Floridan Aquifer System Test Well Program

City of South Bay, Florida

Technical Publication WS-2

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Cover Photo: S-2 Pump Station (foreground) and Lake Okeechobee (background)

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EXECUTIVE SUMMARY

This report documents the results of construction and testing of two new Floridan Aquifer System (FAS) wells by the South Florida Water Management District (District or SFWMD). The wells were constructed north of the City of South Bay, near the District's S-2A pump station in Palm Beach County, Florida. This site was selected to augment data available from other wells and to provide broad, spatial coverage within the District's Lower East Coast (LEC) planning area. The purpose of the drilling and testing program was to assess the subsurface hydrogeologic and water quality properties and to evaluate the water resource potential of the FAS at the site.

The scope of the investigation consisted of constructing and testing two FAS wells. The first well (Well PBF-7) was drilled to a total depth of 2,504 feet below land surface (bls). It was completed as a dual-zone monitor well into two distinct hydrogeologic zones - an *upper* zone between 992 and 1,447 feet bls, and a *lower* zone between 1,968 and 2,040 feet bls. The second well (Well PBF-9) was constructed in stages to allow aquifer performance tests to be conducted at depths corresponding to the monitor intervals of Well PBF-7.

The main findings of the construction and testing program were as follows:

- Surficial sediments extended from land surface to a depth of 208 feet bls and the Hawthorn Group (Upper Confining Unit) was found to extend to approximately 900 feet bls.
- Limestone comprising the uppermost FAS was identified at a depth of approximately 900 feet bls based on lithologic and hydrogeologic observations.
- The uppermost 300 feet of the FAS exhibited a relatively low hydraulic conductivity (between approximately 8 and 22 feet per day [ft/day]). Water sampled from that interval was more saline than immediately underlying zones.
- An *upper* producing zone was identified in the upper FAS between 1,200 and 1,450 feet bls. This zone exhibited a transmissivity of 71,000 gallons per day per foot and a hydraulic conductivity of approximately 38 ft/day. The chloride concentration of water collected from that zone was approximately 1,400 milligrams per liter (mg/L).
- A brown, crystalline dolomite unit was identified at 1,956 feet bls. This is probably the top of the Oldsmar formation. Secondary solutioning and fractures cause this interval to exhibit a transmissivity of approximately 504,000 gallons per day per foot. This interval is referred to as a *lower* producing zone within the upper FAS. Water collected from this zone contained a chloride concentration of 9,350 mg/L.

- The base of the Underground Source of Drinking Water (USDW) was identified by water quality analysis from straddle-packer tests and geophysical log analysis to occur at approximately 1,900 feet bls at the site.
- The potentiometric surfaces of the upper and lower FAS producing zones during the period from October 1997 to December 1999 were approximately 56 and 43 feet above the National Geodetic Vertical Datum of 1929 (NGVD), respectively (unadjusted for density).
- Water levels fluctuated an average of 1 to 4 feet in upper and lower zones over a period of nearly two years.
- When adjusted for density, the groundwater gradient between the upper and lower FAS producing zones is upward.

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INTRODUCTION

The South Florida Water Management District (District or SFWMD) constructed two new wells near the southern end of Lake Okeechobee as part of a Floridan Aquifer System (FAS) exploratory drilling program. The wells are located near the S-2 pump station just north of the City of South Bay in Palm Beach County, Florida. The site is located in Section 26, Township 43 South, Range 36 East, Latitude 26 degrees, 41'58", and Longitude 80 degrees north, 42'57". **Figure 1** presents the locations of the wells described in this report as well as all the wells installed during the exploratory program. The wells were constructed to obtain hydrogeologic and water quality data from the FAS within the District's Lower East Coast planning area. This information can be combined with data from other FAS wells to obtain a better understanding of the water resource potential of the FAS. In addition, this information will be used to assist in the conceptual development and calibration of regional ground water flow models. Aquifer storage and recovery wells have been proposed by the U.S. Army Corp of Engineers and the District in the Comprehensive Everglades Restoration Plan (CERP). Therefore, the local FAS information obtained from these wells will be particularly useful.

Well PBF-7 was first drilled to a total depth of 2,504 feet below land surface (bls), then completed as a dual-zone monitor/observation well. The well taps two zones within the FAS: an upper zone (992 to 1,447 feet bls), and a lower zone (1,968 to 2,040 feet bls). Well PBF-9 was constructed as a dual-zone test-production well. The purpose of this well was to facilitate performance of two aquifer performance tests (APTs), which were conducted to estimate hydraulic properties and water quality within different portions of the FAS. After the pumping tests were performed, Well PBF-9 was completed with an open hole between 1,962 and 2,040 feet bls.

District staff served as overall project managers during this investigation, preparing the well designs and technical specifications, and performing construction oversight of the drilling contractor. All-Webb's Enterprises (AWE), Inc. of Jupiter, Florida was selected as the low-bid contractor to construct the wells. A District drilling contract (C-7660) was executed in December 1995, and a Notice to Proceed was issued in May 1996. Construction began in June 1996 and was completed in April 1997. The contract included drilling, construction, and testing of Well PBF-7 and PBF-9, and installation of associated wellhead piping and appurtenances.

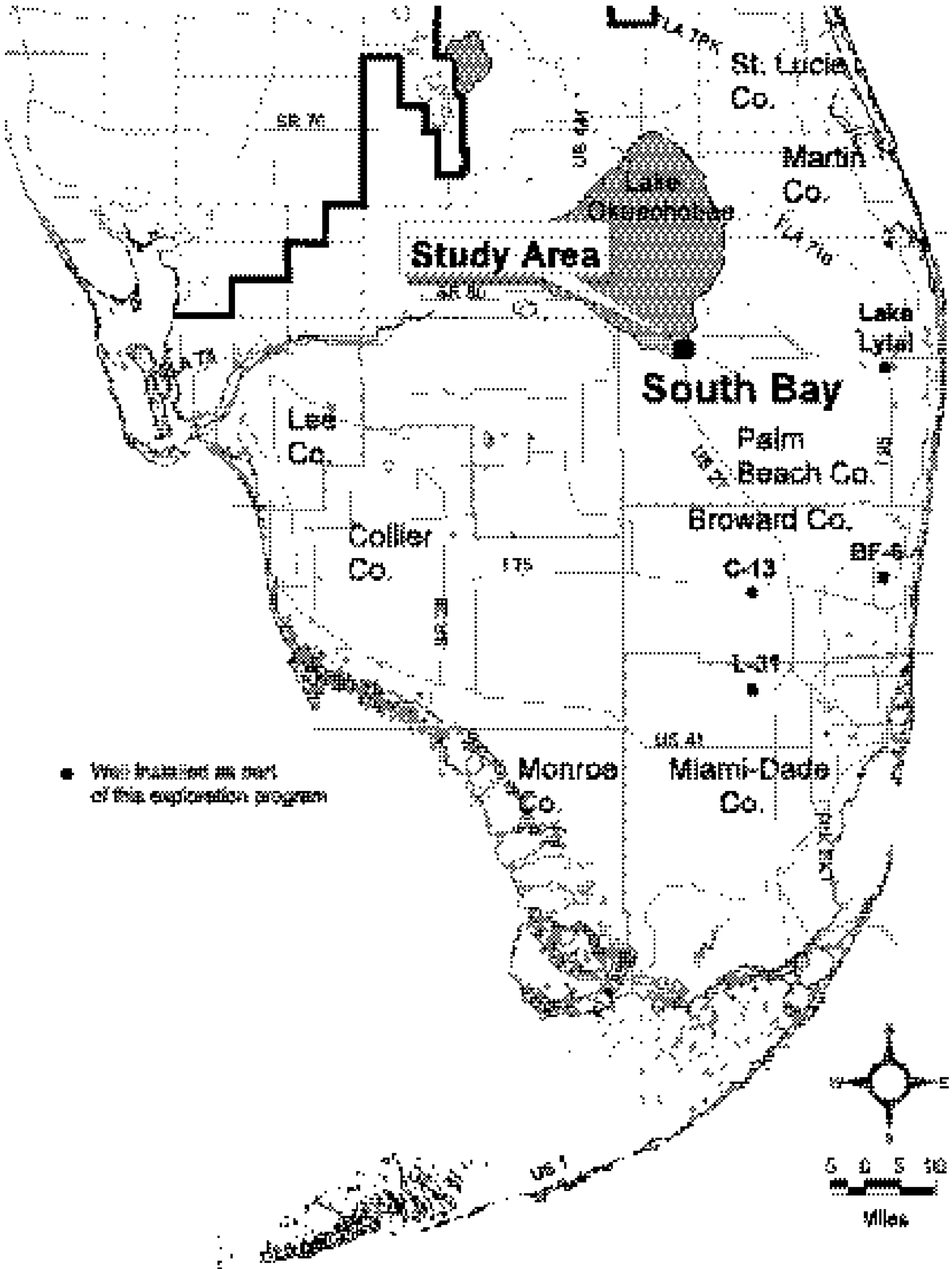

Figure 1. Project Location Map

CONSTRUCTION DETAILS

Two FAS wells were installed near the City of South Bay between June 1996 and April 1997. The locations of the wells, relative to the Hillsboro and Rim Canals, are shown in the vicinity map (**Figure 2**). The drilling schedule and well casing setting depths were designed to conform to the hydrogeologic features observed at the site. Data collected during construction and testing of the wells included lithology, geophysical properties, water quality, water levels, transmissivity, storage, and leakance coefficients that corresponded to the producing zones within the FAS. The data were obtained from collection and description of drill cuttings, borehole geophysical logs, straddle-packer pumping tests, and two APTs.

Well PBF-7 Construction Summary

Construction of Well PBF-7 was initiated in June 1996 and completed in March 1997. Well PBF-7 was initially drilled and tested to a total depth of 2,504 feet bls, then back-plugged with cement to 2,040 feet bls, and completed as a dual-zone monitor well. The upper monitor zone was completed from 992 to 1,447 feet bls; the lower monitor zone was completed from 1,968 to 2,040 feet bls.

Construction included the installation of four concentric casings (24-, 18-, 12-, and 7-inch diameters). The 24-inch diameter pit casing first was vibrated into place to a depth of 15 feet bls. A nominal 10-inch diameter pilot hole was drilled into the top of the Hawthorn Group to a total depth of 242 feet bls, using the mud-rotary method. The pilot hole was reamed to a nominal 24-inch diameter, and a caliper log was conducted. The 18-inch diameter steel surface casing was subsequently cemented in place to a depth of 242 feet bls. The casing was pressure grouted with neat cement containing 12 percent bentonite. Pilot hole drilling resumed using the mud-rotary method to a depth of 1,115 feet bls. Geophysical logs, including the long- and short-normal (LSN) resistivity, natural gamma ray, temperature, fluid resistivity, spontaneous potential (SP), and caliper were conducted. A casing setting depth of 992 feet bls was selected for the 12-inch intermediate casing, based on the presence of a hard, clean, competent limestone at this depth.

The geophysical logs indicated that the top of a limestone-rich interval, as identified by a low gamma ray response, occurred at a depth of 820 feet bls. However, the lithologic samples, between 790 and 900 feet bls, indicated a high content of sand, clay, and silt within the limestone. The first competent, hard limestone was present at 990 feet bls. These data were used to select the setting depth of 990 feet bls for 12-inch diameter casing. The interval between 775 and 890 feet bls was straddle-packer tested later to confirm a relatively low transmissivity, as discussed later in this report in the section on *Formation Testing Results*.

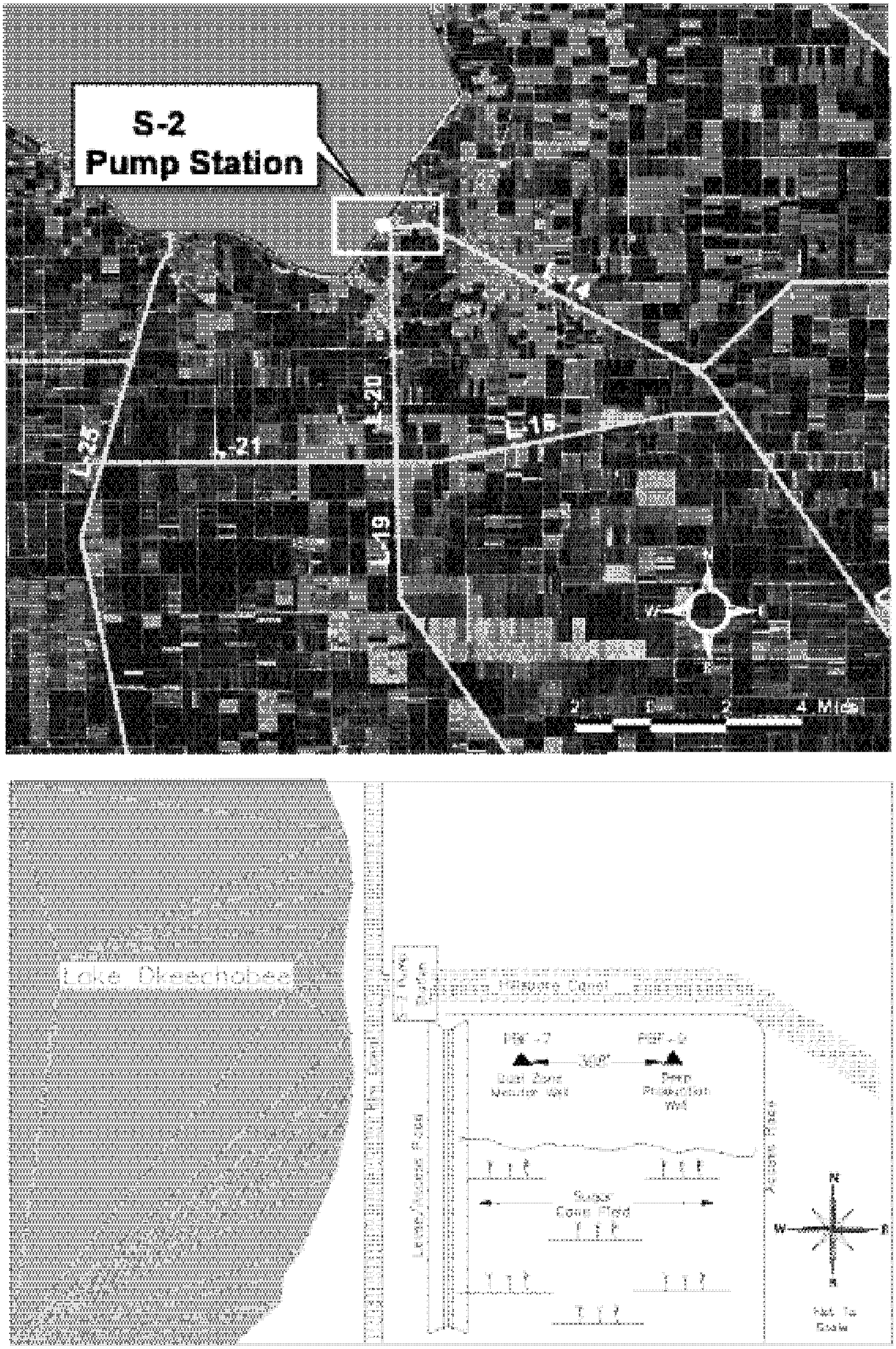

Figure 2. Vicinity Map

The pilot hole subsequently was reamed to a nominal 18-inch diameter to a depth of 992 feet bls. The 12-inch diameter intermediate casing was installed to a depth of 990 feet bls and cemented to land surface. Once the cement cured, the pilot hole was advanced to a depth of 1,297 feet bls using the reverse-air, closed-circulation drilling method. The drill pipe was removed, and the borehole (from 990 to 1,297 feet bls) was developed until discharge water was clear of cuttings. Geophysical logging operations were conducted by AWE. Logs included: gamma ray, LSN, SP, caliper, flowmeter, temperature, and fluid resistivity. Following the geophysical logging, Straddle-Packer Test No. 1 was conducted on the open-hole interval between 992 and 1,297 feet bls. The results of the straddle-packer testing are discussed later in this report in the section on *Formation Testing Results*.

Following Straddle-Packer Test No. 1, pilot-hole drilling resumed using the reverse-air drilling method to a depth of 1,789 feet. The drill pipe was again removed; geophysical logs were conducted between the casing, set at 990 and 1,789 feet bls. Logs included: natural gamma ray, LSN, SP, caliper, temperature, flowmeter, fluid resistivity, and borehole video survey. Results of these logs were used to identify zones for additional packer testing. The intervals between 1,633 and 1,762 feet bls (Straddle-Packer Test No. 2), and between 1,263 and 1,392 feet bls (Straddle-Packer Test No. 3) were tested.

Upon completion of Straddle-Packer Tests Nos. 2 and 3, pilot-hole drilling continued to a total depth of 2,504 feet bls. The drill pipe was withdrawn, and the borehole was air-developed in preparation for geophysical logging and packer testing. Geophysical logs were conducted on January 15, 1997. Logs included: natural gamma ray, LSN, SP, static temperature, static fluid resistivity, flowmeter, caliper, and a downhole video survey. On January 21, 1997, Halliburton Energy Services conducted the following logs: dual induction, spectral density, dual-spaced neutron, sonic, and televiewer. Based on interpretation of these logs, a zone between 1,913 and 2,020 feet bls was selected for further straddle-packer testing. Straddle-Packer Test No. 4 was conducted on February 2, 1997.

The water quality results of Packer Test No. 4 were used, together with other data collected from the well, to establish the setting depth for the 7-inch diameter final casing to a depth of 1,968 feet bls. A nominal 12-inch diameter bit was used to ream the pilot hole to a depth of 1,968 feet bls. A caliper log was then conducted, and the final casing was installed to a depth of 1,968 feet bls. The annular space around the lower-most 100 feet of the final casing was pressure-grouted with neat cement. The remaining portion of the annular space to 1,447 feet bls was cemented using the tremie method, resulting in the creation of an upper monitor zone between 992 and 1,447 feet bls.

The borehole between 2,504 to 2,040 feet bls was backfilled with a slurry of pea gravel and cement. After the cement cured, the lower monitor interval between 1,968 and 2,040 feet bls was cleaned out by reverse air drilling with a 6-inch diameter bit. The lower monitor zone of the well would extend between 1,968 to 2,040 feet bls. Both monitor intervals were air-developed until discharge water was clear of suspended solids.

Subsequently, the wellhead was equipped with monitoring ports for the measurement of potentiometric heads and water quality sampling. The elevation of the monitoring ports and land surface elevations, relative to the National Geodetic Vertical Datum (NGVD) of 1929, were obtained by the District. **Table 1** presents some wellhead elevation measurements from Well PBF-7.

Table 1. Well PBF-7 Elevation Information

Measuring Point	*Elevation in Feet Above NGVD*
Land Surface	19.17
Upper FAS Monitor Zone Petcock	24.25
Lower FAS Monitor Zone Petcock	24.37

A reinforced concrete pad was built around the wellhead, and a chain-link fence with locking hinged gate was installed. An as-built drawing for Well PBF-7 is shown in **Figure 3**.

Well PBF-9 Construction Summary

Construction of PBF-9 was initiated in December 1996 and completed in April 1997. Well PBF-9 was designed and constructed as a dual-zone test-production well. This configuration allowed for the performance of pumping tests at depths corresponding to the monitor zones of Well PBF-7. The upper test zone of Well PBF-9 was completed between 1,202 and 1,447 feet bls; the lower test zone was completed between 1,968 and 2,040 feet bls. The upper monitor zone of Well PBF-7 was completed between 992 and 1,447 feet bls, which was slightly different than the upper test zone in Well PBF-9. The interval between 992 and 1,202 feet bls in Well PBF-7 contained a high silt and chalk content. Silt and chalk have the potential to foul; subsequently, they cause submersible pumps to fail. Since this interval appeared to have relatively low permeability, based on the geophysical logs and lithologic samples collected from Well PBF-7, it would likely not contribute significant flow in the well.

Construction of Well PBF-9 began when the 24-inch diameter pit casing was vibrated in place to an approximate depth of 15 feet bls. A nominal 24-inch diameter hole was drilled by the mud-rotary method to a depth of 242 feet bls, and the borehole was caliper-logged. An 18-inch diameter steel surface casing was installed to a depth of 242 feet bls. The casing was pressure grouted with neat cement. After the cement cured, a nominal 10-inch diameter pilot hole was drilled using the mud-rotary method to a depth of 890 feet bls. Caliper and gamma ray logs were run to verify hole diameter and for correlation purposes before conducting a straddle-packer pumping test.

