Hydrogeologic Investigation of the Floridan Aquifer System: Port Mayaca Site

Martin County, Florida

Technical Publication WS-44

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ACRONYMS AND ABBREVIATIONS

‰	parts per thousand
µmhos/cm	micromhos per centimeter
AIT	high-resolution array induction
ASR	aquifer storage and recovery
b/e	barnes per electron
B.P.	before present
bpl	below pad level
DDC	Diversified Drilling Corp
DSI	dipole sonic imager
FAS	Floridan aquifer system
FDEP	Florida Department of Environmental Protection
FMI	formation micro-imager
g/cm^3	grams per cubic centimeter
GMWL	Global Meteoric Water Line
gpm	gallons per minute
LFA	Lower Floridan aquifer
MFA	Middle Floridan aquifer
mg/L	milligrams per liter
NGS	natural gamma ray spectrometry
PEF	photoelectric factor
PEFZ	photoelectric absorption index
pmC	percent modern carbon
psi	pounds per square inch
psig	pounds per square inch gauge
RO	reverse osmosis
SAS	surficial aquifer system
SFWMD	South Florida Water Management District
SMOW	standard mean ocean water
SP	spontaneous potential
TDS	total dissolved solids
UBI	ultrasonic borehole imager
UFA	Upper Floridan aquifer
USDW	underground source of drinking water

INTRODUCTION

Background

The Comprehensive Everglades Restoration Plan – jointly conducted by the United States Army Corps of Engineers and South Florida Water Management District (SFWMD) – is focused on storing available water currently lost to tide. Aquifer storage and recovery (ASR) technology has been identified as a major storage option, particularly in the vicinity of Lake Okeechobee where available water has been identified. The Lake Okeechobee ASR Pilot Project was designed to address some of the technical and regulatory uncertainties of storing treated surface water via ASR systems. Hydrogeologic testing of smaller diameter test/monitor wells was identified as one of the first tasks in evaluating ASR potential around Lake Okeechobee.

The purpose of this project is to provide site-specific hydrogeologic data on the Floridan aquifer system (FAS) at three sites in support of the Lake Okeechobee ASR Pilot Project. Data collected from the testing and monitoring of these test wells will be instrumental in site selection for future ASR systems, inclusion in the proposed ASR regional study, development of a conceptual hydrogeologic model, and future regional hydrogeologic and hydro-chemical assessments.

Scope

This report primarily describes the drilling, construction, and testing of a 12-inch diameter test/monitor well identified as MF-37 at Port Mayaca. It summarizes and presents data obtained during drilling and testing operations.

Project Description

The Port Mayaca test site is located approximately 30 miles west of the Atlantic Ocean and approximately 1 mile east of the eastern boundary of Lake Okeechobee in unincorporated Martin County, Florida. The MF-37 well was constructed on an SFWMD-owned right-of-way, near the S-153 water control structure on the L-65 Canal in the southeastern quarter of Section 14 of Township 40 South, Range 37 East (**Figure 1**). The geographic coordinates of the MF-37 well are 26°59'29.1" N and 80°36'16.5" W North American Datum of 1983 (NAD83). Land surface was determined by a closed-loop survey at 23.58 ft National Geodetic Vertical Datum of 1929 (NGVD29).

The SFWMD issued a notice to proceed to Diversified Drilling Corp (DDC) on April 16, 2001 to drill and construct three 12-inch diameter test/monitor wells at separate locations proximal to Lake Okeechobee. On May 30, 2001, construction began on the second test/monitor well, identified as MF-37. Drilling, testing, and construction activities related to the MF-37 well continued for approximately 7 months and were completed on January 10, 2002.

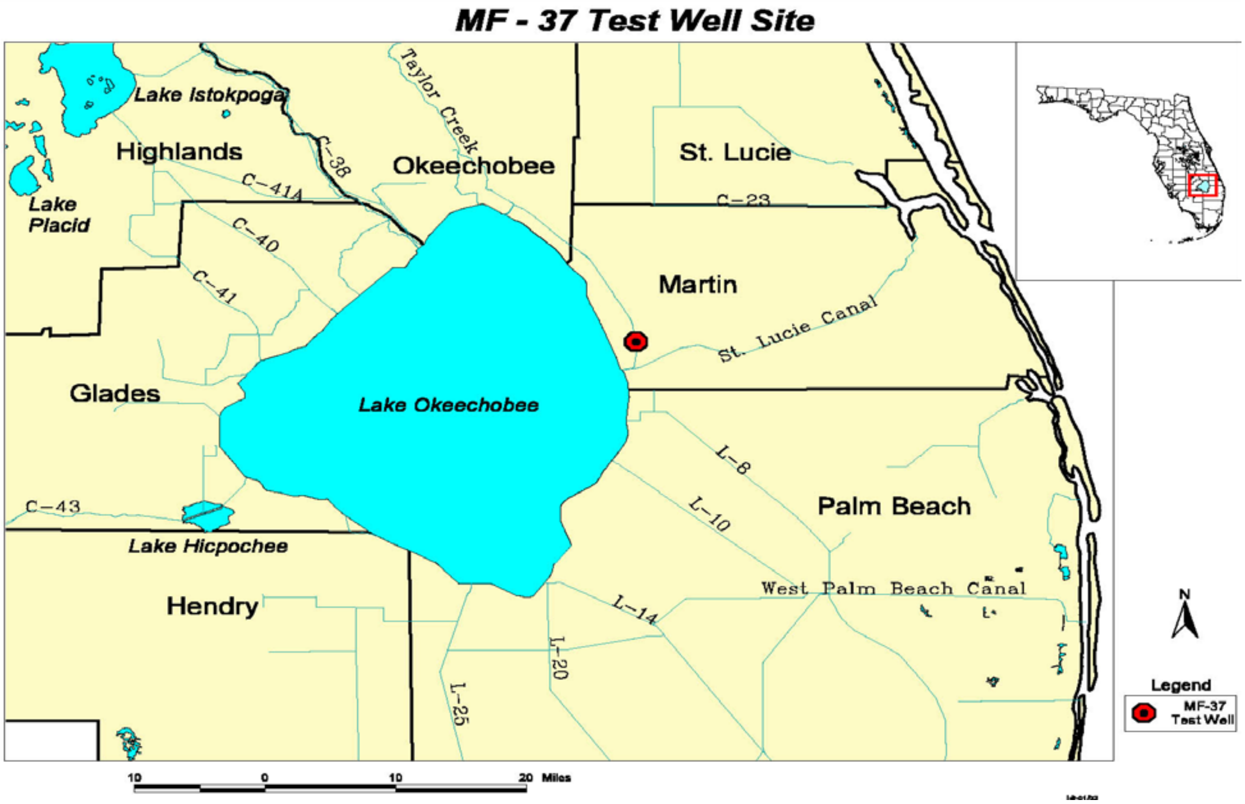

Figure 1. Project Location Map – Test/Monitor Well MF-37

EXPLORATORY DRILLING AND WELL CONSTRUCTION

Test/Monitor Well (MF-37)

DDC began site preparation in mid-May 2001. After minor clearing and rough grading of the site, the ground beneath the drill rig and settling tanks was lined with an impermeable high-density polyethylene (HDPE) liner. The liner was covered with 10 inches of granular fill for protection. A 2-ft thick temporary drilling pad was constructed using crushed limestone. An earthen berm 2 ft in height above pad level surrounded the perimeter of the rig and settling tanks. The earthen berm was constructed to contain drilling fluids and/or formation waters produced during well drilling, testing, and construction activities (**Figure 2**).

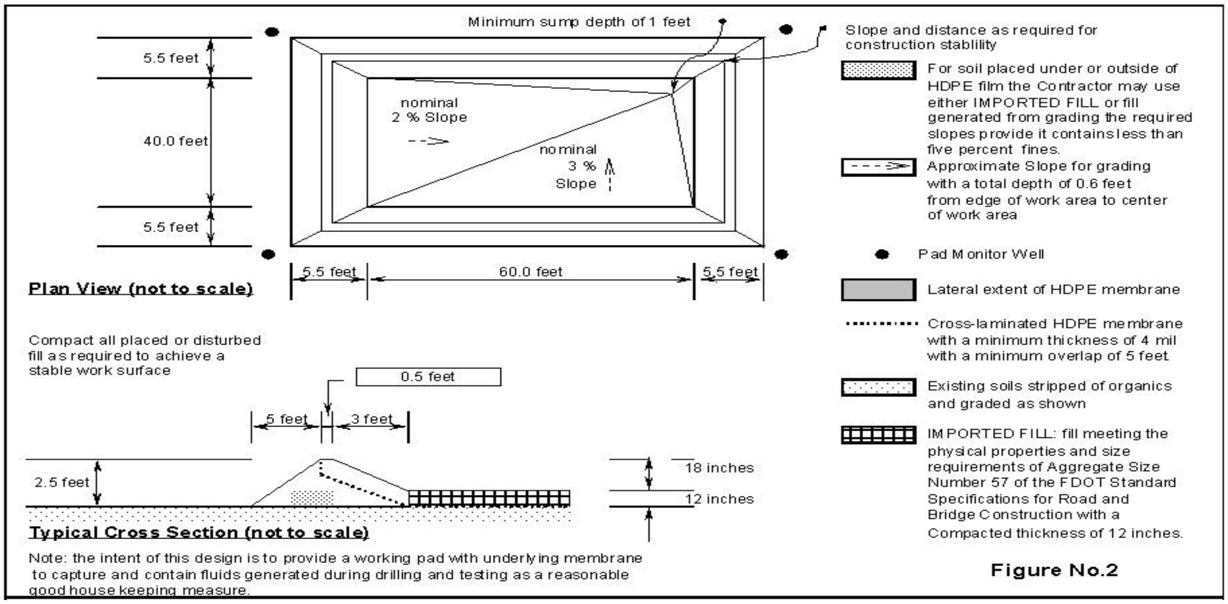

Figure 2. Well Pad Schematic

DDC installed four pad monitor wells at the corners of the temporary drilling pad prior to the start of drilling operations. The SFWMD monitored the water quality of these wells on a weekly basis to ensure no releases of brackish water occurred during construction.

Lithologic (well cuttings), packer test, and borehole geophysical log data were used to determine the actual casing setting depths. The pilot hole was reamed to specified diameters and casings were installed. Three concentric steel casings (24-, 18-, and 12-inch diameters) were used in the construction of MF-37.

DDC initiated drilling activities for MF-37 on May 30, 2001. Drilling operations began by advancing a nominal 10-inch diameter pilot hole to a depth of 87 ft below pad level (bpl) via the mud rotary method. The pilot hole was reamed to a depth of 80 ft bpl using a nominal 30-inch diameter staged reaming bit. In accordance with the well construction specifications, the reamed borehole was geophysically logged (caliper) to verify depths and calculate cement volumes for subsequent cement-grouting operations (**Appendix A**). On June 5, 2001, DDC installed the nominal 24-inch diameter steel pit casing (ASTM A53, Grade B, 0.375-inch wall thickness) in the nominal 30-inch diameter borehole to a depth of 74 ft bpl. The annulus was pressure grouted to land surface using 165 ft^3 of ASTM Type II, Portland cement (15.6 lb/gal). A factory mill certificate for the 24-inch diameter steel pit casing is provided in **Appendix B**.

After installing the 24-inch diameter pit casing, DDC continued drilling the pilot hole with a nominal 8-inch diameter bit using the mud rotary method. On June 8, 2001, DDC advanced the pilot hole through the Pleistocene/Pliocene-aged sediments and into the Hawthorn Group to a depth of 223 ft bpl. On June 13, 2001, MV Geophysical Surveys, Inc. of Fort Myers, Florida, geophysically logged the pilot hole from 74 to 223 ft bpl without incident. The logging suite consisted of the following logs: 4-arm caliper, natural gamma ray, spontaneous potential (SP), and borehole compensated sonic and dual induction/laterolog combination. The individual log traces from geophysical log Run #2 are presented in **Appendix A**.

Using well cuttings and geophysical log data, the base of the surficial aquifer system (SAS) was identified at approximately 146 ft bpl, where a greenish-gray phosphatic silty clay unit was first encountered. In addition, the natural gamma log noted an increase in natural gamma ray emissions, which corresponded to the lower permeable, silty, phosphatic clays found at similar depth. On June 23, 2001, DCC reamed the nominal 8-inch diameter pilot hole to 175 ft bpl using a nominal 23-inch diameter staged bit reamer. The nominal 23-inch borehole was geophysically logged (caliper-natural gamma ray) to verify depths and calculate cement volumes for subsequent grouting operations. The caliper log showed no unusual borehole conditions that would prohibit proper installation of the 18-inch diameter surface casing (see **Appendix A**). DDC then installed the 18-inch diameter steel casing (ASTM A53, Grade B, 0.375-inch wall thickness) in the nominal 23-inch diameter borehole to a depth of 170 ft bpl. Once installed, the 18-inch diameter steel pipe was pressure grouted using 206 ft^3 of ASTM Type II cement. An additional 12 ft^3 of ASTM Type II cement was used to bring cement levels in the annulus to the surface, completing surface casing installation on June 25, 2001.

The surface casing is meant to prevent unconsolidated surface sediments from collapsing into the drilled hole, to isolate the SAS from brackish water contamination, and to provide drill rig stability during continued drilling operations. A factory mill certificate for the 18-inch diameter surface casing is provided in **Appendix B**.

With the surface casing installed, DDC continued to advance a nominal 8-inch diameter pilot hole via closed circulation mud rotary method. On July 5, 2001, DDC completed pilot-hole drilling operations through the unconsolidated to semi-consolidated sediments of Miocene-aged Hawthorn Group. Drilling operations continued through the Oligocene and upper Eocene-aged carbonates of the Upper Floridan aquifer (UFA) to a depth of 1,116 ft bpl. During drilling operations, several 4-inch diameter conventional cores were collected from the carbonate section of the UFA at the following depth intervals: 798 to 808 ft bpl; 931 to 951 ft bpl; and 1,086 to 1,106 ft bpl. During coring operations, minimal lengths of core were retrieved to the surface, with a core recovery efficiency of 36%.

On July 24, 2001, Schlumberger Wireline Services conducted and completed geophysical logging operations without incident in the nominal 8-inch diameter pilot hole from 170 to 1,116 ft bpl. The geophysical logging suite included conventional and specialty logs as follows: caliper, SP, natural gamma ray, natural gamma ray spectrometry (NGS), high-resolution array induction (AIT), dipole sonic imager (DSI), compensated density with photoelectric factor (PEF), compensated neutron, ultrasonic borehole imager (UBI), and fullbore formation micro-imager (FMI). A composite of the geophysical log traces that were exempt from post-processing from geophysical Run #4 is provided in **Appendix A**.

Lithologic data (**Appendices C-1** and **C-2**) and geophysical logs (**Appendix A**) from the borehole indicate that the top of the FAS occurs at approximately 755 ft bpl. However, the final 12-inch steel production casing was set at a depth of 765 ft bpl for the following reasons:

1. Seal off overlying clays of the Hawthorn Group as well as carbonate mud stringers, and fine quartz and phosphatic sands within the lower portion of the Arcadia Formation.

2. Facilitate reverse-air-drilling operations through the underlying permeable horizons of the FAS to an anticipated depth of 2,000 ft bpl.

3. Locate the casing in a competent, well-indurated rock unit to reduce undermining (i.e., erosion) at its base as a result of natural and induced high-velocity upward flow.

4. Evaluate flow characteristics of the FAS within the anticipated open-hole interval of 765 to 2,000 ft bpl.

5. Avoid non-productive, phosphate-bearing silt/sand from approximately 700 to 765 ft bpl – as evidenced by the drill cuttings and peaks on the natural gamma ray log trace, which may impact FAS water quality and further drilling operations.

On July 30, 2001, the nominal 8-inch diameter pilot hole was temporarily back-filled to approximately 700 ft bpl with ⅜-inch diameter crushed limestone gravel. DDC reamed the nominal 8-inch diameter pilot hole using a nominal 17-inch diameter staged bit reamer. During the course of over-drilling the pilot hole, DDC inadvertently drilled 30 ft past the designated depth of 770 ft bpl due to an incorrect drill rod tally. DDC began corrective measures by re-installing ⅜-inch diameter crushed limestone to 750 ft bpl, re-drilling the 17-inch diameter borehole to 780 ft bpl, and installing 5 ft of silica sand capped by a 5-ft thick bentonite seal. These measures limited cement filtrate from penetrating the more permeable crushed limestone material created during pressure-grouting operations.

On August 14, 2001, DDC circulated and geophysically logged (caliper and natural gamma) the nominal 17-inch diameter borehole to its total depth without incident. The caliper log trace (**Appendix A**) showed no unusual borehole conditions that would prohibit proper installation of the 12-inch diameter casing to 765 ft bpl. The 12-inch diameter casing was installed (ASTM A53, Grade B, 0.375-inch wall thickness) to a depth of 765 ft bpl. The factory mill certificate and the casing installation log for the 12-inch diameter casing are provided in **Appendix B**. Once the casing was installed to a depth of 765 ft bpl, it was rotated and reciprocated to discern if it was free within the borehole for subsequent cement grouting. DDC then circulated approximately 10,000 gallons of fluid through the annular space to displace the heavy drilling mud that was required for borehole stabilization. This post-conditioning water flush reduces potential mixing of grout and drilling mud (of similar densities) during grouting operations, reducing the risk of mud channels (annular voids).

After the post-conditioning water flush, pressure-grouting operations began by installing tremie pipe (2.875-inch diameter) to 725 ft bpl. Approximately 445 ft^3 (350 bags at 94 lb/bag) of ASTM C-150 Type II neat cement were pumped during pressure-grouting operations. A temperature/gamma survey was conducted 8 hours after cementing operations ceased. This survey was used to identify the top of the cement within the annulus as a result of pressure grouting. A noticeable shift in the temperature gradient log and corresponding deflection in the temperature differential log occurred at 50 ft bpl (see **Appendix A** for temperature-gamma log), which suggests that the top of the first stage is located at that depth. Steel tubing was used to physically locate (hard tag) the cement level within the annulus. The physical tag indicated the cement level at 45 ft bpl, which was in close agreement to the temperature log. An additional 35 ft^3 of ASTM Type II neat cement were pumped on August 15, 2001 via the tremie method, causing cement returns at the surface. Actual cement volumes pumped during casing installation were in close agreement to theoretical volumes (approximately 97% of theoretical) based on a nominal 17-inch diameter borehole and 12-inch diameter steel with an outer diameter of 12.75 inches.

Once grouting operations were completed, DDC installed a well header on the 12-inch diameter steel casing as part of pressure-testing operations. The wellhead was sealed at the surface by the temporary header to facilitate the test. The well was filled with water and pressurized to approximately 50 pounds per square inch (psi) using a high-pressure water pump. A preliminary 60-minute pressure test was conducted on August 17, 2001. During this test, internal casing pressure decreased by 8 psi (a 16% reduction), which exceeded the specified test tolerance limit of ±5%. DDC then made appropriate adjustments to the wellhead configuration, isolating surface leaks observed during the preliminary pressure tests.

Once properly sealed, the SFWMD notified the Florida Department of Environmental Protection (FDEP) of the scheduled pressure test date for the 12-inch diameter steel casing. The formal pressure test was conducted and successfully completed on August 21, 2001; an FDEP representative opted not to be present during the test. During the course of the 60-minute pressure test, the total pressure within the 12-inch diameter casing decreased 2 psi, representing a 4% decline, which is within the test tolerance limit of ±5% (**Table 1**).

Table 1. Official Pressure Test on 12-Inch Casing String (MF-37)

Date	Time Hour	Elapsed Time (min.)	Pressure Reading (psi)	Change in Pressure (psi)
8/21/01	9:05	0	53.50	0.00
8/21/01	9:10	5	53.25	0.25
8/21/01	9:15	10	53.00	0.50
8/21/01	9:20	15	53.00	0.50
8/21/01	9:25	20	53.00	0.50
8/21/01	9:30	25	53.00	0.50
8/21/01	9:35	30	52.75	0.75
8/21/01	9:40	35	52.50	1.00
8/21/01	9:45	40	52.50	1.00
8/21/01	9:50	45	52.25	1.25
8/21/01	9:55	50	52.00	1.50
8/21/01	10:00	55	51.50	2.00
8/21/01	10:05	60	51.50	2.00

Recorded by: Ed Rectenwald, SFWMD. Engineer of Record: Paul F. Linton, SFWMD.

On August 23, 2001, DDC used a nominal 12-inch diameter bit to drill out the cement plug (a result of pressure grouting) at the base of the final casing string. DDC tripped back in with a nominal 8-inch bit and began to drill out the temporary backfill material (⅜-inch diameter crushed limestone) from the original pilot hole via the closed-circulation mud rotary technique. The pilot hole was re-drilled to its original total depth of 1,116 ft bpl on August 24, 2001.

On August 31, 2001, a conventional core was collected from 1,116 to 1,136 ft bpl, but no core material was recovered at the surface. On September 5, 2001, DDC resumed drilling the 8-inch diameter pilot hole via the mud rotary method. Mud rotary drilling continued through the Eocene-aged carbonates to a depth of 1,500 ft bpl.

A cavernous dolostone unit was encountered at 1,500 ft bpl, which caused a loss of mud circulation and a 3-ft drop of the drill rod. DDC re-mixed and circulated approximately 10,000 gallons of drilling fluid in an effort to regain circulation; however, these efforts were unsuccessful. A decision was made to switch to the reverse-air-drilling method to continue pilot hole drilling to an anticipated depth of 2,000 ft bpl. Consequently, DDC reconfigured the drilling equipment to accommodate reverse-air-drilling operations.

SFWMD personnel installed water quality probes equipped with sondes to collect temperature, pH, specific conductance, dissolved oxygen, and turbidity data in the L-65 Canal. The probes were deployed 100 meters upstream as well as 100 and 800 meters downstream from the point of discharge. During reverse-air-drilling operations, formation water was diverted through a series of 7,500-gallon settling tanks, then discharged into the L-65 Canal via a 12-inch diameter polyvinyl chloride (PVC) pipe equipped with a silt screen to minimize particulate matter being discharged. SFWMD personnel collected water quality data (three times daily) from the L-65 Canal during discharges produced from the MF-37 test/monitor well to comply with FDEP-issued National Pollutant Discharge Elimination System (NPDES) permit monitoring requirements.

On September 18, 2001, DDC began to drill a nominal 8-inch diameter pilot hole from 1,503 to 1,629 ft bpl using the reverse-air-drilling method. On September 22, 2001, a conventional core was cut from 1,629 to 1,637 ft bpl. However, only 8 ft of the anticipated 20-ft section was cored because the core barrel (20 ft in length) plugged off at 1,637 ft bpl, which halted coring operations. The recovered length of core material was 7 ft (87% recovery efficiency). DDC continued reverse-air-drilling operations from 1,637 to 2,046 ft bpl with a conventional core obtained from 1,944 to 1,955 ft bpl (9 ft of core recovered). On October 4, 2001, DDC completed drilling of the pilot hole to a total depth of 2,046 ft bpl. Once the pilot hole was completed, it was air developed and prepared for geophysical logging operations.

A borehole video survey was run to evaluate borehole stability within the open section (765 to 2,046 ft bpl). On October 5, 2001, MV Geophysical Surveys, Inc. completed an unobstructed video log to the full depth of the nominal 8-inch diameter pilot hole. The results of the video log indicated that the pilot hole was stable (e.g., no large rock fragments residing close to the borehole that would obstruct or cause the logging tool to become stuck downhole). As a result, MV Geophysical Surveys, Inc. geophysically logged the pilot hole from 765 to 2,046 ft bpl. The logging suite consisted of x-y caliper, natural gamma ray, SP, borehole compensated sonic, and a dual induction/laterolog combination. On October 8, 2001, MV Geophysical Surveys, Inc. performed static and dynamic production logging operations, including a flowmeter, fluid resistivity, and high-resolution temperature logs. A composite of the geophysical logs conducted by MV Geophysical Surveys, Inc., including the open hole and production type log traces, is provided in **Appendix A**.

Straddle-packer test intervals were selected using the information provided by analysis of the geophysical logs and lithologic data; the first of six tests began on October 16, 2001. The purpose of the tests was to characterize the water quality and production capacities of specific intervals within the larger open-hole interval (765 to 2,046 ft bpl). From a water resource perspective, intervals having total dissolved solids (TDS) concentrations greater than 10,000 milligrams per liter (mg/L) were not considered for further aquifer hydraulic characterization because they are not considered potential sources of drinking water as defined in Chapter 62-520 of the Florida Administrative Code. An underground source of drinking water (USDW) is defined as an aquifer containing water with a TDS concentration of less than 10,000 mg/L.

DDC completed packer testing operations on November 13, 2001. The water quality data obtained from the straddle-packer tests were used with the geophysical logs to identify the base of the USDW at approximately 1,740 ft bpl. The production and water quality results for the various packer tests are presented in the Packer Tests section.

On November 7, 2001, Schlumberger conducted and completed geophysical logging operations within the nominal 8-inch diameter pilot hole from 765 to 2,046 ft bpl without incident. Due to scheduling conflicts, Schlumberger Wireline Services was unable to provide specialty geophysical logging services at the MF-37 site until the first week of November 2001. The geophysical logging suite included the following logs: caliper, SP, NGS, AIT, DSI, compensated density with PEF, compensated neutron, UBI, and fullbore FMI. A composite of the geophysical log traces that were exempt from post-processing during geophysical log Run #8 is provided in **Appendix A**.

Once hydraulic testing and geophysical logging operations were completed, DDC began to permanently back plug the bottom 363 ft of the nominal 8-inch diameter pilot hole. During back-plugging operations (November 19-28, 2001), DDC pumped 550 sacks (693 ft^3) of Type II neat cement with 4% (20-40 grade) quartz sand. This volume brought cement levels from the base of the pilot hole at 2,046 ft bpl to 1,683 ft bpl.

On January 3, 2002, the final stage of well construction began by DDC installing a semi-permanent inflatable packer at 1,500 ft bpl. The packer is meant to isolate the deeper saline waters, thus prohibiting inter-aquifer transfer, and allow flexibility in the final design of the test/monitor well (e.g., single or dual zone monitor well). The current well completion for MF-37 is as follows and illustrated in **Figure 3**:

- Permanent steel casing (12-inch diameter) set to 765 ft bpl;
- Open-hole interval from 765 to 1,500 ft bpl;
- Long-term 7.0-inch diameter (Tam) inflatable packer set at 1,500 ft bpl;
- Open-hole interval from 1,500 to 1,683 ft bpl; and
- Nominal 8-inch diameter pilot hole, back plugged using neat cement and 4% (20-40 grade) sand from 1,683 to 2,046 ft bpl.

