WR-1 ANNUTTELIGA HAMMOCK
DRILLING AND TESTING PROJECT
HERNANDO COUNTY, FLORIDA

Resource Data Section
Resource Conservation and Development Department
Southwest Florida Water Management District
2379 Broad Street
Brooksville, Florida 34604-6899

April 2004

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July 2004

The geological evaluations and interpretations contained in the *Annutteliga Hammock Drilling and Testing Project, Hernando County, Florida* have been prepared by or approved by a licensed Professional Geologist in the State of Florida, in accordance with Chapter 492, Florida Statutes.

_____

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Date: _____

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HERNANDO COUNTY, FLORIDA

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1.0 INTRODUCTION

The WR-1 Annutteliga Hammock project was constructed as part of the Northern District Water Resource Assessment Project (NDWRAP). The NDWRAP will characterize the hydrogeology and ground water resources of the northern District region and establish long-term monitoring sites in areas of sparse data. The project is jointly funded by the District and the Withlacoochee Regional Water Supply Authority (WRWSA). The Annutteliga Hammock project well sites are located in Hernando County on Southwest Florida Water Management District (District) owned land.

2.0 SITE LOCATION

The Annutteliga Hammock project site is located in northwest Hernando County north of the town of Weeki Wachee (Figure 1). The project site is located on land purchased by the District for the Save Our Rivers and Preservation 2000 (SOR/P2000) programs. The Annutteliga Hammock is comprised of temperate upland hardwood forest and sand hills along the Brooksville Ridge (SWFWMD, 1996).

The Annutteliga Hammock project site contains three separate well sites all located in Section 6, Township 21 East, Range 18 South. The entrance to the project site is located at the intersection of US Highway 19 and Yellowhammer Road (Figure 2). Well Site Number 1 is located on Florida Wren Road at latitude: 28° 40' 54.2" longitude: 82° 32' 38.6" at an approximate elevation of 20 feet above the National Geodetic Vertical Datum (NGVD) of 1929. Well Site Number 2 is located on Merwyn Circle at latitude: 28° 41' 10.5" longitude: 82° 32' 32.8" at an approximate elevation of 20 feet above NGVD. Well Site Number 3 is located on Malibar Road at latitude: 28° 41' 21.6" longitude: 82° 32' 11.6" at an approximate elevation of 45 feet NGVD. Figure 2 shows the location of the three well sites.

3.0 DRILLING AND WELL CONSTRUCTION

Cable-tool, hollow-stem auger, mud-rotary and reverse-air drilling methods were used for drilling and monitor well construction at the Annutteliga Hammock well sites. The hollow-stem auger method was used to collect lithologic samples in the unconsolidated sediments. The cable-tool method was used to drive casing through the unconsolidated sediments. The mud-rotary method was used to drill in both unconsolidated and low porosity consolidated sediments. The revere-air method was used in the high porosity consolidated sediments and when water quality samples were required. Table 1 presents the well construction details.

3.1 WELL SITE NUMBER 1 (FLORIDA WREN ROAD)

JRS Geoservices Incorporated performed the drilling at Well Site Number 1 (Florida Wren Road) under contract to the District. Drilling began on July 5, 2000.

3.1.1 Surficial Monitor Wells

Two 12-inch diameter boreholes were drilled from land surface to 13 feet below land surface (BLS) using the mud-rotary drilling method. Ten feet of 6-inch diameter 0.030-inch slot poly vinyl-chloride (PVC) well screen and six feet of 6-inch diameter PVC casing were installed into the borehole. A sand pack consisting of 6-20 grade silica sand was installed in the annulus from two feet BLS to 13 feet BLS. Bentonite chips were installed in the annulus from one foot BLS to two feet BLS and cement grout was installed from land surface to 1 foot BLS. Locking steel covers and cement pads were installed around both wells. Figure 3 presents the surficial well diagram.

3.1.2 Upper Floridan Monitor Well (abandoned)

Construction began on an Upper Floridan well at this site with the drilling of an 8-inch diameter pilot hole from land surface to 34 feet BLS using the mud-rotary drilling method. The hole was reamed to 18-inches from land surface to 32 feet BLS and 12-inch diameter PVC casing was installed and grouted in the borehole. An 11.875-inch borehole was then drilled inside the 12-inch casing from 32 to 129 feet BLS where drilling circulation was lost.

The borehole caved in around the drilling rods and the ground beneath the drill rig began to subside. The borehole was abandoned with grout after several unsuccessful attempts to remove drill rods from borehole. Work stopped at this well location on July 27, 2000.

3.2 WELL SITE NUMBER 2 (MERWYN CIRCLE)

Diversified Drilling Corporation performed the drilling at Well Site Number 2 under contract to the District. Drilling at Well Site Number 2 was performed to replace the unsuccessful well construction attempt at Well Site Number 1. Drilling began on January 8, 2001.

3.2.1 Upper Floridan Well (FMW-1)

Split-spoon sampling was performed in the unconsolidated sediments from land surface to 32 feet BLS where split-spoon refusal was encountered in limestone. A 26-inch borehole was drilled using the mud-rotary drilling method from land surface to 25 feet BLS where drilling circulation was lost. Twenty-five feet of 20-inch diameter steel casing was installed and grouted in the borehole. A 19-inch borehole was then drilled from 25 to 44 feet BLS and 12-inch steel casing was installed and grouted in place. An 11-inch borehole was then drilled inside the 12-inch casing from 44 to 150 feet BLS and 6-inch PVC casing was installed and grouted in place. A 6-inch borehole was then drilled inside the 6-inch PVC casing from 150 to 561 feet BLS. This well is referred to as FMW-1. Figure 4 presents the well diagram.

3.2.2 Upper Floridan Well (FOB-1-abandoned)

Drilling began on another Upper Floridan aquifer well (referred to as FOB-1) on February 5, 2001. Forty-four feet of 12-inch diameter steel casing was driven using the cable-tool drilling method. A 12-inch borehole was then drilled inside the 12-inch steel casing from 44 to 150 feet BLS using the mud-rotary method. The 12-inch borehole collapsed from 135 to 150 feet BLS while installing 6-inch diameter PVC in the borehole. One hundred and thirty-five feet of 6-inch PVC casing was installed and grouted in the borehole. A 6-inch borehole was then drilled inside the 6-inch PVC casing but drilling was stopped at

180 feet BLS due to a sinkhole forming around the 12-inch steel casing. The 6-inch borehole also collapsed from 135 feet BLS to 180 feet BLS. Drilling was terminated on the FOB-1 well due to the formation of a 20-foot diameter sinkhole around the 12-inch steel casing and the collapsed 6-inch borehole. The sinkhole was filled with sand and the FOB-1 well was abandoned with grout from 135 feet BLS to land surface.

3.2.3 Upper Floridan APT well (abandoned)

Drilling began on an aquifer performance test (APT) well at this site on February 5, 2001. A total of 61 feet of 26-inch diameter steel casing was driven using the cable-tool method before stopping due to the opening of a large sinkhole approximately 30 feet away from the FOB-1 well. The 26-inch casing was abandoned with grout to land surface. Diversified Drilling, Inc. stopped work at the Merwyn Circle site on February 14, 2001.

3.2.4 Surficial Monitor Well

A 6-inch diameter surficial monitor well was installed at the Merwyn Road site using the District's Central Mine Equipment (CME) drill rig on May10, 2001. A 12-inch diameter borehole was drilled using the hollow-stem auger method from land surface to 12 feet BLS. Ten feet of 6-inch diameter 0.030-slot PVC screen and five feet of 6-inch diameter PVC casing were installed into the borehole. A sand pack consisting of 6-20 grade silica sand was installed in the borehole annulus from 1 foot BLS to 12 feet BLS. Bentonite chips were installed from 0.5 to 1 foot BLS in the annulus and cement grout was installed from land surface to 0.5 feet BLS. A 2 by 2-foot cement pad and locking steel cover was installed around the 6-inch casing. Figure 5 presents the well diagram.

3.3 WELL SITE NUMBER 3 (MALIBAR ROAD)

Drilling at Well Site Number 3 (Malibar Road) was performed by Diversified Drilling Corporation. The Well Site Number 3 was constructed to replace the unsuccessful well construction attempts at Well Sites Number 1 and Number 2. Drilling began at the Malibar Road site on May 30, 2001.

3.3.1 Upper Floridan Monitor Well (FMW-1A)

Drilling on the Upper Floridan Monitor Well (FMW-1A) began on May 31, 2001. A 6-inch diameter pilot hole was drilled using the mud-rotary method from land surface to 60 feet BLS before losing circulation. Drilling circulation was restored and drilling continued to 100 feet BLS. The 6-inch pilot hole was then reamed to 23-inches from land surface to 62 feet BLS. Sixty feet of 18-inch diameter steel casing was then installed and pressured grouted in place. Cement was tagged at 55 feet BLS inside the 18-inch steel casing. A 6-inch pilot hole was then drilled from 55 to 155 feet BLS inside the 18-inch steel casing. The 6-inch borehole was then reamed to 12-inches from 55 to 155 feet BLS. One hundred and fifty two feet of 6-inch PVC casing was installed and pressure grouted in place. A six-inch borehole was then drilled using the mud-rotary method inside the 6-inch PVC casing from 155 feet BLS to 200 feet BLS where circulation was lost. Drilling changed to the reverse-air method and continued from 200 to 280 feet BLS. A clay lens at 175 feet BLS had to be repeatedly drilled through due to the clay swelling and closing the borehole off. Drilling continued using the reverse-air method from 280 to 350 feet BLS. The borehole was repeatedly re-drilled down to 350 feet BLS to remove fall-in and drill cuttings from the bottom of the borehole. The well was developed using the reverse-air method after installing a PVC airline to depths of 160, 180, 220, 240, 260 and 280 feet BLS. The FMW-1A well was completed on June 13, 2001.

In January 2002 after attempting to log the FMW-1A well, it was determined the well was obstructed by the clay zone encountered at 175 feet BLS. Several attempts to remove the obstruction failed and the well was subsequently plugged and abandoned with cement grout in July 2002. Figure 6 presents the well diagram.

3.3.2 Upper Floridan APT Well

Drilling began on the APT well, located 20 feet away from the 6-inch UFA well, on June 14, 2001. A 6-inch diameter pilot hole was drilled using the mud-rotary method from land surface to 60 feet BLS before drilling circulation was lost. The borehole was then reamed to 12-inches from land surface to 60 feet BLS. The 12-inch borehole was then

reamed to 30-inches from land surface to 60 feet BLS. Sixty feet of 26-inch diameter steel casing was installed and grouted in the borehole. Cement grout was tagged at 53 feet BLS inside the casing following grouting. A 6-inch diameter pilot hole was drilled inside the 26-inch diameter steel casing from 53 feet BLS to 100 feet BLS using the mud-rotary method before drilling circulation was lost. The drilling method was changed to reverse-air at this point, but the reverse-air method failed to remove the unconsolidated sediments and fill from the bottom of the borehole. The drilling method was changed to mud-rotary and the 6-inch pilot hole was reamed to 25 inches from 53 to 75 feet BLS before drilling circulation was lost. In an attempt to stabilize the unconsolidated sediments at the bottom of the borehole, 25 bags of Portland cement were mixed and pumped into the borehole. The hardened cement was tagged at 65 feet BLS inside the borehole. Mud-rotary drilling of the 25-inch borehole continued from 65 feet BLS to 100 feet BLS before drilling circulation was lost. Thirty-five bags of Portland cement were mixed and pumped into the borehole at 100 feet BLS. The hardened cement was tagged at 90 feet BLS. Mud-rotary drilling of the 25-inch borehole resumed from 100 to 196 feet BLS. Twenty-inch steel casing was installed from land surface to 185 feet BLS with difficulty, due to the casing rubbing the borehole wall from 60 feet BLS down to 185 feet BLS. The 20-inch steel casing was pressure grouted in the borehole. Cement was tagged at 168 feet BLS inside the 20-inch casing. A 19-inch borehole was then drilled using the mud-rotary method from 168 feet BLS to 200 feet BLS before losing drilling circulation. The drilling method was changed to reverse-air and drilling of the 19-inch borehole continued from 200 feet BLS to 245 feet BLS. The borehole was re-drilled several times from 195 feet BLS to 245 feet BLS due to fall in. Drilling eventually resumed and a 19-inch borehole was drilled from 245 feet BLS to 350 feet BLS. Figure 7 presents the well diagram prior to the APT.

Following the completion of the aquifer performance test in July 2002, the 20-inch diameter steel casing was lined with 6-inch PVC from three feet above land surface to 161 feet BLS and 12-inch PVC casing from 161 to 172 feet BLS. The well liner was installed in June 2003. Figure 8 presents the well diagram with the 6-inch liner installed.

3.3.3 Surficial Monitor Well

A 6-inch diameter surficial monitor well was installed at the Malibar Road site using the District CME drill rig on May 10, 2001. A 10-inch diameter borehole was drilled using the hollow-stem auger method from land surface to 25 feet BLS. Six-inch diameter 0.010-slot PVC screen was installed from 15 to 25 feet BLS in the borehole. Six-inch diameter PVC casing was installed in the borehole from three feet above land surface to 15 feet BLS. A sand pack consisting of 6-20 grade silica sand was installed in the borehole annulus from 14 feet BLS to 25 feet BLS. Bentonite chips were installed in the annulus from 12 feet BLS to 14 feet BLS. Cement grout was installed from land surface to 12 feet BLS in the annulus. A two-foot by two-foot cement pad and locking steel cover was installed around the 6-inch casing. Figure 9 presents the surficial aquifer monitor well diagram.

4.0 DATA COLLECTION METHODS

Several types of data were collected during the drilling and monitor well construction at the Annutteliga Hammock site. Sediment and rock samples were collected for lithologic description and stratigraphic correlation. Ground-water samples were collected to define the water quality changes with depth and to define the potable thickness of the Upper Floridan aquifer. Geophysical logs were collected to help delineate stratigraphic units, characterize in-situ water quality and borehole conditions and determine packer set locations. Hydraulic tests were performed using borehole packers to estimate the hydraulic conductivity of tested intervals.

4.1 LITHOLOGIC SAMPLING

Unconsolidated surficial samples were collected using split-spoon samplers. Drill cuttings were collected while using the mud-rotary or reverse-air drilling methods. The samples were collected to define the geology and hydrogeology of the well site.

4.2 GROUND-WATER SAMPLING

Periodic ground-water samples were collected from the discharge line during reverse-air drilling of the Well Site Number 2 (Merwyn Circle) UFA well (FMW-1). Prior to sample collection, a volume of water equal to the open-hole interval plus the volume of water in the drill rods and packer was pumped from the well using the airlifting method. The ground-water samples were then collected from the reverse-air discharge line while airlifting.

Because reverse-air samples can be diluted by up-hole water, additional ground water samples were collected from borehole intervals isolated with an off-bottom packer or straddle packer. Figure 10 presents a diagram of the off-bottom packer and Figure 11 presents a diagram of the straddle packer.

Ground water samples collected during drilling were split. One sample was analyzed in the field for temperature, specific conductance, pH, chloride, and sulfate. Oakton and Hach water quality test kits were used in the to test the field sample for chloride and sulfate. The other sample was delivered to the District Environmental Chemistry Laboratory for more

extensive analyses. Chain-of-Custody forms were used to track the samples. Table 1 presents the field analyses collected during drilling. Table 2 presents the laboratory results of the samples. Results of ground-water sample analyses are discussed in Section 7.0.

4.3 GEOPHYSICAL LOGGING

Borehole geophysical logs were collected using the District's Century® geophysical logging equipment at the Annutteliga project site. The Merwyn Circle Upper Floridan aquifer well (FMW-1) was logged from 44 feet BLS to 560 feet BLS prior to installing the 6-inch PVC casing. The geophysical logs collected include: natural gamma (GAM (NAT)), single-point resistance (RES), spontaneous potential (SP), short normal resistivity (RES (16N)), long normal resistivity (RES (64N)), specific conductance (SP COND), and temperature (TEMP). In addition borehole video logs were run in the FMW-1 well. Figure 12 presents the geophysical logs.

