Report For

MECHANICAL INTEGRITY TESTING OF MONITOR WELL MW-1

Prepared for the

City of Fort Lauderdale
Broward County, Florida

Prepared by

CH2M HILL

March 1993
SEF32544.03

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CH2M HILL
Engineers
Planners
Economists
Scientists

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WEST PALM BEACH

March 5, 1993

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Mr. Al Mueller, Jr., P.G., P.E.
TAC Chairman
Florida Department of
Environmental Regulation
1900 South Congress Avenue, Suite A
West Palm Beach, FL 33406-0160

Dear Al:

Subject: City of Fort Lauderdale Monitor Well Investigation
Consent Order No. 91-2455 Paragraphs 24 and 26b.

Attached is our report of the mechanical integrity testing of the City of Fort Lauderdale MW-1. This submittal is made in accordance with Paragraph 24 of the Consent Order and completes the City's responsibilities under that item.

Through the provision of a proposed plan of corrective action to address the deficiencies discovered during the investigation this submittal also partially satisfies the requirements of Paragraph 26b. It is the intent of the City that these actions be carried out on a priority basis in conjunction with the installation of the new Monitor Well MW-2. A fully detailed plan for corrective actions and a timetable for those actions will be prepared after acceptance of this report by FDER and members of the TAC.

Sincerely,

CH2M HILL

Thomas M. McCormick

Thomas M. McCormick
Senior Hydrogeologist

pk/1001228E.DFB
cc: Greg Kisela/Fort Lauderdale
Frank Coulter/Fort Lauderdale
Sean Skehan/CH2M HILL

Mechanical Integrity Testing Report of Monitor Well MW-1 at the George T. Lohmeyer Wastewater Treatment Plant

Prepared for the

City of Fort Lauderdale
Broward County, Florida

In Accordance With the Requirements of
Paragraph 24
Consent Order No. 91-2455

Prepared by

CH2M HILL SOUTHEAST, INC.
Deerfield Beach, Florida

March 1993
SEF32544.03

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Executive Summary

The City of Fort Lauderdale, Florida, operates a deep injection well (DIW) system at the George T. Lohmeyer Waste Water Treatment Plant (WWTP) to dispose of secondary-treated municipal effluent. A location map and a site map of the DIW system layout are presented in Figures 1 and 2, respectively. The system consists of four injection wells (IW-1, IW-2, IW-3, IW-5) and a multi-zone deep monitor well (MW-1). Each injection well is cased with a nominal 24-inch-diameter steel casing to an approximate depth of 2,800 feet below pad level (bpl). Each well is completed with open-hole construction to a depth of approximately 3,500 feet bpl. The injection zone, locally known as the "Boulder Zone", is a highly transmissive zone in the Floridan aquifer system capable of receiving large effluent flows.

Water quality data from MW-1 has indicated a freshening trend (i.e., decreasing chloride, conductivity, and total dissolved solids (TDS) concentrations) in the middle and lower monitor zones. Increasing concentrations of total kjeldahl nitrogen (TKN) and ammonia-nitrogen are also observed in these monitor zones. Water quality parameters from the upper monitoring zone have been stable throughout the monitoring period. Graphs of historical monitoring data from the three monitoring zones are presented in Appendix A.

It is difficult to determine the exact time that the apparent freshening trend began, but chloride and TDS concentrations in the middle zone began declining almost immediately during operational testing in 1985. The Florida Department of Environmental Regulation (FDER) has expressed concern that these trends may indicate migration of effluent from the injection zone upward to monitor intervals within the upper Floridan aquifer system. In accordance with procedures set forth in Chapter 17-28, Florida Administrative Code (FAC) and the operating permit conditions, mechanical integrity tests (MITs) were conducted by CH2M HILL (1991) on the four injection wells. The results of those tests demonstrated that the injection well casings and cement seals met regulatory standards for mechanical integrity.

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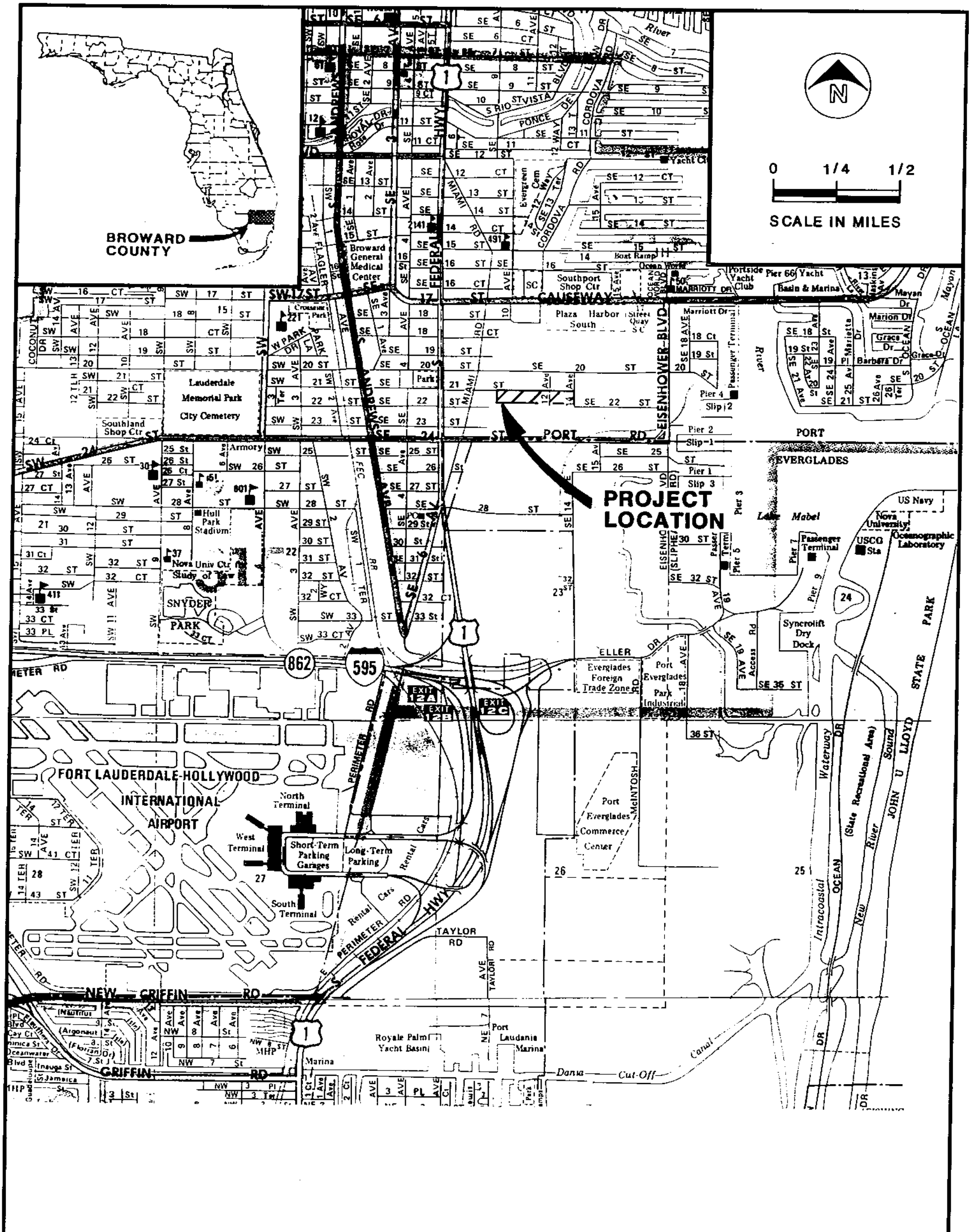

FIGURE 1

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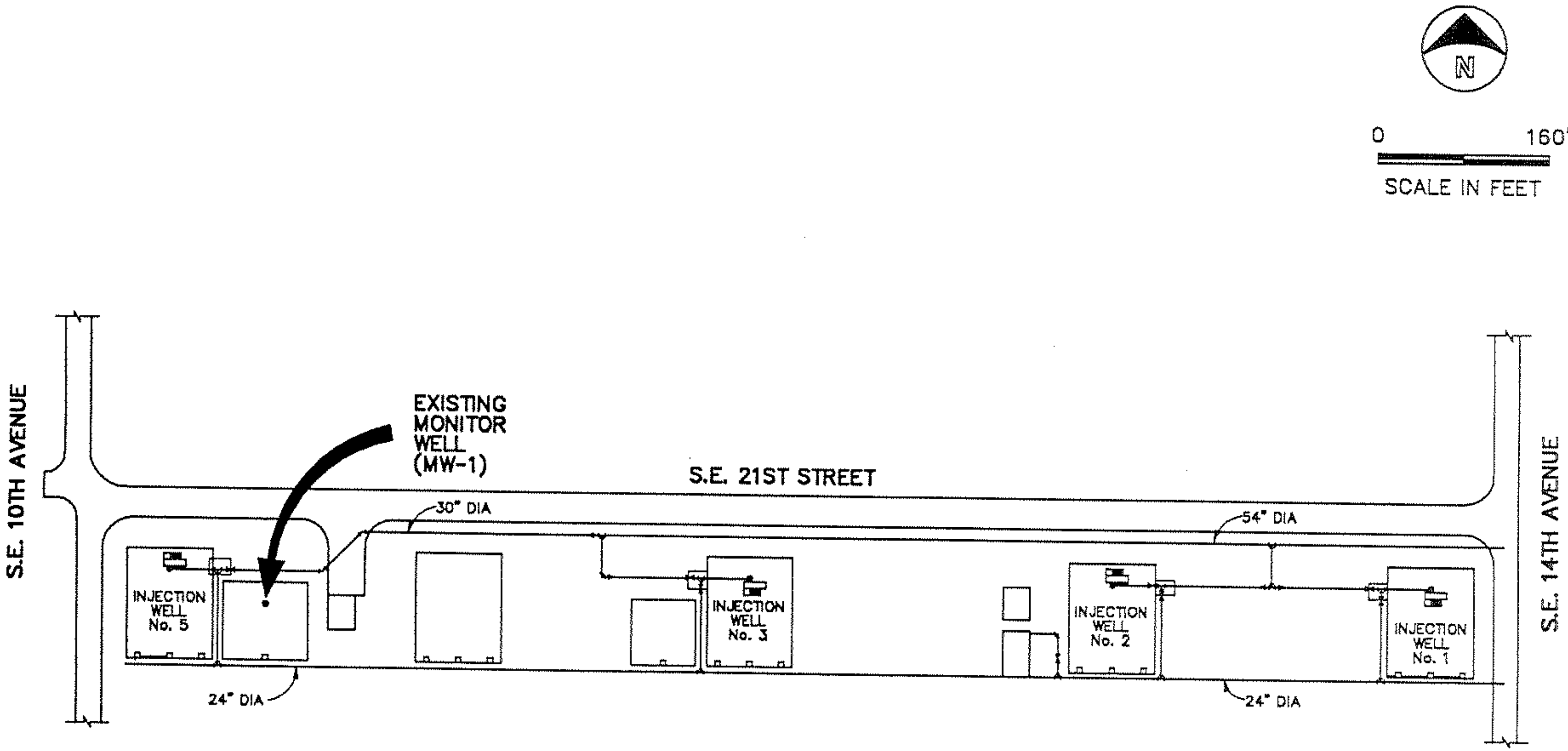

NOTE:

1. SITE PLAN GENERATED FROM AS-BUILT DRAWINGS PREPARED BY HAZEN AND SAWYER, JANUARY 20, 1982.

FIGURE 2
SITE MAP

CH2M HILL

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The City of Fort Lauderdale and FDER entered into a Consent Order (No. 91-2455), dated April 27, 1992, to take steps to determine the cause of the apparent freshening trend in monitor well and establish whether effluent from the injection zone is indeed migrating vertically upward into the upper Floridan aquifer system, which is classified as an underground source of drinking water (USDW).

The results of mechanical integrity testing of the injection wells (CH2M HILL, 1991) suggested that the injection wells were not the cause of the apparent freshening trend. Therefore, it was proposed that mechanical integrity testing be conducted on Monitor Well MW-1 to evaluate the condition of the deep monitor tube, and to determine whether tubing or cement seal failure on the monitor well might be the cause of the observed monitoring trends.

In accordance with the requirements of Paragraph 21 of the Consent Order, a Mechanical Integrity Testing Plan was prepared and submitted to FDER. On July 16, 1992, FDER approved the proposed plan and testing of the Monitor Well commenced. These investigations were concluded on February 5, 1993, and have shown that the Monitor Well MW-1 does not demonstrate mechanical integrity and that leaks exist in the tubing at both the middle and upper monitoring intervals.

This submittal is provided in compliance with the requirements of Paragraph 24 of the Consent Order, and provides a summary of the investigations conducted and the Engineer's proposed corrective actions.

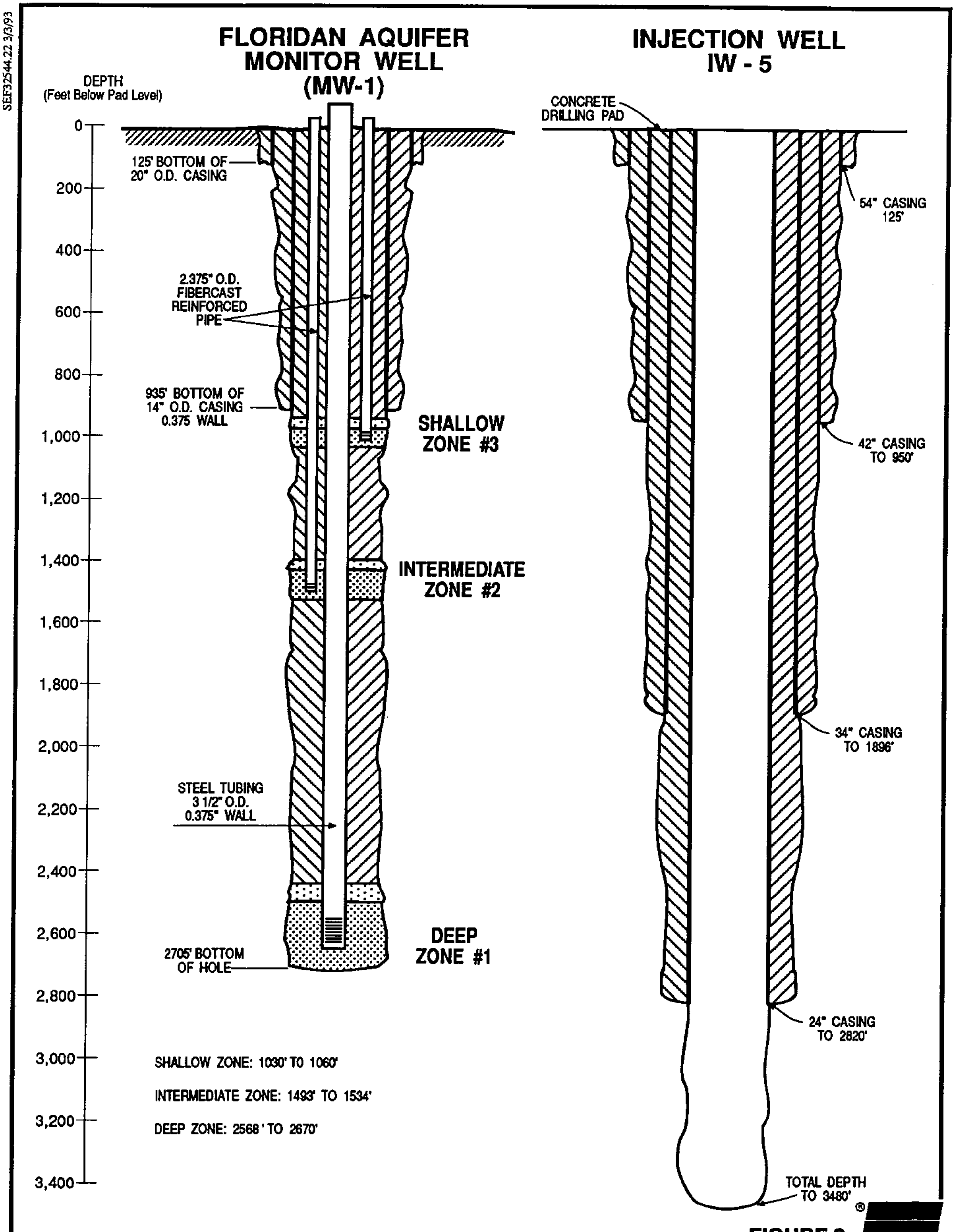
Historical Evaluation of MW-1 Construction

MW-1 was constructed as part of the first effluent disposal well (IW-5) system designed by Hazen and Sawyer Inc., and Geraghty and Miller Inc., for the City of Fort Lauderdale in 1981. Alsay-Pippin Corporation of Lake Worth, Florida, was awarded the contract to perform work, and began actual well drilling on November 7, 1980. MW-1 was constructed with three separate monitor tubes to sample water from different zones within the Floridan aquifer system. These zones are the shallow zone (1,030 to 1,060 feet bpl), the intermediate zone (1,493 to 1,534 feet bpl) and the deep zone (2,568 to 2,670 feet bpl). A fourth potential monitor zone—a dolomite interval at a depth of approximately 2,100 feet bpl—was also delineated with geophysical logging by Geraghty & Miller (1981), but was not constructed.

The shallow and intermediate monitors are reported to be constructed of fibercast reinforced pipe and well screen with an outside diameter of 2.375 inches. The deep zone is reported to be constructed with 3.5-inch-outside-diameter steel pipe attached to a fibercast screen. Each of the three monitor zones was completed with gravel pack material and then cemented to surface. Construction details of IW-5 and MW-1 are presented in Figure 3.

A cement bond log (CBL) was conducted on the deep monitor tube by Schlumberger Well Services at MW-1 (Geraghty & Miller, 1981). The CBL is a geophysical log used to indicate the presence of cement around the casing and the strength of the bond between the casing and the cement. Geraghty & Miller (1981) report that an effective cement seal around the 3.5-inch-outside-diameter tubing was obtained at MW-1. They do report, however, that "low and high amplitude signals as well as some pipe signal can be seen" between 1,950 and 2,200 feet, which could indicate an incomplete cement seal. The depth of this poor cement seal corresponds to the fourth potential monitor zone delineated by Geraghty & Miller (1981). They state that good bonding (low amplitude signal) occurred from 1,826 to 1,950 feet and below 2,200 feet, thereby sealing off the 1,950 to 2,200-foot zone. A combination of low and high amplitude signals was observed from a depth of 1,822 feet to the bottom of the gravel pack of the intermediate monitor zone. The CBL also delineated three areas of high amplitude signals that correspond to the depths of the uncemented screened intervals.

Geraghty & Miller (1981) also reported that certain problems occurred during construction at IW-5. In particular, directional surveys of the 42-inch-diameter reamed


FLORIDAN AQUIFER
MONITOR WELL
(MW-1)
INJECTION WELL
IW - 5
DEPTH
(Feet Below Pad Level)
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
2,600
2,800
3,000
3,200
3,400
125' BOTTOM OF
20" O.D. CASING
2.375" O.D.
FIBERCAST
REINFORCED
PIPE
935' BOTTOM OF
14" O.D. CASING
0.375 WALL
SHALLOW
ZONE #3
INTERMEDIATE
ZONE #2
STEEL TUBING
3 1/2" O.D.
0.375" WALL
DEEP
ZONE #1
2705' BOTTOM
OF HOLE
SHALLOW ZONE: 1030' TO 1060'
INTERMEDIATE ZONE: 1493' TO 1534'
DEEP ZONE: 2568' TO 2670'
CONCRETE
DRILLING PAD
54" CASING
125'
42" CASING
TO 950'
34" CASING
TO 1896'
24" CASING
TO 2820'
TOTAL DEPTH
TO 3480'

and pilot holes indicated that the boreholes were parallel, but were apart from each other. Reaming of the 42-inch-diameter hole was planned to facilitate installation of the 34-inch-diameter casing. Ultimately, the 34-inch-diameter casing was set to 1,896 feet bpl, shallower than planned because of this borehole deviation. The remainder of the 42-inch-diameter reamed hole below the bottom of the casing was filled with gravel and topped with a cement plug to prevent cement loss during casing cementing operations. Following installation of the 34-inch casing, the cement plug and gravel were drilled out and IW-5 construction completed.

Preliminary Investigation

CH2M HILL conducted preliminary logging at MW-1 to obtain some indication of the condition of MW-1. A caliper log of the deep monitor tube was run at MW-1 on August 30, 1991. A weight section was first lowered into the well to confirm access to the well's total depth. The tool would not go below 2,373 feet bpl. The caliper log also confirmed a maximum logging depth of 2,373 feet bpl. The total depth from the record drawing of MW-1 is reported to be 2,670 feet bpl (Geraghty & Miller, 1981). The caliper log showed a gradual decrease in inside diameter (from approximately 2.9 to 2.6 inches) throughout the log, and was less than 2.5 inches from 2,260 to 2,275 feet bpl.

A downhole video survey of MW-1 was conducted on September 23, 1991. A description of the video is provided in Appendix B. Throughout the length of the casing to 2,259 feet bpl, what appeared to be hard concretions were observed on the inside of the casing. At 2,259 feet bpl, build-up of these concretions prevented the camera from proceeding further down the well. The casing also appeared heavily corroded and at some intervals below 2,000 feet bpl, it appeared that the casing might be absent. Results of this log indicated that logging tools greater than approximately 1.5 inches in diameter would not fit down the casing.

A temperature log was conducted at MW-1 by CH2M HILL on October 6, 1991, to determine if any leaks were evident in the casing. This survey indicted a relatively gradual decrease in temperature from 64.5°F to 63.5°F from the top of the casing to 1,000 feet bpl. Between 1,000 feet and 1,500 feet bpl, inflections in the temperature log occur at depths of 1,025 and 1,475 feet bpl, corresponding closely to the depths of the shallow and intermediate monitoring intervals, respectively, of MW-1. Below 1,500 feet bpl, the temperature log shows a relatively constant temperature of 62.1°F to a depth of 2,371 feet bpl, where the tool was obstructed from proceeding further downward.

Further investigation of the monitor well was halted at the request of FDER until completion of consent order negotiations.

Mechanical Integrity Testing

In general the monitor well MIT Plan was divided into three phases of work which included conducting geophysical logs in each of the phases, collecting depth samples from inside the deep monitor tube, analyzing the samples to determine distinctive water quality characteristics, cleaning the monitor tube and performing hydraulic testing.

After analyzing the first suite of geophysical logs and the water quality analyses, it was determined that attempts to clean the deep monitor zone tube would potentially damage the existing integrity of the tubing. This would have made it more difficult to understand and evaluate the existing conditions of the well. As a result, the MIT Plan was modified to conduct as much testing as possible prior to physically disrupting the condition of the deep monitor tubing.

On July 16, 1992, the City of Fort Lauderdale was notified by FDER that the Plan for Mechanical Integrity Testing of Monitor Well MW-1 was approved. As required by paragraph 23 of the Consent Order, CH2M HILL initiated mechanical integrity testing of the monitor well within 45 days of the plan approval. Specific testing techniques that were implemented include the following:

- Geophysical logging—temperature, fluid resistivity
- Depth Sample Water Analyses (General and Isotopic)
- Hydraulic Testing
- Packerless Pressure Testing
- Corrosion Testing

In accordance with paragraph 24 of the consent order the results of testing were to be presented to FDER 30 days after the completion of testing (February 5, 1993). The results of that testing are hereby presented to FDER and members of the technical advisory committee (TAC).

Borehole Geophysics

Investigation and testing commenced with geophysical logging surveys of MW-1. The geophysical logs included temperature, fluid resistivity and the collection of depth samples.

The objective of the geophysical logging was to evaluate differences in temperature and water quality under different conditions within the 3.5-inch-diameter deep zone monitor tube. These conditions included logging the tube while flowing; while static after flowing; while static after a shut-in period; and under variable pumping conditions of the three monitor zones. Table 1 summarizes the different conditions of the monitor zones during each log conducted. The results of each log conducted is discussed below.

