CONSTRUCTION AND TESTING
OF DISPOSAL WELLS 1, 2, AND 3
AT THE
GEORGE T. LOHMEYER PLANT
FORT LAUDERDALE, FLORIDA

VOLUME I

FEBRUARY 1984

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GROUND-WATER CONSULTANTS

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ACKNOWLEDGEMENTS

The combined efforts of many individuals were instrumental in the successful completion of the project. These people, some of whom are members of the Technical Advisory Group, are on the staffs of the City of Fort Lauderdale, the U. S. Environmental Protection Agency, the U. S. Geological Survey, the Florida Department of Environmental Regulation, the South Florida Water Management District, the Broward County Environmental Quality Control Board, Hazen and Sawyer, P.C., the Alsay-Pippin Corporation, and Geraghty & Miller, Inc. Thanks are extended to each of the following individuals for their assistance and cooperation.

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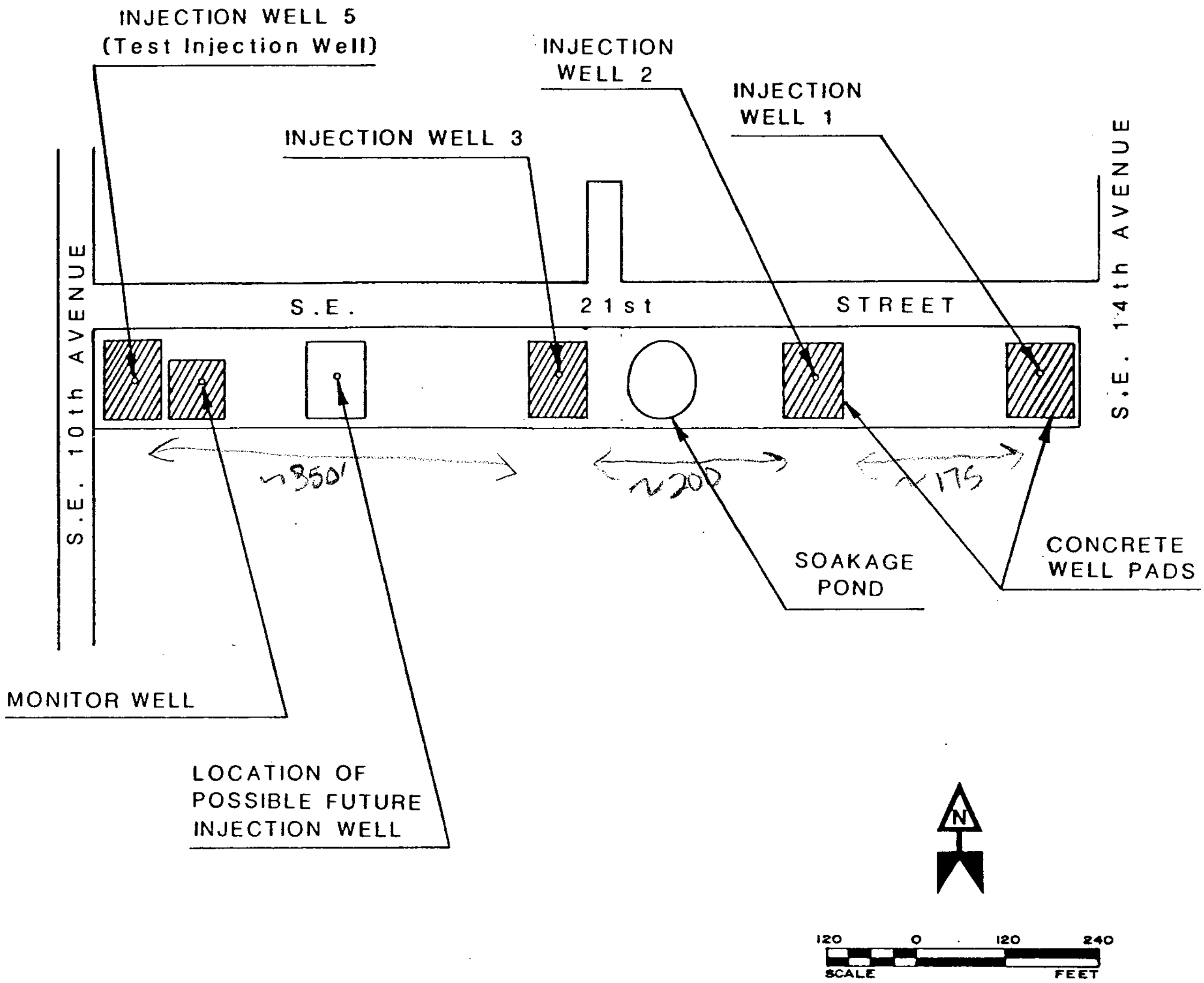
INTRODUCTION

A study completed in 1981 by Geraghty & Miller, Inc., and Hazen and Sawyer, P.C., ("Construction and Testing of The Test Injection Well, City of Fort Lauderdale, Florida", September 1981), confirmed the presence of an areally extensive, highly-transmissive zone of cavernous dolomite beneath the Fort Lauderdale area. That zone, also called the injection zone or boulder zone, was found to be hydrologically suitable for the disposal of treated effluent produced by the George T. Lohmeyer Wastewater Treatment Plant (WWTP); it lies at depths greater than 2900 feet, contains salt water, and is overlain by sequences of rock that function as confining layers. The study also established criteria for the construction of three 24-inch-diameter injection wells that were constructed and tested in the program discussed herein. Well locations are shown on Figure 1.

Specifications for the program were issued in November 1981 and bids were taken on December 23, 1981. These contained provisions for the drilling, construction, and testing of four 24-inch-diameter injection wells, one of which was to be constructed at the City's option. Three wells were to be constructed to depths of 3500 feet and one to a depth of 4000 feet or first contact with an evaporite (gypsum and/or anhydrite). In addition, the specifications called for performing controlled pumping tests to determine the capacity of the boulder zone to accept effluent and for the collection of cores and the making of a variety of geophysical logs to develop additional information on confining bed properties. The contract for the drilling and associated site work was let to the Alsay-Pippin Corporation of Lake Worth, Florida. The well construction started on July 20, 1982, following site



PREPARED FOR

HAZEN AND SAWYER, P.C.

TITLE

LOCATION OF INJECTION AND MONITOR WELLS AT THE GEORGE T. LOHMEYER WWTP FORT LAUDERDALE, FLORIDA

COMPILED BY P.G. Jakob	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE SEPT. 83
DRAWN BY P.Q. Smith		REVISED
CHECKED BY P.G. Jakob	SCALE 1" = 240'	FIGURE 1

preparation, and was substantially completed in May 1983. All wells were successfully completed and constructed in accordance with specifications.

This report documents the results of the program and contains discussions of the well drilling and construction, the capability of the wells to accept effluent, and the integrity of the confining sequence. Recommendations regarding data collection and well operation and injectivity testing also are provided. Also included are copies of the various geophysical logs, geologic logs (samples and cores), laboratory reports of chemical analyses of water samples, and results of gyroscopic surveys, pressure tests, and core tests. This information is contained in the Appendices and in the accompanying volumes.

FINDINGS

1. Evaluation of the various data shows that the wells are properly constructed and can be used for the disposal of treated effluent at their design rates.

2. The data reconfirm the presence of the boulder zone and that it is highly transmissive and saturated with salt water.

3. The top of the boulder zone occurs at an average depth of 2920 feet; the bottom of the zone occurs at a depth of 3580 feet, based on data from Well 3. Exploratory drilling in Well 3 revealed that the bottom of the boulder zone occurs at 3580 feet and that the zone is approximately 660 feet thick.

4. The boulder zone has an extremely high transmissivity which is estimated to be 98 million gpd/ft (gallons per day per foot). Pumping at a rate of 10,000 gpm (gallons per minute) from a well; conversely injection would cause a pressure build-up of 0.20 foot.

5. The boulder zone is capable of accepting enormous quantities of treated effluent at reasonable injection pressures. On the basis of the pumping/injection tests, operating well head injection pressures for each well are estimated to be 52 psi (pounds per square inch) at a rate of 10,000 gpm, 61 psi at 15,000 gpm, and 73 psi at 20,000 gpm.

6. The intervals between approximately 1860 and 2000 feet and 2100 and 2570 feet serve as confining beds. The interval between approximately 2690 and 2920 feet was again shown to provide a slight hydraulic interconnection between the boulder zone and Monitor Zone #1, confirming the results of the 1981 testing.

7. From laboratory core tests, the permeability of the principal confining zone between 2100 and 2570 feet in depth was determined to average .0000579 centimeters per second (1.22 gallons per day per square foot). Based on permeability, an average porosity, and the difference in fluid densities, a travel time of 85 years would be needed for effluent to move through this zone.

RECOMMENDATIONS

1. The tubes in the Monitor Well and all connecting above-ground pipe should be disinfected prior to the collection of any water samples and prior to the injection of effluent.

2. The specific conductance of samples from the Monitor Well should be measured and recorded continuously before and during injection-well operation.

3. Analyses of samples from the Monitor Well tubes should be conducted before injection begins and during operation on a monthly basis. The analyses should be made for the chloride concentration, C.O.D., and for fecal coliform.

4. Records of the injection pressures, injection rates, and daily cumulative volume disposed should be collected from each well when effluent injection begins. The records should be maintained in perpetuity.

5. Injectivity testing on all injection wells should be conducted on a bi-monthly basis during the first year of operation. Testing frequency thereafter should be determined following assessment of the first year's operation; at least two injection rates should be incorporated in each test.

6. Bottom-hole pressure tests on each injection well should be conducted at some time during the first six months of injection. The same range of injection rates should be used for injectivity testing.

7. It is possible that effluent may be detected at some future time in Monitor Zone #1, located in the depth interval from 2570 to 2690 feet. Should that happen, then another monitor well should be constructed by plugging the tubing tapping Monitor Zone #1 with cement and perforating the interval between 2000 and 2100 feet.

DATA COLLECTION

A variety of techniques and equipment was used to collect the information necessary to construct Injection Wells 1, 2, and 3, and to meet criteria established to insure the safe disposal of effluent. A description of each follows, along with comments on its applications.

The project staff maintained an Inspector's Log describing items relating to the construction and testing of the wells and recording time spent on various work tasks (gyroscopic and directional surveys, geophysical logging, pumping tests, and related incidents). Materials used in construction, time spent on contract items, and footages drilled were recorded in a separate log, referred to as a Construction Log. Copies of the Inspector's Log were furnished on a weekly basis to the members of the Technical Advisory Committee (TAC) and to representatives of the City of Fort Lauderdale and the Broward County Environmental Quality Control Board (BCEQCB).

Samples of the rock cuttings were collected during all drilling operations. Times required for the cuttings to circulate from the bottom of the hole to the sampling station (lag times) were computed periodically to insure that accurate sample depths were recorded. The samples were washed, dried, and examined microscopically by a Geraghty & Miller geologist and lithologic logs were prepared. Copies of these logs are contained in Appendix A. One set of samples from each well was furnished to the drilling contractor for submittal to the Florida Bureau of Geology in accordance with permit conditions. Except where noted otherwise, all depth measurements stated in this report are referenced to the concrete drilling pad (elevation +6.0 feet NGVD).

Cores were collected during the drilling operations; three locations were cored within the confining zone in each well. A Christensen core barrel and four-inch-diameter diamond bit were used. The cored intervals were generally ten feet in length. Portions of the cores were sent to a testing laboratory (NFS Services, Inc.) where they were tested to determine their vertical permeability, porosity, specific gravity, compressive strength, and modulus of elasticity. Copies of the core descriptions and laboratory reports are included in Appendix A.

A variety of geophysical logs was run in each of the wells to obtain data on the injection zone and the confining sequence. Dual-induction SFL (shallow, medium, and deep investigation tools), temperature, caliper, electric, gamma ray, neutron porosity, density, sonic, and variable density logs were made. Following cementing of the 24-inch casings, a bond log was performed. Copies of the various logs are contained in Appendix B.

The Dual-Induction SFL was used to differentiate between the limestone-dolomite beds and, along with the gamma ray log, to aid in the correlation of lithologic units among the holes. The "porosity" logs (sonic, neutron, and density) were useful in identifying not only the dolomite beds of the injection zone, but zones that are highly porous (cavernous and/or fractured) and likely to present cementing problems. The variable density log served a similar function.

Television surveys were performed in pilot holes of Wells 1 and 2 when the boulder zone was encountered (± 2900 feet) and in the three completed wells. The surveys were run while the well was being pumped to assist in identifying producing zones and to determine the condition of the open hole in the injection zone. Copies of the videotapes were provided to members of the Technical Advisory Group as requested.

WELL DRILLING AND CONSTRUCTION

This section describes, chronologically, the construction of each of the injection wells. The order of well construction was chosen by the Contractor. Well 3 was completed first, then Wells 1 and 2 were constructed simultaneously. Well 3 was selected by the Contractor to be drilled to a depth of 4000 feet. The bottom 500-foot interval of this well has a completed hole diameter of 17-1/2 inches and was drilled for exploratory purposes as required by the contract. Wells 1 and 2 were drilled to depths of 3500 feet. Selected details of the wells' construction are shown on Plate 1.

As the wells were drilled, cuttings of the sediments were collected at 10-foot intervals and at formation changes. As noted previously, three cores were taken from within the confining interval of each well. Directional surveys of the drilled holes were taken at approximately 60-foot intervals as drilling proceeded. Comparisons were made between the positions of the pilot holes and reamed holes with the use of inclinometer and gyroscopic surveys. Plumbness and alignment tests were conducted on cemented-in-place well casings except the 24-inch casings. Pressure tests were conducted on the 24-inch casings prior to drilling into the injection zone.

Injection Well 3

Construction of Injection Well 3 began on July 20, 1982, following the assembly of the drilling rig and erection of the noise barrier west of the well site. A 62-inch-diameter hole was completed to a depth of 129 feet below pad level on July 24th. A 54-inch-diameter casing, having a 0.312-inch wall thickness, was installed in the hole to a depth of 126 feet. The annular space between casing and drilled hole was filled in one stage with 550 sacks of cement with additives. The cement mixture consisted of Florida Class H cement with 8 percent gel and 1/4 pound of Flocele per sack of cement. Plumbness and alignment tests were performed at 20-foot intervals on the cemented casing; the results indicate an acceptable degree of inclination.

A 14-1/2-inch-diameter pilot hole was begun on July 26th. The pilot hole was drilled by the conventional mud rotary method to a depth of 960 feet. A considerable volume of drilling fluid was lost to the formation in the 900- to 960-foot interval. The pilot hole was subsequently reamed with a 52-inch-diameter bit to a depth of 930 feet. A 42-inch-diameter casing, having a wall thickness of 0.375-inch, was set into the hole to a depth of 925 feet. A total of 4888 cubic feet of cement mixture was pumped into the annular space in two stages. The mixture was Florida Class H cement with from 4 to 12 percent gel, 2 percent calcium chloride, and 1/2 pound of gilsonite per sack of cement. The "tail-in" cement of the first stage contained no gel or calcium chloride. Following cementing, a plumbness and alignment test on the 42-inch casing was performed and indicated an acceptable casing installation.

On August 16th the Contractor began drilling the 40-1/2-inch-diameter borehole for the 34-inch-diameter casing. The Contractor chose not to drill a pilot hole in this interval. Direct mud-rotary drilling was stopped at 1051 feet and reverse-air drilling began below this depth. The 40-1/2-inch hole was drilled to 1909 feet. Geophysical logs run in this hole included the caliper, gamma-ray, temperature, electric, and fluid resistivity logs. Based on these logs and evidence gathered during drilling to this point, Geraghty & Miller recommended setting the 34-inch-diameter casing (wall thickness of 0.500-inch) at a depth of 1900 feet. This was accomplished on September 12th, following a considerable delay in waiting for full delivery of the casing.

Cementing of the 34-inch casing took place in three stages. Except for the "tail-in" cement of the first stage, which contained no gel, the cement mixture consisted of Florida Class H cement, 12 percent gel, with 12.5 pounds of gilsonite and 0.5 pounds of Flocele per sack of cement. The total volume pumped in three stages was 7197 cubic feet. On September 17th, a gyroscopic survey conducted inside the 34-inch casing indicated an acceptable bottom inclination of 21 minutes off the vertical.

Following the gyroscopic survey, a 14-3/4-inch-diameter pilot hole was drilled to a total depth of 2914 feet below pad level. An 18-inch cavity was encountered at this depth signaling the top of the boulder zone. Three core samples were taken during drilling in depth intervals from 2148 to 2158 feet, from 2230 to 2240 feet, and from 2360 to 2370 feet. A gyroscopic survey of the open borehole revealed an acceptable bottom inclination of 30 minutes from the vertical. Geophysical logs were run in the open interval including the caliper, gamma-ray, electric, temperature, dual-induction, borehole-compensated sonic, formation density, and porosity logs. A flow-meter survey also was conducted as the well was pumped. A television survey was attempted, but could not be successfully completed because the water in the well had not clarified after a total of 27 hours of pumping.

On October 2nd, reaming of the pilot hole began with a nominal 34-inch-diameter bit and proceeded to a depth of 2819 feet. A gyroscopic survey of the reamed hole showed no significant departure from the pilot hole. A 24-inch-diameter casing (with a 0.500-inch wall thickness) was run in the hole and its bottom was set at 2800 feet. Results of the evaluation of the drilling, geologic and geophysical log data showed that the 24-inch casing should be set at a depth of 2800 feet to achieve maximum penetration of the confining sequence and remain sufficiently above the injection zone to prevent cement loss. Cementing of the casing was performed in six stages. The total volume of cement pumped was 13,093 cubic feet. The mixture of cement consisted of Florida Class H cement with 8 to 12 percent gel, 0.5 pounds of Flocele, and 12.5 pounds of gilsonite per sack of cement. The "tail-in" cement of the first stage did not contain gel in the mixture. On October 26th, a successful pressure test was conducted on the 24-inch casing.

Drilling of the 22-inch-diameter open-hole portion of the well began on October 26th. Drilling through the hard dolomite of the boulder zone was slow and caused considerable wear on drill bits. On November 21st, the target depth of 3500 feet for the 22-inch hole was reached. Drilling continued with a 17-1/2-inch-diameter bit to extend the hole to 4000 feet (specifications required that the first or second well be drilled to 4000 feet, while other wells were to be drilled to 3500 feet). On November 29th, the 4000-foot depth was reached; the

Contractor drilled to 4010 feet at his option. On the following day, geophysical logs were run including the dual induction, compensated neutron, formation density, gamma-ray, borehole-compensated sonic, variable density, and cement-bond logs.

The cement bond log (CBL) and variable density log (VDL) are the only logs that are used for estimating the character of the cement behind the pipe. Unfortunately, these logs were not designed for use in casings with diameters greater than about 20 inches (personal communication, Schlumberger Well Services 1983). In the absence of other indicators of bonding quality, however, they were run and serve a limited purpose. According to the bond log of Well 3, the VDL display in the pipe-overlap interval from 0 to 1900 feet has a discernible pipe signal from 185 to 825 feet and from 1385 to 1410 feet. Discernible pipe signal again occurs at 1670 feet and continues to the bottom of the 24-inch casing. This feature represents a reduction in acoustic coupling between the casing and the cement due to the presence of mill varnish or scale on the casing or to the presence of a microannulus. Channeling is not indicated because of the consistency of the signal over such a long interval (channeling is shown by strong pipe signals for short intervals because it is a localized condition). If the observed pipe signal is the result of a microannulus, a hydraulic seal exists. High pressure testing on oil wells by Schlumberger Well Services has shown that a microannulus will not be capable of transmitting fluid (Schlumberger, 1975).

No problems were encountered when the 24-inch casing was cemented in stages. Fill up during each stage was within the range of what was expected, and in no case was more fill achieved than was expected (this would indicate channeling). Examination of the VDL logs for the casing reveals the presence of considerable formation signal (particularly below the 34-inch casing) indicating coupling between casing, cement and formation. Furthermore, there was no mud in the annulus during cementing; the annulus contained only salt water, which would minimize the occurrence of channeling. For these reasons, the bond between casing and cement is considered to be adequate.

Injection Well 1

The drilling of Well 1 began on December 10, 1982, following the relocation of the drilling rig from Well 3. A 62-inch-diameter hole was drilled to 128 feet. The 54-inch-diameter conductor casing (wall thickness of 0.312-inch) was installed to a depth of 126 feet and cemented in place with 1100 cubic feet of cement mixture consisting of Florida Class H cement, 8 percent gel, and 1/4 pound of Flocele per sack of cement. A plumbness and alignment test was then performed and indicated acceptable alignment of the 54-inch casing.

On December 6th, drilling of a 17-1/2-inch pilot hole began. The pilot hole was drilled to a depth of 893 feet, then reamed with a 52-inch-diameter reaming assembly to a depth of 776 feet. Smaller diameter reaming assemblies were used to extend the hole depth to 930 feet. The 52-inch assembly was again used to a depth of 920 feet. The loss of drilling fluids between 920 and 930 feet indicated that this zone has a high permeability.

A 42-inch casing (having a wall thickness of 0.375 inch) was set to a depth of 925 feet on January 13, 1983. The casing was cemented in two stages with mixtures containing 4 to 12 percent gel, 12-1/2 pounds of gilsonite, and 1/2 pound of Flocele per sack of cement, and 2 percent calcium chloride. The "tail-in" cement of the first stage contained no gel or calcium chloride. A total volume of 4317 cubic feet was pumped. A plumbness and alignment test conducted on the 42-inch casing indicated an acceptable degree of inclination.

Instead of drilling a pilot hole, the Contractor elected to use a 40-1/2-inch reaming assembly for drilling to a depth of 1910 feet. At 1046 feet, the drilling method was changed from mud-rotary to reverse-air. When the 40-1/2-inch hole was completed, temperature, gamma-ray, caliper, borehole-compensated sonic, variable density, neutron porosity, and dual induction logs were made.

The 34-inch-diameter casing (wall thickness of 0.500 inch) was set to a depth of 1900 feet and cemented in three stages. The cement mixture consisted of 8 to 12 percent gel, 12-1/2 pounds of gilsonite, and 1/2 pound of Flocele per sack of cement, and 2 percent calcium chloride for a total of 6233 cubic feet. The "tail-in" cement of the first stage contained no gel or calcium chloride. A gyroscopic survey run inside the 34-inch casing showed a satisfactory well alignment.

On February 6th, drilling of a 14-3/4-inch pilot hole was initiated from a depth of 1900 feet. During the course of drilling, three 4-inch-diameter cores were taken from the intervals 2110 to 2120 feet, 2180 to 2190 feet, and 2290 to 2300 feet.

The 14-3/4-inch hole was terminated at a depth of 2923 feet on February 21st. A gyroscopic survey and geophysical logging consisting of gamma-ray, caliper, borehole compensated sonic, neutron porosity, dual-induction, and variable density logs were run at this time. The well was then pumped while temperature and flow-meter logs were run. After pumping nearly 4 million gallons, water in the well was still too turbid to run a successful television survey. A tape of the television survey from 1900 feet to 2060 feet, however, showed a high degree of turbulence due to fluid entering the borehole from a cavernous dolomite and was preserved for the well record.

Reaming of the 14-3/4-inch-diameter pilot hole began on March 2nd with a bit assembly having a maximum diameter of 32 inches. The hole was reamed to a depth of 2820 feet. A cement plug consisting of 50 sacks of cement was placed in the bottom of the well prior to setting the 24-inch-diameter casing at a depth of 2800 feet. The casing was cemented in five stages with the cement containing up to 12 percent gel, 12.5 pounds of gilsonite, and 0.5 pounds of Flocele per sack of cement, and 2 percent calcium chloride. The "tail-in" cement of the first stage contained no gel or calcium chloride. A total of 12,111 cubic feet of slurry was used to cement the casing. A successful pressure test was conducted on the 24-inch-diameter casing on March 25th.

Drilling of the 22-inch-diameter open hole below the 24-inch casing began on March 26th. At a depth of 2939 feet, the drill bit encountered a small cavity indicating the top of the boulder zone. Progress through the boulder zone was slow; the total depth of 3520 feet was reached on April 23rd.

The CBL and VDL logs of Well 1 indicate a satisfactory bond between the casing and cement and the formation and cement. In the cemented casing, the trace of the CBL log has a lower amplitude at all depths than in the non-cemented casing from 0 to 50 feet. A slight suggestion of channeling occurs between 1905 and 1965 feet and from 2065 to 2095 feet. If there are channels, they are not capable of transmitting fluid as they are localized and of no consequence. The VDL display also shows formation signals indicating coupling (bonding) between the casing, cement, and formation.

Injection Well 2

The construction of Injection Well 2 commenced on December 1, 1982, with the drilling of a 52-inch-diameter borehole. A 62-inch reamer was added to the bit assembly and drilling continued to 126 feet. The 54-inch-diameter casing (wall thickness of 0.312 inch) was set to 126 feet and cemented in place in one stage. The cement mixture consisted of 8 percent gel and 1/4 pound of Flocele per sack of cement. A total volume of 1100 cubic feet was pumped into the annulus between casing and borehole. A plumbness and alignment test subsequently conducted on the 54-inch casing indicated that the casing inclination was within acceptable limits.

Beginning on December 6th, a 14-3/4-inch pilot hole was advanced to 950 feet and subsequently reamed to 930 feet with a 52-inch-diameter assembly. A 42-inch-diameter casing (wall thickness of 0.375 inch) was set to a depth of 925 feet and cemented in two stages. The mixture consisted of 8 to 12 percent gel, 12-1/2 pounds of gilsonite and 1/2 pound of Flocele per sack of cement, and 2 percent calcium chloride. The "tail-in" cement of the first stage contained no gel or calcium chloride. The total volume of mixture pumped was 4417 cubic feet. The plumbness and alignment test on the 42-inch casing indicated an acceptable degree of inclination.

The Contractor elected to drill a 42-inch-diameter hole from the bottom of the 42-inch casing to a depth of 1910 feet without first drilling a pilot hole. At 964 feet, the drilling method was changed from mud-rotary to the reverse-air method. When the 42-inch assembly reached a depth of 1910 feet, temperature, gamma-ray and caliper logs were run. Subsequent to the logging, drilling operations were halted until a larger drilling rig (capable of bearing the total weight of the 34-inch-diameter casing) was available. The 34-inch casing (with a wall thickness of 0.500 inch) was then set to 1900 feet and cemented in four stages. Except for the "tail-in" cement of the first stage, which contained no gel or calcium chloride, the cement mixture consisted of 8 to 12 percent gel, 12-1/2 pounds of gilsonite, and 1/2 pound Flocele per sack of cement, and 2 percent calcium chloride. The volume of cement pumped was 9513 cubic feet. A gyroscopic survey conducted inside the 34-inch casing showed that the well alignment was within acceptable limits.

On February 11th, a 14-3/4-inch pilot hole was begun and was drilled from 1915 feet to 2930 feet. Cores were taken from 2405 to 2416 feet, 2470 to 2480 feet, and 2589 to 2596 feet. Drilling was temporarily halted at 2916 feet while a gyroscopic survey was performed. A cavity was encountered between 2925 and 2927 feet indicating the presence of the boulder zone. Wireline surveys conducted at the 2930-foot depth included the gamma-ray, caliper, borehole-compensated sonic, neutron porosity, dual-induction, and variable density logs. Flow-meter and temperature logs and a television survey were run while the well was pumped.

On February 26th, reaming began with a bit assembly having a maximum diameter of 32 inches. After the hole had been reamed to a depth of 2820 feet, a cement plug formed of 50 sacks of cement was placed into the hole preparatory to setting the 24-inch-diameter casing. The 24-inch casing was installed to a depth of 2800 feet and cemented in place in five stages. The cement mixture consisted of up to 12 percent gel, 12.5 pounds of gilsonite, and 0.5 pounds of Flocele per sack of cement, and up to 2 percent calcium chloride. The "tail-in" cement of the first stage contained no gel or calcium chloride. Cementing of the 24-inch casing was completed on March 14th.

On March 15th, a casing pressure test was successfully conducted and drilling of the open-hole portion of the well was begun. A 22-inch-diameter bit was used to penetrate the boulder zone to a total depth of 3525 feet. Drilling was relatively slow in this final interval; the total depth was reached on April 9th. Temperature, borehole compensated sonic, neutron porosity, dual-induction, and variable density logs were made when the drilling was finished.

The CBL and VDL logs of Well 2 show a satisfactory casing-to-cement and formation-to-cement bond. There is no indication of microannulus on the VDL display, and the CBL trace generally has a lower amplitude than the uncemented 0- to 50-foot interval. Again, formation signal can be seen on the VDL.

SUBSURFACE CONDITIONS

Background

The specifications of Injection Wells 1, 2, and 3 were based on data obtained during the drilling, construction, and testing of the Floridan Aquifer Monitor Well and the Test Injection Well (Injection Well 5). The final completion details were determined from subsurface conditions in each well. Flexibility for changes in well construction was maintained at all times to allow for site-specific geologic conditions. Any modifications, i.e., casing setting, depths, test points, etc., were made based on evaluation of the formation cuttings, geophysical logs, and other data derived during the drilling of each well.

Geologic Setting

A well-defined, areally-extensive sequence of limestone, clay/marl, and dolomite is present at the site and throughout the area. The various geologic units were found to satisfy the criteria for the injection zone and confinement of the injection zone to permit the disposal of the required quantities of treated effluent using injection wells. A description of the units follows.

From land surface to about 400 feet, the sediment is composed of a fossiliferous limestone with various admixtures of sand, shell, and marl. The color of the limestone varies generally from yellowish brown near the surface to pale orange. Solution features in the upper 200 feet are common and give this unit the high permeability characteristic of the Biscayne aquifer. From approximately 200 to 400 feet, the limestone contains up to 60 percent of marl.

From 400 feet to about 900 feet, the dominant component is marl. In this interval the marl is generally soft, sandy, and silty, and contains streaks of limestone from about 740 feet to 790 feet. Olive-colored clay is present between 800 and 900 feet. The color of the marl is light olive gray, but becomes yellowish in the zone of the limestone. This interval has a low permeability and comprises the main confining zone for the underlying Floridan aquifer.

Rocks above an approximate depth of 900 feet are of Pleistocene, Miocene, and Oligocene age, and include the Anastasia, Ft. Thompson, Tamiami, Hawthorne, Tampa, and Suwannee Formations (Chen, 1965). The Pleistocene rocks contain the only fresh-water aquifer in the region of the injection wells, but the Pleistocene aquifer does not contain fresh water at the location of the injection wells.

Limestone comprises the interval between 900 feet and approximately 2000 feet. The character of the limestone varies widely from soft, porous, and fine-grained to a hard, dense, and medium-grained rock. The color varies from yellow-gray, to light gray to white, to very pale orange, and to pink-gray. A pale orange, medium-grained, biomicritic limestone occurs from 960 to approximately 1250 feet. The sonic and neutron logs indicate that this zone is quite porous. An exception to this generality is a dense, low-porosity limestone layer containing phosphatic sand at a depth of 980 feet. "Spikes" of high gamma-ray and resistivity (induction log) correlate with the Port Everglades Oil Well (Geraghty & Miller, Inc., October 1979); at this depth, indicating that the strike is North 55 degrees West, and the dip is 0.1 degree West.

From 1250 to about 1450 feet, the dominant colors of the rock are pink-gray, white, and yellow-gray; this interval has variable porosity. Between 1450 and about 1500 feet, a light gray, moderately hard limestone is present. This zone can be identified in each of the boreholes by its high resistivity and low porosity shown on the induction logs and neutron and sonic logs. The top of this zone correlated by the dual induction logs among the Port Everglades Oil Well, and Injection Wells 5 and 1, has a strike of North 50 degrees West, and a dip of 0.2 degree West. This is close to the strike and dip shown in the zone near 1000 feet.

Below 1500 feet to about 2000 feet, a biomicritic limestone grades downward with increasing amounts of marl and silt. The color ranges from very pale orange to white and gray tinged with shades of pink and yellow. Within the zone from about 900 to 2000 feet are rocks of Eocene age including the Ocala, Avon Park, and Lake City Formations.

At approximately 2000 feet, the limestone grades into dolomite over an interval of about 20 feet. That depth (2000 feet) apparently marks the top of the Oldsmar Formation of Eocene age (Frederick W. Meyer, U. S. Geological Survey, Miami, Florida; 1983; telephone communication). The Oldsmar Formation extends downward to the bottom of the injection zone near 3600 feet in depth and contains the major occurrences of dolomite encountered during drilling.

Dolomite occurs between 2000 and 2100 feet, except for a zone between about 2040 feet and 2060 feet where limestone dominates. The dolomite is massive and dense and its color is predominantly brown. Within this 100-foot section, cavities are seen in the television survey; the dolomite zone also was shown to be the major source of water while pumping the open hole between about 900 and 2900 feet in Injection Well 1. The dense dolomite creates a high resistivity signal on the induction logs and yields a high natural gamma radiation. Spikes on the dual induction logs indicate, by correlation among wells, that the strike is North 25 degrees East, and the dip is 0.5 degree West.

