PHASE I - DEEP AQUIFER HYDROGEOLOGIC STUDY, COLLIER COUNTY, FLORIDA PRELIMINARY REPORT

M&A **MISSIMER & ASSOCIATES, INC.**

Environmental and Groundwater Services

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prepared for

Collier County Utilities Division
Water and Wastewater Services
2800 North Horseshoe Drive
Naples, Florida 33942

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by

Missimer & Associates, Inc.
428 Pine Island Road, S. W.
Cape Coral, Florida 33991

Project No.
H89-342

Charles W. Walker, Ph.D., P.G.
Senior Hydrogeologist

W. Kirk Martin, P.G.
Professional Geologist #079

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I. SUMMARY

1. Aquifer Storage and Recovery (ASR) is a water management technique whereby underground aquifers are used as a reservoir to store excess water during the wet season which will later be withdrawn for use in the dry season.
2. Two test wells were drilled. One at the Manatee Road site and the second at the Collier County water treatment plant site.
3. A number of staddle packer tests and water quality analyses were performed at each test well.
4. The Manatee Road site has been chosen for the ASR pilot project.
5. The Hawthorn Aquifer System Zone II, occurring at a depth of 475 to 535 feet below land surface, has been chosen for the primary ASR zone.
6. The Lower Hawthorn Aquifer, occurring at a depth of 680 to 780 feet below land surface, has been chosen for the alternate ASR zone.
7. The proposed ASR well will be constructed to serve the dual function of injection and recovery at a rate of about 1.5 MGD.
8. The source of the injected water will come directly from the county's water treatment plant, approximately 8 miles to the north of Manatee Road.

9. A series of tests will be conducted at the new ASR well site, including aquifer performance tests and a series of injection and withdrawal cycles.

10. Solute transport models will be utilized to evaluate system efficiencies, injection and withdrawal rates and durations, final configuration of wells and the economic parameters related to operating an ASR system.

II. INTRODUCTION

On September 11, 1990 the Board of Collier County Commissioners approved an agreement in which Missimer & Associates, Inc. would perform a deep hydrogeological study for the county's utilities division. The agreement outlines the hydrogeological study into two phases. Phase I tasks include the drilling of two deep test wells constructed to an approximate depth of 1600 feet below land surface. The location of the wells is at the Manatee Road site and the existing Collier County water treatment plant site, as shown in Figure 1.

Construction of the first well began in mid-September, 1990 at the Manatee Road site. It was drilled to a total depth of 1608 feet below land surface, penetrating several geologic formations and aquifers. Water samples were taken every 10 feet while drilling with the reverse air method below a depth of 460 feet. Six different zones encountered in the well were tested for aquifer characteristics and water quality. These zones were isolated for testing by placing inflatable packer(s) within the borehole. The zone was either allowed to flow or was pumped while noting discharged water quantity and drawdown. Following this testing, the well was back-plugged with cement to about 760 feet and then completed in a manner which allows monitoring of two separate

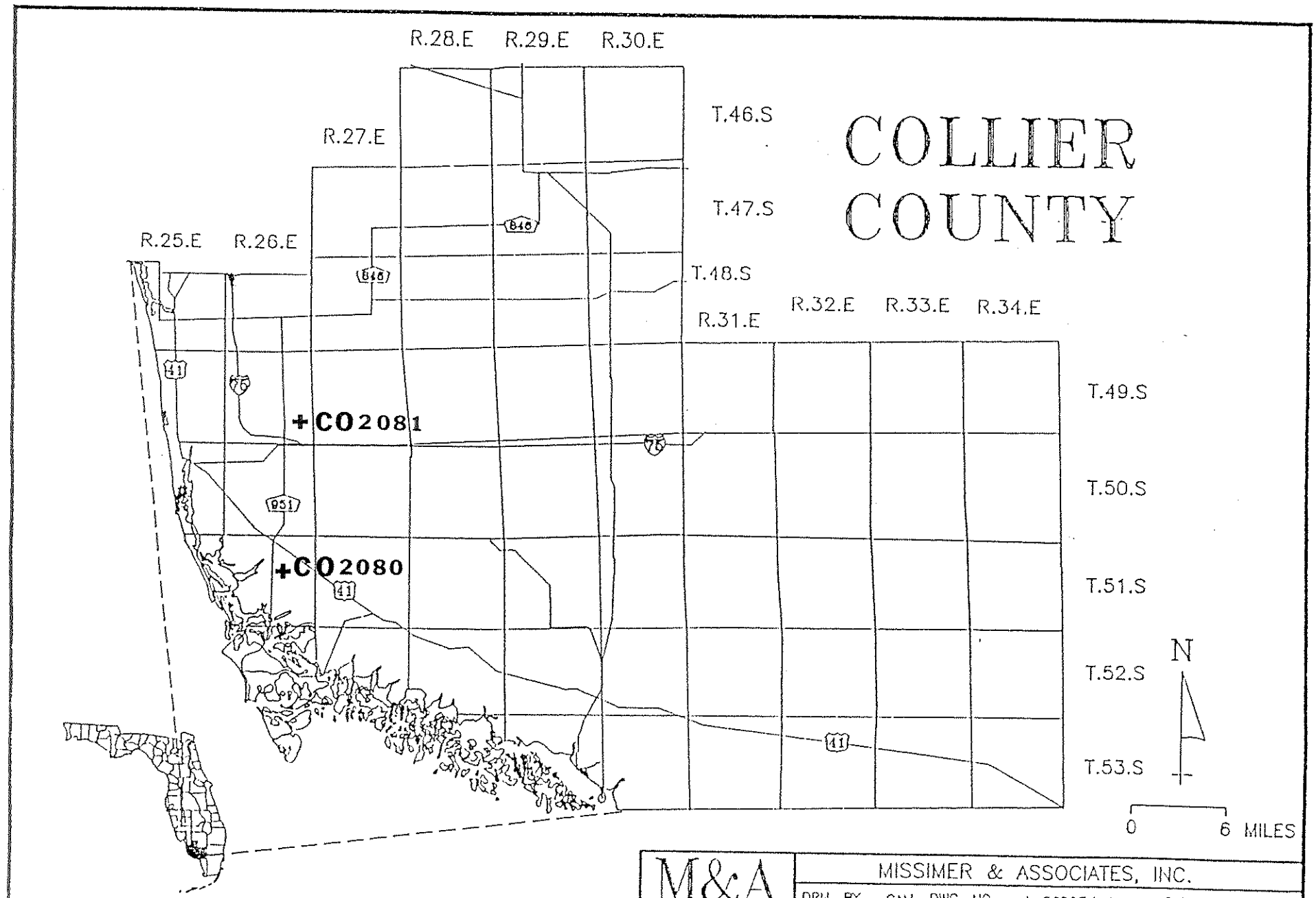


FIGURE 1 MAP SHOWING AREA OF INVESTIGATION.

zones. The drill rig was removed and the site restored in late November, 1990.

Drilling of the second test well began in early December, 1990 at the water treatment plant site. This well was drilled to a depth of 1616 feet below land surface. Some differences in geology and water quality were noted in this new well when compared to the Manatee Road well site. The well was tested and sampled similar to the methods employed at the Manatee Road well. At this time, mid January 1991, the drilling contractor is in the final phases of completing the well construction.

The information presented in this preliminary Phase I report will focus on the Manatee Road well and its testing results. We have chosen this site to conduct the pilot Aquifer Storage and Recovery (ASR) program of Phase II. Favorable parameters at this site relative to the ASR project include geographical position within the county, aquifer characteristics, relatively shallow wells required, groundwater quality and that much of the surface facilities needed for ASR project are presently on site.

III. METHODS OF INVESTIGATION

1. Well Inventory and Water Use Assessment

An inventory of wells on and adjacent to the project site was conducted and it yielded about 60 data points. The water quality information includes dissolved chloride concentration (in mg/l) and some conductivity measurements (in umhos/cm). Well construction details and type of water use along with the water quality data is given in Table 1 with well locations shown in Figure 2.

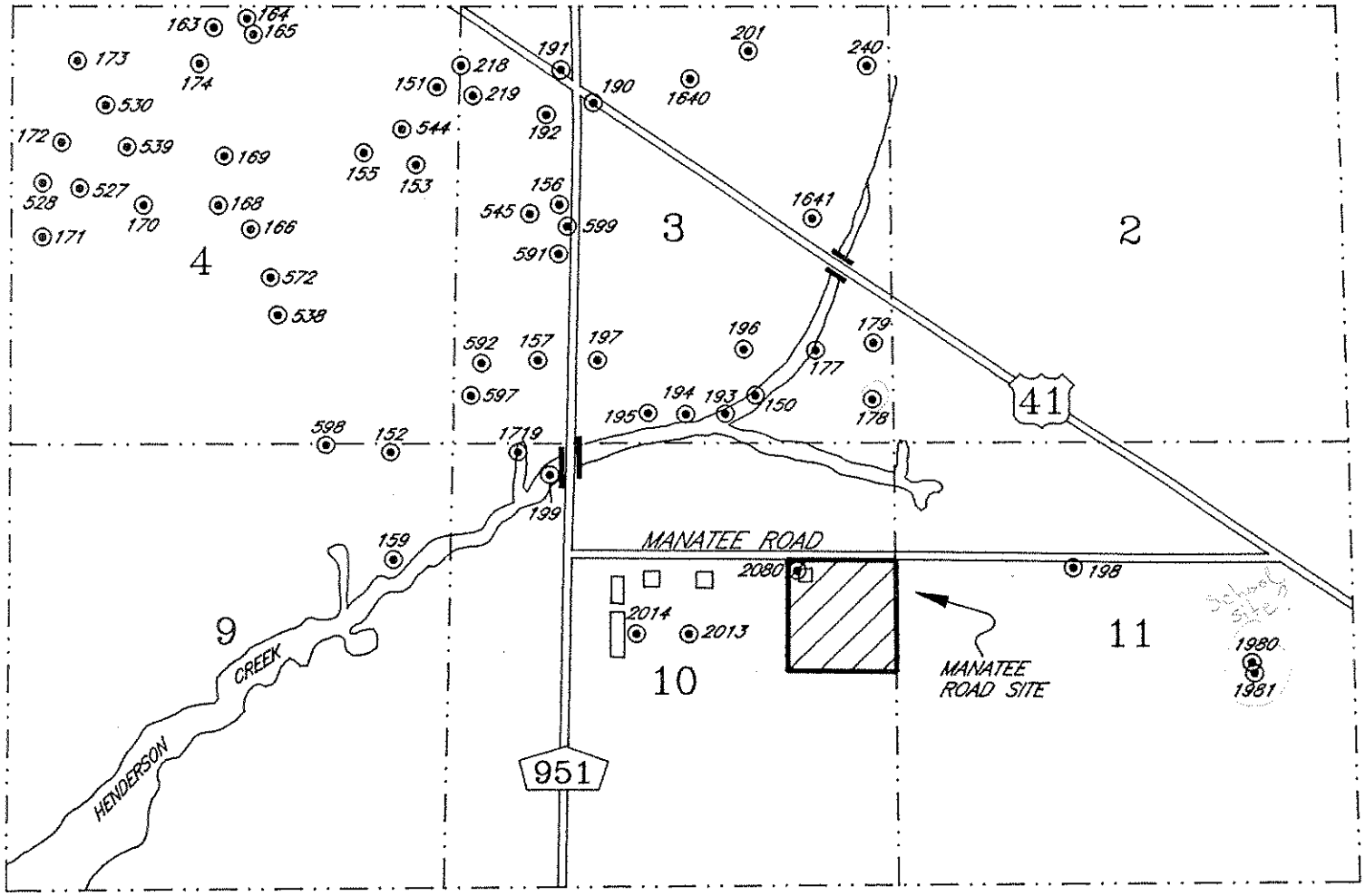
Water use in the adjacent area is primarily related to agricultural operations, mostly to the north and northwest of the site, and a lesser amount used for domestic supply. Both the water-table and Tamiami aquifer terminology are presented in the table. However, there is little to no confinement in the upper sands and limestones down to a depth of about 100 feet, which means that the two described aquifers actually are parts of the same surficial aquifer. An analysis of Table 1 chloride ion concentration for all wells show that within the area the aquifer is density stratified. A layer of fairly fresh water is present in the upper tens of feet. Below this depth, the salinity rapidly increases, resulting in its greater density, and not by the presence of a confining layer.

TABLE 1. WELL INVENTORY AT THE MANATEE ROAD PROJECT SITE

Well Number	Total Depth (ft)	Casing Depth (ft)	Casing Diameter (in)	Use	Aquifer	Dissolved Chlorides (mg/l)	Conductivity
CO-150	----	----	----	Irrigation	----	170	910
CO-151	103	98	2	Observation	Tamiami	720	----
CO-153	66	61	2	Observation	Tamiami	400	----
CO-155	62	57	2	Observation	Tamiami	680	----
CO-156	63	58	2	Observation	Tamiami	440	----
CO-157	65	60	2	Observation	Tamiami	----	----
CO-159	----	----	2	Abandoned	----	2680	----
CO-163	44	38	4	Domestic	Tamiami	220	----
CO-164	----	----	1.25	Domestic	----	150	910
CO-165	----	----	2	Domestic	----	230	----
CO-166	21	----	2	Irrigation	Water Table	220	1250
CO-168	----	----	----	Domestic	----	250	1290
CO-169	----	----	2	Domestic	----	200	1210
CO-170	40	----	2	Domestic	Tamiami	300	1460
CO-171	----	----	2	Domestic	----	420	1870
CO-172	----	----	2	Domestic/Irr.	----	290	1353
CO-173	----	----	----	Domestic/Irr.	----	250	1320
CO-174	----	----	----	Domestic	----	220	1265
CO-177	----	----	----	Irrigation	----	220	1122
CO-178	----	----	----	Irrigation	----	3300	1375
CO-179	----	----	----	Plugged	----	20	380
CO-190	----	----	----	Irrigation	----	12	352
CO-191	----	----	----	Irrigation	----	45	627
CO-192	----	----	----	Irrigation	----	40	528
CO-193	40	----	----	Irrigation	Tamiami	260	1250
CO-194	40	----	2	Irrigation	Tamiami	240	1180
CO-195	40	----	2	Irrigation	Tamiami	300	1430
CO-196	34	----	4	Irrigation	Tamiami	260	1150

TABLE 1. Continued: WELL INVENTORY AT THE MANATEE ROAD PROJECT SITE

Well Number	Total Depth (ft)	Casing Depth (ft)	Casing Diameter (in)	Use	Aquifer	Dissolved Chlorides (mg/l)	Conductivity
CO-197	40	----	2	Irrigation	Tamiami	280	1260
CO-198	186	----	----	Plugged	Upper Hawthorn	300	----
CO-199	102	----	----	Plugged	Upper Hawthorn	300	----
CO-201	----	186	2	----	----	----	----
CO-218	45	40	2	Observation	Tamiami	----	----
CO-219	15	10	2	Observation	Water Table	----	----
CO-240	----	40	2	Observation	Tamiami	----	----
CO-527	18	----	----	Domestic/Irr.	----	320	1800
CO-528	32	----	2	Irrigation	---	370	1775
CO-530	----	30	2	Domestic/Irr.	Tamiami	550	2425
CO-538	47	----	6	Irrigation	Tamiami	660	2445
CO-539	----	----	6	Irrigation	----	280	1645
CO-544	45	30	8	Irrigation	Tamiami	----	----
CO-545	45	26	8	Irrigation	Tamiami	----	----
CO-572	150	----	2	Observation	----	----	----
CO-591	11.5	6.5	2	Observation	Water Table	----	----
CO-592	12.5	7.5	2	Observation	Water Table	----	----
CO-597	40	38	2	Observation	Tamiami	230	----
CO-599	50	43	2	Observation	Tamiami	180	----
CO-1640	96	----	----	----	----	----	----
CO-1641	23	23	2	Observation	Water Table	----	----
CO-1791	62	----	2	Irrigation	Tamiami	540	2519
CO-1980	80	45	4	Observation	Tamiami	----	----
CO-1981	54	45	4	Observation	Tamiami	----	----
CO-2013	40	----	4	Test Boring	Water Table	----	----
CO-2014	40	----	4	Test Boring	Water Table	----	----
CO-2080	1608	360	12 to 4	Observation	Hawthorn/ Suwannee/ Ocala	2000-18000	----



SCALE

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FIGURE 2. MAP SHOWING LOCATION OF INVENTORIED WELLS.

2. Test Drilling and Well Construction

At both the Manatee Road and water treatment plant sites (Figure 1), similar testing and construction practices were employed. Prior to moving the drill rig on-site, the area was prepared by constructing a cement pad and necessary pits. The rig was then moved on site and a concrete block wall was built around the rig work area for the control of saline water, as shown in Photo 1.

Drilling was initiated by the rotary-mud method. Twenty-inch diameter steel surface casing was set into the upper competent limestone. Drilling then continued to a depth of about 400 feet and 12-inch diameter schedule 80 PVC casing installed from the surface on down. Construction then continued by drilling with a nominal 8-inch diameter bit by the reverse-air rotary method to a depth of approximately 1600 feet. Drill cuttings and water samples were taken at least every 10 feet.

A series of single and double straddle packer tests were then conducted. Zones of interest were isolated by the packers and were then either pumped or allowed to flow while performing step-drawdown tests. Water samples were periodically taken during the step tests. A diagram illustrating a typical packer test setup is given in Figure 3. Water levels and pressures were monitored with an In-Situ, Inc. Hermit Environmental Data Logger Model 1000B and

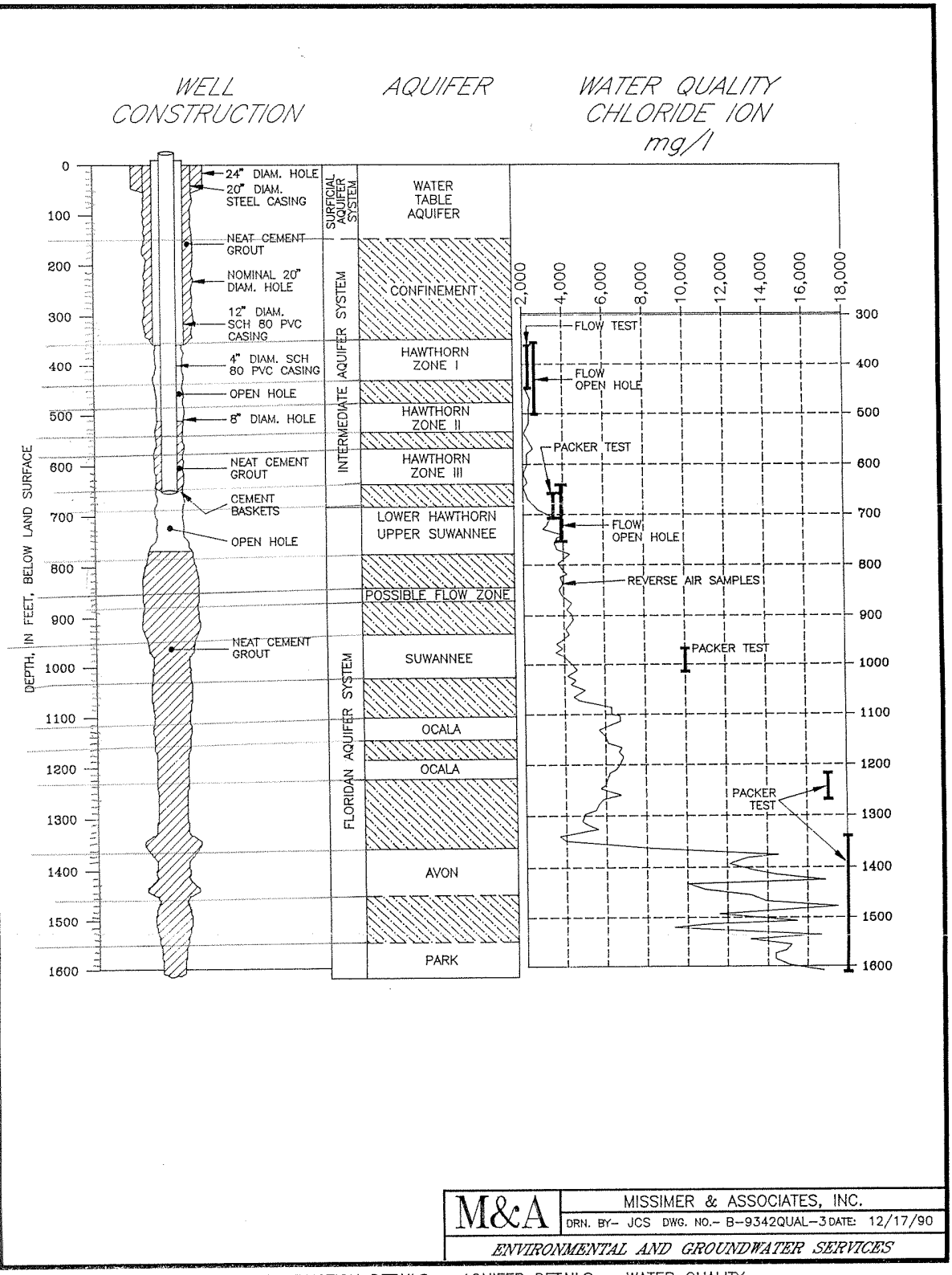

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FIGURE 4 . CO-2080 WELL CONSTRUCTION DETAILS – AQUIFER DETAILS – WATER QUALITY.