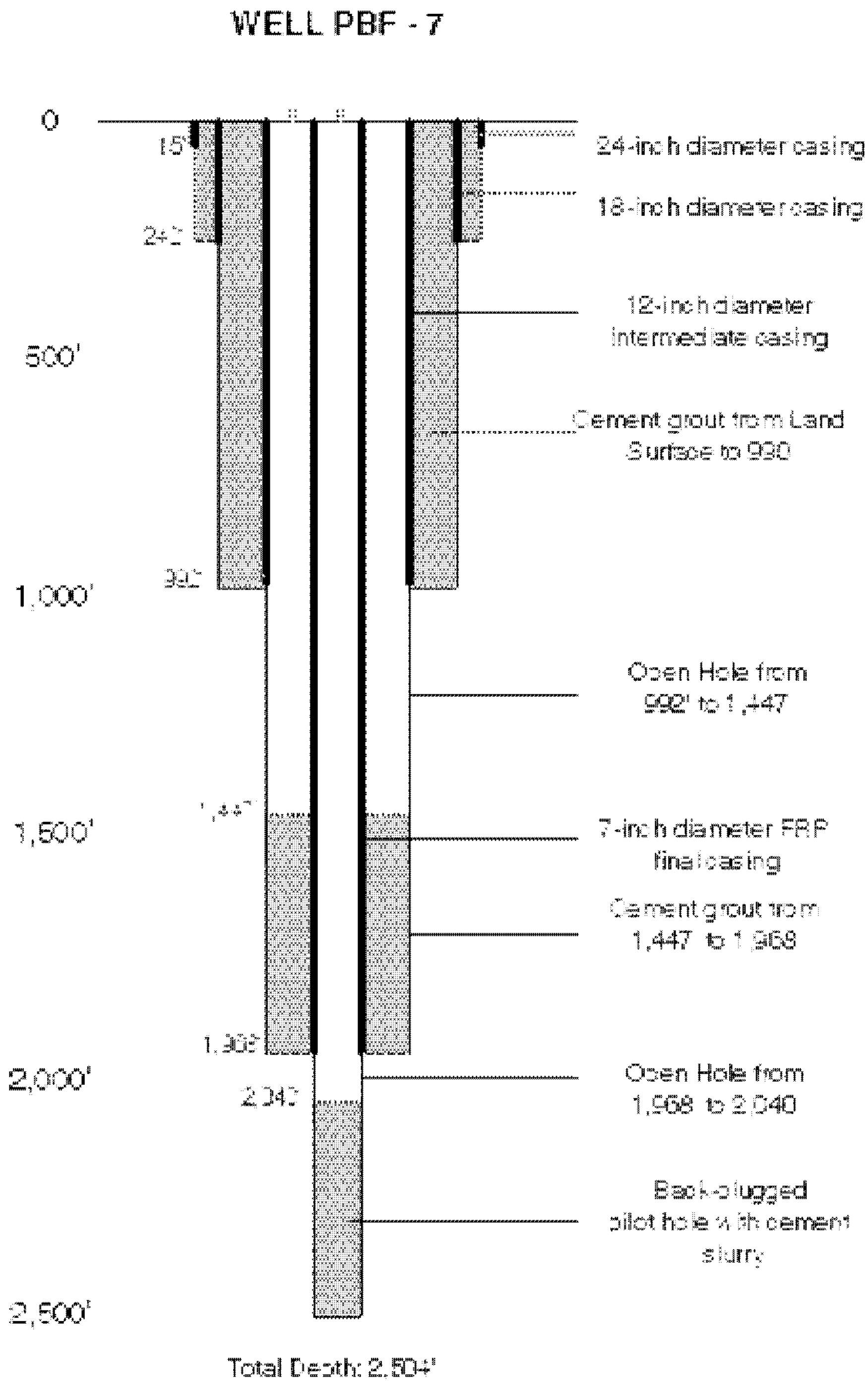

Figure 3. Completion Diagram for Well PBF-7

Straddle-Packer Test No. 5 was conducted on February 19, 1997 between 775 and 890 feet bls to verify the hydraulic properties and water quality within the uppermost FAS. Following Packer Test No. 5, the borehole was reamed to a nominal 18-inch diameter to a depth of 1,202 feet bls. This depth corresponds to the top of the first significant producing zone observed in Well PBF-7. Caliper and gamma ray logs were run from 242 to 1,202 feet bls to verify hole diameter, and for correlation before setting the casing.

A 14-inch diameter steel intermediate casing was pressure grouted using a 12 percent bentonite-cement slurry from 1,202 feet bls to land surface. After the cement cured, the borehole was drilled using the reverse-air method with a nominal 12-inch diameter drill bit to a depth of 1,447 feet bls. This depth was selected since it was near the base of the uppermost producing zones within the upper FAS. The open-hole interval between 1,202 and 1,447 feet bls was developed until discharge water was clear of particulates. On April 3, 1997, APT No. 1 was conducted over the open-hole interval from 1,202 to 1,447 feet bls.

Following APT No. 1, a nominal 14-inch diameter borehole was drilled with the closed-circulation reverse-air method to a depth of 1,960 feet bls. This depth corresponded to the top of a producing zone within the lower FAS observed in Well PBF-7. Upon completion of drilling the nominal 14-inch borehole, a 7-inch (inner) diameter fiberglass reinforced plastic (FRP) casing was installed in the interval between 1,004 and 1,960 feet bls. This final casing was pressure-grouted with neat cement containing 12 percent bentonite up to a depth of 1,005 feet bls. After the cement cured, the borehole was advanced with a 7-inch nominal diameter drill bit using the reverse-air, closed-circulation drilling method to a total depth of 2,040 feet bls. The drill pipe was withdrawn from the well, and the open hole was developed until discharge water was clear of particulates in preparation for APT No. 2.

On May 14, 1997, APT No. 2 was conducted within the open-hole interval from 1,960 to 2,040 feet bls. Once APT No. 2 was complete, a 14-inch diameter iron yolk valve was installed and equipped with a monitoring port for the measurement of piezometric heads and water quality sampling. The wellhead was completed with a reinforced concrete pad surrounded by a locked, chain-link fence, as shown in **Figure 4**. The contractor restored the wellsite and demobilized in October 1997.

FORMATION TESTING PROGRAM

Cuttings Collection During Drilling

Lithologic samples (well cuttings) from Wells PBF-7 and PBF-9 were circulated to land surface while drilling to total depth. The mud-rotary drilling method was used from land surface to a depth of approximately 1,115 feet bls. Below this depth, the reverse-air method was used. During mud-rotary drilling, formation cuttings were circulated from the bottom of the drilled hole to land surface. The cuttings were collected at 10-foot intervals in a sieve that was suspended at the end of the mud discharge line. Cuttings were rinsed with fresh water and described by the site geologist. The cuttings were compared with other information collected from the drilling process, such as penetration rate and flowing wellhead rates, to create a characterization of the penetrated formations. The pilot hole below 1,115 feet bls was drilled using the reverse-air drilling method. The drilled cuttings were collected at 10-foot intervals and/or at formation changes. Cuttings were described by the District's site geologist, noting particularly lithologic type, color, grain size, sorting, accessory minerals, fossils, etc. Observations of bit penetration rate, changes in flow rate observed at the discharge line, and miscellaneous drilling information were recorded in these notes.

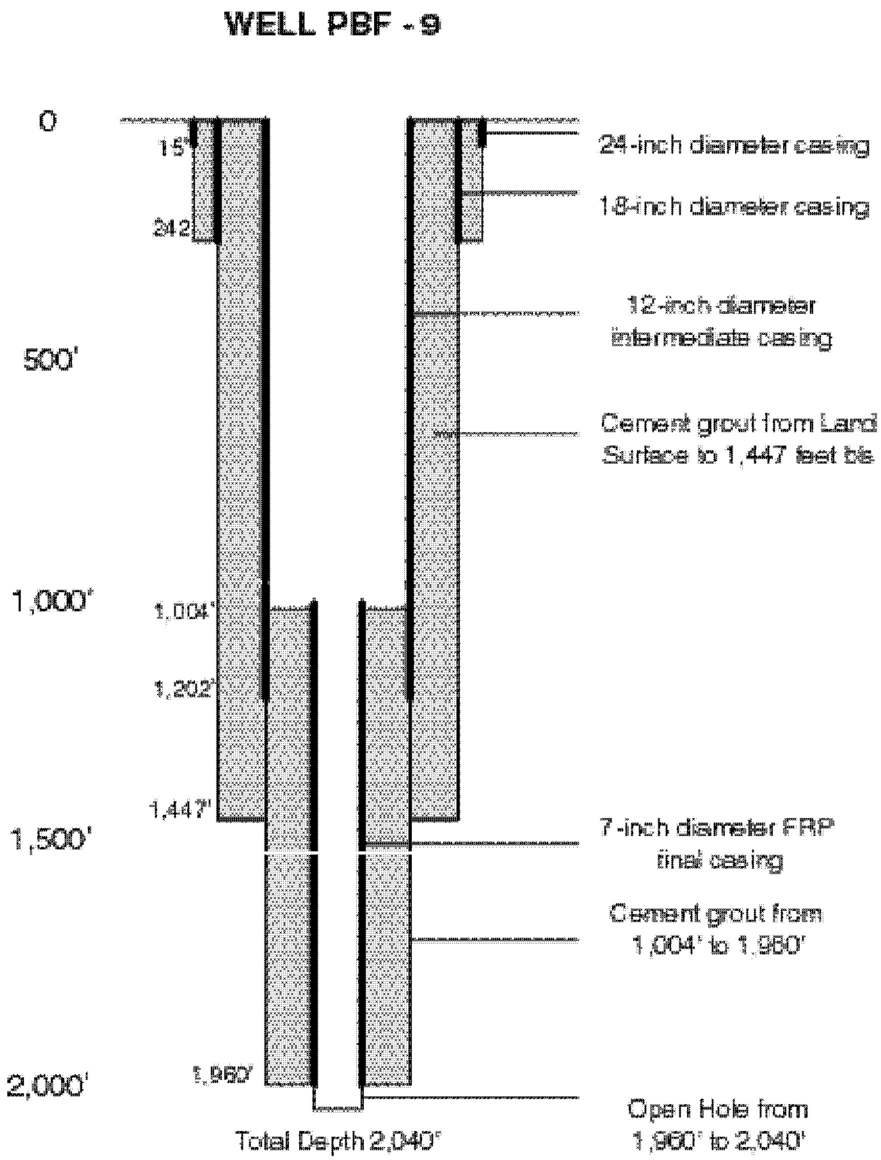

Figure 4. Completion Diagram for Well PBF-9

After they were described, cuttings were bagged and hung to dry onsite. At the end of each week, the cuttings were transported back to the District warehouse located in West Palm Beach. After processing, the cuttings were transferred to the Florida Geological Survey (FGS) in Tallahassee, which is under contract with the District. The FGS provided a detailed FGS lithologic description for Well PBF-7 (FGS Well No. W-17542). This description is available in the FGS geologic database and is provided in **Appendix A.**

Geophysical Logging

Geophysical logs were conducted in the pilot holes of Wells PBF-7 and PBF-9 to correlate formation samples collected during drilling, identify lithologic and formation boundaries, correlate formation boundaries between wells, and obtain data pertinent to the underlying stratigraphic formations and aquifers. These data were used in the selection of the optimum straddle-packer test intervals and for the determination of casing setting depths. Geophysical logging was performed by two different logging companies. AWE ran the logs during the well construction portion of the project. Halliburton Energy Services, a specialty geophysical logging service company, ran a series of high-resolution logging tools in the pilot hole of Well PBF-7 between 990 and 2,504 feet bls. The geophysical logs performed on Well PBF-7 are listed in **Table 2.**

Table 2. Geophysical Log Summary at Well PBF-7

Date	*Log(s)*	*Casing Depth (ft bls)*	*Total Log Depth (ft bls)*
6/1/96	Gamma, LSN Electric, SP, Temperature, Fluid Resistivity	15	241
8/29/96	Gamma, LSN Electric, SP, Temperature, Fluid Resistivity	240	1,115
9/6/96	Caliper	990	1,290
11/21/96	Gamma, LSN Electric, SP, Temperature, Fluid Resistivity, Flowmeter, Caliper	990	1,785
12/9/96	Gamma, LSN Electric, SP, Temperature, Fluid Resistivity, Flowmeter, Caliper, Video	990	2,504
1/15/97	Gamma, LSN Electric, SP, Temperature, Fluid Resistivity, Flowmeter, Caliper, Video	990	2,504
1/21/97	Gamma, SP, Dual Induction, Spectral Density, Neutron, Sonic, Fracture Finder	990	2,504

The following descriptions briefly define the uses and interpretations of the geophysical logs performed:

Caliper Log: Measures the diameter of the borehole. This log is useful in identifying washouts, fractures, and competency (mechanical strength) of the strata.

Gamma Ray Log: Measures the natural gamma radiation produced by the rock, which is normally a function of the clay or phosphate content (in South Florida).

Spontaneous Potential (SP) Log: Measures the natural potential fields that are created between borehole fluids and the surrounding rock materials. These logs are used primarily for correlation purposes.

LSN/Dual Induction/Electric Log: Measures the electrical properties of the formation. The resistivity of the formation is affected by lithology, porosity, and water quality. These logs are comprised of shallow-, medium-, and deep-penetrating sondes that investigate at various distances from the borehole into the formation.

Temperature Log: Measures the temperature of the fluid filling the borehole or casing. It is also used to determine the elevation of emplaced cement during casing installation and provides information about the movement of fluids within drilled boreholes.

Fluid Resistivity Log: Provides a measurement of the in-hole liquid between the log probes, which is a general indicator of the chemical quality of the water within the borehole.

Sonic Log: Measures the acoustic properties of the formation, which is a function of lithology and porosity.

Borehole Television (Video) Log: Provides a visual image of the borehole and casing.

Flowmeter Log: Measures the contribution of water from various sections of the drilled borehole. Useful in determining flow zones and confining units within the penetrated strata.

Cement Bond Log: Measures the acoustic properties of the cemented casing to: (1) evaluate the strength and continuity of the cement bond to the outside of the casing, and (2) detect potential voids in the grout sheath around the casing.

Spectral Density Log: Is primarily used for formation matrix composition/lithology identification. It can differentiate between natural radioactive species in formation matrix, such as uranium, thorium, and potassium.

Neutron Log: Measures the hydrogen content of the borehole environment, which (in water well applications) is an indirect measure of total porosity of the formation.

Fracture Finder Log: Is a sonic waveform log that presents an image of the borehole that is dependent on the amplitude and travel time of a sonic wave transmitted from source to receiver. Fractures tend to disrupt and dampen the signal.

During geophysical logging, the caliper sonde indicated that the majority of the borehole (between 1,000 and 1,900 feet bls) was enlarged to a diameter that exceeded 23 inches. The enlarged borehole caused the pad-type logging probes to lose contact with the borehole wall, generating less reliable density and neutron log responses. Other type of logs (such as the sonic log) also are negatively affected by an enlarged borehole. Intervals of the borehole that were not enlarged were those consisting of well-indurated and crystalline limestones and dolostones. In these intervals, the hole was less than or equal to 12 inches in diameter, causing the probe's pad to come in contact with the borehole wall, resulting in good geophysical log data. Geophysical logs traces for the pilot-hole of Well PBF-7 are provided in **Appendix B**. A complete set of geophysical logs is on file at the District headquarters in West Palm Beach, Florida.

Water Sampling During Drilling

Flowing wellhead water samples were collected during reverse-air drilling at the end of each drill rod (usually at 30-foot intervals). Field water quality parameters, including pH, specific conductance and temperature, were measured on these samples using a Hydrolab multiparameter probe. Chloride concentrations also were determined using a Hach field titration kit. These test results were recorded as part of the data acquisition.

Reverse-air drilling affords the opportunity to collect water samples from near the drill bit as it penetrates the aquifer system. However, these samples do not always accurately reflect the discrete formation water quality. Interpretation of water quality changes within the FAS must, therefore, be made using all available pilot-hole information, including the geophysical logs. The information is confirmed using the water quality results from actual samples obtained during straddle-packer testing and APTs.

Straddle-Packer Pumping Tests

Four separate straddle-packer pumping tests were conducted on the pilot hole of Well PB-7 from 790 to 2,505 feet bls. One straddle-packer pumping test was conducted during construction of Well PBF-9. The purpose of packer testing was to identify hydraulic properties and confirm the water quality of discrete intervals within the pilot hole. Tested intervals were selected using all available field information, including lithologic cuttings, drill reports, reverse-air water sampling results, water-level measurements, and geophysical logs.

During a straddle-packer pumping test, two inflatable packers were attached to a perforated portion of drill pipe and lowered in the well to a preselected depth. Once the inflatable elements were positioned properly, they were inflated with a high pressure nitrogen line from the surface. Water entered the perforated portion of the drill pipe from the isolated interval. A 4-inch diameter submersible pump was lowered approximately 90 feet down into the pipe assembly. This pump had a maximum sustained pumping capacity of approximately 260 gallons per minute (gpm). A discharge hose ran from the pump through an in-line flowmeter and into storage tanks at the surface. Pressure transducers were installed in the drill pipe below the static water level and remained submerged for the duration of the pumping tests. The transducer cables were connected to in situ data-loggers to record water levels as a function of time. Water levels also were manually recorded for all transducers before pumping.

The submersible pump was started, and water level data were recorded. The pumped flow rate, as measured by the in-line flowmeter, also was recorded periodically to ensure that a constant pumping rate was maintained during the test. After the pumped well was evacuated a minimum of three borehole volumes, water samples were collected from the discharge line. These samples were collected using all applicable District Quality Assurance/Quality Control (QA/QC) standards and transported to the District lab for analysis. Major ions were analyzed by the District lab for all water samples; the results of those analyses are discussed in *Formation Testing Results* section.

After steady-state water level was established and maintained for a minimum period of 24 hours, the pump was shut down, and a recovery period commenced. When water levels reached prepumping background conditions, the test was terminated and the packer assembly removed. Field data recorded during the straddle-packer tests are shown in **Appendix C**.

Aquifer Performance Tests

Two APTs were conducted within the FAS at this site. Well PBF-9 served as the pumped well during the APTs, and Well PBF-7 served as the observation well. The APTs were conducted by installing a 10-inch diameter submersible pump into Well PBF-9. The first APT was conducted to test the upper Floridan aquifer producing zone, while the intermediate casing of Well PBF-9 was set at 1,202 feet bls and the open hole extended to 1,447 feet bls. The pumping test was conducted at a pumping rate of 1,550 gpm and a pumping duration of 55 hours.

The second APT was conducted to test the middle Floridan aquifer producing zone after the final casing of Well PBF-9 was set to 1,960 feet bls and the open hole extended to 2,040 feet bls. The pumping test was conducted at a rate of 1,030 gpm for a duration of 69 hours. **Figure 5** presents the configuration of the wells during each of the APTs. The test pump was lowered approximately 100 feet into the well on 10-inch diameter steel discharge pipe. Three-phase electricity was applied to the pump by an onsite generator. Flow rate was measured using a 10-inch diameter orifice weir with an 8-inch diameter orifice plate and verified by an in-line flow meter.

Background water levels were recorded for approximately one day before the start of each APT. During the tests, water levels in the pumped well and observation well were measured with an in situ (30 and 50 pounds per square inch [psi]) pressure transducers connected to a Hermit Series 2000 data logger. APT details are provided in **Appendix D**. A barometer also was used to measure atmospheric pressure variations during the APTs to determine if a barometric correction should have been applied to the data.

Water samples were collected after several hours of continuous pumping during each of the APTs to provide composite water quality data on the pumped interval. The samples were analyzed for standard field parameters with a Hydrolab water quality meter, and transported to the District's laboratory for further analysis. The results of these analyses are provided in the *Formation Testing Results* section.

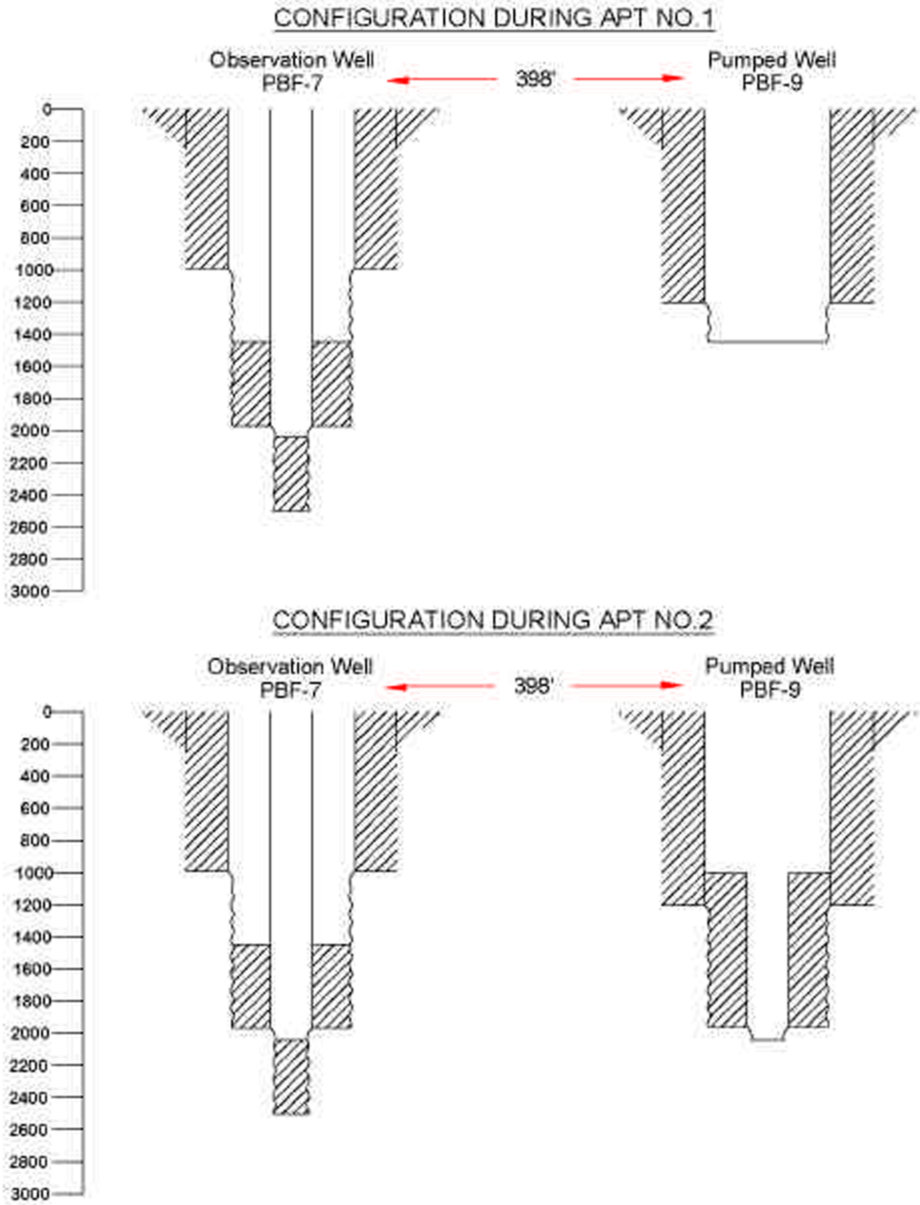

Figure 5. Well Configuration During Each Aquifer Performance Test

SITE GEOLOGY

Strata encountered during the construction of Wells PBF-7 and PBF-9 ranged in age from Eocene to Holocene. The stratigraphic units (in descending order) were as follows: undifferentiated Holocene, Pleistocene, and Pliocene age sediments; the Hawthorn Group of Pliocene-Miocene age; and the Ocala Group and Avon Park Formation of Eocene age. **Figure 6** presents a hydrostratigraphic summary of the site, including depth, lithologic column, geologic age, formation name, hydrogeologic unit, accompanied by a natural gamma-ray, caliper, and resistivity logs. The stratigraphic interpretation was derived from the correlation of formation samples with geophysical logs conducted during pilot-hole drilling of Well PBF-7.