Together, the strike and dip determinations cited above show that the strata are nearly horizontal. This indicates geological uniformity and stability. Plate 2 illustrates the uniform stratigraphy by comparison of the dual-induction logs among on-site wells.

A pinkish-gray to very pale orange, soft, marly and fossiliferous limestone is present below the base of the dolomite at 2100 feet. The limestone persists to about 2570 feet where a sequence of limestone and dolomite begins and continues to approximately 2690 feet. This 120-foot-thick interval can be correlated between wells by its high gamma radiation activity and resistivity. This section also was noted, in a television survey, to produce water upon pumping.

Although minor amounts of dolomite are present, a pale orange limestone continues below 2690 feet as the dominant rock to the depth where dolomite once again predominates. A gradual transition from limestone to dolomite begins at about 2800 feet and ends at about 2920 feet - where dolomite dominates and marks the approximate top of the boulder zone.

Except for Injection Well 3, which was extended to a depth of 4010 feet for exploratory purposes, the injection wells were drilled to about 3500 feet. From the top of the boulder zone to a depth of about 3580 feet, a yellowish brown and hard dolomite was encountered. This interval forms the main injection zone; it is characterized by a high degree of fracturing, high development of secondary porosity, and very high permeability. Also within this interval are several thin beds of soft, white, and granular limestone. These beds are no more than a few feet thick.

Below a depth of 3580 feet, limestone again becomes prevalent and persists to the total depth of Injection Well 3. The depth of 3580 feet marks the top of the rocks of Paleocene age and the Cedar Keys Formation. The limestone is yellowish-brown, fine-grained, and moderately-well cemented. Within this zone (3580 to 4010 feet), dolomite is present in beds totaling no more than 30 feet in thickness between depths of 3580 to 3740 feet. From 3990 to 4010 feet, the rock encountered is a yellowish-brown, fine-grained and friable limestone that also contains a minor amount of soft, white, and chalky gypsum. The first contact with the gypsum, an evaporite, was considered the target depth for the exploratory portion of Injection Well 3.

Hydrogeologic Setting

Subsurface hydrogeologic characteristics were determined by evaluation of the drill cuttings, laboratory tests conducted on cores from the confining zones, and through the use of geophysical and television surveys. The drill cuttings revealed the presence of secondary-porosity features such as vugs and crystal-covered surfaces indicative of a higher permeability. Core testing conducted in the laboratory yielded additional and direct information on the vertical permeability of the rock in the confining zones. Geophysical logs were useful in measuring the relative porosities, densities, and water-bearing and transmitting characteristics of the geologic formations. Evidence from each of these sources is used in the following text to describe hydrogeologic properties of the various confining zones and water-bearing zones between land surface and the base of the boulder zone.

Confining Zones

The most important confining zones above the boulder zone occur between 2100 and 2570 feet, and between 1860 and 2000 feet. The limestone that comprises the confining zones is biomicritic, marly, silty, and chalky; it has a high porosity, but because the pores are not interconnected, the permeability is very low. The zone between 2690 and 2920 feet was shown previously to provide a measurable degree of hydraulic interconnection between the boulder zone and Monitor Zone #1 (Geraghty & Miller, Inc., and Hazen and Sawyer, P.C., 1981, pg. 53) The results of porosity and permeability tests conducted on cores are shown on Table 1. Typical geophysical logs showing the "signatures" of confining beds and injection and monitor zones are shown on Plate 3.

The tops and bottoms of the confining zones are indicated in a general way by the borehole-compensated sonic logs. The zones are distinguished by relatively uniform traces that vary in amplitude over a limited range and indicate a formation material having consistency in composition

TABLE 1

HYDRAULIC PROPERTIES OF CONFINING ZONES
BASED ON CORE TEST DATA

Injection Well 1

Core No.	Depth (feet)	Porosity (%)	Permeability (cm/sec)	Description
1	2180.55-2181.40	31.1	0.0000836	Sandy limestone
2	2112.0 -2112.95	30.4	0.0000560	Sandy limestone
3	2293.63-2294.58	34.7	0.0000340	Sandy limestone

Injection Well 2

Core No.	Depth (feet)	Porosity (%)	Permeability (cm/sec)	Description
1	2494.1 -2595.0	32.4	0.0000083	Limestone
2	2470.55-2471.30	36.1	0.0000144	Limestone
3	2410.0 -2410.8	32.8	0.0000207	Sandy limestone

Injection Well 3

Core No.	Depth (feet)	Porosity (%)	Permeability (cm/sec)	Description
1	2149.0 -2149.8	34.5	0.0003250	Sandy limestone
2	2360.0 -2360.8	34.5	0.0000131	Limestone
3	2369.0 -2370.0	38.1	0.0000165	Limestone

Injection Well 5

Core No.	Depth (feet)	Porosity (%)	Permeability (cm/sec)	Description
3	2543.16-2543.92	27.8	0.0000077	Medium-hard limestone
5	2757.58-2754.42	38.3	0.000120	Soft, vuggy limestone
6	2802.84-2803.84	32.9	0.000155	Soft, porous limestone
7	2854.33-2855.5	34.0	0.0000516	Soft limestone
8	2901.5 -2902.00	31.4	0.000029	Soft limestone

Note: Tests on cores from Wells 1, 2, and 3 were conducted by NSF Services, Inc., Clearwater, Florida; tests on cores from Well 5 were conducted by Florida Testing Laboratories Inc., St. Petersburg, Florida.

(limestones) and porosity. Zones containing dolomite show erratic variations in signal amplitude due principally to cycle skipping caused by rock fractures and borehole irregularities. Interpretation of the sonic logs (Merkel, 1979) indicates that the porosity of the interval from 2100 to 2570 feet varies from 30 to 37 percent, and the interval from 2690 to 2920 feet varies in porosity from about 23 to 43 percent. Values derived from the cores and those based on the sonic logs are in good agreement. Porosities of the confining zones determined on the basis of the borehole-compensated neutron and formation density logs are significantly higher than those reported above. This is due to the influence of the rough surface and the relatively large-diameter of the boreholes for which the logging tool cannot compensate; Schlumberger Well Services' logs contain remarks to this effect. Also, the neutron and density logs measure both secondary and primary porosity, whereas the sonic log measures primary porosity only.

Inspection of the dual-induction logs from all of the injection wells at this facility indicates that the resistivities of the confining zones are low and relatively uniform in amplitude within any confining zone. The confining zones have resistivities that are less than six ohm-meters. Resistivities within the dolomite beds between each confining zone frequently rise to levels ten times higher than in the confining zone. The low resistivities in the confining sequences are characteristic of a porous and dense material.

The caliper logs from the various wells were quite similar due to the flat-lying strata and consistent degree of hardness of each strata. The confining zones were typically "washed out" to diameters as much as two times larger than bit diameters because of the softness of the limestone. The zones containing some portion of dolomite (2000 to 2100 feet, 2570 to 2690 feet, and 2800 to 2920 feet) were not washed out more than a few inches greater than bit size due to the comparative hardness of the rocks. The intervals of confining zone below a dolomite-containing bed generally showed a gently increasing hole diameter that was largest near the center of the confining zone and diminished either abruptly or gradually towards the next lower dolomite-bearing zone.

The confining zones were also delineated by the flow-meter logs. These logs showed where water entered or exited the borehole by changes in the water velocity when the well was pumped. Because the logs indicated no changes in water velocity adjacent to the confining zones that could not be accounted for by changes in hole diameter, these zones were shown to be relatively impermeable in comparison to the boulder zone and monitor zones.

Temperature logs run while the wells were being pumped showed that abrupt temperature changes occur where water enters or exits the borehole. With the well open to the upper portion of the boulder zone, pumping the well at rates from 350 to 800 gpm (gallons per minute) produced a gradual temperature change from about 52 degrees F at the boulder zone to about 57 degrees F at 2100 feet. This profile indicated cold (52 degrees F) water derived from the boulder zone was slowly being warmed by the surrounding rock as it moved upward toward 2100 feet. Water from Monitor Zone #1 (from 2570 to 2690 feet) had no apparent effect on these logs. Water entering the wells in the 2000- to 2100-foot zone, however, was substantial in quantity and produced a marked deviation on the temperature log (Plate 3). The temperature of water in the well from the well head to 2000 feet was about 57 degrees F and represented a blend of water from the boulder zone and the zone from 2000 to 2100 feet. Temperature logs run without pumping the well and following no activity that would alter natural well temperature substantiated that the formation temperature above and below the boulder zone is higher than that in the boulder zone. Plate 3 illustrates typical temperature logs.

Injection Zone

Hydrogeologic characteristics of the injection zone (boulder zone) were investigated during well construction by cuttings evaluations, logging, etc., and after well completion by conducting pumping and injection tests. The results of the pumping and injection tests are reported in a subsequent section. Evidence gathered during drilling confirmed that the injection zone consists of a highly fractured and cavernous dolomite. The depth to the top of the zone averages 2920 feet. The bottom of the zone was encountered at 3580 feet in Well 3.

The injection zone and occurrence of dolomite are shown clearly on the dual induction and borehole-compensated sonic logs presented on Plate 3. The resistivity profile shown on the dual induction logs fluctuates greatly within the injection zone. This response is due to the presence of massive, dense dolomite (high resistivity) and caverns containing salty water (low resistivity) within a relatively limited vertical interval. The greater transit velocities shown on the sonic log in the injection zone indicate that the dolomite has a lower primary porosity than the overlying or underlying limestones. The secondary porosity, however, was determined to be higher in the dolomite by other means including the pumping tests. Other geophysical logs also define the occurrence of the injection zone by the contrast of its rock and water-bearing properties with the limestones.

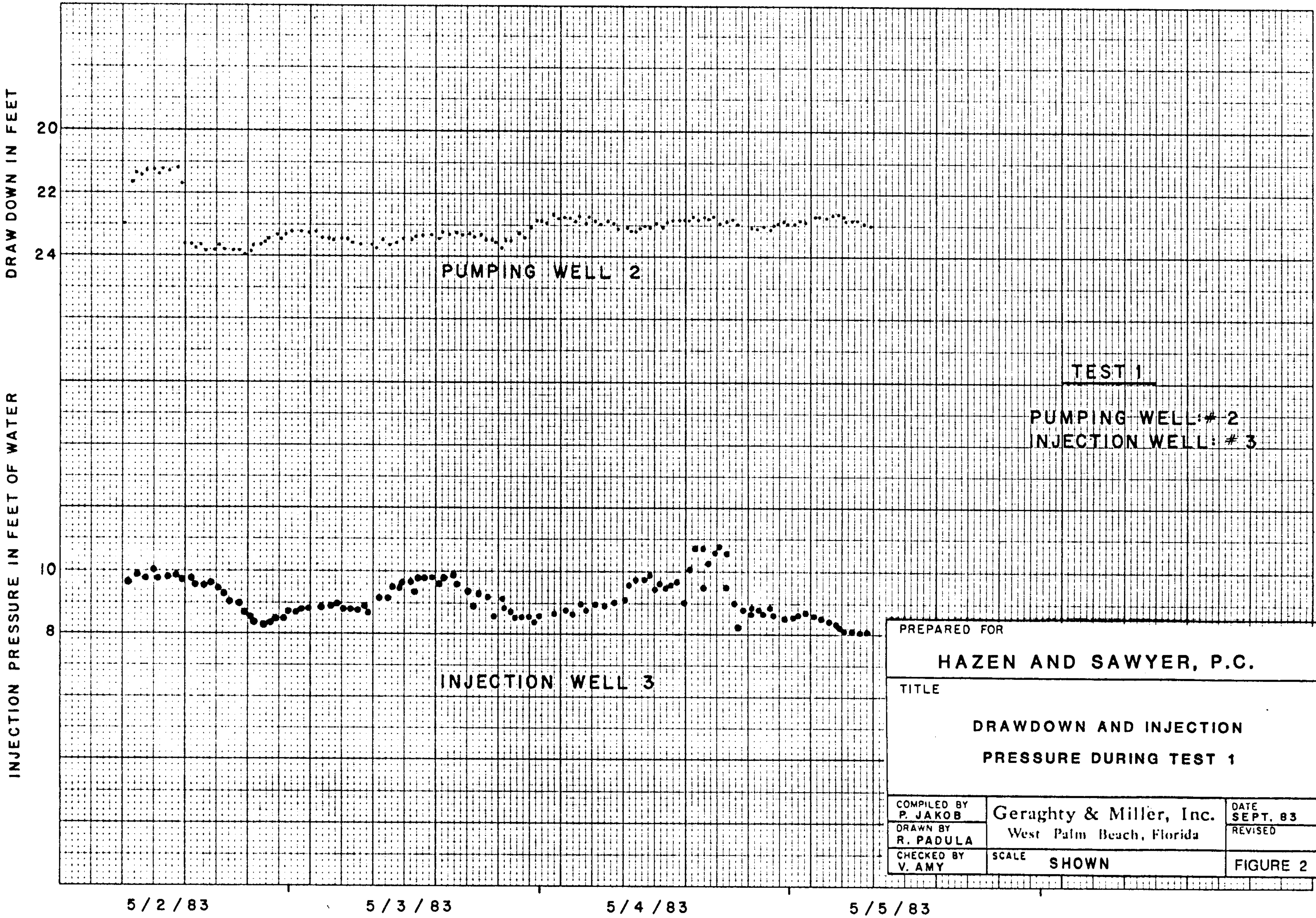
It was reconfirmed that fluid contained in the injection zone has an in-situ temperature of about 52 degrees F and is highly saline. Water samples were collected at the time of the pumping tests and analyzed for selected constituents. The results of these analyses, contained in Appendix A, indicate a naturally occurring water chemistry similar to sea water.

PUMPING AND INJECTION TESTS

Beginning on May 2, 1983, a series of pumping and injection tests was started on Injection Wells 1, 2 and 3. In each of these tests, water was pumped from one well and injected into an adjacent well. The third well was used as an observation well. An "M-scope" was used to make water-level measurements on the pumping well. An array of pressure gauges and a vacuum gauge were monitored at the injection well. Water-level measurements were made using a steel tape and a Stevens F-type water-level recorder in the observation well. In addition, Stevens F-type water-level recorders were operating on Monitor Zones 1 and 2 of the Floridan Aquifer Monitor Well, an on-site barometer was operating, and temperature and specific conductivity measurements were made on the pumped water.

In comparison to the previous pumping and injection tests, the fluid pumped in these tests was returned to the boulder zone. Corrections to injection pressure and drawdown data that might have been necessary due to differences in the density between the water injected and the water in the boulder zone, were not made. Such corrections might have been required if there were significant differences in the temperature or salinity between the water injected and the water in the boulder zone. The treated sewage effluent that will be injected will be relatively warmer and fresher than water in the boulder zone and will require higher well-head injection pressures than those witnessed during the tests.

The first test in the series was started at 9:00 a.m. on May 2, 1983, and was stopped 72 hours later. Water was pumped from Injection Well 2 via a 24-inch-diameter pipeline to Injection Well 3. Figure 2 depicts the drawdown in Well 2 and the pipeline pressure near Well 3. The pumping rate, measured by an in-line flow meter, was established at about 9,600 gpm (gallons per minute) but apparently began to decline



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HAZEN AND SAWYER, P.C.

TITLE

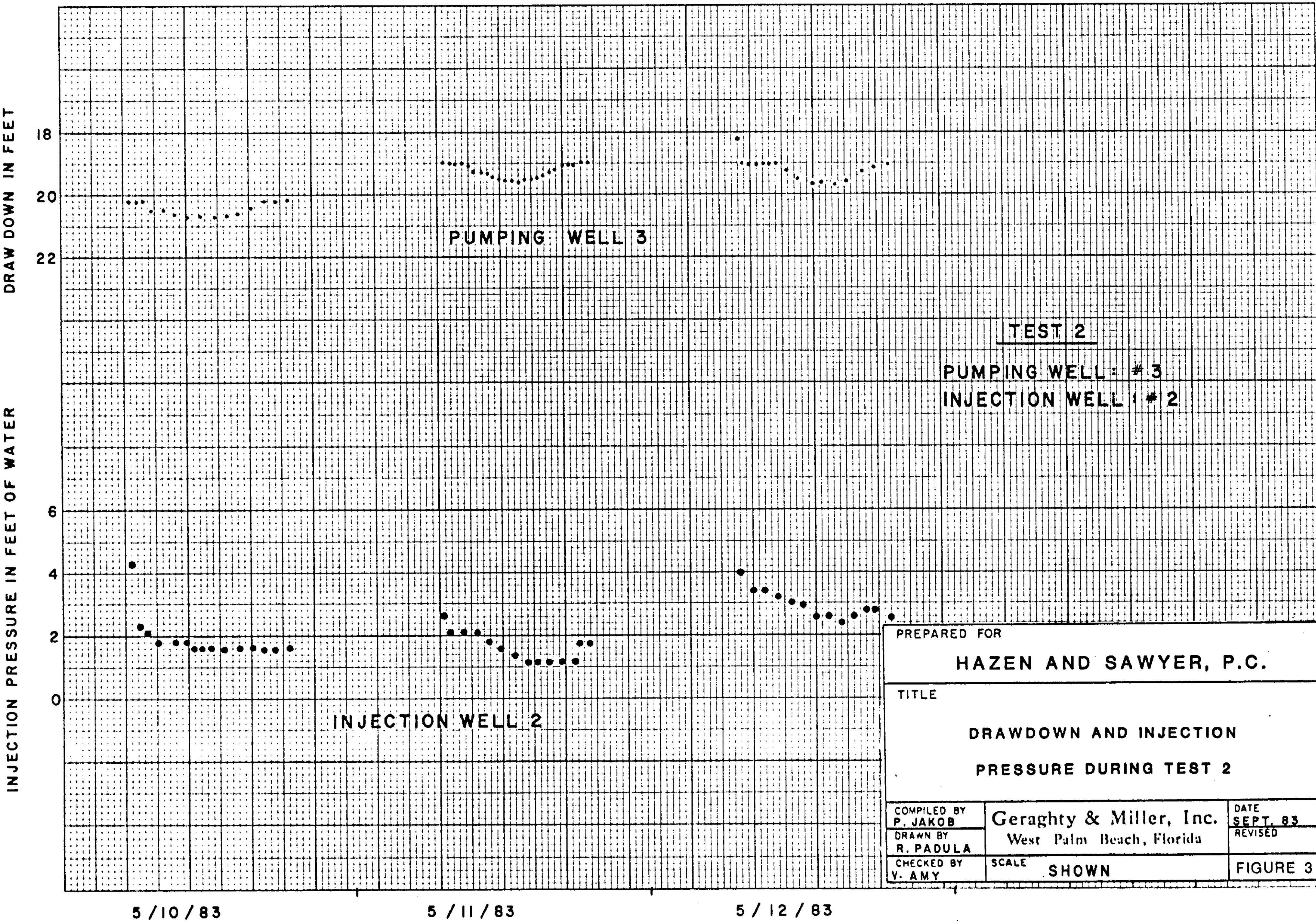
DRAWDOWN AND INJECTION PRESSURE DURING TEST 1

COMPILED BY P. JAKOB	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE SEPT. 83
DRAWN BY R. PADULA		REVISED
CHECKED BY V. AMY	SCALE SHOWN	FIGURE 2

shortly after the start of pumping. An adjustment to the pumping rate was made about five and one-half hours after the test began to increase the rate to 10,250 gpm. Thirty-seven hours from the start of the test, the flowmeter failed. There was, however, no apparent change in the pumping rate between the previous rate change and the end of the test. The drawdown in Well 2 averaged approximately 22.4 feet during the test and varied in response to the tidal effect over a range of about 1.2 feet. Almost all of this drawdown is attributed to the friction loss in the well casing. The injection pressure averaged 9 feet of water during the test and was influenced by tidal changes. The temperature of water taken from a tap near Well 3 dropped from 60 to 52 degrees F within 11 minutes of the start of pumping. The temperature of 60 degrees F reflects the temperature of the upper well casing in Well 2 and the 24-inch-diameter pipeline between wells. The specific conductance of the pumped water varied from 36,000 to 45,000 umhos/cm (micromhos/centimeter). The higher values tend to correspond with the high tide.

The second test consisted of three 12-hour periods of pumping from Well 3, separated by 12-hour periods of no pumping. Pumping from Well 3 was restricted to daylight hours on three successive days to eliminate any night-time noise disturbance in the neighborhood. Water from Well 3 was pumped and injected into Well 2. The pumping rates during the three days of testing were 10,313 gpm, 10,146 gpm, and 10,203 gpm, respectively. The pumping well drawdowns in the three test periods were approximately 20, 19, and 19.6 feet, respectively. The drawdown of water levels in Well 3 and the pipeline pressure near Well 2 during the test are shown on Figure 3. Both the water level and injection pressure respond to the tides. The temperature and specific conductance of the water were quite similar to those measured in the previous test.

The third test began on May 19 at 7:00 a.m. and ended 72 hours later. Water was pumped from Well 1 and into Well 2 at an average rate of 10,259 gpm. The drawdown in the pumping well averaged about 18.5 feet



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TITLE

DRAWDOWN AND INJECTION PRESSURE DURING TEST 2

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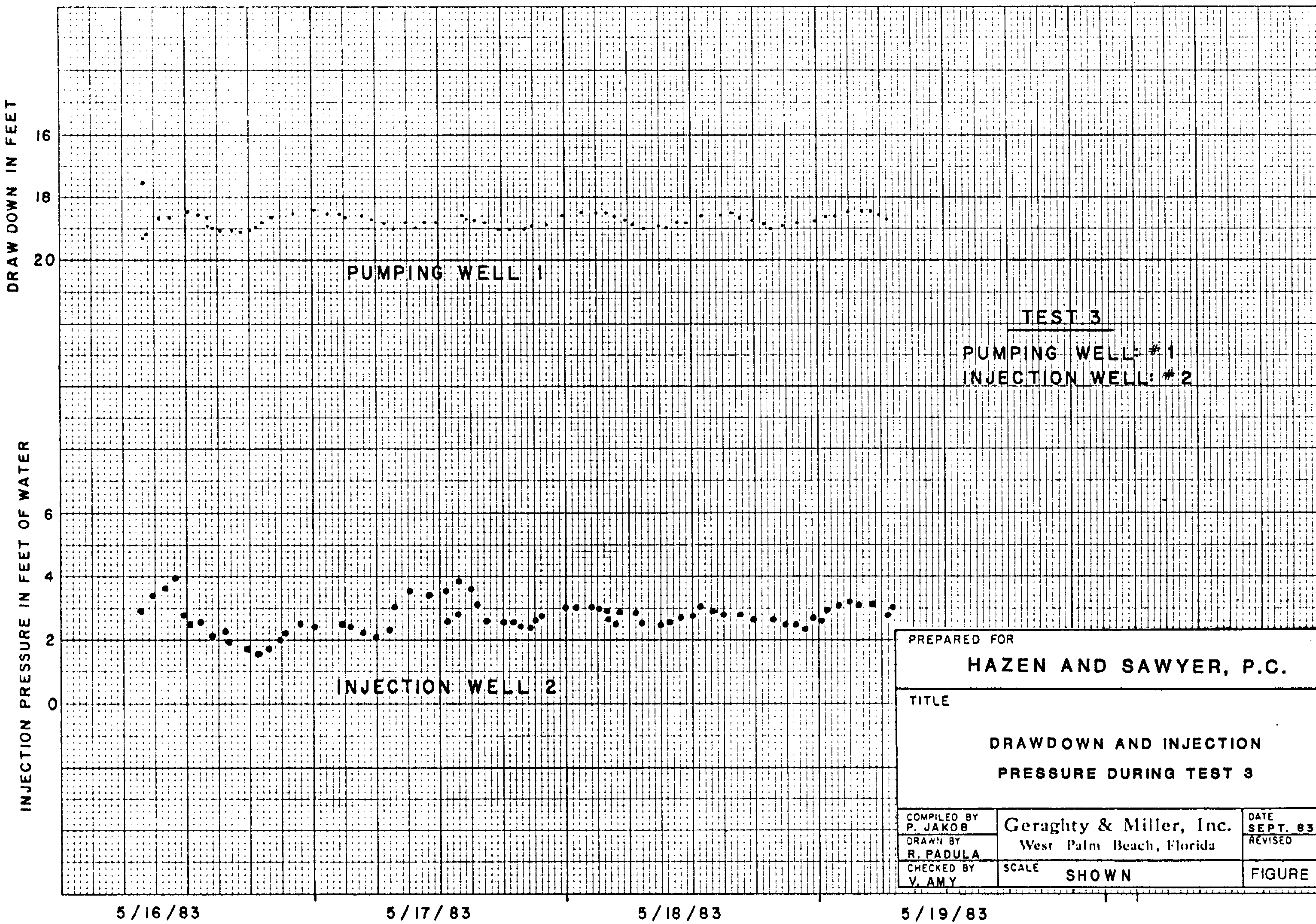
and the pipeline pressure averaged about 2 feet of water. Figure 4 shows the drawdown in water levels in Well 1 and the pipeline pressure near Well 2. Again, the influence of the tide was evident in the water levels and injection pressures. The water temperature decreased early in the test as in previous tests. The specific conductance of the water, however, rose slowly from 12,000 umhos/cm to 36,000 umhos/cm at the end of six hours and thereafter fluctuated between 36,000 and 47,000 umhos/cm.

Monitoring conducted during the three tests on Zones #1 and #2 of the Floridan Aquifer Monitor Well confirmed that there is a degree of hydraulic interconnection between the injection zone and Monitor Zone #1. Well 3, the well closest to the Floridan Aquifer Monitor Well, produced a drawdown response in the Zone #1 record of approximately 0.02 feet. Pumping from Wells 1 and 2 and injecting into Well 3 produced no measurable effect. Likewise, there was no response noticed in Zone #2 due to pumping from or injecting into the boulder zone during all of the tests, confirming the adequacy of the confining sequence determined during the testing of Injection Well 5.

A comparison of specific capacities among the three wells pumped shows that Wells 1 and 3 perform in a very similar manner, but that Well 2 apparently does not perform as well (the specific capacity is a commonly used measure of a well's performance; it equals the pumping rate in gpm divided by the drawdown in feet). The injection pressure near Well 3 was also anomalous (high) when Well 2 was pumped during the first test. These facts, together with the failure of the flowmeter during the first test, lead to the conclusion that the pumping rate during that test was actually higher than indicated by the flowmeter prior to its failure. Because there is no known reason that any well should perform better than any other, it is assumed that the average specific capacity of Wells 1 and 3 (543 gpm/ft) should be approximately the same at Well 2. The total water-level drawdown in the well is caused by the drawdown in the injection zone and that due to friction loss, with the latter being



PREPARED FOR HAZEN AND SAWYER, P.C.		
TITLE DRAWDOWN AND INJECTION PRESSURE DURING TEST 3		
COMPILED BY P. JAKOB	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE SEPT. 83
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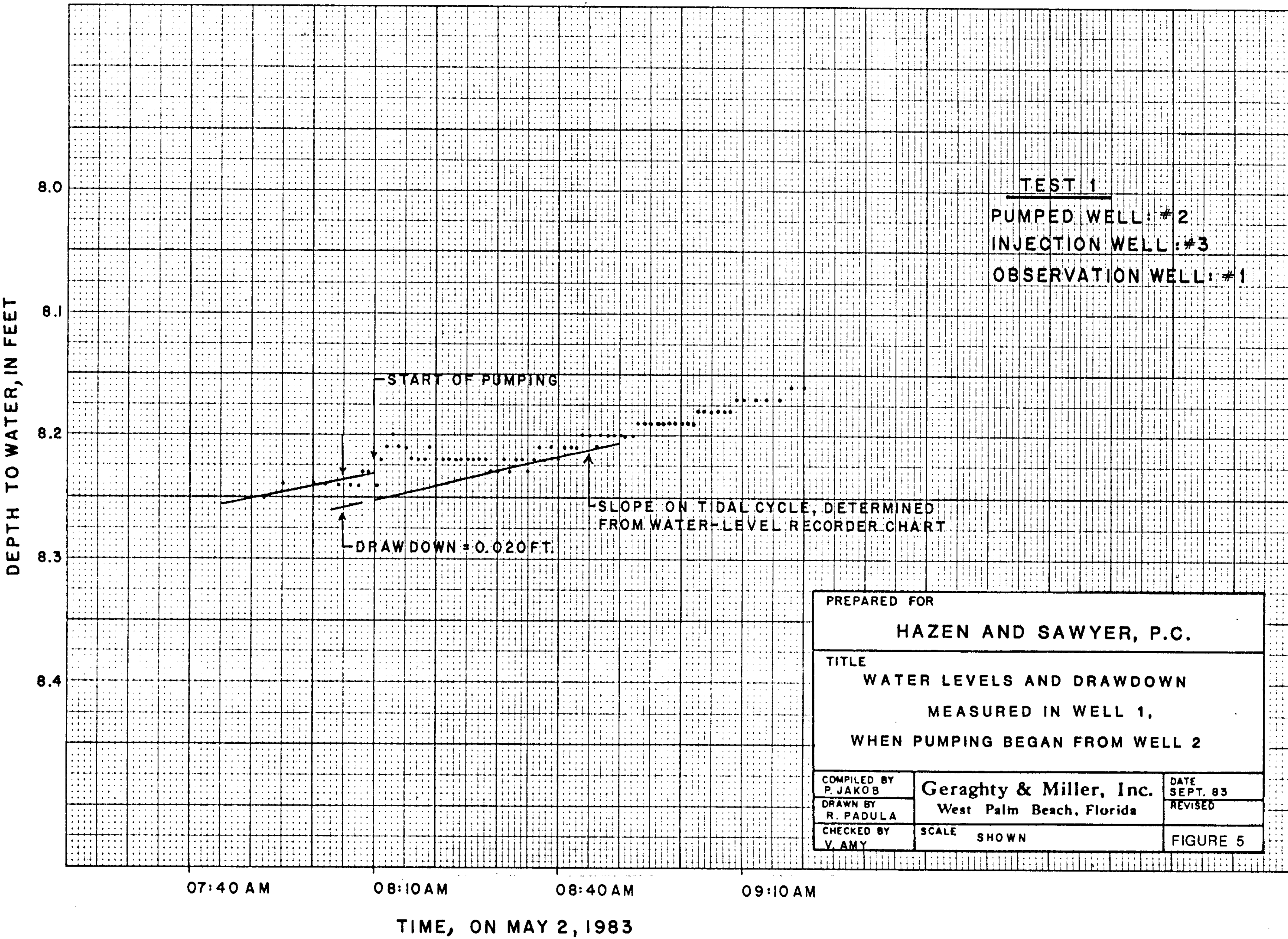
CHECKED BY V. AMY	SCALE SHOWN	FIGURE 4

the major contributor. Therefore, based on a specific capacity of 543 gpm/ft and a drawdown of 23 feet, the pumping rate on Well 2 was determined to be about 12,162 gpm. For the purpose of calculations that are made below, this pumping rate was assumed most representative for the first pumping test.

Estimates of the hydraulic properties of the injection zone were made by analyses of drawdown (or build-up) data collected at the observation well during the three tests. The hydraulic parameter of greatest interest is the coefficient of transmissivity or, simply, the transmissivity. The coefficient of storage of the injection zone cannot be analytically determined from the pumping/injection tests. Estimates of the transmissivity were made using a technique described in a report by W. C. Walton (1962, page 18), that considers the injection well to be an "image well" having a hydraulic effect on the injection zone that is equal but opposite to the pumping well. The data that were used in the analyses and the results of the analyses are summarized in Table 2.

