CDM

Collier County
Public Utilities Division

Carica Road Pump Station
Class V ASR Exploratory Well

Completion Report

December 2004

Collier County Public Utilities

Carica Road Pump Station
Class V ASR Exploratory Well
Well Completion Report

December 2004

CERTIFICATIONS

Collier County – Carica Road Pump Station
Class V ASR Exploratory Well
Well Completion Report
Permit 225211-001-UC

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

OWNER'S CERTIFICATION

Paul Mattausch
Water Director

PROFESSIONAL ENGINEER CERTIFICATION

12/3/04
William S. Manahan, P.E. (FL # 51423)
Water Resources Engineer

PROFESSIONAL GEOLOGIST CERTIFICATION

12/3/04
Robert G. Maliva, Ph.D., P.G. (FL # 1549)
Senior Hydrogeologist

Contents – Well Completion Report

Appendices

Figures

Figure following page no.

Executive Summary

Exploratory well EW-1 was constructed at the Carica Road pump station site from September through November 2004 by Diversified Drilling Company. CDM provided design, permitting, and construction supervision services. The purpose of the exploratory well program is to identify and evaluate a potential storage zone for an aquifer storage and recovery (ASR) system at the site. The Florida Department of Environmental Protection (FDEP) injection well construction permit for EW-1 (225211-001-UC) was issued on August 18, 2004.

Exploratory well EW-1 was constructed with an 18-inch diameter PVC surface casing to 122 feet below land surface (bls), and a 10-inch PVC well casing set at a depth of 287 feet bls. The well was completed with a 9-inch diameter open borehole from 287 to 405 feet bls, the proposed ASR storage zone. The storage zone consists of fossiliferous limestones that are part of the Arcadia formation.

Exploratory well EW-1 was tested in accordance with the requirements of the FDEP injection well construction permit and the State of Florida Underground Injection Control (UIC) rules, per Florida Administrative Code (FAC) Chapter 62-528.

A water sample from the proposed ASR storage zone had chloride, sodium, and total dissolved solids concentrations of 750, 330, and 1,690 mg/L, respectively. The mildly brackish salinity of the proposed ASR storage zone is favorable for the operation of an ASR well using this zone. The well yielded a specific capacity of approximately 7.3 gpm/ft, which indicates that the proposed storage zone is productive enough for ASR wells with a minimum capacity of 1 million gallon per day (Mgd).

Water samples were collected from well EW-1 and from a potable supply line at the site. These water samples were analyzed for primary and secondary drinking water constituents and geochemical parameters. The laboratory analytical results were reviewed and geochemical modeling performed to evaluate geochemical compatibility and regulatory compliance. No concerns regarding geochemical compatibility or regulatory compliance were identified, other than the possibility of arsenic leaching, which is a general concern for ASR systems in Florida. There was no evidence that arsenic leaching would be a problem at the Carica Road site, and it has not been a problem in the Manatee Road ASR system. Nevertheless, the possibility of arsenic leaching in excess of applicable drinking water standards cannot be excluded.

Based on the results of the well installation and testing presented herein, the Carica Road site and Hawthorn Zone I aquifer appear to meet all criteria for the successful implementation of ASR. Therefore, it is recommended that Collier County proceed with implementation of ASR at the site. The next steps in this process are the preparation of a UIC permit application for two ASR wells, and the design and construction of the ASR system. Exploratory well EW-1 will be used as a storage zone monitor well for the Carica Road ASR system.

Section 1
Introduction

CDM was contracted by Collier County, Florida to construct an exploratory well for an aquifer storage and recovery (ASR) system at the Carica Road pump station site located near the intersection of Carica Road and Goodlette-Frank Road in north Naples, Florida. The site location is depicted on **Figure 1-1**. The purpose of the exploratory well is to locate and evaluate a potential ASR storage zone at the site. An ASR system at this site would provide water for meeting local seasonal peaks in demand and emergency storage.

An application for a Class V exploratory well construction permit was submitted to the Florida Department of Environmental Protection (FDEP) in December 2003. A draft permit was issued in June 2004, and the final permit was issued on August 18, 2004. A copy of the construction permit (No. 225211-001-UC) is provided in **Appendix A.**

Construction of exploratory well EW-1 began in September, 2004. Diversified Drilling Corporation was contracted to perform the drilling and testing of the well. The exploratory well was completed in November, 2004. Step drawdown testing and groundwater sampling and analysis of were subsequently conducted in November, 2004, after completion of the well. Water table aquifer monitor well MW-1 was constructed on September 16, 2004. **Figure 1-2** is a site plan depicting the location of the exploratory well and water table aquifer monitor well.

This report documents the well construction and testing performed as part of the exploratory well program. The well was constructed and tested in accordance with FAC Chapter 62-528 (Underground Injection Control), the conditions of the FDEP construction permit, and the technical specifications prepared by CDM and approved by FDEP.

The entire drilling and testing program was overseen by the FDEP Technical Advisory Committee (TAC), which was composed of representatives of the FDEP, South Florida Water Management District (SFWMD), U.S. Environmental Protection Agency (USEPA) and the U.S. Geological Survey (USGS). Daily activity logs, weekly construction summaries, and other pertinent information were submitted to the TAC weekly. Copies of the weekly TAC letters are provided in **Appendix B** and copies of the weekly construction summaries are included in **Appendix C**.

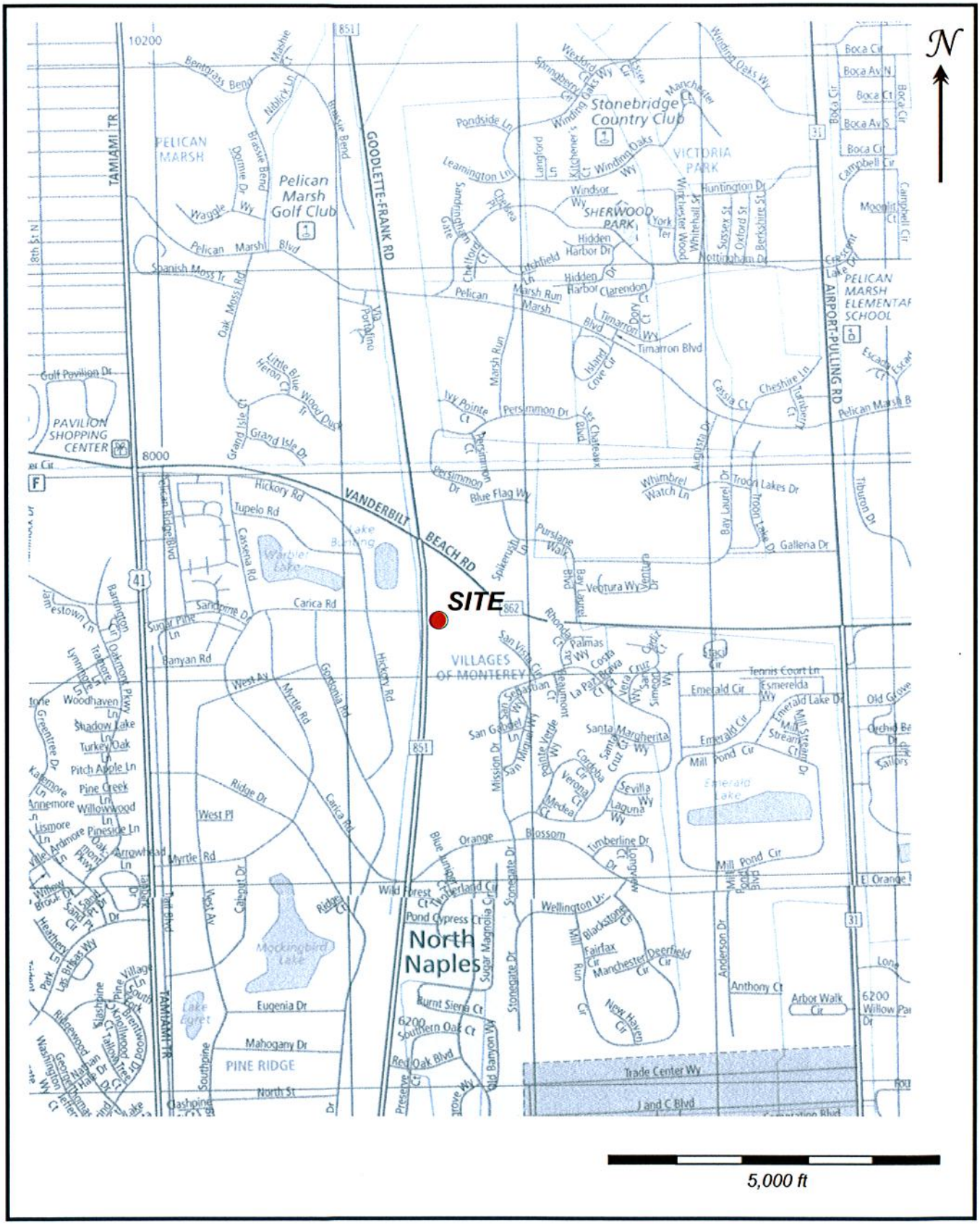
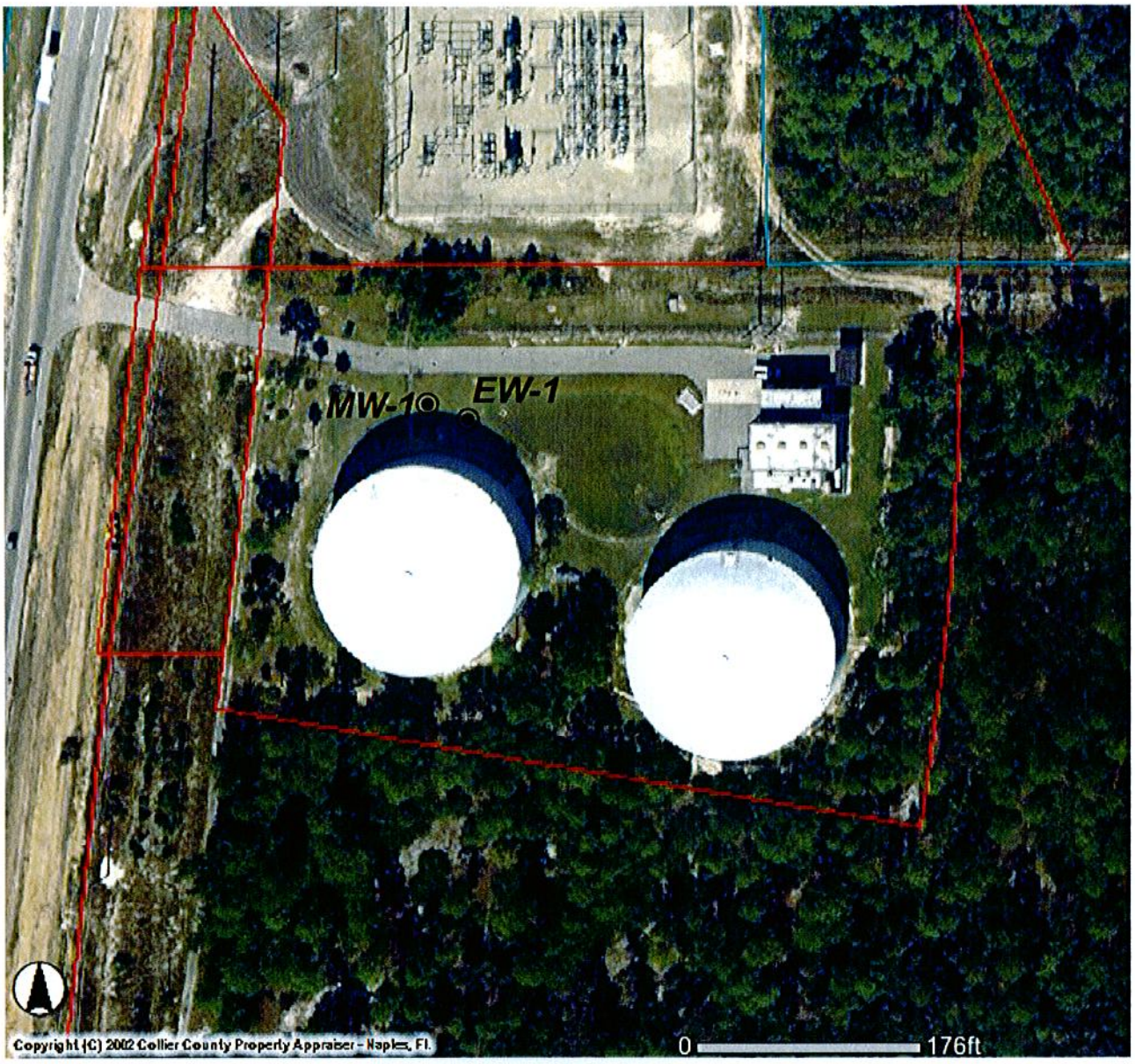


Figure 1-1
Collier County Carica Road ASR
Site Location

CDM



◉ *Locations of exploratory well (EW-1) and water table aquifer monitor well (MW-1)*

CDM

Figure 1-2
Collier County Carica Road ASR
Aerial Photograph of Site Showing Exploratory Well Location

Section 2
Geology and Hydrogeology

The geology and hydrogeology of Collier County has been described in a number of investigations originated by the U.S. Geological Survey, the Florida Geological Survey, the South Florida Water Management District, academic research, and by various consultants, including CDM. The geology and hydrogeology of the Carica Road site are summarized in **Figure 2-1**. The limestone classification system of Dunham (1962) was used to describe the cuttings recovered from exploratory well EW-1. Colors were described verbally and numerically using the Geological Society of America's Rock Color Chart, which is based on the Munsell system. A Geologist Log for well EW-1 is included in **Appendix D**.

2.1 Geology

The stratigraphy encountered during the drilling of injection well EW-1 was interpreted from well cuttings and geophysical logs obtained during well construction. The approximate depths of formation boundaries can generally be identified from the well cuttings. Formation boundaries were more precisely identified using geophysical logs, as lithological changes are usually manifested by changes in geophysical log responses.

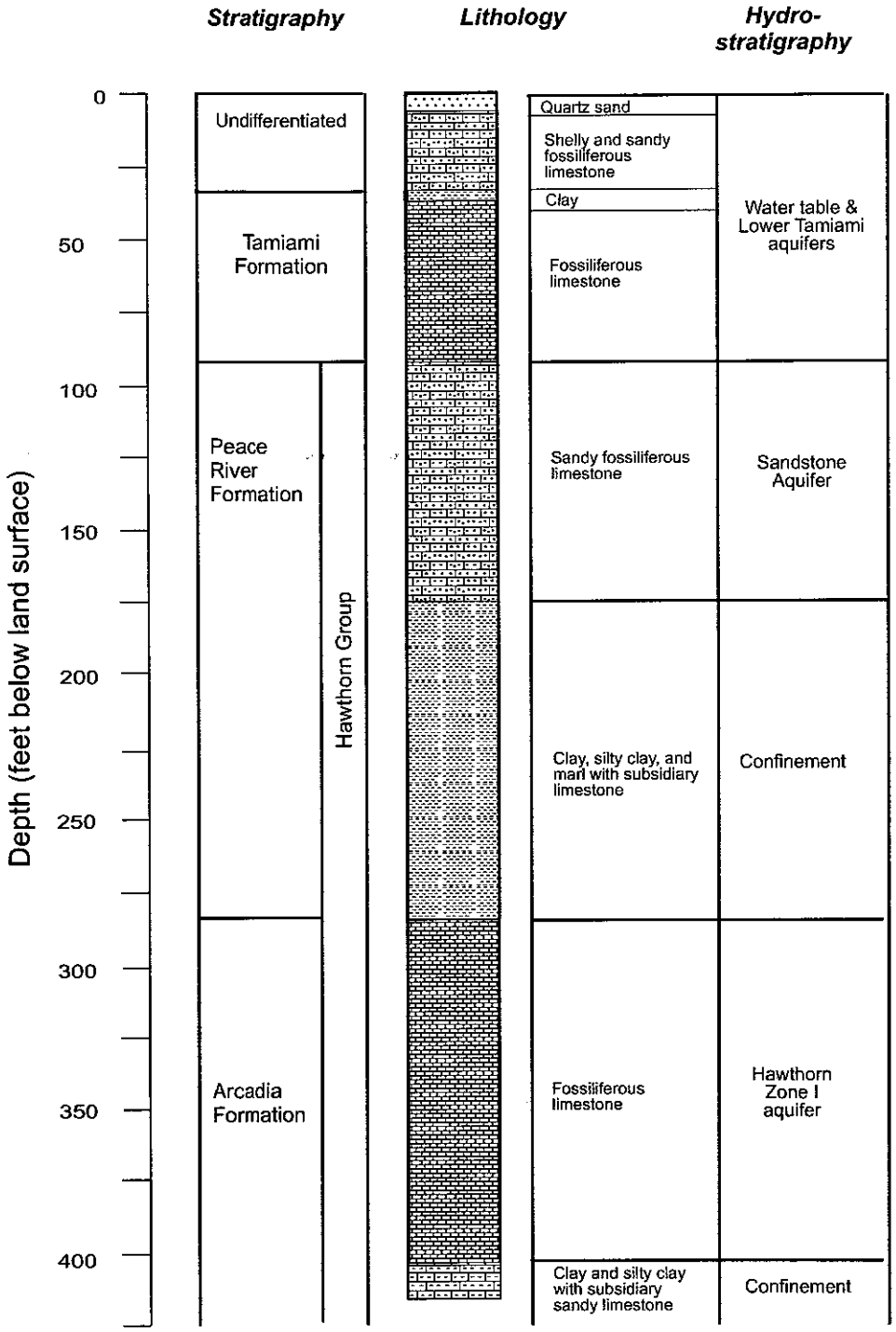
Pamlico Sand

The uppermost formation encountered in western Collier County is the Pamlico Sand. The Pamlico Sand is Late Pleistocene-aged and is present at the surface of much of South Florida. The Pamlico Sand was approximately eight feet thick at exploratory well EW-1. The Pamlico Sand in Southwest Florida consists predominantly of fine to medium-grained quartz sand, with lesser amounts of shell, detrital clays, and organic matter. The permeability of the Pamlico Sand is generally medium to low (10 to 100 ft/day), depending on the quantity of secondary constituents.

Ft. Thompson/Tamiami Formation (Undifferentiated)

The Pamlico Sand is underlain by the Pleistocene-aged Fort Thompson Formation and the Pliocene-aged Tamiami Formation in Southwest Florida. The lithology of the Fort Thompson Formation is highly variable and includes fresh-water, marine, and brackish water limestones, marls, sands, and shells. The Pliocene-aged Tamiami Formation, which unconformably lies below the Fort Thompson Formation, is also lithologically highly variable. At least nine mappable members or facies have been identified in the Tamiami Formation in Southwest Florida, which include such diverse lithologies as marls, sands and sandstones, dolosilt, and limestone (Missimer, 1992). Differentiation of the various members and facies of the Fort Thompson Formation and Tamiami Formation is not always possible, particularly from well cuttings.

Limestone and marl encountered between 8 and 37 ft bls at the Carica Road site are likely part of the upper Tamiami Formation. If the light olive gray clay beds encountered from approximately 35 to 37 ft bls in wells EW-1 is part of the Bonita Spring Marl Member of the Tamiami Formation, then the overlying fossiliferous limestone would be part of the "Unnamed Limestone Member" described by Missimer (1992). Otherwise the entire limestone sequence between the Pamlico Sand and the Hawthorn Group may be part of the Ochopee Member of the Tamiami Formation.



CDM

Figure 2-1
Collier County Carica Road ASR
Hydrogeology of the Carica Road ASR Exploratory Well (EW-1)

The Ochopee Limestone Member of the Tamiami Formation is the only member of the Tamiami Formation definitely identified at the Carica Road site. The Ochopee Limestone Member of the Tamiami Formation was named by Mansfield (1939) for the light gray to white sandy fossiliferous limestone that crops out near the town of Ochopee in Collier County (Hunter, 1968). According to Hunter (1968), the Ochopee Member typically is light gray to white calcarenite that has an extensive development of secondary porosity, formed by the dissolution of the aragonitic shells of mollusks. Well-preserved pectens, oysters, barnacles, and echinoids are also present. The large interconnected molds give the unit a very high permeability. The Ochopee Member is present from about 37 (or possibly higher, see above) to 92 ft bls at the SCWRF.

Hawthorn Group

The mostly Miocene-aged Hawthorn Group lies unconformably beneath the Tamiami Formation. The Hawthorn Group is regionally extensive and underlies most of Florida and parts of Georgia and South Carolina. It is a lithologically diverse unit that contains varying sequences of limestones, dolostones, sands, sandstones, marls, clays, and phosphates. The commonly high phosphate concentration of numerous beds within the Hawthorn Group results in these beds having a distinctive high gamma ray log response. In southern Florida, the Hawthorn Group is subdivided into two formations: the Peace River Formation and the underlying Arcadia Formation.

The contact between the Tamiami Formation and the Peace River Formation occurs at approximately 92 ft bls at the Carica Road site and is marked by a lithological transition downward from fossiliferous limestone to fossiliferous fine-grained sandy limestones that are finely phosphatic. There is a slight down-hole increase in gamma ray activitity at the boundary, which marks an increase in phosphate content.

The upper Peace River Formation sandy limestone interval is approximately 83 ft thick in injection well IW-2, extending downwards to approximately 175 ft bls. The middle and lower parts of the Peace River Formation consist predominantly of olive gray and greenish-gray dolomitic and phosphatic marls and clays with subsidiary limestone beds. The marls and clays are soft (plastically deformable) and have very low permeabilities. The Peace River Formation is approximately 192 ft thick in the SCWRF area.

The boundary between the Peace River Formation and the underlying Arcadia Formation occurs at approximately 284 ft bls in exploratory well EW-1. The formation boundary is marked in western Collier County by a downward lithological change from dark greenish-gray phosphatic clay to very light gray to yellowish-gray fossiliferous limestone. The transition from clay to limestone is marked by an increase in resistivity and decrease in gamma ray activity.

The Arcadia Formation contains a complex assemblage of carbonate and siliciclastic units including light-colored fossiliferous limestones, clay and marl beds, and olive gray and yellowish-brown dolostone beds. The limestones consist mostly of fossiliferous mudstones to grainstones, in which mollusks are the most abundant fossil types. The dolostone in the Arcadia Formation is mostly finely crystalline and very hard. Dolostone beds in the Arcadia Formation may have very high permeabilities due to the presence of fractures. The Arcadia Formation is approximately 400 ft thick in western Collier County.

Exploratory well EW-1 was drilled within the Arcadia Formation to a total depth of 422 ft bls. The underlying Suwannee Limestone is anticipated to be present at a depth of a approximately 700 ft bls at the Carica Road site.

2.2 Hydrogeology

The hydrogeology of western Collier County is characterized by three major aquifer systems: the surficial aquifer system, the intermediate aquifer system, and the Floridan aquifer system. These three principal aquifer systems, when combined, extend from the water table, located several feet below land surface, to near the top of the Cedar Keys Formation, located at approximately 3,400 ft bls. The three principal aquifer systems contain numerous individual aquifers that are separated by intervening low permeability confining units. The hydrogeology of the Carica Road site is summarized below:

Surficial Aquifer System

The surficial aquifer system at the Carica Road site extends from the water table down to a depth of approximately 175 ft bls. The base of the surficial aquifer system is located at the top of the uppermost thick continuous marl or clay bed in the upper Peace River Formation. The surficial aquifer system thus includes the Pamlico Sand, undifferentiated Fort Thompson Formation and Tamiami Formation, and part of the Peace River Formation. Thin marl units form semi-confining beds at several horizons within the aquifer system.

The surficial aquifer system includes the water table aquifer, lower Tamiami aquifer, and the sandstone aquifer. The lower Tamiami aquifer has good water quality and well yields and is used for public water supply in the project site vicinity. The lower Tamiami aquifer is also very widely used for residential landscape irrigation.

Intermediate Aquifer System

The intermediate aquifer system (sometimes referred to as the intermediate confining unit) lies between the surficial aquifer system and the Floridan aquifer system. The intermediate aquifer system at the Carica Road site extends from approximately 284 ft bls to approximately 700 feet bls. The base of the intermediate aquifer system is placed at the bottom of the lowest apparently continuous marl or clay bed in the lower Arcadia Formation. The intermediate aquifer system contains several limestone aquifers separated by clay or marl confining units. The water in the intermediate aquifer system is brackish and requires desalinization in order to be used as a potable water source.

The uppermost unit in the intermediate aquifer system is the Hawthorn Zone I aquifer. This aquifer unit is the interval that was evaluated as the storage zone for an ASR well. At the Carica Road site, Zone I occurs between 284 and 405 ft bls, for a thickness of 121 feet. The top of the Hawthorn Zone I aquifer was anticipated to be found at a depth of approximately 370 feet bls, based on data from nearby wells. The top of the Hawthorn Zone I aquifer thus occurs approximately 86 feet shallower than anticipated based on regional data.

Interbedded clays and fine-grained limestones present between 405 and 422 ft bls are the upper part of the confining unit that separates the Hawthorn Zone I aquifer from the underlying Hawthorn Zone II aquifer.

Section 3
Exploratory Well Construction

3.1 Injection well system design

Exploratory well EW-1 was designed, constructed, and tested in accordance with requirements of Chapter 62-528 FAC. An application for an injection well construction permit was submitted to the FDEP on December 23, 2003. The FDEP construction permit (No. 225211-001-UC) was issued on August 18, 2004, and is valid for five years. An as-built well construction diagram is provided in **Figure 3-1**.

3.2 Site preparation

Exploratory well EW-1 was constructed adjacent to a stormwater retention pond. This pond is normally dry except after rainfall. The drilling contractor, Diversified Drilling Company, began work on September 15, 2004, with mobilization of equipment on site. The drilling site included an aboveground steel drilling mud/water tank and an approximately 60 feet by 80 feet HDPE-lined drilling pad and containment structure.

One shallow (water-table aquifer) monitor well (MW-1) was installed east of well EW-1 on September 16, 2004. The water table aquifer monitor well was installed so that the water table aquifer could be tested during drilling for increases in salinity resulting from spilled saline water. The shallow monitor well was 20 feet deep and were constructed of 2-inch diameter schedule 40 PVC. The bottom 10 feet of the casing was machine-slotted screen, with solid riser to land surface. A quartz sand filter pack was installed around the screen and the remaining annulus was cemented to land surface. The well was sampled weekly by CDM for field measurements of temperature, pH, and specific conductivity, and analysis for chloride concentration. The well was purged prior to sampling ensure collection of representative groundwater samples. The chloride analyses were performed by CDM in house using the argentometric method. Water levels were measured in each well prior to well purging and sampling.

3.3 Exploratory Well Construction

Drilling of exploratory well EW-1 began on September 27, 2004, when a nominal 25-inch borehole was drilled using the and mud rotary method to a depth of 122 ft bls. An 18-inch outer diameter (O.D.) PVC surface casing was set to a depth of 121 feet bls. Pilot hole drilling was then conducted from 122 feet bls to 422 feet bls using a 7-7/8 inch drill bit and mud rotary methods. Originally, pilot hole drilling was anticipated to extend to a depth of approximately 370 feet bls (to the proposed 10-inch casing bottom depth). However, as discussed in Section 2.2, the observed top of the Hawthorn Zone I aquifer was considerably shallower than anticipated. Pilot hole drilling was therefore continued to 422 feet bls in order to confirm the site hydrogeology and determine the appropriate well casing set depth. The drilling of the pilot hole through the Hawthorn Zone I prevented the taking of cores.

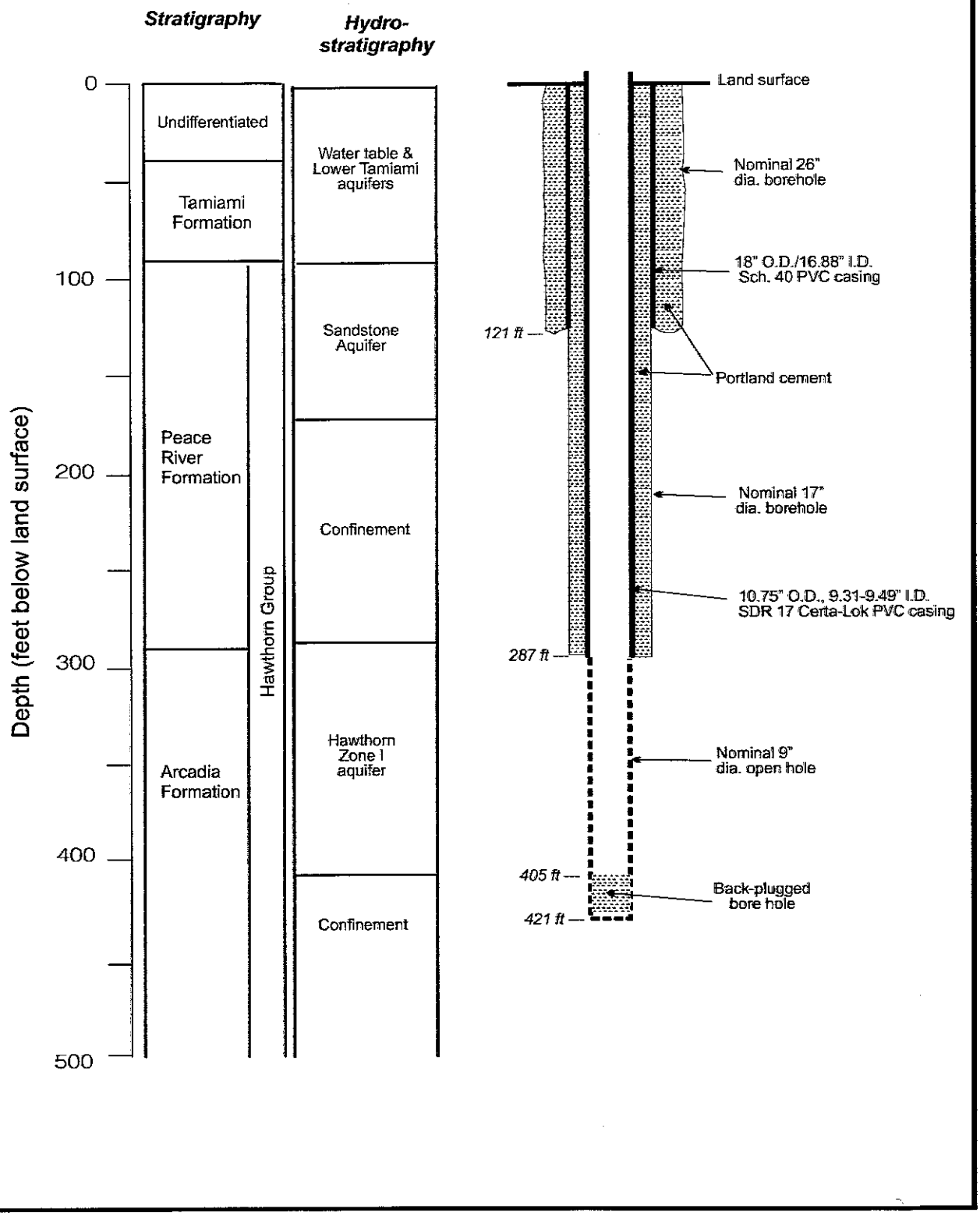


Figure 3-1
Collier County Carica Road ASR
Exploratory Well EW-1 As-Built Construction Diagram

CDM

After completion of the pilot hole, geophysical logging was conducted (caliper, gamma ray, dual-induction, and sonic). A casing seat request was submitted to FDEP on October 11, 2004. The proposed casing seat depth was approved by FDEP on October 12, 2004.

The pilot hole was reamed using a 16-1/2 inch drill bit and mud rotary method to a depth of 288 feet bls. 10-3/4 inch O.D. PVC casing was installed to a depth of 287 feet bls. The casing seat was within hard limestone of the upper Arcadia Formation. The borehole beneath the casing was then drilled using a 9-inch bit to 421 feet bls using reverse air methods. Water samples were collected during reverse air drilling and analyzed for specific conductance and chloride concentration.

A chronology of the well construction and testing is provided in **Table 3-1**.