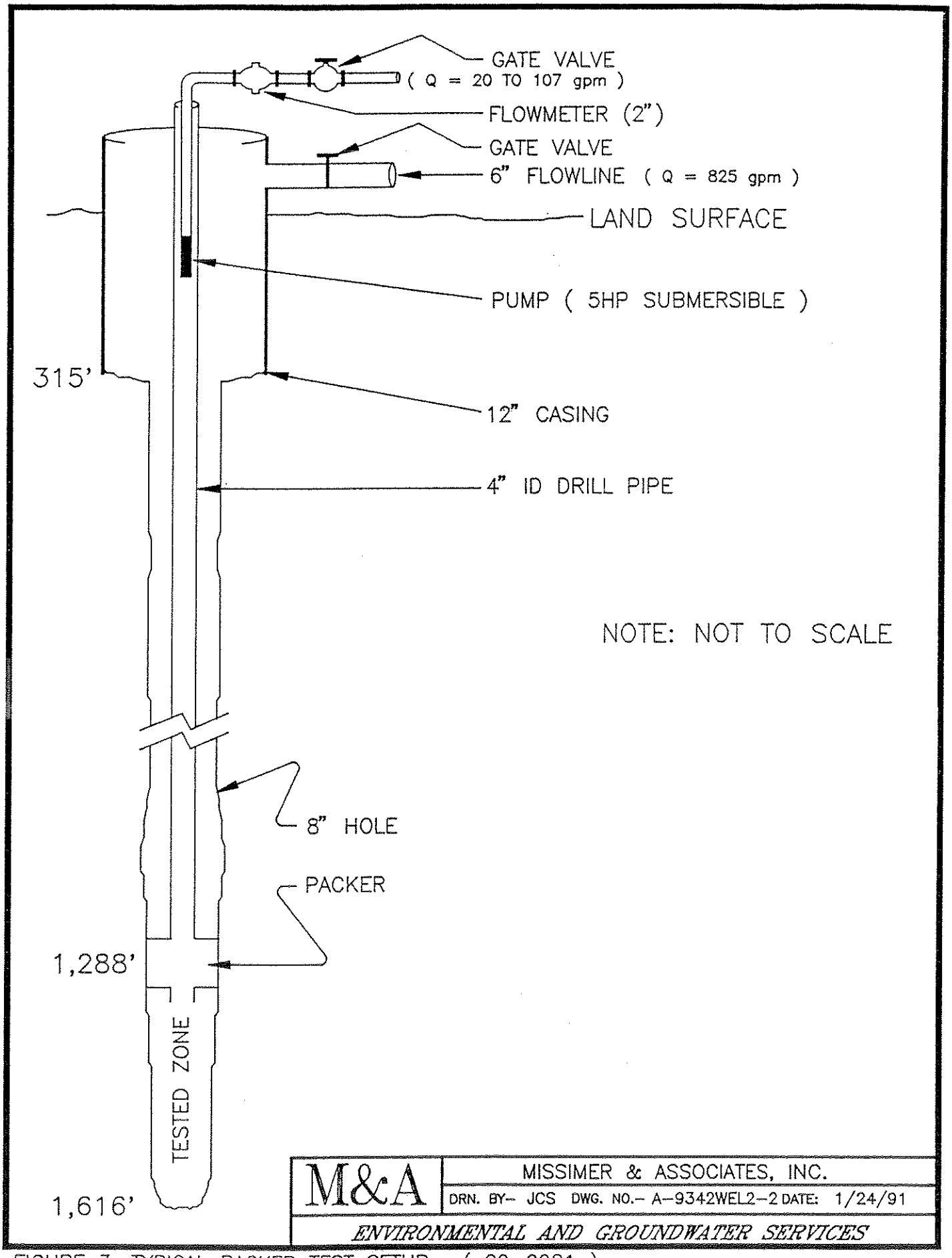


FIGURE 3. TYPICAL PACKER TEST SETUP. (CO-2081)

pressure transducer which automates the measurements. Water levels were also measured with an air gauge and air line pressurized with bottled nitrogen during pumping tests. Discharge rate was measured with either a flow meter or an orifice weir. A typical flow test set-up showing the attachment of the pressure transducer cable to the drill pipe and the flow meter is displayed in Photo 2. Measurement of flow quantity utilizing the orifice weir is shown in Photo 3.

Following the packer testing, the wells were back-plugged with neat cement grout to about a depth of 760 feet in the Manatee Road well and to about 570 feet in the water treatment plant well.

Both wells were completed in such a manner to enable the monitoring of 2 zones within each well. This double completion was done by installation of 4-inch diameter Schedule 80 PVC casing with cement baskets attached to the bottom of the casing. Neat cement grout was then tremied into the space between the 4-inch casing and the 8-inch diameter hole up to the bottom of the upper observation zone. The completed wellhead consists of the 4-inch and 12-inch diameter casings, each having their own hose-bib fitting (Photo 4). Figure 4 illustrates final well construction details for the Manatee well site. Also shown in this figure are the aquifers and confining zones encountered in the well, calipered hole diameter, and chloride ion concentration of samples taken during reverse air drilling and packer tests.

PHOTO 1. Drill rig work area surrounded by concrete block wall for water control
CO-2081

PHOTO 2. Packer flow test with pressure transducer cable and flow meter showing
CO-2080

PHOTO 3. Measurement of flow quantity by use of orifice weir, CO-2080

PHOTO 4. Dual completion well head, CO-2080

3. Aquifer Testing

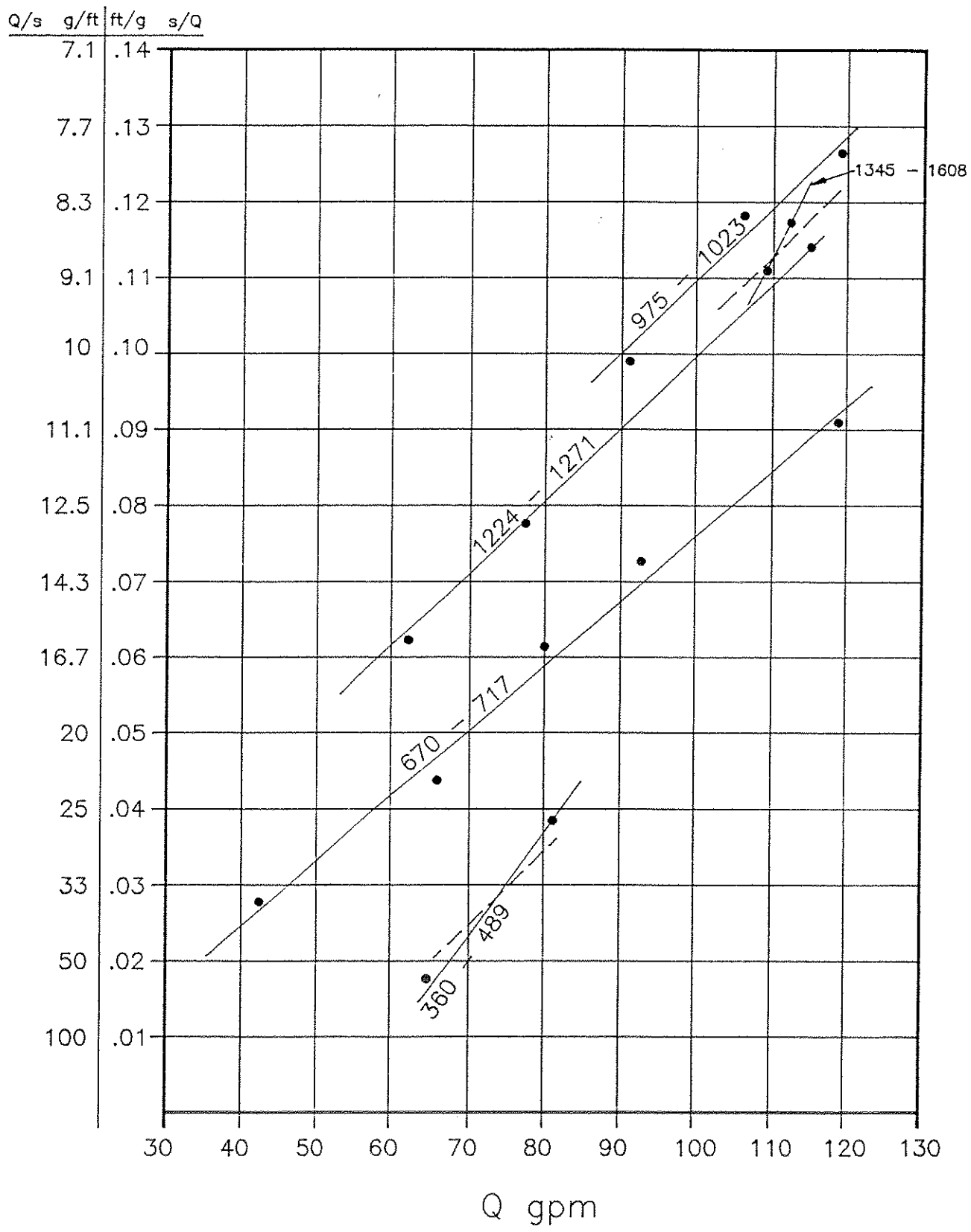
A step-drawdown test usually consisting of 3 to 5 different pumping or flowing rates was performed on each of the aquifer sections isolated by the packer mechanisms. Each step required a constant discharge for a period of time that allowed the water level in the well to stabilize. The rates of pumpage were determined by first conducting a "mini pump (flow) test" in order to determine the maximum discharge and corresponding drawdown that could be realized from the system. This "mini-test" also served to purge the system of nonrepresentative water or drilling additives which may have been present in the well bore or which may had invaded the aquifer. This was particularly important when testing a well open to 2 or more aquifers and using inflatable packer(s) to isolate the study zone.

Following this "mini-test", the step-drawdown test procedure was designed. The rates of discharge were controlled by either adjusting the valving and/or changing the RPM of the pump. The first step of the test was at a rate of approximately 50 percent of the maximum discharge. The following step discharges were increased by increments up to the last step, which was the maximum discharge. Drawdown measurements were taken every minute when using the Data Logger or at least every 3 minutes when manually recorded. Water samples were taken at the end of each step, at minimum.

The specific capacity (Q/s = discharge rate divided by drawdown) for each step was then calculated. Additionally, the reciprocal of Q/s, termed "specific drawdown" (s/Q), was calculated for each step. The Q/s quotient is useful in determining pump size and depth of placement within the well and the s/Q values are useful in determining well efficiency. A plot of specific capacity and specific drawdown versus discharge for each step was done on arithmetic scale paper. When several zones within one well are tested, these steps can be plotted on the same graph. Figure 5 is a plot of 5 tests.

The tests with the most steps (3 to 5) show that the lines of best fit nearly parallel each other, in other words have a similar slope. This indicates that though different zones were tested, the efficiency of the pumping and plumbing system was similar for each test. Two of the tests had only 2 steps, but a line of best fit was placed between the 2 points for each test with a slope corresponding to that of the other tests.

Two points are then taken from the best fit line within the limits of the actual plotted points. The specific capacity for each point is then determined directly from the graph. From these Q/s values, the transmissivity of the aquifer can be approximated by using a modified Walton's equation (1970) for each discharge quantity. The derived



NOTE:

NUMBERS CORRESPONDING TO LINES ARE THE LIMITS OF THE ZONE TESTED – IN FEET BELOW LAND SURFACE.

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FIGURE 5 . WELL CO–2080; STEP DRAWDOWN PACKER TESTS.

transmissivity values are less than the true values because of efficiency losses within the test setup.

A method to remove the affects of this inefficiency is to plot discharge (Q) versus transmissivity (T). A line is then drawn between the two points and extended to intercept the y axis (T) at zero discharge (Q=0). The transmissivity at Q=0 is then the value used to most closely estimate the actual transmissivity of the tested zone. An example of this method is shown in Figure 6.

Table 2 lists the estimated aquifer parameters for the tested zones at the Manatee well site.

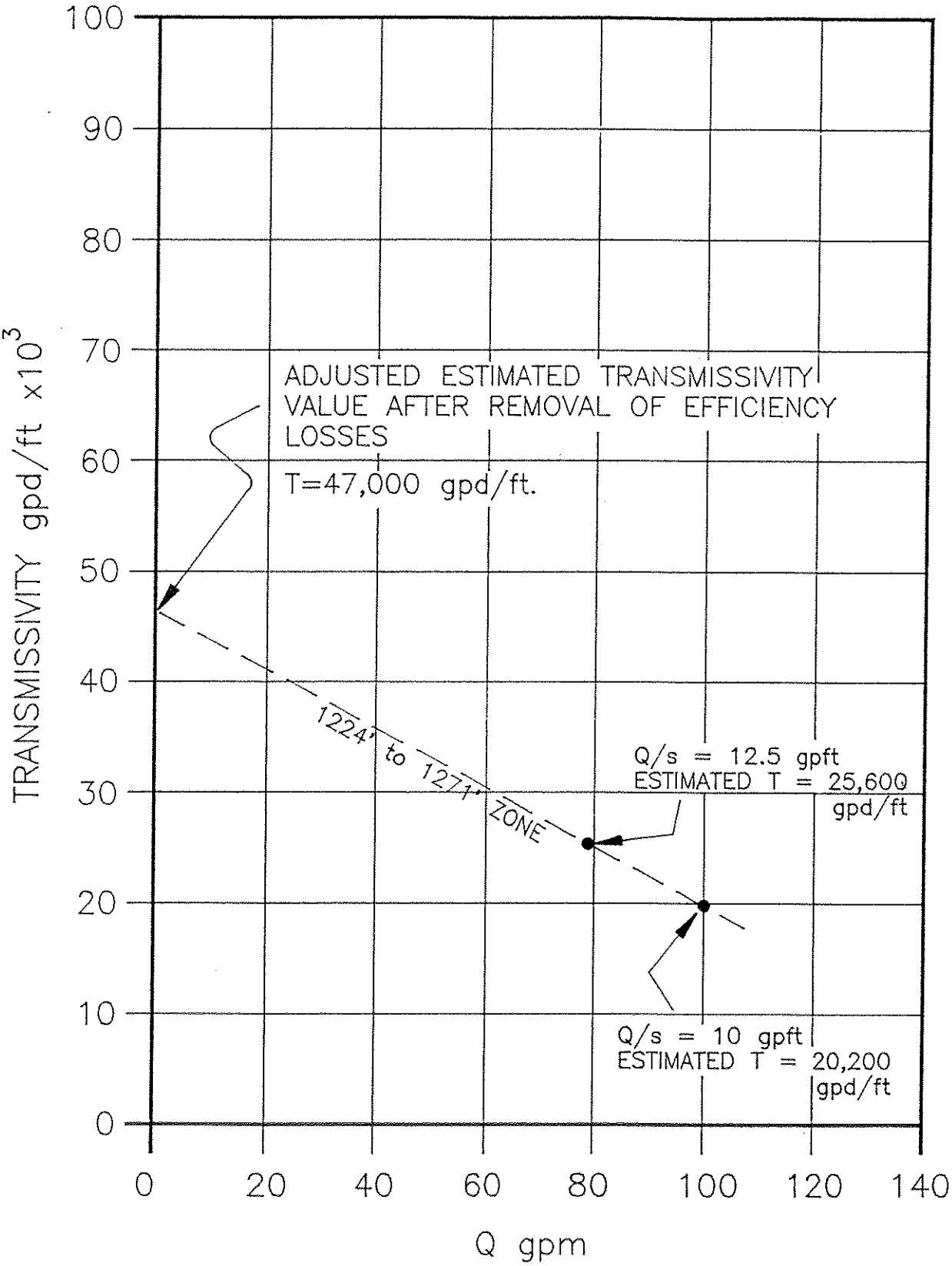

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FIGURE 6 . WELL CO-2080; EXAMPLE OF METHOD USED TO REMOVE THE AFFECTS OF WELL INEFFICIENCY WHEN ESTIMATING TRANSMISSIVITY FROM STEP-DOWN DATA.

TABLE 2. AQUIFER PARAMETERS - WELL CO-2080

Zone	Depth	Static Water Level* (ft above land surface)	Estimated Transmissivity (gpd/ft)
Hawthorn I	360-460	20.8	18,000
Hawthorn II	465-530	24.8±	150,000-200,000
Lower Hawthorn	680-760	23.9	110,000
Suwannee	930-1020	19.0	50,000
Ocala	1180-1220	10.6	47,000
Avon Park	1345-1606	10.0	43,000

*Not density corrected.

IV. GEOLOGY AND HYDROLOGY

1. Geology

The hydrogeology of Collier County has been revealed through a number of investigations originated by the U.S. Geological Survey, the South Florida Water Management District, academic research, and by various consultants including Missimer & Associates, Inc. A partial bibliography is given at the end of this report. The terminology used herein conforms to that given in Missimer & Associates, Inc., 1981 and Florida Geological Survey Special Publications 28 and Bulletin Number 59. A hydrogeologic column for the Manatee Road well is given in Figure 7.

The following is a brief description of the geologic formations and aquifers encountered within the Manatee Road well. They are described from youngest to oldest. The reader is referred to Figure 7 to obtain geologic ages and lithologic descriptions of the penetrated strata. Geologist's logs of the 2 wells are given in the appendix.

Pamlico Sand

The uppermost formation encountered during exploratory drilling is the Pamlico Sand. This surficial, Pleistocene-age deposit occurs throughout most of South Florida. It is predominantly medium to fine grain quartz sand with varying

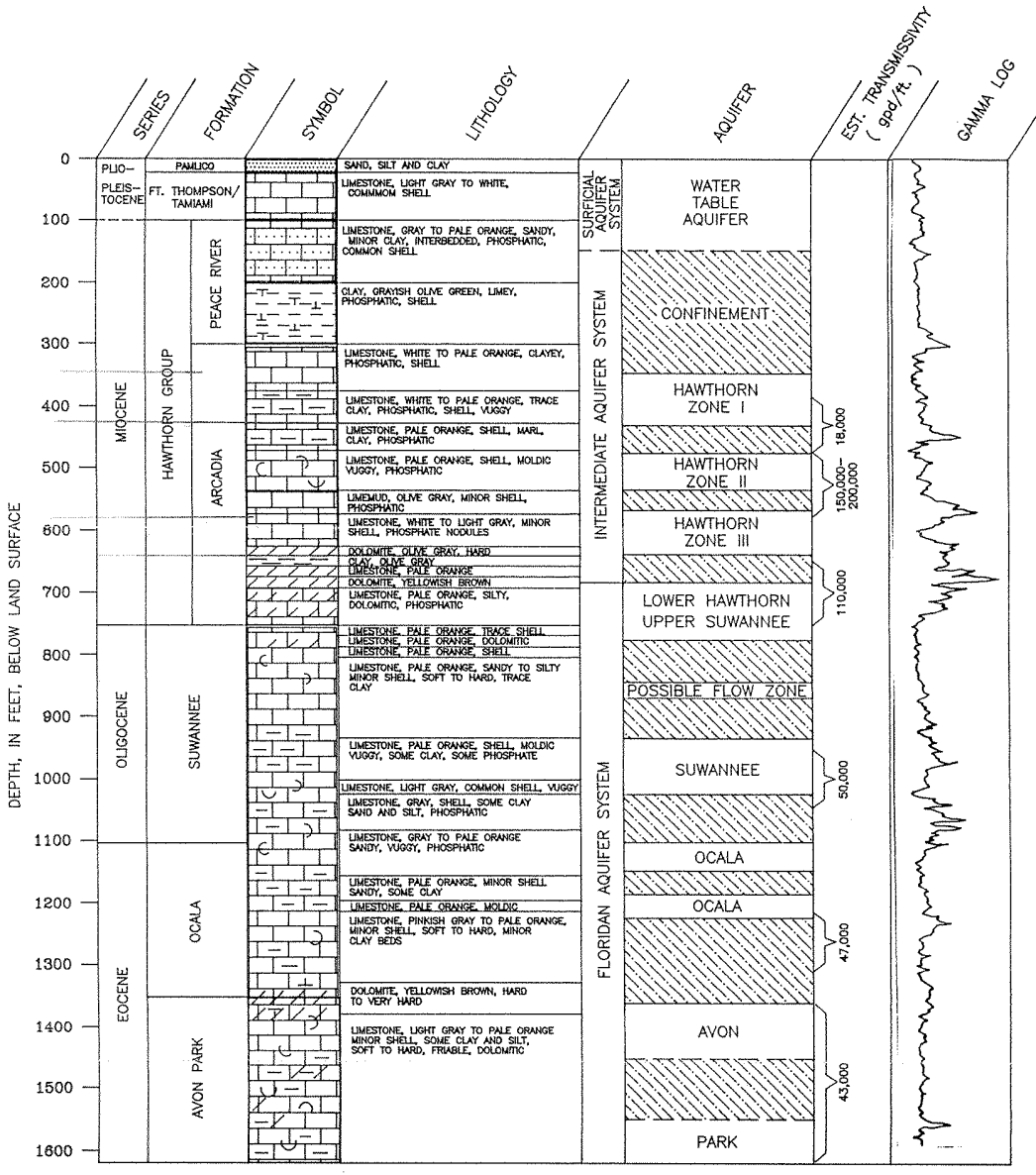

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FIGURE **7.** CO–2080 HYDROSTRATIGRAPHIC COLUMN AND GAMMA LOG.

amounts of shell, detrital clays and organic constituents. These sediments are commonly clayey and the development of soil orizons within the unit is common. Local thickness of the unit ranges from 0 to 15 feet. Permeability is generally medium to low depending on the quantity of secondary constituents.