On August 21, 1992, temperature logs were conducted under both static and flowing conditions. The static logs were conducted after each of the monitor zones had been isolated and their respective pumps turned off for a 12 hour period prior to logging. In order to minimize the disturbance of the static water column, the first log was conducted

Table 1
Summary of Geophysical Logs Conducted on the Deep Monitor Zone During MW-1 Mechanical Integrity Testing

Date	Type of Log	Interval Logged (feet)	Comments
8/21/92	TEMP	99-2,374	All zones closed off. Well static for 12 hours. First day of log.
8/21/92	TEMP	902-2,376	All zones open and pumping. Well flowing at approximately 40 gpm. Second log of day.
9/3/92	FR	99-2,258	All zones closed off. Well static for 60 hours. First day of log.
9/3/92	FR	1,002-2,260	Deep zone open and pumping. Middle and upper zones closed off. Well flowing at approximately 40 gpm.
9/3/92	FR	1,002-2,258	Middle zone open and pumping. Deep and upper zones closed off. Well flowing at approximately 23 gpm.
9/4/92	FR	999-2,259	All zones closed off. Well static for 12 hours. First day of log.
9/4/92	FR	1,002-2,261	All zones open and pumping. Well flowing at approximately 40 gpm. Second log of day.
10/7/92	FR	0-2,261	All zones closed off. Well static for 7 days. First log of day.
10/7/92	TEMP	899-2,376	All zones closed off. Well static for 7 days. Second log of day.
12/3/92	FR	1,901-2,261	Packerless pressure test with 1,000 gallons of potable water.
12/4/92	FR	1-2,261	Packerless pressure test with 1,000 gallons of potable water.

FR = Fluid Resistivity
TEMP = Temperature

while lowering the tool into the well. The resulting log indicated three significant shifts occurring at depths of approximately 1,000 to 1,075 feet, 1,430 to 1,530 feet and 2,000 to 2,250 feet bpl. Both the first and second shifts correspond to the upper and intermediate monitor zones, respectively. These shifts could be explained as heat exchange taking place in the more conductive monitor intervals where the formation waters are in direct contact with the metal of the monitor tube. However, the lower shift does not correspond to any monitor zone and occurs in an interval that should be fully cemented. A possible explanation of this shift is the direct contact of formation water to the deep zone tubing in a poorly cemented interval and or a hole in the tubing allowing mixing with formation waters to occur.

A second temperature log was conducted on 8/21/92 with each of the monitor zone pumps turned on and valves fully opened. The approximate flow rate from the lower monitor zone was 40 gallons per minute (gpm), which equates to an approximate flow rate in the tube of 4.9 feet per second (fps). This log, conducted while logging up out of the well indicated only two significant shifts in temperature. The first shift corresponded to the intermediate monitor zone and the second to the shallow monitor zone. The fact that the lower shift observed under static conditions was not present under pumped conditions tends to support the conclusion that the tube is intact but poorly cemented at that depth. Water from the more productive deep zone would be moving too quickly to experience much heat transfer. The temperature shifts at the other two monitor intervals seemed strongly indicative of tubing failures.

On September 3, 1992, three fluid resistivity logs were conducted. The first log was conducted with the well static for 60 hours prior to the logging event. A stand pipe was not used during this run and the well was allowed to flow for a short period during the tool installation. Once the tool was in the well, the flow was stopped by use of a packoff. This log was conducted on the down run in order to minimize water column disturbance. The resulting log showed no major shifts; however, there was a slight decrease in water quality at approximately 1,920 feet bpl and another at approximately 2,030 feet. There were also two other minor shifts of water quality that were associated with the shallow and the intermediate monitor zones. These findings correspond with the static temperature log conducted on August 21, 1992.

A second log was conducted while logging out of the well with the deep monitor zone pump on and valve open while the shallow and intermediate zones valves were closed and their pumps turned off. The approximate flow rate of the well was 40 gpm. The resulting log had only one minor shift in evidence between 1,950 and 2,150 feet bpl. The water quality at these depths was slightly more saline than the water column above. If leaks were present above the 1,950-foot depth, the blending of the water from the deep monitor zone with the water column above accounts for there being no shifts at either the intermediate or shallow monitor zones.

A third log was conducted, with the intermediate monitor zone valve opened and its pump turned on. The shallow and deep monitor zones valves were closed and their pumps turned off. The approximate flow rate of the well was 23 gpm. The resulting log, conducted on the up run, showed two minor shifts in water quality. The first occurred at 1,750 feet bpl and showed a freshening in the water quality. The second shift occurred at 1,575 feet bpl and indicated a decline in the water quality. The shift at 1,750 feet bpl is consistent with the shifts shown in the first two fluid resistivity logs run, which show a general trend toward freshening of water quality at the lower depths of the well. The second shift towards lower water quality seen at 1,575 feet can be related to the intermediate monitor zone, if you assume a hole in the tube and the fact that it is pumping.

On September 4, 1992, two additional fluid resistivity logs were conducted. The first log was run under static conditions after the well had been shut-in for 12 hours. The log was run on the down run and the flow of the well during tool installation was minimized in order to reduce the disturbance of the water column in the well. The resulting log confirmed the shifts seen on the September 3, 1992 static log. There was a noticeable shift in water quality between the depths of 1,875 and 2,100 feet bpl. The second log conducted was on the up run and the well was flowing with each monitor zone open and their pumps on. The approximate flow rate from the deep monitor zone was 40 gpm. The resulting log showed a general freshening trend throughout the entire log. This appear to be due to the blending of water from all monitor zones.

On October 7, 1992, two fluid resistivity logs were conducted on the well, which was left shut in and undisturbed for 7 days prior to the logging event. Undisturbed static conditions were maintained in the well by using a standpipe, valve, and packoff for tool installation. The first log of this series was a fluid resistivity log run while lowering the tool into the well. The resulting log indicated three shifts in water quality occurring between 900 to 1,110 feet, 1,375 to 1,560 feet, and 2,050 to 2,120 feet bpl. The first two shifts correlate to the depths of the shallow and intermediate monitor zones and are consistent with shifts observed on previous logs. The second log conducted was a temperature log and was also conducted while logging into the well from a depth of 900 feet bpl. The resulting log identified three significant shifts in water temperature. The first two shifts were from 900 to 1,075 feet and 1,350 to 1,550 feet bpl and correspond to the shallow and intermediate monitor zones. The third shift occurred approximately between 2,000 feet and 2,250 feet bpl. This shift is consistent with the static temperature log conducted on August 21, 1992, and with water quality shifts observed on the fluid resistivity logs.

The final logging event took place from 12/2 through 12/4/92 in conjunction with a packerless pressure test. This log is described in the section discussing the packerless pressure test. Copies of each logging run are presented in Appendix F.

The geophysical logs were recorded digitally on a computer hard drive and then downloaded on to a floppy diskette. A Century Geophysical Compu-Log II logging unit was used during this investigation. The log scales were selected to maximize the response curves. Temperature log were recorded in Degrees Fahrenheit (F); and Fluid Resistivity logs in OHM-M.

As part of the QA/QC program, the logging tools were calibrated within a range anticipated for the logging survey. The following are the calibration procedures used for this survey:

1. Temperature—calibrated before each logging event using water baths of known values. The range used for this survey was 10 degrees Celsius to 35 degrees Celsius.

2. Fluid Resistivity—calibrated before each logging event using water baths of known values. The ranges used for this survey were from 0.1 OHM-M to 10 OHM-M for the logs conducted before 12/3/92 and from 0.1 OHM-M to 50 OHM-M for the logs conducted on 12/3 and 12/4/92.

Water Quality Analyses

Depth samples were collected from the deep monitor well under static conditions while using a pack-off to contain flow. Sample depths of 1,350, 1,950 and 2,225 feet bpl were selected on the basis of temperature and water quality data obtained from the geophysical logs. Because the depth sampler's capacity was limited to one liter, multiple runs were necessary to complete sample collection from the selected depths. Data from the analyses (general, solids, metals, anions, nutrients and isotopes) conducted on each of the samples is presented in Table 2, with actual laboratory data presented in Appendix B.

A comparison of the analytical results from each depth sample indicates a significant difference in concentrations of certain parameters between the upper sample (1,300 feet) and the two lower samples (1,950 and 2,225 feet). Of particular interest are the differences observed in conductivity, total dissolved solids, sodium and sulfate. Other differences, although not as significant, are observed in the results for calcium, magnesium, and potassium.

Table 2 Analytical Results of Depth Samples Collected Inside the Deep Monitor Tube at the City of Ft. Lauderdale Injection Monitor Well			
Analytical Parameter	**Depth 1,300 feet**	**Depth 1,950 feet**	**Depth 2,225 feet**
General			
pH (Units)	8.25	8.40	8.30
Conductivity (umhos/cm)	19,500	28,000	29,300
Alkalinity	96	94	198
Bicarbonate (as HC03)	117	93	188
Carbonate (as C03=)	<1.0	11	26
Solids			
Total Dissolved Solids	11,920	18,900	20,600
Metals			
Calcium	121	268	291
Iron	53.0	824	47.2
Magnesium	325	584	654
Potassium	155	222	227
Sodium	3,540	5,360	5,520
Anions			
Chloride	670	660	690
Sulfate	680	1,200	1,580
Nutrients			
Ammonia (as N)	6.13	6.19	5.42
Nitrite (as N)	<0.02	<0.02	<0.02
Nitrate & Nitrite (as N)	<0.02	<0.02	<0.02
Kjeldahl Nitrogen (as N)	6.69	6.63	5.60

Isotopic analyses from each of the sample depths were also conducted for oxygen and deuterium. The results (as presented in Appendix C) indicate insignificant differences in the isotopic values between the different depths.

It is evident from these results that under static conditions water quality within the tube is being affected by water leaking into the deep monitor tube from different depths. Such differences in water quality would not be anticipated if the water within this tube originated from one source.

Hydraulic Testing

Two pumping tests were performed at the monitor well on October 19 and 20, 1992. The purpose of the tests was to hydraulically stress the deep zone casing while monitoring pressure changes in the intermediate and shallow zone casings. Communication of hydraulic stresses from the deep zone casing to other zones may indicate unwanted breaches in the casing.

As shown in Figure 4, pressures were recorded at the intermediate and shallow zone tubings before, during, and after the pumping tests. Over a 5-day period, background data shows that daily pressure fluctuations in these zones is dominated by tidal effects. Because of the expanded time scale (days), it is difficult to distinguish the effects of the pumping tests on the intermediate and shallow zones. When the time scale is magnified (hours), the results from both pumping tests showed communication of the hydraulic stress on the deep zone casing to the intermediate and shallow zone casings.

The pumping tests were performed by using two centrifugal pumps, each with about 20 feet of suction hose inserted into the deep zone tubing. Each pump was able to remove about 20 gpm, (40 gpm total), from the deep monitor zone tubing. Prior to pumping the deep zone the background pressure in the deep zone tubing was 21.4 psi at 3 feet above the concrete pad level (46 feet of water above pad level). While pumping 40 gpm from the deep zone casing, the water level dropped to 10 feet below pad level.

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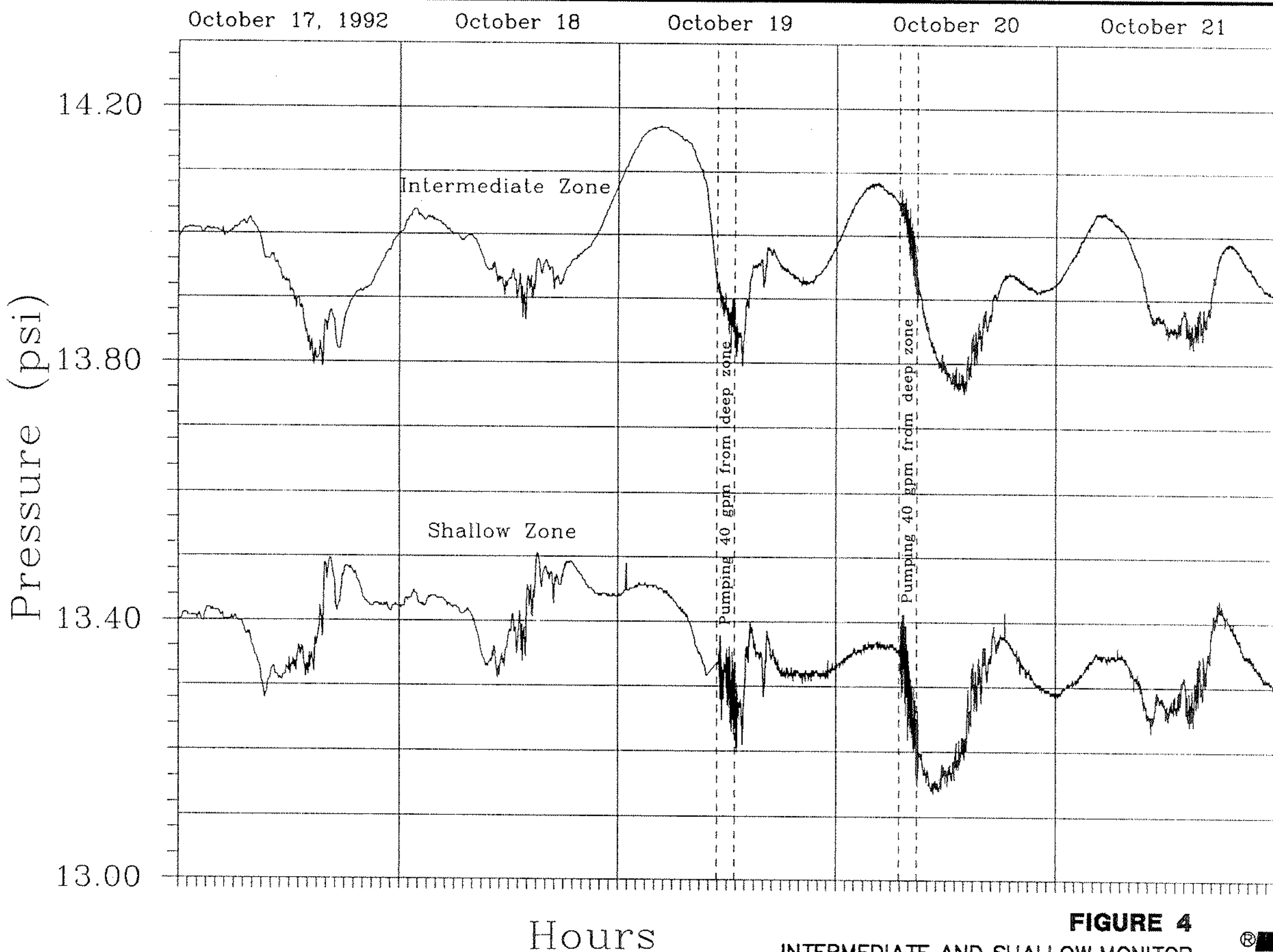

FIGURE 4

INTERMEDIATE AND SHALLOW MONITOR ZONE PRESSURE DATA DURING HYDRAULIC TESTING

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During the 2 days leading up to the first pumping test (October 17 and 18, 1992), background pressure measurements were recorded in the intermediate and shallow zone casings using pressure transducers and a data logger. At approximately 11:00 a.m. on October 19, 1992, the first pumping test began. During the 2-hour pumping test, pressure measurements in the intermediate and shallow zone casings were recorded as shown in Figure 5. Pressure measurements on the intermediate and shallow zone casings continued until the second pumping test started at 7:00 a.m. the next day (October 20, 1992). As shown in Figure 6, this test also lasted about 2 hours. Pressure readings were collected for another 1-1/2 days following the final pumping test as previously presented in Figure 4.

Effects of the pumping on the pressure in the intermediate and shallow zone casings are evident in Figures 5 and 6. These figures show recorded pressures two hours before, during, and one hour after the pumping test on October 19 and 20, 1992. It is clear that pumping water from the deep zone casing affected the pressure measurements in the intermediate and shallow zones. The effect does not appear to be a net drawdown in these zones, but rather additional "noise" in the pressures while the deep zone casing was being pumped. It is believed that the cause for this pressure noise is a direct communication of water from the shallow and intermediate monitor zones. Although the pressure fluctuations are relatively small this is related to the size of the leaks into the deep monitor tube. The amplitude of the "noise" is about 0.1 psi (2.8 inches of water) in the shallow zone and about 0.05 psi (1.4 inches of water) in the intermediate zone.

Packerless Pressure Tests

Three packerless pressure tests were performed on the deep monitor zone as a final step in determining whether leaks existed in the tubing. The tests showed that hydraulic communication exists between the deep zone casing, the intermediate and shallow zone casings and the formation below approximately 1,930 feet bpl. It is assumed that leaks in the deep zone casing are the cause of this communication between zones.

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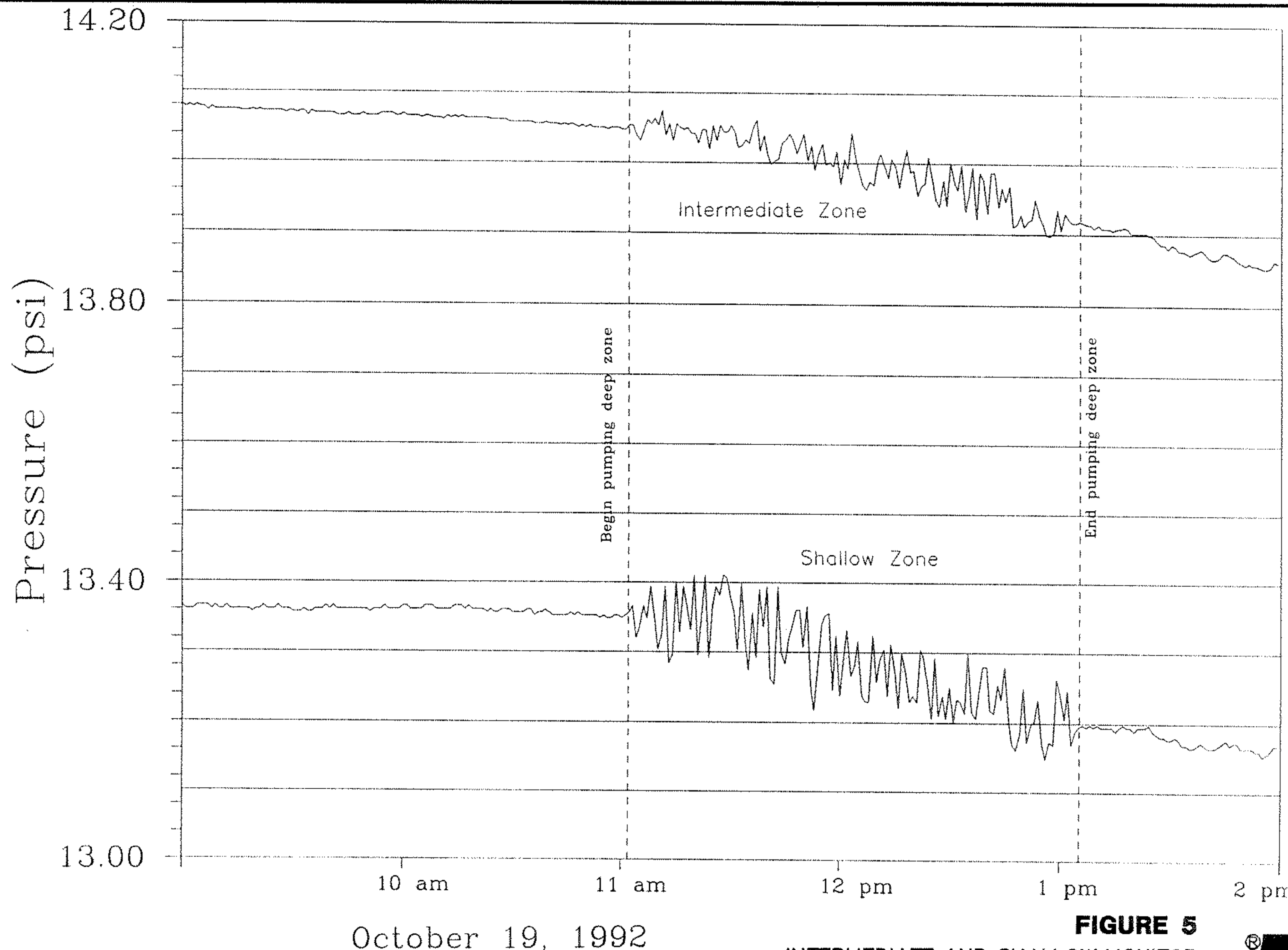

FIGURE 5

INTERMEDIATE AND SHALLOW MONITOR ZONE PRESSURE DATA DURING HYDRAULIC TESTING ON OCTOBER 19, 1992

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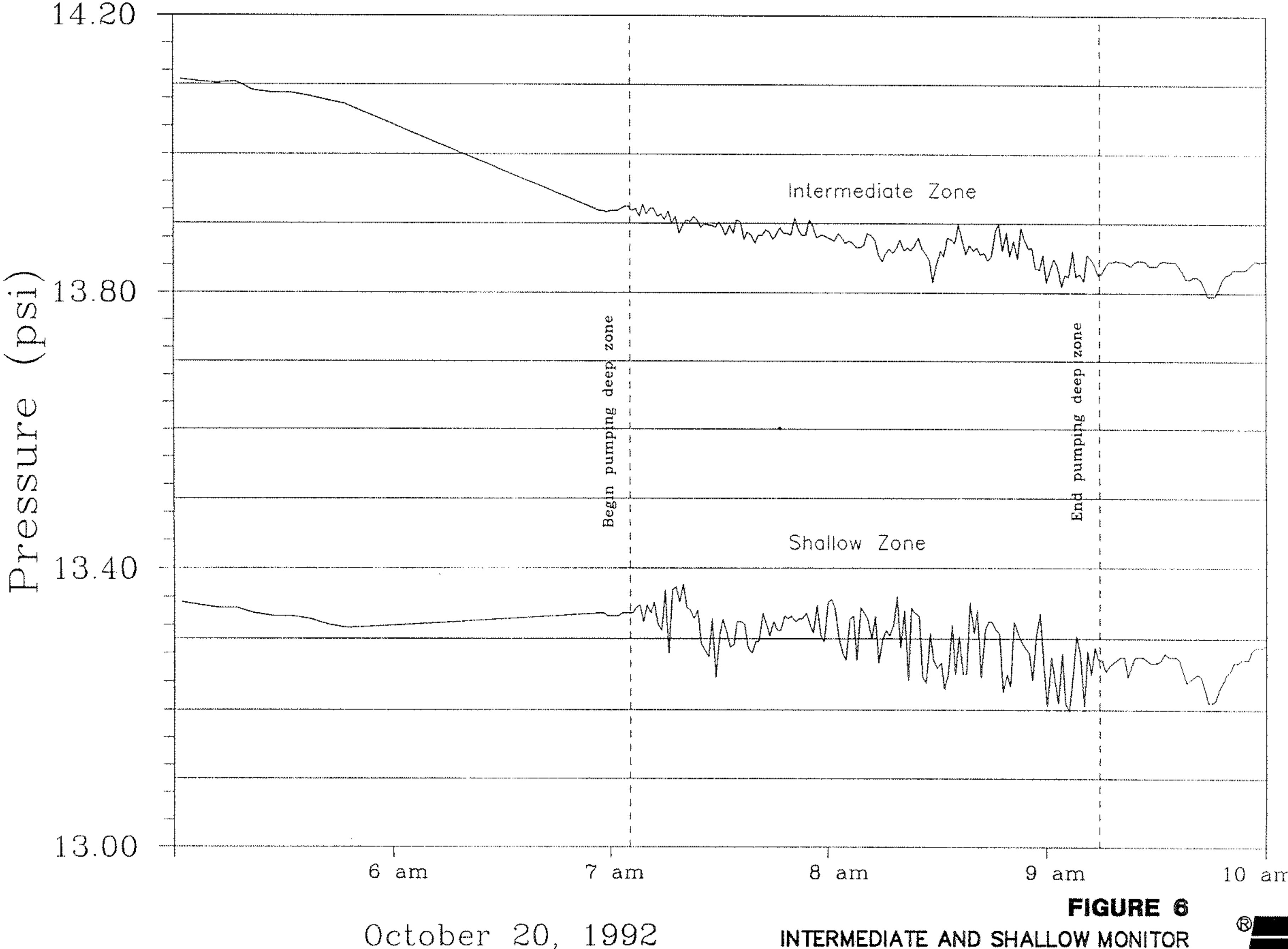

FIGURE 6

INTERMEDIATE AND SHALLOW MONITOR ZONE PRESSURE DATA DURING HYDRAULIC TESTING ON OCTOBER 20, 1992

CH2M HILL

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Each packerless pressure test was performed by injecting 1,000 gallons of fresh water into the deep zone casing, which, under normal conditions, is filled with relatively more dense saline water. This testing procedure was proposed to the Florida Department of Environmental Regulation (FDER) in a letter dated November 20, 1992, (Appendix D). The less-dense fresh water, when pumped into the more-dense saline water in the casing, causes an increase in pressure inside the casing. If leaks are present in the casing, the fresh water will flow out of the casing, and the pressure will decrease in the casing. The location and extent of the leaks, and the difference of pressures inside and outside of the casing, determine the amount and rate of pressure loss. If no leaks are present, the pressure inside the casing should remain relatively constant.