Table 3-1. Exploratory Well EW-1 Construction Chronology

Date	Event
September 15 to 23, 2004	Mobilization, installation of temporary drilling pad and pit casing.
September 16, 2004	Installed monitor well MW-1.
September 27 to 28, 2004	Drilled 25-inch borehole to 122 ft bls.
September 29, 2004	Installed and cemented 18-inch O.D. PVC casing to 121 ft bls.
October 4 to 7, 2004	Drilled nominal 8-inch borehole to 422 ft bls.
October 8, 2004	Performed geophysical logging of pilot hole.
October 11, 2004	Submitted casing seat request to FDEP.
October 12, 2004	Received approval of casing seat request from FDEP.
October 12 to 14, 2004	Reamed nominal 17-inch borehole to 287 ft bls.
October 18, 2004	Wiper reamed nominal 17-inch diameter borehole to 287 ft bls, reamed nominal 17-inch diameter borehole to 288 ft bls, performed caliper logging of reamed borehole.
October 18, 2004	Installed 10-3/4 inch O.D. PVC casing to 287 feet bls.
October 18 to 19, 2004	Cemented 10-3/4 inch O.D. PVC casing.
October 22 to 26, 2004	Drilled nominal 9-inch diameter pilot hole to 421 ft bls.
October 29, 2004	Performed geophysical logging of casing and borehole.
November 8, 2004	Performed step drawdown test #1.
November 16, 2004	Cemented bottom of borehole from 404 feet bls to 421 feet bls.
November 17, 2004	Performed step drawdown test #2.
November 17, 2004	Sampled well EW-1 and potable water supply at site.
November 18, 2004	Re-measured field water quality parameters from well EW-1.
November 18, 2004	Started demobilization.

3.3.1. Casing and Wellhead

The 18-inch O.D. surface casing installed to 121 feet bls is composed of Schedule 40 PVC. The casing has a wall minimum wall thickness of 0.562-inches and an inner diameter (I.D.) of approximately 16.88 inches. The 10-3/4 inch O.D. casing is composed of SDR-17 Certa-Lok™ PVC, manufactured by CertainTeed, that conforms to ASTM Standard Specification F480-02. The casing has a minimum wall thickness of 0.632 inches and an I.D. of 9.31 to 9.49 inches. The Certa-Lok™ casing consists of 20-foot sections that are connected with a coupling and spline-locking system. Centralizers were installed around the casing at seven

depths, including two feet above the casing bottom (285 feet bls), at 49 feet above casing bottom (238 feet bls), and every 40 feet thereafter (depths of 198, 158, 118, 78, 38 feet bls).

The temporary wellhead consists of a stainless steel blind flange with stainless steel bolts, and a 1/4-inch brass sample port and ball valve.

3.3.2 Cementing Program

Casings were cemented in place with ASTM Type II (high sulfate resistance) Portland cement. The 18-inch surface casing was cemented in one stage and the 10-inch well was cemented in two stages. The first cement stage for each casing was pressure grouted. The second stage for the 10-inch well casing had only 14 feet of fill, so the cement was poured into the annular space from land surface.

The 18-inch casing was cemented at the bottom with neat cement (approximately 14 feet from 122 to 108 feet bls) and with 6% bentonite (gel) cement above (from 108 feet bls to land surface). The 10-inch casing was cemented at the bottom with neat cement (approximately 114 feet from 288 to 174 feet bls) and with 6% bentonite cement from 174 to 14 feet bls. The remaining 14 feet was topped off with neat cement.

A summary of the casing cement program is provided in **Table 3-2.**

Table 3-2. Exploratory Well EW-1 Casing Cement Summary

Stage No.	Date	Cement Mixture	Barrels Pumped	Cubic Feet Pumped	Sacks Pumped	Tag Depth (ft bls)	Feet of fill
18-inch diameter casing							
1	9/29/04	6% gel	4.9	208	120	0	122
		Neat	0.7	27	23		
10-inch diameter casing							
1	10/18/04	6% gel	31	14	176	14	274
		Neat	24	16	126		
2	10/19/04	Neat	2.2	12	10	0	14

3.3.3. Water Table Aquifer Well Monitoring Data

The water quality and elevation monitoring data for monitor well MW-1 are compiled in **Table 3-3.** The salinity in the monitor well, as evaluated using specific conductivity and chloride concentration, have fluctuated over the monitoring period, but there is no evidence that well construction activities have had an adverse impact on the water table aquifer at the Carica Road site.

Table 3-3. Water table Aquifer Well Monitoring Data						
Date	Depth to Water (Feet Below TOC)	Water Table Elevation (Ft NGVD)*	Temperature (°C)	Specific Conductance (µmhos/Cm)	pH (Std. Units)	Chloride (mg/L)
9/17/04	4.91	8.41	28.2	503	8.0	40
9/23/04	4.43	8.89	28.6	590	7.8	40
9/30/04	4.94	8.38	28.3	733	7.8	70
10/6/04	4.78	8.54	28.3	838	8.1	100
10/14/04	5.01	8.31	28.1	733	8.1	62
10/20/04	5.39	7.93	27.7	691	8.1	56
10/29/04	5.60	7.72	27.4	338	--	36
11/12/04	6.09	7.23	27.1	549	8.1	44
11/17/04	6.35	6.97	--	438	--	44
* Estimated, based on land surface elevation of 10.6 ft from site plans and measured well stickup of 2.72 ft.						

Section 4
Hydrogeological Testing Program

Data were collected during the drilling of exploratory well EW-1 on the geology and hydrogeology of the penetrated strata. The data were utilized to determine casing depths and to evaluate potential storage and confining zones.

4.1. Formation Sampling

Samples of the well cuttings were collected the drilling of the pilot hole. The cuttings were described on site by CDM hydrogeologists using a hand lens or magnifying glass. Selected samples were tested for mineralogy using dilute hydrochloric acid and Alizarin red stain. The cuttings from the proposed storage zone and adjoining confining strata were subsequently examined in greater detail using a stereomicroscope. The geologist log for exploratory well EW-1 is included in Appendix D.

4.2. Thin Section Petrography

Thin section petrography is a common technique used to analyze the composition and textures of rock samples. Thin sections are approximately 30 µm thick, transparent slices of rock, which are examined using a polarized-light microscope. Thin sections of five cutting samples (308-320, 320-342, 342-350, 373-380, and 405-412 ft bls) from the exploratory well were examined as part of this investigation. The samples were from the ASR storage zone and underlying confining strata. The objectives of the thin section analyses were to obtain information on the lithology and composition of the main rock types encountered in the core, particularly mineralogy, texture, porosity (abundance and type), and apparent hydraulic conductivity.

The thin sections were prepared by Burnham Petrographics, Inc. The samples were impregnated with blue epoxy to highlight pore spaces. The thin section analyses were performed by CDM staff using a Zeiss Incident-Light Photomicroscope with a built in camera. The porosity of samples were visually estimated. Limestones were categorized using the limestone classification scheme of Dunham (1962). The apparent hydraulic conductivity of samples was qualitatively evaluated by the size and abundance of pores and the degree to which pores appeared to be interconnected.

The cuttings samples from the proposed ASR storage zone (287 - 400 ft bls) consists predominantly of limestone, which is composed of calcite. Quartz sand grains are present in varying abundances (5 to 20%). Very fine to fine sand-sized, rounded phosphate (carbonate fluorapatite) grains are present at low abundances (1-3%) throughout the storage zone strata. Other trace minerals include dolomite and iron sulfides (pyrite). The latter is constitutes much less than 1% of rock volume.

The storage zone cuttings consists of two main lithologies (rock types), quartz fossil wackestones and quartz bioclast grainstones and packstones. Large fossil fragments, mostly mollusks) are also common in all the examined samples.

Quartz fossil wackestones, as illustrated in **Figure 4-1** consists of fossil fragments and quartz sand grains in a lithified carbonate mud matrix. The visible porosity (macroporosity) is low to moderate (5 - 25%) and consists mostly of moldic pores that formed by the dissolution of aragonitic fossil fragments (mostly mollusks). Quartz fossil wackestones probably have low hydraulic conductivities because the moldic pores do not appear to be well interconnected.

Quartz fossil grainstones and packstone, as illustrated in **Figures 4-2 and 4-3A,** consist essentially of very fine to fine-grained lithified carbonate sands. In packstone samples, by definition, the spaces between the sand grains are largely filled with carbonate mud (Figure 4-2A). The quartz fossil packstones may have high moldic porosities, but likely have low hydraulic conductivities. In the grainstones samples, the intergranular spaces are largely open pores (Figure 4-2B and 4-3C). Grainstone samples tend to have high total porosities (intergranular and moldic) and likely also have high hydraulic conductivites because the pore spaces are well interconnected. High porosity grainstones are common in all the cutting samples from the storage zone, and will likely accept the bulk of the stored water as matrix flow (as opposed to conduit flow).

An uncommon cutting type in the storage zone, found only in the 308 to 320 ft bls sample, was a quartz and dolomite-rich silt, which also contains several volume percent iron sulfide minerals (**Figure 4-3B**). The dolomitic silt cuttings may be material that fell into the borehole from the overlying confining strata.

The cutting sample from the underlying confining strata also consists of clay and silt- and very-fine sand-sized quartz, phosphate, and calcitic (fossil fragments) grains and dolomite crystals (**Figure 4-4**). Some of the very-fined grained matrix has a high microporoity, as evidenced by the absorption of blue epoxy during thin section preparation (Figure 4-4A), whereas other cuttings appear to be very tight (Figure 4-4B).

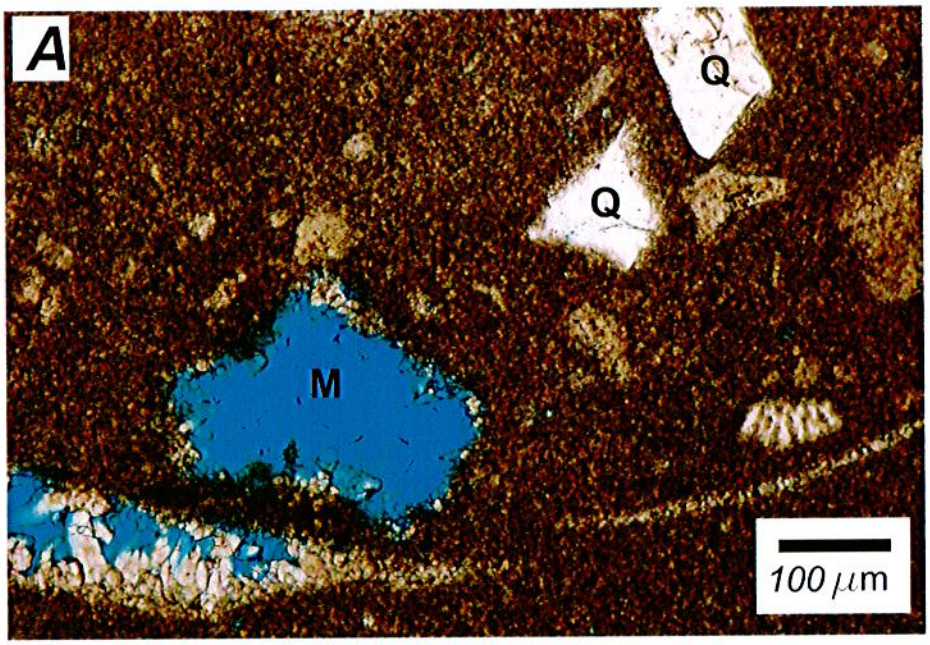
4.3. Groundwater Sampling

Reverse-Air Water Sampling

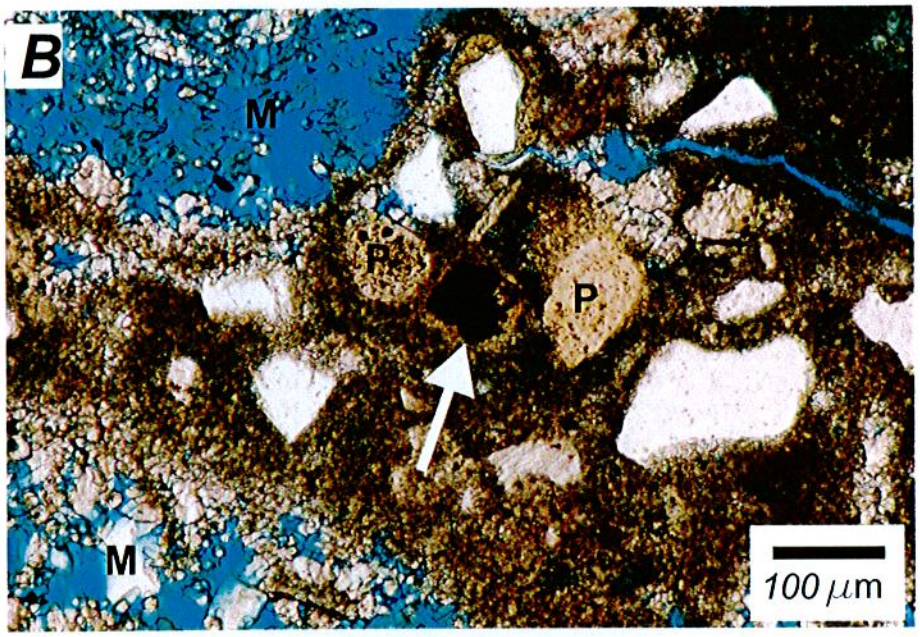
Water samples were collected from the discharge line every 20 feet during reverse-air drilling of the borehole beneath the 10-inch casing. The objective of reverse-air discharge sampling was to obtain data on changes in salinity with depth. The reverse-air discharge samples were tested in the field for specific conductance and salinity, and subsequently analyzed for chloride concentration by CDM using the argentometric method.

The reverse-air discharge water quality data for a given depth is not necessarily representative of the formation water quality at that depth because of mixing with water produced higher in the borehole. Some vertical mixing may also have occurred through the pilot hole. Changes in the composition of the reverse-air discharge can provide qualitative information on formation water quality.

The reverse-air discharge data is compiled in **Table 4-1**. Chloride concentrations in reverse-air discharge samples ranged from 720 to 800 mg/L. Chloride concentrations decreased slightly between 301 and 321 feet bls, but remained relatively constant thereafter. Based on the results of the reverse-air discharge sampling, the Hawthorn Zone I salinity appears to be relatively uniform with depth.



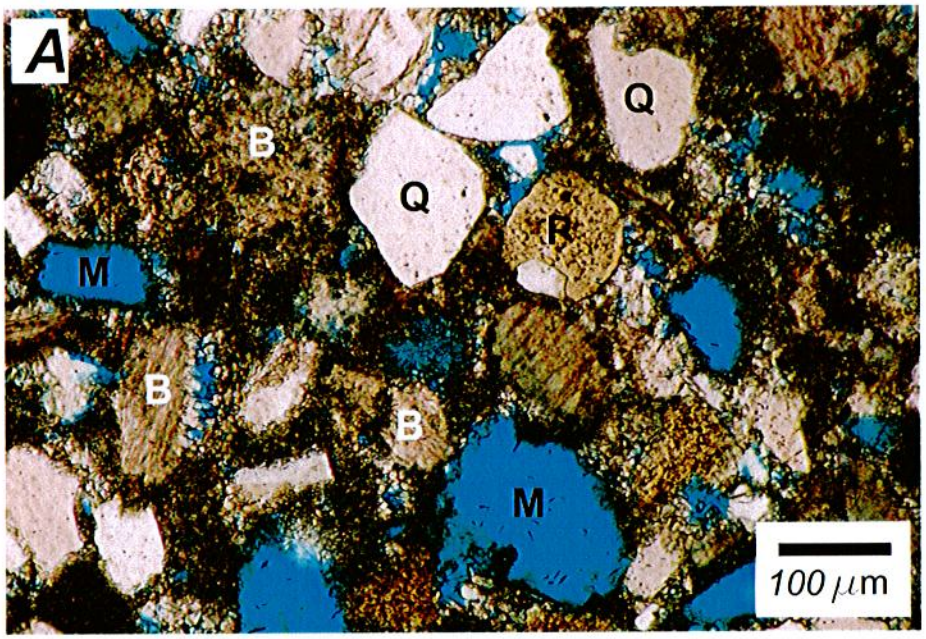
308 - 320 ft bls. Limestone - quartz fossil wackestone. The limestone consists of fossil fragments, quartz sand grains (Q) and moldic pores (M) after aragonitic mollusk fragments. Pore spaces are filled with blue epoxy. The grains are surrounded by lithified carbonate mud (micrite; dark brown material).



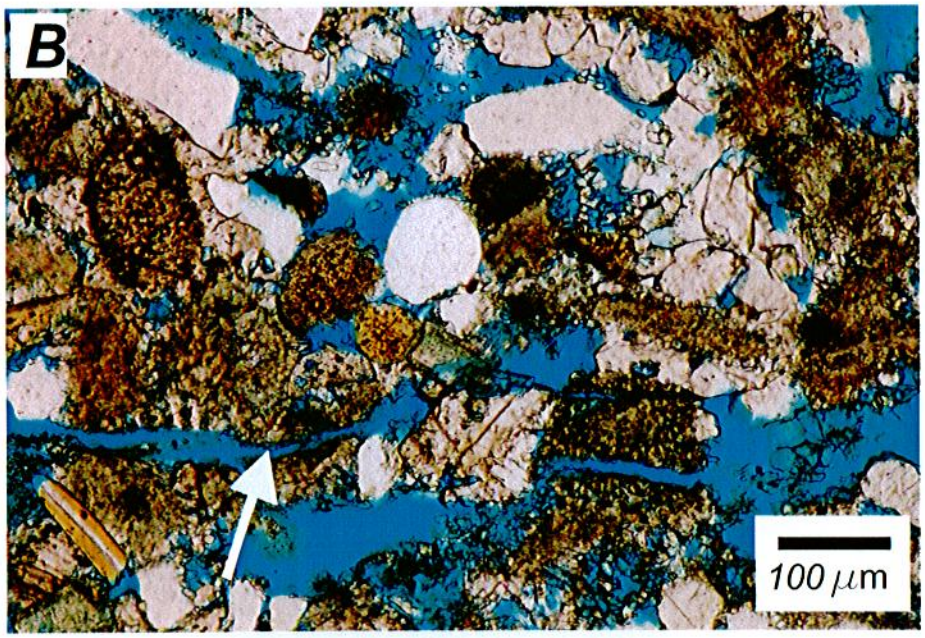
308 - 320 ft bls. Limestone - quartz fossil wackestone. Moldic pores (M) are partially filled with calcite cement. Phosphate sand grains (P) are present, including one with an abundance of an iron sulfide mineral (arrow).

C:/work/carica/carica thin sections.cdr 11/16/04 MALIVA

Figure 4-1
Collier County Carica ASR
Thin section photomicrographs - storage zone



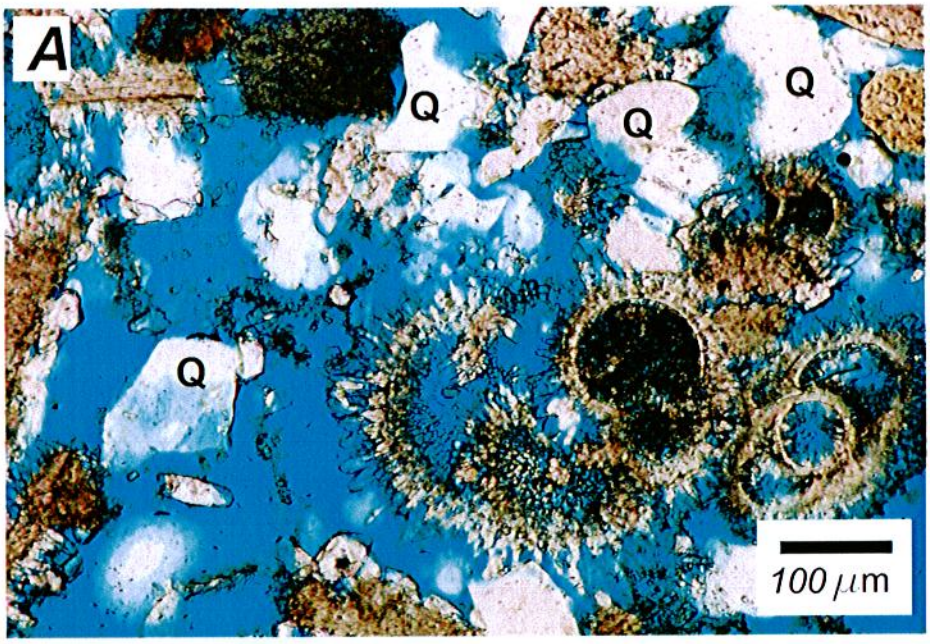
308 - 320 ft bls. Limestone quartz bioclast packstone. Limestone consists most of sand-sized grains, including bioclasts (B, rounded fossil fragments), quartz (Q) and phosphate (P) grains. Moldic pores (M) after aragonitic bioclasts are present. The intergranular space is filled with carbonate mud, which would result in a relatively low hydraulic conductivity.



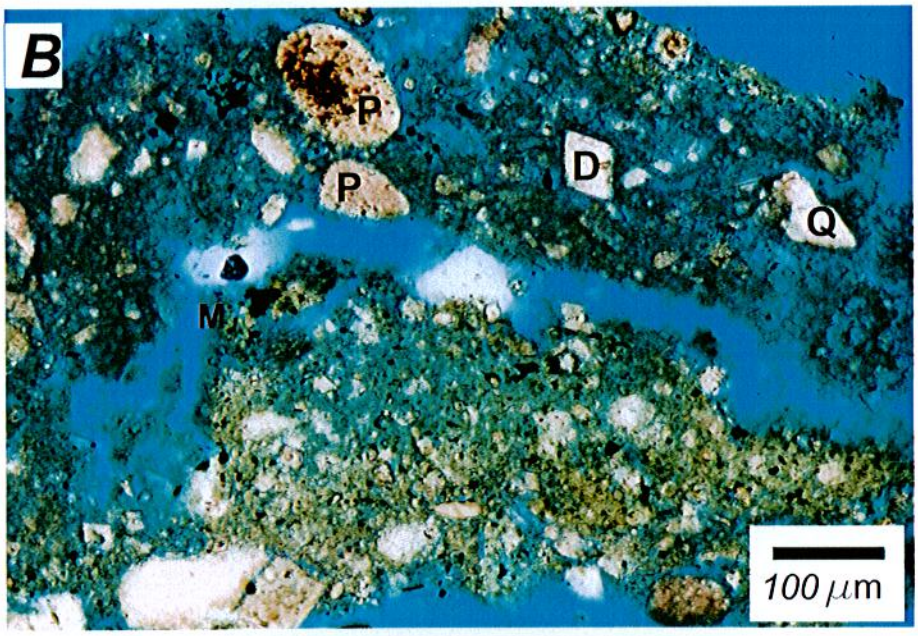
320 - 342 ft bls. Limestone quartz bioclast grainstone.The intergranular pore spaces are largely open and the limestone likely has a moderate to high hydraulic conductivity. The fractures present in the sample (arrow)may have been produced during drilling.

C:/work/carica/carica thin sections.cdr 11/16/04 MALIVA

Figure 4-2
Collier County Carica ASR
Thin section photomicrographs - storage zone



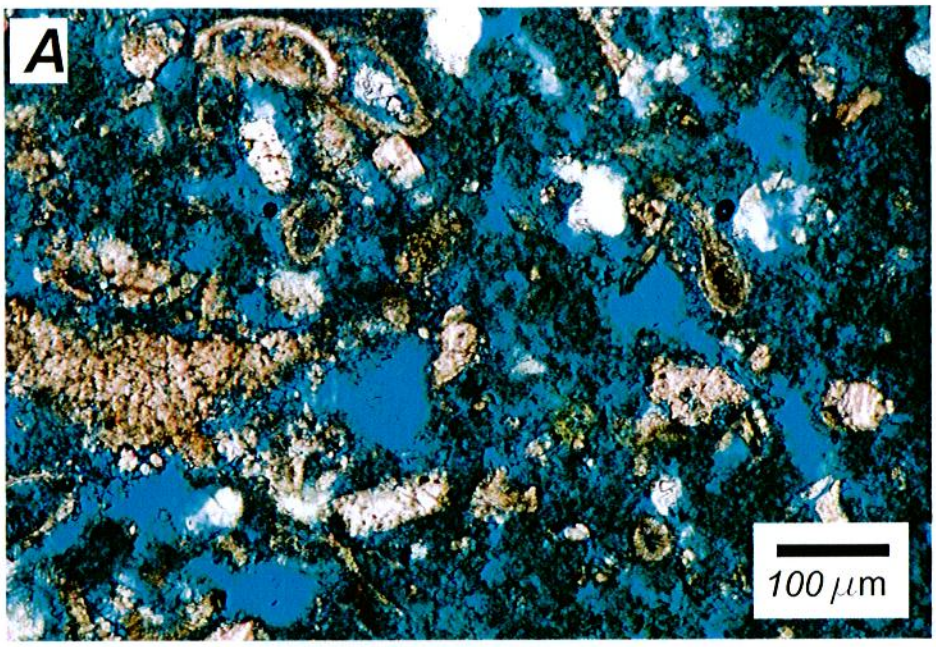
320 - 342 ft bls. Limestone quartz bioclast grainstone. The limestone has a very high intergranular porosity and likely high hydraulic conductivity. A planktonic foraminifera is present in the lower right corner and quartz sand grains (Q) are common.



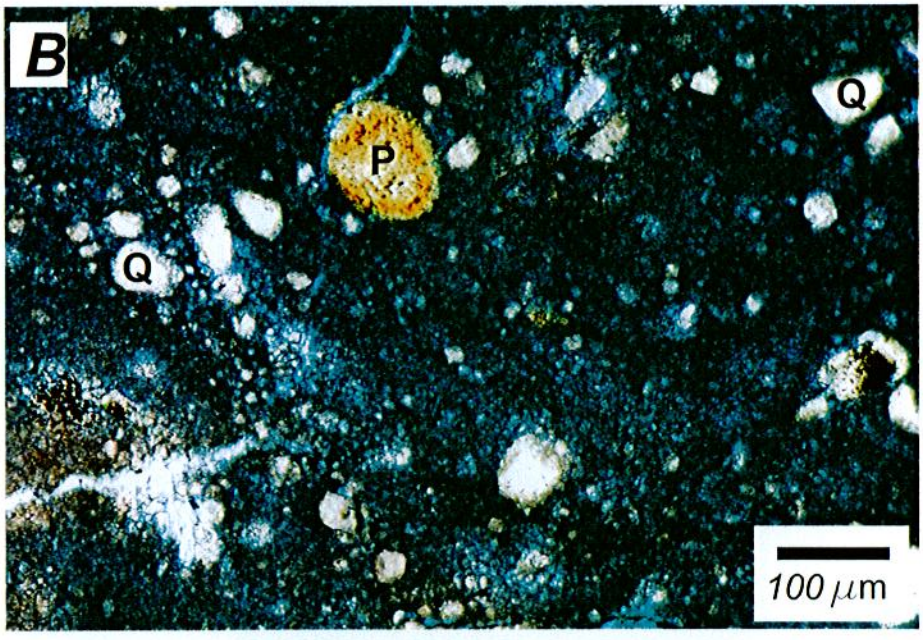
308 - 320 ft bls. Silty limestone or marl. Uncommon rock type for storage zone, which may be material that fell into the well from above (overlying confinement). The sample contains phosphate grains (P), quartz silt and sand (Q), dolomite crystals (D) and finely crystalline iron sulfides (black specks).

C:/work/carica/carica thin sections.cdr 11/16/04 MALIVA

Figure 4-3
Collier County Carica ASR
Thin section photomicrographs - storage zone



405 - 412 ft bls. Silty limestone - peloid fossil wackestone. Sample has a high microporosity as evident by the absorption of blue epoxy into the limestone matrix. Overall hydraulic conductivity is likely low.



405 - 412 ft bls. Dolomitic limestone/marl. Sample contains quartz silt (Q) and phosphate sand grains (P). The hydraulic conductivity is likely very low.

C:/work/carica/carica thin sections.cdr 11/16/04 MALIVA

Figure 4-4
Collier County Carica ASR
Thin section photomicrographs - underlying confining zone

Table 4-1. Reverse-Air Discharge Water Quality Data						
Date	Time	Depth (ft bls)	Conductivity (µmhos)	Chloride (mg/l)	Salinity (mg/l)	Sample Point*
10/22/04	1510	301	2324	800	1.2	RAD
10/22/04	1517	301	389	--	0.2	TOC
10/25/04	0947	321	2345	740	1.2	RAD
10/25/04	1140	341	2175	740	1.1	RAD
10/25/04	1144	341	2189	740	1.1	RAD
10/25/04	1153	--	2276	700	1.1	TOC
10/25/04	1316	361	2440	760	1.3	RAD
10/25/04	1521	381	2466	740	1.3	RAD
10/25/04	1539	--	2348	--	1.2	TOC
10/25/04	1630	401	2455	740	1.3	RAD
10/26/04	0951	421	2407	740	1.2	RAD
10/26/04	1126	--	2308	720	1.2	TOC
* RAD = Reverse Air Discharge, TOC = Top of Casing.						

Exploratory Well and Potable Supply Sampling

Water samples were collected from the completed exploratory well and from onsite potable supply on November 17, 2004. The samples were analyzed for Florida primary and secondary drinking water standards per Rules 62-550.310 & 62.550.320 FAC (except dioxin, asbestos, acrylamide, and epichlohydrin), and additional geochemical parameters.

The results of the water quality sampling are summarized in **Table 4-2** and a copy of the laboratory analytical report is included in **Appendix E**. Sampling of both the exploratory well and the on-site potable water was conducted for regulatory compliance purposes and to evaluate compatibility of the potable water and the formation water. No constituents were detected at concentrations greater than their respective regulatory threshold concentrations. An evaluation of water compatibility is provided in Section 5.

Table 4-2. Summary of water quality data		
Parameter	**Concentration**	
	Storage zone water	**Source (potable) water**
Chloride (mg/L)	750	49
Sodium (mg/L)	330	37.1
Sulfate (mg/L)	83	71
Total dissolved solids (mg/L)	1,690	270
Bicarbonate (mg/L)	205	39
Calcium (mg/L)	75	25
Magnesium (mg/L)	63.0	4.7

4.4 Geophysical Logging Program

Borehole geophysical surveys are performed by lowering sensing devices attached to a wireline into the borehole and recording various physical properties of the borehole. The geophysical logging program implemented during the construction and testing of exploratory well EW-1 was designed to collect information on the hydrogeology of penetrated strata, data on borehole geometry and volume that would assist in the setting and cementing of well casing, and evaluating the integrity of the casing cements. All geophysical logs were run by MV Geophysical. CDM field geologists witnessed all geophysical logging. A summary of all borehole geophysical logs run during the construction and testing of exploratory well EW-1 is provided in **Table 4-3.** Interpretations of the geophysical logs are included in **Appendix F.** Copies of the geophysical logs are included in **Appendix G.**

Table 4-3. Exploratory Well EW-1 Summary of Geophysical Logs

Date	Construction Phase	Depth (feet bls)	Geophysical logs
October 8, 2004	Nominal 8" borehole	0 – 422	Caliper, gamma ray, dual induction, sonic
October 18, 2004	Reamed nominal 17" borehole	0 – 288	Caliper
October 29, 2004	10" Casing	0 – 287	Caliper, gamma ray.
October 29, 2004	Nominal 9" borehole	287 – 421	Caliper, gamma ray, borehole compensated sonic with VDL, dual induction, fluid conductivity, temperature, and flowmeter.

Fluid conductivity, temperature, and flowmeter logs were performed both under static (non-flowing) and dynamic (flowing conditions). The following conclusions were made based on the geophysical logs:

- The top of the Hawthorn Zone I aquifer is at a depth of approximately 280 feet bls, based on gamma and dual induction log response.
- Most of the water produced within the open borehole of the exploratory well (below the casing depth of 287 feet bls), is produced between 287 and approximately 320 feet bls. The lower portion of the open borehole (beneath 320 feet bls) appears to yield significantly less water than the upper portion.
- The dual induction log indicates that formation water salinity does not appear to increase with depth in the proposed storage zone and upper part of the underlying confining zone.

4.5 Step Drawdown Testing

Two step drawdown tests were performed. Test #1 was performed on November 8, 2004, prior to plugging of the bottom of the borehole, and Test #2 was performed on November 17, 2004, subsequent to plugging of the bottom of the borehole. Copies of step drawdown test logs are included in Appendix F.