Ft. Thompson/Tamiami Formation

The Fort Thompson Formation consists of 6 feet of alternating fresh-water, marine, and brackish-water marls, limestones, shell beds and sand at the type locality on the Caloosahatchee River, near LaBelle (Parker and others, 1955). In northwestern Collier County, the Fort Thompson consists chiefly of hard sandy limestone and calcareous sandstone containing pockets of quartz sand and thin beds of dense, hard fresh-water limestone.

The Ochopee Limestone Member of the Tamiami Formation was named by Mansfield (1939) for the light gray to white sandy fossiliferous limestone which crops out near the town of Ochopee in Collier County (Hunter, 1968). The Ft. Thompson/Ochopee lies beneath the Pamlico at a depth of 10 feet below land surface at the Manatee Road site and within 2 feet at the water treatment plant. Lithologically, the Ochopee is a sandy biomicrudite with extensive primary and secondary porosity. The dissolution of shell material, creating large interconnection shell molds, accounts for the

high permeability of this unit. No attempt was made in this study to differentiate the two formations.

Hawthorn Group

The Hawthorn Group lies unconformably beneath the Tamiami Formation. The Hawthorn Group is regionally extensive and underlies most of Florida and parts of Georgia and South Carolina. The Hawthorn Group includes both carbonate and siliciclastic rock and sediment that are Miocene in age. On-site (Manatee Road), the top of the Hawthorn Group occurs at a depth of about 100 feet below land surface and extends down to a depth of about 710 feet below land surface. Beneath the study site, two formations within the Hawthorn Group were penetrated; the Peace River and Arcadia Formations.

The upper formation of the Hawthorn Group is the Peace River, which is a phosphatic green sandy dolosilt containing a sandy limestone section. This unit extends from 100 feet to 300 feet below land surface on-site.

The Arcadia Formation occurs at approximately 300 feet and extends to a depth of 740 feet. The mixed carbonate and clastic assemblage is extremely complex, containing several lithologies including limestone, dolomite, lime mud, and clay. Secondary components of this sequence include sandstone, phosphate, and shell. The majority of the limestones are characterized lithologically as friable

limestone with interbedded fine lime mud. These limestones lack extensive secondary porosity. Some of the limestones are quite clean, very pale orange in color and have moldic and vuggy porosity.

Suwannee Limestone

The upper boundary of the Suwanee Limestone is marked by a change from the light gray, sandy, phosphatic limestones of the Hawthorn Group to a tan, phosphate free, calcarenitic limestone of the Suwannee formation. The contact between the two formations is also characterized by an abrupt attenuation of activity on natural gamma ray logs. Although the contact between the Hawthorn Group and the Suwannee Limestone is unconformable throughout much of South Florida (Scott, 1988), in the study area the contact can be somewhat gradational and is not always obvious in the field. The present study utilized a combined review of geologists logs and geophysical logs to determine the depth of the contract.

The Suwannee Limestone is composed of Oligocene-age rocks ranging from unlithified lime muds, to well-consolidated dolomites. The characteristic lithology of the Upper Suwannee Limestone is a very pale orange or light tan biomicrite to biosparite (packstone to grainstone) having a medium grained calcarenite texture. Typically, they are moderately indurated and are composed of moderately to well sorted foraminifera, pellets, and abraded echinoderm and

mollusk fragments. Porosity is mostly intergranular in the calcarenities and is relatively high in the Upper Suwannee Aquifer. The Lower Suwanee Aquifer is composed of interbedded limestones and carbonate muds. Limestones in the lower unit are similar to those in the upper unit but typically contain more lime mud and fine grained phosphatic clastic material. Rock types range from mudstones to packstones and porosity is much reduced but variable in the Lower Suwannee Aquifer. This interbedded sequence shows elevated activity on gamma ray logs.

Ocala Group

The contact between the Ocala Group and the overlying Suwannee Limestone is marked by a change from the tan calcarenite limestones and interbedded clays of the Lower Suwannee Limestone, to the very pale orange, chalky coquinoid limestone of the Ocala Group, accompanied by a slight reduction of activity on gamma ray logs.

The Ocala Group is an Upper Eocene-age unit composed primarily of light gray micrites and biomicrites (mudstone to packstones). These limestones exhibit a broad range of textural fabrics ranging from very fine grained, chalky muds to coquinea-like grainstones. The Ocala Group is characterized by an abundance of larger foraminifera tests such as Operculinoides sp., Nummulites sp. and Lepidocyclina sp., sometimes comprising the entire rock. The Ocala was

subdivided into three distinct units by Puri (1957) when it was elevated to Group status. These three formations are not readily apparent in the subsurface of the study area. Detailed paleontological work, which was beyond the scope of this study could provide further subdivisions of the Ocala Group in the study area based on faunal differences.

Avon Park Limestone

The Middle Eocene age Avon Park Limestone consists of interbedded limestones and dolomites. The lithology at the top of the unit is predominantly a hard, light brown, finely crystalline to sucrosic dolomite which contrasts to the overlying white, chalky limestones of the Ocala Group. Porosity in the Avon Park Limestone is extremely variable because of variations in depositional textures, which range from mudstones to grainstones (Puri and Winston, 1974), degree of recrystallization of the dolomite, and degree of secondary dissolution. Thickness of the Avon Park Limestone ranges from 250 to 500 feet beneath South Florida (Missimer, 1984). Approximately 260 feet of interbedded limestones and dolomites of the Avon Park Limestone were penetrated before reaching a total depth of 1,608 feet in the Manatee Road well. It is believed that the Avon Park was never reached in the 1616 feet deep water treatment plant well. It is believed that a thicker Hawthorn section in this well

indicates a structural low in this area from at least early Avon Park time through most of the Hawthorn time.

2. Hydrology

A. Aquifer and Confining Bed Description

There are numerous aquifers and confining units underlying the study site (refer to hydrogeologic column, Figure 7). As the upper aquifers contain water with fairly high salinity, and in the case of the Manatee Road well a low transmissivity, only aquifers and confining units that will potentially affect the goals of this project will be described herein.

Confining Beds Between the Surficial Aquifer System and the Hawthorn Zone I Aquifer

There is considerable confinement between the water-table aquifer and the Hawthorn Zone I. The confining beds are about 200 feet thick and occur at 150 to 350 feet below land surface. They are composed of an olive-green clay to dolosilt, phosphatic, and minor limestone beds.

Hawthorn Aquifer System Zone I

The Hawthorn Zone I Aquifer occurs between 350 and 430 feet below land surface. The aquifer consists of a clayey,

phosphatic limestone, somewhat vuggy. It is thought to be a low yield zone.

Confining Beds Between the Hawthorn Aquifer System Zone I and Hawthorn Aquifer System Zone II

The confining strata separating the Hawthorn Zone I and the Hawthorn Zone II Aquifer lies within the Arcadia Formation. The unit consists of approximately 45 feet of marly limestone occurring between 430 and 475 feet below land surface. Permeability in this unit is low.

Hawthorn Aquifer System Zone II

Hawthorn Aquifer System Zone II occurs in a permeable limestone in the Arcadia Formation. The Hawthorn Zone II Aquifer occurs between depths of 475 and 535 feet below land surface and consists of limestone, sandstone, and dolomite. The aquifer is generally characterized by moderate permeability. Beneath the project site, however, a high flow zone, indicating high permeability was found to occur between 475 and 500 feet below land surface. It is in this zone that the Aquifer Storage and Recovery (ASR) project is to be constructed.

Confining Beds Between Hawthorn Zone II and Zone III

The confining beds separating Hawthorn Zones II and III occur between 535 and 565 feet below land surface and consists of interbedded lime mud and marly limestone.

Hawthorn Aquifer System Zone III

The Hawthorn Zone III Aquifer occurs between 565 and 635 feet below land surface. The aquifer consists of 70 feet of limestone and is generally characterized as being a low yield aquifer.

Confining Beds Between Hawthorn Zone III and the Floridan Aquifer System

The confining beds between Hawthorn Zone III and the upper Floridan Aquifer occur between 635 and 680 feet below land surface and consist mainly of carbonate lime muds and dolomite. The lime mud sequence is about 45 feet thick and has a low permeability.

Floridan Aquifer System

The top of the Floridan Aquifer System occurs at 680 feet below land surface. It is one of the most productive aquifers in the United States and underlies all of Florida and portions of Alabama, Georgia, and South Carolina for a total area of about 100,000 mi^2. It consists of an extensive sequence of thickly bedded Tertiary Age carbonate rocks that are hydraulically connected in various degrees to form a regional aquifer system. The system includes permeable sediments of the lower part of the Hawthorn Group, the Suwannee Limestone, the Ocala Group, the Avon Park Limestone, and the Oldsmar Limestone. The base of the system is generally placed at the top of the first occurrence of

evaporite beds in the Oldsmar Limestone, and the top of the system is placed at the bottom of the Lower Hawthorn confining unit.

Attempts have been made in previous studies to identify individual aquifers occurring in the Floridan Aquifer System. For this report delineation of individual aquifers is accomplished based on formational boundaries, lithologic variations at boundaries and within the formation, and water quality changes with depth where confinement was indicated. The term aquifer is used herein to denote all permeable beds containing significant amounts of water within the designated formation (e.g. Ocala Aquifer denotes all permeable beds occurring within the Ocala Group).

Confining horizons within the Floridan Aquifer System in Collier County range greatly in thickness and vertical conductivity. A thin, limey clay may provide a higher degree of confinement than a much thicker bed of marly limestone. Often, a confining sequence consists of competent limestone but which is relatively much lower in hydraulic conductivity than adjacent limestone aquifer units. Vertical fractures and solution features may locally be present within the confining beds, resulting in a higher degree of hydraulic connection between the juxtaposed aquifers. Description of these confining units in this report are strictly qualitative, based on the units lithology and geophysical log characteristics.

Lower Hawthorn Aquifer

The Lower Hawthorn Aquifer is composed primarily of fossiliferous and sometimes dolomitic micrites and biomicrites (wackestones to packstones) ranging in color from very pale orange to yellowish-gray. These limestone typically contain some quartz silt or sand and are characterized by a high phosphate content. Porosity is primarily moldic and intergranular ranging from slightly porous to very porous. Like other units of the Hawthorn Group, the Lower Hawthorn Aquifer exhibits high activity on natural gamma-ray logs. The thickness of the Lower Hawthorn Aquifer at the Manatee Road site is about 90 feet. This zone is the alternate ASR target.

Confining Beds Between the Lower Hawthorn and the Suwannee Aquifer

Confinement between the Lower Hawthorn Aquifer and the Suwannee Aquifer is quite marginal. Depth to the top of the confining beds is about 780 feet below land surface. Thickness of the confining beds is slightly greater than 150 feet in the Manatee Road area. The confining unit consists of interbedded carbonate clays, marls, and limestones or dolomites of variable permeability. As such, the actual degree of confinement between the two aquifers is thought to be rather poor. In other areas, the hydraulic connection between the two zones is reported to be quite good. A possible thin higher flow zone near the center of the

confining unit was tentatively identified in the resistivity log.

Suwannee Aquifer

The Suwannee Aquifer occurs between 935 and 1022 feet below land surface. The aquifer consists of almost 90 feet of light gray to pale orange limestone. It has moldic and vuggy porosity but also some clay and phosphatic sands which results in a moderate transmissivity overall.

Confining Beds Between the Suwannee Aquifer and the Ocala Aquifer

The confining beds separating the Suwannee and Ocala Aquifers occur between 1022 and 1100 feet below land surface and consists of gray limestones and interbedded clays and phosphatic silts and sands.

Ocala Aquifers

Two thin zones (about 40 feet thick) of moderate porosity occur in the upper Ocala Group. Both these zones consists of gray to very pale orange limestone with secondary vuggy porosity.

Confining Beds Between the Ocala Aquifer and the Avon Park Aquifer

The confining beds between the Ocala and Avon Park aquifers occur between 1220 and 1355 feet below land surface.

Lithology of this unit is a fairly consistent limestone, pinkish-gray to pale orange in color with some interbedded clays. The actual degree of confinement between the two aquifers is thought to be rather poor.

Avon Park Aquifers

The upper Avon Park Aquifer consists of 2 high yield sections separated by an approximately 100 feet thick semi-confining unit. The top of the upper aquifer occurs at a depth of 1355 to 1445 feet below land surface. Both aquifers are thought to have moderate porosity. They are composed of limestone, dolomitic limestone and dolomite.

V. AQUIFER STORAGE AND RECOVERY

1. Introduction

Aquifer Storage and Recovery (ASR) is a water management technique whereby underground aquifers are used as a reservoir to store excess water which will later be withdrawn for use. ASR is not a source of water but is a method of obtaining dry season peak demands. The major potential advantages for Collier County are as follows:

* Reduction of facilities expansion costs, typically exceeding 50 percent, by seasonal storage of treated water.
* Improved utility system reliability in the event of droughts or emergency loss of water sources, long transmission mains or other key facilities.

Due to climatic factors and the seasonal nature of water demand in Collier County, excess treated water would be made available during the wet season. Depending on availability and demand considerations, the water would potentially be injected into one or more of the aquifers underlying the county and be withdrawn during periods of high demand and otherwise limited availability of treated fresh water.

2. Technical Feasibility

In order for an ASR system to satisfy the requirements of the Florida Department of Environmental Regulation and other regulatory agencies, the injected water must be treated to meet the applicable water quality standards for the aquifer selected for storage. Presently, this requires treatment of the source water to potable standards of Chapter 17-550 FAC for any system proposing to store water within a G-2 aquifer. The source of the injected water will come directly from the county's water treatment plant approximately 8 miles to the north and will be stored in the existing tank at the Manatee Road site prior to injection.

After treatment and injection of the water, some mixing of the native water and stored water will occur, and the recovered water will usually contain some increased concentrations of constituents. At the beginning of the recovery process, the water quality is very near that of the injected water. However, with time the water quality will approach that of the native water. The first recovery period will generally show significant deterioration in quality; however, after each cycle, the recovery efficiency improves. The recovery efficiency of an ASR system is based on both the system design and certain hydraulic and dispersivity characteristics of the aquifer. Depending on dispersivity

parameters, the recovery efficiency can range between 80 and 95 percent after several injection/recovery cycles.

The suitability of an aquifer to function as a storage zone is dependent on a number of hydrogeologic factors. These factors affect the abilities of the zone to both receive injected water and to return the water to the user in the approximate quality at which it was injected.

The aquifer characteristic which measures its ability to receive and give up water in response to pressure changes is transmissivity. This characteristic is dependent on the thickness and permeability of the geologic formation. An aquifer having a high transmissivity receives and gives up water more easily or under less pressure than an aquifer having a low transmissivity. This would appear to indicate that for underground storage, a high transmissivity aquifer is preferred. However, transmissivity can be too high for ASR and cause the loss of a major portion of the injected fluid, because of excessive mixing with natural water, or because of migration of injected water beyond the point of recovery.

On the other hand, an aquifer having too low a transmissivity would require high pressure to recharge and high pumping lifts to withdraw water. Therefore, pumping costs would be high. Also, such an aquifer could become clogged more easily by suspended debris or chemical precipitation than one having a higher transmissivity.

The leakance coefficient of an aquifer is a measure of the amount of water entering or leaving the aquifer in a vertical direction through its upper and lower confining layers. In the case of injection of stored water, this factor affects the amount of water which may be lost from the system. In the case of recovery, the leakance factor not only affects the amount of poor quality water which enters the system from other aquifers, but also affects the extent of the cone of depression which recaptures the stored water.

3. Hawthorn Zone II Aquifer as a Storage Zone

The uppermost aquifer at the Manatee Road site which is considered for freshwater storage is the Hawthorn Zone II. This aquifer is fairly well confined and could be expected to retain most of the injected water. The zone has an estimated transmissivity of 150,000 to 200,000 gpd/ft. This value is on the high end of acceptable transmissivities. However, the Hawthorn Zone II is relatively thin (55 feet) and the background hydraulic gradient is low (about 1 ft/mile); two factors that favor recovery efficiency. Also effecting recovery efficiency is the difference between injected freshwater and the saline native water. As this difference becomes greater, recovery efficiency decreases because of increased buoyancy stratification. Native salinity in the Hawthorn Zone II is about 20 times higher than the injected

water, not a very large difference and should result in minor buoyancy stratification. The relative thinness of the injection zone will also limit the potential for stratification.

At this time, we do not know the amount of hydrodynamic dispersion within the Hawthorn Zone II Aquifer, a major factor limiting recovery efficiency. The recovery efficiency decreases as the level of dispersive mixing increases and as more freshwater combines with saline water (Merritt, et.al., 1983). More testing of this zone is needed to define its dispersivity characteristics.

4. Lower Hawthorn Aquifer as a Storage Zone

The Lower Hawthorn Aquifer was chosen as an alternate storage and recovery zone. It is sufficiently confined, has the desired transmissivity, but is almost twice as saline as the Hawthorn Zone II Aquifer. This higher salinity and the fact that it is about 200 feet deeper than the primary zone, are the reasons why we consider this an alternate zone. Only if testing of the upper zone proves that it is not a viable choice will the Lower Hawthorn be considered.

5. Aquifer Storage and Recovery Well Design

The ASR well will be constructed to serve the dual function of injection and recovery. The pilot project involves injecting about 1.5 MGD potable water for, as yet, an unspecified time. Recovery will be at a similar rate. The technical procedure for drilling the production/injection well is as follows:

1) construct a cement pad to completely enclose the rig work area for control of saltwater (to prevent contamination of the water-table aquifer)

2) set-up drilling rig

3) drill a 40 foot +/- pilot hole

4) set and grout with neat cement, a 22-inch diameter steel surface casing to approximately 40 feet

5) drill an 8-inch nominal test hole by the rotary-mud method to a depth of approximately 470 feet +\-

6) ream the hole to a nominal diameter of about 22-inches to 100 feet and 18-inches to 470 feet

7) set approximately 100 feet +\- of 16-inch fiberglass casing to 100 feet with 370 feet of 12-inch fiberglass casing (reducer fitting between casings) and grout with neat cement

8) drill a nominal 12-inch diameter open hole by the reverse-air rotary method to a depth of approximately 520 feet

9) complete the wellhead

10) restore the site

11) all drilling fluids and well flows will be controlled to conform with regulations concerning discharge of saline water

Alternate Zone Construction

12) drill a nominal 12-inch diameter hole by the reverse-air rotary method to a depth of 730 feet +/-

13) set and grout with neat cement, an 8-inch diameter fiberglass liner extending from an approximate depth of 450 feet (inside 12-inch casing) to 675 feet +/-

14) assure the seal integrity between the 12-inch diameter casing and the 8-inch diameter liner.

Complete steps 9, 10 and 11 of above

Figure 8 illustrates construction details of the dual function injection and recovery well.

In addition to the ASR well, two observation wells will be constructed using standard rotary-mud drilling techniques. These wells will be open to the same interval as the ASR production well. Additionally, the previously constructed test well will be used as an observation well.

6. Testing

Initially, an aquifer performance test (APT) of up to 72-hours will be conducted using a turbine pump with a continuous pumping rate of up to 700 gpm. During this test, water samples will be taken periodically.

The APT will be followed by a series of injection and withdrawal cycles to verify the feasibility of using the Hawthorn Zone II for ASR purposes. These tests will be designed to maximize the gain in information within the

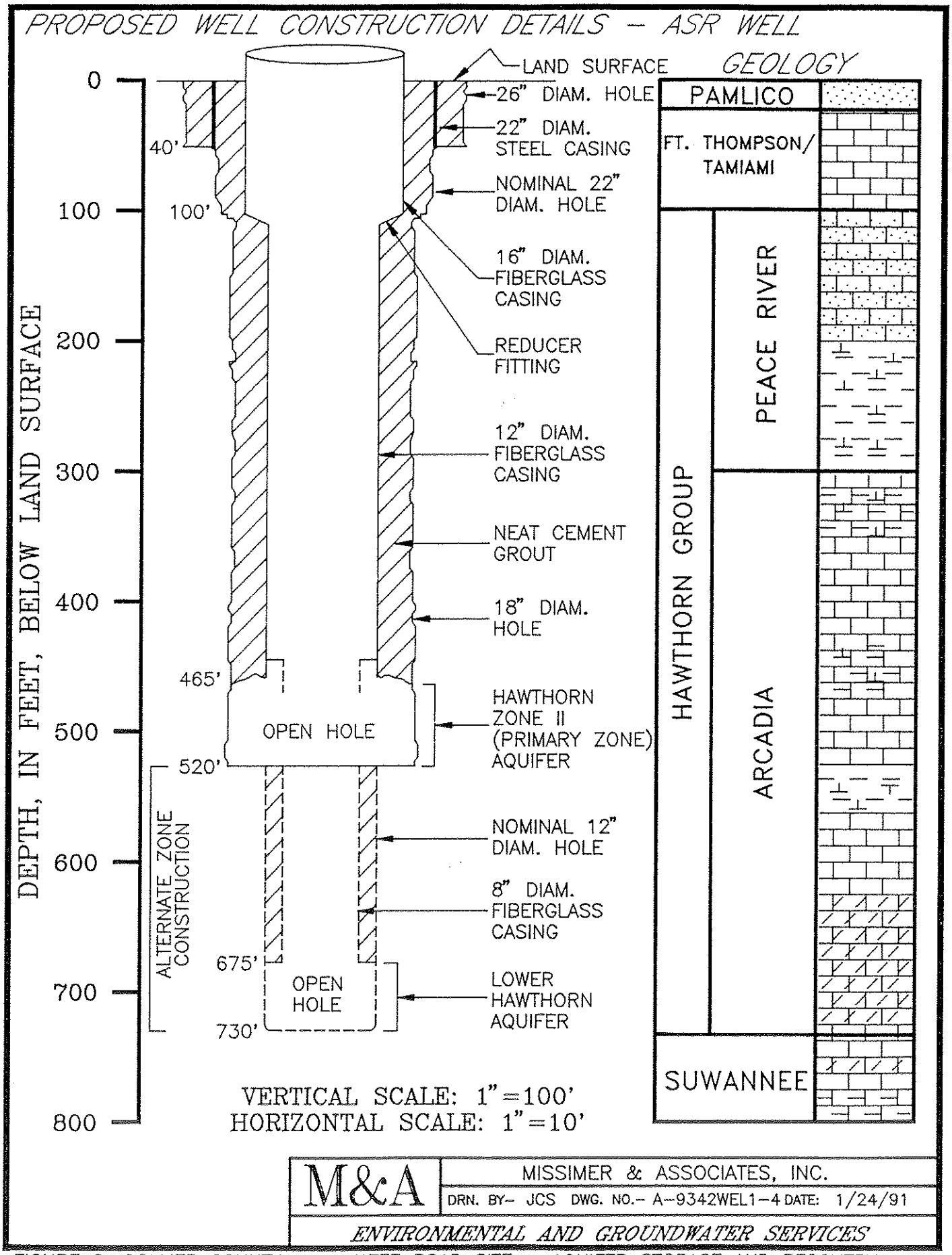

FIGURE 8. COLLIER COUNTY – MANATEE ROAD SITE – AQUIFER STORAGE AND RECOVERY.

permitting economic factors. The exact number of cycles and their duration is yet to be determined. This determination will be based on the results of the APT, computer modeling, and the desires of the permitting agencies.