The packerless pressure tests were conducted by piping potable water from a fire hydrant into the wellhead piping of the deep monitor zone. Piping components included a flow-meter, backflow preventors and isolation valves. For each test, 1,000 gallons of fresh water was injected into the tubing. This volume of water was sufficient to displace the entire 2,568 feet of 2.75-inch inside diameter casing. Pressures inside each of the zones (shallow, intermediate, and deep) were monitored before and after the tests using pressure transducers and a data logger. Pressures in the deep zone casing were also measured and confirmed at the wellhead using a 60 psi Heise pressure gauge calibrated in 0.5 psi increments. Once the fresh water was injected into the deep zone tubing a valve on the wellhead was closed and, the piping from the hydrant disconnected. All valves and connections at the surface were then checked for leaks. Following the completion of each test and prior to conducting subsequent tests the fresh water was purged from the casing until background parameters were measured.

Figure 7 shows the pressure data from the deep zone tubing during the first packerless pressure test on November 19, 1992. The pressure reading in the deep zone before pumping fresh water into the casing was 21.7 psi (about 3 feet above pad level). After injecting 1,000 gallons of water the tubing was shut-in and the pressure recorded at 33.0 psi. The pressure inside the tubing decreased over the next 4 days (with fluctuations

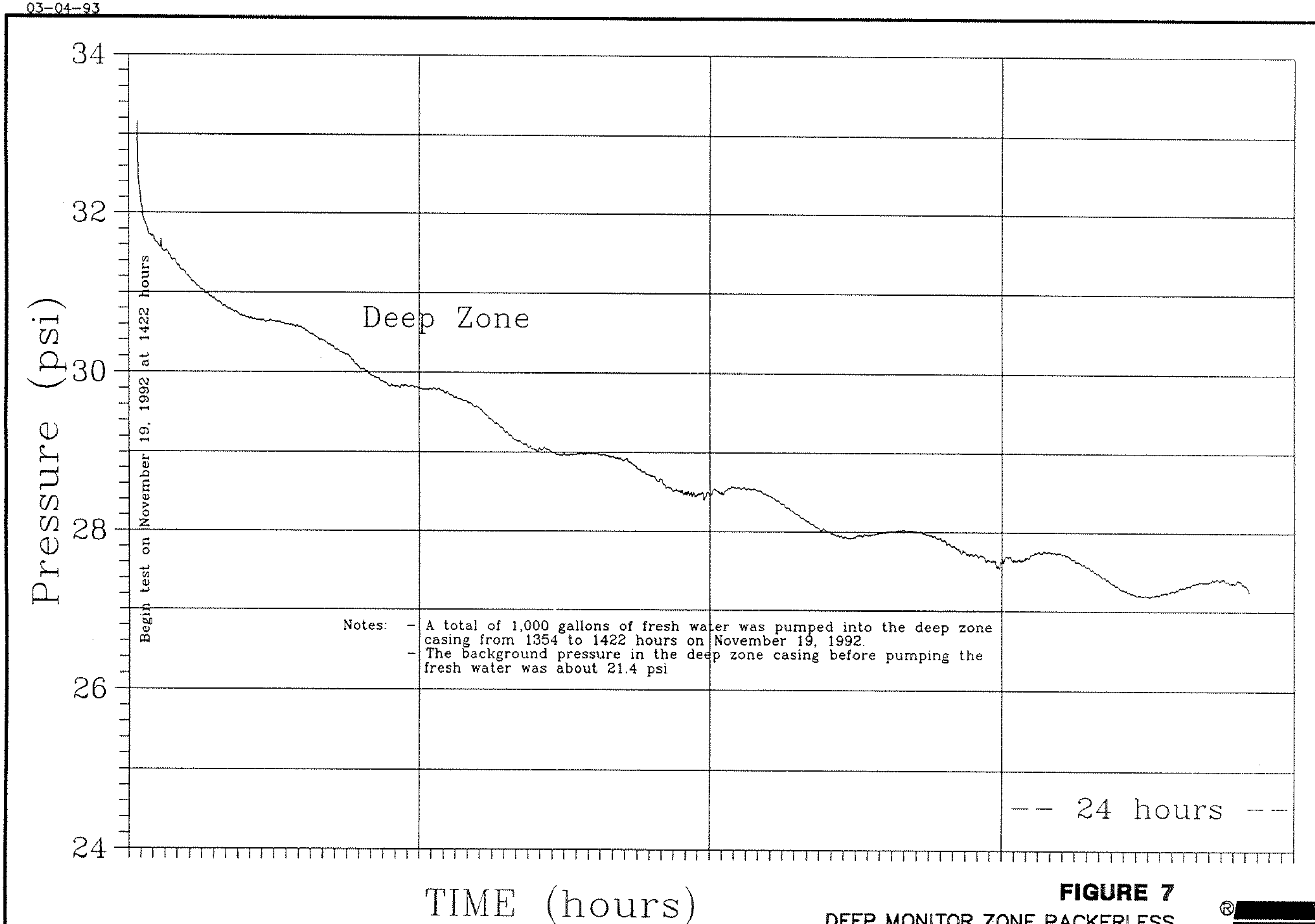

FIGURE 7
DEEP MONITOR ZONE PACKERLESS
PRESSURE TEST NO 1
CONDUCTED ON NOVEMBER 19, 1992

CH2M HILL

SEF32544.03

due to tidal stresses) to 27.2 psi. During the test period there were no observed fluctuations or changes in pressures at either the shallow or intermediate monitor zones. The pressure drop is an indication that the fresh water was being lost from the deep zone casing (i.e. saline water is intruding into the casing).

Using the same procedures a second packerless pressure test was performed on the deep zone casing on November 23, 1992. The results of the second test are presented in Figure 8. The shut-in pressure, following the addition of the fresh water, was just over 33 psi (as measured by the Heise gauge). Once again, the pressure decreased over time to 26.9 psi after 7 days. As before the shallow and intermediate monitor zones showed no unusual change in pressure. The second test confirmed the results of the first test and indicate that fresh water from the deep zone casing was escaping through breaches in the tubing.

Figure 9 summarizes the pressure data collected in all three zones during the first two packerless pressure tests. It shows the changes in pressure in the deep zone casing as fresh water was added on November 19 and 23, 1992. During the first test, the pressure in the deep zone casing increased above 33 psi (from a background pressure of 21.4 psi), then decreased to about 27 psi before the second test began. The pressure increased again to about 33 psi when fresh water was added during the second test, then decreased to about 27 psi 1 week after. Pressures in the intermediate and shallow zones are seemingly unaffected by the packerless pressure tests. It may be that leaks from the deep zone casing to these zones are not significant enough to noticeably change the pressure.

A third packerless pressure test was started on December 2, 1992. In addition to monitoring pressure during this test a downhole geophysical logging tool (fluid resistivity) was installed to a depth of 2,261 feet bpl. The tool was installed prior to injecting the 1,000 gallons of fresh water in order to measure water quality changes within the deep monitor tubing before, after and during the test.

03-04-93

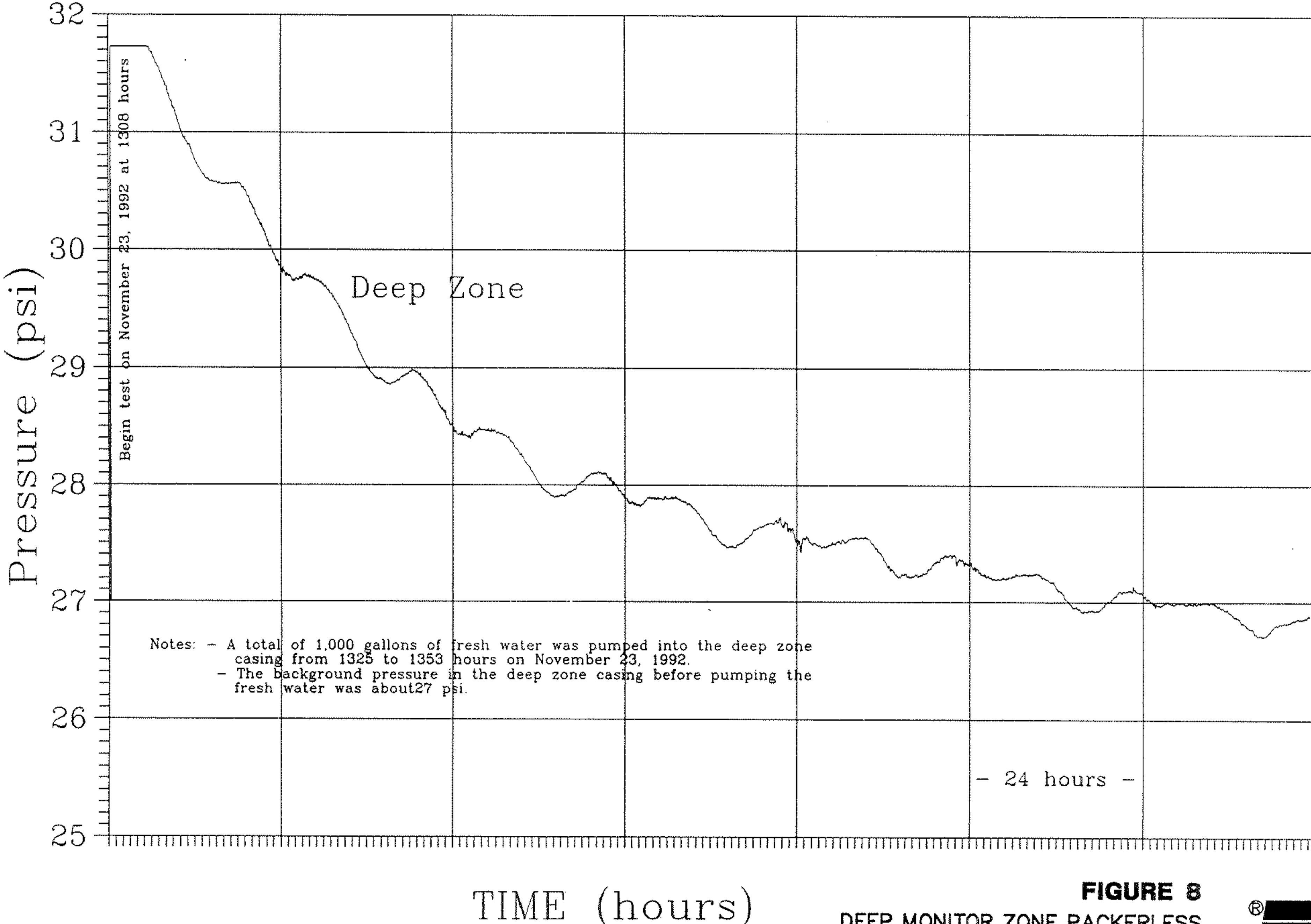

FIGURE 8
DEEP MONITOR ZONE PACKERLESS PRESSURE TEST NO 2
CONDUCTED ON NOVEMBER 23, 1992

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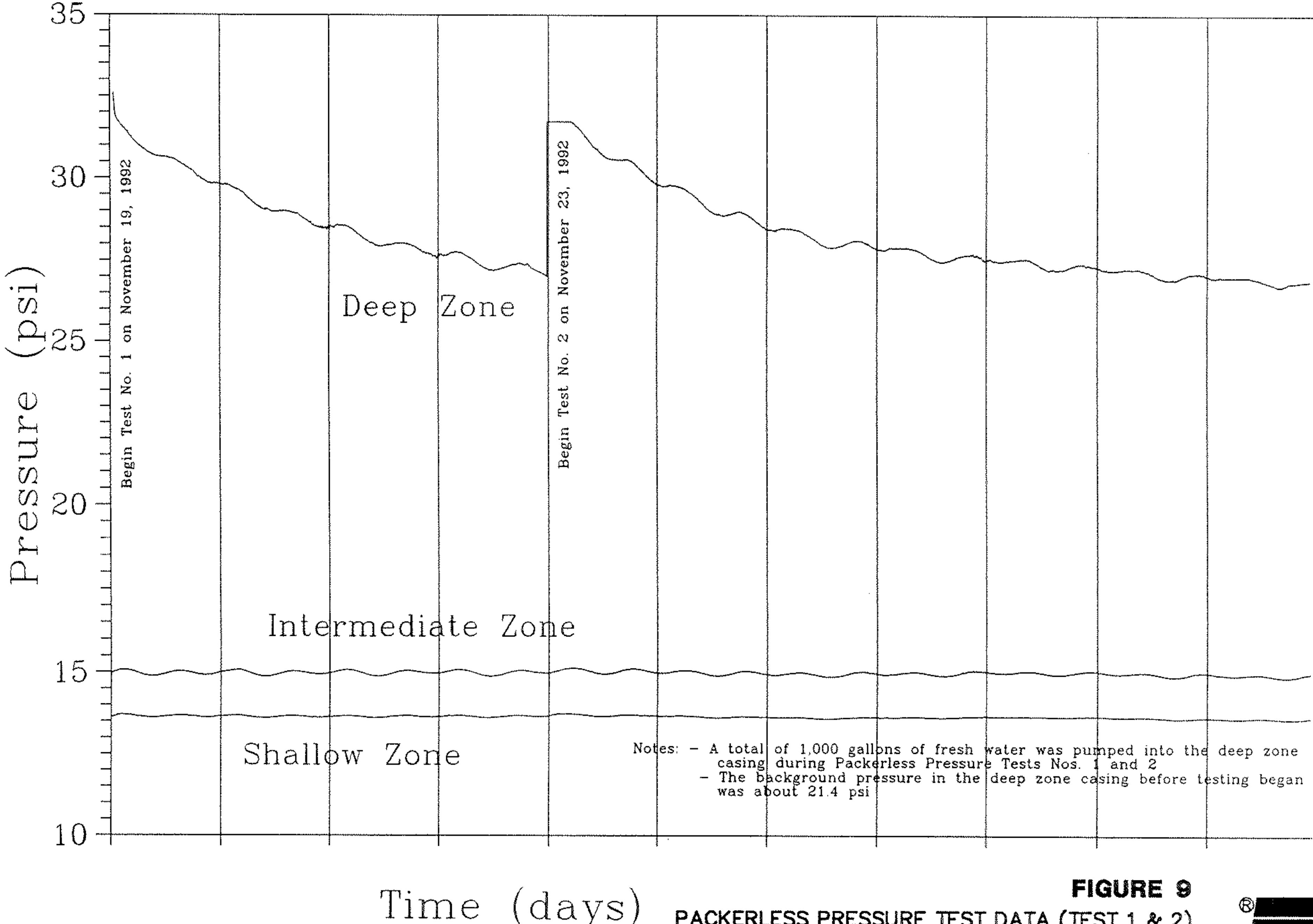


FIGURE 9
PACKERLESS PRESSURE TEST DATA (TEST 1 & 2)
FROM THE SHALLOW, INTERMEDIATE AND
DEEP MONITOR ZONES

SEF32544.03

As previously assumed, if a leak were to exist, fresh water will flow out of the casing at the point of a leak and be replaced by the more dense saline waters. The fluid resistivity tool would identify any water quality changes within the tubing.

Prior to injecting the fresh water a check of the water quality at the 2,261-foot depth indicated saline waters similar to that seen on previous fluid resistivity logs. The logging cable and fluid resistivity tool were then sealed in the tubing by means of a hydraulic packoff device located on top of the wellhead. Using the same procedure as for the first two packerless pressure tests, 1,000 gallons of fresh water was injected into the deep zone tube.

After injecting the fresh water, the tubing was shut-in at a pressure of 32.5 psi. Water quality was again checked with the fluid resistivity tool and indicated that fresh water had reach the depth of the tool at 2,261 feet bpl. As with the previous two tests pressure was also being monitored on each of the three monitor zones with pressure transducers.

On December 3, 1992, a fluid resistivity log was conducted (deep zone pressure was equal to 29.1 psi) from 2,261 to approximately 1,900 feet bpl. The log indicated a significant salt/fresh water interface, at a depth of approximately 1,940 feet bpl and thus confirmed that the fresh water column had migrated. To avoid mixing of the water column above the 1,900-foot depth and to wait for further movement of the interface the log was stopped and the tool lowered back to 2,261 feet bpl. On December 4, 1992, (with the deep zone pressure at approximately 28.5 psi) a continuous fluid resistivity log was conducted to land surface. This log, as graphically presented in Figure 10, indicates several significant shifts in water quality. Figure 11 presents the pressure data in the deep monitor zone during the 2-day test.

As described above, a salt/fresh water interface was seen to occur at approximately 1,940 feet on December 3, 1992. On the second log, a sharp water quality shift (from saline to fresh) is observed at 1,933 feet bpl and continues to approximately 1,845 feet bpl. At 1,845 feet bpl, another sharp shift (from fresh to saline) is observed. Above

03-03-93

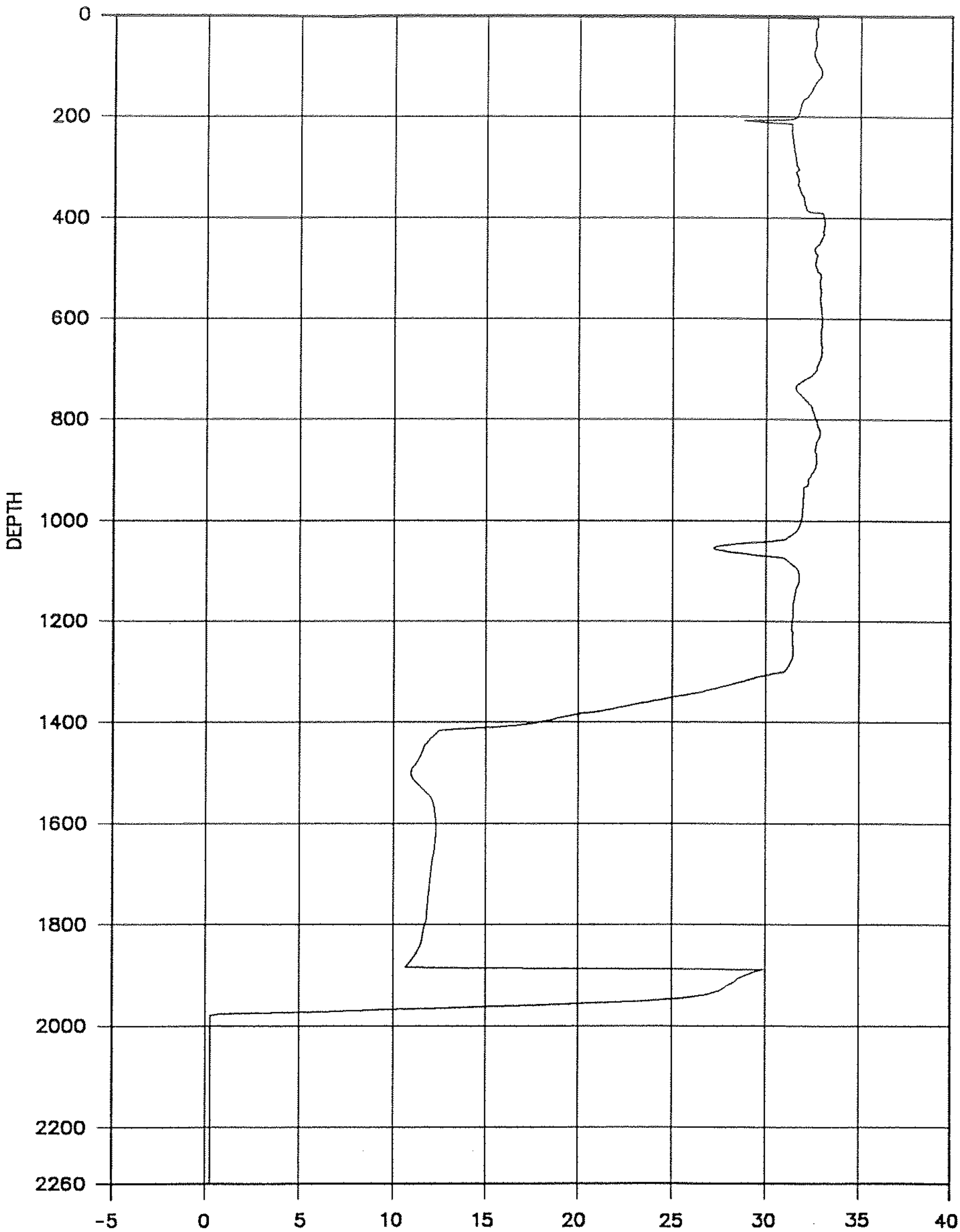


FIGURE 10

PACKERLESS PRESSURE TEST No. 3
FLUID RESISTIVITY LOG

CH2M HILL

D:\SEF32544.03\0322F01.DWG

03-04-93

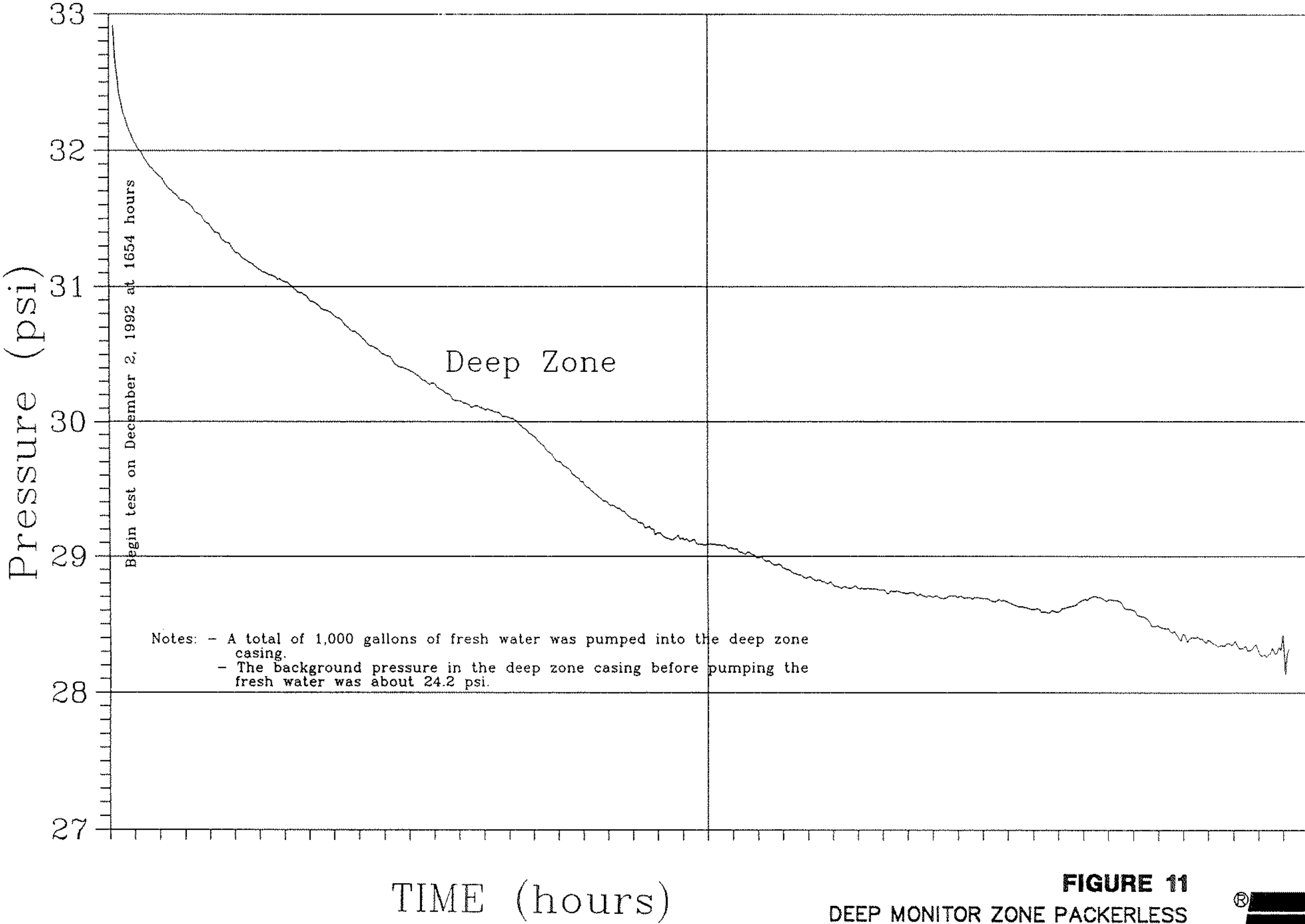


FIGURE 11
DEEP MONITOR ZONE PACKERLESS
PRESSURE TEST NO 3
CONDUCTED ON DECEMBER 2, 1992

CH2M HILL

SEF32544.03

1,845 to 1,270 feet bpl a zone of blended water (relatively saline) is observed. From 1,270 feet bpl to land surface, the log indicates fresh water with the exception of a narrow interval of mixing between 1,050 and 1,015 feet bpl. This interval corresponds directly to the depth of the shallow monitor zone 1,030 to 1,060 feet bpl.