On October 29, 2004, the static water level was measured at 17.0 feet above land surface using an electronic water level meter in a 22-foot PVC pipe temporarily installed in the well for geophysical logging purposes.

On November 8, 2004, a submersible pump was installed within the well and the well head was configured with a discharge hose and pressure transducer port. The static water level was calculated at 17.25 feet above land surface, based on a pressure reading of 7.1 psi at 0.85 feet above land surface. Test # 1 consisted of three steps pumping at 277 gpm, 442 gpm, and between 477 and 504 gpm. The third step was at a fluctuating pumping rates because of difficulties in maintaining a constant rate. Maximum drawdown during the three steps was 34.7, 62.4, and 73.1 feet bls, respectively. Specific capacity for these three steps were 7.6, 6.9, and 6.9 gpm/ft, respectively.

Test #2 consisted of pumping at a constant rate of 420 gpm. The specific capacity for this pumping rate was 7.3 gpm/ft. The transmissivity of the proposed ASR storage zone is calculated to be 17,000 gpd/ft, Cooper and Jacob (1946) modification of the Theis (1935) non-equilibrium equation.

Section 5
Compatibility Analysis

A compatibility analysis was performed to evaluate the potential for adverse fluid-mixing and fluid-rock interactions resulting from the recharge of potable water into the Hawthorn Zone I aquifer system. The compatibility analysis includes two components: (1) a qualitative evaluation of potential geochemical reactions, and (2) quantitative modeling of fluid-mixing.

5.1 Qualitative Analysis

The main geochemical processes involved in potable water ASR systems are oxidation-reduction (redox) reactions, caused by the introduction of oxygenated water into an anoxic aquifer, and carbonate dissolution and precipitation reactions, caused by the different saturation states of the potable recharge and native formation waters. The introduction of oxygen into the aquifer would cause the oxidation and precipitation of reduced dissolved metal species, particularly Fe^{+2} and Mn^{+2}. The precipitation of iron and manganese oxides and hydroxides can clogs pores. However, as the total concentration of reduced metal is typically no more than several mg/L in brackish Hawthorn Zone I aquifer water, the amount of potential porosity reduction is very small.

A more significant concern is the potential for adverse redox reactions between oxygenated recharge water and reduced aquifer minerals and native water. Increased arsenic concentrations were detected in recovered water from five ASR sites in south Florida, which may be due to the oxidation and dissolution of finely disseminated arsenic-bearing pyrite or organic matter (Arthur *et al.*, 2000; 2001) or the partial dissolution of the host limestone. Of particular concern is that the arsenic concentrations of some recovered water samples exceeded the new arsenic maximum contaminant level (MCL) of 10 µg/L. However, it appears as though the arsenic concentration of water recovered from ASR systems decreases over time. Increased uranium concentrations were also detected in the recovered water from two sites, which is thought to have mobilized from the carbonate matrix and/or associated uranium-bearing organic matter (Arthur *et al.*, 2000; Williams et al., 2002). It must be emphasized that the release of arsenic and radionuclides in concentrations of concern has not been reported in most ASR systems. If the cause of the problem is the oxidation of reduced mineral phases, such as pyrites, then preventative measures can be taken, such as the removal of dissolved oxygen from recharge waters.

Potable water is often undersaturated with respect to calcite and dolomite, the main minerals present in carbonate aquifers. Some dissolution of the host rock may occur, which could increase the hardness of the stored water.

5.2 Modeling of Fluid Mixing

The potential for mineral dissolution and precipitation as the result of recharge of potable water into the lower Floridan aquifer storage zone was evaluated using the PHREEQC, a computer program developed by the U.S. Geological Survey for speciation, reaction-path, advective transport, and inverse geochemical calculations (Parkhurst, 1995). The

AquaChem software package, developed by Waterloo Hydrogeologic, was used for pre-processing the water chemistry data.

The saturation state of the end-member solutions (potable water and native storage zone water) with respect to mineral phases of concern are summarized in **Table 5-1**. Saturation state is expressed as the saturation index (SI) defined as:

$$SI = Log\ (IAP/K_{sp})$$

Where: IAP is the ion activity production of the solution and K_{sp} = the solubility product of a mineral. Solutions undersaturated with respect to a mineral have a SI of less than 0. Supersaturated solutions have a SI of greater than 0. The saturation indices of mixed solutions with 10%, 50%, and 90% source water are summarized in **Table 5-1**.

Table 5-1: Fluid-Mixing Modeling Results

Solutions (% storage zone and source waters)					
Storage Zone	100	0	90	50	10
Source	0	100	10	50	90
Mineral	Saturation Index (SI)				
Calcite	0.06	-0.19	0.02	-0.19	-0.32
Aragonite	-0.08	-0.33	-0.12	-0.33	-0.46
Dolomite	0.42	-0.75	0.33	-0.75	-0.74
Gypsum	-1.90	-2.08	-1.91	-2.08	-2.05
Anhydrite	-2.11	-2.30	-2.12	-2.30	-2.27
Rhodochrosite	-2.72	-2.48	-2.73	-2.48	-2.67
Barite	-0.60	-0.67	-0.61	-0.67	-0.67
Fe(OH)3	-5.65	1.45	0.35	1.45	1.41
Goethite	0.24	7.34	6.24	7.34	7.30
Hematite	2.62	16.72	14.62	16.72	16.66
Manganite	-14.66	-2.12	-8.61	-2.11	-6.57
Pyrolusite	-26.23	-3.09	-14.19	-3.07	-11.27
Pyrite	-2.24	-159.66	-86.38	-159.80	-102.02

A key point concerning calculation of mineral saturation states is that values for carbonate minerals are dependent on formation water pH and for iron and manganese minerals on Eh (redox potential). Obtaining accurate values for the latter in particular is notoriously difficult. Caution must therefore be exercised in the quantitative interpretation of the data.

The modeling results indicated that the native storage zone water is at about saturation with respect to calcite, which would be expected in a carbonate aquifer. Typically, pore waters in carbonate aquifers equilibrate with the most soluble carbonate mineral present. The storage zone waters are also supersaturated with respect to the iron oxide/hydroxide minerals minerals goethite and hematite.

The source water (potable water from the pump station) is undersaturated with respect to carbonate and sulfate minerals and is supersaturated with respect to all of the common iron oxide/hydroxide minerals. The source water is also greater undersaturated with respect to iron sulfide minerals, such as pyrite. The introduction of potable water into the storage zone would therefore be expected to initiate the oxidation of sulfide minerals. However,

iron sulfide mineral appears to be present in only trace quantities within the storage zone rock.

The modeling of fluid-mixing indicate that the introduction of potable water into the storage zone would likely cause some dissolution of residual calcite. The introduction of potable water with a high pE would cause the precipitation of dissolved (ferrous) iron in the storage zone water, likely as an iron hydroxide, which precipitate more readily than the less soluble iron oxide minerals. Inasmuch as the iron concentration of the storage zone water is low (0.016 mg/L), iron hydroxide precipitation would be volumetrically minor.

The results of the geochemical modeling indicate no evidence of likely adverse fluid-rock interactions resulting from the introduction of potable water into the proposed ASR storage zone, other than the potential for the oxidation of trace iron minerals. Oxidation of iron sulfide minerals is believed to be the source of arsenic enrichment in stored water. However, it must be emphasized that fluid-mixing and fluid-rock interaction modeling only gives insights into what reactions are thermodynamically favorable to occur, not the degree to which reactions will occur within any given time frame. Whether or not arsenic leaching will be a significant process in an ASR system depends up the concentration of iron sulfide minerals, their location within the aquifer rock, the concentration of arsenic in the minerals, and the kinetics of the alteration reaction, in addition to water chemistry.

Section 6
ASR Feasibility Analysis

6.1. Factors Affecting ASR Feasibility

The storage zone chosen for an ASR should have hydraulic and water quality parameters favorable for high recovery efficiencies. Ideally, the storage zone for ASR systems in brackish water should have the following characteristics:

- Storage zone native water chloride concentrations in the 250 to 3,000 mg/L range, and preferably less than 1,500 mg/L. The storage zone should also not be located close (vertically or horizontally) to more highly saline water.
- Storage zone transmissivity and anticipated ASR well specific capacity to efficiently accept the target well capacity, which for the Carica Road ASR system is 1 MGD or greater.
- Flow into and out of the ASR storage zone should be largely from matrix flow rather than conduit (fracture) flow.
- Adequate confinement should be present above and below the proposed storage zone to minimize vertical flow into and out of the storage zone.
- The potential for adverse reactions between the storage zone rock and water and the stored water should be minimal.

6.2. Carica Road ASR Feasibility Evaluation

The preferred ASR storage zone identified in the Carica Road ASR exploratory well, the Hawthorn Zone I aquifer, extends from 287 to 405 feet bls. This interval consists predominantly of fossiliferous limestone with minor sandy limestone.

The geology from 175 to 280 feet bls consists of silty clay and marl. This lithology will restrict the upward migration of stored water and thus provide excellent upper confinement. Beneath the proposed storage zone, clay was present from 405 to 419 feet bls. The degree of confinement below the proposed storage zone is less certain then the upper confinement, however, flow logs suggest that the top 33 feet of the storage zone (upper third) is significantly more conductive than the lower part. Combined with the observed clays beneath the proposed storage zone, lower confinement is expected to be sufficient.

ASR wells would be expected to have a capacity of a minimum of 1 Mgd (694 gpm). Drawdown of approximately 101 feet below static level (approximately 84 feet bls) would be anticipated with a specific capacity of 6.9 gpm/ft. The ASR wells would have a larger diameter and therefore higher specific capacity than the exploratory well.

The results of the Carica Road ASR exploratory well program indicate that implementation of the ASR system with a target minimum capacity of 1 MGD is feasible at the Carica Road site. The following site-specific factors are favorable for successful implementation of ASR:

- The native storage zone water is only mildly brackish. The chloride and total dissolved solids concentrations are 750 mg/L and 1,690 mg/L, respectively, as measured at the end of the step-drawdown test. Native storage zone water salinity is the most important variable in controlling recovery efficiency in the ASR systems, particularly in the early stages of operation. Chloride concentrations in the 250 to 500 mg/L range are ideal for brackish water ASR systems, however concentration less than 1,000 mg/L are also considered very good. It should be noted that the actual chloride concentration in the Hawthorn Zone I aquifer is significantly lower than anticipated, based on other wells completed in this aquifer in the area.

- The strata immediately above and below the proposed ASR storage zone also contains either mildly brackish or fresh water, based on data from other wells in the area. The lack of more saline water either above or below lessens the probability of significant deterioration of stored water quality by vertical leakage.

- The ASR storage zone interval has an adequate transmissivity specific capacity to efficiently accept the 1 Mgd system design capacity.

- One uncertain issue is the potential for unacceptable leaching of arsenic and radionuclides into stored water. At the present time, it is not possible for any ASR system to determine with any certainty whether or not arsenic or radionuclide leaching in excess of drinking water standards will occur. Examination of cuttings samples from the Carica Road ASR storage zone indicated that minerals that are believed to be the source of arsenic in ASR systems, particularly pyrite, are present in only minute quantities. Arsenic levels in water stored in ASR systems decreases over time and there are pretreatment options to retard arsenic leaching. Furthermore, arsenic leaching in excess of drinking water standards has not been reported in all ASR systems (e.g., Manatee Road).

Section 7
Preliminary ASR System Design

Two injection/recovery ASR wells are proposed for the Carica Road property. An aerial photograph showing the proposed ASR well locations and associated piping is provided in **Figure 7-1**. Proposed well ASR-1 is located near the northeast corner of the pump station property and proposed well ASR-2 is located near the south west corner of the pump station property. Well ASR-2 is located hydraulically downgradient of well ASR-1 (groundwater flows to the southwest) to maximize ASR well recovery efficiency.

Figure 7-1 also shows proposed monitor well locations. The ASR system will have two storage zone monitor wells (SZMW-1 and SZMW-2) and a shallow monitoring well (SMW-1). The storage zone monitor wells will be completed with the same open intervals as the ASR wells. The shallow monitor wells will be completed with open intervals within the sandstone aquifer immediately above the confining zone that separates the Hawthorn Zone I aquifer from the surficial aquifer system. ASR and monitoring well design are discussed below in Section 7.2.

The final ASR system design must be permitted with the FDEP, and is, therefore, subject to change. The following subsections present anticipated system performance, proposed ASR and monitoring well design, proposed pilot (cycle) testing, utility connections, and proposed wellhead completions.

7.1 Anticipated System Performance

7.1.1 ASR System Capacity

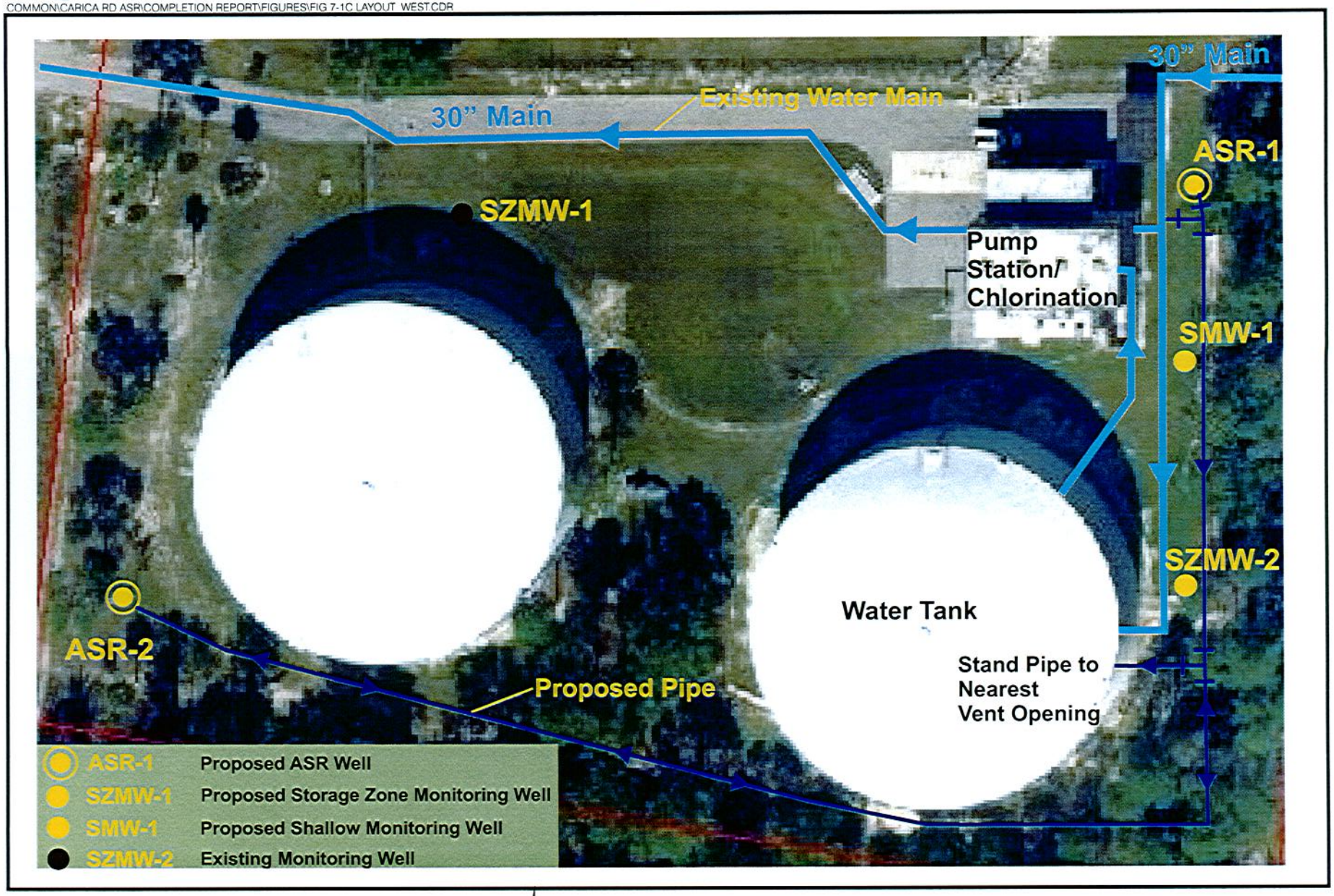
The capacity of a two-well pilot ASR system will depend largely upon the specific capacity of the ASR wells. The target minimum capacity of the ASR system is 1 Mgd (694 gpm) for each well or 2 Mgd (1388 gpm) total. The exploratory well had a specific capacity of approximately 7.3 gpm/ft at a pumping rate of approximately 400 gpm, which corresponds to 95 feet of drawdown at a 1 Mgd pumping rate. Less drawdown of may be expected in a larger diameter ASR well. It should be emphasized that the 1 Mgd capacity for the pilot ASR system is a minimum acceptable rate. It may be possible to operate the system at a higher rate, depending upon the hydraulics of the ASR well.

7.1.2 Recovery Efficiency

The recovery efficiency of the ASR system is dependent upon a number of variables including storage zone water quality, the transmissivity, dispersivity, leakances, nature of hydraulic conductivity (conduit/fracture versus matrix), effective porosity, heterogeneity and anisotropy of the ASR storage zones, and hydraulic gradients. Solute-transport modeling can be used to predict ASR system performance, but the results of such modeling is of dubious value in the absence of data for model calibration. At the current phase of the Carica Road ASR program there is too much uncertainty over the values for the aquifer hydraulic parameters for predictive modeling to have any meaningful quantitative value.

Modeling studies performed by CDM (Maliva *et al.*, 2003) and others (Merritt, 1985; Quinones-Aponte and Wexler, 1995, Yobbi, 1996; 1997) all indicate that storage zone salinity

COMMON\CARICA RD ASR\COMPLETION REPORT\FIGURES\FIG 7-1C LAYOUT_WEST.CDR



CDM

Figure 7-1
Collier County Carica Road ASR
Conceptual Site Layout

is an important, if not the most important, variable in controlling the recovery efficiency of ASR systems in brackish water. Low salinities favor high recovery efficiencies because more mixing of recharge water and native water can occur before the recharge water exceeds drinking water standards.

The low salinities in the proposed Carica Road ASR storage zone, as well as in the adjoining confining strata, are favorable for high recovery efficiencies. Modeling studies suggest that degree of confinement and hydraulic gradient within the storage zone are also factors which strongly effect recovery efficiency. Lithological and flow meter testing suggest that confinement is very good both above and below the proposed storage zone. No data are available regarding the hydraulic gradient in the Hawthorn Zone I aquifer at the site, however, regional data suggest that hydraulic gradient should be acceptable for successful application of ASR.

7.2 ASR and Monitor Well Design

Proposed well construction diagrams for ASR recharge and recovery wells and shallow (deep Surficial aquifer) monitor wells are provided in **Figures 7-2** and **7-3**. **Figure 7-4** presents the proposed well construction for storage zone monitoring well SZMW-2. The design of well SZMW-2 is similar to the exploratory well, but has a smaller diameter (the exploratory well was designed for an optional deeper completion).

ASR Wells

Wells ASR-1 and ASR-2 will be constructed with a 24-inch outer diameter (O.D.) steel surface casing set to approximately 120 ft bls to case off the lower Tamiami aquifer freshwater production zones. The final well casing string will be a nominal 16-inch O.D. (approximately 14-inch inner diameter) SDR-17 PVC casing that will be set to the top of the ASR storage zone at approximately 285 ft bls. The ASR well will be completed with a nominal 13-inch diameter hole to approximately 405 ft bls. The open-hole interval will be drilled using the reverse-air rotary method. The borehole for the surface and final casings will be drilled using the mud-rotary method.

Shallow Monitoring Wells

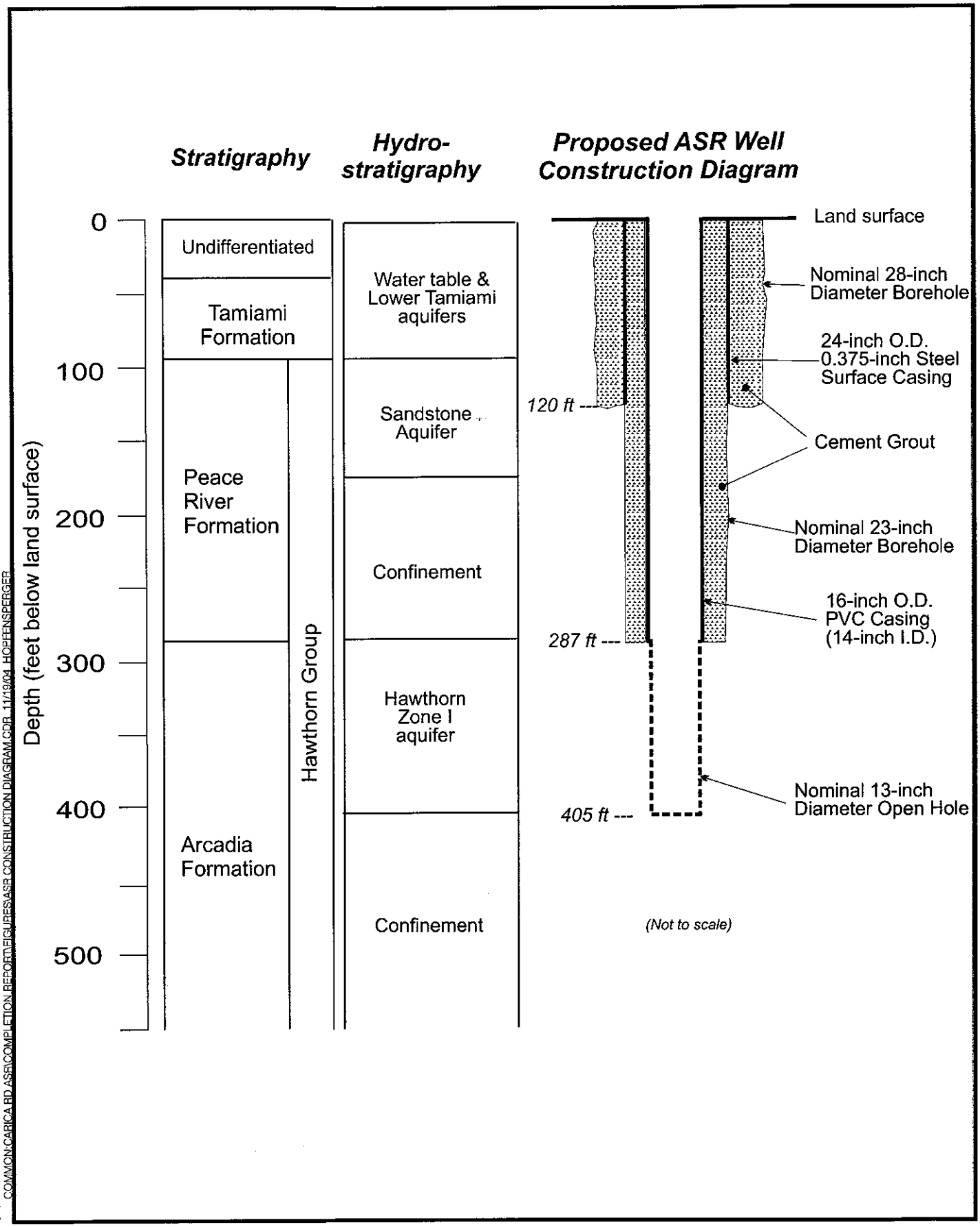
The shallow monitor well will be completed within the sandstone aquifer near the base of the surficial aquifer system, immediately above the confining unit that separates the Hawthorn Zone I aquifer from the Surficial aquifer. The shallow monitor well will be constructed of a 6-inch diameter (approximately 5.8-inch inner diameter) SDR-17 PVC casing set to approximately 145 ft bls. The monitor well will be completed with an nominal 6-inch diameter open hole to approximately 175 ft bls.

Storage Zone Monitoring Wells

Storage zone monitor well SZMW-2 will be constructed with a 6-inch diameter (approximately 5.8-inch inner diameter) SDR-17 PVC casing set to approximately 285 ft bls. The monitor well will be completed with a nominal 6-inch diameter open hole to approximately 405 ft bls.

7.3 Operational (Cycle)Testing Program

As discussed above, operational (cycle) testing serves two purposes) to create a freshwater storage zone or "bubble" within the brackish water aquifer, and 2) to confirm that the ASR



COMMON:CARICA RD ASR\COMPLETION REPORT\FIGURES\ASR CONSTRUCTION DIAGRAM.CDR 11/19/04 HOPFENSPERGER

Figure 7-2
Collier County Carica Road ASR
Proposed ASR Well Construction Diagram

CDM

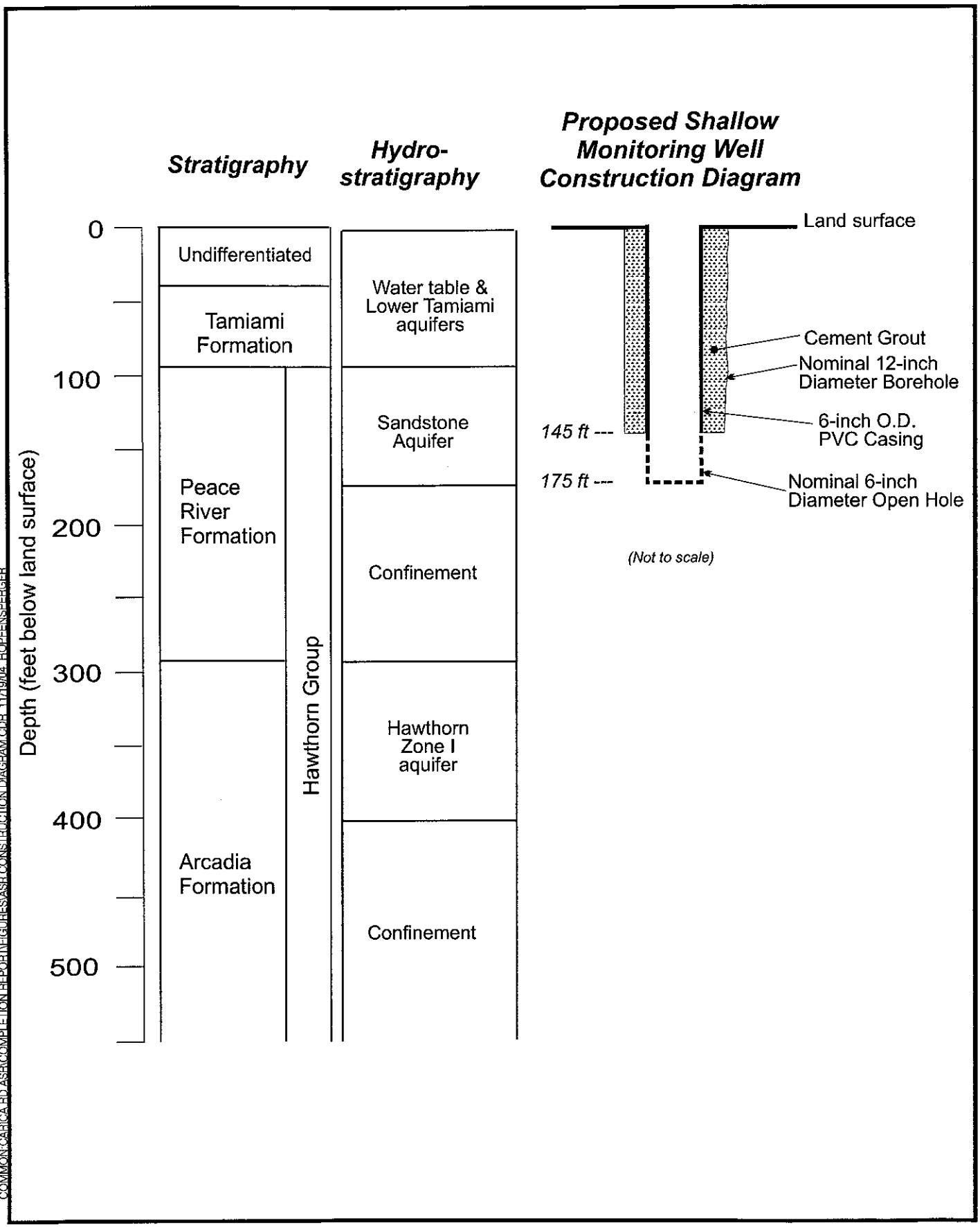
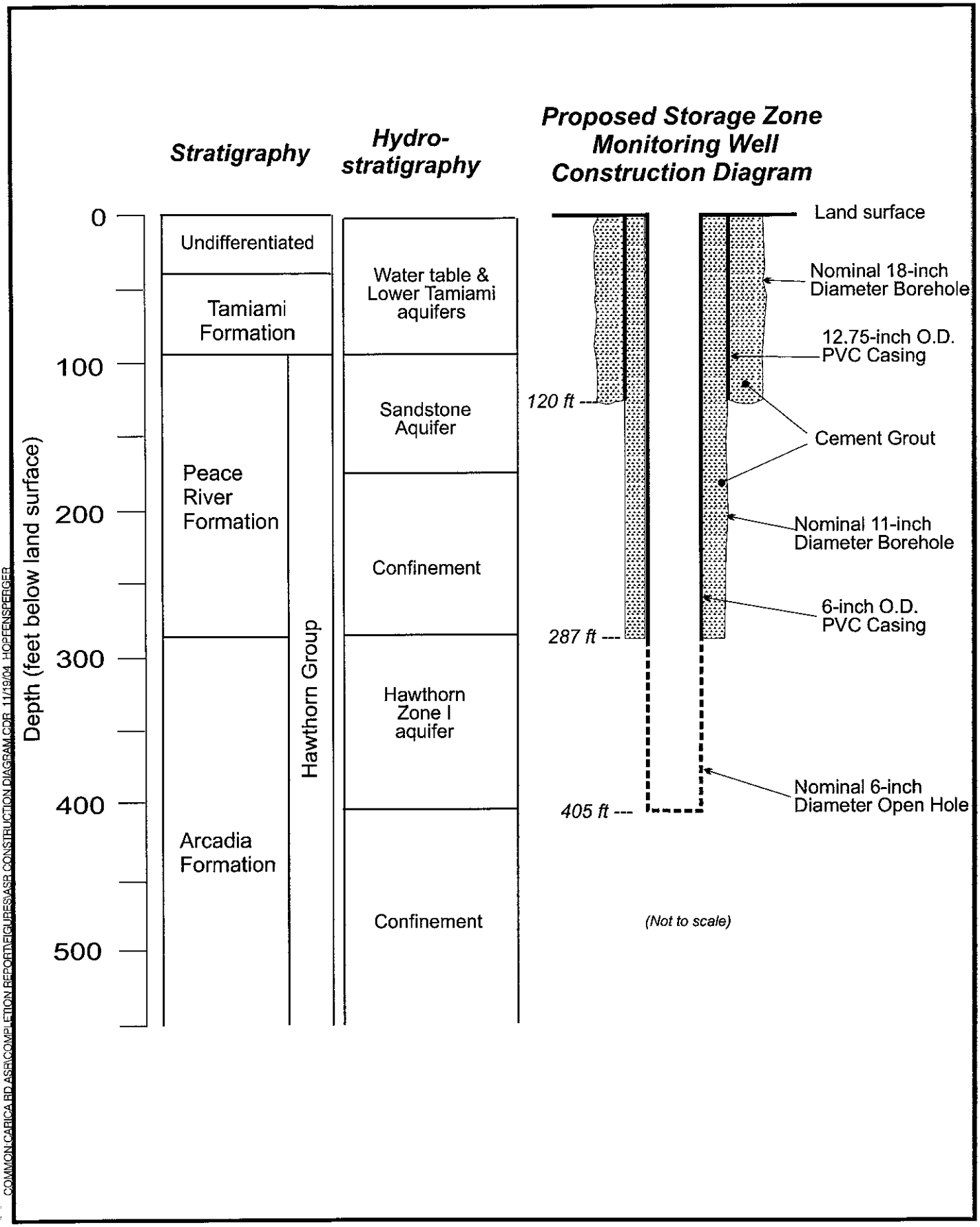


Figure 7-3
Collier County Carica Road ASR
Proposed Shallow Monitor Well Construction Diagram

CDM



COMMON\CARICA RD ASR\COMPLETION REPORT\FIGURES\ASR CONSTRUCTION DIAGRAM.CDR 11/19/04 HOPFENSPERGER

Figure 7-4
Collier County Carica Road ASR
Proposed Storage Zone Monitor Well Construction Diagram

CDM

system will operate as designed and in accordance of FDEP regulations. In order to optimize long-term performance of the ASR system, cycle testing should be conducted consecutively, first at well ASR-1, then at ASR-2. This will enable the freshwater injected into well ASR-1 to migrate towards well ASR-2, prior to injecting freshwater in well ASR-2. This approach is intended to minimize potential trapping of brackish water between the two ASR wells.