The cited analysis yields a solution for the transmissivity as a function of the pumping rate; the distances from the observation well to the pumping well and to the injection (image) well; and the drawdown, build-up, or recovery that occurs in the observation well. Whether a drawdown or build-up occurred in the observation well depended upon the distances from the observation well to the other wells. When the observation well was closer to the pumping well, a drawdown was observed in that well. When the observation well was closer to the injection well, a build-up was observed. The changes in water level in the observation wells were recorded on a Steven's F-type recorder and measured manually. The manually-measured data points surrounding the beginning and end of the tests were plotted as shown in Figures 5 through 8. The drawdowns and recoveries were superimposed on tidal fluctuations in water levels and measurable only at the beginning or end of pumping, but not during the pumping period. This was due to the small size of the drawdown and the rapid achievement of a steady-state



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TITLE

WATER LEVELS AND DRAWDOWN MEASURED IN WELL 1, WHEN PUMPING BEGAN FROM WELL 2

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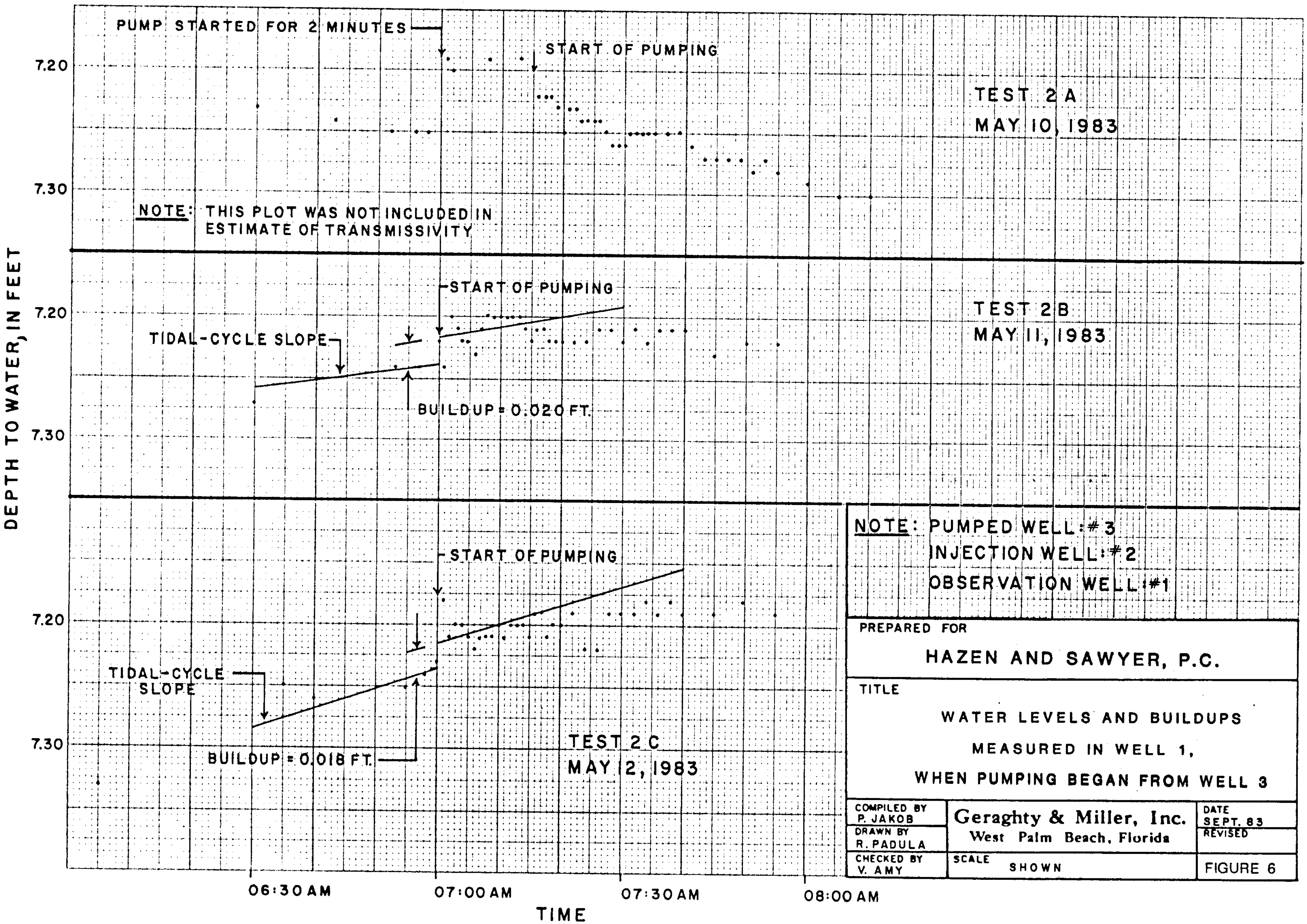
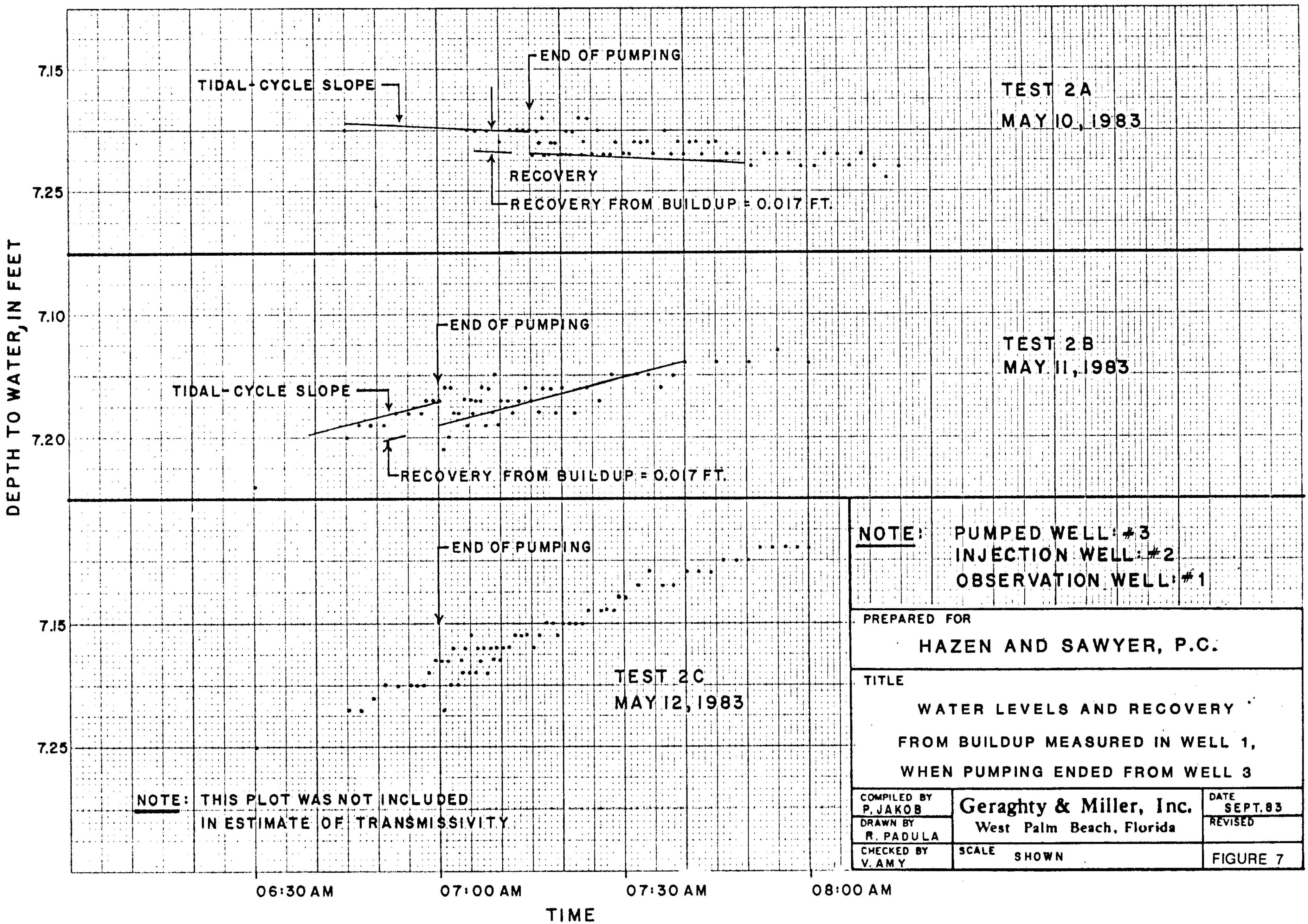
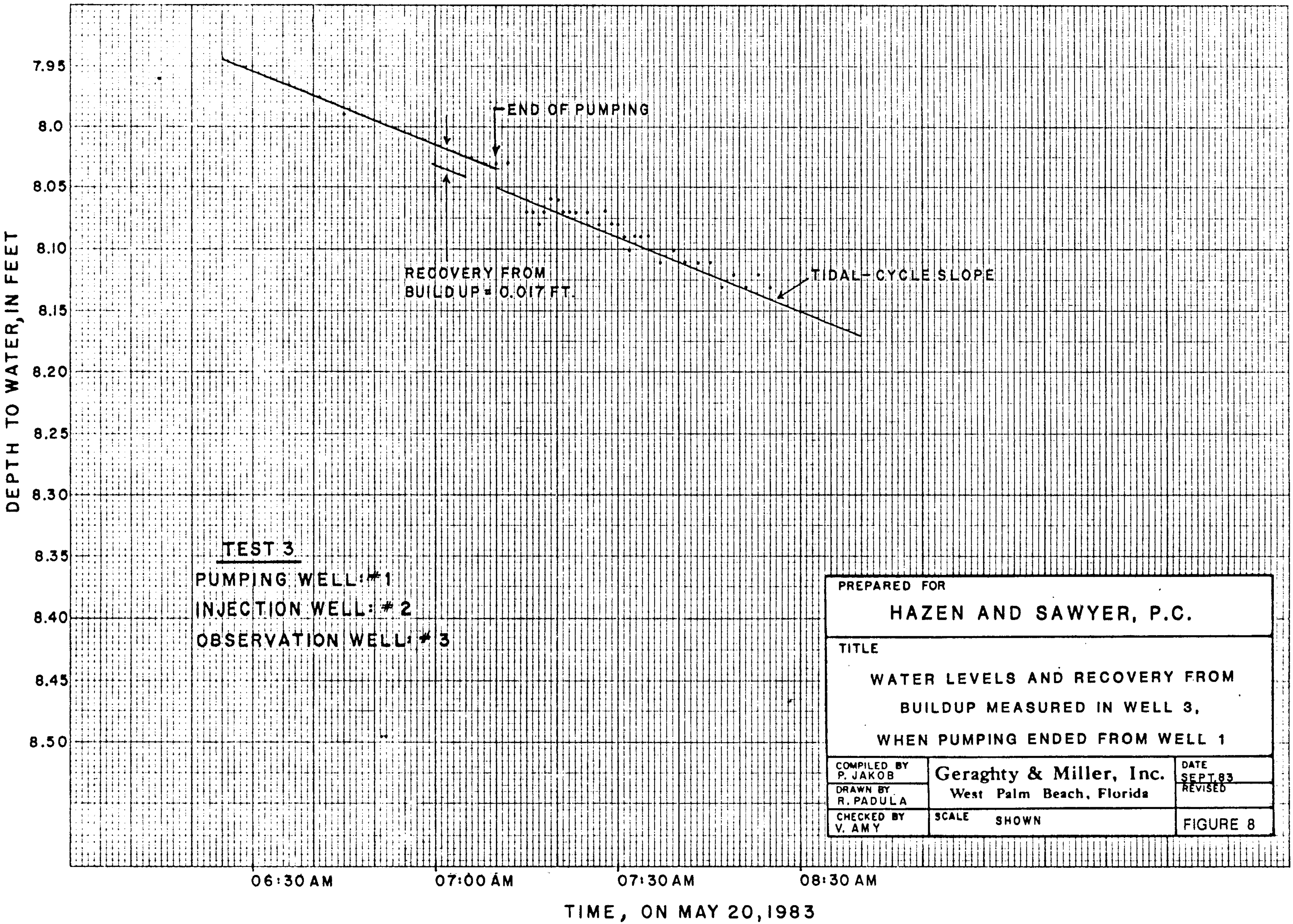
CHECKED BY V. AMY	SCALE SHOWN	FIGURE 5


PUMP STARTED FOR 2 MINUTES
START OF PUMPING
TEST 2 A
MAY 10, 1983
NOTE: THIS PLOT WAS NOT INCLUDED IN ESTIMATE OF TRANSMISSIVITY
START OF PUMPING
TEST 2 B
MAY 11, 1983
TIDAL-CYCLE SLOPE
BUILDUP = 0.020 FT.
START OF PUMPING
TIDAL-CYCLE SLOPE
BUILDUP = 0.018 FT.
TEST 2 C
MAY 12, 1983
7.20
7.30
DEPTH TO WATER, IN FEET
06:30 AM
07:00 AM
07:30 AM
08:00 AM
TIME
NOTE: PUMPED WELL: #3
INJECTION WELL: #2
OBSERVATION WELL: #1
PREPARED FOR
HAZEN AND SAWYER, P.C.
TITLE
WATER LEVELS AND BUILDUPS MEASURED IN WELL 1, WHEN PUMPING BEGAN FROM WELL 3
COMPILED BY P. JAKOB
DRAWN BY R. PADULA
CHECKED BY V. AMY
Geraghty & Miller, Inc.
West Palm Beach, Florida
SCALE SHOWN
DATE SEPT. 83
REVISED
FIGURE 6


DEPTH TO WATER, IN FEET
7.15
7.25
7.10
7.20
7.15
7.25
TIDAL-CYCLE SLOPE
END OF PUMPING
RECOVERY
RECOVERY FROM BUILDUP = 0.017 FT.
TEST 2A
MAY 10, 1983
END OF PUMPING
TIDAL-CYCLE SLOPE
RECOVERY FROM BUILDUP = 0.017 FT.
TEST 2B
MAY 11, 1983
END OF PUMPING
TEST 2C
MAY 12, 1983
NOTE: THIS PLOT WAS NOT INCLUDED IN ESTIMATE OF TRANSMISSIVITY
NOTE: PUMPED WELL: #3
INJECTION WELL: #2
OBSERVATION WELL: #1
06:30 AM
07:00 AM
07:30 AM
08:00 AM
TIME
PREPARED FOR
HAZEN AND SAWYER, P.C.
TITLE
WATER LEVELS AND RECOVERY FROM BUILDUP MEASURED IN WELL 1, WHEN PUMPING ENDED FROM WELL 3
COMPILED BY P. JAKOB
DRAWN BY R. PADULA
CHECKED BY V. AMY
Geraghty & Miller, Inc.
West Palm Beach, Florida
DATE SEPT. 83
REVISED
SCALE SHOWN
FIGURE 7



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TITLE
WATER LEVELS AND RECOVERY FROM BUILDUP MEASURED IN WELL 3, WHEN PUMPING ENDED FROM WELL 1

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CHECKED BY V. AMY	SCALE SHOWN	FIGURE 8

TABLE 2

PUMPING/INJECTION TEST PARAMETERS AND COEFFICIENTS OF TRANSMISSIVITY OF THE BOULDER ZONE

	Test 1	Test 2	Test 3
Beginning Date of Test	5/2/83	5/10/83	5/16/83
Pumping Well No.	2	3	1
Average Drawdown (ft)	22.4	19.5	18.2
Injection Well No.	3	2	2
Observation Well No.	1	1	3
Average Drawdown (ft)	0.020 (1)	-.0178 (2) (4)	-.017 (1) (4)
Average Pumping Rate (gpm)	12,162 (3)	10,221	10,259
Average Transmissivity (gpd/ft)	104,890,000	97,944,000	88,201,000

Notes: (1) Based on one of two observations
(2) Based on four of six observations
(3) Based on equal specific capacity assumption made in test.
(4) Minus number indicates buildup, or negative drawdown.

regime in which water levels did not change due to pumping. The effect of the tidal fluctuation was eliminated from the data by measuring its slope from the recorder charts and plotting this slope through the manually-measured data points shown on the figures. The amount of shift in the trend of points at the beginning and ending of pumping was equal to the drawdown or recovery.

Of 10 sets of data that might have been used in an analysis for transmissivity, three sets contained an excessive amount of spurious data and could not be used. The remaining seven sets yield transmissivities ranging from 88,000,000 gpd/ft (gallons per day per foot) to 105,000,000 gpd/ft. The average transmissivity is 98,000,000 gpd/ft. If the thickness of the injection zone is considered to be 600 feet (it varies slightly among the wells), then the average permeability of the injection zone is 163,000 gallons per day per square foot. The extremely high permeability and transmissivity indicate that the injection zone is capable of accepting high rates of effluent disposal. Indeed, to the knowledge of the consultant, these are the highest recorded values of transmissivities.

Operating pressures required to drive effluent from the well head to the injection zone were calculated for various injection rates. These pressures are due to the following factors: (1) the resistance to flow within the injection zone, which is equal but opposite to formation drawdown, (2) the resistance to flow caused by the friction of moving water through the well casing, and (3) the resistance to flow caused by the bouyancy of the relatively fresh (light weight) effluent as it is forced into the injection zone filled with saline water. The injection pressures at the well head during the pumping/injection tests were measured with pressure gauges that indicated, within the expected accuracy of such gauges, pressures comparable to the drawdowns measured in the pumping wells. The drawdowns reflected the effects of factors (1) and (2) and provide the basis for estimating those factors at various injection rates. Factor (3) did not affect the tests because saline water was both pumped and injected; therefore, the effect of this factor at various injection rates was estimated on a theoretical basis only.

The average specific capacity of the injection wells, based on the average transmissivity, is 50,000 gpm/ft. Pumping at a rate of 10,000 gpm would therefore cause a formation drawdown of 0.2 foot (0.1 psi). Subtracting this amount from the average drawdown (corrected to reflect a pumping rate of exactly 10,000 gpm) measured during the three pumping/injection tests, yields the drawdown due to pipe friction. That factor was found to average 18.2 feet (7.9 psi). Substituting the drawdown due to friction and other known parameters into the Hazen-Willliams formula yields a roughness coefficient (C_1) equal to 141 (based on the condition of the interior wall of the pipe at the time of the tests). This coefficient was used to calculate the pipe friction factor at injection rates significantly different than 10,000 gpm. The third component, the effluent bouyancy, was previously determined (Geraghty & Miller, Inc., and Hazen and Sawyer, P.C., 1981) to be equal to the difference in specific gravity between the effluent and water in the injection zone—equal to 0.031 multiplied by the vertical interval (in feet) of heavier fluid to be displaced. This interval is taken to be from pad level to approximately 2900 feet below pad level. The resistance due to bouyancy is 89.9 feet (37.1 psi), or 0.031 x 2900 feet.

After the wells are placed in operation, the interior walls of the 24-inch casing will become rougher, increasing the friction loss. Based on a Hazen & Williams coefficient of 100 (Shaw and Loomis, 1970) calculated well head pressures for various injection rates, including the density differential, are listed in Table 3.

TABLE 3

INJECTION PRESSURES AT VARIOUS INJECTION RATES

Injection Rate (gpm)	Pressure (ft of Water)	Pressure (psi)
4,500	98	42
6,500	106	46
8,300	115	49
10,000	125	54
12,000	140	60
13,000	148	64
14,000	156	67

WELL OPERATIONS

When the injection wells are operating, a variety of data will be collected to (1) satisfy statutory/permit requirements, and (2) assist in managing the system. Information will be collected from the injection and monitor wells. This section discusses the basic requirements for data collection to aid in permit compliance (it is based on current policy of the Florida Department of Environmental Regulation [DER]), guidelines for collecting that information, and procedures for performing periodic injectivity tests and recording and evaluating the various data. Recommendations for bottom-hole pressure testing also are presented. These discussions are limited to the disposal well operation; data collection procedures associated with the operation of a wastewater treatment plant are not included.

Injection Well Data Collection

Records of the injection pressure and rate and cumulative volume disposed should be collected from each well, beginning with the start of injection. It is essential that performance data be collected from the start in order to establish baseline information not only to satisfy regulatory requirements, but also to serve as a benchmark for future data comparison and analysis of performance. This information should be maintained permanently, either in some form of computer-based storage and retrieval system or on conventional strip or circular recorder charts. Nothing should be discarded.

Values of injection pressure and rate will be recorded on a daily basis for monthly submission to the DER and the Broward County Environmental Quality Control Board. Peak and "average" values will be recorded each day from the continuous record. Care should be taken not to mistake any pressure surges associated with the turning on or off of a pump for peaks. The true peak is the greatest injection pressure and rate occurring on any given day. Also, measurements of pressure and rate occurring at the same time will be recorded so that correlations between these two values can be made.

Monitor Well Data Collection

Each of the tubes at the monitor well will be equipped with a sampling pump, which could be operated continuously. A similar system has been operating successfully at the West Palm Beach regional plant since December 1977. Water samples could be collected or direct measurements made of selected parameters (i.e. conductivity) on any basis ranging from continuously to some prearranged schedule.

The purpose of monitoring is to detect a change in water quality in the monitor zones that could be attributed to the injection of treated effluent. The parameter(s) established for analysis should be limited to those that have simple, easy, and comparatively inexpensive analyses and are likely indicators. In the case of fresh effluent, analyses for the chloride ion and determination of conductivity meet each of these criteria. The chloride content of water in the various monitor zones ranges from moderate to high, whereas that of the effluent is low. Conductivity of the effluent is comparatively low, while that of the water in each of the monitor zones is significantly greater. Both chloride content and conductivity are readily measured with a high degree of accuracy and the analyses can be performed by technicians. Fecal coliform counts and B.O.D. will be determined also as they are a requirement of an operating permit. A C.O.D. determination, however, is preferential to a B.O.D. determination. Because of difficulties in seeding the saline water samples (from the monitor tubes) and making accurate determinations, the City of West Palm Beach has been granted a variance by the DER to use the C.O.D. determination instead of B.O.D.

Analyses or determinations for chloride, C.O.D., and fecal coliform are recommended for the monitor well samples. Results of the analyses will be reported to the DER on a monthly basis along with the other data required for a wastewater treatment plant operating permit. These determinations and their frequency would be acceptable to the DER and to the Broward County Environmental Quality Control Board. Water-quality changes, if they were to occur, would be slow and a monthly frequency is more than adequate. Conductivity is the easiest parameter to measure; it could be determined and recorded on a continuous basis if desired by the City.

These determinations should be made prior to the start of any injection. Particular attention should be paid to the fecal coliform determinations. The monitor-well tubes were disinfected after completion in 1981 and may have to be disinfected again. It is not known whether the above-ground piping connecting these tubes has been disinfected; if it hasn't, it should be. In any event, the various determinations should be made prior to injection to insure that the system is working and to collect baseline information.

<u>Injectivity Testing</u>

Injectivity is defined as the injection rate expressed as gallons per minute per foot (of pressure) or psi of injection pressure. Either unit of pressure can be used as long as it is stated and used consistently. A well's injectivity is a function of (1) friction loss in the casing, (2) the bottom-hole driving pressure, and (3) the density differential between fresh, treated effluent and saline ground water. The latter is a constant and can be determined by subtracting the well's shut-in pressure from the observed operating injection pressure. Friction loss in the casing and bottom-hole driving pressure can vary as the pipe ages and scale builds up and as a result of the plugging of the face of the borehole with particulate matter. Generally, pressures build slowly with respect to time (for a given pumping rate) as the pipe "ages." Similarly, plugging with solids can cause a gradual pressure build-up, particularly if the injection zone does not contain large cavities.

Periodic determination of a well's injectivity can be used as a measure of a well's changing efficiency, and it is recommended as a mangement tool for the injection wells. Performing the test is relatively simple; it involves injecting into a well at two or more injection rates and recording the injection pressure for each rate. The injectivity is calculated by dividing the injection rate by the injection pressure (well-head pressure minus the static or non-pumping pressure). The result is expressed as gallons per minute per psi (or foot of pressure).

Injectivity testing can be accomplished quite simply by operating with all the wells open. The injection rate can be controlled and varied by placing the pumps in manual control and adjusting the injection rate to the desired value and recording the injection rate and pressure at each well. The rate need only be maintained for two minutes or so before recording the data, as the injection zone responds rapidly owing to its extremely high transmissivity. As noted, at least two rates should be used for each well. High rates may require the shutting in of one or more wells. This will require the services of a valve turning crew who should communicate with the operator by radio.

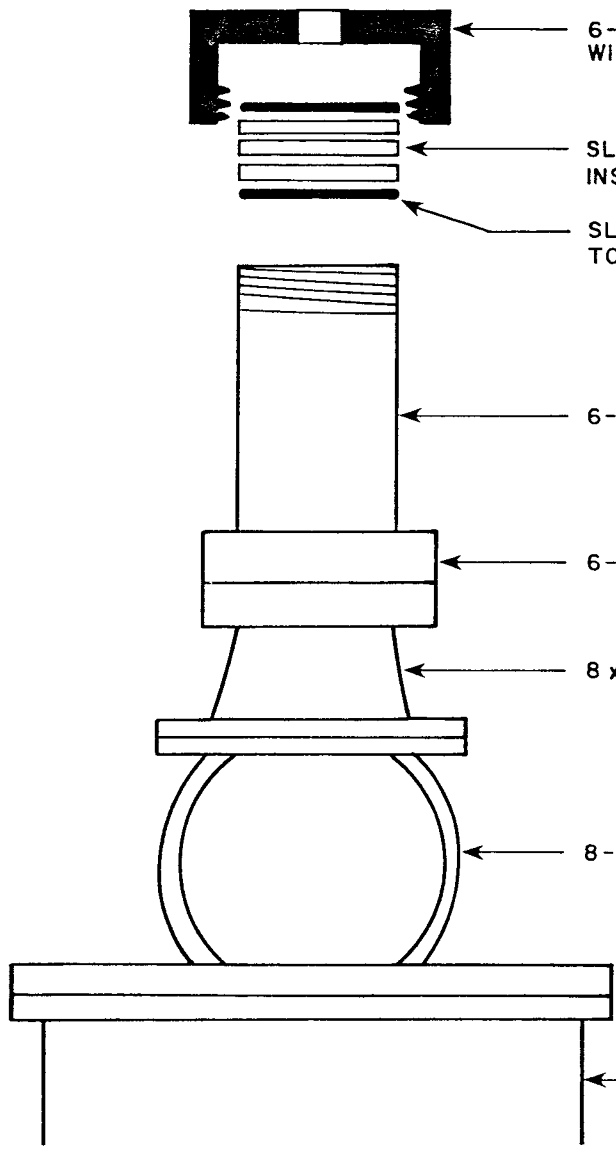
Nothing is known about the performance of the wells while injecting fresh effluent, and it is impossible to recommend a specific procedure or rates for injectivity testing. This will be accomplished by trial and error and a procedure should be established as soon as the wells are placed in operation to collect baseline operating data. The procedure should be repeatable so that injectivities can be computed for the same injection rates. Testing should be done bi-monthly for the first year of operation; if past operations at the West Palm Beach plant are any indication, the frequency could be reduced to every six months after the first year.

Injection pressure and injectivity changes, if they occur, will be the result of scale build-up on the casing and/or plugging of the injection zone. The former is unavoidable; any reduction in efficiency from this cause will reach some level and stabilize. This is compensated for in the pump design. Plugging (either by particulate matter or collapse) can cause a serious reduction in efficiency, possibly to the point where rehabilitation may be necessary.

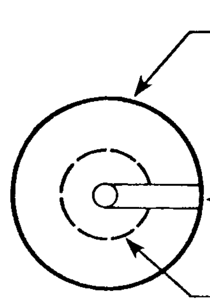
At some time in the future, it may be necessary to determine the cause of a loss of efficiency. This may require a knowledge of the bottom-hole injection pressure in order to discriminate between friction losses in the casing and those arising from plugging. It is recommended that within six months after the start of injection where procedures for injectivity testing have been formulated and operations are proceeding on a routine basis, bottom-hole pressures for a range in injection rates be obtained from each well. The information obtained should be kept on file for possible future use.

The bottom-hole pressure measurements can be obtained using the same type of wireline pressure measuring and surface recording device used during the testing of Well 5. The heads of the injection wells are designed to be used with a tool known as a stripper head or lubricator that permits a wireline tool to be installed in the well while it is operating under pressure.

The stripper head is simply a short length of 6-inch pipe flanged to attach to the 6-inch by 8-inch reducer on top of the well after the air/vacuum valve has been removed. A sealing or pack-off device is attached to the top of the pipe. This seals around the wireline and permits the tool to be installed and lowered into a well without leakage. Details of the device are shown on Figure 9. The slotted rubber washers are set inside of the cap, around the wire line, after the tool is lowered into the well. The slots are oriented in different directions; in effect, the only hole through which fluid could leak is in the center of the washer where the wire line passes through the washer assembly. Sealing is achieved by tightening the cap so that the rubber washers squeeze around the wire line. Generally, the assembly is



WASHER DETAILS



PREPARED FOR

HAZEN AND SAWYER, P.C.

TITLE

DETAILS OF STRIPPER HEAD ASSEMBLY

GEORGE T. LOHMEYER WWTP
FORT LAUDERDALE, FLORIDA

COMPILED BY V. AMY	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE SEPT. 83
DRAWN BY R. PADULA		REVISED
CHECKED BY	SCALE NONE	FIGURE 9

tightened to a point that allows a small leak and permits the wire line to pass through the assembly. The tool is installed after the 24-inch valve at the well head and the in-line valve leading to the well are closed, permitting the 8-inch valve at the top of the well to be opened. The air/vacuum valve is removed and the stripper head installed.

The bottom-hole pressure tests are performed by installing the tool in the well on the wire line and setting it at the top of the injection zone. Some form of support such as a "cherry picker" or a similar piece of equipment is required to carry the weight of the pressure tool and the wire line. Pulleys or sheaves for the wire line are attached to the well head and the support; the wire line is reeved through the well-head pulley then the support pulley, which is positioned directly above the stripper head.

Fortunately, the well-head crosses are positioned above the well-head valves so that only a short length of pipe is needed for the stripper head. This furnishes room (about 5 feet) above the 24-inch valve to accommodate the tool; in effect, the well-head cross acts as the stripper head and eliminates the need for a long, cumbersome piece of pipe, facilitating testing.

The same procedure and rates used for the injectivity testing should be used. Both well head and bottom-hole pressures are measured and recorded. Initial test data will make it possible to distinguish between friction loss in the casing and bottom-hole driving pressure for the wells in a virtually original condition. Following the initial bottom-hole pressure testing, the procedure need only be repeated in the future if it appears to be necessary.

PLUGGING AND ABANDONMENT

Section 28.27(2) of Chapter 17-28 requires that "an application for an Underground Injection Control permit shall be required to submit a plan for plugging and abandonment." The DER can order the plugging of an injection well when it has been abandoned or has been "determined to be a threat to the waters of the State." Additionally, a plugging and abandonment (P&A) plan should be included in the O&M manual for the treatment facility so that it can be implemented promptly in the unlikely event it is ever needed.

The objective of a proper P&A plan is to effectively plug or seal the bore hole through the confining bed and prevent the upward migration of injected treated effluent and the circulation of ground water (of differing salinity) between beds. The plan also should be designed so that a well can be plugged without interfering with the operation of the other wells. The program described in this section accomplishes these objectives.

In the event any one of the wells at the G. T. Lohmeyer plant has to be abandoned, two obstacles will have to be overcome before the well can be plugged successfully. Because the well to be abandoned will be under pressure (greater than 30 psi), fluid with weight material (drilling mud or salt) will have to be added to suppress the tendency to flow, permitting the well head to be opened up to allow access for tools. Also, a bridge plug will have to be set at the base of the casing to prevent the loss of cement downhole. Details of the bridge plug and the P&A design are shown on Figures 10 and 11, respectively.