It is evident from this log that there are several areas in the deep monitor zone tubing where fresh water has escaped and/or native saline waters have entered into the tubing. This log confirms previous assumptions that the deep monitor zone tubing does not have mechanical integrity and should be considered as the primary cause of water quality changes observed in the monthly operating reports for the monitor well.

Stray Current Analysis

The possibility that interference corrosion may have contributed to failure of the deep monitor tubing was raised as a result of the presence of a number of impressed current cathodic protection systems in the tank farms in the vicinity of the injection well site. One of the operational features of impressed current cathodic protection systems is the discharge of dc current into the earth through a ground remote from the protected structure. If it does not return to the protected structure, this discharge can collect as stray current, or interference current on other structures (such as the deep monitor tubing). As this current discharges from the structure it can accelerate corrosion.

CH2M HILL carried out field testing to determine if the monitor tubing might be carrying a current at levels that would contribute to an accelerated corrosion rate. This testing consisted of three sets of structure-to-soil DC current potential measurements using a Digital Fluke Model 23 high input impedance voltmeter and a copper/copper sulfate reference electrode. Readings were taken with the reference electrode set at varying distance and direction around the well.

The first set of measurements were taken on January 27, 1993, shortly after a significant rainfall so that soil moisture was at a fairly high level. Structure to soil potential was recorded with the reference electrode placed at varying distances and directions from the monitor tube.

On February 3, 1993, the rectifier of one of the closest impressed current cathodic protection systems was turned off and the measurements were repeated with the ground electrode placed in the same approximate location as the first series of measurements. The maximum variation between paired readings was 0.032 volt. To confirm that differing soil moisture conditions were not impacting the measurements, the cathodic protection system was returned to service and readings were collected at selected intervals.

Table 3 presents the values observed during testing.

Table 3
Resistance Measurements (Volts)

Date	1	2	3	4	5	6	7	Comments
1/27/93	.678	.666	.628	.673	.608	.670	.626	Rectifier on
2/3/93	.649	.683	.636	.686	.640	.661	.656	Rectifier off
2/3/93	---	---	---	.673	.623	.673	---	Rectifier on

The average of the seven measurements taken with the rectifier of the cathodic protection system turned on was .650 volt, with the deep monitor zone tube reading positive to the reference ground electrode. The average of the seven measurements taken with the rectifier turned off was .659 volt, with the deep monitor tube again reading positive to the reference ground electrode.

The changes in resistance observed range from .009 to .032 volts, and changes of this magnitude are not considered indicative of conditions likely to support interference corrosion. A difference of volts or tenths of volts would be expected as evidence that significant interference corrosion was occurring.

This test procedure is limited to observations of prevailing conditions and unfortunately cannot identify what may have occurred at some time in the past. Based on the available data, we believe the cause of failure of the monitor tube to be corrosion related, and stray current corrosion may in fact have been the cause, but we are unable to establish any definitive evidence that this is the case.

Conclusions

A variety of mechanical integrity testing techniques were used during the investigation of the multi-zone monitor well. These tests included a video survey, geophysical logs, water quality analyses for both general and isotopic parameters, hydraulic testing and monitoring of the three monitor zones, compilation of historic monitoring data, packerless pressure testing and an investigation stray current analysis for corrosion potential. The results from each of these testing techniques contributed to an better understanding of the conditions that currently exist in the well. As demonstrated, those conditions appear to have contributed to the degradation of water quality in the intermediate and lower monitor zones.

The results of an initial video survey indicated that the tubing had; a build-up of hard concretions on the interior, appeared to be heavily corroded and in places appeared to be absent. Because concretions restricted the passage of tools it was not possible to determine the condition of the well below a depth of 2,259 feet bpl.

A number of geophysical logs (temperature and fluid resistivity) were conducted during the initial stages of testing the deep monitor tubing. The logs, conducted under a variety of different conditions, indicated several water quality and temperature anomolies that generally correlated to the depths of the upper (1,030 to 1,060 feet bpl) and intermediate

(1,493 to 1,534 feet bpl) monitor zones and to and an interval from 1,850 to 2,050 feet bpl in the deep monitor tube.

Based on the anomolies observed on the geophysical logs and the video survey it was assumed that leaks might be present in the deep monitor tubing and that there could be some affect on water quality. In order to determine if there were water quality differences samples were collected at three different depths (1,300, 1,950, and 2,225) inside the tubing. Laboratory analyses of these samples confirmed that there were significant differences in specific water quality parameters between the upper sample and the two lower samples.

To further demonstrate the potential for communication between the three monitor zones hydraulic testing of the monitor zones was conducted. During two different test periods, using pressure transducers on the upper and intermediate monitor zones and while pumping the lower monitor zone, communication was demonstrated by detecting pressure changes between each of the monitor zones.

As a final procedure of nondestructive testing, packerless pressure tests were conducted in the deep monitor zone tubing. They were conducted by injecting less dense fresh water into the more dense, saline water of the deep monitor zone, resulting in increased pressure. Pressure losses from a closed in system would demonstrate a leak. When monitored on three different occasions, pressure losses of similar magnitude were clearly demonstrated and thus loss of fluid through a leak in the tubing. In order to determine the actual depth of leaks within the tubing, water quality was monitored during the third test. A profile of the water quality confirmed that several leaks existed within the tubing.

From the results of the testing procedures described above it has been clearly demonstrated that the deep zone monitor tube does not have mechanical integrity. Additionally, the changes in water quality observed in the long term monitoring data (for the intermediate and deep monitoring zones) can also be attributed to the lack of mechanical integrity in the monitoring well.

Recommendations

The conclusion of this investigation is that the deep monitor tube of the multi-zone monitor well has failed and is responsible for the apparent movement of secondary effluent from the deep monitor into the intermediate monitor. It is the opinion of the Engineer that the deep monitor zone should be abandoned and the intermediate and upper monitor zones redeveloped and reconstructed.

In accordance with the requirements of Paragraph 26 b of the Consent Order, the following general plan of corrective action is proposed to address the deficiencies discovered during this investigation:

1. Remove all three of the existing monitor tubes, gravel pack and cement seal to the nominal diameter and depth of the original borehole of the monitor well. Examine the condition of the existing 14"diameter casing, and if necessary, install a fully cemented steel liner to the depth of the shallow monitor zone.

2. Abandon the lower monitor interval by plugging with cement.

3. Restore the integrity of the confining intervals above the lower monitor interval by plugging the borehole with cement to the base of the intermediate monitor interval.

4. Install a six-inch diameter monitor tube to the depth of the intermediate monitor and cement in place using exterior cement packers and neat cement. Restore the intermediate monitor interval to background conditions by air-lift development and extended pumping.

5. Complete the well by cementing to the base of the shallow monitor interval.

It is the intent of the City that these actions be carried out on a priority basis in conjunction with the installation of the new Monitor Well MW-2. A fully detailed plan for corrective actions and a timetable for those actions will be prepared after acceptance of this report by FDER and members of the TAC.

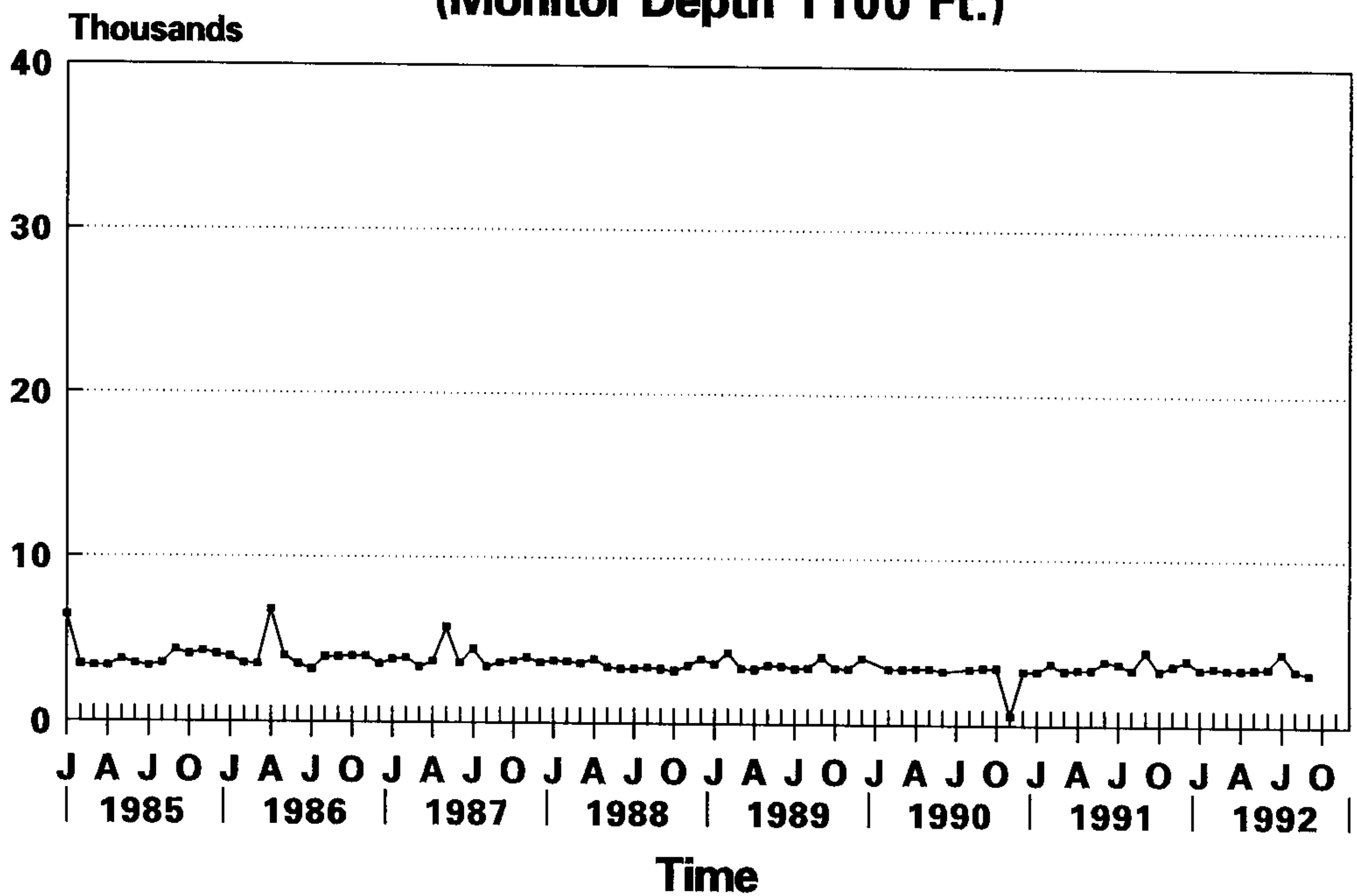
Appendix A
Historical Monitor Well Operating Data

- **Shallow Monitor Interval**
  (1,030' to 1,061')

Chlorides

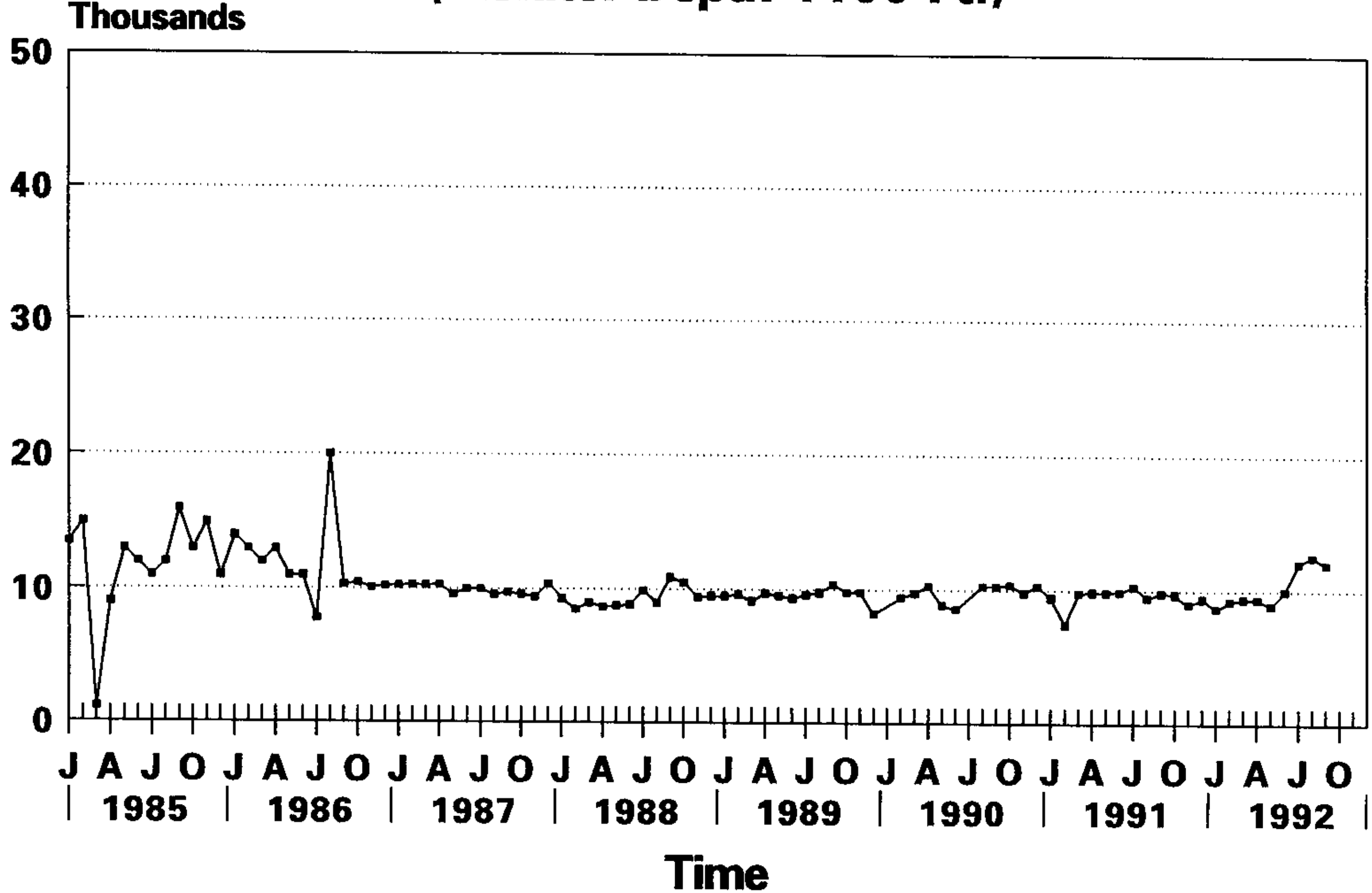
Monitor Interval 1030' to 1061'

(Monitor Depth 1100 Ft.)



Note: Background Chlorides = 3350 mg/L
(Injection Well Const. Rpt. by Geraghty & Miller, Inc. 1981)

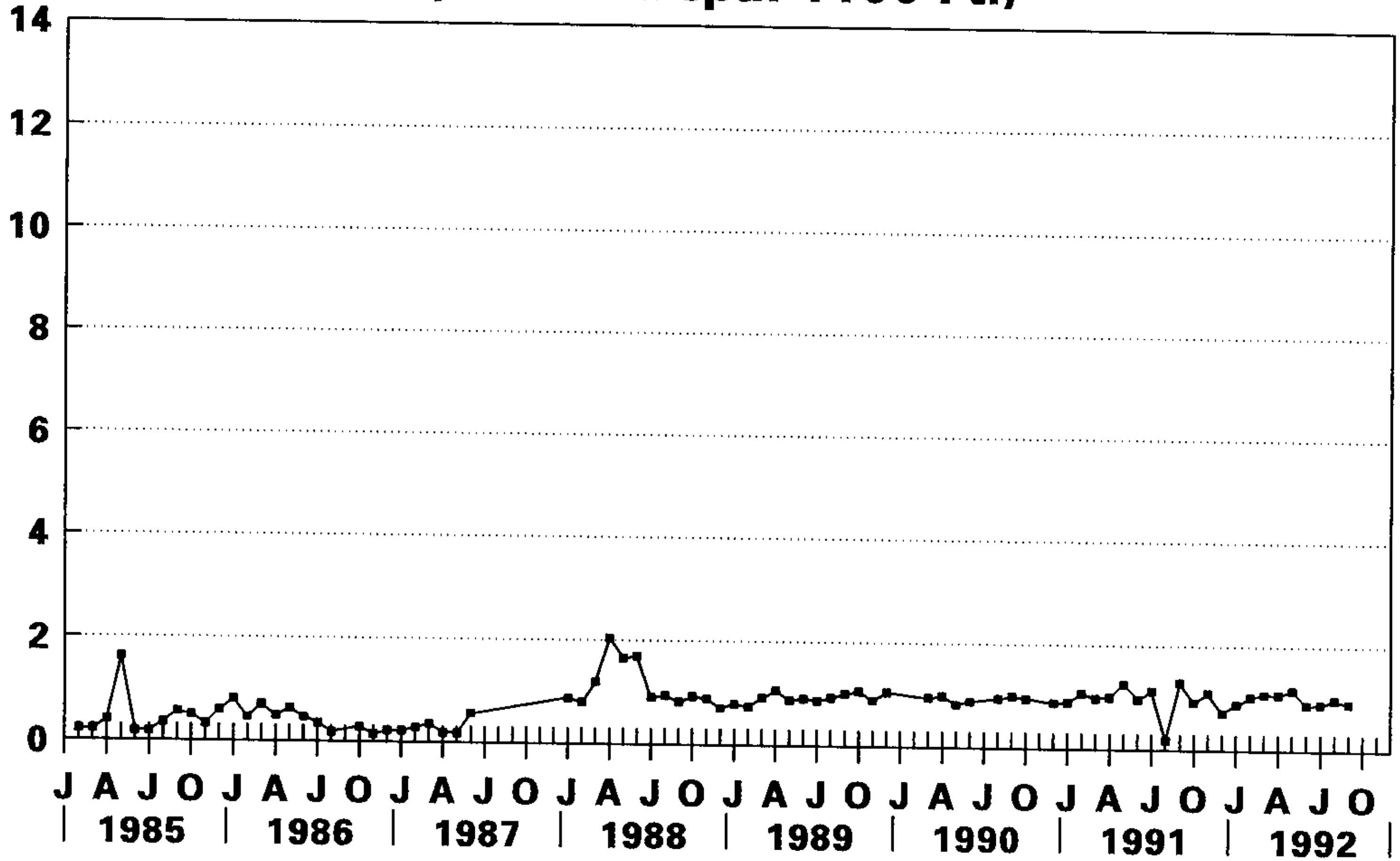
Conductivity
Monitor Interval 1030' to 1061'
(Monitor Depth 1100 Ft.)



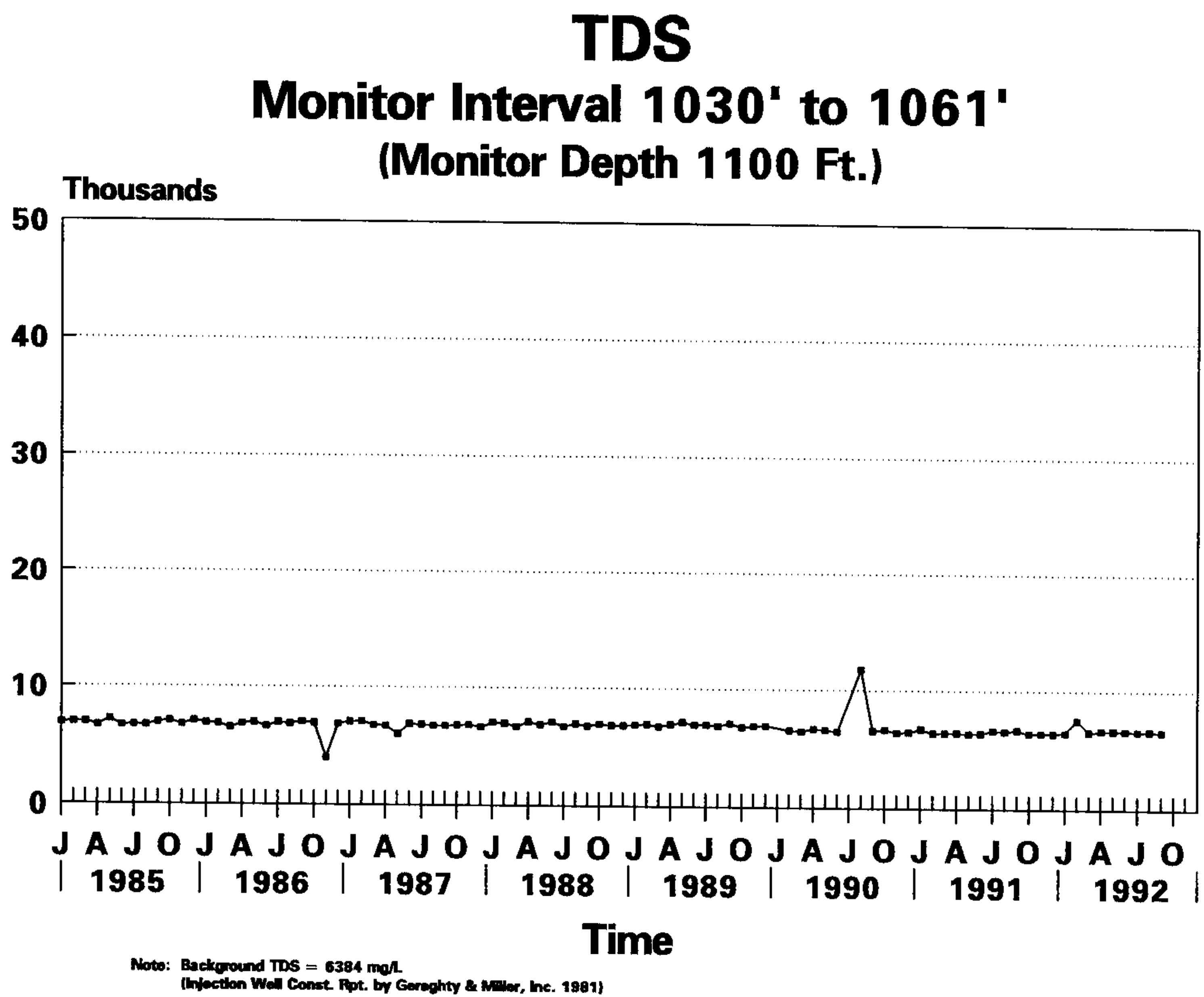
NH3

Monitor Interval 1030' to 1061'

(Monitor Depth 1100 Ft.)