4.4 HYDRAULIC TESTING

Short-term packer tests were performed while drilling the Upper Floridan aquifer well (FMW-1) at the Merwyn Circle well site. Packer tests allow a discrete section of the borehole to be isolated for water quality and/or hydraulic testing. Both off-bottom and straddle packers were used to collect water quality samples and to perform hydraulic tests on isolated portions the borehole.

An APT was performed on the Malibar Road 20-inch diameter Upper Floridan APT well after the well construction was complete. The APT was performed to determine transmissivity values for the Upper Floridan aquifer at the well site. The results of the packer testing and aquifer performance test are discussed in Section 8.

4.4.1 Merwyn Circle Well Site (FMW-1)

Two off-bottom and two straddle packer tests were conducted on the FMW-1 well. The airlifting method was used to pump the interval isolated by the packers. Water level changes were collected with pressure transducers and recorded on a data logger for both

the drawdown and recovery phases of the test. One pressure transducer was installed inside the drill rods above the packer to monitor the water level changes in the test interval. A second transducer was installed in the annulus between the drill rods and the casing. The second transducer measured the water level above the packer test interval so that a poor seal between the packer and the borehole wall could be detected.

4.4.2 Malibar Road Well Site (APT Well)

A 24-hour single-well APT was performed at the Malibar Road site from July 23, 2002 to July 24, 2002. The 20-inch diameter Upper Floridan aquifer APT well was pumped with a diesel powered line-shaft turbine pump at 1220 gallons per minute (GPM) for 24 hours. The discharge water was pumped through an 8-inch diameter pipe 200 feet to a dry creek bed located southwest of the well site. The discharge rate was measured with an in-line flowmeter, and an orifice plate and manometer tube. During the drawdown and recovery phases of the test, water level changes were measured in the 20-inch pumped well (APT well). Data from an observation well was not available due to the obstruction in the FMW-1A well. Water level changes in the 20-inch well were measured with pressure transducers and recorded on a data logger.

5.0 GEOLOGY

The Annutteliga project site is composed of Holecene to Pleistocene age undifferentiated sands and clays underlain by Eocene-age limestone and dolomite. The site is located within the Northern Gulf Coastal Lowlands Physiographic province described by White (1970). The elevation at Well Site Number 1(Florida Wren Road) and Number 2 (Merwyn Circle) is approximately 20 feet above NGVD. The elevation at Well Site Number 3 is approximately 45 feet above NGVD. The well sites are within the District's Springs Coast Hydrologic Basin. The Annutteliga stratigraphy was defined from lithologic descriptions of drill cuttings and geophysical logs collected while constructing the monitor wells. Figure 12 presents selected geophysical logs and the hydrogeology of the Number 2 (Merwyn Circle) Well Site. The lithologic log for the site is presented in Appendix A.

5.1 UNDIFFERENTIATED SURFICIAL DEPOSITS

The Holocene to Pleistocene age undifferentiated surficial deposits are the uppermost geologic unit in the Annutteliga Project area. The surficial deposits are comprised of unconsolidated medium to fine-grained quartz sand and sandy clay. The surficial deposits extend from land surface to approximately 30 feet BLS.

5.2 OCALA LIMESTONE

The Ocala Limestone is Eocene in Age and lies unconformably below the undifferentiated surficial deposits. The Ocala is the first limestone encountered below the surficial deposits due to the absence of the Suwannee Limestone. The Ocala Limestone is comprised of very fine to medium grained fossiliferous limestone and dolostone. Fossils include benthic foraminifera, echinoids, and fossil fragments. The surface of the Ocala Limestone is very irregular indicating that the Ocala was highly eroded during the time of previous exposure. Several cavities were encountered during drilling. Some of the cavities were described as being filled with sand and clay. The Ocala Limestone extends from 30 to 230 feet BLS.

5.3 AVON PARK FORMATION

The Avon Park Formation is Eocene in Age and is composed primarily of intergranular, vugular, fossiliferous dolostone. The Avon Park Formation extends from 230 feet BLS to more than 560 feet BLS. Drilling stopped at 560 feet BLS at the Annutteliga project site so the full extent of the Avon Park was not determined. Fossils described included mollusks, benthic foraminifera, gastropods, and pelecypods.

6.0 HYDROGEOLOGY

The Annutteliga Hammock project site hydrogeology was defined during the drilling at the three well locations. Aquifer systems were delineated from lithologic descriptions, hydraulic testing, potentiometric levels, geophysical log data, and water quality data collected during drilling.

6.1 SURFICIAL AQUIFER

The surficial aquifer at Annutteliga Hammock is unconfined and extends from land surface to approximately 25 feet BLS. Medium to very coarse-grained quartz sand and silt of the undifferentiated surficial deposits form the surficial aquifer. The surficial aquifer was not identified at Well Site Number 3 (Malibar Road). The surficial aquifer monitor well installed at this well site was dry. Where present, the surficial aquifer base is formed by thin layers of clay of the undifferentiated surficial deposits and or thin layers of low permeability limestone of the Ocala Limestone. The water level in the surficial aquifer at Well Site Number 1 (FL Wren Road) was approximately 1.9 feet BLS on October 14, 2003. The water level in the surficial aquifer well at Well Site Number 2 (Merwyn Circle) was 6.6 feet BLS on October 14, 2003.

6.2 UPPER FLORIDAN AQUIFER

The UFA is poorly confined at the Annutteliga Hammock site. The top of the UFA occurs at the contact between the undifferentiated surficial deposits and the Ocala Limestone around 30 feet BLS. The UFA is comprised of the Ocala Limestone and Avon Park Formation. The Ocala Limestone is characterized by numerous cavities many of which are filled with sand and clay from previous depositional events. Cavities, fractures other secondary porosity features are typically indicative of high porosity zones. The sand and clay fill in many of the cavities may have reduced the normally high permeability of this section of the Ocala Limestone. The most permeable zones of the UFA occur in the Avon Park Formation. Video logging revealed fracture zones at 220 and 250 feet BLS that appear to be permeable. The packer testing conducted near the bottom of the borehole indicated several permeable layers of varying hydraulic conductivity. The total

depth of the UFA at the Annutteliga site was not determined, exploratory drilling stopped at 560 feet BLS. The water level of the UFA monitor well at Well Site Number 2 (Merwyn Circle) was 6.7 feet BLS on October 14, 2003.

7.0 GROUND-WATER QUALITY

Ground-water samples were collected periodically during reverse-air drilling from 160 feet BLS to 560 feet BLS in the UFA. The field analyses and laboratory analyses of the ground-water samples are presented in Tables 2, 3, and 4. Figure 13 presents a graph of the laboratory analyzed chloride and sulfate concentrations and specific conductance measurements of the ground-water samples collected while reverse-air drilling.

7.1 SURFICIAL AQUIFER

A ground-water sample was collected from the Florida Wren Road site surficial well (screened interval 5 to 13 feet BLS) in March 2004. Water quality in the surficial aquifer was within secondary drinking water standards. The chloride concentration was 3 milligrams per liter (mg/L), the sulfate concentration was 11 mg/L, and the total dissolved solids (TDS) concentration was 84 mg/L.

7.2 UPPER FLORIDAN AQUIFER

Ground-water samples were collected from the reverse-air discharge and from isolated intervals using off-bottom and straddle packers while drilling in the UFA. The laboratory analyses of the samples collected from the reverse-air discharge are as follows: Chloride concentrations ranged from 6 mg/L at 180 feet BLS to 742 mg/L at 560 feet BLS. Sulfate concentrations ranged from 4 mg/L at 180 feet BLS to 512 mg/L at 560 feet BLS. The TDS ranged from 2 mg/L at 180 feet BLS to 2,075 mg/L at 560 feet BLS.

The laboratory analysis of the ground-water samples collected from the packer tests are as follows: The off-bottom packer sample collected between 518 and 560 feet BLS (PT-1) had chloride concentrations of 3,794 mg/L, sulfate concentrations of 2,550 mg/L and TDS of 10,570 mg/L. The off-bottom packer sample collected between 542 and 561 feet BLS (PT-2) had chloride concentrations of 3825 mg/L, sulfate concentrations of 2,569 mg/L and TDS of 8,900 mg/L. The straddle packer sample collected between 499 and 518 feet BLS (PT-3) had chloride concentrations of 2,247 mg/L, sulfate concentrations of 1,298 mg/L, and TDS

of 593 mg/L. The straddle packer sample collected between 420 and 439 feet BLS (PT-4) had chloride concentrations of 464 mg/L, sulfate concentrations of 134 mg/L, and TDS was 1,108 mg/L. The decrease in water quality below 400 feet BLS is shown on the specific conductance geophysical log shown in Figure 12.

8.0 HYDRAULIC DATA

Several short-term packer tests were performed at the Merwyn Circle well site during the drilling of the FMW-1 well. Also a 24-hour single well aquifer performance test was performed on the 20-inch UFA well at the Malibar Road well site. The tests were performed to collect hydraulic data on the permeable and confining zones at the Annutteliga Hammock project site.

8.1 PACKER TESTS

Packer tests were conducted to estimate the hydraulic properties of the FMW-1 borehole at the Merwyn Circle site. The airlifting method was used to pump the portion of the borehole isolated with the packer during the slug test. Water level changes were measured with a pressure transducer installed in the drill rods and recorded with a data-logger. A second transducer installed in the annulus between the drill rods and the well casing was used to detect water level changes caused by a poor seal between the packer and the borehole wall.

The water level data was transferred from the data logger to a spreadsheet and graphs of the drawdown and recovery data were created. A specific capacity (yield per unit of drawdown) was then calculated for each packer test. An estimated transmissivity value was then calculated for each interval using an equation developed by Theis (1963). The transmissivity for a confined aquifer is given by (Fetter, 2001):

$$T = \frac{Q}{(h_0 - h)} \frac{2.3}{4\pi} \log \frac{2.25Tt}{r^2 S} \qquad (1)$$

where

$\frac{Q}{(h_0 - h)}$ is specific capacity of the well

t is the period of pumping

r is the radius of the pumping well

T is the aquifer transmissivity

S is the aquifer storativity

Horizontal hydraulic conductivity values were calculated from

$$T = K \bullet b \qquad (2)$$

where

K = horizontal hydraulic conductivity

b = thickness of the aquifer

A total of four short-term pumping tests using inflatable packers were performed in the FMW-1 well during exploratory drilling at the Merwyn Circle well site. Two off-bottom packer tests were conducted from 518 to 560 feet BLS and from 542 to 560 feet BLS. Two straddle packer tests were conducted from 499 to 518 feet BLS and from 420 to 439 feet BLS.

The estimated horizontal hydraulic conductivity (K) values for the intervals tested ranged from a low of 3 feet/day for the 420 – 439 feet BLS interval, to a high of 125 feet/day for the 542 – 560 feet BLS interval. The drawdown curves for packer test No 3 (499 – 518 feet BLS) displayed an oscillatory response indicative of highly permeable formations. The lithologic description for this zone lists intergranular and vuggy porosity. Table 5 presents the estimated hydraulic values. The graphs for the drawdown curves are presented in Appendix B. The specific capacity data for each packer test is presented in Appendix C.

8.2 SINGLE WELL APT

A single well APT was performed on the Malibar Road 20-inch diameter UFA well in July 2002. The 19-inch borehole was open from 185 to 350 feet BLS. The well was pumped at 1,220 GPM for 24 hours with a diesel powered line-shaft turbine pump. The discharge rate was monitored with an in-line flowmeter and an orifice plate and manometer tube. Maximum drawdown during the test was 13.5 feet. The specific capacity was 72 gallons per minute/foot (gpm/ft). The water level changes in the pumped well were monitored with a pressure transducer and recorded on a data logger.

The transmissivity estimated from the specific capacity measurement (using equation 1 above) was approximately 20,000 feet^2 /day. The horizontal hydraulic conductivity calculated (using equation 2 above) was 120 feet/day, which is in the range of values for karst limestone aquifers (Driscoll, 1986). The drawdown data from the pumped well was analyzed with AQTESOLV for Windows Pro 3.5® software (HydroSOLVE, Inc. 1996-2003). The Hantush (1960) Leaky Aquifer method was used to match the curve. The AQTESOLV calculated transmissivity was approximately 16,000 feet^2 /day. Appendix D presents specific capacity analysis and the AQTESOLV Hantush method curve match for the single well test.

9.0 SUMMARY

Exploratory drilling and testing at the Annutteliga Hammock Project Site was conducted intermittently from July 2000 to July 2002. Three separate monitor well sites were constructed due to the adverse drilling conditions (sinkholes) encountered at the first two drilling locations. Mud-rotary and reverse-air drilling was used to collect drill cuttings for lithologic description and stratigraphic correlation. Ground-water samples were collected periodically while drilling to characterize the water quality in the UFA. Water levels were collected daily while drilling to aid in delineating aquifer systems and permeable zones.

The results of the drilling investigation indicate the Annutteliga Hammock site is underlain by an unconfined surficial aquifer (land surface to ~25 feet BLS) and a poorly confined UFA (25 feet BLS to >560 ft BLS). Ground-water quality in the surficial aquifer is generally within secondary drinking water standards. Ground-water samples collected with the packer indicate water quality in the UFA exceeds secondary drinking water standards below 400 feet BLS (Table 4). Hydraulic data for the UFA was obtained by performing several short duration pumping tests on isolated borehole intervals using an inflatable packer at the Merwyn Circle well site location. In addition, a 24-hour single well APT was performed on a UFA well at the Malibar Road well site location. Hydraulic conductivity values for the UFA ranged from 2 to 120 feet/day.

Six permanent monitor wells were constructed at the Annutteliga project site. Following the APT, the 20-inch APT well at Well Site Number 3 (Malibar Road) was lined with 6-inch PVC and converted to a permanent monitor well. Table 1 details the well construction at each well site. All monitor wells will be equipped with automatic water level recorders and will be sampled periodically for water-quality changes.

10.0 REFERENCES

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TABLES

Table 1. Well Construction Details

Site No.	Street	Well Type	UID#	WCP#	TOC (feet ALS)	Casing Depth (feet BLS)	Total Depth (feet BLS)	DTW (feet BLS)	Approx WL (feet MSL)	Approximate Site Elevation (feet MSL)	Lattitude	Longitude
1	Florida Wren Road	6" Surficial	2964-18076-0	634502	2.30	3	13	11.80	8.20	20.00	28 40 54.2	82 32 38.6
1	Florida Wren Road	6" Surficial	2964-2404-0	639163	2.35	3	13	11.70	8.30	20.00	28 40 54.3	82 32 38.4
2	Merwyn Circle	6" UFA	2575-18303-0	646605	1.85	150	560	6.70	13.30	20.00	28 41 10.5	82 32 32.8
2	Merwyn Circle	6" Surficial	2965-2405-0	653233	1.80	3	12	6.62	13.38	20.00	28 41 10.2	82 32 32.2
3	Malibar Road	6" UFA	2575-2166-0	686529	2.46	185	350	38.81	6.19	45.00	28 41 21.1	82 32 11.3
3	Malibar Road	6" Surficial	2966-2406-0	652668	2.42	15	25	Dry		45.00	28 41 21.6	82 32 11.6

Table 2. Field and Laboratory Analyses of FMW-1 Ground-Water Samples Collected During Drilling.

