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HYDROGEOLOGIC STUDY
FOR
THE SEMINOLE TRIBE OF FLORIDA

July, 1987

by

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HYDROGEOLOGIC STUDY
FOR
THE SEMINOLE TRIBE OF FLORIDA

INTRODUCTION

The Seminole Indians of Florida (the "Tribe"), undertaking the task of identifying their water rights in the State, particularly within South Florida Water Management District (SFWMD), have agreed to establish a Water Rights Compact (the "Compact") between the Tribe, the State of Florida, and SFWMD. During the Compact negotiations, the Tribe and United States Sugar Corporation (USSC) entered into an agreement in order to avoid controversy over the development of the groundwater and surface water resources in lands adjacent to the Big Cypress Seminole Reservation (the "Reservation").

The agreement between the Tribe and USSC outlines the method by which water resources in this area will be shared between the two parties. To implement this method, site specific aquifer characteristics are needed. The purpose of this study is to determine the aquifer characteristics of the Lower Tamiami Aquifer within the Reservation by aquifer performance testing. This testing involves withdrawing a measured quantity of water from a well and measuring the head (or water level) changes in the aquifer both during and after the period of discharge.

The study presented here discusses the local and site specific geology and hydrogeology, the Aquifer Performance Test (APT) results, and general water availability.

DESCRIPTION OF STUDY AREA

General

The test site and area of the Reservation included in this study are located in the southeast corner of Hendry County, within Ranges 32, 33, and 34 East and Township 48 South, as shown in Figure 1. Of the lands included in the study area, about 25% are improved pasture, 4% are citrus grove, and the balance are undeveloped uplands and wetlands. The test site for the study is located in an area of improved pasture, which lies in Section 14, Township 48 South, Range 34 East.

Geology

The geology of Hendry County has been generally described by Klein, Schroeder, and Lichten (1964). The general sequence of the geologic formations underlying the study area, according to Klein, et. al., are shown in Table 1.

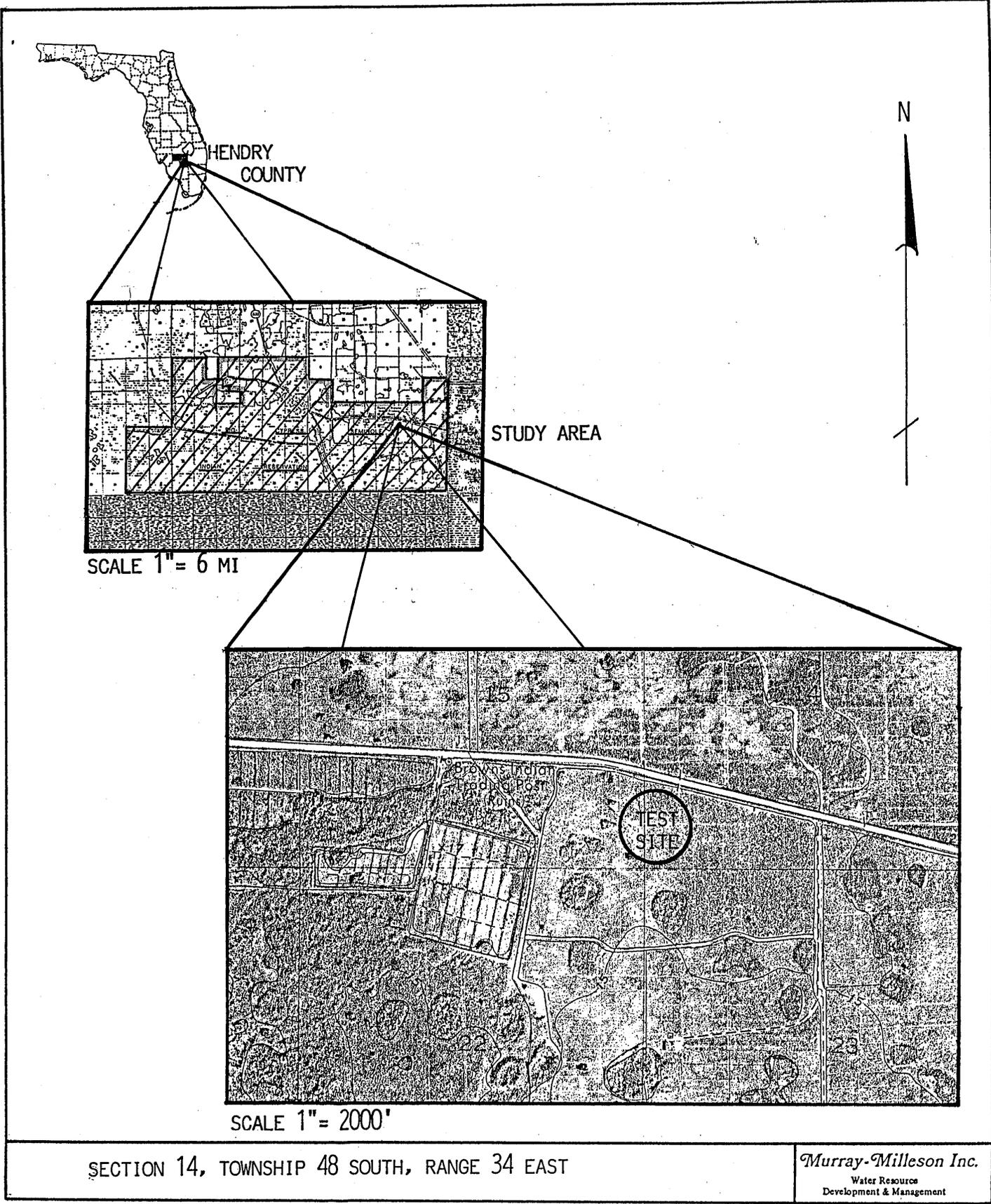


FIGURE 1: LOCATION MAP

TABLE 1: GENERAL SEQUENCE OF GEOLOGIC FORMATIONS
IN THE STUDY AREA

FORMATION or GROUP	ESTIMATED THICKNESS (FEET)	LITHOLOGY
Post-Miocene*	60	Sand, shell, silt/clay, marl and limestone
Tamiami Formation	90	Sand, marl, shell beds, and limestone
Hawthorn Formation	350	Clay marl, sand, gravel, and limestone
Tampa Formation	190	Sandy limestone
Suwannee Formation	350	Limestone
Ocala Group	300	Limestone and dolomite
Avon Park Limestone	200	Limestone and dolomite

*General term identifying sediments of Recent to Miocene age.

The geologic formations encountered at the test site include about 35 feet of Undifferentiated sediments underlain by 90-100 feet of the Tamiami Formation. The Undifferentiated sediments consist of pinkish gray quartz sands and shell, and light gray to olive gray sandy clays. The Tamiami Formation is predominately light gray fossiliferous limestone and minor sandy clay, marl, and sand. Figure 2 shows a general lithologic column for the test area. The sediments described as Post-Miocene by Klein, et. al., are identified in this report as Undifferentiated sediments.