7. Modeling/Wellfield Design

A series of hydraulic and solute transport models will be used to assess a number of problems. The capacity of the aquifer at the Manatee Road site to receive and yield water will be evaluated. The models will also be used to assess the number and location of possible ASR wells, and to assess the future changes in water quality. A model has begun to be developed for the aquifer storage and recovery well at the Manatee Road site to assess the potential maximum viable size of the system, to assess changes in the quality of water, and to assess movement of the freshwater stored.

The modeling effort will be used to design the final configuration of wells. Pumping or injection rates will be determined on the basis of physical realities and economics.

A preliminary model of injection and recovery of potable water into and from the Hawthorn Zone II Aquifer was created using the very limited amount of data available. The hydraulic flow and solute transport model was developed using the three-dimensional finite difference flow and transport code FTWORK (GeoTrans, 1990). This code was selected because

it solves the transport equations for a conservative solute subject to advection and dispersion and provides all the hydraulic flow features of the U.S. Geological Survey MODFLOW code (McDonald and Harbaugh, 1988). The FTWORK code simulates ground water flow, potentiometric heads, and solute concentrations using aquifer parameters for hydraulic conductivity, transmissivity, vertical leakance, storativity, specific yield, and longitudinal and transverse dispersivity. Flow and transport variables are posed in terms of hydraulic head and solute concentration.

The estimated parameters used in this model are as follows:

INPUT

Injection = 1.5 MGD for 210 days
Recovery = 1.5 MGD for 150 days
Model Dimensions = 2000 ft. x 2000 ft.
Aquifer Thickness = 55 feet
Steady-state flow under confined conditions
Injected water chloride ion concentration = 100 mg/l
Native aquifer water chloride ion concen. = 2000 mg/l
Aquifer Transmissivity = 150,000 gpd/ft
Aquifer Porosity = 0.25
Longitudinal Dispersivity = 50 ft.
Transverse Dispersivity = 5 ft.
Retardation Factor = 1

OUTPUT

Chloride concentration at 420 nodes spaced 100 ft apart at time = 30, 60, 90, 120, 150, 180, and 210 days (injection) and 30, 60, 90, 120 and 150 days (recovery)

Hydraulic heads at 420 nodes at time = 0 days and 210 days

Eight observation wells located along a line 100 ft to 800 feet from ASR well - Monitored at 5 day intervals for 365 days for chloride ion concentration and hydraulic heads

Figure 9 is a plot of time versus chloride ion concentration for each of the simulated observation wells. This model attempts to compute hydraulic heads and chloride concentrations, for the initial injection/withdrawal cycle. From this same figure, is can be seen that recovery efficiency will improve with successive cycles, if each simulated withdrawal phase is stopped when withdrawn water reaches a selected limiting salinity value. For example, the first cycle model predicts that chloride concentration will increase to 250 mg/l after withdrawal for 45 days at 1.5 MGD. This relates to an initial recovery efficiency of about 20 percent. It must be remembered that the variables used in the model are only approximations. As testing proceeds, the new data will be incorporated into the new models.

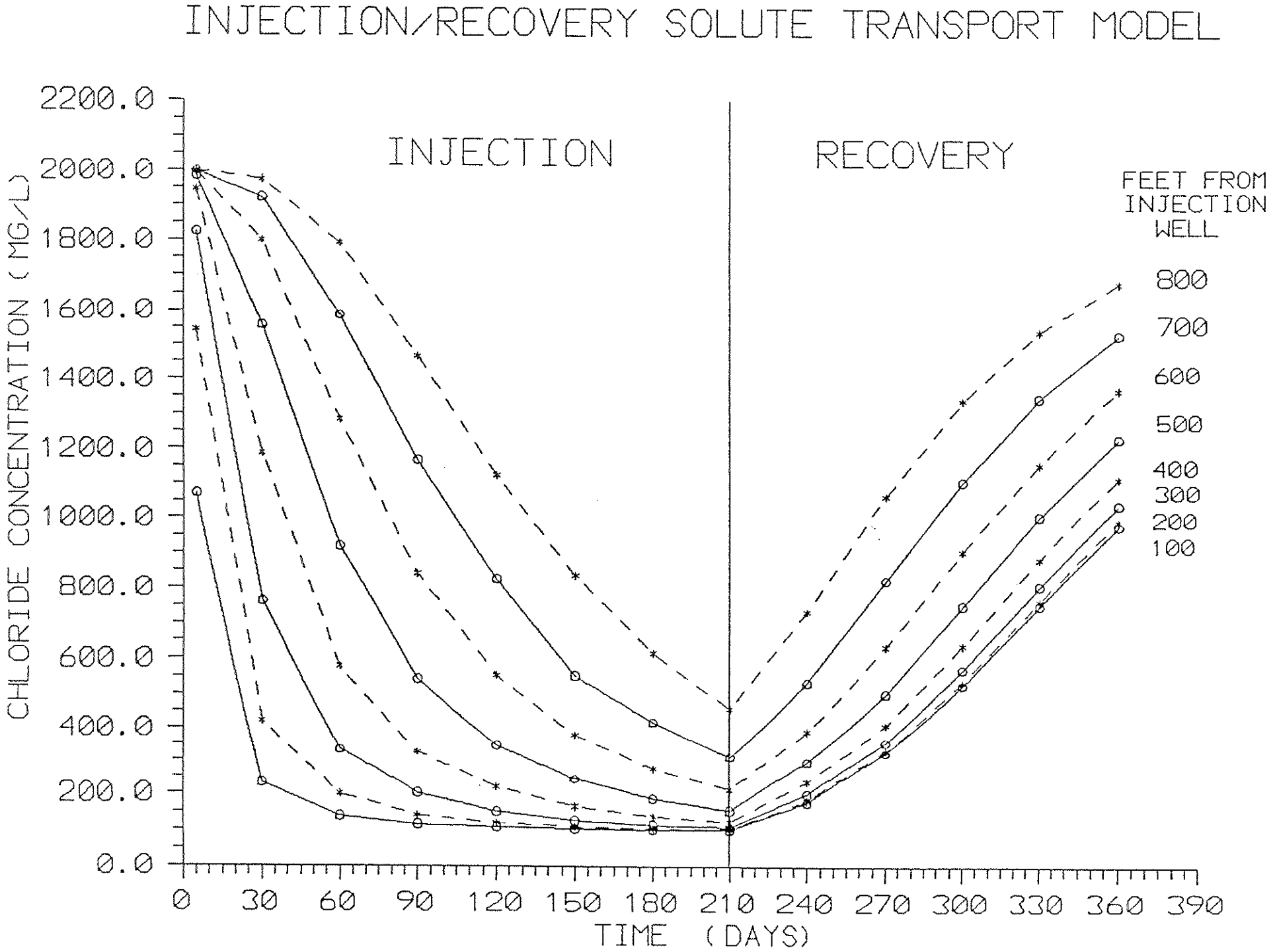

FIGURE 9. GRAPH OF CHLORIDE CONCENTRATION VS. TIME AND DISTANCE FROM INJECTION WELL BASED ON COMPUTER ANALYSIS OF INJECTION/RECOVERY

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APPENDICES

APPENDIX A

WATER QUALITY ANALYSIS RESULTS AND CORRESPONDENCE FROM COLLIER COUNTY UTILITIES

COLLIER COUNTY GOVERNMENT

UTILITIES DIVISION
WATER AND WASTEWATER SERVICES

2800 NORTH HORSESHOE DRIVE
NAPLES, FL 33942
(813) 643-8480

A CERTIFIED BLUE CHIP COMMUNITY

January 18, 1991

Mr. Buzz Walker
Missimer and Associates, Inc.
Rt. 8, Box 625-D
Cape Coral, Florida 33909

RE: Tac Committee Requirements

Dear Buzz:

Enclosed please find seven (7) copies of the aerial photographs of the Manatee Road site as 24" x 36" prints. Also included is a copy of the finished water analysis for our system (also comparison to the Golden Gate system but that should be deleted) and the THM analysis. As for the present facilities on the Manatee Road site, we have a 2 MG Crom concrete storage tank and a smaller Crom tank that has been converted into a finished water pumping station. Our intent, should an ASR project prove feasible at this site, is to add a chloramine disinfection system to this station so that we can maintain turn-over of water in the tanks and disinfection throughout the system. Disinfection could also be done on the ASR water should it prove necessary. Previously there were seven (7) surface water wells on the site, but I believe all have been plugged. The previous water plant owned by Capri Water Works, was dismantled when the pump station was built. The post-recovery treatment we hope would not extend beyond disinfection, although as you are aware Mike Newman suspects there may be some need for filtering this water should the TDS be too high. I think we should shoot for a maximum acceptable recovery TDS and chlorides would be a value that is 75% of the Safe Drinking Water Act requirements (all the Safe Drinking Water Act requirements are shown on the enclosed water analysis). Most other items we would not want to have exceed about 75% so that should some odd-ball water sample come up in the ASR well, we would not create a problem throughout our system.

During the summer months of June, July, August and September, we would have at least 1.5 MG each day to pump into the ASR well and probably have up to 1 MGD through mid-November. We would hope to be able to recover at least the 1.5 MGD during the March, April and May time period and perhaps more. You indicated that we might perhaps be able to get 2 or 2.5 MGD out of a well that we are pumping 1.5 MGD into. This would significantly help us. As to a monthly and yearly basis, approximately 45 MG during the summer, and a total in the summer and fall exceeding 200 MG should be available. Should you have any further questions, please let us know.

Very truly yours,

Fred Bloetscher, P.E.
Assistant Utilities Administrator

FB:smc

Attachments

cc: Michael K. Arnold, Utilities Administrator
C. W. Temby, Utilities Engineering Director
Michael R. Newman, Water Department Director

APPENDIX

FINISHED WATER ANALYSIS
AS COMPARED TO SAFE DRINKING WATER ACT
(expressed as mg\l)

SUBSTANCE	COLLIER CO.	GOLDEN GATE (Not Applicable)	SDWA-EPA REQ
Endrin	ND	NA	0.0002
Lindane	ND	NA	0.004
Methoxychlor	ND	NA	0.1
Tozaphene	ND	NA	0.005
2,4-D	ND	NA	0.1
2,4,5-TP (Silvex)	ND	NA	0.01
Arsenic	ND	ND	0.05
Barium	ND	0.1	1.0
Cadmium	ND	ND	0.01
Chromium	ND	0.02	0.05
Flouride	0.97	1.3	4.0
Lead	ND	ND	0.05
Mercury	ND	ND	0.002
Nitrate (as N)	ND	0.24	10.0
Selenium	ND	ND	0.01
Silver	ND	ND	0.05
Sodium	45	65	160.0
Calcium (as CaCO3)	34	166	no standard
Chloride	50	103	250.0
Copper	ND	ND	1.0
Total Hardness	75	NA	no standard
Iron	ND	ND	0.3
Manganese	0.018	ND	0.05
Sulfate	17	88	250.0
Zinc	ND	ND	5.0
Carbon Dioxide	ND	NA	no standard
Color	10 parts	7 parts**	15 parts
Odor	ND	ND	3 TON
pH (min.)	8.6	8.5	6.5
Total alkalinity	78	20	no standard
Total Dissolved Solids	210	488	500.0
Langlier Index	8.51	.06	no standard
Foaming Agents	ND	.02	0.5
Corrosivity	0.2	NA	+\- 0.2
Turbidity	ND	.63 NTU**	1.0 NTU
Ethylene Dibromide	ND	ND	0.00002

NOTES: * Sample does not meet SDWA requirementsas per EPA regulations
** Sample meets SDWA requirements, but other samples on monthly reports have failed this parameter
NA Data Not Available for this parameter
ND Substance was Not Detected in analysis

APPENDIX
(continued)

SUBSTANCE	COLLIER CO.	GOLDEN GATE	SDWA-EPA REQ
p-Dichlorobenzene	ND	ND	0.075
Vinyl Chloride	ND	ND	0.001
1,1-Dichloroethene	ND	ND	0.003
1,2-Dichloroethane	ND	ND	0.003
1,1,1-Trichloroethane	ND	ND	0.2
Carbon Tetrachloride	ND	ND	0.003
Trichloroethene	ND	ND	0.003
Tetrachloroethene	ND	ND	0.003
Benzene	ND	ND	0.001
Chloromethane	ND	ND	detection
Dichlorodiflouromethane	ND	ND	detection
Bromomethane	ND	ND	detection
Chloroethane	ND	ND	detection
Trichloroflouromethane	ND	ND	detection
trans-1,3-dichloropropene	ND	NA	detection
cis-1,3-dichloropropene	ND	ND	detection
Methyl-tert-butyl-ether	ND	ND	detection
cis-1,2-dichloroethene	ND	ND	detection
Dibromomethane	ND	ND	detection
1,1-dichloropropene	ND	ND	detection
1,3-dichloropropane	ND	ND	detection
1,2,3-trichloropropane	ND	ND	detection
Chloroform	ND	ND	detection
Bromoform	ND	ND	detection
Bromochloromethane	ND	ND	detection
Dibromochloromethane	ND	ND	detection
p-xylene	ND	ND	detection
Methylene Chloride	ND	ND	detection
o-chlorotoluene	ND	ND	detection
p-chlorotoluene	ND	ND	detection
m-dichlorobenzene	ND	ND	detection
o-dichlorobenzene	ND	ND	detection
1,1-dichloroethane	ND	ND	detection
trans-1,2-dichloroethylene	ND	ND	detection
1,2-dichloropropane	ND	ND	detection
1,1,2-trichloroethane	ND	ND	detection
1,1,1,2-tetrachloroethane	ND	ND	detection
1,1,2,2-tetrachloroethane	ND	ND	detection
Chlorobenzene	ND	ND	detection
Toluene	ND	ND	detection

NOTES: * Sample does not meet SDWA requirementsas per EPA regulations
** Sample meets SDWA requirements, but other samples on monthly reports have failed this parameter
NA Data Not Available for this parameter
ND Substance was Not Detected in analysis

APPENDIX
(Continued)

SUBSTANCE	COLLIER CO.	GOLDEN GATE	SDWA-EPA REQ.
Ethylbenzene	ND	ND	detection
Bromobenzene	ND	ND	detection
m-xylene	ND	ND	detection
Styrene	ND	ND	detection
o-xylene	ND	ND	detection
Dalapon	ND	ND	detection
Oxyamyl	ND	ND	detection
Simazine	ND	ND	detection
Pinchloram	ND	ND	detection
Dinoseb	ND	ND	detection
Aldicarb Sulfoxide	ND	ND	detection
Aldicarb Sulfone	ND	ND	detection
Metolachlor	ND	ND	detection
Carbofuran	ND	ND	detection
Aldicarb	ND	ND	detection
Atrazine	ND	ND	detection
Alachlor (lasso)	ND	ND	detection
Heptachlor	ND	ND	detection
Aldrin	ND	ND	detection
Dieldrin	ND	ND	detection
Dicamba	ND	ND	detection
Chlordane	ND	ND	detection
Pentachlorophenol	ND	ND	detection
Hexachlorocyclopentadiene	ND	ND	detection
Dioxin	ND	ND	detection
Isophorone	ND	ND	detection
2,4-dinitrotoluene	ND	ND	detection
Dimethylphthalate	ND	ND	detection
Diethylphthalate	ND	ND	detection
Di-n-butylphthalate	ND	ND	detection
Butyl-benzyl-phthalate	ND	ND	detection
Bis(2-ethyexly)-phthalate	ND	ND	detection
1,2,4-trichlorobenzene	ND	ND	detection
PCB-1016	ND	ND	detection
PCB-1221	ND	ND	detection
PCB-1232	ND	ND	detection
PCB-1248	ND	ND	detection
PCB-1254	ND	ND	detection
PCB-1260	ND	ND	detection

NOTES: * Sample does not meet SDWA requirementsas per EPA regulations
** Sample meets SDWA requirements, but other samples on monthly reports have failed this parameter
NA Data Not Available for this parameter
ND Substance was Not Detected in analysis

APPENDIX
(Continued)

SUBSTANCE	COLLIER CO.	GOLDEN GATE	SDWA-EPA REQ.
Dioctylphthalate	ND	ND	detection
2-chlorophenol	ND	ND	detection
2 methyl-4,6-dinitrophenol	ND	ND	detection
Phenol	ND	ND	detection
2,4,6-trichlorophenol	ND	ND	detection
Gross Alpha(Radionucleide)	ND	6.5 pCi*	5.0 pCi

NOTES: * Sample does not meet SDWA requirementsas per EPA regulations
** Sample meets SDWA requirements, but other samples on monthly reports have failed this parameter
NA Data Not Available for this parameter
ND Substance was Not Detected in analysis

Envirolab, Inc.
1042 U.S. Highway 1 • P.O. Box 607
Ormond Beach, Florida 32174 • (904) 672-5668

Drinking Water Certification
HRS #83160

Environmental Certification
HRS #E83079

COLLIER COUNTY UTILITIES

2800 N. HORSESH OE DR.
NAPLES FL 33942
ATTN: JOHN AUGUSTINE

escription: 4 Samples Received on 10/18/90

Sampled By: CLIENT

Client Job/PO Number: 100348

eference Number: 917934
Invoice Number: 91-7934

Reported Date : 10/31/90

ample	Description	Client Id
0001		LELY SALES CENTER
)002		810 GULF PAVILLION
)003		THE HAMMOCKS
0004		CAPRI FIRE DEPT.