Date (m/d/y)	Time	Well Depth (feet BLS)	Field Measurements						Laboratory Measurements	
			pH	Specific Conductance (umhos/cm)	Fluid Temp. (^{0}C)	Chloride (ppm) Oakton Test Kit	Chloride (ppm) Hach Test Kit	Sulfate (ppm) Hach	Chloride (ppm)	Sulfate (ppm)
1/22/2001	12:00	160	8.45	214	22.8	N/A	N/A	N/A	N/A	N/A
1/23/2001	11:00	180	8.19	217	22.1	8	20	<50	5.5	3.9
1/23/2001	12:30	190	8.78	240	22.4	21	N/A	N/A	N/A	N/A
1/23/2001	14:00	200	8.82	234	22	18	60	<50	5.5	4.3
1/23/2001	14:40	210	8.41	242	22.4	N/A	N/A	N/A	N/A	N/A
1/23/2001	15:20	220	9.41	222	21.7	19	60	<50	5.4	6.1
1/23/2001	15:40	230	11.59	483	22.6	24	N/A	N/A	N/A	N/A
1/23/2001	16:00	240	12.24	221	22.8	20	60	<50	5.4	5.2
1/23/2001	16:50	260	8.40	276	22.5	25	60	<50	6.8	5.7
1/23/2001	17:15	270	8.58	250	22.7	33	60	<50	N/A	N/A
1/25/2001	16:00	300	8.42	291	23.6	29	60	<50	7.6	8.3
1/29/2001	12:30	340	8.37	283	23.5	22	60	<50	N/A	N/A
1/29/2001	13:10	360	8.37	283	23.5	23	N/A	N/A	N/A	N/A
1/29/2001	13:45	380	8.32	290	23.5	18	60	<50	N/A	N/A
1/29/2001	14:30	400	8.42	297	23.5	31	60	<50	N/A	N/A
1/29/2001	14:52	420	8.44	330	23.7	44	80	<50	N/A	N/A
1/29/2001	15:33	440	8.45	386	23.6	72	80	<50	N/A	N/A
1/29/2001	16:30	460	8.32	374	23.5	54	80	<50	N/A	N/A
1/30/2001	8:00	500	8.20	832	20.6	148	200	90	N/A	N/A
1/30/2001	8:20	520	8.30	915	22.1	167	210	100	N/A	N/A
1/30/2001	9:00	540	8.38	915	22.5	183	200	125	N/A	N/A
1/31/2001	10:15	560	8.26	3530	22.9	640	800	400	N/A	N/A
1/1/2004	10:00	13*	6.16	125		N/A	N/A	N/A	3.0	11.0

* sample collected from completed surficial well at the Florida Wren Road well site
6-inch PVC casing 0 - 150 feet BLS
N/A - Not Analyzed
wq.xls

Table 3. Laboratory Analyses of FMW-1 Ground-Water Samples Collected from the Reverse-Air Discharge.

Date m/d/y	Time	Depth* (ft bls)	Specific Conductance (umhos/cm)	Na	K	Ca	Mg	Cl	HCO3	CO3	SO4	Fe	SiO2	TDS	Sr	Ion Balance %	TDS Calc
				all concentrations reported in ppm													
1/23/2001	1100	180	248	3.7	0.3	39.1	6.4	6	71.9	<1	4	<25	8.9	155	0	1.9	130.8
1/23/2001	1400	200	237	3.6	0.3	39.9	5.6	6	69.4	<1	4	<25	10.6	153	0	1.9	128.7
1/23/2001	1520	220	210	3.6	0.4	31.5	6.6	5	58.1	<1	6	<25	13.3	136	0.25	1.9	111.5
1/23/2001	1600	240	225	3.6	0.4	35.7	7.9	5	63.3	<1	5	<25	11.8	146	0.28	2.0	121.5
1/23/2001	1650	260	297	4.4	0.3	44.4	8.3	7	86.5	<1	6	<25	10.1	182	0.56	1.8	156.4
1/25/2001	1600	300	298	5.5	1.4	38.6	9.3	8	78.0	<1	8	<25	13.1	187	0.84	1.8	148.7
1/29/2001	1230	340	294	4.8	1.4	44.2	10.1	7	84.0	<1	6	<25	10.7	185	0.61	1.9	157.7
1/29/2001	1340	360	320	4.6	0.7	42.8	9.9	7	87.1	<1	6	<25	10.7	171	0.08	1.8	158.4
1/29/2001	1452	420	352	10.3	1.0	45.5	10.0	20	86.5	<1	9	<25	11	200	0.29	1.7	181.4
1/29/2001	1145	460	387	17.7	1.4	46.5	10.1	31	81.0	<1	13	<25	10.6	220	0.05	1.6	200.6
1/30/2001	800	500	906	93.3	4.7	64.0	19.9	152	87.1	<1	77	<25	10.4	516	1.97	1.2	497.6
1/30/2001	820	520	952	94.5	4.9	66.2	20.4	158	87.1	<1	82	<25	10.3	531	1.68	1.2	512.7
1/30/2001	900	540	930	105.0	5.0	67.3	19.9	155	81.6	<1	87	<25	10.4	522	1.29	1.3	520.7
1/30/2001	1015	560	3340	438.0	18.2	161.0	66.5	742	85.3	<1	512	<25	11.9	2075	3.62	1.0	2023.0

*6-inch PVC casing from 0 - 150 feet BLS

wq.xls

Table 4. Laboratory Analyses of FMW-1 Ground-Water Samples Collected with Inflatable packer.

Date m/d/y	Time	ID	Depth * (feet BLS)	Specific Conductance (umhos/cm)	Na	K	Ca	Mg	Cl	HCO3	CO3	SO4	Fe	SiO2	TDS	Sr	Ion Balance %
					all concentrations reported in ppm												
1/31/2001	1500	PT-1 (off-bottom)	539	14570	2340.0	92.9	689.0	329.0	3794	173.0	<1	2550	0.3	18.5	10570	13.5	N/A
1/31/2001	1700	PT-2 (off-bottom)	551	12600	2360.0	104.0	650.0	331.0	3825	173.0	<1	2569	0.2	18.8	8900	13.2	N/A
2/1/2001	1320	PT-3 (straddle)	509	8650	1330.0	59.9	216.0	183.0	2247	141.0	<1	1298	0.6	13.7	593	13.3	N/A
2/1/2001	1450	PT-4 (straddle)	430	1950	252.0	12.3	88.1	39.2	464	150.0	<1	134	0.2	12.6	1108	2.9	N/A
3/19/2004	1501	Merwyn Surf	13**	125	0.7	0.2	22.8	0.4	3	NA	NA	11	12.2	1.9	84	0.0	1.3

6-inch PVC casing 0 - 150 feet BLS

* depth interval is assigned as the middle of the packer interval.

** Sample collected from permanent surficial well

wq.xls

Table 5. Hydraulic Test Results

Date	Test No.	Well	Test Interval (feet BLS)	Interval Thicknes (feet BLS)	Pumping Rate (GPM)	Maximum Drawdown (feet BLS)	Specific Capacity (GPM/foot)	Viual Lithologic Characterization	Hydrogeologic Zone	Analytical Method	Horizontal Hydraulic Conductivity (K) (feet/day)	Notes
1/31/2001	PT 1	FMW-1	518-560	42	18	35	0.5	Dolostone	UFA	Estimated from Specific Capacity	**2**	Off-bottom Packer Test (Airlifted)
1/31/2001	PT 2	FMW-1	542-560	18	18	3	6	Dolostone	UFA	Estimated from Specific Capacity	**100**	Off-bottom Packer Test (Airlifted)
2/1/2001	PT 3	FMW-1	499-518	19	6	3	2.0	Dolostone	UFA	Estimated from Specific Capacity	**39**	Straddle Packer Test (Airlifted)
2/1/2001	PT 4	FMW-1	420-439	19	6	21	0.29	Dolostone	UFA	Estimated from Specific Capacity	**3**	Straddle Packer Test (Airlifted)
7/1/2002	APT	20-inch	185-350	165	1220	17	71.8	Limestone & Dolostone	UFA	Estimated from Specific Capacity	**120**	Single Well APT -pumped with lineshaft turbine
7/1/2002	APT	20-inch	185-350	165	1220	17	71.76	Limestone & Dolostone	UFA	AQTESOLV-Hantush method	**96**	Single Well APT -pumped with lineshaft turbine

hydraulic.xls

FIGURES

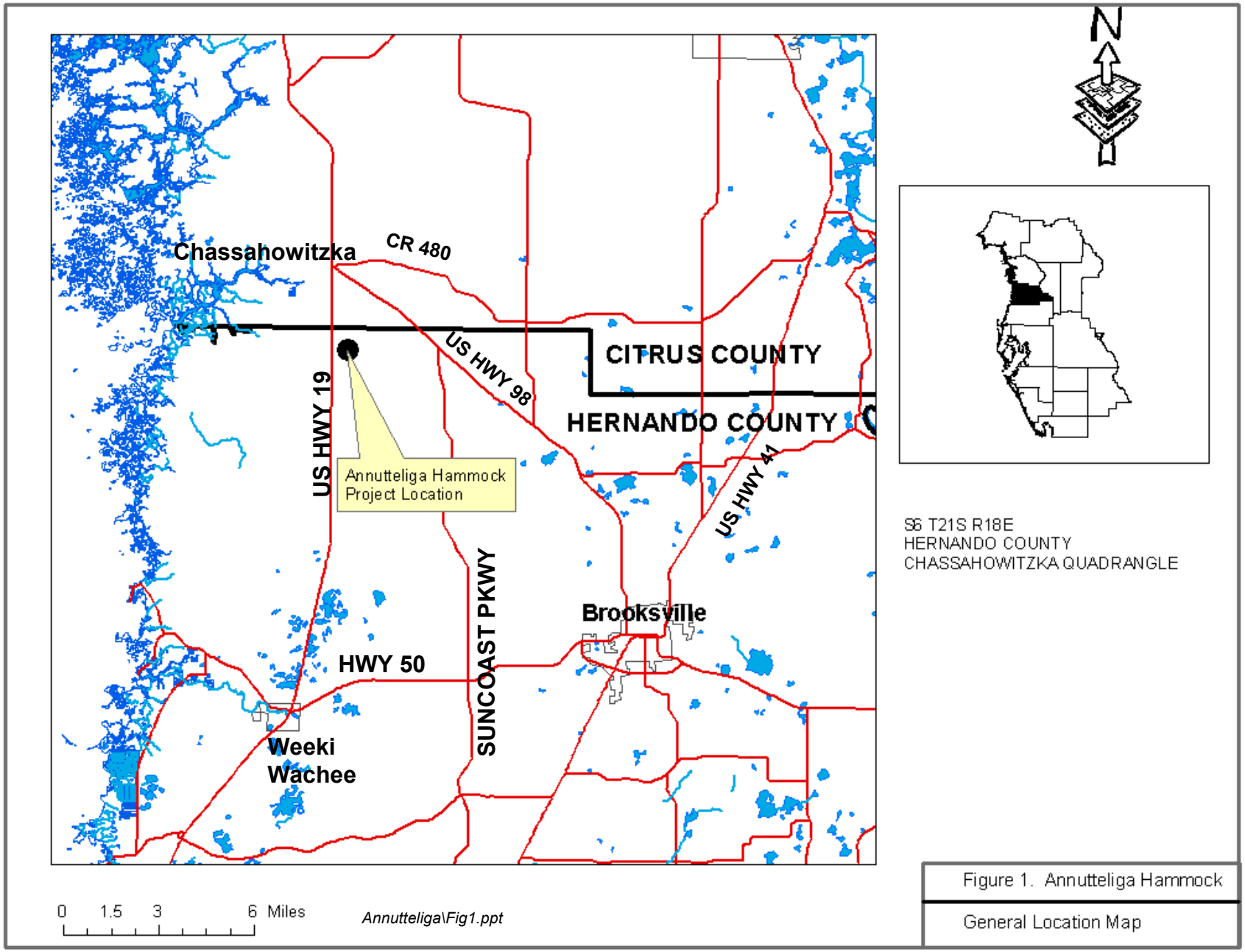
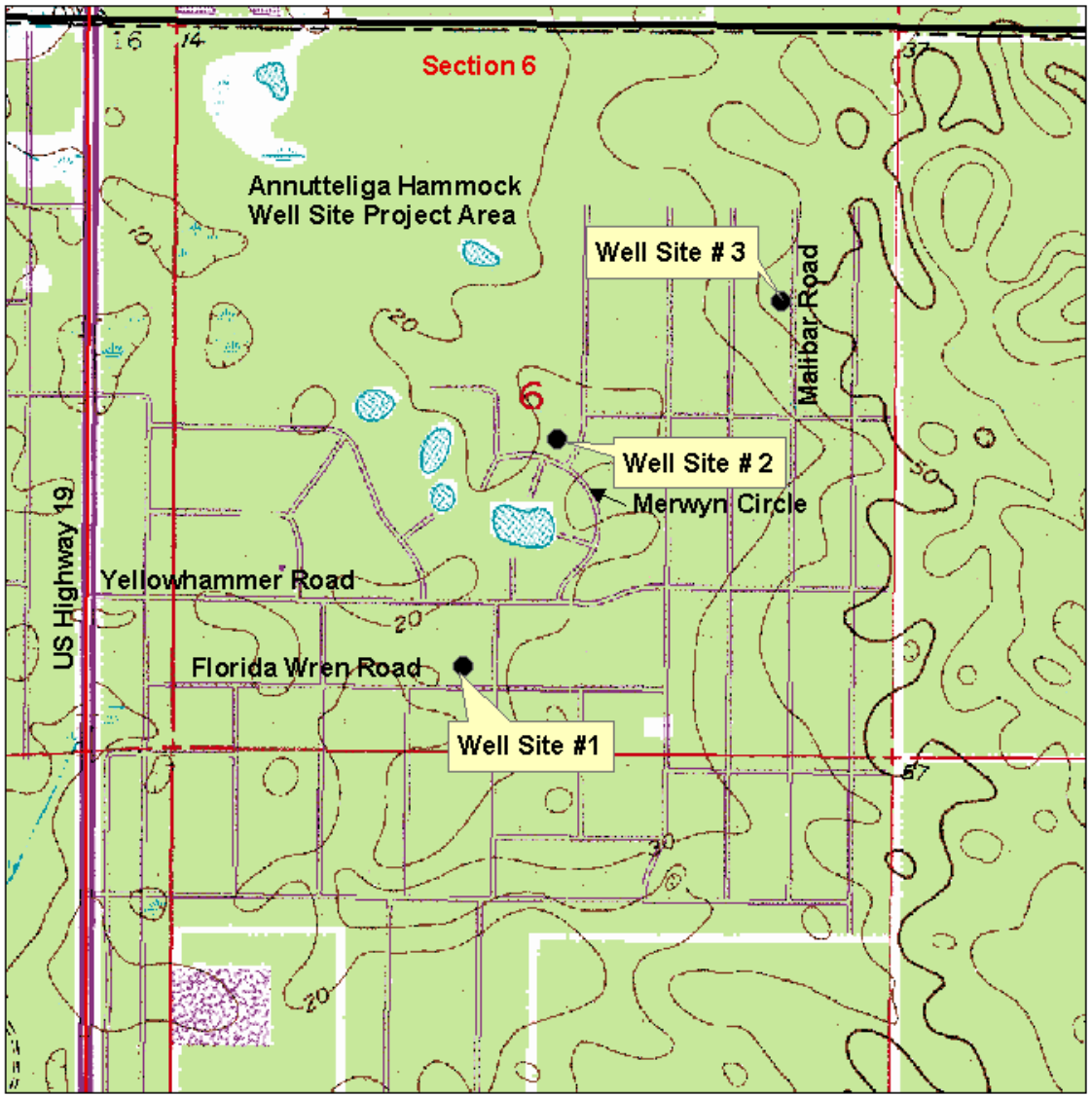
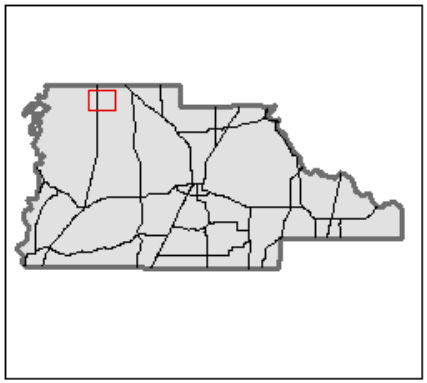


