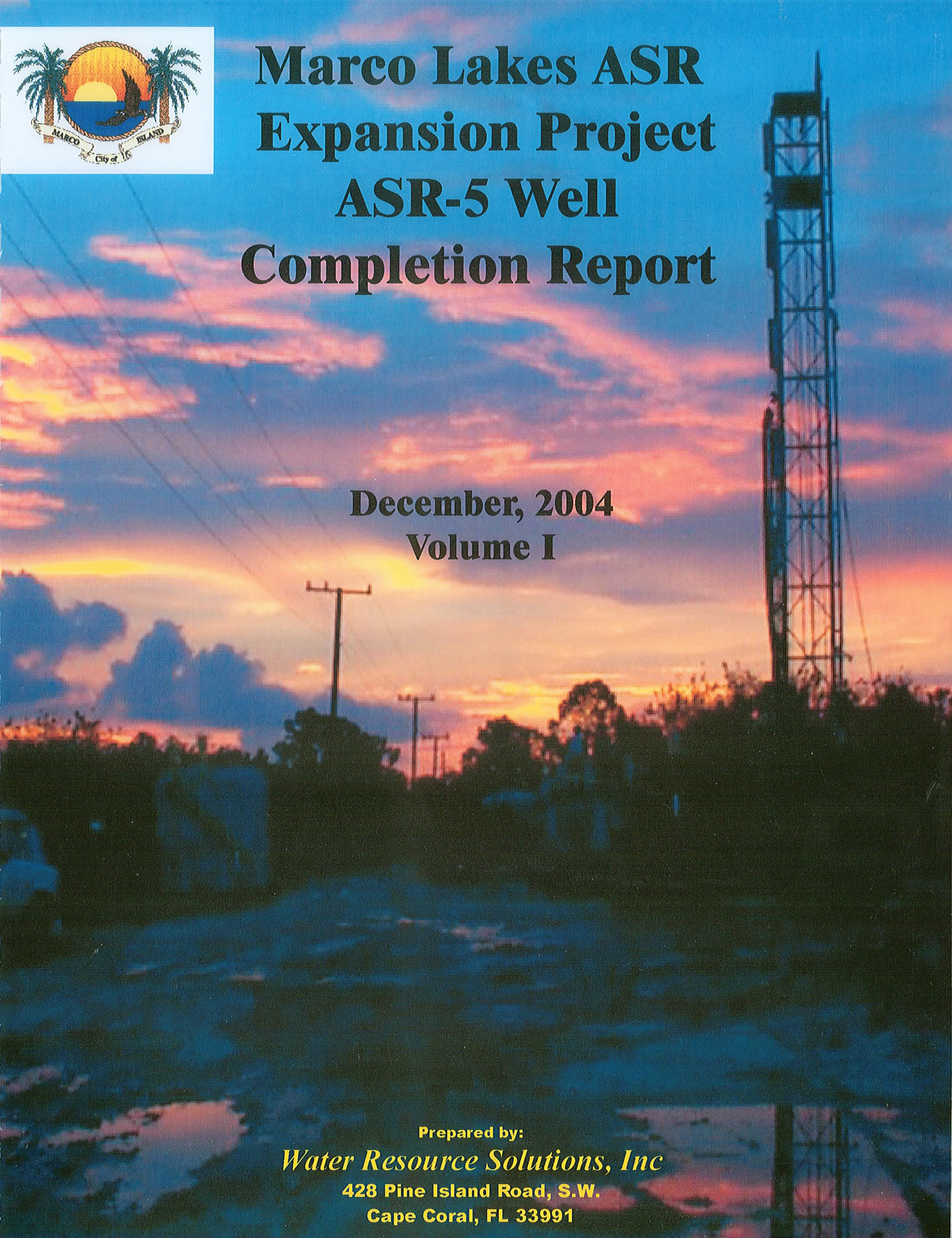
Marco Lakes ASR Expansion Project ASR-5 Well Completion Report



December, 2004

Volume I

Prepared by:

Water Resource Solutions, Inc

428 Pine Island Road, S.W.

Cape Coral, FL 33991

MARCO LAKES ASR-5
EXPANISON PROJECT
WELL COMPLETION REPORT

Prepared for:

Marco Island Utilities
Marco Island, Florida

December 2004

Prepared by:

Water Resource Solutions, Inc.
428 Pine Island Road, S.W.
Cape Coral, Florida 33991

Project No. 01-04773.01

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Senior Scientist

Lloyd E. Horvath, P.E.
Licensed Professional Engineer #25260
Date: 12-14-04

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428 Pine Island Road SW • Cape Coral, Florida 33991 239 574-1919 Fax: 239 574-8106

December 20, 2004

Mr. Jack Myers, P.G.
State Of Florida
Department of Environmental Protection
South District
Groundwater Section – UIC
P.O. Box 2549
Fort Myers, FL 33902-2549

Re: Completion Report for Well ASR5 – Marco Lakes
FDEP PERMIT NUMBERS: 141218-004 UC

Dear Mr. Myers:

I have attached this letter to the Completion Report for ASR 5 at the City of Marco Island's Marco Lakes facility. The piping to this well is currently being installed and the well is being prepared for injection. If you have any questions, please contact me at your earliest convenience.