Hydrogeology

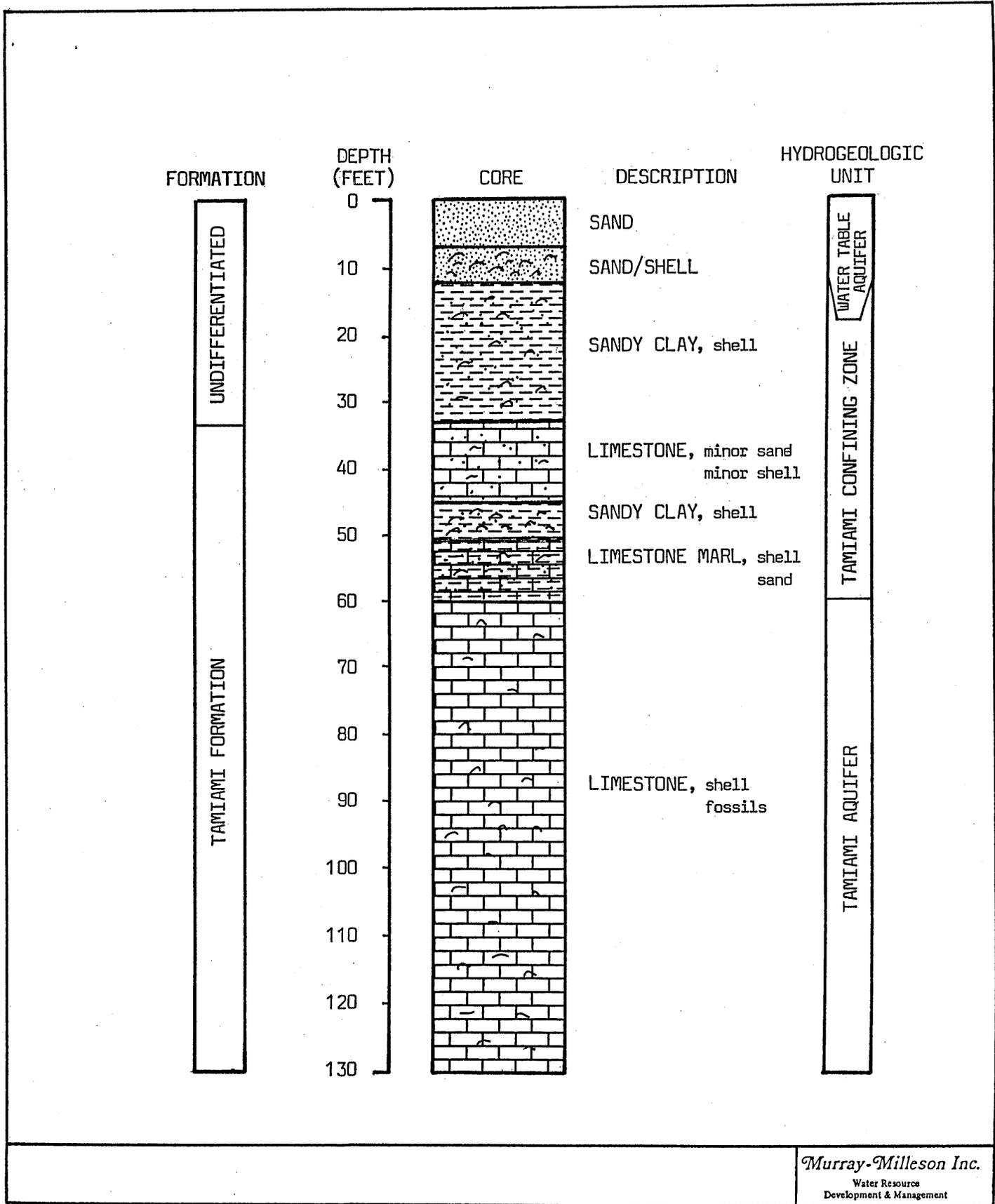
A review of previous hydrogeologic work done in the area of the Reservation was conducted. The only published data found was work done by Klein, et. al. (1964) in an area north of the Reservation. According to this work, two aquifer systems are identified: the shallow aquifer system and the Floridan Aquifer. The shallow aquifer system consists of the sediments above the Tamiami Formation and the permeable beds of shell, limestone or mixtures of sand and gravel in the Tamiami Formation and the upper part of the Hawthorn Formation. The Floridan Aquifer consists of water-bearing limestones that start at the base of the Hawthorn Formation and extend to an unknown depth below the Avon Park Limestone.

As part of a study that SFWMD is currently conducting in Hendry and Glades counties, aquifer data was collected from two sites within the Reservation. The results of that work are preliminary and subject to revision, but are provisionally presented here for discussion purposes. The aquifers encountered during their work are identified as follows: the Surficial Aquifer System which includes the Water Table Aquifer and Lower Tamiami Aquifer, consisting of the water-bearing sediments within the Undifferentiated sediments and the Tamiami Formation, and; the mid-Hawthorn Aquifer, consisting of the permeable limestones in the upper part of the Hawthorn Formation. The unnamed shallow aquifers identified by Klein, et. al., correlate to the Water Table, Lower Tamiami and mid-Hawthorn Aquifers identified by SFWMD.

Hydrogeologic data has been collected by USSC as part of their citrus development. This data collection effort includes three areas, located just north of the Reservation, where aquifer tests were performed. This data was provided as part of the above mentioned agreement.

Aquifer characteristics for the Lower Tamiami Aquifer were determined by pump testing at each of the areas cited above. Figure 3 shows a map with the location of each test and the corresponding aquifer characteristics. In general, it appears that the transmissivity values increase to the south.

The aquifers encountered at the test site for this study were the Water Table Aquifer and the Lower Tamiami Aquifer. Because the



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FIGURE 2: GENERAL ON-SITE GEOLOGIC COLUMN

