the deeper zones of the Floridan aquifer. An essential part of this investigation is the drilling, testing, and instrumentation of a deep test well network of 5 to 7 wells in northeast Florida.

This report presents the hydrogeologic and water chemistry data collected during construction and after completion of a test well at the City of Jacksonville's Kathryn Abbey Hanna Park.

This well will be used to monitor changes in water level and water chemistry. It will also aid in determining the depth to the freshwater-saltwater interface and the possible movement of saline water.

Acknowledgments

The authors wish to express their appreciation to the Chairman, the Governing Board, and staff of the St. Johns River Water Management District, and the Mayor, City Council, and staff of the City of Jacksonville for their support of this investigation. Particular acknowledgment is given to Douglas Munch, Director, Resource Evaluation Division, St. Johns River Water Management District, and Gary Weise, Bio-Environmental Services, City of Jacksonville, for their assistance during the drilling and testing of the test well. The authors also wish to thank Cecil Butler, Park Ranger, Kathryn Abbey Hanna Park, for his help during all phases of drilling and testing of the well.

WELL CONSTRUCTION

The location of the test well is shown in figure 1. The well was drilled from November 1980 to July 1981. As shown schematically in figure 2, the well was drilled to a total depth of 2,026 feet. It was drilled to a depth of 450 feet by the standard mud-rotary method, cased with 12-inch diameter steel casing from land surface to a depth of 429 feet, and grouted from 450 feet to the surface. The remainder of the hole, 450 to 2,026 feet, was drilled by the reverse-air rotary method. Six-inch diameter steel casing was then installed from land surface to 1,892 feet and grouted to the surface. The interval 1,892 to 2,026 was left open to the formation.

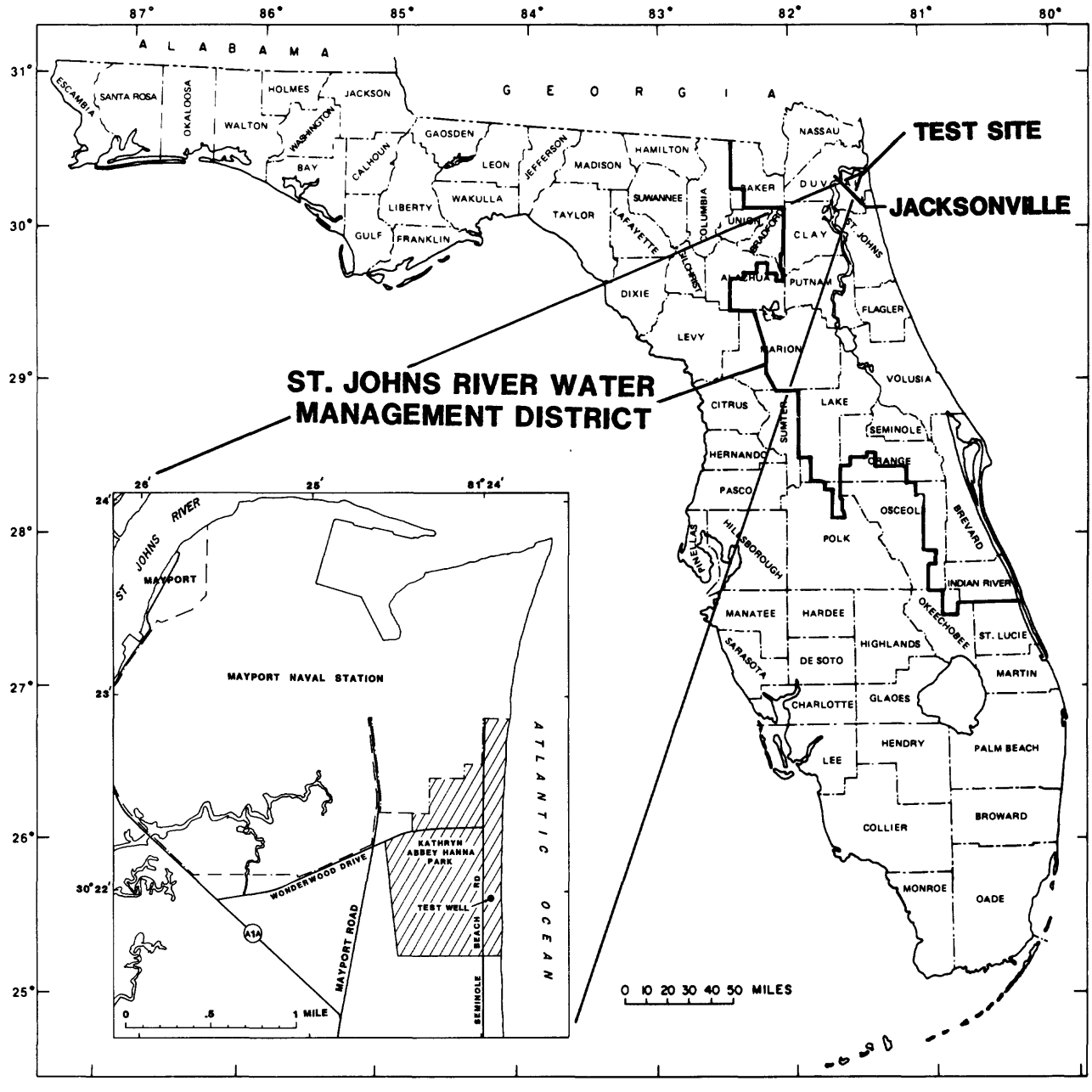

Figure 1.--Location of test well.

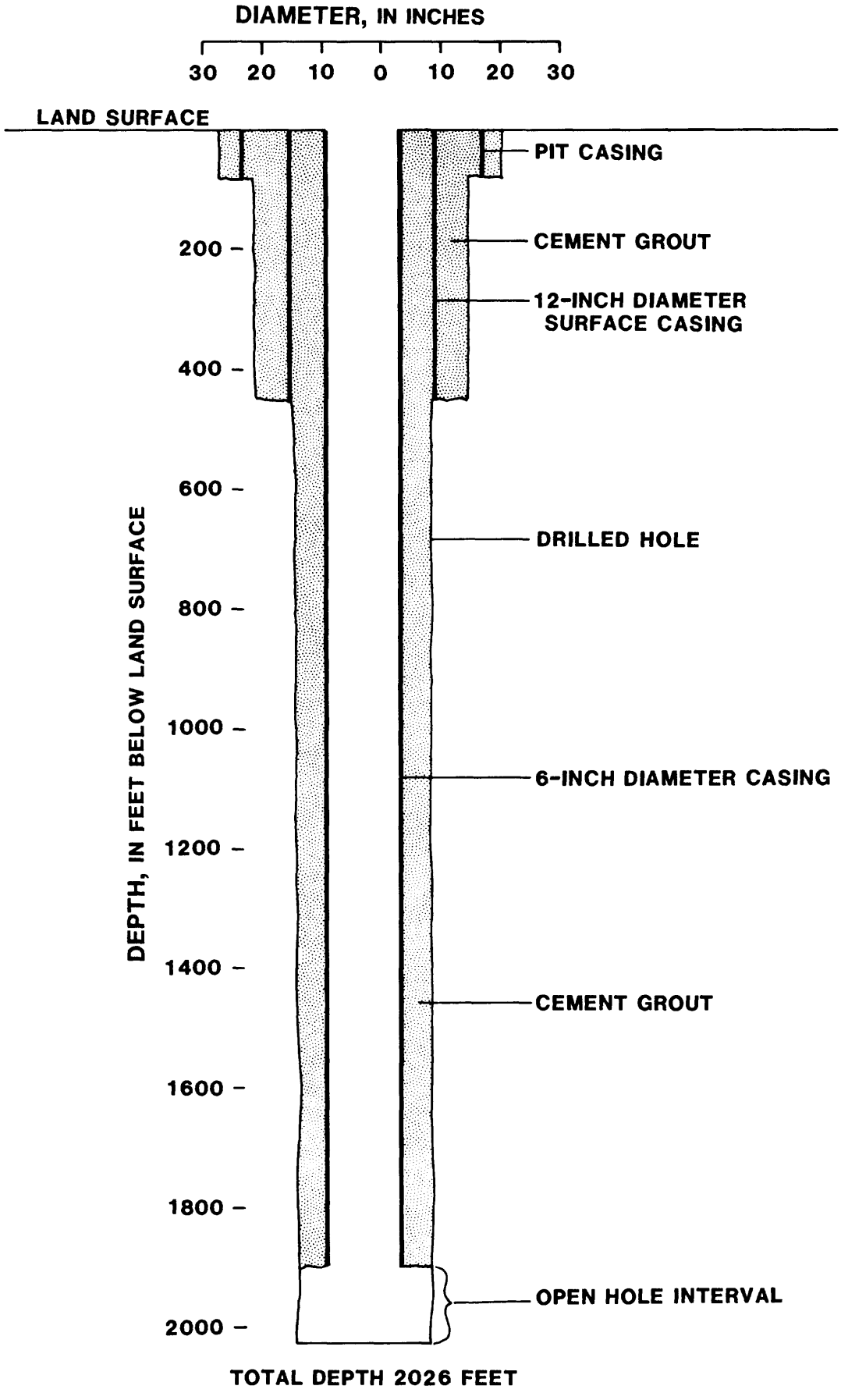

Figure 2.--Schematic diagram of well construction.

GEOLOGIC DATA

Drill cuttings were collected at intervals of about 10 feet and at changes in lithology. The lithologic log (table 1) is based on an examination of the cuttings. The uppermost 411 feet of material penetrated by the test well consists of sand, clayey sand, phosphatic sandy clay, coquina, sandy limestone, and dolostone (fig. 3). These materials range in age from Miocene (Hawthorn Formation) to Holocene. The remaining material consists of fragmented and granular limestone and massive to finely crystalline dolostone of Paleocene to Eocene (?) age. The formations, which comprise the Floridan aquifer in northeast Florida, in ascending order are the Cedar Keys (?), Oldsmar, Lake City, Avon Park, and Ocala Limestones. A core of rock was taken during drilling from 1,194 to 1,216 feet below land surface (10 feet of core recovered).

Geophysical logs were made during construction of the well, and selected logs are included in this report as figures 4 through 11.

HYDROLOGIC DATA

Water Levels

Water levels were measured in the drill stem near or at the bottom of the drill hole and in the annular space between the drilled hole and the drill stem as the test well was drilled from 600 to 2,021 feet below land surface (table 2 and fig. 12). Water-levels were all above land surface and were measured in feet. The altitude of land surface at the test site was about 18 feet above sea level.

When the well was drilled to a depth of 1,378 feet, a mechanically inflatable packer was installed in the test well at a depth of 1,205 feet. The interval, 1,205 to 1,378 feet, was thereby isolated, and the water level in the interval was measured continuously for about 39 hours. During this period, the water level ranged from 20.5 to 21.5 feet above land surface (fig. 12). At the same time, water level in the interval 429 to 1,205 feet, ranged from about 15 to 16 feet above land surface.

Figure 13 shows periodic and daily high and low water levels from January to August 1982 in the interval, 1,892 to 2,026 feet below land surface, after the well was completed. Water levels ranged from about 13 to 20 feet above land surface.

Figure 14 shows the daily water-level fluctuations in the test well, August 1-2, 1982. Water-level fluctuations are cyclic tidal induced with a daily variation of about 1 to 2 feet.