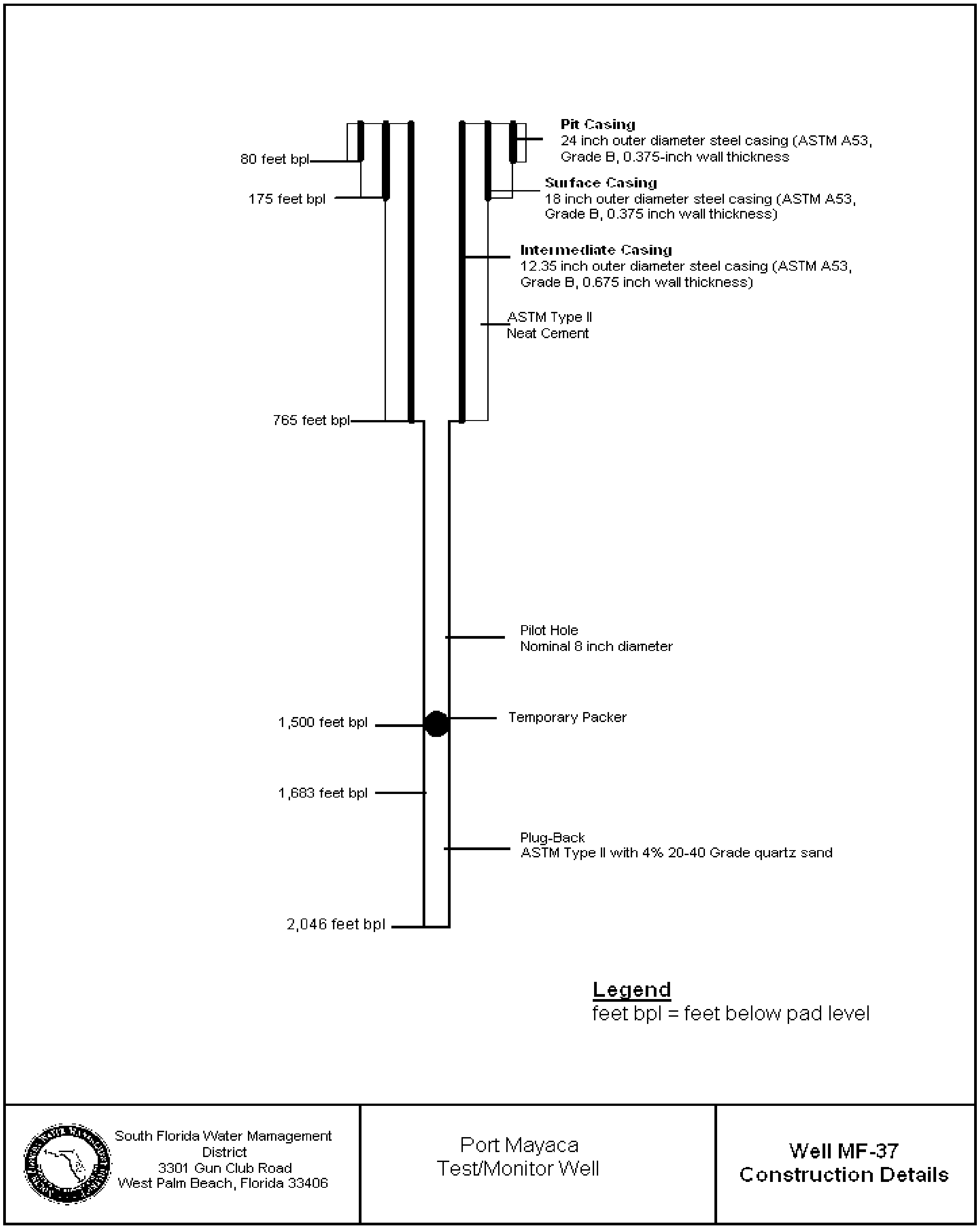

Figure 3. Well Completion Diagram, Test/Monitor Well (MF-37)

The technical specifications for the semi-permanent inflatable packer are provided in **Appendix B**.

During January 7-11, 2002, DDC installed a 12-inch diameter wellhead and 6-ft by 6-ft concrete pad with 4-ft high steel corner posts, completing well construction activities at the site (**Figure 4**). Well construction and testing activities related to MF-37 are summarized in **Table 2**.

After construction was completed, MF-37 was surveyed relative to permanent reference points by a Florida-registered land surveyor, plotted on a site plan map by latitude and longitude, and documented in the public record (**Appendix F**).

Figure 4. Completed Wellhead – Test/Monitor Well (MF-37)

Table 2. Construction and Testing Activities Associated with MF-37

Date	Description of Activities
04/16/01	Project initiation (Notice to Proceed)
05/10/01	Site preparation and mobilization
06/01/01	Drilled a 9.875-inch pilot hole to 87 ft bpl
06/05/01	Reamed pilot hole with a 30-inch diameter bit to 85 ft bpl
06/05/01	Geophysical logged reamed pilot hole (Run #1)
06/05/01	Install pit casing (74 ft; 24-inch diameter steel)
06/08/01	Drilled a 7.875-inch diameter pilot hole to 223 ft bpl
06/13/01	Geophysical logged pilot hole to 223 ft bpl (Run #2)
06/21/01	Reamed pilot hole with a 23-inch diameter bit 175 ft bpl
06/22/01	Geophysical logged reamed pilot hole (Run #3)
06/22/01	Install surface casing (170 ft; 18-inch diameter steel)
07/05/01	Drilled a 7.875-inch diameter pilot hole to 778 ft bpl
07/06/01	Cored from 778 to 798 ft bpl (no recovery)
07/10/01	Cored from 798 to 808 ft bpl (8 ft of recovery)
07/12/01	Drilled a 7.875-inch diameter pilot hole to 931 ft bpl
07/16/01	Cored from 931 to 951 ft bpl (10 ft of recovery)
07/17/01	Drilled a 7.875-inch diameter pilot hole to 1,086 ft bpl
07/18/01	Cored from 1,086 to 1,106 ft bpl (0% recovery)
07/23/01	Drilled a 7.875-inch diameter pilot hole to 1,116 ft bpl
07/24/01	Schlumberger geophysical logged pilot hole to 1,116 ft bpl (Run #4)
08/08/01	Reamed pilot hole with 17-inch diameter bit to 800 ft bpl
08/09/01	Back fill pilot hole to 770 ft bpl with crushed limestone
08/14/01	Geophysical logged reamed pilot hole to 770 ft bpl (Run #5)
08/14/01	Installed 12-inch diameter steel casing to 765 ft bpl
08/14/01	Pressure grouted using 340 sacks (94 lb) of neat cement
08/15/01	Conducted temperature survey to verify top of cement at 45 ft bpl (Run #6)
08/15/01	Second stage of grouting (25 sacks of neat cement) completed to land surface
08/21/01	Conducted 50-psi pressure test of 12-inch diameter casing
08/22/01	Drilled out cement plug (as a result of pressure grouting) with 12-inch diameter bit
08/23/01	Re-drilled a 7.875-inch diameter pilot hole to 1,116 ft bpl
08/31/01	Cored from 1,116 to 1,16 ft bpl (0% recovery)
09/05/01	Drilled a 7.875-inch diameter pilot hole to 1,362 ft bpl
09/11/01	Cored from 1,362 to 1,382 ft bpl (9.5 ft of recovery)
09/12/01	Drilled a 7.875-inch diameter pilot hole to 1,503 ft bpl (lost circulation at 1,500 ft bpl)
09/13/01	Contractor switched to reverse-air-drilling method
09/18/01	Drilled a 7.875-inch diameter pilot hole to 1,629 ft bpl
09/22/01	Cored from 1,629 to 1,649 ft bpl (7 ft of recovery)
10/01/01	Drilled a 7.875-inch diameter pilot hole to 1,942 ft bpl
10/02/01	Cored from 1,942 to 1,962 ft bpl (2 ft of recovery, bit plugged at 1,944 ft bpl)
10/03/01	Cored from 1,944 to 1,964 ft bpl (9 ft of recovery, bit plugged at 1,953 ft bpl)
10/04/01	Drilled a 7.875-inch diameter pilot hole to 2,046 ft bpl
10/05/01	Geophysical logged pilot hole to 2,046 ft bpl (Run #7)
10/16/01	Packer test conducted on 1,993 to 2,046 ft bpl interval
10/23/01	Packer test conducted on 1,782 to 1,850 ft bpl interval
10/26/01	Packer test conducted on 1,496 to 1,543 ft bpl interval
10/30/01	Packer test conducted on 1,610 to 1,657 ft bpl interval
11/01/01	Packer test conducted on 1,241 to 1,288 ft bpl interval
11/07/01	Schlumberger geophysical logged pilot hole to 2,046 ft bpl (Run #8)
11/13/01	Packer test conducted on 765 to 900 ft bpl interval
11/28/01	Back plugged nominal 8-inch diameter pilot hole to 1,683 ft bpl
11/30/01	Demobilization
01/03/02	Set temporary packer at 1,500 ft bpl
01/31/02	Geophysical logged pilot hole 765 to 1,500 ft bpl (Run #9)

ft bpl = feet below pad level; lb = pounds; psi = pounds per square inch.

Hydrogeologic Testing

Specific information was collected during the drilling program to determine the lithologic, hydraulic, and water quality characteristics of the FAS at the MF-37 (Port Mayaca) site. The data were to be used in the preliminary design of the MF-37 test/monitor well. Once the specific ASR horizon is identified, the MF-37 test/monitor well will be completed and used in a site-specific aquifer test. In addition, it will be incorporated into the SFWMD long-term FAS water level and quality monitoring program.

Formation Sampling

Geologic formation samples (well cuttings) were collected, washed, and described (using the Dunham [1962] classification scheme) on site during the pilot-hole drilling. Formation samples were collected and separated based on their dominant lithologic or textural characteristics, and to a lesser extent, color. If a massively bedded unit was encountered, composite samples were taken at a minimum of 5-ft intervals. The field lithologic descriptions for MF-37 are provided in **Appendix C-1**. Representative formation samples were sent to the Florida Geological Survey for detailed analysis and long-term storage. **Appendix C-2** contains a copy of the Florida Geological Survey's detailed lithologic description for the pilot hole/monitor well (Reference #W-18256).

During drilling of the MF-37 test/monitor well, DDC obtained conventional cores using a 4-inch diameter, 20-ft long, diamond-tipped core barrel. Six rock cores of various lengths were recovered from the FAS between 778 and 1,964 ft bpl, with core recoveries of 0% to 87%. The six cores were sent to Core Laboratories in Midland, Texas to determine the following parameters: horizontal and vertical permeability; porosity; grain density; elastic, electric, and acoustic properties; and lithologic character.

Formation Fluid Sampling

During reverse-air-drilling of the pilot hole, samples were taken from circulated return fluids (composite formation water) at 30-ft intervals (average length of drill rod) from 1,500 to 2,046 ft bpl. A Hydrolab multi-parameter probe measured field parameters, including temperature, specific conductance, and pH, on each sample. **Figure 5** shows field-determined specific conductance values and calculated TDS concentrations (Hem, 1994) with respect to depth. Between 1,518 and 1,642 ft bpl, specific conductance values and TDS concentrations averaged 2,235 micromhos per centimeter (µmhos/cm) and 1,342 mg/L, respectively. Between 1,642 and 1,672 ft bpl, specific conductance readings increased to 7,605 µmhos/cm, with similar values continuing to a depth of 1,764 ft bpl. A second distinct change in specific conductance readings occurred between 1,764 and 1,792 ft bpl. Within this 28-ft interval, an increase in specific conductance of approximately 12,000 µmhos/cm was recorded, which transects the base of the USDW with a calculated TDS concentration of 12,100 mg/L at 1,792 ft bpl. Specific conductance values gradually increased to 28,865 µmhos/cm at 1,888 ft bpl, remained constant for the next 90 ft, and then gradually increased to 52,828 µmhos/cm at 2,046 ft bpl.

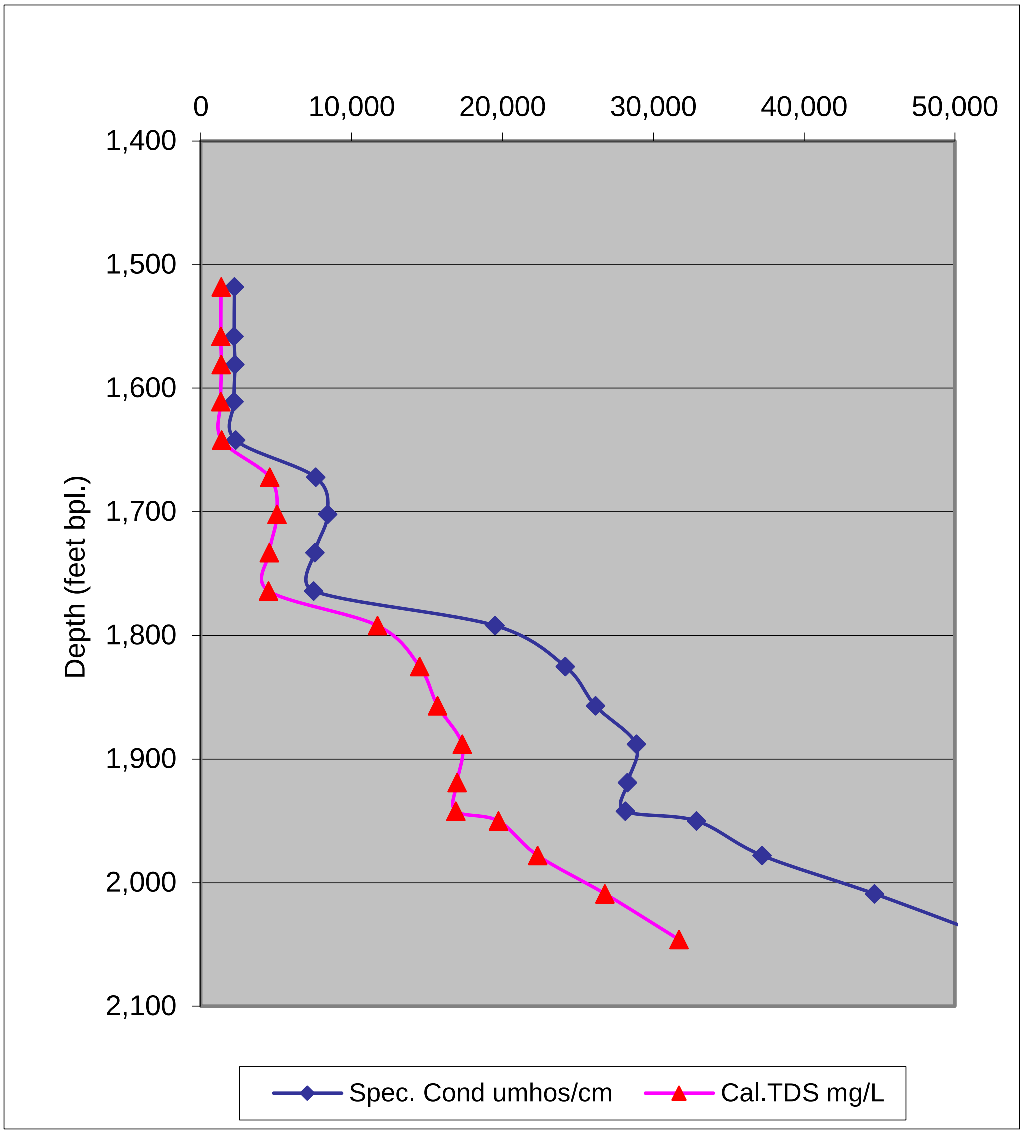

Figure 5. Water Quality with Depth – Reverse-Air Returns

Geophysical Logging

Geophysical logs were conducted in the pilot hole after each stage of drilling and before casing installation. The logs provide a continuous record of the physical properties of the subsurface formations and their contained fluids. The logs were used later to assist in the interpretation of lithology; to provide estimates of permeability, porosity, bulk density, and resistivity of the aquifer; and to determine the salinity of the groundwater (using Archie's [1942] equation). In addition, the extent and degree of confinement of specific intervals can be discerned from individual logs. The geophysical logs also provided data to determine the desired casing setting depths on the MF-37 test/monitor well. A cement bond log was conducted to assess the quality of grouting operations on the 12-inch diameter casing for MF-37.

Schlumberger Wireline Services (the geophysical logging contractor) downloaded all geophysical log data directly from the on-site logging processor in log ASCII standard version 1.2 or 2.0 format. The neutron and density porosity values calculated from geophysical log data during Runs #4 and #8 were derived using a limestone matrix with a density of 2.71 grams per cubic centimeter (g/cm^3).

The geophysical log traces from log Runs #1 through #8 for well MF-37 are presented in **Appendix A**. **Table 3** provides a summary of the geophysical logging operations conducted at the site. Specialty logging operations conducted by Schlumberger Wireline Services are summarized in **Table 4**.

Table 3. Summary of Geophysical Logging Program (MF-37)

Run #	Date	Logged Interval (ft bpl)	Caliper	Natural Gamma	SP	DIL	Sonic	Flowmeter	Temp.	Fluid Res.	Video
1	06/05/01	0-85	X	X							
2	06/13/01	0-223	X	X	X	X	X				
3	06/24/01	0-175	X	X							
5	08/14/01	175-770	X	X							
6	08/15/01	175-770		X					X		
7	10/5-8/01	770-2,046	X	X	X	X	X	X	X	X	X

DIL = dual induction log; ft bpl = feet below pad level; SP = spontaneous potential.
Logging company: MV Geophysical.

Table 4. Summary of Specialty Geophysical Logging Program (MF-37)

Run #	Date	Logged Interval (ft bpl)	NGS	AIT Imager	Compensated Density Neutron (PEF)	DSI	FMI	UBI
4	07/24/01	175-1,116	X	X	X	X	X	X
8	11/07/01	765-2,046	X	X	X	X	X	X

AIT = high-resolution array induction; DSI = dipole sonic imager; FMI = formation micro-imager; ft bpl = feet below pad level; NGS = natural gamma ray spectrometry; PEF = photoelectric factor; UBI = ultrasonic borehole imager.
Logging company: Schlumberger.

Packer Tests

Six straddle-packer tests were conducted in the FAS from 765 to 2,046 ft bpl at the MF-37 well site. The purpose of the tests was to gain water quality and production capacity data on discrete intervals (approximately 75 ft in length) and to establish the depth of the 10,000-mg/L TDS interface.

The following procedures were used to conduct individual packer tests in MF-37 at the Port Mayaca site:

1) Lower packer assembly to the interval selected for testing based on geophysical logs and lithologic data.

2) Set and inflate packers, and open the ports between the packers to the test interval.

3) Install a 15-horsepower submersible pump to a depth of 60 to 120 ft below the drill floor, with a pumping capacity of 30 to 300 gallons per minute (gpm).

4) Install two 100-pounds per square inch gauge (psig) pressure transducers inside the drill pipe and one 30-psig transducer in the annulus connected to a Hermit 3000 Data Logger to measure and record water level changes during testing operations.

5) Purge a minimum of three drill-stem volumes.

6) Monitor pressure-transducer readings and field parameters (e.g., temperature, specific conductance, pH) from the purged formation water until stable. These parameters are used to determine the quality of isolation of the packed-off interval.

7) Once the interval is effectively isolated, perform constant rate drawdown test.

8) Collect formation water samples for laboratory water quality analyses following the SFWMD quality assurance/quality control (QA/QC) sampling protocol.

9) Record recovery data until water levels return to static conditions.

Before groundwater sampling, the packer intervals were purged until three borehole volumes were evacuated or until field parameters of samples collected from the discharge port had stabilized. Chemical stability was determined using a limit of ±5% variation in consecutive field parameter readings. Field parameters, including temperature, specific conductance, and pH, were determined for each sample using a Hydrolab multi-parameter probe. Chloride concentrations were determined using a field titration method (Hach Kit). The water flow from the discharge point adjusted to minimize aeration and disturbance of the samples. Unfiltered and filtered samples were collected directly from the discharge point into a clean plastic bucket. Equipment blanks were obtained prior to sampling to qualify sampling procedures. Replicate samples were collected from consecutive bailers in accordance with the SFWMD (1999) Comprehensive Quality Assurance Plan.

Once samples were collected, the bottles were preserved and immediately placed on ice in a closed container. The composite samples were submitted to the SFWMD Water Quality Laboratory and analyzed for major cations and anions using United States Environmental Protection Agency and/or Standard Method procedures (SFWMD, 1999). The analytical results for the samples obtained during the six packer tests are reported in **Table 5**.

Table 5. Packer Test Water Quality Data from the MF-37 Test/Monitor Well

ID	Depth Interval (ft bpl)	Sample Date	Cations (mg/L)				Anions (mg/L)			Field Parameters			
			Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	Alka. as $CaCO_3$	SO_4^{2-}	TDS (mg/L)	Specific Conductance (µmhos/cm)	Temp. (°C)	pH
PT6	765-900	11/13/01	385	13	103	77	731	121	285	1,759	3,057	27.03	7.54
PT5	1,241-1,288	11/01/01	81	5	71	45	135	127	234	709	1,141	28.03	7.53
PT3	1,496-1,543	10/26/01	905	25	179	132	1,867	119	384	3,775	6,516	27.92	7.69
PT4	1,613-1,660	10/30/01	1,415	38	240	192	2,910	119	448	5,799	9,211	28.90	7.27
PT2	1,782-1,850	10/23/01	5,423	128	741	670	10,538	104	1,362	20,803	31,823	29.67	7.20
PT1	1,993-2,046	10/16/01	9,588	328	668	1,056	18,356	120	2,409	33,401	48,591	30.11	7.31

Friction loss coefficients were obtained from *Appendix 17.A Ground Water and Wells* (Driscoll, 1989) according to pipe diameter used during testing operations. This coefficient was multiplied by the length of pipe to calculate the friction (head) losses as a result of induced flow up the drill pipe. Head losses were used to correct the drawdown data for specific capacity determinations using the following method:

$$\text{Specific Capacity} = Q/s \qquad \text{Equation 1}$$

Where:

Q = pumping rate in gpm as measured by an in-line flowmeter

S = aquifer head loss in ft; measured drawdown minus the pipe friction loss component

Curve-matching techniques were not used to determine transmissivity values from the drawdown or recovery data collected from straddle-packer tests because they generally involve partial penetration, friction loss in small pipe, and a short pumping period, which violate the analytical method's basic assumptions. In addition, the productive nature of several of the tested intervals enabled them to respond almost instantaneously to the limited applied pumping stress, which induced a pressure wave into the formation. The response to the pressure wave masks the true drawdown and recovery responses. The drawdown and recovery semi-log plots from the individual packer tests are provided in **Appendix D**. The production and static water level data from the individual packer tests are summarized in **Table 6**.

Table 6. Packer Test Specific Capacity Data

Test Name	Interval Tested (ft bpl)	Pump Rate (gpm)	Total Volume Pumped (gal)	Initial Head (ft H_2O)	Final Head (ft H_2O)	Total Drawdown (ft)	Total Friction Loss (ft)	Corrected Drawdown (ft)	Specific Capacity (gpm/ft)
PT6	765-900	210	43,064	98.84	98.76	82.60	64.40	18.20	11.5
PT5	1,241-1,288	107	22,221	81.93	81.79	79.54	31.53	48.01	2.2
PT3	1,496-1,543	170	16,434	100.16	100.24	95.23	93.63	1.60	106.2
PT4	1,610-1,657	123	23,845	89.95	90.12	69.24	55.67	13.57	9.1
PT2	1,782-1,850	129	33,067	82.49	82.18	63.71	61.62	2.09	61.7
PT1	1,992-2,046	155	33,300	77.36	77.42	77.42	71.72	5.70	27.2

Petrophysical and Petrologic Data

During drilling, DDC obtained conventional cores using a 4-inch diameter, 20-ft long, diamond-tipped core barrel. DDC retrieved six rock cores from the FAS between 798 and 1,955 ft bpl, with core recoveries between 0% and 88%. **Table 7** summarizes the full diameter coring program conducted at the site.

Table 7. Summary of Full Diameter Coring Operations

Core #	Core Interval (ft bpl)	Core Footage (ft)	Core Recovered (ft)	Percent Recovery
1	798-808	20	8.1	40.5
2	931-951	20	10.0	50.0
3	1,086-1,106	20	0.0	0.0
4	1,116-1,136	20	3.0	15.0
5	1,629-1,637	8	7.0	87.5
6	1,944-1,955	11	9.0	81.8
	Total	**99**	**37.1**	**37.5**

Petrophysical Analyses

SFWMD sent six rock cores to Core Laboratories located in Midland, Texas, to determine the following parameters: horizontal permeability, porosity, grain density, and lithologic characteristics. Upon arrival, Core Laboratories recorded a spectral gamma log on each core for downhole correlation. Full diameter and plug samples (when core conditions necessitated) were selected for core analyses, and fluid removal was achieved by convection oven drying.

Core Laboratories determined full diameter porosity by direct pore volume measurement using the Boyle's Law Helium Expansion Method. Once the samples were cleaned and dried, Core Laboratories determined bulk volume by Archimedes' Principle, with grain density calculated from the dry weight, bulk volume, and pore volume measurements using Equation 2 (American Petroleum Institute, 1998).

$$\text{Grain Density} = \text{Dry Weight} / (\text{Bulk Volume} - \text{Pore Volume}) \qquad \text{Equation 2}$$

Porosity (as a percent) was calculated using bulk volume and grain volume measurements via Equation 3.

$$\text{Porosity} = ([\text{Bulk Volume} - \text{Grain Volume}]/\ \text{Bulk Volume}) \times 100 \qquad \text{Equation 3}$$

After cleaning, Core Laboratories measured bulk volume on the individual samples by Archimedes' Principle with porosity calculated via Equation 3. Steady-state air permeability was measured on the full diameter core samples in two horizontal directions and vertically while confined in a Hassler rubber sleeve at a net confining stress of 400 psi. **Appendix E** lists the results of the petrophysical analyses. **Figure 6** shows a semi-log cross-plot of laboratory-derived horizontal permeability versus (helium) porosity. The R-square statistic indicates that the linear regression model explains 57.8% of the variability of the $\log_{10}$ transformed horizontal permeability data. The equation of the fitted linear regression model, which describes the relationship between the $\log_{10}$ transformed horizontal permeability (y) and porosity (x) is $\log_{10}(y) = 0.0743(x) - 0.6042$. The correlation coefficient equals 0.76 (a value of 1.0 suggests a strong positive relationship), indicating a moderately strong relationship between the two variables.