A preliminary proposed operational (cycle) testing program for the Carica Road ASR system is presented in **Table 7-1**. The program presents CDM's best understanding of current FDEP requirements, based on our recent experiences permitting other potable water ASR systems. FDEP requirements for ASR systems are constantly evolving, so the final operational testing program may vary from the program presented in Table 7-1.

Table 7-1
Proposed Cycle Testing Program for Carica Road Pilot ASR System

Cycle	Injection (Mgal)	Storage (days)	Recovery (duration varies)
1	20	30	10 Mg or to 250 mg/L chloride*
2	20	30	10 Mg or to 250 mg/L chloride*
3	20	30	10 Mg or to 250 mg/L chloride*
4**	60-90	30+	30 Mg or to 250 Mg/L chloride*
5***	60-90	30+	30 Mg or to 250 Mg/L chloride*
6***	60-90	30+	30 Mg or to 250 Mg/L chloride*
Totals	450		Up to 130 Mg

Notes:
* Recovery will continue to specified volume or 250 mg/L chloride, whichever is reached first.
** Test 4 will simulate actual operating conditions.
*** Tests 5 and 6 will only be performed if required by FDEP

Table 7-2 contains a proposed monitoring schedule for the operational (cycle testing) period. The parameters and frequency included in Table 7-2 were recently agreed to by the FDEP for a near potable water system in Lee County, Florida, and represents the minimal regulatory requirements. The actual monitoring requirements for the Carica Road ASR system would be determined during the FDEP permitting process.

The FDEP will likely additional require four quarterly rounds of analysis of the source water for drinking water standards prior to the start of the operational testing. The recovered water will likely also have to be analyzed for drinking water standards prior to its return to the potable water system.

Table 7-2. Proposed Monitoring Schedule for Operational Testing		
Parameter	**Monitoring Frequency – Injected Water**	**Monitoring Frequency – Recovered Water and Shallow and Storage-zone Monitoring Wells *****
Total dissolved solids (mg/L)	Quarterly	Weekly*
Sodium (mg/L)	Quarterly	Weekly*
Chloride (mg/L)	Quarterly	Weekly*
Sulfate (mg/L)	Quarterly	Weekly*
pH (stnd. Units)	Quarterly	Weekly*
Temperature (°C)	Quarterly	Weekly*
Specific conductance (µmhos/cm)	Quarterly	Weekly*
Arsenic (mg/L)	Quarterly	Weekly*
Total THMs (µg/L)	Quarterly	Weekly*
Calcium (mg/L)	Quarterly	Monthly
Bicarbonate (mg/L)	Quarterly	Monthly
Potassium (mg/L)	Quarterly	Monthly
Magnesium (mg/L)	Quarterly	Monthly
Iron (mg/L)	Quarterly	Monthly
Manganese (mg/L)	Quarterly	Monthly
Gross Alpha (pCi/L)	Quarterly	Monthly**

Notes:

* Weekly sampling to be performed during recharge and recovery periods, sampling to decrease to monthly during storage periods.

** Recovery period only.

*** Monitoring will also be conducted at Well ASR-2 during cycle testing of well ASR-1.

7.4 Utility Connections

A conceptual layout for the ASR system is provided in Figure 7-1. Potable water would be injected into the ASR wells under line pressure from the 30-inch diameter main that runs along the eastern property boundary. A booster pump may be necessary if the line pressure is less than the required wellhead pressure necessary to inject at a rate of approximately 1 Mgd. The recovered water from the ASR wells would discharge to the easternmost on-site storage tank. The most cost-effective option would be a stand-pipe into a vent at the top of the tank, such as was done for the Manatee Road ASR system. A stand-alone disinfection system would not be necessary, as the water from the tanks is disinfected in the pump station before leaving the site. The recovered water from the initial cycle testing could be discharged to an on-site stormwater retention pond via a purge line, so that the tank connection is not made until the operational (cycle) testing results indicate that the ASR system is ready to be brought on line.

7.4 ASR and Monitor Wellheads

A wellhead construction and piping diagram for the ASR well is provided in **Figures 7-5 and 7-6**. The ASR wellhead design will be same a used for the Manatee Road ASR system. Water from the ASR well will be recovered using a vertical turbine pump. Water will be injected into the annulus between the well casing and pump column. Inasmuch as the ASR storage zone is a flowing artesian aquifer, cascading of water during injection will not be an issue. The instrumentation for the ASR well will include an electrical flowmeter, water level probe/pressure transducer, and conductivity probe, all of which will be tied to the County's SCADA system.

The storage zone monitoring wells will be completed with a steel blind flange with sampling and pressure transducer ports. The zone monitoring wells will be equipped with a pressure transducer. A pump will not be necessary for sampling as the well flows at land surface.

The shallow monitoring wells will be equipped with a submersible sampling pump and water level transducer. The FDEP typically requires recording of maximum, minimum and average water levels in monitoring wells for ASR systems and weekly water quality sampling, for at least the operational testing period, hence the need for pressure/water level transducers. Shallow monitoring wellheads will be completed with access for well pump, water level meter, and pressure transducer.

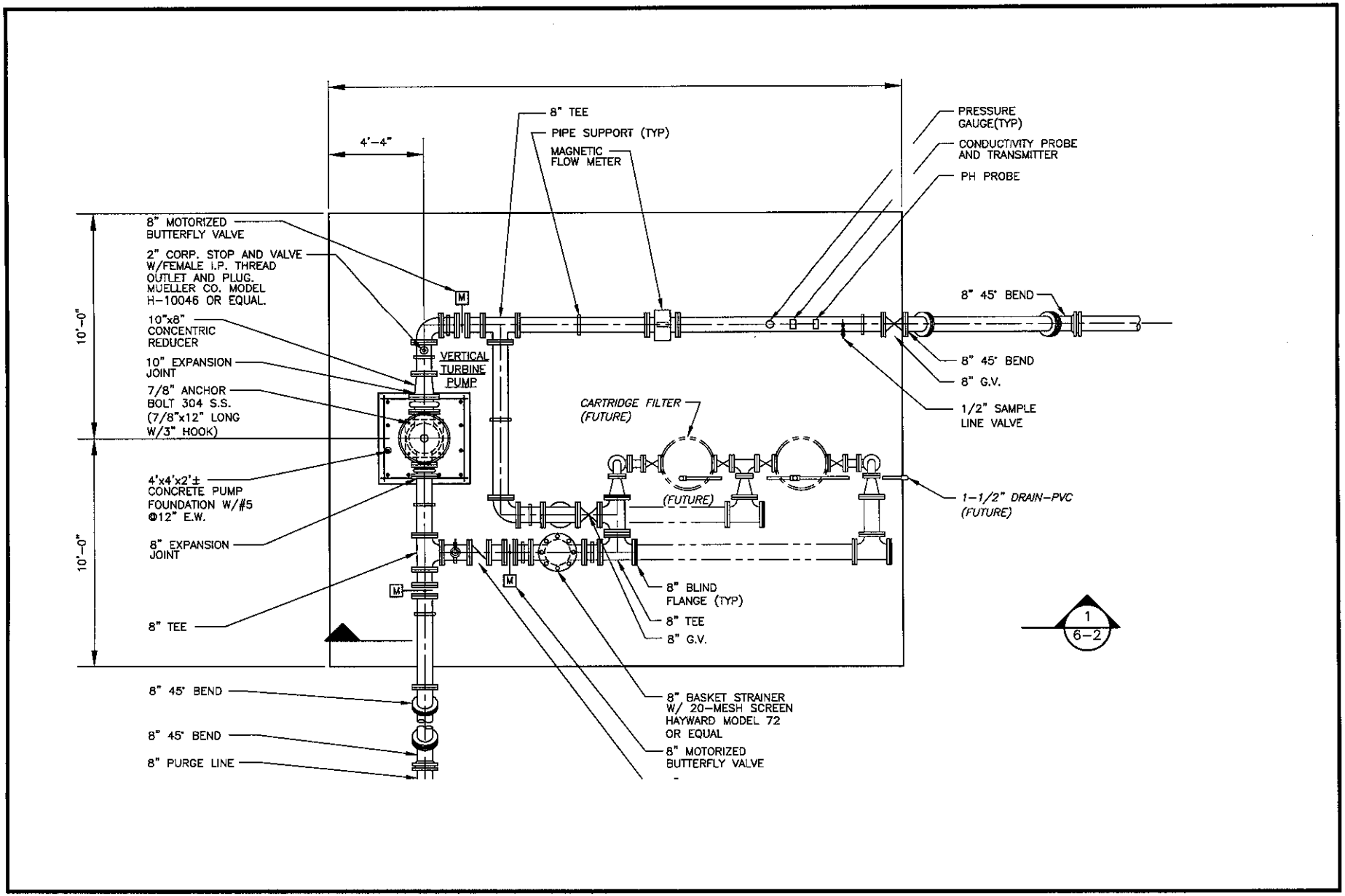
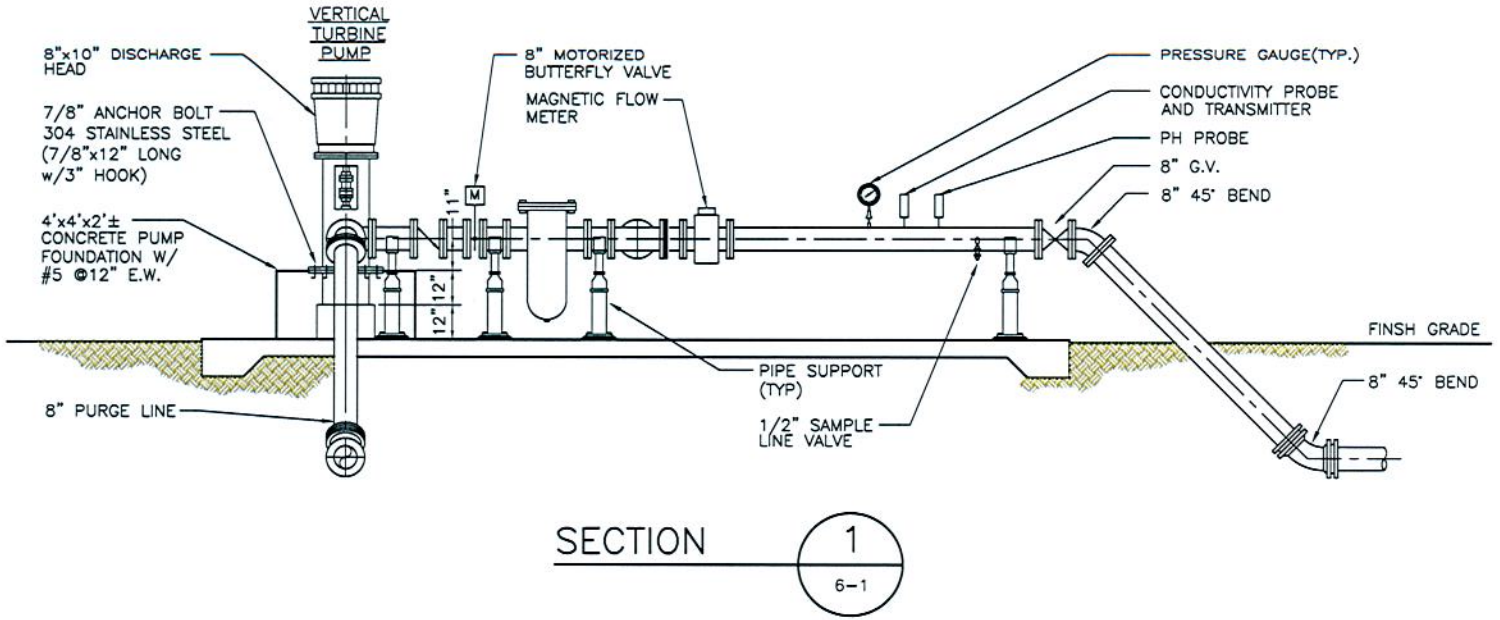


Figure 7-5
Collier County Carica Road ASR
Well Site Layout

CDM



CDM

Figure 7-6
Collier County Carica Road ASR
Wellhead Section

Section 8
Conclusions

Exploratory well EW-1 was constructed tested in accordance with the requirements of the FDEP injection well construction permit and the State of Florida Underground Injection Control (UIC) rules, per Florida Administrative Code (FAC) Chapter 62-528. Hawthorn Zone I aquifer, located between 287 and 405 ft bls, was identified as the preferred ASR storage zone at the Carica Road pump station site.

A water sample from the proposed ASR storage zone had chloride, sodium, and total dissolved solids concentrations of 750, 330, and 1,690 mg/L, respectively. The mildly brackish salinity of the proposed ASR storage zone is favorable for the operation of an ASR well using this zone. The well yielded a specific capacity of approximately 7.3 gpm/ft, which indicates that the proposed storage zone is productive enough for ASR wells with a minimum capacity of 1 million gallon per day (Mgd).

Review of water quality data for the ASR storage zone and potable (recharge) water and geochemical modeling reviewed no concerns regarding geochemical compatibility or regulatory compliance were identified, other than the possibility of arsenic leaching, which is a general concern for ASR systems in Florida. There was no evidence that arsenic leaching would be a problem at the Carica Road site, and it has not been a problem in the Manatee Road ASR system. Nevertheless, the possibility of arsenic leaching in excess of applicable drinking water standards cannot be excluded.

Based on the results of the well installation and testing presented herein, Hawthorn Zone I aquifer appears to be suitable for the successful implementation of ASR at the Carica Road pump station site. Therefore, it is recommended that Collier County proceed with implementation of ASR at the site. The next steps in this process are the preparation of a UIC permit application for two ASR wells, and the design and construction of the ASR system.

Section 9
References

Arthur, J.D., Cowart, J.B., and Dabous, A.A., 2000. Arsenic and Uranium Mobilization During Aquifer Storage and Recovery in the Floridan Aquifer System: Proceedings of the 2000 Ground Water Protection Council Annual Forum, p. 17.

Arthur, J.D., Cowart, J.B., and Dabous, A.A., 2001. Florida Aquifer Storage and Recovery Geochemical Study: Year Three Progress Report: Florida Geological Survey Open File Report 83 46 pp.

Cooper, H.H., Jr., and Jacob, C.E., 1946, A generalized graphical method for evaluating formation constants and summarizing wellfield history: Transactions American Geophysical Union, vol. 27, p. 526-534.

Dunham, R.J., 1962, Classification of Carbonate Rocks According to Depositional Texture, in Ham, W.E. (eds.) Classification of Carbonate Rocks: American Association of Petroleum Geologists Memoir 1, p. 108-121.

Hunter, M.E., 1968, Molluscan guide fossils in late Miocene sediments of southern Florida, Transactions of the Gulf Coast Association of Geological Societies, v. 18, p. 439-450.

Maliva, R., Guo, W., Martin, W.K., and Missimer, T.M., 2003, Evaluation of Hydrogeology and Recovery of ASR in Brackish Water: AWRA's 2003 Annual Water Resources Conference Abstract.

Mansfield, W.C., 1939, Notes on the upper Tertiary and Pleistocene mollusks of peninsular Florida: Florida Geol. Surv. Bull. No. 18, 57 p.

Merritt, M.L., 1985, Subsurface Storage of Freshwater in South Florida: a Digital Analysis of Recoverability: U.S. Geological Survey, Water-Supply Paper No. 2261, 44 pp.

Missimer, T.M., 1992, Stratigraphic relationships of the sediment facies within the Tamiami Formation of Southwest Florida: Proposed intraformational correlations, in T.M. Scott and W.D. Allmon (eds.), The Plio-Pleistocene Stratigraphy and Paleontology of South Florida: Florida Geol. Surv. Spec. Publ. No. 36, p. 63-92.

Parkhurst, D.L., 1995, User's Guide to PHREEQC - a Computer Program for Speciation, Reaction-Path, Advective Transport, and Inverse Geochemical Calculations: U.S. Geological Survey, Water-Resources Investigations Report 95-4227, 143 pp.

Quinones-Aponte, V., and Wexler, E.J., 1995, Preliminary Assessment of Injection, Storage and Recovery of Freshwater in the Lower Hawthorn Aquifer, Cape Coral, Florida: U.S. Geological Survey, Water-Resources Investigations Report 94-4121, 102 pp.

Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986, Hydrogeology Units of Florida: Florida Geol. Surv. Spec. Publ. No. 28, 9 p.

Theis, C.V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage: Transactions American Geophysical Union, vol. 2, p. 519-524.

Williams, H., Cowart, J.B., and Arthur, J.D., 2002. Florida Aquifer Storage and Recovery Geochemical Study, Southwest Florida: Year One and Two Progress Report: Florida Geological Survey Report of Investigations No. 100, 129 pp.

Yobbi, D.K., 1996, Simulation of Subsurface Storage and Recovery of Treated Effluent Injected in a Saline Aquifer, St. Petersburg, Florida: U.S. Geological Survey, Water-Resources Investigations Report 95-4271, 29 pp.

Yobbi, D.K., 1997, Simulation of Subsurface Storage and Recovery of Effluent using Multiple Wells, St. Petersburg, Florida: U.S. Geological Survey, Water-Resources Investigations Report 97-4024, 30 pp.

Appendix A

FDEP Class V ASR Exploratory Well Construction Permit

Department of Environmental Protection

Jeb Bush
Governor

South District
P.O. Box 2549
Fort Myers, Florida 33902-2549

Colleen M. Castille
Secretary

BY ELECTRONIC MAIL:

In the Matter of an
Application for Permit by:

Mr. Paul Mattausch
Collier County Utilities Water Director
8005 Vanderbilt Beach Road Extension
Naples, FL 34120-0000
paulmattausch@colliergov.net

Collier County -UIC/DW
FDEP File No. 225211-001-UC
Carica Road Pump Station
Class V ASR Exploratory Well

NOTICE OF PERMIT ISSUANCE

Enclosed is Permit Number 225211-001-UC to construct one Class V Group Nine Exploratory Well (EW-1), issued pursuant to Section(s) 403.087, Florida Statutes.

Any party to this Order (permit) has the right to seek judicial review of the permit pursuant to Section 120.68, Florida Statutes, by the filing of a Notice of Appeal pursuant to Rule 9.110, Florida Rules of Appellate Procedure, with the Clerk of the Department in the Office of General Counsel, 3900 Commonwealth Boulevard, Mail Station 35, Tallahassee, Florida 32399-3000; and by filing a copy of the Notice of appeal accompanied by the applicable filing fees with the appropriate District Court of Appeal. The Notice of Appeal must be filed within 30 days from the date this Notice is filed with the Clerk of the Department.

Executed in Fort Myers, Florida.

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL PROTECTION

Jon M. Iglehart
Acting Director of District Management

CERTIFICATE OF SERVICE

The undersigned duly designated deputy clerk hereby certifies that this PERMIT and all copies were mailed before the close of business on August 18, 2004 to the listed persons.

Clerk Stamp

FILING AND ACKNOWLEDGMENT

FILED, on this date, pursuant to Section.120.52, Florida Statutes, with the designated Department Clerk, receipt of which is hereby acknowledged.

Mary Fitzgerald 8/18/04

Clerk Date

JMI/JBM/mjf

Enclosure

Copies furnished to:

Nancy Marsh marsh.nancy@epamail.epa.gov
Steve Anderson sanderso@sfwmd.gov
Joe Haberfeld joe.haberfeld@dep.state.fl.us
Ron Reese rsreese@usgs.gov
William S. Manahan, P.E. manahanws@cdm.com
Peter Schalt peterschalt@colliergov.net

Department of Environmental Protection

Jeb Bush
Governor

South District
P.O. Box 2549
Fort Myers, Florida 33902-2549

Colleen M. Castille
Secretary

BY ELECTRONIC MAIL:

PERMIT

PERMITTEE:

Collier County Utilities
8005 Vanderbilt Beach Road Extension
Naples, Florida 34120-0000
paulmattausch@colliergov.net

Collier County – UIC/DW
Permit File Number: 225211-001-UC
Date of Issue: August 18, 2004
Expiration Date: August 17, 2009
County: Collier
Latitude: 26° 14' 35" N
Longitude: 81° 47' 17" W
Section/Town/Range: 3/49S/25E
Project: Carica Road Pump Station
Class V ASR Exploratory Well

This permit is issued under the provisions of Chapter 403 of the Florida Statutes (F.S.) and Rules 62-4, 62-520, 62-528, and 62-550 of the Florida Administrative Code. The above named permittee is hereby authorized to perform the work or operate the facility shown on the application and approved drawing(s), plans, and other documents, attached hereto or on file with the Department and made a part hereof and specifically described as follows:

Construct one Class V Group Nine Exploratory Well (EW-1) to test the feasibility of an Aquifer Storage and Recovery (ASR) injection well system for the storage and recovery of potable water in the Hawthorn aquifer. The basic well design will consist of a 10-inch diameter well to a proposed total depth of approximately 520 feet and cased to approximately 370 feet below land surface (bls). If this zone is found to be a suitable ASR storage zone, the well will be completed as a storage zone monitor well. If the zone is unsuitable then the well will be deepened to approximately 720 feet bls and cased with 4-inch diameter casing to approximately 520 feet bls and completed as a storage zone monitor well. If the results are favorable, the future proposed ASR well would be designed to inject a maximum of 1.5 million gallons per day (MGD).

The Application to Construct/Operate/Abandon Class I, III, or V Injection Well System (DEP Form 62-528.900(1)), was received December 23, 2003, with supporting documents and additional information last received January 20, 2004. The location for this project is 7200 Goodlette-Frank Road, Naples, Collier County, Florida.

Subject to Specific Conditions 1-6.

1. General Criteria:

a. This permit approval is based upon evaluation of the data contained in the application, plans and specifications submitted in support of the application. Any changes, except as provided elsewhere in this permit, must be approved by the Department before implementation.

b. No drilling operations shall begin without an approved disposal site for drill cuttings, fluids or waste. It shall be the Water Well Contractor's responsibility to obtain any necessary Department and local agency approval for disposal prior to the start of construction.

c. No fluid shall be injected without written authorization from the Department. The issuance of this construction permit does not obligate the Department to permit its operation, unless the well, monitoring system and surface appurtenances qualify for an operation permit.

d. No underground injection is allowed that causes or allows movement of fluid into an underground source of drinking water if such fluid movement may cause a violation of any primary drinking water standard or may otherwise adversely affect the health of persons.

e. If historical or archaeological artifacts, such as Indian canoes, are discovered at any time within the project site, the permittee shall notify the FDEP Fort Myers District office and the Bureau of Historic Preservation, Division of Archives, History and Records Management, R. A. Gray Building, Tallahassee, Florida 32301, telephone number (850) 487-2073.

f. Signatories and Certification Requirements

(1) All reports and other submittals required to comply with this permit shall be signed by a person authorized under Rules 62-528.340(1) or (2), F.A.C.

(2) In accordance with Rule 62-528.340(4), F.A.C., all reports shall contain the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based upon my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

g. Plugging/abandonment and Alternate use plans – Permittees who are unable to operate the ASR well to meet its intended purpose shall within 180 days of FDEP notification:

(1) Submit a plugging and abandonment permit application in accordance with Rules 62-528.625 and 62-528.645, F.A.C., or

(2) Submit an alternate use plan for the well. Alternate use may commence after the plan has been approved by the Department, including any necessary permit or permit modifications as required by the Department or any other agency.

h. The permittee shall be aware of and operate under General Conditions F.A.C. Rule 62-528.307(1)(a) through (x). General Conditions are binding upon the permittee and enforceable pursuant to Chapter 403 of the Florida Statutes.

2. Site Requirements

a. A drilling pad shall be provided to collect spillage of contaminants and to support the heaviest load that will be encountered during drilling.

b. The disposal of drilling fluids, cuttings, formation water or waste shall be in a sound environmental manner that avoids violation of surface and ground water quality standards. The disposal method shall be approved by the Department prior to start of construction.

c. Provide specific temporary drilling pad dimensions and design drawings for Department approval prior to commencing construction and shortly after selection of the drilling contractor.

d. The water table monitoring well shall be sampled and analyzed prior to drilling this exploratory well and then weekly thereafter. Sampling shall include specific conductance, pH, chloride, temperature and water level.

3. Construction and Testing Requirements

a. The permittee shall contact the Technical Advisory Committee (TAC) chairman so that he may schedule progress review meetings at appropriate times with the TAC and permittee for the purpose of reviewing the results of tests, geophysical logging, surveys, drilling records and construction problems.

b. All drilling shall be inside a blow out preventer if drilling is extended into the Floridan Aquifer.

c. Department approval and Technical Advisory Committee (TAC) review pursuant to F.A.C. Chapter 62-528 is required for the following stages of construction prior to the final casing seat selection:.

(1) The cementing program, as required in Section 62-528.410(5), Florida Administrative Code, shall be submitted to the Department and the Technical Advisory Committee for review. Cementing shall not commence prior to approval being granted.

(2) All temperature surveys (except for mechanical integrity demonstration) shall be run within 48 hours after cementing.

(3) TAC meetings are scheduled on the 1st Tuesday of each month subject to a 10 working day prior notice and timely receipt (at least 10 working days before scheduled TAC meeting) of critical data by all TAC members. Emergency meetings may be arranged when justified to avoid undue construction delay.

(4) The Engineer of Record shall insure that safe internal pressures are maintained during the cementing of all casings.

(5) The exploratory and monitor well(s) at the site shall be abandoned when no longer usable for their intended purpose, or when posing a potential threat to the quality of the waters of the State. Within 180 days of well abandonment, the permittee shall submit to the Department and the TAC the proposed plugging method, pursuant to Rule 62-528.435, F.A.C.

(6) All salt used in well drilling shall be stored in an environmentally sound manner. Accurate records shall be kept on the amount of salt used.

4. Quality Assurance/Quality Control

a. This permit approval is based upon evaluation of the data contained in the application dated December 23, 2003, and the plans and/or specifications submitted in support of the application. Any changes in the plans and/or technical specifications, except as provided elsewhere in this permit, must be approved by the Department before being implemented.

b. A professional engineer registered pursuant to Chapter 471, Florida Statutes shall be retained throughout the construction period to be responsible for the construction operation and to certify the application, specifications, completion report and other related documents. The Department shall be notified immediately of any change of engineer.

c. Where required by Chapter 471 (P.E.) or Chapter 492 (P.G.) F.S., applicable portions of permit applications and supporting documents that are submitted to the Department for public record shall be signed and sealed by the professional(s) who approved or prepared them.

d. The Department shall be notified immediately of any problems that may seriously hinder compliance with this permit, construction progress, or good construction practice. The Department may require a detailed written report describing the problem, remedial measures taken to assure compliance and measures taken to prevent recurrence of the problem.

e. Issuance of a Class V Exploratory well permit does not obligate the Department to authorize operational testing of the injection or monitor wells, unless the wells qualify for a construction and testing permit applied for by the permittee and issued by the Department.

5. Reporting Requirements

a. All reports and surveys required by this permit must be submitted concurrently to all the numbers of the TAC and to the U.S. EPA. The TAC consists of representatives from these agencies:

Florida Department of Environmental Protection
South District
P.O. Box 2549
Fort Myers, FL 33902-2549

Florida Department of Environmental Protection
Bureau of Water Facilities Regulation
UIC Program, Mail Station 3530
2600 Blair Stone Rd.
Tallahassee, FL 32399-2400

South Florida Water Management District
P.O. Box 24860
West Palm Beach, FL 33416-4860

U.S. Geological Survey
9100 NW 36th Street, Suite 107
Miami, FL 33178

In addition, all reports and surveys required by this permit shall be sent to:

United States Environmental Protection Agency, Region IV
UIC Section
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-8909

b. Members of the TAC and the U.S. EPA shall receive a weekly summary of the daily log kept by the contractor. The weekly reporting period shall run Friday through Thursday and reports shall be mailed each Friday. The report shall include but is not limited to the following:

(1) Description of daily footage drilled by diameter of bit or size of hole opener or reamer being used.

(2) Description of formation and depth encountered; and specific conductance of water samples collected during drilling. Description of work during installation and cementing of casings; include amounts of casing and actual cement used versus calculated volume required.

(3) Lithological description of drill cuttings collected every ten feet or at every change in formation. Description of work and type of testing accomplished, geophysical logging, pumping tests, and coring results.

(4) Description of any construction problems that develop and their status to include a description of what is being done or has been done to correct the problem.

(5) Description of the amount of salt used.

(6) Results of any water quality analyses performed as required by this permit

(7) Copies of the driller's log are to be submitted with the weekly summary.

c. The Department must be notified 72 hours prior to all testing for mechanical integrity on the exploratory well. Testing should begin during daylight hours Monday through Friday.

d. Annotated copies of geophysical logs, lithologic descriptions and logs and water quality data (from drilling and packer tests) must be submitted to TAC and the U.S. EPA for final casing seat selection approvals by the Department.

e. An Evaluation of all test results and geophysical logs must be submitted with all test data.

f. After completion of construction and testing, a final report shall be submitted to the Department, TAC and the U.S. EPA. The report shall include, but not be limited to, all construction and testing information and data with appropriate interpretations. Mill certificates for the casing(s) shall be included in this report. To the extent possible, the transmissivity of the injection zone and maximum capacity within safe pressure limits shall be estimated.

6. The permittee is reminded of the necessity to comply with the pertinent regulations of any other regulatory agency, as well as any county, municipal, and federal regulations applicable to the project. These regulations may include, but not limited to, those of the Federal Emergency Management Agency in implementing flood control measures. This permit should not be construed to imply compliance with the rules and regulations of other regulatory agencies.

Note: In the event of an emergency the permittee shall contact the Department by calling (800) 320-0519. During normal business hours, the permittee shall call (239) 332-6975.

Issued this 18th day of August 2004.

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL PROTECTION

Jon M. Iglehart
Acting Director of
District Management

Appendix B

Weekly Technical Advisory Committee Letters

CDM

9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

September 17, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County Calrica Road ASR Exploratory Well
Weekly Construction Report (Week 1)
September 9 through September 16, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from September 9 at 1900 hours through September 16 at 1900 hours. Diversified Drilling Corporation has mobilized on site and installed the water table aquifer monitor well. Activities scheduled for next week include completion of the containment structure and installation of the 18-inch diameter conductor casing.

Please do not hesitate to contact me should you have any question concerning the reported well construction and testing activities.

Very truly yours,

Robert G. Maliva, Ph.D., P.G.
Senior Project Manager
Camp Dresser & McKee Inc.

Enclosures

pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM

9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

September 24, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County Carica Road ASR Exploratory Well
Weekly Construction Report (Week 2)
September 16 through September 23, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from September 16 at 1900 hours through September 23 at 1900 hours. Diversified Drilling Corporation has constructed the containment structure and set up for drilling (including the drilling platform and mud tank assembly). CDM has sampled the newly installed water table aquifer monitor wells and sampling results are attached. Activities scheduled for next week include installation of the 18-inch diameter conductor casing and initiation of pilot hole drilling.

Please do not hesitate to contact me should you have any question concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures

pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM

9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

October 1, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 3)
September 23 through September 30, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from September 23 at 1900 hours through September 30 at 1900 hours. Activities conducted this week include pilot hole drilling from 0 to 122 feet below land surface (bls), installation and cementing of the 18-inch surface casing to 121 feet bls, and wellhead fabrication. Activities scheduled for next week include 8-inch diameter pilot hole drilling below 122 feet bls to approximately 380 feet bls, geophysical logging of the pilot hole, and reaming of the pilot hole to prepare for setting the 10-inch diameter casing. We will submit a casing seat request to you prior to installing the 10-inch casing (after conducting geophysical logging of the pilot hole).