Undifferentiated Holocene, Pleistocene, and Pliocene Series

From land surface to a depth of approximately 208 feet bls, the lithology consists of poorly to well consolidated shells, sands, silts, and limestone. Although not differentiated, formations comprising the Holocene to Pliocene series at this site may include portions of the Pamlico Sand, Fort Thompson, and Tamiami Formations. The top of the Hawthorn Group was not uniquely distinguishable on the natural gamma-ray log, but was identified at a depth of 208 feet bls, based on the first occurrence of olive-green sandstone and clays.

Miocene and Oligocene Series – Hawthorn Group

Peace River and Arcadia Formations

The top of the Hawthorn Group was found at 208 feet bls at the site. The Hawthorn Group is commonly characterized by a variable siliclastic and phosphate content, a gray to olive green color, and a relatively high gamma-ray log response. The Hawthorn Group, as defined by Scott (1988), is divided into the Peace River and Arcadia Formations. Reese and Memberg (2000) identified two distinct units within the lower portion of the Hawthorn Group, based on gamma-ray log responses and lithologic character. The upper unit, designated as a *marker unit*, contains thin beds with higher gamma-ray activity marking its upper and lower boundaries, and contains lower phosphate content and fewer shells. It is generally finer grained than the overlying and underlying beds. This unit is present throughout Palm Beach County and extends west of the study area into Lee, Hendry, and Collier Counties (Reese, 1999); it occurs between 630 and 730 feet bls at this site.

The basal Hawthorn unit is Oligocene in age and lies beneath the marker unit. The top of the basal unit is characterized on the gamma-ray log by relatively high gamma-ray activity, and at its base by moderate to low gamma ray activity. The basal Hawthorn unit was identified between 730 and 900 feet bls at Well PBF-7. The lithology is highly variable, consisting of calcareous clay or silt; sandy, fossiliferous limestone; quartz sand or sandstone; dolomite; shells; and phosphatic sand.

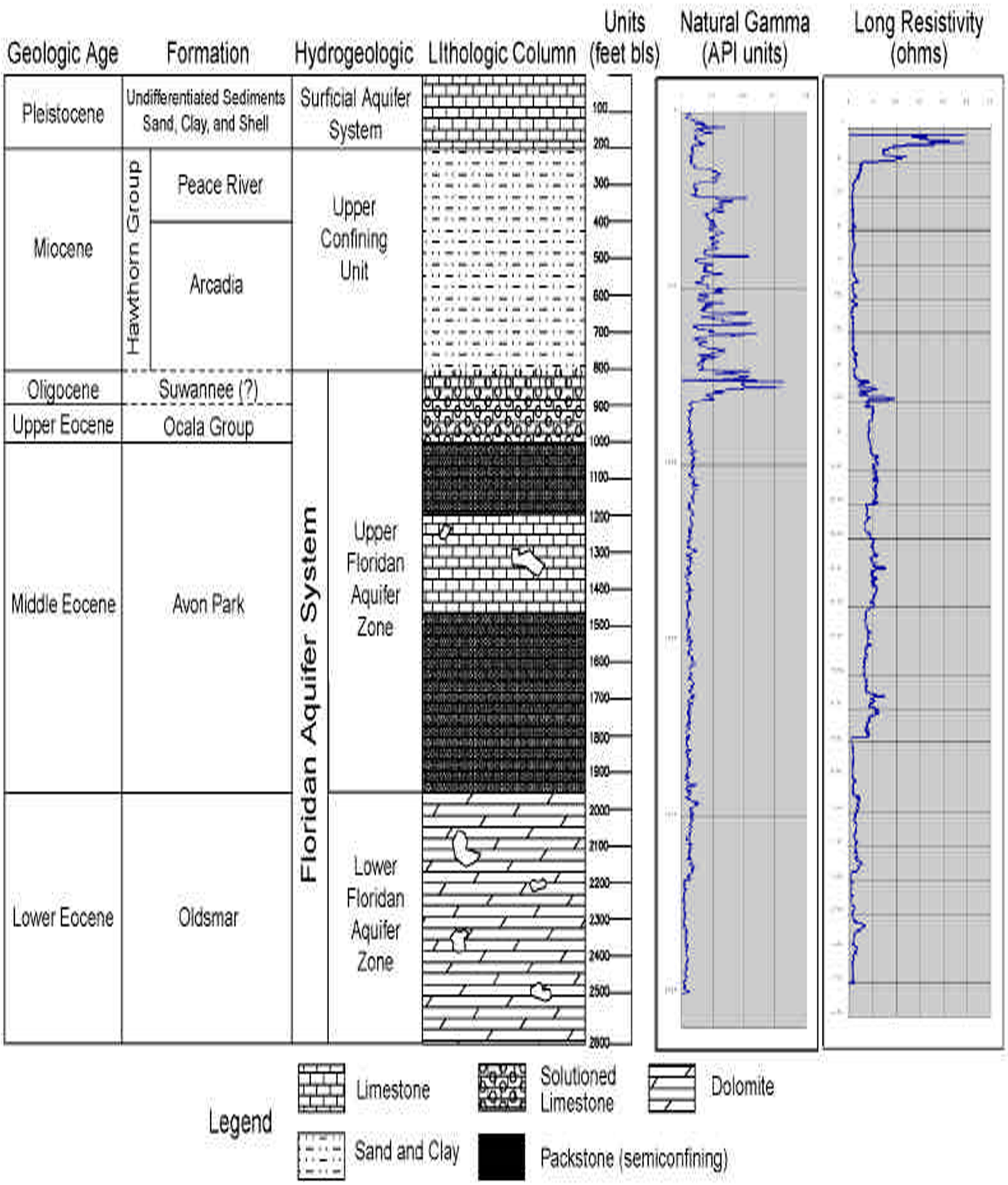

Figure 6. Hydrostratigraphic Summary of Well PBF-7.

Suwannee Limestone

The Suwannee Limestone was not recognized in the cuttings recovered from the wells at the site. The typical lithology of the Suwannee Limestone in Southwestern Florida is pale-orange to tan, fossiliferous, medium-grained calcarenite with minor amounts of quartz sand. Phosphatic mineral grains are rare within the formation. According to Reese and Memberg (2000), the Suwannee Limestone pinches out in the eastern portion of Palm Beach County, although it is possible that the formation is not present in most of the county. Reese and Memberg included what is often referred to as the Suwannee Limestone along the southeast coast of Florida as part of the basal Hawthorn Group; the nomenclature is used in this report.

Eocene Group

The boundary between the Hawthorn Group and the Eocene Group at the site was determined to be at a depth of 900 feet bls. Identification of distinct Eocene-aged geologic formations in South Florida is difficult due to similarities in lithology and geophysical log responses. Difficulties in differentiating individual formations within the Eocene section from well cuttings has long been recognized by workers in the area, and was most recently discussed by Powers and McNeal (2000). Therefore, these formations have been grouped together and are informally referred to as the Eocene Group in this report. Descriptions of three geologic units within the Eocene Group and their occurrence at the site are summarized below.

Ocala Limestone

Between the depths of 900 and 980 feet bls, poorly indurated, chalky, silty, and sandy clay and packstone were observed. This transitional Ocala interval probably represents reworked sediments as part of a regional unconformity that exists at the top of the Eocene section of South Florida. The first occurrence of a clean, competent limestone at the site was found at a depth of 980 feet bls. The lithology of the Ocala Limestone varies from micritic or chalky limestone, to a medium-grained calcarenitic or coquinoid limestone. It is characterized by abundant larger benthic foraminifera, such as *Operculinoids sp.*, *Camerina sp.*, and *Lepidocyclina sp.* (Peacock, 1983). *Lepidocyclina sp.* were observed in the cuttings by the field geologist from 848 to 940 feet bls. However, the top of the Ocala Limestone was placed at 900 feet bls at Well PBF-7, based primarily on correlation with other wells in the vicinity. The base of the Ocala Limestone was identified at 980 feet bls.

Avon Park Formation

The Avon Park Formation consists predominantly of calcarenitic to micritic, fossiliferous limestone. Occasionally, it contains a large percentage of fine- to medium-grained, moderately- to well-sorted carbonate sand. Characteristic foraminifera include *Dictyoconus cookei* and *Dictyoconous americanus*. The first occurrence of these indicator fossils at Well PBF-7 was at a depth of 980 feet bls, providing the only tangible evidence of this formation's occurrence in the section. This interval was present between 980 and 1,950 feet bls.

Oldsmar Formation

The Oldsmar Formation is typically a massive dolomitic interval near the lower portion of the Avon Park Formation in this area of Palm Beach County. This unit contains occasional thin limestone beds and was identified between 1,950 and 2,504 feet bls at Well PBF-7. This interval has been interpreted as representing the uppermost member of the Oldsmar Formation. The lower portion of this formation contains a highly transmissive dolomitic interval locally known as the *Boulder Zone*. This interval is usually present at a depth of approximately 3,000 feet bls in western Palm Beach County and was not penetrated by the wells at this site.

FORMATION TESTING RESULTS

The formation testing program at the site included lithologic examination, measurements while drilling (rate of penetration, weight on bit, drilling characteristics, and wellhead water flow), geophysical surveys, straddle packer pumping tests, APTs, water quality analyses, and subsequent measurements of water levels. Raw data and laboratory analyses are contained in the appendices of this report; a summary of the results is provided in this section.

Water Quality and Flow Rates with Drilled Depth

Artesian flow data and water-quality samples were collected at the wellhead of Well PBF-7 at 30-foot intervals. Reverse-air drilling was performed through the FAS. The recorded data consisted of artesian flow rate measured in gallons per minute (gpm), chloride concentration, temperature, and specific conductivity data. The purpose of collecting and analyzing the flowing wellhead water samples was to provide a generalized profile of water-producing zones and water quality, with respect to depth.

Figure 7 graphically represents wellhead water quality and flow rate as a function of depth. This graph demonstrates that wellhead flow rate increased gradually with depth, as additional producing zones within the FAS were penetrated. Distinct increases in flow rates were observed below 1,200 and 1,900 feet bls. These intervals would later become defined as the upper and lower producing zones.

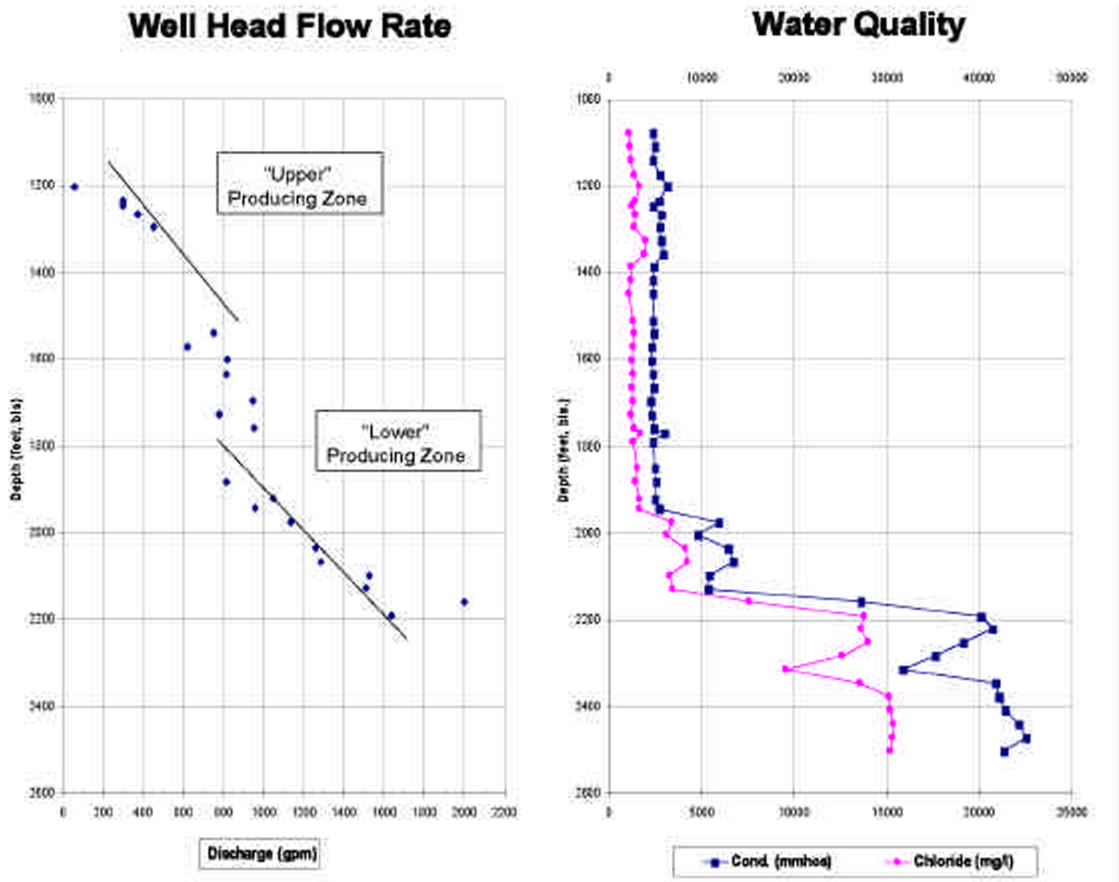

Figure 7. Wellhead Water Quality and Flow Rate as a Function of Depth

Water quality parameters remained fairly consistent during the drilling operations until the depth of approximately 1,900 feet bls. At 1,900 feet bls, the salinity of the water began to increase significantly. This depth was later established at the base of the Underground Source of Drinking Water (USDW). Below a depth of 2,200 feet bls, the salinity of the water was near that of the concentration of seawater.

Geophysical Logs

Geophysical logs were conducted in Well PBF-7 and Well PBF-9 to complement lithologic samples, identify formation boundaries, correlate between wells, and obtain specific information pertaining to the geologic formations and aquifers, including delineation of producing zones. Geophysical log traces for several of the logging runs were digitized and are provided in **Appendix B**. A description of the video log is provided in Appendix B, Table B-1. Original geophysical log and video surveys are archived and available at the District headquarters in West Palm Beach.

Video Survey and Flowmeter and Fluid Resistivity Logs: The producing zones within the FAS are commonly characterized by secondary features, such as solution cavities and vertical fracturing. Discrete flow zones exist throughout the vertical section of most Floridan wells, which cumulatively contribute to the total flow observed at the wellhead.

Logs particularly useful in delineating flow zones, while the well is flowing, include the down-hole video survey, flowmeter, fluid resistivity, and temperature logs. Dual-induction and sonic logs are useful in delineating layers of higher permeability where flow is more likely. Review of these logs indicated that flow zones in Well PBF-7 occurred within the following intervals:

- 1,246 to 1,325 feet bls
- 1,975 to 2,024 feet bls
- 2,124 to 2,198 feet bls
- 2,363 to 2,424 feet bls.

Most of the flow zones were observed in the crystalline dolomite found below 1,950 feet bls. A visual display of the depths at which the flow zones occurred, as well as an overall hydrogeologic interpretation summary of the site, are presented in **Figure 8.**

Induction Log: The dual-induction log indicated a spread between the shallow, medium, and deep investigation curves between the depths of 1,000 and 1,900 feet bls. This indicated that the limestone within this interval exhibited some permeability. Between 1,900 and 2,200 feet bls, the resistivity increased and displayed multiple spikes as a result of the hard, dense, thinly-bedded, fractured dolomite within this interval. The low resistivity (~2 ohm-meters) exhibited on the Dual-Induction log at 2,200 feet bls corresponds to degrading (higher salinity) water quality observed while drilling.

Caliper Log: The caliper log of Well PBF-7 indicated a rather uniform borehole diameter of 20 to 24 inches from the base of final casing (992 feet bls) to 1,675 feet bls. Below this depth, the borehole enlarged to approximately 30 inches to 1,800 feet bls. Increases in borehole diameter are observed on the caliper log between 2,180 and 2,280 feet bls, consistent with fractured dolomite layers.

Sonic Log: The sonic log read an average interval velocity of 120 microseconds per foot within the interval from 1,000 to 1,400 feet bls. This velocity could be equated to a primary porosity of approximately 37 percent within a clean limestone formation. The interval between 1,450 and 1,600 feet bls was not recorded by the log, due to large borehole conditions. The interval between 1,600 and 1,900 feet bls read an average interval velocity of 100 microseconds per foot, which was equated to a limestone porosity of 32 percent. The interval below 1,900 feet bls read velocities of approximately 70 microseconds per foot, which was a result of dolomite comprising the formation matrix.

Gamma-Ray Log: The gamma-ray log exhibits low counts (less than 15 API units) throughout the interval between 800 and 1,900 feet bls. This indicated a relatively clean limestone, containing little clay or phosphate. The dolomitic interval between 1,950 and 2,200 feet bls is evident by the slightly higher gamma counts. Below the dolomitic interval, the gamma-ray counts indicate relatively clean limestone matrix.

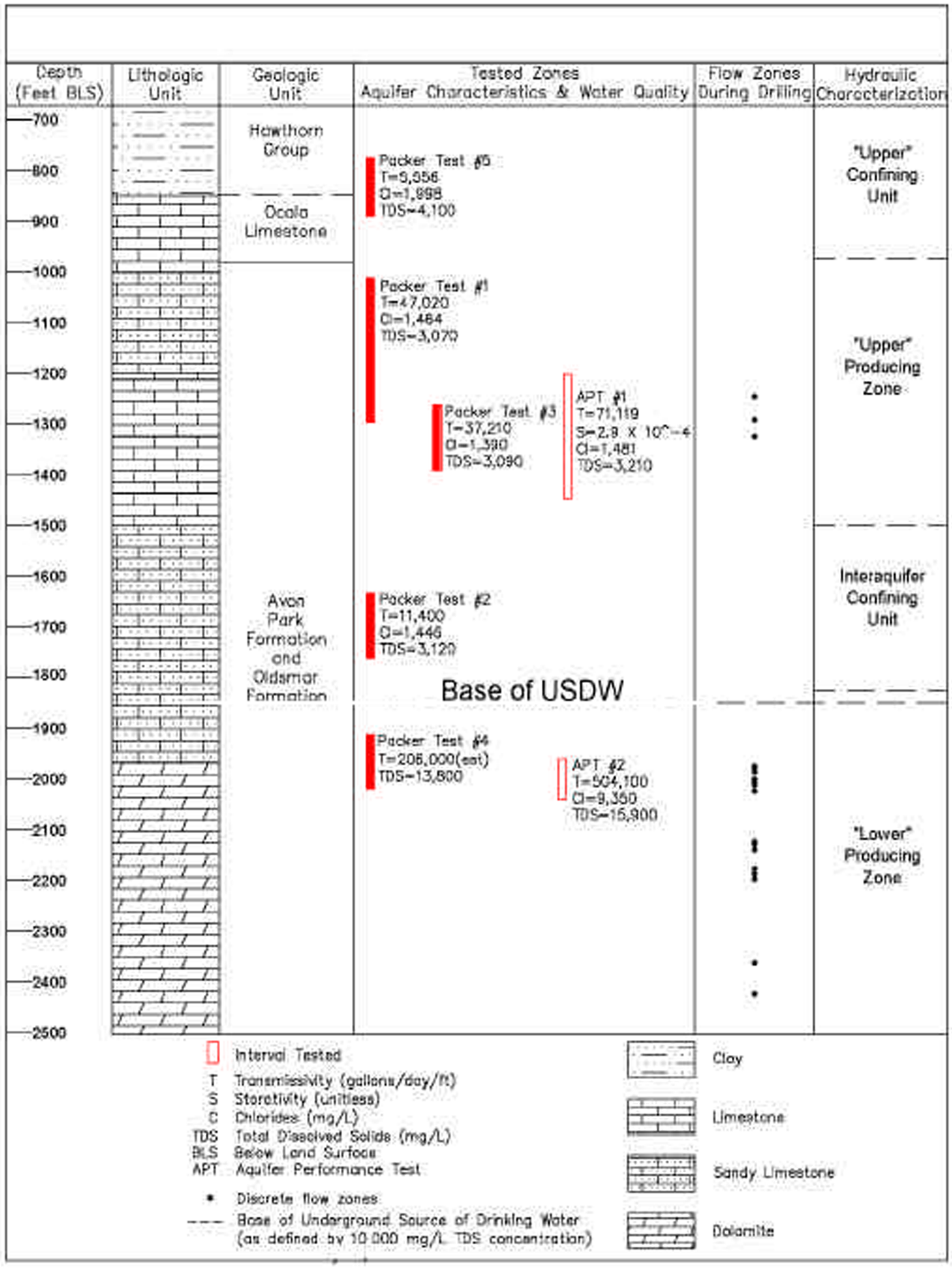

Figure 8. Hydrogeological Interpretation and Aquifer Characteristics of Site

Temperature Log: The temperature profile indicates a gradual increase from 25.5°C at 1,078 feet bls to 26.3°C at 2,504 feet bls. Subtle deviations from this gradual temperature increase coincide with flow zones.

Straddle-Packer Pumping Test Results

Straddle-packer pumping tests were conducted during the drilling operations to isolate four selected FAS zones in Well PBF-7, and one FAS zone in Well PBF-9. A summary of the packer test logistics and analyses results is provided in **Tables 3** and **4**. Packer-test field summary sheets and time drawdown plots are provided in **Appendix C**.

Table 3. South Bay Straddle Packer Pumping Test Logistics Summary

Packer Test Number	Tested Well	Interval (ft bls)	Static Water Level* (ft above NGVD)	Q (gpm)	Maximum Drawdown (ft)	Total Pumping Time (min)
1	PBF-7	1,012-1,297	54.8	250	14.7	600
2	PBF-7	1,633-1,762	53.1	204	80	270
3	PBF-7	1,263-1,392	49.5	210	65	540
4	PBF-7	1,913-2,020	54.4	206	2	240
5	PBF-9	775-890	51.3	94	79	360
* Static water level is reported uncorrected for equivalent freshwater head.						

Table 4. South Bay Straddle-Packer Pumping Test Hydraulic Results Summary

Packer Test Number	Interval (ft bls)	Test Interval Thickness (ft)	Q (gpm)	Specific Capacity (gpm/ft)	Transmissivity (gpd/ft)	Hydraulic Conductivity (ft/day)
1	1,012-1,297	285	250	17	47,020	22
2	1,633-1,762	129	204	2.6	11,400	12
3	1,263-1,392	129	210	3.2	37,210	38
4	1,913-2,020	107	206	103	206,000 (est.)	257
5	775-890	115	94	1.2	5,556	6.5

Straddle-Packer Test No. 1: Packer Rest No. 1, conducted November 26, 1996, consisted of pumping the interval between 1,012 and 1,297 feet bls (upper portion of FAS) in Well PBF-7. This interval was pumped for 10 hours at an average discharge rate of 250 gpm. The static water level before pumping the well was measured as 54.8 feet NGVD. The land surface at the site was approximately 19.2 feet above NGVD. The maximum measured drawdown, while pumping was 14.7 feet. The specific capacity was calculated as 17 gpm/ft. A transmissivity of 47,020 gpd/ft was estimated based on a plot of the time-drawdown data using the straight-line Jacob method. Chlorides and total dissolved solids (TDS) sampled from the zone were 1,464 and 3,070 mg/L, respectively.