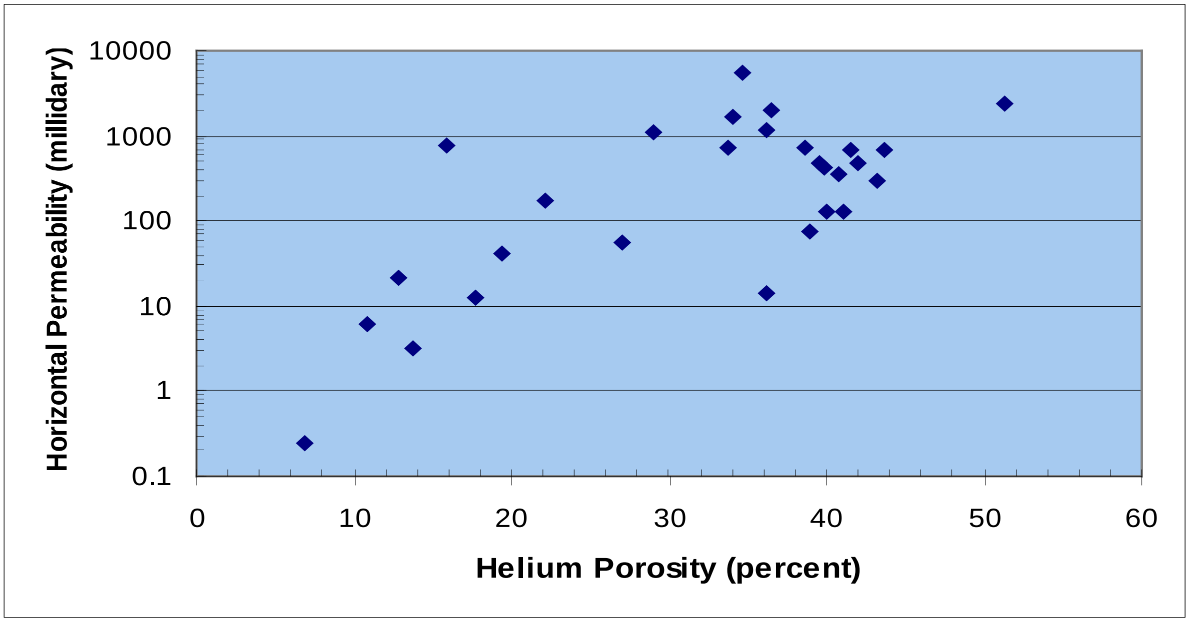

Figure 6. Cross-Plot of Laboratory-Derived Horizontal Permeability and Porosity

SFWMD staff used the petrophysical data to determine a horizontal permeability anisotropy ratio for each sample by dividing the two laboratory-determined horizontal permeability values. A maximum horizontal permeability value (K_{max}) was determined for the sample, and then a second horizontal value (K_{90}) was measured perpendicular to K_{max}. An average horizontal anisotropy ratio of 0.83 was calculated from the 28 core samples obtained from 798 to 1,955 ft bpl. In addition, a horizontal to vertical permeability anisotropy ratio of 0.63 was determined from the same sample set.

After Core Laboratories completed the petrophysical analyses, rock cores were slabbed, boxed, and photographed under natural and ultraviolet light. Core Laboratories then scanned the negatives of the core photographs and stored them on a compact disc. The photographs are available for download from the SFWMD's DBHYDRO database.

Petrologic Analyses

Once Core Laboratories completed their measurements, Dr. Hughbert Collier of Collier Consulting, Inc. (2002) conducted a petrologic study to provide preliminary data on the gross aquifer heterogeneity and depositional environment (facies) controls on porosity and permeability development within the FAS. As part of the study, Dr. Collier examined and described the slabbed cores in detail. He selected intervals from which to prepare thin sections and stained the thin sections with Alizarin Red S to determine dolomite content. Dr. Collier then examined the thin sections using a Nikon SMZ-2T binocular microscope and Nikon petrographic microscope. Thin-section analyses included the identification of porosity types, visual estimation of porosity, rock type, cement type, mineralogy, dominant allochems, fossil types, grain size, sorting, and sand content. Once compiled, this information was used to determine the lithofacies and depositional environment of the various core intervals. Results from Dr. Collier's work are available for download from the SFWMD's DBHYDRO database.

The petrologic analyses combined with the petrophysical data indicate variations in horizontal permeability and porosity based on lithofacies and corresponding depositional environments. The highest horizontal permeabilities (2,901 and 2,224 millidarcies) correspond to cored sections at approximately 726 and 821 ft bpl, respectively. These two cored sections consist of packstone and boundstone, likely deposited in an open-lagoonal shoal environment (Bennett, 2001a,b, 2002). Petrologic analyses of three other SFWMD-owned FAS wells, one located in eastern Hendry County (L2-TW) and two in Collier County (I75-TW and ISWD-TW) had similar results, with the highest mean horizontal permeability occurring in a packstone unit.

Stable Isotope and Carbon-14 Data

Stable isotope data complement inorganic geochemistry and physical hydrogeology investigations. SFWMD staff plan to use the isotopic data collected at this site in a regional investigation to better understand groundwater circulation patterns of the FAS (Kohout, 1965, 1967) and to identify recharge and discharge areas. If an interval has a particular isotopic signature, it may be used to identify and map the lateral extent of ASR and reverse osmosis (RO) zones within the UFA. Radiocarbon data often complement stable isotope and inorganic data. These data have been used to estimate regional flow velocities within the FAS (Hanshaw et al., 1964).

Water samples collected during packer tests from well MF-37 were sent to the University of Waterloo Environmental Isotope Laboratory for stable isotope determinations, including compositions for $\delta^{18}O$, $\delta^{2}H$ or δD (deuterium), $\delta^{13}C$, and $\delta^{34}S$.

$\delta^{18}O$ values were determined by carbon dioxide (CO_2) equilibration using standard procedures outlined by Epstein and Mayeda (1953) and Drimmie and Heemskerk (1993). Hydrogen isotope compositions were determined using the methods of Coleman et al. (1982) and Drimmie et al. (1991).

$$\delta_x = \delta_{x-std} = \left(\frac{Rx}{R_{S\tan dard}} - 1 \right) \times 1{,}000 \qquad \text{Equation 4}$$

Where:

Rx = the isotope ratio of the sample (e.g., $^2H/^1H$)
$R_{Standard}$ = the isotopic standard

The standard related to δD and ^{18}O is standard mean ocean water (SMOW). The precision for $\delta^{18}O$ and δD were ±0.05 parts per thousand (‰) and ±0.5‰, respectively.

Water samples received by the University of Waterloo Environmental Isotope Laboratory for $\delta^{13}C$ determinations were acidified under vacuum with phosphoric acid. The released CO_2, which is produced from dissolved inorganic carbon in the sample, is purified using cold distillation and analyzed via mass spectrometry (Drimmie et al., 1990). The results are compared to the Pee Dee Belemnitella (PDB) carbon standard, in which the carbon isotope ratio is derived from the CO_2 liberated from belemnites of the Cretaceous-aged Pee Dee Formation of South Carolina. The results are presented as ‰ deviations with respect to the standard using the δ notation.

$$\delta^{13}C\ (\text{‰, PDB}) = \left(\frac{^{13}C/^{12}C_{sample}}{^{13}C/^{12}C_{s\tan dard}} - 1 \right) \times 1{,}000 \qquad \text{Equation 5}$$

Where:

$^{13}C/^{12}C_{sample}$ = ratio of stable carbon isotope concentration in the sample
$^{13}C/^{12}C_{standard}$ = ratio of stable carbon isotopes in the PDB standard

An accelerator mass spectrometer at the Rafter Radiocarbon Laboratory (Institute of Geological and Nuclear Sciences, New Zealand) was used to determine radiocarbon age, $\delta^{14}C$, and percent modern carbon (pmC). The ^{14}C activities or pmC values are absolute relative to the National Bureau of Standards oxalic acid standard (HOxI) corrected for decay since 1950. The activity of "modern carbon" is 95% of the ^{14}C in the 1950 National Bureau of Standards oxalic acid standard, and $\delta^{14}C$ is the relative difference between the absolute standard activity and the sample activity corrected for age.

$$\delta^{14}C = (A_s/A_{abs} - 1) \times 1{,}000 \qquad \text{Equation 6}$$

Where:

A_s = activity of the sample
A_{abs} = activity of the standard

The modern activity of ^{14}C is set at 13.56 decays per minute per gram of carbon. The "zero year" for this activity is 1950 (pre-thermonuclear testing) with an activity of 100 pmC. The conventional radiocarbon age (^{14}C age) is determined in the following manner:

$$t = -8{,}033 \ln (A_{sn}/A_{on}) \qquad \text{Equation 7}$$

Where:

t = uncorrected radiocarbon age
A_{sn} = normalized sample activity
A_{on} = normalized oxalic acid activity (count rate)

Radiocarbon ages are reported in years before present (B.P.; 1950), and ^{14}C activities are reported as pmC. System error for $\delta^{13}C$ and ^{14}C are ±0.3‰ and 0.4‰ (equals ±32 radiocarbon years), respectively. However, t is not the actual date of recharge because ^{14}C may be preferentially added or removed as water moves through the hydrologic system. Soil activities can concentrate ^{14}C, but dissolution of carbonate aquifer material with "dead carbon" can dilute ^{14}C activity. In order to calculate the date of recharge, Equation 7 must be modified as follows:

$$t = -8{,}267 \ln (A_t/A_o) \qquad \text{Equation 8}$$

Where:

t = time since recharge
A_t = current ^{14}C activity
A_o = initial ^{14}C activity

Determining time since recharge (t) requires information on the current ^{14}C activity (A_t), which is measured, and the initial ^{14}C activity (A_o), which is estimated.

Pearson and Hanshaw (1970) developed a method to correct the initial age estimate (as obtained from Equation 8) that considers soil processes and carbonate dissolution. Their correction method uses approximations of the $\delta^{13}C$ values of the soil and aquifer material in addition to information on soil activities. This information is used to evaluate the initial activity of groundwater at time of recharge. The Pearson and Hanshaw (1970) correction method for ^{14}C is as follows:

$$A_o = ([A_g - A_c][\delta_T - \delta_c]/[\delta_g - \delta_c]) + A_c \qquad \text{Equation 9}$$

Where:

A_o = initial ^{14}C activity
A = ^{14}C activity
δ = $\delta^{13}C$ stable isotope ratio
g = soil gas component
c = solid carbonate component
T= total dissolved inorganic carbon

Table 8 summarizes the stable isotope and radiocarbon results from the MF-37 well site.

Table 8. Summary of Stable Isotope and ^{14}C Results

ID	Aquifer	Sample Interval (ft bpl)	Sample Date	$\delta^{18}O$ (‰ SMOW)	$\delta^{2}H$ (‰ SMOW)	$\delta^{13}C$ (‰ PDB)	$\delta^{24}S$ (‰ CDT)	$\delta^{14}C$ (‰)	^{14}C (pmC)	Uncorrected ^{14}C yr B.P.
PT6	UFA	765-900	11/13/01	-1.36	-5.83	-2.54	21.70	-972.8	2.72	28,980
PT5	UFA	1,241-1,288	11/01/01	-1.27	-4.94	-0.24	21.49	-936.4	6.05	22,480
PT3	MFA	1,496-1,543	10/26/01	-0.96	-4.23	-2.99	22.56	-976.3	2.37	30,020
PT4	MFA	1,613-1,660	10/30/01	-1.10	-4.68	-2.93	22.31	-972.5	2.75	28,800
PT2	MCU	1,782-1,850	10/23/01	0.03	-1.28	-2.81	20.76	-967.8	2.88	28,430
PT1	LFA	1,993-2,046	10/16/01	0.26	0.13	-2.73	20.20	-973.3	2.67	29,050

CDT = Canon Diablo Meteorite Standard; ft bpl = feet below pad level; LFA = Lower Floridan aquifer; MCU = middle confining unit; MFA = Middle Floridan aquifer; PDB = Pee Dee Belemnitella Standard; pmC = percent modern carbon; SMOW = standard mean ocean water; UFA = Upper Floridan aquifer; yr B.P. = years before present (1950).

The plot of $\delta^{18}O$ versus δD in **Figure 7** indicates depletion of the heavy isotopes among the UFA samples with respect to SMOW, suggesting meteoric precipitation plays a role in aquifer recharge. Samples are offset from the Global Meteoric Water Line (GMWL) (as defined by Craig [1961]) and mean isotopic composition of recent Everglades rainfall (Meyers et al., 1993), possibly due to precipitation during the last glacial period (Plummer et al., 1993). Stable isotope data from other locations in South Florida (Meyer, 1989; Bennett, 2001a,b, 2002) produce similar results where UFA waters are depleted, and plot near the GMWL. The occurrence of $\delta^{18}O$ and δD values near the GWML indicate that the waters likely are meteoric in origin.

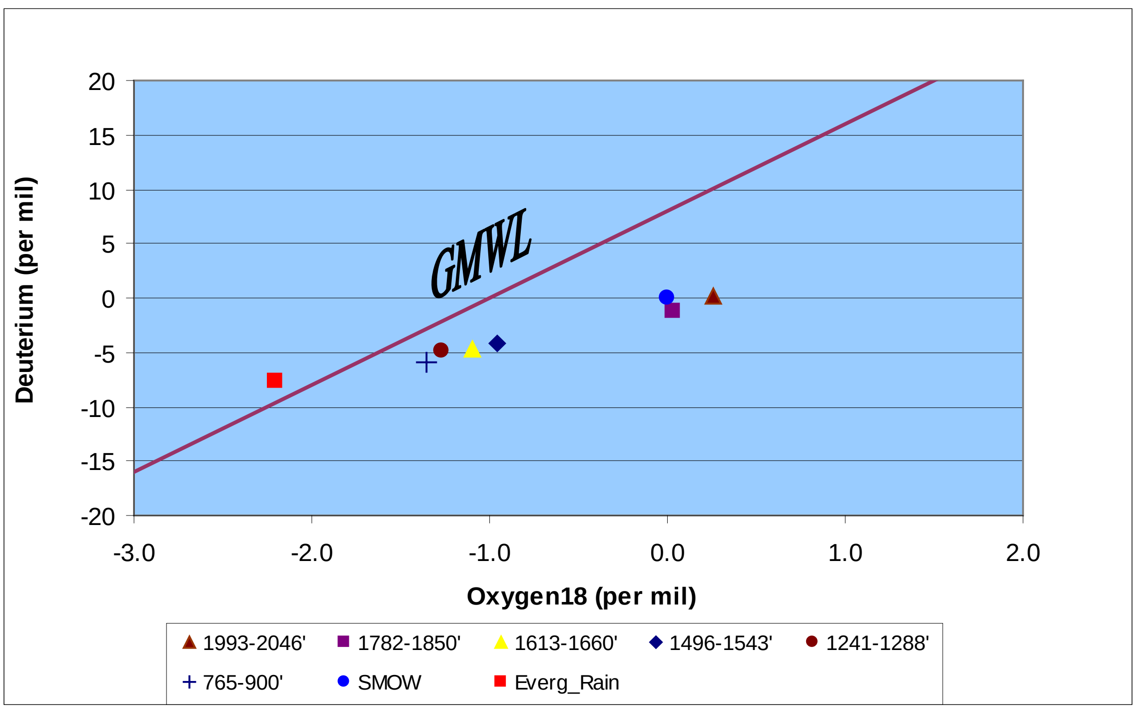

Figure 7. Cross-Plot of Stable Isotopes ^{18}O and Deuterium (δD)

Stable isotope results of the Middle Floridan aquifer (MFA) water are depleted in ^{18}O and deuterium compared to SMOW, but plot closer to SMOW than the UFA samples. The inorganic water quality results from the cavernous dolostone from 1,495 to 1,543 ft bpl indicate the water is brackish in composition. The stable isotope and inorganic data from this horizon suggest a mixing of groundwater and seawater. The cavernous dolostone unit (zone of high permeability) may provide the mechanism (conduit) for seawater inflow.

The ^{14}C activity of groundwater samples from the UFA (765 to 1,225 ft bpl) and MFA (1,645 to 1,759 ft bpl) produced values of 0.62 and 0.83 pmC, respectively. The uncorrected radiocarbon ages of water from the UFA and MFA are approximately the same, 40,795 and 38,690 years B.P., respectively. In order to be meaningful, however, the reported radiocarbon ages were corrected using the Pearson and Hanshaw (1970) method, which uses a ^{13}C correction for a closed system. The corrected radiocarbon ages from the UFA and MFA are 29,171 and 20,403 years B.P., respectively. If the corrected radiocarbon ages are considered absolute ages (assuming a closed system and little or no chemical or isotopic dilution), meteoric recharge to the UFA occurred during the late Pleistocene epoch. The stable isotope and corrected radiocarbon age for the MFA suggests meteoric recharge during the late Pleistocene, but with later intrusion by younger seawater as a result of sea level rise during the Holocene epoch. The influx of younger seawater mixed with meteoric recharge may account for the lower corrected radiocarbon age and shift in the $\delta^{18}O$ and δD values towards SMOW.

^{18}O and δD data, ^{14}C activities, and reported radiocarbon ages of Lower Floridan aquifer (LFA) waters from other locations in South Florida suggest that two different water masses may be present in the FAS (Meyer, 1989; Kaufmann and Bennett, 1997; Bennett, 2001b, 2002). The UFA waters appear to be meteoric, but the LFA seems to have been intruded by younger seawater that entered along the Florida Straits and moved inland through the Boulder Zone or other highly permeable rock units during Holocene sea level rise. Unfortunately, SFWMD staff were unable to collect water samples from the LFA at the MF-37 well location because unstable borehole conditions below 1,760 ft bpl prohibited sampling activities.

HYDROGEOLOGIC FRAMEWORK

Two major aquifer systems underlie this site: the SAS and the FAS, with the FAS being the focus of this test well program. These aquifer systems are composed of multiple discrete aquifers separated by low-permeability confining units (such as the Intermediate Confining Unit) that occur throughout the Tertiary/Quaternary-aged sequence. **Figure 8** shows a hydrogeologic section underlying the Port Mayaca site.

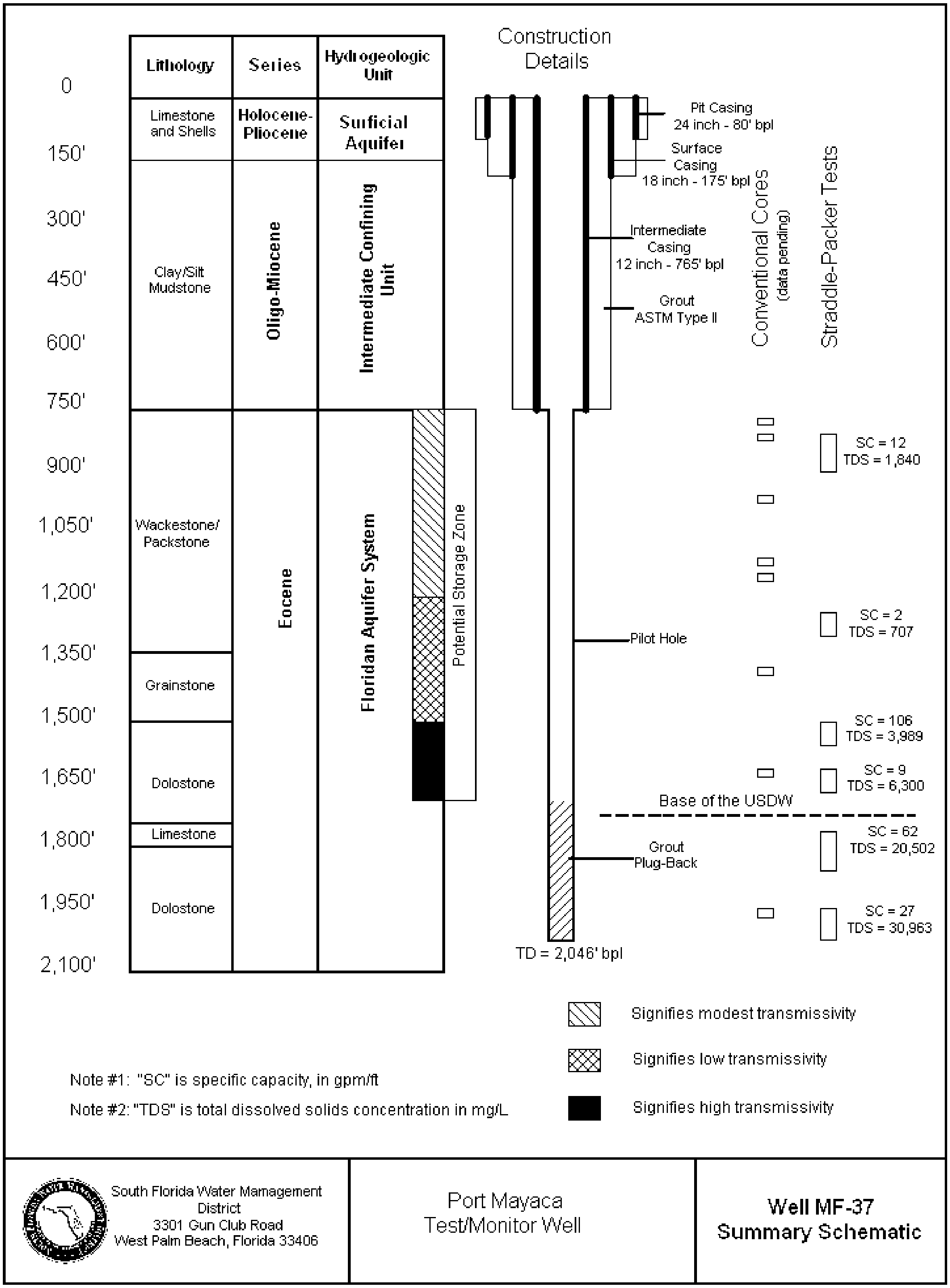

Figure 8. Hydrogeologic Section for the Port Mayaca Site

Surficial Aquifer System

The SAS extends from land surface (top of the water table) to a depth of 146 ft bpl. It consists of Holocene- and Pliocene/Pleistocene-aged sediments. The undifferentiated Holocene sediments occur from land surface to 10 ft bpl, and consist of unconsolidated orange to light gray, very fine to coarse-grained quartz sands and shell fragments within a calcilutite matrix. The sediments from 10 to 146 ft bpl are composed primarily of yellowish gray, moderately indurated limestone with intermittent shell beds 5 to 10 ft thick. Low-permeability arenaceous calcilutite at 146 ft bpl forms the base of the SAS at the MF-37 site. A substantial increase in the natural gamma ray activity below a depth 170 ft bpl suggests an increase in clay content and phosphate percentages with emissions above 30 American Petroleum Institute units.

Intermediate Confining Unit

Below the SAS lies the Intermediate Confining Unit, which extends from 146 to 755 ft bpl at the MF-37 well site. The Peace River and Arcadia Formations of the Miocene/Pliocene-aged Hawthorn Group (Scott, 1988) act as confining units separating the FAS from the SAS. Lithologic information obtained from drill cuttings from MF-37 indicate that Hawthorn Group sediments consist predominately of soft non-indurated detrital clays, silts, and poorly to moderately indurated mudstones/wackestones with minor amounts of sand and shell material (see lithologic descriptions in **Appendix C**).

The signature of the photoelectric absorption index (PEFZ) log indicates a clayey silt to fine sand unit with a minor carbonate component (interpreted to be the Peace River Formation) that extends from 146 to 430 ft bpl with average values of 2 barnes per electron (b/e). The bulk density and derived porosity logs suggest that this unit is composed of low-density, high-porosity sediments (average of 48 porosity units). The irregular shape of the caliper log and borehole diameters exceeds bit size (nominal 8-inch), indicating that this interval is poorly indurated. A change in lithology occurs below 430 ft bpl, identified by an increase in bulk density readings and natural gamma radiation, with a corresponding decrease in derived porosity and sonic transit times (possibly the Arcadia Formation). The PEFZ log values within this interval range between 3 and 4 b/e, indicating a carbonate lithology with a minor silt/sand component (Hallenburg, 1998). The natural gamma log below 430 ft bpl produces thin, intermittent gamma radiation peaks primarily associated with intervals of substantial phosphate sand/silt content.

The lithology from 655 to 755 ft bpl is primarily a moderately indurated packstone unit with 30% to 40% clay, silt, and phosphatic sands. This interval is identified by a positive shift in resistivity, photoelectric, and bulk density values with a corresponding reduction in derived porosity. These low-permeability units form the lower boundary of the Intermediate Confining Unit.

Floridan Aquifer System

The FAS consists of a series of Tertiary limestone and dolostone units. The system includes sediments of the lower Arcadia Formation, Suwannee and Ocala Limestones, Avon Park Formation, and Oldsmar Formation. The Paleocene-aged Cedar Keys Formation with evaporitic gypsum and anhydrite forms the lower boundary of the FAS (Miller, 1986).

Upper Floridan Aquifer

The top of the FAS, as defined by the Southeastern Geological Society AdHoc Committee on Florida Hydrostratigraphic Unit Definition (1986), coincides with the top of a vertically continuous, permeable, early Miocene- to Oligocene-aged carbonate sequence. The UFA consists of thin, high-permeability, water-bearing horizons interspersed with thick, low-permeability units of early Miocene- to middle Eocene-aged sediments, including the basal Arcadia Formation, Suwannee and Ocala Limestones, and Avon Park Formation. At the MF-37 site, the top of the FAS occurs at a depth of 755 ft bpl, which coincides with the basal Hawthorn Unit (Reese, 2000), part of the Arcadia Formation.

The Arcadia Formation, from 755 to 788 ft bpl, is composed primarily of moderately indurated packstone and grainstone units containing approximately 5% to 10% shell fragments and 5% to 7% phosphatic sands and silts. The dual induction, bulk density, neutron-density derived porosity and caliper logs all indicate a competent, low-porosity unit from 755 to 788 ft bpl. The resistivity values increase from 12 to 40 ohm-meters. The bulk density increase, with a corresponding decrease in porosity and the caliper log, shows a relatively gauged borehole (similar to the diameter of the drill bit).

The sharp formation contact between the Miocene-aged Arcadia Formation (Hawthorn Group) and the underlying Oligocene-aged Suwannee Limestone at a depth of 788 ft bpl is identified by a change in lithology from a dark gray, well-indurated wackestone to a yellowish-gray packstone that continues to 825 ft bpl. The discontinuity at 788 ft bpl is evidenced by a notable attenuation of the natural gamma activity, a decrease in the formation resistivity and bulk density, and a corresponding increase in porosity (based on the log-derived, density-neutron porosity data).