Please do not hesitate to contact me should you have any question concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures

pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM

9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

October 8, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 4), September 30 through October 7, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from September 30 at 1900 hours through October 7 at 1900 hours. Activities conducted this week include well head fabrication and 8-inch diameter pilot hole drilling from 122 to 422 feet below land surface (bls). Originally, the 8-inch pilot hole drilling was anticipated to extent to approximately 380 feet bls, with the Hawthorn Zone I aquifer (ASR injection zone) anticipated to extend from approximately 380 to 470 feet bls. However, observed lithological conditions varied from expected, and pilot hole drilling proceeded to 422 feet bls. Preliminary data review suggests that a suitable ASR injection zone may be present between 288 feet and 383 feet bls.

Activities scheduled for next week include geophysical logging of the pilot hole, and reaming of the pilot hole to prepare for setting the 10-inch diameter PVC casing. We will submit a casing seat request to you prior to installing the 10-inch casing (after conducting geophysical logging of the pilot hole).

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

October 15, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County - Carica Road ASR Exploratory Well
Weekly Construction Report (Week 5), October 7 through October 14, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from October 7 at 1900 hours through October 14 at 1900 hours. Activities conducted this week include geophysical logging of the 8-inch diameter pilot hole, and reaming of the pilot hole using a 16.5-inch diameter drill bit from 122 feet below land surface (bls) to 287 feet bls. A casing seat request was submitted to you on October 11, 2004 and approved on October 12, 2004.

Activities scheduled for next week include additional reaming of the borehole to approximately 288 feet bls, caliper logging of the reamed borehole, setting and cementing the 10-inch diameter PVC casing to an approximate depth of 287 feet bls, and reaming of the open hole section of the well to a nominal diameter of 10 inches.

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

October 22, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 6), October 14 through October 21, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from October 14 at 1900 hours through October 21 at 1900 hours. Activities conducted this week included wiper reaming and caliper logging of the borehole, installation of 10-5/8 inch O.D. PVC casing to 287 feet below land surface (bls), and cementing of the casing.

Activities scheduled for next week include drilling nominal 10-inch borehole inside the casing to a depth of approximately 422 feet bls, geophysical logging inside the open hole, and step drawdown testing.

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

November 5, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Avenue
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 8), October 28 through November 4, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from October 28 at 1900 hours through November 4 at 1900 hours. Activities conducted this week included geophysical logging inside the well casing and open borehole.

Activities scheduled for next week include step drawdown testing. If results of the step drawdown testing are positive, as expected, then the bottom of the borehole will be cemented, and step drawdown testing conducted again. We expect to cement the bottom of the borehole from approximately 405 feet below land surface (bls) to the total depth of 421 feet bls. The well surface will be completed and groundwater samples will be collected after cementing and step testing.

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

November 12, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Avenue
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 9), November 4 through November 11, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from November 4 at 1900 hours through November 11 at 1900 hours. Activities conducted this week included step drawdown testing. Results of step drawdown testing are consistent with use of the Hawthorn Zone I aquifer as a one million gallons per day (MGD) ASR storage zone.

Activities scheduled for next week include cementing the bottom of the borehole, and a second step drawdown test. We expect to cement the bottom of the borehole from approximately 405 feet below land surface (bls) to the total depth of 421 feet bls. The well surface will be completed and groundwater samples will be collected after cementing and step testing are complete.

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

November 19, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Avenue
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Final Weekly Construction Report (Week 10)
November 11 through November 18, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from November 11 at 1900 hours through November 18 at 1900 hours, and is the final weekly report. Activities conducted this week included cement plugging of the bottom of the borehole (from 404 to 421 feet below land surface), a second step drawdown test, and sampling of the exploratory well. The well construction is complete with the exception of wellhead completion and demobilization.

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM

9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

September 17, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County Calrica Road ASR Exploratory Well
Weekly Construction Report (Week 1)
September 9 through September 16, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from September 9 at 1900 hours through September 16 at 1900 hours. Diversified Drilling Corporation has mobilized on site and installed the water table aquifer monitor well. Activities scheduled for next week include completion of the containment structure and installation of the 18-inch diameter conductor casing.

Please do not hesitate to contact me should you have any question concerning the reported well construction and testing activities.

Very truly yours,

Robert G. Maliva, Ph.D., P.G.
Senior Project Manager
Camp Dresser & McKee Inc.

Enclosures

pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

September 24, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County Carica Road ASR Exploratory Well
Weekly Construction Report (Week 2)
September 16 through September 23, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from September 16 at 1900 hours through September 23 at 1900 hours. Diversified Drilling Corporation has constructed the containment structure and set up for drilling (including the drilling platform and mud tank assembly). CDM has sampled the newly installed water table aquifer monitor wells and sampling results are attached. Activities scheduled for next week include installation of the 18-inch diameter conductor casing and initiation of pilot hole drilling.

Please do not hesitate to contact me should you have any question concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures

pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM

9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

October 1, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 3)
September 23 through September 30, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from September 23 at 1900 hours through September 30 at 1900 hours. Activities conducted this week include pilot hole drilling from 0 to 122 feet below land surface (bls), installation and cementing of the 18-inch surface casing to 121 feet bls, and wellhead fabrication. Activities scheduled for next week include 8-inch diameter pilot hole drilling below 122 feet bls to approximately 380 feet bls, geophysical logging of the pilot hole, and reaming of the pilot hole to prepare for setting the 10-inch diameter casing. We will submit a casing seat request to you prior to installing the 10-inch casing (after conducting geophysical logging of the pilot hole).

Please do not hesitate to contact me should you have any question concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures

pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

October 8, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 4), September 30 through October 7, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from September 30 at 1900 hours through October 7 at 1900 hours. Activities conducted this week include well head fabrication and 8-inch diameter pilot hole drilling from 122 to 422 feet below land surface (bls). Originally, the 8-inch pilot hole drilling was anticipated to extent to approximately 380 feet bls, with the Hawthorn Zone I aquifer (ASR injection zone) anticipated to extend from approximately 380 to 470 feet bls. However, observed lithological conditions varied from expected, and pilot hole drilling proceeded to 422 feet bls. Preliminary data review suggests that a suitable ASR injection zone may be present between 288 feet and 383 feet bls.

Activities scheduled for next week include geophysical logging of the pilot hole, and reaming of the pilot hole to prepare for setting the 10-inch diameter PVC casing. We will submit a casing seat request to you prior to installing the 10-inch casing (after conducting geophysical logging of the pilot hole).

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

October 15, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 5), October 7 through October 14, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from October 7 at 1900 hours through October 14 at 1900 hours. Activities conducted this week include geophysical logging of the 8-inch diameter pilot hole, and reaming of the pilot hole using a 16.5-inch diameter drill bit from 122 feet below land surface (bls) to 287 feet bls. A casing seat request was submitted to you on October 11, 2004 and approved on October 12, 2004.

Activities scheduled for next week include additional reaming of the borehole to approximately 288 feet bls, caliper logging of the reamed borehole, setting and cementing the 10-inch diameter PVC casing to an approximate depth of 287 feet bls, and reaming of the open hole section of the well to a nominal diameter of 10 inches.

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

October 22, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 6), October 14 through October 21, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from October 14 at 1900 hours through October 21 at 1900 hours. Activities conducted this week included wiper reaming and caliper logging of the borehole, installation of 10-5/8 inch O.D. PVC casing to 287 feet below land surface (bls), and cementing of the casing.

Activities scheduled for next week include drilling nominal 10-inch borehole inside the casing to a depth of approximately 422 feet bls, geophysical logging inside the open hole, and step drawdown testing.

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

October 29, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 7), October 21 through October 28, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from October 21 at 1900 hours through October 28 at 1900 hours. Activities conducted this week included drilling of the borehole via reverse air drilling using a 9-inch drill bit from a depth of 288 feet below land surface (bls) to 421 feet bls. Water samples were collected during reverse air drilling. Preparations were made for geophysical logging of the borehole.

Activities scheduled for next week include geophysical logging inside the open hole, step drawdown testing, and cementing the bottom of the borehole below the storage zone.

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures

pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

October 29, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Street
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 7), October 21 through October 28, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from October 21 at 1900 hours through October 28 at 1900 hours. Activities conducted this week included drilling of the borehole via reverse air drilling using a 9-inch drill bit from a depth of 288 feet below land surface (bls) to 421 feet bls. Water samples were collected during reverse air drilling. Preparations were made for geophysical logging of the borehole.

Activities scheduled for next week include geophysical logging inside the open hole, step drawdown testing, and cementing the bottom of the borehole below the storage zone.

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

November 5, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Avenue
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 8), October 28 through November 4, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from October 28 at 1900 hours through November 4 at 1900 hours. Activities conducted this week included geophysical logging inside the well casing and open borehole.

Activities scheduled for next week include step drawdown testing. If results of the step drawdown testing are positive, as expected, then the bottom of the borehole will be cemented, and step drawdown testing conducted again. We expect to cement the bottom of the borehole from approximately 405 feet below land surface (bls) to the total depth of 421 feet bls. The well surface will be completed and groundwater samples will be collected after cementing and step testing.

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

November 12, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Avenue
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Weekly Construction Report (Week 9), November 4 through November 11, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from November 4 at 1900 hours through November 11 at 1900 hours. Activities conducted this week included step drawdown testing. Results of step drawdown testing are consistent with use of the Hawthorn Zone I aquifer as a one million gallons per day (MGD) ASR storage zone.

Activities scheduled for next week include cementing the bottom of the borehole, and a second step drawdown test. We expect to cement the bottom of the borehole from approximately 405 feet below land surface (bls) to the total depth of 421 feet bls. The well surface will be completed and groundwater samples will be collected after cementing and step testing are complete.

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

CDM
9311 College Parkway, Suite 1
Fort Myers, Florida 33919
tel: 239 432-9494
fax: 239 432-9453

November 19, 2004

Jack Myers, P.G.
Water Facilities
Florida Dept. of Environmental Protection
2295 Victoria Avenue
Fort Myers, FL 33901-3881

Subject: Collier County – Carica Road ASR Exploratory Well
Final Weekly Construction Report (Week 10)
November 11 through November 18, 2004
FDEP File No. 225211-001-UC

Dear Mr. Myers:

CDM is pleased to provide you with the following weekly summary report for the Collier County Carica Road ASR Exploratory Well. This report covers the reporting period from November 11 at 1900 hours through November 18 at 1900 hours, and is the final weekly report. Activities conducted this week included cement plugging of the bottom of the borehole (from 404 to 421 feet below land surface), a second step drawdown test, and sampling of the exploratory well. The well construction is complete with the exception of wellhead completion and demobilization.

Please do not hesitate to contact me should you have any questions concerning the reported well construction and testing activities.

Very truly yours,

Frank P. Winslow

Frank P. Winslow
Project Geologist
Camp Dresser & McKee Inc.

Enclosures
pc. Joe Haberfeld, FDEP- Tallahassee
Nancy Marsh, USEPA
Steve Anderson, SFWMD
Ron Reese, USGS
Pete Schalt, Collier County

Appendix C

Weekly Construction Summaries

CDM

CONSTRUCTION SUMMARY

WELL: EXPLORATORY WELL (EW-1) PROJECT NO.: 6295-40845 PAGE: 1 of 1

SITE LOCATION: CARICA ROAD PERMIT NO.: 225211-001-UC CONTRACTOR: DIVERSIFIED

WEEK NO.: 1 ENDING DATE: 9/16/04

DATE	SHIFT	OBSERVER	ACTIVITY SUMMARY
9/9/04	Day	--	No activity.
9/10/04	Day	--	No activity.
9/11/04	Day	--	No activity.
9/12/04	Day	--	No activity.
9/13/04	Day	--	No activity.
9/14/04	Day	--	No activity.
9/15/04	Day	--	Diversified starting mobilizing equipment on-site.
9/16/04	Day	KPH	Water table aquifer monitor well installed.

CDM

CONSTRUCTION SUMMARY

WELL: Exploratory Well | PROJECT NO.: 6295-40845 | PAGE: 1 of 1

SITE LOCATION: Carica Road | PERMIT NO.: 225211-001-UC | CONTRACTOR: Diversified

WEEK NO.: 2 ENDING DATE: 9/24/04

DATE	SHIFT	OBSERVER	ACTIVITY SUMMARY
9/17/04	Day	KPH	CDM sampled water table aquifer monitor well
9/18/04	Day	---	Weekend, no site activity.
9/19/04	Day	---	Weekend, no site activity.
9/20/04	Day	KPH	Began platform assembly.
9/21/04	Day	KPH	Construction of drilling platform and berm.
9/22/04	Day	KPH	Continued construction of drilling platform.
9/23/04	Day	SAD	Finalized platform and mud tank assembly; collected monitor well water sample.

CDM

CONSTRUCTION SUMMARY

WELL: Exploratory Well | PROJECT NO.: 6295-40845 | PAGE: 1 of 1

SITE LOCATION: Carica Road | PERMIT NO.: 225211-001-UC | CONTRACTOR: Diversified

WEEK NO.: 3 ENDING DATE: 9/30/04

DATE	SHIFT	OBSERVER	ACTIVITY SUMMARY
9/24/04	Day	KPH	No site activity. Drilling to begin 9/27/04.
9/25/04	Day	---	Weekend, no site activity.
9/26/04	Day	---	Weekend, no site activity.
9/27/04	Day	KPH	Drilled 24-inch borehole from 0-73' bls.
9/28/04	Day	KPH	Drilled 24-inch borehole from 73-122' bls.
9/29/04	Day	KW	Installed 18-inch PVC surface casing to 121' bls. 120 bags with 6% gel, 23 bags neat Portland cement pressure pumped.
9/30/04	Day	KW	Worked on wellhead fabrication; cement tagged at 110' bls inside casing; began drilling out cement (110-117' bls), cement at surface in annulus.

CDM

CONSTRUCTION SUMMARY

WELL: Exploratory Well | PROJECT NO.: 6295-40845 | PAGE: 1 of 1

SITE LOCATION: Carica Road | PERMIT NO.: 225211-001-UC | CONTRACTOR: Diversified

WEEK NO.: 4 ENDING DATE: 10/7/04

DATE	SHIFT	OBSERVER	ACTIVITY SUMMARY
10/1/04	Day	---	No site activity, drillers working in shop.
10/2/04	Day	---	Weekend, no site activity.
10/3/04	Day	---	Weekend, no site activity.
10/4/04	Day	KPH	Drilled 8-inch diameter borehole from 122-202' bls.
10/5/04	Day	KPH	Drilled 8-inch diameter borehole from 202-282' bls. Assembled flanged wellhead.
10/6/04	Day	KW	Drilled 8-inch diameter borehole from 282-417' bls. Collected monitoring well sample.
10/7/04	Day	RAS	Drillers repaired drill rig. Drilled 8-inch diameter borehole from 417-422' bls. Circulated mud to prepare for geophysical logging.

CDM

CONSTRUCTION SUMMARY

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 1 of 1

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC CONTRACTOR: Diversified

WEEK NO.: 5 ENDING DATE: 10/14/04

DATE	SHIFT	OBSERVER	ACTIVITY SUMMARY
10/8/04	Day	KPH	Conducted caliper, gamma ray, dual induction, borehole compensated sonic logs of nominal 8-inch diameter pilot hole, 120-420 feet bls.
10/9/04	Day	---	Weekend, no site activity.
10/10/04	Day	---	Weekend, no site activity.
10/11/04	Day	KPH	Conducted rig maintenance; prepared stabilizer and bit to begin reaming hole for 10-inch casing installation.
10/12/04	Day	KLW	Reamed borehole from 120-184 feet bls using 16.5-inch bit.
10/13/04	Day	SAD	Reamed borehole from 184-244 feet bls using 16.5-inch bit.
10/14/04	Day	SAD	Reamed borehole from 244-287 feet bls (to casing seat depth) using 16.5-inch bit.

CDM

CONSTRUCTION SUMMARY

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 1 of 1

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC CONTRACTOR: Diversified

WEEK NO.: 6 ENDING DATE: 10/21/04

DATE	SHIFT	OBSERVER	ACTIVITY SUMMARY
10/15/04	Day	KPH	Conducted rig maintenance, site cleanup, preparation for casing installation.
10/16/04	Day	---	Weekend, no site activity.
10/17/04	Day	---	Weekend, no site activity.
10/18/04	Day	KPH	Wiper reamed borehole from 121-287 feet bls using 16.5-inch bit, reamed borehole from 287-288 feet bls, caliper logged borehole, installed 10-5/8 inch O.D. PVC casing to 287 feet bls, pressure grouted cement from 288 feet bls to 14 feet bls (bottom 114 feet neat cement, upper 160 feet 6% bentonite).
10/19/04	Day	KPH	Grouted with neat cement from 14 feet bls to land surface.
10/20/04	Day	RAS	Drillers prepared for drilling inside casing. Sampled monitoring well.
10/21/04	Day	---	No site activity, driller had family emergency.

CDM

CONSTRUCTION SUMMARY

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 1 of 1

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC CONTRACTOR: Diversified

WEEK NO.: 7 ENDING DATE: 10/28/04

DATE	SHIFT	OBSERVER	ACTIVITY SUMMARY
10/22/04	Day	KPH	Drilled via reverse air using 9-inch bit from 288 feet bls to 301 feet bls. Collected reverse air water quality samples.
10/23/04	Day	---	Weekend, no site activity.
10/24/04	Day	---	Weekend, no site activity.
10/25/04	Day	SAD	Drilled via reverse air using 9-inch bit from 301 feet bls to 401 feet bls. Collected reverse air water quality samples.
10/26/04	Day	SAD	Drilled via reverse air using 9-inch bit from 401 feet bls to 421 feet bls. Collected reverse air water quality samples. Removed drill stem from borehole.
10/27/04	Day	SAD	Drillers prepared for geophysical logging. Unable to do static logging due to insufficient seal. Geophysical logging rescheduled for Friday 10/29/04.
10/28/04	Day	RAS	No site activity by Drillers. Attempted to sample monitoring well, however, site was inaccessible. Will sample monitoring well on Friday 10/29/04.

CDM

CONSTRUCTION SUMMARY

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 1 of 1

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC CONTRACTOR: Diversified

WEEK NO.: 8 ENDING DATE: 11/4/04

DATE	SHIFT	OBSERVER	ACTIVITY SUMMARY
10/29/04	Day	SAD	Conducted geophysical logging inside casing (0 to 288 feet below land surface)and inside open borehole (288 to 421 feet below land surface). Sampled monitoring well.
10/30/04	Day	---	Weekend, no site activity.
10/31/04	Day	---	Weekend, no site activity.
11/01/04	Day	---	Driller not available, no site activity.
11/02/04	Day	---	Driller not available, no site activity.
11/03/04	Day	---	Driller not available, no site activity.
11/04/04	Day	---	Driller not available, no site activity.

CDM

CONSTRUCTION SUMMARY

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 1 of 1

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC CONTRACTOR: Diversified

WEEK NO.: 9 ENDING DATE: 11/11/04

DATE	SHIFT	OBSERVER	ACTIVITY SUMMARY
11/05/04	Day	---	Driller not available, no site activity.
11/06/04	Day	---	Weekend, no site activity.
11/07/04	Day	---	Weekend, no site activity.
11/08/04	Day	KPH	Conducted step drawdown test #1.
11/09/04	Day	---	Driller not available, no site activity.
11/10/04	Day	---	Driller not available, no site activity.
11/11/04	Day	---	Driller not available, no site activity.

CDM

CONSTRUCTION SUMMARY

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 1 of 1

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC CONTRACTOR: Diversified

WEEK NO.: 10 ENDING DATE: 11/18/04

DATE	SHIFT	OBSERVER	ACTIVITY SUMMARY
11/12/04	Day	RAS	Driller not available, sampled monitoring well, measured site locations.
11/13/04	Day	---	Weekend, no site activity.
11/14/04	Day	---	Weekend, no site activity.
11/15/04	Day	---	Driller not available, no site activity.
11/16/04	Day	KPH	Cemented bottom of open hole from 404 ft to 421 ft below land surface (bls).
11/17/04	Day	KPH	Conducted step drawdown test #2. Sampled exploratory well (EW-1) and tap water (TW-1).
11/18/04	Day	KPH	Re-measured field parameters from EW-1. Drillers began demobilization.

Appendix D

Lithologic Log

LITHOLOGICAL LOG
EXPLORATORY WELL

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 1 of

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC SAMPLE TYPE: grab

SAMPLE DESCRIPTION BY: KPH DATE DRILLED: 9/27/04 - 10/704

DEPTH INTERVAL (FEET)	THICK-NESS (FEET)	SAMPLE DESCRIPTION
0 - 8	8	SAND (100%), olive gray (5Y 3/2), quartz, medium- to fine-grained, very well sorted.
8 - 13	5	Shelly LIMESTONE to SHELL (100%), yellowish gray (5Y 8/1), poorly consolidated to unconsolidated shell, primarily mollusks, high apparent permeability/porosity, trace fine-grained phosphate.
13 - 24	11	Sandy LIMESTONE (100%), light olive gray (5Y 6/1), very soft to soft, wackestone, high moldic macroporosity, mollusk fragments, trace fine-grained phosphate, quartz.
24 - 35	11	LIMESTONE (100%), yellowish gray (5Y 8/1), soft to moderately hard, wackestone, high moldic macroporosity, ~1% fine-grained phosphate, fewer mollusk fragments than 13 - 24.
35 - 37	2	CLAY (80%), light olive gray (5Y 6/1), silty, soft, ~1% fine-grained phosphate LIMESTONE (20%), yellowish gray (5Y 8/1), soft to moderately hard, wackestone, high moldic macroporosity, ~1% fine-grained phosphate, fewer mollusk fragments than 13 - 24.
37 - 40	3	LIMESTONE (80%), yellowish gray (5Y 8/1), moderately hard, grainstone, high intergranular and moldic macroporosity, ~1% fine-grained phosphate, abundant mollusks. CLAY (20%), light olive gray (5Y 6/1), silty, soft, ~1% fine-grained phosphate.
40 - 47	7	LIMESTONE (100%), yellowish gray (5Y 8/1), soft to moderately hard, wackestone, high moldic macroporosity, ~1% fine-grained phosphate, fewer mollusk fragments than 13 - 24.
47 - 64	17	LIMESTONE (100%), medium light gray (N6), hard, wackestone, moderate moldic macroporosity, mollusks, quartz, trace fine-grained phosphate.

LITHOLOGICAL LOG
EXPLORATORY WELL

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 2 of

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC SAMPLE TYPE: grab

SAMPLE DESCRIPTION BY: KPH DATE DRILLED: 9/27/04 - 10/7/04

DEPTH INTERVAL (FEET)	THICK-NESS (FEET)	SAMPLE DESCRIPTION
64 - 73	7	LIMESTONE (100%), medium light gray (N7) and yellowish gray (5Y 8/1), hard, wackestone, low to moderate intergranular and moldic macroporosity, mollusks.
73 - 83	10	LIMESTONE (100%), yellowish gray (5Y 8/1), wackestone, very hard, low to moderate moldic macroporosity, trace fine-grained phosphate, mollusk fragments.
83-92	9	LIMESTONE (100%), yellowish gray (5Y 8/1), wackestone, hard to very hard, moderate moldic macroporosity, gastropods, mollusks, trace fine-grained phosphate, quartz.
92 - 99	7	LIMESTONE (100%), yellowish gray (5Y 8/1), wackestone, moderately hard, moderate moldic macroporosity, ~1% fine-grained phosphate, sandy, mollusks.
99 - 108	9	LIMESTONE (100%), yellowish gray (5Y 7/2), wackestone, soft, moderate moldic macroporosity, sandy, ~1% fine-grained phosphate, mollusks.
108 - 116	8	LIMESTONE (100%), yellowish gray (5Y 7/2), wackestone, soft, low to moderate moldic macroporosity, low intergranular macroporosity, trace fine-grained phosphate, minor amounts of mollusk fragments
116 - 122	6	LIMESTONE (100%), yellowish gray (5Y 7/2), wackestone, moderately hard to hard, moderate moldic macroporosity, mollusks, ~1% fine-grained phosphate.
122 - 142	20	LIMESTONE (100%), yellowish gray (5Y 8/1), wackestone, soft to moderately hard, low to moderate moldic macroporosity, mollusks ~1% medium-grained phosphate, sample is 90-95% cement cuttings.
142 - 148	6	LIMESTONE (100%), yellowish gray (5Y 8/1), wackestone, moderately hard to hard, low moldic macroporosity, mollusks, quartz, trace fine-grained phosphate.
148 - 161	13	Sandy LIMESTONE (100%), dusky yellowish gray (5Y 6/4), wackestone, moderately hard, moderate moldic and intergranular macroporosity, mollusks, quartz, echinoids.

LITHOLOGICAL LOG
EXPLORATORY WELL

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 3 of

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC SAMPLE TYPE: grab

SAMPLE DESCRIPTION BY: KPH DATE DRILLED: 9/27/04 - 10/7/04

DEPTH INTERVAL (FEET)	THICK-NESS (FEET)	SAMPLE DESCRIPTION
142 - 148	6	LIMESTONE (100%), yellowish gray (5Y 8/1), wackestone, moderately hard to hard, low moldic macroporosity, mollusks, quartz, trace fine-grained phosphate.
148 - 161	13	Sandy LIMESTONE (100%), dusky yellowish gray (5Y 6/4), wackestone, moderately hard, moderate moldic and intergranular macroporosity, mollusks, quartz, echinoids.
161 - 172	11	LIMESTONE (100%), yellowish gray (5Y 8/1), wackestone, moderately hard to hard, moderate moldic macroporosity, low intergranular macroporosity, trace fine- to medium-grained phosphate, mollusks, quartz.
172 - 175	3	LIMESTONE (100%), yellowish gray (5Y 8/1), wackestone, hard to very hard, mollusks, moderate moldic macroporosity, trace fine-grained phosphate.
175 - 190	15	Silty CLAY (100%), light olive gray (5Y 6/1), soft, silty, ~1% fine-grained phosphate.
190 - 202	12	Silty CLAY (75%), light olive gray (5Y 6/1), soft, silty, ~1% fine-grained phosphate. LIMESTONE (25%), yellowish gray (5Y 8/1), wackestone, moderately hard to hard, moderate to high moldic macroporosity, mollusks, trace fine-grained phosphate.
202 - 204	2	Silty CLAY (80%), greenish gray (5GY 6/1), soft, silty, ~1% fine- to medium-grained phosphate. LIMESTONE (20%), yellowish gray (5Y 8/1), wackestone, hard, low moldic macroporosity, trace medium-grained phosphate, mollusks, echinoids.
204 - 218	14	Silty CLAY (100%), greenish gray (5GY 6/1), soft, silty, ~1% fine- to medium-grained Phosphate.
218 - 223	5	MARL (100%), yellowish gray (5Y 8/1), soft, gritty, ~4% medium- to fine-grained phosphate, silty.

LITHOLOGICAL LOG
EXPLORATORY WELL

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 4 of

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC SAMPLE TYPE: grab

SAMPLE DESCRIPTION BY: KPH DATE DRILLED: 9/27/04 - 10/7/04

DEPTH INTERVAL (FEET)	THICK-NESS (FEET)	SAMPLE DESCRIPTION
218 - 223	5	MARL (100%), yellowish gray (5Y 8/1), soft, gritty, ~4% medium- to fine-grained phosphate, silty.
223 - 234	11	MARL (70%), yellowish gray (5Y 8/1), soft, gritty, ~4% medium- to fine-grained phosphate, silty.
		CLAY (30%), dusky yellowish green (5GY 5/2), soft, sticky, quartz, trace fine-grained phosphate.
234 - 236	2	CLAY (50%), medium gray (N7), soft, tight, quartz, trace medium- to fine-grained phosphate. MARL (50%), yellowish gray (5Y 8/1), soft, gritty, ~4% medium- to fine-grained phosphate, silty.
236 - 260	24	CLAY (100%), medium gray (N7), soft, tight, quartz, trace medium- to fine-grained phosphate.
260 - 280	22	CLAY (100%), dark greenish gray (5GY 4/1), soft, silty, ~2% fine-grained phosphate.
280 - 284	2	Silty CLAY (90%), greenish gray (5GY 6/1), soft, silty, ~2% fine-grained phosphate. LIMESTONE (10%), yellowish gray (5Y 8/1), wackestone, hard, low to moderate moldic macroporosity, ~1% fine-grained phosphate.
284 - 288	4	LIMESTONE (60%), yellowish gray (5Y 8/1), wackestone, hard, low to moderate moldic macroporosity, ~2% fine-grained phosphate. Silty CLAY (40%), greenish gray (5GY 6/1), soft, silty, ~2% fine-grained phosphate. Very low apparent permeability.
288 - 297	9	Dolomitic LIMESTONE (100%), yellowish gray (5Y 8/1 to 5Y 7/2), wackestone, hard, low moldic macroporosity, ~1-3% fine-grained phosphate, low moldic macroporosity, dolomite occurring as microcrystalline masses (< 1.0 cm) and as small(<< 1.0 mm) microcrystalline coating, mollusks. Variable quartz sand. Low Apparent permeability.

LITHOLOGICAL LOG
EXPLORATORY WELL

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 5 of

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC SAMPLE TYPE: grab

SAMPLE DESCRIPTION BY: KPH DATE DRILLED: 9/27/04 - 10/7/04

DEPTH INTERVAL (FEET)	THICK-NESS (FEET)	SAMPLE DESCRIPTION
297 - 308	11	LIMESTONE (100%), yellowish gray (5Y 8/1) and light gray (N7), fossil wackestone, to grainstone, hard, low to moderate moldic and intergranular macroporosity, ~2% fine-grained phosphate, mollusks, less dolomitic (< 1% dolomite) than 288 - 297. Low to moderate apparent permeability.
308 - 320	12	LIMESTONE (100%), yellowish gray (5Y 8/1) and light gray (N7), fossil packstone to grainstone, hard, low to moderate moldic and intergranular macroporosity, ~2% fine-grained phosphate, mollusks, coral, no dolomite. Low to moderate apparent permeability.
320 - 342	22	LIMESTONE (90%), yellowish gray (5Y 8/1) and light gray (N7), fossil packstone to grainstone, hard, low to moderate moldic, intergranular, and intragranular macroporosity, ~2% fine-grained phosphate, mollusks, bryozoansl, no dolomite. SANDSTONE (10%), dusky yellow (5Y 2/4), soft, fine- to medium-grained, quartz, low moldic and intergranular macroporosity, trace fine-grained phosphate. Low to moderate apparent permeability.
342 - 348	6	LIMESTONE (100%), yellowish gray (5Y 8/1), fossil packstone to grainstone, moderate hard to hard, moderate moldic and intergranular macroporosity, mollusks, bryozoans, trace fine-grained phosphate. Moderate apparent permeability.
348 - 350	2	LIMESTONE (85%), yellowish gray (5Y 8/1), fossil packstone to grainstone, moderate hard to hard, low to moderate moldic macroporosity, mollusks, coral trace fine-grained phosphate. Low to moderate apparent permeability. Silty CLAY (15%), light gray (N7), soft, silty, trace fine-grained phosphate
350 - 357	7	LIMESTONE (100%), yellowish gray (5Y 8/1), fossil wackestone to grainstone, moderate hard to hard, moderate moldic and less common intergranular macroporosity, mollusks, trace fine-grained phosphate. Moderate apparent permeability.