Table 1.--Lithologic log of test well

Description	Thickness (feet)	Depth to base (feet)
Sand and coquina, sand is tan, fine, angular, 1-5 percent dark colored heavy minerals, some pieces of sandstone: loosely cemented fine sand, yellow-orange to dark yellow; coquina is dark gray, mainly whole small pelecypods and other shell fragments.	16	36
Coquina and sand, dark gray, same as above, less sand, some brown clay and silt as cement, some partially lithified coquina and sand, more large pelecypod fragments, some quartz pebbles.	32	68
Sand, silt and coquina, dark greenish brown, sand is medium to fine grained, silica; coquina is dark gray to white shell fragments, few whole pelecypods; silt is dolomitic and is cementing agent.	12	80
Limestone and dolostone, limestone is white to light gray, calcisiltite, hard, contains some very fine sand size to silt size silica (subrounded) and much very fine sand to silt size black phosphate grains; dolostone is black, microcrystalline, hard, contains silica as silt size grains (subrounded to angular) and fine sand size grains (subrounded).	10	90
Silt, light to dark green, dolomitic, sandy, phosphatic: pebbles.	11	101
Silt, as above, dark green, some dark gray shell fragments.	12	113
Silt, dark green, same as 90-101, less shell fragments and phosphate.	10	123
Silt, same as 90-101, sand fraction fine to coarse, less phosphate, a few large shell fragments.	10	133
Sand and silt, green, sand is medium to coarse, silica; silt is dolomitic, much phosphate: sand to pebble sized, few shell fragments.	12	145
Sand, tan to very light green, medium to coarse, very little silt, sand size phosphate.	10	155
Sand, as above, less coarse, more silt and shell fragments: white.	10	165
Sand, tan to light green, medium to coarse, small amount of silt: light green, dolomite, sand size phosphate.	11	176
Sand, green, very little silt, sand size phosphate.	10	186
Sand, tan to light green, slightly more silt, sand size phosphate.	22	208

Table 1.--Lithologic log of test well--Continued

Description	Thickness (feet)	Depth to base (feet)
Silt, dark green, dolomite, sandy (medium grained, silica), little phosphate.	10	218
Clay, dark green, slightly silty, dolomite.	10	228
Clay, as above except scattered silt size to sand size phosphate.	53	281
Silt, green to light gray, dolomite, sandy (medium to fine), clayey, pebble phosphate.	10	291
Clay and silt, green, sandy (medium to fine), dolomite, sand size phosphate.	12	303
Sand and silt, dark olive brown, dolomite, some green clay: dolomite.	10	313
Sand and silt, dark olive brown, dolomite, some hard brown dolostone, phosphate: pebbles and sand sized.	21	334
Clay, dark green, some silt, some sand, some dolostone: brown to tan, hard, a few small phosphate pebbles.	10	344
Dolostone, sand and silt, dolostone is black, very fine grained; sand and silt is same as 313-334.	10	354
Dolostone, sand and silt, upper part as above. Silt, lower part, light green, dolomite.	12	366
Silt, upper part same as above. Dolostone, sand and silt, lower part same as 354-366, upper part same as 354-366; also some dolostone, brown, hard, pure to sandy and phosphatic.	10	376
Silt, olive brown, some sand, sand size phosphate; some dolostone, brown, sucrosic, hard, phosphatic; some silt, light green.	10	386
Silt and dolostone, olive brown to brown, dolostone is black to brown, very hard, sucrosic to very fine grained, phosphatic (sand size); silt is slightly sandy, dolomitic, contains phosphate pebbles.	22	408
Dolostone, upper part, gray, very hard, fine grained, phosphatic (sand and silt sized). Limestone, lower part, white, recrystallized, biological debris, well-cemented, coarse to very fine grained, moderate moldic porosity.	10	418
Limestone, white to light tan, biological debris, well cemented and partially recrystallized, cement is very fine grained, chalky, white; limestone as a whole is medium fine to coarse grained.	12	430
Limestone, white biological debris, well cemented, hard and partially recrystallized, medium fine to coarse grained, cement is very fine grained, chalky, white.	10	440
Limestone, same as 418-430.	10	450
Limestone, same as 418-430, much less cement.	12	462

Table 1.--Lithologic log of test well--Continued

Description	Thickness (feet)	Depth to base (feet)
Limestone, same as 418-430.	31	493
Limestone, same as 418-430, white.	10	503
Limestone, same as 418-430, slightly less cemented.	12	515
Limestone, same as 418-430.	51	566
Limestone, same as 418-430, some yellow iron staining.	12	578
Limestone, same as 418-430, slightly finer grained, more chalky limestone cement, increase in gray pelecypod fragments.	10	588
Missing	72	660
Limestone, tan to gray, well cemented, fine to very fine grained, slightly dolomitic to dolomitic.	11	671
Limestone, as above, white to tan.	10	681
Dolostone and limestone, dolostone is brown, fine to very fine grained, very hard, some porosity; limestone is white, hard, chalky; some peat, very dark brown, relatively hard and lithified.	10	691
Dolostone and limestone, dolostone is dark brown, fine grained, low intergranular porosity, hard, with unaltered single small forams appearing as white spots uniformly distributed in dolostone; limestone is white, fine grained, chalky, biological debris; some black peat flecks in dolostone.	12	703
Dolomitic limestone, tan, biological debris, fine to very fine grained, chalky.	10	713
Dolostone, brown, sucrosic, very hard, some embedded flecks of peat.	10	723
Dolostone and dolomitic limestone, dolostone is brown, hard, sucrosic, some unaltered small white forams; dolomitic limestone is tan to light brown, medium to fine grained.	12	735
Dolomitic limestone, light brown, hard, biological debris, medium to fine grained.	10	745
Dolomitic limestone, upper part, as above. Limestone, lower part, tan, composed of small foram tests exclusively, well cemented but not much cement visible, high intergranular porosity.	10	755
Limestone, same as above: lower part, more chalky cement between forams.	11	766
Dolostone and dolomitic limestone, dolostone same as 713-723, but no peat; interval mainly: dolomitic limestone, tan to light brown, hard, very recrystallized and cemented, forams altered in place.	10	776
Limestone, tan, well cemented, cement is recrystallized, slightly dolomitic in places; some limestone, same as lower part, 745-755.	10	786

Table 1.--Lithologic log of test well--Continued

Description	Thickness (feet)	Depth to base (feet)
Dolomitic limestone, tan, hard, much cement visible, forams both loose and much altered in place.	12	798
Dolomitic limestone, tan to light brown, much cement and recrystallization, hard, most forams altered.	10	808
Limestone and dolomitic limestone, limestone is white to tan, foram and biological debris, forams are slightly to much altered and well cemented; dolomitic limestone is tan, forams much altered and well cemented.	10	818
Dolomitic limestone and limestone, dolomitic limestone is tan, hard and well cemented, biological debris altered in place, many forams; limestone is less well cemented and less altered.	11	829
Dolostone, tan to brown, hard, relict forams still visible, black peat flecks.	10	839
Dolostone and peat, dolostone is grayish brown, hard, much recrystallized, scattered unaltered (white) forams in place; peat is contained in dolostone as very fine grained uniform particles, black to very dark brown.	10	849
Dolostone, light to dark brown, well cemented, biological debris, slightly to very altered, some dolostone with scattered unaltered (white) forams.	12	861
Dolomitic limestone, tan, mainly unaltered biological debris (forams) cemented with brown dolostone or with tan dolomitic limestone.	10	871
Limestone, tan, foram and biological debris, well cemented, much to very little cement visible, high intergranular porosity when very little cement visible, when well cemented some alteration of in-place biological debris present.	10	881
Limestone, as above, many coarse sand size forams present.	11	892
Limestone, white to tan, well cemented biological debris, much cement visible.	10	902
Limestone, as above, tan, poorly to well cemented and recrystallized.	10	912
Limestone and dolostone, limestone is white to tan, same as 871-881; dolostone is light brown to brown, silt size grains, no unaltered biological debris present; interval is mainly limestone.	12	924
Limestone, tan, well cemented biological debris but very little to moderate amount of cement visible, high intergranular porosity, very homogeneous in composition and texture.	10	934

Table 1.--Lithologic log of test well--Continued

Description	Thickness (feet)	Depth to base (feet)
Limestone, tan, hard, well cemented biological debris, much cement and recrystallization present, biological debris altered in place, some black to dark brown peat flecks present.	10	944
Limestone, tan, well cemented, unaltered biological debris, very little cement visible, high intergranular porosity, some limestone present with moderate degree of recrystallization and cement, some black to dark brown peat flecks, some dolomitic limestone.	11	955
Limestone, tan, many coarse sand size forams, moderately to weakly cemented, high intergranular porosity, some hard, well cemented, recrystallized forams with much cement visible.	10	965
Dolostone, dark tan to brown, biological debris ranges from unaltered scattered white "spots" in brown dolomitic cement to fine grained pure dolostone with no traces of biological material, many loose forams altered to dolomite (brown), some limestone, as above.	10	975
Dolomitic limestone, same as 955-965.	12	987
Limestone, tan, biological debris well cemented with not much to moderate amount of cement visible, high to moderate intergranular porosity, many loose, coarse, sand size forams.	10	997
Limestone, upper part, as above. Dolomitic limestone, lower part, tan, hard, much cement visible, very low porosity, biological materials much altered.	10	1,007
Dolomitic limestone, tan, hard, much cement and recrystallization, most biological materials altered.	12	1,019
Limestone, dark gray to white, very hard, recrystallized, very little evidence of biological material remaining.	10	1,029
Limestone, gray to white, less recrystallized, some less recrystallized areas show recognizable biological debris.	10	1,039
Missing	11	1,050
Limestone, same as 1,019-1,029, white.	10	1,060
Limestone, same as 1,019-1,029, white to gray, slightly more dolomitic limestone.	10	1,070
Limestone, same as 1,029-1,039, white, higher intergranular porosity.	12	1,082

Table 1.--Lithologic log of test well--Continued

Description	Thickness (feet)	Depth to base (feet)
Limestone, white, hard, recrystallized, some biological debris recognizable, some loose forams present, chalky.	10	1,092
Limestone, upper part, same as 1,082-1,092. Dolostone, lower part, dark gray, very fine grained, very hard.	10	1,102
Limestone, tan, biological debris, well cemented, medium amount of cement apparent, many loose, sand size forams.	11	1,113
Limestone, tan, biological debris coquina, low to moderate amount cement apparent, well cemented, very little recrystallization.	10	1,123
Limestone, upper part, tan, hard, recrystallized, much cement apparent, some biological material altered in place. Dolostone, lower part, brown, pure, fine grained, no trace of biological material remaining, very hard, occasional white unaltered foram in brown dolostone cement, some dark gray to black peaty dolostone.	9	1,132
Limestone and dolostone, limestone is tan to light tan, hard, recrystallized, well cemented, biological debris recognizable; dolostone is dark brown to very dark brown, pure and fine grained to containing white unaltered single forams scattered throughout, very hard.	12	1,144
Limestone, tan, biological debris coquina, very little to moderate amount of cement obvious, well cemented, moderate to high intergranular porosity, many loose forams.	10	1,154
Limestone and dolostone, limestone is tan, biological debris, well cemented but moderate to little cement visible, moderate to high intergranular porosity; dolostone is brown, hard, pure and fine grained to containing isolated, white unaltered forams.	10	1,164
Limestone, tan, biological debris, well cemented and hard, not much cement apparent, intergranular porosity ranges between moderate and high.	10	1,174
Limestone and dolostone, limestone is tan, biological debris, well cemented, moderate intergranular porosity; dolostone is brown, hard, containing isolated, white, unaltered, single forams and biological debris.	10	1,184
Dolostone, brown to dark brown, sucrosic (high intergranular porosity) to fine grained and pure with low intergranular porosity, recrystallized, very hard, dolomite rhombs abundant.	31	1,215

Table 1.--Lithologic log of test well--Continued

Description	Thickness (feet)	Depth to base (feet)
Dolostone, as above, very dark brown massive dolostone and pyrite, massive to poorly crystallized.	10	1,225
Dolostone, same as 1,184-1,215 slightly finer grained, slightly lighter brown.	11	1,236
Limestone, white to light gray, hard, very recrystallized, much fine grained cement, most biological debris altered.	10	1,246
Dolostone, brown to dark brown, sucrosic to fine grained, very hard, dolomite rhombs abundant.	21	1,267
Limestone, same as 1,236-1,246.	10	1,277
Limestone, same as 1,236-1,246, white to gray.	10	1,287
Dolostone, gray, very hard, recrystallized, very finely crystalline (rhombs).	12	1,299
Dolostone, same as above, some gray, hard dolostone, recrystallized, with scattered white unaltered forams and biological debris.	10	1,309
Dolomitic limestone, very light gray to gray, very fine grained (no rhombs), hard, very light gray dolomitic limestone contains some unaltered white biological debris, recrystallized biological material or very small flecks of dark colored peaty dolostone.	10	1,319
Dolomitic limestone, light gray to very light tan, recrystallized biological material, hard, contains some very scattered dark green flecks of glauconite and some very fine heavy mineral grains.	11	1,330
Limestone, gray to light gray, hard, recrystallized biological material, some pyrite present, less impure than above.	10	1,340
Limestone, gray and white, coquina of white unaltered biological material cemented by recrystallized gray limestone, much cement visible, moderate intergranular porosity.	10	1,350
Glauconitic limestone, white to light gray to very light tan, recrystallized biological material, hard, contains many fine sand size green grains of glauconite, most biological material recrystallized and unrecognizable.	11	1,361
Glauconitic limestone, white to very light tan to light gray, hard, completely recrystallized biological material to recognizable biological material well cemented with much cement apparent and moderate intergranular porosity, slightly less glauconite present than above, somewhat dolomitic in places.	10	1,371
Missing	37	1,408