A slight change in lithology from a yellowish-gray wackestone to light orange-gray, friable, moderately indurated wackestone-packstone identifies the upper boundary of the Ocala Limestone at a depth of 825 ft bpl. This formation boundary coincides with a slight attenuation of natural gamma activity, a slight increase in sonic travel times, a spiked signature of the resistivity log trace, and an enlarged borehole (see geophysical log traces from Run #4 in **Appendix A**).

Generally, two predominant permeable zones exist within the UFA, with the uppermost zone typically between 700 and 1,300 ft bpl. The most transmissive part usually occurs near the top, coincident with an unconformity at the top of the Oligocene- or Eocene-aged formations (Miller, 1986). Well cuttings and production-type geophysical logs suggest that neither of these productive horizons exist within the UFA at the MF-37 site, resulting in limited productive capacities. A slight deflection in the temperature differential log trace at 825 ft bpl suggests the presence of a minor flow zone. However, a specific capacity test straddling the Suwannee-Ocala Formation contact from 765 to 900 ft bpl, yielded only 12 gpm/ft of drawdown when pumped at a rate of 210 gpm. Brown (1980) noted similar production potential of the UFA along the eastern boundary of Lake Okeechobee in Martin County. Within this area, transmissivity values ranged between 25,000 and 50,000 gallons per day per foot.

Based on lithologic and geophysical log data, the Ocala Limestone was separated into three distinct units. The upper portion of Ocala Limestone occurs from 825 to 890 ft bpl and consists of low to moderately permeable, orangish-gray, moderately indurated wackestones and packstones, inter-bedded with light-gray micrite. The middle portion of Ocala Limestone occurs from 890 to 1,003 ft bpl, and consists of moderately to well-indurated wackestones and packstones. This unit was evident on the geophysical logs by a positive shift in the resistivity and bulk density log values as well as a decrease in sonic transit times and borehole diameter (as compared to above and below) and lower log-derived, density-neutron porosity values (**Appendix A**). The lower portion of Ocala Limestone consists of white to light gray, friable wackestones and packstones present from 1,003 to 1,186 ft bpl. There was little evidence of substantial water production during drilling operations or from the lithologic and geophysical log data over the lower portion of Ocala Limestone at the MF-37 site.

Middle Floridan Confining Unit

The lithologic character of the upper portion of the Avon Park Formation generally is very similar in lithologic character to the lower Ocala Limestone. The top of the Avon Park Formation was tentatively identified at depth of 1,186 ft bpl based on a lithologic change from a white to light gray, friable packstone to a dolomitic mudstone/wackestone. In addition, this lithologic change is evident in the geophysical log data by a slight increase in natural gamma activity; distinctive photoelectric log signature; and a general decrease in sonic transit times, bulk density, and porosity values (**Appendix A**). The upper Avon Park Formation from 1,003 to 1,487 ft bpl forms an inter-aquifer confining unit within the FAS at the MF-37 site. This interval consists of low-permeability mudstones and wackestones. A packer test in the upper part of the Avon Park Formation (1,241 to 1,288 ft bpl) yielded a specific capacity of 2 gpm/ft. Formation samples from this interval do not show evidence of large-scale secondary porosity development (e.g., good pinhole or moldic porosity). In addition, the production-type geophysical log traces indicate no notable productive horizons, as seen by smooth log traces in the temperature and flowmeter logs, which support the confining nature of this interval.

Middle Floridan Aquifer

Permeable intervals have been documented within the Avon Park Formation, ranging in depth from 1,400 to 1,600 ft bpl (Miller, 1986). At MF-37, well-indurated crystalline dolostones interbedded with moderate to well-indurated packstone to grainstone units occur from 1,487 to 1,790 ft bpl. The dolostone units are cryptocrystalline to surcosic in nature with the limestone units showing evidence of pinhole and moldic porosity development of varying degrees. A cavernous dolostone unit was encountered at 1,500 ft bpl, which caused a loss of mud circulation and a 3-ft drop of the drill rod. DDC re-mixed and circulated approximately 10,000 gallons of drilling fluid in an effort to regain circulation; these efforts were unsuccessful. During reverse-air-drilling, the majority of the natural artesian flow is produced below this depth. A specific capacity test between 1,496 and 1,543 ft bpl, straddling the cavernous dolostone unit, yielded 106 gpm/ft of drawdown. Water quality analysis of samples taken during this test yielded chloride and TDS concentrations of 1,867 mg/L and 3,775 mg/L, respectively. A second specific capacity test was conducted within a crystalline dolostone unit from 1,613 to 1,660 ft bpl, and the results identified the unit as relatively unproductive, producing 9 gpm/ft of drawdown with a measured TDS concentration of 5,800 mg/L.

Miller (1986) observed that portions of the lower Avon Park Formation are fine grained and have low permeability, thereby acting as inter-aquifer confining units within the FAS. At MF-37, an inter-aquifer confining unit composed of well-indurated mudstone to packstone units with intermittent brown to gray dolostone occurs from 1,660 to 1,795 ft bpl.

Lower Floridan Aquifer

A notable lithologic change from limestone to predominately well-indurated crystalline dolostones occurs below 1,795 ft bpl at the MF-37 site. The dolostones are moderately to highly permeable, fractured, and cavernous, interspersed within less permeable dolostone and limestone units. This change in lithology is noted by the caliper log measuring a relatively gauged borehole similar to the drill bit diameter, an increase in resistivity, and a decrease in sonic travel times. In addition, the photoelectric log produces values of 3 b/e and derived neutron-porosity readings are approximately 6 porosity units greater than those of the density porosity log, both of which are indicative of dolostones (see **Appendix A**).

A well-defined flow zone from 1,790 to 1,805 ft bpl near the top of the dolostone sequence was noted by a substantial increase in water production during reverse-air-drilling. Deflections in the temperature and dynamic flowmeter log traces as well as information from the borehole video log confirmed its productive nature log (see **Appendix A**). Straddle-packer test #2 (1,782 to 1,850 ft bpl) was conducted to isolate this flow zone. This flow zone generated a specific capacity of 62 gpm/ft of drawdown stressed at 129 gpm, but produced saline waters with a laboratory-determined TDS concentration of 20,502 mg/L.

Based on information provided by Meyer (1989) and Reese (2000), the interval from 1,795 to 2,046 ft bpl (total depth of the pilot hole) was identified as the upper dolostone unit of the LFA.

The top of the Oldsmar Formation often is difficult to identify because of a lack of diagnostic microfossils, which generally are obliterated by diagenetic effects, and the lithologic character often is similar to the overlying Avon Park Formation. In South Florida, the top of the Oldsmar Formation often is identified based on the presence of a dolostone unit that occurs below 2,000 ft bpl. This unit is discerned on geophysical logs by increased gamma ray counts and resistivity values as well as decreased sonic travel times. If these criteria are used, the Oldsmar Formation could be identified at 1,795 ft bpl, which corresponds to the occurrence of a well-indurated crystalline (euhedral to subhedral) dolostone. Based on lithologic criteria defined by Miller (1986), the lack of a glauconite marker bed used by Duncan et al. (1994), and the absence of early Eocene index fossils such as *Helicostegina gyralis* (Chen, 1965), the Oldsmar Formation was not encountered at MF-37.

SUMMARY

1) A 12.75-inch outer diameter test/monitor well (MF-37) was constructed and tested successfully in accordance with SFWMD technical specifications at the Port Mayaca site.

2) Lithologic information and geophysical logs obtained from MF-37 indicate that soft, non-indurated detrital clays, silts, and poorly indurated mudstones of the Hawthorn Group predominate from 175 to 755 ft bpl. These low-permeability sediments act as confining units separating the FAS from the SAS.

3) The top of the FAS, as defined by the Southeastern Geological Society AdHoc Committee on Florida Hydrostratigraphic Unit Definition (1986) was identified at a depth of approximately 755 ft bpl.

4) Lithologic and geophysical logs, packer test results, and specific capacity results indicate moderate production capacity of the UFA from 755 to 1,003 ft bpl.

5) A productive horizon in the MFA from 1,487 to 1,570 ft bpl yielded a specific capacity of 106 gpm/ft of drawdown.

6) The production type logs (e.g., flow logs, temperature logs) indicate good production from flow zones between 1,490 and 1,600 ft bpl. Below 1,610 ft bpl, the productive capacity is limited (as indicated by the fluid-type logs) suggesting low-permeability, semi-confining units near the base of the productive horizon.

7) Composite water quality sampling during straddle-packer tests and geophysical log data were used in tandem to identify the base of the USDW at approximately 1,740 ft bpl. TDS concentrations below 1,860 ft bpl are similar to seawater.

CONCLUSIONS

1) Potential ASR zones generally exist from the top of the FAS (755 ft bpl) to the base of the USDW (1,740 ft bpl) at the MF-37 site.

2) Additional production-type geophysical logging (e.g., flowmeter, temperature, fluid resistivity) should be conducted from the base of casing (765 ft bpl) to the temporary packer (1,500 ft bpl) to more fully evaluate the upper and middle portions of the FAS for ASR potential. This approach will ensure that the highly productive zones below 1,500 ft

bpl will not overwhelm the less-permeable overlying zones during testing, so a better evaluation of this interval for ASR potential can be obtained.

3) Following the recommended flow logging, an evaluation should be conducted if acidization or additional specific capacity testing of MF-37 is warranted to further evaluate ASR potential.

4) If the Port Mayaca site is chosen as a site for an ASR system as part of the Lake Okeechobee ASR Pilot Project, MF-37 will need to be modified to accommodate monitor zone(s) consistent with the future ASR well.