The well will be plugged with a combination of neat, Class H cement and a mixture of crushed limestone and "mud" made with Zeogel—a trade name for a drilling fluid blend made with attapulgite (a clay that does not floc when exposed to salt water). The plugging program will require the services of a qualified contractor and equipment capable of installing

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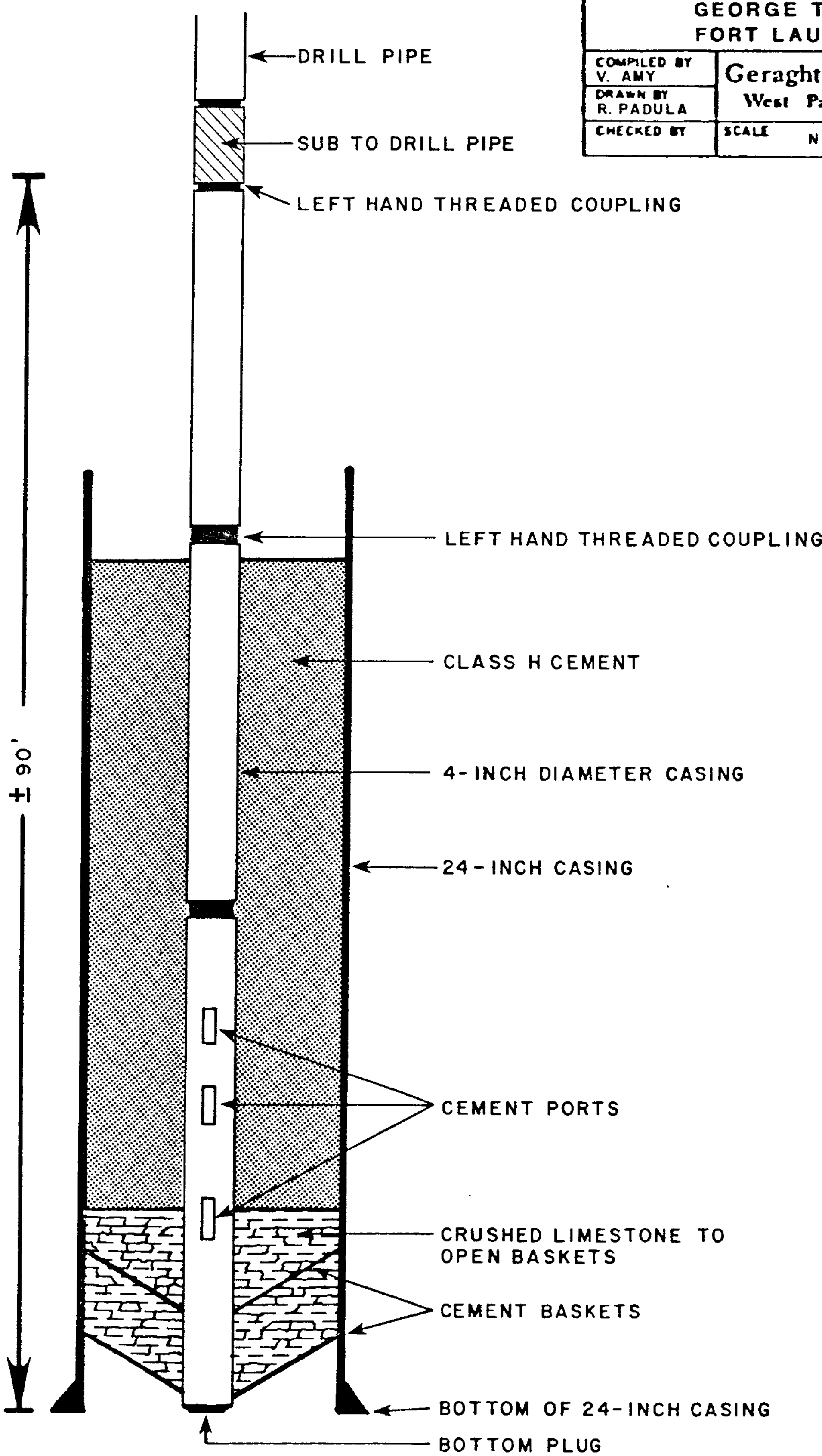
TITLE DETAILS OF BRIDGE PLUG FOR INJECTION WELL P&A PROGRAM GEORGE T. LOHMEYER WWTP FORT LAUDERDALE, FLORIDA		
COMPILED BY V. AMY	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE SEPT. 83
DRAWN BY R. PADULA		REVISED
CHECKED BY	SCALE NONE	FIGURE 10



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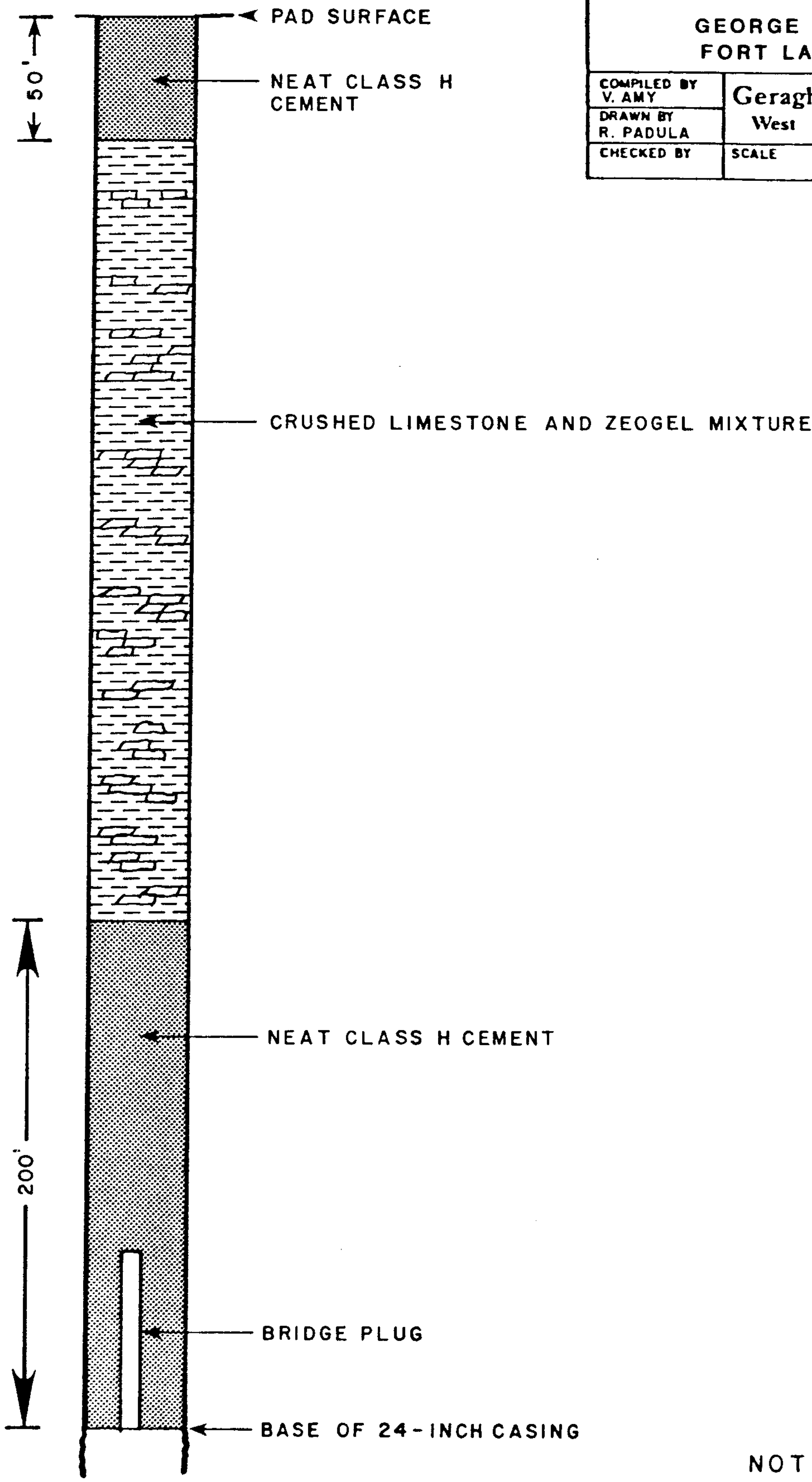
TITLE

DETAILS OF
INJECTION WELL PLUGGING PLAN

GEORGE T. LOHMEYER WWTP
FORT LAUDERDALE, FLORIDA

COMPILED BY V. AMY	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE SEPT. 83
DRAWN BY R. PADULA		REVISED
CHECKED BY	SCALE NONE	FIGURE 11



NOT TO SCALE

drill pipe to a depth of approximately 2900 feet, pumping neat cement, and mixing and pumping drilling fluid or salt to suppress flow, as well as the capability to provide some form of blow-out prevention equipment.

The initial step in the program will be to isolate the well from the rest of the system by closing the 30-inch ball valve in the above-ground line leading to the well and the valve in the backwash line (assuming it has been installed); mix a solution of weight material; and pump it into the well to suppress flow. The weight material can be pumped into the well by removing the 6-inch air and vacuum valve at the well head and connecting a line at the 8-inch valve. Sufficient weight material should be added to the well to depress the fluid level to approximately 20 feet below pad level, or deeper if the Contractor so desires. A supply of bag salt or mixed drilling fluid should be kept on-site as weight material will have to be added periodically to maintain the desired fluid level in the well. Following the addition of the weight material, the well-head cross, the ball valve, and the spool piece could then be removed to permit easy access into the well. The blow-out preventer would be installed at this time.

The bridge plug will be formed by the device shown on Figure 10. The device, consisting of 4-inch-diameter threaded casing and two cement baskets, is assembled on location and lowered into the well on a string of drill pipe. A careful tally of pipe lengths should be kept to permit setting the tool with the cement baskets about 5 feet above the bottom of the 24-inch casing.

The cement baskets will be expanded and set by adding about ten cubic feet of crushed limestone to the well and allowing it to settle. A mixture of neat, Class H cement is then pumped into the hole either through the drill pipe through the cement ports or by means of a tremie pipe set a few feet above the top of the limestone fill; the tremie pipe should have a diverter plate on the bottom to prevent the limestone from being washed away and cement lost downhole. The quantity of cement pumped should be equivalent to the volume of slurry required to fill the casing from the top of the limestone to one foot below the lowermost lefthand threaded coupling (Figure 10).

The cement is allowed to set for 24 hours, then it is "tagged" with a wire line to determine if fill-up has been achieved. If not, additional crushed limestone is added and another stage of cement is added (a single stage of cement usually is sufficient to build the first portion of the bridge plug). Assuming fill-up has been achieved, the Contractor then attempts to pull on the pipe. A strain of no more than 1000 pounds above drill string weight should be exerted. If no movement occurs (other than pipe stretching), the plug is deemed set and the Contractor can proceed with disconnecting the assembly by rotating and "backing off" the drill pipe (right-hand rotation will unscrew the pipe from the left-hand threaded couplings. Then two successive small stages of no more than 30 feet of cement fill-up are pumped before proceeding to complete a cement plug totalling 200 feet.

The remainder of the casing is then filled up to within 50 feet of the pad level with the mixture of crushed limestone and the Zeogel drilling mud. The Zeogel should be mixed to a weight of 10 pounds per gallon. The plugging is completed by filling the remainder of the casing with Class H cement. All Class H cement slurries should be neat and mixed with 4.3 gallons of water per sack to produce a slurry yield of 1.06 cubic feet per sack and a weight of 16.4 pounds per gallon.

Respectfully submitted,
GERAGHTY & MILLER, INC.

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Senior Scientist

Vincent P. Amy
Principal

28 February 1984

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APPENDIX A

HYDROGEOLOGIC DATA FROM INJECTION WELLS 1, 2, AND 3

Geologic Logs

Results of Core Tests

Results of Pressure Tests on the Inner Casing

Results of Gyroscopic Surveys

Results of Water Analyses

GEOLOGIC LOGS

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 1
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SANDY, SHELLY LIMESTONE - Limestone, 60%, very pale yellowish brown, fine to medium-grained, moderately well cemented; Shell, 20%, bleached, broken fragments; Sand, 20%, quartz, pale yellowish brown, fine- to medium-grained, interbedded with shell and limestone.	0 - 40	40
SHELLY LIMESTONE - Limestone, 80%, very pale orange, fine- to medium-grained, moderately well cemented; Shell, 20%, bleached, broken and crushed fragments.	40 - 60	20
SANDY, SHELLY LIMESTONE - Limestone, 60%, very pale yellowish brown, fine- to medium-grained, moderately well cemented; Shell, 20%, bleached, broken fragments; Sand, 20%, quartz, pale yellowish brown, fine- to medium-grained, interbedded with shell and limestone.	60 - 100	40
SHELLY LIMESTONE - Limestone, 80%, very pale orange, fine- to medium-grained, moderately well cemented; Shell, 20%, bleached, broken fragments; Sand, trace, quartz.	100 - 200	100
MARLY LIMESTONE - Limestone, 70%, pale yellowish brown to very pale orange, fine- to medium-grained, moderately well cemented; Marl, 20%, gray, silty; Shell, 10%, small broken fragments, bleached; Sand, trace, quartz.	200 - 250	50

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 1
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
MARLY LIMESTONE - Limestone, 70%, very pale orange, fine- to medium-grained, moderately well cemented; Marl, 20%, gray, silty; Shell, 10%, bleached, broken fragments; Sand, trace, quartz.	250 - 300	50
MARLY LIMESTONE - Limestone, 70%, very pale orange to light gray, fine- to medium-grained, moderately well cemented; Marl, 20%, gray, silty; Shell, 10%, bleached, fine broken fragments; Sand, trace.	300 - 340	40
MARLY LIMESTONE - Limestone, 70%, very pale orange, light gray and light olive gray, fine- to medium-grained, moderately well cemented; Marl, 20%, gray, silty; Shell, 10%, bleached, fine broken fragments; Sand, trace.	340 - 360	20
MARLY LIMESTONE - Limestone, 60%, light gray to light olive gray, fine- to medium-grained, moderately well cemented; Marl, 30%, gray, silty; Shell, 10%, bleached, broken fragments; Sand, trace.	360 - 376	16
MARLY LIMESTONE - Limestone, 60%, light gray, fine- to medium-grained, moderately well cemented; Marl, 40%, light olive gray, fine- to medium-grained, silty.	376 - 410	34
SANDY MARL - Marl, 90%, light olive gray, silty; Sand, 10%, quartz, phosphatic, clear and frosted, very fine-grained, well sorted, rounded grains.	410 - 580	170

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 1
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SANDY MARL - Marl, 70%, grayish olive, silty; Sand, 20%, calcareous, clear and frosted, fine-grained; Sand, 10%, quartz, clear and frosted, very fine-grained; Sand, trace, phosphatic, black, very fine-grained.	580 - 670	90
SAND MARL - Marl, 70%, light olive gray, silty, soft; Sand, 20%, calcareous, fine-grained; Sand, 10%, quartz, clear to frosted, very fine-grained; Sand, trace, phosphatic, black, very fine-grained.	670 - 770	100
SANDY MARL AND LIMESTONE - Marl, 80%, grayish olive, plastic, soft; Sand, 10%, quartz, frosted, very fine-grained; Limestone, 10%, yellowish gray, biomicrite.	770 - 810	40
MARL - Marl, 95%, grayish olive, dry; Sand, 5%, quartz, frosted, very fine-grained.	810 - 870	60
SANDY MARL AND LIMESTONE - Marl, 70%, grayish olive, dry; Marl, 10%, light gray, plastic, silty, trace of phosphatic sand; Limestone, 10%, yellowish gray, fine-grained, biomicrite; Sand, 10%, quartz and phosphatic, clear, frosted, black, very fine-grained.	870 - 890	20
MARL AND LIMESTONE - Marl, 50%, grayish olive, plastic; Limestone, 50%, pale yellowish brown, fine-grained, poorly cemented.	890 - 920	30

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 1
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
MARLY LIMESTONE - Limestone, 75%, pale yellowish brown, fine- to medium-grained, moderately well cemented; Marl, 15%, pale greenish yellow, plastic; Sand, 10%, quartz, phosphatic, clear and black, very fine-grained, sub-angular to sub-rounded grains.	920 - 940	20
LIMESTONE - Limestone, 100%, grayish orange to pinkish gray, fine-grained, poorly cemented; Clay, trace, dusky yellowish green, soft.	940 - 990	50
LIMESTONE - Limestone, 80%, grayish orange to pinkish gray, fine- to medium-grained, poorly cemented, foraminifera in matrix; Limestone, 10%, medium gray, very fine-grained, moderately well cemented; Marl, 10%, white, soft.	990 - 1020	30
LIMESTONE - Limestone, 100%, pinkish gray, fine- to medium-grained, poorly cemented, foraminifera in matrix; Limestone, 45%, very pale orange to pale yellowish brown, fine-grained, well cemented; Marl, 5%, yellowish gray, plastic.	1020 - 1070	50
LIMESTONE - Limestone, 50%, pinkish gray, fine- to medium-grained, poorly cemented, foraminifera in matrix; Limestone, 45%, very pale orange to pale yellowish brown, fine-grained, well cemented; Marl, 5%, yellowish gray, plastic.	1070 - 1100	30
LIMESTONE - Limestone, 100%, pinkish gray, fine- to medium-grained, moderately well to poorly cemented, foraminifera in matrix.	1100 - 1130	30

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 1
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE - Limestone, 60%, pinkish gray to grayish orange pink, fine-grained, moderatley well cemented to poorly cemented, foraminifera in matrix; Limestone, 40%, grayish orange pink, fine-grained, very well cemented; Marl, trace, very pale orange, plastic.	1130 - 1160	30
LIMESTONE - Limestone, 60%, grayish orange pink, fine-grained, very well cemented; Limestone, 40%, pinkish gray to grayish orange pink, fine-grained, moderately well to poorly cemented, foraminifera in matrix.	1160 - 1210	50
LIMESTONE AND MARL - Limestone, 70%, pinkish gray to grayish orange pink, fine-grained, moderately well to poorly cemented, foraminifera in matrix; Marl, 30%, very pale orange, plastic.	1210 - 1230	20
LIMESTONE - Limestone, 100%, pinkish gray to grayish orange pink, fine-grained, moderately well to poorly cemented, foraminifera in matrix.	1230 - 1250	20
LIMESTONE - Limestone, 50%, grayish orange, medium-grained, poorly cemented; Limestone, 40%, pinkish gray, very fine-grained, poorly cemented, chalky; Marl, 10%, very pale orange, plastic.	1250 - 1310	60
LIMESTONE - Limestone, 100%, grayish orange, medium-grained, poorly cemented.	1310 - 1330	20

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 1
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE - Limestone, 75%, pinkish gray, fine-grained, poorly cemented; Limestone, 25%, very pale orange, fine- to medium-grained, poorly cemented, vugs.	1330 - 1370	40
LIMESTONE - Limestone, 60%, grayish orange to pinkish gray, fine- to medium-grained, poorly cemented, foraminifera in matrix; Limestone, 20%, bluish white, very fine-grained, poorly cemented; Limestone, 20%, medium light gray, fine-grained, poorly cemented.	1370 - 1420	50
LIMESTONE - Limestone, 60%, yellowish gray to pale yellowish orange, very fine-grained, moderately well cemented; Limestone, 40%, medium gray, fine-grained, moderately well cemented; Marl, trace, medium light gray.	1420 - 1450	30
LIMESTONE - Limestone, 80%, pinkish gray, very fine-grained, moderately well cemented; Limestone, 20%, medium dark gray, fine-grained, vugs.	1450 - 1455	5
LIMESTONE AND MARL - Limestone, 70%, light gray to light olive gray, very fine-grained, moderately well cemented; Marl, 30%, light blue-gray, dry.	1455 - 1460	10
LIMESTONE - Limestone, 80%, pale yellowish brown to very pale orange, fine- to medium-grained, moderately well cemented, solution vugs; Limestone, 20%, light gray, very well cemented.	1460 - 1470	10

GEOLOGIC LOG OF EFFLUENT DISPOSAL WELL 1 CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE - Limestone, 80%, medium light gray, very well cemented; Limestone, 20%, very pale orange, fine- to medium-grained, moderately well cemented, solution vugs.	1470 - 1500	30
LIMESTONE - Limestone, 70%, very pale orange to pale yellowish brown, fine- to medium-grained, moderately well cemented, solution vugs; Limestone, 30%, very light gray, very well cemented.	1500 - 1700	200
LIMESTONE - Limestone, 80%, very pale orange to pale yellowish brown, fine- to medium-grained, moderately well cemented, solution vugs; Limestone, 20%, very light gray, well cemented; Marl, trace, yellowish gray.	1700 - 1710	10
LIMESTONE - Limestone, 90%, pale yellowish brown, fine- to medium-grained, moderately well cemented, foraminifera in matrix; Marl, 10%, yellowish gray, plastic.	1710 - 1723	13
LIMESTONE - Limestone, 100%, very pale orange to pale yellowish brown, fine- to medium-grained, moderately well cemented, foraminifera in matrix.	1723 - 1730	7
LIMESTONE - Limestone, 80%, pale yellowish brown to light gray, fine- to medium-grained, moderately well cemented, foraminifera in matrix; Limestone, 20%, light gray, very well cemented; Clay, trace, yellowish gray, plastic.	1730 - 1770	40

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 1
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE - Limestone, 80%, grayish orange pink, very fine- to medium-grained, poorly cemented; Limestone, 20%, medium gray, fine-grained, poorly cemented.	1770 - 1920	150
LIMESTONE - Limestone, 100%, pinkish gray, fine- to medium-grained, poorly to moderately well cemented.	1920 - 2000	80
DOLOMITE - Dolomite, 90%, dark yellowish brown, fine-grained, crystalline, hard; Limestone, 10%, very pale orange, fine- to medium-grained, poorly cemented.	2000 - 2050	50
LIMESTONE AND DOLOMITE - Limestone, 60%, very pale orange, fine- to medium-grained, moderately to poorly cemented; Dolomite, 20%, dark to moderately yellowish brown, very fine-grained, well cemented, small solution vugs; Dolomite, 20%, pale yellowish brown, cryptocrystalline, hard.	2050 - 2060	10
DOLOMITE - Dolomite, 90%, pale yellowish brown, cryptocrystalline, hard; Dolomite, 10%, dark yellowish brown, very fine-grained, crystalline, moderately hard, solution vugs.	2060 - 2080	20
MARL, LIMESTONE AND DOLOMITE - Marl, 40%, pale yellowish brown, soft, plastic; Limestone, 20%, very pale orange, fine- to medium-grained, poorly cemented; Dolomite, 20%, pale yellowish brown, cryptocrystalline, hard; Dolomite, 20%, dark yellowish brown, very fine-grained, crystalline, moderately hard, small solution cavities.	2080 - 2090	10

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 1
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE - Limestone, 85%, very pale orange, fine- to medium-grained, poorly cemented; Marl, 8%, pale yellowish brown, soft, plastic; Dolomite, 7%, dark yellowish brown, very fine-grained, crystalline, moderately hard, small solution cavities.	2090 - 2110	20
LIMESTONE - Limestone, 100%, very pale orange, fine- to medium-grained, poorly to moderately well cemented, fossiliferous.	2110 - 2130	20
LIMESTONE - Limestone, 100%, very pale orange and pale yellowish brown, fine- to medium-grained, poorly to moderately well cemented.	2130 - 2180	50
LIMESTONE - Limestone, 100%, very pale orange, fine- to medium-grained, poor to moderately well cemented, fossiliferous, traces of dark yellowish brown limestone.	2180 - 2210	30
LIMESTONE - Limestone, 100%, very pale orange, fine- to medium-grained, moderately well cemented, fossiliferous.	2210 - 2370	160
LIMESTONE - Limestone, 100%, very pale orange, fine- to medium-grained, moderately well cemented, fossiliferous, traces of yellowish brown to gray limestone.	2370 - 2500	130

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 1
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE AND DOLOMITE - Limestone, 60%, very pale orange, fine- to medium-grained, moderately well cemented; Dolomite, 40%, pale to moderate brown, medium- to fine-grained, hard, solution vugs.	2500 - 2590	90
LIMESTONE AND DOLOMITE - Limestone, 50%, very pale orange, pinkish gray, well cemented, microcrystalline, hard; Dolomite, 50%, brownish gray, microcrystalline, hard, very well cemented.	2590 - 2620	30
LIMESTONE AND DOLOMITE - Limestone, 80%, very pale orange, fine- to medium-grained, moderately well cemented, moderately soft; Dolomite, 20%, brown to grayish black, microcrystalline, very well cemented, very hard.	2620 - 2670	50
LIMESTONE - Limestone, 95%, white to pinkish gray, fine- to medium-grained, moderately well cemented, moderately soft; Dolomite, 5%, gray microcrystalline, hard, in thin layers.	2670 - 2880	210
LIMESTONE AND DOLOMITE - Limestone, 70%, white, fine- to medium-grained, moderately well to poorly cemented, moderately soft; Dolomite, 30%, gray to yellowish brown, microcrystalline, hard.	2880 - 2910	30
DOLOMITE AND LIMESTONE - Dolomite, 80%, gray to yellowish brown, microcrystalline, very hard; Limestone, 20%, white, fine- to medium-grained, poorly to moderately well cemented.	2910 - 2920	10

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 1
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
DOLOMITE - Dolomite, 100%, pale yellowish brown, microcrystalline, very hard, well cemented, calcite filled interstices.	2920 - 2960	40
DOLOMITE - Dolomite, 100%, pale yellowish brown to light gray, microcrystalline, very well cemented, moderately hard, fair to good cleavage.	2960 - 2980	20
DOLOMITE - Dolomite, 100%, pale yellowish brown, microcrystalline, very well cemented, fair to good cleavage, calcite filled interstices.	2980 - 3030	50
DOLOMITE - Dolomite, 100%, pinkish gray, very well cemented, good cleavage, calcite filled interstices.	3030 - 3050	20
DOLOMITE - Dolomite, 100%, pale yellowish brown, microcrystalline, very well cemented, good cleavage, calcite filled interstices.	3050 - 3060	10
DOLOMITE - Dolomite, 100%, pinkish gray, microcrystalline, very well cemented, good cleavage, calcite filled interstices.	3060 - 3090	30
DOLOMITE - Dolomite, 100%, pinkish gray to pale yellowish brown, microcrystalline, very well cemented, good cleavage, calcite filled interstices.	3090 - 3150	60

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 1
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
DOLOMITE - Dolomite, 100%, grayish brown to pale yellowish brown, microcrystalline, very hard, good cleavage, calcite crystals in vugs.	3150 - 3180	30
DOLOMITE - Dolomite, 100%, pale to dark yellowish brown, microcrystalline, hard, good to fair cleavage, calcite crystals in vugs.	3180 - 3450	270
DOLOMITE - Dolomite, 100%, dark yellowish brown and dark gray, microcrystalline, very hard, good cleavage, calcite filled interstices.	3450 - 3470	20
DOLOMITE - Dolomite, 100%, pale to dark yellowish brown, microcrystalline, very hard, good cleavage, calcite filled interstices.	3470 - 3520	50

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 2
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SANDY LIMESTONE - Limestone, 60%, very pale orange to pale yellowish brown, fine- to medium-grained, moderately well cemented; Shell, 20%, bleached fragments; Sand, 20%, quartz, pale yellowish brown to very pale orange, fine-grained; Trace, organics.	0 - 40	40
SHELLY LIMESTONE - Limestone, 90%, very pale orange, moderately well cemented; Shell, 10%, bleached, broken fragments.	40 - 50	10
SHELLY SANDY LIMESTONE - Limestone, 80%, very pale orange, fine- to medium-grained, moderately well cemented; Shell, 10%, bleached, broken fragments; Sand, 10%, quartz, very pale orange, fine-grained.	50 - 200	150
MARLY LIMESTONE - Limestone, 60%, pale yellowish brown, fine-grained, moderately well cemented; Marl, 30%, silty; Shell, 5%, bleached, broken fragments; Sand, 5%, quartz.	200 - 380	180
MARL AND LIMESTONE - Marl, 80%, light olive gray, silty; Limestone, 20%, light gray, fine- to medium-grained, poorly cemented; Trace, sand, quartz.	380 - 770	390
SANDY MARL - Marl, 90%, olive gray, plastic, soft; Sand, 10%, quartz, fine- to coarse-grained, interbedded with clay.	770 - 920	150
MARLY LIMESTONE - Limestone, 70%, pale yellowish brown, fine-grained, moderately well cemented; Marl, 30%, olive gray, highly plastic.	920 - 940	20

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 2
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE - Limestone, 100%, very pale orange, fine-grained, well cemented, fossils in matrix.	940 - 1060	120
LIMESTONE - Limestone, 70%, light gray to very pale orange, very fine-grained to microcrystalline, moderately well to very well cemented; Limestone, 30%, white, very fine-grained; poorly cemented, chalky, interbedded with other limestone.	1060 - 1080	20
LIMESTONE - Limestone, 100%, pale yellowish brown, fine- to medium-grained, moderately well cemented, fossiliferous, biomicrite.	1980 - 1180	100
LIMESTONE - Limestone, 60%, pale yellowish brown, fine- to medium-grained, moderately well cemented; Limestone, 40%, grayish orange pink, very fine-grained, well cemented matrix.	1180 - 1210	30
LIMESTONE - Limestone, 60%, grayish orange, fine- to medium-grained, poorly cemented, fossiliferous; Limestone, 40%, very pale orange, very fine-grained, poorly cemented.	1210 - 1250	40
MARLY LIMESTONE - Limestone, 60%, grayish orange, medium-grained, poorly cemented; Limestone, 30%, pinkish gray, very fine-grained, poorly cemented, chalky; Marl, 10%, very pale orange, dry to plastic.	1250 - 1280	30
LIMESTONE - Limestone, 60%, grayish orange, fine- to medium-grained, poorly cemented; Limestone, 40%, very pale orange, very fine-grained, poorly cemented.	1280 - 1310	30

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 2
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE - Limestone, 80%, very pale orange to grayish orange, medium-grained, poorly cemented, microfossils in matrix; Limestone, 20%, medium light gray, fine-grained, poorly cemented.	1310 - 1400	90
LIMESTONE - Limestone, 50%, very pale orange to grayish orange, medium-grained, poorly cemented, microfossils in matrix; Limestone, 50%, medium light gray, fine-grained, moderately well cemented.	1400 - 1460	60
LIMESTONE - Limestone, 40%, very pale orange, fine-grained, moderately well cemented; Limestone, 35%, pale yellowish brown, moderately cemented, fossiliferous; Limestone, 25%, moderate yellowish brown, fine-grained, moderately well cemented.	1460 - 1480	20
LIMESTONE - Limestone, 80%, dusky yellowish brown to moderate yellowish, brown, fine-grained, well cemented; Limestone, 20%, grayish orange, medium-grained, poorly cemented, with microfossils in matrix; Trace, marl, very pale orange, plastic.	1480 - 1510	30
LIMESTONE - Limestone, 60%, light gray to medium gray, fine-grained, moderately well cemented; Limestone, 40%, very pale orange, fine- to medium-grained, poorly cemented, microfossils in matrix.	1510 - 1550	40

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 2
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE - Limestone, 40%, grayish orange, medium-grained, poorly cemented, foraminifera in matrix; Limestone, 40%, very pale orange, fine-grained, poorly cemented; Limestone, 20%, medium dark gray, fine-grained, moderately well cemented, pinpoint vugs.	1550 - 1600	50
LIMESTONE - Limestone, 60%, very pale orange, very fine-grained, poorly cemented; Limestone, 20%, grayish orange, medium-grained, poorly cemented; Limestone, 20%, medium dark gray, fine-grained, moderately well cemented.	1600 - 1750	150
LIMESTONE - Limestone, 80%, pale yellowish brown to very pale orange, fine- to medium-grained, moderately well cemented, foraminifera in matrix; Limestone, 20%, very light gray, fine- to medium-grained, well cemented.	1750 - 1880	130
LIMESTONE - Limestone, 85%, very pale orange, fine- to medium-grained, poorly cemented, foraminifera in matrix; Limestone, 15%, medium light gray, fine- to medium-grained, moderately well cemented; Marl, trace, white, plastic.	1880 - 1980	100
LIMESTONE AND DOLOMITE - Limestone, 50%, very pale orange, fine- to medium-grained, poor to moderately well cemented; Dolomite, 50%, dark yellowish brown, very fine-grained, crystalline, small solution cavities.	1980 - 2014	34
DOLOMITE - Dolomite, 80%, dark yellowish brown, very fine-grained, crystalline, moderately hard, small solution cavities; Dolomite, 20%, pale yellowish brown, cryptocrystalline, hard.	2014 - 2040	26

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 2
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE AND DOLOMITE - Limestone, 80%, very pale orange, fine- to medium-grained, poorly cemented; Dolomite, 10%, pale yellowish brown, cryptocrystalline, hard; Dolomite, 10%, dark yellowish brown, very fine-grained, crystalline, moderately hard, small solution vugs.	2040 - 2060	20
DOLOMITE - Dolomite, 70%, dark yellowish brown, very fine-grained, crystalline, moderately hard, small solution vugs; Dolomite, 20%, pale yellowish brown, cryptocrystalline, hard; Limestone, 10%, very pale orange, fine- to medium-grained, poorly cemented, biomicrite.	2060 - 2090	30
LIMESTONE - Limestone, 95%, pale yellowish brown, fine-grained, poorly cemented, biomicrite; Marl, 5%, very pale orange, soft, plastic.	2090 - 2130	40
LIMESTONE - Limestone, 100%, very pale orange, fine- to medium-grained, poor to moderately well cemented, abundant foraminifera.	2130 - 2260	130
LIMESTONE - Limestone, 100%, very pale orange, fine- to medium-grained, moderately well cemented, fossiliferous; Limestone, trace, white, chalky, soft.	2260 - 2370	110
LIMESTONE - Limestone, 95%, very pale orange, fine- to medium-grained, moderately well cemented, fossiliferous; Limestone, 5%, light gray, microcrystalline to crystalline, very hard, in thin layers.	2370 - 2405	35

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 2
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE - Limestone, 100%, very pale orange, fine- to medium-grained, moderately well cemented, fossiliferous.	2405 - 2520	115
LIMESTONE AND DOLOMITE - Limestone, 70%, very pale orange, fine- to medium-grained, moderately well cemented, soft; Dolomite, 30%, pale to moderate brown, fine- to medium-grained, well cemented, hard, interbedded with limestone.	2520 - 2610	90
LIMESTONE AND DOLOMITE - Limestone, 80%, very pale orange, fine- to medium-grained, moderately well to poorly cemented, moderately soft; Dolomite, 20%, grayish brown to medium dark gray, microcrystalline, hard, very good cleavage.	2610 - 2640	30
DOLOMITE - Dolomite, 100%, grayish brown to medium dark gray, microcrystalline, hard, very good cleavage.	2640 - 2660	20
LIMESTONE - Limestone, 90%, gray, fine- to medium-grained, poorly cemented, soft; Limestone, 10%, very pale orange, soft, granular.	2660 - 2690	30
LIMESTONE AND DOLOMITE - Limestone, 90%, grayish brown, fine- to medium-grained, well cemented, moderately hard; Dolomite, 10%, gray, hard.	2690 - 2720	30