Sincerely,

Mark S. Pearce

Mark S. Pearce, Ph.D.
Senior Scientist

c. J. Haberfeld, FDEP
N. Marsh, USEPA
S. Anderson SFWMD
R. Reese USGS
B. Weinstein City Of Marco Island

EXECUTIVE SUMMARY

This report summarizes the construction of the fourth Aquifer Storage and Recovery (ASR) well, ASR-5, at Marco Island Utility's, Marco Lakes Facility. Ultimately, a total of nine ASR wells are proposed to be operational at this site. The grid pattern and 400 feet spacing between the recently constructed wells and the future wells is based on a wellfield design developed to maximize the volume of injected water that can be recovered at this site.

The current wellfield expansion was undertaken based on the excellent operational performance of the existing ASR wells. All wells constructed and proposed at this site will be completed to store water within the basal Hawthorn, upper Suwannee Formations, located between approximately 730 and 780 feet below land surface.

ASR-5 was constructed using 17.4-inch O.D. CertainTeed, Certa-Lok SDR 17 PVC casing to conduct water between the surface and the ASR storage zone. The storage zone is intersected by ASR-5 from 730 to 780 feet below ground level. The wellhead is constructed using 316 stainless steel. Tests performed on the new ASR well indicate that the new well can operate at the design rate of 1000 gpm.

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1.0 INTRODUCTION

This Well Completion Report summarizes the construction of Well ASR-5 at Marco Island Utility's raw water facility at Marco Lakes (Figure 1-1). The drilling, construction, and testing activities conducted to complete ASR-5 are documented in this report.

Construction of ASR-5 was authorized by the Florida Department of Environmental Protection as a part of a permit to expand the existing ASR wellfield. Permission to construct eight (8) Class V Group Seven Aquifer Storage and Recovery injection wells at this site was granted by FDEP on April 22, 1999 through issuance of permit numbers 141218-001 through 008-UC (Appendix 1.1). Collier County also issued a permit for construction of ASR-5 and assigned the Florida Unique I.D. # CC07164-N (Appendix 1.2). ASR-2 and ASR-3 were previously completed and first utilized for injection in August of 2001. Permit numbers were assigned to each well based on the anticipated wellfield configuration shown in Figure 1-2. The site of ASR-5 was determined to be the most readily accessible and convenient of the remaining available sites in the wellfield and was selected for the current phase of construction

The current expansion is designed to increase the ultimate storage capacity of the wellfield to approximately 600 MG. It is anticipated that the newly expanded wellfield will be able to deliver more than 450 million gallons of water for use at Marco Island on a seasonal basis and a 100 MG cycle storage volume per well.

Locations of all wells included in the current and proposed ASR wells are indicated on Figure 1-2. Two ASR wells, ASR-2 and ASR-3 and two monitor wells, SZ-2 and DZ-2, were completed during the initial phase of the ASR expansion project. (WRS, 2000). One ASR well (ASR-1), and one dual zone monitor well (DZMW) were constructed previously as part of the initial ASR pilot project (ViroGroup, 1998).

2.0 HYDROGEOLOGY

2.1 Geology

The description of the geology at the project site is based on previously obtained information and on the analyses of drill cuttings, geophysical logs (Appendix 2.1), and hydrologic tests conducted during the construction of ASR-5. A lithologic log for ASR-5 is provided in Appendix 2.2. The deepest formation penetrated in this borehole was the upper Suwannee Limestone at 780 feet below pad level (bpl). The general stratigraphic description of the site is summarized below and is provided as a stratigraphic column in Figure 2-1. A north-south hydrogeologic cross-section based on correlated gamma logs is provided as Figure 2-2.

The geologic formations penetrated during well construction range in age from Holocene (recent) to Oligocene (25-30 million years). They consist of undifferentiated Quaternary deposits, the Tamiami Formation, the Peace River and Arcadia formations of the Hawthorn Group, and the Suwannee Limestone Formation. The ASR storage zone, which extends from 730 to 780 feet bpl at this well, occurs within carbonate rocks in the basal portion of the Arcadia Formation and the uppermost strata of the Suwannee Limestone.

Undifferentiated Quaternary Deposits

Undifferentiated sediments of Pleistocene to Holocene age (0-1.6 million years) range from less than 10 feet to over 30 feet thick across the site and form the uppermost strata encountered. These surficial deposits consist mainly of shell and quartz sand, but may also include marl, and sandy limestone. A distinctive layer of consolidated limestone "caprock" was encountered in the uppermost section of surficial deposits from 7 to 12 feet below pad level. This limestone consists mainly of bivalve shells and shell fragments cemented in a matrix of recrystallized calcite.