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APPENDICES

Appendix A

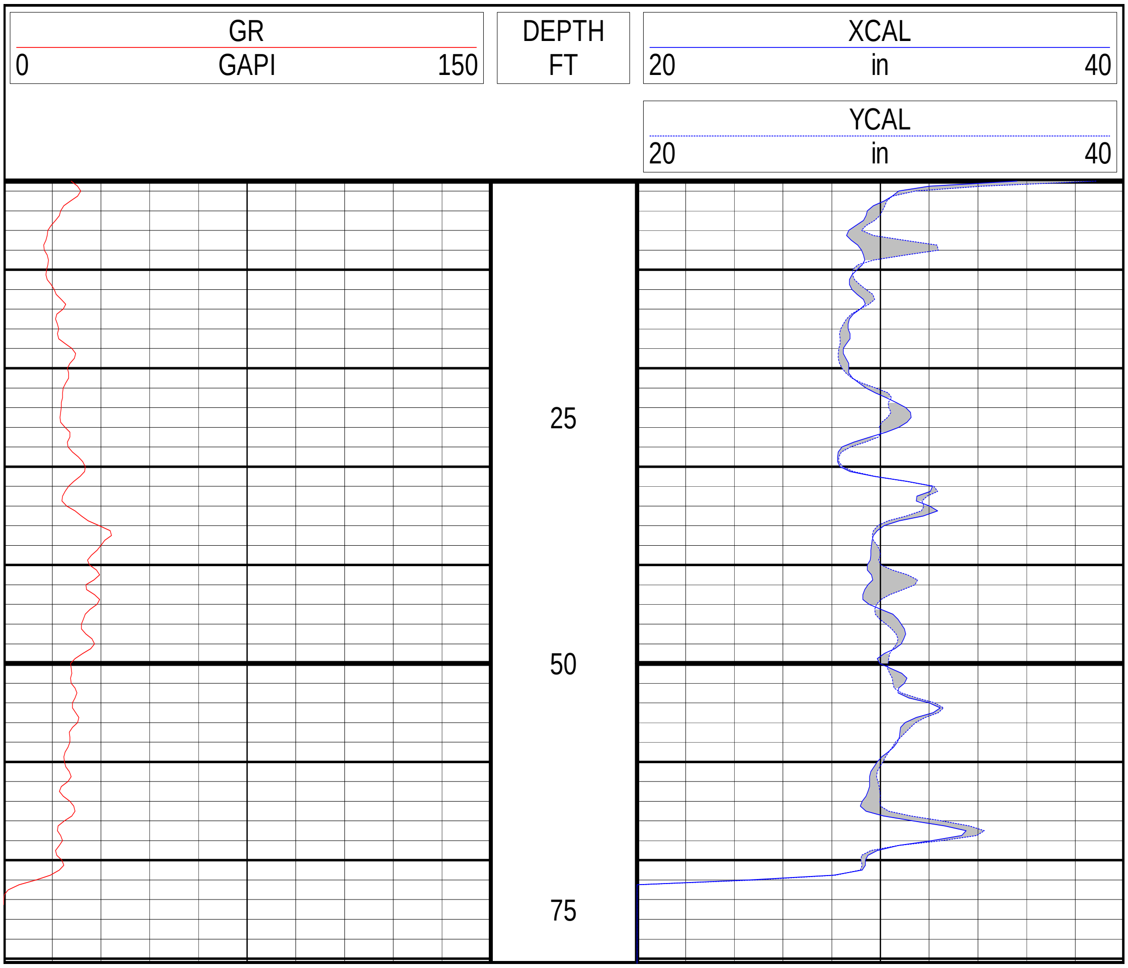

Figure A-1. Geophysical Log Run No. 1 – MF-37

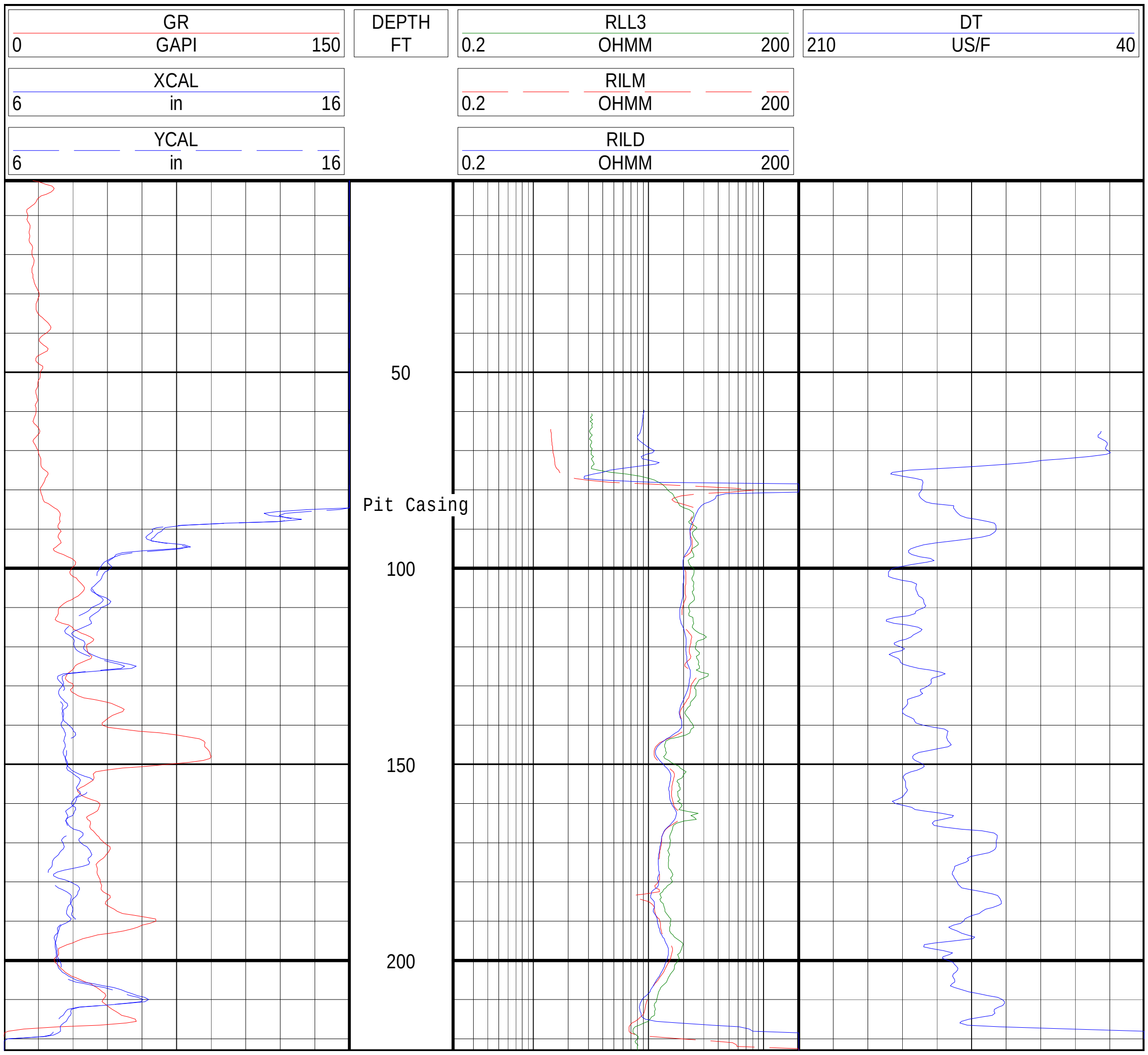

Figure A-2. Geophysical Log Run No. 2 – MF-37

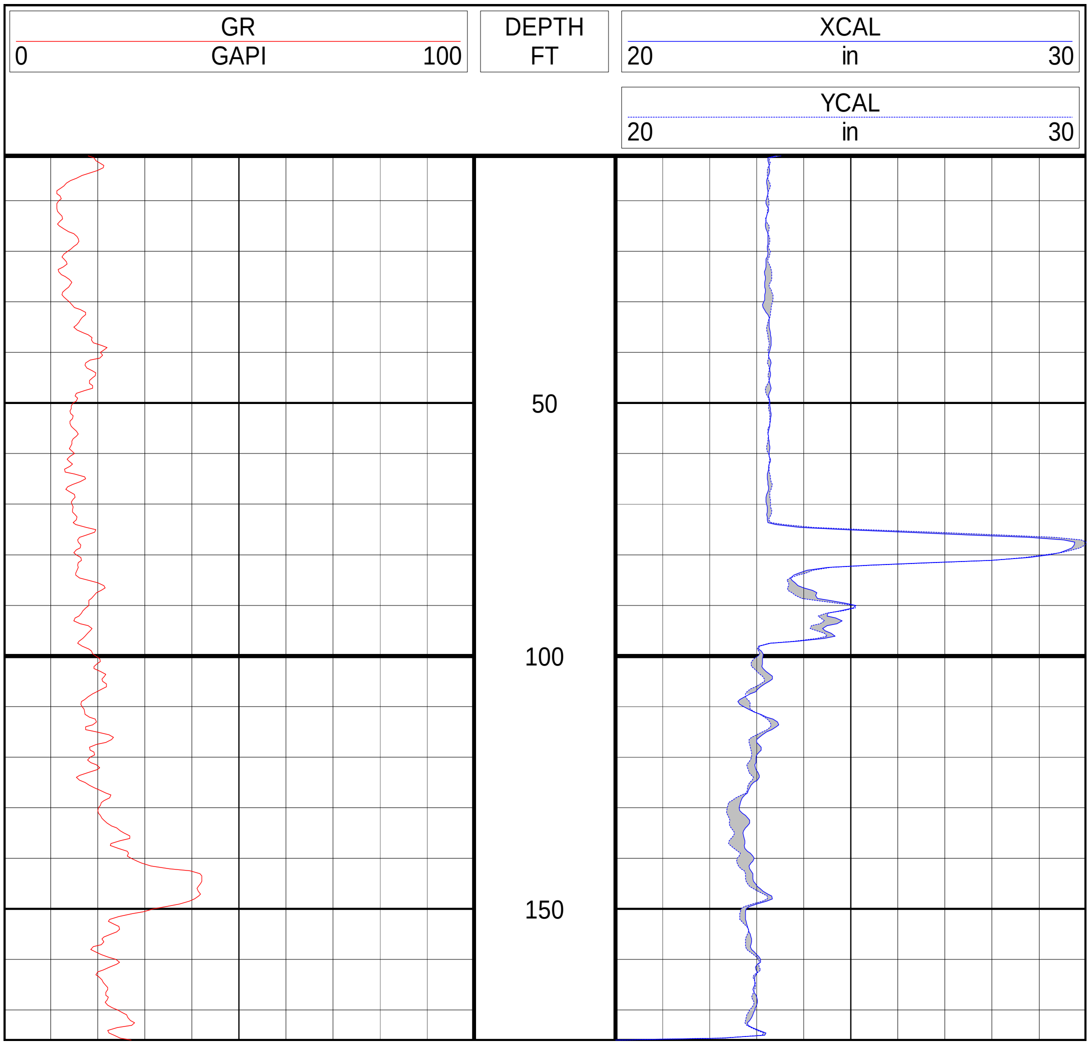

Figure A-3. Geophysical Log Run No. 3 – MF-37

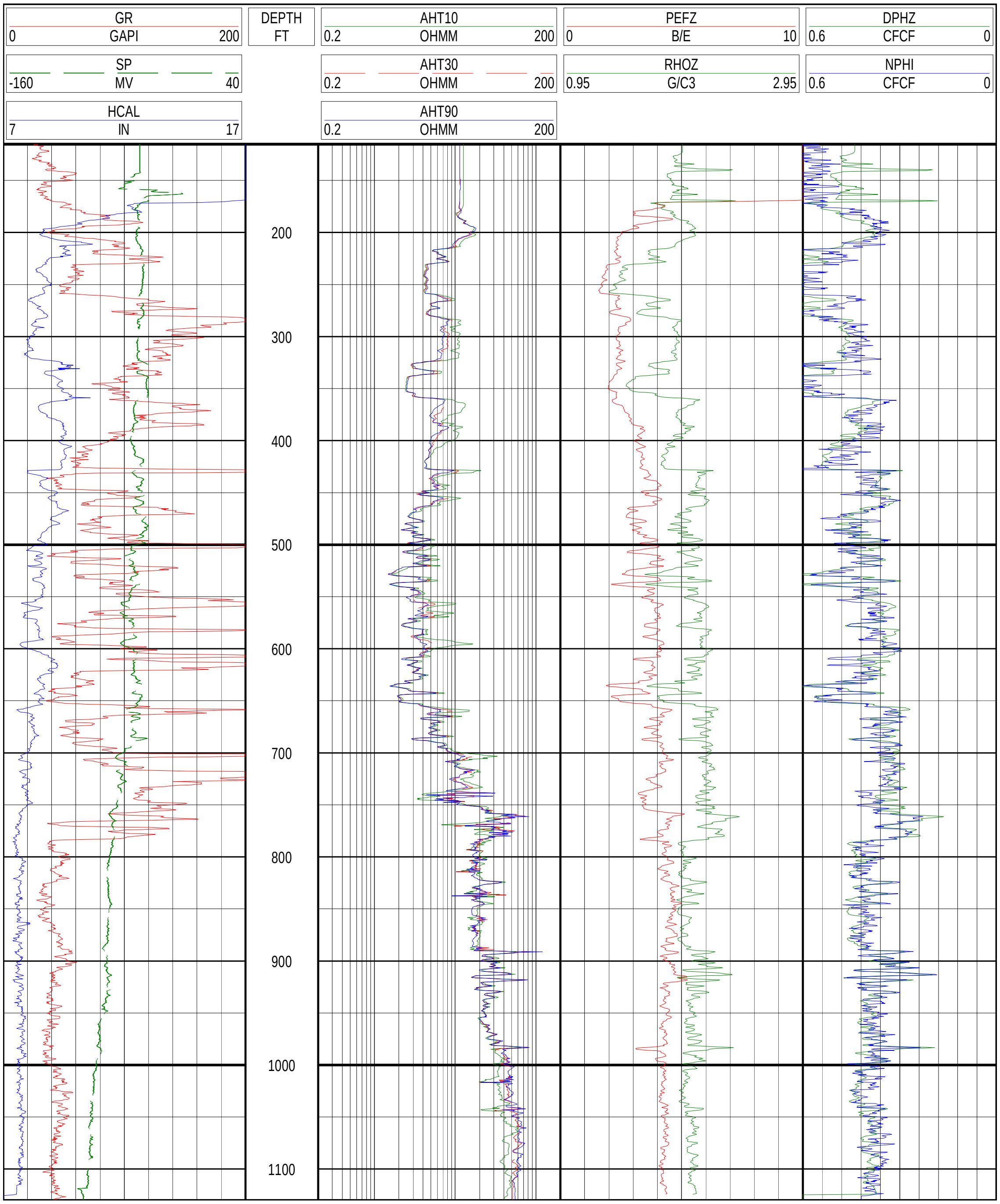

Figure A-4. Geophysical Log Run No. 4 – MF-37

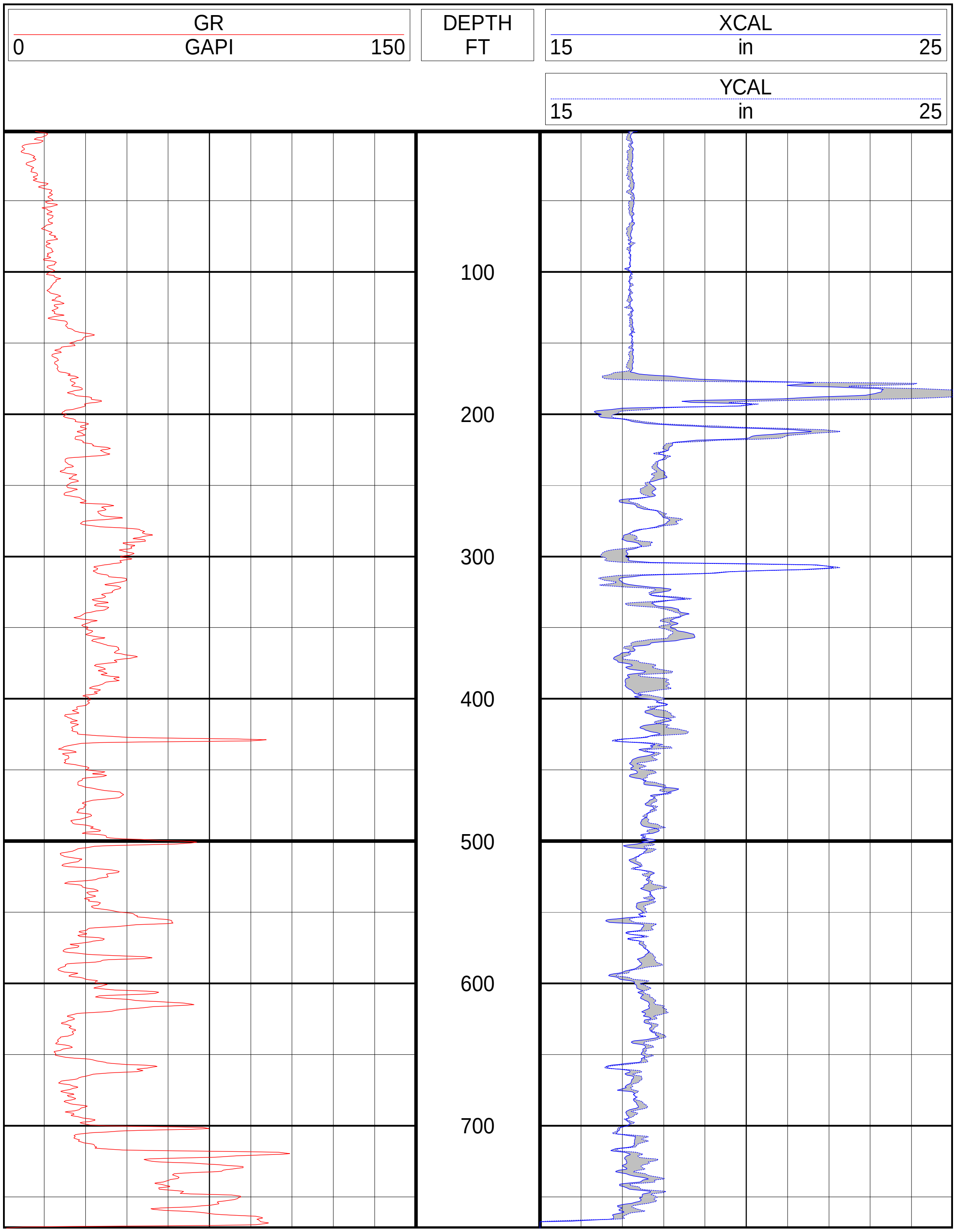

Figure A-5. Geophysical Log Run No.5 – MF-37

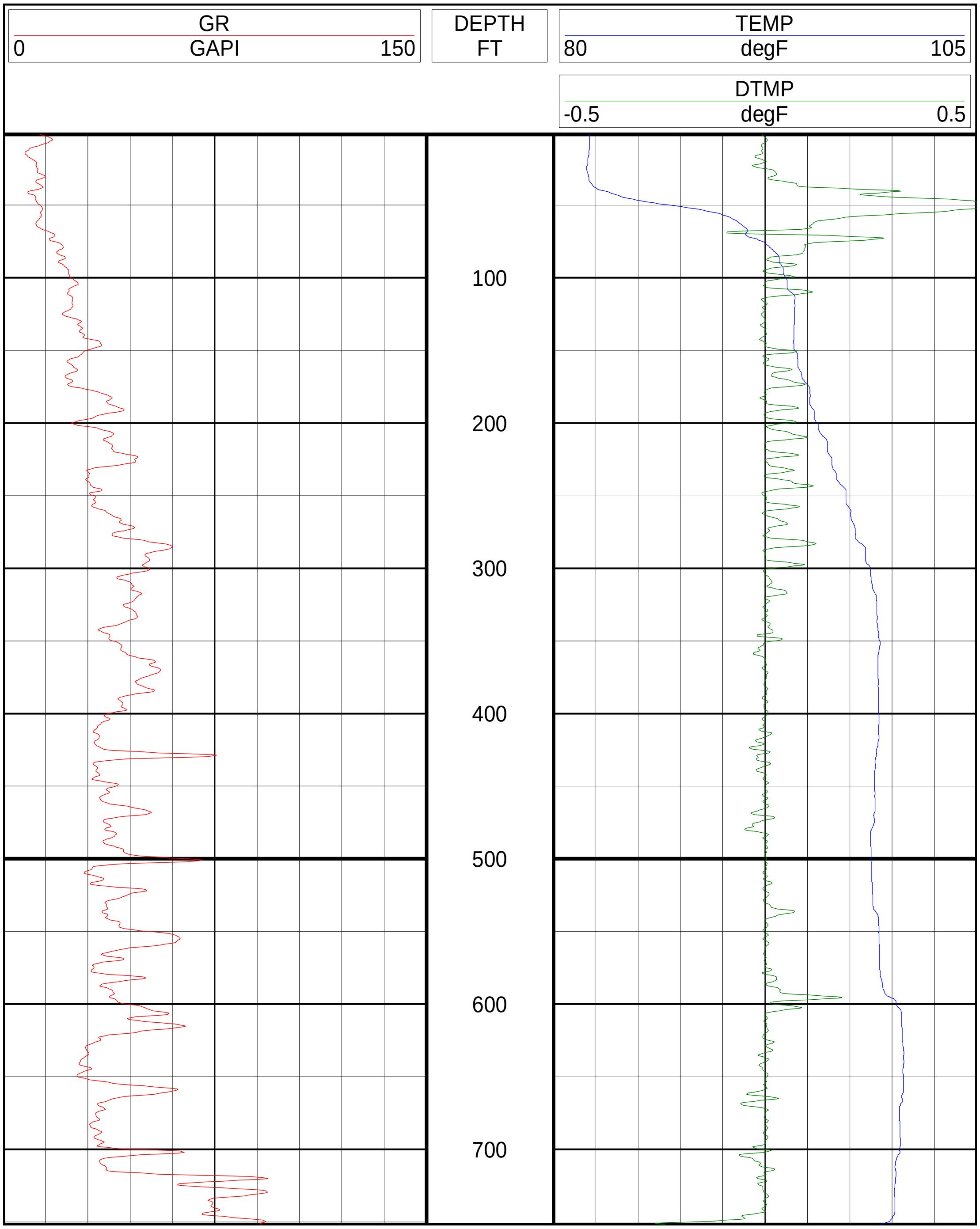

Figure A-6. Geophysical Log Run No.6 – MF-37

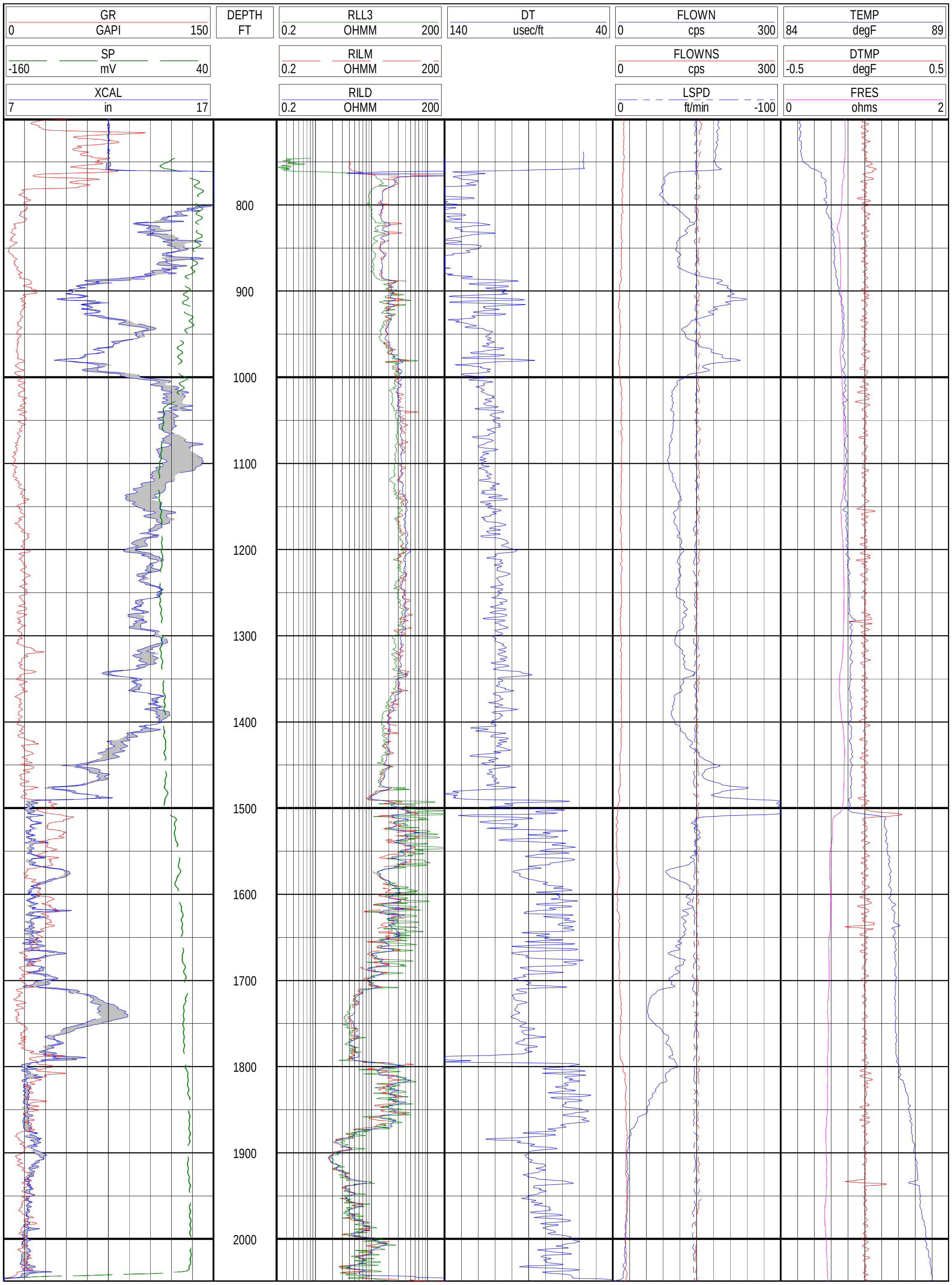

Figure A-7. Geophysical Log Run No.7 – MF-37

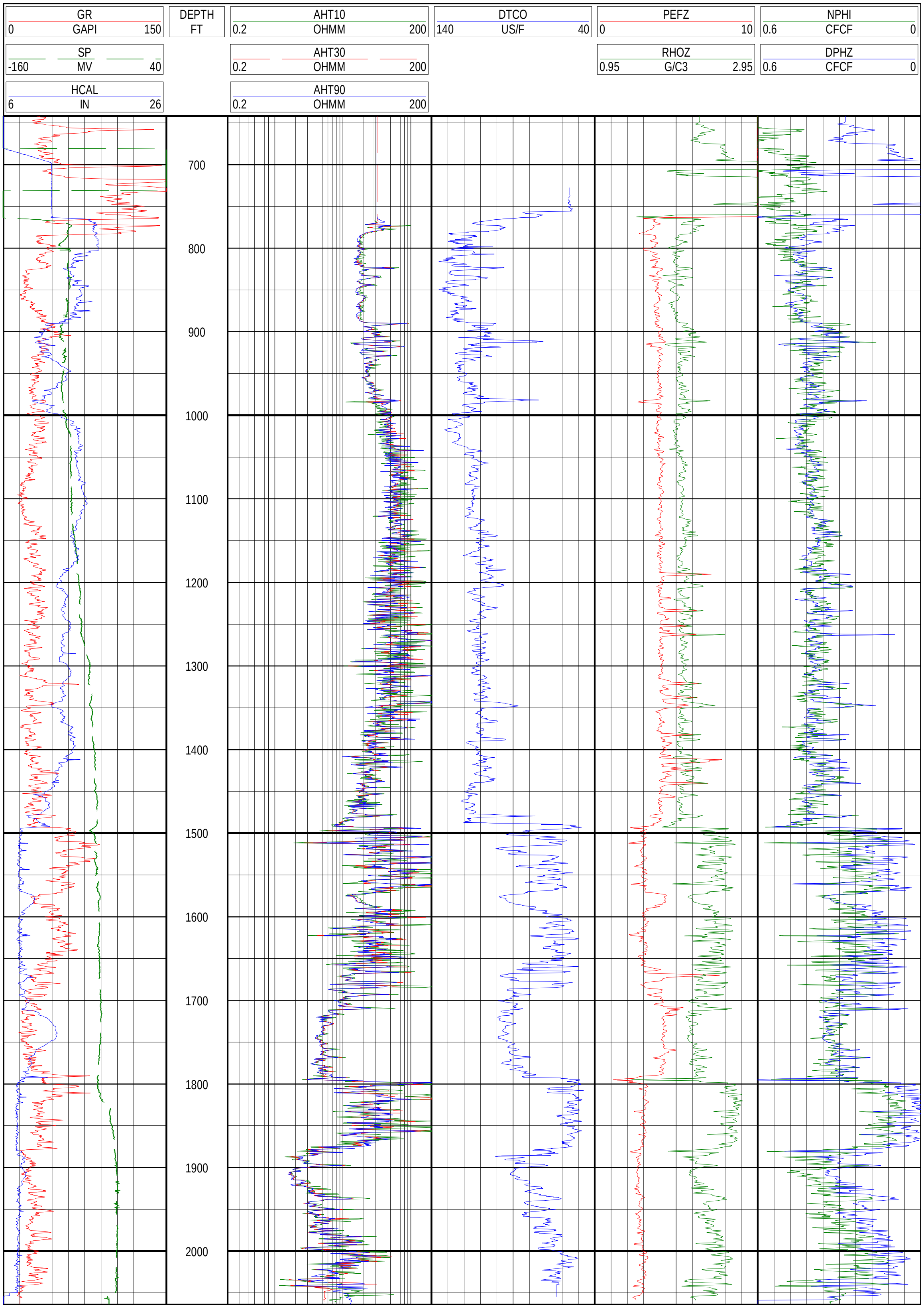

Figure A-8. Geophysical Log Run No.8 – MF-37

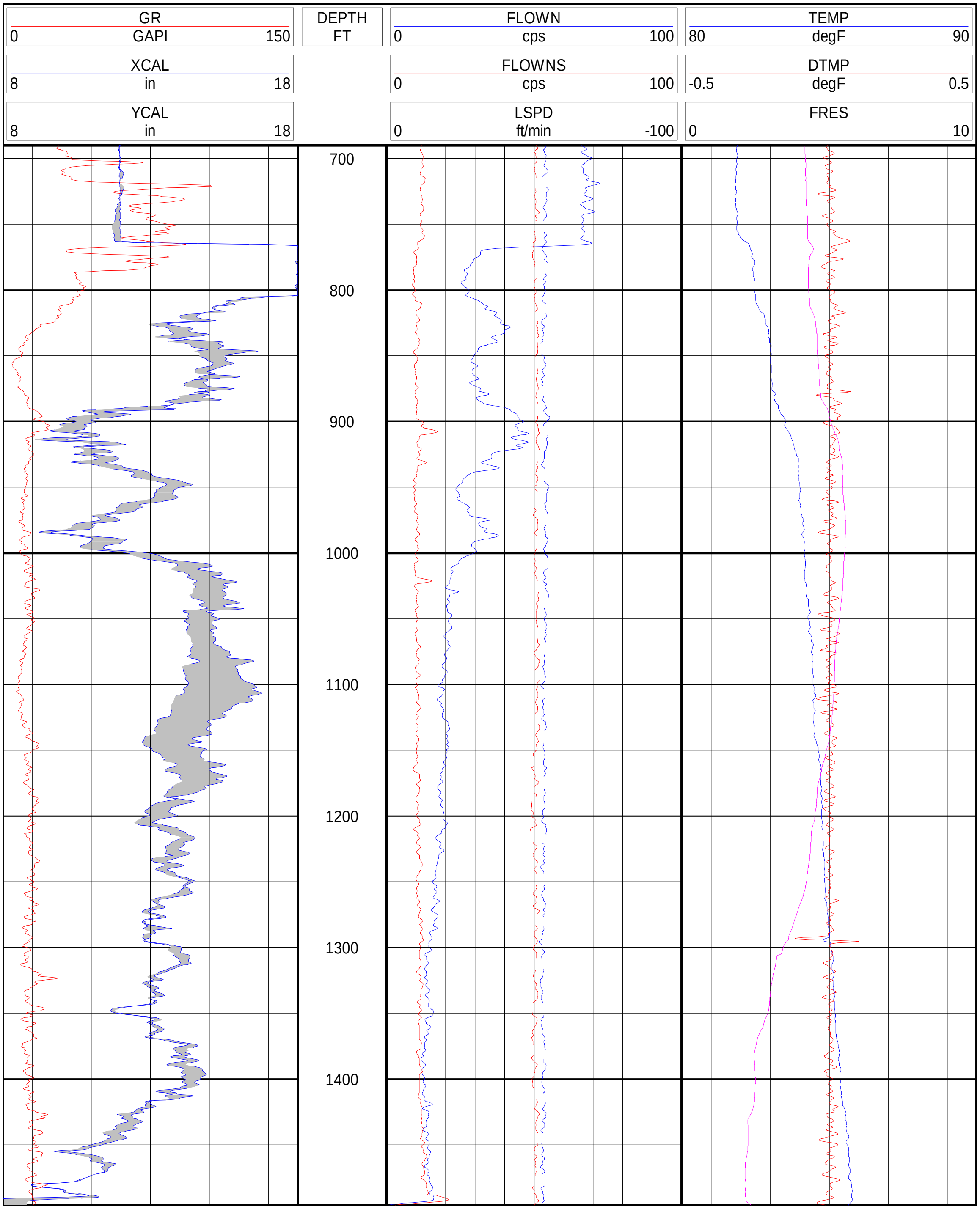

Figure A-9. Geophysical Log Run No.9 – MF-37

Appendix B

검 사 증 명 서(A)
MILL INSPECTION CERTIFICATE

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증서번호 CERTIFICATE NO: E09070 페이지 PAGE: 1
발행일자 DATE OF ISSUE: AUG. 28. 2000. E4035103
계약번호 CONTRACT (P/O) NO:
품명 COMMODITY: E.R.W. STEEL PIPE
적용규격 SPECIFICATION: API 5L X42/API 5LB/ASTM A53B/ASME SA53B
수요가 CUSTOMER:

G.GOOD

관종 TYPE OF PIPE END (*1) (*2)	치수 DIMENSION 외경×두께×길이 (OUTDIA. × THICK. × LENGTH) (*3) (*4)	수량 QUANTITY (PCS)	중량 WEIGHT (KG)	수압시험 HYDRO-STATIC TEST kg/cm² / PSI	Tests *5–*14	도금시험 COATING TEST	경도 HARDNESS	제강번호 HEAT NO.	항복점 YIELD STRENGTH PSI	인장강도 TENSILE STRENGTH B	인장강도 TENSILE STRENGTH W	연신율 ELONGATION %	C ×100	Si	Mn	P ×1000	S	Cu ×100	Ni	Cr	Mo	V	Nb ×1000	Al	Ceq	충격시험 IMPACT
BVBE OD 24"	x .375" x21.000'	106	95.451	83	G G G G G	G		A80707	35.8	50.9	53.5	36	20	2	86	18	5	1	2	1	Tr	Tr				
	(610.0mm x 9.53mm x 6.401M)			1180					50900	72400	76100															
								A01636	34.5	49.2	52.0	34	18	1	80	15	7	1	2	1	Tr	Tr				
									49100	70000	74000															
								A01638	34.2	49.3	52.0	37	17	2	78	15	5	1	2	1	1	Tr				
									48600	70000	74000															
								A01700	32.5	47.4	50.0	39	18	1	74	13	8	1	2	1	Tr	Tr				
									46200	67400	71100															
BVBE OD 24"	x .375" x42.000'	143	261.139	83	G G G G G	G		A80720	31.7	48.5	51.2	37	18	1	80	15	7	1	1	2	Tr	Tr				
	(610.0mm x 9.53mm x 12.802M)			1180					45000	69000	72800															
								A01636	34.5	49.2	52.0	34	18	1	80	15	7	1	2	1	Tr	Tr				
									49100	70000	74000															
								A01629	34.2	49.3	52.0	37	17	2	78	15	5	1	2	1	1	Tr				
									48600	70100	74000															
								A01641	37.0	51.5	53.9	30	20	2	76	15	7	1	2	1	Tr	Tr				

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Co./Dept.		From Ann	
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		Fax #	

주기 NOTE
(*1) Type of pipe End 관종
X: B: Black; G: Galvanized; E: Enameled
X: V: Varnish; R: Removal Varnish; O: Oiling Coating; P: PE Coating; C: Coaltar Coating; A: Asphalt Coating
XX: PE: Plain End; BE: Bevel End; TE: Thread End; TC: Thread Coupling; BL: Bell End; SE: Swaging End; WJ: Victaulic Joint
(*2) NS: Nominal Size 호칭경, OD: Outside Diameter
(*3) Unit 단위 mm
(*5) G: Good
(*6) Visual & Dimension
(*8) Weld Ductility Test 용접부 연성시험
(*9) Nondestructive Test
(*11) Flaring Test 판퍼짐시험
(*12) Crush Test 충격시험
(*14) Heat Treatment 열처리
(*15) Base Metal 모재
(*17) H: Heat(Ladle) Analysis 용해분석, P: Product Analysis 제품분석

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WE CERTIFY THAT THE DESCRIBED MATERIAL HAS HEREIN BEEN ACCEPTED IN ACCORDANCE WITH THE PRESCRIBED SPECIFICATION AND ORDER

SURVEYOR

H. G. Lee
QUALITY ASSURANCE TEAM GENERAL MGR

HPS-B10' 631-0-OLT
HYUNDAI PIPE CO., LTD.

검 사 증 명 서 (A)

MILL INSPECTION CERTIFICATE

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HYUNDAI PIPE CO.,LTD.
HEAD OFFICE (ULSAN PLANT) # 265, YUMPO-DONG, BUK-KU, ULSAN, KOREA
TEL:280-0114 FAX:(052)287-6918
TLX:HDPIPE K 52778
SEOUL OFFICE # 77, MUGYO-DONG, JOONG-KU, SEOUL, KOREA
TEL:3455-0600 FAX 775-7056

CERTIFICATE NO	B09070
PAGE	2
DATE OF ISSUE	AUG. 28. 2000. E4035103
CONTRACT (P/O) NO	
COMMODITY	E.R.W. STEEL PIPE
SPECIFICATION	API 5L X42/API 5LB/ASTM A53B/ASME SA53B
CUSTOMER	

TYPE OF PIPE END	DIMENSION (OUTDIA. - THICK. x LENGTH)	QUANTITY (PCS)	WEIGHT (KG)	HYDROSTATIC TEST (PSI)	HEAT NO.	TENSILE TEST YIELD STRENGTH (PSI)	TENSILE STRENGTH (PSI)		ELONGATION %	CHEMICAL COMPOSITION	IMPACT
	(610.0mm x 9.53mm x 12.802M)			1180		52600	73300	76700			
	TOTAL ->	251	356,590								

THESE MILL TEST REPORTS APPLY TO
YOUR P.O. # 981 - Okeechobee
BARTOW STEEL REF. # 3610

REMARK

NOTES

+1 Type of pipe End
B : Black, G : Galvanized, E : Enamelled
V : Varnish, R : Removal Varnish, O : Oiling Coating, F : PE Coating, C : Coaltar Coating, A : Asphalt Coating
PE Plain End, BE Bevel End, TE Thread End, TC Thread Coupling, BL Bell End, SG Swaging End, VJ Victaulic Joint

현 제품은 제반규격에 합격되었음을 보증합니다.
WE CERTIFY THAT THE DESCRIBED MATERIAL HAS HEREIN BEEN ACCEPTED IN ACCORDANCE WITH THE PRESCRIBED SPECIFICATION AND ORDER.

SURVEYOR

H. G. Lee
QUALITY ASSURANCE TEAM GENERAL MGR

HYUNDAI PIPE CO., LTD.

검 사 증 명 서 (A)

MILL INSPECTION CERTIFICATE

현대강관주식회사
HYUNDAI PIPE CO.,LTD.
•본사·공장: 울산광역시 북구 염포동 265번지
HEAD OFFICE: # 265, YUMPO-DONG, BUK-KU, ULSAN, KOREA
(ULSAN PLANT) TEL:280-0114 FAX:(052)287-8918
TLX:HDPIPE K 53775
•서울사무소: 서울특별시 중구 무교동 77번지
SEOUL OFFICE: # 77, MUKYO-DONG, JOONG-KU, SEOUL, KOREA
TEL:3455-6600 FAX:775-7395

증명서번호 CERTIFICATE NO: E04259 페이지 PAGE: 1
발행일자 DATE OF ISSUE: MAR. 31, 2000. E4012000
계약번호 CONTRACT (P.O.) NO:
품명 COMMODITY: E.R.W. STEEL PIPE
규격 SPECIFICATION: API 5L 5X42/A53/A500/ASTM A53B/ASME SA53B
수요가 CUSTOMER:

DIMENSION (OUTDIA. x THICK. x LENGTH)	QUANTITY (PCS)	WEIGHT (KG)	HYDROSTATIC TEST PSI	TESTS (G:GOOD)	HEAT NO.	YIELD STRENGTH PSI	TENSILE STRENGTH		ELONG. %	C ×100	Si	Mn	P ×1000	S	Cu ×100	Ni	Cr	Mo	V
18" x .250" x21.000'	39	13.458	200	G G G G G G	477912	29.8	44.7	47.5	38	15	1	71	18	10	1	1	2	Tr	Tr
(457.0mm x 6.35mm x 6.400M)			2900			42400	63600	67600											
18" x .250" x42.000'	63	57.368	70	G G G G G G	477912	29.8	44.7	47.5	38	15	1	71	18	10	1	1	2	Tr	Tr
(457.0mm x 6.35mm x 12.802M)			1000			42400	63600	67600											
					305644	32.7	47.7	47.4	35	15	1	66	14	10	4	1	2	Tr	Tr
						46500	67800	67400											
					006404	34.1	48.3	50.0	34	15	1	68	13	9	3	1	1	Tr	Tr
						48500	68700	71100											
18" x .375" x21.000'	64	42.954	105	G G G G G G	A80018	36.5	51.5	53.9	36	20	1	87	15	7	3	1	1	Tr	Tr
(457.0mm x 9.53mm x 6.400M)			1490			51900	73300	76700											
					A80026	31.2	50.2	53.0	40	18	1	82	14	7	3	1	2	Tr	Tr
						44400	71400	75400											
					005441	32.7	49.7	52.4	39	18	2	75	13	9	2	1	1	Tr	2
						46500	70700	74500											
					005207	33.3	51.8	54.5	37	19	1	76	15	9	3	2	1	Tr	1

THESE MILL TEST REPORTS APPLY TO:
YOUR P.O.# 9981 - Okeechobee
BARTOW STEEL REF.# 3610

비고 REMARK

주 NOTES
Type of pipe End 관끝
X: B: Black, G: Galvanized, E: Enameled
X: V: Varnish, R: Rust Preventive Varnish, O: Oiling Coating, F: FE Coating, C: Coaltar Coating, A: Asphalt Coating
XX: PE: Plain End, BE: Bevel End, TE: Thread End, TC: Thread Coupling, BL: Bell End, SE: Swaging End, VJ: Victaulic Joint

본 제품은 관련규격에 합격되었음을 보증합니다.
WE CERTIFY THAT THE DESCRIBED MATERIAL HAS HEREIN BEEN ACCEPTED IN ACCORDANCE WITH THE PRESCRIBED SPECIFICATION AND ORDER.