Table 1.--Lithologic log of test well--Continued

Description	Thickness (feet)	Depth to base (feet)
Limestone and dolostone, limestone is gray to tan, moderately to very recrystallized, biological material, much cement in evidence, some glauconite grains present; dolostone is brown to very dark gray, very hard, sucrosic (dolomite rhombs), relatively high porosity.	11	1,419
Limestone, light gray, two types: (1) much fine grained silt size cement between dolomite and calcite crystals, somewhat friable and brittle, and (2) recrystallized, much cement, moderate amount of glauconite grains present.	10	1,429
Dolostone and limestone, two types: (1) gray, hard, calcic, sucrosic (dolomite rhombs), well cemented to relatively loose, and (2) brown, sucrosic (rhombs), hard, moderately high porosity, and Limestone, light gray to white, hard to brittle and moderately cemented, recrystallized, much to moderate amount of cement visible, moderate amount of heavy minerals and glauconite.	10	1,439
Dolostone and limestone, as above, less brown dolostone, more brittle and crumbly (weakly cemented) limestone with original unaltered (white) forams and biological material	10	1,449
Limestone and dolostone, limestone is tan, relatively hard, recrystallized biological material, much cement visible, some dolomite rhombs as finely crystalline cement, fewer forams recognizable than above; dolostone is gray to tan, very hard, very finely crystalline, recrystallized, with original unaltered (white) forams scattered throughout.	10	1,459
Dolostone and dolomitic limestone, dolostone is light brown to brown, hard to very hard, sucrosic (rhombs) to fine grained with scattered traces of unaltered (white) biological material; dolomitic limestone is white to light gray, hard, calcite cement with many intersperced dolomite rhombs, fine grained.	10	1,469
Dolostone, brown, very hard, sucrosic (rhombs) to very fine grained.	11	1,480
Dolostone, as above, some very high porosity sucrosic dolostone.	10	1,490
Dolostone and dolomitic limestone, dolostone is as above and containing some scattered unaltered (white) biological material; dolomitic limestone is tan, relatively hard, fine to medium grained, biological material recognizable and well cemented, much cement visible, relatively low intergranular porosity.	10	1,500

Table 1.--Lithologic log of test well--Continued

Description	Thickness (feet)	Depth to base (feet)
Dolomitic limestone, limestone, and dolostone, dolomitic limestone and dolostone, as above; limestone is tan, well cemented, fine to medium grained, biological material recognizable and relatively physically unaltered.	12	1,512
Dolostone and dolomitic limestone, dolostone same as 1,469-1,480; dolomitic limestone is light tan, hard, fine grained, well cemented, recrystallized, much cement visible, biological material completely altered to recognizable and not physically altered, generally more calcic than dolomitic.	10	1,522
Dolostone, brown, fine sucrosic to very fine grained, very hard.	10	1,532
Dolostone and dolomitic limestone, dolostone as above; dolomitic limestone is tan, hard, well cemented, much cement in evidence, biological material completely recrystallized to recognizable, some brown dolomite rhombs in cement of tan dolomitic limestone.	10	1,542
Limestone, tan, hard, biological material completely recrystallized to recognizable and physically unaltered, fine to very fine grained, slightly dolomitic, some dolostone, same as 1,522-1,532.	10	1,552
Dolostone and dolomitic limestone, same as 1,532-1,542, mostly dolomitic limestone.	10	1,562
Dolomitic limestone, same as dolomitic limestone 1,532-1,542.	11	1,573
Dolostone and dolomitic limestone, same as 1,532-1,542.	10	1,583
Limestone, tan, very recrystallized, hard, very little recognizable biological material, somewhat dolomitic.	10	1,593
Dolomitic limestone, same as 1,562-1,573.	12	1,605
Dolomitic limestone and dolostone, upper part, dolomitic limestone is tan, very hard, recrystallized, not much biological material recognizable, very low porosity; dolostone same as 1,522-1,532. Dolostone, lower part, gray to dark gray, very hard, very fine grained, homogeneous.	10	1,615
Dolomitic limestone, dolostone, and quartz, dolomitic limestone and dolostone are as above; quartz is white to clear, macroscopically crystalline.	10	1,625
Dolostone and dolomitic limestone, dolostone is brown, hard, fine to very fine grained, homogeneous; dolomitic limestone is greenish tan, moderately hard, some scattered evidence of biological material, mostly recrystallized, much cement in evidence, some chalky limestone.	11	1,636

Table 1.--Lithologic log of test well--Continued

Description	Thickness (feet)	Depth to base (feet)
Limestone, greenish tan to dark greenish tan, chalky, soft, silt size grains, slightly to moderately dolomitic, some hard dolomitic limestone (tan).	20	1,656
Dolostone and limestone, dolostone is of two types: (1) brown, very finely sucrosic (rhombs), hard homogeneous, and (2) dark gray, hard, very fine grained (silt size), homogeneous, some silt size dark colored heavy mineral grains; limestone is greenish tan, very fine grained to fine grained, relatively hard, somewhat chalky, homogeneous, silt size grains, some scattered dolomite rhombs in chalky cement.	12	1,668
Dolostone, limestone, and chert, dolostone and limestone as above, no dark gray dolostone; chert is dark brown to olive brown, semitransparent, concoidal fracture, very hard, some relict biological material visible.	10	1,678
Dolomitic limestone and chert, dolomitic limestone is greenish tan, chalky and fine grained (silt size), medium soft, homogeneous; chert as above.	10	1,688
Chert, dolostone, and limestone, chert same as 1,668-1,678; dolostone is brown, fine grained, sucrosic, hard, some black peat flecks, some pyrite; limestone same as 1,656-1,668, somewhat dolomitic.	12	1,700
Limestone and dolostone, is greenish tan, soft to medium soft, fine grained (silt size), no biological material visible, peat flecked (black); dolostone is brown, finely sucrosic (rhombs), peat flecked, hard; some dark brown chert.	10	1,710
Dolomitic limestone, chert, and quartz, dolomitic limestone is tan, hard, glauconitic, peat flecked (black), recrystallized, very little biological material remains unaltered; chert is brown, hard, same as 1,668-1,678; quartz is same as 1,615-1,625.	10	1,720
Dolomitic limestone and chert, dolomitic limestone is tan to greenish tan, relatively hard, fine grained, no biological material visible, peat flecked, calcic; chert is gray to dark gray, very hard, many relict markings visible.	11	1,731
Glauconitic dolomitic limestone, tan, very glauconitic, relatively hard, fine grained, no biological material visible, calcic to more dolomitic, some pyrite.	10	1,741
Limestone, chert, and quartz, limestone is tan, relatively hard, very finely peat flecked, fine grained, no biological material recognizable, homogeneous; chert is gray to dark olive gray, very hard, many relict markings visible; quartz same as 1,615-1,625.	10	1,751

Table 1.--Lithologic log of test well--Continued

Description	Thickness (feet)	Depth to base (feet)
Limestone and chert, chert is as above; limestone is two types: (1) as above, and (2) tan, very fine grained, relatively hard, no biological material discernible, very homogeneous, very small amount of silt size peat flecks.	11	1,762
Dolostone, light brown to tan to very light gray, glauconitic, very hard, recrystallized, no biological material visible to some rough outlines of recrystallized biological material visible, very fine grained.	10	1,772
Glauconitic dolomitic limestone, light brown to tan, very glauconitic, very hard, completely recrystallized, no biological material visible, some very calcic zones, some faint outlines of biological debris.	10	1,782
Glauconitic dolomitic limestone, as above, more unrecrystallized biological material, very hard, slightly less glauconitic.	15	1,797
Limestone, white to light tan, medium to fine grained, biological material, well cemented to completely recrystallized, moderate intergranular porosity, moderately to very hard, very small amount of glauconite in recrystallized limestone, some dolomitic limestone.	10	1,807
Dolomitic limestone, white to light tan, very little glauconite, some biological material, high intergranular porosity, well cemented, much cement visible, some completely recrystallized dolomitic limestone, very hard to weakly cemented.	10	1,817
Limestone and dolomitic limestone, limestone is white to light gray, well cemented biological material, much cement visible, moderately hard; dolomitic limestone is tan, hard, completely recrystallized, some incorporated organics.	11	1,828
Limestone, tan, biological material, well cemented and some recrystallization, much cement visible, moderately high intergranular porosity.	52	1,880
Limestone, as above, more recrystallized and chalky, finer grained.	11	1,891
Limestone, upper part, as above. Dolostone, lower part, dark gray, very hard, medium to fine grained, some biological material recognizable but recrystallized, some calcic portions, some intergranular (moldic?) porosity.	10	1,901
Dolostone, dark gray to brown, very fine grained, very hard, completely recrystallized, some portions finely sucrosic.	10	1,911
Dolostone, as above, mainly dark brown to blackish brown.	11	1,922

Table 1.--Lithologic log of test well--Continued

Description	Thickness (feet)	Depth to base (feet)
Dolostone, very hard, very fine grained (very finely sucrosic:rhombs): three types: (1) dark brownish gray, no porosity; (2) brown, slightly finer grained: very finely sucrosic, slightly more porosity; and (3) light salmon-tan, very massive and fine to very fine grained, some macroscopic dolomite crystals.	9	1,931
Dolostone, very hard: (1) dark brown to light brown, medium to very finely sucrosic to very fine grained and massive; (2) light tan to light brown, very fine grained, some less altered to unaltered biological material in brown dolomite cement, calcic; (3) same as (3) above.	10	1,941
Dolostone and limestone, dolostone is brown, very fine grained and massive, somewhat sucrosic (fine), very hard, some unaltered biological material in the groundmass; limestone is tan, medium to fine grained, well cemented, much cement visible, moderately hard, recrystallized to easily visible biological material (and all stages between).	12	1,953
Limestone and dolostone, interval is predominantly limestone: tan, relatively hard, well cemented, much cement visible (cement is dolomite rhombs), biological material, partially recrystallized, medium intergranular porosity; dolostone is brown to dark brown, very hard, sucrosic to very finely crystalline.	10	1,963
Limestone and dolostone, (and all stages between), limestone is tan, relatively hard, well cemented, cement is dolomite rhombs, much cement visible, biological material unaltered to very recrystallized and barely recognizable; dolostone is very hard, dark brown, sucrosic (dolomite rhombs), some very finely crystalline dolostone also, lighter brown in color.	10	1,973
Dolostone and quartz, dolostone ranges between (1) very fine grained with no dolomite rhombs visible, dark brown, very hard, to (2) brown, hard, medium to fine sucrosic (rhombs) with moderate porosity, to (3) very light brown, micro-crystalline, very high secondary porosity (resembling light colored scoria) and very low specific gravity; quartz is gray to tan, crystal (euhedral) encrusted.	12	1,985
Dolostone and quartz, dolostone as above, less of the scoria-like very porous endmember; quartz: slightly less, many clear crystals.	10	1,995

Table 1.--Lithologic log of test well--Continued

Description	Thickness (feet)	Depth to base (feet)
Dolostone, upper part, as above. Dolostone, lower part, brownish black, microcrystalline, very hard, almost zero porosity, finely grained crystalline on small fracture planes.	9	2,004
Dolostone, same as lower part above, some coarse dolomite crystals.	13	2,017
Dolostone, as above, slightly finer grained and more grayish brown.	7	2,024