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 2
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE AND DOLOMITE - Limestone, 90%, white to pinkish gray and pale orange, fine-grained, moderately well cemented; Dolomite, 10%, gray to yellowish brown, microcrystalline, very well cemented, hard, interbedded with limestone.	2720 - 2890	170
DOLOMITE AND LIMESTONE - Dolomite, 70%, medium light gray to pale yellowish brown, very hard; Limestone, 30%, very pale orange, fine- to medium-grained, moderately well cemented.	2890 - 2910	20
DOLOMITE AND LIMESTONE - Dolomite, 90%, pale yellowish brown, microcrystalline, very hard; Limestone, 10%, very pale orange, fine- to medium-grained, moderately to poorly cemented.	2910 - 2930	20
DOLOMITE - Dolomite, 100%, pale to dark yellowish brown, microcrystalline, very hard, well cemented, good cleavage, some solution vugs and calcite filled interstices.	2930 - 3000	70
DOLOMITE - Dolomite, 100%, pinkish gray to pale yellowish brown, microcrystalline, very hard, some solution vugs and calcite filled interstices.	3000 - 3030	30
DOLOMITE - Dolomite, 100%, pale to dark yellowish brown, very hard, well cemented, good cleavage, calcite filled interstices.	3030 - 3280	250
DOLOMITE - Dolomite, 100%, grayish to dark yellowish brown, microcrystalline, very well cemented, very hard, good cleavage, solution vugs, calcite filled interstices.	3280 - 3310	30

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 2
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
DOLOMITE - Dolomite, 100%, pale to dark yellowish brown, microcrystalline, very hard, well cemented, good cleavage, solution vugs, calcite filled interstices.	3310 - 3400	90
DOLOMITE - Dolomite, 100%, dark to pale yellowish brown with a trace of pinkish gray, very hard, good cleavage, some microcrystalline, calcite filled interstices.	3400 - 3420	20
DOLOMITE - Dolomite, 100%, pale to dark yellowish brown and pinkish gray, microcrystalline, very hard, well cemented, good cleavage.	3420 - 3460	40
DOLOMITE - Dolomite, 100%, pale to dark yellowish brown, microcrystalline, very hard, well cemented, good cleavage.	3460 - 3480	20
DOLOMITE - Dolomite, 100%, pinkish gray and pale to dark yellowish brown, microcrystalline, very hard, well cemented, good cleavage.	3480 - 3525	45

GEOLOGIC LOG OF EFFLUENT DISPOSAL WELL 3 CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMEY SHELLY SAND - Sand, 60%, quartz, pale yellowish brown, fine- to medium-grained, loose, moderately well sorted; Shell, 30%, bleached, broken fragments; Limestone, 10%, white, chalky, poorly cemented with sand grains.	0 - 30	30
SHELLY LIMESTONE - Limestone, 90%, very pale orange to pale yellowish brown, medium- to fine-grained, moderately well cemented; Shell, 10%, bleached, broken and whole, interbedded with limestone.	30 - 170	140
SANDY LIMESTONE - Limestone, 70%, light gray, fine-grained to microcrystalline, moderately hard; Sand, 30%, light yellowish brown to gray, medium- to fine-grained, moderately well sorted, well cemented in calcareous matrix.	170 - 210	40
MARLY LIMESTONE WITH SHELL INTERBEDDED - Limestone, 50%, yellowish gray, fine- to medium-grained, moderately well cemented; Marl, 40%, yellowish green, granular texture, poorly cemented, non-plastic; Shell, 10%, bleached, broken fragments, poorly cemented, interbedded in limestone.	210 - 330	120
MARLY LIMESTONE - Limestone, 15%, light yellowish to olive gray, fine- to medium-grained, poorly cemented; Marl, 40%, light olive gray, non-plastic, very soft; Shell, 10%, bleached, broken fragments.	330 - 400	70
MARL - Marl, 100%, olive green, granular texture, non-plastic.	400 - 720	320

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 3
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE AND CHERT INTERBEDDED - Limestone, 70%, light yellow brown, medium- to fine-grained, well cemented, moderately hard; Chert, 30%, blue-black, quartz, cryptocrystalline, very hard, excellent cleavage, interbedded in limestone.	720 - 790	70
MARLY CLAY - Clay, 90%, olive green, highly plastic; Marl, 10%, olive green, granular texture, non-plastic, poorly cemented.	790 - 905	115
LIMESTONE - Limestone, 90%, yellowish gray, medium- to fine-grained, moderately hard, well cemented; Chert, 10%, black, cryptocrystalline, very hard, good cleavage, thin streaks interbedded with limestone.	905 - 960	55
CHALKY LIMESTONE - Limestone, 80%, pale yellowish brown to light gray, medium- to fine-grained, moderately well cemented, some solution vugs, foraminifera abundent throughout; Chalk, 20%, white to very pale yellow, very fine-grained, silty texture, soft, interbedded in limestone.	960 - 1750	790
LIMESTONE - Limestone, 60%, very pale orange to very light gray, fine- to medium-grained, moderately hard, fossiliferous; Limestone, 40%, medium light gray, granular texture, moderately hard; Clay, trace, medium gray, soft, pliable.	1750 - 1760	10
LIMESTONE - Limestone, 100%, very pale yellow and orange gray, fine- to medium-grained, moderately well cemented, fossiliferous, solution vugs.	1760 - 1960	200

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 3
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE - Limestone, 100%, yellowish brown, microcrystalline, very well cemented, good cleavage, hard, solution vugs, smooth surfaces.	1960 - 1975	15
LIMESTONE - Limestone, 100%, very pale orange, medium- to fine-grained, poorly cemented, friable.	1975 - 1990	15
DOLOMITE AND LIMESTONE - Dolomite, 75%, dark yellowish brown, very fine-grained, crystalline, moderately hard; Limestone 25%, very pale orange, very fine-grained, moderately well cemented, biomicrite, many small solution vugs.	1900 - 2050	60
LIMESTONE AND DOLOMITE - Limestone, 50%, very pale orange, fine- to medium-grained, moderately well cemented, biomicrite; Dolomite, 30%, pale yellowish brown, cryptocrystalline, hard; Dolomite, 20%, dark yellowish brown to moderate yellowish brown, very fine-grained, crystalline, moderately hard, small solution cavities.	2050 - 2070	20
DOLOMITE - Dolomite, 90%, dark yellowish brown, very fine-grained, crystalline, moderately hard, small solution vugs; Dolomite, 10%, pale yellowish brown, cryptocrystalline, hard.	2070 - 2090	20
LIMESTONE - Limestone, 90%, very pale orange, fine- to medium-grained, moderately well cemented, biomicrite; Dolomite, 10%, dark yellowish brown, very fine-grained, crystalline, moderately hard, small solution vugs.	2090 - 2110	20

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 3
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE - Limestone, 100%, very pale yellowish brown, medium- to fine-grained, granular texture, poorly cemented, friable.	2110 - 2157	47
LIMESTONE - Limestone, 98%, pale yellowish brown, medium- to fine-grained, granular texture, poorly cemented, friable; Chert, trace, blue-gray, interbedded with limestone.	2157 - 2157.5	0.5
LIMESTONE - Limestone, 90%, very pale orange, medium- to fine-grained, poorly cemented, friable, fossiliferous; Limestone, 10%, dark yellowish brown, microcrystalline, hard, well cemented, solution vugs, trace foraminifera, interbedded limestones.	2157.5 - 2210	52.5
LIMESTONE - Limestone, 100%, pale yellowish brown-orange, fine- to medium-grained, poorly to moderately well cemented, well indurated, solution vugs, trace foraminifera.	2210 - 2350	140
LIMESTONE - Limestone, 90%, very pale orange, medium- to fine-grained, granular texture, poorly cemented, slightly friable, fossiliferous; Limestone, 10%, dark yellow to pale yellow-orange, microcrystalline, very hard, good cleavage, abundant foraminifera.	2350 - 2370	20
LIMESTONE - Limestone, 100%, grayish orange-pink, medium- to fine-grained, moderately well cemented, well indurated, trace of foraminifera.	2370 - 2480	110

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 3
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE AND DOLOMITE, INTERBEDDED - Limestone, 80%, very pale orange, fine- to medium-grained, moderately well cemented, poor cleavage, friable; Dolomite, 20%, dark yellowish brown, microcrystalline, hard, smooth surfaces, good cleavage, well cemented.	2480 - 2500	20
LIMESTONE - Limestone, 90%, very pale orange, fine- to medium-grained, fair to poorly cemented, well indurated, foraminifera; Dolomite, 10%, dark yellow brown, microcrystalline, very hard, good cleavage, smooth cut surfaces, interbedded with limestones.	2500 - 2560	60
LIMESTONE AND DOLOMITE, INTERBEDDED - Limestone, 60%, very pale orange to yellow brown, fine- to medium-grained, moderately well cemented; Dolomite, 40%, dark yellow brown, microcrystalline, very hard, good cleavage, solution vugs.	2560 - 2570	10
LIMESTONE - Limestone, 90%, very pale orange, fine- to medium-grained, fair to poorly cemented, friable, fossiliferous; Dolomite, 10%, dark yellow to brown-gray, microcrystalline, hard, well cemented, good cleavage.	2570 - 2600	30
DOLOMITE AND LIMESTONE, INTERBEDDED - Dolomite, 90%, dark gray to dark yellowish brown, microcrystalline, very well cemented, good cleavage, solution vugs; Limestone, 10%, pale yellow brown, fine- to medium-grained, poorly cemented.	2600 - 2620	20

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 3
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE - Limestone, 100%, pale yellowish brown, fine- to medium-grained.	2620 - 2630	10
DOLOMITE AND LIMESTONE - Dolomite, 70%, dark yellow brown-gray, microcrystalline, very hard, well cemented, good cleavage, smooth cut surfaces; Limestone, 30%, pale yellowish brown, fine- to medium-grained, poorly cemented, interbedded with dolomite.	2630 - 2660	30
LIMESTONE AND DOLOMITE, INTERBEDDED - Limestone, 90%, pale yellowish brown, fine- to medium-grained, poorly cemented; Dolomite, 10%, grayish and dark yellowish brown, microcrystalline, hard, good cleavage.	2660 - 2690	30
LIMESTONE AND DOLOMITE, INTERBEDDED - Limestone, 90%, pale yellowish brown, fine- to medium-grained, granular texture, moderately well cemented, rough surfaces; Dolomite, 10%, dark yellow brown-gray, microcrystalline, hard, well cemented, good cleavage.	2690 - 2730	40
LIMESTONE AND DOLOMITE, INTERBEDDED - Limestone, 90%, pale yellowish brown, fine- to medium-grained, moderately well cemented; Dolomite, 8%, dark yellow brown-gray, microcrystalline, hard, good cleavage; Clay, 2%, grayish green, compacted, non-plastic, friable.	2730 - 2740	10
LIMESTONE AND DOLOMITE, INTERBEDDED - Limestone, 95%, pale yellowish brown, fine- to medium-grained, granular texture, poorly cemented, chalky and clean; Dolomite, 5%, dark brown-gray, microcrystalline, good to fair cleavage, moderately hard.	2740 - 2850	110

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 3
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE AND DOLOMITE - Limestone, 50%, pale yellowish brown, fine- to medium-grained, moderately well cemented, solution vugs; Dolomite, 50%, dark yellowish brown-gray, microcrystalline, hard, well cemented, vugular with calcite growth in veins.	2850 - 2890	40
DOLOMITE - Dolomite, 100%, dark yellowish brown to buff, very hard, microcrystalline, vugs and channels filled with calcite crystals, very good cleavage.	2890 - 3245	355
DOLOMITE AND LIMESTONE, INTERBEDDED - Dolomite, 50%, pale yellowish brown, microcrystalline, hard, well cemented, solution vugs, good cleavage; Dolomite, 40%, grayish brown, microcrystalline, very hard, well cemented, good cleavage; Limestone, 10%, white, soft, granular texture, chalky.	3245 - 3250	5
DOLOMITE - Dolomite, 50%, pale yellowish brown, microcrystalline, hard, well cemented, solution vugs, good cleavage; Dolomite, 50%, grayish brown, microcrystalline, very hard, good cleavage.	3250 - 3294	44
DOLOMITE AND LIMESTONE - Dolomite, 90%, dusky gray brown, microcrystalline, very hard, very well cemented, good cleavage; Limestone, 10%, white, soft, granular texture.	3294 - 3350	56
DOLOMITE - Dolomite, 100%, moderate yellowish brown and gray, soft to hard, moderately well cemented, solution vugs.	3350 - 3558	208

GEOLOGIC LOG
OF
EFFLUENT DISPOSAL WELL 3
CITY OF FORT LAUDERDALE, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
LIMESTONE AND SANDSTONE - Limestone, 50%, medium gray, microcrystalline, moderately hard, fair cleavage; Sandstone, 50%, pale yellowish brown, fine- to medium-grained, poorly cemented.	3558 - 3565	7
DOLOMITE - Dolomite, 100%, blue-gray to brown, microcrystalline, very hard, very well cemented, very good cleavage.	3565 - 3579	14
LIMESTONE AND DOLOMITE - Limestone, 90%, yellowish gray to brown, fine-grained, well cemented; Dolomite, 10%, gray, well cemented, microcrystalline, good cleavage.	3579 - 3631	52
LIGNITE AND LIMESTONE - Lignite, 90%, black, slightly lustrous, fair cleavage, flammable; Limestone, 10%, yellow-brown to off white, fine-grained, soft.	3631 - 3632	1
LIMESTONE AND DOLOMITE - Limestone, 80%, yellowish brown, fine-grained, moderate cementation; Dolomite, 20%, light gray, fine-grained, moderately well cemented.	3632 - 3740	108
LIMESTONE - Limestone, 100%, yellow-brown, fine-grained, moderately well cemented; Limestone, trace, white, soft, chalky.	3740 - 3990	250
LIMESTONE - Limestone, 95%, yellowish brown, fine-grained, moderately well cemented, friable; Gypsum, 5%, white, soft, chalky.	3990 - 4010	20

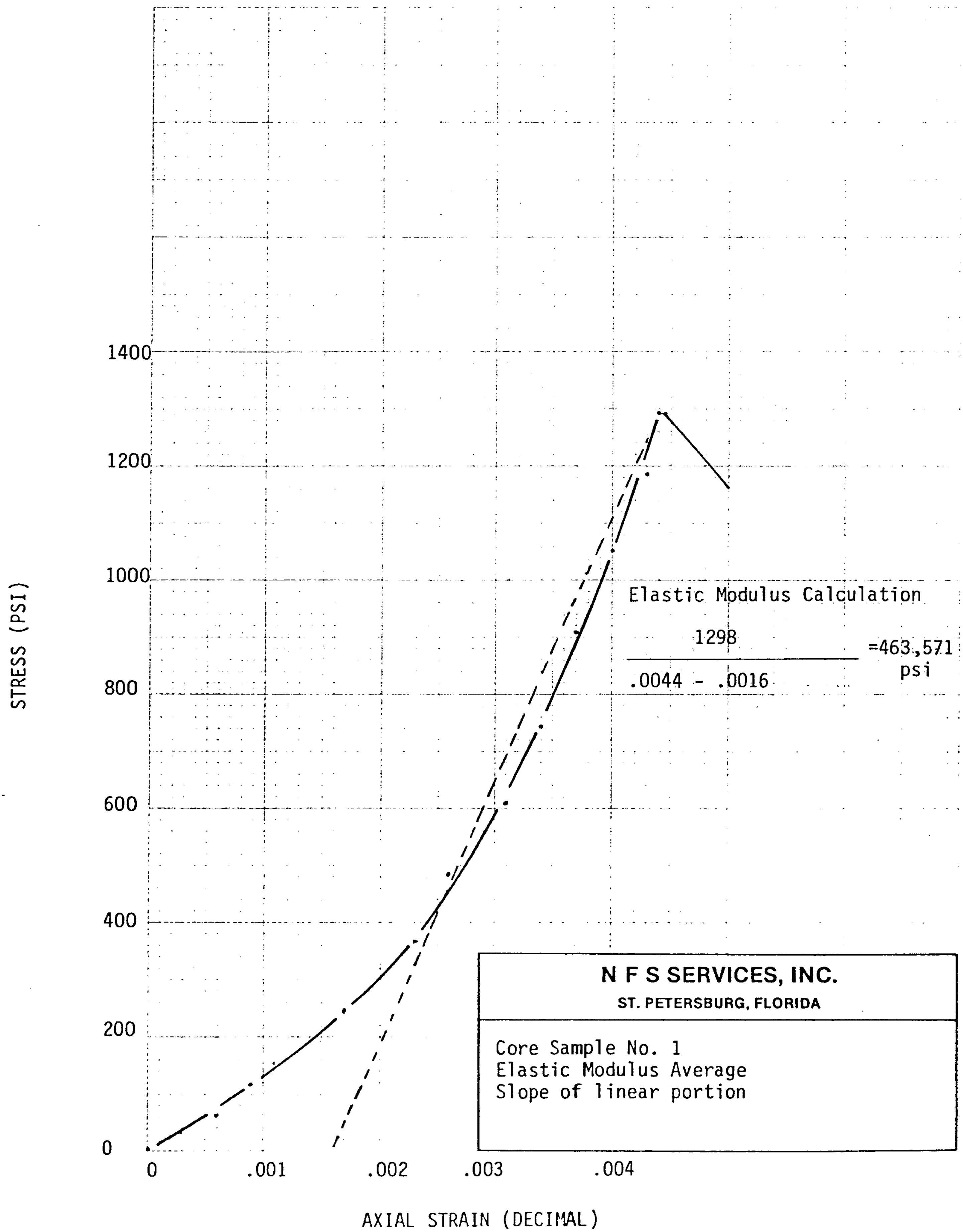
RESULTS OF CORE TESTS

TEST RESULTS

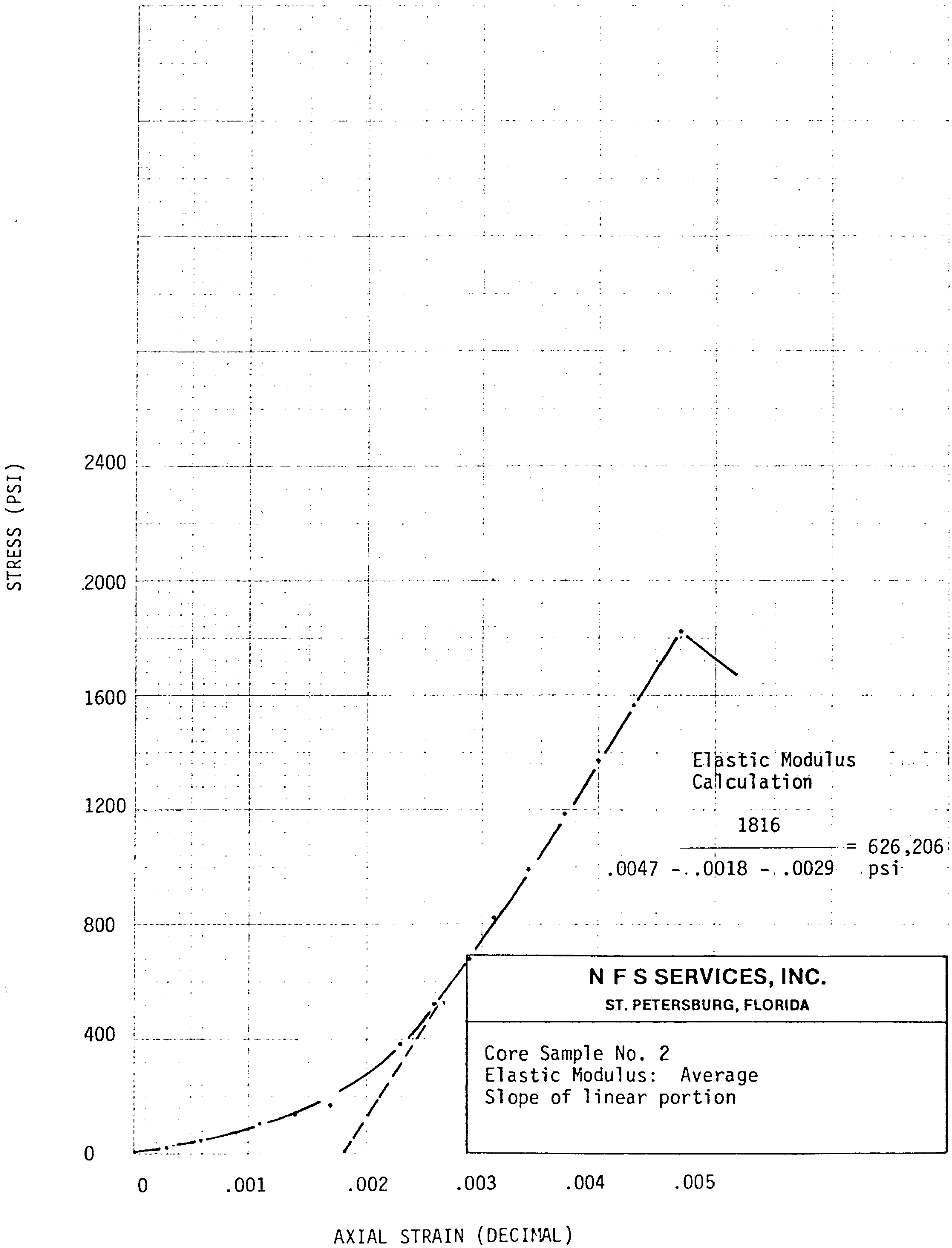
Sample No.	Core #1	Core #2	Core #3
Description	Medium hard, cream, colored, sandy limestone. Slightly unggy.	Hard, cream colored, sandy limestone	Medium hard, cream colored sandy limestone.
UNIT WEIGHT			
Height of trimmed sample	7.009 inches	6.996 inches	6.900
Diameter of trimmed sample	3.955 inches	3.945 inches	3.915
Moisture Content	10.2 %	2.3 %	13.9 %
Dry Unit Weight	115.3 pcf	117.3 pcf	109.6 pcf
UNCONFINED COMPRESSION TEST			
Length to diameter ratio	1.77	1.77	1.76
Compressive Strength	1298 psi	1816 psi	1088
Elastic Modulus	463,571 psi	626,206 psi	435,200 psi
COEFFICIENT OF PERMEABILITY			
Coefficient of Permeability	8.36×10^{-5} cm/sec	5.60×10^{-5} cm/sec	3.40×10^{-5}
Specific Gravity	2.68	2.70	2.69
Porosity	31.1 %	30.4 %	34.7 %

* Dimensions of samples used for the Unconfined Compression tests and permeability tests correspond to unit weight measurements.

INJECTION WELL 1



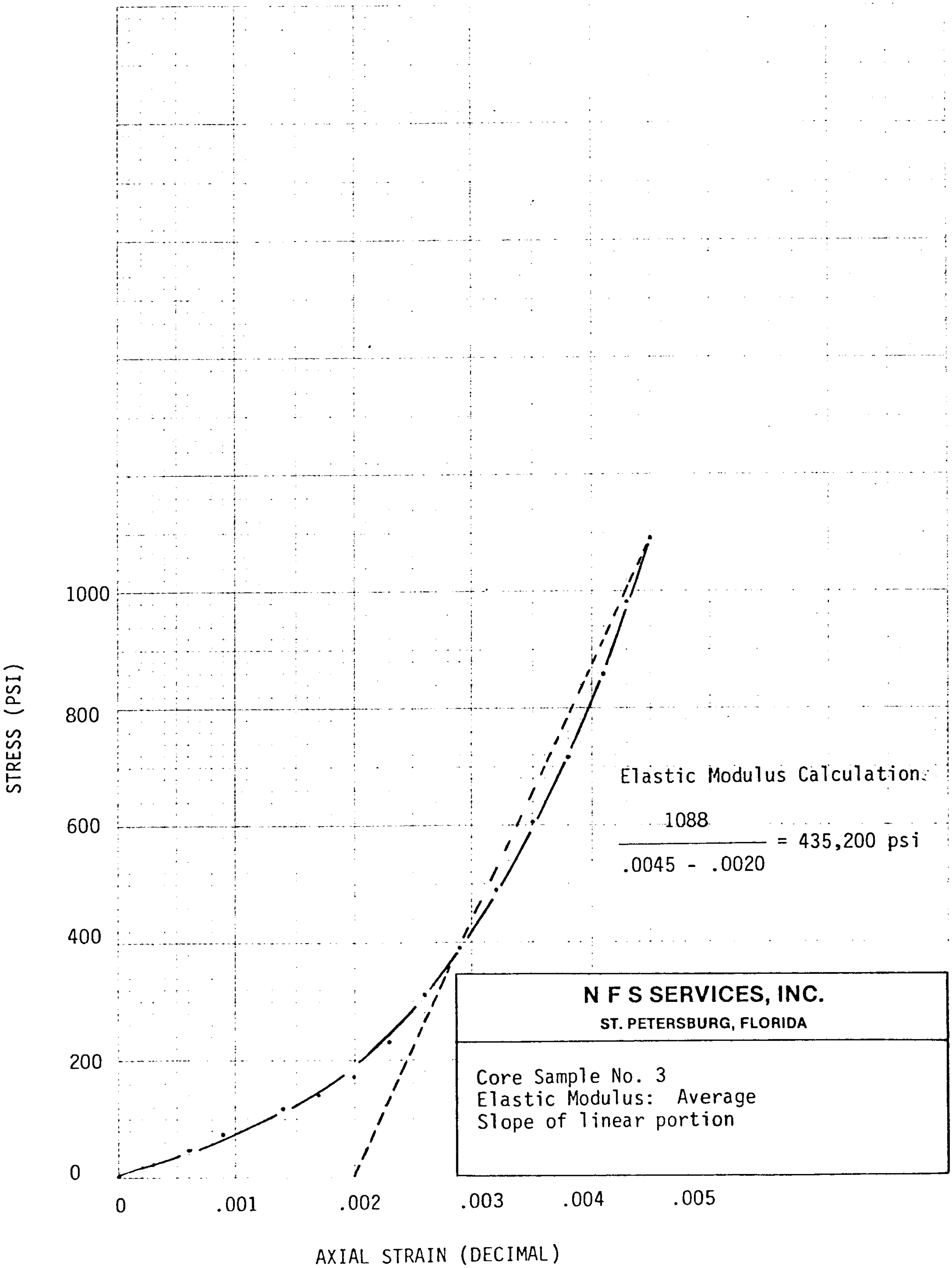
INJECTION WELL 1



N F S SERVICES, INC.
ST. PETERSBURG, FLORIDA

Core Sample No. 2
Elastic Modulus: Average
Slope of linear portion

INJECTION WELL 1



Form 018

TEST RESULTS

Sample No.	Core #4	Core #5	Core #6
Description	Hard light tan limestone	Medium hard, cream colored limestone.	Medium hard, cream colored sandy limestone, fossil-ferrous.

UNIT WEIGHT

Weight of trimmed sample	6.600 inches	6.840	6.084
Diameter of trimmed sample	3.905 inches	3.965	3.950
Moisture Content	7.5 %	12.2	2.1 %
Dry Unit Weight	113.6	106.5	112.8

UNCONFINED COMPRESSION TEST

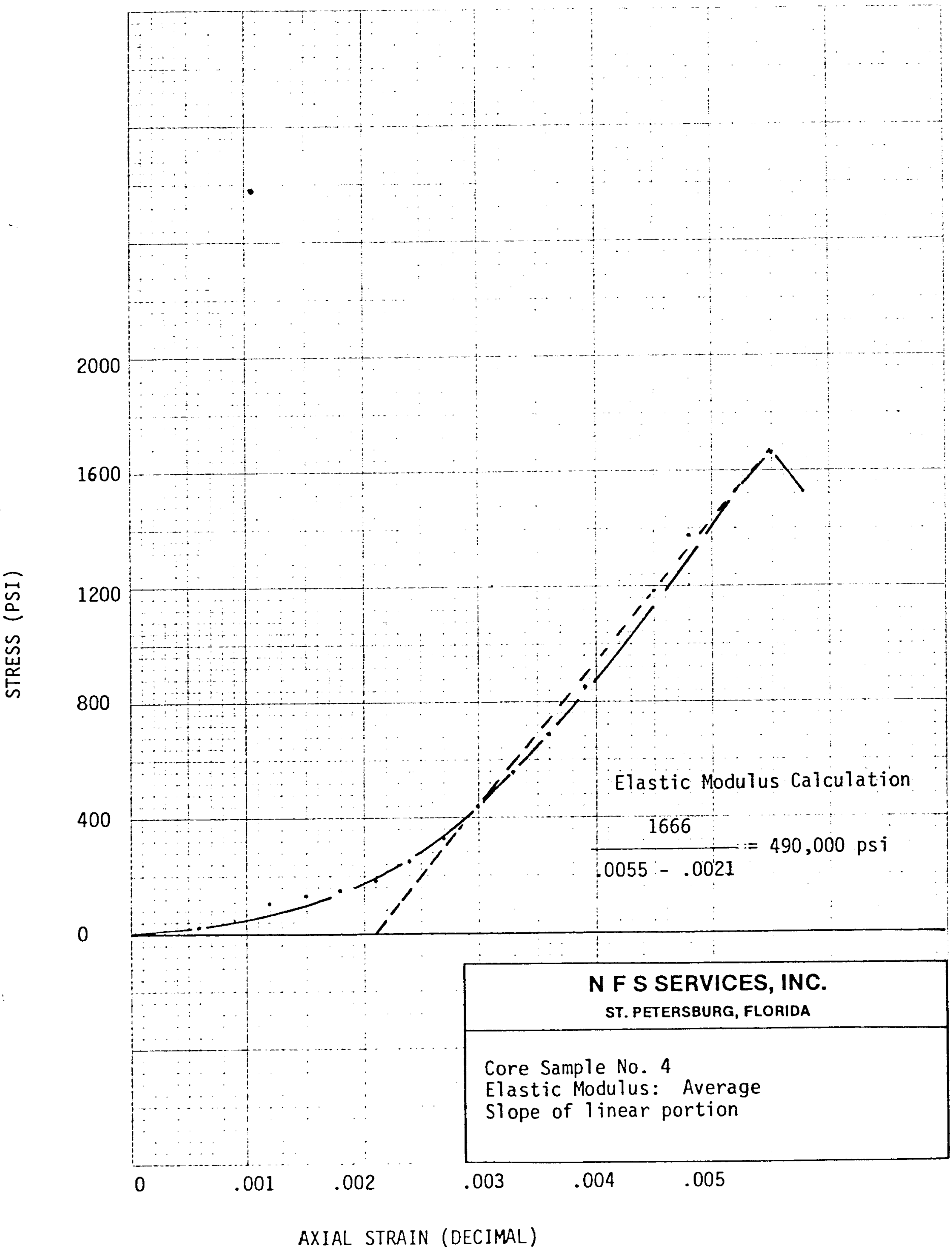
Length to Diameter Ratio	1.69	1.73	1.54
Compressive Strength	1666 psi	1438	1347 psi
Elastic Modulus	490,000 psi	435,758	464,483

COEFFICIENT OF PERMEABILITY

Coefficient of Permeability	8.30×10^{-6} cm/sec	1.44×10^{-5} cm/sec	2.07×10^{-5} cm/sec
Specific Gravity	2.69	2.67	2.66
Porosity	32.4	36.1	32.8

* Dimensions of samples used, for the unconfined Compression tests and permeability test correspond to Unit weight measurements.