SURVEYOR

H. G. Lee
QUALITY ASSURANCE TEAM GENERAL MGR.

HYUNDAI PIPE CO., LTD.

검 사 증 명 서(A)

MILL INSPECTION CERTIFICATE

현대강관주식회사
HYUNDAI PIPE CO.,LTD.
HEAD OFFICE: (ULSAN PLANT) ULSAN, KOREA TEL: FAX:
SEOUL OFFICE: SEOUL, KOREA TEL: FAX:

검사서번호: CERTIFICATE NO: [illegible] 페이지: PAGE: 2

발행일자: DATE OF ISSUE: MAR. 31. 2000 [illegible]

계약번호: CONTRACT (P/O) NO:

품명: COMMODITY: E.R.W. STEEL PIPE

제품규격: SPECIFICATION: API 5L [illegible]/ASTM A53B/ASME SA53B

수요가: CUSTOMER:

Type of pipe end	Dimension (Outside x Thick. x Length)	Quantity (PCS)	Weight (KG)	Hydrostatic test (MPa / kg/cm² / PSI)	Tests (G: Good)	Hardness	Heat No.	Yield strength (PSI)	Tensile strength		Elongation (%)	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Nb	Al	Ceq	Impact
	(457.0mm x 9.53mm x 6.401M)			1490				(74[illegible])	(310[illegible])	(7740[illegible])															
BBK	18" x .375" x42.000'	50	128,886	1050	G G G G G 16		[illegible]	33.7	51.8	58.4	37	19	1	76	15	9	3	2	1	Tr	1				
	(457.0mm x 9.53mm x 12.800M)			1490				(4/400)	(7900)	(774[illegible])															
	TOTAL ->	247	234,780																						

THESE MILL TEST REPORTS APPLY TO:
YOUR P.O.# 9581 – Okeechobee
BARTOW STEEL REF. # 3610

비고 REMARK

주 NOTE

Type of pipe End 형틀: B: Bevel, D: Galvanized(?), E: Ends; V: Varnish, R: ..., F: PE Coating, C: Coating, A: Asphalt Coating; PE: Plain End, BE: Bevel End, TE: Thread End, TC: Thread Coupling, SL: ..., SE: ..., VJ: Victaulic Joint

We certify that the described material has herein been accepted in accordance with the prescribed specification and order.

본 제품은 관련규격에 합격되었음을 보증합니다.

WE CERTIFY THAT THE DESCRIBED MATERIAL HAS HEREIN BEEN ACCEPTED IN ACCORDANCE WITH THE PRESCRIBED SPECIFICATION AND ORDER.

SURVEYOR

H. G. Lee
QUALITY ASSURANCE TEAM GENERAL MGR.

HPS-[illegible]

HYUNDAI PIPE CO., LTD.

FORM RP 59
July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT MF-37 WELL NO. MF-37 DATE 8/14/01

Lake Okee Project

DEPTH		DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER							
Sequence	Jt #	Heat #	Tag #	Length (ft)	Depth (ft)	Time submerged	Start weld	End weld	Weld #
1	1	67750	LK69446	12.43					
2	2	B33092	LK71429	42.20	54.63	1110	1037	1050	1
3	3	B-33092	LK71437	42.17	96.80	1142	1114	1122	2
4	4	B33092	LK71438	42.20	139.00	1203	1148	1158	3
5	5	75743	LK69447	42.20	181.20	1221	1208	1216	4
6	6	75739	LK69448	42.25	223.45	1243	1229	1238	5
7	7	75739	LK69453	42.16	265.61	1307	1252	1302	6
8	8	B33092	LK72059	42.15	307.76	1315	1312	1320	7
9	9	B33092	LK71435	42.17	349.93	1345	1330	1340	8
10	10	B33098	LK71436	42.15	392.08	1403	1350	1358	9
11	11	B33092	LK71430	42.20	434.28	1427	1412	1422	10
12	12	B33092	LK71433	42.15	476.43	1454	1440	1449	11
13	13	B33098	LK71431	42.23	518.66	1515	1502	1510	12
14	14	B33092	LK71434	42.17	560.83	1542	1523	1537	13
15	15	B33098	LK71429	42.15	602.98	1604	1550	1559	14
16	16	B33098	LK71440	42.15	645.13	1630	1646	1625	15
17	17	B33090	LK71390	42.15	687.28	1654	1640	1649	16
18	18	B33090	LK71391	42.17	729.45	1715	1700	1710	17
19	19	B33098	LK71389	41.55	771.00	1740	1725	1735	18
1750		659. set @ 765' bls							

검 사 증 명 서 (A)
MILL INSPECTION CERTIFICATE

현대강관주식회사
HYUNDAI PIPE CO.,LTD.
• 본사·공장: 울산광역시 북구 염포동 265번지
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TLX:HDPIPE K 53776
• 서울사무소: 서울특별시 중구 무교동 77번지
SEOUL OFFICE: # 77, MUGYO-DONG, JOONG-KU, SEOUL, KOREA
TEL:3455-0500 FAX:775-7095

성적서번호 CERTIFICATE NO : E14219 페이지 PAGE : 2
발행일자 DATE OF ISSUE : APR. 25. 2001. E4113101
계약번호 CONTRACT (P/O) NO :
품명 COMMODITY : E.R.W. STEEL PIPE
제품규격 SPECIFICATION : ASTM A53 GR.B
수요가 CUSTOMER :

G:GOOD

관종 TYPE OF PIPE END ÷1	÷2	치수 DIMENSION 외경 x 두께 x 길이 (OUTDIA. x THICK. x LENGTH) ※3 ※4	수량 QUANTITY (PCS)	중량 WEIGHT (KG)	수압시험 HYDROSTATIC TEST MPa kg f/cm² PSI ※5	6 VISUAL & DIMENSION TEST	7 FLATTENING (B) TEST	8 WELD DUCTILITY TEST	9 N.D.	10 DRIFT TEST	11 FLARING TEST	12 CRUSH TEST	13 R-FLATTENING TEST	14 HEAT TREATMENT	도막시험 COATING TEST 아연부착량 WEIGHT OF ZINC COAT g/m² OZ/FT²	균일성 DIP TEST TIMES ※5	경도 HARDNESS HRB HV	재강번호 HEAT NO.	항복강도 YIELD STRENGTH PSI	인장강도 TENSILE STRENGTH B ※15 kg f/mm² N/mm²	W ※16	연신율 ELONGATION %	C ×100	Si	Mn	P ×1000	S	Cu ×100	Ni	Cr	Mo	V	Nb ×1000	Al	Ceq	충격시험 IMPACT Absorbed EGY. J/C/E SHEAR AREA %
		(323.8mm x 9.53mm x 12.802M)			1250														46200	71100	75100															
																		B33098	31.6	49.4	52.1	36	18	1	77	13	6	1	2	1	Tr	Tr				
																			44900	70300	74100															
BVBE	NB	12" x .500" x21.000'	33	20.582	116	G	G	G	G					G				A06394	32.6	50.0	52.8	33	18	1	80	16	8	1	2	1	Tr	Tr				
		(323.8mm x12.70mm x 6.401M)			1650														46400	71100	75100															
																		B33089	31.1	49.1	52.0	34	17	3	74	11	6	1	2	1	Tr	Tr				
																			44200	69800	74000															
																		B33098	31.6	49.4	52.1	36	18	1	77	13	6	1	2	1	Tr	Tr				
																			44900	70300	74100															
																		B33100	31.4	49.1	52.0	38	17	1	77	14	5	2	1	1	Tr	Tr				
																			44700	69800	74000															
BVBE	NB	12" x .500" x42.000'	16	19.958	116	G	G	G	G					G				B33098	31.6	49.4	52.1	36	18	1	77	13	6	1	2	1	Tr	Tr				
		(323.8mm x12.70mm x 12.802M)			1650														44900	70300	74100															
		TOTAL ->	1623	493.809																																

THESE MILL TEST REPORTS APPLY TO
YOUR P.O. # 11068
BARTOW STEEL REF. # 38902

비고 REMARK
MF-57

ORIGINAL

주의 NOTES

÷1 Type of pipe End 관종
X — B : Black, G : Galvanized, E : Enameled
X — V : Varnish, R : Removal Varnish, O : Oiling Coating, F : PE Coating, C : Coaltar Coating, A : Asphalt Coating
XX — PE : Plain End, BE : Bevel End, TE : Thread End, TC : Thread Coupling, BL : Bell End, SE : Swaging End, VJ : Victaulic Joint

÷2 NB : Nominal Bore 호칭경, OD : Outside Diameter
÷3 Unit 단위 (M : mm, I : Inch)
÷4 Unit 단위 (M : Meter, F : Feet, I : Inch)
÷5 G : Good
÷6 Visual & Dimension Test 육안 및 치수검사
÷7 Flattening or Bending Test 편평 또는 굽힘시험
÷8 Weld Ductility Test 용접부 연성시험
÷9 Nondestructive Test 비파괴검사 ( )
÷10 Drift Test 관통시험
÷11 Flaring Test 압확시험
÷12 Crush Test 좌굴시험
÷13 Reverse Flattening Test 역편평시험
÷14 Heat Treatment 열처리
÷15 B : Base Metal 모재부
÷16 W : Weld Part 용접부
÷17 H : Heat(Ladle)Analysis 용강분석, P:Product Analysis 제품분석

본 제품은 관련규격에 합격되었음을 보증합니다.
WE CERTIFY THAT THE DESCRIBED MATERIAL HAS HEREIN BEEN ACCEPTED IN ACCORDANCE WITH THE PRESCRIBED SPECIFICATION AND ORDER.

SURVEYOR

H. G. Lee
QUALITY ASSURANCE TEAM GENERAL MGR.

HPS B 301-631-0-QLT (350 x 280)

HYUNDAI PIPE CO.,LTD.

Bartow Steel

검 사 증 명 서 (A)
MILL INSPECTION CERTIFICATE

현대강관주식회사
HYUNDAI PIPE CO.,LTD.
• 본사 · 공장 : 울산광역시 북구 염포동 265번지 ⑥⑧③-⓪②⓪
HEAD OFFICE : # 265, YUMPO-DONG, BUK-KU, ULSAN , KOREA
(ULSAN PLANT) TEL:280-0114 FAX:(052)287-8916
TLX:HDPIPE K 53776
• 서울사무소:서울특별시 중구 무교동 77번지 ①⓪⓪-①⑦⓪
SEOUL OFFICE : # 77, MUGYO-DONG, JOONG-KU, SEOUL, KOREA
TEL:3455-0500 FAX:775-7095

성적서번호 CERTIFICATE NO : E14219 페이지 PAGE : 1
발행일자 DATE OF ISSUE : APR. 25. 2001. E4113101
계약번호 CONTRACT (P/O) NO :
품명 COMMODITY : E.R.W. STEEL PIPE
제품규격 SPECIFICATION : ASTM A53 GR.B
수요가 CUSTOMER :

↓↓↓↓↓↓↓↓↓ G:GOOD

관종 TYPE OF PIPE END ÷1	÷2	치수 DIMENSION 외경×두께×길이 (OUTDIA. × THICK. × LENGTH) ÷3 ≡4	수량 QUANTITY (PCS)	중량 WEIGHT (KG)	수압시험 HYDROSTATIC TEST MPa kg f/cm² PSI	÷5	6 VISUAL & DIMENSION TEST	7 FLATTENING (B) TEST	8 WELD DUCTILITY TEST	9 N.D.T.	10 DRIFT TEST	11 FLARING TEST	12 CRUSH TEST	13 R-FLATTENING TEST	14 HEAT TREATMENT	도막시험 COATING TEST 아연부착량 WEIGHT OF ZINC COAT g/m² OZ/FT²	균일성 DIP TEST TI-MES ÷5	경도 HARDNESS HRB HV	제강번호 HEAT NO.	항복강도 YIELD STRENGTH PSI	인장강도 TENSILE STRENGTH B ÷15 kg f/mm² N/mm²	W ÷16	연신율 ELONGATION %	C ×100	Si ×100	Mn ×100	P ×1000	S ×1000	Cu ×100	Ni ×100	Cr ×100	Mo ×100	V ×100	Nb ×1000	Al ×1000	Ceq ×1000	충격시험 IMPACT Absorbed EGY JOULE	SHEAR AREA %
BVBE	NB	3" x .216" x21.000'	756	54.613	176	G	G	G		G					G				31341843	30.5	47.2		29	16	Tr	68	14	7	1	2	1	Tr	Tr					
		(88.9mm x 5.49mm x 6.401M)			2500															43400	67100																	
																			31341853	35.4	48.0		36	16	3	33	16	7	1	2	1	Tr	1					
																				50400	68300																	
																			31341873	34.2	46.5		30	15	1	68	12	9	1	2	1	Tr	Tr					
																				48600	66100																	
BVBE	NB	3" x .216" x42.000'	252	36.409	176	G	G	G		G					G				31341843	30.5	47.2		29	16	Tr	68	14	7	1	2	1	Tr	Tr					
		(88.9mm x 5.49mm x 12.802M)			2500															43400	67100																	
BVBE	NB	12" x .375" X21.000'	365	172.386	88	G	G	G		G					G				B33090	33.3	51.1	53.9	31	19	2	76	12	7	1	2	1	Tr	Tr					
		(323.8mm x 9.53mm x 6.401M)			1250															47400	72700	76700																
																			B33092	32.5	50.0	52.8	34	19	1	78	12	6	1	2	1	Tr	Tr					
																				46200	71100	75100																
BVBE	NB	12" x .375" x42.000'	201	189.861	88	G	G	G		G					G				B33090	33.3	51.1	53.9	31	19	2	76	12	7	1	2	1	Tr	Tr					
		(323.8mm x 9.53mm x 12.802M)			1250															47400	72700	76700																
																			B33092	32.5	50.0	52.8	34	19	1	78	12	6	1	2	1	Tr	Tr					

비고 REMARK

THESE MILL TEST REPORTS APPLY TO
YOUR P.O. # 11068
BARTOW STEEL REF. # 38902

MF-37

ORIGINAL

비고 NOTES

÷1 Type of pipe End 관종

X: B : Black, G : Galvanized, E : Enameled
X: V : Varnish, R : Removal Varnish, O : Oiling Coating, F : PE Coating, C : Coaltar Coating, A : Asphalt Coating
XX: PE : Plain End, BE : Bevel End, TE : Thread End, TC : Thread Coupling, BL : Bell End, SE : Swaging End, VJ : Victaulic Joint

÷2 NB Nominal Bore 호칭경, OD: Outside Diameter
÷3 Unit 단위 (M mm, I : Inch)
÷4 Unit 단위 (M : Meter, F : Feet, I : Inch)
÷5 G . Good
÷6 Visual & Dimension Test 육안 및 치수검사
÷7 Flattening or Bending Test 편평 또는 굽힘시험
÷8 Weld Ductility Test 용접부 연성시험
÷9 Nondestructive Test 비파괴검사 ( )
÷10 Drift Test 전롤시험
÷11 Flaring Test 압확시험
÷12 Crush Test 총압시험
÷13 Reverse Flattening Test 전개시험
÷14 Heat Treatment 열처리
÷15 B Base Metal 모재부
÷16 W Weld Part 용접부
÷17 H : Heat(Ladle)Analysis 용탕분석, P Product Analysis 제품분석

본 제품은 관련규격에 합격되었음을 보증합니다.
WE CERTIFY THAT THE DESCRIBED MATERIAL HAS HEREIN BEEN ACCEPTED IN ACCORDANCE WITH THE PRESCRIBED SPECIFICATION AND ORDER.

SURVEYOR

H. G. Lee
QUALITY ASSURANCE TEAM GENERAL MGR

HPS - B 301 - 631 - 0 - QLT (350 × 280)

HYUNDAI PIPE CO.,LTD.

Appendix C-1

Table C-1. Lithologic log for SFWMD L-65 Canal Test Well MF-37 in Martin County, Florida.

From	To	Lithologic Description MF-37
0	10	No Samples
10	17	Shell bed, 10% limestone, light gray to white, hard
17	19	Limestone, light gray, very hard, poor intergranular and moldic porosity
19	42	Shell bed, 10% limestone, light gray to white, moderately hard, moderate loss of circulation at 28 ft bpl
42	45	Limestone, light gray, very hard, poor intergranular and moldic porosity
45	118	Shell bed, 10% limestone, light gray to white, moderately hard, moderate loss of circulation at 28 ft bpl
118	146	Limestone, light gray to white, hard, 40% shell fragments, 20% clay, lt. olive green, loose, 20% phosphate
146	181	Greenish grey wackestone, sticky, 40% allochems, 30% phosphate, <5% limestone
181	200	Greenish grey wackestone, v. sticky, 15% allochems, 30% phosphate
200	210	Greenish grey wackestone, slightly sticky, 25% allochems, 30% phosphate
210	223	Greenish grey mudstone, v. sticky, 30% phosphate, <5% allochems
223	265	Greenish grey mudstone, v. sticky, 20% phosphate
265	278	Greenish grey mudstone, v. sticky, 20% phosphate, 10% allochems and limestone *drilling speed increased from 265 to 275 ft bpl
278	414	Greenish grey mudstone, v. sticky, 25% phosphate, 5% allochems and limestone *drilling speed increased from 355 to 370 ft bpl
414	430	Greenish grey mudstone, v. sticky, 30% phosphate, 10% allochems and limestone
430	499	Greenish grey wackestone, v. sticky, 30% phosphate, 20% allochems and limestone
499	530	Greenish grey wackestone, v. sticky, 60% phosphate, 20% allochems and limestone
530	665	Greenish grey wackestone, v. sticky, 60% phosphate, 25% allochems and limestone
665	703	Light grey wackestone, sticky, 50% phosphate, 30% allochems and limestone
703	761	Light grey packstone, sticky, 50% phosphate, 40% allochems, and 30% clay
761	765	Dark grey to grey limestone, hard, 30% clay, 5% allochems, phosphatic, good to poor intergranular porosity.
765	778	Dark grey to light grey grainstone (limestone), hard, 5% allochems, <5% phosphate, good intergranular porosity
778	825	Pinkish grey wackestone (limestone), friable, moderately to well indurated, 10% allochems, <5% phosphate, good intergranular and moldic porosity.
825	847	Pinkish grey wackestone (limestone), friable, moderately to well indurated, 25% allochems, good intergranular and moldic porosity.
847	852	Same as above with thin layers of light grey clay, loose, poor to moderate intergranular and moldic porosity.
852	880	Pinkish grey packstone (limestone), friable, moderately to well indurated, 35% allochems, good intergranular and moldic porosity.
880	884	Same as above with thin layers of light grey clay, loose, poor to moderate intergranular and moldic porosity.
884	910	Pinkish grey packstone (limestone), friable, moderately to well indurated, 35% allochems, good intergranular and moldic porosity.
910	931	Pinkish grey to grey packstone (limestone), friable to hard, moderately to well indurated, 35% allochems, good intergranular and moldic porosity.
931	972	Pinkish grey to medium grey packstone (limestone), friable to moderately hard, very well indurated, 35% allochems, 15% sand, good moldic porosity.
972	980	Light grey to brown wackestone (dolomitic limestone), moderately hard, 10% allochems, 5% sand, moderately good intergranular porosity.

From	To	Lithologic Description MF-37
980	991	Brown wackestone (dolomitic), very hard, well indurated, 10% allochems, poor intercrystalline porosity.
991	1,003	Light grey to brown wackestone (dolomitic limestone), moderately hard, well indurated, 15% allochems, moderately good intergranular porosity.
1,003	1,036	White to light grey mudstone (limestone), friable, micritic, 10% allochems, 10% dolomite, good intergranular porosity.
1,036	1,086	White to light grey mudstone (limestone), friable, micritic, 10% allochems, good intergranular porosity.
1,086	1,117	White to light grey mudstone (limestone), friable, micritic, 5% allochems, good intergranular porosity.
1,117	1,176	White to light grey packstone (limestone), friable, micritic, 35% allochems, low intergranular porosity.
1,176	1,186	White to light grey packstone (limestone), friable, micritic, 50% allochems, low intergranular porosity.
1,186	1,191	White to grey mudstone (limestone), friable, micirtic, 5-10% allochems, low intergranular porosity.
1,191	1,342	Tan to grey mudstone/wackestone (limestone), friable, micritic, 5-10% allochems, 5% dolomite, low intergranular porosity.
1,342	1,357	Tan to grey wackestone (limestone), friable, micritic, 15% allochems, 10% dolomite, low intergranular porosity.
1,357	1,362	Tan to grey mudstone/wackestone (limestone), friable, micritic, 5-10% allochems, 5% dolomite low intergranular porosity.
1,362	1,480	Tan to grey grainstone (limestone), friable, micritic, 5-10% allochems, good intergranular porosity.
1,480	1,487	Tan to grey wackestone (limestone), friable, micritic, 10% allochems, 10% dolomite, low intergranular porosity.
1,487	1,502	Light grey to brown grainstone (dolomitic limestone), moderately hard, well indurated, 10% allochems, moderately good intergranular porosity. Lost mud circulation
1,502	1,545	Brown grainstone (dolomite), very hard, 10% limestone, 10% allochems, low intercrystalline porosity.
	1,518	Reverse-air Water Quality Data taken @ 10:44 hr on 9/18/01 Temp = 28.19°C; pH = 7.93 S.U.; Sp. Cond. = 2,224 µmhos/cm
1,545	1,550	Same as above, 25% limestone.
	1,550	Reverse-air Water Quality Data taken @ 12:44 hr on 9/18/01 Temp = 28.35°C; pH = 8.03 S.U.; Sp. Cond. = 2,204 µmhos/cm
1,550	1,556	Light grey grainstone (limestone), friable, micritic, 15% allochems, good intergranular porosity.
1,556	1,568	Brown crystalline carbonate (dolomite), very hard, 10% allochems, 5% limestone, low intercrystalline porosity.
1,568	1,573	Very dark brown to black crystalline carbonate (dolomite), very hard, 5% limestone, low intercrystalline porosity.
1,573	1,581	Brown crystalline carbonate (dolomite), very hard, 30% limestone, 15 % allochems, low intercrystalline porosity.
	1,581	Reverse-air Water Quality Data taken @ 13:51 hr on 9/18/01 Temp = 28.88°C; pH = 7.89 S.U.; Sp. Cond. = 2,255 µmhos/cm
1,581	1,592	Light grey grainstone (limestone), friable, micritic, 15% allochems, <5% dolomite, good intergranular porosity.
1,592	1,597	Same as above, 30% dolomite.
1,597	1,611	Brown crystalline carbonate (dolomite), very hard, 5% limestone, low intercrystalline porosity.
	1,611	Reverse-air Water Quality Data taken @ 15:20 hr on 9/18/01 Temp = 28.93°C; pH = 8.03 S.U.; Sp. Cond. = 2,188 µmhos/cm
1,611	1,616	Light grey grainstone (limestone), friable, micritic, 10% allochems, good intergranular porosity.
1,616	1,629	Brown crystalline carbonate (dolomite), very hard, 15 % limestone, low intercrystalline porosity.

From	To	Lithologic Description MF-37
1,629	1,636	Brown crystalline carbonate (dolomite), very hard, 10% limestone, low intercrystalline porosity.
1,636	1,643	Brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
	1,642	Reverse-air Water Quality Data taken @ 17:02 hr on 9/24/01 Temp = 31.5°C; pH =7.71 S.U.; Sp. Cond. = 2,313 µmhos/cm
1,643	1,648	Dark brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
1,648	1,665	Brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
1,665	1,670	Tan mudstone/wackestone (limestone), friable, micritic, 10%allochems, 5% clay, good intergranular porosity.
1,670	1,680	Brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
	1,672	Reverse-air Water Quality Data taken @ 12:43 hr on 9/25/01 Temp = 29.87°C; pH =7.54 S.U.; Sp. Cond. = 7,605 µmhos/cm
1,680	1,685	Tan mudstone/wackestone (limestone), friable, micritic, 10%allochems, 10% clay, good intergranular porosity.
1,685	1,690	Brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
1,690	1,699	Tan packstone (limestone), friable, micritic, good intergranular porosity.
1,699	1,702	Brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
	1,702	Reverse-air Water Quality Data taken @ 14:11 hr on 9/25/01 Temp = 29.79°C; pH =7.55 S.U.; Sp. Cond. = 8,400 µmhos/cm
1,702	1,743	Tan mudstone/wackestone (limestone), friable, micritic, 10% allochems, good intergranular porosity.
	1,733	Reverse-air Water Quality Data taken @ 15:11 hr on 9/25/01 Temp = 30.33°C; pH =7.54 S.U.; Sp. Cond. = 7,548 µmhos/cm
1,743	1,745	Brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
1,745	1,760	Tan mudstone/wackestone (limestone), friable, micritic, 10% allochems, good intergranular porosity.
1,760	1,762	Brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
1,762	1,770	Tan mudstone/wackestone (limestone), friable, micritic, 10% allochems, good intergranular porosity.
	1,764	Reverse-air Water Quality Data taken @ 16:22 hr on 9/25/01 Temp = 30.86°C; pH =7.68 S.U.; Sp. Cond. = 7,485 µmhos/cm
1,770	1,775	Same as above with 5 - 10% grey limestone and 1 - 3% brown dolomite.
1,775	1,780	Tan wackestone (limestone), friable, micritic, 10% allochems, 40% brown dolomite, good intergranular porosity.
1,780	1,781	Tan wackestone (limestone), friable, micritic, 10% allochems, 5% brown dolomite, good intergranular porosity.
1,781	1,785	Dark brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
1,785	1,792	Brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
	1,792	Reverse-air Water Quality Data taken on 9/26/01 Sp. Cond. = 19,512 µmhos/cm
1,792	1,794	Dark brown to black crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
1,794	1,820	Brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
1,820	1,831	Brown and grey crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
	1,825	Reverse-air Water Quality Data taken @ 19:30 hr on 9/27/01 Temp = 28.79°C; pH =7.52 S.U.; Sp. Cond. = 24,154 µmhos/cm
1,831	1,835	Grey crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
1,835	1,853	Brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
1,853	1,865	Light brown and grey crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
	1,857	Reverse-air Water Quality Data taken @ 12:35 hr on 9/28/01 Temp = 28.05°C; pH =7.52 S.U.; Sp. Cond. = 26,161 µmhos/cm
1,865	1,870	Dark brown to black crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
1,870	1,873	Dark tan grainstone (limestone), hard, micritic, moderate intergranular porosity.