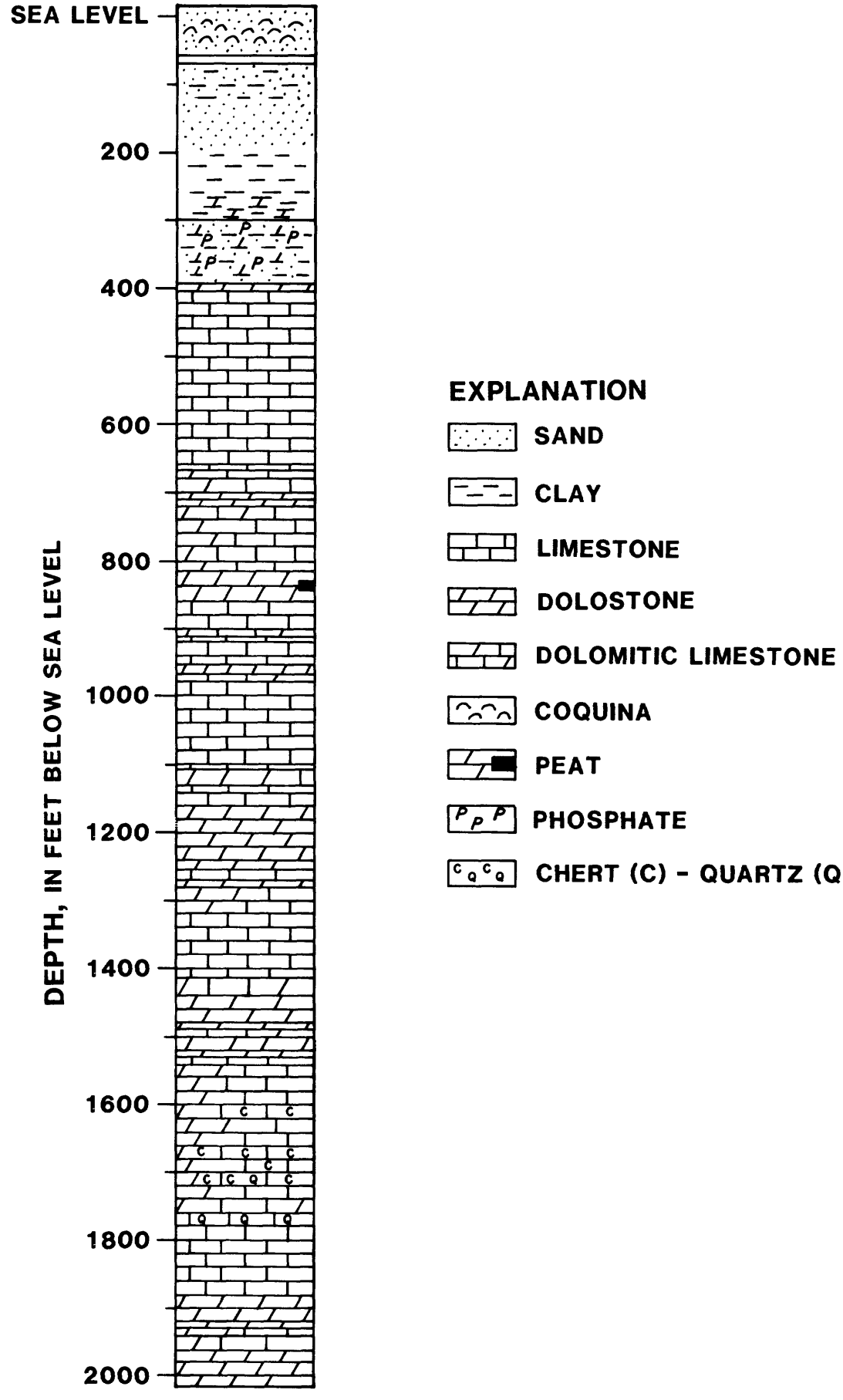

Figure 3.--Lithologic columnar section at test well.

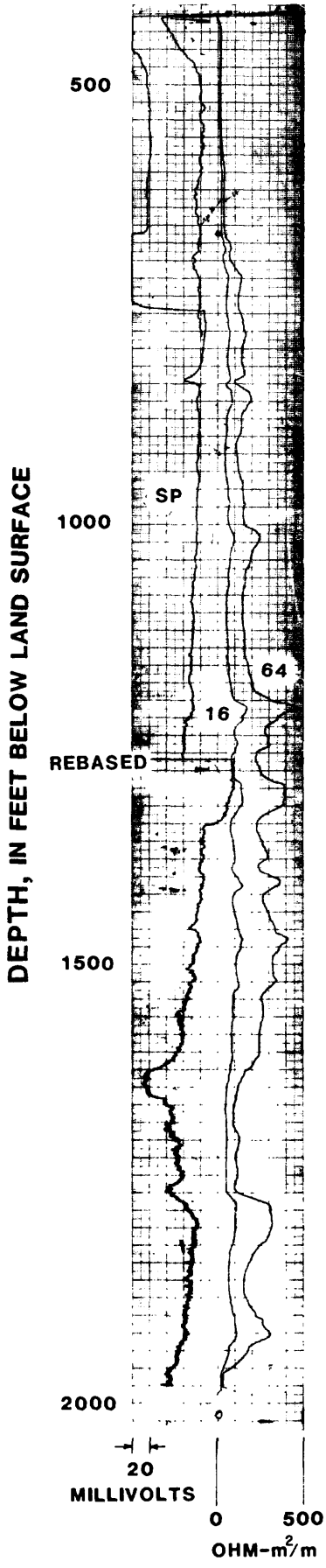

Figure 4.--Electric log; long and short normal resistivity, and spontaneous potential.

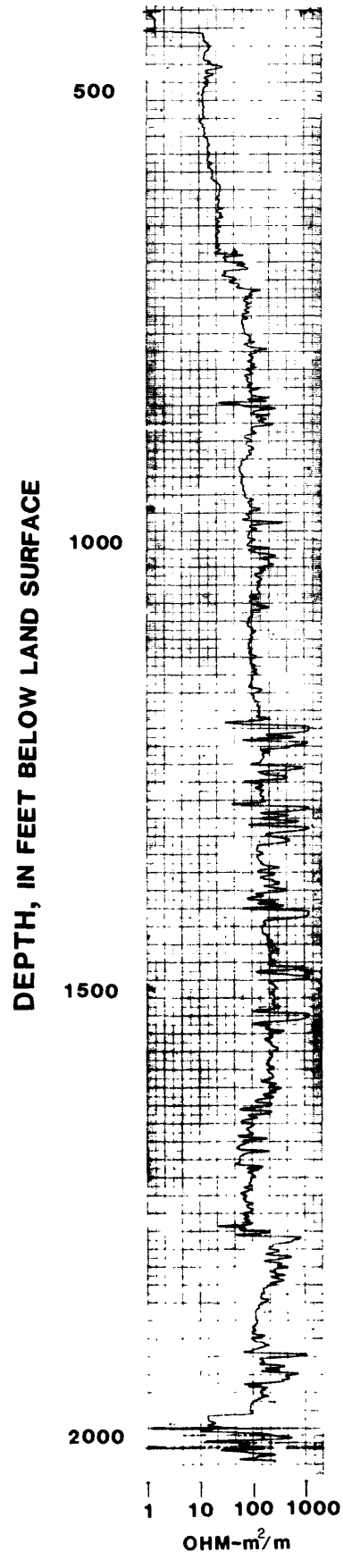

Figure 5.--Electric log (focused resistivity).

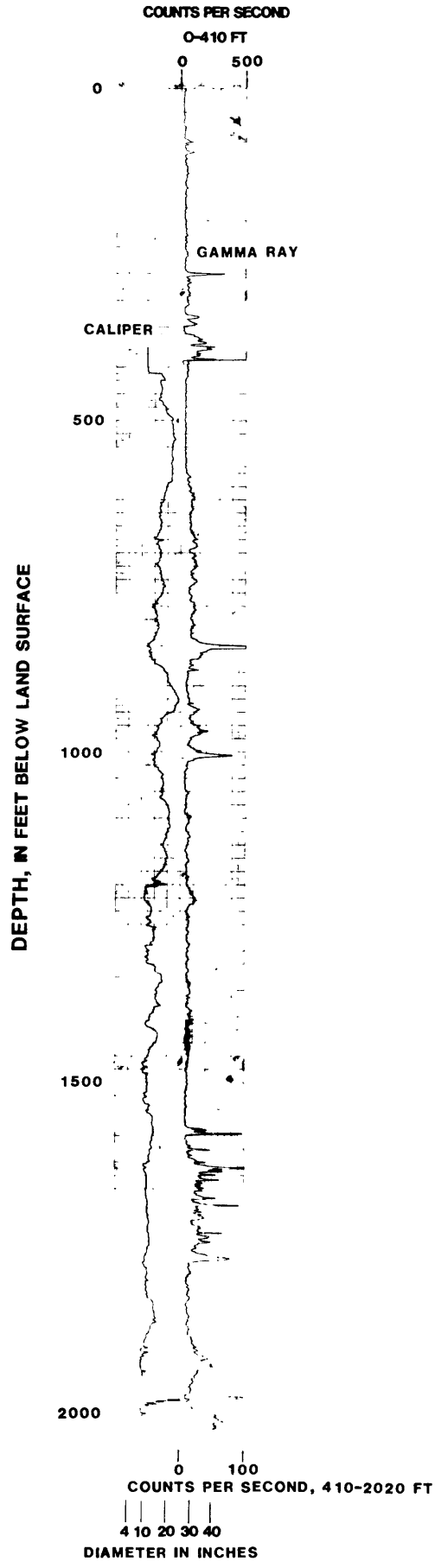

Figure 6.--Caliper and natural gamma logs.

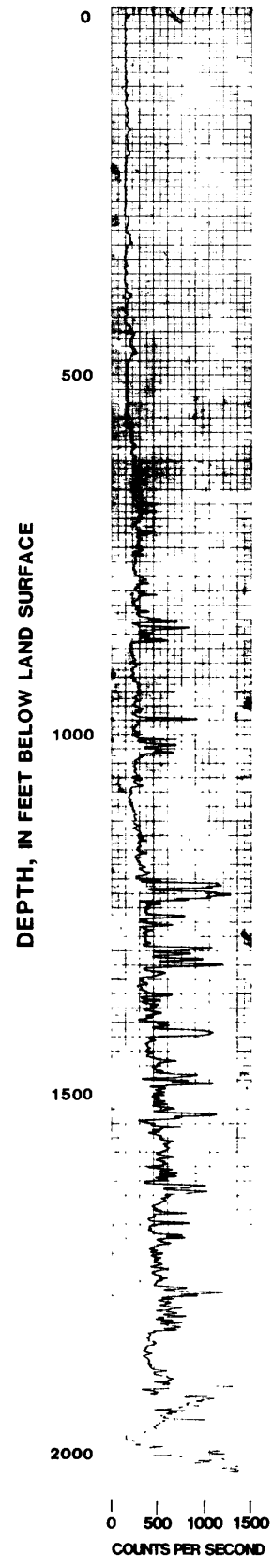

Figure 7.--Neutron porosity log.

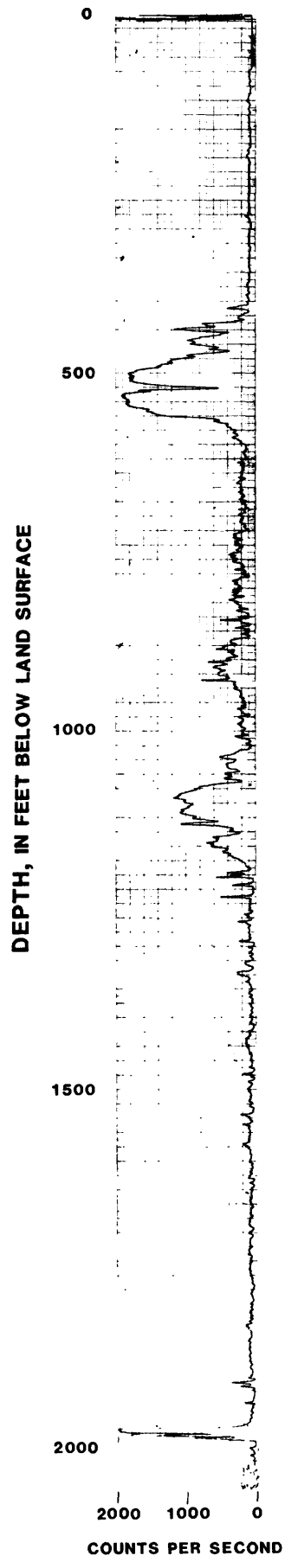

Figure 8.--Gamma-gamma density log.