Figure 1. Annutteliga Hammock

General Location Map





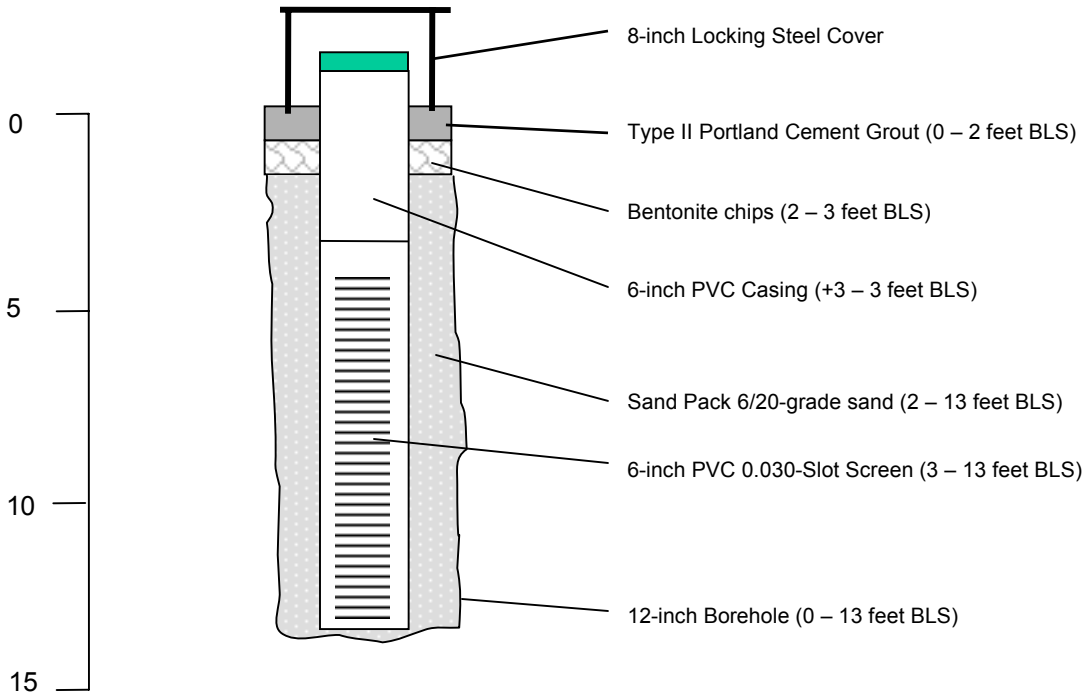
S6 T21S R18E
HERNANDO COUNTY
CHASSAHOWITZKA QUADRANGLE

0 0.1 0.2 0.4 Miles

Annutteliga\figure2.ppt

Figure 2. Annutteliga Hammock
Well Site Location Map

Land Surface Elev: 20 feet NGVD	**Measuring Point Elev:**
S-T-R: 6-21S-18E	**WCP:** 634502.01, 639163.01 **UID:** WEL-2964-18076-0, WEL-2964-2404-0
Lat: 28 40 54.2 **Long:** 82 32 38.6	**Static WL:** 11.6 feet BLS
Completion Date: 7-27-2001	**Spec Cap:**



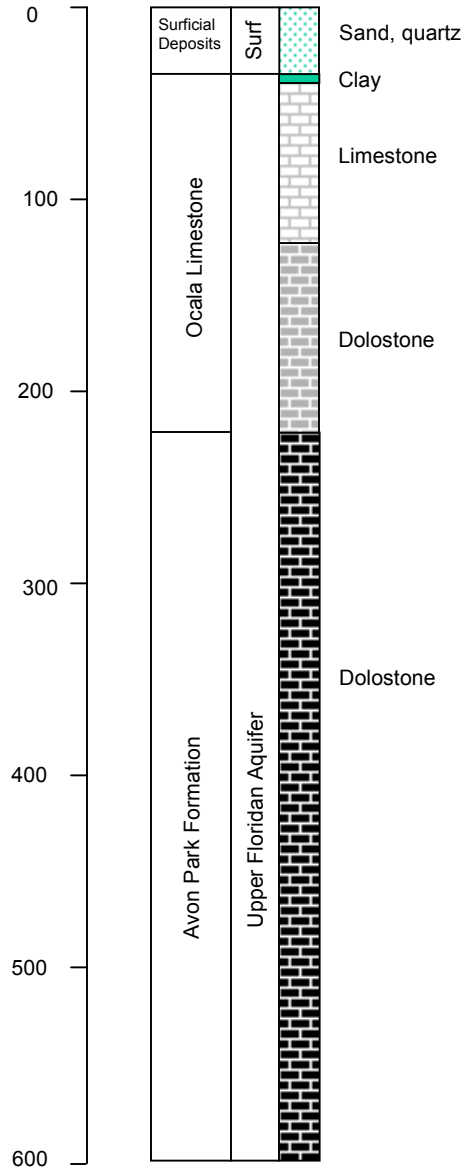
Note: There are two identical surficial monitor wells at this site.

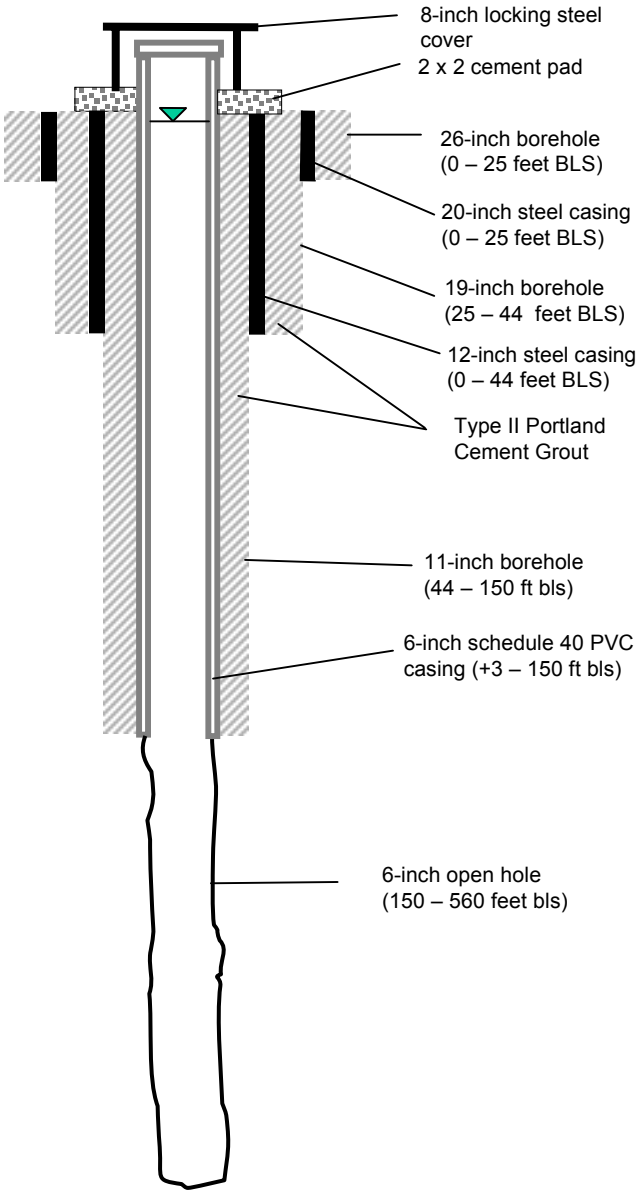
Figure 3. Annutteliga Hammock

Well Site Number 1 (FL Wren Rd)
Surficial Aquifer Monitor Wells

Figure3_FLWren_surficial.ppt
7/29/2004

Land Surface Elev: 20 feet NGVD	**Measuring Point Elev:**
S-T-R: 18-21S-18E	**WCP:** 646605.01 **UID:** WEL 0018303
Lat: 28 41 10.5 **Long:** 82 32 32.8	**DTW:** 6.7 feet bls
Completion Date: 2-14-2001	**Spec Cap:**





Annutteliga\6-inch_ufa.ppt
7/29/2004

Figure 4. Annutteliga Hammock

Well Site Number 2 (Merwyn Circle)
Upper Floridan Aquifer Monitor Well (FMW-1)

Land Surface Elev: 20 feet NGVD	**Measuring Point Elev:**
S-T-R: 6-21S-18E	**WCP:** 653233.01 **UID:** WEL-2965-2405-0
Lat: 28 41 10.2 **Long:** 82 32 32.2	**Static WL:** 6.6 feet BLS
Completion Date: 5-10-2001	**Spec Cap:**

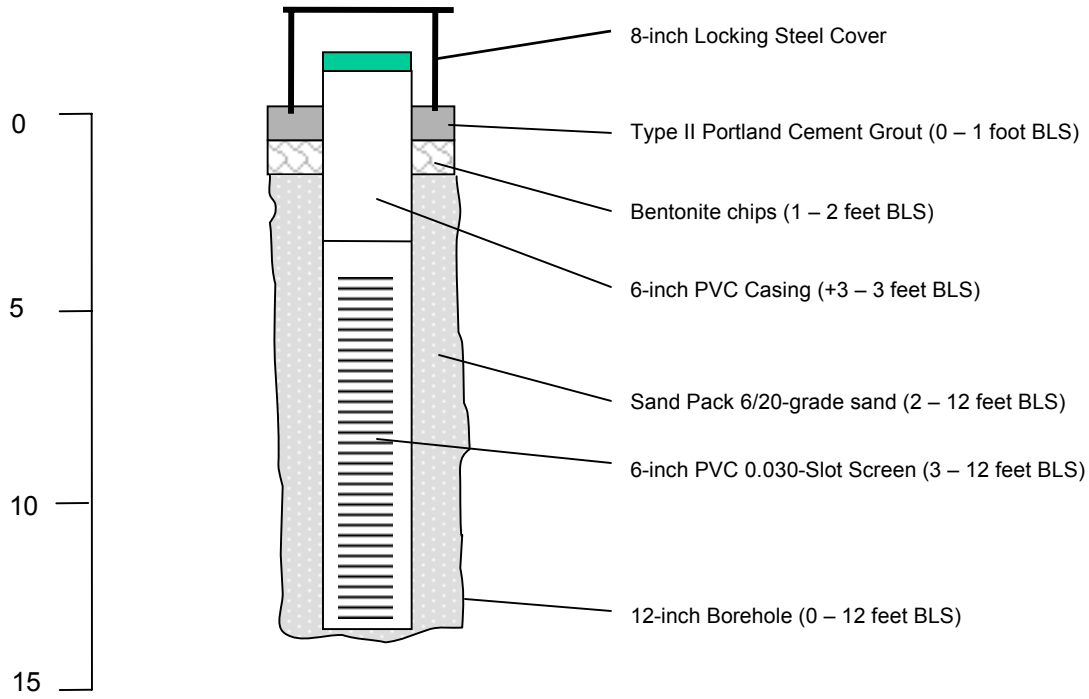


Figure 5. Annutteliga Hammock

Well Site Number 2 (Merwyn Cirlce)
Surficial Aquifer Monitor Well

Fig5_Merwyn_surficial.ppt
7/29/2004

Land Surface Elev: 45 feet NGVD	**Measuring Point Elev:**
S-T-R: 18-21S-18E	**WCP:** 647375.01 **UID:**
Lat: 28 41 21.2 **Long:** 82 32 11.4	**DTW:** **38.8** feet bls
Completion Date: 6-21-2001	**Spec Cap:**

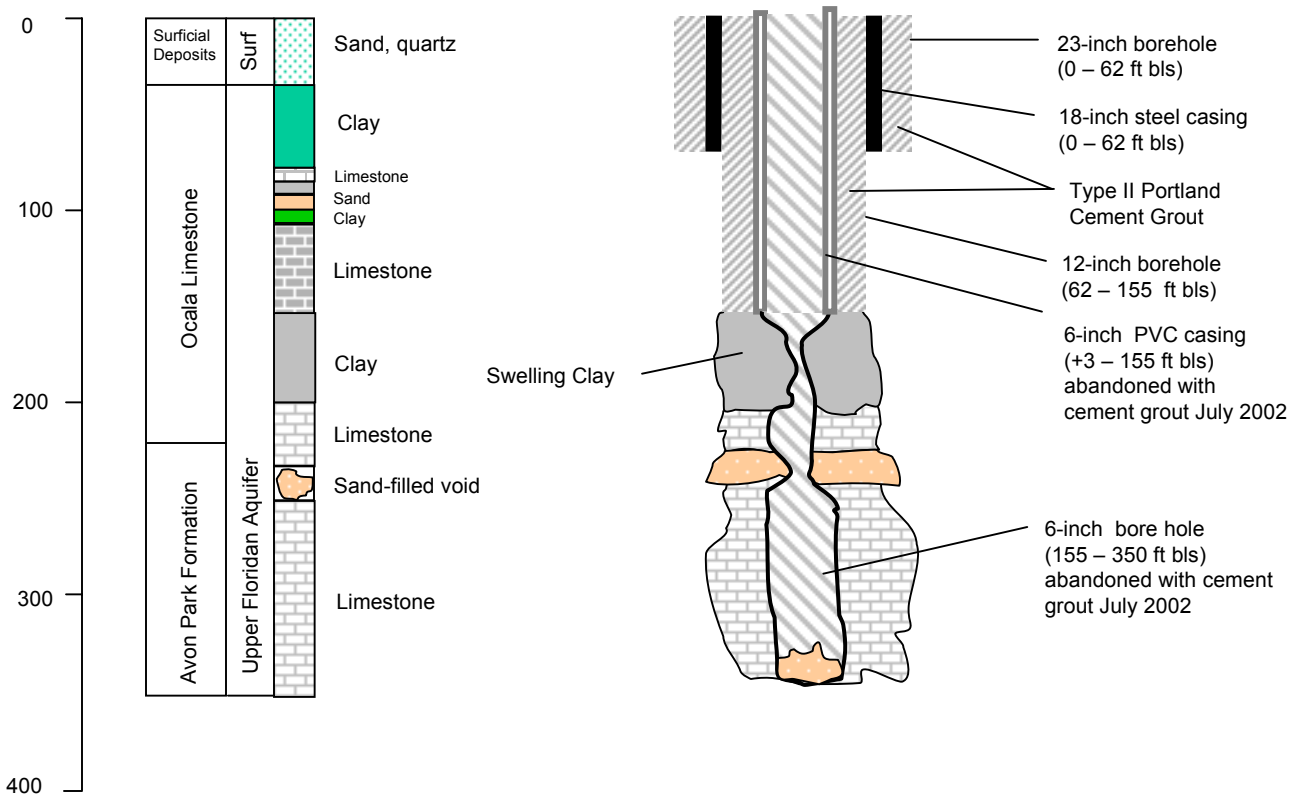


Figure 6. Annutteliga Hammock

Well Site Number 3 (Malibar Road)
Upper Floridan Aquifer Monitor Well (FMW-1A)

Fig6_Merwyn_ufa.ppt
7/29/2004

Land Surface Elev: 45 feet NGVD	**Measuring Point Elev:**
S-T-R: 18-21S-18E	**WCP:** 647376.01 **UID:** WEL 2575 2166
Lat: 28 41 21.1 **Long:** 82 32 11.3	**DTW:** 38.8 feet BLS
Completion Date: 7-24-2001 (Diversified)	**Spec Cap: (20-inch)** 72 GPM/foot

Figure 7. Annutteliga Hammock

Well Site Number 3 (Malibar Road)
Upper Floridan Aquifer APT Well (before liner)