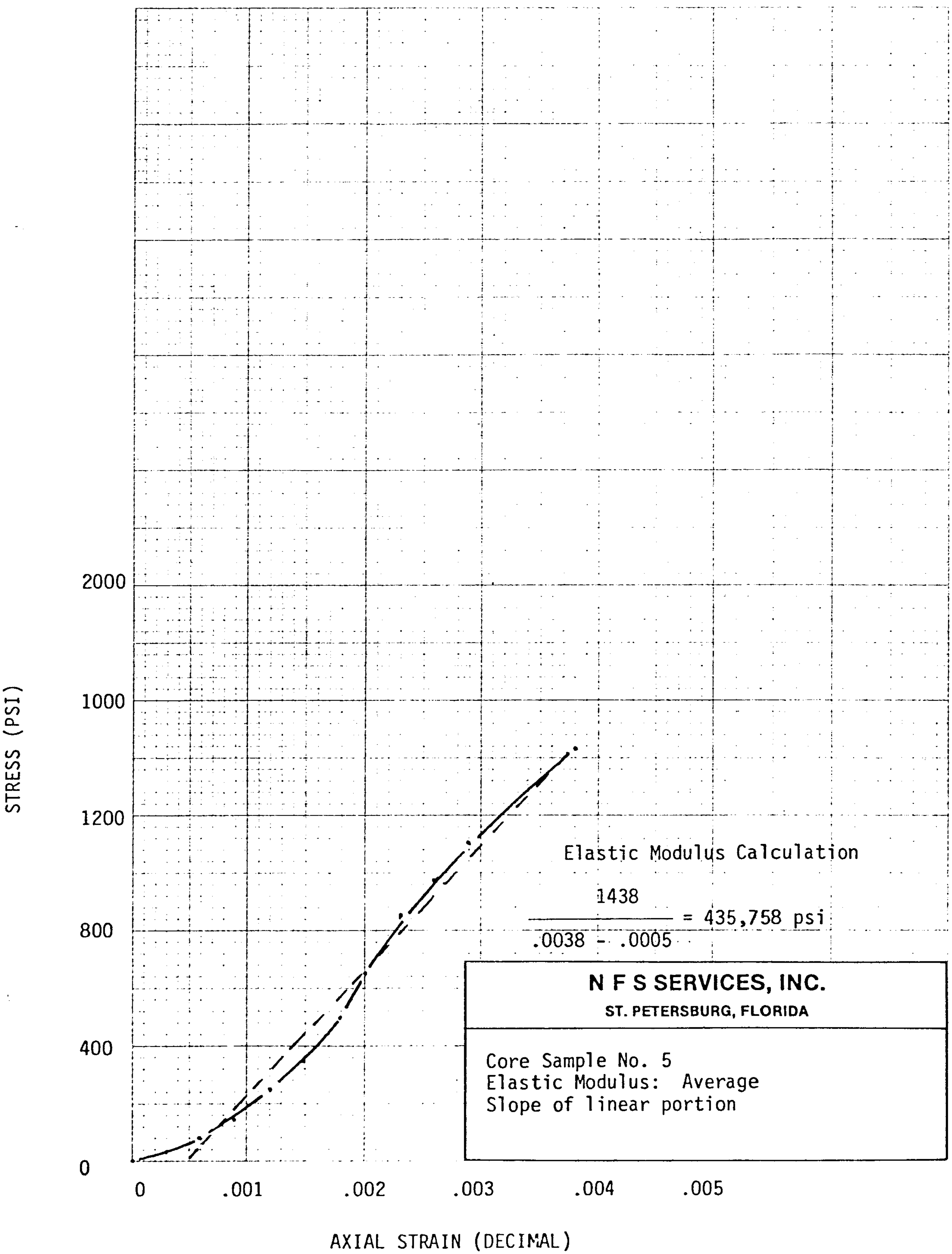
INJECTION WELL 2



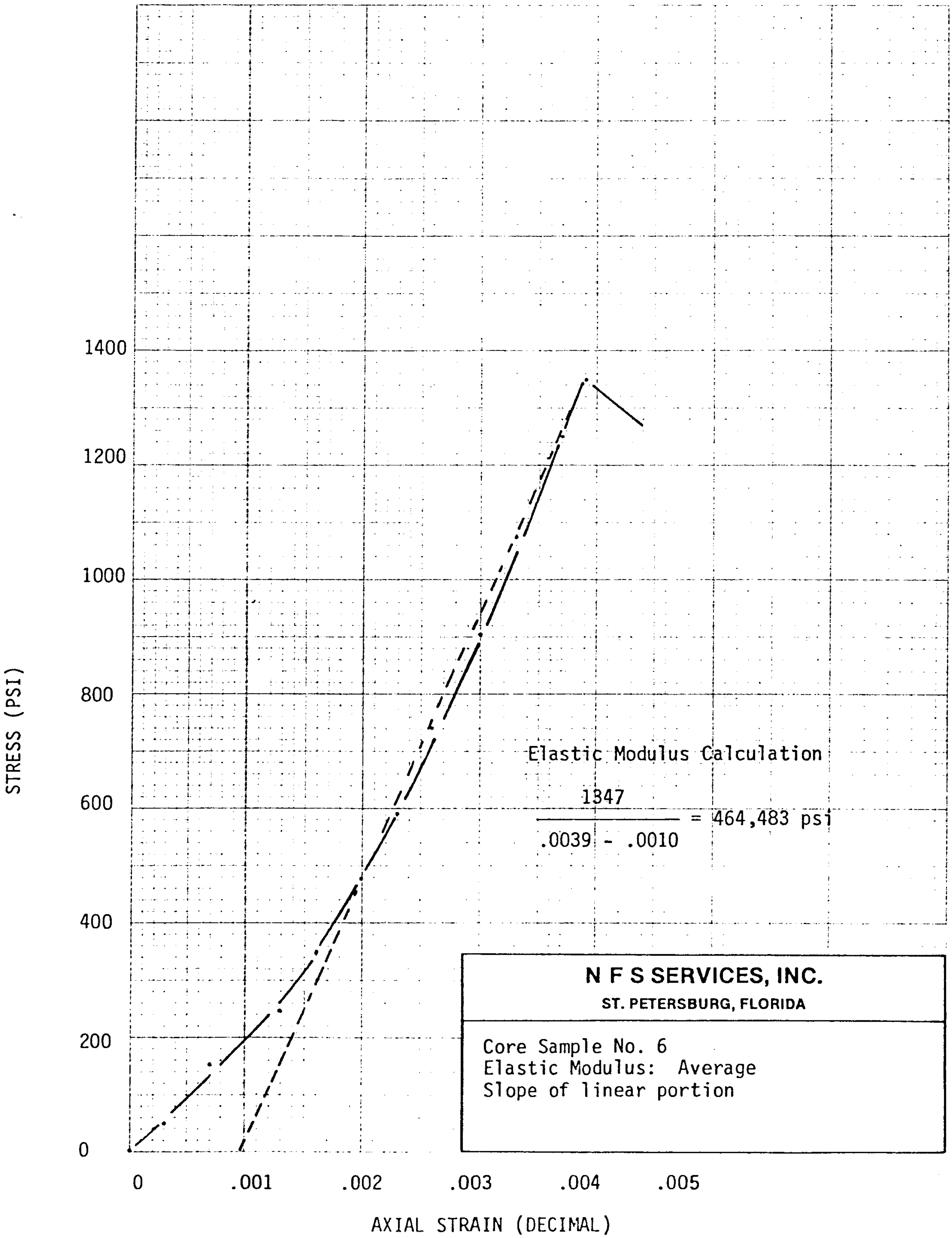
N F S SERVICES, INC.
ST. PETERSBURG, FLORIDA

Core Sample No. 4
Elastic Modulus: Average
Slope of linear portion

INJECTION WELL 2



INJECTION WELL 2



Form 018

TEST RESULTS

Sample No.	Core #1	Core #2	Core #3
Depth	2149.0' to 2149.8'	2360.0' to 2360.8'	2369.0' to 2370.0'
Description	Medium hard, cream colored, sandy limestone	Hard, cream colored limestone	Hard, cream colored limestone
Untrimmed Core Length	10.25"	10.0"	10.5"

UNCONFINED COMPRESSION TEST

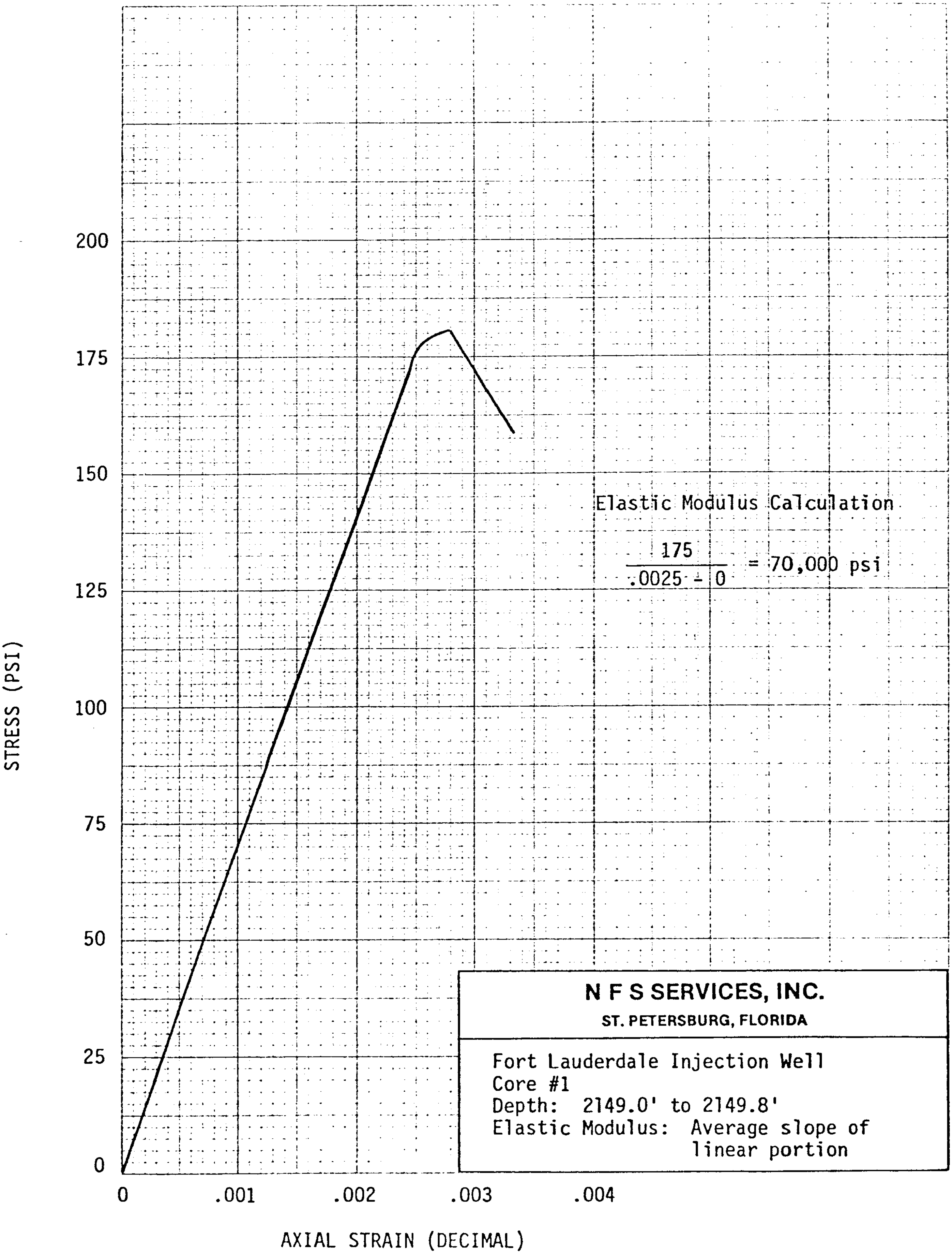
Height of test trimmed specimen	6.938 inches	7.005 inches	7.250 inches
Diameter of test specimen	3.968 inches	3.933 inches	3.925 inches
Oven dry weight of test specimen	3003.9 grams	2890.5 grams	2933.2 grams
Length to diameter ratio *	1.75	1.78	1.85
Compressive Strength	180 psi	2020 psi	970 psi
Moisture Content of test core	2.3%	0.5%	10.8%
Elastic Modulus	70,000 psi	795,454 psi	470,588 psi
Dry Unit Weight	110.5 pcf	111.6 pcf	104.8 pcf

COEFFICIENT OF PERMEABILITY

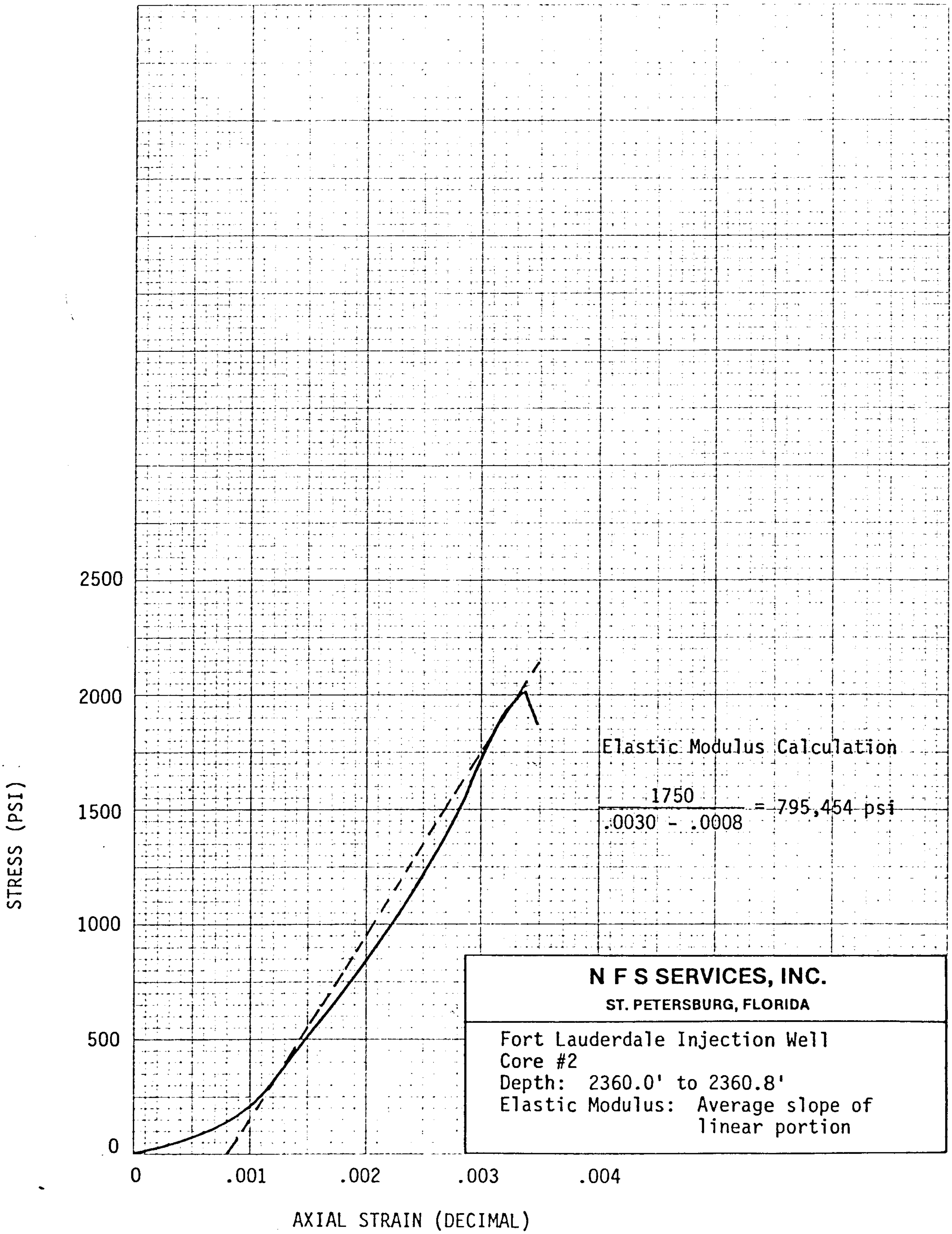
Height of trimmed test specimen	6.938 inches	7.005 inches	7.250 inches
Diameter of test specimen	3.968 inches	3.933 inches	3.925 inches
Coefficient of Permeability	3.25×10^{-4} cm/sec	1.31×10^{-5} cm/sec	1.65×10^{-5} cm/sec
Specific Gravity	2.70	2.73	2.71
Porosity	34.5%	34.5%	38.1%

* L/D Ratio of unconfined compression test cores 1, 2 & 3 is less than 2.0, as recommended by ASTM D2938.

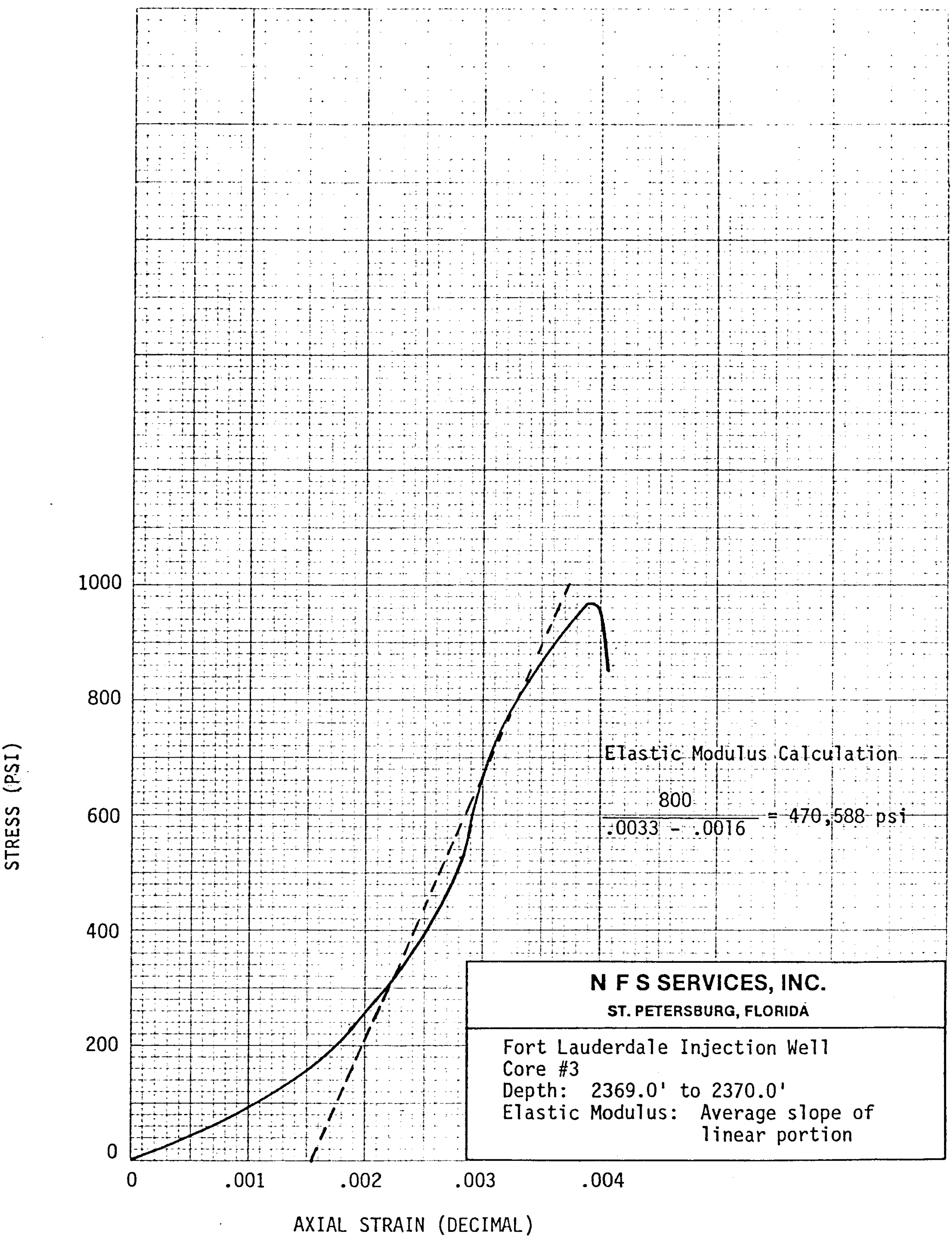
INJECTION WELL 3



Form 018


STRESS (PSI)
2500
2000
1500
1000
500
0
0
.001
.002
.003
.004
AXIAL STRAIN (DECIMAL)
Elastic Modulus Calculation
$\frac{1750}{.0030 - .0008} = 795,454$ psi
N F S SERVICES, INC.
ST. PETERSBURG, FLORIDA
Fort Lauderdale Injection Well
Core #2
Depth: 2360.0' to 2360.8'
Elastic Modulus: Average slope of linear portion

INJECTION WELL 3



RESULTS OF PRESSURE TESTS ON THE INNER CASING

Injection Well 3

Date: October 27, 1982
Time: 02:50 to 03:50 hours

Pressure inside 24-inch-diameter casing was established at 150 pounds per square inch and did not vary during the 60-minute test period.

Witnesses: John O. Hoffman; Robert B. Neufer

Injection Well 2

Date: March 16, 1983
Time: 08:15 to 09:15 hours

Pressure inside 24-inch-diameter casing was established at 150 pounds per square inch and did not vary during the 60-minute test period.

Witnesses: Terry A. Lawrence; William Woolet

Injection Well 1

Date: March 25, 1983
Time: 22:40 to 23:40 hours

Pressure inside 24-inch-diameter casing was established at 162 pounds per square inch and did not vary during the 60-minute test period.

Witnesses: William A. Rueckert; Robert B. Neufer

RESULTS OF GYROSCOPIC SURVEYS

Eastman Whipstock
A PETROLANE COMPANY

REPORT
of
SUB-SURFACE
DIRECTIONAL
SURVEY

ALSAY PIPPINS CORPORATION
COMPANY

FT. LAUDERDALE DISPOSAL WELL #1
WELL NAME

BROWARD COUNTY, FL
LOCATION

JOB NUMBER	TYPE OF SURVEY	DATE
B283-G-0154	GYROSCOPIC SURVEY	2/4/83
B283-G-0167	GYROSCOPIC SURVEY	2/22/93

SURVEY BY BROOKHAVEN, MS OFFICE

ALSAY PIPPINS
FT. LAUDERDALE DISPOSAL WELL NO. 1
BROWARD COUNTY, FL.
FILE 1-291
4-FEB-83
B283-G-0154
GYROSCOPIC MULTI-SHOT
DECLINATION 2 WEST
R. LOFTON
EASTMAN WHIPSTOCK

Eastman Whipstock
A PETROLANE COMPANY

RECORD OF SURVEY

MINIMUM CURVATURE METHOD

SAY PIPPINS
. LAUDERDALE DISPOSAL WELL NO. 1
OWARD COUNTY, FL.

COMPUTATION PAGE NO. 1
TIME DATE
14:24:16 24-FEB-83

MEASURED DEPTH FEET	DRIFT ANGLE D M	DRIFT DIRECTION D M	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	RECTANGULAR COORDINATES FEET		DOGLEG SEVERITY DG/100FT
0.	0 0	0 0	0.	0.00	0.00	0.00	0.00
30.	0 5	N 61 0 W	30.	30.00	0.01 N	0.02 W	0.28
60.	0 3	S 61 0 E	30.	60.00	0.01 N	0.03 W	0.44
90.	0 0	0 0	30.	90.00	0.01 N	0.02 W	0.17
120.	0 6	N 37 0 E	30.	120.00	0.03 N	0.00 E	0.33
150.	0 4	S 22 0 W	30.	150.00	0.03 N	0.01 E	0.55
180.	0 4	N 75 0 W	30.	180.00	0.02 N	0.01 W	0.29
210.	0 5	N 80 0 W	30.	210.00	0.03 N	0.05 W	0.06
240.	0 12	N 53 0 E	30.	240.00	0.07 N	0.03 W	0.83
270.	0 5	N 28 0 W	30.	270.00	0.12 N	0.00 W	0.68
300.	0 7	N 55 0 W	30.	300.00	0.15 N	0.04 W	0.19
330.	0 6	N 66 0 W	30.	330.00	0.18 N	0.08 W	0.09
360.	0 3	N 10 0 W	30.	360.00	0.21 N	0.11 W	0.28
390.	0 5	N 61 0 W	30.	390.00	0.23 N	0.13 W	0.22
420.	0 5	S 77 0 E	30.	420.00	0.23 N	0.13 W	0.55
450.	0 3	N 48 0 W	30.	450.00	0.24 N	0.12 W	0.43
480.	0 12	N 16 0 W	30.	480.00	0.30 N	0.14 W	0.53
510.	0 8	N 2 0 E	30.	510.00	0.38 N	0.16 W	0.28
540.	0 6	N 74 0 E	30.	540.00	0.42 N	0.13 W	0.47
570.	0 10	N 29 0 W	30.	570.00	0.47 N	0.13 W	0.71
600.	0 9	N 24 0 E	30.	600.00	0.54 N	0.13 W	0.47
630.	0 5	N 2 0 E	30.	630.00	0.60 N	0.11 W	0.26
660.	0 3	N 23 0 E	30.	660.00	0.64 N	0.11 W	0.14
690.	0 3	S 88 0 E	30.	690.00	0.65 N	0.09 W	0.19
720.	0 2	N 74 0 E	30.	720.00	0.65 N	0.07 W	0.07
750.	0 4	N 48 0 E	30.	750.00	0.66 N	0.05 W	0.13
780.	0 4	S 36 0 E	30.	780.00	0.66 N	0.02 W	0.33
810.	0 4	N 41 0 W	30.	810.00	0.66 N	0.02 W	0.44
840.	0 5	S 68 0 E	30.	840.00	0.66 N	0.02 W	0.49
870.	0 2	S 77 0 E	30.	870.00	0.65 N	0.01 E	0.17

. LAUDERDALE DISPOSAL WELL NO. 1
OWARD COUNTY, FL.

TIME 14:34:16 DATE 24-FEB-83

MEASURED DEPTH FEET	DRIFT ANGLE D M	DRIFT DIRECTION D M	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	RECTANGULAR COORDINATES FEET		DOGLEG SEVERITY DG/100FT
900.	0 4	S 89 0 E	30.	900.00	0.65 N	0.04 E	0.12
930.	0 4	N 9 0 E	30.	930.00	0.67 N	0.06 E	0.29
960.	0 8	N 72 0 E	30.	960.00	0.70 N	0.09 E	0.40
990.	0 6	S 50 0 E	30.	990.00	0.69 N	0.15 E	0.39
1020.	0 6	S 6 0 W	30.	1020.00	0.65 N	0.17 E	0.31
1050.	0 8	N 86 0 E	30.	1050.00	0.62 N	0.20 E	0.60
1080.	0 3	S 1 0 E	30.	1080.00	0.61 N	0.23 E	0.48
1110.	0 5	S 89 0 E	30.	1110.00	0.60 N	0.25 E	0.32
1140.	0 5	S 15 0 W	30.	1140.00	0.58 N	0.27 E	0.44
1170.	0 6	N 84 0 E	30.	1170.00	0.56 N	0.29 E	0.50
1200.	0 6	S 35 0 E	30.	1200.00	0.54 N	0.33 E	0.34
1230.	0 7	S 30 0 W	30.	1230.00	0.49 N	0.33 E	0.39
1260.	0 7	S 9 0 W	30.	1260.00	0.44 N	0.31 E	0.14
1290.	0 4	N 17 0 E	30.	1290.00	0.42 N	0.31 E	0.61
1320.	0 10	S 28 0 E	30.	1320.00	0.40 N	0.34 E	0.73
1350.	0 9	S 34 0 E	30.	1350.00	0.33 N	0.38 E	0.08
1380.	0 5	N 66 0 E	30.	1380.00	0.31 N	0.42 E	0.53
1410.	0 3	S 68 0 E	30.	1410.00	0.31 N	0.45 E	0.20
1440.	0 8	S 56 0 E	30.	1440.00	0.29 N	0.50 E	0.28
1470.	0 11	S 57 0 E	30.	1470.00	0.24 N	0.56 E	0.17
1500.	0 5	N 52 0 E	30.	1500.00	0.23 N	0.62 E	0.58
1530.	0 9	S 14 0 E	30.	1530.00	0.20 N	0.65 E	0.66
1560.	0 4	S 27 0 E	30.	1560.00	0.15 N	0.67 E	0.29
1590.	0 9	S 70 0 E	30.	1590.00	0.12 N	0.71 E	0.37
1620.	0 3	S 70 0 E	30.	1620.00	0.10 N	0.76 E	0.33
1650.	0 7	S 20 0 W	30.	1650.00	0.07 N	0.76 E	0.42
1680.	0 6	S 12 0 W	30.	1680.00	0.02 N	0.75 E	0.07
1710.	0 14	S 47 0 E	30.	1710.00	0.05 S	0.79 E	0.67
1740.	0 14	S 18 0 E	30.	1740.00	0.15 S	0.85 E	0.39
1770.	0 9	S 41 0 E	30.	1770.00	0.24 S	0.89 E	0.37

MEASURED DEPTH FEET	DRIFT ANGLE D M	DRIFT DIRECTION D M	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	RECTANGULAR COORDINATES FEET		DOGLEG SEVERITY DG/100FT
1800.	0 7	S 21 0 E	30.	1800.00	0.30 S	0.93 E	0.19
1830.	0 4	N 18 0 E	30.	1830.00	0.31 S	0.95 E	0.58
1860.	0 2	S 31 0 W	30.	1860.00	0.30 S	0.95 E	0.33
1890.	0 7	N 0 0 E	30.	1890.00	0.28 S	0.94 E	0.49
1920.	0 7	S 86 0 W	30.	1920.00	0.25 S	0.91 E	0.57
1950.	0 9	N 64 0 W	30.	1950.00	0.23 S	0.85 E	0.25
1980.	0 8	N 80 0 W	30.	1980.00	0.21 S	0.78 E	0.14
2010.	0 22	N 76 0 W	30.	2010.00	0.18 S	0.65 E	0.78
2040.	0 10	N 48 0 W	30.	2040.00	0.13 S	0.52 E	0.78
2070.	0 14	N 22 0 W	30.	2070.00	0.04 S	0.47 E	0.37
2130.	0 10	N 17 0 W	30.	2130.00	0.15 N	0.40 E	0.11
2160.	0 11	N 60 0 W	30.	2160.00	0.22 N	0.34 E	0.43
2190.	0 7	N 25 0 W	30.	2190.00	0.27 N	0.29 E	0.37
2220.	0 8	N 71 0 W	30.	2220.00	0.31 N	0.24 E	0.33
2250.	0 12	N 41 0 W	30.	2250.00	0.36 N	0.18 E	0.36
2280.	0 8	N 59 0 E	30.	2280.00	0.42 N	0.17 E	0.86
2310.	0 8	N 9 0 W	30.	2310.00	0.47 N	0.20 E	0.50
2340.	0 6	S 42 0 W	30.	2340.00	0.49 N	0.17 E	0.70
2370.	0 15	N 13 0 W	30.	2370.00	0.53 N	0.14 E	1.06
2400.	0 17	N 24 0 W	30.	2399.99	0.66 N	0.10 E	0.20
2430.	0 9	N 57 0 W	30.	2429.99	0.75 N	0.03 E	0.59
2460.	0 10	N 60 0 W	30.	2459.99	0.80 N	0.04 W	0.06
2490.	0 12	N 15 0 W	30.	2489.99	0.87 N	0.09 W	0.48
2520.	0 12	N 32 0 W	30.	2519.99	0.96 N	0.13 W	0.20
2550.	0 16	N 36 0 W	30.	2549.99	1.06 N	0.20 W	0.23
2580.	0 16	N 16 0 E	30.	2579.99	1.19 N	0.22 W	0.78
2610.	0 6	N 67 0 E	30.	2609.99	1.26 N	0.18 W	0.73
2640.	0 2	S 30 0 E	30.	2639.99	1.27 N	0.15 W	0.34
2670.	0 4	N 21 0 W	30.	2669.99	1.28 N	0.15 W	0.33
2700.	0 19	N 55 0 E	30.	2699.99	1.34 N	0.09 W	1.02

SAY PIPPINS | COMPUTATION | PAGE NO. 4
. LAUDERDALE DISPOSAL WELL NO. 1 | TIME | DATE
OWARD COUNTY, FL. | 14:34:16 | 24-FEB-83

MEASURED DEPTH FEET	DRIFT ANGLE D M	DRIFT DIRECTION D M	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	RECTANGULAR COORDINATES FEET		DOGLEG SEVERITY DG/100FT
2730.	0 10	N 28 0 E	30.	2729.99	1.43 N	0.00 W	0.61
2760.	0 15	N 29 0 E	30.	2759.99	1.52 N	0.05 E	0.28
2790.	0 15	N 35 0 E	30.	2789.99	1.63 N	0.12 E	0.09
2820.	0 11	N 54 0 E	30.	2819.99	1.71 N	0.20 E	0.32
2850.	0 9	N 8 0 E	30.	2849.99	1.78 N	0.24 E	0.45
2880.	0 17	N 15 0 E	30.	2879.99	1.89 N	0.26 E	0.45

FINAL CLOSURE - DIRECTION: N 7 DEGS 58 MINS 28 SECS E
DISTANCE: 1.91 FEET

Eastman Whipstock
A PETROLANE COMPANY

14:40:25 24-FEB-83

SAY PIPPINS
. LAUDERDALE DISPOSAL WELL NO. 1
ROWARD COUNTY, FL.
LE 1-291
FEB-83
83-G-0154
ROSCOPIC MULTI-SHOT
CLINATION 2 WEST
LOFTON
STMAN WHIPSTOCK