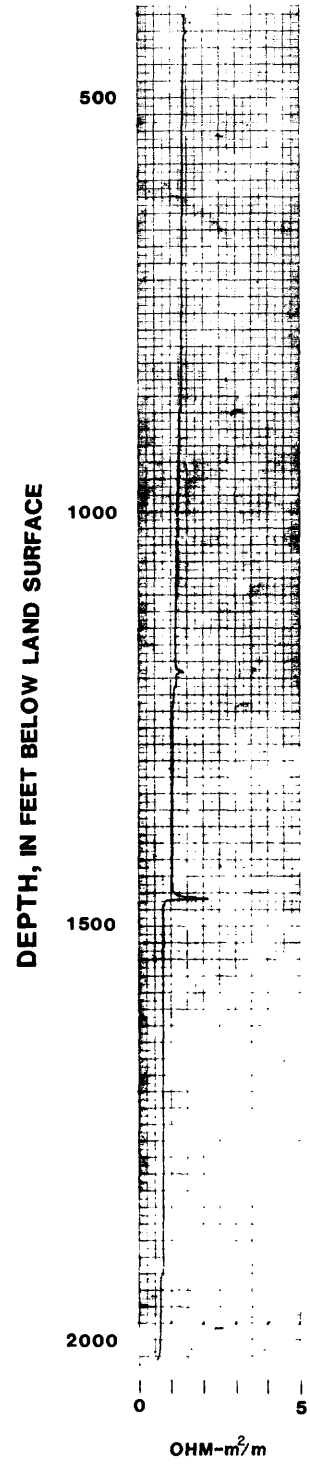

Figure 9.--Fluid resistivity log.

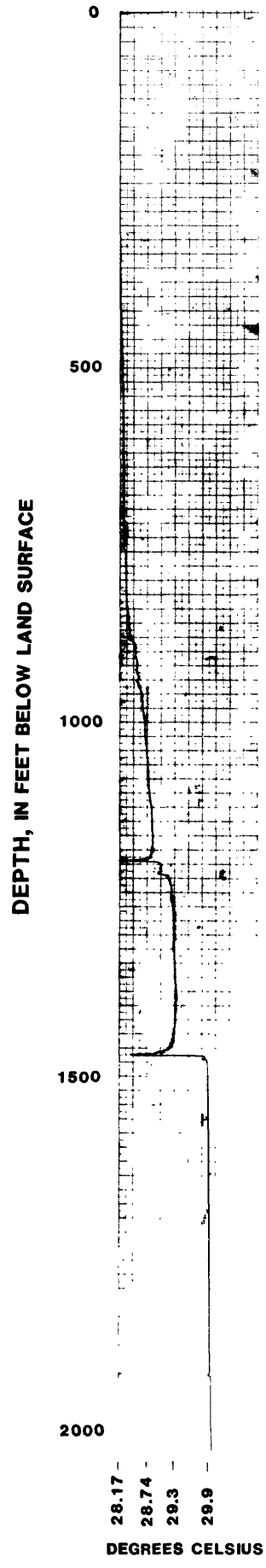

Figure 10.--Temperature log.

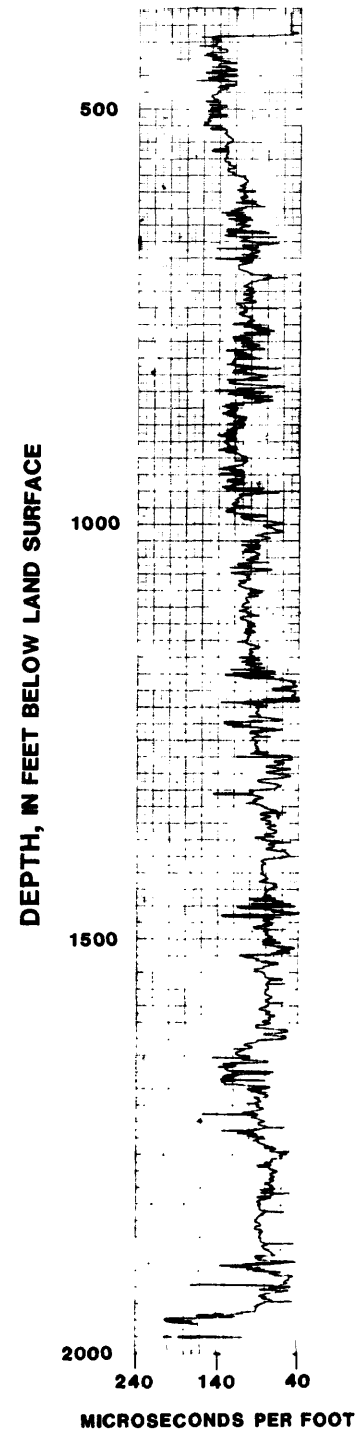

Figure 11.--Acoustic velocity log.

Table 2.--Water levels in drill stem and in annulus during drilling of test well

Date	Well depth (feet below land surface)	Water level (in feet above land surface)	
		Drill stem	Well head
1-23-81	600	13.0	----
1-28-81	820	15.5	15.5
1-29-81	975	16.3	16.3
1-30-81	1,133	16.3 (est.)	16.3
1-30-81	1,194	----	17.7
1-30-81	1,209	17.7	17.7
5-22-81	1,470	16.8	16.4
5-25-81	1,532	16.3	15.9
5-28-81	1,636	16.9	16.4
5-29-81	1,660	17.0	16.6
6-04-81	1,672	16.6	16.3
6-05-81	1,694	16.4	16.1
6-08-81	1,751	16.2	15.8
6-29-81	1,800	17.2	16.8
7-06-81	1,848	16.7	16.4
7-07-81	1,880	16.5	16.4
7-09-81	1,906	16.2	16.5
7-10-81	1,922	16.9	17.1
7-14-81	1,953	16.7	17.3
7-15-81	1,985	11.8	16.6
7-17-81	2,004	11.1	16.6
7-21-81	2,021	10.9	16.6

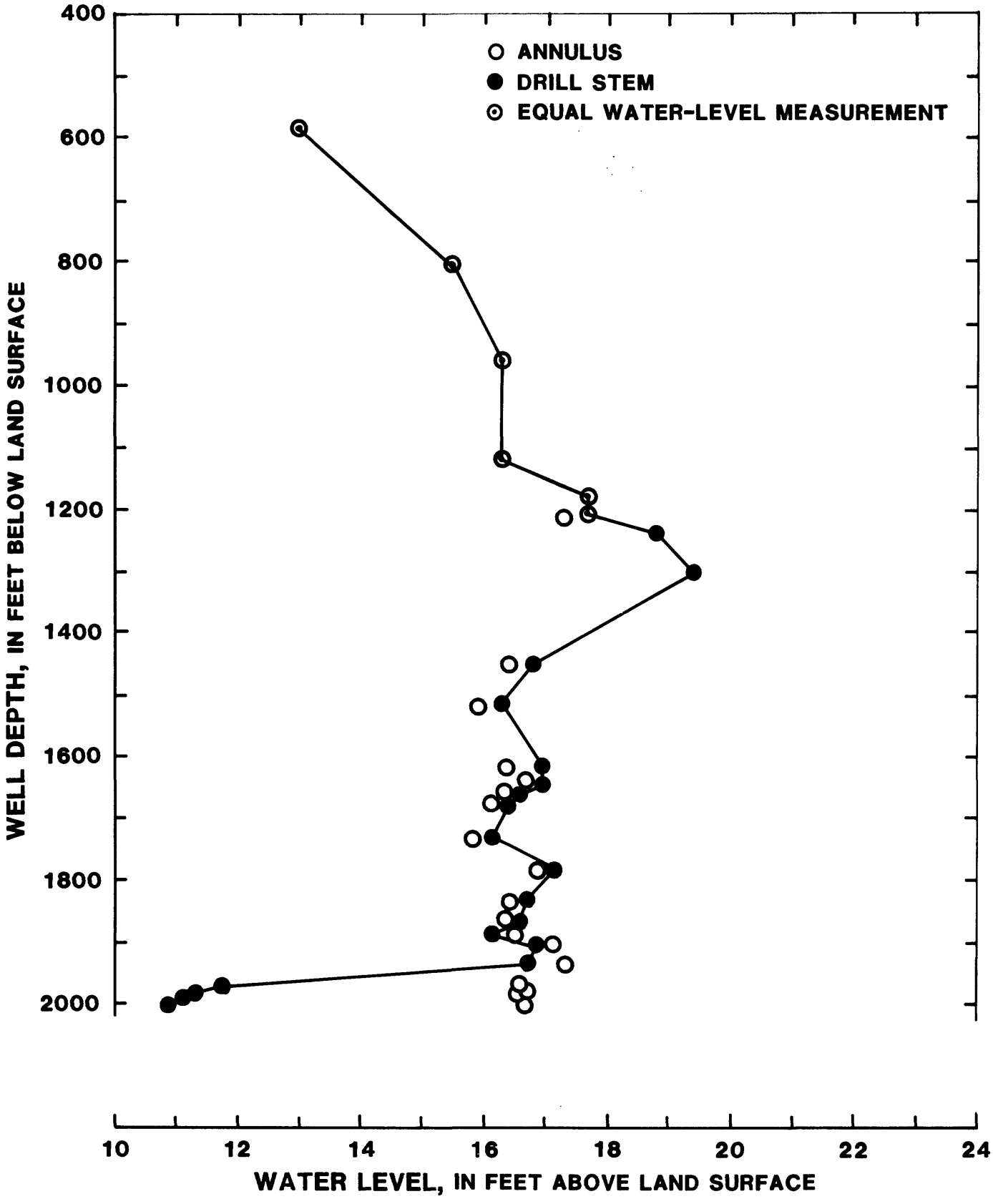

Figure 12.--Water levels in drill stem and in annulus during drilling of test well.

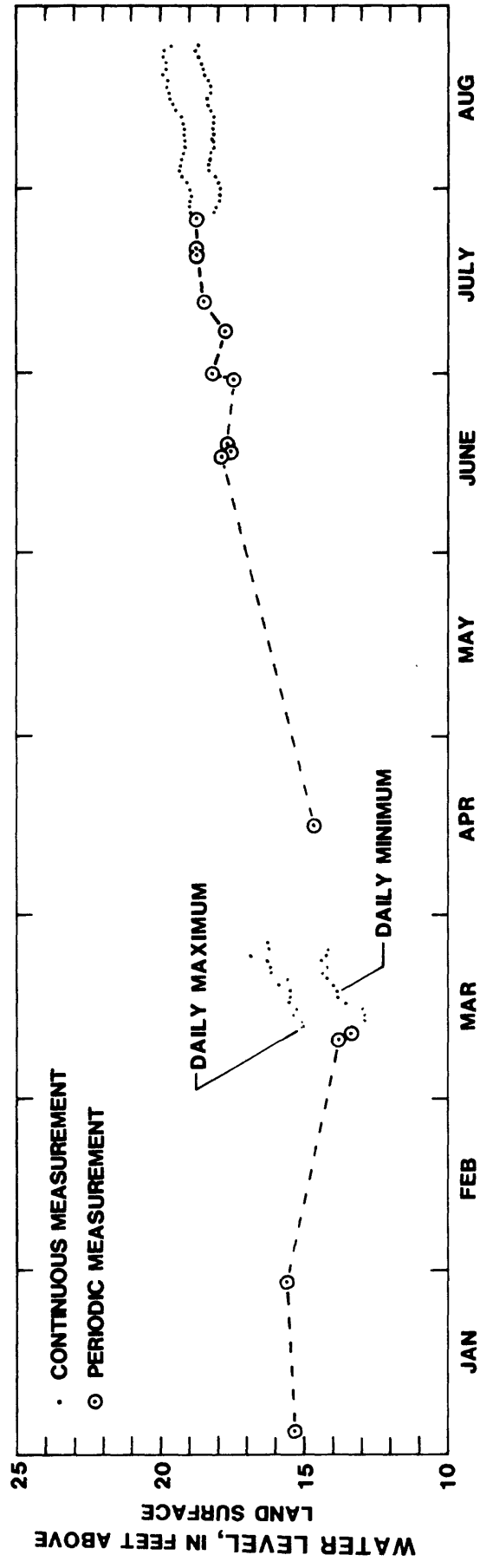

Figure 13.--Water level in test well, open-hole interval 1,892 to 2,026 feet below land surface, January to August 1982.