Tamiami Formation

The Pliocene age Tamiami Formation (1.6 to 5.3 million years in age) unconformably underlies the undifferentiated surficial sediments. The Tamiami Formation extends from approximately 30 to 140 feet bpl at the project site. The Tamiami can be subdivided into upper and lower limestone units (Pinecrest and Ochopee members), that are separated by a gray to green marl or marly limestone (Bonita Springs member). The limestones generally exhibit good to excellent moldic porosity, and become more sandy with depth. The Bonita Springs marl is typically 10 or less feet thick across in the area penetrated during this expansion. The combined thickness of the Tamiami Formation is over 110 feet.

Peace River Formation (Hawthorn Group)

The predominantly Miocene-age Hawthorn Group (5.3 to 25.5 million years in age) in south Florida is divided into an upper unit of mainly siliciclastic sediments, referred to as the Peace River Formation; and a lower unit consisting predominantly of carbonate rocks, termed the Arcadia Formation (Scott, 1988). The Peace River Formation extends from approximately 140 to 290 feet bpl at the project site. The upper 30 feet of the formation consist mainly of unconsolidated quartz sand, variably indurated sandstone, and sandy limestone. The sands are underlain by finer-grained sediments that include dolosilt, lime mud, and sandy clay. Phosphatic sand and gravel are common throughout the Peace River Formation. A noteworthy occurrence of well-rounded and flattened quartz gravel was observed in clays present from 200 to 250 feet bpl. The thickness of the Peace River Formation is approximately 150 feet.

Arcadia Formation (Hawthorn Group)

The top of the Arcadia Formation is marked by a transition from a green clay to a phosphatic limestone at a depth of 287 feet bpl at this site. The base of the formation is picked at approximately 750 feet bpl across the site.

The Arcadia Formation consists of an interbedded sequence of phosphatic carbonate rocks and lime mud. Porosity of the limestones is variable; tending to be best developed where fossil shell has dissolved to form molds. The lower portion of the Arcadia Formation contains thick sequences of marl and marly limestone that form the confining beds above the ASR storage zone. The basal portion of the Arcadia Formation is included in the ASR storage zone, and consists of pale orange limestone wackestone with good moldic porosity and low gamma activity. The thickness of the Arcadia Formation is approximately 460 feet.

Suwannee Limestone Formation

The Suwannee Limestone Formation is early to middle Oligocene in age (25.5-30 million years). The upper 30 feet of strata in the Suwannee are included in the ASR storage zone and consist predominantly of very pale limestone packstone with good to excellent moldic porosity and low gamma activity that is difficult to distinguish from the basal Arcadia Formation. White to very light gray lime mud was encountered near the base of the storage zone at approximately 780 feet bpl, which was the deepest point penetrated during this project.

2.2 Aquifer Designations

The strata penetrated are grouped into three principal systems; the surficial aquifer system, intermediate aquifer system, and the Floridan aquifer system. The aquifers and confining units identified at the site are illustrated in Figure 2-1. The surficial aquifer system includes the water table and lower Tamiami aquifers. The intermediate aquifer system includes a series of aquifers and confining units within the Hawthorn Group. The upper section of the Floridan aquifer includes the carbonate strata of the basal portion of the Arcadia Formation and the upper portion of Suwannee Limestone and is the hydraulic unit identified as the storage interval at this site.

2.3 Storage and Confining Interval Description

The ASR storage interval occurs within permeable limestones present in the lower 20 feet of the Arcadia Formation and the upper 30 feet of the Suwannee Limestone (730 to 780 feet bls). Flow log data from the ASR-5 well (Figure 2-3) indicate that the fairly uniform flow comes from an upper unit between 735 and 745 feet and from a lower unit between 750 and 768 feet. Little flow occurs from the region below 768 feet.

The confining beds overlying the storage zone consist of approximately 125 feet of phosphatic, low-permeability lime mud and marly limestones with interbeds of more permeable carbonates in the lower portion of the Arcadia Formation. Natural gamma activity is generally high within this interval.

Minor amounts of lime mud were encountered near the base of the storage interval at approximately 780 feet bpl. Drill-cuttings were monitored closely during drilling of the open-hole to avoid breaching any natural lower formation confinement of the storage zone.

2.4 Formation Water Quality

Fresh water resources in the region surrounding the site are generally limited to the water table aquifer and the upper portion of the lower Tamiami aquifer. Groundwater in deeper aquifers is brackish to saline.

Water samples were taken every ten feet at ASR-5 during reverse-air drilling of the open hole from 730 to 780 feet. The samples were analyzed in the field for conductivity (Table 2-4) Conductivity was observed to decrease with depth and is believed to reflect a decreasing amount of residual kill fluid in the formation as reverse circulation flushed the ASR zone.

Formation water from the new well was later sampled after approximately 21 well volumes had been purged from the well during aquifer testing. These samples were analyzed for all primary and secondary drinking water parameters including unregulated chemicals by Southern Analytical Laboratories, Inc. A review of the chemical analyses results (Appendix 2.3) shows that the overall water quality within the injection zone indicates arrival of injected water from ASR-2. The location of the injected water reflects the concept behind the wellfield design and the desire to have significant overlapping of bubbles from adjacent wells.