Straddle-Packer Test No. 2: Packer Test No. 2 isolated the interval between 1,633 and 1,762 feet bls in Well PBF-7. The drawdown test was conducted by pumping this interval for 4.5 hours at an average rate of 204 gpm. The static water level was measured at 53.1 feet above NGVD. Maximum drawdown measured while pumping was 80 feet, and the specific capacity calculated as 2.6 gpm/ft. A transmissivity of 11,400 gpd/ft was estimated using the Jacob straight line method. Chlorides and TDS sampled from the zone were 1,446 and 3,120 mg/L, respectively.

Straddle-Packer Test No. 3: Packer Test No. 3 isolated the interval between 1,263 and 1,392 feet bls in Well PBF-7. The drawdown test was conducted by pumping this interval for 9 hours at an average rate of 210 gpm. The static water level was measured at 49.4 feet above NGVD. The maximum drawdown was 64.9 feet, and the specific capacity calculated as 3.2 gpm/ft. A transmissivity of 37,210 gpd was using the Jacob straight line method. Chlorides and TDS sampled from the zone were 1,390 and 3,090 mg/L, respectively.

Straddle-Packer Test No. 4: Packer Test No. 4 isolated the interval between 1,913 and 2,020 feet bls in Well PBF-7. The drawdown test was conducted by pumping this interval for 3.4 hours at an average rate of 206 gpm. The static water level was measured as 54.4 feet above NGVD. The maximum measured drawdown was 1.7 feet, and the specific capacity calculated as 103 gpm/ft. The water level recovered too quickly in the well for application of conventional methods for the computation of aquifer characteristics. However, this is evidence of very high transmissivity exhibited by the interval. For purposes of estimation, a transmissivity of 206,000 gpd/ft was estimated for this interval by multiplying the specific capacity by 2,000 using a method described by Fetter (1992). Chlorides and TDS sampled from the zone were 8,179 and 13,800 mg/L, respectively. The water quality results from this test were used in combination with the geophysical log analysis to determine that the base of the USDW was at a depth of approximately 1,900 feet at the site.

Straddle-Packer Test No. 5: Packer Test No. 5 consisted of pumping the interval between 775 and 890 feet bls in Well PBF-9. This was the only packer test conducted in Well PBF-9, and the only test conducted in a mud-filled borehole. This test was particularly important since it provided information about the productivity of the uppermost portion of the upper Floridan aquifer. The test was conducted by pumping this interval for 6 hours at an average discharge rate of 94 gpm. The static water level was measured as 51.3 feet above NGVD. Maximum drawdown was 78.5 feet and the specific capacity calculated as 1.2 gpm/ft. A transmissivity of 5,556 gpd/ft was estimated using the Jacob straight-line method. Chlorides and TDS sampled from the zone were 1,998 and 4,100 mg/L, respectively.

Aquifer Performance Tests

Two APTs were conducted to evaluate subsurface flow and water quality characteristics of the FAS. The results of these tests are provided in **Table 5**. In addition, detailed APT summary sheets and time-drawdown plots are provided in **Appendix D**.

Table 5. South Bay Aquifer Performance Test Analysis Summary

Interval (ft bls)	Thickness (ft)	Static Water Level (NGVD)	Observation Well Max Dd (ft)	Q (gpm)	T (gpd/ft)	Hydraulic Conductivity (ft/day)	Storage Coefficient	r/B	Leakance (gpd/cu ft)
Pumping Test 1									
1202-1447	245	53.2	12.2	1,550	71,100	39	2.9×10^{-4}	0.1004	0.0048
Pumping Test 2									
1960-2040	80	44.3	1.1	1,030	504,100	842	2.6×10^{-5} (t)	0.1 (t)	0.032(t)
t = tentative									

APT No. 1: The first test, begun April 3, 1997, consisted of pumping the interval between 1,202 to 1,447 feet bls (upper portion of FAS) in Well PBF-9 for 55 hours at a constant discharge rate of 1,550 gpm, while monitoring water levels in the upper monitoring zone of Well PBF-7. The static water level in Well PBF-9 was measured as 53.2 above NGVD before the initiation of pumping. The specific capacity in the pumped well was estimated at 127 gpm/ft.

The maximum drawdown during pumping recorded at the observation well (located 398 feet away) was 12.2 feet. A transmissivity of 71,100 gpd/ft and storage coefficient of 2.9×10^{-4} were estimated based on a log-log plot of the time-drawdown data (**Appendix D**) using the Hantush-Jacob curve matching method. Since the tested interval had a thickness of 245 feet, a hydraulic conductivity of 39 feet per day was estimated for the interval. This estimate was in good agreement with that derived from the straddle-packer pumping tests. A leakance of 0.0047 gpd per cubic foot (gpd/ft^3) was estimated using the Walton (1960) method.

APT No. 2: The second APT was conducted on May 14, 1997, and consisted of pumping the interval between 1,968 to 2,040 feet bls (middle portion of upper FAS) in Well PBF-9 for 69 hours at a constant discharge rate of 1,030 gpm, while monitoring water levels in the lower monitoring zone of Well PBF-7. The static water level in Well PBF-9 was measured as 44.3 above NGVD prior to the initiation of pumping.

The maximum drawdown measured in the observation well during pumping was 1.1 feet. The drawdown was achieved after only 30 minutes of pumping, and remained fairly stable for the remaining 68 hours of the test. The tested interval was a fractured dolomite with extensive secondary porosity, so some contribution from conduit-type flow was probably occurring during the test. A transmissivity of 504,100 gpd/ft and storage coefficient of 2.6 X 10^{-5} was calculated using the Theis recovery method. Since the tested interval had a thickness of 80 feet, a hydraulic conductivity of 842 feet per day was estimated for the interval. This estimate was not in very good agreement with that derived from the straddle-packer pumping tests, however, the estimate from the straddle-packer pumping test was based on empirical relationships based on specific capacity information. A leakance of 0.032 gpd/ft^3 was tentatively estimated using the Walton (1960) method.

Water Quality from the Pumping Tests

Chlorides and TDS concentrations in water sampled from the zone between 1,202 and 1,447 feet bls during APT No. 1 were 1,481 and 3,210 mg/L, respectively. Chlorides and TDS concentrations in water sampled from the zone between 1960 and 2,040 feet bls during APT No. 2 were 9,350 and 15,900 mg/L, respectively. **Table 6** lists the analytical results of water quality samples collected during the APTs and **Table 7** describes the results of water quality analyses from packer pumping tests. Examination of the tables indicates that water in the uppermost FAS is more saline than water in the middle portion of the upper FAS. This indicates that water in the uppermost zone may be more "relict" and less well flushed than water in the middle portion of the upper FAS.

Table 6. Summary of Water Quality Data from Aquifer Performance Tests

Well Name/ Sample Depth	Na (Mg/L)	K (Mg/L)	Ca (Mg/L)	Mg^{2+} (Mg/L)	Cl (Mg/L)	SO_4 (Mg/L)	Alkalin. As $CaCO_3$ (Mg/L)	F (Mg/L)	Sr (Mg/L)	TDS (Mg/L)	pH	SC (mmhos/ cm)
PBF-7U/ 1202-1447	861	43.3	133.0	112.0	1481.0	528	117.7	1.4	25.8	3,210	7.7	5,484
PBF-7L/ 1960-2040	4695	221.0	473.0	558.0	9350.5	1076	108.8	0.5	47.1	15,900	6.8	27,030
SC = Specific conductivity (micromhos/centimeter)												

Table 7. Summary of Water Quality Data from Packer Tests

Well Name/ Sample Depth	#	Na (Mg/L)	K (Mg/L)	Ca (Mg/L)	Mg (Mg/L)	Cl (Mg/L)	SO_4 (Mg/L)	Alkalin. As $CaCO_3$ (Mg/L)	F (Mg/L)	Sr (Mg/L)	TDS (Mg/L)	SC (mmhos/ cm)
PBF-7/1012-1297	1	556	17.1	105.6	90.8	1463.7	511.7	120.8	0.745	21,800	3,070	5,550
PBF-7/1633-1762	2	604	21	111	104	1445.8	513.6	133.3	0.788	20,000	3,120	5,340
PBF-7/1263-1392	3	837	35.1		114	1390.8	475.3	275.8	0.844	20,600	3,090	5,340
PBF-7/1913-2020	4	3780	141.2	380	448	8179.1	977.6	108.4	0.486	41,200	13,80 0	23,310
PBF-9/775-890	5	1060	51.4	138	170	1997.9	660.0	255.5	1.06	11,320	4,100	7,110

The chemical composition of groundwater within the FAS is influenced by several factors, including lithology, flow patterns, presence of solution features, and residence time. The hydrochemical facies of groundwater can be classified on the basis of the dominant ions by means of a trilinear diagram and an ionic strength analysis described by Frazee (1982). **Table 8** presents the computation of the relative strengths of the major cations and anions in the water samples collected during the straddle-packer tests and the APTs. Water samples obtained from Well PBF-7 during the two APTs were plotted in the trilinear diagram shown in **Figure 9**. Data from the straddle-packer tests were not used for the trilinear diagram analysis because several of the anion-cation balance computations resulted in errors of greater than the recommended 5 percent range. The points plotted in similar positions on the diagram defined as of "lateral intrusion or seawater origin" facies, which is dominated primarily by the sodium and chloride ion species.

Depth of Base of Underground Source of Drinking Water

The base of the Underground Source of Drinking Water (USDW) is defined by the State as the depth to which water containing a TDS concentration of less than 10,000 mg/L extends. The concentration of TDS sampled from between 1,913 and 2,020 feet bls during straddle-packer Test No. 4 was 13,800 mg/L, which was therefore below the base of the USDW. The concentration of TDS sampled from between 1,633 and 1,762 feet bls during straddle-packer test No. 2 was 3,120 mg/L, which is above the base of the USDW. The water quality results from these tests were used in combination with the geophysical log analysis to determine that the base of the USDW was at a depth of approximately 1,900 feet at the site. The depth correlates very closely with the depth of the base of the USDW determined at the City of Belle Glade Wastewater Treatment Plant deep injection well system, located approximately three miles to the east, by Geraghty and Miller (1991).

Water Levels

Water levels in both zones of Well PBF-7 were measured monthly during the period from October 1997 to December 1999. Water levels referenced to NGVD of 1929 are plotted on a hydrograph presented in **Figure 10**. The hydrograph illustrates how water levels (unadjusted for density) in the upper Floridan aquifer are approximately 14 feet higher than those in the lower Floridan aquifer. Most of this differential was subsequently found to be a result of the different densities of the fluids within zones of the aquifer. Water from the lower zone is more saline, and thus heavier than water in the upper zone. The mean water level for the period of record (October 1997 to December 1999) for the upper and lower Floridan aquifers at the site were 56.5 and 42.7 feet above NGVD, respectively. The minimum and maximum water levels recorded for the same period in the upper Floridan aquifer were 51.9 (March 1998) and 58.5 (February 1999) feet above NGVD, respectively. The minimum and maximum water levels for the lower Floridan were 40.3 (April 1999) and 44.7 (February 1999) feet above NGVD, respectively. Overall, levels fluctuate seasonally, increasing to an annual high in the months preceding March and April. In March and April, they decline to their annual lows by approximately 3 to 4 feet in the upper and 1 to3 feet in the lower Floridan aquifers.

Table 8. Ionic Balance Analysis

Conversion to milliequivalents per liter (me/L) - Frazee Method						Input data on yellow line				
Packer Test No. 1 (1,012' - 1,297')										
	Ca	Mg	Na	K	Cation Total	Cl	SO_4	$CaCO_3$	CO_3	Anion Total
mg/L	106	91	556	17		1464	511	120	0	
me/L	5.29	7.49	24.19	0.43	**37.40**	41.30	10.64	2.40	0.00	**54.34**
%	14.14	20.02	64.68	1.16	100.00	76.00	19.59	4.42	0.00	100.00
										Error % = -18.47
Packer Test No. 2 (1,633' - 1,762')										
	Ca	Mg	Na	K	Cation Total	Cl	SO_4	$CaCO_3$	CO_3	Anion Total
mg/L	111	104	604	21		1445	513	133	0	
me/L	5.54	8.56	26.27	0.54	**40.90**	40.76	10.69	2.66	0.00	**54.11**
%	13.54	20.91	64.23	1.31	100.00	75.34	19.75	4.92	0.00	100.00
										Error % = -13.90
Packer Test No. 3 (1,263' - 1,392')										
	Ca	Mg	Na	K	Cation Total	Cl	SO_4	$CaCO_3$	CO_3	Anion Total
mg/L	156	114	837	35		1390	475	275	0	
me/L	7.78	9.38	36.41	0.89	**54.47**	39.21	9.89	5.50	0.00	**54.61**
%	14.29	17.22	66.85	1.64	100.00	71.81	18.12	10.07	0.00	100.00
										Error % = -0.13
Packer Test No. 4 (1,913' - 2,020')										
	Ca	Mg	Na	K	Cation Total	Cl	SO_4	$CaCO_3$	CO_3	Anion Total
mg/L	380	448	3780	141		8179	977	108	0	
me/L	18.96	36.85	164.43	3.61	**223.85**	230.73	20.35	2.16	0.00	**253.24**
%	8.47	16.46	73.46	1.61	100.00	91.11	8.04	0.85	0.00	100.00
										Error % = -6.16
Packer Test No. 5 (775' - 890')										
	Ca	Mg	Na	K	Cation Total	Cl	SO_4	$CaCO_3$	CO_3	Anion Total
mg/L	138	170	1060	51		1998	660	255	0	
me/L	6.89	13.98	46.11	1.30	**68.28**	56.36	13.75	5.10	0.00	**75.21**
%	10.08	20.48	67.53	1.91	100.00	74.94	18.28	6.78	0.00	100.00
										Error % = -4.83
APT No. 1 (1,202' - 1,447')										
	Ca	Mg	Na	K	Cation Total	Cl	SO_4	$CaCO_3$	CO_3	Anion Total
mg/L	133	112	861	43		1481	528	117	0	
me/L	6.64	9.21	37.45	1.10	**54.40**	41.78	11.00	2.34	0.00	**55.12**
%	12.20	16.94	68.84	2.02	100.00	75.80	19.95	4.25	0.00	100.00
										Error % = -0.65
APT No. 2 (1,960' - 2,040')										
	Ca	Mg	Na	K	Cation Total	Cl	SO_4	$CaCO_3$	CO_3	Anion Total
mg/L	473	558	4695	221		9350	1076	108	0	
me/L	23.60	45.90	204.23	5.65	**279.39**	263.76	22.41	2.16	0.00	**288.34**
%	8.45	16.43	73.10	2.02	100.00	91.48	7.77	0.75	0.00	100.00
										Error % = -1.58

Note: Alkalinity is expressed as $CaCO_3$, and milliequivalents per liter were computed with a conversion multipier of 0.02.

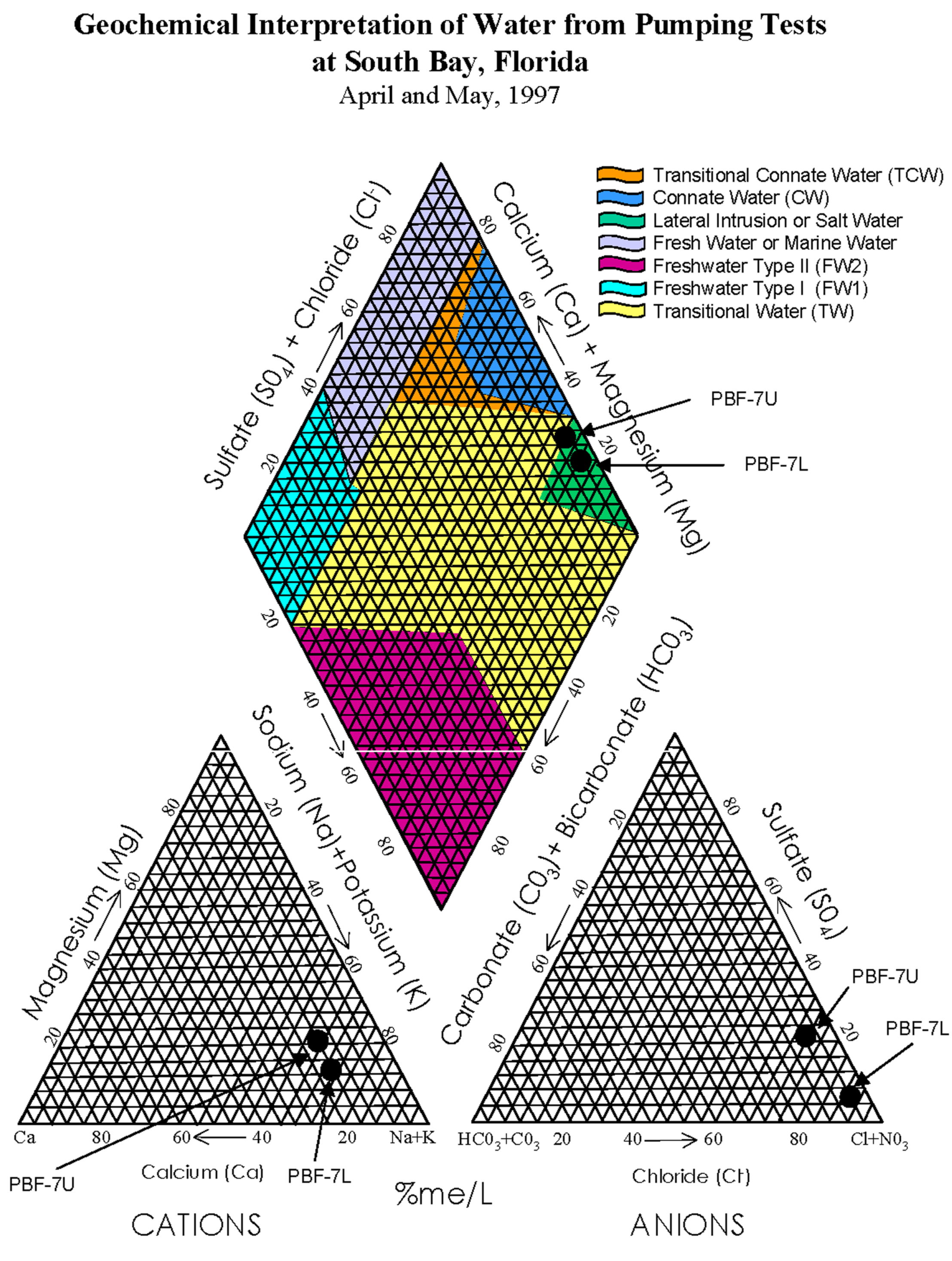

Figure 9. Trilinear Diagram of PBF-7 Upper and Lower Zones

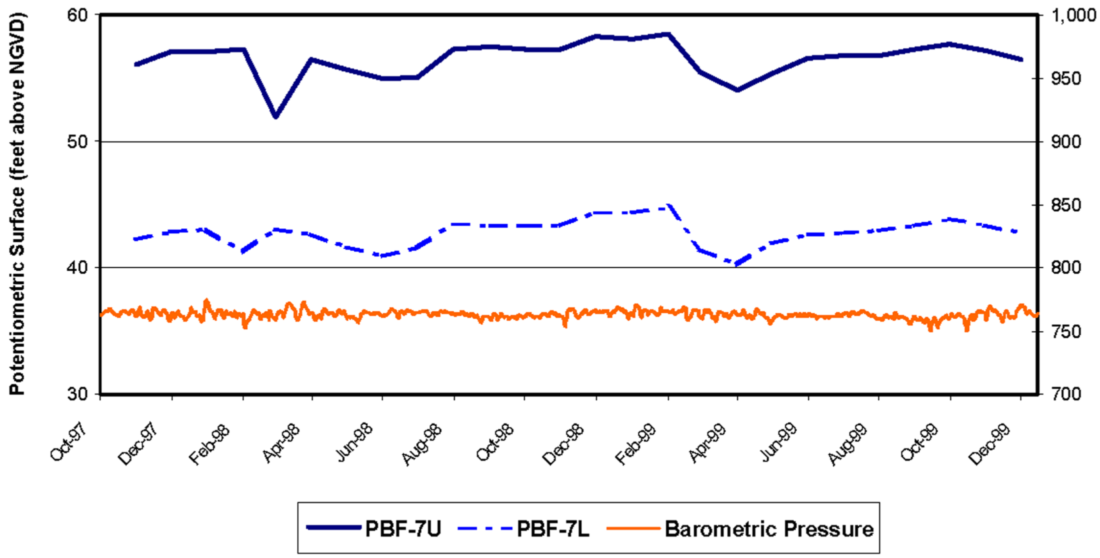

Figure 10. Hydrograph of PBF-7 Upper and Lower Aones with Associated Barometric Pressure

Equivalent Freshwater Head Correction

The raw water levels recorded at the wellhead were converted to equivalent freshwater heads using the Ghyben-Herzberg method. To perform the correction, the specific gravity of the water collected from each of the monitor zones was computed, the results of which are presented in **Table 9**.

Table 9. Specific Gravity Calculation for Water from Well PB-7

Monitoring	***Total Dissolved Solids***	***Specific Gravity***
Zone	*Concentration (mg/L)*	*(g/cm^3)*
PB-7 Upper	3,210	1.002
PB-7 Lower	15,900	1.009

A freshwater equivalent hydrograph for both the upper and lower Floridan zones is shown in **Figure 11**. The average water levels (converted to equivalent freshwater head) over the period of record for the upper and lower zones in PBF-7 were 59.2 and 60.8, respectively. The groundwater gradient between the upper and lower Floridan aquifers is on average, 1.6 feet in an upward direction. This upward gradient is consistent with observations of head differences in the FAS documented elsewhere in the literature for St. Lucie County (Lukasiewicz, 1992) and the Orlando area (Tibbals, 1991).