LITHOLOGICAL LOG
EXPLORATORY WELL

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 6 of

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC SAMPLE TYPE: grab

SAMPLE DESCRIPTION BY: KPH DATE DRILLED: 9/27/04 - 10/7/04

DEPTH INTERVAL (FEET)	THICK-NESS (FEET)	SAMPLE DESCRIPTION
357 - 362	5	Sandy LIMESTONE to LIMESTONE (100%), yellowish gray (5Y 8/1), quartz fossil wackestone to packstone, hard, low to moderate moldic and intergranular macroporosity, quartz, trace silty white marl, ~1% fine-grained phosphate. Low to moderate apparent permeability.
362 - 373	11	LIMESTONE (100%), yellowish gray (5Y 8/1), fossil packstone to grainstone, moderately hard to hard, low to moderate moldic and intergranular macroporosity, mollusks, ~2% fine-grained phosphate, quartz, trace amounts of light gray silty clay. Low to moderate apparent permeability.
373 - 380	7	LIMESTONE (100%), yellowish gray (5Y 8/1), fossil packstone to grainstone, moderately hard, low to moderate moldic macroporosity, ~3% fine-grained phosphate, trace light gray marly silt, quartz, mollusks. Low to moderate apparent permeability.
380 - 383	3	LIMESTONE (100%), yellowish gray (5Y 8/1), wackestone, hard, low moldic macroporosity, ~2% fine-grained phosphate, mollusks, very fine quartz sand. Low apparent permeability.
383 - 398	15	Sandy LIMESTONE (100%), yellowish gray (5Y 8/1), quartz bioclast wackestone to packstone, moderate hard, quartz, low moldic and intergranular macroporosity, ~2% fine-grained phosphate, mollusks, 10-25% very fine quartz sand. Low apparent permeability.
398 - 405	7	Calcareous SANDSTONE (100%), yellowish gray (5Y 8/1), soft, calcareous, ~3% fine-grained phosphate, quartz, mollusks, low intergranular and moldic macroporosity. Low apparent permeability.
405 - 414	9	SANDSTONE (70%), yellowish gray (5Y 8/1), soft, calcareous, ~3% fine-grained phosphate, quartz, mollusks, low intergranular and moldic macroporosity Silty CLAY (30%), yellowish gray (5Y 8/1), soft, sticky, ~2% fine-grained phosphate. Low apparent permeability.

LITHOLOGICAL LOG
EXPLORATORY WELL

WELL: Exploratory Well PROJECT NO.: 6295-40845 PAGE: 7 of

SITE LOCATION: Carica Road PERMIT NO.: 225211-001-UC SAMPLE TYPE: grab

SAMPLE DESCRIPTION BY: KPH/RAS DATE DRILLED: 9/27/04 - 10/7/04

DEPTH INTERVAL (FEET)	THICK-NESS (FEET)	SAMPLE DESCRIPTION
414 - 416	2	SANDSTONE (50%), yellowish gray (5Y 8/1), soft, calcareous, ~3% fine-grained phosphate, quartz, mollusks, low intergranular and moldic macroporosity. Silty CLAY (50%), yellowish gray (5Y 8/1), soft, sticky, ~2% fine-grained phosphate.
416 - 417	1	Silty CLAY (40%), yellowish gray (5Y 8/1), soft, sticky, ~2% fine-grained phosphate SANDSTONE (30%), yellowish gray (5Y 8/1), soft, calcareous, ~3% fine-grained phosphate, quartz, mollusks, low intergranular and moldic macroporosity. CLAY (30%), light olive gray (5Y 6/1), soft, sticky, quartz, trace fine-grained phosphate.
417 - 419	2	Clay (100%), pale olive (10Y 6/2), soft, sticky, sandy, trace of very fine grained Phosphate.
419 - 419.3	0.3	Clay (100%), light olive gray (5Y 5/2), silty, soft.
419.3 - 422	2.7	Limestone (70%), yellowish gray (5Y 8/1), wackestone, moderately hard, low moldic macroporosity, mollusks. Clay (30%), light olive gray (5Y 5/2), silty, soft.

Appendix E

Storage Zone and Potable Water Laboratory Report

PC&B Environmental Laboratories, Inc.
210 Park Road
Oviedo, FL 32765-8901
PHONE: 407-359-7194
FAX: 407-359-7197

Report of Analysis
Total Trihalomethanes

CLIENT NAME: Camp Dresser & McKee, Inc.
PROJECT NAME: Carica Rd
PROJECT NUMBER:
DATE RECEIVED: 11/16/2004
ANALYTICAL PROTOCOL: EPA 524.2

Lab Reference Number	2041110184-1
Client Sample ID	TW-1
Date/Time Sampled	11/17/2004 00:00
Date/Time Extracted	11/24/2004 00:00
Date/Time Analyzed	11/24/2004 12:36
Sample Matrix (as Received)	DW
Analysis Confirmed	GCMS
Dilution Factor	1
Result Units	ug/l

Chloroform	3.8	*2
Bromodichloromethane	4.7	*2
Dibromochloromethane	2.9	*2
Bromoform	0.5	U*2
TTHM	11.4	*2

U = Undetected. The value preceeding the 'U' is the RL for the analyte, based on dilution. Results reported on a Wet Weight basis.

NELAP- FDOH Certification # E83239

Reviewed by : _____

PC&B Environmental Laboratories, Inc.
210 Park Road
Oviedo, FL 32765-6601
PHONE: 407-359-7184
FAX: 407-359-7197

Report of Analysis
Total Trihalomethanes

CLIENT NAME: Camp Dresser & McKee. Inc.
PROJECT NAME: Carlos Rd
PROJECT NUMBER:
DATE RECEIVED: 11/18/2004
ANALYTICAL PROTOCOL: EPA 524.2

Lab Reference Number	204110183-1	
Client Sample ID	EW-1	
Date/Time Sampled	11/17/2004 00:00	
Date/Time Extracted	11/24/2004 00:00	
Date/Time Analyzed	11/24/2004 15:00	
Sample Matrix (as Received)	DW	
Analysis Confirmed	GCMS	
Dilution Factor	1	
Result Units	ug/l	
Chloroform	0.5	U*2
Bromodichloromethane	0.5	U*2
Dibromochloromethane	0.5	U*2
Bromoform	0.5	U*2
TTHM	0.5	U*2

U = Undetected. The value preceeding the 'U' is the RL for the analyte, based on dilution. Results reported on a Wet Weight basis.
NELAP- FLDOH Certification # E83236

Reviewed by: _____

PC&B Environmental Laboratories, Inc.

210 Park Road
Oviedo, FL 32765-8801
407-359-7194 - (FAX) 407-359-7197

Case Narrative

Frank Winslow
Camp Dresser & McKee, Inc.
9311 College Pkwy, Suite 1
Ft Myers, FL 33919-

CASE NARRATIVE for Work Order: 204110184
Project Number:
Project Name: Carica Rd

This Case Narrative is a summary of events and/or problems encountered with this Work Order.

*1-Analysis for EPA 547 and 531 were performed by Southern Analytical, HRS #84129.
*2-Analysis for EPA 524.2, Cyanide, and NH3 were performed by Environmental Science Corp, DOH #E87487.

Definition of Flags

A	=	Value reported is an average of 2 or more determinations
DL	=	No surrogate result due to dilution or matrix interference.
H	=	Value based on field kit determination, results may not be accurate
I	=	The reported value is between MDL and PQL
J	=	Estimated Value, value not accurate.
J1	=	Estimated value surrogate limits have been exceeded
J4	=	Estimated value matrix interference
K	=	Off scale low
L	=	Off-scale high. Actual value is greater than value given. Above calibration curve.
M	=	Presence of material is verified but not quantified. Should be lab PQL
N	=	Presumptive evidence of presence of material
Q	=	Sample analyzed beyond the accepted holding time.
T	=	Value less than the lab MDL
T2	=	Analysis from an unpreserved or improperly preserved sample
V	=	Analyte was both detected in the method blank and sample.
Y	=	Analysis from an unpreserved or improperly preserved sample

PC&B Environmental Laboratories, Inc.
210 Park Road
Oviedo, FL 32765-8801
PHONE: 407-359-7194
FAX: 407-359-7197

Report of Analysis
Regulated Volatile Organics

CLIENT NAME: Camp Dresser & McKee, Inc.
PROJECT NAME: Carlos Rd
PROJECT NUMBER:
DATE RECEIVED: 11/18/2004
ANALYTICAL PROTOCOL: EPA 524.2

Lab Reference Number	204110184-1
Client Sample ID	TW-1
Date/Time Sampled	11/17/2004
Date/Time Extracted	11/24/2004
Date/Time Analyzed	11/24/2004
Sample Matrix (as Received)	DW
Analysis Confirmed	GCMS
Dilution Factor	1
Result Units	ug/l
Benzene	0.5 U*2
Carbon tetrachloride	0.5 U*2
Chlorobenzene	0.5 U*2
1,2-Dichorobenzene	0.5 U*2
1,4-Dichlorobenzene	0.5 U*2
1,2-Dichloroethane	0.5 U*2
1,1-Dichloroethene	0.5 U*2
cis-1,2-Dichloroethene	0.5 U*2
trans-1,2-Dichloroethene	0.5 U*2
1,2-Dichloropropane	0.5 U*2
Ethylbenzene	0.5 U*2
Methylene chloride	0.5 U*2
Styrene	0.5 U*2
Tetrachloroethene	0.5 U*2
Toluene	0.5 U*2
1,2,4-Trichlorobenzene	0.5 U*2
1,1,1-Trichloroethane	0.5 U*2
1,1,2-Trichloroethane	0.5 U*2
Trichloroethene	0.5 U*2
Vinyl chloride	0.5 U*2
Xylenes, total	0.5 U*2

U = Undetected. The value preceeding the 'U' is the RL for the analyte, based on dilution. Results reported on a Wet Weight basis.

NELAP- FDOH Certification # E83239

Reviewed by : _____

PC&B Environmental Laboratories, Inc.
210 Park Road
Oviedo, FL 32765-8601
PHONE: 407-359-7194
FAX: 407-359-7197

Report of Analysis
EDB/DBCP

CLIENT NAME: Camp Dresser & McKee, Inc.
PROJECT NAME: Carica Rd
PROJECT NUMBER:
DATE RECEIVED: 11/18/2004
ANALYTICAL PROTOCOL: EPA 504/504.1

Lab Reference Number	204110184-1	
Client Sample ID	TW-1	
Date/Time Sampled	11/17/2004	
Date/Time Extracted	11/22/2004	
Date/Time Analyzed	11/22/2004 11:03	
Sample Matrix (as Received)	DW	
Analysis Confirmed	No	
Dilution Factor	1	
Result Units	ug/l	
Ethylene dibromide (EDB)	0.01	U
1,2-Dibromo-3-chloropropane	0.1	U
(Surr) BFB (%)	105	

U = Undetected. The value preceeding the 'U' is the RL for the analyte, based on dilution. Results reported on a Wet Weight basis.

NELAP- FDOH Certification # E83239

Reviewed by : _____

PC&B Environmental Laboratories, Inc.
210 Park Road
Oviedo, FL 32765-8801
PHONE: 407-359-7194
FAX: 407-359-7197

Report of Analysis
Chlorinated Pesticides/PCBs

CLIENT NAME: Camp Dresser & McKee, Inc.
PROJECT NAME: Carlca Rd
PROJECT NUMBER:
DATE RECEIVED: 11/18/2004
ANALYTICAL PROTOCOL: EPA 508

Lab Reference Number	204110184-1
Client Sample ID	TW-1
Date/Time Sampled	11/17/2004
Date/Time Extracted	11/18/2004
Date/Time Analyzed	11/19/2004 19:23
Sample Matrix (as Received)	DW
Analysis Confirmed	No
Dilution Factor	1
Result Units	ug/l
Gamma_BHC (Lindane)	0.02 U
Endrin	0.02 U
Heptachlor	0.02 U
Heptachlor Epoxide	0.02 U
Hexachlorobenzene	0.02 U
Methoxychlor	0.02 U
Toxaphene	1.0 U
Chlordane(technical)	0.8 U
Total PCBs	0.25 U

U = Undetected. The value preceeding the 'U' is the RL for the analyte, based on dilution. Results reported on a Wet Weight basis.

NELAP- FDOH Certification # E83239

Reviewed by : _____

PC&B Environmental Laboratories, Inc.
210 Park Road
Oviedo, FL 32765-8601
PHONE: 407-359-7194
FAX: 407-359-7197

Report of Analysis
Regulated Herbicides

CLIENT NAME: Camp Dresser & McKee, Inc.
PROJECT NAME: Carica Rd
PROJECT NUMBER:
DATE RECEIVED: 11/18/2004
ANALYTICAL PROTOCOL: EPA 515.1

Lab Reference Number	204110184-1
Client Sample ID	TW-1
Date/Time Sampled	11/17/2004
Date/Time Extracted	11/22/2004
Date/Time Analyzed	11/24/2004 15:26
Sample Matrix (as Received)	DW
Analysis Confirmed	No
Dilution Factor	1
Result Units	ug/l
2,4-D	0.05 U
Dalapon	0.05 U
Dinoseb	0.05 U
Picloram	0.05 U
2,4,5-TP (silvex)	0.05 U
PCP	0.05 U

U = Undetected. The value preceeding the 'U' is the RL for the analyte, based on dilution. Results reported on a Wet Weight basis.

NELAP- FDOH Certification # E83239

Reviewed by : _____

PC&B Environmental Laboratories, Inc.
210 Park Road
Oviedo, FL 32765-8801
PHONE: 407-359-7194
FAX: 407-359-7197

Report of Analysis
Regulated Semivolatile Organic

CLIENT NAME: Camp Dresser & McKee, Inc.
PROJECT NAME: Carica Rd
PROJECT NUMBER:
DATE RECEIVED: 11/18/2004
ANALYTICAL PROTOCOL: EPA 525.2

Lab Reference Number	204110184-1
Client Sample ID	TW-1
Date/Time Sampled	11/17/2004
Date/Time Extracted	11/22/2004
Date/Time Analyzed	11/23/2004 16:00
Sample Matrix (as Received)	DW
Analysis Confirmed	GCMS
Dilution Factor	1
Result Units	ug/l
Atrazine	1.0 U
Benzo(a)pyrene	0.1 U
bis(2-ethylhexyl)phthalate	1.0 U
bis(2-ethylhexyl)adipate	1.0 U
Hexachlorocyclopentadiene	1.0 U
Pentachlorophenol	0.4 U
Simazine	1.0 U
Alachlor	1.0 U

U = Undetected. The value preceeding the 'U' is the RL for the analyte, based on dilution. Results reported on a Wet Weight basis.

NELAP- FDOH Certification # E83239

Reviewed by : _____

PC&B Environmental Laboratories, Inc.
210 Park Road
Oviedo, FL 32765-8801
PHONE: 407-359-7194
FAX: 407-359-7197

Report of Analysis
Regulated Carbamate Pesticides

CLIENT NAME: Camp Dresser & McKee, Inc.
PROJECT NAME: Carica Rd
PROJECT NUMBER:
DATE RECEIVED: 11/18/2004
ANALYTICAL PROTOCOL: EPA 531.1

Lab Reference Number	204110184-1
Client Sample ID	TW-1
Date/Time Sampled	11/17/2004
Date/Time Extracted	11/24/2004
Date/Time Analyzed	11/24/2004
Sample Matrix (as Received)	DW
Analysis Confirmed	No
Dilution Factor	1
Result Units	ug/l
Carbofuran	0.5 U*1
Oxamyl	0.5 U*1

U = Undetected. The value preceeding the 'U' is the RL for the analyte, based on dilution. Results reported on a Wet Weight basis.
NELAP- FDOH Certification # E83239

Reviewed by : _____

PC&B Environmental Laboratories, Inc.
210 Park Road
Oviedo, FL 32765-8801
PHONE: 407-359-7194

Report of Analysis

CLIENT NAME: Camp Dresser & McKee, Inc.
PROJECT NAME: Carica Rd
PROJECT NUMBER:
DATE RECEIVED: 11/18/2004

Lab Reference Number			204110184-1	
Client Sample ID			TW-1	
Date/Time Sampled			11/17/2004	
Sample Matrix (as Received)			DW	
EPA 110.2	Color	PCU	10	
EPA 140.1	Odor	TON	20	Y
EPA 150.1	pH	Unit	8.04	Q
EPA 350.1	Ammonia Nitrogen	mg/l	0.5	*2
SM 2320-B	Bicarbonate	mg/l	39	
EPA 6010/200.7	Calcium, Total	mg/l	25	
SM 2320-B	Carbonate	mg/l	1	U
EPA 325.3	Chloride	mg/l	49	
EPA 335.3	Cyanide	mg/l	0.005	U*2
EPA 340.2	Fluoride	mg/l	0.66	
SM5540C	MBAS as LAS(MW 318)	mg/l	0.05	U
EPA 6010/200.7	Magnesium, Total	mg/l	4.7	
EPA 353.3	Nitrate/Nitrite	mg/l	0.03	U
353.3/SM4500NO3E	Nitrate	mg/l	0.03	U
EPA 354.1	Nitrite	mg/l	0.03	U
EPA 160.1	Residue, Filterable (TDS)	mg/l	270	
EPA 6010/200.7	Sodium, Total	mg/l	37.1	
EPA 375.4	Sulfate	mg/l	71	
EPA 310.1	Total Alkalinity	mg/l	39	
EPA 6010/200.7	Aluminum, Total	ug/l	10	U
EPA 200.9	Antimony, Total	ug/l	5	U
EPA 6010/200.7	Arsenic, Total	ug/l	5	U
EPA 6010/200.7	Barium, Total	ug/l	20	U
EPA 6010/200.7	Beryllium, Total	ug/l	3	U
EPA 6010/200.7	Cadmium, Total	ug/l	0.5	U
EPA 6010/200.7	Chromium, Total	ug/l	3	
EPA 6010/200.7	Copper, Total	ug/l	1	U
EPA 549.2	Diquat	ug/l	1	U
EPA 548.1	Endothall	ug/l	10	U
EPA 547	Glyphosate	ug/l	10	U*1
EPA 6010/200.7	Iron, Total	ug/l	44	
EPA 200.9	Lead, Total	ug/l	3	U
EPA 6010/200.7	Manganese, Total	ug/l	1	U
EPA 245.1	Mercury, Total	ug/l	0.2	U
EPA 6010/200.7	Nickel, Total	ug/l	11	
EPA 200.9	Selenium, Total	ug/l	5	U
EPA 6010/200.7	Silver, Total	ug/l	5	U
EPA 200.9	Thallium, Total	ug/l	1.0	U
EPA 6010/200.7	Zinc, Total	ug/l	5	U

U = Undetected. The value preceeding the 'U' is the RL for the analyte. Results reported on a Wet Weight basis.

NELAP- FDOH Certification # E83239

Reviewed by : _____

Appendix F

Geophysical Log Interpretations & Step-Drawdown Test Data

Geophysical Log Interpretations
Carica Road ASR Exploratory Well

Depths on logs printouts are given below. The geophysical log depths correspond approximately to the driller's depths and geologist's logs depths.

Logs run on the 7 7/8-inch diameter pilot hole (10/8/04)

Caliper Log

Depth (ft bls)	Description
0 – 120	Surface casing – 17.6 to 17.8 inches in diameter.
120 – 420	Borehole diameter is close to bit size; maximum borehole diameter is approximately 9.2-inches for a 7 7/8-inch diameter bit.

Gamma Ray Log

Depth (ft bls)	Description
0 – 20	Gamma ray peak (70 GAPI) at 15 ft bls.
20 – 230	Low gamma ray activity (≤ 40 GAPI).
230 – 280	Increased gamma ray activity (> 40 GAPI), which corresponds to an increase in phosphate content, as observed in the well cuttings. Peak in gamma ray activity (maximum of approximately 165 GAPI) between 248 and 280 ft bls, which is an interval of phosphatic clay and marl.
280 – 402	Relatively low gamma ray activity, mostly < 20 GAPI, reflecting a lower phosphate content of the Hawthorn Zone I aquifer limestones.
402 – 420	Increased gamma ray activity (> 40 GAPI) with a 160 GAPI peak at 410 ft bls.

Dual Induction Log

Minimal separation of deep, medium, and shallow logs.

Depth (ft bls)	Description
130 - 280	Variable resistivity reflecting differences in lithology and porosity. Clay-rich beds tend to have low resistivities (< 12 ohm-m), whereas limestones tend to have resistivities ≥ 20 ohm-m.
280 - 305	Sharp increase in resistivity (deep resistivities of 20 to 60 ohm-m). This interval consists of relatively low porosity dolomitic limestones and limestones.
305 - 336	Uniform resistivities of approximately 18 ohm-m. This interval consists of porous limestones and is a flow zone.
336 - 364	Increase in resistivities (deep) to 20 to 38 ohm-m, which likely reflects lower porosities.
364 - 400	Uniform resistivities of 19-20 ohm-m; porous limestone. There is little down-hole change in resistivity in the porous limestones, which would suggest that salinity does not significant change with depth.
400 - 405	Increased resistivities (> 20 ohm-m)

Borehole Compensated Sonic

Depth (ft bls)	Description
130 - 240	Variable sonic transit times reflecting heterogeneities in lithology and porosity in the upper Hawthorn Group.
240 - 280	Sonic transit times in clay/marl of 140 to 170 µsec/ft.
280 - 286	Interval of reduced transit time (increased hardness) to 127 µsec/ft.
286 - 294	Increased travel time to a peak of 201 µsec/ft at 288 ft bls.
294 - 306	Interval of reduced transit time (increased hardness) to 107 µsec/ft. This interval consists of relatively low porosity dolomitic limestones and limestones.
306 - 336	Sonic transit times in porous limestone of 150 to 170 µsec/ft.

336 - 360	Increased sonic transit times, presumably reflecting a decrease in porosity. Bed at 367 ft bls has a transit time of 101 µsec/ft.
360 - 369	Increased transit times to 180 µsec/ft.
369 - 414	Transit times from 134 to 182 µsec/ft.

Logs run on the 16-inch diameter reamed hole (10/18/04)

Caliper Log

Depth (ft bls)	Description
120 - 285	Borehole diameter is close to bit size (15-inches). Maximum diameter is approximately 19.7-inche.

Logs run on the 9-inch diameter reamed open hole (10/29/04)

Caliper Log

287 - 422	Borehole diameter is close to bit size (9-inches). Maximum diameter is approximately 10.5-inches

Gamma Ray Log

Depth (ft bls)	Description
0 - 422	Same pattern as obtain for log on 7 7/8-inch diameter pilot hole. range.

Dual Induction Log

Depth (ft bls)	Description
287 - 303	Variable signal, likely casing depth interference.
303 - 314	Deep resistivity is mostly in the 15 - 20 Ohm/m range.

314 – 318	Resistivity peaks at approximately 65 Ohm/m 316 ft then sharply decreases to 9 Ohm/mat 317 ft.
318 – 340	Deep resistivity is mostly in the 15 – 20 Ohm/m range.
340 – 352	Sharp increase in deep resistivity peaking at approximately 55 Ohm/m at 346 ft.
352 – 356	Sharp decreases in deep resistivity, minimum value approximately 24 Ohm/m at 354 ft.
356 – 364	Sharp increase in deep resistivity peaking at approximately 80 Ohm/m 358 ft.
364 – 401	Deep resistivity is mostly in the 18 – 22 Ohm/m range.
401 – 410	Sharp increase in deep resistivity peaking at approximately 45 Ohm/m at 407 ft.
410 – 422	Variable signal, likely bottom hole interference.

Interpretation: overall, the dual induction log is marked by a relatively consistent resistivity indicating few abrupt, significant salinity changes. There are three prominent resistivity peaks (346, 358, 407 ft). These peaks are likely caused by a decrease in rock porosity associated with the presence of dolomite. There is one interval (314 – 318 ft) characterized by a sharp increase then a sharp decrease in resistivity. This could be associated with a brief interval of softer limestone.

Borehole-Compensated Sonic with Variable Density Log

Depth (ft bls)	Description
287 – 349	The travel time generally ranges from 140 to 170 µsec/ft.
349 – 360	Travel times range from 110 to 140 µsec/ft.
360 – 370	Travel times range from 140 to 190 µsec/ft.
370 – 414	Travel times range from 110 to 155 µsec/ft.

Interpretations: The sonic log indicates that a zone of relatively high porosity is present from 287 to 349 feet. The lower part of the well is generally in less porous material, although there is a more porous zone at 360 to 370 feet.

Flowmeter Log

Depth (ft bls)	Description

Static and dynamic down passes were made at 50 fpm. In the dynamic log Q = 250 gpm.

Static Log

230 - 418	The static flowmeter is consistently 14.5 to 15.5 cps.

Dynamic Log

230 - 300	The flowmeter fluctuates from 39.5 cps to 43.1 cps.
300 - 340	The flowmeter rate decreases form 41.1 cps to 18.9 cps.
340 - 420	The flowmeter rate fluctuates from 15.0 cps to 18.9 cps.

Flowmeter Interpretation Log

287 - 303	No flow into the well
303 - 342	Approximately 91% of flow entered the well in this interval.
342 - 420	Remaining 9% of the flow gradually enter the well over this interval.

Interpretation: These logs indicate that the main flow zone (permeable zone) in the proposed ASR storage zone is located from 303 to 342 ft bls. Flow appears to enter the well gradually over this interval, as opposed to from a single thin flow zone (fracture/conduit).

Temperature Logs

Depth (ft bls)	Description

Dynamic Log (Q = 250 gpm)

250 - 320	The temperature is consistently at 80.8 to 81.0 degrees F.
320 - 420	The temperature is gradually increasing from 81.0 to 81.8 degrees F.

Static Log

250 - 275	The temperature is consistently 84.2 to 84.3 degrees F.
275 - 295	The temperature decreases to 80.6 degrees F.
295 - 420	The temperature gradually increases to 81.8 degrees F.

Fluid Conductivity Logs

Depth (ft bls)	Description
Dynamic Log (Q = 250 gpm)	
287 – 324	The conductivity ranges from 2765 to 2766 ohm-m.
324 – 420	The conductivity gradually increases from 2766 to 2794 ohm-m.
Static Log	
287 – 312	The conductivity ranges from 2755 to 2756 ohm-m.
312 – 420	The conductivity gradually increases from 2766 to 2794 ohm-m.

Interpretation: The fluid conductivity logs show that salinity is near constant in the ASR storage zone. There is no suggestion of a significant increase in salinity with depth.

Carica Road ASR Exploratory Well
Step-Drawdown Test #1

Test Date: November 8, 2004
Recorded by: Karl Hopfensperger
Static Water Level = 17.25 feet above land surface. Top of casing (= measuring point, MP) =0.85 feet above land surface.

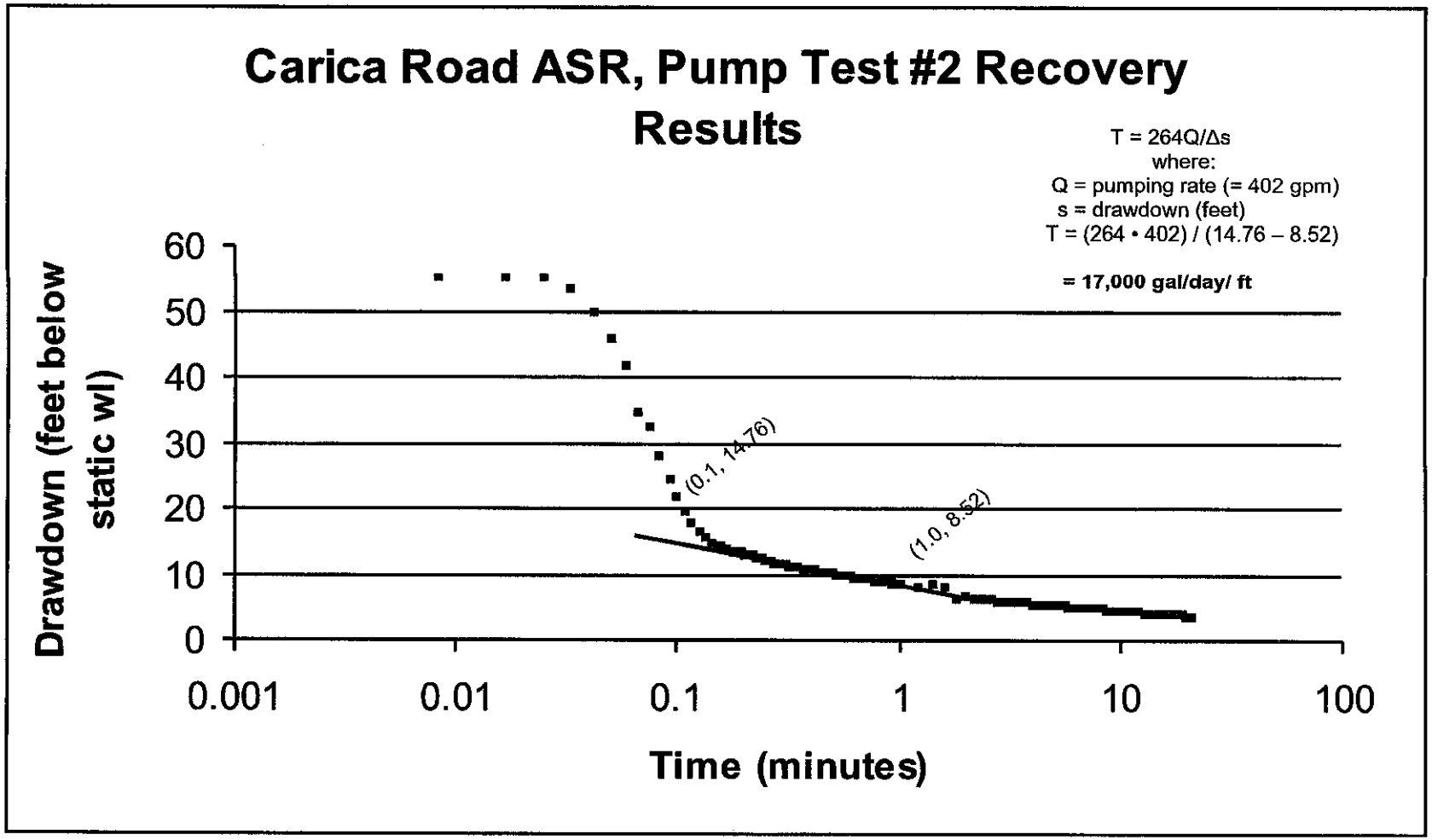
Pumping Rate (GPM)	Time (Minutes)	Pumping Water Level (ft below land surface)	Drawdown (Feet)	Specific Capacity (GPM/Ft)
277	0	-17.25	00.00	
	5	17.20	34.45	
	10	17.20	34.45	
	20	17.45	34.45	
	30	17.45	34.70	
	40	17.45	34.70	
	50	17.45	34.70	
	60	17.45	34.70	7.98
442	5	44.70	61.95	
	10	44.75	62.00	
	20	44.95	62.20	
	30	45.15	62.40	
	40	45.15	62.40	
	50	45.15	62.40	
	60	45.15	62.40	7.08
504	5	55.80	73.05	6.90
502	10	55.40	72.65	6.91
496	20	55.10	72.35	6.86
492	30	54.25	71.50	6.88
475	40	53.55	70.80	6.71
471	50	53.15	70.40	6.69
477	60	53.65	70.90	6.73

Carica Road ASR Exploratory Well
Step-Drawdown Test #2

Test Date: November 17, 2004
Recorded by: Karl Hopfensperger, Shelley Day
Static Water Level = 17.25* feet above land surface. Top of casing (= measuring point, MP) =0.85 feet above land surface.

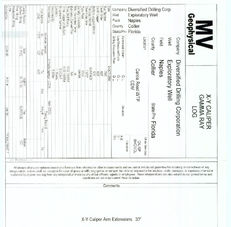
Pumping Rate (GPM)	Time (Minutes)	Pumping Water Level (ft below land surface)	Drawdown (Feet)	Specific Capacity (GPM/Ft)
402	0	-17.25	0.00	
	5	N/A**	N/A**	
	10	38.55	55.80	
	20	38.15	55.40	
	30	38.10	55.35	
	40	38.00	55.25	
	50	37.90	55.15	
	60	38.00	55.25	
	70	38.00	55.25	
	80	38.03	55.28	
	90	38.02	55.27	
	100	38.03	55.28	
	110	38.03	55.28	
	120	38.03	55.28	
	130	38.03	55.28	7.27

* Unable to measure static water level on November 17 due to salt used to kill well for November 16 cement back-plug.
** Electric tape measuring malfunction.