The base of the underground source of drinking water (USDW), defined in applicable state and federal regulations as 10,000 mg/l total dissolved solids, was not penetrated at the project site. The USDW was picked at a depth of 1,095 feet in well CO-2080, located about 2 miles south of the Marco Lakes (ViroGroup, 1996b). Native groundwater in the storage interval and overlying aquifers is most appropriately classified a G-II, groundwater with a TDS content between 3,000 and 10,000 mg/l (F.A.C. 62-520.410).

3.0 WELL CONSTRUCTION PROGRAM

The new ASR well is completed in the basal Arcadia/Upper Suwannee formations (ASR zone). Weekly summary reports were prepared for the FDEP and TAC during well construction (Appendix 3.1). Daily drilling reports were prepared by the contractor and were previously submitted with the weekly summary reports.

3.1 Site Preparation

Two site surveys were conducted by Metron, Inc. of Fort Myers, Florida to stake the well positions on the property and to establish reference elevations. A final survey will be conducted upon completion of this phase of the expansion. Removal of brush, ground foliage, and rocks was necessary at this site prior to the start of well construction. Figure 3-1 shows the construction site with the general equipment layout, well locations, and the route of the temporary surface discharge line.

3.1.1 Produced Water Discharge

Prior to beginning the reverse-air drilling phase of this well, a temporary 10-inch diameter PVC line was installed from the well site to SZ-2 where it was connected to a pre-existing pipeline used for discharge of saline formation water. The pre-existing 8-inch diameter pipeline discharges at a point downstream of the Henderson Creek weir at the intersection of U.S. 41 and Henderson Creek (Figure 3-2).

Discharge below the weir at Henderson Creek was permitted under the State of Florida's Generic NPDES permit for the discharge of produced water from a non-contaminated site activity. A copy of this permit is included as Appendix 3.2. All drilling solids were used as fill material for site restoration and preparation.

3.1.2 Temporary Drill Pad Construction

A temporary drilling pad 60 feet long by 20 feet wide, surrounded by a two-foot high berm, was constructed at the well site to contain water and drilling fluids at the wellhead and around the drilling rig. The well pad was graded to provide stability for the drilling rig. A 10-millimeter thick polyethylene liner was installed prior to installation of a gravel bed inside the pad. Plywood tracks were laid on the gravel bed inside the pad to distribute the weight of the drilling rig as it was moved into the pad area. Excess water and drilling fluid was pumped from the containment pad to fluid storage tanks as needed. The containment pad was removed once construction of the well was completed.

3.1.3 Pad Monitor Well Construction

The contractor received a permit from Collier County to construct two pad monitor wells prior to drilling ASR-5 (Appendix 3.3). The two wells are approximately 20 feet in depth (Figure 3-3), and were installed at the NW and SE corners of the drill pad prior to drilling to monitor for excess spills and leakage of salt water from the containment pad during drilling operations. The two 4-inch wells were drilled using the mud rotary method and were gravel packed, grouted, and developed by a subcontractor for the contractor. Construction details for the pad monitor wells are included in Table 3-1. Measurements of the static water levels were recorded and the pad monitor wells were purged and sampled weekly for the duration of the drilling and construction phase of the project. Field analyses and measurements were performed for chlorides, conductivity, pH, and temperature are summarized in Tables 3-2 and 3-3.

3.2 ASR-5 Well Construction

Well construction at ASR-5 commenced on July 26, 2004 and the drilling rig was moved off the well on November 3. A schematic of the final construction of ASR-5 is included as Figure 3-4. Work on ASR-5 was delayed by threats from four major hurricanes; Charlie, Francis, Ivan, and Jeanne. In each case, the contractor lowered the derrick on the drill rig and secured the site well in advance of the possible arrival of the storms.

3.2.1 Pit Casing Installation

Well construction began with the installation of a 26-inch O.D. steel pit casing set into a 35-inch nominal wellbore drilled to 50 feet below pad level (bpl). A single length of 26-inch, spiral welded, 3/8-inch wall thickness, steel casing was set to a depth of 47 feet bpl and tremie grouted in place using neat portland, type II cement. Mill certificates for this pipe are included as Appendix 3-4.

3.2.2 Production Casing Installation

After installation of the pit casing, a 12½ -inch diameter bit was used to drill to a depth of 745 feet bpl using the mud rotary method to control artesian flow. Inclination surveys were completed in the pilot hole as well as the reamed hole every 90 feet and are included as Table 3-4. Rates of bit penetration were measured at various intervals over much of the pilot hole depth and are included as Table 3-5. A drill pipe tally was recorded for the drilling of the pilot hole and includes the lengths of all units in the drill string (Table 3-6)

Upon completion of the nominal 12½ -inch borehole, natural gamma, XY caliper, dual induction, and sonic/VDL logs were run from the bottom of pit casing to total depth (TD). A casing setting depth of 730 feet was selected based on the lithologic and geophysical logs. The hole was then reamed to a depth of 730 feet bpl with a 25-inch diameter bit. A tally of the pipe string used during this phase of drilling is included as Table 3-7. The borehole was re-reamed and circulated with conditioned drilling fluid in preparation for setting casing. Natural gamma and XY-caliper logs were run in the reamed hole to assist in the final casing setting depth selection and estimation of annular borehole volume.