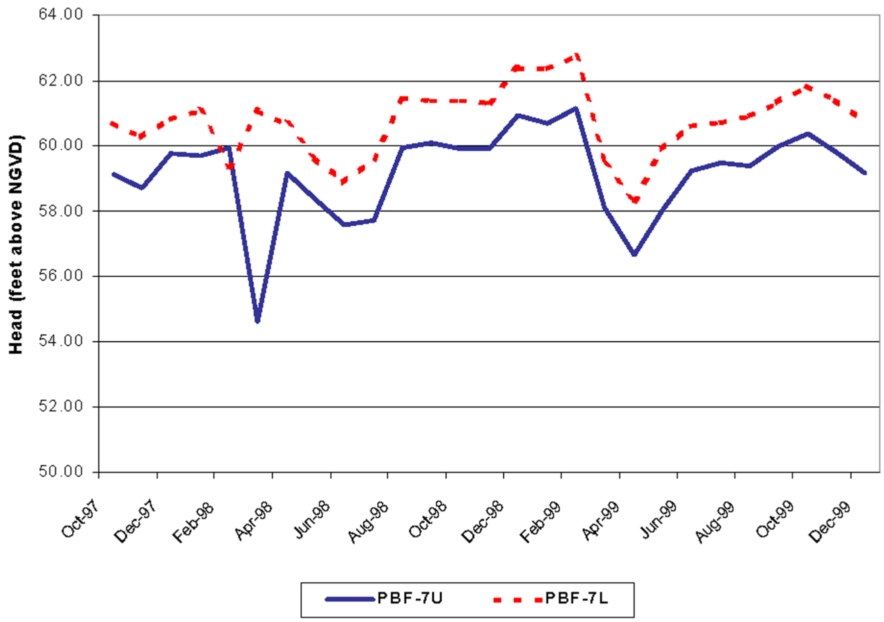

Figure 11. Freshwater Equivalent Head Hydrograph

The minimum and maximum equivalent fresh water heads recorded for the period of record in the upper Floridan aquifer were 54.6 (March 1998) and 61.1 (February 1999) feet NGVD, respectively. This is a 6.5-foot difference between the recorded highs and lows. The minimum and maximum equivalent fresh water heads for the lower Floridan were 58.3 (April 1999) and 61.8 feet (February 1999) NGVD, respectively, equating to a 3.5-foot differential.

CONCLUSIONS

Two exploratory wells were constructed near the City of South Bay as part of a program to obtain hydrogeologic and water quality data from the FAS within the District's Lower East Coast planning area. Hydrogeologic information was obtained to a depth of 2,500 feet bls from the wells. The main findings of the construction and testing program are summarized in the paragraphs below:

Surficial sediments extended from land surface to a depth of 208 feet bls and the clay-rich Hawthorn Group (Upper Confining Unit) was found to extend to approximately 790 feet bls.

The Ocala Limestone, comprising the uppermost FAS, was identified at a depth of approximately 900 feet (bls) based on lithologic and hydrogeologic observations. The uppermost 300 feet of the FAS exhibited a relatively low hydraulic conductivity (approximately 8 ft/day). Water sampled from that interval was slightly more saline than immediately underlying zones.

One "upper" producing zone was identified in the upper FAS between 1,202 and 1,447 feet bls. This zone exhibited a transmissivity of 71,000 gpd/ft and a hydraulic conductivity of approximately 38 ft/day. The chloride concentration of water collected from that zone was approximately 1,400 mg/L. A dolomite-rich "lower" producing zone was identified at 1,956 feet bls. This is probably the top of the Oldsmar Formation. Secondary solutioning and fractures cause this interval to exhibit a relatively high transmissivity – approximately 504,000 gpd/ft. However, water collected from this zone contained a chloride concentration of 9,350 mg/L.

The base of the USDW was identified by geophysical logs and water quality analysis from packer tests to occur at approximately 1,900 feet bls at the site. The potentiometric surfaces of the upper and middle FAS producing zones were approximately 56 and 43 feet above the NGVD (unadjusted for density), respectively, during the period from October 1997 to December 1999. Water levels fluctuated an average of 1 to 4 feet in upper and lower zones over a period of nearly two years. When adjusted for density, the groundwater gradient between the upper and middle FAS producing zones is upward.

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APPENDIX A

LITHOLOGIC DESCRIPTION FOR WELL PBF-7

The detailed Florida Geological Survey (FGS) lithologic description for Well PBF-7 (FGS Well No. W-17542) is available in the FGS geologic database and is provided in this appendix.

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LITHOLOGIC WELL LOG PRINTOUT                      SOURCE - FGS

WELL NUMBER:   W-17542                           COUNTY -   PALM BEACH
TOTAL DEPTH:    2504 FT.                         LOCATION: T.44S R.36E S. 1
SAMPLES - NONE                                             LAT = 26D 41M 58S
                                                           LON = 80D 42M 57S
COMPLETION DATE: 10/01/97                         ELEVATION: 10 FT
OTHER TYPES OF LOGS AVAILABLE - NONE

OWNER/DRILLER:099-64

WORKED BY:STEPHEN PALMES
WELL NAME- PBF-7

    0.   -   20.8 121PCPC   PLIOCENE-PLEISTOCENE
  208.   -   94.0 122HTRN   HAWTHORN GROUP
  940.   -   98.0 124OCAL   OCALA GROUP
  980.   -      .   124AVPK   AVON PARK FM.
    0.   -     .7 000NOSM   NO SAMPLES
  273.   -   28.0 000NOSM   NO SAMPLES
  525.   -   53.5 000NOSM   NO SAMPLES
  930.   -   94.0 000NOSM   NO SAMPLES
  111.6 - 112.4 000NOSM   NO SAMPLES
  241.5 - 243.5 000NOSM   NO SAMPLES

    0 -    7   NO SAMPLES

    7 -   10   SHELL BED; YELLOWISH GRAY TO DARK GRAY
              30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
               POOR INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
              ACCESSORY MINERALS: ORGANICS-20%, CALCILUTITE-15%
               OTHER FEATURES: FOSSILIFEROUS
               FOSSILS: MOLLUSKS
               GASTROPODS COMMON
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10 -   20   PACKSTONE; YELLOWISH GRAY TO MODERATE DARK GRAY
            30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
            GRAIN TYPE: CALCILUTITE, SKELETAL
            30% ALLOCHEMICAL CONSTITUENTS
            GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO COARSE
            POOR INDURATION
            CEMENT TYPE(S): CALCILUTITE MATRIX
            ACCESSORY MINERALS: ORGANICS-05%
            OTHER FEATURES: FOSSILIFEROUS
            FOSSILS: MOLLUSKS
            GASTROPODS COMMON

20 -   33   PACKSTONE; YELLOWISH GRAY
            25% POROSITY: INTERGRANULAR, INTRAGRANULAR
            GRAIN TYPE: SKELETAL, CALCILUTITE
            35% ALLOCHEMICAL CONSTITUENTS
            GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
            POOR INDURATION
            CEMENT TYPE(S): CALCILUTITE MATRIX
            OTHER FEATURES: FOSSILIFEROUS
            FOSSILS: MOLLUSKS
            GASTROPODS COMMON

33 -   40   SHELL BED; YELLOWISH GRAY
            30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
            UNCONSOLIDATED
            ACCESSORY MINERALS: CALCILUTITE-25%, ORGANICS-02%
            OTHER FEATURES: FOSSILIFEROUS
            FOSSILS: MOLLUSKS
            GASTROPODS COMMON

40 -   50   SHELL BED; VERY LIGHT ORANGE TO MODERATE LIGHT GRAY
            30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
            UNCONSOLIDATED
            ACCESSORY MINERALS: CALCILUTITE-10%
            OTHER FEATURES: FOSSILIFEROUS
            FOSSILS: MOLLUSKS
            GASTROPODS COMMON; FOSSIL SHELLS BROKEN AND ABRADED

50 -   94   SHELL BED; LIGHT OLIVE GRAY TO LIGHT GRAY
            30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
            UNCONSOLIDATED
            ACCESSORY MINERALS: SPAR-02%, CALCILUTITE-05%
            FOSSILS: MOLLUSKS, BRYOZOA
            GASTROPODS COMMON; FOSSIL SHELLS BROKEN
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 94 - 100   SHELL BED; LIGHT OLIVE GRAY TO LIGHT GRAY
             30% POROSITY: INTERGRANULAR, MOLDIC
             POSSIBLY HIGH PERMEABILITY; UNCONSOLIDATED
             ACCESSORY MINERALS: QUARTZ SAND-02%, CALCILUTITE-05%
             FOSSILS: MOLLUSKS, BRYOZOA
             15% OF INTETVALIS A WELL-INDURATED SANDSTONE

100 - 123   SHELL BED; LIGHT OLIVE GRAY TO LIGHT GRAY
             30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
             INTRAGRANULAR; UNCONSOLIDATED
             ACCESSORY MINERALS: CALCILUTITE-10%, QUARTZ SAND-04%
             PHOSPHATIC SAND-01%
             FOSSILS: MOLLUSKS
             SOME ALLOCHEMS ARE RECRYSTALLIZED.

123 - 130   WACKESTONE; LIGHT OLIVE GRAY
             20% POROSITY: INTERGRANULAR
             GRAIN TYPE: SKELETAL, CRYSTALS, CALCILUTITE
             30% ALLOCHEMICAL CONSTITUENTS
             GRAIN SIZE: FINE; RANGE: VERY FINE TO VERY COARSE
             POOR INDURATION
             CEMENT TYPE(S): CALCILUTITE MATRIX
             ACCESSORY MINERALS: PHOSPHATIC SAND-02%, QUARTZ SAND-05%
             SPAR-03%
             OTHER FEATURES: LOW RECRYSTALLIZATION
             FOSSILS: MOLLUSKS
             GASTROPODS PRESENT

130 - 160   WACKESTONE; VERY LIGHT GRAY TO LIGHT GRAY
             20% POROSITY: INTERGRANULAR
             GRAIN TYPE: SKELETAL, CRYSTALS
             40% ALLOCHEMICAL CONSTITUENTS
             GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
             POOR INDURATION
             CEMENT TYPE(S): CALCILUTITE MATRIX
             ACCESSORY MINERALS: SPAR-07%, PHOSPHATIC SAND-03%
             QUARTZ SAND-%
             OTHER FEATURES: MEDIUM RECRYSTALLIZATION
             FOSSILS: FOSSIL MOLDS, MOLLUSKS
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160 - 186	PACKSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR INTERCRYSTALLINE GRAIN TYPE: SKELETAL, CRYSTALS 70% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE;POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC SAND-01% OTHER FEATURES: DOLOMITIC FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BRYOZOA DOLOMITE CONTENT IS COMPLETELY RECRYSTALLIZED.
186 - 208	PACKSTONE; LIGHT OLIVE GRAY 20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE GRAIN TYPE: SKELETAL, CRYSTALS 60% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:MEDIUM;RANGE:FINE TO COARSE; POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC SAND-02% OTHER FEATURES: DOLOMITIC FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS
208 - 242	CLAY; LIGHT OLIVE GRAY POOR INDURATION CEMENT TYPE(S): CLAY MATRIX ACCESSORY MINERALS: QUARTZ SAND-02% OTHER FEATURES: CALCAREOUS FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS GASTROPODS PRESENT; PHOSPHATIC SILT PRESENT
242 - 260	CLAY; LIGHT OLIVE POOR INDURATION CEMENT TYPE(S): CLAY MATRIX ACCESSORY MINERALS: LIMESTONE-05%, QUARTZ SAND-% OTHER FEATURES: CALCAREOUS FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS PHOSPHATIC SILT PRESENT
260 - 273	CLAY; YELLOWISH GRAY POOR INDURATION CEMENT TYPE(S): CLAY MATRIX, CALCILUTITE MATRIX ACCESSORY MINERALS: LIMESTONE-10% OTHER FEATURES: CALCAREOUS FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS PHOSPHATIC SILT PRESENT
273 - 280	NO SAMPLES

280 - 306	CLAY; YELLOWISH GRAY POOR INDURATION CEMENT TYPE(S): CLAY MATRIX, CALCILUTITE MATRIX ACCESSORY MINERALS: SHELL-15%, QUARTZ SAND-02% OTHER FEATURES: CALCAREOUS FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS GASTROPODS PRESENT; PHOSPHATIC SILT PRESENT
306 - 338	PACKSTONE; YELLOWISH GRAY 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: CRYSTALS, SKELETAL 40% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION CEMENT TYPE(S): CLAY MATRIX, CALCILUTITE MATRIX ACCESSORY MINERALS: CLAY-05%, QUARTZ SAND-03% PHOSPHATIC SAND-02% OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: FOSSIL FRAGMENTS, BARNACLES, FOSSIL MOLDS MOLLUSKS GASTROPODS PRESENT
338 - 368	CLAY; LIGHT OLIVE GRAY TO YELLOWISH GRAY POOR INDURATION CEMENT TYPE(S): CLAY MATRIX ACCESSORY MINERALS: SPAR-03%, PHOSPHATIC SAND-02% SHELL-10%, QUARTZ SAND-% OTHER FEATURES: CALCAREOUS FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS GASTROPODS PRESENT
368 - 400	CLAY; LIGHT OLIVE GRAY TO GRAYISH GREEN POOR INDURATION CEMENT TYPE(S): CLAY MATRIX, CALCILUTITE MATRIX ACCESSORY MINERALS: QUARTZ SAND-05%, SHELL-03%, SPAR-07% PHOSPHATIC SAND-01% OTHER FEATURES: CALCAREOUS FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS
400 - 462	CLAY; LIGHT OLIVE GRAY POOR INDURATION CEMENT TYPE(S): CLAY MATRIX ACCESSORY MINERALS: QUARTZ SAND-02%, PHOSPHATIC SAND-% MICA-% OTHER FEATURES: CALCAREOUS FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BRYOZOA GASTROPODS PRESENT

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462 - 525   CLAY; YELLOWISH GRAY
              POOR INDURATION
              CEMENT TYPE(S): CLAY MATRIX
              ACCESSORY MINERALS: SPAR-03%, QUARTZ SAND-%
              OTHER FEATURES: CALCAREOUS
              FOSSILS: FOSSIL FRAGMENTS

525 - 535   NO SAMPLES

535 - 566   CLAY; YELLOWISH GRAY
              POOR INDURATION
              CEMENT TYPE(S): CLAY MATRIX
              ACCESSORY MINERALS: SPAR-07%, QUARTZ SAND-%
              DOLOMITE-03%, LIMESTONE-15%
              OTHER FEATURES: CALCAREOUS
              FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS

566 - 587   CLAY; LIGHT OLIVE GRAY TO YELLOWISH GRAY
              POOR INDURATION
              CEMENT TYPE(S): CLAY MATRIX
              ACCESSORY MINERALS: SPAR-08%, PHOSPHATIC SAND-02%
              QUARTZ SAND-%
              OTHER FEATURES: CALCAREOUS
              FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS
              GASTROPODS PRESENT

587 - 629   WACKESTONE; LIGHT OLIVE GRAY
              GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
              20% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
              POOR INDURATION
              CEMENT TYPE(S): CALCILUTITE MATRIX
              ACCESSORY MINERALS: CLAY-05%, SPAR-04%
              PHOSPHATIC SAND-01%
              FOSSILS: SHARKS TEETH, MOLLUSKS, FOSSIL FRAGMENTS

629 - 650   MUDSTONE; YELLOWISH GRAY TO LIGHT OLIVE
              GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
              10% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
              POOR INDURATION
              CEMENT TYPE(S): CALCILUTITE MATRIX
              ACCESSORY MINERALS: PHOSPHATIC SAND-05%, QUARTZ SAND-02%
              SPAR-05%
              PHOSPHATIC FOSSIL MOLDS
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650 - 660   WACKESTONE; LIGHT GRAYISH GREEN
              25% POROSITY: INTERGRANULAR, INTRAGRANULAR
              GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
              25% ALLOCHEMICAL CONSTITUENTS
             GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
              POOR INDURATION
              CEMENT TYPE(S): CALCILUTITE MATRIX
             ACCESSORY MINERALS: SPAR-03%, PHOSPHATIC GRAVEL-02%
              PHOSPHATIC SAND-02%
              FOSSILS: CORAL, MOLLUSKS
              GASTROPODS PRESENT

660 - 775   WACKESTONE; YELLOWISH GRAY
              25% POROSITY: INTERGRANULAR, INTRAGRANULAR
              GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
              20% ALLOCHEMICAL CONSTITUENTS
             GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
              POOR INDURATION
              CEMENT TYPE(S): CALCILUTITE MATRIX
              ACCESSORY MINERALS: SPAR-<5%, PHOSPHATIC SAND-%
              OTHER FEATURES: CHALKY
              FOSSILS: MOLLUSKS, FOSSIL MOLDS

775 - 826   WACKESTONE; YELLOWISH GRAY
              25% POROSITY: INTERGRANULAR, INTRAGRANULAR
              GRAIN TYPE: CALCILUTITE, CRYSTALS
              20% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
              POOR INDURATION
              CEMENT TYPE(S): CALCILUTITE MATRIX
              ACCESSORY MINERALS: SPAR-03%, PHOSPHATIC SAND-%
              FOSSILS: BRYOZOA, MOLLUSKS
             30% OF SAMPLE IS A WELL-INDURATED LIMESTONE