Note: Background NH3 = .66 mg/L
(Injection Well Const. Rpt. by Geraghty & Miller, Inc. 1981)

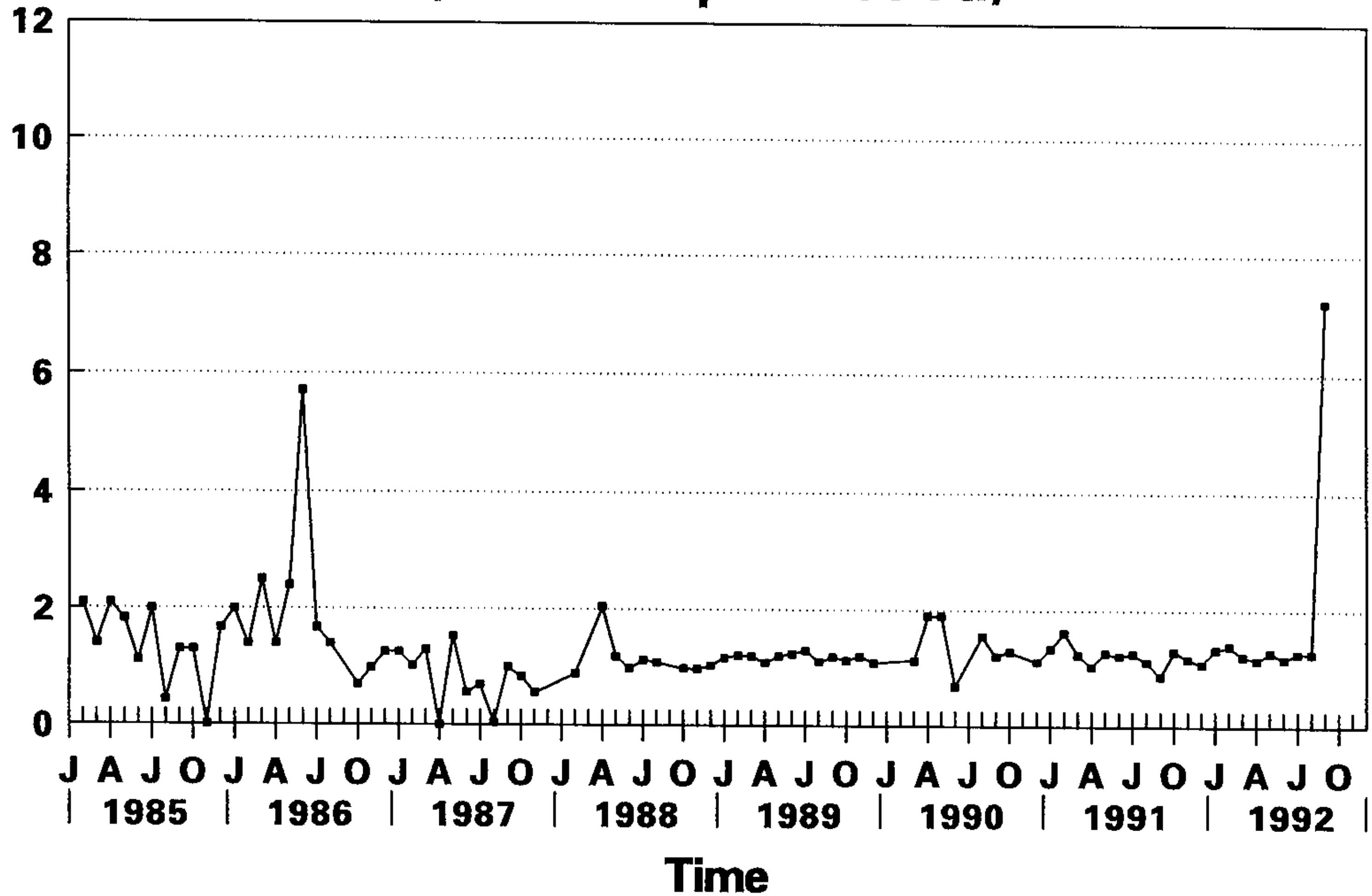


TDS
Monitor Interval 1030' to 1061'
(Monitor Depth 1100 Ft.)
Thousands
50
40
30
20
10
0
J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A J O
1985 1986 1987 1988 1989 1990 1991 1992
Time
Note: Background TDS = 6384 mg/L
(Injection Well Const. Rpt. by Geraghty & Miller, Inc. 1981)

TKN

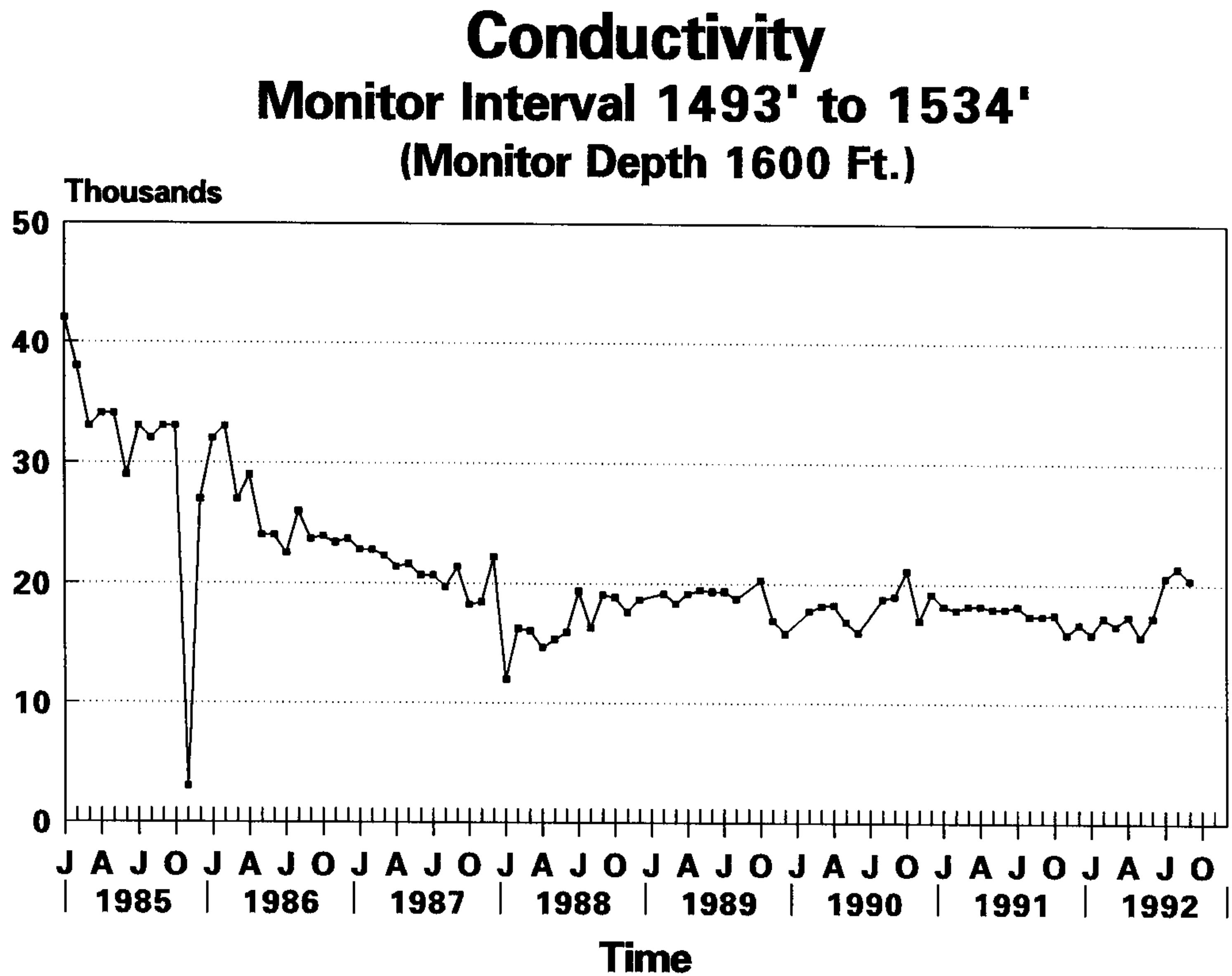
Monitor Interval 1030' to 1061'

(Monitor Depth 1100 Ft.)



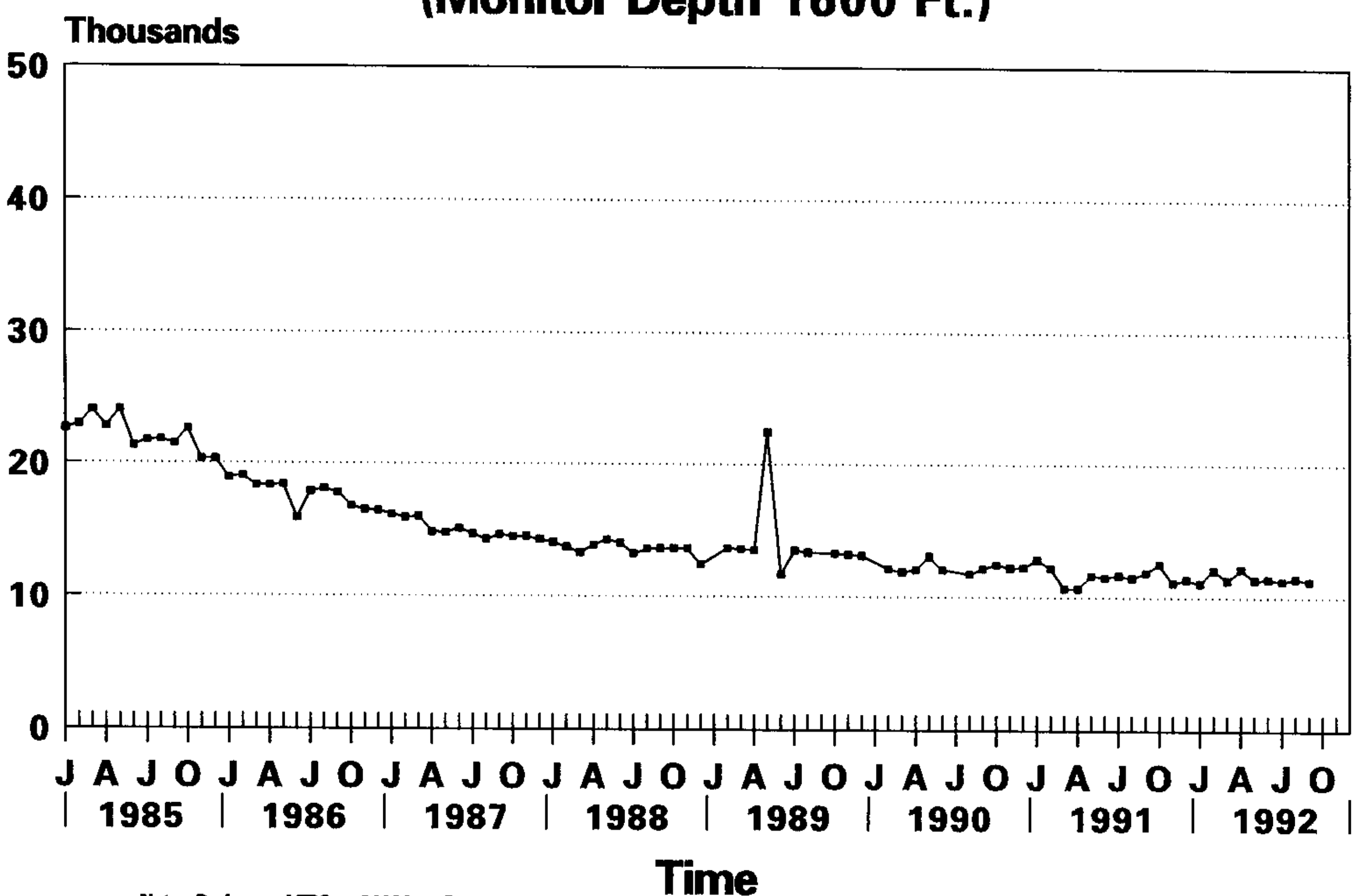
Note: Background TKN = .76 mg/L
(Injection Well Const. Rpt. by Geraghty & Miller, Inc. 1981)

- **Intermediate Monitor Interval (1,493' to 1,534')**



Conductivity
Monitor Interval 1493' to 1534'
(Monitor Depth 1600 Ft.)
Thousands
50
40
30
20
10
0
J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A J O
1985
1986
1987
1988
1989
1990
1991
1992
Time

TDS
Monitor Interval 1493' to 1534'
(Monitor Depth 1600 Ft.)

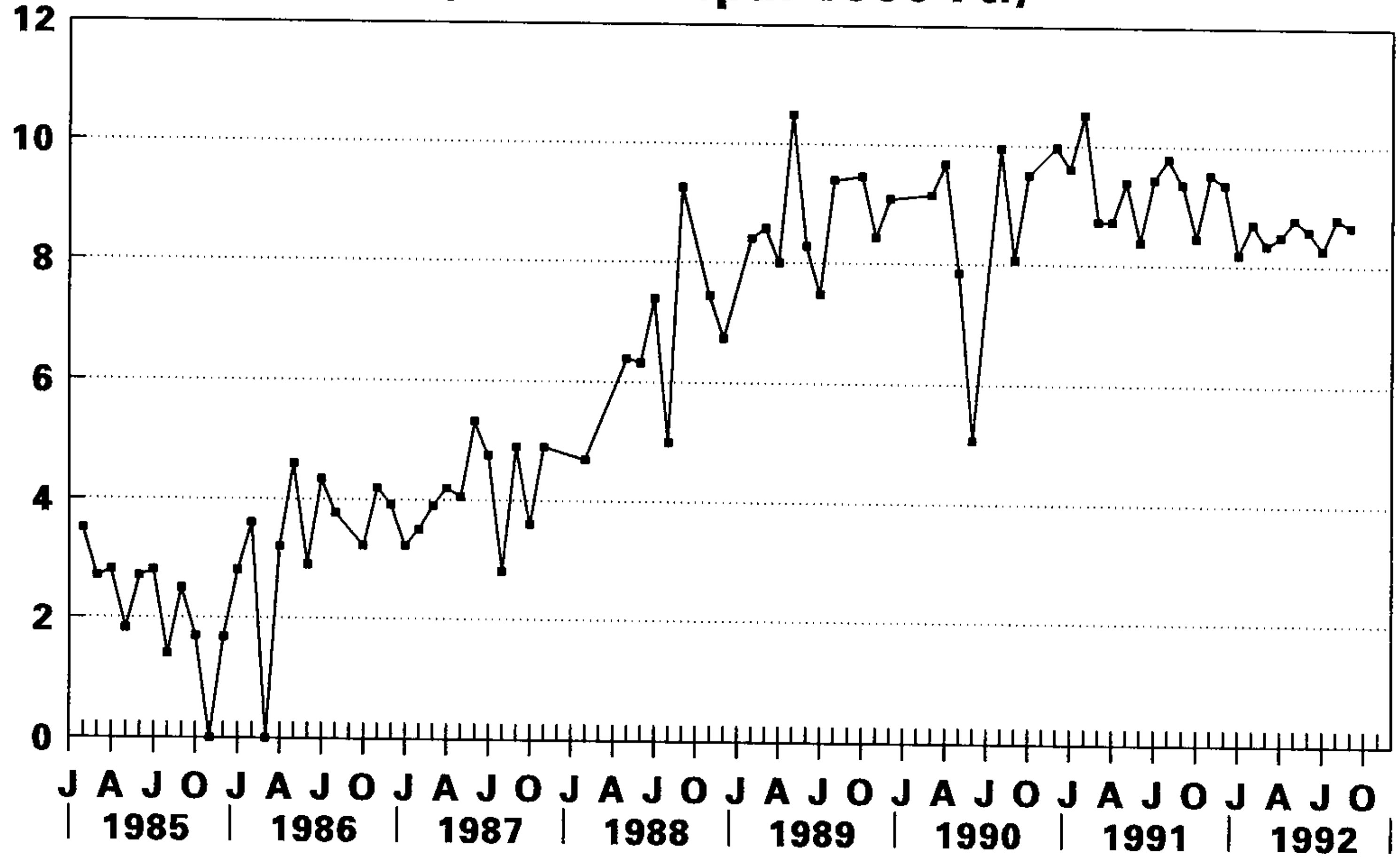


Note: Background TDS = 24036 mg/L
(Injection Well Const. Rpt. by Geraghty & Miller, Inc. 1981)

TKN

Monitor Interval 1493' to 1534'

(Monitor Depth 1600 Ft.)

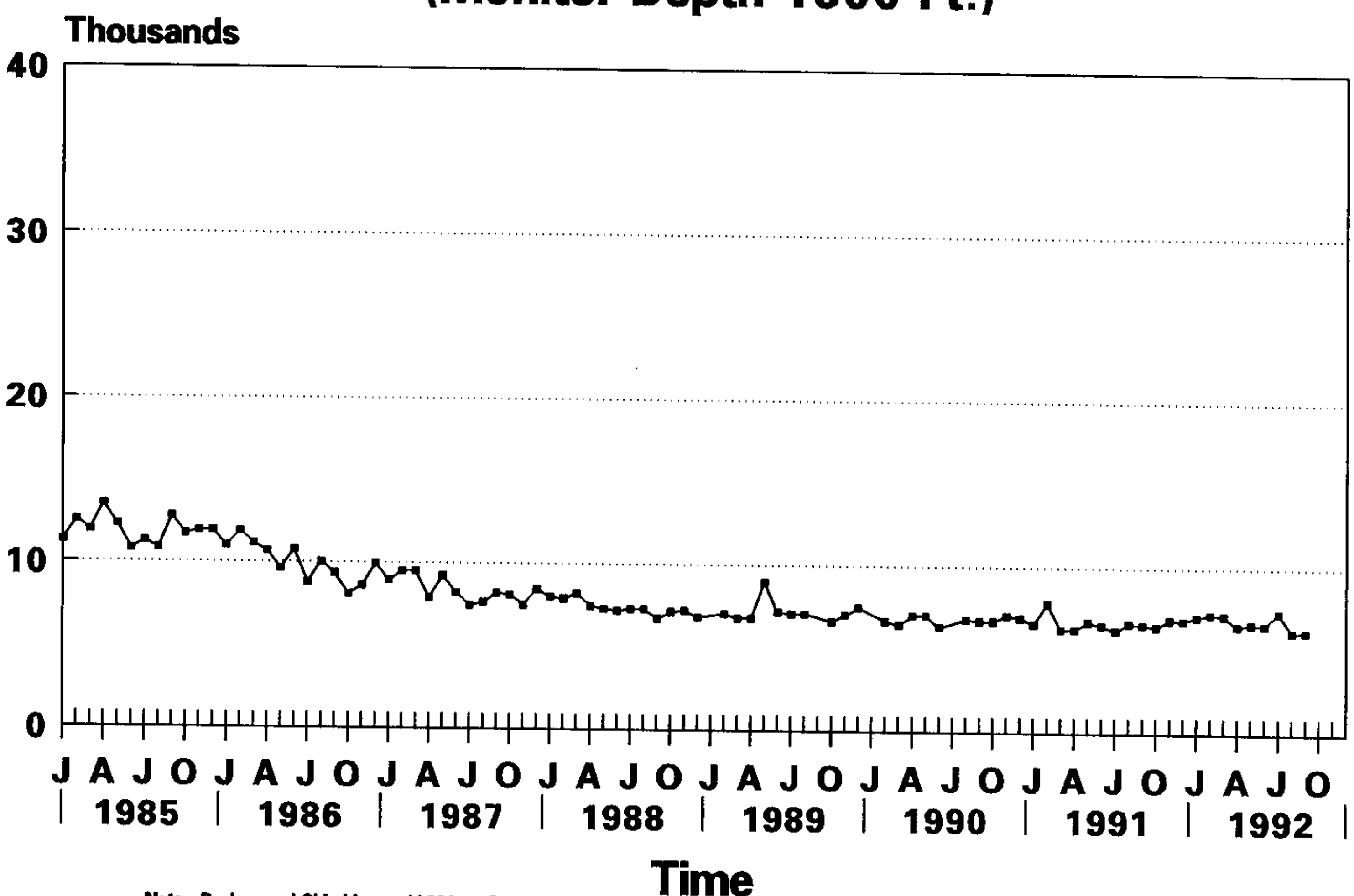


Note: Background TKN = .63 mg/L
(Injection Well Const. Rpt. by Geraghty & Miller, Inc. 1981)

Chlorides

Monitor Interval 1493' to 1534'

(Monitor Depth 1600 Ft.)

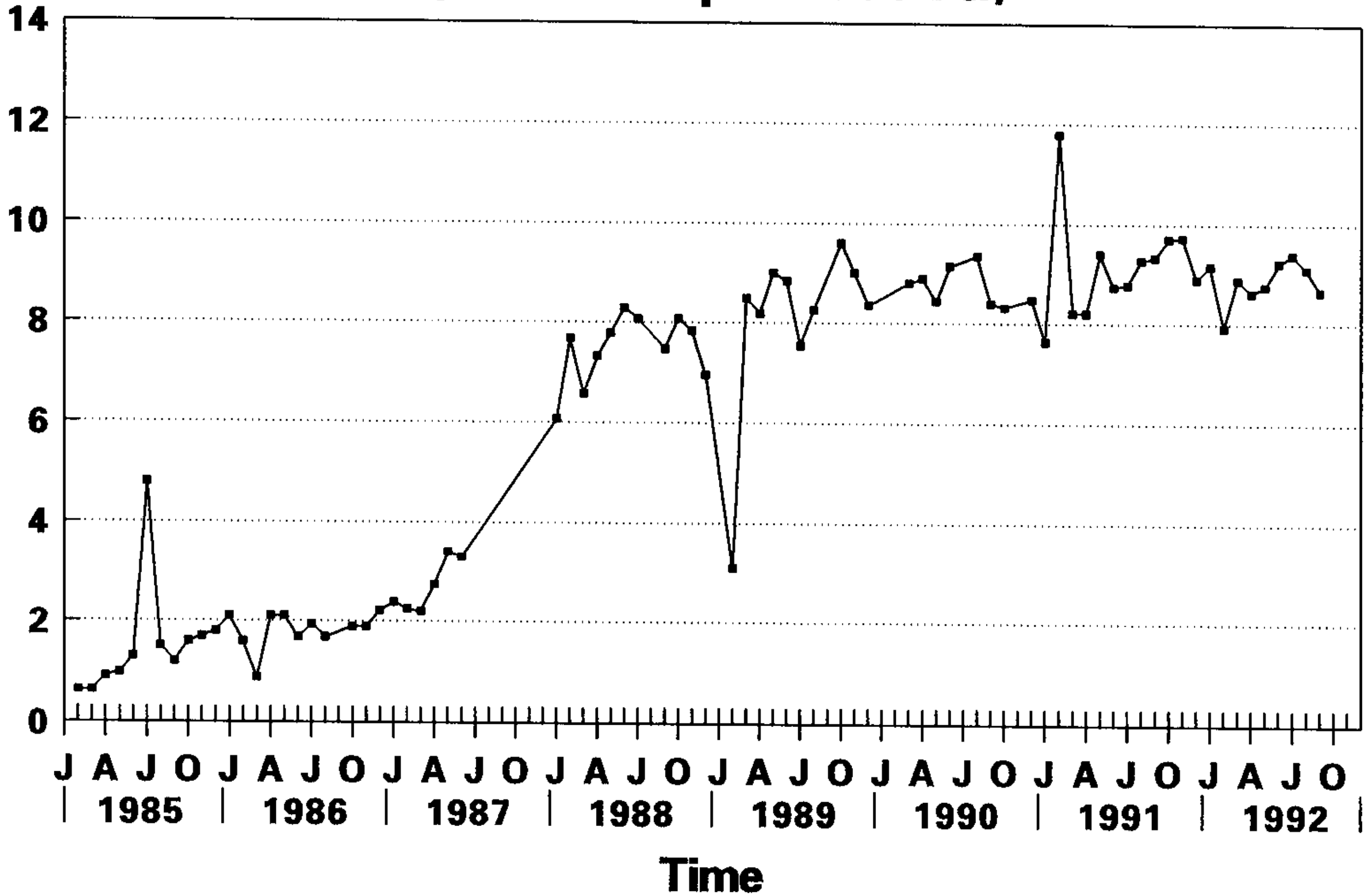


Note: Background Chlorides = 10600 mg/l.
(Injection Well Const. Rpt. by Geraghty & Miller, Inc. 1981)

NH3

Monitor Interval 1493' to 1534'

(Monitor Depth 1600 Ft.)