CertainTeed, Certa-Lok 17.4-inch O.D. SDR 17 PVC casing was run to the setting depth of 730 feet bpl. Table 3-8 provides a summary of the production casing installed.

Specifications for the production casing string are included as Appendix 3.5. Prior to casing installation, a cement basket was installed around the base of the casing expanded to 25-inches, and filled with ¾-inch bentonite pellets. Cement grout was emplaced in the annulus by the tremie method in a series of 5 stages containing a total of 865 sacks of cement and 15 sacks of bentonite. The first three cement stages contained neat cement and water in a mix ratio of 6 gallons of water per sack of cement. Cement stage 4 contained cement with 2.5% by weight bentonite and cement stage 5 contained 1.56% by weight bentonite. Details of cementing operations were recorded in a cementing log Table 3-9. Pressure was maintained inside the casing during tremie grouting to help equalize the pressure exerted by the cement column. Table 3-10 summarizes the volume of cement pumped and the annular height for each stage. Fluid temperature logs were performed after cement stages 2, 3, and 4, between 7 and 12 hours after cement pumping to estimate the annular grout level. Cement returns were observed at the surface at the end of the 5th and final cement stage.

3.2.3 Casing Pressure Test

The drilling mud was flushed from the casing by the reverse-air method and the artesian flow from the well was suppressed with injection of a saturated solution in order to allow installation of a packer at a depth of 718 feet below pad level. A one-hour pressure test of the casing was conducted with an initial pressure of 131 psi and a final pressure of 130 psi. The pressure inside the casing was recorded at 5-minute intervals and the official record was signed and witnessed by WRS and Southern Well Services (Appendix 3.6). FDEP representatives gave permission to run the test without their presence. The accuracy of the pressure gauge was certified by testing against a pressure standard deadweight tester (Appendix 3.7). The volume of water released from the casing at the end of the test was 7.1 gallons, which reflects a compressibility factor of 7.4×10^{-6} /psi. A value of 7.4×10^{-6} /psi is an acceptable value for this test in PVC casing.

3.2.4 Open-Hole Construction

Reverse-air drilling of the open hole portion of ASR-5 commenced on October 19, 2004 using a 15-inch bit. A tally was prepared of the lengths of all pieces of that drill string and is included as Table 3-11. Cuttings samples were collected at five-foot intervals and formation water samples were taken every ten feet and analyzed for conductivity. The borehole was advanced from the base of the PVC casing at 730 feet to a total depth of 780 feet bpl. Artesian flow was evidenced when the air supply was shut off during this phase of drilling.

3.3 Well Development and Suppression

The well was developed for two hours by reverse-air through the drill string as the drill string was raised and lowered through the open hole section of the well. At the completion of development, produced water was clear of sediment. All water produced during reverse-air drilling and development was retained in storage tanks for settling before being discharged to Henderson Creek downstream of the weir. At the completion of development, the artesian flow of the well was suppressed using a salt solution to facilitate installation of a submersible pump for aquifer performance testing. At the completion of pump installation, the salt solution was pumped from the well and held in storage for later reuse. After pump testing was completed, the well was once again suppressed in order to remove the submersible pump.

3.4 Final Geophysical Logging and Video Survey

MV Geophysical Surveys, Inc. performed a video survey and caliper/gamma log of the entire well and also the following open hole logs; flowmeter, fluid resistivity/temperature, dual induction, and borehole compensated sonic/variable density log. The geophysical logs indicate that the bubble from ASR-2 has reached the ASR-5 location. The flow log suggests that there are two fairly uniform flow units within the 50 feet of open hole.

3.5 Wellhead and Pad Completion

At the completion of well construction and testing, the well was killed using NaCl in preparation for wellhead installation. A 16-inch by 12-inch, flanged, schedule 40, 316 stainless steel tee with a 12-inch butterfly valve was connected to the well column with a stainless steel to Certa-Lok to flange adaptor (Appendix 3.8). The top of the 16-inch tee was temporarily completed with a blind flange. Two 2.5-inch and one 3-inch diameter stainless steel access ports with ball valves were provided on the wellhead assembly (Figure 3-4).

The final well pad was constructed at an elevation of 7.5 feet NGVD by others.

4.0 FLOW TESTS AND ANALYSES

A certified calibration was performed on the contractor's water meter using an ultrasonic flowmeter prior to aquifer pump testing (Appendix 4.1). On October 28, 2004, a step drawdown test was initially conducted on ASR-5. Pressure changes due to pumping were recorded during this test at ASR-2, located 400 feet from ASR-5, and DZ-2, located at 1607 feet from ASR-5. The second test was a single rate test conducted at 818 gpm. Pressures in the three wells were recorded simultaneously at a frequency of one reading per minute. Drawdown data for the three wells and flow data from ASR-5 were compiled into Appendix 4.2 for the entire period of pumping and recovery.