PROBABILITY CALCULATIONS

EXPECTED VALUE :		VARIANCE :		COVARIANCE :	
EAST-WEST COORDINATE :	0.3 FT.	EAST-WEST :	0.0	EW-NS :	0.0
NORTH-SOUTH COORDINATE:	1.9 FT.	NORTH-SOUTH :	0.0	EW-V :	0.0
VERTICAL COORDINATE :	2880.0 FT.	VERTICAL :	0.0	NS-V :	-0.0

RESULTS ARE BASED ON THE FOLLOWING TOOLS:

0.0 TO 2880.0 TOOL NUMBER 3 = 5 DEGREE UNIT GYRO WITH TAC

LIPSE OF UNCERTAINTY V2.10 INJECTION WELL 1
R FILE 0

```
                                     EAST-WEST
          -5.       -3.       -1.        1.        3.        5.
           +---------+---------+---------+---------+---------+
       8.+
         -
         -
         -
         -
       6.+
         -
         -
         -
         -
       4.+
         -
         -
         -
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RTH-SOUTH  2.+
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       0.+
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      -2.+
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      -4.+
          -5.       -3.       -1.        1.        3.        5.
           +---------+---------+---------+---------+---------+
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Eastman Whipstock
A PETROLANE COMPANY

ROBABILITY IS 0.99 THAT BOTTOM-HOLE COORDINATES ARE WITHIN THIS ELLIPSE AND
HAT TRUE VERTICAL DEPTH IS BETWEEN 2880.0 FT. AND 2880.0 FT.
ENTER OF ELLIPSE IS 1.9 FT. NORTH AND 0.3 FT. EAST AT A DEPTH OF 2880.0 FT.
AJOR AXIS IS 1.2 FT. AND IS ROTATED 32. DEG COUNTER-CLOCKWISE FROM EAST
INOR AXIS IS 1.2 FT. VERTICAL THICKNESS IS 0.0 FT.

Eastman Whipstock

A PETROLANE COMPANY

REPORT of SUB-SURFACE DIRECTIONAL SURVEY

ALSAY PIPPINS CORPORATION
COMPANY

32" CASING DISPOSAL WELL #2
WELL NAME

BROWARD COUNTY, FL
LOCATION

JOB NUMBER	TYPE OF SURVEY	DATE
B283-G-0160	GYROSCOPIC SURVEY	2/11/83
B283-G-0168	GYROSCOPIC SURVEY	2/22/83

SURVEY BY BROOKHAVEN, MS OFFICE

ALSAY PIPPINS
32" CASING #2
BROWARD COUNTY, FLA.
FILE # 296
11-FEB-83
B283-G-0160
GYRO MULTIPLE SHOT SURVEY
DECLINATION 2 DEGREES WEST
WENDELL REDD
EASTMAN WHIPSTOCK; INC.

Eastman Whipstock
A PETROLANE COMPANY

RECORD OF SURVEY

MINIMUM CURVATURE METHOD

SAY PIPPINS
CASING #2
WARD COUNTY, FLA.

COMPUTATION PAGE NO. 1
TIME DATE
14:50:08 24-FEB-83

MEASURED DEPTH FEET	DRIFT ANGLE D	DRIFT ANGLE M	DRIFT DIRECTION D	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	RECTANGULAR COORDINATES FEET		DOGLEG SEVERITY DG/100FT
0.	0	0	0	0.	0.00	0.00	0.00	0.00
30.	0	5	N 75 E	30.	30.00	0.01 N	0.02 E	0.28
60.	0	3	N 69 E	30.	60.00	0.02 N	0.05 E	0.11
90.	0	5	N 11 W	30.	90.00	0.04 N	0.06 E	0.30
120.	0	2	N 78 E	30.	120.00	0.07 N	0.07 E	0.30
150.	0	5	S 10 W	30.	150.00	0.05 N	0.07 E	0.34
180.	0	6	S 38 E	30.	180.00	0.00 N	0.08 E	0.25
210.	0	6	N 12 W	30.	210.00	0.01 N	0.09 E	0.65
240.	0	10	N 68 E	30.	240.00	0.05 N	0.13 E	0.60
270.	0	6	N 70 E	30.	270.00	0.08 N	0.19 E	0.22
300.	0	7	N 17 W	30.	300.00	0.11 N	0.21 E	0.50
330.	0	7	N 64 W	30.	330.00	0.16 N	0.17 E	0.31
360.	0	7	S 45 W	30.	360.00	0.15 N	0.12 E	0.45
390.	0	5	N 37 W	30.	390.00	0.14 N	0.09 E	0.51
420.	0	3	N 45 W	30.	420.00	0.17 N	0.07 E	0.12
450.	0	5	S 49 E	30.	450.00	0.17 N	0.07 E	0.44
480.	0	6	S 13 E	30.	480.00	0.13 N	0.10 E	0.20
510.	0	3	N 19 W	30.	510.00	0.11 N	0.10 E	0.50
540.	0	3	N 45 E	30.	540.00	0.13 N	0.10 E	0.18
570.	0	7	S 83 W	30.	570.00	0.14 N	0.08 E	0.53
600.	0	8	N 30 E	30.	600.00	0.17 N	0.07 E	0.75
630.	0	2	N 87 E	30.	630.00	0.20 N	0.10 E	0.40
660.	0	7	N 10 E	30.	660.00	0.23 N	0.11 E	0.38
690.	0	1	N 18 E	30.	690.00	0.26 N	0.12 E	0.33
720.	0	4	N 43 W	30.	720.00	0.28 N	0.11 E	0.20
750.	0	9	S 58 W	30.	750.00	0.27 N	0.06 E	0.51
780.	0	6	S 36 W	30.	780.00	0.23 N	0.01 E	0.23
810.	0	3	S 47 W	30.	810.00	0.20 N	0.01 W	0.17
840.	0	5	N 58 E	30.	840.00	0.20 N	0.00 W	0.44
870.	0	3	S 28 E	30.	870.00	0.20 N	0.02 E	0.33

SAY PIPPINS
' CASING #2
OWARD COUNTY, FLA.

MEASURED DEPTH FEET	DRIFT ANGLE D M	DRIFT DIRECTION D	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	RECTANGULAR COORDINATES FEET		DOGLEG SEVERITY DG/100FT
0.	0 0	0	0.	0.00	0.00	0.00	0.00
30.	0 5	N 75 E	30.	30.00	0.01 N	0.02 E	0.28
60.	0 3	N 69 E	30.	60.00	0.02 N	0.05 E	0.11
90.	0 5	N 11 W	30.	90.00	0.04 N	0.06 E	0.30
120.	0 2	N 78 E	30.	120.00	0.07 N	0.07 E	0.30
150.	0 5	S 10 W	30.	150.00	0.05 N	0.07 E	0.34
180.	0 6	S 38 E	30.	180.00	0.00 N	0.08 E	0.25
210.	0 6	N 12 W	30.	210.00	0.01 N	0.09 E	0.65
240.	0 10	N 68 E	30.	240.00	0.05 N	0.13 E	0.60
270.	0 6	N 70 E	30.	270.00	0.08 N	0.19 E	0.22
300.	0 7	N 17 W	30.	300.00	0.11 N	0.21 E	0.50
330.	0 7	N 64 W	30.	330.00	0.16 N	0.17 E	0.31
360.	0 7	S 45 W	30.	360.00	0.15 N	0.12 E	0.45
390.	0 5	N 37 W	30.	390.00	0.14 N	0.09 E	0.51
420.	0 3	N 45 W	30.	420.00	0.17 N	0.07 E	0.12
450.	0 5	S 49 E	30.	450.00	0.17 N	0.07 E	0.44
480.	0 6	S 13 E	30.	480.00	0.13 N	0.10 E	0.20
510.	0 3	N 19 W	30.	510.00	0.11 N	0.10 E	0.50
540.	0 3	N 45 E	30.	540.00	0.13 N	0.10 E	0.18
570.	0 7	S 83 W	30.	570.00	0.14 N	0.08 E	0.53
600.	0 8	N 30 E	30.	600.00	0.17 N	0.07 E	0.75
630.	0 2	N 87 E	30.	630.00	0.20 N	0.10 E	0.40
660.	0 7	N 10 E	30.	660.00	0.23 N	0.11 E	0.38
690.	0 1	N 18 E	30.	690.00	0.26 N	0.12 E	0.33
720.	0 4	N 43 W	30.	720.00	0.28 N	0.11 E	0.20
750.	0 9	S 58 W	30.	750.00	0.27 N	0.06 E	0.51
780.	0 6	S 36 W	30.	780.00	0.23 N	0.01 E	0.23
810.	0 3	S 47 W	30.	810.00	0.20 N	0.01 W	0.17
840.	0 5	N 58 E	30.	840.00	0.20 N	0.00 W	0.44
870.	0 3	S 28 E	30.	870.00	0.20 N	0.02 E	0.33

MEASURED DEPTH FEET	DRIFT ANGLE D M	DRIFT DIRECTION D	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	R E C T A N G U L A R C O O R D I N A T E S FEET		DOGLEG SEVERITY DG/100FT
900.	0 6	N 49 E	30.	900.00	0.21 N	0.05 E	0.40
930.	0 8	N 13 W	30.	930.00	0.26 N	0.06 E	0.41
960.	0 7	N 88 E	30.	960.00	0.29 N	0.08 E	0.64
990.	0 6	S 57 W	30.	990.00	0.28 N	0.09 E	0.70
1020.	0 9	N 81 E	30.	1020.00	0.27 N	0.11 E	0.82
1050.	0 7	N 28 W	30.	1050.00	0.31 N	0.13 E	0.73
1080.	0 4	N 24 E	30.	1080.00	0.35 N	0.12 E	0.31
1110.	0 4	N 30 W	30.	1110.00	0.38 N	0.12 E	0.20
1140.	0 8	N 7 W	30.	1140.00	0.43 N	0.11 E	0.26
1170.	0 12	S 35 W	30.	1170.00	0.42 N	0.08 E	1.04
1200.	0 4	S 51 W	30.	1200.00	0.37 N	0.03 E	0.46
1230.	0 6	S 11 W	30.	1230.00	0.33 N	0.01 E	0.22
1260.	0 5	S 2 W	30.	1260.00	0.28 N	0.01 E	0.07
1290.	0 7	S 20 E	30.	1290.00	0.23 N	0.02 E	0.17
1320.	0 2	S 26 E	30.	1320.00	0.20 N	0.03 E	0.28
1350.	0 5	S 53 E	30.	1350.00	0.17 N	0.05 E	0.19
1380.	0 6	S 69 E	30.	1380.00	0.15 N	0.09 E	0.10
1410.	0 5	S 67 E	30.	1410.00	0.13 N	0.14 E	0.06
1470.	0 5	N 44 E	60.	1470.00	0.15 N	0.21 E	0.16
1500.	0 7	N 54 E	30.	1500.00	0.18 N	0.25 E	0.13
1530.	0 5	N 30 E	30.	1530.00	0.22 N	0.28 E	0.18
1560.	0 2	S 27 W	30.	1560.00	0.23 N	0.29 E	0.39
1590.	0 8	N 22 E	30.	1590.00	0.25 N	0.30 E	0.56
1620.	0 4	N 18 E	30.	1620.00	0.30 N	0.32 E	0.22
1650.	0 10	N 50 E	30.	1650.00	0.35 N	0.36 E	0.39
1680.	0 8	N 4 W	30.	1680.00	0.41 N	0.39 E	0.46
1710.	0 11	N 25 E	30.	1710.00	0.49 N	0.41 E	0.31
1740.	0 5	N 72 W	30.	1740.00	0.54 N	0.41 E	0.70
1770.	0 7	N 29 W	30.	1770.00	0.57 N	0.37 E	0.27
1800.	0 12	S 50 E	30.	1800.00	0.57 N	0.40 E	1.04

SAY PIPPINS
" CASING #2
OWARD COUNTY, FLA.

TIME 14:50:08 DATE 24-FEB-83

MEASURED DEPTH FEET	DRIFT ANGLE D M	DRIFT DIRECTION D	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	RECTANGULAR COORDINATES FEET		DOGLEG SEVERITY DG/100FT
1830.	0 14	S 51 E	30.	1830.00	0.49 N	0.48 E	0.11
1860.	0 13	S 41 E	30.	1860.00	0.41 N	0.57 E	0.14
1890.	0 18	S 66 E	30.	1890.00	0.34 N	0.68 E	0.46
1920.	0 15	N 68 E	30.	1920.00	0.33 N	0.81 E	0.73
1950.	0 14	N 22 E	30.	1950.00	0.41 N	0.89 E	0.63
1980.	0 4	S 14 E	30.	1980.00	0.45 N	0.92 E	0.97
2010.	0 8	S 57 E	30.	2010.00	0.42 N	0.95 E	0.32
2040.	0 6	N 90 E	30.	2040.00	0.40 N	1.01 E	0.25
2070.	0 11	N 38 E	30.	2070.00	0.43 N	1.07 E	0.48
2100.	0 14	S 16 E	30.	2100.00	0.41 N	1.11 E	1.24
2130.	0 13	S 6 E	30.	2130.00	0.30 N	1.13 E	0.14
2160.	0 16	S 30 E	30.	2160.00	0.18 N	1.18 E	0.37
2190.	0 16	S 41 E	30.	2190.00	0.07 N	1.26 E	0.17
2220.	0 18	S 26 W	30.	2220.00	0.06 S	1.27 E	1.05
2250.	0 18	S 19 E	30.	2249.99	0.20 S	1.26 E	0.77
2280.	0 17	S 23 E	30.	2279.99	0.34 S	1.31 E	0.09
2310.	0 14	S 29 E	30.	2309.99	0.46 S	1.37 E	0.19
2340.	0 13	S 36 E	30.	2339.99	0.56 S	1.43 E	0.11
2370.	0 13	S 39 E	30.	2369.99	0.65 S	1.50 E	0.04
2400.	0 11	S 42 E	30.	2399.99	0.73 S	1.57 E	0.12
2430.	0 4	S 42 E	30.	2429.99	0.78 S	1.62 E	0.39
2460.	0 14	S 1 E	30.	2459.99	0.86 S	1.63 E	0.63
2490.	0 13	S 10 E	30.	2489.99	0.97 S	1.64 E	0.13
2520.	0 13	S 1 E	30.	2519.99	1.09 S	1.65 E	0.11
2550.	0 15	S 16 E	30.	2549.99	1.20 S	1.67 E	0.23
2580.	0 15	S 26 E	30.	2579.99	1.33 S	1.72 E	0.15
2610.	0 12	S 29 W	30.	2609.99	1.43 S	1.72 E	0.71
2640.	0 27	S 17 W	30.	2639.99	1.59 S	1.66 E	0.86
2670.	0 16	S 10 W	30.	2669.99	1.77 S	1.61 E	0.63
2700.	0 17	S 4 E	30.	2699.99	1.91 S	1.61 E	0.23

MEASURED DEPTH FEET	DRIFT ANGLE D M	DRIFT DIRECTION D	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	RECTANGULAR COORDINATES FEET		DOGLEG SEVERITY DG/100FT
2730.	0 15	S 18 E	30.	2729.99	2.05 S	1.63 E	0.24
2760.	0 12	S 41 W	30.	2759.99	2.15 S	1.62 E	0.75
2790.	0 14	S 22 W	30.	2789.99	2.25 S	1.56 E	0.26
2800.	0 19	S 22 W	10.	2799.99	2.29 S	1.54 E	0.83

FINAL CLOSURE - DIRECTION: S 33 DEGS 55 MINS 2 SECS E
DISTANCE: 2.76 FEET

Eastman Whipstock
A PETROLANE COMPANY

14:58:02 24-FEB-83

SAY PIPPINS
" CASING #2
OWARD COUNTY, FLA.
LE # 296
-FEB-83
83-G-0160
RO MULTIPLE SHOT SURVEY
CLINATION 2 DEGREES WEST
NDELL REDD
STMAN WHIPSTOCK;INC.

Eastman Whipstock
A PETROLANE COMPANY

PROBABILITY CALCULATION:

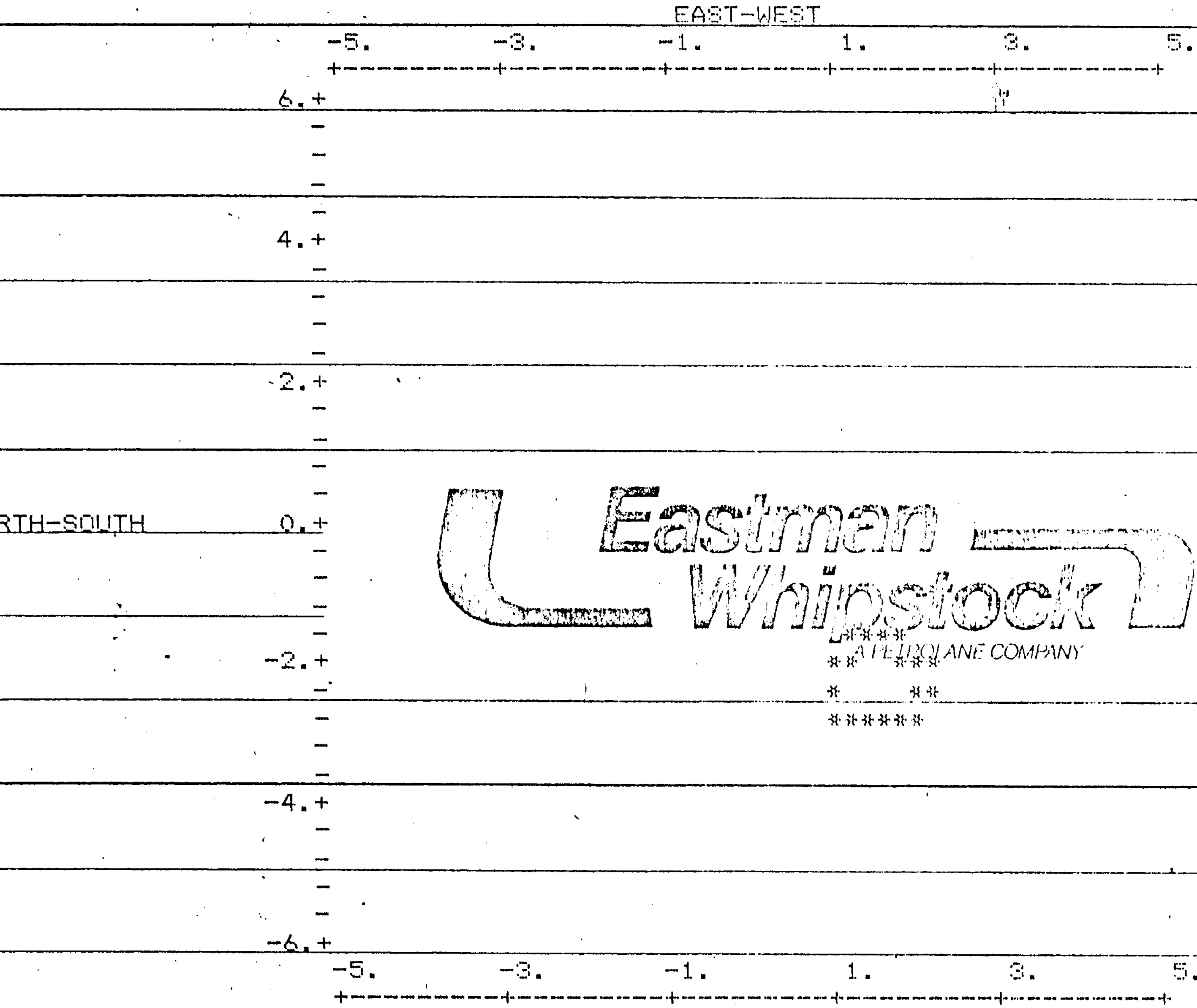
EXPECTED VALUE :		VARIANCE :		COVARIANCE :	
EAST-WEST COORDINATE :	1.5 FT.	EAST-WEST :	0.0	EW-NS :	0.0
NORTH-SOUTH COORDINATE:	-2.3 FT.	NORTH-SOUTH :	0.0	EW-V :	-0.0
VERTICAL COORDINATE :	2800.0 FT.	VERTICAL :	0.0	NS-V :	0.0

RESULTS ARE BASED ON THE FOLLOWING TOOLS:

0.0 TO 2800.0 TOOL NUMBER 3 = 5 DEGREE UNIT GYRO WITH TAC

LIPSE OF UNCERTAINTY V2.10
R FILE 0

INJCETION WELL 2



OBABILITY IS 0.99 THAT BOTTOM-HOLE COORDINATES ARE WITHIN THIS ELLIPSE AND
AT TRUE VERTICAL DEPTH IS BETWEEN 2800.0 FT. AND 2800.0 FT.
NTER OF ELLIPSE IS 2.3 FT. SOUTH AND 1.5 FT. EAST AT A DEPTH OF 2800.0 FT.
JOR AXIS IS 1.2 FT. AND IS ROTATED 7. DEG COUNTER-CLOCKWISE FROM EAST
NOR AXIS IS 1.2 FT. VERTICAL THICKNESS IS 0.0 FT.

Eastman Whipstock

A PETROLANE COMPANY

PRELIMINARY DISTRIBUTION

REPORT of SUB-SURFACE DIRECTIONAL SURVEY

ALSAY PIPPINS CORPORATION

COMPANY

DISPOSAL WELL #3

WELL NAME

BROWARD COUNTY, FL

LOCATION

JOB NUMBER	TYPE OF SURVEY	DATE
B982-G-0017	GYROSCOPIC SURVEY	9/17/82
B982-G-0028	GYROSCOPIC SURVEY	9/28/82

SURVEY BY BROOKHAVEN, MS OFFICE

ALSAY PIPPINS
DISPOSAL WELL NO. 3
BROWARD COUNTY, FL.
FILE 1-243
17-SEP-82
B982-G-0017
GYROSCOPIC MULTI-SHOT
DECLINATION 2 WEST
R. LOFTON
EASTMAN WHIPSTOCK

Eastman Whipstock
RECORD OF SURVEY
A PETROLANE COMPANY

MINIMUM CURVATURE METHOD

MEASURED DEPTH FEET	DRIFT ANGLE D M	DRIFT DIRECTION D M	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	RECTANGULAR COORDINATES FEET		CLOSURE DISTANCE FEET	CLOSURE DIRECTION D M	DOGLEG SEVERITY DG/100FT
0.	0 0	0 0	0.	0.00	0.00	0.00	0.00	0 0	0.00
30.	0 2	S 5 0 E	30.	30.00	0.01 S	0.00 E	0.01	S 3 0 E	0.11
60.	0 9	S 44 0 W	30.	60.00	0.05 S	0.03 W	0.05	S 30 0 W	0.43
90.	0 10	S 44 0 W	30.	90.00	0.11 S	0.08 W	0.13	S 38 34 W	0.06
120.	0 4	S 6 0 W	30.	120.00	0.15 S	0.12 W	0.19	S 37 0 W	0.40
150.	0 9	S 27 0 W	30.	150.00	0.21 S	0.14 W	0.25	S 33 20 W	0.30
180.	0 7	S 21 0 W	30.	180.00	0.27 S	0.16 W	0.32	S 31 22 W	0.12
210.	0 11	S 5 0 E	30.	210.00	0.35 S	0.17 W	0.39	S 26 19 W	0.31
240.	0 6	N 61 0 W	30.	240.00	0.38 S	0.19 W	0.43	S 26 29 W	0.84
270.	0 10	S 11 0 E	30.	270.00	0.41 S	0.20 W	0.46	S 26 26 W	0.81
300.	0 3	S 42 0 E	30.	300.00	0.46 S	0.19 W	0.50	S 22 0 W	0.42
330.	0 8	S 81 0 W	30.	330.00	0.48 S	0.21 W	0.52	S 23 59 W	0.55
360.	0 2	S 45 0 E	30.	360.00	0.49 S	0.24 W	0.55	S 26 12 W	0.52
390.	0 7	S 30 0 E	30.	390.00	0.52 S	0.22 W	0.57	S 22 48 W	0.28
420.	0 1	N 28 0 E	30.	420.00	0.55 S	0.20 W	0.58	S 20 22 W	0.42
450.	0 2	S 69 0 E	30.	450.00	0.55 S	0.19 W	0.58	S 19 27 W	0.12
480.	0 1	S 33 0 W	30.	480.00	0.55 S	0.19 W	0.58	S 18 41 W	0.13
510.	0 5	N 39 0 W	30.	510.00	0.54 S	0.20 W	0.58	S 20 38 W	0.30
540.	0 9	N 76 0 W	30.	540.00	0.51 S	0.25 W	0.57	S 26 26 W	0.32
570.	0 8	S 73 0 E	30.	570.00	0.51 S	0.26 W	0.57	S 26 49 W	0.94
600.	0 10	S 17 0 W	30.	600.00	0.57 S	0.24 W	0.61	S 22 55 W	0.71
630.	0 5	N 89 0 W	30.	630.00	0.61 S	0.27 W	0.67	S 24 16 W	0.55
660.	0 9	N 2 0 E	30.	660.00	0.57 S	0.29 W	0.64	S 27 24 W	0.58
690.	0 4	S 74 0 W	30.	690.00	0.53 S	0.31 W	0.62	S 30 9 W	0.61
720.	0 4	S 21 0 W	30.	720.00	0.55 S	0.33 W	0.65	S 30 59 W	0.20
750.	0 1	N 62 0 E	30.	750.00	0.57 S	0.33 W	0.66	S 30 31 W	0.27
780.	0 6	N 74 0 W	30.	780.00	0.56 S	0.36 W	0.66	S 32 31 W	0.38
810.	0 4	S 33 0 W	30.	810.00	0.57 S	0.39 W	0.69	S 34 37 W	0.34
840.	0 8	S 14 0 W	30.	840.00	0.61 S	0.41 W	0.74	S 33 38 W	0.25
870.	0 3	S 32 0 W	30.	870.00	0.66 S	0.42 W	0.78	S 32 45 W	0.29

SAY PIPPINS
SPOSAL WELL NO. 3
OWARD COUNTY, FL.

TIME 01:05:25 DATE 30-SEP-82

MEASURED DEPTH FEET	DRIFT ANGLE D M	DRIFT DIRECTION D M	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	RECTANGULAR COORDINATES FEET		CLOSURE DISTANCE FEET	CLOSURE DIRECTION D M	DOGLEG SEVERITY DG/100FT
900.	0 3	S 50 0 W	30.	900.00	0.68 S	0.44 W	0.81	S 33 0 W	0.05
930.	0 4	S 41 0 W	30.	930.00	0.70 S	0.46 W	0.84	S 33 26 W	0.06
960.	0 2	S 6 0 E	30.	960.00	0.72 S	0.47 W	0.86	S 33 13 W	0.17
990.	0 2	N 25 0 E	30.	990.00	0.72 S	0.47 W	0.86	S 32 56 W	0.21
1020.	0 7	S 2 0 E	30.	1020.00	0.75 S	0.46 W	0.88	S 31 52 W	0.49
1050.	0 3	N 84 0 E	30.	1050.00	0.77 S	0.45 W	0.90	S 30 7 W	0.43
1080.	0 2	N 33 0 E	30.	1080.00	0.77 S	0.43 W	0.88	S 29 24 W	0.13
1110.	0 6	S 78 0 W	30.	1110.00	0.76 S	0.45 W	0.89	S 30 38 W	0.42
1140.	0 7	S 82 0 E	30.	1140.00	0.77 S	0.45 W	0.89	S 30 4 W	0.71
1170.	0 2	N 81 0 W	30.	1170.00	0.78 S	0.43 W	0.89	S 28 46 W	0.50
1200.	0 6	S 61 0 W	30.	1200.00	0.79 S	0.46 W	0.91	S 30 9 W	0.26
1230.	0 10	S 75 0 W	30.	1230.00	0.81 S	0.52 W	0.97	S 32 47 W	0.25
1260.	0 11	S 41 0 W	30.	1260.00	0.86 S	0.60 W	1.05	S 34 45 W	0.35
1290.	0 6	N 10 0 E	30.	1290.00	0.87 S	0.62 W	1.07	S 35 37 W	0.91
1320.	0 1	N 81 0 E	30.	1320.00	0.84 S	0.61 W	1.04	S 36 5 W	0.32
1350.	0 9	S 66 0 W	30.	1350.00	0.86 S	0.65 W	1.07	S 36 57 W	0.55
1380.	0 15	S 49 0 W	30.	1380.00	0.92 S	0.73 W	1.17	S 38 33 W	0.38
1410.	0 9	N 55 0 W	30.	1410.00	0.94 S	0.81 W	1.24	S 40 55 W	0.86
1440.	0 4	S 82 0 W	30.	1440.00	0.92 S	0.86 W	1.26	S 43 13 W	0.37
1470.	0 5	S 52 0 E	30.	1470.00	0.93 S	0.86 W	1.27	S 42 43 W	0.46
1500.	0 11	S 43 0 W	30.	1500.00	0.98 S	0.88 W	1.32	S 41 47 W	0.69
1530.	0 4	N 18 0 W	30.	1530.00	1.00 S	0.92 W	1.36	S 42 28 W	0.74
1560.	0 7	S 12 0 W	30.	1560.00	1.01 S	0.93 W	1.37	S 42 27 W	0.59
1590.	0 6	S 12 0 E	30.	1590.00	1.07 S	0.93 W	1.42	S 40 58 W	0.16
1620.	0 9	N 78 0 W	30.	1620.00	1.09 S	0.96 W	1.45	S 41 30 W	0.70
1650.	0 7	S 4 0 E	30.	1650.00	1.11 S	1.00 W	1.49	S 41 58 W	0.71
1680.	0 5	N 25 0 E	30.	1680.00	1.12 S	0.99 W	1.49	S 41 28 W	0.65
1710.	0 10	S 83 0 W	30.	1710.00	1.11 S	1.02 W	1.50	S 42 43 W	0.74
1740.	0 5	N 19 0 W	30.	1740.00	1.09 S	1.07 W	1.53	S 44 29 W	0.57
1770.	0 9	S 53 0 W	30.	1770.00	1.09 S	1.11 W	1.56	S 45 25 W	0.64

A' IPP
POSAL WELL NO. 3
WARD COUNTY, FL.

JMP TIC AGE .

TIME DATE
01:05:25 30-SEP-82

MEASURED DEPTH FEET	DRIFT ANGLE D M	DRIFT DIRECTION D M	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	RECTANGULAR COORDINATES FEET		CLOSURE DISTANCE FEET	CLOSURE DIRECTION D M	DOGLEG SEVERITY DG/100FT
1800.	0 11	S 82 0 W	30.	1800.00	1.12 S	1.19 W	1.64	S 46 36 W	0.30
1830.	0 17	N 72 0 W	30.	1830.00	1.11 S	1.31 W	1.71	S 49 43 W	0.48
1860.	0 21	S 75 0 W	30.	1860.00	1.11 S	1.47 W	1.84	S 52 54 W	0.64
1890.	0 8	N 74 0 W	30.	1890.00	1.12 S	1.59 W	1.94	S 54 45 W	0.82
1920.	0 7	N 50 0 W	30.	1920.00	1.09 S	1.64 W	1.97	S 56 23 W	0.18
1950.	0 4	S 79 0 W	30.	1950.00	1.08 S	1.69 W	2.00	S 57 25 W	0.30
1980.	0 3	N 73 0 W	30.	1980.00	1.08 S	1.71 W	2.02	S 57 53 W	0.11
2010.	0 3	N 76 0 W	30.	2010.00	1.07 S	1.74 W	2.04	S 58 26 W	0.01
2040.	0 9	N 76 0 W	30.	2040.00	1.06 S	1.79 W	2.08	S 59 27 W	0.33
2070.	0 5	N 83 0 W	30.	2070.00	1.04 S	1.85 W	2.13	S 60 34 W	0.23
2100.	0 4	S 71 0 W	30.	2100.00	1.05 S	1.89 W	2.16	S 60 59 W	0.12
2130.	0 5	S 70 0 W	30.	2130.00	1.06 S	1.93 W	2.20	S 61 9 W	0.06
2160.	0 7	N 49 0 W	30.	2160.00	1.05 S	1.97 W	2.23	S 61 59 W	0.35
2190.	0 7	S 76 0 W	30.	2190.00	1.04 S	2.02 W	2.27	S 62 53 W	0.36
2220.	0 9	S 67 0 W	30.	2220.00	1.06 S	2.09 W	2.34	S 63 7 W	0.13
2250.	0 12	N 83 0 W	30.	2250.00	1.07 S	2.18 W	2.42	S 63 53 W	0.34
2280.	0 9	S 61 0 W	30.	2280.00	1.08 S	2.26 W	2.51	S 64 29 W	0.39
2310.	0 7	N 72 0 W	30.	2310.00	1.09 S	2.33 W	2.57	S 64 54 W	0.37
2340.	0 9	N 89 0 W	30.	2340.00	1.08 S	2.39 W	2.63	S 65 44 W	0.17
2370.	0 10	S 78 0 W	30.	2370.00	1.09 S	2.48 W	2.70	S 66 17 W	0.13
2400.	0 11	S 56 0 W	30.	2399.99	1.12 S	2.56 W	2.79	S 66 17 W	0.23
2430.	0 16	S 70 0 W	30.	2429.99	1.17 S	2.66 W	2.91	S 66 13 W	0.33
2460.	0 9	N 50 0 W	30.	2459.99	1.17 S	2.76 W	3.00	S 66 58 W	0.77
2490.	0 10	S 71 0 W	30.	2489.99	1.16 S	2.83 W	3.06	S 67 41 W	0.52
2520.	0 13	N 73 0 W	30.	2519.99	1.16 S	2.93 W	3.15	S 68 23 W	0.43
2550.	0 11	S 48 0 W	30.	2549.99	1.18 S	3.02 W	3.24	S 68 43 W	0.66
2580.	0 12	N 89 0 W	30.	2579.99	1.21 S	3.10 W	3.33	S 68 46 W	0.47
2610.	0 15	N 90 0 W	30.	2609.99	1.21 S	3.22 W	3.44	S 69 29 W	0.17
2640.	0 16	S 76 0 W	30.	2639.99	1.22 S	3.36 W	3.57	S 69 59 W	0.22
2670.	0 14	S 51 0 W	30.	2669.99	1.28 S	3.47 W	3.70	S 69 47 W	0.38

AY PIPPINS
POSAL WELL NO. 3
WARD COUNTY, FL.

TIME 01:05:25 DATE 30-SEP-82

MEASURED DEPTH FEET	DRIFT ANGLE D M	DRIFT DIRECTION D M	COURSE LENGTH FEET	TRUE VERTICAL DEPTH FEET	RECTANGULAR COORDINATES FEET		CLOSURE DISTANCE FEET	CLOSURE DIRECTION D M	DOGLEG SEVERITY DG/100FT
2700.	0 15	S 63 0 W	30.	2699.99	1.35 S	3.58 W	3.82	S 69 23 W	0.18
2730.	0 18	S 82 0 W	30.	2729.99	1.39 S	3.71 W	3.96	S 69 31 W	0.34
2760.	0 26	S 78 0 W	30.	2759.99	1.42 S	3.90 W	4.15	S 69 59 W	0.45
2790.	0 27	S 48 0 W	30.	2789.99	1.52 S	4.10 W	4.37	S 69 37 W	0.76
2820.	0 30	S 65 0 W	30.	2819.99	1.66 S	4.31 W	4.61	S 68 57 W	0.50

FINAL CLOSURE - DIRECTION: S 68 DEGS 56 MINS 46 SECS W
DISTANCE: 4.61 FEET

Eastman Whipstock
A PETROLANE COMPANY

01:04:10 30-SEP-82

AY PIPPINS
POSAL WELL NO. 3
WARD COUNTY, FL.
E 1-243
SEP-82
2-G-0017
OSCOPIC MULTI-SHOT
LINATION 2 WEST
LOFTON
STMAN WHIPSTOCK

PROBABILITY CALCULATIONS

EXPECTED VALUE :		VARIANCE :		COVARIANCE :	
EAST-WEST COORDINATE :	-4.3 FT.	EAST-WEST :	0.0	EW-NS :	-0.0
NORTH-SOUTH COORDINATE:	-1.7 FT.	NORTH-SOUTH :	0.0	EW-V :	0.0
VERTICAL COORDINATE :	2820.0 FT.	VERTICAL :	0.0	NS-V :	0.0

RESULTS ARE BASED ON THE FOLLOWING TOOLS:

0.0 TO 2820.0 TOOL NUMBER 3 = 5 DEGREE UNIT GYRO WITH TAC

IPSE OF UNCERTAINTY   V2.10   INJECTION WELL 3
FILE 0