Carica Road ASR, Pump Test #2 Recovery Results
T = 264Q/Δs
where:
Q = pumping rate (= 402 gpm)
s = drawdown (feet)
T = (264 • 402) / (14.76 – 8.52)
= 17,000 gal/day/ ft
Drawdown (feet below static wl)
60
50
40
30
20
10
0
0.001
0.01
0.1
1
10
100
Time (minutes)
(0.1, 14.76)
(1.0, 8.52)

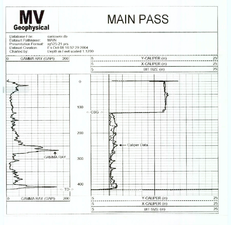
Appendix G

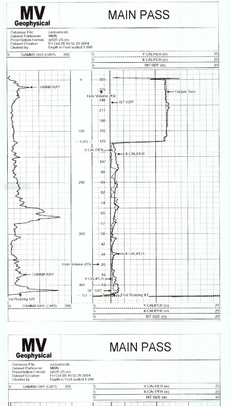
Geophysical Logs

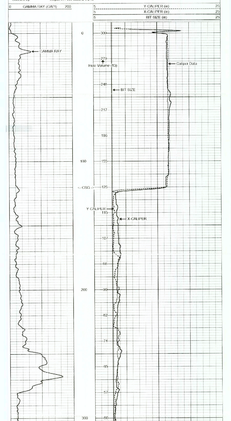


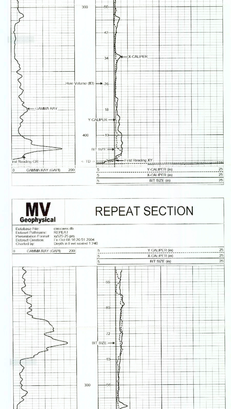
Comments:

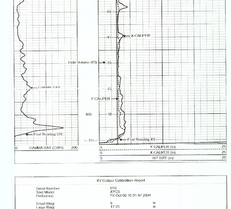
X-Y Caliper Arm Extension: 37"

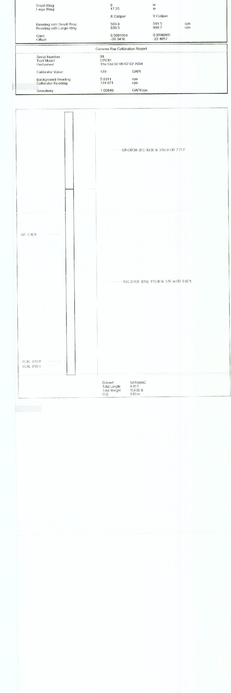












Company Diversified Drilling Corp.
Well Exploratory Well
Field Naples
County Collier
State/Prv Florida

MV Geophysical

X-Y CALIPER GAMMA RAY LOG

Company	Diversified Drilling Corporation
Well	Exploratory Well
Field	Naples
County	Collier
State/Prv	Florida
Location	Garcia Road WTP CDM
Other Services	DIL/SP BHC/VDL
Permanent Datum	G.L.
Log Measured From	G.L.
Drilling Measured From	G.L.
Elevation	K.B. D.F. G.L.

Date	18-OCT-2004
Run Number	TWO
Depth Driller	288'
Depth Logger	288'
Bottom Logged Interval	286'
Top Log Interval	SURFACE
Open-Hole Size	10"
Type Fluid	MUD
Density / Viscosity	NA/NA
Max. Recorded Temp.	na
Estimated Cement Top	NA
Time Well Ready	16:00 10/17/2004
Time Logger on Bottom	18:00 10/18/2004
Equipment Number	MVGS-1
Location	Ft. Myers
Recorded By	S. Miller
Witnessed By	K. Hopfensperger (CDM) Ralph Nalls (DDC)

Borehole Record / Tubing Record

Run Number	Bit	From	To	Size	Weight	From	To
ONE	7.875"	20'	430'				
TWO	16"	20'	288'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	16" PVC	16.75" ID	SURFACE	20'
Prot. String				
Production String				
Liner				

Invoice No. 2004153 P.O. # Job No. * FINALPRINT *

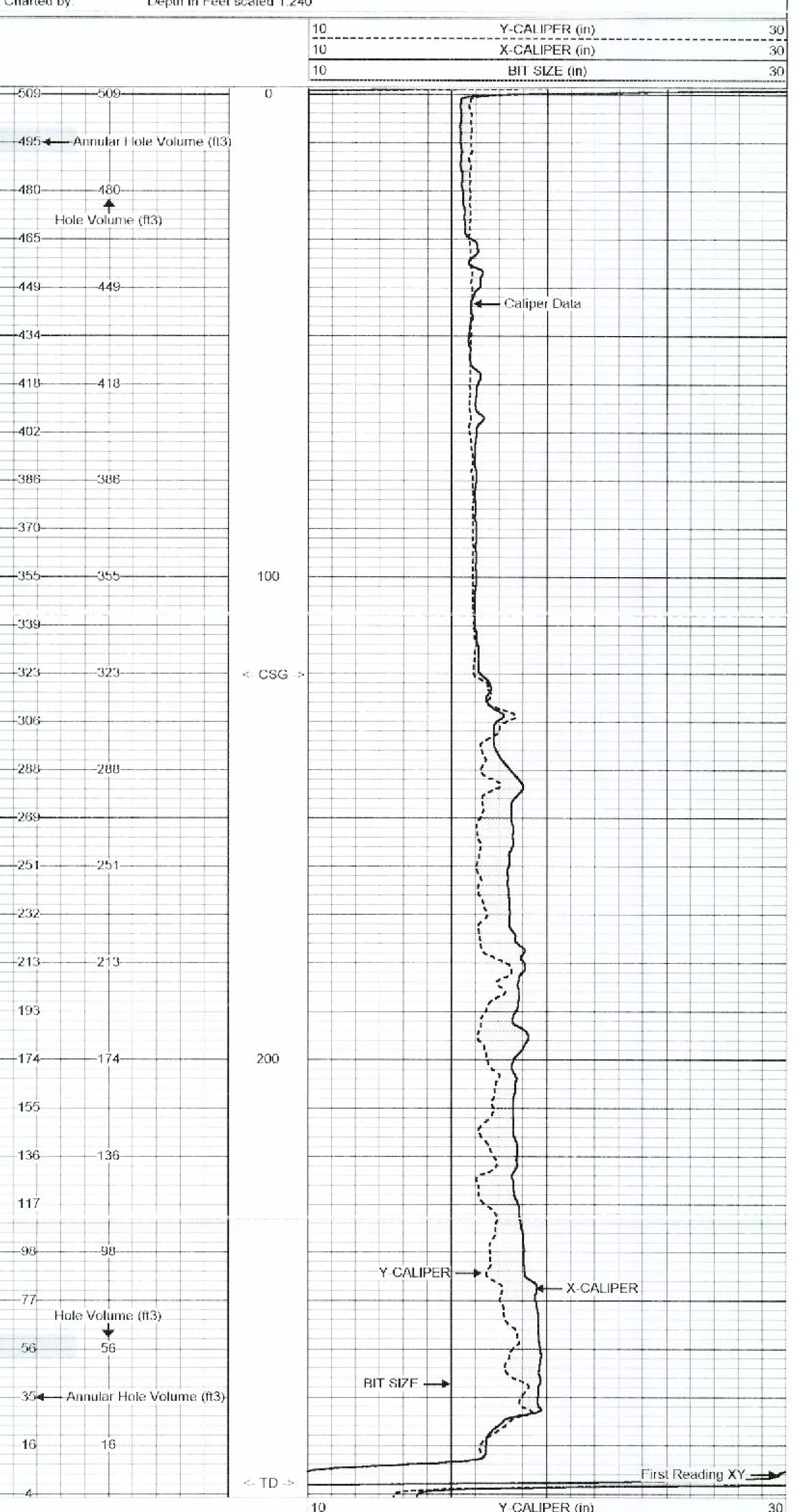
Comments

X-Y Caliper Arm Extensions: 51"

FUTURE CASING SIZE: 10.625"

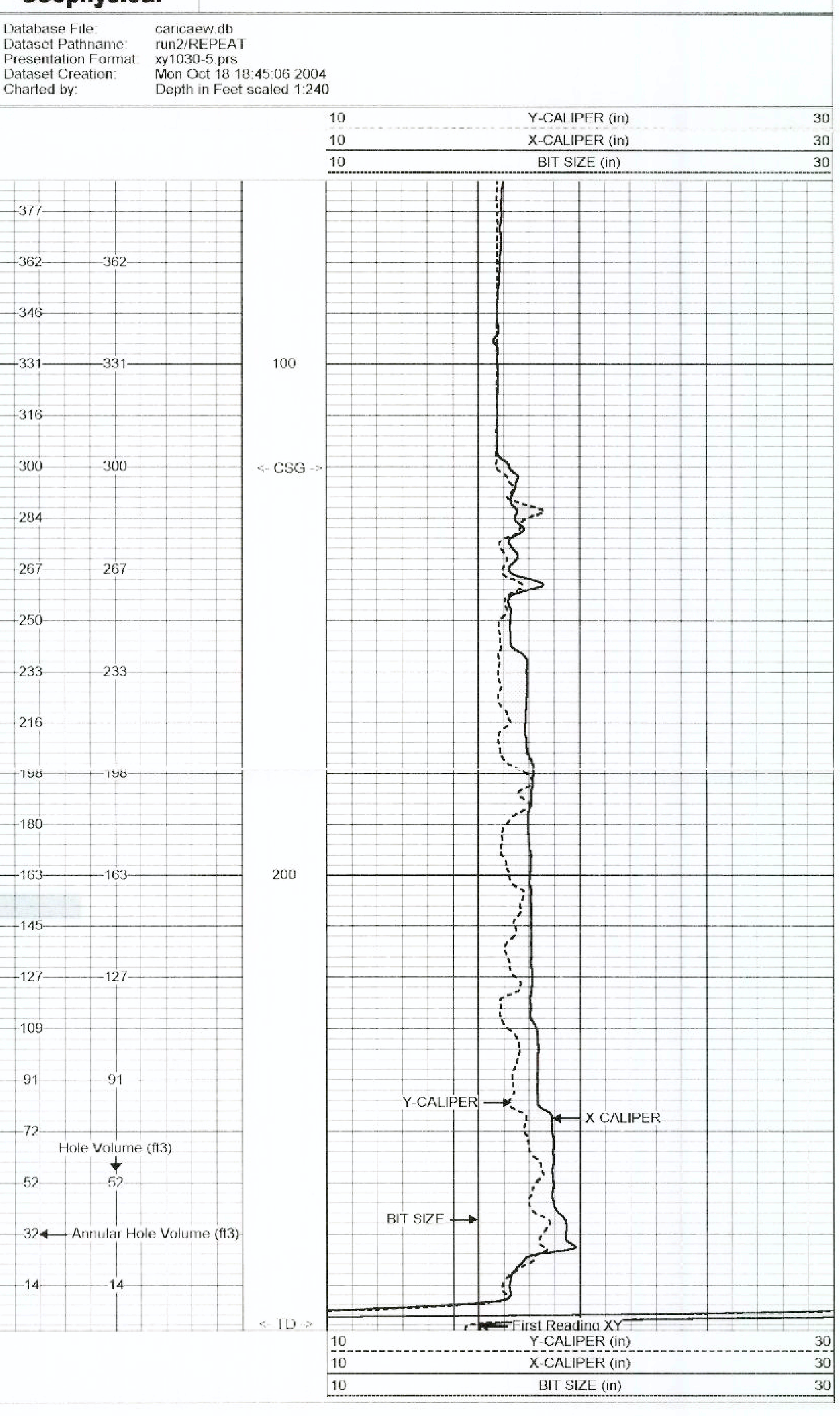
MV Geophysical — MAIN PASS

Database File: caricaew.db
Dataset Pathname: run2/MAIN
Presentation Format: xy1030-5.prs
Dataset Creation: Mon Oct 18 18:24:19 2004
Charted by: Depth in Feet scaled 1:240



MV Geophysical — REPEAT SECTION

Database File: caricaew.db
Dataset Pathname: run2/REPEAT
Presentation Format: xy1030-5.prs
Dataset Creation: Mon Oct 18 18:45:06 2004
Charted by: Depth in Feet scaled 1:240

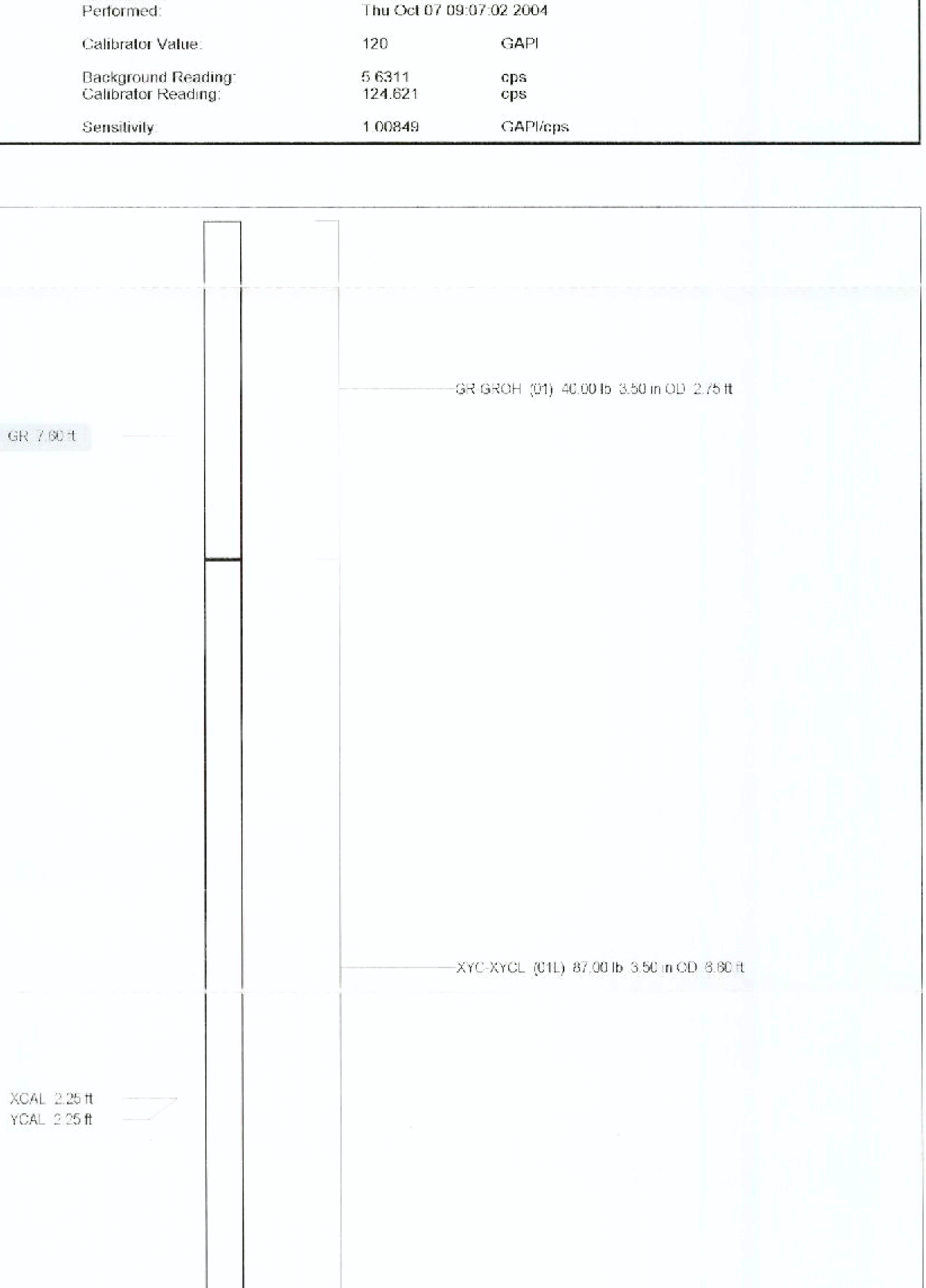


XY Caliper Calibration Report

Serial Number:	01L		
Tool Model:	XYCL		
Performed:	Mon Oct 18 18:38:10 2004		
Small Ring:	16.75	in	
Large Ring:	51	in	
	X Caliper	Y Caliper	
Reading with Small Ring:	556.5	574.3	cps
Reading with Large Ring:	1024.71	1050.51	cps
Gain:	0.0731509	0.071922	
Offset:	-23.9585	-24.5548	

Gamma Ray Calibration Report

Serial Number:	01	
Tool Model:	GROH	
Performed:	Thu Oct 07 09:07:02 2004	
Calibrator Value:	120	GAPI
Background Reading:	5.6311	cps
Calibrator Reading:	124.621	cps
Sensitivity:	1.00849	GAPI/cps



Dataset: run2/pass2
Total Length: 9.35 ft
Total Weight: 127.00 lb
O.D.: 3.50 in

MV Geophysical

DUAL INDUCTION LL3 / SP LOG

Company	Diversified Drilling Corp.
Well	Exploratory Well
Field	Naples
County	Collier
State/Prv	Florida

Company	Diversified Drilling Corporation
Well	Exploratory Well
Field	Naples
County	Collier
State/Prv	Florida
Location	Carcia Road WTP CDM
Other Services	XY/GR BHC/FCT FLOW

Permanent Datum	G.L.	Elevation	
Log Measured From	G.L.		K.B.
Drilling Measured From	G.L.		D.F.
			G.L.

Date	26-OCT-2004
Run Number	THREE
Depth Driller	422
Depth Logger	421
Bottom Logged Interval	413
Top Logged Interval	288
Open Hole Size	9"
Type Fluid	WATER
Density / Viscosity	NA/NA
Max. Recorded Temp.	na
Estimated Cement Top	NA
Time Well Ready	08:00 10/29/04
Time Logger on Bottom	10:00 10/29/04
Equipment Number	MVGS-1
Location	Ft. Myers
Recorded By	S Miller
Witnessed By	S. Day (CDM)

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	7.875"	120'	420'				
TWO	12"	120'	288'				
THREE	9"	288'	422'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	16" PVC	10.75 ID	SURFACE	120'
Prot. String	10" PVC	9.625 ID	SURFACE	288'
Production String				
Liner				

Invoice No. 2004153 P.O. # Job No. *FINAL PRINT*

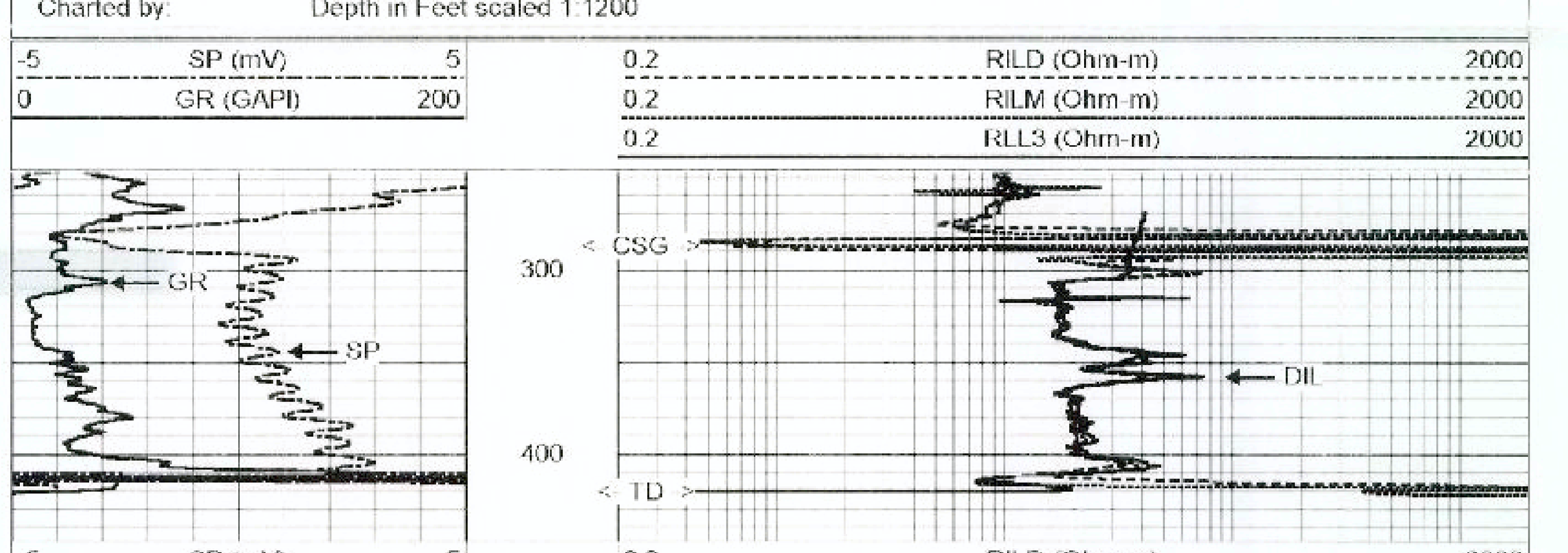
Comments

Rw= 3.627 ohm @ 80.8 degF

MV Geophysical — MAIN PASS

Database File: caricaew.db
Dataset Pathname: run3/MAIN
Presentation Format: dil1200.prs
Dataset Creation: Fri Oct 29 10:04:53 2004
Charted by: Depth in Feet scaled 1:1200

-5	SP (mV)	5	0.2	RILD (Ohm-m)	2000
0	GR (GAPI)	200	0.2	RILM (Ohm-m)	2000
			0.2	RLL3 (Ohm-m)	2000

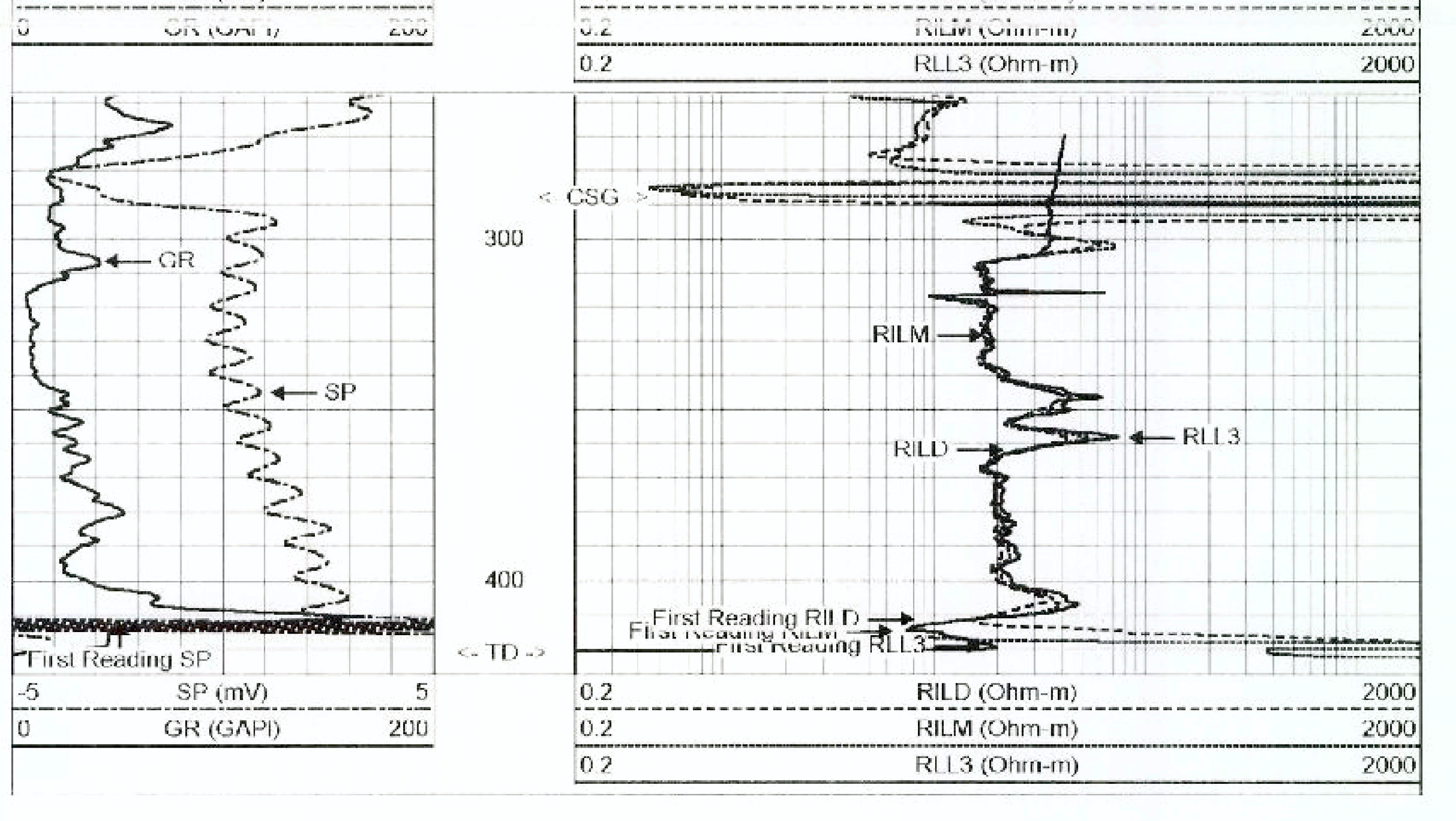


-5	SP (mV)	5	0.2	RILD (Ohm-m)	2000
0	GR (GAPI)	200	0.2	RILM (Ohm-m)	2000
			0.2	RLL3 (Ohm-m)	2000

MV Geophysical — MAIN PASS

Database File: caricaew.db
Dataset Pathname: run3/MAIN
Presentation Format: dil200.prs
Dataset Creation: Fri Oct 29 10:04:53 2004
Charted by: Depth in Feet scaled 1:600

-5	SP (mV)	5	0.2	RILD (Ohm-m)	2000
0	GR (GAPI)	200	0.2	RILM (Ohm-m)	2000
			0.2	RLL3 (Ohm-m)	2000

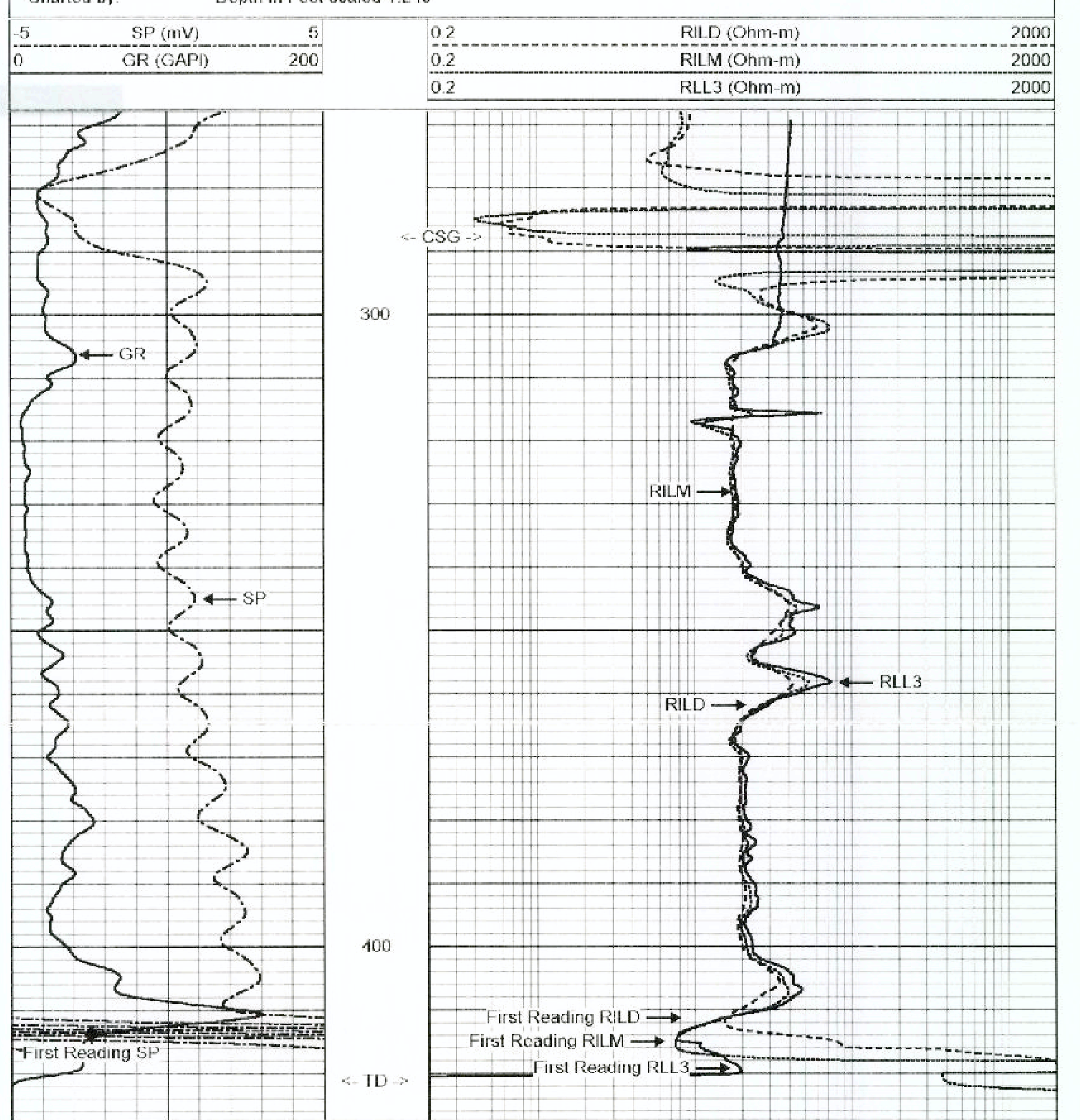


-5	SP (mV)	5	0.2	RILD (Ohm-m)	2000
0	GR (GAPI)	200	0.2	RILM (Ohm-m)	2000
			0.2	RLL3 (Ohm-m)	2000

MV Geophysical — MAIN PASS

Database File: caricaew.db
Dataset Pathname: run3/MAIN
Presentation Format: dil200.prs
Dataset Creation: Fri Oct 29 10:04:53 2004
Charted by: Depth in Feet scaled 1:240

-5	SP (mV)	5	0.2	RILD (Ohm-m)	2000
0	GR (GAPI)	200	0.2	RILM (Ohm-m)	2000
			0.2	RLL3 (Ohm-m)	2000

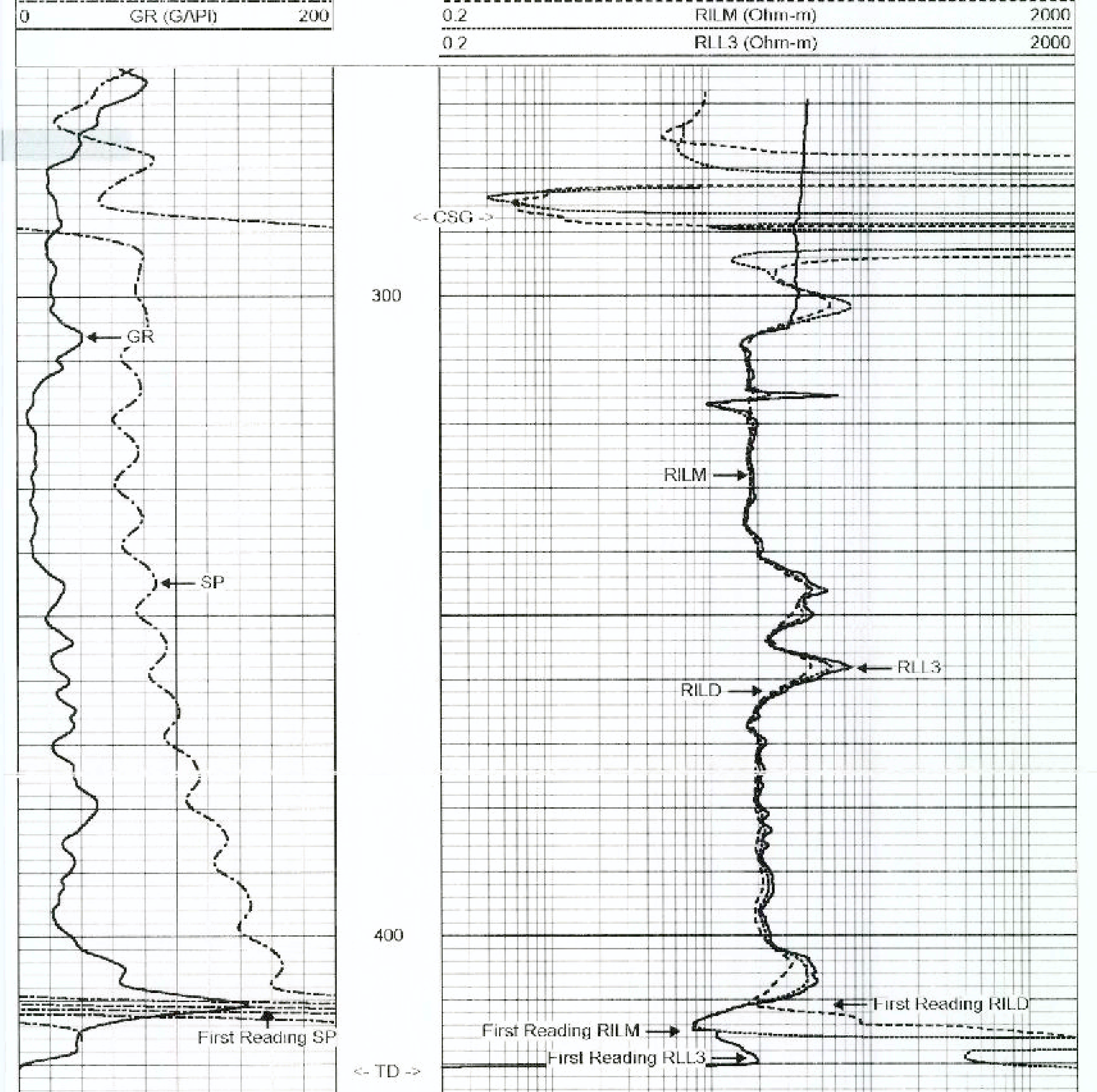


-5	SP (mV)	5	0.2	RILD (Ohm-m)	2000
0	GR (GAPI)	200	0.2	RILM (Ohm-m)	2000
			0.2	RLL3 (Ohm m)	2000