Fig7X_Malibar_apt.ppt
7/29/2004

Land Surface Elev: 45 feet NGVD	**Measuring Point Elev:**
S-T-R: 18-21S-18E	**WCP:** 647376.01 **UID:** WEL 2575 2166
Lat: 28 41 21.1 **Long:** 82 32 11.3	**DTW:** 38.8 feet BLS
Completion Date: 7-24-2001 (Diversified)	**Spec Cap:**

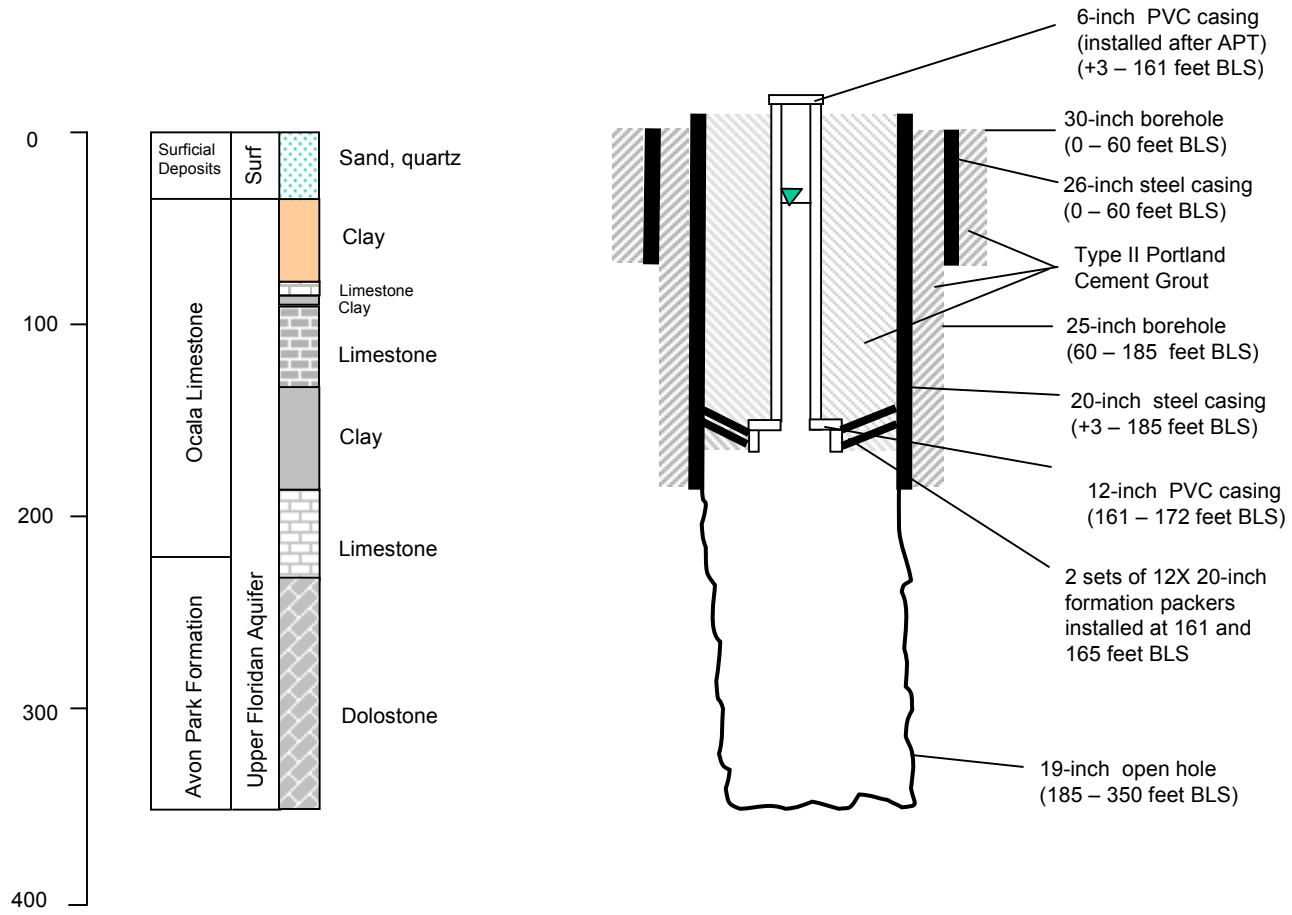


Figure 8. Annutteliga Hammock

Well Site Number 3 (Malibar Road)
Upper Floridan Aquifer APT Well (with liner)

Fig8_Malibar_liner.ppt
7/29/2004

Land Surface Elev: 45 feet NGVD	**Measuring Point Elev:**
S-T-R: 6-21S-18E	**WCP:** 652668.01 **UID:** WEL-2966-2406-0
Lat: 28 41 21.6 **Long:** 82 32 11.6	**Static WL:** DRY
Completion Date: 5-10-2001	**Spec Cap:**