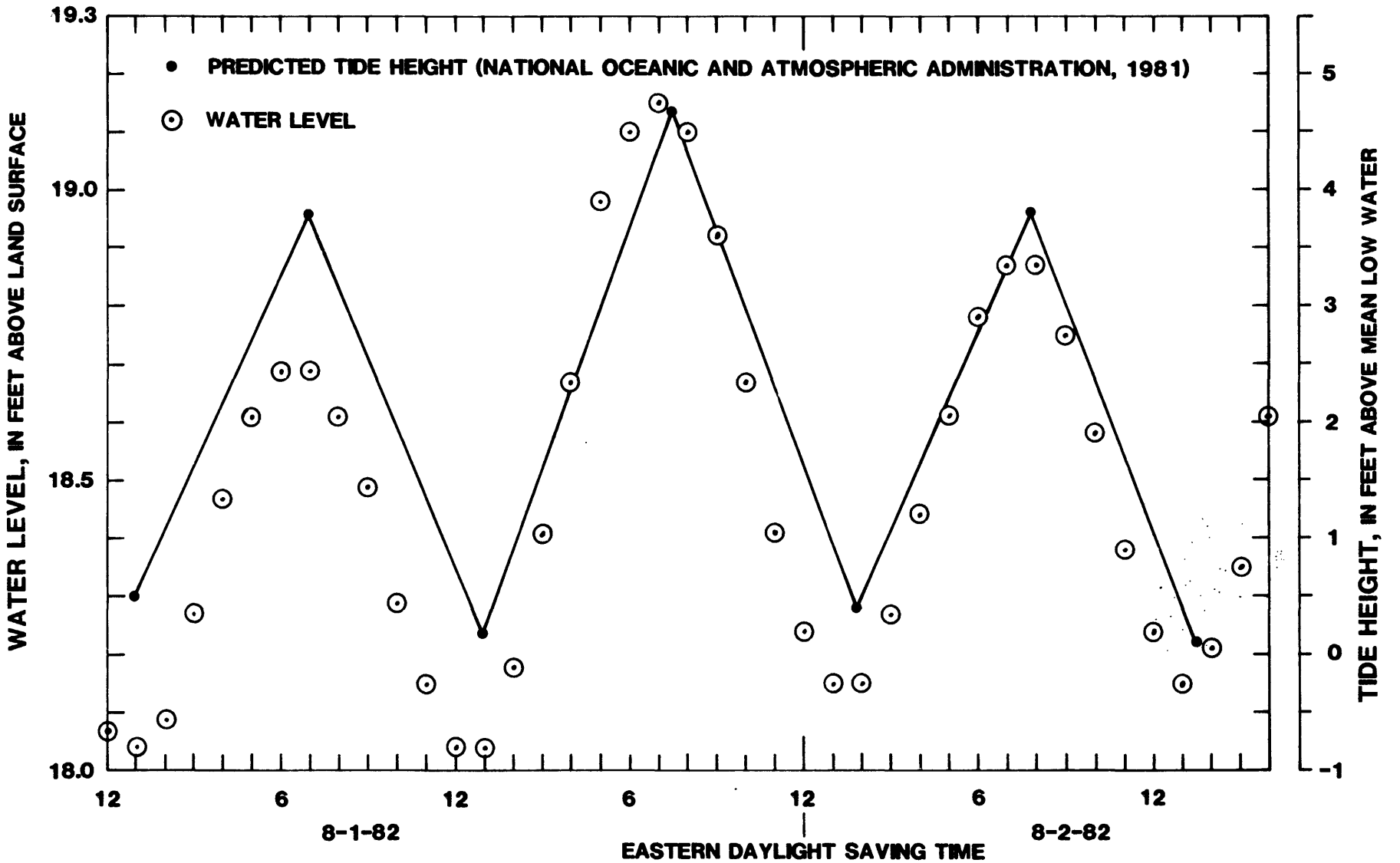

Figure 14.--Water level in the test well and predicted tides at Mayport, Florida, August 1 and 2, 1982.

Water-level data presented in this section have not been adjusted for density differences between freshwater and the mineralized water found in the monitored zone.

The water level or static head measured in the annulus or drill stem is the sum of the elevation head and the pressure head (Lohman and others, 1972). The pressure head depends on fluid density; thus, water level measurements for wells containing salty water can be adjusted to equivalent freshwater heads in order to compare with the head in wells containing freshwater. Adjustments are made as described in Cooper and others, 1964, p. C28:

$$l_f = \frac{p_s}{p_f} l_s$$

Where l_f = equivalent length of freshwater column;
p_s = density of saltwater column;
p_f = density of freshwater;
l_s = measured length of saltwater column.

For example, if a water-level measurement made in a well containing salty water having a salinity of about 7,100 mg/L (a density of 1.0046 gm/cm^3) indicates a pressure head of about 15 feet above the top of the well casing, and the casing length is 1,892 feet, then l_s = 1,907 feet and

$$l_f = \frac{1.0046}{1.0000} \times 1{,}907 \text{ feet} = 1{,}916 \text{ feet}$$

Therefore, the equivalent freshwater level would be 1,916 feet above the base of the casing or 24 feet above the top of the casing, a difference in water level of 9 feet.

Artesian Flow

The artesian flow of the test well was measured periodically during drilling (fig. 15). A velocity-measuring current meter was used to determine the flow in a plastic-lined ditch. The flow increased from 1,100 gal/min at a depth of 1,120 feet to 1,900 gal/min at a depth of 1,200 feet. The maximum flow measured after the test well was drilled to a total depth of 2,026 feet was 2,940 gal/min.

Down-hole flow-meter traverses were made in the open-hole intervals 429 to 1,378 feet and 429 to 2,026 feet below land surface during construction of the test well. In the open-hole interval 429 to 1,378 feet, traverses were made when the well was naturally flowing at 1,900 gal/min at land surface, and with zero flow at land surface (table 3 and fig. 16). In the open-hole interval 429 feet to 2,026 feet, traverses were made when the well was naturally flowing at 2,700 gal/min and 130 gal/min at land surface (table 4 and fig. 17).

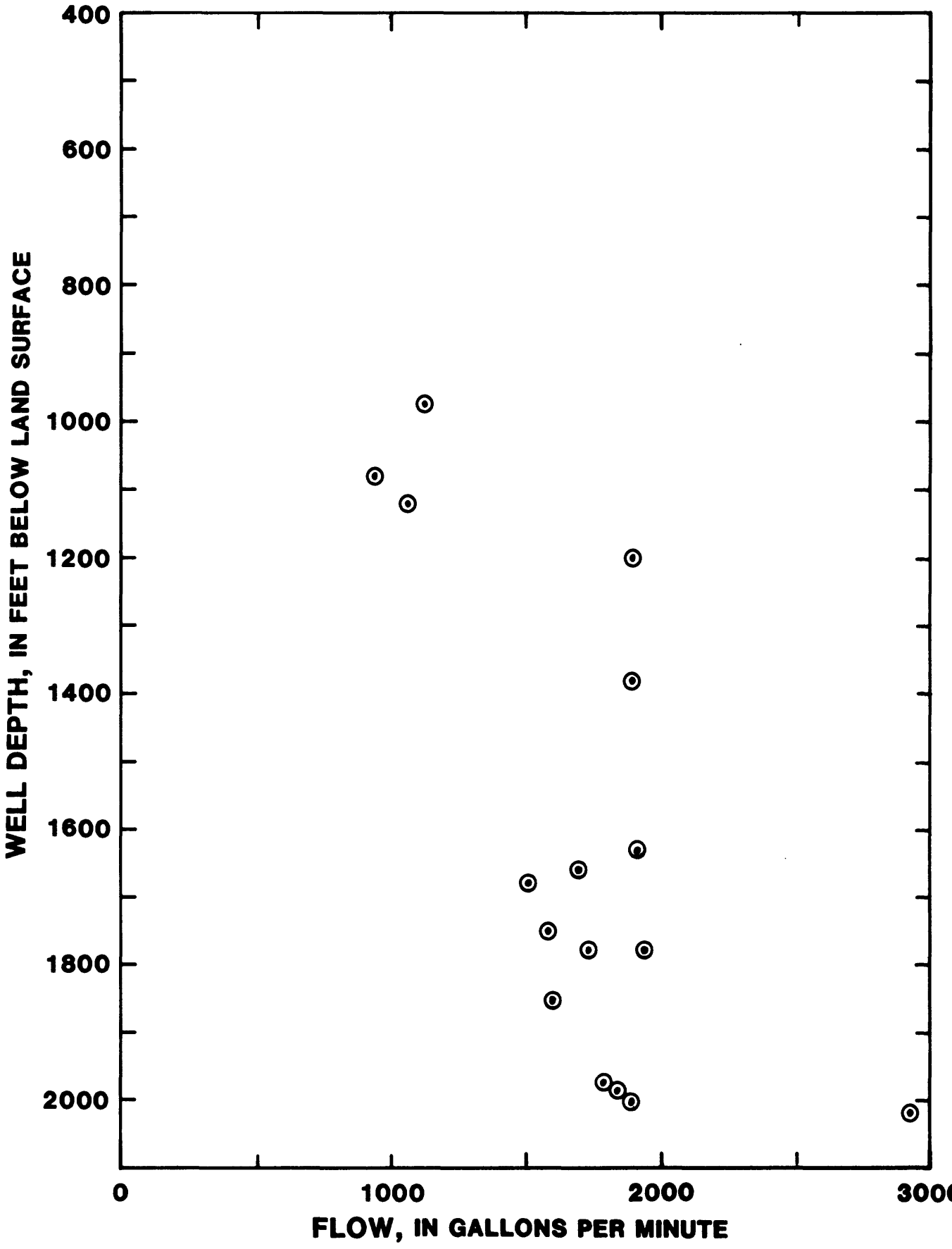

Figure 15.--Artesian flow of test well during drilling.