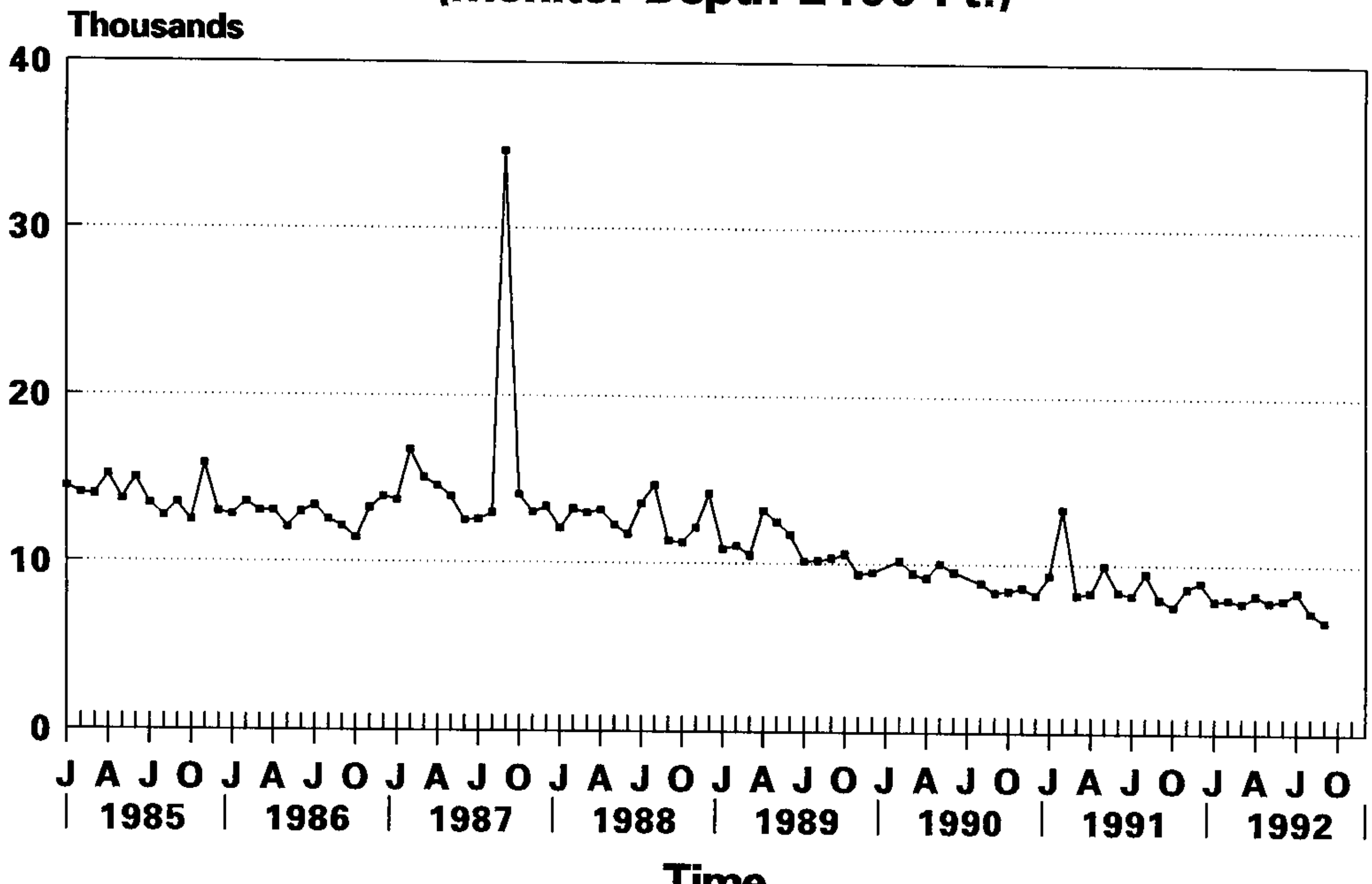
Note: Background NH3 = .59 mg/L
(Injection Well Const. Rpt. by Geraghty & Miller, Inc. 1981)

- **Deep Monitor Interval (2,568' to 2,670')**

Chlorides

Monitor Interval 2568' to 2670'

(Monitor Depth 2400 Ft.)

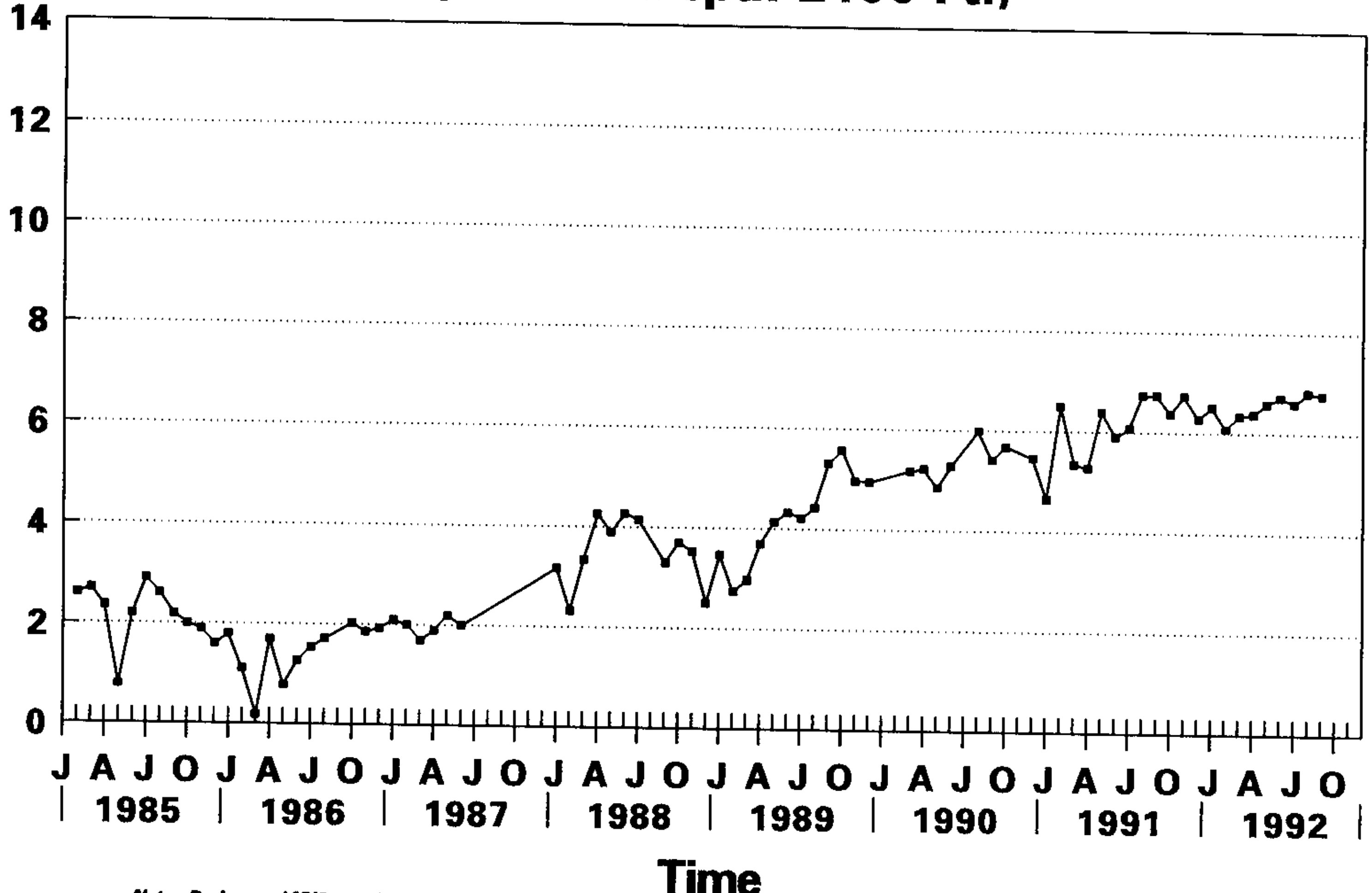


Note: Background Chlorides = 20000 mg/L
(Injection Well Const. Rpt. by Geraghty & Miller, Inc. 1981)

NH3

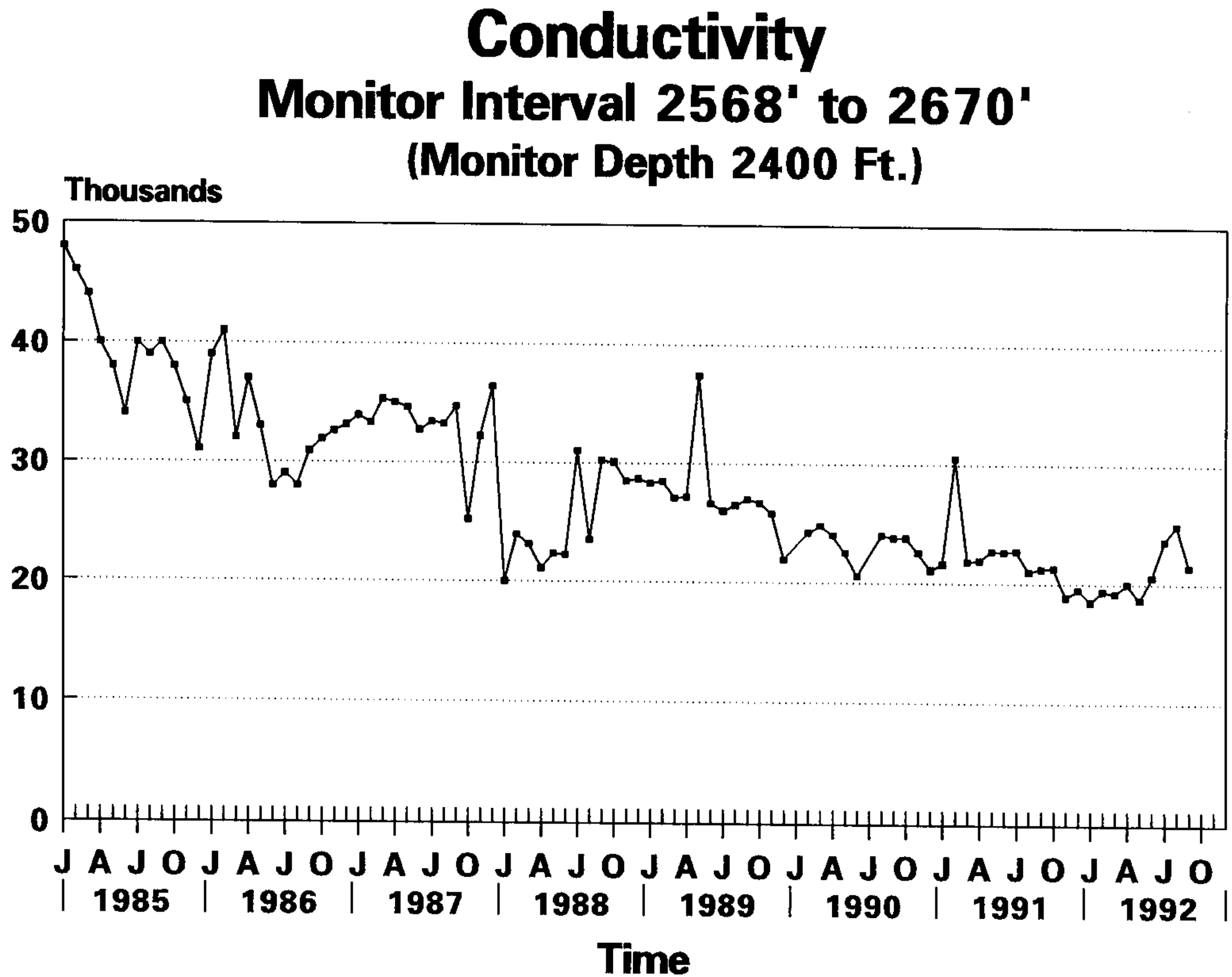
Monitor Interval 2568' to 2670'

(Monitor Depth 2400 Ft.)

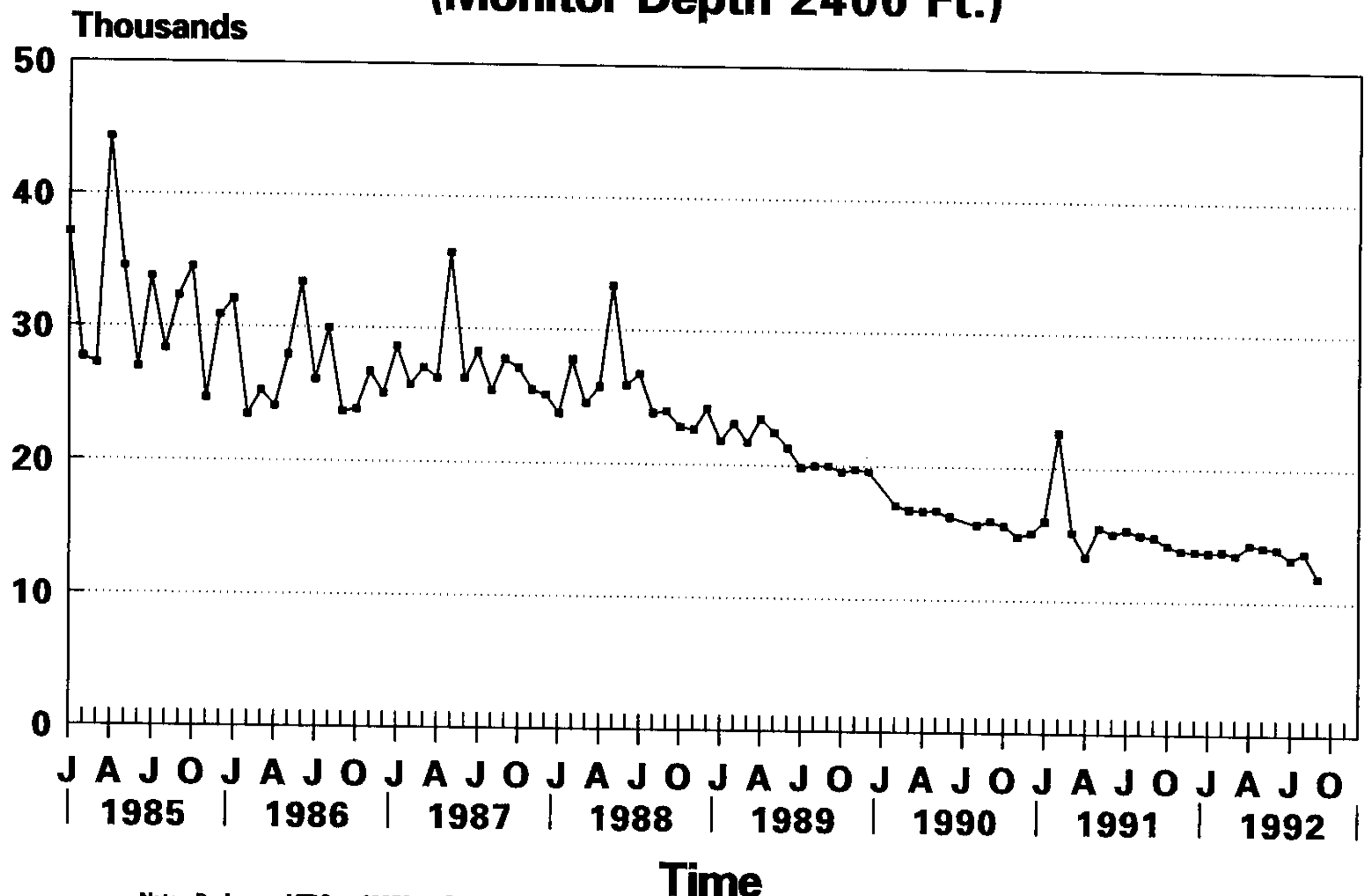


Note: Background NH3 = < 0.1 mg/L

(Injection Well Const. Rpt. by Geraghty & Miller, Inc. 1981)

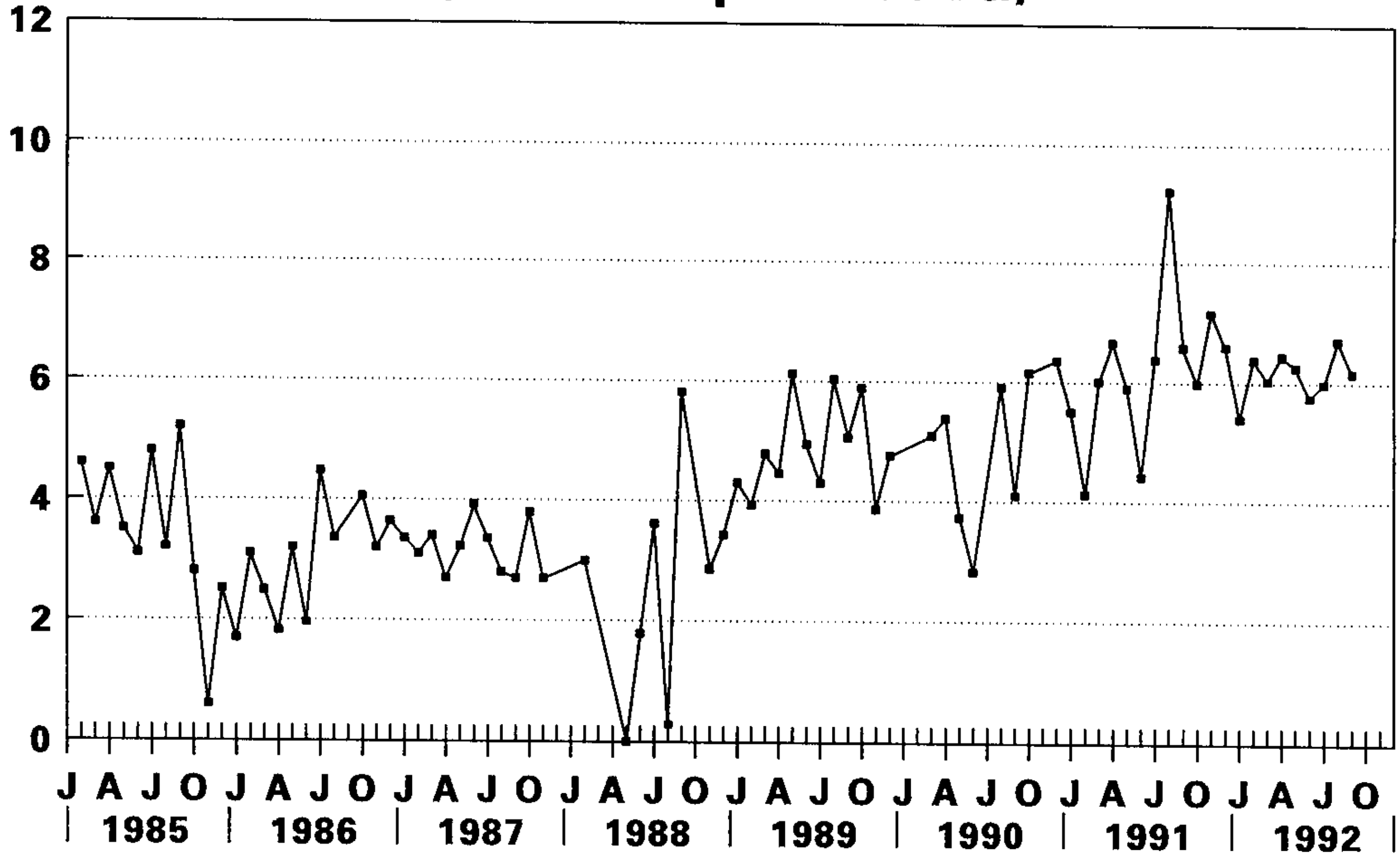

Conductivity
Monitor Interval 2568' to 2670'
(Monitor Depth 2400 Ft.)
Thousands
50
40
30
20
10
0
J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A J O
1985
1986
1987
1988
1989
1990
1991
1992
Time

TDS
Monitor Interval 2568' to 2670'
(Monitor Depth 2400 Ft.)



Note: Background TDS = 43358 mg/l.
(Injection Well Const. Rpt. by Geraghty & Miller, Inc. 1981)

TKN
Monitor Interval 2568' to 2670'
(Monitor Depth 2400 Ft.)