The step drawdown test was primarily performed to establish the specific capacity of this interval for pump sizing and to determine the drawdown at adjacent wells. Table 4-1 summarizes the data obtained during this test.

As indicated in Table 4-1, specific capacity values measured in ASR-5 were 101.2 gpm/ft at 163 gpm, 46.6 gpm/ft at 299 gpm, 40.2 gpm/ft at 518 gpm, and 31.8 gpm/ft 784 gpm. A plot of pumping rate vs. specific capacity is provided as Figure 4-1. By extrapolating the "pumping rate vs. specific capacity" curve to the production rate of 1000 gpm, it is estimated that the specific capacity of ASR-5 under production conditions will be approximately 25 gpm/ft.

The drawdown in ASR-2 and DZ-2 versus the pumping rate in ASR-5 is provided in Figure 4-2. This plot indicates that the additive drawdown at ASR-2 will be approximately 8 feet at a pumping rate of 1000 gpm and that DZ-2 will experience approximately 4 feet of additional drawdown.

Transmissivity (T) was calculated using distance drawdown curves generated from pump test data by the analysis techniques described by Driscoll (1986):

$$T=528Q/\Delta s$$

where Q is the average pumping rate in gpm and Δs (ft) is the drawdown per log cycle of distance from pumping well. The analysis method can be applied to a semi-log distance-drawdown plot (Figure 4-3) of head changes in ASR-2 (400 feet southeast of the pumped well) and in DZ-2 (1607 feet northeast of the pumped well) to calculate the drawdown per log cycle, Δs. Two discharge rates were analyzed to determine transmissivity values (163 and 818 gpm). Transmissivity calculations are summarized in Table 4-2. The average transmissivity was computed to be 81,250 gpd/ft, (10,860 ft^2/day). Transmissivity calculations of the storage zone made during the pilot study ranged from 61,000 to 68,000 gpd/ft, (8,100 to 9,100 ft^2/day). The average storage coefficient was estimated to be 3.9×10^{-5}, based on the 163 and 818 gpm drawdown curves, and indicates a relatively confined unit.

5.0 REFERENCES

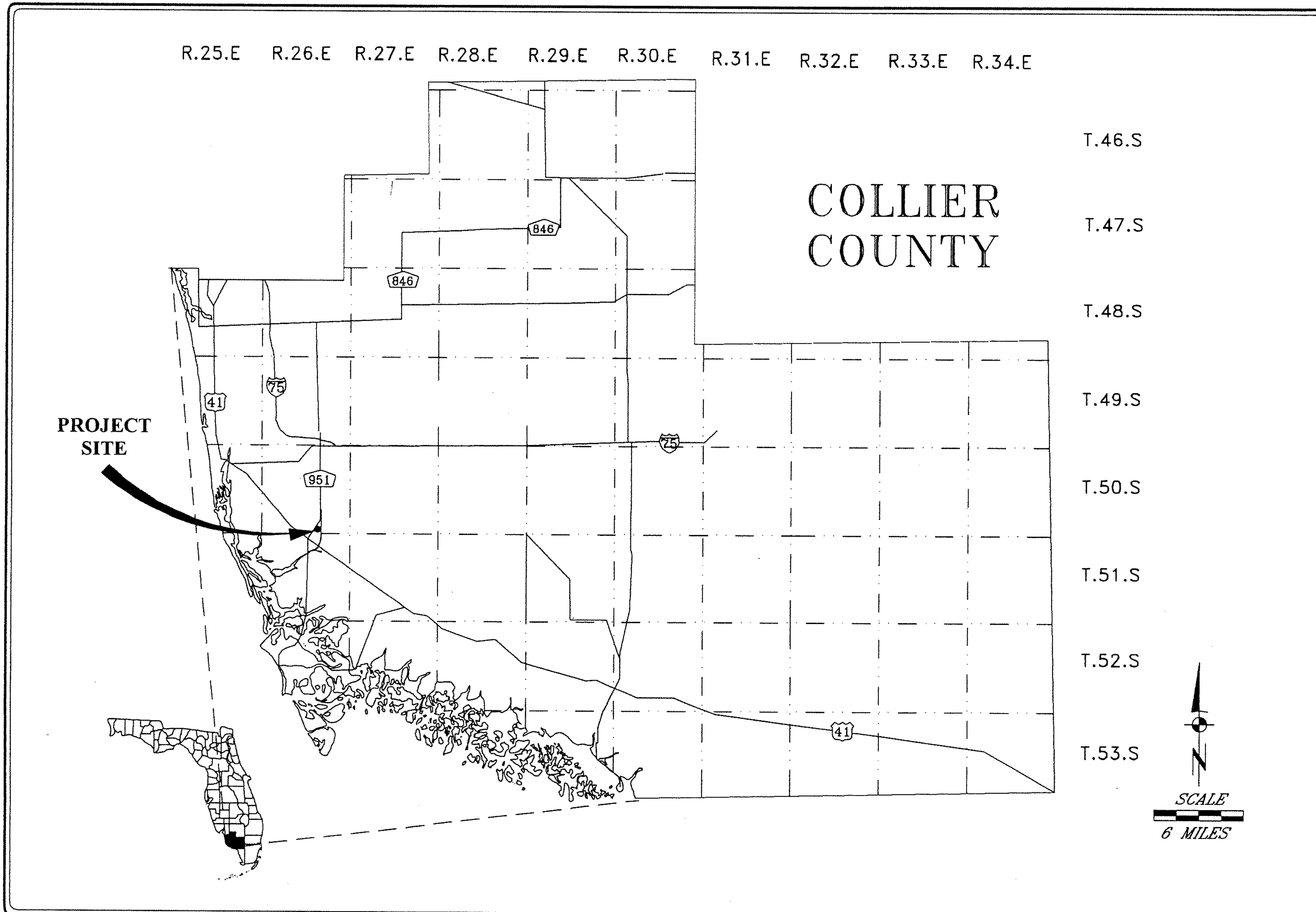
Driscoll, F.G. 1986, Groundwater and Wells, Second Edition, Johnson Filtration Systems Inc., St. Paul Minnesota, pp. 236-237.