PARAMETER		SAMPLE NUMBER 0001	0002	0003	0004
ROFILE: TRIHALOMETHANES					
..OMODICHLOROMETHANE	UG/L	2.6	2.4	2.6	3.5
BROMOFORM	UG/L	< 1	< 1	< 1	< 1
LOROFORM	UG/L	13.2	12.0	12.8	12.4
BROMOCHLOROMETHANE	UG/L	< 1	< 1	< 1	< 1
TOTAL TRIHALOMETHANE	UG/L	15.8	14.4	15.4	15.9

APPROVED BY:

Michael C. Price
Laboratory Manager

APPENDIX B

GEOLOGIST'S LOGS OF WELLS CO-2080 AND CO-2081

GEOLOGIST'S LOG OF WELL CO-2080

Depth (feet)	Description
0 - 5	Sandy soil, tan and brown, silty, common organics, occasional limestone fragments.
5 - 10	Sand, moderate brown 5YR 4/4, fine to medium grain, clayey, minor limestone fragments and organic material.
10 - 15	Sand, tan to light gray, fine, clayey, low to moderate permeability, common limestone fragments.
15 - 25	Limestone, light gray N-7, minor shell (bivalves), medium hard, moderate to high permeability.
25 - 30	Limestone, light gray N-7, medium hard, common shell, high permeability.
30 - 37	Limestone, light gray N-7, medium hard, abundant shell, moderate to high permeability.
37 - 43	Limestone, medium gray N-5, hard with a few soft lenses, abundant shell, moderate permeability.
43 - 60	Limestone, light gray N-7, medium hard, abundant shell-gastropods and bivalves, moderate permeability.
60 - 74	Limestone, pinkish gray 5YR 8/1, medium hard, common shell and fossil, moldic, vuggy.
74 - 84	Limestone, white N-9 to light gray N-7, sandy, soft to medium hard, common shell and fossil, moldic, vuggy.
84 - 94	Limestone, very pale orange 10YR 8/2, soft to medium hard, very sandy, casts and molds, occasional shell.
94 - 104	Limestone, very pale orange 10YR 8/2, soft to medium hard, sandy, casts and molds, common shell, finely phosphatic.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
104 - 114	Limestone, very pale orange 10YR 8/2, soft, very sandy, occasional shell, finely phosphatic.
114 - 125	Limestone, very pale orange 10YR 8/2, medium hard, sandy, moldic, friable, occasional shell, finely phosphatic.
125 - 135	Limestone, very pale orange 10YR 8/2, soft to medium hard, sandy, occasional shell, finely phosphatic.
135 - 145	Limestone, yellowish gray 5Y 8/1, medium hard, sandy, common shell and fossil, casts and molds.
145 - 155	Limestone, medium dark gray N-4, hard, common shell, minor clay interbedding.
155 - 165	Limestone, medium gray N-5, medium hard, vuggy, common shell fragments, minor clay, minor coarse quartz sand.
165 - 175	Sandy limestone, pinkish gray 5YR 8/1, medium hard, common shell fragments, vuggy, casts and molds, common coarse quartz sand.
175 - 185	Sandy limestone, as above with abundant coarse quartz sand.
185 - 195	Limestone as above.
195 - 205	Limestone, medium gray N-5, medium hard, common shell and sand, common green clay.
205 - 215	Clay, grayish olive green 5GY 3/2, soft, minor shell and rock material.
215 - 225	Clay, as above.
225 - 235	Clay, grayish olives green 5GY 3/2, soft, minor shell and rock fragments.
235 - 249	Clay, grayish olive green 5GY 3/2, soft, fine phosphate interbedding, minor shell and rock fragments.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
249 - 255	Clay, grayish olive green 5GY 3/2, soft, phosphatic, minor white phosphatic marl interbedded.
255 - 260	Clay, as above.
260 - 270	Clay, grayish blue green 5BG 5/2, finely phosphatic, common shell fragments, common coarse phosphate nodules.
270 - 280	Clay, pale blue 5B 6/2, soft, finely phosphatic, minor shell and coarse phosphate fragments.
280 - 290	Clay, pale blue 5B 6/2, soft, sticky, finely phosphatic, trace shell and coarse phosphate.
290 - 300	Clay, as above.
300 - 310	Limestone, white N-9 to light gray N-7, hard, well indurated, common shell fragments, casts and molds, finely phosphatic.
310 - 320	Limestone, as above but interbedded with minor soft clay.
320 - 330	Limestone, white N-9 to very pale orange 10YR 8/2, medium hard, phosphatic, moldic, occasional shell and fossil, minor clay.
330 - 340	Limestone, white N-9 to light gray N-7, medium hard, common shell and fossil, moldic, vuggy, finely phosphatic.
340 - 350	Limestone, white N-9 to very pale orange 10YR 8/2, soft to medium hard, sandy, phosphatic, occasional shell.
350 - 360	Limestone, white N-9 to very pale orange 10YR 8/2, soft to medium, sandy, finely phosphatic, occasional shell, moldic, vuggy, friable.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
360 - 370	Limestone, very pale orange 10YR 8/2, medium hard, casts and molds, common shell and fossil, trace clay.
370 - 380	Limestone, as above.
380 - 390	Limestone, very pale orange 10YR 8/2, medium hard, moldic, vuggy, finely phosphatic, occasional shell and fossil, trace clay.
390 - 400	Limestone, very pale orange 10YR 8/2, medium hard, common shell and fossil, casts and molds, vuggy, finely phosphatic.
400 - 410	Limestone, very pale orange 10YR 8/2, soft to medium hard, friable, occasional shell and fossil, finely phosphatic, minor clay.
410 - 421	Limestone, very pale orange 10YR 8/2, soft to medium hard, occasional shell and fossil, finely phosphatic, trace clay.
421 - 432	Limestone, very pale orange 10YR 8/2, soft to medium hard, friable, sandy, occasional shell and fossil, moldic, finely phosphatic.
432 - 442	Limestone, as above with minor clay.
442 - 452	Limestone, very pale orange 10YR 8/2, medium hard, common shell, minor phosphate, common clay interbedded from 447-452.
452 - 462	Limestone, very pale orange 10YR 8/2, medium hard, common shell and fossil, marl and clay interbedded.
462 - 465	Limestone, very pale orange 10YR 8/2, medium hard, sandy, casts and molds, abundant shell.
465 - 475	Limestone, very pale orange, 10YR 8/2, medium hard to hard, moldic, common shell and fossil, minor well rounded elliptical quartz disks.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
475 - 480	Limestone, very pale orange, 10YR 8/2, medium hard, well indurated, moldic, common shell and brachiopod, occasional conchoidal fracture.
480 - 490	Limestone, very pale orange, 10YR 8/2, medium hard, moldic, minor shell.
490 - 510	Limestone, very pale orange, 10YR 8/2, medium hard, moldic, vuggy, common shell, and fossil including coral and gastropods.
510 - 520	Limestone, as above.
520 - 530	Limestone, very pale orange, 10YR 8/2, medium hard to hard, occasional shell, minor gray phosphatic lime mud.
530 - 540	Limestone, as above.
540 - 545	Limestone, yellowish-gray, 5Y 7/2, soft, minor shell, common gray phosphatic lime mud.
545 - 550	Lime mud, very light gray, N-8, minor limestone interbedded.
550 - 555	Lime mud, light olive-gray, 5Y 6/1, partially lithified, finely phosphatic.
555 - 557	Lime mud, as above.
557 - 560	Limestone, white N-9, soft, finely phosphatic, minor calcitic shell, common lime mud interbedded.
560 - 565	Limestone and lime mud, as above, except with increasing phosphate.
565 - 580	Limestone, white N-9 to very pale orange, 10YR 8/2, medium hard to soft, occasional shell, minor phosphatic lime mud interbedded.
580 - 595	Limestone, very pale orange, 10YR 8/2, medium hard, finely phosphatic, minor shell and fossil.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
595 - 617	Limestone, pinkish-gray, 5YR 8/1, soft to medium hard, minor shell.
617 - 620	Limestone, as above, except with minor amounts of phosphate nodules.
620 - 625	Lime mud, yellowish-gray, 5Y 8/1, phosphatic, partially lithified.
625 - 630	Lime mud, yellowish-gray, 5Y 8/1, phosphatic, minor limestone interbedded.
630 - 645	Lime mud, light olive-gray, 5Y 6/1, phosphatic, minor limestone interbedded.
645 - 650	Dolomite, light olive-gray, 5Y 5/2, hard, low apparent permeability, minor phosphate nodules.
650 - 655	Clay, light olive-gray, 5Y 6/1, soft, sticky, phosphatic, abundant limestone fragments.
655 - 660	Clay and limestone fragments, as above.
660 - 665	Limestone, very pale orange, 10YR 8/2, medium hard, casts and molds, fossiliferous, phosphatic.
665 - 670	Limestone, very pale orange, 10YR 8/2, medium hard, moldic, phosphatic, interbedded with common hard gray sucrosic dolomite.
670 - 675	Limestone, as above.
675 - 680	Limestone, very pale orange, 10YR 8/2, medium hard, moldic, finely phosphatic, minor shell fragments, common dolomite (hard, gray, crystalline).
680 - 685	Dolomite, pale yellowish-brown, 10YR 6/2, very hard, well indurated, crystalline, finely phosphatic, common limestone and shell fragments.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
685 - 690	Dolomite, pale yellowish-brown, 10YR 6/2, hard, well indurated, common limestone and shell fragments.
690 - 695	Limestone, white N-9, hard, well indurated, moldic, common shell and fossil, minor dolomitization.
695 - 700	Limestone, as above.
700 - 705	Limestone, very pale orange, 10YR 8/2, medium hard, finely phosphatic, common dolomite interbedded.
705 - 711	Limestone and dolomite, as above.
711 - 716	Limestone, white N-9, soft to medium hard, slightly marly, interbedded with hard tan dolomite.
716 - 721	Limestone, very pale orange, 10YR 8/2, soft to medium hard, silty, finely phosphatic, minor dolomite.
721 - 726	Limestone, very pale orange, 10YR 8/2 to white N-9, medium hard, silty, moldic, vuggy, common shell and fossil, minor dolomite.
726 - 731	Limestone, very pale orange, 10YR 8/2, medium hard, phosphatic, sandy, casts and molds, minor shell and dolomite.
731 - 736	Limestone, as above.
736 - 743	Limestone, very pale orange, 10YR 8/2 to light gray N-7, medium hard, common white marl.
743 - 748	Limestone, very pale orange, 10YR 8/2, soft, sandy, friable, trace shell fragments.
748 - 753	Limestone, as above.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
753 - 758	Limestone, very pale orange, 10YR 8/2 to light gray N-7, soft to medium hard, moldic, common shell, trace hard green dolomite.
758 - 763	Limestone, as above.
763 - 768	Limestone, very pale orange, 10YR 8/2, soft, sandy, moldic, occasional shell fragments.
768 - 774	Limestone, as above.
774 - 779	Limestone, very pale orange, 10YR 8/2, soft to medium hard, silty, moldic, minor shell and fossil.
779 - 784	Limestone, very pale orange, 10YR 8/2, soft, very silty, friable.
784 - 789	Limestone, as above.
789 - 794	Limestone, very pale orange, 10YR 8/2, soft to medium hard, very silty, friable, trace shell.
794 - 806	Limestone, as above.
806 - 811	Limestone, very pale orange, 10YR 8/2, soft, friable, silty, minor marl.
811 - 816	Limestone, as above, except no marl.
816 - 821	Limestone, very pale orange, 10YR 8/2, medium hard, well indurated, moldic, vuggy, silty, occasional shell and fossil.
821 - 837	Limestone, very pale orange, 10YR 8/2, soft to medium hard, silty, vuggy.
837 - 842	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, very sandy/silty.
842 - 847	Limestone, as above.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
847 - 852	Limestone, very pale orange, 10YR 8/2, medium hard to hard, well indurated, moldic, vuggy, occasional shell and fossil.
852 - 857	Limestone, pinkish-gray, 5YR 8/1, soft to medium hard, friable, sandy.
857 - 868	Limestone, as above.
868 - 873	Limestone, very pale orange, 10YR 8/2, soft to medium hard, sandy, casts and molds, minor shell.
873 - 883	Limestone, as above.
883 - 888	Limestone, pinkish-gray, 5YR 8/1, medium hard, moderately well indurated, sandy, casts and molds, minor shell.
888 - 893	Limestone, very pale orange, 10YR 8/2, soft, silty, friable.
893 - 900	Limestone, pinkish-gray, 5YR 8/1, soft to medium hard, sandy, moldic, occasional shell.
900 - 905	Limestone, pinkish-gray, 5YR 8/1, hard, well indurated, micritic matrix, minor shell fragments, trace clay.
905 - 910	Limestone, medium gray, N-5, medium hard, moderately well indurated, casts and molds, minor shell.
910 - 915	Limestone, very pale orange, 10YR 8/2, medium hard, silty, vuggy, minor shell and fossil.
915 - 920	Lime mud, very pale orange, 10YR 8/2, soft, common limestone, interbedded.
920 - 925	Limestone, pinkish-gray, 5YR 8/1, soft to medium hard, casts and molds, silty, minor shell and fossil.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
925 - 932	Limestone, yellowish-gray, 5Y 8/1, medium hard, casts of molds, occasional shell.
932 - 937	Limestone, very pale orange, 10YR 8/2, soft, silty, friable, interbedded with occasional tan dolosilt.
937 - 942	Limestone, as above with only minor dolosilt.
942 - 947	Limestone, pinkish-gray, 5YR 8/1, medium hard, moldic, minor shell fragments, silty.
947 - 952	Limestone, very pale orange, 10YR 8/2, sandy, medium hard to soft, minor dolosilt.
952 - 957	Limestone, very pale orange, 10YR 8/2, sandy, medium hard, casts and molds, common shell and fossil.
957 - 963	Limestone, pinkish-gray, 5YR 8/1, sandy-silty, medium hard, casts and molds, vuggy, common shell and fossil.
963 - 968	Limestone, yellowish-gray, 5Y 8/1, soft to medium hard, moldic, vuggy, occasional shell and fossil, minor white phosphatic clay.
968 - 973	Limestone, pinkish-gray, 5YR 8/1, soft to medium hard, moldic, vuggy, occasional shell and fossil, minor white phosphatic clay.
973 - 978	Limestone, as above, with common shell and fossil and no clay.
978 - 980	Lime mud, pinkish-gray, 5YR 8/1, soft, common limestone fragments.
980 - 983	Dolomite, dusky yellow-green, 5GY 5/2, very hard, finely phosphatic, common limestone fragments.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
983 - 988	Limestone, yellowish-gray, 5Y 8/1, medium hard, casts and molds, occasional shell and fossil, minor marl.
988 - 993	Limestone, light gray N-7 to medium gray, N-5, medium hard, moldic, vuggy, common shell and fossil.
993 - 998	Limestone, pinkish-gray, 5YR 8/1, medium hard, sandy, casts and molds, vuggy, common shell and fossil.
998 - 1003	Limestone, pinkish-gray, 5YR 8/1, medium hard, sandy, moldic, common shell and fossil, occasional white and gray clay.
1003 - 1008	Limestone, very pale orange 10YR 8/2, soft to medium hard, sandy, casts and molds, vuggy.
1008 - 1013	Limestone, pinkish-gray, 5YR 8/1, hard, well indurated, moldic, vuggy, common shell and fossil.
1013 - 1018	Limestone, as above.
1018 - 1024	Limestone, very pale orange, 10YR 8/2, sandy, soft to medium hard, casts and molds, minor shell fragments.
1024 - 1029	Limestone, as above.
1029 - 1034	Limestone, as above.
1034 - 1039	Limestone, medium gray, N-5, hard, well indurated, casts and molds, vuggy, common shell and fossil.
1039 - 1044	Limestone, multicolored, soft to medium hard, finely phosphatic, silty, minor clay, minor shell and fossil.
1044 - 1049	Limestone, very pale orange, soft to medium hard, sandy, silty, minor white clay, minor shell.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
1049 - 1055	Limestone, medium gray, N-5, sandy, soft to medium hard, finely phosphatic, occasional shell.
1055 - 1060	Limestone, pinkish-gray, 5YR 8/1, soft to medium hard, very silty, finely phosphatic, occasional shell.
1060 - 1065	Limestone, light gray, N-7, soft to medium hard, silty, occasional shell, minor white phosphatic clay.
1065 - 1070	Limestone, as above, with occasional gray clay.
1070 - 1075	Limestone, multicolored, medium hard, minor fine phosphate, common shell and fossil.
1075 - 1080	Limestone, yellowish-gray, 5Y 8/1, medium hard, well indurated, casts and molds, vuggy, common shell and fossil.
1080 - 1087	Limestone, very pale orange, 10YR 8/2, medium hard to hard, moderately well indurated, sandy, moldic.
1087 - 1092	Limestone, very pale orange, 10YR 8/2, medium hard, very sandy (fine grained), finely phosphatic, minor shell.
1092 - 1097	Limestone, very pale orange, 10YR 8/2, soft to medium hard, sandy, moldic, vuggy, common shell and fossil.
1097 - 1102	Limestone, pinkish-gray, 5YR 8/1, medium hard, well indurated, moldic, abundant shell and fossil.
1102 - 1107	Limestone, as above.
1107 - 1112	Limestone, very pale orange, 10YR 8/2, medium hard, sandy, casts and molds, occasional shell and fossil.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
1112 - 1118	Limestone, very pale orange, 10YR 8/2, soft to medium hard, sandy, moldic, occasional shell and fossil.
1118 - 1123	Limestone, pinkish-gray, 5YR 8/1, soft, sandy, friable, casts, occasional shell and fossil, minor fine phosphate.
1123 - 1128	Limestone, pinkish-gray, 5YR 8/1, soft, sandy, friable, slightly moldic, occasional shell and fossil, finely phosphatic.
1128 - 1133	Limestone, as above.
1133 - 1138	Limestone, very pale orange, 10RY 8/2, soft to medium hard, sandy, slightly moldic, occasional shell and fossil.
1138 - 1143	Limestone, as above.
1143 - 1148	Limestone, very pale orange, 10YR 8/2, medium hard, moderately well indurated, moldic, common shell and fossil, trace white clay.
1148 - 1153	Limestone, pinkish-gray, 5YR 8/1, medium hard, casts and molds, common shell and fossil.
1153 - 1158	Limestone, white, N-9, soft to medium hard, sandy, minor gray clay, minor shell fragments.
1158 - 1163	Limestone, as above.
1163 - 1168	Limestone, pinkish-gray, 5YR 8/1, soft to medium hard, sandy, minor shell, trace clay.
1168 - 1175	Limestone, very pale orange, 10YR 8/2, medium hard, casts and molds, vuggy, sandy, common shell and fossil.
1175 - 1180	Limestone, as above.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
1180 - 1193	Limestone, very pale orange, 10YR 8/2, sandy, medium hard, slightly moldic, minor shell and gastropods, trace clay.
1193 - 1197	Limestone, pinkish-gray, 5YR 8/1, biomicritic, medium hard.
1197 - 1200	Limestone, as above, with dolomite lense.
1200 - 1210	Limestone, very pale orange, 10YR 8/2, soft to medium hard, casts and molds, minor gastropods.
1210 - 1218	Limestone, as above.
1218 - 1228	Limestone, very pale orange, 10YR 8/2, soft to medium hard, moldic, minor shell.
1228 - 1230	Limestone, very pale orange, 10YR 8/2, soft to medium hard, moldic, minor shell and fossil, minor white lime mud.
1230 - 1232	Limestone, very pale orange, 10YR 8/2, soft, minor shell and fossil, minor white lime mud.
1232 - 1238	Limestone, pinkish-gray, 5YR 8/1, soft to medium hard, moldic, finely phosphatic.
1238 - 1243	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, casts and molds, minor crystalline shell.
1243 - 1252	Limestone, very pale orange, 10YR 8/2, medium hard, moderately well indurated, slightly moldic, minor fossil, minor white lime mud.
1252 - 1258	Limestone, very pale orange, 10YR 8/2, medium hard, moldic, minor crystalline shell and gastropods.
1258 - 1262	Limestone, as above.
1262 - 1270	Lime mud, light gray, N-7, partially lithified.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
1270 - 1274	Limestone, very pale orange, 10YR 8/2, soft to medium hard, minor fossil, minor lime mud.
1274 - 1288	Limestone, very pale orange, 10YR 8/2, soft, silty, low apparent permeability.
1288 - 1290	Limestone, pinkish-gray, 5YR 8/1, soft, silty, slightly moldic.
1290 - 1298	Limestone, very pale orange, 10YR 8/2, soft, silty, casts and molds, minor gastropods.
1298 - 1305	Limestone, pinkish-gray, 5YR 8/1, soft, silty, low apparent permeability.
1305 - 1309	Lime mud, pinkish-gray, 5YR 8/1, partially lithified, low apparent permeability.
1309 - 1320	Limestone, very pale orange, 10YR 8/2, soft to medium hard, vuggy, minor shell and fossil.
1320 - 1332	Limestone, as above.
1332 - 1335	Dolomite, pale yellowish-brown, 10YR 6/2, very hard, well indurated, sucrosic texture.
1335 - 1342	Dolomite, pale yellowish-brown, 10YR 6/2, very hard, well indurated, interbedded with hard brown limestone.
1342 - 1345	Limestone, pale yellowish-brown, 10YR 6/2, medium hard, interbedded dolomite.
1345 - 1353	Dolomite, yellowish-gray, 5Y 7/2, hard, conchoidal fracture.
1353 - 1355	Dolomite, as above.
1355 - 1358	Dolomite, yellowish-gray, 5Y 7/2, hard, well indurated, occasional lime mud, minor fossil.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
1358 - 1364	Dolomite, pale yellowish-brown, 10YR 6/2, hard, well indurated, minor limestone and lime mud.
1364 - 1368	Dolomite, dark yellowish-brown, 10YR 4/2, hard, sucrosic texture.
1368 - 1375	Dolomite, medium dark gray, N-4, hard, sucrosic texture, vuggy.
1375 - 1380	Dolomite, medium dark gray, N-4, very hard, well indurated, occasional limestone interbedded, minor echinoderm spines.
1380 - 1385	Limestone, white, N-9, medium hard, moldic, vuggy, occasional shell and fossil.
1385 - 1399	Limestone, light gray N-8 to white N-9, medium hard, moldic, vuggy, biomicritic, minor gray dolomite.
1399 - 1405	Limestone, pinkish-gray, 5YR 8/1, medium hard to hard, well indurated, casts and molds, occasional shell and fossil, trace hard gray dolomite.
1405 - 1410	Limestone, as above.
1410 - 1415	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, silty, minor casts and shell molds, minor gray dolomite.
1415 - 1420	Limestone, very pale orange, 10YR 8/2, medium hard, moderately well indurated, moldic, vuggy, common shell and fossil.
1420 - 1425	Limestone, as above, with minor sucrosic dolomite.
1425 - 1430	Limestone, pinkish-gray, 5YR 8/1, medium hard, casts and molds, common shell and fossil, occasional gray sucrosic dolomite, interbedded.
1430 - 1435	Limestone, pinkish-gray, 5YR 8/1, hard, well indurated, casts and molds, common shell and fossil, minor dolomite.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
1435 - 1440	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, silty, common dolomite.
1440 - 1445	Limestone, as above.
1445 - 1450	Limestone, very pale orange, 10YR 8/2, medium hard, sandy, casts and shell molds, minor dolomite.
1450 - 1455	Limestone, pinkish-gray, 5YR 8/1, hard, moldic, occasional shell, minor dolomite.
1455 - 1462	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, silty, minor shell, minor dolomite.
1462 - 1467	Limestone, as above.
1467 - 1472	Limestone, as above.
1472 - 1477	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, silty, minor shell fragments, trace dolomite.
1477 - 1482	Limestone, as above.
1482 - 1487	Limestone, as above.
1487 - 1493	Limestone, very pale orange, 10YR 8/2, soft to medium hard, silty, friable, casts and shell molds, occasional gray sucrosic dolomite.
1493 - 1498	Limestone, as above.
1498 - 1503	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, silty, minor shell fragments, minor gray dolomite.
1503 - 1508	Limestone, as above.
1508 - 1513	Limestone, as above.
1513 - 1518	Limestone, pinkish-gray, 5YR 8/1, soft to medium hard, friable, silty, minor shell, minor gray dolomite.