Note: Background TKN = <0.1 mg/L
(Injection Well Const. Rpt. by Geraghty & Miller, Inc. 1981)

Appendix B

Deep Monitor Zone Video Survey

RECORD OF UNDERWATER VIDEO SURVEY

Project: SEF32544.02

Well: Fort Lauderdale Injection System Deep Monitor

Survey By: Deep Venture

Survey Date: September 23, 1991

Witnessed By: Sean Skehan and Tom McCormick/CH2M Hill
Mike Bailey/Fort Lauderdale

Reviewed By: Sean Skehan

DEPTH IN FEET		OBSERVATIONS
From	To	
0	300	Visibility poor due to suspended black material in the water and on the casing, caliper arm tracks clearly visible
300	400	As above, at 325 feet a concentric concretion of material built up on the casing, very rough, camera shifts as it passes, shows up on the caliper log, at 345 and 351 feet appears to be a rock on the side of the casing, at 364 feet appears to be a breach in casing, concentric ring of built up material, appears on the caliper as a larger diameter, from 364 to 394 feet well wall is very rough, at 396 feet concentric ring of built up material, appears to be a breach in the casing
400	500	Continue to have numerous concretions on well bore, very rough, camera will shift as it passes by, at 432 and 472 feet appears to be rocks, possible hole in casing, at 489 feet a large concretion
500	600	Casing continues to have numerous concretions, very rough, at 511 feet - appears to be rocks, possible hole in the casing, at 537 feet a large concretion
600	700	Visibility continues to be poor, casing very rough, small to large concretions on casing
700	800	As above, at 728 feet very large concentric concretion, from 712 to 745 feet casing extremely rough
800	900	As above, visibility is somewhat improved, well bore continues to

		be very rough, small to large concretions on casing cause camera to shift
900	1000	Visibility becomes poor from 910 to 975 feet, possibly due to camera offset, at 985 feet an apparent casing joint, from 995 to 1000 feet well bore appears to be some what smoother
1,000	1,100	Improved visibility, realatively smooth with concretions; apparent casing joints at 1,025 and 1,065, large concretions at 1,077 and 1,092 feet
1,100	1,200	As above, with apparent casing joints at 1,104, 1,144, and 1,184 feet; area around 1,144 feet is very rough; an apparent hole in the well bore at 1,177 feet
1,200	1,300	As above, well bore is very rough with large to small concretions; apparent casing joints at 1,224 and 1,264 feet
1,300	1,400	Apparent casing joint at 1,342 feet, large concretions at 1,351 and 1,381 feet, continue to have uphole flow
1,400	1,500	Possible casing joints at 1,420 and 1,459 feet, well bore is extremely rough with heavy concretions that appear to be rocks down to 1,500 feet
1,500	1,600	Relatively smooth well bore with fewer concretions, a possible casing joint at 1,538 feet, uphole flow still apparent at 1,550 feet
1,600	1,700	Picture becomes darker, relatively smooth with large to small concretion, a possible casing joint at 1,697 feet
1,700	1,800	As above; a very rough concentric ring at 1,737 and 1,778 feet - possible casing joints
1,800	1,900	As above; from 1,850 feet concretions become more numerous, extremely rough at 1,858 feet, diameter of well bore becomes smaller, casing does not appear to be present, uphole flow continues to be present, a heavy concretion ring at 1,897 feet
1,900	2,000	Buildup appears to be less down to a depth of 1,977 feet, at 1,977 feet well bore becomes extremely rough down to 2,000 feet
2,000	2,100	Well bore continues to be extremely rough, casing is not apparent, at 2,018 and 2,057 feet heavy concentric concretions

2,100	2,200	Well bore continues to be extremely rough, casing is not apparent; at 2,137, 2,178, 2,193 feet heavy concentric concretions
2,200	2,259	Well bore continues to be extremely rough; at 2,218 feet diameter becomes smaller because of large concretions; a 2,257 feet hole diameter becomes more restrictive, camera hanging up, can not proceed any further than 2,259 feet because of extremely heavy buildup as shown on the caliper.

Appendix C

Laboratory Analytical Data From Depth Samples

QUALITY ANALYTICAL LABORATORIES

November 5, 1992

Sean Skehan
CH2M HILL/DFB

RE: Analytical Data for Ft. Lauderdale
LGN Laboratory No. 119099 - 119108

Dear Sean Skehan:

On October 15, 1992, the CH2M HILL Gainesville Laboratory received nine samples with a request for analysis of selected inorganic parameters.

The analytical results and associated quality control data are enclosed. Any unusual difficulties encountered during the analyses of these samples are discussed in the case narratives.

Under CH2M HILL policy, your samples will be stored for up to 30 days after reporting. If you have not given us prior instructions for disposal, we will contact you if any samples require disposal as hazardous waste.

CH2M HILL Laboratories appreciate your business and look forward to serving your analytical needs again. If you should have any questions concerning the data, or if you need additional information, please call Barry Patterson in Client Services, or myself, at 904-462-3050.

Sincerely,

for Tom Emenhiser
Manager
Client Services

Enclosures

State Certifications:

Florida No. 82112, E82124
Alabama No. 40080

CH2M HILL Gainesville Laboratory One Innovation Drive, Suite C, Alachua, FL 32615-9586 P.O. Box 370, Alachua, FL 32615-0370 904.462.3050 FAX 904.462.1670

TABLE OF CONTENTS

CH2M HILL Laboratory No. 119099 - 119108

CLIENT SAMPLE CROSS-REFERENCE

CH2M HILL Laboratory No. 119099 - 119108

LGN Sample ID.	Client Sample ID.
119099	MW1-1300
119100	MW1-1300
119101	MW1-1300
119102	MW1-1950
119103	MW1-1950
119104	MW1-1950
119105	MW1-2225
119106	MW1-2225
119107	MW1-2225

CASE NARRATIVE
Cations

Lab Number: 119099 - 119108

Client/Project: Ft. Lauderdale

I. Holding Time:
All holding times were met.

II. Digestion Exceptions:
None

III. Analysis:

A. Calibration:
All acceptance criteria were met.

B. Blanks:
All acceptance criteria were met.

C. ICP Interference Check Sample:
All acceptance criteria were met.

D. Spike Sample(s):
All acceptance criteria were met.

E. Duplicate Sample(s):
All acceptance criteria were met.

F. Laboratory Control Sample(s):
All acceptance criteria were met.

G. ICP Serial Dilution:
Not required for this level QC.

H. Other:
None.

IV. Documentation Exceptions:
None

V. I certify that this data package is in compliance with the terms and conditions agreed to by the client and CH2M HILL, both technically and for completeness, except for the conditions detailed above. Release of the data contained in this hardcopy data package has been authorized by the Laboratory Manager or his designee, as verified by the following signature.

SIGNED: Isaac O. Lynch DATE: 11/05/92
Isaac Lynch
Supervisor, Inorganics Division

CASE NARRATIVE
General Chemistry

Lab Number: 119099 - 119108

Client/Project: Ft. Lauderdale

I. Holding Time:
All holding times were met.

II. Analysis:

A. Calibration:
All acceptance criteria were met.

B. Blanks:
All acceptance criteria were met.

C. Matrix Spike Sample(s):
All acceptance criteria were met.

D. Duplicate Sample(s):
All acceptance criteria were met.

E. Lab Control Sample(s):
All acceptance criteria were met.

F. Other:
None.

III. Documentation Exceptions:
None.

IV. I certify that this data package is in compliance with the terms and conditions agreed to by the client and CH2M HILL, both technically and for completeness, except for the conditions detailed above. Release of the data contained in this hardcopy data package has been authorized by the Laboratory Manager or his designee, as verified by the following signature.

SIGNED: Isaac O. Lynch DATE: 11/05/92

Isaac Lynch
Supervisor, Inorganics Division

Ft. Lauderdale	CH2M Hill
Attention: S. Skehan Address: DFB	Project No: SEF32544.03.20 Received: 10/15/92 Reported: 11/03/92

Collected: 10/12/92 by Mark Schilling
Type: water, grab
Location: Ft. Lauderdale

SAMPLE NUMBER	119099	119100	119101	119102	119103
SAMPLE DESCRIPTIONS	MW1-1300 10/12/92 10:40	MW1-1300 10/12/92 11:30	MW1-1300 10/12/92 13:00	MW1-1950 10/12/92 14:40	MW1-1950 10/12/92 15:40
GENERAL					
pH (Units)	n/r n/r	8.25 10/15/92	n/r n/r	n/r n/r	n/r n/r
Conductivity (umhos/cm)	n/r n/r	19,500 10/29/92	n/r n/r	n/r n/r	n/r n/r
Alkalinity	n/r n/r	96 10/29/92	n/r n/r	n/r n/r	n/r n/r
Bicarbonate (as HCO3)	n/r n/r	117 10/29/92	n/r n/r	n/r n/r	n/r n/r
Carbonate (as CO3=)	n/r n/r	<1.0 10/29/92	n/r n/r	n/r n/r	n/r n/r
SOLIDS					
Total Dissolved Solids	n/r n/r	11,920 10/15/92	n/r n/r	n/r n/r	n/r n/r
METALS					
Calcium - ICP	n/r n/r	n/r n/r	121 10/30/92	n/r n/r	268 10/30/92
Iron - ICP	n/r n/r	n/r n/r	53.0 10/30/92	n/r n/r	824 10/30/92
Magnesium - ICP	n/r n/r	n/r n/r	325 10/30/92	n/r n/r	584 10/30/92
Potassium - ICP	n/r n/r	n/r n/r	155 10/30/92	n/r n/r	222 10/30/92

NOTE: Values are mg/l as substance unless otherwise stated.

Respectfully submitted,

Isaac D. Lynch

Isaac D. Lynch, Inorganics Supervisor

n/r = not requested

NOTE: This report contains test data and no interpretation is intended or implied.

SAMPLE NUMBER	119099	119100	119101	119102	119103
SAMPLE DESCRIPTIONS	MW1-1300 10/12/92 10:40	MW1-1300 10/12/92 11:30	MW1-1300 10/12/92 13:00	MW1-1950 10/12/92 14:40	MW1-1950 10/12/92 15:40
Sodium - ICP	n/r	n/r	3540	n/r	5360
	n/r	n/r	10/30/92	n/r	10/30/92
ANIONS					
Chloride	n/r	670	n/r	n/r	n/r
	n/r	10/22/92	n/r	n/r	n/r
Sulfate	n/r	680	n/r	n/r	n/r
	n/r	10/27/92	n/r	n/r	n/r
NUTRIENTS					
Ammonia (as N)	6.13	n/r	n/r	6.19	n/r
	10/26/92	n/r	n/r	10/26/92	n/r
Nitrite (as N)	n/r	<0.02	n/r	n/r	n/r
	n/r	10/15/92	n/r	n/r	n/r
Nitrate & Nitrite (as N)	<0.02	n/r	n/r	<0.02	n/r
	10/21/92	n/r	n/r	10/21/92	n/r
Kjeldahl Nitrogen (as N)	6.69	n/r	n/r	6.63	n/r
	10/27/92	n/r	n/r	10/27/92	n/r

NOTE: Values are mg/l as substance unless otherwise stated.

Respectfully submitted,

Isaac D. Lynch, Inorganics Supervisor

n/r = not requested

NOTE: This report contains test data and no interpretation is intended or implied.

Ft. Lauderdale	CH2M Hill
Attention: S. Skehan Address: DFB	Project No: SEF32544.03.20 Received: 10/15/92 Reported: 11/03/92
Collected: 10/12/92 by Mark Schilling Type: water, grab Location: Ft. Lauderdale	

SAMPLE NUMBER	119104	119105	119106	119107	119108
SAMPLE DESCRIPTIONS	MW1-1950 10/12/92 09:50	MW1-2225 10/13/92 12:00	MW1-2225 10/13/92 13:10	MW1-2225 10/13/92 15:35	Laboratory Method Blank
GENERAL					
pH (Units)	8.40	n/r	8.30	n/r	Not Applicable
	10/15/92	n/r	10/15/92	n/r	10/15/92
Conductivity (umhos/cm)	28,000	n/r	29,300	n/r	<2.0
	10/29/92	n/r	10/29/92	n/r	10/29/92
Alkalinity	94	n/r	198	n/r	<1.0
	10/29/92	n/r	10/29/92	n/r	10/29/92
Bicarbonate (as HCO3)	93	n/r	188	n/r	<1.0
	10/29/92	n/r	10/29/92	n/r	10/29/92
Carbonate (as CO3=)	11	n/r	26	n/r	<1.0
	10/29/92	n/r	10/29/92	n/r	10/29/92
SOLIDS					
Total Dissolved Solids	18,900	n/r	20,600	n/r	<1.0
	10/15/92	n/r	10/15/92	n/r	10/15/92
METALS					
Calcium - ICP	n/r	n/r	n/r	291	<0.500
	n/r	n/r	n/r	10/30/92	10/30/92
Iron - ICP	n/r	n/r	n/r	47.2	<0.020
	n/r	n/r	n/r	10/30/92	10/30/92
Magnesium - ICP	n/r	n/r	n/r	654	<0.050
	n/r	n/r	n/r	10/30/92	10/30/92
Potassium - ICP	n/r	n/r	n/r	227	<1.00
	n/r	n/r	n/r	10/30/92	10/30/92

NOTE: Values are mg/l as substance unless otherwise stated.

Respectfully submitted,

Isaac D. Lynch

Isaac D. Lynch, Inorganics Supervisor

n/r = not requested

NOTE: This report contains test data and no interpretation is intended or implied.

SAMPLE NUMBER	119104	119105	119106	119107	119108
SAMPLE DESCRIPTIONS	MW1-1950 10/12/92 09:50	MW1-2225 10/13/92 12:00	MW1-2225 10/13/92 13:10	MW1-2225 10/13/92 15:35	Laboratory Method Blank
Sodium - ICP	n/r n/r	n/r n/r	n/r n/r	5520 10/30/92	<0.500 10/30/92
ANIONS					
Chloride	660 10/22/92	n/r n/r	690 10/22/92	n/r n/r	<1.0 10/22/92
Sulfate	1200 10/27/92	n/r n/r	1580 10/27/92	n/r n/r	<1.0 10/27/92
NUTRIENTS					
Ammonia (as N)	n/r n/r	5.42 10/26/92	n/r n/r	n/r n/r	<0.04 10/26/92
Nitrite (as N)	<0.02 10/15/92	n/r n/r	<0.02 10/15/92	n/r n/r	<0.02 10/15/92
Nitrate & Nitrite (as N)	n/r n/r	<0.02 10/21/92	n/r n/r	n/r n/r	<0.02 10/21/92
Kjeldahl Nitrogen (as N)	n/r n/r	5.60 10/27/92	n/r n/r	n/r n/r	<0.04 10/27/92

NOTE: Values are mg/l as substance unless otherwise stated.

Respectfully submitted,

Isaac D. Lynch

Isaac D. Lynch, Inorganics Supervisor

n/r = not requested

NOTE: This report contains test data and no interpretation is intended or implied.

Rec'd metals RG
Date + Time 10/15/92

CH2M HILL QUALITY ANALYTICS

CHAIN OF CUSTODY RECORD

PROJECT NUMBER	PROJECT NAME	CLIENT ADDRESS AND PHONE NUMBER
SEF32544.03.20	FT. LAUDERDALE	

CLIENT NAME: FT. LAUDERDALE

PROJECT MANAGER: S. SKEHAN/DFB

COPY TO:

REQUESTED COMP. DATE: STANDARD

SAMPLING REQUIREMENTS: SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____

FOR LAB USE ONLY

LAB#	GN00449
LAB#	AAH309
PROJECT NO.	
ACK	VERIFIED 7R 10/15
QUOTE#	BS
NO. OF SAMP 9	PG 1 OF 1

ANALYSES REQUESTED ✓ ✱

STA NO.	1992 DATE	TIME	COMP	GRAB	SOIL	SAMPLE DESCRIPTIONS (12 CHARACTERS)	# OF CONTAINERS	NH_3, TKN, NO_{23} (H_2SO_4)	Ca, Mg, Fe, Na, K (HNO_3)	BiCARB, CARB, SO_4, NO_2, Cl^-, TDS, pH, COND		NH3, TKN, NO3/2, CARB, SO4, NO2, CL, TDS, PH, COND, HCO3, CA2, MG2, FE2, NA2, K2		LAB ID	REMARKS
1	10-12	1040		X		MW1-1300	1	1					119 099	001	✱ NOTE THE ADDITION OF pH & CONDUCTIVITY ANALYSIS
2	10-12	1130		X		MW1-1300	1			1			100	002	
3	10-12	1300		X		MWX1-1300 (MS)	1		1				101	003	
4	10-12	1440		X		MW1-1950	1	1					102	004	
5	10-12	1540		X		MW1-1950	1		1				103	005	
6	10-13	0950		X		MW1-1950	1			1			104	006	
7	10-13	1200		X		MW1-2225	1	1					105	007	
8	10-13	1310		X		MW1-2225	1			1			106	008	
9	10-13	1535		X		MW1-2225	1		1				107	009	
										Method blank			108		

SAMPLED BY AND TITLE	DATE/TIME	RELINQUISHED BY:	DATE/TIME
M. [signature]	10-13-92 / 1700	M. [signature]	10-14-92 / 1200
RECEIVED BY:	DATE/TIME	RELINQUISHED BY:	DATE/TIME
RECEIVED BY:	DATE/TIME	RELINQUISHED BY:	DATE/TIME
RECEIVED BY LAB: D Ward	DATE/TIME 10/15/92 1020	SAMPLE SHIPPED VIA: UPS (BUS) FED-EX HAND OTHER ____	AIR BILL# 106 578 233 3

HAZWRAP/NEESA	Y (N)
QC LEVEL	(1) 2 3
COC Y	ICE Yes
ANA REQ Y	TEMP 2°C
CUST SEAL Y	Ph
SAMPLE COND. Good	

REMARKS

ENTERED INTO LIMS 7R 10/15 COC REVIEWED 7R 10/15

Appendix D
Isotopic Analytical Data

GGC GLOBAL *GEO*CHEMISTRY CORPORATION

TELEX: 4720127
FAX: (818) 992-8940

6919 ETON AVENUE • CANOGA PARK • CALIFORNIA 91303-2194 (818) 992-4103

December 22, 1992

Mr. Sean Skehan
CH^2M Hill
800 Fairway Drive, Suite 350
Deerfield Beach, FL 33441

Dear Mr. Skehan,

We are extremely sorry for the delay in completion of your project. Our primary concern was the anomalous values that we were obtaining for the oxygen and deuterium isotope analyses. We processed the three waters, three separate time, until realistic values were obtained. We feel that there was some component of the matrix which affected the values.

If there are any questions or comments, please call us. We will be closed December 24, 1992 through January 4, 1993. Best wishes for the happiest of holidays!

Jim Drury

Jim Drury
Sample Management Supervisor

jd/skehan-1.let

A1056 11-25-1992

Ammonium and Nitrate concentration for samples submitted by CH2M Hill.

Sample ID	GGC ID	NH4 (mg/L)	NO3 (mg/L)
MW1-1300	A1056-1	8.50	<0.015
MW1-1950	A1056-2	7.53	<0.016
MW1-2225	A1056-3	6.67	<0.016

Isotope data for samples submitted by CH2M Hill

Global Geochemistry Corporation 12-21-1992

Data file: W01056

Sample	GGCID	d18O	d18O Dup	NH4 Water d15N	d2H	d2H Dup
MW1-1300	1056-1	-1.0	-1.0	8.6	-2	-2
MW1-1950	1056-2	-0.7		7.6	-3	-4
INSERT BLANK	1056-3	-0.8		8.6	-3	-1
STANDARD						
1056-DL-1-296					-214	
1056-DL-2-296					-215	
1056-NH-1-296					32	
1056-NH-2-296					36	
1030-NH-1-296					35	
1029-NI-2-287		-11.6				
1029-NI-3-287		-11.7				
1067-KN-7				-3.6		

ESTABLISHED STANDARD VALUES

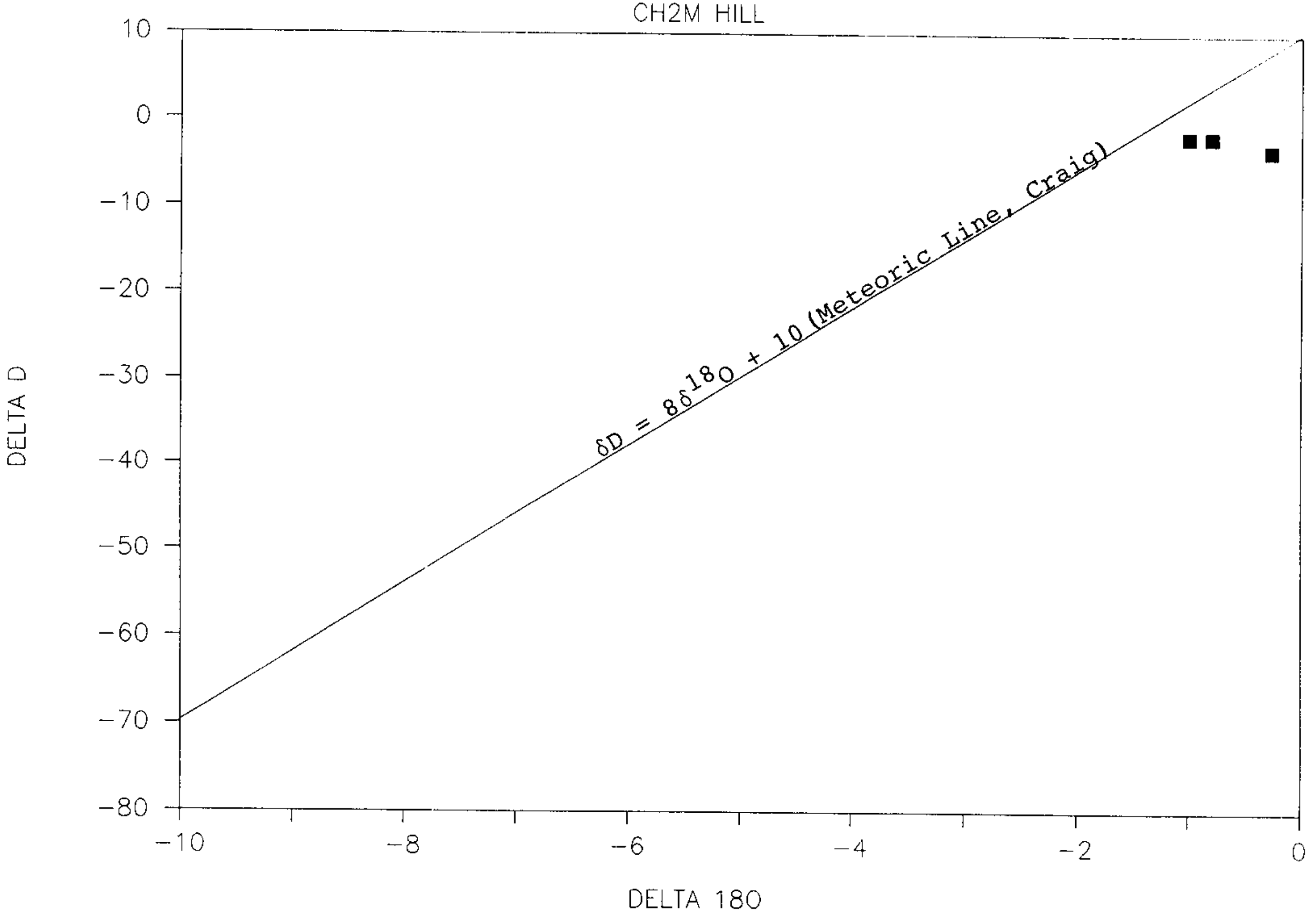
STANDARD	$\delta^{18}O$	δD	$\delta^{15}N$
NH		34	
DL		-215	
NI	-11.65		
KN			-3.6

Values are reported in $^{o}/oo$ relative to SMOW and AIR

Analyst

Supervisor

DELTA 18O VS. DELTA D



Appendix E

November 20, 1992 Letter to FDER Concerning Packerless Pressure Testing

CH2M HILL
Engineers
Planners
Economists
Scientists

November 20, 1992

SEF32544.03

Mr. Rich Duereling
Underground Injection Control Program
Florida Department of Environmental Regulation
2600 Blair Stone Road
Tallahassee, FL 32301

Dear Mr. Duereling:

Subject: Investigation of the Mechanical Integrity of the Multi-zone Monitor Well at the City of Fort Lauderdale G.T. Lohmeyer Wastewater Treatment Plant (WWTP)
Consent Order OGC 91-2455

This letter is to advise you of our discussions with the TAC Chairman (Mr. Al Mueller) on November 17, 1992, concerning the investigation of the mechanical integrity of the multi-zone monitor well at the G.T. Lohmeyer WWWTP. Recently collected depth samples (1,300 feet, 1950 feet and 2,225 feet) from the deep monitor tube (monitoring interval 2,568 to 2,670) demonstrate considerable differences in concentrations for several important analytical parameters. Table 1 presents a summary of the analytical data available to date. These samples were collected under static conditions after the monitor tube had been shut in for a period of 2 weeks.

While not conclusive, we interpret this preliminary data as strong evidence that there is a leak of some sort in the deep monitor tube, and as discussed with Mr. Mueller we are moving forward with a packerless pressure test to identify the location and approximate rate of a leakage. The packerless pressure test procedure will involve filling the deep monitor tube with potable water, and then shutting the tube in and observing the decay of the pressure caused by the difference in fluid densities. The rate of decay of the pressure head will give some approximation of the magnitude of the leak, and once the pressure stabilizes, the depth of the leak will be identified with a conductivity probe. Pressure within the two overlying monitor zones will be observed and recorded during this period, and if there is any evidence of connection, further investigations will attempt to confirm a migration pathway through the use of a suitable (non-radioactive) tracer. The data from this testing will be presented to the TAC at a meeting to be scheduled in the near future.