```
                                        EAST-WEST
                    -10.       -8.       -6.       -4.       -2.       0.
                     +---------+---------+---------+---------+---------+
               6. +
                  -
                  -
                  -
                  -
               4. +
                  -
                  -
                  -
                  -
               2. +
                  -
                  -
                  -
                  -
RTH-SOUTH      0. +
                  -
                  -
                  -
                  -
              -2. +
                  -
                  -
                  -
                  -
              -4. +
                  -
                  -
                  -
                  -
              -6. +
                    -10.       -8.       -6.       -4.       -2.       0.
                     +---------+---------+---------+---------+---------+
```

OBABILITY IS 0.99 THAT BOTTOM-HOLE COORDINATES ARE WITHIN THIS ELLIPSE AND
AT TRUE VERTICAL DEPTH IS BETWEEN 2820.0 FT. AND 2820.0 FT.
NTER OF ELLIPSE IS   1.7 FT. SOUTH AND   4.3 FT. WEST AT A DEPTH OF 2820.0 FT.
JOR AXIS IS   1.1 FT. AND IS ROTATED 28. DEG CLOCKWISE FROM NORTH
NOR AXIS IS   1.1 FT. VERTICAL THICKNESS IS   0.0 FT.

RESULTS OF WATER ANALYSES

GEO TEC INC. 1602 CLARE AVENUE • WEST PALM BEACH, FL 33401 • 305/833-7280

MFORMA ANALYSIS REPORT

ALSAY-PIPPIN CORPORATION	CLIENT NAME AND ADDRESS
P O BOX 6650	
LAKE WORTH, FL 33460	
00255	SAMPLE NUMBER
5-17-83 CLIENT	DATE/TIME COLLECTED/BY
5-17-83	DATE/TIME RECEIVED
WELL # 1	LOCATION
	PURPOSE

PARAMETER	STORET #	DATE BY NBR	RESULT, mg/L
BOD(5)	00310	5-17 MR 46-363	2
CHLORIDE	00940	6-9 MS 48-246	20,078
COD	00340	6-2 MS 48-205	3364
COLOR	00081	5-19 MR 47-119	30 PCU
NITRATE NITROGEN	00630	6-6 JP 49-119	0.34
TKN NITROGEN	00625	5-26 JP 49-140	6.35
ODOR	00085	5-19 MR 47-128	1 T.O.N.
TOTAL PHOSPHORUS	00665	5-21 MR 47-128	0.08
pH	00400	5-19 MR 47-128	7.5
TOTAL NITROGEN			6.69
AMMONIA NITROGEN	00610	5-26 JP 49-140	<0.10
ORGANIC NITROGEN			6.35
NON FILTERABLE RESIDUE	00530	5-23 MS 48-228	37
SPECIFIC CONDUCTANCE	00095	6-8 MS 48-260	43,000 umho/c
TEMPERATURE	00010		11 C
TURBIDITY	00076	5-19 MR 47-128	3.9
SETTLEABLE SOLIDS	50086	5-19 BM	<1
OIL & GREASE	00556	6-8 JP 49-100	<1

GEO TEC INC. 1602 CLARE AVENUE • WEST PALM BEACH, FL 33401 • 305/833-7280

00225

FECAL COLIFORM MPN	5-17 JP 44-239	<2
TOTAL COLIFORM MPN	5-17 JP 44-239	<2

DATE 8-12-83 BY [signature]

EVERGLADES LABORATORIES INC. 1602 CLARE AVENUE • WEST PALM BEACH, FL 33401 • 305/833-4200

LAB ID 86109

PRIMARY ORGANICS

SAMPLE NO. 00255

ALSAY-PIPPIN

DATE REC'D 5-19-83

PROJECT NO. ______

DATE COLL 5-17-83

BY client TIME ______ LOCATION WELL # 1

DATE EXTRACTED 5-24-83 DATE OF ANALYSIS 6-23-83

	STORET NO.	METHOD CODE	MCL µg/L	FOUND µg/L	FOUND mg/L
ENDRIN	39390	1	0.2	<0.01	<0.00001
LINDANE	39782	1	4	<0.003	<0.000003
METHOXYCHLOR	39480	1	100	<0.07	<0.00007
TOXAPHENE	39400	1	5	<0.4	<0.0004
2,4-D		2	100	<0.03	<0.00003
2,4,5-TP	39760	2	10	<0.005	<0.000005

METHODS: 1. METHOD FOR ORGANOCHLORINE PESTICIDES IN INDUSTRIAL EFFLUENTS. EPA 1973

2. METHOD FOR CHLORINATED PHENOXY ACID HERBICIDES IN INDUSTRIAL EFFLUENTS, EPA 1973

3. METHOD 608, ORGANOCHLORINE PESTICIDES AND PCBs FEDERAL REGISTER VO. 44 DEC. 3, 1979

4. OTHER:

[signature] DATE 6-30-83

GEO TEC inc. 1602 CLARE AVENUE • WEST PALM BEACH, FL 33401 • 305/833-7280

MFORMA ANALYSIS REPORT

ALSAY-PIPPIN CORPORATION	CLIENT NAME AND ADDRESS
P O BOX 6650	
LAKE WORTH, FL 33460	
00148	SAMPLE NUMBER
5-11-83 CLIENT	DATE/TIME COLLECTED/BY
5-11-83	DATE/TIME RECEIVED
WELL # 2	LOCATION
	PURPOSE

PARAMETER	STORET #	DATE BY NBR	RESULT, mg/L
BOD(5)	00310	5-11 MR 46-360	1
CHLORIDE	00940	6-9 MS 48-246	17,174
COD	00340	6-2 MS 48-205	1418
COLOR	00081	5-11 LK	20
NITRATE NITROGEN	00630	6-6 JP 49-119	0.48
TKN NITROGEN	00625	5-26 JP 49-140	5.81
ODOR	00085	5-11 MR	1
TOTAL PHOSPHORUS	00665	5-22 MR 47-153	42.5
pH	00400	5-11 MR 47-117	7.5
TOTAL NITROGEN			6.29
AMMONIA NITROGEN	00610	5-26 JP 49-140	<0.10
ORGANIC NITROGEN			5.81
NON FILTERABLE RESIDUE	00530	5-18 MS 48-228	22
SPECIFIC CONDUCTANCE	00095	6-8 MS 48-260	43,500 umho/c
TEMPERATURE	00010		11 C
TURBIDITY	00076	5-11 MR 47-117	1.8
SETTLEABLE SOLIDS	50086	5-11 BM	<1
OIL & GREASE	00556	6-8 JP 49-100	<1

GEO TEC

GEO TEC inc. 1602 CLARE AVENUE • WEST PALM BEACH, FL 33401 • 305/833-7280

00148

FECAL COLIFORM MPN	5-11 JP 44-236	<2
TOTAL COLIFORM MPN	5-11 JP 44-236	<2

DATE 8-12-83 BY [signature]

EVERGLADES LABORATORIES INC. 1602 CLARE AVENUE • WEST PALM BEACH, FL 33401 • 305/833-4200

LAB ID 86109

PRIMARY ORGANICS

ALSAY-PIPPIN CORP
P O BOX 6650
LAKE WORTH, FL 33460

SAMPLE NO. 00148
DATE REC'D 5-11-83
PROJECT NO.
DATE COLL 5-11-83

BY client TIME LOCATION SAMPLE # 2

DATE EXTRACTED 5-11-83 DATE OF ANALYSIS 5-12-83

	STORET NO.	METHOD CODE	MCL µg/L	FOUND µg/L	FOUND mg/L
ENDRIN	39390	1	0.2	<0.009	<0.000009
LINDANE	39782	1	4	<0.002	<0.000002
METHOXYCHLOR	39480	1	100	<0.06	<0.00006
TOXAPHENE	39400	1	5	<0.38	<0.00038
2,4-D		2	100	<0.09	<0.00009
2,4,5-TP	39760	2	10	<0.02	<0.00002

METHODS:
1. METHOD FOR ORGANOCHLORINE PESTICIDES IN INDUSTRIAL EFFLUENTS. EPA 1973
2. METHOD FOR CHLORINATED PHENOXY ACID HERBICIDES IN INDUSTRIAL EFFLUENTS, EPA 1973
3. METHOD 608, ORGANOCHLORINE PESTICIDES AND PCBs FEDERAL REGISTER VO. 44 DEC. 3, 1979
4. OTHER:

DATE 6-2-83

GEO TEC INC. 1602 CLARE AVENUE • WEST PALM BEACH, FL 33401 • 305/833-7280

MFORMA ANALYSIS REPORT

ALSAY-PIPPIN CORPORATION	CLIENT NAME AND ADDRESS
P O BOX 6650	
LAKE WORTH, FL 33460	
00160	SAMPLE NUMBER
5-12-83 CLIENT	DATE/TIME COLLECTED/BY
5-12-83	DATE/TIME RECEIVED
WELL # 3	LOCATION
	PURPOSE

PARAMETER	STORET #	DATE BY NBR	RESULT, mg/L
BOD(5)	00310	5-18 MR 46-363	1
CHLORIDE	00940	6-9 MS 48-246	14,020
COD	00340	6-2 MS 48-205	1448
COLOR	00081	5-12 MR 47-119	20 PCU
NITRATE NITROGEN	00630	6-6 JP 49-119	0.31
TKN NITROGEN	00625	5-26 JP 49-141	8.43
ODOR	00085	5-12 MR 47-119	1 T.O.N.
TOTAL PHOSPHORUS	00665	5-19 MR 47-128	0.41
pH	00400	5-12 MR 47-119	7.5
TOTAL NITROGEN			8.74
AMMONIA NITROGEN	00610	5-26 JP 49-140	<0.10
ORGANIC NITROGEN			8.43
NON FILTERABLE RESIDUE	00530	5-17 MS 48-228	111
SPECIFIC CONDUCTANCE	00095	6-8 MS 48-260	46,000 umho/c
TEMPERATURE	00010		11 C
TURBIDITY	00076	5-12 MR 47-119	1.1
SETTLEABLE SOLIDS	50086	5-12 BM	<1
OIL & GREASE	00556	6-8 JP 49-100	<1

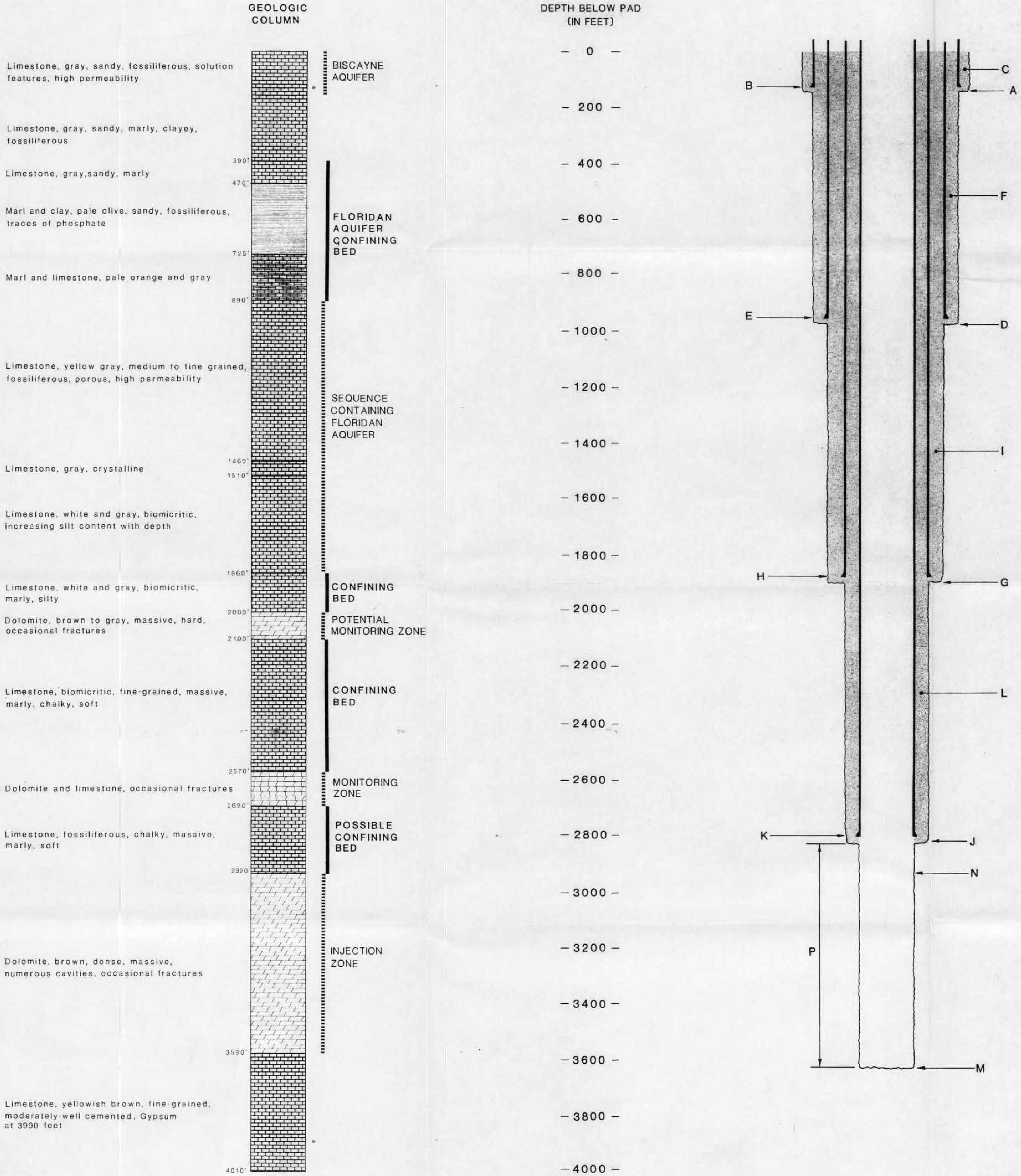
GEO TEC

GEO TEC INC. 1602 CLARE AVENUE · WEST PALM BEACH, FL 33401 · 305/833-7280

00.160 PAGE 2

FECAL COLIFORM MPN	5-13 JP 44-237	<2
TOTAL COLIFORM MPN	5-13 JP 44-237	<2

DATE 8-12-83 BY [signature]



CONSTRUCTION DETAILS

KEY	ITEM	UNIT	No. 1	No. 2	No. 3	No. 5
A	62" OPEN HOLE DEPTH	feet	128	127	129	125
B	54" CASING, 0.312" WALL	feet	126	126	126	125
C	CEMENT VOLUME	$feet^3$	1100	1100	1100	
D	52" OPEN HOLE DEPTH	feet	930	930	930	953
E	42" CASING, 0.375" WALL	feet	925	925	925	950
F	CEMENT VOLUME	$feet^3$	4317	4417	4888	
G	40.5" OPEN HOLE DEPTH	feet	1910	1910	1909	1970
H	34" CASING, 0.5" WALL	feet	1900	1900	1900	1896
I	CEMENT VOLUME	$feet^3$	6233	9513	7197	
J	32" OPEN HOLE DEPTH	feet	2820	2820	2819	2829
K	24" CASING, 0.5" WALL	feet	2800	2800	2800	2820
L	CEMENT VOLUME	$feet^3$	12,111	10,860	13,093	
M	TOTAL WELL DEPTH	feet	3520	3525	4010	3480
N	TOP OF INJECTION ZONE	feet	2915	2925	2914	2930
P	OPEN HOLE INTERVAL	feet	2800-3520	2800-3525	2800-4010	2820-3480
	CORED INTERVALS	feet	2110-2120 2180-2190 2290-2300	2405-2416 2470-2480 2589-2596	2148-2158 2230-2240 2360-2370	1605-1615 2038-2048 2540-2550 2650-2660 2750-2760 2796-2806 2850-2860 2900-2912 2950-2956

NOTES:

(1) Geologic column is based on Test Injection Well (No. 5) except for interval from 3480 feet to 4010 feet, which is based on Injection Well No. 3.

(2) Open-hole interval in Injection Well No. 3 has a 22-inch diameter from 2800 feet to 3500 feet, and a 17.5-inch diameter from 3500 feet to 4010 feet.

(3) Depth measurements referenced to pad datum (elevation '6 feet NGVD).

PREPARED FOR HAZEN AND SAWYER, P.C.		
TITLE GEOLOGIC LOG AND AS BUILT CONSTRUCTION DETAILS OF INJECTION WELLS 1, 2, 3 AND 5 GEORGE T. LOHMEYER WASTEWATER TREATMENT PLANT FORT LAUDERDALE, FLORIDA		
COMPILED BY P.JAKOB	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE 10/83
DRAWN BY P. SMITH		REVISED 1/84
CHECKED BY V. AMY	SCALE AS SHOWN	PLATE 1

PREPARED FOR

HAZEN AND SAWYER, P.C.

TITLE

CORRELATION OF THE DUAL INDUCTION LOGS OF INJECTION WELLS 1,2,3 AND 5

GEORGE T. LOHMEYER WASTEWATER TREATMENT PLANT FORT LAUDERDALE, FLORIDA

COMPILED BY P. JAKOB	Geraghty & Miller, Inc.	DATE	10/83
DRAWN BY P. SMITH	West Palm Beach, Florida	REVISED	1/84
CHECKED BY V. AMY	SCALE AS SHOWN		PLATE 2

PREPARED FOR

HAZEN AND SAWYER, P.C.

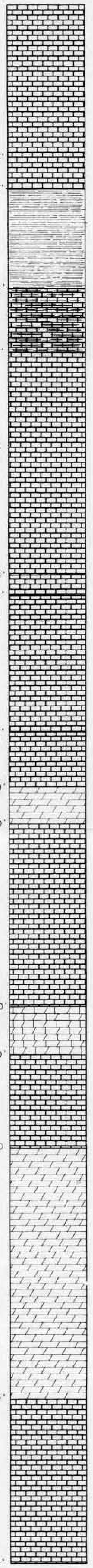
TITLE

GEOLOGIC AND SELECTED GEOPHYSICAL LOGS OF INJECTION WELL 3

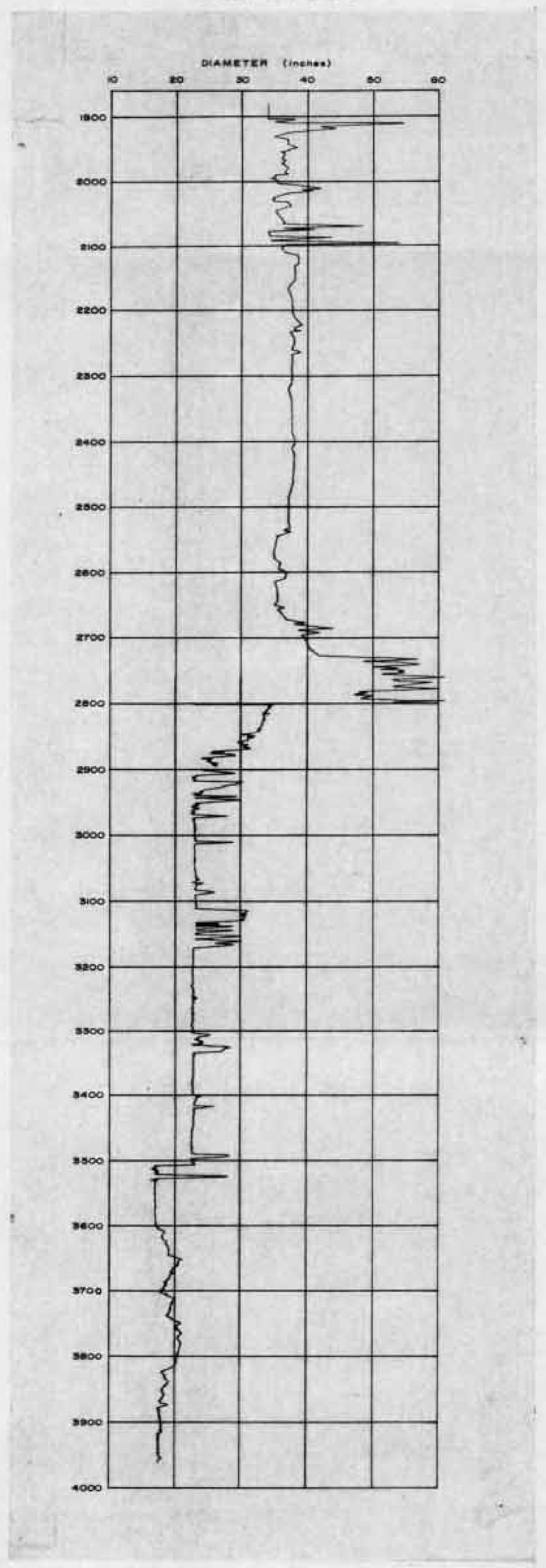
GEORGE T. LOHMEYER WASTEWATER TREATMENT PLANT FORT LAUDERDALE, FLORIDA

COMPILED BY P. JAKOB	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE 10/83
DRAWN BY P. SMITH		REVISED 1/84
CHECKED BY V. AMY	SCALE AS SHOWN	PLATE 3

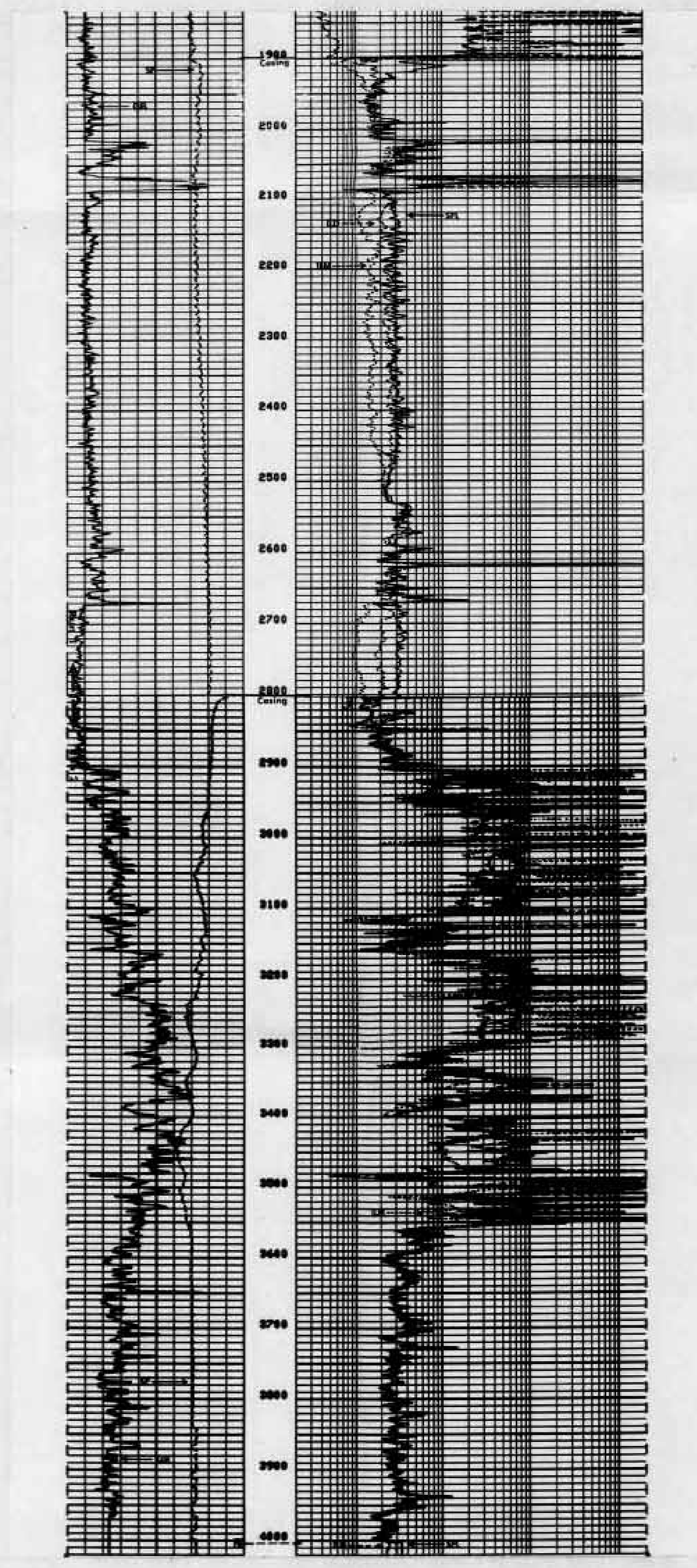
Limestone, gray, sandy, fossiliferous, solution features, high permeability		BISCAYNE AQUIFER
Limestone, gray, sandy, marly, clayey, fossiliferous	390'	
Limestone, gray, sandy, marly	470'	FLORIDAN AQUIFER CONFINING BED
Marl and clay, pale olive, sandy, fossiliferous, traces of phosphate	725'	
Marl and limestone, pale orange and gray	890'	
Limestone, yellow gray, medium to fine grained, fossiliferous, porous, high permeability	1460'	SEQUENCE CONTAINING FLORIDAN AQUIFER
Limestone, gray, crystalline	1510'	
Limestone, white and gray, biomicritic, increasing silt content with depth	1860'	
Limestone, white and gray, biomicritic, marly, silty	2000'	CONFINING BED
Dolomite, brown to gray, massive, hard, occasional fractures	2100'	POTENTIAL MONITORING ZONE
Limestone, biomicritic, fine-grained, massive, marly, chalky, soft	2570'	CONFINING BED
Dolomite and limestone, occasional fractures	2690'	MONITORING ZONE
Limestone, fossiliferous, chalky, massive, marly, soft	2920'	POSSIBLE CONFINING BED
Dolomite, brown, dense, massive, numerous cavities, occasional fractures	3580'	INJECTION ZONE
Limestone, yellowish brown, fine-grained, moderately-well cemented, Gypsum at 3990 feet	4010'	



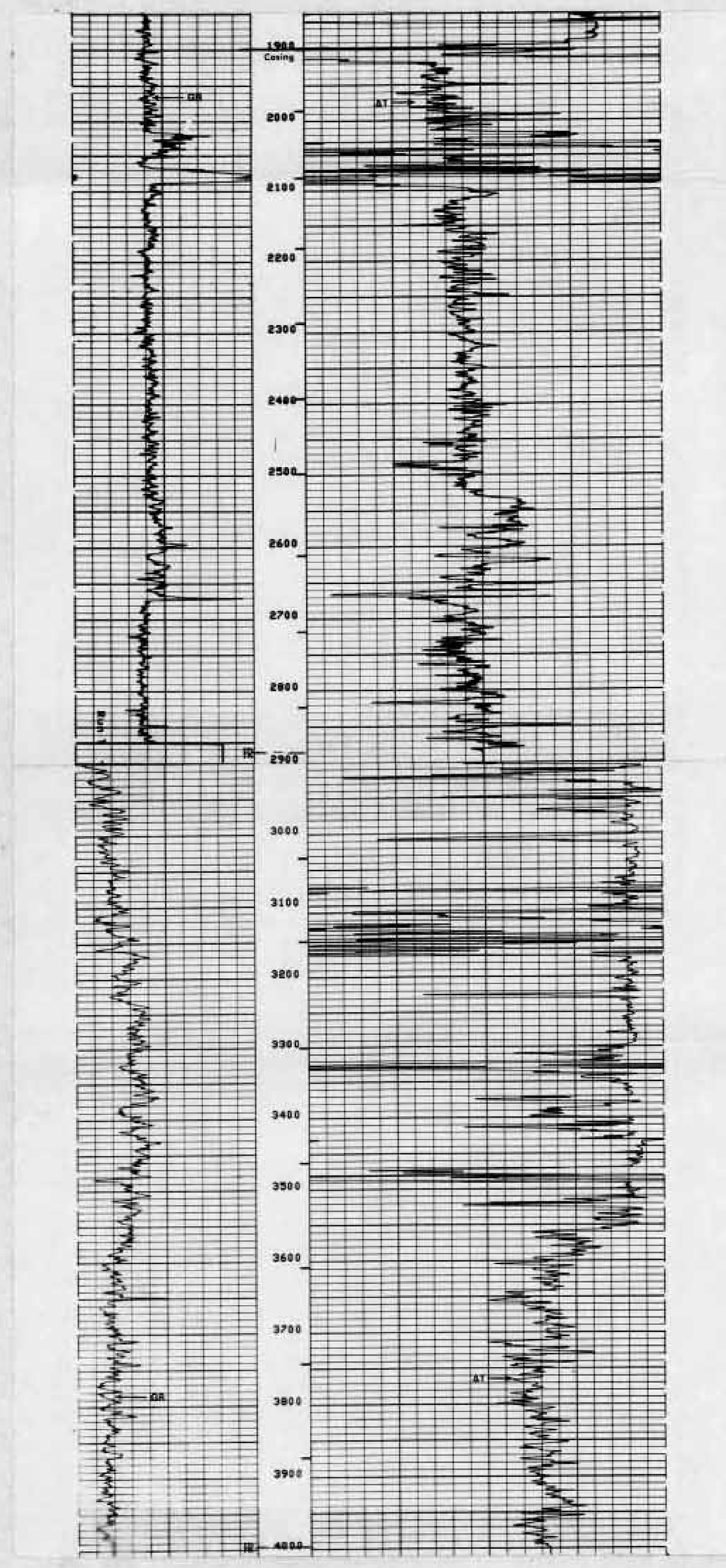
CALIPER LOG



DUAL INDUCTION LOG



BHC SONIC LOG



TEMPERATURE LOGS