GEOLOGIST'S LOG OF WELL CO-2080
Continued:

Depth (feet)	Description
1518 - 1525	Limestone, as above.
1525 - 1530	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, silty, occasional gray dolomite, minor shell.
1530 - 1535	Limestone, as above.
1535 - 1540	Limestone, very pale orange, 10YR 8/2, soft to medium hard, silty, common stiff white clay, trace dolomite fragments.
1540 - 1545	Limestone, very pale orange, 10YR 8/2, soft to medium hard, silty, friable, slightly moldic, minor shell and dolomite.
1545 - 1550	Limestone, as above.
1550 - 1556	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, silty, minor shell fragments, trace dolomite.
1556 - 1561	Limestone, as above.
1561 - 1566	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, silty, minor shell fragments, trace dolomite.
1566 - 1571	Limestone, as above.
1571 - 1576	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, silty, casts and molds, common shell and fossil, trace dolomite.
1576 - 1581	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, silty, minor shell fragments.
1581 - 1586	Limestone, as above.
1586 - 1591	Limestone, very pale orange, 10YR 8/2, soft to medium hard, friable, silty, minor shell, occasional gray sucrosic dolomite.
1591 - 1608	Limestone, as above.

GEOLOGIST'S LOG OF WELL CO-2081

Depth (feet)	Description
0 - 5	Limestone, grayish orange (10YR 7/4), very hard, well indurated, minor sand and organics, trace shell fragments.
5 - 9	Limestone, very pale orange (10YR 8/2), very hard, well indurated, minor shell fragments.
9 - 15	Limestone, pinkish gray (5YR 8/1), soft to medium hard, moldic, vuggy, common shell.
15 - 30	Marl, yellowish gray (5Y 8/1), soft, abundant shell.
30 - 40	Limestone, multicolored, medium hard, casts and molds, vuggy, common shell and fossil.
40 - 50	Limestone, yellowish gray (5Y 8/1), medium hard, vuggy, moldic, common shell and fossil.
50 - 60	Limestone, as above.
60 - 70	Limestone, very pale orange (10YR 8/2), hard, moderately well indurated, moldic common shell.
70 - 80	Limestone, very pale orange (10YR 8/2), hard, well indurated, minor shell.
80 - 90	Limestone, very pale orange (10YR 8/2), medium hard, moderately well indurated, slightly moldic, occasional shell fragments.
90 - 100	Limestone, as above.
100 - 110	Limestone, yellowish gray (5Y 7/2), medium hard, sandy, finely phosphatic, minor shell.
110 - 120	Limestone, as above.
120 - 130	Limestone, yellowish gray (5Y 8/1), soft to medium hard, friable, sandy, finely phosphatic, minor shell fragments.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
130 - 140	Limestone, pinkish gray (5YR 8/1) to medium light gray (N-6), soft to medium hard, friable, finely phosphatic, sandy, occasional shell.
140 - 150	Limestone, multicolored, medium hard, sandy, occasional shell fragments.
150 - 155	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, silty, minor shell.
155 - 160	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, moldic, vuggy, occasional shell.
160 - 165	Limestone, as above.
165 - 170	Limestone, very pale orange (10YR 8/2) to pale brown (5YR 5/2), medium hard, casts and molds, common shell and fossil, minor clay.
170 - 175	Clay, pinkish-gray (5YR 8/1), soft, abundant coarse quartz sand, phosphatic, minor limestone fragments.
175 - 180	Clay, light olive-gray (5Y 6/1), soft, sticky, occasional shell and limestone fragments, minor phosphate grains.
180 - 190	Clay, as above.
190 - 200	Clay, olive-gray (5Y 4/2), soft, sticky, common shell and limestone, minor sand and phosphate.
200 - 205	Limestone, light olive-gray (5Y 6/1), medium hard, occasional quartz sand (coarse to pebble sizes), abundant green clay.
205 - 210	Clay, dark greenish-gray (5GY 4/1), soft, sticky, common shell and limestone fragments, occasional coarse quartz sand.
210 - 220	Clay, as above.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
220 - 228	Clay, as above.
228 - 235	Limestone, yellowish-gray (5Y 7/2), medium hard, highly phosphatic, occasional clay, minor coarse quartz sand.
235 - 240	Clay, dark greenish-gray (5GY 4/1), soft, sticky, occasional limestone and shell fragments, phosphatic.
240 - 250	Clay, as above.
250 - 260	Clay, dark greenish-gray (5GY 4/1), soft, sticky, common fine phosphate, minor shell and rock fragments.
260 - 273	Clay, as above.
273 - 285	Clay, as above.
285 - 304	Limestone, yellowish-gray (5Y 8/1), medium hard, finely phosphatic, moldic, common shell and fossil (gastropods).
304 - 319	Limestone, as above.
319 - 334	Limestone, as above.
334 - 340	Limestone, yellowish-gray (5Y 8/1), hard, casts and molds, finely phosphatic, common shell and fossil.
340 - 350	Limestone, yellowish-gray (5Y 8/1), medium hard, occasional shell and fossil, minor clay.
350 - 366	Limestone, yellowish-gray (5Y 8/1), soft to medium hard, common shell fragments, trace clay.
366 - 382	Limestone, very pale orange (10YR 8/2), medium hard, casts and molds, common shell fragments.
382 - 398	Limestone, yellowish-gray (5Y 7/2), soft to medium hard, friable, finely phosphatic, occasional shell.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
398 - 403	Limestone, as above.
403 - 408	Limestone, yellowish-gray (5Y 7/2), medium hard, finely phosphatic, occasional shell, minor marl.
408 - 414	Limestone, pinkish-gray (5YR 8/1), medium hard, moldic, common shell and fossil, finely phosphatic.
414 - 420	Limestone, pinkish-gray (5YR 8/1), medium hard, casts and molds, abundant shell, minor white phosphatic marl.
420 - 425	Lime mud, yellowish-gray (5Y 8/1), soft, finely phosphatic, occasional phosphate nodules, minor shell.
425 - 428	Dolomite, light olive-gray (5Y 6/1), hard, well indurated, occasional shell, minor phosphate, minor clay.
428 - 430	Clay, light olive-gray (5Y 5/2), soft, sticky, common limestone and shell fragments.
430 - 435	Limestone, yellowish-gray (5Y 7/2), hard, well indurated, moldic, common shell and fossil.
435 - 440	Limestone, very pale orange (10YR 8/2), medium hard, finely phosphatic, occasional shell and fossil.
440 - 445	Limestone, pinkish-gray (5YR 8/1), medium hard, casts and molds, common shell and fossil.
445 - 450	Limestone, yellowish-gray (5Y 7/2) to light olive-gray (5Y 5/2), hard, well indurated, moldic, vuggy, occasional shell.
450 - 460	Limestone, pinkish-gray (5YR 8/1), hard, well indurated, moldic, vuggy, common shell and fossil.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
460 - 465	Limestone, as above.
465 - 470	Limestone, yellowish-gray (5Y 8/1), medium hard, casts and molds, common shell and fossil, finely phosphatic.
470 - 475	Limestone, as above.
475 - 480	Limestone, pinkish-gray (5YR 8/1), medium hard, casts and molds, common shell and fossil, trace fine phosphate.
480 - 485	Limestone, as above with minor lime mud.
485 - 492	Limestone, yellowish-gray (5Y 8/1), hard, well indurated, casts and molds, vuggy, common shell and fossil.
492 - 498	Limestone, pinkish-gray (5YR 8/1), medium hard, moldic, common shell and fossil, trace marl.
498 - 503	Limestone, very pale orange (10YR 8/2), medium hard, common shell, minor marl.
503 - 508	Limestone, pinkish-gray (5YR 8/1), soft to medium hard, slightly moldic, occasional white lime mud.
508 - 513	Limestone, yellowish-gray (5Y 8/1), medium hard, abundant phosphatic lime mud, minor shell.
513 - 518	Limestone, as above.
518 - 523	Clay, light olive-gray (5Y 5/2), stiff, finely phosphatic, common limestone and shell fragments.
523 - 528	Clay, as above with common phosphate nodules.
528 - 533	Limestone, white (N-9), medium hard, abundant white phosphatic lime mud, common shell, minor phosphate nodules.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
533 - 538	Limestone, very pale orange (10YR 8/2) to dark gray (N-3), hard, well indurated, moldic, vuggy, phosphatic, common shell and fossil.
538 - 543	Limestone, yellowish-gray (5Y 8/1), medium hard, vuggy, phosphatic, common shell.
543 - 548	Limestone, very pale orange (10YR 8/2), soft to medium hard, casts, finely phosphatic, common shell.
548 - 555	Lime mud, yellowish-gray (5Y 8/1), soft, phosphatic, common limestone and shell fragments.
555 - 560	Limestone, yellowish-gray (5Y 8/1), medium hard, silty, minor shell.
560 - 565	Limestone, as above with common shell.
565 - 570	Limestone, very pale orange (10YR 8/2), hard, well indurated, moldic, vuggy, common shell and fossil.
570 - 575	Lime mud, yellowish-gray (5Y 7/2), soft, phosphatic, minor shell and limestone fragments.
575 - 580	Limestone, yellowish-gray (5Y 7/2), soft to medium hard, abundant phosphatic lime mud, common shell.
580 - 587	Clay, yellowish-gray (5Y 7/2), soft, sticky, common shell and limestone fragments.
587 - 592	Clay, as above.
592 - 597	Lime mud, white (N-9), soft, sticky, common shell and limestone fragments.
597 - 603	Clay, light olive-gray (5Y 6/1), soft, sticky, common shell and limestone fragments.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
603 - 608	Clay, light olive-gray (5Y 5/2), soft, common phosphate nodules, occasional shell and limestone fragments.
608 - 613	Clay, as above.
613 - 618	Clay, dark greenish-gray (5GY 4/1), soft, sticky, minor shell and limestone fragments.
618 - 623	Limestone, pinkish-gray (5YR 8/1), medium hard, casts and molds, common shell and fossil.
623 - 628	Limestone, very pale orange (10YR 8/2), medium hard, moldic, vuggy, occasional shell, minor marl.
628 - 633	Limestone, yellowish-gray (5Y 8/1), medium hard, occasional shell, minor marl.
633 - 638	Clay, yellowish-gray (5Y 7/2), sticky, common shell and limestone fragments, minor fine phosphate.
638 - 643	Limestone, pinkish-gray (5YR 8/1), medium hard, casts and molds, finely phosphatic, minor shell.
643 - 648	Limestone, as above.
648 - 655	Limestone, yellowish-gray (5Y 7/2), hard, well indurated, micritic, trace shell fragments.
655 - 658	Limestone, pinkish-gray (5YR 8/1), hard, well indurated, casts and molds, common shell and fossil.
658 - 663	Limestone, as above.
663 - 668	Limestone, pinkish-gray (5YR 8/1), medium hard, slightly moldic, occasional shell and fossil.
668 - 673	Limestone, as above.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
673 - 680	Limestone, yellowish-gray (5Y 8/1), medium hard, moldic, finely phosphatic, occasional recrystallized shell fragments.
680 - 685	Dolomite, light olive-gray (5Y 6/1), hard, well indurated, common shell and limestone fragments.
685 - 690	Limestone, white (N-9), medium hard, moldic, minor shell.
690 - 695	Dolomite, pale yellowish-brown (10YR 6/2), hard, well indurated, common shell and limestone fragments.
695 - 700	Dolomite, as above.
700 - 705	Dolomite, dark yellowish-brown (10YR 4/2), hard, well indurated, occasional shell and limestone fragments.
705 - 711	Limestone, very pale orange (10YR 8/2), medium hard, casts and molds, occasional shell.
711 - 716	Limestone, very pale orange (10YR 8/2), medium hard, moldic, occasional shell and fossil.
716 - 721	Limestone, very pale orange (10YR 8/2), medium hard, silty, casts and molds, minor shell.
721 - 726	Limestone, as above with occasional white lime mud.
726 - 731	Lime mud, white (N-9), soft, sticky, common shell and limestone fragments.
731 - 752	Lime mud, as above.
752 - 757	Dolomite, light olive-gray (5Y 5/2), hard, well indurated, common limestone and shell fragments.
757 - 761	Dolomite, as above.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
761 - 763	Dolomite, dark yellowish-brown (10YR 4/2), hard, well indurated, casts, minor shell fragments.
763 - 765	Clay, white (N-9), soft, sticky, minor shell.
765 - 769	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, silty, vuggy, trace marl.
769 - 773	Clay, dark yellowish-brown (10YR 4/2), soft, minor shell and limestone fragments.
773 - 778	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, moldic, vuggy, sandy, minor shell.
778 - 783	Limestone, as above.
783 - 788	Clay, yellowish-gray (5Y 8/1), soft, sticky, minor limestone fragments, minor phosphate nodules.
788 - 805	Limestone, very pale orange (10YR 8/2), soft to medium hard, slightly moldic.
805 - 810	Limestone, very pale orange (10YR 8/2), soft to medium hard, moldic, vuggy, minor shell.
810 - 815	Lime mud, yellowish-gray (5Y 8/1), soft, interbedded with limestone.
815 - 820	Limestone, pinkish-gray (5YR 8/1), soft to medium hard, friable, sandy.
820 - 827	Limestone, white (N-9), hard, well indurated, silty.
827 - 830	Limestone, very pale orange (10YR 8/2), medium hard, sandy.
830 - 835	Limestone, pale yellowish-brown (10YR 6/2), medium hard, casts and molds, vuggy, very fossiliferous, occasional shell.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
835 - 840	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, vuggy, casts.
840 - 845	Limestone, as above.
845 - 850	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, moldic, minor shell.
850 - 853	Lime mud, very pale orange (10YR 8/2), soft, sticky.
853 - 856	Lime mud, as above.
856 - 860	Clay, pale yellowish-brown (10YR 6/2), soft, sticky.
860 - 862	Clay, as above.
862 - 866	Limestone, very pale orange (10YR 8/2), medium hard, moldic, vuggy.
866 - 870	Limestone, yellowish-gray (5Y 8/1), soft, friable, minor shell.
870 - 873	Clay, light olive-gray (5Y 6/1), soft, sticky.
873 - 885	Clay, light olive-gray (5Y 6/1), soft, sticky, minor shell and limestone fragments.
885 - 888	Clay, light olive-gray (5Y 5/2), as above.
888 - 891	Limestone, very pale orange (10YR 8/2), medium hard, moldic, vuggy.
891 - 895	Clay, multicolored, soft, sticky, common shell and limestone fragments.
895 - 900	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, vuggy, sandy.
900 - 905	Limestone, very pale orange (10YR 8/2), medium hard, vuggy, common clay.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
905 - 910	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, slightly, moldic, vuggy, sandy.
910 - 915	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, occasional white clay.
915 - 920	Limestone, very pale orange (10YR 8/2), medium hard, silty, casts, minor shell.
920 - 925	Limestone, yellowish-gray (5Y 8/1), soft to medium hard, vuggy, sandy.
925 - 931	Limestone, as above with minor white clay.
931 - 936	Clay, white (N-9), stiff.
936 - 941	Clay, as above.
941 - 946	Limestone, very pale orange (10YR 8/2), medium hard to hard, well indurated, moldic, vuggy, conchoidal fracture.
946 - 951	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, sandy, trace shell.
951 - 956	Limestone, as above.
956 - 961	Limestone, very pale orange (10YR 8/2), medium hard, casts and molds, vuggy.
961 - 966	Limestone, yellowish-gray (5Y 8/1), medium hard to hard, well indurated, casts and molds, minor shell.
966 - 971	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, silty, casts, vuggy.
971 - 976	Limestone, yellowish-gray (5Y 8/1), soft to medium hard, friable, casts and molds.
976 - 981	Limestone, very pale orange (10YR 8/2), medium hard to hard, well indurated, micritic, minor clay.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
981 - 986	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, slightly moldic, trace shell.
986 - 993	Limestone, as above.
993 - 998	Limestone, very pale orange (10YR 8/2), soft to medium, silty, common clay.
998 - 1003	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, trace shell.
1003 - 1008	Limestone, as above.
1008 - 1013	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, casts and molds, silty.
1013 - 1018	Limestone, very pale orange (10YR 8/2), hard, well indurated, silty, minor shell.
1018 - 1025	Limestone, very pale orange (10YR 8/2), medium hard, casts and molds, silty, minor clay.
1025 - 1030	Limestone, very pale orange (10YR 8/2), hard well indurated, silty, minor shell, minor clay.
1030 - 1035	Limestone, very pale orange (10YR 8/2), medium hard, casts, occasional clay.
1035 - 1040	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, moldic, silty.
1040 - 1045	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, silty, casts, minor clay.
1045 - 1050	Limestone, very pale orange (10YR 8/2), medium hard, moderately well indurated, minor shell fragments, minor clay.
1050 - 1055	Limestone, very pale orange (10YR 8/2), medium hard, moldic, vuggy, common shell, minor clay.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
1055 - 1060	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, sandy, minor shell.
1060 - 1065	Limestone, as above.
1065 - 1070	Limestone, very pale orange (10YR 8/2), hard, well indurated, casts and molds, minor shell.
1070 - 1075	Limestone, very pale orange (10YR 8/2), medium hard, silty, minor shell.
1075 - 1080	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, moldic, silty, common clay.
1080 - 1085	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, moldic, vuggy, sandy.
1085 - 1090	Limestone, yellowish-gray (5Y 8/1), medium hard, casts and molds, vuggy, minor shell.
1090 - 1095	Limestone, very pale orange (10YR 8/2), medium hard, casts and molds, minor shell.
1095 - 1100	Limestone, as above.
1100 - 1105	Limestone, very pale orange (10YR 8/2), medium hard, casts and molds, fossiliferous (forams).
1105 - 1110	Limestone, very pale orange (10YR 8/2), soft, silty, common clay.
1110 - 1117	Limestone, very pale orange (10YR 8/2), medium hard, casts and molds.
1117 - 1122	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, moldic, vuggy, sandy, minor shell fragments.
1122 - 1127	Limestone, very pale orange (10YR 8/2), medium hard, casts and molds, vuggy.
1127 - 1132	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, silty.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
1132 - 1137	Limestone, pinkish-gray (5YR 8/1), soft to medium hard, friable, casts and molds, minor shell.
1137 - 1142	Limestone, as above.
1142 - 1148	Limestone, yellowish-gray (5Y 8/1), medium hard, slightly moldic, vuggy, occasional shell.
1148 - 1153	Limestone, yellowish-gray (5Y 8/1), medium hard, common white clay, minor shell.
1153 - 1160	Limestone, very pale orange (10YR 8/2), medium hard, casts and molds, common shell fragments.
1160 - 1163	Clay, very pale orange (10YR 8/2), firm, common limestone fragments.
1163 - 1168	Limestone, very pale orange (10YR 8/2), hard, well indurated, casts and molds, vuggy, common shell and fossil.
1168 - 1173	Limestone, as above.
1173 - 1178	Limestone, yellowish-gray (5Y 8/1) to black (N-1), hard, well indurated, moldic, vuggy, common shell and fossil.
1178 - 1188	Clay, yellowish-gray (5Y 8/1), soft, sticky, minor shell and limestone fragments.
1188 - 1193	Clay, as above, with large shell fragments.
1193 - 1208	Limestone, very pale orange (10YR 8/2), medium hard, sandy.
*1208 - 1212	Sand, yellowish-gray (5Y 8/1), very fine to fine, well sorted, subangular.
1212 - 1216	Limestone, pale yellowish-brown (10YR 6/2), hard, well indurated, sandy, casts and molds, vuggy.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
1216 - 1224	Sand, yellowish-gray (5Y 8/1), very fine to fine, well sorted, subangular.
1224 - 1228	Limestone, pale yellowish-brown (10YR 6/2), hard, well indurated, casts and molds, vuggy.
1228 - 1238	Limestone, as above, with trace black dolomite.
1238 - 1242	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, moldic, common white clay.
1242 - 1247	Limestone, very pale orange (10YR 8/2), hard, well indurated, sandy, minor shell.
1247 - 1252	Limestone, as above.
1252 - 1257	Limestone, light olive-gray (5Y 6/1), to very pale orange (10YR 8/2), hard, well indurated, moldic, vuggy, abundant shell and fossil.
1257 - 1262	Limestone, light olive-gray (5Y 6/1), medium hard, casts and molds, minor shell.
1262 - 1267	Limestone, very pale orange (10YR 8/2), hard, well indurated, moldic, occasional shell.
1267 - 1272	Limestone, very pale orange (10YR 8/2), hard, well indurated, casts and molds, vuggy, common shell and fossil.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
1272 - 1277	Limestone, yellowish brown (10YR 5/2), hard, well indurated, casts and molds, vuggy.
1277 - 1282	Limestone, yellowish gray (5Y 8/1), hard, well indurated, moldic, vuggy.
1282 - 1287	Limestone, very pale orange (10YR 8/2), hard, well indurated, sandy, casts and molds.
1287 - 1292	Limestone, as above.
1292 - 1297	Limestone, very pale orange (10YR 8/2), medium hard, casts, sandy.
1297 - 1303	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, sandy.
1303 - 1308	Limestone, as above.
1308 - 1313	Limestone, as above.
1313 - 1318	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, sandy, minor shell fragments.
1318 - 1323	Limestone, as above.
1323 - 1328	Limestone, as above.
1328 - 1335	Limestone, very pale orange (10YR 8/2), medium hard, casts and molds, sandy, minor shell fragments.
1335 - 1340	Limestone, as above.
1340 - 1345	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, minor shell fragments.
1345 - 1351	Limestone, very pale orange (10YR 8/2), medium hard, minor casts and molds.
1351 - 1356	Limestone, as above except softer.
1356 - 1361	Limestone, as above.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

Depth (feet)	Description
1361 - 1366	Limestone, very pale orange (10YR 8/2), medium hard, sandy, trace shell.
1366 - 1371	Limestone, as above.
1371 - 1376	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, minor casts and molds.
1376 - 1381	Limestone, very pale orange (10YR 8/2), medium hard, slightly moldic, vuggy, trace shell.
1381 - 1387	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, minor shell casts.
1387 - 1393	Limestone, as above.
1393 - 1398	Limestone, very pale orange (10YR 8/2), soft, friable, minor shell fragments.
1398 - 1403	Limestone, very pale orange (10YR 8/2), hard, well indurated, casts and molds, vuggy.
1403 - 1408	Limestone, as above.
1408 - 1413	Limestone, as above.
1413 - 1418	Limestone, very pale orange (10YR 8/2), medium hard, silty, slightly moldic.
1418 - 1423	Limestone, as above.
1423 - 1429	Limestone, yellowish gray (5Y 8/1), medium hard, silty.
1429 - 1435	Limestone, yellowish gray (5Y 8/1), hard, vuggy, minor casts and molds.
1435 - 1440	Limestone, yellowish gray (5Y 8/1), hard, well indurated, vuggy, slightly moldic.
1440 - 1445	Limestone, as above.