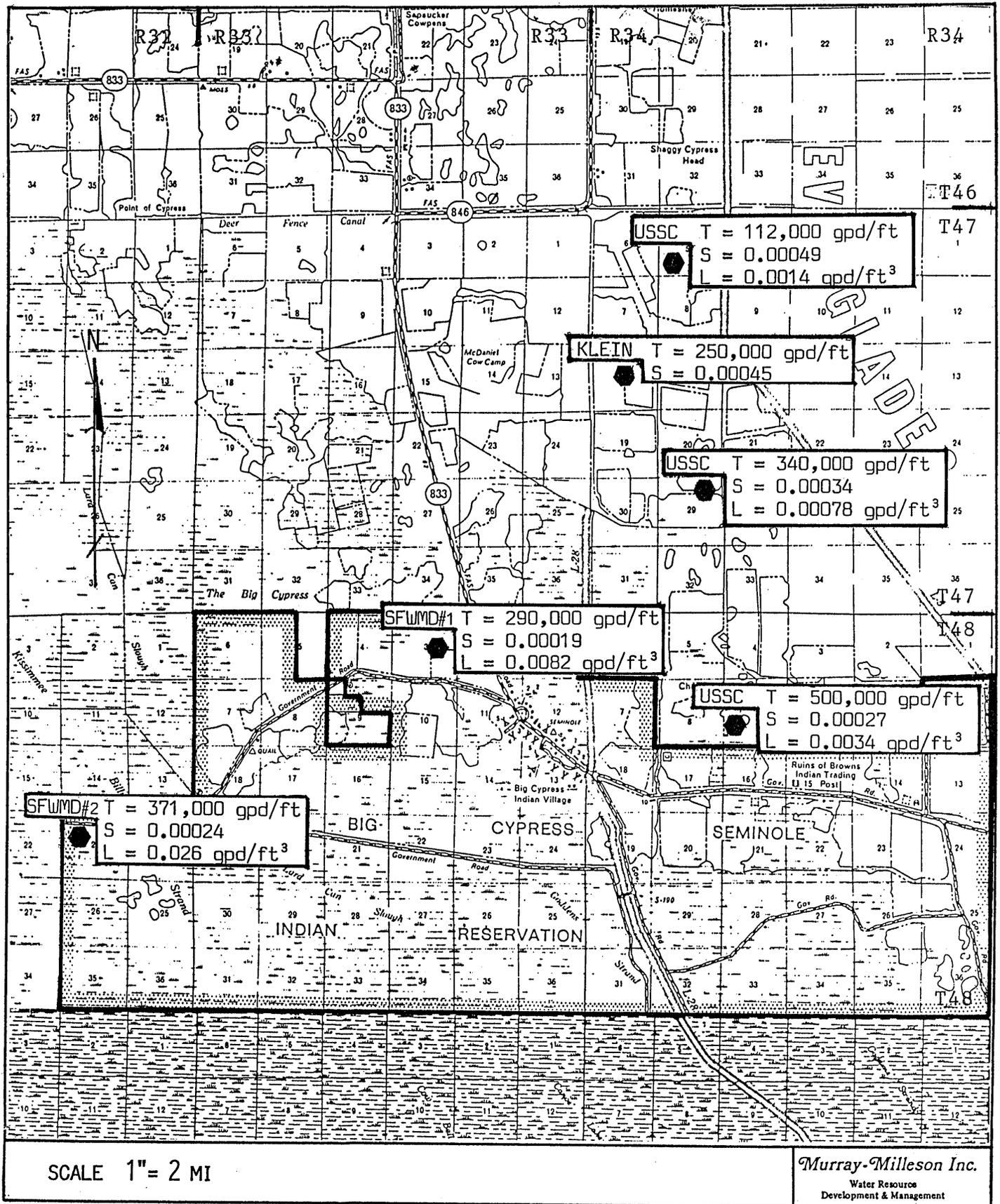


FIGURE 3: LOWER TAMAMIAMI AQUIFER CHARACTERISTICS

Water Table Aquifer consists of low permeable sediments and yields small amounts of water, this study concentrates on the Lower Tamiami Aquifer.

METHOD OF STUDY

Well Descriptions

The test production well and three (3) of the monitoring wells used during the APT were installed by Costello Well Drilling. These wells are four (4) inches in diameter, were constructed with PVC pipe by mud-rotary drilling to the dimensions described in Table 2, and were developed by airlifting. The test production well (PW) and two (2) monitoring wells (OB 1 and OB 2) were completed into the Lower Tamiami Aquifer. One (1) monitoring well (WT) was drilled only into the Water Table Aquifer. An existing 8-inch diameter steel well completed into the Lower Tamiami Aquifer was also used during the test.

Aquifer Performance Test

The set-up of the pump test is depicted in Figure 4. A portable 3-inch, 5-horsepower centrifugal pump with 20 feet of intake pipe was used to pump the test production well. The discharge rate was monitored at the end of the discharge pipe by using a 4-inch by 3-inch orifice and plastic manometer tube. So the discharge would not interfere with the results of the test, it was routed away from the site through an existing ditch which was lined with plastic for 500 feet. The water levels in each monitoring well were measured with electric tapes.

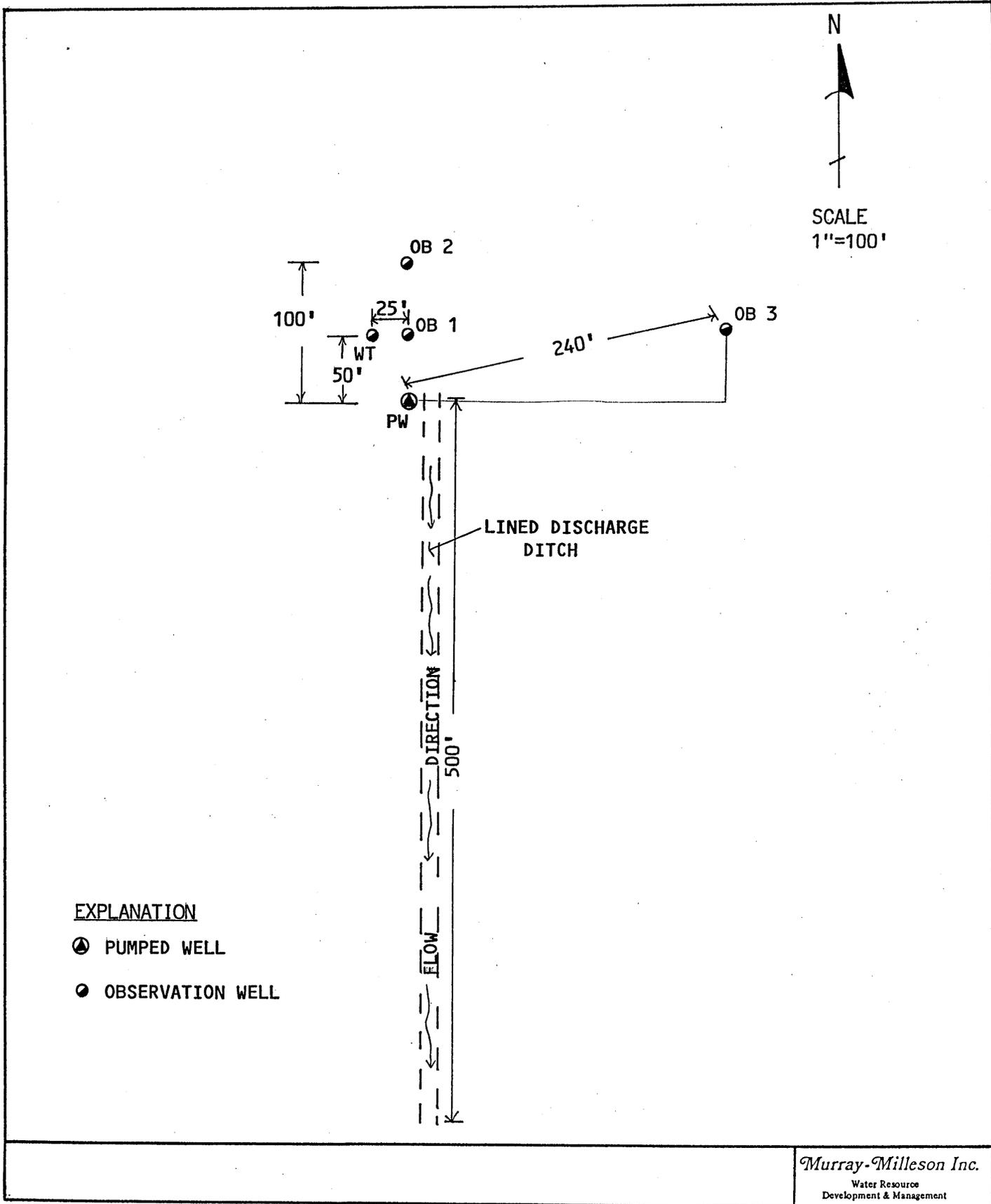
Background water level data collected prior to the test indicated only minor fluctuations which were probably caused by barometric pressure changes. A 72-hour pump test was originally planned, however, mechanical problems abbreviated the plans. The test started on May 23, 1987 and continued for 24 hours pumping 230 gallons per minute (gpm) when the pump stopped. After reviewing the data and determining it to be unsatisfactory because of pump fluctuations, the test was restarted after the aquifer recovered for 10 hours. The test was restarted and continued at a pumping rate of 197 gpm for 12 hours before the pump again malfunctioned and stopped. Four (4) hours of recovery data was collected from the continuous recorder installed on OB 2. Even though the duration of the second test was shorter than the first, the data did not show pump fluctuations. Consequently, the data from the second test was used in the calculations to determine the aquifer characteristics. The test results from the second test are tabulated and included in the Appendix.