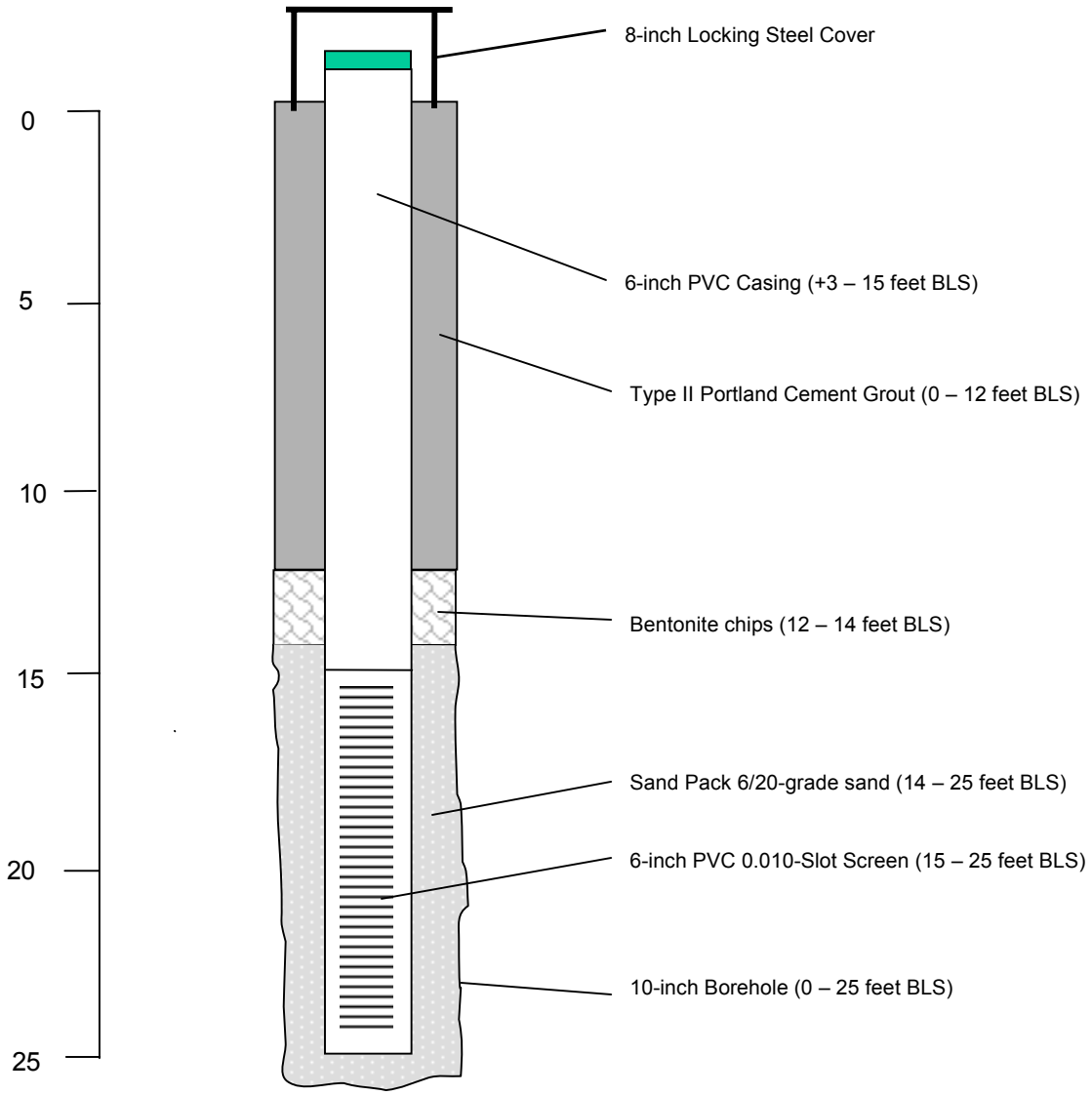


Figure 9. Annutteliga Hammock

Well Site Number 3 (Malibar Road)
Surficial Aquifer Monitor Well

Fig9_Malibar_surficial.ppt
7/29/2004

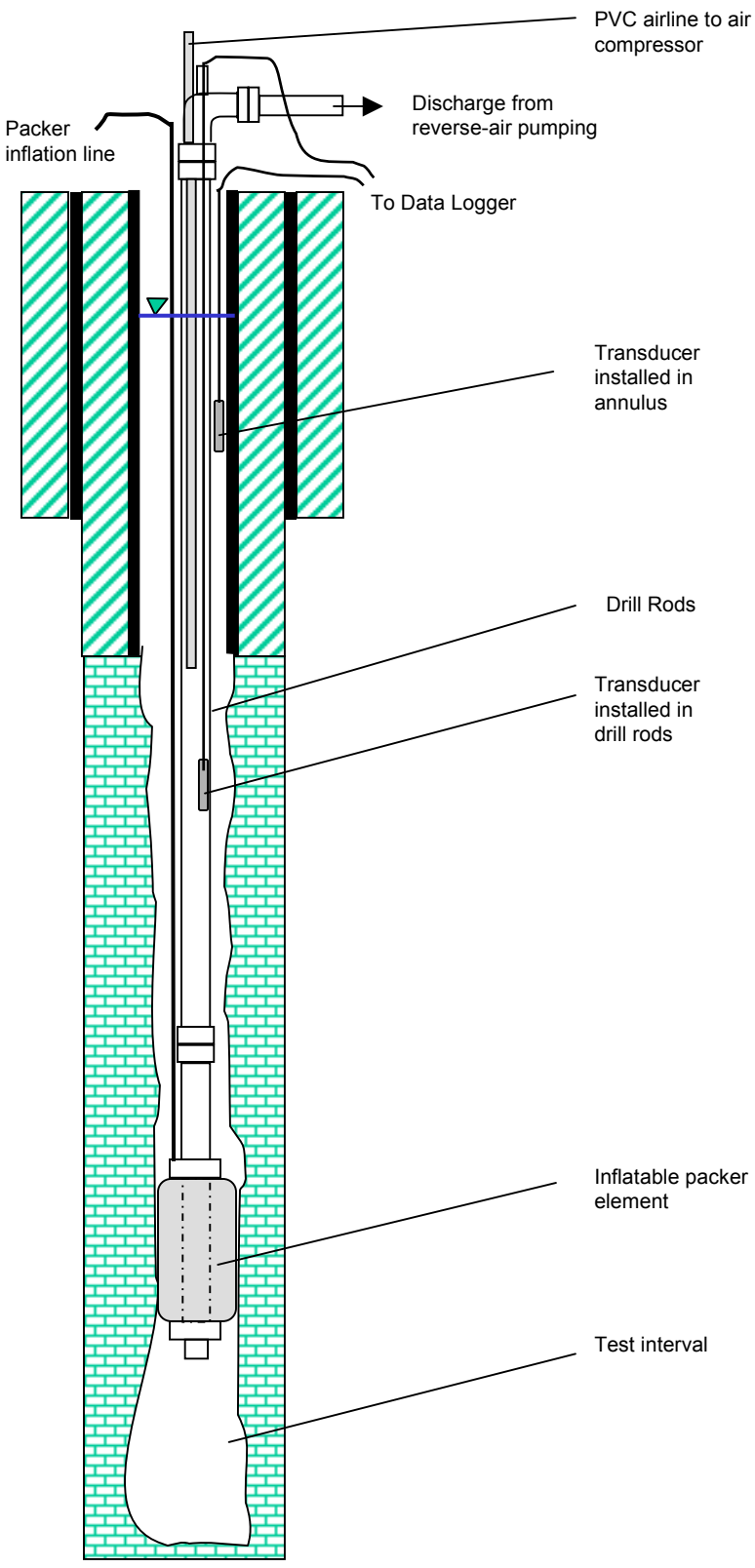


Figure 10. Annutteliga Hammock

Off-bottom Packer Diagram

Fig10_offbottompacker.ppt

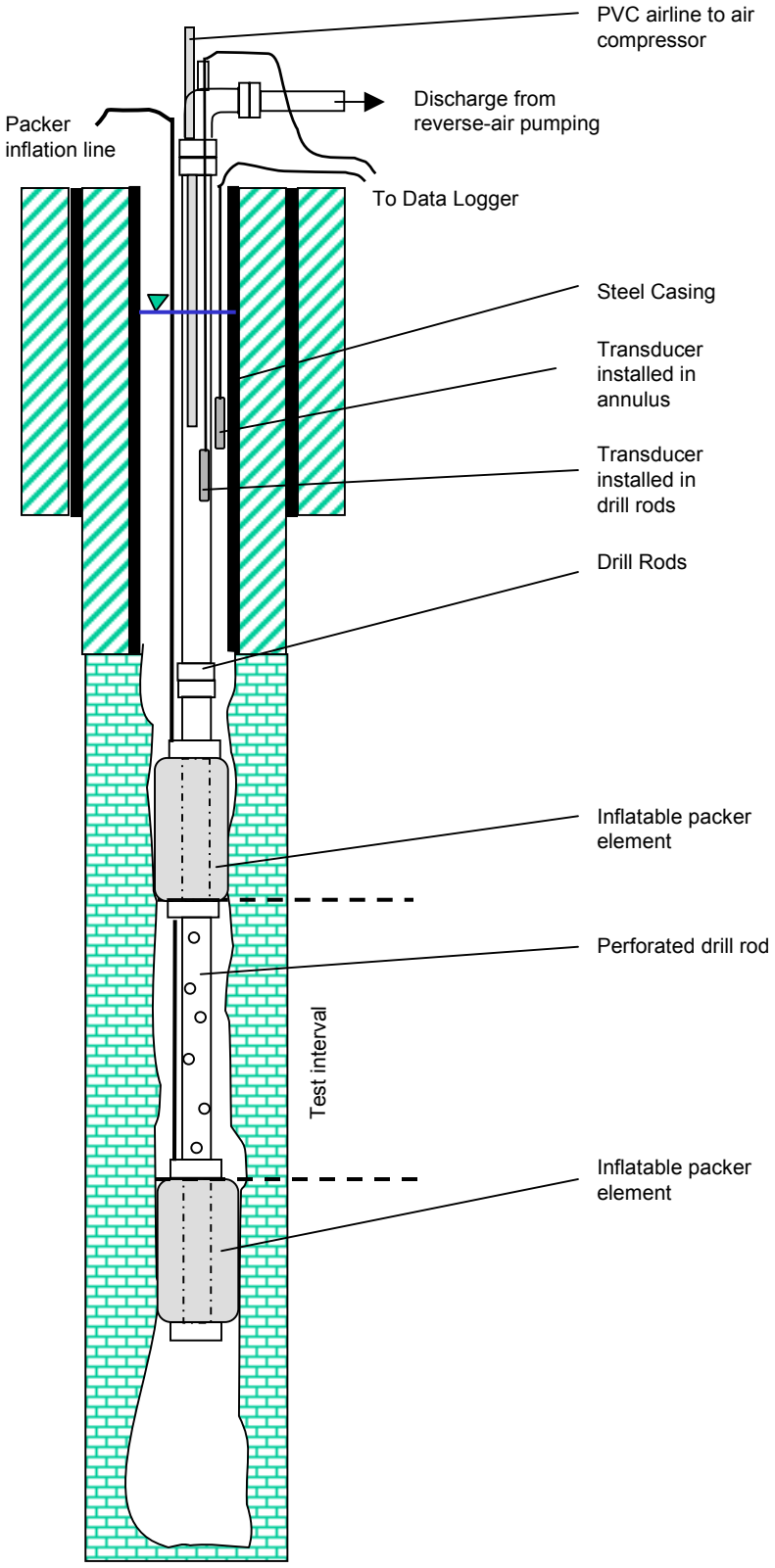


Figure 11. Annutteliga Hammock

Straddle Packer Diagram

Fig11_straddlepacker.ppt

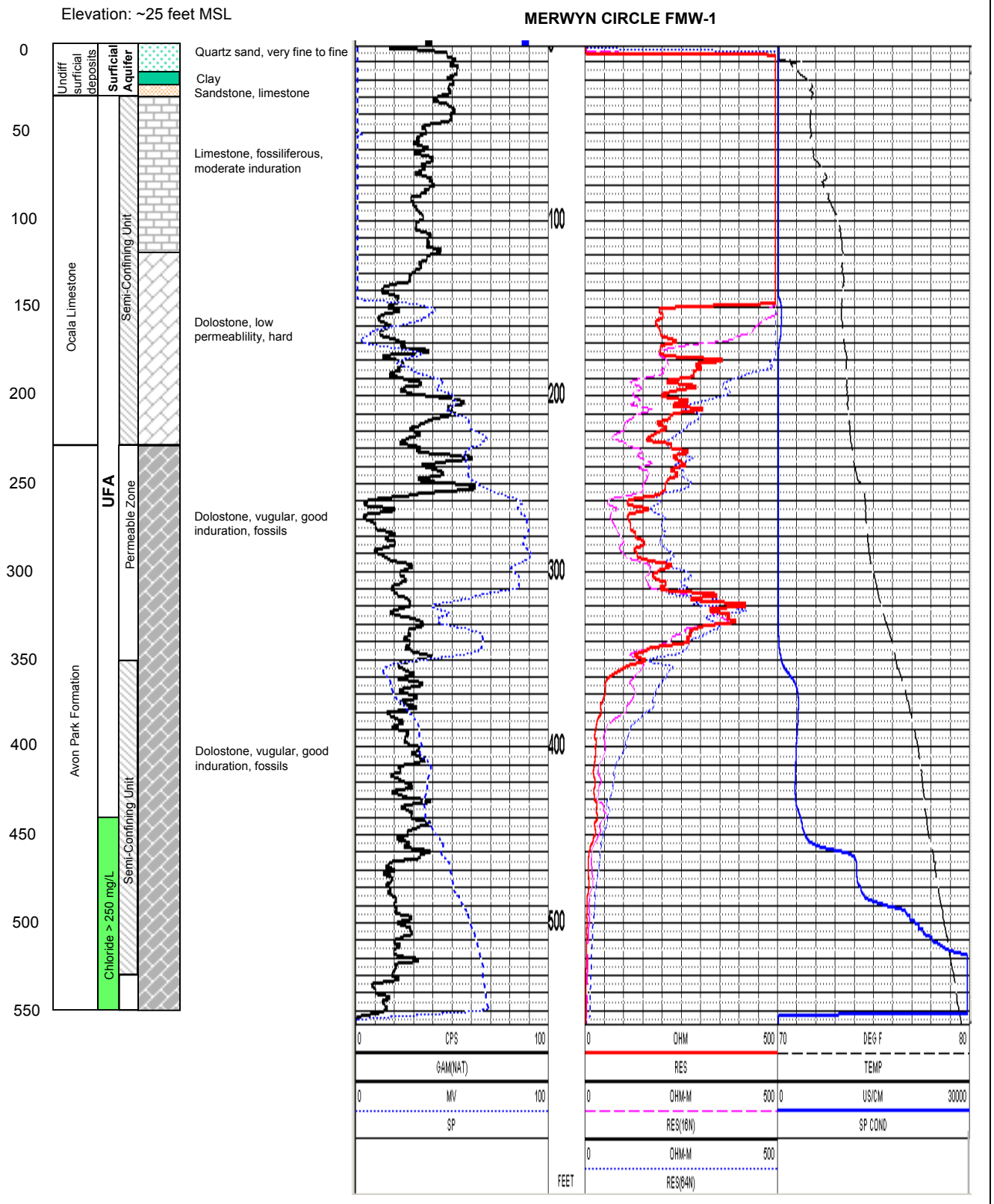
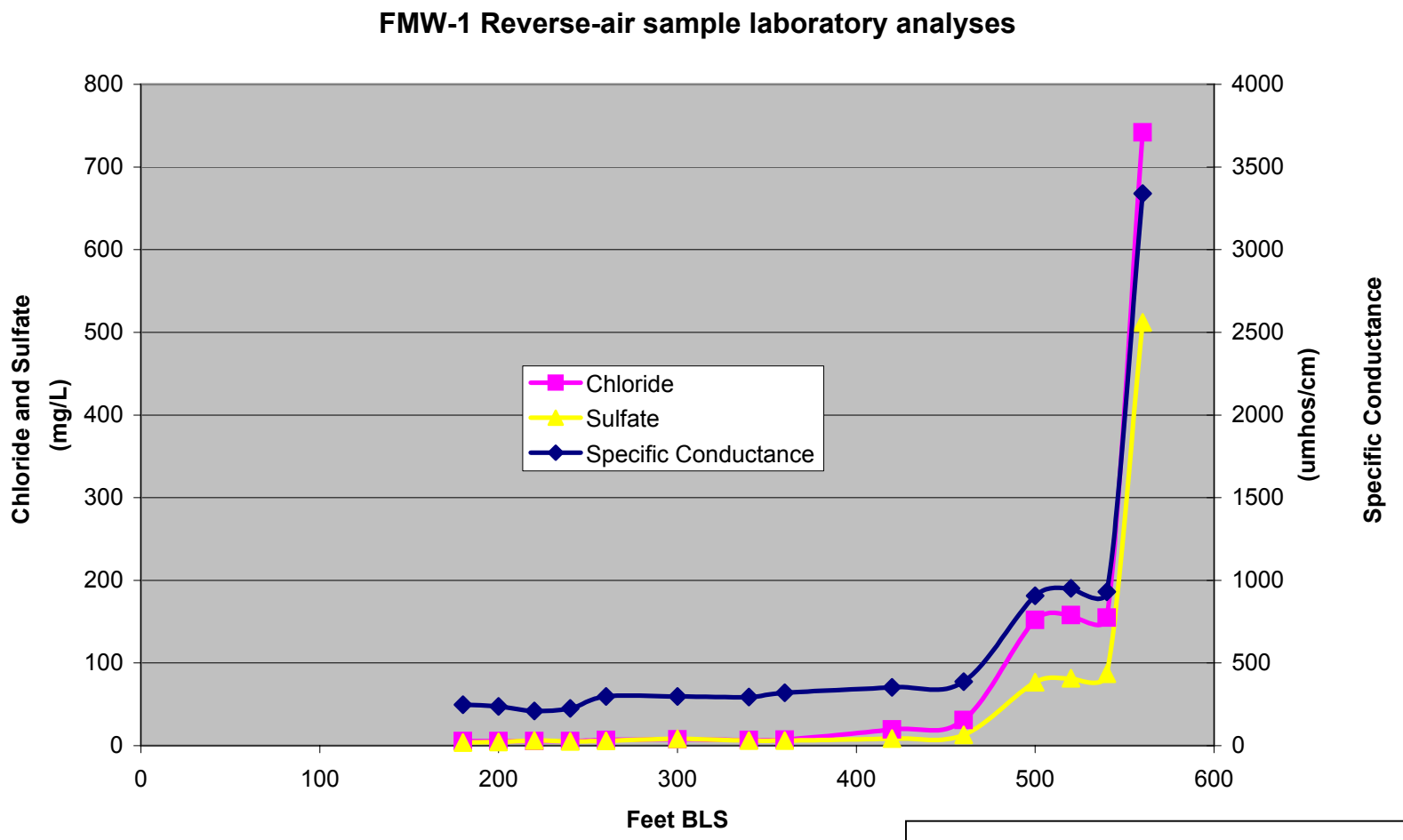


Figure 12. Annutteliga Hammock Geophysical Logs and Hydrogeology

Figure12_geopysical logs.ppt



wq.xls

Figure 13. Annutteliga Hammock

Chloride, Sulfate, and Specific Conductance Graph

APPENDIX A
Lithologic Log

LITHOLOGIC WELL LOG PRINTOUT

SOURCE - FGS

WELL NUMBER: W-34000
TOTAL DEPTH: 00560 FT.
SAMPLES - NONE

COUNTY - HERNANDO
LOCATION: T.21S R.18E S.06
LAT = 28D 41M 10S
LON = 82D 32M 33S

COMPLETION DATE: 01/30/01
OTHER TYPES OF LOGS AVAILABLE - 1

ELEVATION: 20 FT

OWNER/DRILLER:OWNER: S.W.F.W.M.D. DRILLER: MAX LANINGHAM, BOBBY ?, BILLY ?, DIVERSIFIED DRILLING CORP.

WORKED BY:DON THOMPSON AND STEPHANIE HERTZ;
WEL-2575/18303 ROMP ANNUTTELIGA HAMMOCK
CODED AND ENTERED BY S. HERTZ (2/01)
SPLIT SPOON SAMPLES DESCRIBED FROM LS TO 45 FEET BELOW LS
CUTTINGS DESCRIBED FROM 45 FEET TO 560 FEET BELOW LS
ROMP SITE ANNUTTELIGA HAMMOCK IS LOCATED APPROX. 1/2 MILE EAST OF US 19 IN NORTHWEST HERNANDO COUNTY

0. - 15. 090UDSC UNDIFFERENTIATED SAND AND CLAY
15. - 220. 124OCAL OCALA GROUP
220. - 560. 124AVPK AVON PARK FM.

0 - .5 LIMESTONE;
DRILLING PAD

.5- 3 SAND; LIGHT GRAYISH BROWN TO GRAYISH BROWN
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: ROUNDED TO SUB-ANGULAR; MEDIUM SPHERICITY
ACCESSORY MINERALS: ORGANICS- %

3 - 7 SAND; VERY LIGHT ORANGE TO GRAYISH BROWN
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: ROUNDED TO SUB-ANGULAR; MEDIUM SPHERICITY
ACCESSORY MINERALS: CLAY-05%, SILT-10%
POSSIBLE CLAY STRINGER AT 6 FEET; SOME OF SAMPLE APPEARS TO BE FALLING FROM ABOVE.

7 - 15 SAND; VERY LIGHT ORANGE TO GRAYISH BROWN
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: ROUNDED TO SUB-ANGULAR; MEDIUM SPHERICITY
ACCESSORY MINERALS: CLAY-30%
IRON STAIN PREVALENT; GRADES TO SANDY CLAY AT BASE.

15 - 20 CLAY; VERY LIGHT ORANGE
ACCESSORY MINERALS: QUARTZ SAND-30%

20 - 32 SANDSTONE; VERY LIGHT ORANGE
POOR INDURATION
ACCESSORY MINERALS: LIMESTONE-60%
WEATHERED LIMESTONE

32 - 45 NO SAMPLES

45 - 50 LIMESTONE; GRAYISH ORANGE PINK TO VERY LIGHT ORANGE
GRAIN TYPE: BIOGENIC, CALCILUTITE
GRAIN SIZE: FINE; RANGE: MEDIUM TO VERY FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
SEDIMENTARY STRUCTURES: BEDDED, BIOTURBATED
OTHER FEATURES: FOSSILIFEROUS, WEATHERED, GRANULAR
FOSSILS: BENTHIC FORAMINIFERA, ECHINOID, FOSSIL FRAGMENTS
FOSSIL MOLDS

50 - 60 LIMESTONE; GRAYISH ORANGE PINK TO VERY LIGHT ORANGE
GRAIN TYPE: BIOGENIC, CALCILUTITE
GRAIN SIZE: FINE; RANGE: MEDIUM TO FINE

MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
SEDIMENTARY STRUCTURES: BEDDED, BIOTURBATED
OTHER FEATURES: FOSSILIFEROUS, WEATHERED, GRANULAR
FOSSILS: BENTHIC FORAMINIFERA, ECHINOID, FOSSIL FRAGMENTS
FOSSIL MOLDS
FOSSIL HASH

60 - 80 LIMESTONE; GRAYISH ORANGE PINK TO VERY LIGHT ORANGE
GRAIN TYPE: BIOGENIC, CALCILUTITE
GRAIN SIZE: FINE; RANGE: MEDIUM TO VERY FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
SEDIMENTARY STRUCTURES: BEDDED, BIOTURBATED
OTHER FEATURES: FOSSILIFEROUS, WEATHERED, GRANULAR
FOSSILS: BENTHIC FORAMINIFERA, ECHINOID, FOSSIL FRAGMENTS
FOSSIL MOLDS
RARE IRON STAINED LIMESTONE

80 - 90 LIMESTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
GRAIN TYPE: BIOGENIC, CALCILUTITE
GRAIN SIZE: FINE; RANGE: MEDIUM TO VERY FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
SEDIMENTARY STRUCTURES: BEDDED, BIOTURBATED
OTHER FEATURES: FOSSILIFEROUS, WEATHERED, GRANULAR
FOSSILS: BENTHIC FORAMINIFERA, ECHINOID, FOSSIL FRAGMENTS
FOSSIL MOLDS
LEPIDOCYCLINA OCALANA, ECHINOID SPINES

90 - 120 LIMESTONE; VERY LIGHT ORANGE
GRAIN TYPE: BIOGENIC, CALCILUTITE
GRAIN SIZE: FINE; RANGE: MEDIUM TO VERY FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
SEDIMENTARY STRUCTURES: BEDDED, BIOTURBATED
OTHER FEATURES: FOSSILIFEROUS, WEATHERED, GRANULAR
FOSSILS: BENTHIC FORAMINIFERA, ECHINOID, FOSSIL FRAGMENTS
FOSSIL MOLDS
COLOR SLIGHTLY VARIABLE

120 - 180 DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN
POROSITY: INTERGRANULAR, PIN POINT VUGS, LOW PERMEABILITY
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-05%
OTHER FEATURES: HIGH RECRYSTALLIZATION, PLATY
HARD DOLOSTONE, CUTTINGS FLAKY AND CONCHOIDAL

180 - 200 DOLOSTONE; YELLOWISH GRAY TO DARK GRAYISH YELLOW
POROSITY: INTERGRANULAR, VUGULAR, PIN POINT VUGS
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
ACCESSORY MINERALS: LIMESTONE-10%
OTHER FEATURES: GRANULAR
RARE LIMESTONE CUTTINGS, MAY BE FROM ABOVE. SOME CUTTINGS FLAKY AND CONCHOIDAL

200 - 210 DOLOSTONE; VERY LIGHT ORANGE TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, PIN POINT VUGS, LOW PERMEABILITY
50-90% ALTERED; ANHEDRAL

GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
ACCESSORY MINERALS: LIMESTONE-05%, CLAY-05%
OTHER FEATURES: GRANULAR, COQUINA, HIGH RECRYSTALLIZATION
CLAY FILLED FRACTURES

210 - 220 DOLOSTONE; YELLOWISH GRAY TO DARK GRAYISH YELLOW
POROSITY: INTERGRANULAR, VUGULAR, PIN POINT VUGS
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
ACCESSORY MINERALS: ORGANICS- %
OTHER FEATURES: GRANULAR
TRACE ORGANICS

220 - 230 DOLOSTONE; VERY LIGHT ORANGE TO LIGHT YELLOWISH ORANGE
POROSITY: INTERGRANULAR, VUGULAR, PIN POINT VUGS
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED, BIOTURBATED
ACCESSORY MINERALS: LIMESTONE- %
OTHER FEATURES: FOSSILIFEROUS
FOSSILS: FOSSIL FRAGMENTS, FOSSIL MOLDS, MOLLUSKS
BENTHIC FORAMINIFERA
NUMMULITIES? GASTROPODS, PELECYPODS

230 - 250 DOLOSTONE; DARK GRAYISH YELLOW TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, VUGULAR, PIN POINT VUGS
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
ACCESSORY MINERALS: LIMESTONE- %
VERY SMALL CUTTINGS, MAY BE RE-DRILLED

250 - 264 VOID

264 - 310 DOLOSTONE; VERY LIGHT ORANGE TO LIGHT YELLOWISH ORANGE
POROSITY: INTERGRANULAR, VUGULAR, PIN POINT VUGS
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
ACCESSORY MINERALS: IRON STAIN- %
OTHER FEATURES: GRANULAR
SLIGHT IRON STAINING

310 - 330 DOLOSTONE; MODERATE YELLOWISH BROWN TO LIGHT YELLOWISH ORANGE
POROSITY: INTERGRANULAR, VUGULAR, PIN POINT VUGS
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED

ACCESSORY MINERALS: IRON STAIN- %
OTHER FEATURES: GRANULAR
TRACE LIMESTONE. ECHINOID PLATES.