826 - 848   PACKSTONE; YELLOWISH GRAY
              25% POROSITY: INTERGRANULAR, MOLDIC
              GRAIN TYPE: CRYSTALS, SKELETAL, SKELTAL CAST
              60% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: MEDIUM; RANGE: FINE TO VERY COARSE
              MODERATE INDURATION
             CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
              ACCESSORY MINERALS: PHOSPHATIC SAND-02%
              FOSSILS: FOSSIL MOLDS
```

848 - 899	PACKSTONE; YELLOWISH GRAY 25% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: CRYSTALS, SKELETAL 80% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: FINE TO VERY COARSE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: CLAY-03% OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS RECRYSTALLIZED CARBONATE SAND PRESENT; PHOSPHATIC SILT PRESENT
899 - 930	WACKESTONE; YELLOWISH GRAY 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: CRYSTALS, SKELETAL, CALCILUTITE 20% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: SPAR-02%
930 - 940	NO SAMPLES
940 - 980	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: CRYSTALS, SKELETAL 60% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX OTHER FEATURES: CHALKY FOSSILS: BENTHIC FORAMINIFERA, FOSSIL MOLDS NUMMULITES SP PRESENT
980 - 1030	WACKESTONE; VERY LIGHT ORANGE 25% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS 40% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: SPAR-05% OTHER FEATURES: CHALKY FOSSILS: BENTHIC FORAMINIFERA, FOSSIL MOLDS, ECHINOID DICTYOCONUS AMERICANUS PRESENT;UP TO 40% OF INTERVAL IS A PACKSTONE ECHINOID SPINES PRESENT

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1030 - 1054 PACKSTONE; VERY LIGHT ORANGE
            25% POROSITY: INTERGRANULAR, INTRAGRANULAR
            GRAIN TYPE: SKELETAL, BIOGENIC
            65% ALLOCHEMICAL CONSTITUENTS
            GRAIN SIZE:MEDIUM;RANGE:FINE TO COARSE; POOR INDURATION
            CEMENT TYPE(S): CALCILUTITE MATRIX
            ACCESSORY MINERALS: SPAR-03%
            OTHER FEATURES: CHALKY
            FOSSILS: FOSSIL MOLDS, BENTHIC FORAMINIFERA, ECHINOID
            DICTYOCONUS AMERICANUS PRESENT

1054 - 1070 PACKSTONE; VERY LIGHT ORANGE
            25% POROSITY: INTERGRANULAR, INTRAGRANULAR
            GRAIN TYPE: SKELETAL, BIOGENIC
            80% ALLOCHEMICAL CONSTITUENTS
            GRAIN SIZE: COARSE; RANGE: FINE TO COARSE
            MODERATE INDURATION
            CEMENT TYPE(S): CALCILUTITE MATRIX
            ACCESSORY MINERALS: SPAR-02%
            FOSSILS: FOSSIL MOLDS, BENTHIC FORAMINIFERA, ECHINOID
            DICTYOCONUS AMERICANUS PRESENT; 5% ACCESSORY DOLOMITE
            OCCURS FROM 1060 - 1065 FEET

1070 - 1116 PACKSTONE; VERY LIGHT ORANGE
            25% POROSITY: INTERGRANULAR, INTRAGRANULAR
            GRAIN TYPE: SKELETAL, CALCILUTITE, BIOGENIC
            60% ALLOCHEMICAL CONSTITUENTS
            GRAIN SIZE: COARSE; RANGE: FINE TO COARSE
            MODERATE INDURATION
            CEMENT TYPE(S): CALCILUTITE MATRIX
            FOSSILS: BENTHIC FORAMINIFERA, FOSSIL MOLDS, ECHINOID
            DICTYOCONUS AMERICANUS PRESENT

1116 - 1124 NO SAMPLES

1124 - 1173 PACKSTONE; VERY LIGHT ORANGE
            20% POROSITY: INTERGRANULAR, INTRAGRANULAR
            GRAIN TYPE: SKELETAL, BIOGENIC
            70% ALLOCHEMICAL CONSTITUENTS
            GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION
            CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
            ACCESSORY MINERALS: DOLOMITE-02%
            FOSSILS: BENTHIC FORAMINIFERA, ECHINOID, FOSSIL MOLDS
            DICTYOCONUS AMERICANUS PRESENT
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1173 - 1185	PACKSTONE; VERY LIGHT ORANGE TO LIGHT GRAY 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, BIOGENIC 80% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: COARSE; RANGE: FINE TO VERY COARSE GOOD INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX ACCESSORY MINERALS: SPAR-03%, DOLOMITE-05% FOSSILS: BENTHIC FORAMINIFERA, FOSSIL MOLDS, ECHINOID MOLLUSKS
1185 - 1201	PACKSTONE; GRAYISH ORANGE 20% POROSITY: INTERGRANULAR, MOLDIC, INTRAGRANULAR GRAIN TYPE: SKELETAL, BIOGENIC 70% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:MEDIUM; RANGE:FINE TO COARSE; GOOD INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-05%, SPAR-05% OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: ECHINOID, BENTHIC FORAMINIFERA, FOSSIL MOLDS MOLLUSKS
1201 - 1205	GRAINSTONE; GRAYISH ORANGE 25% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, BIOGENIC 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:COARSE; RANGE: FINE TO COARSE; GOOD INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-05% OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA, ECHINOID
1205 - 1233	PACKSTONE; GRAYISH ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, BIOGENIC 60% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-15% OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA, ECHINOID LITUONELLA FLORIDANA PRESENT; D. AMERICANUS PRESENT

1233 - 1265	PACKSTONE; GRAYISH ORANGE TO LIGHT GRAY 20% POROSITY: INTERGRANULAR, INTRAGRANULAR, VUGULAR GRAIN TYPE: SKELETAL, BIOGENIC 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX OTHER FEATURES: DOLOMITIC, LOW RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA, ECHINOID DOLOMITE CONTENT RANGES FROM 0-20%. UP TO 20% OF INTERVAL IS A GRAINSTONE
1265 - 1285	GRAINSTONE; GRAYISH ORANGE TO LIGHT GRAY 20% POROSITY: INTERGRANULAR, VUGULAR GRAIN TYPE: SKELETAL, BIOGENIC 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA, ECHINOID DOLOMITE RANGES FROM 5 - 10% OF INTERVAL
1285 - 1300	DOLOSTONE; LIGHT GRAY TO GRAYISH ORANGE 15% POROSITY: INTERGRANULAR, LOW PERMEABILITY 50-90% ALTERED; ANHEDRAL GRAIN SIZE: VERY FINE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-20% ACCESSORY LIMESTONE IS A PACKSTONE
1300 - 1325	PACKSTONE; GRAYISH ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR, VUGULAR GRAIN TYPE: SKELETAL, BIOGENIC 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE MODERATE INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA, ECHINOID, FOSSIL MOLDS UP TO 10% DOLOMITE
1325 - 1340	GRAINSTONE; GRAYISH ORANGE 25% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, BIOGENIC 95% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:FINE; RANGE: VERY FINE TO MEDIUM UNCONSOLIDATED CARBONATE SAND

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1340 - 1365   PACKSTONE; GRAYISH ORANGE
              20% POROSITY: INTERGRANULAR, MOLDIC, INTRAGRANULAR
              GRAIN TYPE: SKELETAL, BIOGENIC
              85% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION
              CEMENT TYPE(S): SPARRY CALCITE CEMENT
              OTHER FEATURES: LOW RECRYSTALLIZATION
              FOSSILS:BENTHIC FORAMINIFERA, ECHINOID, FOSSIL MOLDS
              D.AMERICANUS PRESENT

1365 - 1425 PACKSTONE; VERY LIGHT ORANGE
              20% POROSITY: INTERGRANULAR, MOLDIC, VUGULAR
              GRAIN TYPE: SKELETAL, BIOGENIC
              75% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION
              CEMENT TYPE(S): SPARRY CALCITE CEMENT
              OTHER FEATURES: LOW RECRYSTALLIZATION, DOLOMITIC
              FOSSILS: BENTHIC FORAMINIFERA, ECHINOID
              D. AMERICANUS PRESENT

1425 - 1460   PACKSTONE; VERY LIGHT ORANGE
              20% POROSITY: INTERGRANULAR, INTRAGRANULAR
              GRAIN TYPE: SKELETAL, BIOGENIC
              70% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM
              MODERATE INDURATION
              CEMENT TYPE(S): CALCILUTITE MATRIX
              ACCESSORY MINERALS: SPAR-03%
              FOSSILS: BENTHIC FORAMINIFERA
              D. AMERICANUS PRESENT

1460 - 1470   GRAINSTONE; VERY LIGHT ORANGE
              25% POROSITY: INTERGRANULAR, INTRAGRANULAR
              GRAIN TYPE: SKELETAL, BIOGENIC
              90% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO COARSE
              UNCONSOLIDATED
              ACCESSORY MINERALS: SPAR-01%

1470 - 1570 PACKSTONE; VERY LIGHT ORANGE
              20% POROSITY: INTERGRANULAR, INTRAGRANULAR, MOLDIC
              GRAIN TYPE: SKELETAL, BIOGENIC
              75% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
              GOOD INDURATION
              CEMENT TYPE(S): SPARRY CALCITE CEMENT
              ACCESSORY MINERALS: SPAR-02%
              FOSSILS: BENTHIC FORAMINIFERA
              D. AMERICANUS PRESENT
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1570 - 1590 PACKSTONE; VERY LIGHT ORANGE
            20% POROSITY: INTERGRANULAR, INTRAGRANULAR
            GRAIN TYPE: SKELETAL, BIOGENIC, CALCILUTITE
            55% ALLOCHEMICAL CONSTITUENTS
            GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION
            CEMENT TYPE(S): SPARRY CALCITE CEMENT
            ACCESSORY MINERALS: SPAR-01%
            FOSSILS: BENTHIC FORAMINIFERA, ECHINOID

1590 - 1653 PACKSTONE; VERY LIGHT ORANGE
            25% POROSITY: INTERGRANULAR, INTRAGRANULAR
            GRAIN TYPE: SKELETAL, BIOGENIC
            80% ALLOCHEMICAL CONSTITUENTS
            GRAIN SIZE: MEDIUM; RANGE: FINE TO VERY COARSE
            GOOD INDURATION
            CEMENT TYPE(S): SPARRY CALCITE CEMENT
            ACCESSORY MINERALS: SPAR-05%
            FOSSILS: BENTHIC FORAMINIFERA
            D. AMERICANUS PRESENT

1653 - 1665 PACKSTONE; VERY LIGHT ORANGE TO LIGHT OLIVE GRAY
            20% POROSITY: INTERGRANULAR, INTRAGRANULAR
            GRAIN TYPE: CRYSTALS, SKELETAL
            65% ALLOCHEMICAL CONSTITUENTS
            GRAIN SIZE: MEDIUM; RANGE: FINE TO VERY COARSE
            GOOD INDURATION
            CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
            OTHER FEATURES: DOLOMITIC

1665 - 1670 DOLOSTONE; GRAYISH BROWN
            15% POROSITY: INTERCRYSTALLINE, VUGULAR; 90-100% ALTERED
            EUHEDRAL
            GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
            GOOD INDURATION
            CEMENT TYPE(S): DOLOMITE CEMENT

1670 - 1675 PACKSTONE; VERY LIGHT ORANGE
            20% POROSITY: INTERGRANULAR, INTRAGRANULAR
            GRAIN TYPE: SKELETAL, BIOGENIC
            60% ALLOCHEMICAL CONSTITUENTS
            GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
            GOOD INDURATION
            CEMENT TYPE(S): SPARRY CALCITE CEMENT
            ACCESSORY MINERALS: DOLOMITE-05%
            OTHER FEATURES: LOW RECRYSTALLIZATION
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1675 - 1680	GRAINSTONE; VERY LIGHT ORANGE 25% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, CRYSTALS 95% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM; UNCONSOLIDATED FOSSILS: BENTHIC FORAMINIFERA CARBONATE SAND; D. AMERICANUS PRESENT
1680 - 1747	WACKESTONE; YELLOWISH GRAY 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, CRYSTALS 80% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT OTHER FEATURES: FOSSILIFEROUS FOSSILS: BENTHIC FORAMINIFERA, FOSSIL MOLDS D. AMERICANUS PRESENT
1747 - 1770	GRAINSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR, MOLDIC GRAIN TYPE: SKELETAL, CRYSTALS 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT OTHER FEATURES: FOSSILIFEROUS, LOW RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA, FOSSIL MOLDS, ECHINOID SOME ALLOCHEMS RECRYSTALLIZED; D. AMERICANUS PRESENT
1770 - 1789	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, CRYSTALS 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:MEDIUM; RANGE: FINE TO MEDIUM; GOOD INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT SEDIMENTARY STRUCTURES: LAMINATED OTHER FEATURES: PLATY FOSSILS: BENTHIC FORAMINIFERA, FOSSIL MOLDS, ECHINOID D. AMERICANUS PRESENT
1789 - 1794	DRILLERS MUD