Scott, T.M., 1988, The lithostratigraphy of the Hawthorn Group (Miocene) of Florida: Fla. Geol. Survey Bul. No. 59, 148 p.

ViroGroup, Inc., 1996b, Marco Island R.O. Wellfield Expansion Project Well Construction Report: Report to Southern States Utilities (September 1996).

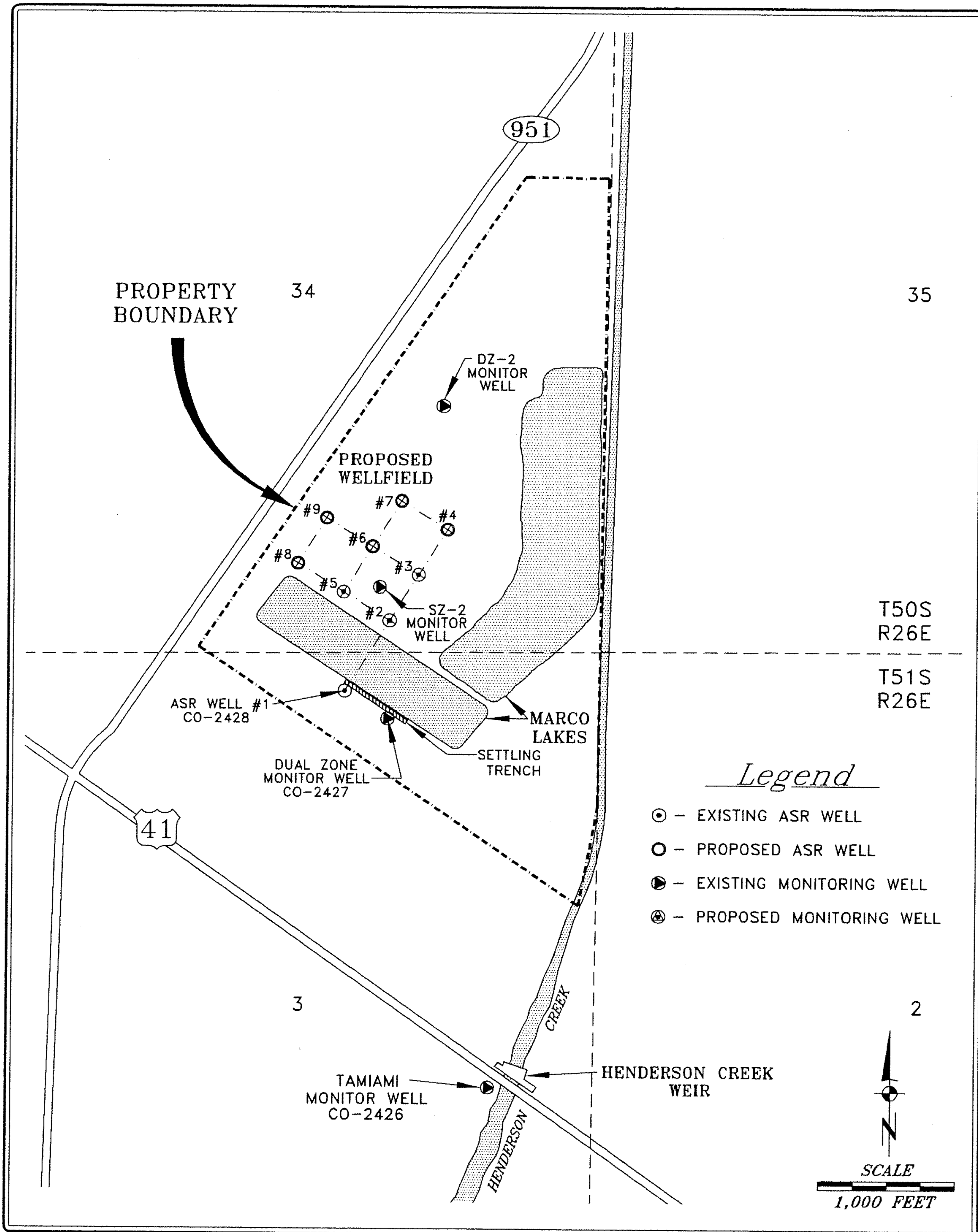
ViroGroup, Inc. 1998, Marco Lakes Aquifer Storage and Recovery Pilot Project-Final Report, Collier County, Florida: Report to Florida Water Services, Inc.