RESULTS AND DISCUSSION

To properly assess the effects of pumping a confined or semi-confined aquifer, it is necessary to determine three hydraulic coefficients: transmissivity, storage, and leakance.

TABLE 2: CONSTRUCTION DETAILS OF TEST WELLS

	OB 1	OB 2	OB 3	PW	WT
Diameter (Inches)	4	4	8	4	4
Cased Depth (Feet)	63	70	75	63	10
Total Depth (Feet)	120	120	126	120	20
Casing Type	PVC	PVC	STEEL	PVC	PVC
Finish	Open	Open	Open	Open	Screen



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FIGURE 4: SCHEMATIC DIAGRAM OF TEST SET-UP

Transmissivity (T) is the rate at which water is transmitted through a unit width of an aquifer (1 foot) and extending the full saturated thickness, under a unit hydraulic gradient of 1; usually expressed as gallons per day per foot (gpd/ft). Storage (S) is the volume of water that an aquifer releases from or takes into storage per unit surface area of aquifer per unit change in head, a dimensionless number. Leakage (L) is the rate that water leaks through a confining bed as a result of head declines, usually expressed as gallons per day per cubic foot (gpd/cu ft). Values of T can range from less than 1,000 to more than 1 million gpd/ft. If an aquifer has a transmissivity of less than 1,000 gpd/ft, it can supply only enough water for small domestic wells. When the transmissivity is 10,000 gpd/ft or more, well yields can be adequate for municipal or irrigation purposes; however, the higher the value, the more the aquifer yields with less drawdown to the aquifer water levels.

These three coefficients are determined by analyzing the data collected from the aquifer performance test. To describe the flow regime of the groundwater, mathematical equations are used to relate well discharge to drawdown. The equations used to analyze the data from this test are described below.

Glover analysis of leaky aquifers, using a family of type curves (Ahrens, et. al., 1985)

$$T = \frac{229.2Q}{s} \quad S = \frac{0.134Ttx^2}{r^2} \quad L = \frac{Tx^2}{r^2}$$

where,

T = transmissivity, gpd/ft
 Q = pumping rate, gpm
 s = drawdown, ft
 r = distance of observation well from pumped well, ft
 t = time, days
 x = value of the matched type curve
 S = storage coefficient, dimensionless
 L = leakage, gpd/ft³

Jacob-Hantush time-drawdown, straight-line, approximation (Driscoll, 1986)

$$T = \frac{264Q}{\Delta s} \quad S = \frac{0.3Tt}{r^2} t_0$$

where,

Δs = the change in drawdown over one log cycle, ft
 t_0 = intercept of the straight line at zero drawdown, days

Jacob-Hantush distance-drawdown approximation (Driscoll, 1986)

$$T = \frac{528Q}{\Delta s} \quad S = \frac{0.3Tt}{(r_0)^2} \quad L = \frac{1.25T}{(r_0)^2}$$

where,

t = time since pumping started, days

r₀ = intercept of extended straight line at zero drawdown, ft

Jacob-Hantush recovery (Ahrens, et. al., 1985)

$$T = \frac{264Q}{\Delta s'}$$

where,

Δs' = the change in residual drawdown over one log cycle, ft

The above equations assume the aquifer to be homogeneous, anisotropic, infinite in areal extent, of constant thickness, the production and observation wells having no storage capacity, and the wells fully penetrating the aquifer.

The test data for each well were plotted on the appropriate graph paper for each analysis and then matched with the corresponding family of type curves, if appropriate.

The results of the test varied slightly depending on the method of analysis and monitoring well location. In general, the aquifer characteristics are as follows: transmissivity of 520,000 gpd/ft, storage coefficient of 0.00043 and leakance of 0.0026 gpd/ft³. The leakance value could be questionable because of the short test duration; however, because the value is consistent with the others in the area and is feasible based on the lithology of the test site, the value is considered to be reasonable. During the test, the shallow monitoring well water level did not change significantly. Because of the relatively high leakance value, a slight decrease in the Water Table aquifer probably would have been recorded if the test had gone longer and was pumped at a higher rate. The plotted data for the test is presented in the Appendix, with the calculations for the aquifer characteristics shown on each graph. A summary of the calculated values is presented in Table 3.

Table 4 is a tabulation of water quality data from the Lower Tamiami Aquifer that were collected during this study and during the SFWMD study. The water appears to be of good quality, and should not create many problems if used for agricultural purposes. If used for municipal or industrial projects, some treatment may be needed to meet the appropriate water quality standards.

The results of this test are consistent with the previous work done in the area, which indicates an increase in transmissivity from the north to the south. Based on this work and the other work done on the Reservation, the Lower Tamiami Aquifer is a very productive aquifer. It is a leaky aquifer, which means water flows through an aquitard from above and/or below the aquifer. At the Reservation, an aquitard separates the Lower Tamiami Aquifer from the Water Table Aquifer. Theoretically, when the

TABLE 3: SUMMARY OF AQUIFER CHARACTERISTICS

WELL NO.	METHOD	TRANSMISSIVITY (gpd/ft)	STORAGE COEFFICIENT	LEAKANCE (gpd/ft ³)
OB 1	Curve Matching	501,700	0.00036	0.0032
	Straight Line	520,080	0.00039	
OB 2	Curve Matching	537,529	0.00042	0.0019
	Straight Line	520,080	0.00051	
OB 3	Straight Line	520,080	0.00046	0.0140
	Distance-Drawdown	452,243	0.00170	
<u>RECOVERY</u>				
OB 2	Straight Line	547,453		

TABLE 4: WATER QUALITY DATA

PARAMETERS	TEST SITE	SFWMD #1	SFWMD #2
Calcium (mg/l)		131.7	77.6
Magnesium (mg/l)		14.6	27.5
Chloride (mg/l)	90.0	129.9	101.7
Sulfate (mg/l)		24.2	93.2
Total Iron (mg/l)		<0.1	0.1
Total Dissolved Iron (mg/l)	0.2	<0.1	<0.1
Total Dissolved Solids (mg/l)		686.0	813.0
Color (units)		46.0	29.0
Conductivity (micromhos/cm)	750.0	1119.0	
pH	7.0	7.1	

Lower Tamiami Aquifer is stressed by pumpage, the lowered head in the aquifer will cause the water from the aquitard to flow downward, thus lowering the water levels in the Water Table Aquifer. The only time this would create a problem for the Tribe, is if heavy development is proposed near a protected wetland area.

As work plans are developed on the Reservation, the results of this study can be used to aid in the design of the groundwater supply systems.

SUMMARY AND CONCLUSIONS

To comply with a stipulation of an agreement between the Tribe and USSC, a 12-hour Aquifer Performance Test was conducted at the Big Cypress Seminole Reservation in Section 14, Township 48 South, Range 34 East, on May 25, 1987. The results of the test indicate that the Lower Tamiami Aquifer in the area of the test is a semi-confined aquifer with the following characteristics:

Transmissivity	520,000 gpd/ft
Storage Coefficient	0.00043
Leakance	0.0026 gpd/ft ³

Because the aquifer is semi-confined, development around protected wetlands will need special consideration.