1794 - 1810	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: CALCILUTITE, SKELETAL 60% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: COARSE; RANGE: FINE TO VERY COARSE MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-05%, SPAR-02% OTHER FEATURES: FOSSILIFEROUS FOSSILS: BENTHIC FORAMINIFERA, ECHINOID D. AMERICANUS PRESENT; SOME ALLOCHEMS RECRYSTALLIZED
1810 - 1820	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR, MOLDIC GRAIN TYPE: SKELETAL, CRYSTALS 80% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT OTHER FEATURES: MEDIUM RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA, FOSSIL MOLDS D. AMERICANUS PRESENT
1820 - 1851	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, CALCILUTITE 55% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX OTHER FEATURES: CHALKY, FOSSILIFEROUS FOSSILS: BENTHIC FORAMINIFERA SOME ALLOCHEMS RECRYSTALLIZED; D. AMERICANUS PRESENT
1851 - 1856	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, CRYSTALS 80% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX D. AMERICANUS PRESENT
1856 - 1881	GRAINSTONE; VERY LIGHT ORANGE 25% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, CRYSTALS 95% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; UNCONSOLIDATED FOSSILS: BENTHIC FORAMINIFERA CARBONATE SAND; D. AMERICANUS PRESENT

1881 - 1913	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, CRYSTALS 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA D. AMERICANUS PRESENT
1913 - 1923	DOLOSTONE; GRAYISH BROWN 15% POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; EUHEDRAL GRAIN SIZE: MICROCRYSTALLINE RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT FOSSILS: BENTHIC FORAMINIFERA, ECHINOID 20% PACKSTONE
1923 - 1950	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR GRAIN TYPE: SKELETAL, CALCILUTITE 55% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:MEDIUM; RANGE: FINE TO MEDIUM; POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA D. AMERICANUS PRESENT
1950 - 1955	DOLOSTONE; GRAYISH BROWN 15% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY 50-90% ALTERED; ANHEDRAL GRAIN SIZE: MICROCRYSTALLINE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-04%
1955 - 1980	DOLOSTONE; DARK YELLOWISH BROWN 15% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY 90-100% ALTERED; EUHEDRAL GRAIN SIZE: VERY FINE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT
1980 - 2005	DOLOSTONE; GRAYISH BROWN 10% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY 90-100% ALTERED; ANHEDRAL GRAIN SIZE: MICROCRYSTALLINE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT

2005 - 2020	DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN 15% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY PIN POINT VUGS; 90-100% ALTERED; EUHEDRAL GRAIN SIZE: FINE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT
2020 - 2097	DOLOSTONE; VERY LIGHT ORANGE 10% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY 90-100% ALTERED; ANHEDRAL GRAIN SIZE: MICROCRYSTALLINE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT
2097 - 2115	DOLOSTONE; GRAYISH BROWN TO LIGHT YELLOWISH ORANGE 10% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY 90-100% ALTERED; SUBHEDRAL GRAIN SIZE: VERY FINE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT
2115 - 2128	DOLOSTONE; OLIVE GRAY 10% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY 90-100% ALTERED; EUHEDRAL GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT
2128 - 2175	DOLOSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY 10% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY 90-100% ALTERED; SUBHEDRAL GRAIN SIZE: VERY FINE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT
2175 - 2185	DOLOSTONE; YELLOWISH GRAY 10% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY 90-100% ALTERED; ANHEDRAL GRAIN SIZE: MICROCRYSTALLINE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT
2185 - 2210	PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, BIOGENIC 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-25% FOSSILS: BENTHIC FORAMINIFERA ACCESSORY DOLOMITE AS ABOVE

2210 - 2240 DOLOSTONE; DARK YELLOWISH ORANGE
15% POROSITY: INTERCRYSTALLINE, VUGULAR; 90-100% ALTERED
EUHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT

2240 - 2245 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
20% POROSITY: INTERGRANULAR, INTRAGRANULAR, MOLDIC
GRAIN TYPE: SKELETAL, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-20%
FOSSILS: BENTHIC FORAMINIFERA, FOSSIL MOLDS

2245 - 2260 DOLOSTONE; GRAYISH ORANGE
15% POROSITY: INTERCRYSTALLINE; 90-100% ALTERED; EUHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-05%

2260 - 2270 GRAINSTONE; VERY LIGHT ORANGE
25% POROSITY: INTERGRANULAR, INTRAGRANULAR
GRAIN TYPE: SKELETAL, CRYSTALS
95% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; UNCONSOLIDATED
OTHER FEATURES: LOW RECRYSTALLIZATION
SOME ALLOCHEMS RECRYSTALLIZED

2270 - 2280 PACKSTONE; VERY LIGHT ORANGE TO YELLOWISH GRAY
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
GRAIN TYPE: SKELETAL, CRYSTALS
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: ECHINOID, FOSSIL MOLDS
DOLOMITE < 40%

2280 - 2290 DOLOSTONE; MODERATE YELLOWISH BROWN
15% POROSITY: INTERCRYSTALLINE, VUGULAR, LOW PERMEABILITY
90-100% ALTERED; EUHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT

2290 - 2300	GRAINSTONE; VERY LIGHT ORANGE 25% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, CRYSTALS 95% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; UNCONSOLIDATED DOLOMITE < 15%
2300 - 2415	DOLOSTONE; DARK YELLOWISH BROWN 10% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY 90-100% ALTERED; SUBHEDRAL GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-<5%
2415 - 2435	NO SAMPLES
2435 - 2471	PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 20% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, CALCILUTITE 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: FINE TO GRANULE GOOD INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-10% FOSSILS: BENTHIC FORAMINIFERA, ECHINOID
2471 - 2490	DOLOSTONE; GRAYISH ORANGE TO VERY LIGHT ORANGE 15% POROSITY: INTERCRYSTALLINE; 90-100% ALTERED; EUHEDRAL GRAIN SIZE:MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-10%
2490 - 2504	GRAINSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 25% POROSITY: INTERGRANULAR, INTRAGRANULAR GRAIN TYPE: SKELETAL, CRYSTALS, CALCILUTITE 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: FINE TO GRANULE MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-20%
2504 TOTAL DEPTH	

A-20

APPENDIX B

GEOPHYSICAL LOG TRACES

The geophysical logs of PBF-7 are shown in **Figures B-1** through **B-5**. A videotaping of PBF-7, conducted January 17, 1996, is summarized in **Table B-1**.

Table B-1. Video Survey for PBF-7

Videotaping Date	January 17, 1997
Depth Taped	985-2367 feet below sea level (ft bls)
Depth Correction	Videotape and these notes up to 17 ft deeper than geophysical logs (Haliburton) at base of hole
Feet bls	***Description***
993	Base of casing
993-1110	Well indurated, white packstone; no flow evident; wallowed out hole
1110-1292	As above, more white and chalky; less wallowed hole, smaller diameter
1292-1294	Very thin, minor flow zone; cream-white, undulating lense. Visible, minor flow evidenced by fuzzy water clarity as in isohaline change; trace rust staining in rock
1294-1325	Well indurated, white packstone as above
1325-1326	~1 foot thick, very minor flow zone; grey and white mottled limestone; well indurated packstone, without trace rust staining; flow possible but not strong
1326-1812	Packstone, well indurated as above; increased whiteness due apparently to more chalk content; mottled black concentric rings intermittently down the section
1812-1870	Packstone, increased hardness, better indurated than above, grey and white, and tan brown color, no evident flow.
1870-1924	Packstone, white, softer, chalkier than above; no visible flow zones
1924-1925	Dolomite, dark brown and black mottled; crystalline; no apparent flow
1925-1970	Packstone, white; well-indurated with black concentric rings interbedded
1970-2199	Dolomite, brown, hard, crystalline, black mottled; dramatic change in lithology from above; Flow zones evidenced by hazy, isohaline water clarity changes, swirling eddy currents, rust staining, mounds of white precipitate, etc., occurred at the following thin intervals ranging from 1 to 3 feet thick: 1975, 1979, 1986, 2001, 2005, 2012, 2024, 2124, 2129, 2140, 2177, 2188, 2198
2199-2210	Packstone, white-tan, well indurated; dramatic lithology change from dolomite above
2210-2248	Dolomite, brown, crystalline; no visible flow zones
2248-2363	Packstone and crystalline dolomite interbedded; visible fracturing in sidewalls in places
2363-2367	Dolomite, gray, crystalline; large flow zone evident
2367	Loss of signal, end of tape; remainder of borehole not on video

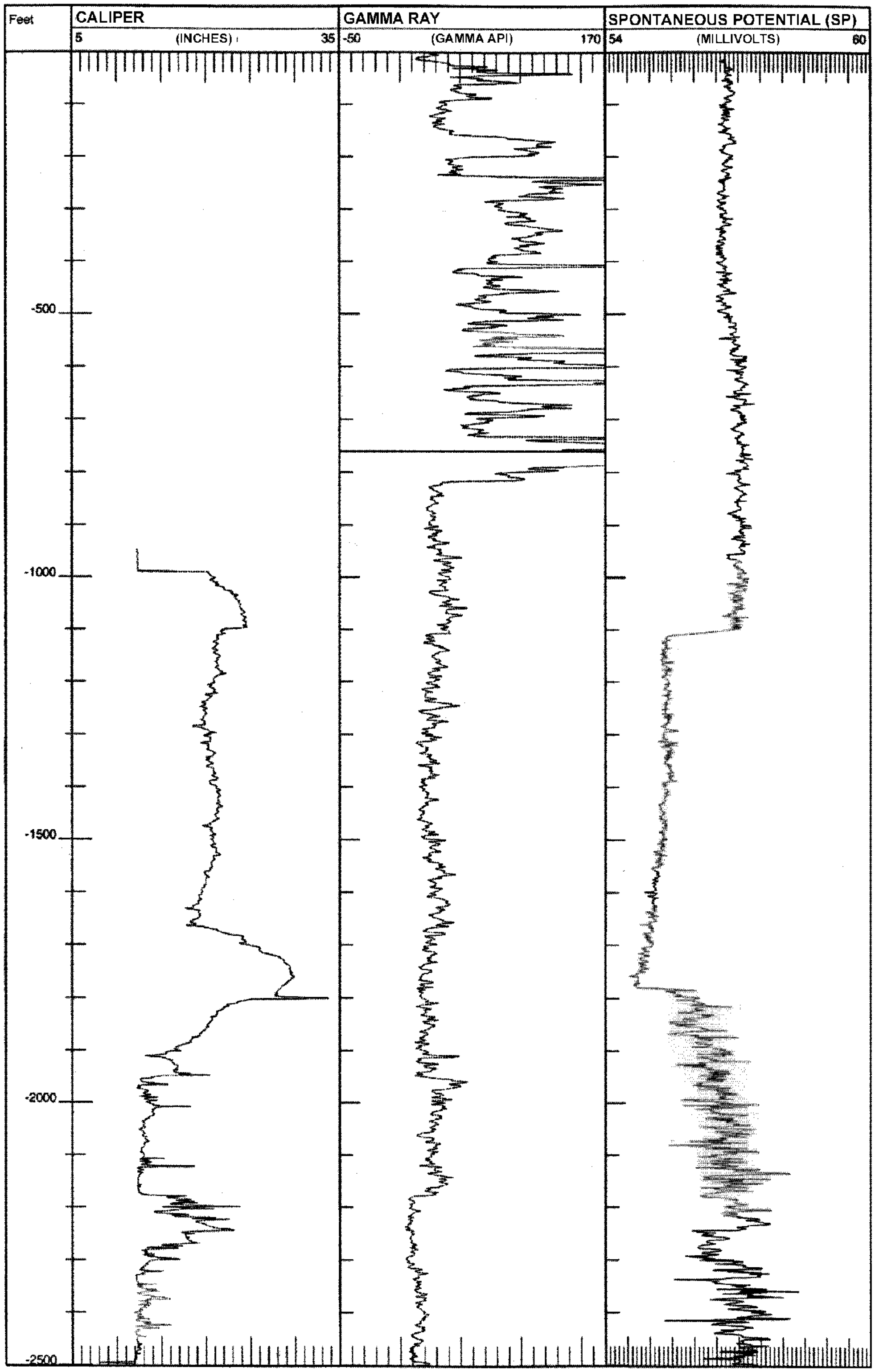


Figure B-1. Geophysical Log of PBF-7 (Sheet 1 of 5)

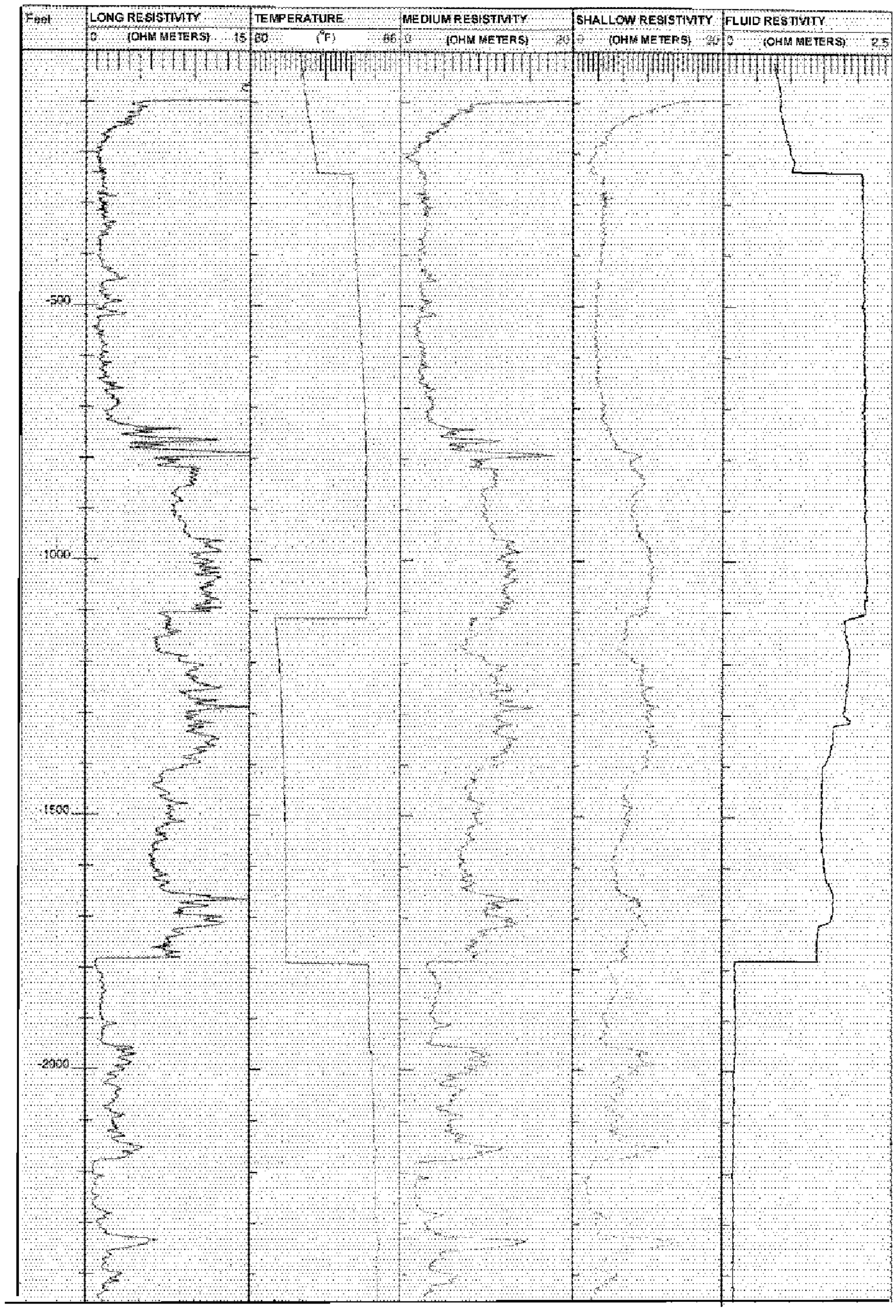


Figure B-2. Geophysical Log of PBF-7 (Sheet 2 of 5)

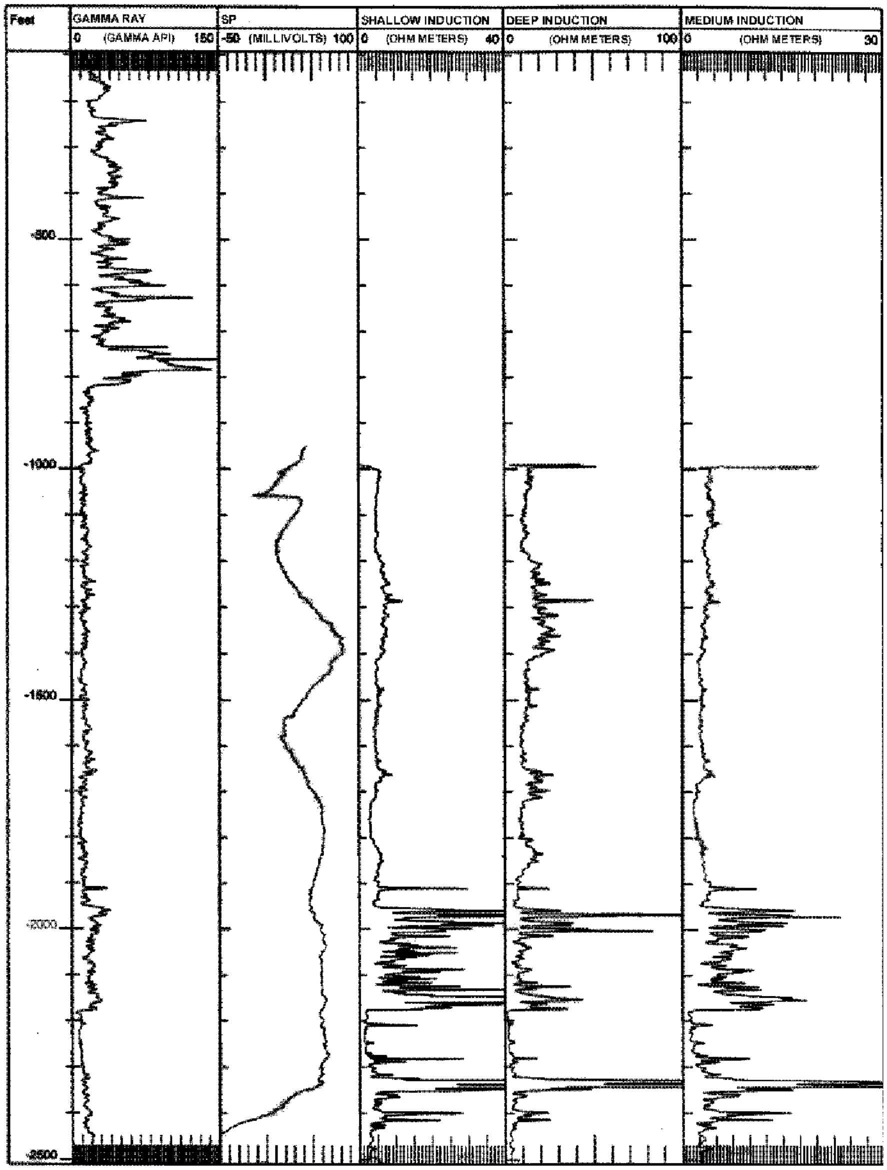


Figure B-3. Geophysical Log of PBF-7 (Sheet 3 of 5)

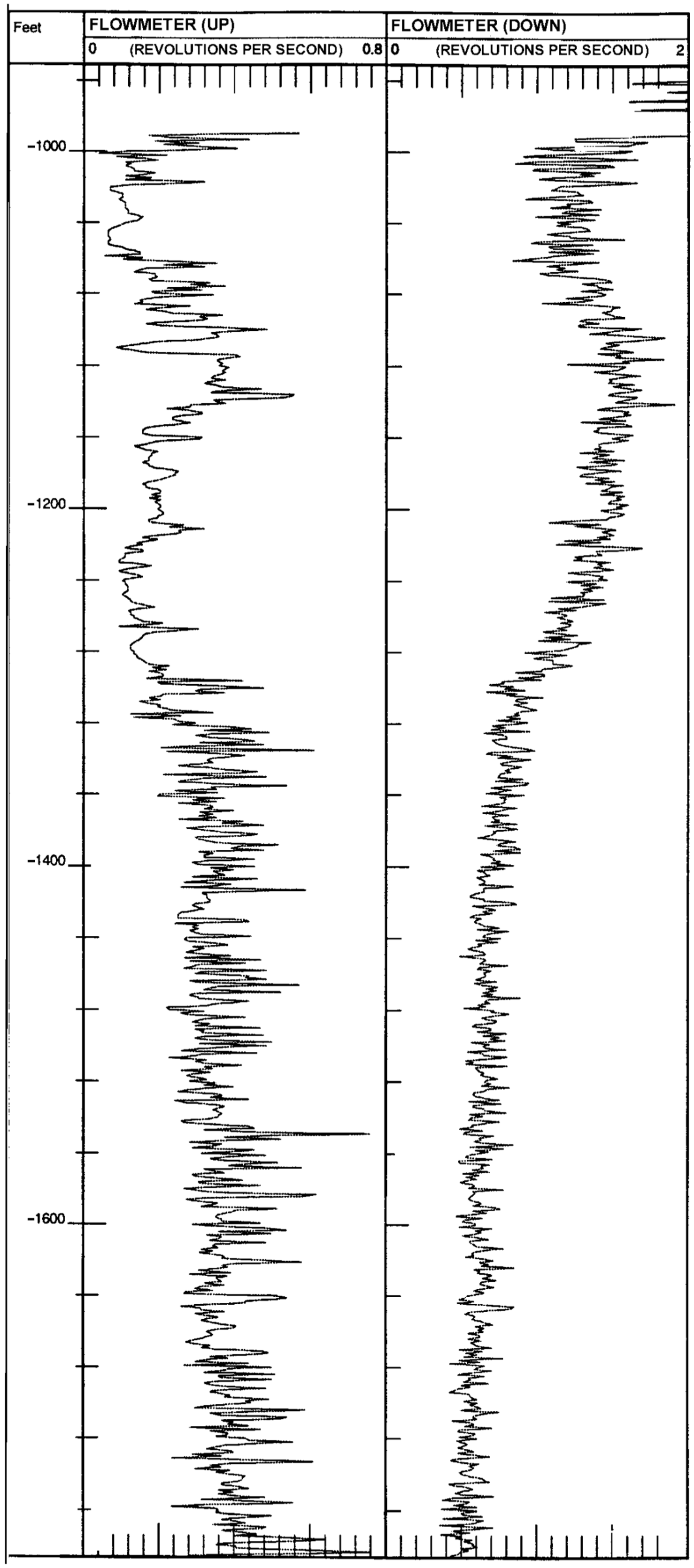


Figure B-4. Geophysical Log of PBF-7 (Sheet 4 of 5)

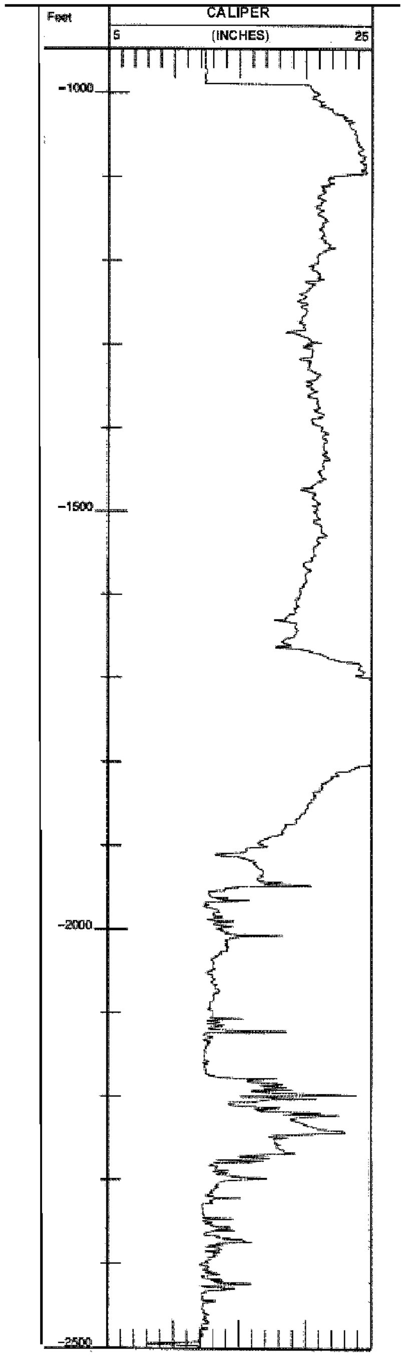


Figure B-5. Geophysical Log of PBF-7 (Sheet 5 of 5)

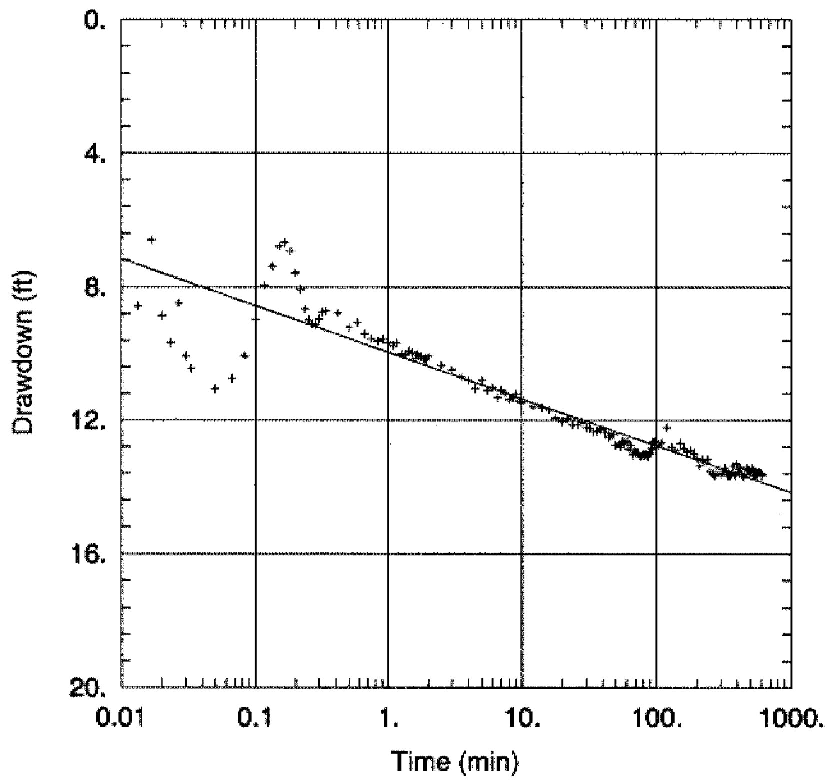
APPENDIX C

PACKER TEST DATA AND ANALYSES

Packer test details are provided in **Tables C-1** through **C-5** and **Figures C-1** through **C-4**.

Table C-1. PBF-7 Packer Test No. 1

Background Data		
Packer Test No.: 1	Date: 26 Nov 96	Interval Tested: 1012-1297 ft
Static Water Level (G.L.) Before Pumping: +35.68 ft		After Recovery:
Measuring Point Distance to Kelly Bushing: +27.00 ft		
Distance from G.L. to Rig's Kelly Bushing: 8.68 ft		
Maximum Drawdown During Pumping: 14.72 ft		Total Pumping: 600 minutes
Average Pumping Rate (gpm): 250		
Minimum Pumping Rate (gpm): 248		Max. Pumping Rate (gpm): 254
Pump Type: 3-inch submersible 3 hp		Depth to Pump Intake from K.B.: 64.15 ft
I.D. Drill Pipe: 3.5 inch	Tester: Baker	Driller: RST Inc.
Hermit #		
Input #1 Transducer #: 1544DB	Range: 30 psi	Depth Lowered to: 20.00 ft b.toc
Input #2 Transducer #: 1835DD	Range: 30 psi	Depth Lowered to: 20.00 ft b.toc
Time Pumping Started: 1100	Time Pumping Ended: 2100	Total Pumping Time: 10 hours
Aquifer Analysis		
Transmissivity: 47,020 gpd/ft		
Method of Analysis: Jacob		
Software Used: Fetter & Aqtesolv		
Specific Capacity: 31.75 gpm/ft/dd		
Friction Loss (Observed): 6.72 ft		
Static Head: +35.68 ft		
Water Quality		
Field Paramaters	***Major Ion Concentrations (mg/L)***	
	Cations (mg/L)	Anions (mg/L)
Cond.: 5550	MG = 91	$ALCO_3$ = 121
TDS: 3070	NA = 556	CL = 1464
Temp.: 26.1	K = 17	SO_4 = 512
pH: 7.1		F = 0.75
Definitions		
G.L. = ground level		
hp = horsepower		
dd = drawdown		
b.toc = below top of casing		



SOUTHBAY PACKER TEST #1, DRAWDOWN

Data Set: D:\Data\sbay_1200\fact sheet\pmptst\pckr_data\PCKR1\Pckr1dd.aqt
Date: 01/10/01 Time: 16:53:07

PROJECT INFORMATION

Company: SFWMD
Test Location: Southbay, Florida
Test Well: PBF-7
Test Date: 26 Nov 96

AQUIFER DATA

Saturated Thickness: 285. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

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

Observation Wells

Well Name	X (ft)	Y (ft)
+ PBF-7	0	0

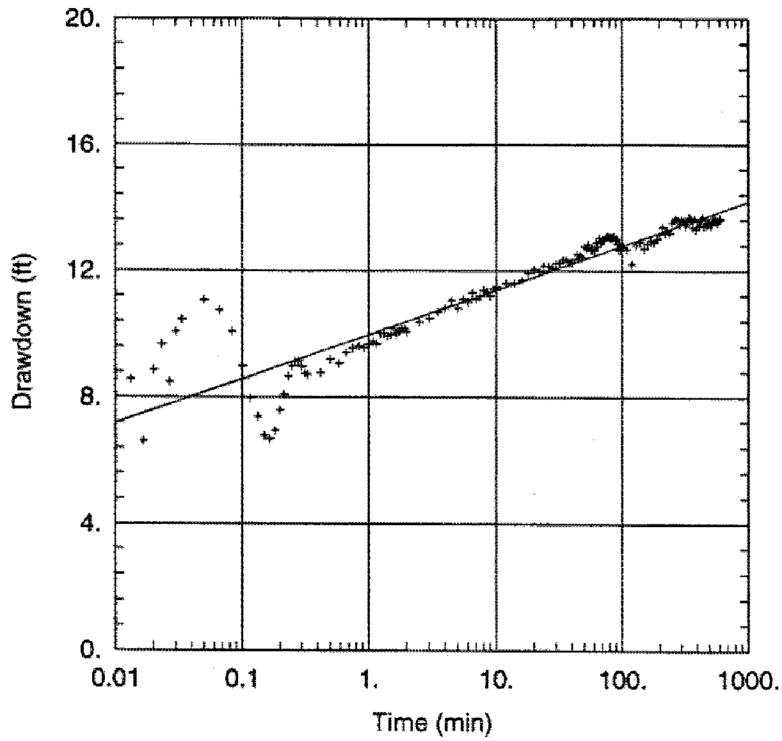
SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Jacob
T = 4.702E+04 gal/day/ft S = 3.1E-06

Figure C-1. Water Level Plot for Packer Test No. 1, 01/10/01

Table C-2. PBF-7 Packer Test No. 2

Background Data		
Packer Test No.: 2	Date: 16 Nov 96	Interval Tested: 1633-1762 ft
Static Water Level (G.L.) Before Pumping: +33.90 ft		After Recovery:
Measuring Point Distance to Kelly Bushing: +43.90 ft		
Distance from G.L. to Rig's Kelly Bushing: 9.30 ft		
Maximum Drawdown During Pumping: 79.86 ft		Total Pumping: 270 minutes
Average Pumping Rate (gpm): 204		