From	To	Lithologic Description MF-37
1,873	1,876	Same as above with blue-grey limestone.
1,876	1,884	Very light tan to off-white grainstone (limestone), hard, micritic, moderate intergranular porosity.
1,884	1,886	Light tan grainstone (limestone), hard, micritic, moderate intergranular porosity.
1,886	1,888	Brown crystalline carbonate (dolomite), very hard, low intercrystalline porosity.
	1,888	Reverse-air Water Quality Data taken @ 14:17 hr on 9/28/01 Temp = 28.85°C; pH =7.51 S.U.; Sp. Cond. = 28,865 µmhos/cm
1,888	1,903	Light tan grainstone (limestone), moderately hard, micritic, moderate intergranular porosity.
1,903	1,914	Same as above with blue-grey limestone.
1,914	1,925	Light tan grainstone (limestone), hard, micritic, moderate intergranular porosity.
	1,919	Reverse-air Water Quality Data taken @ 9:40 hr on 10/01/01 Temp = 28.79°C; pH =7.60 S.U; Sp. Cond. = 28,296 mhos/cm
1,925	1,944	Tan grainstone (dolomitic limestone), hard, crystalline, moderate intergranular porosity.
	1,942	Reverse-air Water Quality Data taken @ 10:45 hr on 10/01/01 Temp = 28.61°C; pH =7.57 S.U.; Sp. Cond. = 28,154 µmhos/cm
1,944	1,948	Light tan grainstone (limestone), hard, micritic, moderate intergranular porosity.
1,948	1,959	Very light tan and blue-gray grainstone (limestone), hard, vugular (core), moderate intergranular porosity.
	1,950	Reverse-air Water Quality Data taken @ 12:00 hr on 10/04/01 Temp = 29.65°C; pH =7.34 S.U.; Sp. Cond. = 32,866 mhos/cm
1,959	1,962	Off white grainstone (limestone), hard, vugular, good intergranular porosity.
1,962	1,970	Light tan grainstone (limestone), hard, micritic, moderate intergranular porosity.
1,970	1,975	Tan and blue-gray grainstone (limestone), moderately hard, vugular, moderate intergranular porosity.
1,975	1,985	Tan grainstone (dolomitic limestone), hard, crystalline, moderate intergranular porosity.
	1,978	Reverse-air Water Quality Data taken @ 12:00 hr on 10/04/01 Temp = 29.43°C; pH =7.47 S.U.; Sp. Cond. = 37,216 mhos/cm
1,985	1,990	Light grey grainstone (limestone), hard, micritic, good intergranular porosity.
1,990	1,993	Light blue-grey grainstone (limestone), hard, micritic, good intergranular porosity.
1,993	2,001	Tan to light tan grainstone (dolomitic limestone), hard, crystalline, poor intergranular porosity.
2,001	2,005	Same as above with blue-grey limestone.
2,005	2,009	Brown crystalline carbonate (dolomite), very hard, crystalline, 10% limestone, poor intercrystalline porosity.
	2,009	Reverse-air Water Quality Data taken @ 14:05 hr on 10/04/01 Temp = 29.91°C; pH =7.44 S.U.; Sp. Cond. = 44,666 mhos/cm
2,009	2,015	Light blue-grey grainstone (limestone), hard, micritic, good intergranular porosity.
2,015	2,020	Brown crystalline carbonate (dolomite), very hard, crystalline, 20% limestone, poor intercrystalline porosity.
2,020	2,027	Tan and blue-gray grainstone (limestone), moderately hard, vugular, moderate intergranular porosity.
2,027	2,035	Tan grainstone (limestone), friable, micritic, good intergranular porosity.
2,035	2,046	Brown crystalline carbonate (dolomite), hard, crystalline, 15% limestone, poor intercrystalline porosity.
	2,046	Reverse-air Water Quality Data taken @ 15:08 hr on 10/04/01 Temp = 29.28°C; pH =7.59 S.U.; Sp. Cond. = 52,828 mhos/cm

Appendix C-2

Lithologic Well Log Printout

Well Number: W-18256
Total Depth: 2040 ft
Samples: None
Completion Date: N/A
Other Types of Logs Available: None
Owner/Driller: South Florida Water Management District
Worked by: Described by Edward Marks May 2002
Samples are in 5-foot intervals

Source: FGS
County: Martin
Location: T.40S R.37E S.14
Latitude: 28D 59M 0S
Longitude: 80D 36M 15S
Elevation: 15 ft

0-140	121PCPC	Pliocene-Pleistocene
140-425	122PCRV	Peace River Formation
435-780	122ARCA	Arcadia Formation
780-895	124OCAL	Ocala Group
895-2040	124AVPK	Avon Park Formation

Depth (ft)	Lithologic Log
0-10	No samples
10-20	Wackestone; yellowish gray to light olive gray Porosity: intergranular, moldic Possibly high permeability Grain type: skeletal, calcilutite 40% allochemical constituents Grain size: granule; range: medium to granule Moderate induration Cement type(s): calcilutite matrix, sparry calcite cement Accessory minerals: quartz sand-15% Fossils: mollusks, barnacles
20-35	Wackestone; grayish brown to white Porosity: intergranular, moldic, possibly high permeability Grain type: skeletal, calcilutite, 40% allochemical constituents Grain size: granule; range: medium to granule, moderate induration Cement type(s): calcilutite matrix, sparry calcite cement Accessory minerals: quartz sand-10% Fossils: mollusks, barnacles
35-45	Packstone; yellowish gray to white Porosity: intergranular, moldic, possibly high permeability Grain type: skeletal, calcilutite, 60% allochemical constituents Grain size: granule; range: medium to granule, moderate induration Cement type(s): calcilutite matrix, sparry calcite cement Accessory minerals: quartz sand-10% Fossils: mollusks, barnacles
45-50	No samples
50-60	Shell bed; grayish brown to white Porosity: intergranular, moldic, possibly high permeability; unconsolidated Accessory minerals: quartz sand-03%, limestone-10% Fossils: mollusks, barnacles, bryozoa
60-65	No samples

Depth (ft)	Lithologic Log
65-90	Shell bed; yellowish gray to moderate light gray Porosity: intergranular, possibly high permeability, unconsolidated Accessory minerals: quartz sand-02%, limestone-10% Fossils: mollusks, barnacles
90-115	Shell bed; yellowish gray to moderate light gray Porosity: intergranular, possibly high permeability, unconsolidated Accessory minerals: quartz sand-05%, limestone-10% Fossils: mollusks, barnacles
115-130	Shell bed; yellowish gray to moderate light gray Porosity: intergranular, possibly high permeability, unconsolidated Accessory minerals: quartz sand-05%, limestone-30% Fossils: mollusks, barnacles
130-140	Packstone; yellowish gray to white Porosity: intergranular, possibly high permeability Grain type: skeletal, calcilutite, 70% allochemical constituents Grain size: granule; range: medium to granule, poor induration Cement type(s): calcilutite matrix Accessory minerals: quartz sand-20% Fossils: mollusks, barnacles
140-165	Shell bed; yellowish gray to light olive gray Porosity: intergranular; poor induration Cement type(s): calcilutite matrix, clay matrix Accessory minerals: quartz sand-10%, phosphatic sand-02%, limestone-10%, silt-10% Fossils: mollusks, barnacles
165-200	Shell bed; yellowish gray to light olive gray Porosity: intergranular; poor induration Cement type(s): calcilutite matrix, clay matrix Accessory minerals: quartz sand-10%, phosphatic sand-02%, limestone-07%, silt-20% Fossils: mollusks, barnacles, echinoid
200-205	No samples
205-210	Shell bed; yellowish gray to light olive gray Porosity: intergranular; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: quartz sand-10%, phosphatic sand-02%, limestone-10%, silt-20% Fossils: mollusks, bryozoa, barnacles
210-225	Silt-size dolomite; olive gray to yellowish gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: quartz sand-10%, phosphatic sand-03% Fossils: mollusks, barnacles
225-260	Silt-size dolomite; light olive gray to light grayish green Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: quartz sand-10%, phosphatic sand-05% Fossils: mollusks, barnacles
260-280	Silt-size dolomite; light olive gray to olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix Accessory minerals: quartz sand-05%, phosphatic sand-05% Fossils: mollusks, bryozoa, barnacles Plio/Pleistocene cavings

Depth (ft)	Lithologic Log
280-310	Silt-size dolomite; light olive gray to olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, dolomite cement Accessory minerals: quartz sand-10%, phosphatic sand-05% Fossils: mollusks
310-315	Silt-size dolomite; light olive gray to yellowish gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, dolomite cement Accessory minerals: quartz sand-05%, phosphatic sand-05%, mica-01% Fossils: mollusks
315-340	Silt-size dolomite; light olive gray to olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, dolomite cement Accessory minerals: quartz sand-05%, phosphatic sand-03% Fossils: mollusks, bryozoa
340-350	Silt-size dolomite; olive gray to light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, dolomite cement Accessory minerals: quartz sand-05%, phosphatic sand-02% Fossils: mollusks, bryozoa
350-365	Silt-size dolomite; olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, dolomite cement Accessory minerals: quartz sand-05%, phosphatic sand-02% Fossils: mollusks, bryozoa
365-390	Silt-size dolomite; light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, dolomite cement Accessory minerals: quartz sand-05%, phosphatic sand-03% Fossils: mollusks, bryozoa
390-415	Silt-size dolomite; light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, dolomite cement Accessory minerals: quartz sand-05%, phosphatic sand-03% Fossils: mollusks, sharks teeth
415-425	Silt-size dolomite; light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, dolomite cement Accessory minerals: quartz sand-02%, phosphatic sand-02%, phosphatic gravel-02% Fossils: benthic foraminifera, mollusks, many foraminifera; however extremely small in size being barley identifiable at 30 power. Size is comparable to point On exploration pick
425-435	Silt-size dolomite; light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, dolomite cement Accessory minerals: limestone-20%, quartz sand-07%, limestone is highly recrystalized retaining some evidence of fossil content, unidentified
435-455	Silt-size dolomite; yellowish gray to light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, dolomite cement Accessory minerals: phosphatic sand-05%, quartz sand-05%

Depth (ft)	Lithologic Log
455-470	Silt-size dolomite; yellowish gray to light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic sand-05%, quartz sand-05%, limestone-20%
470-475	Wackestone; yellowish gray Porosity: intergranular, low permeability Grain type: skeletal, calcilutite, 25% allochemical constituents Grain size: granule; range: medium to granule, poor induration Cement type(s): clay matrix, calcilutite matrix, dolomite cement Accessory minerals: silt-20%, phosphatic sand-05%, phosphatic gravel-03%, quartz sand-10% Fossils: mollusks Phosphate grains are broken pieces of larger pebble sized grains, silt is actually dolosilt
475-485	Wackestone; yellowish gray to light olive gray Porosity: intergranular, low permeability Grain type: skeletal, calcilutite, 25% allochemical constituents Grain size: granule; range: fine to granule, poor induration Cement type(s): calcilutite matrix, clay matrix Accessory minerals: quartz sand-03%, phosphatic sand-07%, silt-20% Fossils: mollusks, bryozoa, fossil fragments
485-495	Silt-size dolomite; light olive gray to yellowish gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix, dolomite cement Accessory minerals: quartz sand-02%, clay-10% Fossils: mollusks, echinoid, fossil fragments
495-500	Wackestone; yellowish gray to olive gray Porosity: intergranular Grain type: skeletal, calcilutite, 20% allochemical constituents Grain size: granule; range: fine to granule, poor induration Cement type(s): calcilutite matrix, clay matrix Accessory minerals: phosphatic sand-05%, phosphatic gravel-02%, clay-15% Fossils: mollusks, bryozoa, sharks' teeth, echinoid fossil fragments
500-510	Silt-size dolomite; yellowish gray to light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic sand-07%, phosphatic gravel-01%, limestone-30% Fossils: mollusks, bryozoa, fossil fragments
510-540	Wackestone; yellowish gray to light olive gray Porosity: intergranular Grain type: skeletal, calcilutite, 30% allochemical constituents Grain size: granule; range: fine to granule, poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic sand-20%, phosphatic gravel-02%, quartz sand-0 % Fossils: mollusks, fossil fragments Good arcadia limestone
540-545	Wackestone; yellowish gray to dark greenish gray Porosity: intergranular, pin point vugs Grain type: skeletal, calcilutite, 20% allochemical constituents Grain size: granule; range: coarse to granule, poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic sand-03%, phosphatic gravel-01%, silt-30% Fossils: mollusks, bryozoa, sharks' teeth, echinoid fossil fragments

Depth (ft)	Lithologic Log
545-555	Wackestone; yellowish gray to light olive gray Porosity: intergranular, low permeability Grain type: skeletal, calcilutite, 15% allochemical constituents Grain size: medium; range: medium to granule, poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic sand-20%, quartz sand-02%, silt-30% Fossils: mollusks, bryozoa, echinoid, fossil fragments Majority of phospate grains are of fine to very fine grain size
555-570	Wackestone; yellowish gray Grain type: skeletal, calcilutite, 40% allochemical constituents Grain size: granule; range: medium to granule, poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic sand-10%, quartz sand-02%, silt-20%, phosphatic gravel-01% Fossils: mollusks, bryozoa, echinoid, fossil fragments
570-575	Packstone; yellowish gray to dark greenish gray Porosity: intergranular Grain type: skeletal, calcilutite, 60% allochemical constituents Grain size: granule; range: medium to granule, poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic sand-05%, quartz sand-02%, silt-15%, phosphatic gravel-02% Fossils: mollusks, bryozoa, echinoid, sharks' teeth, fossil fragments
575-585	Silt-size dolomite; yellowish gray to light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic gravel-02%, phosphatic sand-03%, limestone-30%, quartz sand-03% Fossils: mollusks, fossil fragments
585-590	Silt-size dolomite; yellowish gray to light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic gravel-02%, phosphatic sand-10%, limestone-30%, quartz sand-03% Fossils: mollusks, sharks' teeth, fossil fragments
590-615	Silt-size dolomite; yellowish gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic gravel-01%, phosphatic sand-07%, limestone-40%, quartz sand-03% Fossils: mollusks, sharks' teeth, fossil fragments
615-625	Silt-size dolomite; yellowish gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic gravel-02%, phosphatic sand-03%, quartz sand-01%, limestone-20% Fossils: mollusks
625-635	Silt-size dolomite; yellowish gray to light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic gravel-02%, phosphatic sand-05%, clay-20%, limestone-05% Fossils: mollusks, bryozoa
635-640	Silt-size dolomite; light olive gray to yellowish gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic gravel-01%, phosphatic sand-03%, quartz sand-01%, limestone-05% Fossils: mollusks, bryozoa

Depth (ft)	Lithologic Log
640-655	Silt-size dolomite; yellowish gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic gravel-02%, phosphatic sand-03%, quartz sand-02%, limestone-10% Fossils: mollusks, echinoid
655-665	Silt-size dolomite; light olive gray to yellowish gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic gravel-01%, phosphatic sand-02%, quartz sand-01%, limestone-20% Fossils: mollusks
665-690	Silt-size dolomite; yellowish gray to light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic gravel-01%, phosphatic sand-03%, quartz sand-01%, limestone-30% Fossils: mollusks
690-705	Silt-size dolomite; yellowish gray to light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic sand-01%, quartz sand-01%, limestone-07%, quartz sand-01% Fossils: mollusks, echinoid
705-735	Silt-size dolomite; yellowish gray to light olive gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic gravel-01%, phosphatic sand-02%, limestone-40%, quartz sand-01% Fossils: echinoid, mollusks
735-760	Silt-size dolomite; yellowish gray Porosity: intergranular, low permeability; poor induration Cement type(s): clay matrix, calcilutite matrix Accessory minerals: phosphatic gravel-05%, phosphatic sand-07%, limestone-03%, quartz sand-02% Fossils: mollusks, echinoid, sharks' teeth
760-765	Dolostone; olive gray to light olive gray Porosity: intergranular; 50-90% altered; euhedral Grain size: medium; range: very fine to medium, moderate induration Cement type(s): dolomite cement Accessory minerals: phosphatic gravel-15%, phosphatic sand-07%, silt-20%, quartz sand-02% Other features: sucrosic Fossils: mollusks, echinoid, sharks' teeth
765-780	Wackestone; white to olive gray Porosity: intergranular, low permeability, 20% allochemical constituents Grain size: granule; range: medium to granule, moderate induration Cement type(s): calcilutite matrix Accessory minerals: phosphatic gravel-02%, phosphatic sand-10%, quartz sand-03%, dolomite- % Fossils: mollusks, sharks' teeth
780-805	Wackestone; yellowish gray Porosity: intergranular, pin point vugs, low permeability Grain type: pellet, skeletal, 30% allochemical constituents Grain size: fine; range: very fine to granule, moderate induration Cement type(s): calcilutite matrix, accessory minerals: quartz sand-03% Fossils: mollusks, echinoid, coral Limestone grains have poor preservation characteristics making positive identification and percentage difficult.

Depth (ft)	Lithologic Log
805-815	Packstone; yellowish gray Porosity: intergranular, pin point vugs, possibly high permeability Grain type: pellet, skeletal, calcilutite, 70% allochemical constituents Grain size: fine; range: very fine to medium, moderate induration Cement type(s): calcilutite matrix, sparry calcite cement, accessory minerals: quartz sand-03% Other features: low recrystallization Fossils: benthic foraminifera, bryozoa, mollusks. Forams lepidocyclina and nummulities as well as good packstone denote good Ocala lithology.
815-830	Packstone; yellowish gray Porosity: intergranular, pin point vugs, possibly high permeability Grain type: pellet, skeletal, calcilutite, 70% allochemical constituents Grain size: fine; range: very fine to granule, moderate induration Cement type(s): calcilutite matrix, sparry calcite cement Fossils: mollusks, benthic foraminifera
830-865	Packstone; yellowish gray Porosity: intergranular, pin point vugs, possibly high permeability Grain type: pellet, skeletal, calcilutite, 80% allochemical constituents Grain size: fine; range: very fine to granule, moderate induration Cement type(s): calcilutite matrix, sparry calcite cement Fossils: mollusks, echinoid, benthic foraminifera
865-890	Packstone; yellowish gray Porosity: intergranular, pin point vugs, possibly high permeability Grain type: pellet, skeletal, calcilutite, 80% allochemical constituents Grain size: fine; range: very fine to granule, moderate induration Cement type(s): calcilutite matrix, sparry calcite cement Fossils: mollusks, bryozoa, echinoid, benthic foraminifera cones. First appearance of *D. cookei*
890-895	No samples
895-915	Wackestone; yellowish gray to white Porosity: intergranular, pin point vugs Grain type: pellet, calcilutite, skeletal, 40% allochemical constituents Grain size: very coarse; range: fine to granule, moderate induration Cement type(s): calcilutite matrix Fossils: mollusks, benthic foraminifera, echinoid, cones
915-930	Wackestone; yellowish gray to white Porosity: intergranular, pin point vugs Grain type: pellet, calcilutite, skeletal 40% allochemical constituents Grain size: very coarse; range: fine to granule Moderate induration Cement type(s): calcilutite matrix Other features: low recrystallization Fossils: mollusks, benthic foraminifera, echinoid Ostracods, cones
930-940	Packstone; yellowish gray Porosity: intergranular Grain type: pellet, skeletal, calcilutite, moderate induration Cement type(s): calcilutite matrix, sparry calcite cement Other features: low recrystallization Fossils: mollusks, cones, echinoid. Traditional Avon Park lithology, many cones, *D. cookei* and *D. americanus*.

Depth (ft)	Lithologic Log
940-970	Grainstone; yellowish gray Porosity: pin point vugs, intergranular Grain type: pellet, calcilutite, skeletal, 90% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix, sparry calcite cement Other features: low recrystallization Fossils: mollusks, cones, benthic foraminifera, echinoid cribrobulimina @ fabularia foraminifera as well as cones
970-975	Packstone; yellowish gray Porosity: pin point vugs, intergranular Grain type: pellet, calcilutite, skeletal, 80% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix, sparry calcite cement, dolomite cement Accessory minerals: dolomite-20%
975-990	Dolostone; grayish brown to yellowish gray Porosity: pin point vugs, intergranular; 50-90% altered subhedral, moderate induration Cement type(s): calcilutite matrix, sparry calcite cement, dolomite cement Accessory minerals: limestone-30%
990-1010	Dolostone; grayish brown to yellowish gray Porosity: pin point vugs, intergranular; 50-90% altered subhedral, moderate induration Cement type(s): calcilutite matrix, sparry calcite cement, dolomite cement Accessory minerals: limestone-30%
1010-1025	Dolostone; grayish brown to yellowish gray Porosity: pin point vugs, intergranular; 50-90% altered subhedral, moderate induration Cement type(s): calcilutite matrix, sparry calcite cement, dolomite cement Accessory minerals: limestone-20%
1025-1050	Packstone; yellowish gray Porosity: pin point vugs, intergranular Grain type: pellet, skeletal, calcilutite, 50% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix, sparry calcite cement Other features: low recrystallization Fossils: mollusks, cones, echinoid
1050-1075	Packstone; yellowish gray Porosity: pin point vugs, intergranular Grain type: pellet, skeletal, calcilutite, 70% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix, sparry calcite cement Other features: low recrystallization Fossils: organics, mollusks, cones, echinoid
1075-1105	Packstone; yellowish gray Porosity: pin point vugs, intergranular Grain type: pellet, skeletal, calcilutite, 80% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix, sparry calcite cement Other features: low recrystallization Fossils: cones, mollusks, echinoid

Depth (ft)	Lithologic Log
1105-1115	Packstone; yellowish gray Porosity: pin point vugs, intergranular Grain type: pellet, skeletal, calcilutite, 80% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix, sparry calcite cement Other features: low recrystallization Fossils: cones, mollusks
1115-1116	No samples
1116-1186	Interval consists almost entirely of Plio/Pleistocene cavings voiding any value to sample
1186-1196	Packstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 60% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Other features: low recrystallization Fossils: cones, benthic foraminifera Cavings are abundant, including Plio/Pleistocene, Peace River, and Arcadia being obvious upon initial inspection
1196-1216	Packstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 70% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Other features: low recrystallization Fossils: cones, benthic foraminifera
1216-1231	Packstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 70% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Other features: low recrystallization Fossils: cones, benthic foraminifera
1231-1253	Packstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 60% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Other features: low recrystallization Fossils: cones, benthic foraminifera, echinoid
1253-1283	Packstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 80% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Other features: low recrystallization Fossils: cones, benthic foraminifera, echinoid

Depth (ft)	Lithologic Log
1283-1298	Packstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 80% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Other features: low recrystallization Fossils: cones, benthic foraminifera, echinoid
1298-1332	Grainstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 90% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Other features: low recrystallization Fossils: cones, benthic foraminifera, echinoid
1332-1357	As above
1357-1395	Packstone; Grain type: pellet, skeletal, calcilutite, 80% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Other features: low recrystallization Fossils: cones, echinoid
1395-1425	Grainstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 90% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Other features: low recrystallization Fossils: cones, echinoid
1425-1430	Packstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: calcilutite, pellet, skeletal, 80% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Other features: low recrystallization Fossils: cones, echinoid Plio/Pleistocene cavings abundant along with many other lithologies evident.
1430-1450	Grainstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: calcilutite, pellet, skeletal, 90% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Fossils: cones
1450-1470	Grainstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: calcilutite, skeletal, pellet, 90% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Fossils: cone
1470-1480	As above
1480-1485	As above Sample is contaminated with silt and sand and some drilling mud(bentonite).