Based on this work and previous work in the area, it is concluded that the Lower Tamiami Aquifer is very productive. With the proper design and management, the aquifer should be able to supply water needs for agricultural developments, such as, citrus, vegetables, sugar cane, etc., moderate industrial activities, and moderate municipal developments.

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Florida, Florida Geological Survey Report of Investigations
No. 37

APPENDIX

LITHOLOGIC DESCRIPTION

SEMINOLE TRIBE

OBSERVATION WELL #2

DEPTH (Feet)	DESCRIPTION
0 - 7	Sand, pinkish gray, medium to very coarse grained, subangular to subrounded
7 - 12	Sand and shell, pinkish gray, coarse to very coarse grained, subrounded; shell fragments, small, gastropods, bivalves
12 - 33	Sandy clay, light gray to olive gray; shell fragments
33 - 45	Limestone, light gray, sandy; minor shell
45 - 51	Sandy clay, light olive gray; large white to light gray oyster shell fragments
51 - 60	Fossiliferous limestone marl, light gray, soft, sandy, moldic
60 - 105	Fossiliferous limestone, light gray to very light gray, oyster shells, barnacles, coral, bivalves, sand dollars
105 - 120	Same as above except softer

AQUIFER PERFORMANCE TEST FORM

NAME: Seminole Indian Tribe
 PROJECT NAME:

DATE OF TEST: 5/24/87
 LOCATION: S14 T48 R34

DISTANCE FROM PUMPED WELL: 50 FEET WEATHER CONDITIONS: Clear
 PUMPING RATE: 197 GPM

WELL #: OB1 STATIC W L (FT BELOW TOC) 3.50

TIME (IN MINUTES)	WATER LEVEL FROM TOC	DRAWDOWN IN FEET
0.25	3.63	0.13
0.50	3.69	0.19
0.75	3.70	0.20
1.00	3.71	0.21
1.25	3.72	0.22
1.50	3.73	0.23
1.75	3.74	0.24
2.00		
2.50	3.75	0.25
3.00	3.76	0.26
3.50		
4.00	3.77	0.27
4.50		
5.00	3.78	0.28
6.00	3.79	0.29
7.00		
8.00	3.80	0.30
9.00		
10.00	3.81	0.31
11.00		
12.00	3.82	0.32
13.00		
14.00		
15.00		

PROJECT: Tribe
TIME
(IN MINUTES)

DATE: 5/24/87
WATER LEVEL
FROM TOC

WELL#: OB1
DRAWDOWN
IN FEET

20.00	3.84	0.34
25.00		
30.00	3.85	0.35
35.00		
40.00	3.87	0.37
45.00		
50.00	3.88	0.38
55.00		
60.00	3.89	0.39
70.00		
80.00	3.9	0.40
90.00		
100.00	3.91	0.41
110.00		
120.00	3.92	0.42
150.00	3.93	0.43
180.00	3.94	0.44
210.00		
240.00	3.95	0.45
270.00		
300.00	3.96	0.46
360.00		
420.00	3.97	0.47
540.00	3.98	0.48
720.00	3.99	0.49

AQUIFER PERFORMANCE TEST FORM

NAME: Seminole Indian Tribe
 PROJECT NAME:

DATE OF TEST: 5/24/87
 LOCATION: S14 T48 R34

DISTANCE FROM PUMPED WELL: 100 FEET WEATHER CONDITIONS: Clear

PUMPING RATE: 197 GPM

WELL #: OB2 STATIC W L (FT BELOW TOC) 4.67

TIME (IN MINUTES)	WATER LEVEL FROM TOC	DRAWDOWN IN FEET
0.25	4.76	0.09
0.50	4.80	0.13
0.75		
1.00	4.81	0.14
1.25	4.82	0.15
1.50		
1.75	4.83	0.16
2.00	4.84	0.17
2.50	4.85	0.18
3.00	4.86	0.19
3.50		
4.00	4.87	0.20
4.50	4.88	0.21
5.00		
6.00	4.89	0.22
7.00		
8.00		
9.00	4.90	0.23
10.00		
11.00	4.91	0.24
12.00		
13.00	4.92	0.25
14.00		
15.00		

PROJECT: Tribe
TIME
(IN MINUTES)

DATE: 5/24/87
WATER LEVEL
FROM TOC

WELL#: OB2
DRAWDOWN
IN FEET

20.00	4.94	0.27
25.00	4.95	0.28
30.00	4.96	0.29
35.00		
40.00	4.97	0.30
45.00		
50.00	4.98	0.31
55.00		
60.00	4.99	0.32
70.00		
80.00	5.00	0.33
90.00		
100.00	5.01	0.34
110.00		
120.00	5.02	0.35
150.00	5.03	0.36
180.00	5.04	0.37
210.00		
240.00	5.05	0.38
270.00		
300.00	5.06	0.39
360.00		
420.00	5.07	0.40
540.00	5.08	0.41
720.00	5.09	0.42

AQUIFER PERFORMANCE TEST FORM

NAME: Seminole Indian Tribe
 PROJECT NAME:

DATE OF TEST: 5/24/87
 LOCATION: S14 T48 R34

DISTANCE FROM PUMPED WELL: FEET WEATHER CONDITIONS: Clear

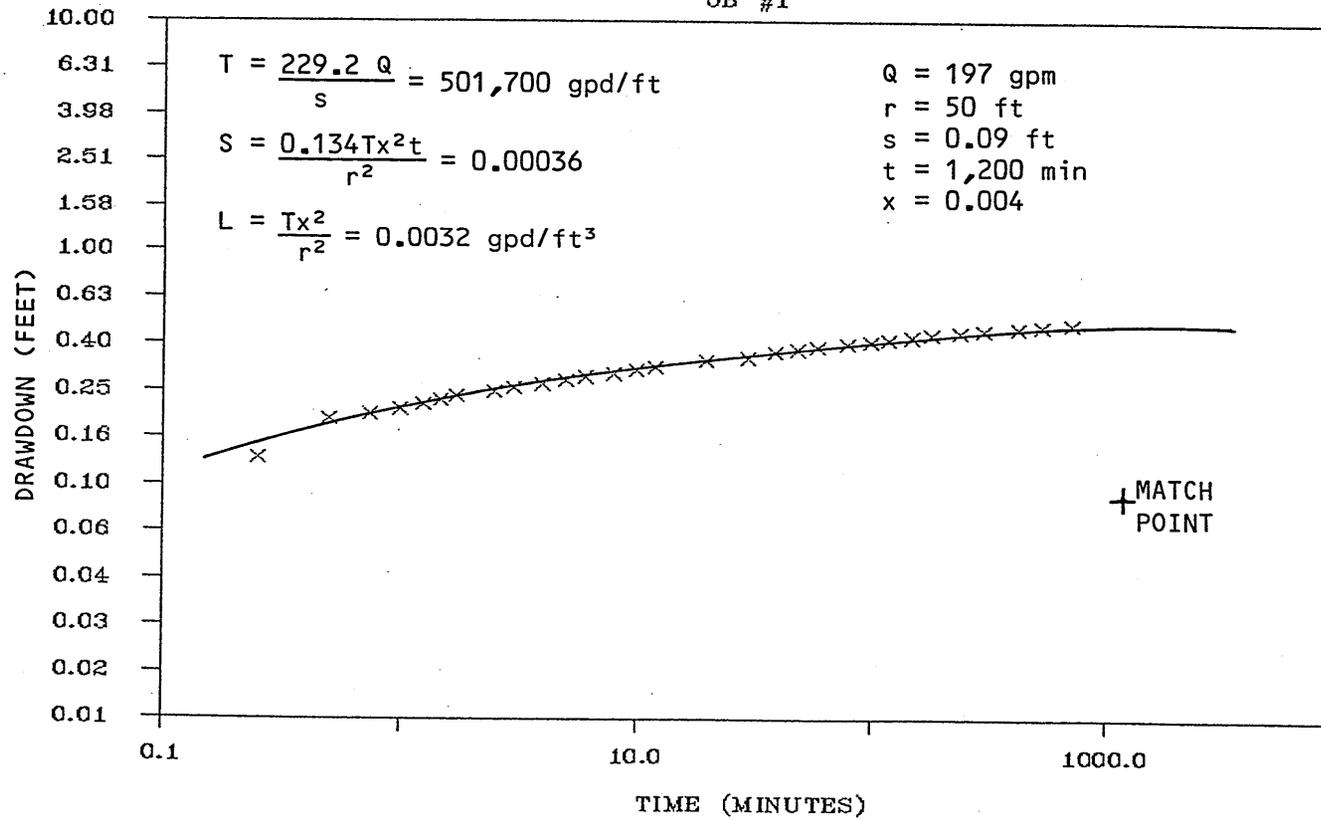
PUMPING RATE: 197 GPM

WELL #: OB3 STATIC W L (FT BELOW TOC) 4.20

TIME (IN MINUTES)	WATER LEVEL FROM TOC	DRAWDOWN IN FEET
18.00	4.38	0.18
23.00	4.39	0.19
35.00	4.40	0.20
53.00	4.42	0.22
69.00	4.44	0.24
85.00	4.45	0.25
103.00	4.45	0.25
123.00	4.46	0.26
155.00	4.47	0.27
186.00	4.47	0.27
240.00	4.48	0.28
300.00	4.49	0.29
420.00	4.50	0.30
640.00	4.52	0.32
720.00	4.53	0.33