Minimum Pumping Rate (gpm): 202		Max. Pumping Rate (gpm): 212
Pump Type: 3-inch submersible 3 hp		Depth to Pump Intake from K.B.: 122 ft
I.D. Drill Pipe: 3.5 inch	Tester: Baker	Driller: RST Inc.
Hermit #		
Input #1 Transducer #: 5395GH	Range: 50 psi	Depth Lowered to: 110.00 ft b.toc
Input #2 Transducer #: 4073FD	Range: 50 psi	Depth Lowered to: 110.00 ft b.toc
Time Pumping Started: 0930	Time Pumping Ended: 1408	Total Pumping Time: 4.5 hours
Aquifer Analysis		
Transmissivity: 11,400 gpd/ft		
Method of Analysis: Theis Recovery		
Software Used: Fetter & Aqtesolv		
Specific Capacity: 2.6 gpm/ft/dd		
Friction Loss (Observed): 58.80 ft		
Static Head: +33.90 ft		
Water Quality		
Field Paramaters	***Major Ion Concentrations (mg/L)***	
	<u>*Cations (mg/L)*</u>	<u>*Anions (mg/L)*</u>
Cond.: 5340	MG = 104	$ALCO_3$ = 133
TDS: 3120	NA = 604	CL = 1446
Temp.: 26.26	K = 21	SO_4 = 514
pH: 7.1		F = 0.79



SOUTHBAY PACKER TEST #1, DRAWDOWN

Data Set: C:\MYDOCU~1\DATA\SBAY\FACTSH~1\PMPTST\PCKR_D~1\PCKR1\PCKR1DD.AQT
Date: 02/03/00 Time: 15:42:12

PROJECT INFORMATION

Company: SFWMD
Test Location: Southbay, Florida
Test Well: PBF-7
Test Date: 26 Nov 96

AQUIFER DATA

Saturated Thickness: 285. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PBF-7	0	0

Observation Wells

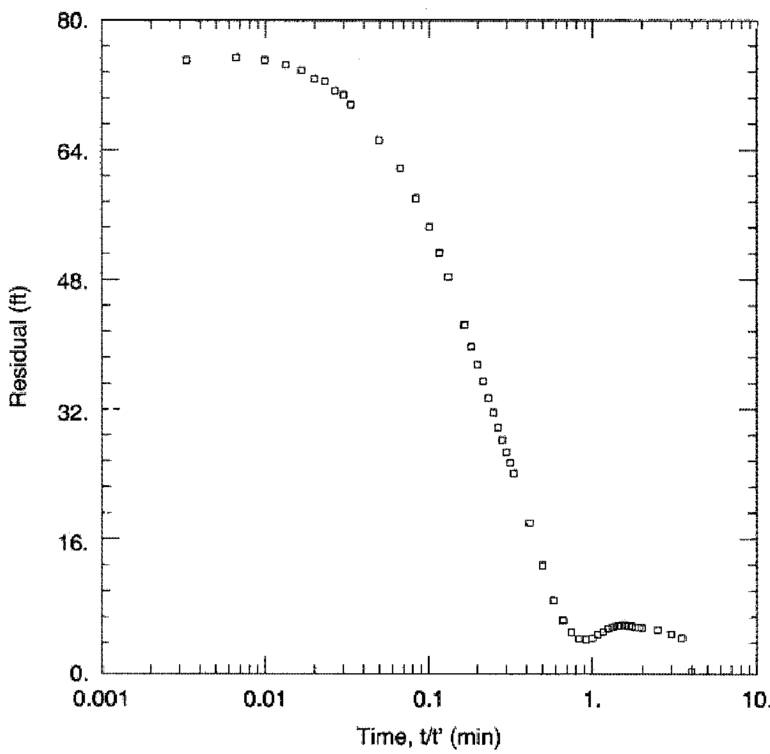
Well Name	X (ft)	Y (ft)
+ PBF-7	0	0

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Jacob

T = 4.702E+04 gal/day/ft
S = 3.1E-06

Figure C-2. Water Level Plot for Packer Test No. 1, 02/03/00



WELL TEST ANALYSIS

Data Set: D:\Data\sbay_1200\fact sheet\pmptst\pckr_data\PCKR2\pt2rec.aqt
Date: 01/10/01 Time: 17:37:38

PROJECT INFORMATION

Company: SFWMD
Test Location: South Bay
Test Well: PBF-7
Test Date: 12/20/96

AQUIFER DATA

Saturated Thickness: 129. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

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

Observation Wells

Well Name	X (ft)	Y (ft)
▫ PBF-7	0	0

SOLUTION

Aquifer Model: Confined
T = 1.14E+04 gal/day/ft

Solution Method: Cooper-Jacob
S = 0.001

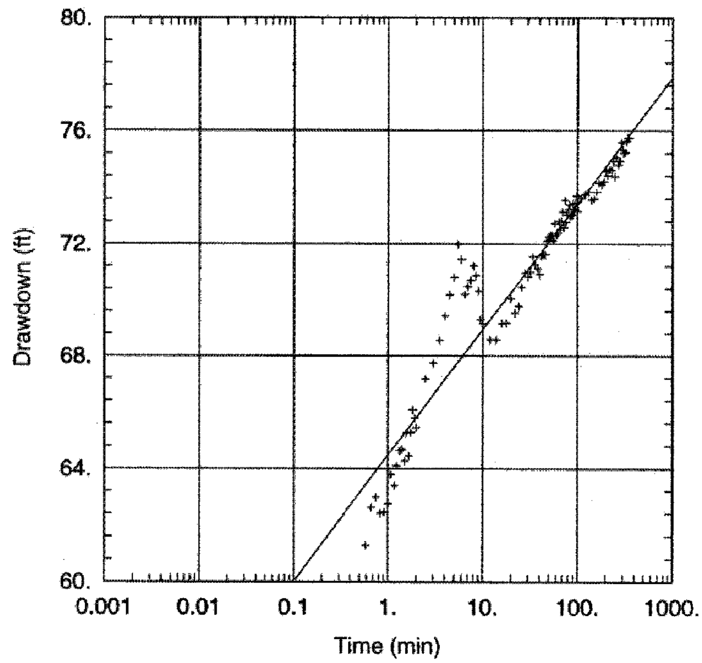
Figure C-3. Water Level Plot for Packer Test No. 2

Table C-3. PBF-7 Packer Test No. 3

Background Data		
Packer Test No.: 3	Date: 19 Dec 96	Interval Tested: 1263-1392 ft
Static Water Level (G.L.) Before Pumping: +30.18 ft		After Recovery:
Measuring Point Distance to Kelly Bushing: +34.00 ft		
Distance from G.L. to Rig's Kelly Bushing: 9.30 ft		
Maximum Drawdown During Pumping: 64.86 ft		Total Pumping: 540 minutes
Average Pumping Rate (gpm): 210		
Minimum Pumping Rate (gpm): 208		Max. Pumping Rate (gpm): 236
Pump Type: 3-inch submersible 3 hp		Depth to Pump Intake from K.B.: 128 ft
I.D. Drill Pipe: 3.5 inch	Tester: Baker	Driller: RST Inc.
Hermit #		
Input #1 Transducer #: 5395GH	Range: 50 psi	Depth Lowered to: 110.00 ft b.toc
Input #2 Transducer #: 4073FD	Range: 50 psi	Depth Lowered to: 110.00 ft b.toc
Time Pumping Started: 0941	Time Pumping Ended: 1803	Total Pumping Time: 9 hours
Aquifer Analysis		
Transmissivity: 37,210 gpd/ft		
Method of Analysis: Theis Recovery		
Software Used: Fetter & Aqtesolv		
Specific Capacity: 3.2 gpm/ft/dd		
Friction Loss (Observed): 48.15 ft		
Static Head: +20.88 ft		
Water Quality		
Field Paramaters	***Major Ion Concentrations (mg/L)***	
	Cations (mg/L)	*Anions (mg/L)*
Cond.: 5340	MG = 114	$ALCO_3$ = 275
TDS: 3090	NA = 837	CL = 1390
Temp.: 25.63	K = 35.1	SO_4 = 475
pH: 7.24		F = 0.84

Table C-4. PBF-7 Packer Test No. 4

Background Data		
Packer Test No.: 4	Date: 7 Feb 97	Interval Tested: 1913-2020 ft
Static Water Level (G.L.) Before Pumping: +35.15 ft		After Recovery:
Measuring Point Distance to Kelly Bushing: +33.65 ft		
Distance from G.L. to Rig's Kelly Bushing: 9.50 ft		
Maximum Drawdown During Pumping: 1.65 ft		Total Pumping: 240 minutes
Average Pumping Rate (gpm): 206		
Minimum Pumping Rate (gpm): 204		Max. Pumping Rate (gpm): 206
Pump Type: 3-inch submersible 3 hp		Depth to Pump Intake from K.B.: 112 ft
I.D. Drill Pipe: 3.5 inch	Tester: Baker	Driller: RST Inc.
Hermit #		
Input #1 Transducer #: 1835DD	Range: 30 psi	Depth Lowered to: 70 ft b.toc
Input #2 Transducer #: 5395GH	Range: 50 psi	Depth Lowered to: 110.00 ft b.toc
Time Pumping Started: 1115	Time Pumping Ended: 1503	Total Pumping Time: 4.0 hours
Aquifer Analysis		
Transmissivity: High gpd/ft		
Method of Analysis:		
Software Used: Fetter & Aqtesolv		
Specific Capacity: 103 gpd		
Friction Loss (Observed):		
Static Head: +43.10 ft		
Water Quality		
Field Paramaters	***Major Ion Concentrations (mg/L)***	
	Cations (mg/L)	*Anions (mg/L)*
Cond.: 23310	MG = 448	$ALCO_3$ = 108
TDS: 13800	NA = 1060	CL = 8179
Temp.: 27.23	K = 141.2	SO_4 = 977
pH: 7.44		F = 0.486



SOUTHBAY PACKER TEST #5, DRAWDOWN

Data Set: C:\MYDOCU~1\DATA\SBAY\FACTSH~1\PMPTST\PCKR_D~1\PCKR5\DDPCKR5.AQT
Date: 02/10/00 Time: 14:26:03

PROJECT INFORMATION

Company: SFWMD
Test Location: Southbay, Florida
Test Well: PBF-9
Test Date: 19 Feb 97

AQUIFER DATA

Saturated Thickness: 115. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

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

Observation Wells

Well Name	X (ft)	Y (ft)
+ PBF-9	5	0

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Jacob

T = 5556.9 gal/day/ft
S = 1.668E-16

Figure C-4. Water Level Plot for Packer Test No. 5

Table C-5. PBF-7 Packer Test No. 5

Background Data		
Packer Test No.: 5	Date: 19 Feb 97	Interval Tested: 775 - 890 ft
Static Water Level (G.L.) Before Pumping: +32.14 ft		After Recovery: 27.74 ft
Measuring Point Distance to Kelly Bushing: +29.74 ft		
Distance from G.L. to Rig's Kelly Bushing: 4.40 ft		
Maximum Drawdown During Pumping: 78.50 ft		Total Pumping: 360 minutes
Average Pumping Rate (gpm): 94		
Minimum Pumping Rate (gpm): 94		Max. Pumping Rate (gpm): 96
Pump Type: 3-inch submersible 3 hp		Depth to Pump Intake from K.B.: 120 ft
I.D. Drill Pipe: 3.5 inch	Tester: Baker	Driller: RST Inc.
Hermit # 2		
Input #1 Transducer #: 4073FD	Range: 50 psi	Depth Lowered to: 110.00 ft b.toc
Input #2 Transducer #: 5395GH	Range: 50 psi	Depth Lowered to: 110.00 ft b.toc
Time Pumping Started: 1404	Time Pumping Ended: 2000	Total Pumping Time: 6 hours
Aquifer Analysis		
Transmissivity: 5,556 gpd/ft		
Method of Analysis: Cooper-Jacob		
Software Used: Fetter & Aqtesolv		
Specific Capacity: 1.2 gal/ft/dd		
Friction Loss (Observed): 6.87 ft		
Static Head: +26.74 ft		
Water Quality		
Field Paramaters	***Major Ion Concentrations (mg/L)***	
	Cations (mg/L)	*Anions (mg/L)*
Cond.: 7110	MG = 170	$ALCO_3$ = 255.5
TDS: 4100	NA = 1060	CL = 1998
Temp.: 27.23	K = 51.4	SO_4 = 660
pH: 7.4		F = 1.06

APPENDIX D

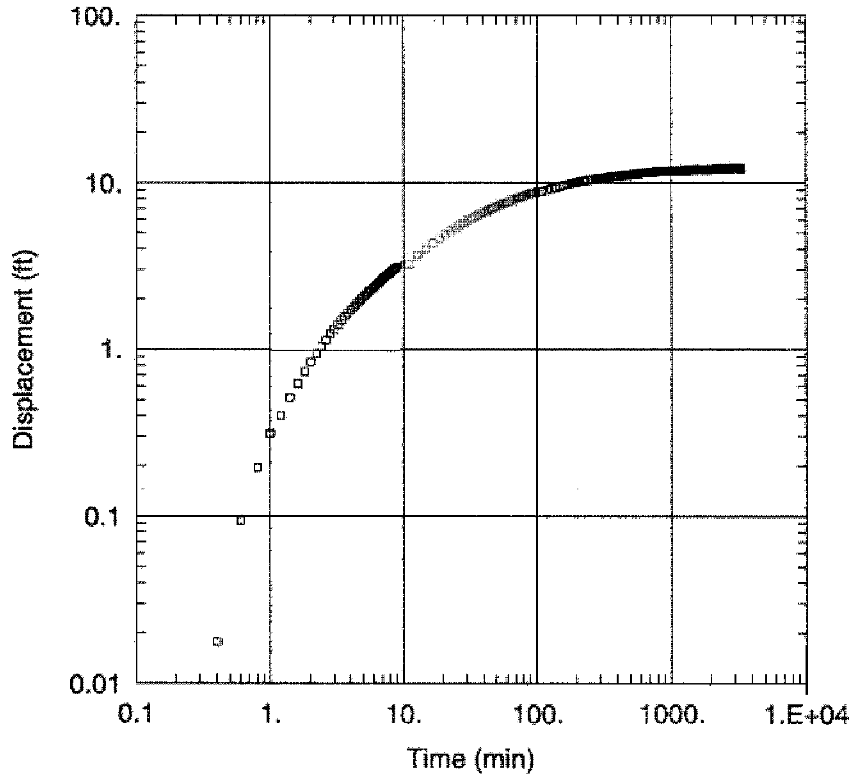
AQUIFER PERFORMANCE TEST DATA

AND ANALYSES

Aquifer performance test (APT) details are provided in **Tables D-1** and **D-2** and **Figures D-1** through **D-4**.

Table D-1. PBF-7 Aquifer Test No. 1

Background Data		
Aquifer Test No.: 1	Date: 3 April 97	Interval Tested: 1202-1447 ft
Static Water Level (G.L.) Before Pumping: +33.94 ft		After Recovery: +33.91 ft
Measuring Point Distance to Kelly Bushing: +5.0 ft		Ground Level (NGVD): 19.16 ft
Distance from G.L. to Rig's Kelly Bushing: 8.68 ft		
Maximum Drawdown During Pumping: 12.21 ft		Total Pumping: 3330 minutes
Average Pumping Rate (gpm): 1550		
Minimum Pumping Rate (gpm): 1550		Max. Pumping Rate (gpm): 1550
Pump Type: 3-inch submersible 3 hp		Depth to Pump Intake from K.B.: 120.0 ft
I.D. Drill Pipe: 3.5 inch	Tester: SFWMD	Driller: All Webb Enterprise
Hermit # 2		
Input #1 Transducer #: 1544DB	Range: 30 psi	Depth Lowered to: 5.0 ft a.l.s.
Input #2 Transducer #: 5392GH	Range: 50 psi	Depth Lowered to: 5.0 ft a.l.s.
Time Pumping Started: 0803	Time Pumping Ended: 1200	Total Pumping Time: 55.5 hours
Aquifer Analysis		
Transmissivity: 71,119 gpd/ft		
Method of Analysis: Hantush-Jacob		
Software Used: Aqtesolv		
Specific Capacity: 127 gal/ft/dd		
Friction Loss (Observed): 8.31 ft		
Static Head: +28.94 ft		
Water Quality		
Field Paramaters	***Major Ion Concentrations (mg/L)***	
	Cations (mg/L)	Anions (mg/L)
Cond.: 5484	CA = 133	$ALCO_3$ = 118
TDS: 3210	MG = 112	CL = 1481
Temp.: 24.89	NA = 861	SO_4 = 528
pH: 7.7	K = 43.3	F = 1.41
		SIO_2 = 13.20
Definitions		
G.L. = ground level		
hp = horsepower		
dd = drawdown		
a.l.s. =		



WELL TEST ANALYSIS

Data Set: D:\...\sbapt1dd.aqt
Date: 01/11/01 Time: 16:28:15

PROJECT INFORMATION

Company: SFWMD
Test Location: South Bay
Test Well: APT TEST #1
Test Date: 3 APR 97

AQUIFER DATA

Saturated Thickness: 245. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PBF-9	0	0

Observation Wells

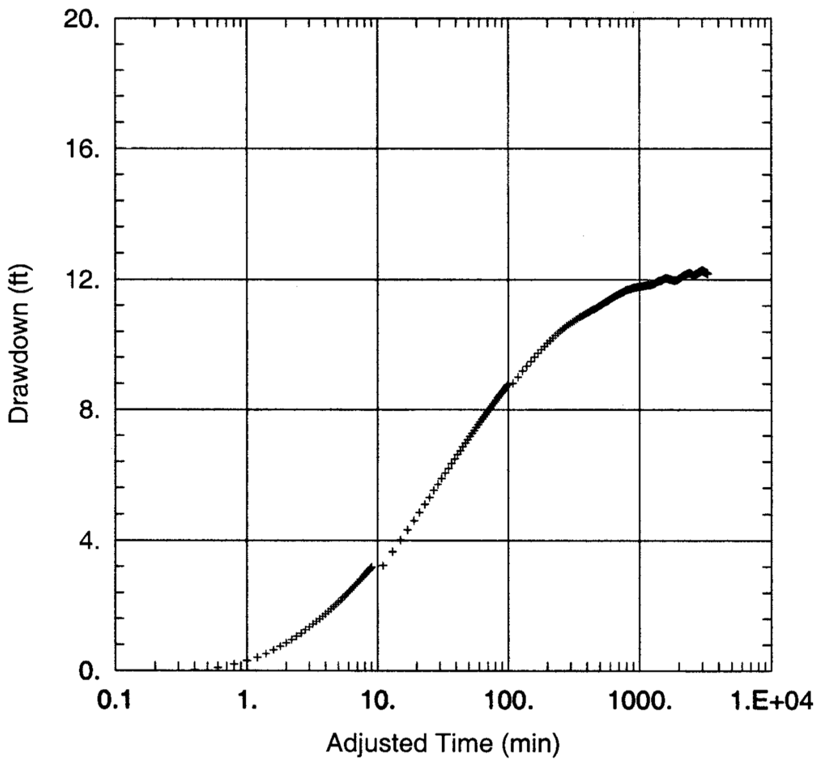
Well Name	X (ft)	Y (ft)
▫ PBF-7U	398	0

SOLUTION

Aquifer Model: Confined Solution Method: Hantush (Wedge)

T = 7.119E+04 gal/day/ft S = 0.0002937
r/a = 0.1

Figure D-1. Aquifer Test No. 1 Displacement Data



WELL TEST ANALYSIS

Data Set: D:\...\sbapt1dd_coop.aqt
Date: 01/11/01 Time: 16:27:50

PROJECT INFORMATION

Company: SFWMD
Test Location: South Bay
Test Well: APT TEST #1
Test Date: 3 APR 97

AQUIFER DATA

Saturated Thickness: 245. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PBF-9	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
+ PBF-7U	398	0

SOLUTION

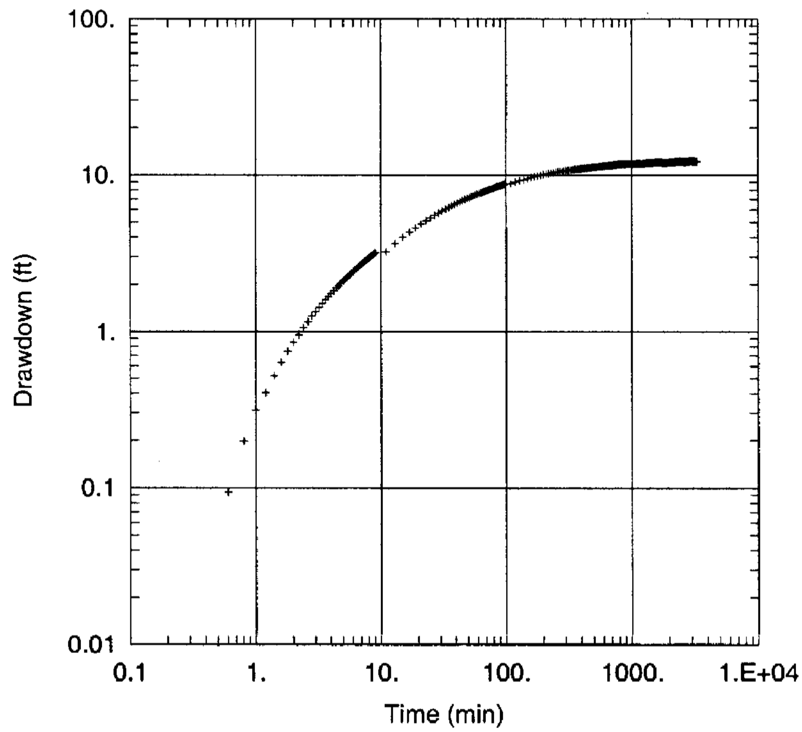
Aquifer Model: Confined Solution Method: Cooper-Jacob

T = 6.896E+04 gal/day/ft S = 0.0002779

Figure D-2. Aquifer Test No. 1 Drawdown Data (Cooper-Jacob)

Table D-2. PBF-7 Aquifer Test No. 2

Background Data		
Aquifer Test No.: 2	Date: 14 May 97	Interval Tested: 1960-2040 ft
Static Water Level (G.L.) Before Pumping: +25.1 ft		After Recovery: +20.38 ft
Measuring Point Distance to Kelly Bushing: +3.80 ft (land surface to petcock valve)		
Distance from G.L. to Rig's Kelly Bushing: 8.68 ft		Ground Level (NGVD): 19.16 ft
Maximum Drawdown During Pumping: 1.10 ft		Total Pumping: 4140 minutes
Average Pumping Rate (gpm): 1030		
Minimum Pumping Rate (gpm): 1030		Max. Pumping Rate (gpm): 1030
Pump Type: 3-inch submersible 3 hp		Depth to Pump Intake from K.B.: 120.0 ft
I.D. Drill Pipe: 3.5 inch	Tester: SFWMD	Driller: All Webb Enterprise
Hermit #		
Input #1 Transducer #: 205283	Range: 30 psi	Depth Lowered to: 3.80 ft a.l.s.
Input #2 Transducer #: 1836DD	Range: 30 psi	Depth Lowered to: 5.0 ft a.l.s.
Time Pumping Started: 1258	Time Pumping Ended: 1120	Total Pumping Time: 69.0 hours
Aquifer Analysis		
Transmissivity: 504,100 gpd/ft		
Method of Analysis: Theis Recovery		
Software Used: Aqtesolv		
Specific Capacity: 17.34 gal/ft/dd		
Friction Loss (Observed):		
Static Head: +21.28 ft		
Water Quality		
Field Paramaters	***Major Ion Concentrations (mg/L)***	
	Cations (mg/L)	*Anions (mg/L)*
Cond.: 27,030	CA = 473	$ALCO_3$ = 109
TDS: 15,900	MG = 558	CL = 9350
Temp.: 27.89	NA = 4695	SO_4 = 1076
pH: 6.8	K = 221	F = 0.496
		SIO_2 = 10.84



WELL TEST ANALYSIS

Data Set: D:\...\sbapt1dd.aqt
Date: 01/11/01 Time: 16:44:03

PROJECT INFORMATION

Company: SFWMD
Test Location: South Bay
Test Well: APT TEST #1
Test Date: 3 APR 97

AQUIFER DATA

Saturated Thickness: 245. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PBF-9	0	0

Observation Wells

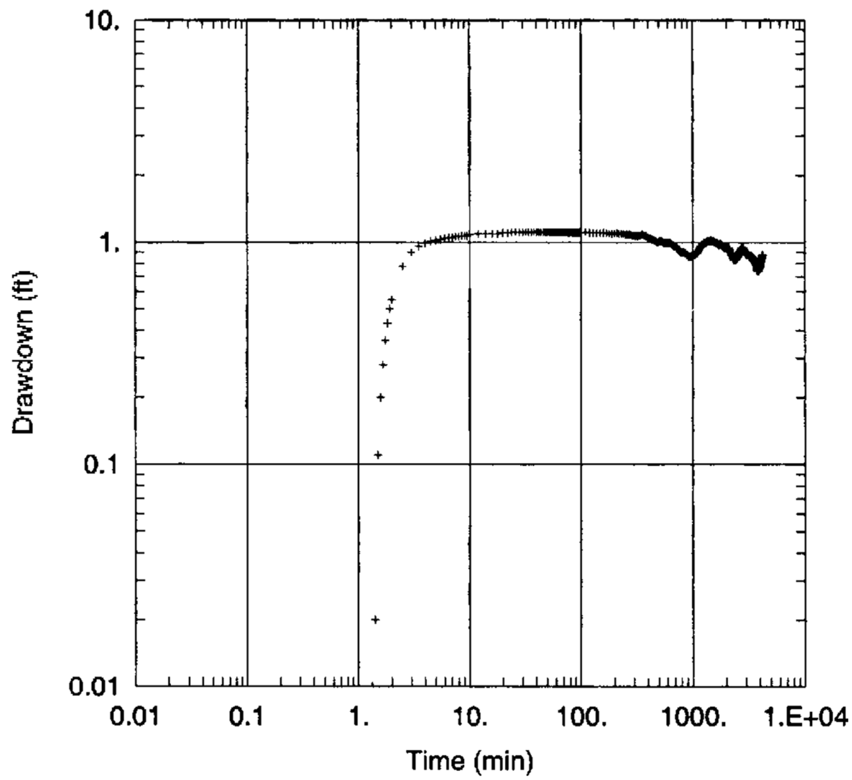
Well Name	X (ft)	Y (ft)
+ PBF-7U	398	0

SOLUTION

Aquifer Model: Confined Solution Method: Hantush (Wedge)

T = 7.119E+04 gal/day/ft S = 0.0002937
r/a = 0.1

Figure D-3. Aquifer Test No. 1 Drawdown Data (Hantush)



WELL TEST ANALYSIS

Data Set: D:\...\sbapt2dd.aqt
Date: 01/11/01 Time: 16:41:33

PROJECT INFORMATION

Company: SFWMD
Test Location: South Bay
Test Well: APT #2
Test Date: 14 May 97

AQUIFER DATA

Saturated Thickness: 80. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PBF-9	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
+ PBF-7L	398	0

SOLUTION

Aquifer Model: Confined Solution Method: Hantush (Wedge)

T = 5.041E+05 gal/day/ft S = 2.65E-05
r/a = 0.1

Figure D-4. Aquifer Test No. 2 Drawdown Data (Hantush)