Table 3.--Flow-meter traverses in test well, open-hole interval 429 to 1,378 feet below land surface, February 22, 1981

Depth (feet below land surface)	Flowing at 1,900 gal/min at surface: Flow (gal/min)	No flow at surface: Flow (gal/min)
200	1,900	0
400	1,900	0
500	1,740	---
600	1,200	---
640	1,100	190
700	1,280	---
800	1,110	---
841	-----	250
900	1,070	---
1,020	580	200
1,144	650	170
1,190	580	130
1,204	300	76
1,220	210	30
1,250	200	38
1,295	120	23
1,330	70	0
1,360	40	0
1,370	0	0
1,378	0	0

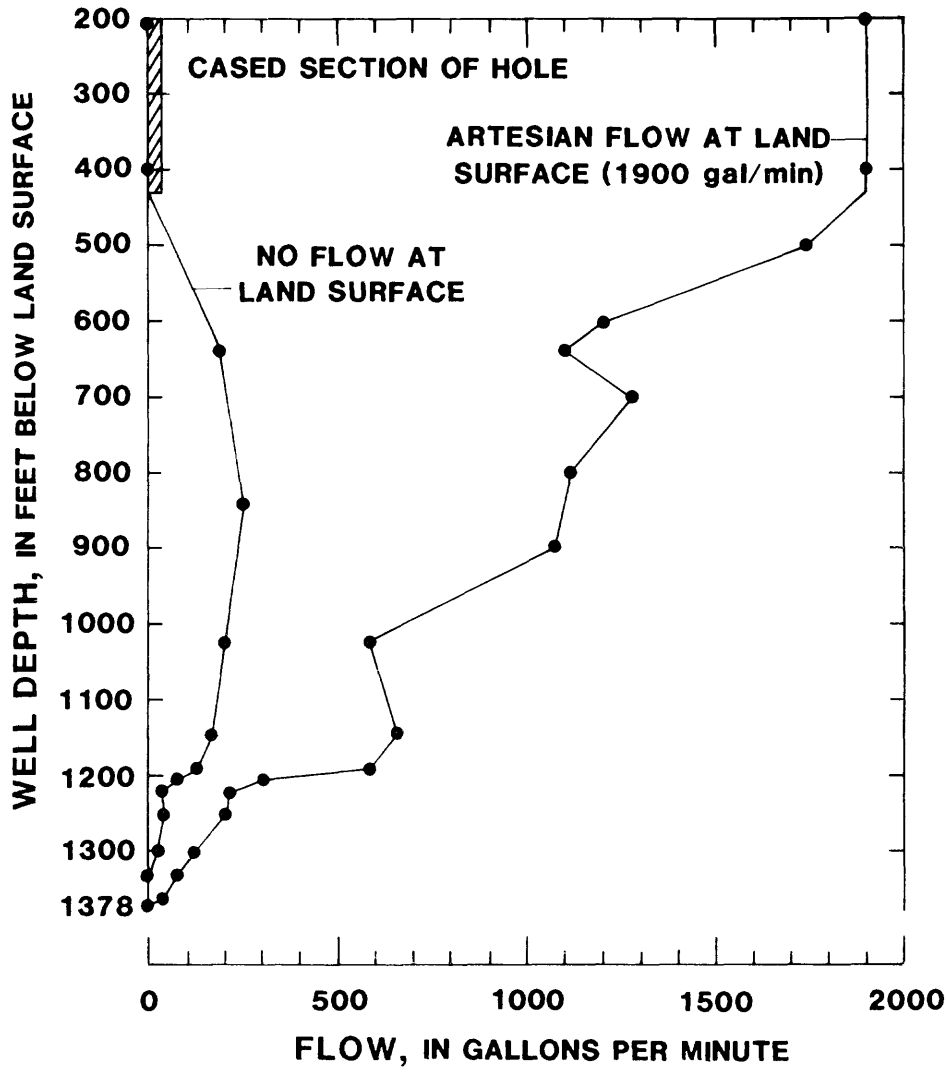

Figure 16.--Flow-meter traverses in test well, open-hole interval 429 to 1,378 feet below land surface, February 22, 1981.

Table 4.--Flow-meter traverses in test well, open-hole interval 429 to 2,026 feet below land surface, July 27, 1981

Depth (feet below land surface)	Flowing at 2,700 gal/min at surface: Flow (gal/min)	Flowing at 130 gal/min at surface: Flow (gal/min)
400	2,700	130
460	2,700	130
700	2,370	390
800	2,240	430
840	2,130	---
976	2,260	400
1,016	2,170	380
1,100	2,060	400
1,190	2,210	350
1,205	1,510	350
1,221	1,620	300
1,310	1,470	240
1,410	1,470	280
1,470	1,050	180
1,500	1,350	240
1,560	1,000	180
1,690	950	180
1,800	1,020	190
1,905	870	110
1,940	810	160
1,960	810	140

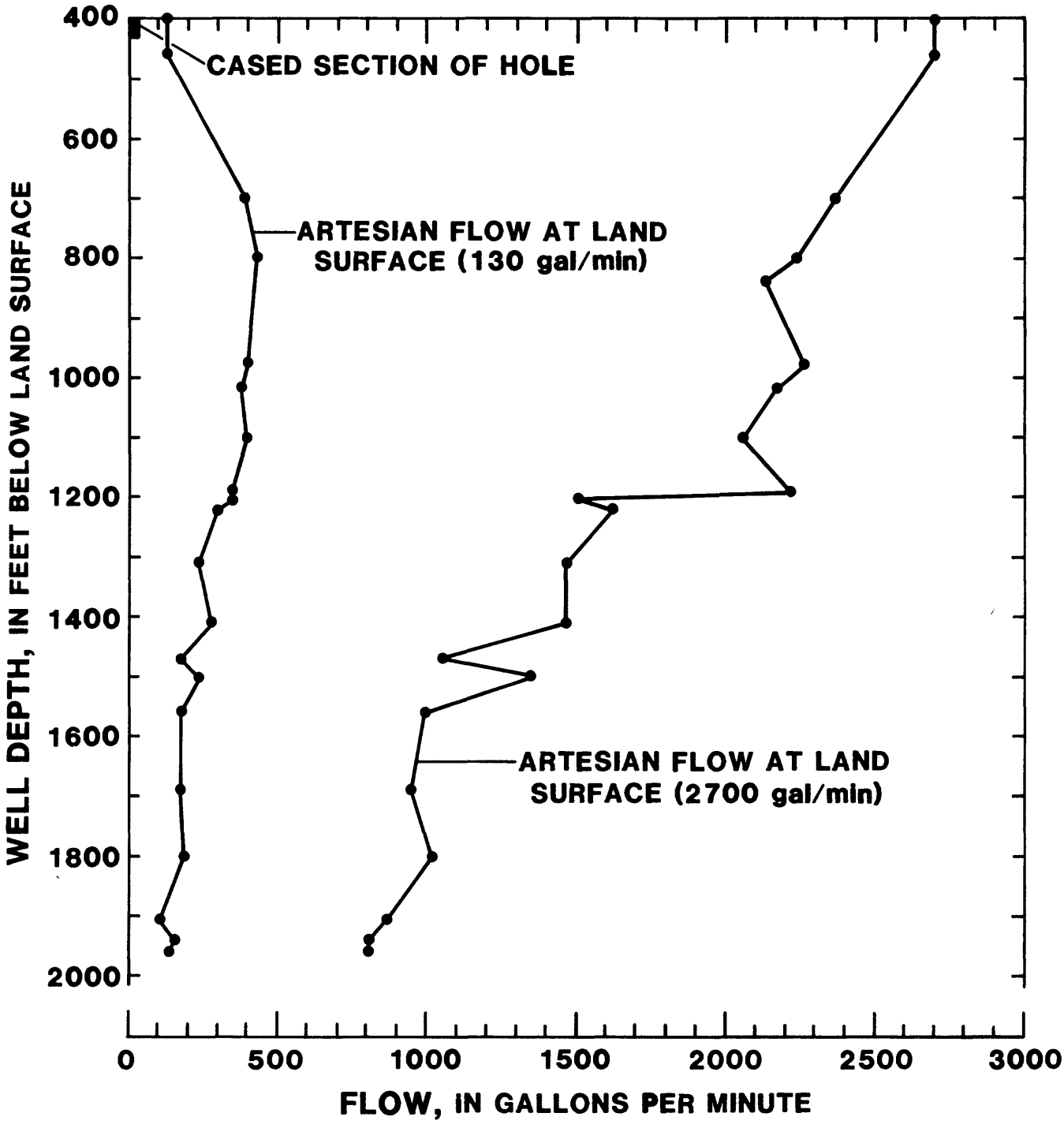

Figure 17.--Flow-meter traverses in test well, open-hole interval 429 to 2,026 feet below land surface, July 27, 1981.

Water Chemistry

Table 5 shows the specific conductance and chloride concentrations of water obtained from the drill stem and the annulus as the test well was drilled from 691 to 2,024 feet below land surface. Specific conductance of water obtained from the drill stem ranged from 542 to 12,700 umhos/cm at 25°C and from the annulus, 520 to 4,700 umhos/cm at 25°C. Chloride concentrations ranged from 6.4 to 3,300 mg/L for water obtained from the drill stem and 5.6 to 1,050 mg/L for water obtained from the annulus.

Chloride concentrations of water obtained from the drill stem between 691 to 1,906 feet below land surface ranged from a low of 6.4 mg/L at 723 feet to a high of 68 mg/L at 1,205 and 1,215 feet. Chloride concentrations increased markedly below 1,918 feet to a maximum of 3,300 mg/L at 2,022 feet (fig. 18). Specific conductance showed similar patterns, ranging from 540 to 700 umhos/cm at 25°C between 691 to 1,918 feet and increasing markedly below 1,918 feet to a maximum of 12,700 umhos/cm at 25°C at 2,022-2,024 feet (fig. 19).

After the test well was completed, water samples were collected periodically and analyzed for selected physical and chemical constituents (table 6). During the first sampling in March 1982, three water samples were collected: two at depths of 1,950 and 2,010 feet by an electronically-controlled downhole sampler, and the third from natural flow at the well head. Dissolved solids concentrations ranged from 5,920 to 7,430 mg/L and chloride concentrations ranged from 3,100 to 3,900 mg/L. In May 1982, another sample was collected at the well head. Dissolved solids concentration was 7,080 mg/L and chloride concentration was 3,000 mg/L.

Table 5.--Specific conductance and chloride concentrations of water obtained from the drill stem and the annulus as the test well was drilled from 691 to 2,024 feet

Depth (feet below land surface)	Drill stem		Annulus	
	Specific conductance (umhos/cm)	Chloride Cl^- (mg/L)	Specific conductance (umhos/cm)	Chloride Cl^- (mg/L)
691	595	7.6	525	5.6
723	580	6.4	520	6.6
755	600	15	520	9.0
786	600	9.4	530	9.0
818	590	12	530	12
849	630	12	520	10
881	605	11	550	13
912	630	9.0	600	11
944	580	8.0	580	12
1,007	570	9.0	565	10
1,039	575	8.0	575	12
1,070	580	10	560	14
1,102	600	12	575	13
1,144	560	11	578	11
1,154	542	12	550	10
1,164	575	12	551	8
1,174	560	12	570	8
1,184	570	10	568	8
1,194	670	50	575	8
1,205	690	68	610	29
1,215	690	68	600	30
1,225	640	67	660	33
1,236	700	61	645	34
1,246	700	62	643	36
1,256	670	58	630	35
1,267	---	--	---	--
1,277	---	--	---	--
1,287	---	--	---	--
1,292	660	47	660	34
1,299	680	53	630	33
1,309	680	52	630	31
1,319	660	48	630	31
1,330	635	38	600	29
1,340	610	36	600	29
1,350	590	40	590	28
1,361	620	37	610	30
1,371	610	35	600	30
1,381	600	33	610	29

Table 5.--Specific conductance and chloride concentrations of water obtained from the drill stem and the annulus as the test well was drilled from 691 to 2,024 feet

Depth (feet below land surface)	Drill stem		Annulus	
	Specific conductance (umhos/cm)	Chloride Cl^- (mg/L)	Specific conductance (umhos/cm)	Chloride Cl^- (mg/L)
1,407	660	38	---	--
1,419	635	35	690	40
1,429	700	42	670	43
1,439	700	48	665	40
1,449	640	35	695	40
1,459	650	37	690	40
1,469	660	35	690	40
1,480	610	20	640	32
1,490	590	20	620	32
1,500	580	22	620	32
1,512	580	20	630	32
1,522	590	22	610	32
1,532	580	20	620	34
1,542	600	22	630	36
1,552	580	23	640	34
1,562	590	22	630	34
1,573	580	24	630	32
1,583	580	22	620	31
1,593	580	20	610	31
1,605	570	21	620	31
1,615	580	20	620	32
1,625	580	23	620	33
1,636	570	18	620	30
1,646	580	20	620	32
1,656	590	22	620	30
1,668	585	22	630	36
1,678	590	22	620	28
1,688	580	20	615	26
1,700	580	24	620	28
1,710	585	26	620	26
1,720	580	20	610	30
1,731	580	20	620	28
1,741	580	24	615	30
1,751	580	23	620	32
1,762	590	26	620	34
1,772	580	24	625	30
1,782	575	24	615	34
1,787	590	26	---	--
1,792	590	24	---	--
1,797	580	26	610	32
1,802	580	28	---	--

Table 5.--Specific conductance and chloride concentrations of water obtained from the drill stem and the annulus as the test well was drilled from 691 to 2,024 feet--Continued