LOG-LOG GRAPH OF DRAWDOWN VS TIME

OB #1



SEMI-LOG GRAPH OF DRAWDOWN VS TIME

OB #1

$$T = \frac{264Q}{\Delta S} = 520,080 \text{ GPD/FT}$$

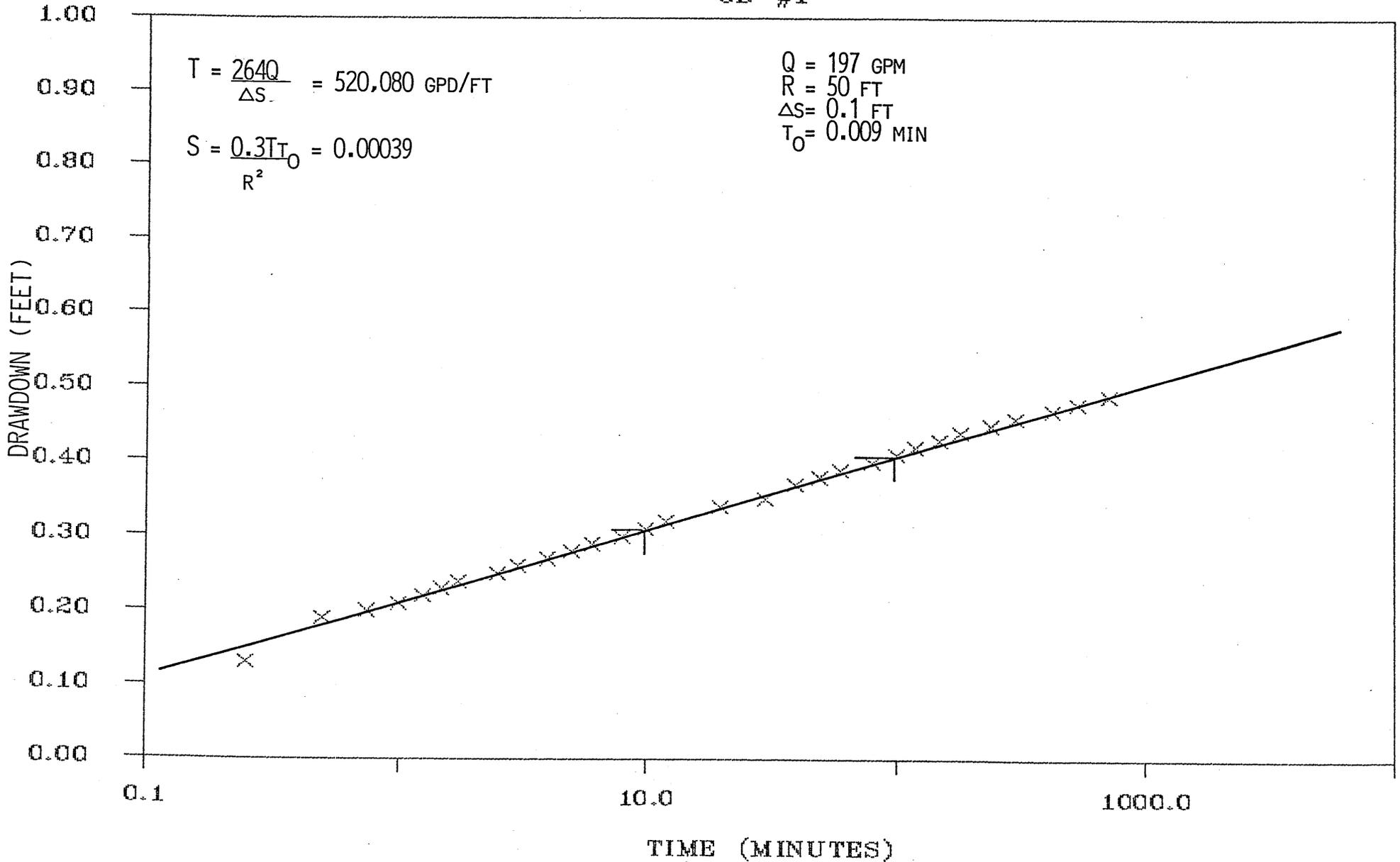
$$S = \frac{0.3T T_0}{R^2} = 0.00039$$

$$Q = 197 \text{ GPM}$$

$$R = 50 \text{ FT}$$

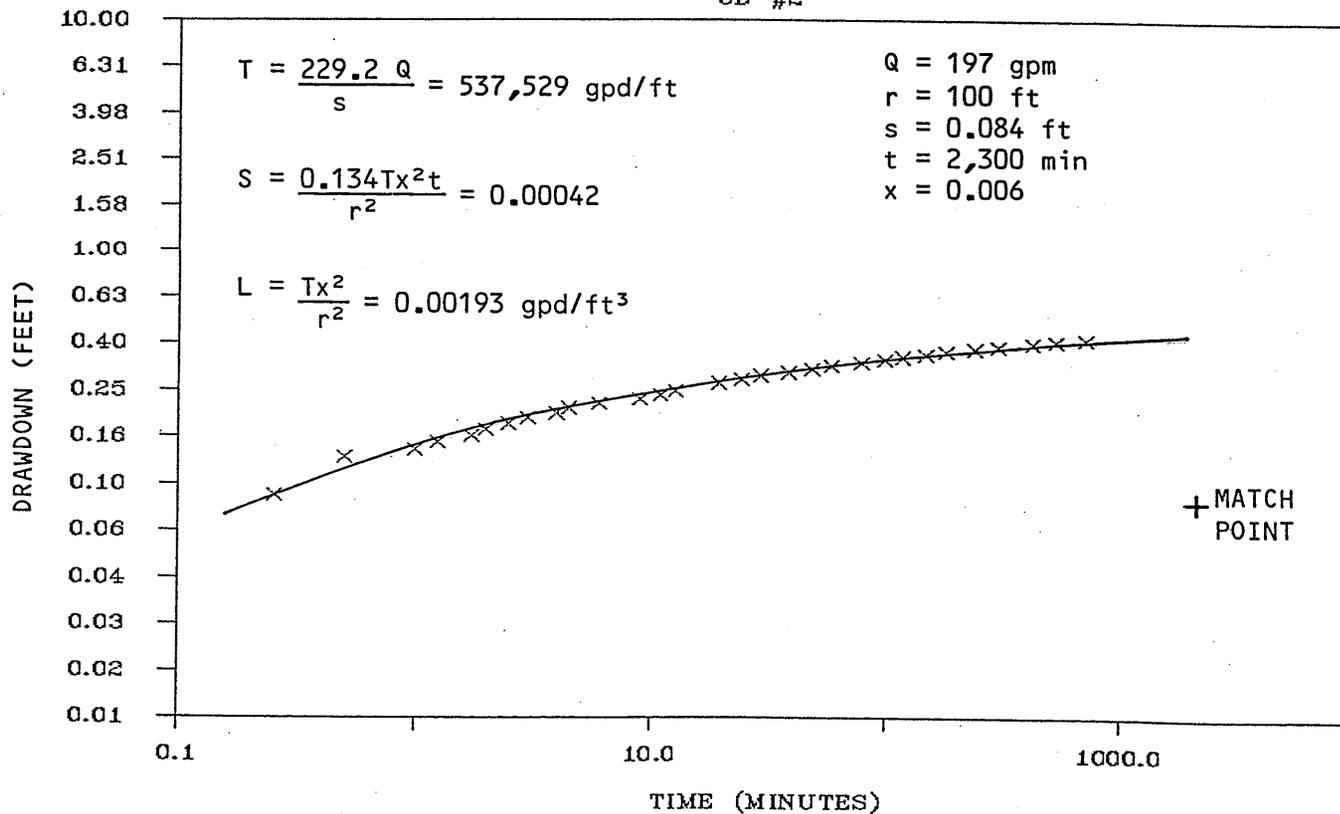
$$\Delta S = 0.1 \text{ FT}$$

$$T_0 = 0.009 \text{ MIN}$$



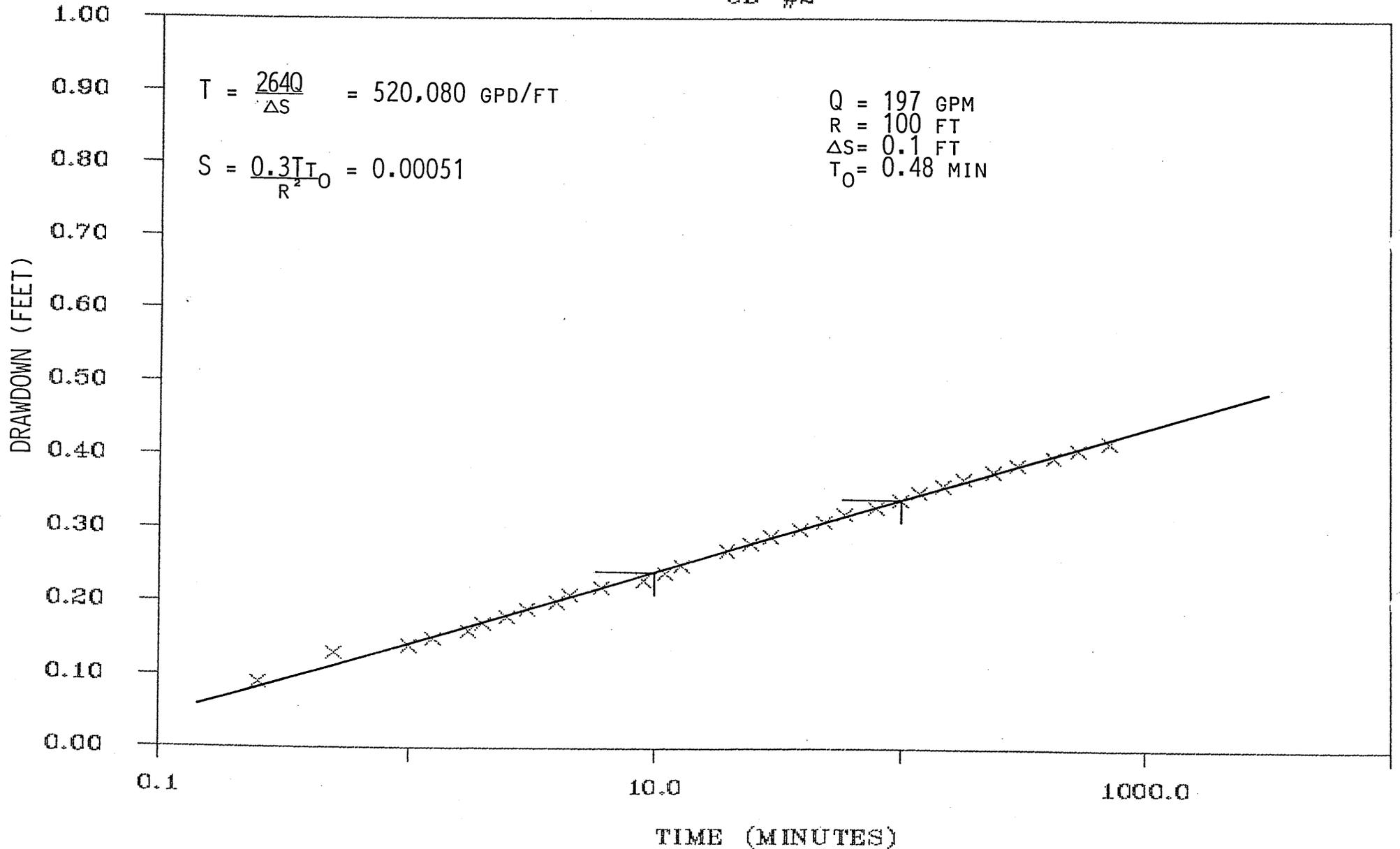