CH2M HILL Deerfield Beach Office 800 Fairway Drive, Suite 350
Deerfield Beach,
Florida 33441
305.426.4008
407.737.6665
Fax 305.698.6010

Table 1			
Description	**Depth 1,300 feet**	**Depth 1,950 feet**	**Depth 2,225 feet**
General			
pH (Units)	8.25	8.40	8.30
Conductivity (umhos/cm)	19,500	28,000	29,300
Alkalinity	96	94	198
Bicarbonate (as HC03)	117	93	188
Carbonate (as C03=)	<1.0	11	26
Solids			
Total Dissolved Solids	11,920	18,900	20,600
Metals			
Calcium	121	268	291
Iron	53.0	824	47.2
Magnesium	325	584	654
Potassium	155	222	227
Sodium	3,540	5,360	5,520
Anions			
Chloride	670	660	690
Sulfate	680	1,200	1,580
Nutrients			
Ammonia (as N)	6.13	6.19	5.42
Nitrite (as N)	<0.02	<0.02	<0.02
Nitrate & Nitrite (as N)	<0.02	<0.02	<0.02
Kjeldahl Nitrogen (as N)	6.69	6.63	5.60

If you have any questions concerning this matter, please feel free to contact me at (305) 426-4008.

Sincerely,

CH2M HILL

Thomas M. McCormick
Senior Hydrogeologist

set/10011C2C.DFB

cc: Al Mueller/FDER/WPB
Frank Coulter/City of Fort Lauderdale
Mike Bailey/City of Fort Lauderdale
Sean Skehan/CH2M HILL

Appendix F

Deep Monitor Zone Geophysical Logs

TEMPERATURE

CH2M HILL

MW-1, DEEP ZONE

COMPANY	: CITY OF FT. LAUDERDALE			OTHER SERVICES:			
WELL	: MW-1, DEEP ZONE						
LOCATION/FIELD	: PORT EVERGLADES						
COUNTY	: BROWARD						
STATE	: FL						
SECTION	: 14	TOWNSHIP	: 50S	RANGE	: 42E		
DATE	: 08/21/92	PERMANENT DATUM	: PL	ELEVATIONS			
DEPTH DRILLER	: 2670	ELEV. PERM. DATUM:		KB	:		
LOG BOTTOM	: 2374.00	LOG MEASURED FROM:	PL	DF	:		
LOG TOP	: 99.50	DRL MEASURED FROM:	PL	GL	:		
CASING DRILLER	: 2670	LOGGING UNIT	: 1				
CASING TYPE	: STEEL	FIELD OFFICE	: DFB				
CASING THICKNESS	: .375	RECORDED BY	: M. SCHILLING				
BIT SIZE	: 00000000	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL		
MAGNETIC DECL.	: 7.5	RM	: 0	TYPE	: WTEM		
MATRIX DENSITY	: 2.68	RM TEMPERATURE	: 0	LOG	: 5		
FLUID DENSITY	: 1.0	MATRIX DELTA T	: 57	PLOT	: MARK 11		
NEUTRON MATRIX	: LIMESTONE	FLUID DELTA T	: 210	THRESH	: 2500		

REMARKS :
OBSERVER: S. SKEHAN - CH2M HILL (DFB), LOG START TIME AT APPROX. 1030 AM
MULTI-ZONE WELL W/ALL ZONES CLOSED OFF, 1ST LOG OF DAY

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS

CHART NO. WD

TEMPERATURE

MW-1, DEEP ZONE

04

COMPANY	: CITY OF FT. LAUDERDALE			OTHER SERVICES:	
WELL	: MW-1, DEEP ZONE				
LOCATION/FIELD	: PORT EVERGLADES				
COUNTY	: BROWARD				
STATE	: FL				
SECTION	: 14	TOWNSHIP	: 50S	RANGE	: 42E
DATE	: 08/21/92	PERMANENT DATUM	: PL	ELEVATIONS	
DEPTH DRILLER	: 2670	ELEV. PERM. DATUM:		KB	:
LOG BOTTOM	: 2376.00	LOG MEASURED FROM:	PL	DF	:
LOG TOP	: 902.00	DRL MEASURED FROM:	PL	GL	:
CASING DRILLER	: 2670	LOGGING UNIT	: 1		
CASING TYPE	: STEEL	FIELD OFFICE	: DFB		
CASING THICKNESS:	.375	RECORDED BY	: M. SCHILLING		
BIT SIZE	: 00000000	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL
MAGNETIC DECL.	: 7.5	RM	: 0	TYPE	: WTEM
MATRIX DENSITY	: 2.68	RM TEMPERATURE	: 0	LOG	: 6
FLUID DENSITY	: 1.0	MATRIX DELTA T	: 57	PLOT	: MARK 11
NEUTRON MATRIX	: LIMESTONE	FLUID DELTA T	: 218	THRESH:	2500

REMARKS :
OBSERVER: S. SKEHAN - CH2M HILL (DFB), LOG START TIME AT APPROX. 1200 PM
MULTI-ZONE WELL W/ALL ZONES PUMPING & FLOWING @ APPROX. 40 GPM, 2ND LOG OF DAY

FLUID RESISTIVITY

CH2M HILL

MW-1, DEEP ZONE

COMPANY	: CITY OF FT. LAUDERDALE			OTHER SERVICES:	
WELL	: MW-1, DEEP ZONE				
LOCATION/FIELD	: PORT EVERGLADES				
COUNTY	: BROWARD				
STATE	: FL				
SECTION	: 14	TOWNSHIP	: 50S	RANGE	: 42E
DATE	: 09/03/92	PERMANENT DATUM	: PL	ELEVATIONS	
DEPTH DRILLER	: 2670	ELEV. PERM. DATUM:		KB	:
LOG BOTTOM	: 2250.00	LOG MEASURED FROM:	PL	DF	:
LOG TOP	: 99.00	DRL MEASURED FROM:	PL	GL	:
CASING DRILLER	: 2670	LOGGING UNIT	: 1		
CASING TYPE	: STEEL	FIELD OFFICE	: DFB		
CASING THICKNESS	: .375	RECORDED BY	: M. SCHILLING		
BIT SIZE	: 00000000	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL
MAGNETIC DECL.	: 7.5	RM	: 0	TYPE	: WELR
MATRIX DENSITY	: 2.68	RM TEMPERATURE	: 0	LOG	: 7
FLUID DENSITY	: 1.0	MATRIX DELTA T	: 57	PLOT	: MARK 13
NEUTRON MATRIX	: LIMESTONE	FLUID DELTA T	: 210	THRESH:	2500

REMARKS :
OBSERVER: S. SKEHAN - CH2M HILL (DFB), 1ST LOG OF DAY
MULTI-ZONE WELL W/ALL ZONES CLOSED OFF, WELL STATIC FOR APPROX. 60 HRS

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS

FLUID RESISTIVITY

CH2M HILL

MW-1, DEEP ZONE

COMPANY	: CITY OF FT. LAUDERDALE			OTHER SERVICES:	
WELL	: MW-1, DEEP ZONE				
LOCATION/FIELD	: PORT EVERGLADES				
COUNTY	: BROWARD				
STATE	: FL				
SECTION	: 14	TOWNSHIP	: 50S	RANGE	: 42E
DATE	: 09/03/92	PERMANENT DATUM	: PL	ELEVATIONS	
DEPTH DRILLER	: 2670	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 2260.00	LOG MEASURED FROM	: PL	DF	:
LOG TOP	: 1002.00	DRL MEASURED FROM	: PL	GL	:
CASING DRILLER	: 2670	LOGGING UNIT	: 1		
CASING TYPE	: STEEL	FIELD OFFICE	: DFB		
CASING THICKNESS	: .375	RECORDED BY	: M. SCHILLING		
BIT SIZE	: 00000000	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL
MAGNETIC DECL.	: 7.5	RM	: 0	TYPE	: WELR
MATRIX DENSITY	: 2.68	RM TEMPERATURE	: 0	LOG	: 8
FLUID DENSITY	: 1.0	MATRIX DELTA T	: 57	PLOT	: MARK 13
NEUTRON MATRIX	: LIMESTONE	FLUID DELTA T	: 210	THRESH	: 2500

REMARKS :
OBSERVER: S. SKEHAN - CH2M HILL (DFB), 2ND LOG OF DAY
MULTI-ZONE WELL W/DEEP ZONE PUMPING @ APPROX. 40 GPM. OTHER ZONES CLOSED OFF.

FLUID RESISTIVITY

CH2M HILL

MW-1, DEEP ZONE

COMPANY	: CITY OF FT. LAUDERDALE	OTHER SERVICES:			
WELL	: MW-1, DEEP ZONE				
LOCATION/FIELD	: PORT EVERGLADES				
COUNTY	: BROWARD				
STATE	: FL				
SECTION	: 14	TOWNSHIP	: 50S	RANGE	: 42E
DATE	: 09/03/92	PERMANENT DATUM	: PL	ELEVATIONS	
DEPTH DRILLER	: 2670	ELEV. PERM. DATUM:		KB	:
LOG BOTTOM	: 2258.00	LOG MEASURED FROM:	PL	DF	:
LOG TOP	: 1002.00	DRL MEASURED FROM:	PL	GL	:
CASING DRILLER	: 2670	LOGGING UNIT	: 1		
CASING TYPE	: STEEL	FIELD OFFICE	: DFB		
CASING THICKNESS:	.375	RECORDED BY	: M. SCHILLING		
BIT SIZE	: 00000000	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL
MAGNETIC DECL.	: 7.5	RM	: 0	TYPE	: WFLR
MATRIX DENSITY	: 2.68	RM TEMPERATURE	: 0	LOG	: 0
FLUID DENSITY	: 1.0	MATRIX DELTA T	: 57	PLOT	: MARK 13
NEUTRON MATRIX	: LIMESTONE	FLUID DELTA T	: 210	THRESH:	2500
REMARKS	:				

OBSERVER: S. SKEHAN - CH2M HILL (DFB), 3RD LOG OF DAY
MULTI-ZONE WELL W/MIDDLE ZONE PUMPING @ APPROX 23 GPM. OTHER ZONES CLOSED OFF.

FLUID RESISTIVITY

CH2M HILL

MW-1, DEEP ZONE

COMPANY	: CITY OF FT. LAUDERDALE			OTHER SERVICES:	
WELL	: MW-1, DEEP ZONE				
LOCATION/FIELD	: PORT EVERGLADES				
COUNTY	: BROWARD				
STATE	: FL				
SECTION	: 14	TOWNSHIP	: 50S	RANGE	: 42E
DATE	: 09/04/92	PERMANENT DATUM	: PL	ELEVATIONS	
DEPTH DRILLER	: 2670	ELEV. PERM. DATUM:		KB	:
LOG BOTTOM	: 2259.00	LOG MEASURED FROM:	PL	DF	:
LOG TOP	: 999.50	DRL MEASURED FROM:	PL	GL	:
CASING DRILLER	: 2670	LOGGING UNIT	: 1		
CASING TYPE	: STEEL	FIELD OFFICE	: DFB		
CASING THICKNESS:	.375	RECORDED BY	: M. SCHILLING		
BIT SIZE	: 00000000	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL
MAGNETIC DECL.	: 7.5	RM	: 0	TYPE	: WFLR
MATRIX DENSITY	: 2.68	RM TEMPERATURE	: 0	LOG	: 1
FLUID DENSITY	: 1.0	MATRIX DELTA T	: 57	PLOT	: MARK 13
NEUTRON MATRIX	: LIMESTONE	FLUID DELTA T	: 210	THRESH:	2500
REMARKS	:				

OBSERVER: S. SKEHAN - CH2M HILL(DFB), LOG START TIME AT APPROX. 1030 AM
MULTI-ZONE WELL W/ALL ZONES CLOSED OFF, 1ST LOG OF DAY

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS

FLUID RESISTIVITY

CH2M HILL

MW-1, DEEP ZONE

COMPANY	CITY OF FT. LAUDERDALE	OTHER SERVICES:			
WELL	MW-1, DEEP ZONE				
LOCATION/FIELD	PORT EVERGLADES				
COUNTY	BROWARD				
STATE	FL				
SECTION	14	TOWNSHIP	50S	RANGE	42E
DATE	09/04/92	PERMANENT DATUM	PL	ELEVATIONS	
DEPTH DRILLER	2670	ELEV. PERM. DATUM:		KB	:
LOG BOTTOM	2261.50	LOG MEASURED FROM:	PL	DF	:
LOG TOP	1002.00	DBL MEASURED FROM:	PL	GL	:
CASING DRILLER	2670	LOGGING UNIT	1.		
CASING TYPE	STEEL	FIELD OFFICE	DFB		
CASING THICKNESS	.375	RECORDED BY	M. SCHILLING		
BIT SIZE	00000000	BOREHOLE FLUID	WATER	FILE	ORIGINAL
MAGNETIC DECL.	7.5	RM	0	TYPE	WFLR
MATRIX DENSITY	2.68	RM TEMPERATURE	0	LOG	2
FLUID DENSITY	1.0	MATRIX DELTA T	57	PLOT	MARK 13
NEUTRON MATRIX	LIMESTONE	FLUID DELTA T	210	THRESH	2500

REMARKS :
OBSERVER: S. SKEHAN - CH2M HILL(DFB). LOG START TIME AT APPROX. 1130 AM
MULTI-ZONE WELL W/ALL ZONES PUMPING & FLOWING @ APPROX. 40 GPM. 2ND LOG OF DAY

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS

FLUID RESISTIVITY

CH2M HILL

MW-1, DEEP ZONE

COMPANY	CITY OF FT. LAUDERDALE			OTHER SERVICES:	TEMP
WELL	MW-1, DEEP ZONE				
LOCATION/FIELD	PORT EVERGLADES				
COUNTY	BROWARD				
STATE	FL				
SECTION	14	TOWNSHIP	50S	RANGE	42E
DATE	10/07/92	PERMANENT DATUM	PL	ELEVATIONS	
DEPTH DRILLER	2670	ELEV. PERM. DATUM		KB	
LOG BOTTOM	2261.27	LOG MEASURED FROM	PL	DF	
LOG TOP	-.73	DRL MEASURED FROM	PL	GL	
CASING DRILLER	2670	LOGGING UNIT	1		
CASING TYPE	STEEL	FIELD OFFICE	DFB		
CASING THICKNESS	.375	RECORDED BY	M. SCHILLING		
BIT SIZE	11.875	BOREHOLE FLUID	WATER	FILE	ORIGINAL
MAGNETIC DECL.	7.5	RM	0	TYPE	WFLB
MATRIX DENSITY	2.68	RM TEMPERATURE	0	LOG	3
FLUID DENSITY	1.0	MATRIX DELTA T	57	PLOT	MARK 13
NEUTRON MATRIX	LIMESTONE	FLUID DELTA T	210	THRESH	2500

REMARKS :
OBSERVER: S. SKEHAN - CH2M HILL (DFB). LOG START TIME AT APPROX. 1105 AM
MULTI-ZONE WELL W/ALL ZONES CLOSED OFF, STATIC FOR 7 DAYS, 1ST LOG OF DAY

TEMPERATURE

CH2M HILL

MW-1, DEEP ZONE

COMPANY	CITY OF FT. LAUDERDALE			OTHER SERVICES:	
WELL	MW-1, DEEP ZONE			FL, RES	
LOCATION/FIELD	PORT EVERGLADES				
COUNTY	BROWARD				
STATE	FL				
SECTION	14	TOWNSHIP	50S	RANGE	42E
DATE	10/07/92	PERMANENT DATUM	PL	ELEVATIONS	
DEPTH DRILLER	2670	ELEV. PERM. DATUM:		KB	
LOG BOTTOM	2376.50	LOG MEASURED FROM:	PL	DF	
LOG TOP	899.00	DRL MEASURED FROM:	PL	GL	
CASING DRILLER	2670	LOGGING UNIT	1		
CASING TYPE	STEEL	FIELD OFFICE	DFB		
CASING THICKNESS	.375	RECORDED BY	M. SCHILLING		
BIT SIZE	11.875	BOREHOLE FLUID	WATER	FILE	ORIGINAL
MAGNETIC DECL.	7.5	RM	0	TYPE	WTEM
MATRIX DENSITY	2.68	RM TEMPERATURE	0	LOG	5
FLUID DENSITY	1.0	MATRIX DELTA T	57	PLOT	MARK 11
NEUTRON MATRIX	LIMESTONE	FLUID DELTA T	210	THRESH:	2500

REMARKS :
OBSERVER: S. SKEHAN - CH2M HILL (DFB), LOG START TIME AT APPROX. 1355 PM
MULTI-ZONE WELL W/ALL ZONES CLOSED OFF, WELL STATIC FOR 7 DAYS. 2ND LOG OF DAY

FLUID RESISTIVITY

CH2M HILL

MW-1, DEEP ZONE

COMPANY	: CITY OF FT. LAUDERDALE			OTHER SERVICES:	
WELL	: MW-1, DEEP ZONE				
LOCATION/FIELD	: PORT EVERGLADES				
COUNTY	: BROWARD				
STATE	: FL				
SECTION	: 14	TOWNSHIP	: 50S	RANGE	: 42E
DATE	: 12/03/92	PERMANENT DATUM	: PL	ELEVATIONS	
DEPTH DRILLER	: 2670	ELEV. PERM. DATUM:		KB	:
LOG BOTTOM	: 2261.00	LOG MEASURED FROM:	PL	DF	:
LOG TOP	: 1901.50	DRL MEASURED FROM:	PL	GL	:
CASING DRILLER	: 2670	LOGGING UNIT	: 1		
CASING TYPE	: STEEL	FIELD OFFICE	: DFB		
CASING THICKNESS:	.375	RECORDED BY	: M. SCHILLING		
BIT SIZE	: 00000000	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL
MAGNETIC DECL.	: 7.5	RM	: 0	TYPE	: WFLR
MATRIX DENSITY	: 2.68	RM TEMPERATURE	: 0	LOG	: 7
FLUID DENSITY	: 1.0	MATRIX DELTA T	: 57	PLOT	: MARK 13
NEUTRON MATRIX	: LIMESTONE	FLUID DELTA T	: 210	THRESH:	2500

REMARKS :
OBSERVER: S. SKEHAN - CH2M HILL (DFB)
LOGGED ON A PACKERLESS PRESSURE TEST W/1000 GALS. POTABLE WATER

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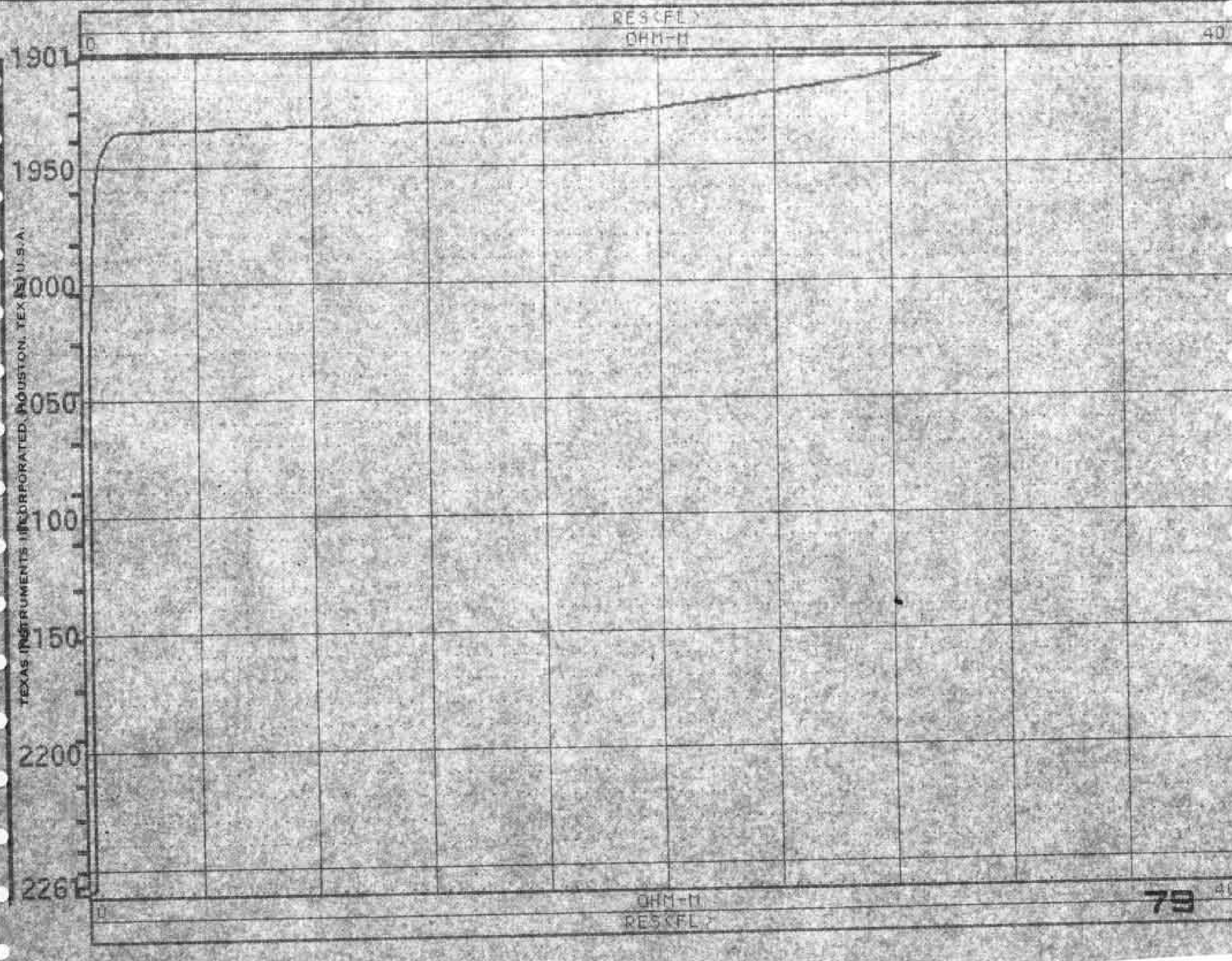

FLUID RESISTIVITY

CH2M HILL

MW-1, DEEP ZONE

COMPANY	: CITY OF FT. LAUDERDALE			OTHER SERVICES:	
WELL	: MW-1, DEEP ZONE				
LOCATION/FIELD	: PORT EVERGLADES				
COUNTY	: BROWARD				
STATE	: FL				
SECTION	: 14	TOWNSHIP	: 50S	RANGE	: 42E
DATE	: 12/04/92	PERMANENT DATUM	: PL	ELEVATIONS	
DEPTH DRILLER	: 2670	ELEV. PERM. DATUM:		KB	:
LOG BOTTOM	: 2261.00	LOG MEASURED FROM:	PL	DF	:
LOG TOP	: 1.00	DRL MEASURED FROM:	PL	GL	:
CASING DRILLER	: 2670	LOGGING UNIT	: 1		
CASING TYPE	: STEEL	FIELD OFFICE	: DFB		
CASING THICKNESS:	.275	RECORDED BY	: M. SCHILLING		
BIT SIZE	: 00000000	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL
MAGNETIC DECL.	: 7.5	RM	: 0	TYPE	: WFLR
MATRIX DENSITY	: 2.68	RM TEMPERATURE	: 0	LOG	: 8
FLUID DENSITY	: 1.0	MATRIX DELTA T	: 57	PLOT	: MARK 13
NEUTRON MATRIX	: LIMESTONE	FLUID DELTA T	: 210	THRESH:	2500

REMARKS

OBSERVER: S. SKEHAN - CH2M HILL <DFB>, LOG START TIME AT APPROX. 1500 PM

LOGGED ON A PACKERLESS PRESSURE TEST W/1000 GALS. POTABLE WATER

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS

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