Depth (feet below land surface)	Drill stem		Annulus	
	Specific conductance (umhos/cm)	Chloride Cl^- (mg/L)	Specific conductance (umhos/cm)	Chloride Cl^- (mg/L)
1,807	575	28	615	36
1,812	575	28	---	--
1,817	580	26	615	34
1,823	575	22	---	--
1,828	565	26	610	34
1,833	570	28	---	--
1,838	560	28	600	32
1,843	550	30	---	--
1,848	560	30	610	33
1,855	570	31	---	--
1,860	575	29	620	38
1,865	560	32	---	--
1,870	570	31	600	35
1,875	570	31	---	--
1,880	575	33	610	36
1,886	590	28	---	--
1,891	585	33	610	36
1,896	600	34	---	--
1,901	590	34	610	36
1,906	610	34	---	--
1,911	650	50	610	30
1,918	700	75	---	--
1,922	1,300	300	760	74
1,926	2,400	590	---	--
1,931	2,320	570	670	52
1,936	2,320	570	---	--
1,941	2,380	590	655	48
1,948	2,500	630	---	--
1,953	2,500	620	680	55
1,958	2,530	650	---	--
1,963	2,500	620	720	68
1,968	2,570	640	---	--
1,973	1,500	300	690	59
1,980	5,500	1,600	-----	-----
1,985	10,000	2,950	2,350	600
1,990	11,800	3,150	-----	-----
1,995	11,700	3,175	2,700	680
2,000	11,500	3,200	-----	-----
2,004	11,600	3,250	3,800	1,025
2,012	11,600	3,225	-----	-----
2,017	12,000	3,275	4,100	975
2,022	11,500	3,300	-----	-----
2,024	12,700	3,300	4,700	1,050

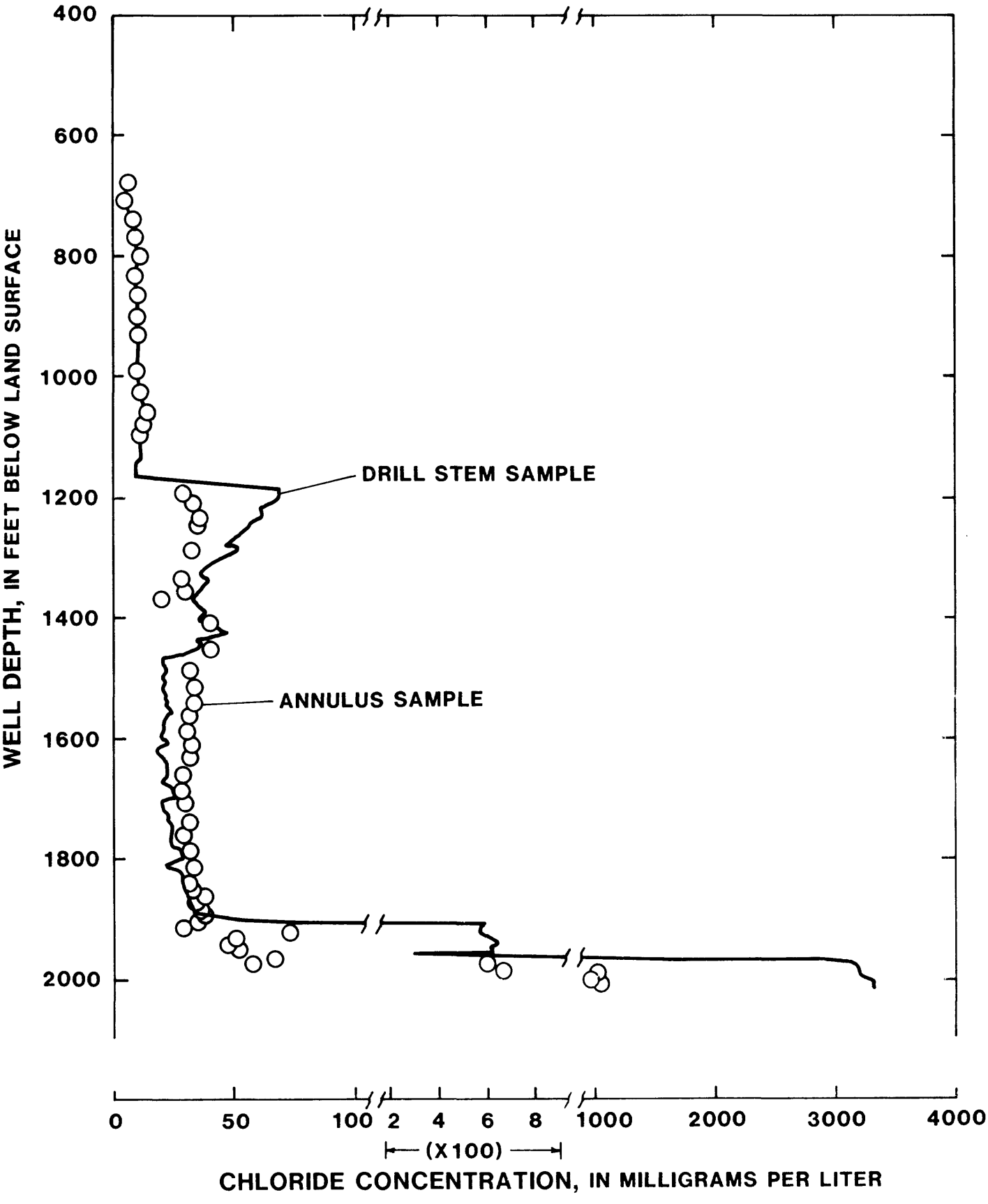

Figure 18.--Chloride concentrations of water obtained from the drill stem and the annulus as the test well was drilled from 691 to 2,024 feet.

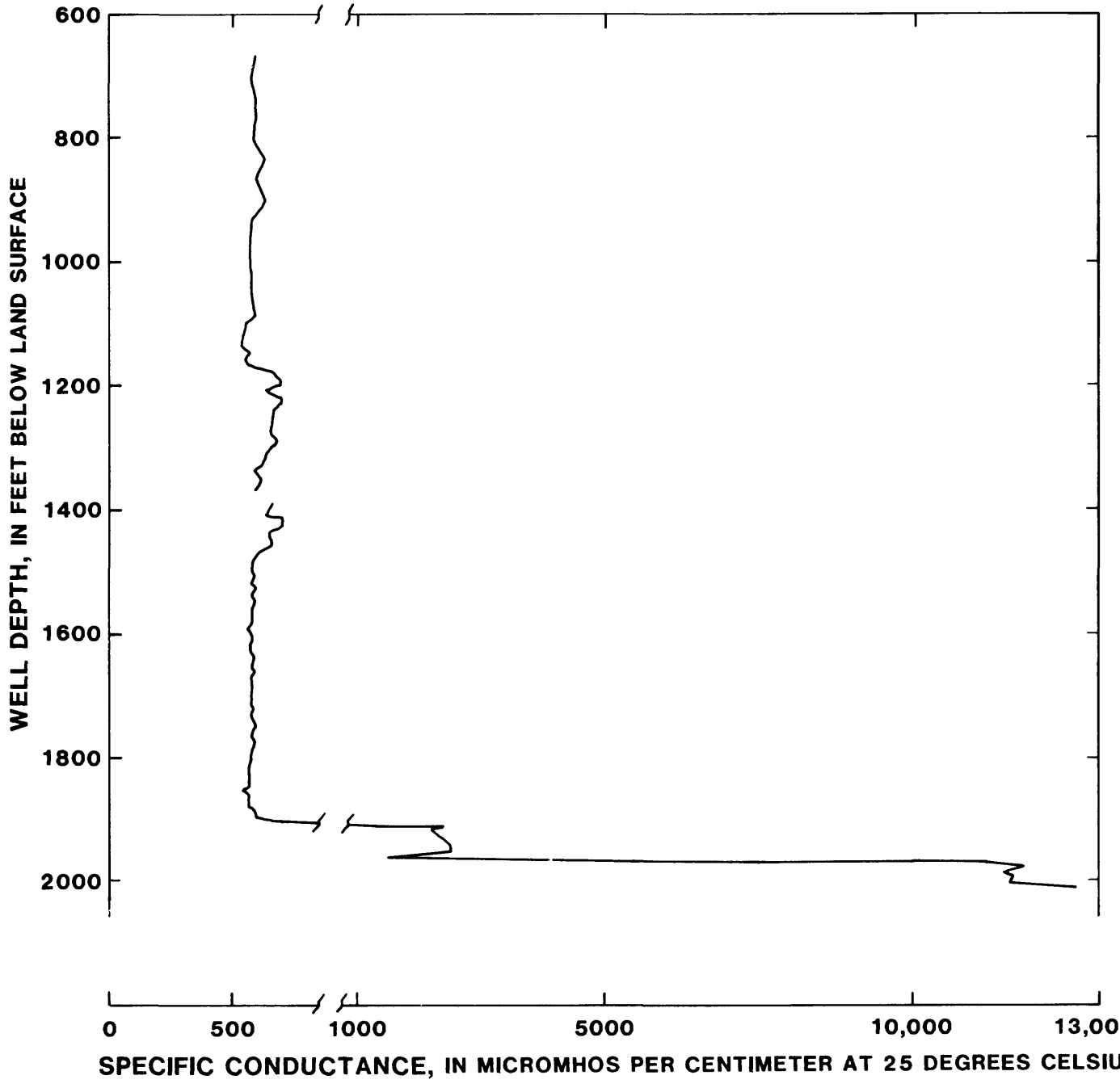

Figure 19.--Specific conductance of water from the drill stem as the test well was drilled from 691 to 2,024 feet.

Table 6.--Selected chemical and physical constituents of water from test well, open-hole interval 1,892 to 2,026 feet

DATE	TIME	SAMPLING DEPTH (FEET) (00003)	TEMPERATURE (DEG C) (00010)	SPECIFIC CONDUCTANCE (UMHOS) (00095)	PH LAB (UNITS) (00403)	CARBON DIOXIDE DISSOLVED (MG/L AS CO2) (00405)	ALKALINITY FIELD (MG/L AS CACO3) (00410)
MAR, 1982							
09...	1100	[a]2010	--	--	7.8	--	--
09...	1200	[a]1950	--	--	7.6	--	--
09...	1300	[b]	29.5	--	7.5	--	--
MAY							
21...	1415	[b]	29.5	10600	7.4	67	164

DATE	BICARBONATE FET-FLD (MG/L) AS HCO3) (00440)	CARBONATE FET-FLD (MG/L AS CO3) (00445)	HARDNESS (MG/L AS CACO3) (00900)	CALCIUM DISSOLVED (MG/L AS CA) (00915)	MAGNESIUM, DISSOLVED (MG/L (AS MG) (00925)	SODIUM, DISSOLVED (MG/L AS NA) (00930)	SODIUM ADSORPTION RATIO (00931)
MAR, 1982							
09...	--	--	1900	400	220	1800	18
09...	--	--	1700	380	200	1500	16
09...	--	--	1800	390	210	1500	15
MAY							
21...	200	0	2400	550	260	1400	12

DATE	POTASSIUM, DISSOLVED (MG/L AS K) (00935)	CHLORIDE, DISSOLVED (MG/L AS CL) (00940)	SULFATE DISSOLVED (MG/L AS SO4) (00945)	FLUORIDE, DISSOLVED (MG/L AS F) (00950)	STRONTIUM, DISSOLVED (UG/L AS SR) (01080)	SOLIDS, RESIDUE AT 180 DEG C DISSOLVED (MG/L) (70300)	SPECIFIC CONDUCTANCE LAB (UMHOS) (90095)	ALKALINITY LAB (MG/L AS CACO3) (90410)	HARDNESS NONCARBONATE (MG/L AS CACO3) (95902)
MAR, 1982									
09...	29	3900	700	.6	8000	7430	10500	140	1800
09...	24	3100	490	.6	7000	6570	9380	140	1600
09...	23	3200	590	.6	7400	5920	9500	130	1700
MAY									
21...	24	3000	720	.5	6800	7080	9580	136	2300

[a]Sample obtained by an electronically-controlled down-hole sampler.
[b]Sample obtained at the well head.

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