330 - 340 DOLOSTONE; GRAYISH ORANGE TO LIGHT YELLOWISH ORANGE
POROSITY: INTERGRANULAR, VUGULAR, PIN POINT VUGS
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: IRON STAIN-05%
OTHER FEATURES: FOSSILIFEROUS, GRANULAR
FOSSILS: FOSSIL FRAGMENTS, FOSSIL MOLDS

340 - 430 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: INTERGRANULAR, VUGULAR, PIN POINT VUGS
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
OTHER FEATURES: FOSSILIFEROUS, GRANULAR
FOSSILS: FOSSIL FRAGMENTS, FOSSIL MOLDS
ECHINOID PLATES

430 - 440 DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN
POROSITY: INTERGRANULAR, VUGULAR, PIN POINT VUGS
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
OTHER FEATURES: FOSSILIFEROUS, GRANULAR
FOSSILS: FOSSIL FRAGMENTS, FOSSIL MOLDS

440 - 450 DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN
POROSITY: INTERGRANULAR, VUGULAR, PIN POINT VUGS
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: ORGANICS-30%
OTHER FEATURES: FOSSILIFEROUS, GRANULAR
FOSSILS: FOSSIL FRAGMENTS, FOSSIL MOLDS
DARK STAINING FROM ORGANICS

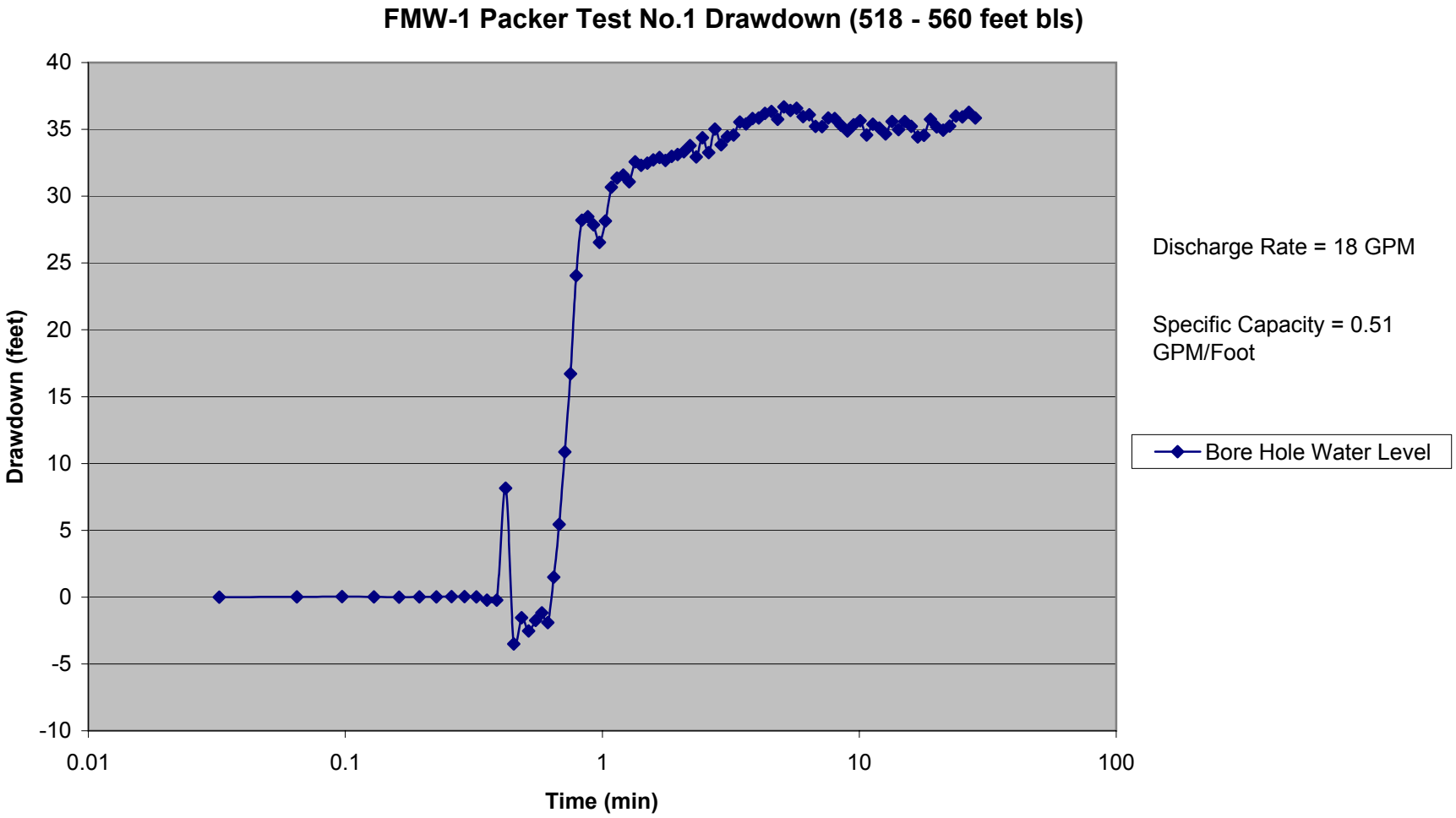
450 - 460 SILT-SIZE DOLOMITE; VERY LIGHT ORANGE TO GRAYISH BROWN
POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX
POORLY INDURATED DOLO-SILT; HIGHLY WEATHERED

460 - 560 DOLOSTONE; GRAYISH ORANGE PINK TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR, VUGULAR, PIN POINT VUGS
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: MICROCRYSTALLINE TO CRYPTOCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: ORGANICS- %, QUARTZ-O5%
OTHER FEATURES: GRANULAR, FOSSILIFEROUS
FOSSILS: FOSSIL FRAGMENTS, FOSSIL MOLDS
TRACE QUARTZ CRYSTALS NOTED FROM 530 TO TD

560 TOTAL DEPTH

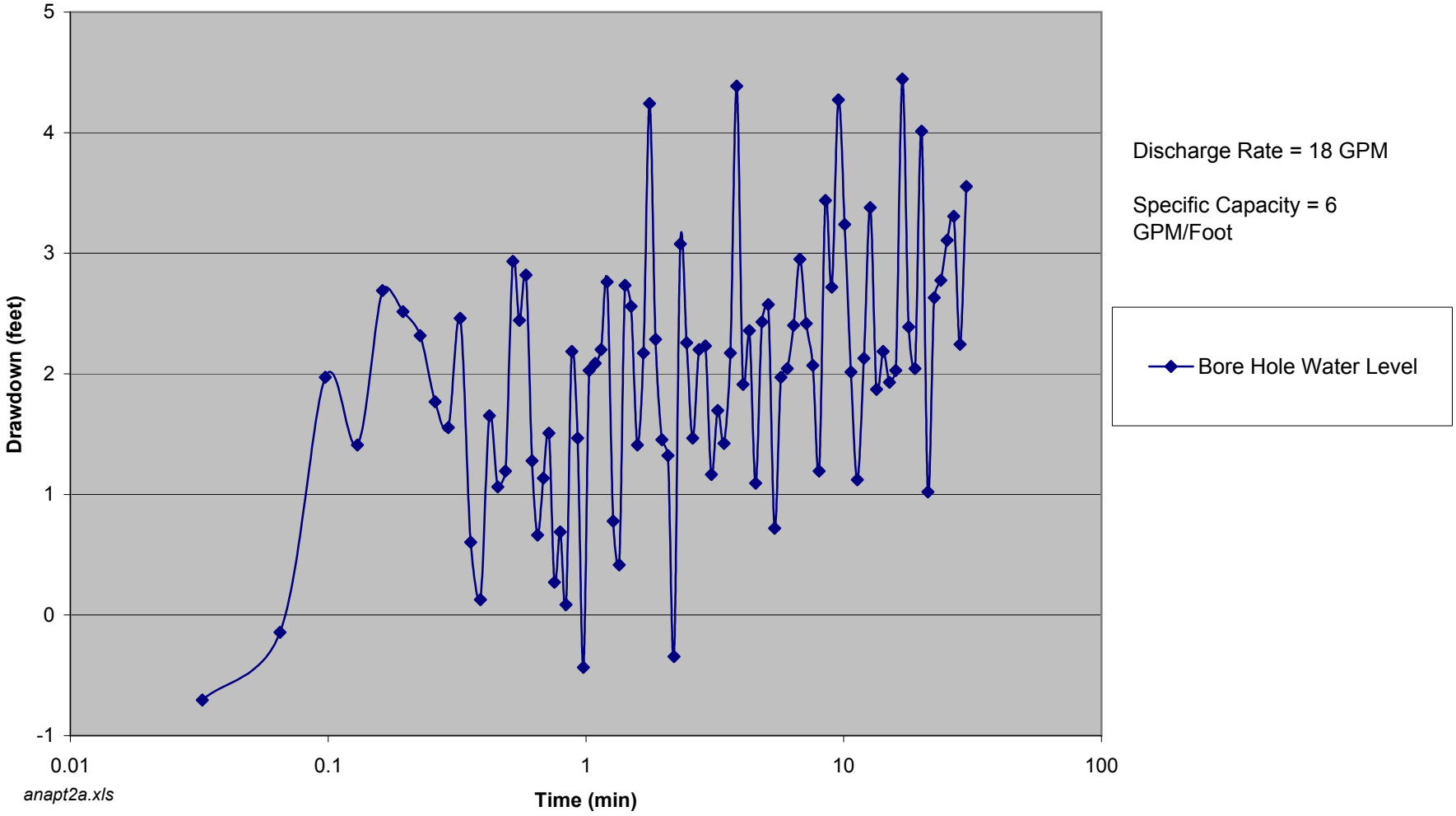
APPENDIX B

Packer Test Drawdown Graphs

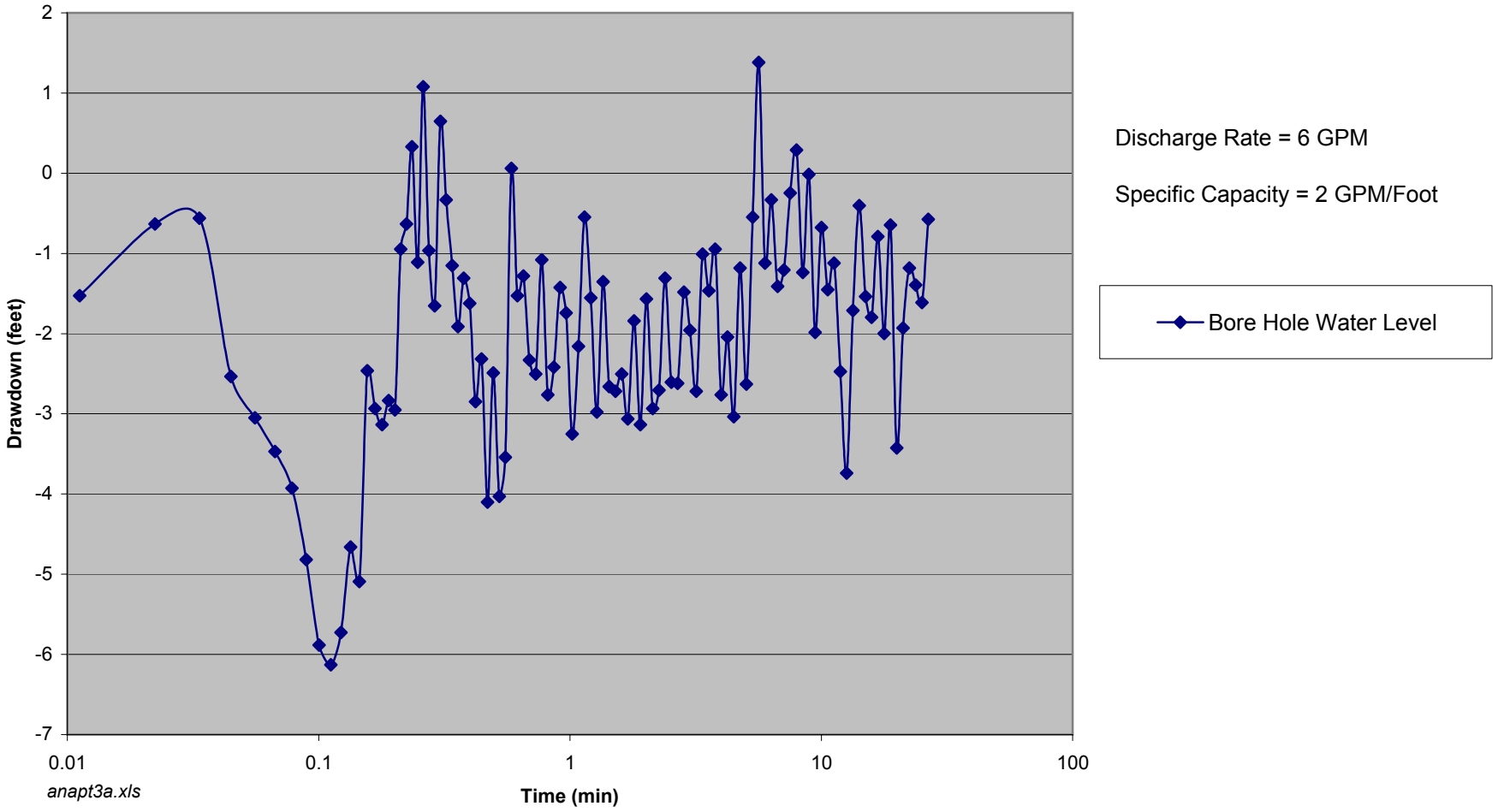

FMW-1 Packer Test No.1 Drawdown (518 - 560 feet bls)
Drawdown (feet)
40
35
30
25
20
15
10
5
0
-5
-10
0.01
0.1
1
10
100
Time (min)
Discharge Rate = 18 GPM
Specific Capacity = 0.51 GPM/Foot
Bore Hole Water Level