GEOLOGIST'S LOG OF WELL CO-2081
Continued:

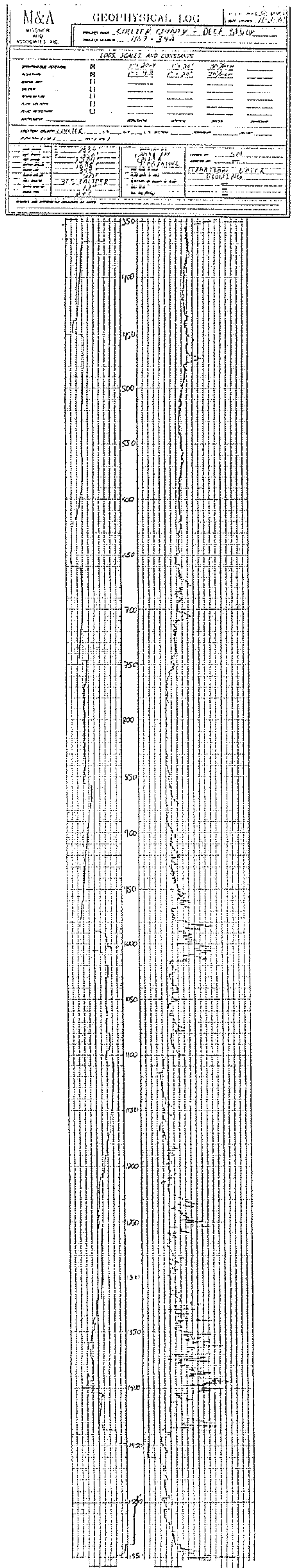
Depth (feet)	Description
1445 - 1450	Limestone, very pale orange (10YR 8/2), medium hard, silty, vuggy, slightly moldic.
1450 - 1455	Limestone, as above.
1455 - 1460	Limestone, as above.
1460 - 1465	Limestone, yellowish gray (5Y 8/1), medium hard, vuggy, casts and molds.
1465 - 1470	Limestone, very pale orange (10YR 8/2), medium hard, vuggy, casts and molds.
1470 - 1475	Limestone, as above.
1475 - 1480	Limestone, yellowish gray (5Y 8/1), soft to medium hard, friable, silty.
1480 - 1485	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, silty.
1485 - 1491	Limestone, as above.
1491 - 1496	Limestone, very pale orange, (10YR 8/2), medium hard, casts and molds, silty.
1496 - 1501	Limestone, as above.
1501 - 1506	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, silty.
1506 - 1511	Limestone, as above.
1511 - 1516	Limestone, as above.
1516 - 1521	Limestone, as above.
1521 - 1526	Limestone, very pale orange (10Yr 8/2), soft to medium hard, friable, silty, trace shell fragments.
1526 - 1531	Limestone, very pale orange (10YR 8/2), medium hard, moderately well indurated, casts and molds, vuggy.
1531 - 1536	Limestone, as above.

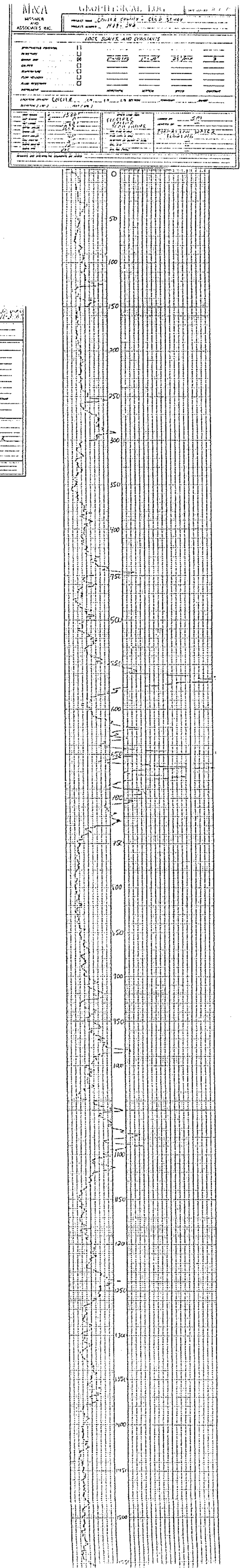
GEOLOGIST'S LOG OF WELL CO-2081
Continued:

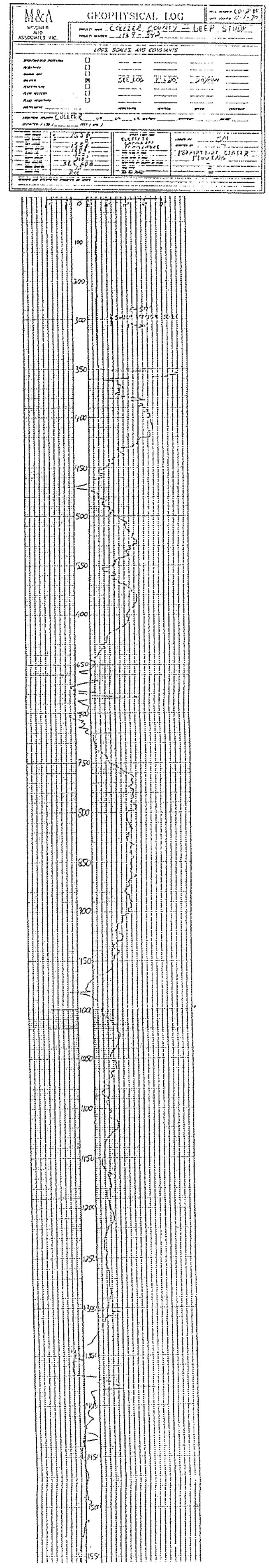
Depth (feet)	Description
1536 - 1542	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, silty.
1542 - 1547	Limestone, as above.
1547 - 1553	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, silty, minor shell fragments.
1553 - 1558	Limestone, pale yellowish brown (10YR 7/2), soft to medium, friable, silty, common white forams.
1558 - 1563	Limestone, very pale orange (10YR 5/2), soft, poorly indurated, sandy, common shell fragments.
1563 - 1568	Limestone, as above.
1568 - 1573	Limestone, very pale orange (10YR 8/2), soft to medium hard, silty, common shell fragments.
1573 - 1578	Limestone, as above.
1578 - 1583	Limestone, as above.
1583 - 1588	Limestone, very pale orange (10YR 8/2), soft to medium hard, very silty, minor shell fragments.
1588 - 1593	Limestone, as above.
1593 - 1598	Limestone, very pale orange (10YR 8/2), medium hard, silty.
1598 - 1604	Limestone, as above.
1604 - 1610	Limestone, very pale orange (10YR 8/2), soft to medium hard, friable, silty, minor shell fragments.
1610 - 1616	Limestone, as above.

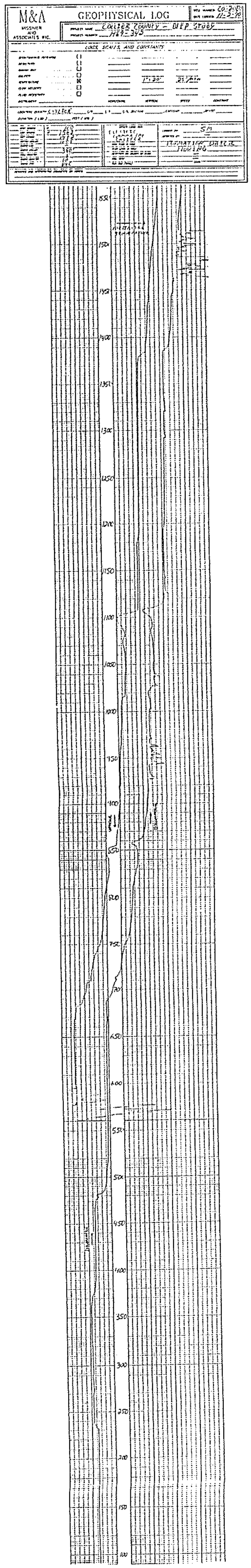
APPENDIX C

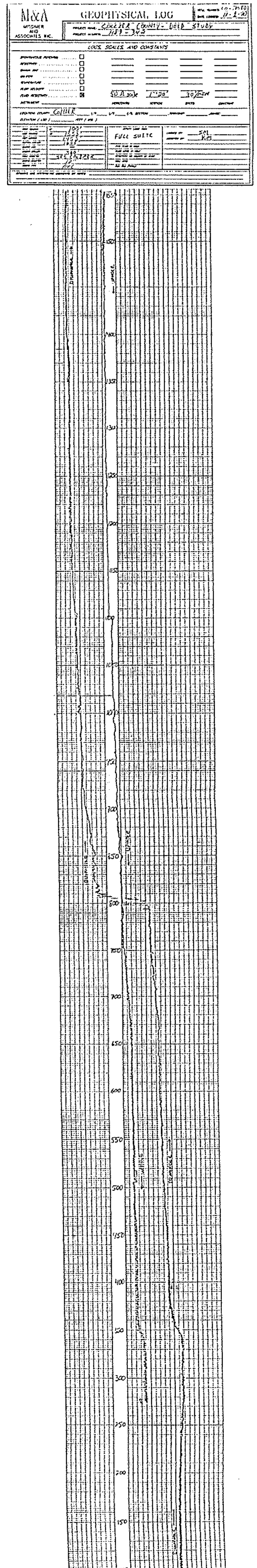
GEOPHYSICAL LOGS OF WELL CO-2080


M&A
MISSIMER AND ASSOCIATES INC.
GEOPHYSICAL LOG
COLLIER COUNTY - DEEP STUDY
LOGS, SCALES, AND CONSTANTS


M&A
MISSIMER AND ASSOCIATES INC.
GEOPHYSICAL LOG
COLLIER COUNTY - DEEP STUDY
LOGS, SCALES, AND CONSTANTS


M&A
MISSIMER AND ASSOCIATES INC.
GEOPHYSICAL LOG
COLLIER COUNTY - DEEP STUDY
LOGS, SCALES, AND CONSTANTS


M&A
MISSNER AND ASSOCIATES INC.
GEOPHYSICAL LOG
COLLIER COUNTY – DEEP STUDY
H89-345
LOGS, SCALES, AND CONSTANTS
1"=20'
25'/MIN
COLLIER
SM
FORMATION WATER FLOWING
1550
1500
1450
1400
1350
1300
1250
1200
1150
1100
1050
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100


M&A
ASSOCIATES INC.
GEOPHYSICAL LOG
COLLIER COUNTY – DEEP STUDY
H89-345
LOGS, SCALES, AND CONSTANTS
50 Ω scale
1"=20'
30'/MIN
COLLIER
FULL SUITE
SM
1550
1500
1450
1400
1350
1300
1250
1200
1150
1100
1050
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100

APPENDIX D

WATER QUALITY VS. DEPTH FOR WELLS CO-2080 AND CO-2081

REVERSE AIR SAMPLES
WATER QUALITY VARIATION WITH DEPTH
COLLIER COUNTY UTILITIES ASR TEST WELL CO-2080

Depth (feet)	Dissolved Chloride Concentration (mg/l)	Conductivity (umhos/cm)
460	2300	7090
470	2350	8000
480	2400	8010
490	2450	8010
500	2400	8010
310	2400	8010
520	2400	8010
530	2450	8010
540	2300	7800
550	2250	7090
560	2400	8010
570	2500	8030
580	2600	8050
590	2350	8010
600	2300	8000
610	2300	7090
620	2300	7090
630	2250	7090
640	2300	7080
650	2350	7080
660	2200	8000
670	2250	8000
680	2350	8100
690	2700	9700
700	2900	9900
710	3550	11100
720	3400	11000
730	3350	11000
740	3200	11000
750	4100	13500
760	3750	12500
770	3700	12000
780	3800	13500
790	4500	14100
800	4250	13100
810	3950	14000
820	4050	14000
830	4350	13900
840	4000	13500
850	4100	13100
860	4000	13500
870	4050	13800
880	4250	14100
890	4550	14200
900	4300	14100

TABLE

REVERSE AIR SAMPLES
WATER QUALITY VARIATION WITH DEPTH
COLLIER COUNTY UTILITIES ASR TEST WELL CO-2080
Continued:

Depth (feet)	Dissolved Chloride Concentration (mg/l)	Conductivity (umhos/cm)
910	4500	14100
920	4600	14000
930	4400	13900
940	4300	13900
950	4400	13500
960	4100	13500
970	3900	12900
980	4100	12800
990	3800	12000
1000	4300	13000
1010	4400	13500
1020	4700	14000
1030	4800	14900
1040	4400	14500
1050	4800	14000
1060	4500	14000
1070	5200	14000
1080	4700	14500
1090	4900	14500
1100	6500	20000
1110	6500	19100
1120	6900	18000
1130	6900	18000
1140	6300	19000
1150	5900	17900
1160	6200	19100
1170	6300	19000
1180	7000	20900
1190	6900	20300
1200	7000	20900
1210	6900	20300
1220	6700	20100
1230	6400	20100
1240	6300	19700
1250	6200	19100
1260	6000	18800
1270	6900	20900
1280	6100	19000
1290	5800	18000
1300	5700	17800
1310	5200	16400
1320	5100	16100
1330	5300	16900
1340	5800	17500
1350	4000	13100

TABLE

REVERSE AIR SAMPLES
WATER QUALITY VARIATION WITH DEPTH
COLLIER COUNTY UTILITIES ASR TEST WELL CO-2080
Continued:

Depth (feet)	Dissolved Chloride Concentration (mg/l)	Conductivity (umhos/cm)
1360	4200	13900
1370	8300	25000
1380	14500	40100
1390	13000	36200
1400	12200	34800
1410	13100	38900
1420	14400	43800
1430	16800	47800
1440	10100	29700
1450	10900	31000
1460	13200	39000
1470	14000	42200
1480	17400	52000
1490	15600	50000
1500	11700	32000
1510	15400	47600
1520	11300	36500
1530	9500	29100
1540	16600	49800
1550	13100	34800
1560	15200	41200
1570	15000	42000
1580	14400	42000
1590	14400	41800
1600	15200	41000
1610	16800	48000

REVERSE AIR SAMPLES
WATER QUALITY VARIATION WITH DEPTH
COLLIER COUNTY UTILITIES ASR TEST WELL CO-2081

Depth (feet)	Dissolved Chloride Concentration (mg/l)	Conductivity (umhos/cm)
335	2700	7500
345	2550	7200
355	2650	7200
366	2450	7100
376	2350	7000
386	2450	7200
398	2600	7400
408	2350	7200
420	2300	7100
430	2350	7000
440	2500	7200
450	2250	7000
460	2400	7200
470	2300	7100
480	2450	7100
492	2350	7000
503	2400	7000
513	2450	7100
523	2400	7000
533	2450	7000
543	2350	7100
555	2350	7200
565	2100	7100
575	2550	7100
587	2500	7200
597	2400	7200
608	2300	7000
618	2500	7200
628	2350	7000
638	2250	7200
648	2050	7000
658	2450	7000
663	2400	7100
668	2400	7000
680	2350	7000
690	2300	7000
695	2250	7200
711	2100	7000
721	2050	6500
731	2250	7000
742	2200	7100
752	2050	6500
773	2300	7200
783	2350	7000
788	2350	7200

REVERSE AIR SAMPLES
WATER QUALITY VARIATION WITH DEPTH
COLLIER COUNTY UTILITIES ASR TEST WELL CO-2081
Continued:

Depth (feet)	Dissolved Chloride Concentration (mg/l)	Conductivity (umhos/cm)
805	2375	7000
820	2250	7000
835	2100	7590
845	2200	7590
866	2100	7180
873	2050	6860
891	1900	6860
900	2050	6340
915	2000	6940
931	2000	6730
941	2050	6940
961	2000	6730
971	1900	6730
993	2050	6970
1003	2000	6430
1013	2000	7040
1025	2050	7380
1035	2150	7280
1045	2000	6970
1055	2100	7070
1065	2150	7180
1085	2300	7040
1095	2400	8110
1117	2450	8060
1132	2750	9080
1148	3350	10000
1160	3950	12060
1173	3600	11440
1178	4350	13000
1188	4200	13000
1208	5000	14280
1223	5250	15290
1242	4950	14870
1257	6100	17580
1272	6300	17680
1287	4800	15160
1303	5700	16430
1318	5100	15550
1335	5200	16020
1350	5700	16730
1366	5500	16730
1381	6650	19790
1396	5250	16520
1413	5200	16160
1428	4600	14380

REVERSE AIR SAMPLES
WATER QUALITY VARIATION WITH DEPTH
COLLIER COUNTY UTILITIES ASR TEST WELL CO-2081
Continued:

Depth (feet)	Dissolved Chloride Concentration (mg/l)	Conductivity (umhos/cm)
1453	5700	17280
1468	6500	19500
1483	7050	20400
1498	5950	18560
1513	6200	18380
1528	6850	20600
1543	6200	18970
1558	6650	19480
1573	8300	23460
1583	6500	19760
1598	7550	21940
1616	9100	26360

APPENDIX E

TIME AND HEAD DATA FOR WELL CO-2080 PACKER TESTS

WELL CO-2080
SINGLE PACKER TEST
ZONE TESTED: 360' TO 489'
FLOW THROUGH 2" METER

Q = 8 gpm thru 2"

3[illegible]9008
Environmental Logger
11/02 12:37
Unit# 00913 Test# 2

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 0 11/07 11:34

Elapsed Time	Value
0.0000	0.23
0.0033	0.22
0.0066	0.22
0.0099	0.23
0.0133	0.28
0.0166	0.55
0.0200	0.97
0.0233	0.96
0.0266	0.94
0.0300	0.92
0.0333	0.93
0.0500	5.61
0.0666	4.24
0.0833	3.66
0.1000	4.69
0.1166	4.81
0.1333	3.95
0.1500	4.38
0.1666	4.29
0.1833	4.13
0.2000	4.12
0.2166	4.41
0.2333	4.52
0.2500	4.73
0.2666	4.60
0.2833	4.65
0.3000	4.47
0.3166	4.98
0.3333	4.17
0.4167	4.83
0.5000	4.69
0.5833	5.04
0.6667	4.59
0.7500	4.27
0.8333	4.45
0.9167	4.30
1.0000	4.41
1.0833	4.33
1.1667	4.29
1.2500	4.66
1.3333	4.43
1.4166	4.34
1.5000	4.58
1.5833	4.35
1.6667	3.95
1.7500	4.10
1.8333	4.43
1.9167	4.39
2.0000	4.69
2.0833	4.24
2.1666	4.30
2.2500	4.46
2.3333	4.50
2.4166	4.20
2.5000	4.43
2.5833	4.15
2.6666	4.04
2.7500	4.59
2.8333	4.44
2.9166	4.50
3.0000	4.59
3.0833	4.78
3.1666	4.75
3.2500	4.19
3.3333	4.15
3.4166	3.67
3.5000	3.22
3.5833	3.19
3.6666	2.86
3.7500	3.47
3.8333	3.43
3.9166	3.00
4.0000	2.82
4.0833	2.90
4.1666	3.36
4.2500	3.38
4.3333	3.12
4.4166	3.16
4.5000	3.10
4.5833	3.50
4.6666	3.01
4.7500	3.25
4.8333	3.10
4.9166	3.09
5.0000	3.06
5.0833	3.07

END

Environmental Logger
11/02 12:49

Unit# 00913 Test# 2

Q = 6 gpm thru 2"