MV Geophysical — REPEAT SECTION

Database File: caricaew.db
Dataset Pathname: run3/REPEAT
Presentation Format: dil200.prs
Dataset Creation: Fri Oct 29 09:28:03 2004
Charted by: Depth in Feet scaled 1:240

-5	SP (mV)	5	0.2	RILD (Ohm-m)	2000
0	GR (GAPI)	200	0.2	RILM (Ohm-m)	2000
			0.2	RLL3 (Ohm-m)	2000



-5	SP (mV)	5	0.2	RILD (Ohm m)	2000
0	GR (GAPI)	200	0.2	RILM (Ohm-m)	2000
			0.2	RLL3 (Ohm-m)	2000

Dual Induction Calibration Report

Serial Model: 5390-R
Surface Cal Performed: Mon Feb 24 16:52:46 2003
Downhole Cal Performed: Fri Oct 29 09:56:35 2004
After Survey Verification Performed: Fri Oct 29 10:42:34 2004

Surface Calibration

Loop	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	0.041	0.637	V	0.000	400.000	mmho-m	670.900	27.223
Medium	-0.006	0.700	V	0.000	464.000	mmho-m	656.366	4.251

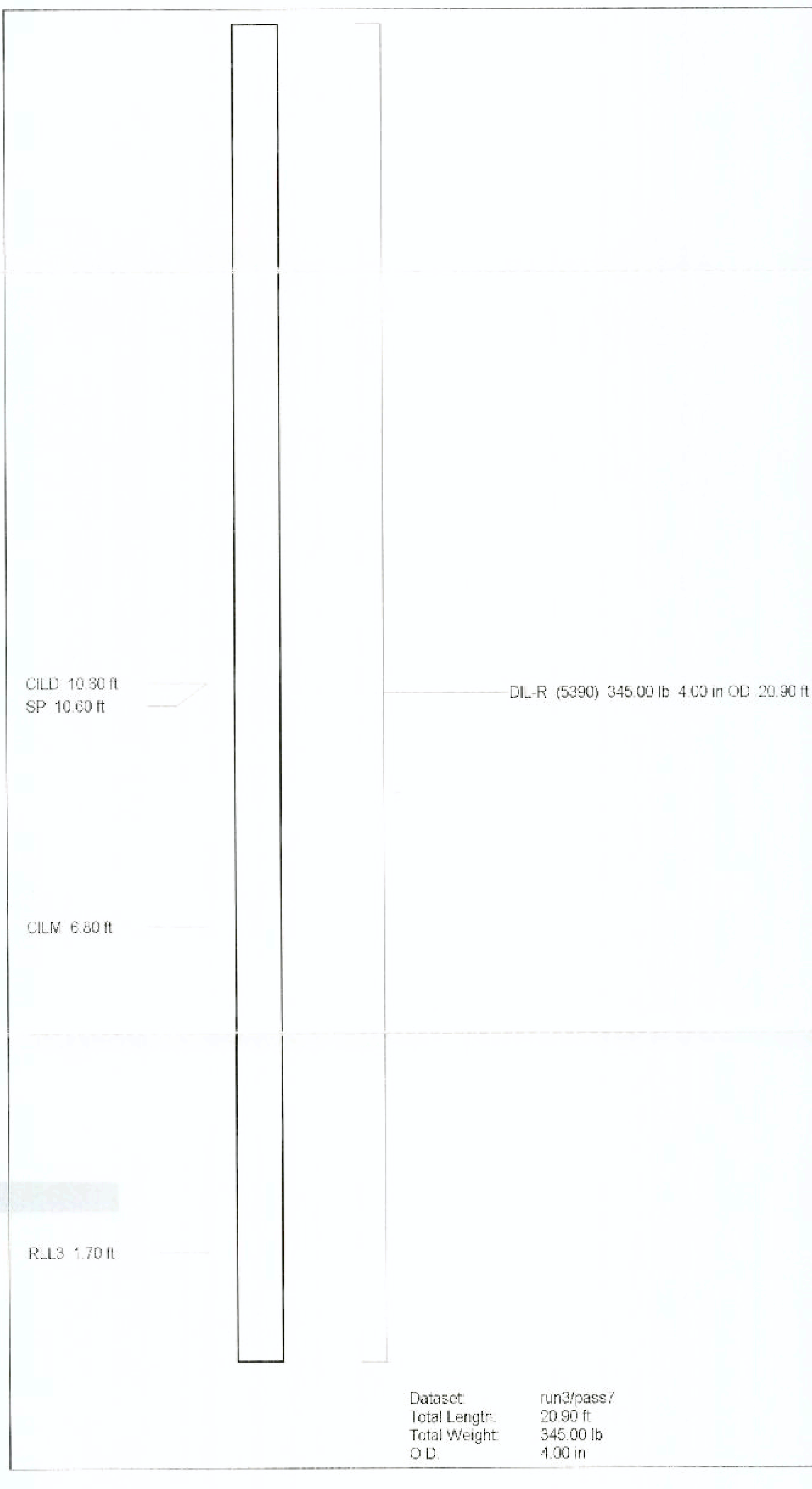
Internal	Zero	Cal		Zero	Cal		m	b
Deep	0.011	0.647	V	0.000	400.000	mmho-m	628.552	-6.783
Medium	-0.011	0.749	V	0.000	464.000	mmho-m	610.612	6.720

Downhole Calibration

Internal	Readings Zero	Readings Cal		References Zero	References Cal		Results m	Results b
Deep	-17.567	400.742	mmho-m	-19.983	406.966	mmho-m	1.021	2.053
Medium	14.294	490.464	mmho-m	-2.972	495.796	mmho-m	1.047	-17.945
Shallow	2.504	0.025	V	494.500	2.000	Ohm-m	198.683	-2.912

After Survey Verification

Internal	Readings Zero	Readings Cal		Targets Zero	Targets Cal		Results m'	Results b'
Deep	-19.643	398.756	mmho-m	17.567	400.742	mmho-m	1.021	-2.053
Medium	12.612	488.706	mmho-m	14.295	490.464	mmho-m	1.047	17.945
Shallow	493.699	1.529	Ohm-m	494.500	2.000	Ohm-m	1.001	0.469



Dataset: run3/pass7
Total Length: 20.90 ft
Total Weight: 345.00 lb
O.D.: 4.00 in

Company	Diversified Drilling Corp.
Well	Exploratory Well
Field	Naples
County	Collier
State/Prv	Florida

MV Geophysical

BOREHOLE COMPENSATED SONIC w/ VARIABLE DENSITY LOG

Company	Diversified Drilling Corporation
Well	Exploratory Well
Field	Naples
County	Collier
State/Prv	Florida
Location	Carola Road WTP CDM

Other Services: XY/GR, DIL/FCT, FLOW

		Elevation		Elevation
Permanent Datum	G.L.		KB	
Log Measured From	G.L.		DF	
Drilling Measured From	G.L.		GL	

Date	29-OCT-2004
Run Number	THREE
Depth Driller	422'
Depth Logger	421'
Bottom Logged Interval	413'
Top Log Interval	250'
Open Hole Size	8"
Type Fluid	WATER
Density / Viscosity	N/A/N/A
Max. Recorded Temp.	na
Estimated Cement Top	NA
Time Well Ready	08:00 10/29/04
Time Logged on Bottom	11:00 10/29/04
Equipment Number	MV05
Location	Ft. Myers
Recorded By	S. Miller
Witnessed By	S. Day (CDM)

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	7.875"	120'	420'				
TWO	16"	0	288'				
THREE	8"	288	422'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	16" PVC	16.75" ID	SURFACE	120'
Prot. String	10" PVC	9.635" ID	SURFACE	289'
Production String				
Liner				

Invoice No. 2204133 P.O. # Job No. * FINALPRINT *

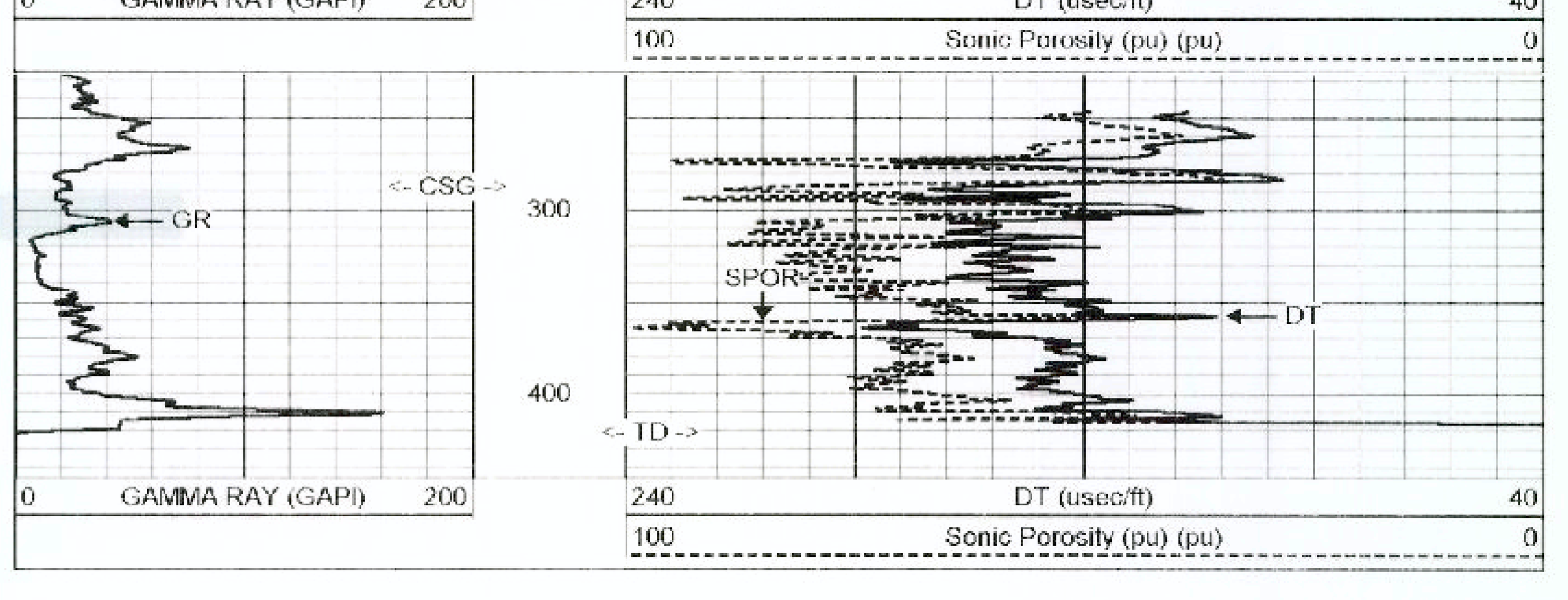
All interpretations are opinions based on inferences from electrical or other measurements and we cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to our general terms and conditions set out in our current Price Schedule.

Comments

Sonic Porosity was run on a Limestone Matrix (=47.5)

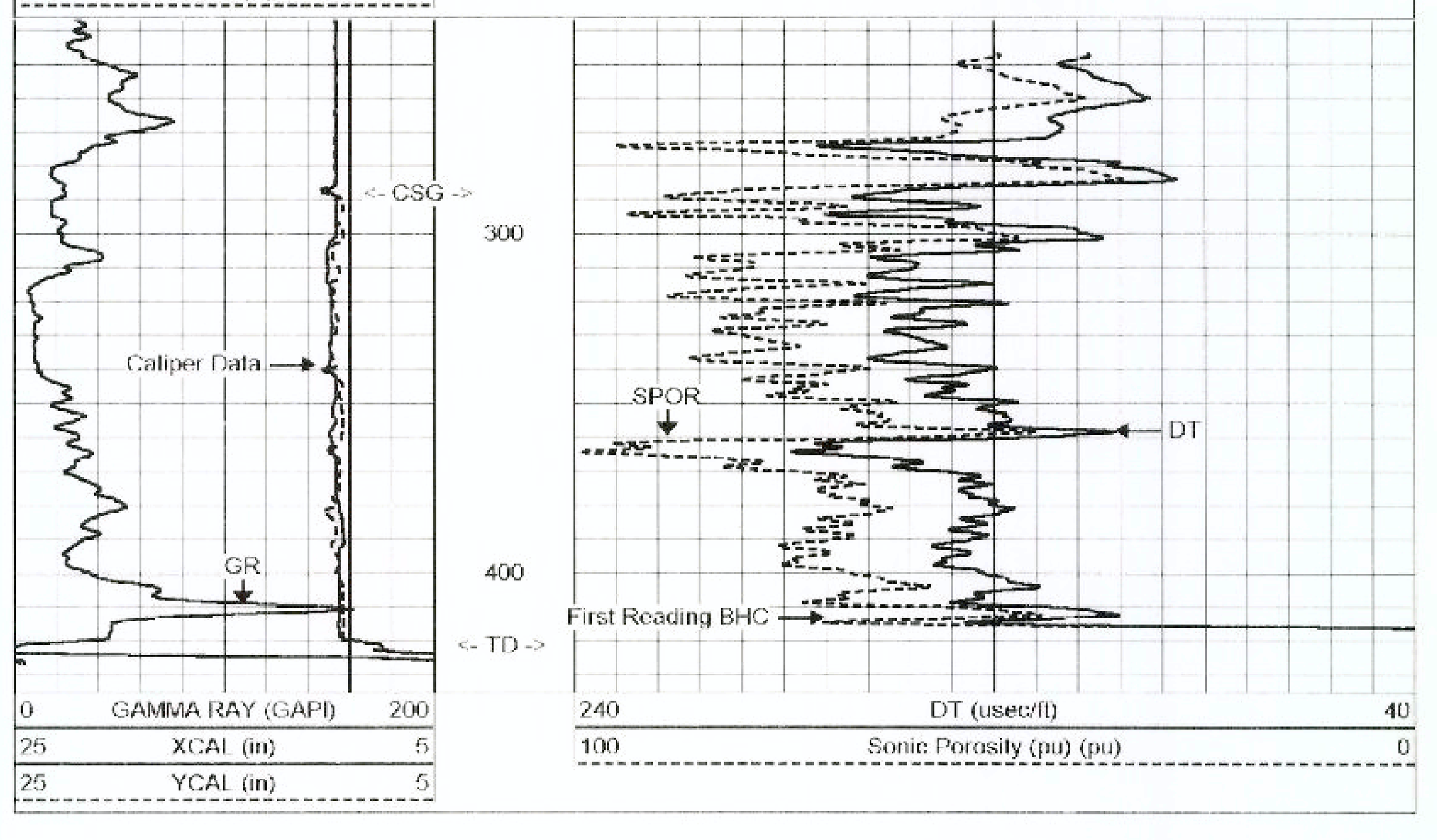
MV Geophysical — MAIN PASS

Database File: caricaew.db
Dataset Pathname: run3/MAIN
Presentation Format: dtg_12.prs
Dataset Creation: Fri Oct 29 10:04:53 2004
Charted by: Depth in Feet scaled 1:1200



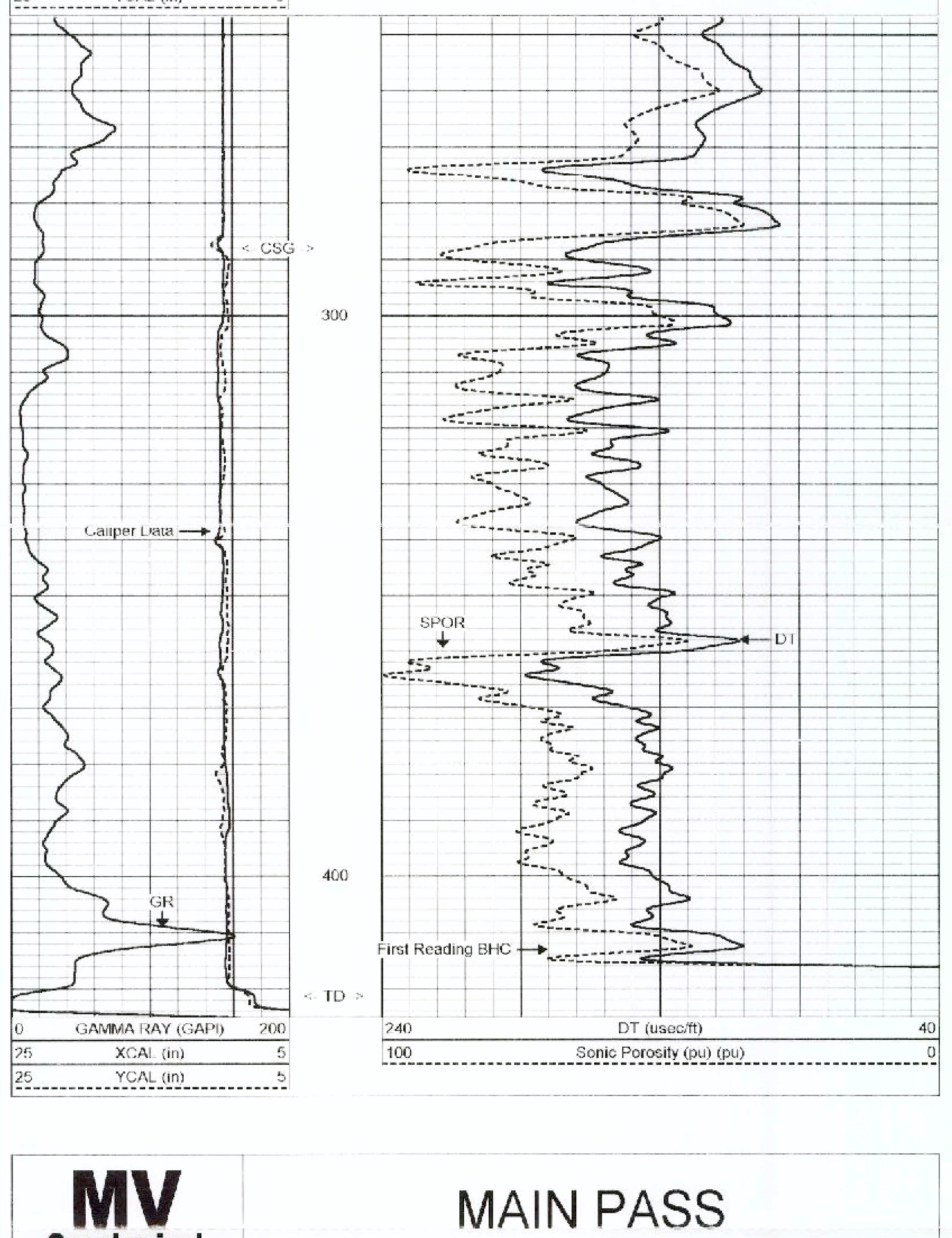
MV Geophysical — MAIN PASS

Database File: caricaew.db
Dataset Pathname: run3/MAIN
Presentation Format: dtxy525g.prs
Dataset Creation: Fri Oct 29 10:04:53 2004
Charted by: Depth in Feet scaled 1:600



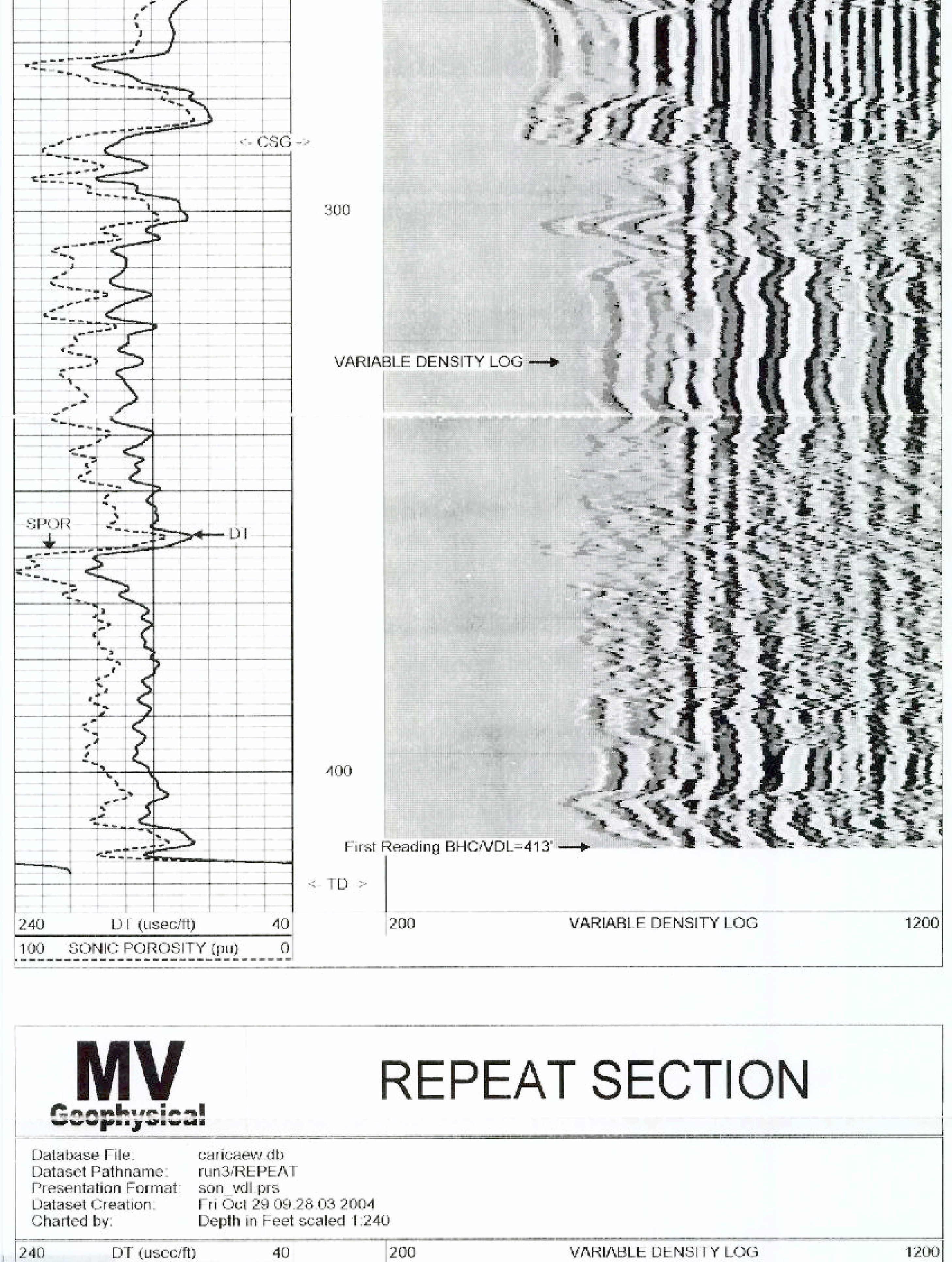
MV Geophysical — MAIN PASS

Database File: caricaew.db
Dataset Pathname: run3/MAIN
Presentation Format: dtxy525g.prs
Dataset Creation: Fri Oct 29 10:04:53 2004
Charted by: Depth in Feet scaled 1:240



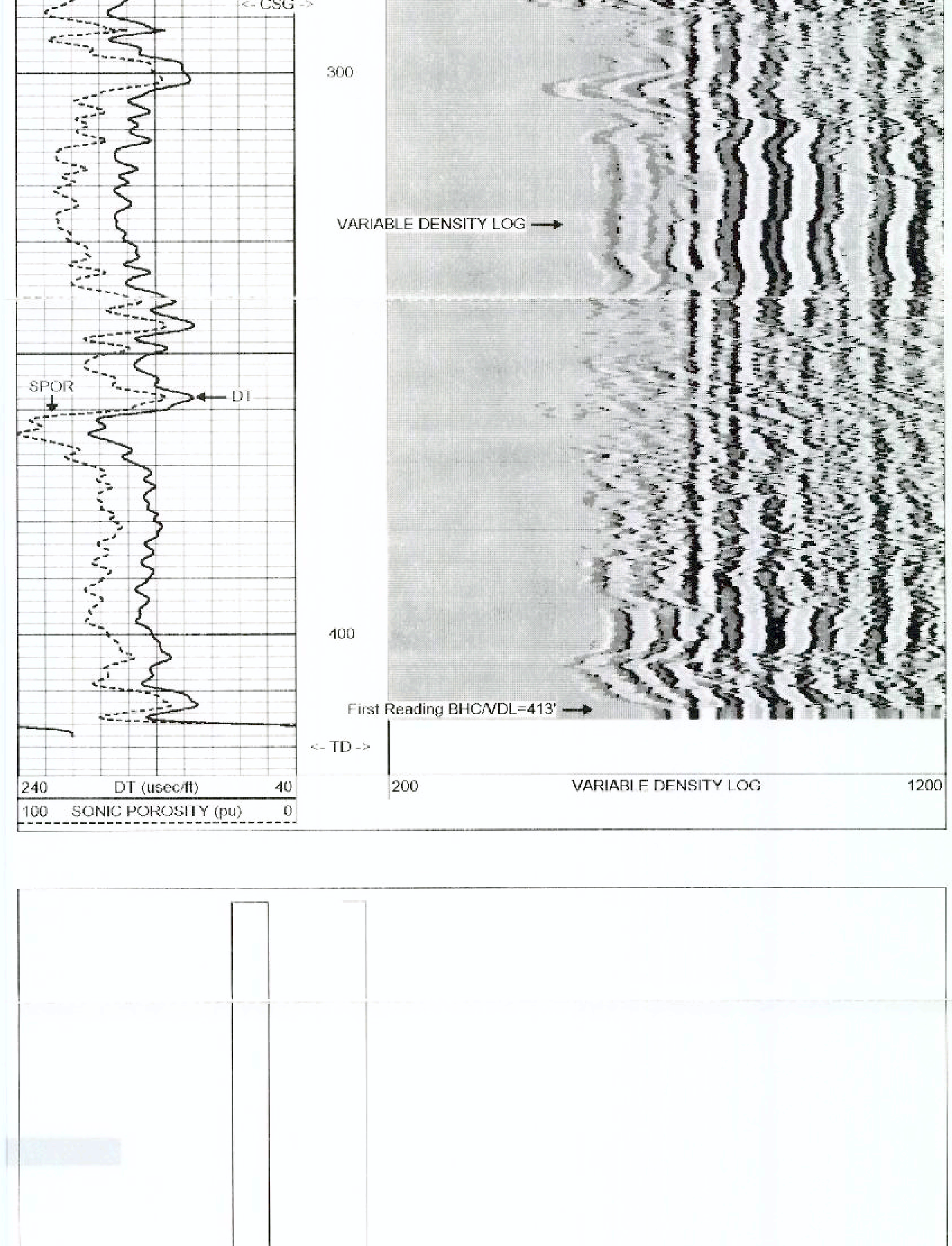
MV Geophysical — MAIN PASS

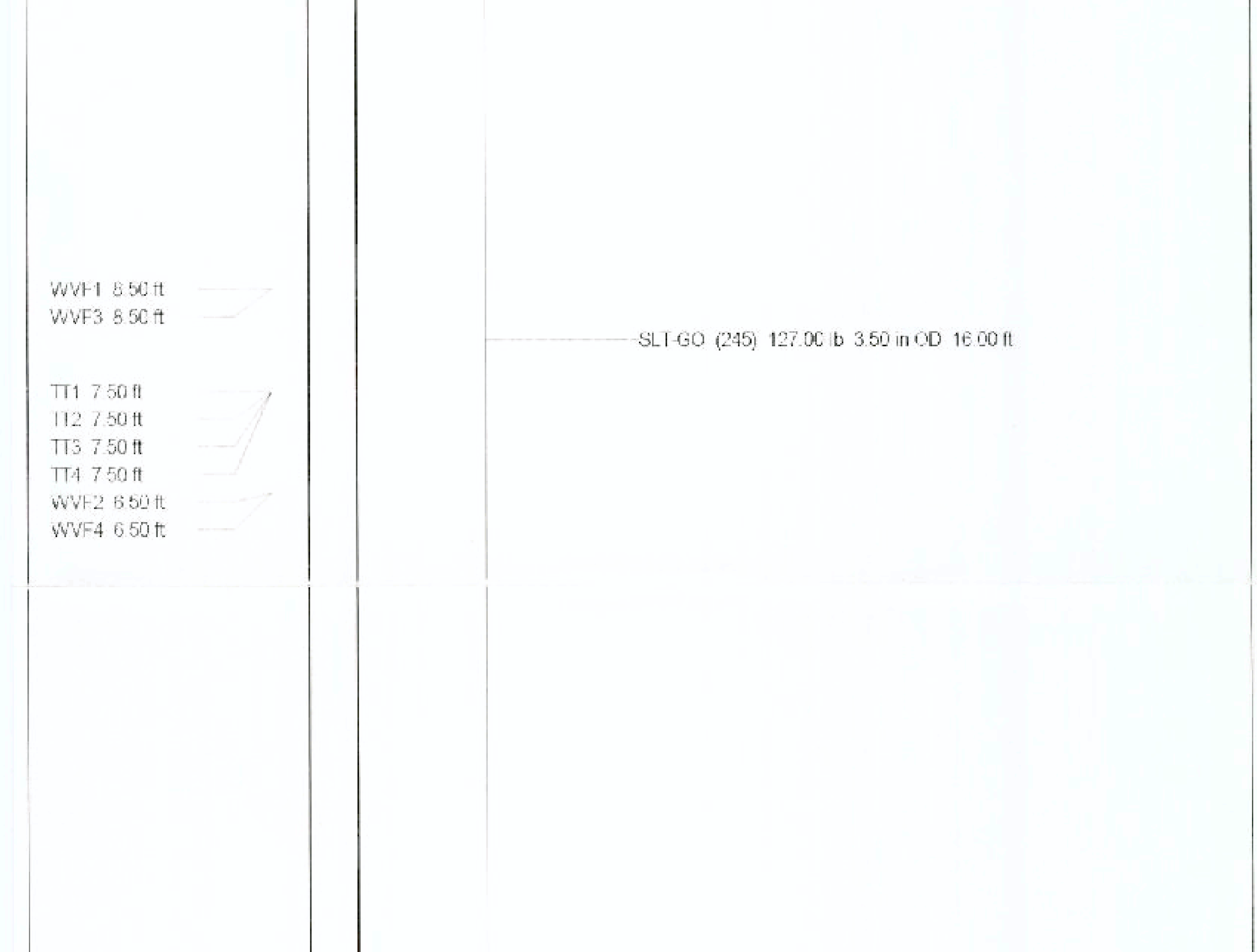
Database File: caricaew.db
Dataset Pathname: run3/MAIN
Presentation Format: son_vdl.prs
Dataset Creation: Fri Oct 29 10:04:53 2004
Charted by: Depth in Feet scaled 1:240



MV Geophysical — REPEAT SECTION

Database File: caricaew.db
Dataset Pathname: run3/REPEAT
Presentation Format: son_vdl.prs
Dataset Creation: Fri Oct 29 09:28:03 2004
Charted by: Depth in Feet scaled 1:240





Dataset: run3/pass14
Total Length: 16.00 ft
Total Weight: 127.00 lb
O.D.: 3.50 in