anapt1a.xls

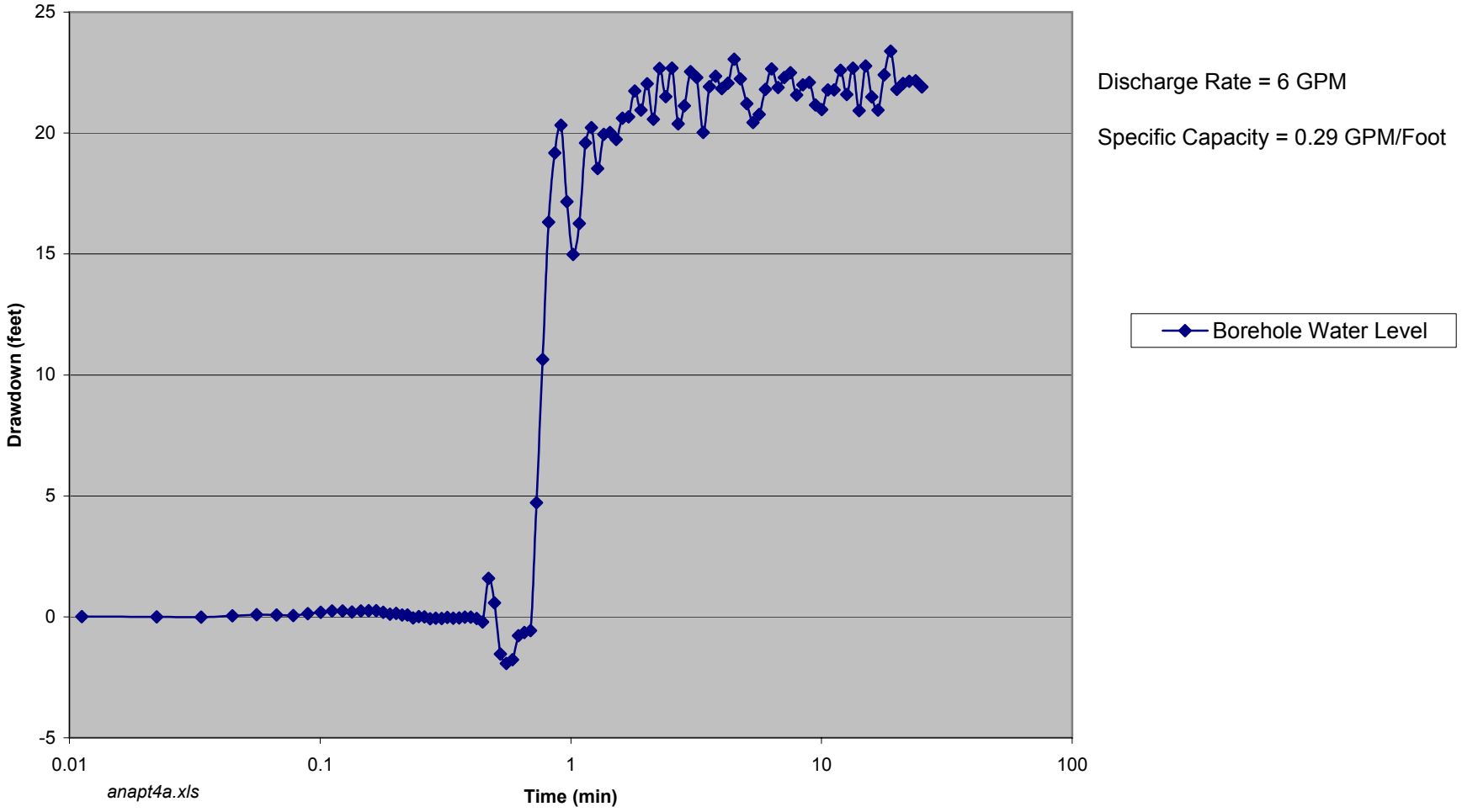
FMW-1 Packer Test No.2 Drawdown (542-560 feet bls)



FMW-1 Packer Test No. 3 Drawdown (499-518 feet BLS)



FMW-1 Packer Test No. 4 Drawdown (420-439 feet BLS)



APPENDIX C

Packer Test Specific Capacity Data

Estimating Aquifer Transmissivity and Hydraulic Conductivity from Specific Capacity Data

$$T = \frac{Q}{(h_o - h)} \frac{2.3}{4\pi} \log \frac{2.25Tt}{r^2 S}$$

where

$\frac{Q}{(h_o - h)}$ is specific Capacity of the well (L^2/T)

t is the period of pumping (T)
r is the radius of the pumping well (L)
T is the aquifer transmissivity (L^2/T)
S is the aquifer storativity (d'less)

INPUTS

$\frac{Q}{(h_o - h)}$	=	0.51	gpm/ft
t	=	10	min.
r	=	3	in.
T_i	=	200	ft^2/d - INITIAL ESTIMATE
S	=	0.001	d'less - ESTIMATE
b	=	42	ft

OUTPUTS

				Discrepancy
T_1	=	84	ft^2/d	136.76%
T_2	=	78	ft^2/d	8.66%
T_3	=	77	ft^2/d	0.84%
T_4	=	**77**	ft^2/d	0.08%
T_4	=	**576**	gpd/ft	
K_4	=	**1.8**	ft/d	

Instructions: Complete the "Inputs" using the indicated units. You must enter an initial estimate for the transmissivity and an estimate for storitivity. The calculated transmissivity and hydraulic conductivity are in the "Outputs" section indicted by the subscript 4.

Note: Discrepancy is the ratio of the T_i and T_4. This method may be referred to Herr's Method.

Assumptions: Thies assumptions & pumped well 100% efficient.

Reference: Thies 1963

Storage: well-confined -> 0.00001; semi-confined -> 0.0001; poorly-confined -> 0.001; and unconfinded -> 0.01 - 0.1

Comments: **Merwyn Circle FMW-1 Well PT No. 1 (518-560)**

Estimating Aquifer Transmissivity and Hydraulic Conductivity from Specific Capacity Data

$$T = \frac{Q}{(h_o - h)} \frac{2.3}{4\pi} \log \frac{2.25Tt}{r^2 S}$$

where

$\frac{Q}{(h_o - h)}$ is specific Capacity of the well (L^2/T)

t is the period of pumping (T)
r is the radius of the pumping well (L)
T is the aquifer transmissivity (L^2/T)
S is the aquifer storativity (d'less)

INPUTS

$\frac{Q}{(h_o - h)}$	=	9	gpm/ft
t	=	10	min.
r	=	3	in.
T_i	=	500	ft^2/d - INITIAL ESTIMATE
S	=	0.001	d'less - ESTIMATE
b	=	18	ft

OUTPUTS

				Discrepancy
T_1	=	1,617	ft^2/d	-69.08%
T_2	=	1,779	ft^2/d	-9.09%
T_3	=	1,792	ft^2/d	-0.73%
T_4	=	**1,793**	ft^2/d	-0.06%
T_4	=	**13,412**	gpd/ft	
K_4	=	**99.6**	ft/d	

Instructions: Complete the "Inputs" using the indicated units. You must enter an initial estimate for the transmissivity and an estimate for storitivity. The calculated transmissivity and hydraulic conductivity are in the "Outputs" section indicted by the subscript 4.

Note: Discrepancy is the ratio of the T_i and T_4. This method may be referred to Herr's Method.

Assumptions: Thies assumptions & pumped well 100% efficient.

Reference: Thies 1963

Storage: well-confined -> 0.00001; semi-confined -> 0.0001; poorly-confined -> 0.001; and unconfinded -> 0.01 - 0.1

Comments: **Merwyn Circle FMW-1 Well PT No. 2 (542-560)**

Estimating Aquifer Transmissivity and Hydraulic Conductivity from Specific Capacity Data

$$T = \frac{Q}{(h_o - h)} \frac{2.3}{4\pi} \log \frac{2.25Tt}{r^2 S}$$

where

$\frac{Q}{(h_o - h)}$ is specific Capacity of the well (L^2/T)

t is the period of pumping (T)
r is the radius of the pumping well (L)
T is the aquifer transmissivity (L^2/T)
S is the aquifer storativity (d'less)

INPUTS

$\frac{Q}{(h_o - h)}$	=	4	gpm/ft
t	=	10	min.
r	=	3	in.
T_i	=	500	ft^2/d - INITIAL ESTIMATE
S	=	0.001	d'less - ESTIMATE
b	=	19	ft

OUTPUTS

				Discrepancy
T_1	=	719	ft^2/d	-30.42%
T_2	=	741	ft^2/d	-3.00%
T_3	=	743	ft^2/d	-0.25%
T_4	=	**743**	ft^2/d	-0.02%
T_4	=	**5,557**	gpd/ft	
K_4	=	**39.1**	ft/d	

Instructions: Complete the "Inputs" using the indicated units. You must enter an initial estimate for the transmissivity and an estimate for storitivity. The calculated transmissivity and hydraulic conductivity are in the "Outputs" section indicted by the subscript 4.

Note: Discrepancy is the ratio of the T_i and T_4. This method may be referred to Herr's Method.

Assumptions: Thies assumptions & pumped well 100% efficient.

Reference: Thies 1963

Storage: well-confined -> 0.00001; semi-confined -> 0.0001; poorly-confined -> 0.001; and unconfinded -> 0.01 - 0.1

Comments: **Merwyn Circle FMW-1 Well PT No. 3 (499-518)**

Estimating Aquifer Transmissivity and Hydraulic Conductivity from Specific Capacity Data

$$T = \frac{Q}{(h_o - h)} \frac{2.3}{4\pi} \log \frac{2.25Tt}{r^2 S}$$

where

$\frac{Q}{(h_o - h)}$ is specific Capacity of the well (L^2/T)

t is the period of pumping (T)
r is the radius of the pumping well (L)
T is the aquifer transmissivity (L^2/T)
S is the aquifer storativity (d'less)

INPUTS

$\frac{Q}{(h_o - h)}$	=	0.29	gpm/ft
t	=	10	min.
r	=	3	in.
T_i	=	200	ft^2/d - INITIAL ESTIMATE
S	=	0.0001	d'less - ESTIMATE
b	=	19	ft

OUTPUTS

				Discrepancy
T_1	=	58	ft^2/d	243.32%
T_2	=	53	ft^2/d	10.38%
T_3	=	52	ft^2/d	0.84%
T_4	=	**52**	ft^2/d	0.07%
T_4	=	**391**	gpd/ft	
K_4	=	**2.8**	ft/d	

Instructions: Complete the "Inputs" using the indicated units. You must enter an initial estimate for the transmissivity and an estimate for storitivity. The calculated transmissivity and hydraulic conductivity are in the "Outputs" section indicted by the subscript 4.

Note: Discrepancy is the ratio of the T_i and T_4. This method may be referred to Herr's Method.

Assumptions: Thies assumptions & pumped well 100% efficient.

Reference: Thies 1963

Storage: well-confined -> 0.00001; semi-confined -> 0.0001; poorly-confined -> 0.001; and unconfinded -> 0.01 - 0.1

Comments: **Merwyn Circle FMW-1 PT No. 4 (420-439)**

APPENDIX D

Single Well Test Specific Capacity Data
and Hantush Curve Analysis

Estimating Aquifer Transmissivity and Hydraulic Conductivity from Specific Capacity Data

$$T = \frac{Q}{(h_o - h)} \frac{2.3}{4\pi} \log \frac{2.25Tt}{r^2 S}$$

where

$\frac{Q}{(h_o - h)}$ is specific Capacity of the well (L^2/T)

t is the period of pumping (T)
r is the radius of the pumping well (L)
T is the aquifer transmissivity (L^2/T)
S is the aquifer storativity (d'less)

INPUTS

$\frac{Q}{(h_o - h)}$	=	72	gpm/ft
t	=	1440	min.
r	=	10	in.
T_i	=	15,000	ft^2/d - INITIAL ESTIMATE
S	=	0.001	d'less - ESTIMATE
b	=	165	ft

OUTPUTS

				Discrepancy
T_1	=	19,508	ft^2/d	-23.11%
T_2	=	19,797	ft^2/d	-1.46%
T_3	=	19,814	ft^2/d	-0.08%
T_4	=	**19,815**	ft^2/d	0.00%
T_4	=	**148,233**	gpd/ft	
K_4	=	**120.1**	ft/d	

Instructions: Complete the "Inputs" using the indicated units. You must enter an initial estimate for the transmissivity and an estimate for storitivity. The calculated transmissivity and hydraulic conductivity are in the "Outputs" section indicted by the subscript 4.

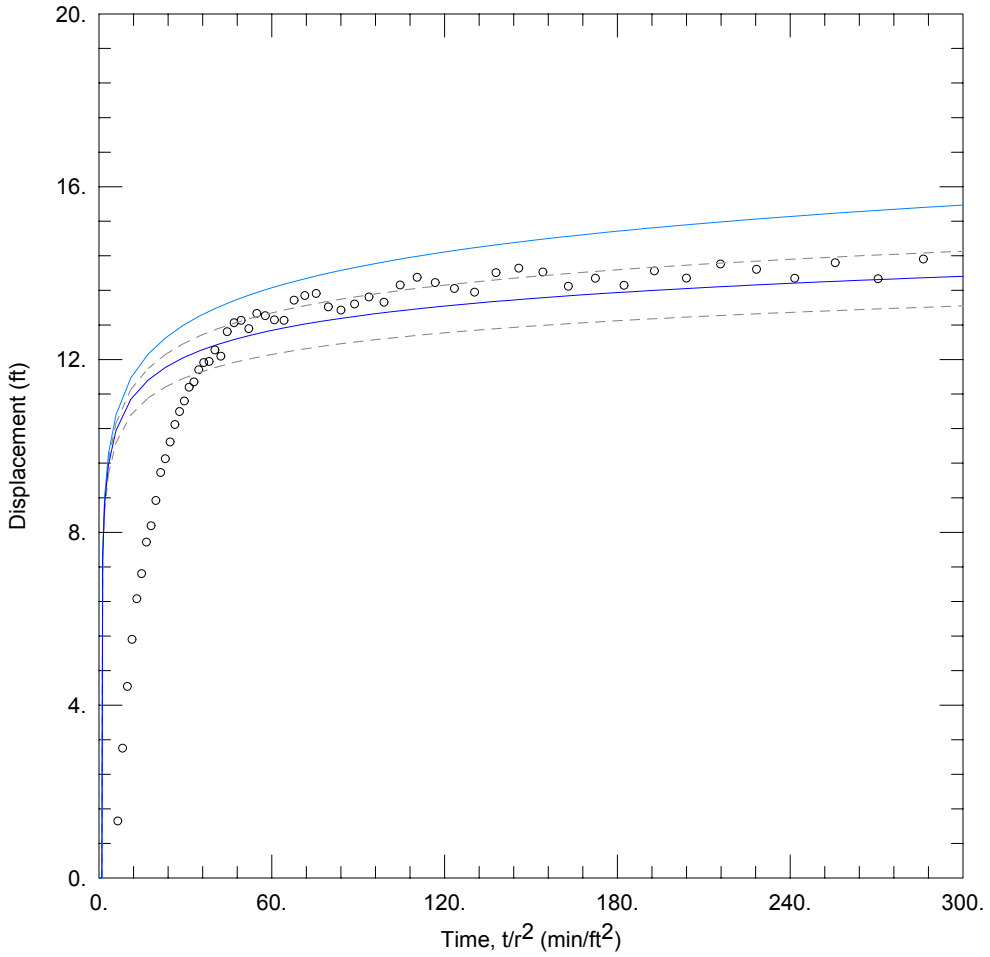
Note: Discrepancy is the ratio of the T_i and T_4. This method may be referred to Herr's Method.

Assumptions: Thies assumptions & pumped well 100% efficient.

Reference: Thies 1963

Storage: well-confined -> 0.00001; semi-confined -> 0.0001; poorly-confined -> 0.001; and unconfinded -> 0.01 - 0.1

Comments: **Malibar Road 20-inch single well 24-hour APT**



WELL TEST ANALYSIS

Data Set: D:\MyFiles\Annuteliga Project\Annutteliga Hammock APT.aqt
Date: 07/29/04 Time: 16:49:16

PROJECT INFORMATION

Company: SWFWMD

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW 1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
○ OW 1	0	0.1

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1.582E+4 ft^2/day
ß = 0.001236
b = 164. ft

S = 0.01381
Kz/Kr = 0.01012