Depth (ft)	Lithologic Log
1485-1490	Grainstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: calcilutite, skeletal, pellet, 90% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Fossils: cones, echinoid Drilling bentonite mud.
1490-1500	Grainstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: calcilutite, skeletal, pellet, 90% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix Sedimentary structures: bedded Accessory minerals: organics-0 % Other features: low recrystallization, sucrosic Fossils: cones, echinoid, mollusks First appearance of good dolomite in Avon Park complete. Dolomite recrystalization with euhedral sucrosic fine size.
1500-1515	Dolostone; grayish brown Porosity: intergranular, pin point vugs; 90-100% altered euhedral Grain size: fine; range: very fine to medium, good induration Cement type(s): dolomite cement Other features: sucrosic
1515-1525	Dolostone; grayish brown to very light orange Porosity: intergranular, pin point vugs; 90-100% altered euhedral Grain size: fine; range: very fine to medium, good induration Cement type(s): dolomite cement Other features: sucrosic
1525-1550	Dolostone; grayish brown Porosity: intergranular, pin point vugs; 90-100% altered euhedral Grain size: fine; range: very fine to medium, good induration Cement type(s): dolomite cement Other features: sucrosic
1550-1555	Dolostone; grayish brown Porosity: intergranular, pin point vugs; 90-100% altered euhedral Grain size: fine; range: very fine to medium, good induration Cement type(s): dolomite cement Other features: sucrosic Younger Avon Park limestone cavings.
1555-1560	Dolostone; grayish brown Porosity: intergranular, pin point vugs; 90-100% altered euhedral Grain size: fine; range: very fine to medium, good induration Cement type(s): dolomite cement Other features: sucrosic
1560-1565	Dolostone; grayish brown to very light orange Porosity: intergranular, pin point vugs; 90-100% altered euhedral Grain size: fine; range: very fine to medium, good induration Cement type(s): dolomite cement Other features: sucrosic

Depth (ft)	Lithologic Log
1565-1580	Dolostone; grayish brown Porosity: intergranular, pin point vugs; 90-100% altered euhedral Grain size: fine; range: very fine to medium, good induration Cement type(s): dolomite cement Other features: sucrosic
1580-1585	Packstone; yellowish gray to dark yellowish brown Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 80% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix, clay matrix Fossils: cones, benthic foraminifera, echinoid Sample is possibly shallower Avon Park limestone cavings with some Ocala cavings as well as having lepidocyclina and numulities foraminifera.
1585-1590	Packstone; yellowish gray to dark yellowish brown Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 80% allochemical constituents Grain size: fine; range: very fine to granule, poor induration Cement type(s): calcilutite matrix, clay matrix Accessory minerals: dolomite-15%
1590-1600	Dolostone; grayish brown Porosity: intergranular, pin point vugs, possibly high permeability; 90-100% altered; subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement Other features: sucrosic
1600-1605	Dolostone; dark yellowish brown to dark yellowish brown Porosity: intergranular, pin point vugs, possibly high permeability; 90-100% altered; subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement Other features: sucrosic
1605-1630	Dolostone; grayish brown Porosity: intergranular, pin point vugs; 90-100% altered, subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement Other features: sucrosic
1630-1635	No samples
1635-1640	Dolostone; grayish brown Porosity: intergranular, pin point vugs; 90-100% altered, subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement Other features: sucrosic
1640-1645	Dolostone; dark yellowish brown to grayish brown Porosity: intergranular, pin point vugs, possibly high permeability; 90-100% altered; subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement Other features: sucrosic
1645-1665	Dolostone; grayish brown Porosity: intergranular, pin point vugs; 90-100% altered, subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement Other features: sucrosic

Depth (ft)	Lithologic Log
1665-1670	Packstone; yellowish gray to moderate yellowish brown Porosity: intergranular Grain type: pellet, skeletal, calcilutite, 60% allochemical constituents Grain size: fine; range: very fine to granule Cement type(s): phosphate cement, calcilutite matrix, dolomite cement Accessory minerals: dolomite-30% Other features: sucrosic Sample is a packstone with sucrosic dolomite grains evenly dispersed throughout matrix.
1670-1680	Dolostone; grayish brown Porosity: intergranular, pin point vugs; 90-100% altered, subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement Other features: sucrosic
1680-1685	Wackestone; yellowish gray to dark yellowish brown Porosity: intergranular, low permeability Grain type: pellet, calcilutite, 40% allochemical constituents Grain size: fine; range: very fine to granule Accessory minerals: dolomite-40% Other features: sucrosic
1685-1690	Dolostone; grayish brown Porosity: intergranular, pin point vugs; 90-100% altered, subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement Other features: sucrosic
1690-1700	Dolostone; yellowish gray to moderate yellowish brown Porosity: intergranular; 50-90% altered; euhedral Grain size: fine; range: very fine to medium, moderate induration Cement type(s): dolomite cement, calcilutite matrix Accessory minerals: limestone-40% Other features: sucrosic Fossils: cones
1700-1705	Dolostone; grayish brown to dark yellowish brown Porosity: intergranular, pin point vugs; 90-100% altered, subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement
1705-1720	Packstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 80% allochemical constituents Grain size: fine; range: very fine to medium Accessory minerals: dolomite-15% Fossils: cones
1720-1740	Packstone; yellowish gray Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 80% allochemical constituents Grain size: fine; range: very fine to medium Fossils: cones

Depth (ft)	Lithologic Log
1740-1765	Packstone; grayish brown to dark yellowish brown Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 80% allochemical constituents Grain size: fine; range: very fine to medium Accessory minerals: dolomite-30% Fossils: cones
1765-1780	Packstone; yellowish gray to dark yellowish brown Porosity: intergranular, pin point vugs Grain type: pellet, skeletal, calcilutite, 70% allochemical constituents Grain size: fine; range: very fine to medium Accessory minerals: dolomite-10%
1780-1785	Dolostone; moderate yellowish brown Porosity: intergranular, possibly high permeability, 90-100% altered; euhedral Grain size: medium; range: fine to coarse, moderate induration Cement type(s): dolomite cement Other features: sucrosic Euhedral and very sucrosic sample possibly yielding high porosity.
1785-1800	Dolostone; grayish brown to dark yellowish brown Porosity: intergranular, low permeability; 90-100% altered, subhedral Grain size: fine; range: very fine to medium, good induration Cement type(s): dolomite cement Other features: sucrosic
1800-1815	As above
1815-1820	Dolostone; moderate yellowish brown to moderate light gray Porosity: intergranular, low permeability; 90-100% altered, subhedral Grain size: microcrystalline Range: cryptocrystalline to fine; good induration Cement type(s): dolomite cement Other features: sucrosic
1820-1825	Dolostone; grayish brown to dark yellowish brown Porosity: intergranular, low permeability; 90-100% altered, subhedral Grain size: very fine; range: microcrystalline to medium, good induration Cement type(s): dolomite cement Other features: sucrosic
1825-1835	Dolostone; grayish brown Porosity: intergranular, low permeability; 90-100% altered, subhedral Grain size: very fine; range: microcrystalline to medium, good induration Cement type(s): dolomite cement Other features: sucrosic
1835-1840	Dolostone; grayish brown Porosity: intergranular, pin point vugs Possibly high permeability; 90-100% altered; subhedral Grain size: very fine; range: microcrystalline to medium, good induration Cement type(s): dolomite cement Other features: sucrosic
1840-1855	Dolostone; grayish brown Porosity: intergranular, pin point vugs; 90-100% altered, subhedral Grain size: very fine; range: microcrystalline to medium, good induration Cement type(s): dolomite cement Other features: sucrosic

Depth (ft)	Lithologic Log
1855-1870	Dolostone; grayish brown to dark yellowish brown Porosity: intergranular, pin point vugs; 90-100% altered, subhedral Grain size: very fine; range: microcrystalline to medium, good induration Cement type(s): dolomite cement Other features: sucrosic
1870-1875	Dolostone; very light orange to grayish brown Porosity: intergranular, low permeability; 50-90% altered, subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement Other features: sucrosic
1875-1880	Dolostone; grayish brown Porosity: intergranular, pin point vugs; 50-90% altered, subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement Other features: sucrosic
1880-1885	Dolostone; yellowish gray to white Porosity: intergranular; 50-90% altered; anhedral Grain size: medium; range: microcrystalline to very fine, good induration Cement type(s): dolomite cement
1885-1890	Dolostone; grayish brown to very light orange Porosity: intergranular, pin point vugs; 50-90% altered, anhedral Grain size: medium; range: microcrystalline to very fine, good induration Cement type(s): dolomite cement
1890-1915	Dolostone; yellowish gray Porosity: intergranular, pin point vugs; 10-50% altered, anhedral Grain size: medium; range: microcrystalline to medium, moderate induration Cement type(s): dolomite cement, calcilutite matrix Sample appears to have differential dolomite alteration with limestone appearing to range from low to medium alteration.
1915-1940	Dolostone; yellowish gray Porosity: intergranular, low permeability; 50-90% altered, subhedral Grain size: microcrystalline Range: cryptocrystalline to very fine; good induration Cement type(s): dolomite cement, calcilutite matrix Other features: sucrosic
1940-1955	Dolostone; dark yellowish orange to yellowish gray Porosity: intergranular, pin point vugs, possibly high permeability; 50-90% altered; anhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement, calcilutite matrix
1955-1965	Dolostone; very light orange Porosity: intergranular, low permeability; 50-90% altered, anhedral Grain size: microcrystalline Range: cryptocrystalline to very fine; good induration Cement type(s): dolomite cement, calcilutite matrix
1965-1975	Dolostone; grayish brown to very light orange Porosity: intergranular; 90-100% altered; anhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement

Depth (ft)	Lithologic Log
1975-1985	Dolostone; grayish brown to very light orange Porosity: intergranular, pin point vugs; 90-100% altered, subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement Other features: sucrosic
1985-1990	Dolostone; yellowish gray Porosity: intergranular, low permeability; 50-90% altered, subhedral Grain size: microcrystalline Range: cryptocrystalline to very fine; good induration Cement type(s): dolomite cement
1990-1995	Dolostone; grayish brown to moderate light gray Porosity: intergranular, pin point vugs; 90-100% altered, subhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement Other features: sucrosic
1995-2005	Dolostone; grayish brown to yellowish gray Porosity: intergranular, pin point vugs; 90-100% altered, anhedral Grain size: very fine; range: microcrystalline to fine, good induration Cement type(s): dolomite cement
2005-2010	Dolostone; dark yellowish brown to grayish brown Porosity: intergranular, pin point vugs; 90-100% altered, euhedral Grain size: fine; range: very fine to medium, good induration Cement type(s): dolomite cement Other features: sucrosic
2010-2025	Dolostone; yellowish gray to very light gray Porosity: intergranular; 90-100% altered; anhedral Grain size: microcrystalline Range: cryptocrystalline to very fine; good induration Cement type(s): dolomite cement
2025-2040	Dolostone; moderate yellowish brown to grayish brown Porosity: intergranular, pin point vugs, possibly high permeability; 90-100% altered; euhedral Grain size: fine; range: very fine to medium, good induration Cement type(s): dolomite cement Other features: sucrosic
2040	Total depth

Appendix D

Packer test results can be found in the attached Excel sheets.

Appendix E

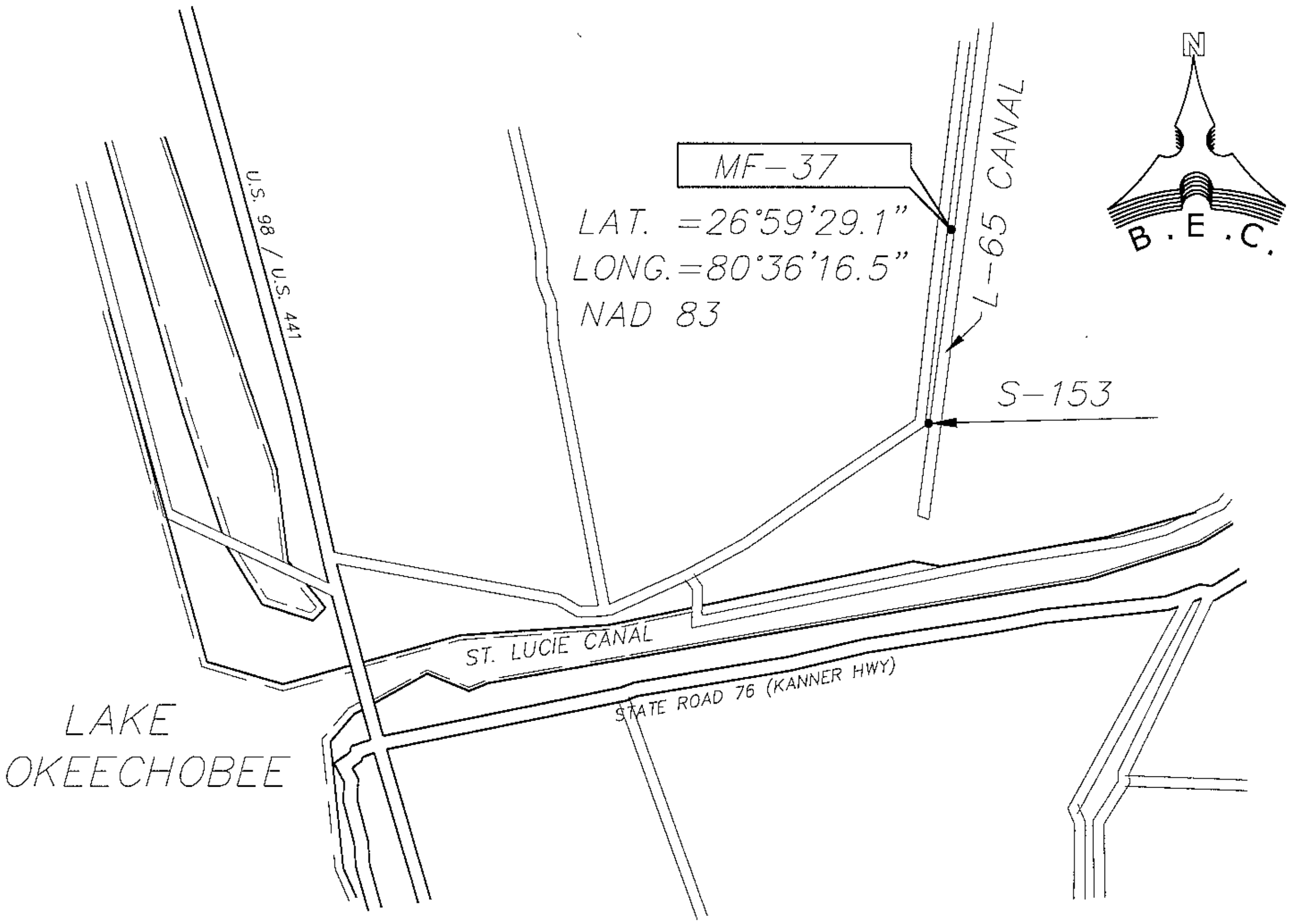
Core No.	Sample No.	Depth Top (ft)	Depth Bottom (ft)	K(max) md	K(90) md	Horizontal Anisotropy Ratio	Vertical Perm. md	Vertical/ Horizontal Anisotropy	Porosity (%)	Grain Density (gm/cc)	Description
1	1	798.0	798.5	1909.60	740.37	0.39	-999.00		33.8	2.71	Lim, wht, broken frac, foss, chalk
1	2	800.0	800.7	315.27	302.99	0.96	161.50	0.53	43.3	2.70	Lim, wht, foss, chalk, pp moldic
1	3	801.7	802.0	-999.00	2380.00		-999.00		51.3	2.71	Lim, wht, foss, chalk, pp moldic
1	4	803.2	803.5	625.04	481.79	0.77	301.73	0.63	41.9	2.70	Lim, wht, foss, chalk, pp moldic
2	5	931.3	931.7	1195.31	1100.69	0.92	203.20	0.18	29.0	2.72	Lim, wht, foss, chalk, sl pp moldic
2	6	933.0	933.6	2244.64	1963.13	0.87	807.14	0.41	36.5	2.71	Lim, wht, foss, sl chalk, pp moldic
2	7	934.5	935.0	692.44	678.01	0.98	1111.97	1.64	43.7	2.71	Lim, wht, foss, chalk, pp moldic
2	8	936.3	936.8	731.44	678.16	0.93	658.29	0.97	41.5	2.72	Lim, wht, foss, chalk, pp moldic
2	9	938.0	939.0	1739.13	1196.09	0.69	301.81	0.25	36.1	2.71	Lim, wht, foss, chalk, pp moldic
2	10	939.3	939.9	644.86	469.57	0.73	348.74	0.74	39.5	2.72	Lim, wht, foss, chalk, pp moldic
3	11	1372.2	1372.9	383.06	362.14	0.95	141.47	0.39	40.8	2.70	Lim, wht, foss, chalk, pp moldic
3	12	1372.7	1373.7	726.69	710.14	0.98	363.37	0.51	38.7	2.70	Lim, wht, foss, chalk, pp moldic
3	13	1376.4	1376.9	420.38	413.87	0.98	405.29	0.98	39.9	2.71	Lim, wht, foss, chalk, pp moldic
3	14	1376.9	1377.8	77.19	75.79	0.98	70.34	0.93	38.9	2.71	Lim, wht, foss, chalk, pp moldic
3	15	1378.7	1379.2	137.11	131.02	0.96	87.15	0.67	40.0	2.71	Lim, wht, foss, chalk, pp moldic
3	16	1379.7	1380.4	129.41	129.41	1.00	104.70	0.81	41.0	2.70	Lim, wht, foss, chalk, pp moldic
3	17	1381.0	-999.0	-999.00	13.81		-999.00		36.1	2.69	Lim, wht, foss, chalk, pp moldic
4	18	1629.2	1629.8	7.67	6.15	0.80	0.03		10.8	2.81	Dol, tn brn, vf xln, sl pp vug
4	19	1631.0	1631.4	14.81	12.91	0.87	1.68	0.13	17.8	2.79	Dol, tn brn, vf xln, sli calc, sh lam
4	20	1632.0	1632.4	56.57	40.20	0.71	15.15	0.38	19.4	2.82	Dol, tn brn, vf xln, sl pp moldic
4	21	1632.6	1632.9	187.67	177.02	0.94	39.44	0.22	22.1	2.81	Dol, tn brn, vf xln, sli calc, sh lam, pp moldic
4	22	1633.8	1634.2	4.22	3.23	0.77	2.30	0.71	13.8	2.81	Dol, tn brn, slt-vf xln, sh lam
5	23	1942.1	1942.3	1749.00	1692.00	0.97	415.45	0.25	34.0	2.77	Dol, tn, foss, sli calc, pp moldic
5	24	1942.5	1942.8	5859.95	5494.43	0.94	6116.60	1.11	34.6	2.78	Dol, tn, foss, sli calc, pp moldic vug
5	25	1945.1	1945.4	59.25	57.34	0.97	9.29	0.16	27.0	2.79	Dol, tn, foss, sh lam, pp moldic sl vug
5	26	1947.3	1947.6	45.11	21.02	0.47	22.11	1.05	12.8	2.71	Dol, tn gry, sl moldic
5	27	1949.0	1950.0	857.77	776.95	0.91	2429.69		15.9	2.71	Dol, tn, vug rootlet
5	28	1951.8	1952.4	0.91	0.25	0.27	0.23	0.91	6.9	2.80	Dol, tn, tr vug
						0.83		0.63			

Appendix F

WELLHEAD AS-BUILT

MF-37

SCALE: NOT TO SCALE



LOCATION SKETCH

MARTIN COUNTY

IN S.E. 1/4 OF SEC. 14 TWP 40 RNG 37

SHEET 1 OF 3

ORDER No.	03-76221
FIELD BOOK No.	2423/26, 2407/22
DATE:	2-08-02
FOR:	DIVERSIFIED DRILLING CO.

Biscayne Engineering Company
FOUNDED 1898

BISCAYNE ENGINEERING COMPANY, INC.

Consulting Engineers Planners Surveyors

MIAMI
529 WEST FLAGLER STREET
FLORIDA, 33130
PH: (305) 324-7671
FAX: (305) 324-0809

WEB SITE: www.biscayneengineering.com
E-MAIL: info@biscayneengineering.com

FT. LAUDERDALE
6561 SUNSET STRIP
SUNRISE, FLORIDA 33313
PH: (305) 748-1800
FAX: (305) 749-5628

DRAWING NO. 2087-SS-29

DRAWING NO. 2087-SS-29

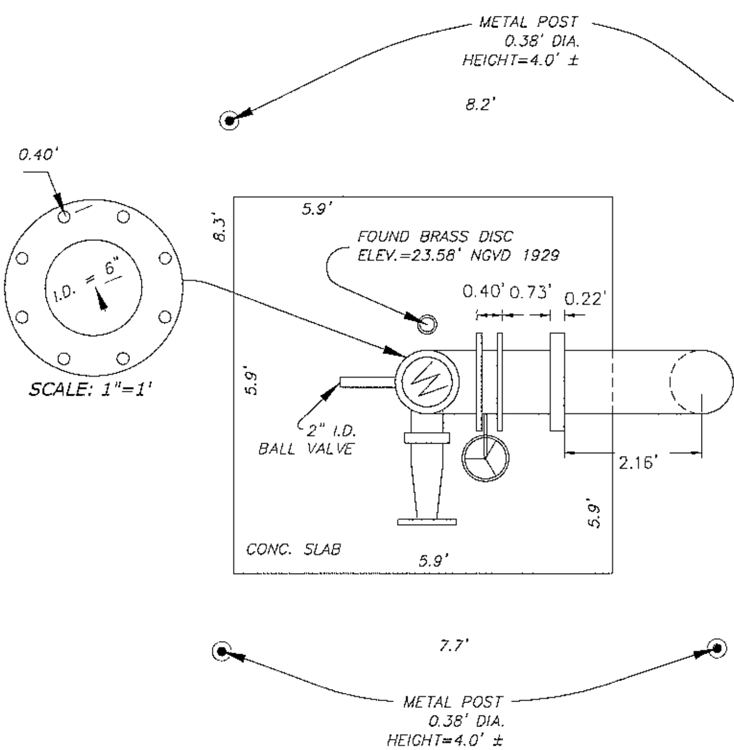
WELLHEAD AS-BUILT

MF-37

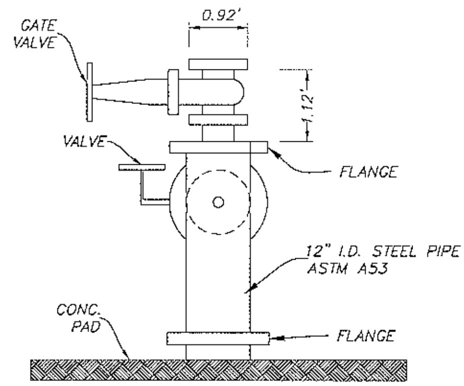
SCALE: 1" = 3'

B.M. OF ORIGIN =SFWMD BENCH MARK ID "B.M. S-153 1995" ELEV.=32.65 1929 (AS PROVIDED BY SFWMD)

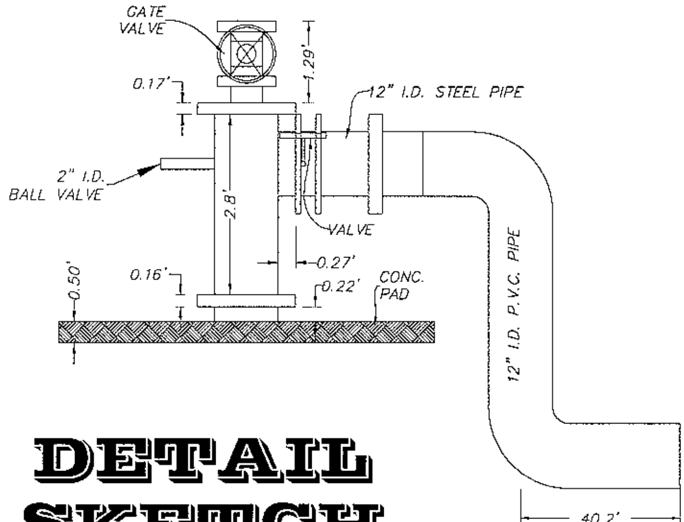
TOP VIEW



SIDE VIEW



SIDE VIEW



SFWMD = SOUTH FLORIDA WATER MANAGEMENT DISTRICT

DIA. = DIAMETER

DETAIL SKETCH

MARTIN COUNTY

IN S.E. 1/4 OF SEC. 14 TWP 40 RNG 37

SHEET 2 OF 3

ORDER No.	03-76221
FIELD BOOK No.	2423/26, 2407/22
DATE:	2-8-02
FOR:	DIVERSIFIED DRILLING CO.

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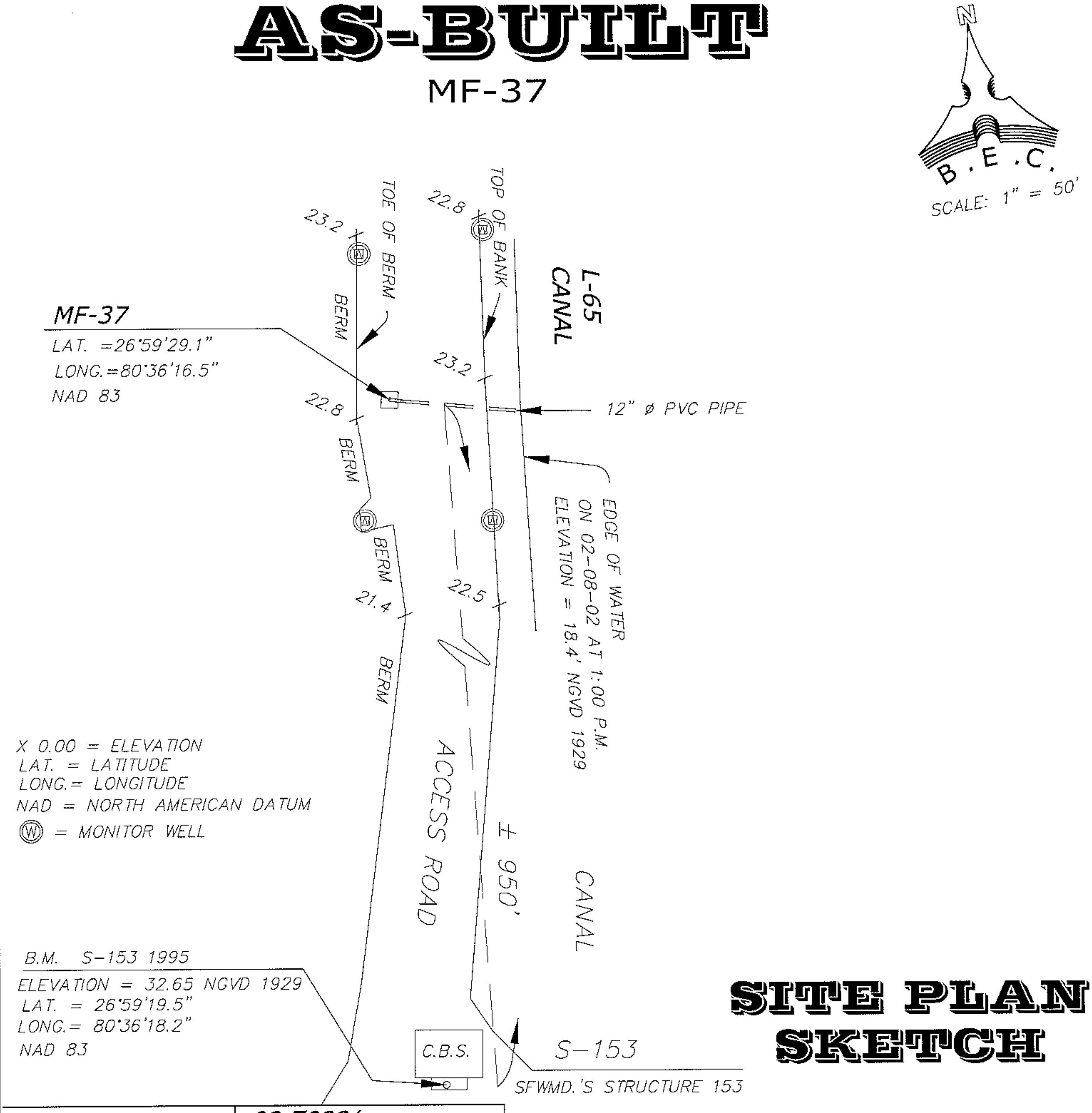
DRAWING NO. 2087-SS-29

DRAWING NO. 2087-SS-29

WELLHEAD AS-BUILT

MF-37

DRAWING NO. 2087-SS-29



SITE PLAN SKETCH

MARTIN COUNTY

IN S.E. 1/4 OF SEC. 14 TWP 40 RNG 37

SHEET 3 OF 3

ORDER No.	03-76221
FIELD BOOK No.	2423/26, 2407/22
DATE:	2-8-02
FOR:	DIVERSIFIED DRILLING CO.

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