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 1 11/07 10:27

Elapsed Time	Value
0.0000	0.86
0.0033	1.17
0.0066	1.15
0.0099	1.09
0.0133	1.04
0.0166	1.07
0.0200	1.80
0.0233	2.21
0.0266	2.25
0.0300	2.11
0.0333	2.00
0.0500	2.48
0.0666	2.01
0.0833	1.96
0.1000	2.23
0.1166	2.28
0.1333	2.33
0.1500	2.38
0.1666	2.05
0.1833	2.12
0.2000	1.96
0.2166	1.98
0.2333	2.12
0.2500	2.13
0.2666	2.17
0.2833	2.20
0.3000	2.27
0.3166	2.30
0.3333	2.13
0.4167	2.05
0.5000	2.27
0.5833	2.21
0.6667	2.17
0.7500	2.20
0.8333	2.19
0.9167	2.17
1.0000	2.86
1.0833	2.86
1.1667	2.69
1.2500	3.21
1.3333	2.72
1.4166	2.80
1.5000	2.91
1.5833	2.76
1.6667	2.76
1.7500	2.83
1.8333	3.24
1.9167	2.57
2.0000	2.77
2.5000	2.82
3.0000	1.40
3.5000	1.18
4.0000	1.13
4.5000	1.38
5.0000	1.25
5.5000	0.99
6.0000	1.25
6.5000	1.21
7.0000	0.95
7.5000	1.34
8.0000	1.30
8.5000	1.32
9.0000	1.28
9.5000	1.14
10.0000	1.09
10.5000	1.20

End

WELL CO-2080
DOUBLE PACKER TEST
ZONE TESTED: 670' TO 717'
PUMP THROUGH 2" METER

Environmental Logger
11/09 15:21

Unit# 00913 Test# 2

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 0 11/09 12:42

Elapsed Time	Value
0.0000	0.00
1.0000	1.52
2.0000	1.74
3.0000	1.74
4.0000	1.77
5.0000	1.81
6.0000	1.91
7.0000	1.88
8.0000	1.58
9.0000	1.69
10.0000	1.43
11.0000	1.36
12.0000	1.33
13.0000	1.20
14.0000	1.13
15.0000	1.09
16.0000	1.20
17.0000	1.10
18.0000	1.10
19.0000	1.09
20.0000	1.00
21.0000	0.98
22.0000	1.02
23.0000	0.96
24.0000	0.91
25.0000	0.87
26.0000	0.84
27.0000	0.78
28.0000	0.75
29.0000	0.77
30.0000	0.74
31.0000	0.66
32.0000	0.66
33.0000	0.65
34.0000	0.58
35.0000	0.56
36.0000	0.42
37.0000	0.47
38.0000	0.52
39.0000	0.48
40.0000	0.31

END

Q=43gpm

SE10006
Environmental Logger
11/09 15:33

Unit# 00913 Test# 2

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 1 11/09 13:22

Elapsed Time	Value
0.0000	0.48
1.0000	2.37
2.0000	2.34
3.0000	2.36
4.0000	2.34
5.0000	2.38
6.0000	2.39
7.0000	2.34
8.0000	2.34
9.0000	2.37
10.0000	2.38
11.0000	2.36
12.0000	2.36
13.0000	2.40
14.0000	2.39
15.0000	2.36
16.0000	2.39
17.0000	2.34
18.0000	2.27
19.0000	2.34
20.0000	2.36
21.0000	2.38
22.0000	2.34
23.0000	2.30
24.0000	2.32
25.0000	2.29
26.0000	2.28
27.0000	2.27
28.0000	2.22
29.0000	2.25
30.0000	2.28

END

Q=64gpm

SE10006
Environmental Logger
11/09 15:35

Unit# 00913 Test# 2

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 2 11/09 13:53

Elapsed Time	Value
0.0000	1.30
1.0000	4.15
2.0000	4.13
3.0000	4.09
4.0000	4.12
5.0000	4.12
6.0000	4.09
7.0000	4.14
8.0000	4.21
9.0000	4.20
10.0000	4.22
11.0000	4.19
12.0000	4.25
13.0000	4.17
14.0000	4.26
15.0000	4.24
16.0000	4.23
17.0000	4.22
18.0000	4.17
19.0000	4.23
20.0000	4.23
21.0000	4.24
22.0000	4.25
23.0000	4.22
24.0000	4.22
25.0000	4.27
26.0000	4.26
27.0000	4.20
28.0000	4.25
29.0000	4.21

END

80gpm

CONTINUATION OF 670' TO 717'
DOUBLE PACKER TEST

SE10006
Environmental Logger
11/05 15:07

Unit# 00910 Test# 2

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.00

Step# 3 11/05 14:23

Elapsed Time	Value x10
0.0000	6.49
1.0000	6.11
2.0000	6.01
3.0000	6.06
4.0000	6.06
5.0000	6.09
6.0000	6.05
7.0000	6.12
8.0000	6.08
9.0000	6.01
10.0000	6.07
11.0000	6.09
12.0000	6.15
13.0000	6.07
14.0000	6.16
15.0000	6.05
16.0000	6.12
17.0000	6.12
18.0000	6.12
19.0000	6.15
20.0000	6.15
21.0000	6.08
22.0000	6.16
23.0000	6.17
24.0000	6.14
25.0000	6.13
26.0000	6.10
27.0000	6.10
28.0000	6.11
29.0000	6.10
30.0000	6.10

END

92 gpm

SE10006
Environmental Logger
11/05 15:32

Unit# 00910 Test# 2

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.00

Step# 4 11/05 14:50

Elapsed Time	Value x10
0.0000	6.11
1.0000	11.76
2.0000	10.17
3.0000	10.16
4.0000	10.14
5.0000	10.19
6.0000	10.20
7.0000	10.04
8.0000	10.26
9.0000	10.09
10.0000	10.20
11.0000	10.29
12.0000	10.09
13.0000	10.25
14.0000	10.17
15.0000	10.17
16.0000	10.22
17.0000	10.26
18.0000	10.21
19.0000	10.28
20.0000	10.24
21.0000	10.16
22.0000	10.17
23.0000	10.23
24.0000	10.28
25.0000	10.22
26.0000	10.13
27.0000	10.20
28.0000	10.16
29.0000	10.22
30.0000	10.18

END

119 gpm

WELL CO-2080
DOUBLE PACKER TEST
ZONE TESTED: 975' TO 1023'
FLOW THROUGH 2" METER

SE10006
Environmental Logger
11/12 15:55

Unit# 00913 Test# 4

INPUT 2: Level (F) TOC

Reference actual 0.00
Scale factor 10.01
Offset - 0.00

Step# 0 11/12 15:57

Elapsed Time	Value
0.0000	- 0.04
1.0000	1.01
2.0000	1.07
3.0000	1.04
4.0000	1.04
5.0000	1.06
6.0000	1.05
7.0000	1.07
8.0000	1.04
9.0000	1.01
10.0000	1.00
11.0000	1.00
12.0000	1.00
13.0000	1.00
14.0000	1.03
15.0000	1.16
16.0000	1.04
17.0000	1.49

END

Flow 55 gpm

SE10006
Environmental Logger
11/12 16:57

Unit# 00913 Test# 4

INPUT 2: Level (F) TOC

Reference 0.00
Scale factor 10.01
Offset - 0.00

Step# 1 11/12 15:29

Elapsed Time	Value
0.0000	3.59
1.0000	4.05
2.0000	4.00
3.0000	4.15
4.0000	4.20
5.0000	4.11
6.0000	3.98
7.0000	3.98
8.0000	3.97
9.0000	4.08
10.0000	4.16
11.0000	4.07

END

59 gpm

SE10006
Environmental Logger
11/12 16:57

Unit# 00913 Test# 4

INPUT 2: Level (F TOC

Reference 0.00
Scale factor 10.01
Offset - 0.00

Step# 2 11/12 17:26

Elapsed Time	Value
0.0000	4.39
1.0000	4.45
2.0000	4.42
3.0000	4.12
4.0000	4.79
5.0000	4.44
6.0000	4.44
7.0000	4.69
8.0000	4.57
9.0000	4.40
10.0000	4.38

END

Q=62 gpm

SE10006
Environmental Logger
11/12 17:00

Unit# 00913 Test# 4

INPUT 2: Level (F) TOC

Reference 0.00
Scale factor 10.01
Offset - 0.00

Step# 3 11/12 17:47

Elapsed Time	Value
0.0000	4.71
1.0000	5.24
2.0000	5.54
3.0000	5.39
4.0000	5.95
5.0000	5.29
6.0000	4.84
7.0000	5.50
8.0000	5.43
9.0000	6.26
10.0000	6.27
11.0000	5.86
12.0000	6.34
13.0000	6.01
14.0000	6.31
15.0000	5.90
16.0000	6.14
17.0000	6.24
18.0000	6.23
19.0000	6.11
20.0000	6.64
21.0000	6.16
22.0000	6.24
23.0000	6.39

END

70 gpm

WELL CO-2080
DOUBLE PACKER TEST
ZONE TESTED: 975' TO 1023'
PUMP THROUGH 2" METER

Environmental Logger
11/12 16:52

Unit# 00913 Test# 3

INPUT 2: Level (F) TOC

Reference 0.00
Scale factor 10.01
Offset - 0.03

Step# 0 11/12 17:19

Elapsed Time	Value
0.0000	0.01
1.0000	0.03
2.0000	0.09
3.0000	0.09
4.0000	0.02
5.0000	0.15
6.0000	- 0.16
7.0000	- 0.07
8.0000	- 0.15
9.0000	0.00
10.0000	- 0.06
11.0000	0.01
12.0000	- 0.06
13.0000	- 0.02
14.0000	- 0.06
15.0000	- 0.07
16.0000	- 0.07
17.0000	- 0.12

END

Pump 93 gpm

SE1000B
Environmental Logger
11/12 16:54

Unit# 00913 Test# 3

INPUT 2: Level (F) TOC

Reference 0.00
Scale factor 10.01
Offset - 0.03

Step# 1 11/12 17:37

Elapsed Time	Value
0.0000	- 0.11
1.0000	4.97
2.0000	5.00
3.0000	5.05
4.0000	5.10
5.0000	5.07
6.0000	5.04
7.0000	5.09
8.0000	4.99
9.0000	5.17
10.0000	5.34
11.0000	5.45
12.0000	5.73
13.0000	5.92
14.0000	6.06
15.0000	6.16
16.0000	6.20
17.0000	6.26
18.0000	6.29
19.0000	6.30
20.0000	6.32
21.0000	6.34
22.0000	6.36
23.0000	6.37
24.0000	6.39
25.0000	6.40
26.0000	6.42
27.0000	6.44
28.0000	6.46

END

119 gpm

SE1000B
Environmental Logger
11/12 14:55

Unit# 00913 Test# 3

INPUT 2: Level (F) TOC

Reference 0.00
Scale factor 10.01
Offset - 0.03

Step# 2 11/12 14:05

Elapsed Time	Value
0.0000	3.80
1.0000	3.93
2.0000	3.89
3.0000	3.87
4.0000	3.81
5.0000	3.79
6.0000	3.81
7.0000	3.76
8.0000	3.78
9.0000	3.67
10.0000	3.66
11.0000	3.63
12.0000	3.66
13.0000	3.61
14.0000	3.54

END

107 gpm

WELL CO-2080
SINGLE PACKER TEST
ZONE TESTED: 1345' TO 1608'
PUMP THROUGH 2" METER

Environmental Logger
11/06 11:15

Unit# 00913 Test# 1

INPUT 1: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 0 11/06 10:23

Q = 110

Elapsed Time	Value
0.0000	7.73
0.0033	5.56
0.0066	6.31
0.0099	5.09
0.0133	6.63
0.0166	7.65
0.0200	6.87
0.0233	7.84
0.0266	8.94
0.0300	9.90
0.0333	9.97
0.0500	11.50
0.0666	13.17
0.0833	14.49
0.1000	16.08
0.1166	16.82
0.1333	17.43
0.1500	17.83
0.1666	18.03
0.1833	18.06
0.2000	17.69
0.2166	17.40
0.2333	16.99
0.2500	16.55
0.2666	16.14
0.2833	15.89
0.3000	15.43
0.3166	15.00
0.3333	14.78
0.4167	13.29
0.5000	13.07
0.5833	12.88
0.6667	13.14
0.7500	13.13
0.8333	13.13
0.9167	13.28
1.0000	13.20
1.0833	13.13
1.1667	13.37
1.2500	13.38
1.3333	13.06
1.4166	13.17
1.5000	13.21
1.5833	13.24
1.6667	13.16
1.7500	13.23
1.8333	13.20
1.9167	13.14
2.0000	13.08
2.5000	13.14
3.0000	13.25
3.5000	13.10
4.0000	12.76
4.5000	12.85
5.0000	12.23
5.5000	11.92
6.0000	10.60
6.5000	10.96
7.0000	11.97
7.5000	11.26
8.0000	10.43
8.5000	11.38
9.0000	12.00
9.5000	12.32
10.0000	12.70
12.0000	12.73
14.0000	12.70
16.0000	12.65
18.0000	12.79
20.0000	12.27
22.0000	12.25
24.0000	12.29
26.0000	12.16
28.0000	12.20
30.0000	6.88
32.0000	- 0.15
34.0000	0.08

END

Environmental Logger
11/06 15:07

Unit# 00913 Test# 0

Q = 113

INPUT 1: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 0 11/06 13:24

Elapsed Time	Value
0.0000	- 0.00
0.0033	0.00
0.0066	- 0.00
0.0099	- 0.00
0.0133	12.33
0.0166	13.21
0.0200	- 0.61
0.0233	- 0.61
0.0266	9.78
0.0300	6.45
0.0333	- 0.61
0.0500	8.67
0.0666	9.86
0.0833	11.52
0.1000	13.72
0.1166	14.99
0.1333	16.03
0.1500	16.93
0.1666	17.47
0.1833	17.65
0.2000	17.76
0.2166	17.64
0.2333	17.50
0.2500	17.13
0.2666	16.82
0.2833	16.43
0.3000	16.03
0.3166	15.65
0.3333	15.26
0.4167	13.79
0.5000	13.06
0.5833	13.00
0.6667	13.21
0.7500	13.35
0.8333	13.46
0.9167	13.63
1.0000	13.66
1.0833	13.79
1.1667	13.72
1.2500	13.76
1.3333	13.73
1.4166	13.79
1.5000	13.80
1.5833	13.81
1.6667	13.84
1.7500	13.71
1.8333	13.77
1.9167	13.73
2.0000	13.76
2.5000	13.73
3.0000	13.74
3.5000	13.79
4.0000	13.73
4.5000	13.74
5.0000	13.60
5.5000	13.59
6.0000	13.54
6.5000	13.61
7.0000	13.49
7.5000	13.45
8.0000	13.39
8.5000	13.45
9.0000	13.50
9.5000	13.54
10.0000	13.47
12.0000	13.41
14.0000	13.35
16.0000	13.43
18.0000	13.38
20.0000	13.40
22.0000	13.38
24.0000	13.45
26.0000	13.42
28.0000	13.38
30.0000	13.41
32.0000	13.36
34.0000	13.38
36.0000	13.46
38.0000	13.43
40.0000	13.35
42.0000	13.34
44.0000	13.32
46.0000	13.38
48.0000	13.32
50.0000	13.38
52.0000	13.29
54.0000	13.26
56.0000	13.26
58.0000	13.24
60.0000	13.29
62.0000	13.30
64.0000	13.16
66.0000	13.28
68.0000	13.16
70.0000	13.22
72.0000	13.19
74.0000	13.19
76.0000	13.14
78.0000	13.17
80.0000	13.20
82.0000	13.20
84.0000	13.21
86.0000	13.12
88.0000	13.17
90.0000	13.15

END

WELL CO-2080
DOUBLE PACKER TEST
ZONE TESTED: 1224' TO 1271'
PUMP THROUGH 2" METER

SE10008
Environmental Logger
11/08 18:36

Unit# 00913 Test# 1

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 0 11/08 18:37

Elapsed Time	Value
0.0000	0.00
1.0000	2.66
2.0000	3.47
3.0000	3.53
4.0000	3.48
5.0000	3.47
6.0000	3.46
7.0000	3.56
8.0000	3.46
9.0000	3.28
10.0000	3.29
11.0000	3.19
12.0000	3.04
13.0000	3.00
14.0000	2.97
15.0000	2.97
16.0000	2.91
17.0000	2.87
18.0000	2.74
19.0000	2.69
20.0000	2.73
21.0000	2.79
22.0000	2.79
23.0000	2.78
24.0000	2.87
25.0000	2.98
26.0000	2.96
27.0000	3.17
28.0000	3.30
29.0000	3.15

END

Q=52

SE10008
Environmental Logger
11/08 18:38

Unit# 00913 Test# 1

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 1 11/08 17:02

Elapsed Time	Value
0.0000	3.06
1.0000	3.97
2.0000	3.93
3.0000	3.92
4.0000	4.01
5.0000	4.00
6.0000	4.01
7.0000	3.98
8.0000	3.97
9.0000	3.97
10.0000	3.94
11.0000	3.87
12.0000	3.86
13.0000	3.87
14.0000	3.83
15.0000	3.92
16.0000	3.93
17.0000	3.94
18.0000	3.90
19.0000	3.90
20.0000	3.93

END

Q=62

SE10008
Environmental Logger
11/08 18:39

Unit# 00913 Test# 1

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 1 11/08 17:22

Elapsed Time	Value
0.0000	3.97
1.0000	3.85
2.0000	5.71
3.0000	5.77
4.0000	6.12
5.0000	6.10
6.0000	5.96
7.0000	5.91
8.0000	5.92
9.0000	5.86
10.0000	5.75
11.0000	5.74
12.0000	5.74
13.0000	5.86
14.0000	5.88
15.0000	5.94
16.0000	5.89
17.0000	5.94
18.0000	5.96
19.0000	5.95
20.0000	6.05
21.0000	6.03
22.0000	6.02
23.0000	6.07
24.0000	6.05
25.0000	6.03

END

Q=77

SE10008
Environmental Logger
11/08 18:40

Unit# 00913 Test# 1

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 2 11/08 17:46

Elapsed Time	Value
Ready	
0.0000	6.19
1.0000	11.89
2.0000	11.78
3.0000	11.91
4.0000	12.80
5.0000	12.66
6.0000	12.48
7.0000	12.41
8.0000	12.35
9.0000	12.48
10.0000	12.50
11.0000	12.55
12.0000	12.54
13.0000	12.56
14.0000	12.62
15.0000	12.68
16.0000	12.71
17.0000	12.75
18.0000	12.84
19.0000	12.85
20.0000	12.90
21.0000	12.91
22.0000	12.95
23.0000	12.96
24.0000	12.95
25.0000	12.93
26.0000	13.09
27.0000	13.12
28.0000	13.13
29.0000	13.10
30.0000	13.18
31.0000	13.13
32.0000	13.11
33.0000	13.13
34.0000	13.08
35.0000	13.14
36.0000	13.12
37.0000	13.10
38.0000	13.05
39.0000	- 2.21
40.0000	- 0.42

END

Q=115

WELL CO-2080
SINGLE PACKER TEST
ZONE TESTED: 360' TO 489'
FLOW THROUGH 6" ORIFICE

SE1000B
Environmental Logger
11/07 15:32

Unit# 00913 Test# 3

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 0 11/07 14:14

Elapsed Time	Value
0.0000	- 0.02
1.0000	0.52
2.0000	0.50
3.0000	0.47
4.0000	0.50
5.0000	0.48
6.0000	0.48
7.0000	0.53

END

SE1000B
Environmental Logger
11/07 15:33

Unit# 00913 Test# 3

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 1 11/07 14:21

Elapsed Time	Value
0.0000	0.51
1.0000	1.08
2.0000	1.16
3.0000	1.19
4.0000	1.27
5.0000	1.30
6.0000	1.37
7.0000	1.36
8.0000	1.39
9.0000	1.34
10.0000	1.39

END

SE1000B
Environmental Logger
11/07 15:34

Unit# 00913 Test# 3

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 2 11/07 14:32

Elapsed Time	Value
0.0000	1.36
1.0000	1.99
2.0000	2.13
3.0000	2.14
4.0000	2.20
5.0000	2.26
6.0000	2.30
7.0000	2.29
8.0000	2.22
9.0000	2.24
10.0000	2.24
11.0000	2.23
12.0000	2.18

END

SE1000B
Environmental Logger
11/07 15:35

Unit# 00913 Test# 3

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 3 11/07 14:44

Elapsed Time	Value
0.0000	2.21
1.0000	2.87
2.0000	3.01
3.0000	3.04
4.0000	3.15
5.0000	3.22
6.0000	3.19
7.0000	3.16
8.0000	3.14
9.0000	3.22
10.0000	3.17
11.0000	3.15
12.0000	3.24

END

SE1000B
Environmental Logger
11/07 15:36

Unit# 00913 Test# 3

INPUT 2: Level (F) TOC

Reference	0.00
Scale factor	10.01
Offset	- 0.03

Step# 4 11/07 14:56

Elapsed Time	Value
0.0000	3.20
1.0000	4.63
2.0000	4.65
3.0000	4.75
4.0000	4.77
5.0000	4.82
6.0000	4.82
7.0000	4.86
8.0000	4.88
9.0000	4.93
10.0000	4.91
11.0000	4.90
12.0000	4.87
13.0000	4.84
14.0000	4.88
15.0000	4.89

END