LOG-LOG GRAPH OF DRAWDOWN VS TIME

OB #2



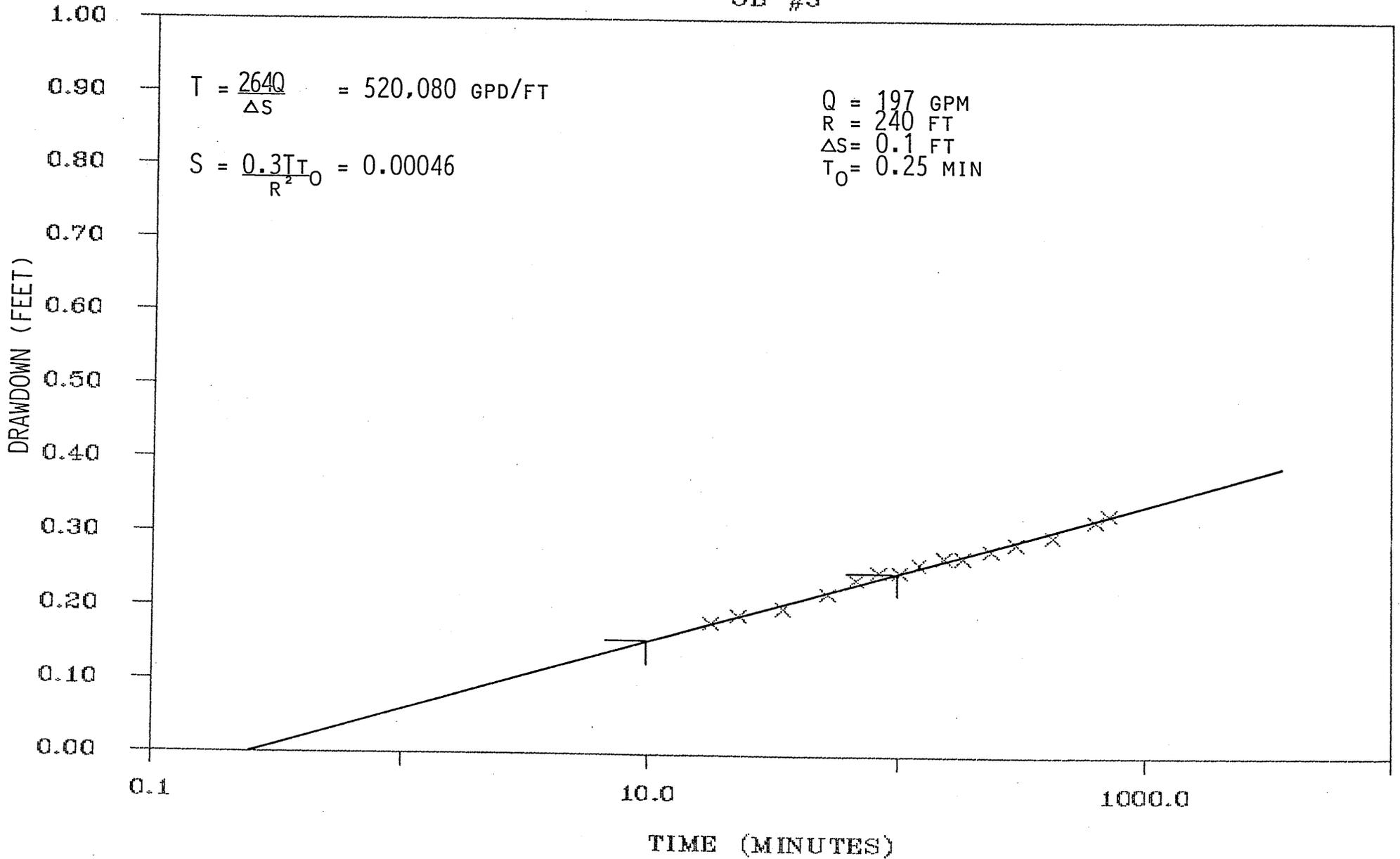
SEMI-LOG GRAPH OF DRAWDOWN VS TIME

OB #2



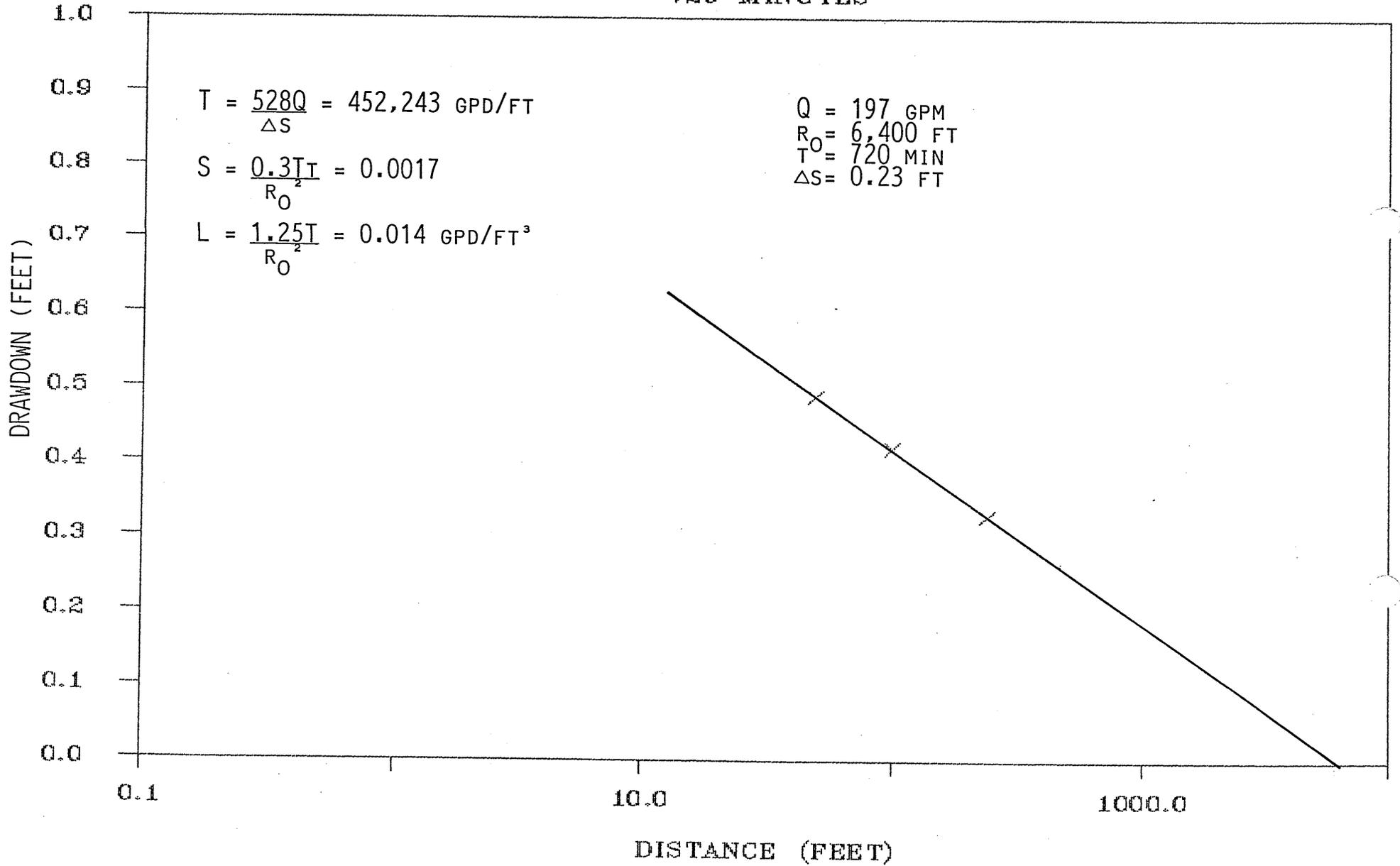
SEMI-LOG GRAPH OF DRAWDOWN VS TIME

OB #3



SEMI-LOG GRAPH OF DISTANCE-DRAWDOWN

720 MINUTES



SEMI-LOG GRAPH OF RECOVERY DATA

OB #2

$$T = \frac{264Q}{\Delta S} = 547,453 \text{ GPD/FT}$$

$$Q = 197 \text{ GPM}$$
$$\Delta S = 0.95 \text{ FT}$$