Water Resource Solutions, Inc. 2000, Marco Lakes ASR Expansion Project Well Completion Report: Report to Florida Water Services, Inc (April 2000).



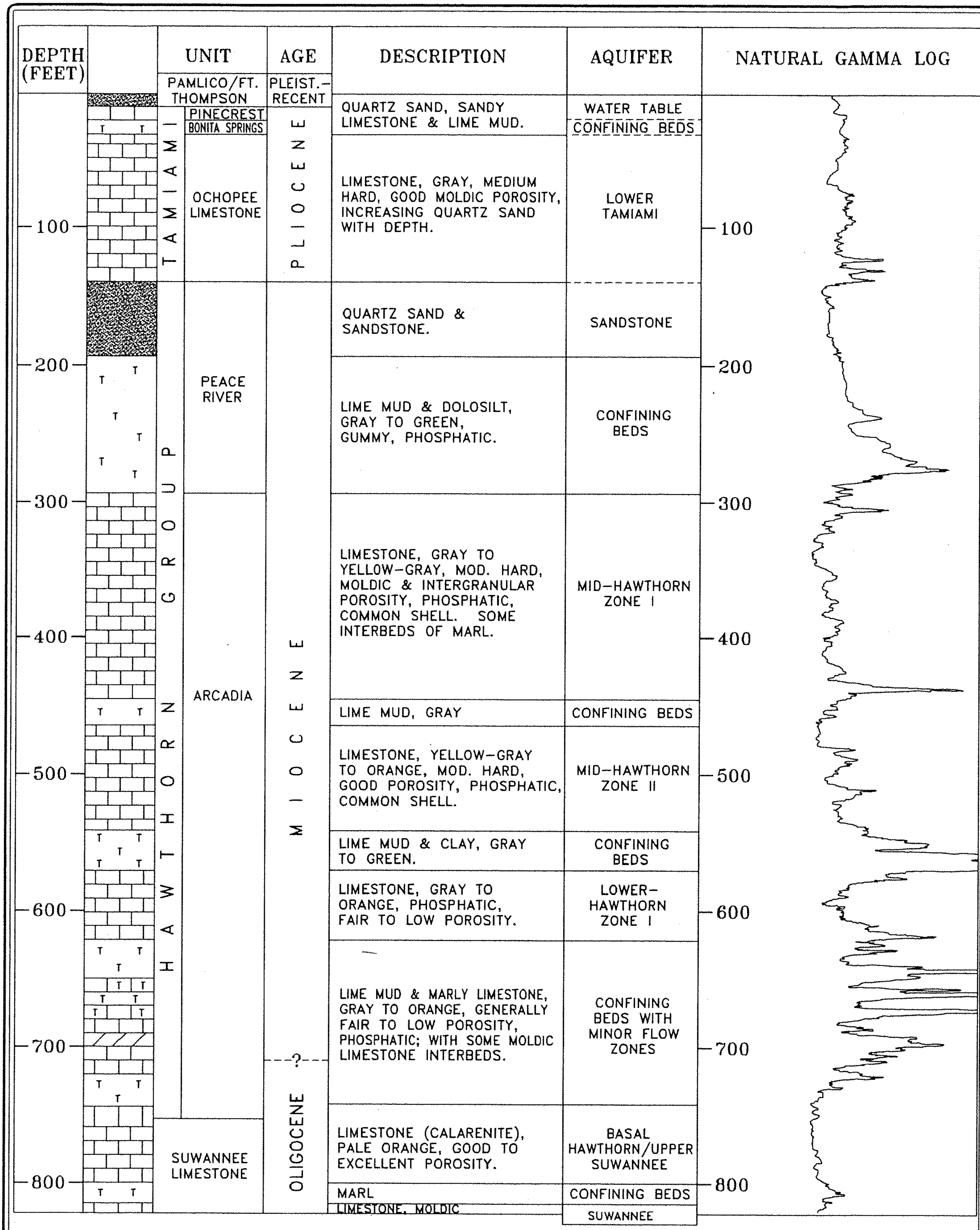
Water Resource Solutions	PROJECT NAME: MARCO ISLAND UTILITIES	DWG. NUMBER: A-014773M3
	PROJECT NUMBER: 01-04773.02	DATE: 11/22/04

FIGURE 1-1. GENERAL SITE LOCATION MAP.



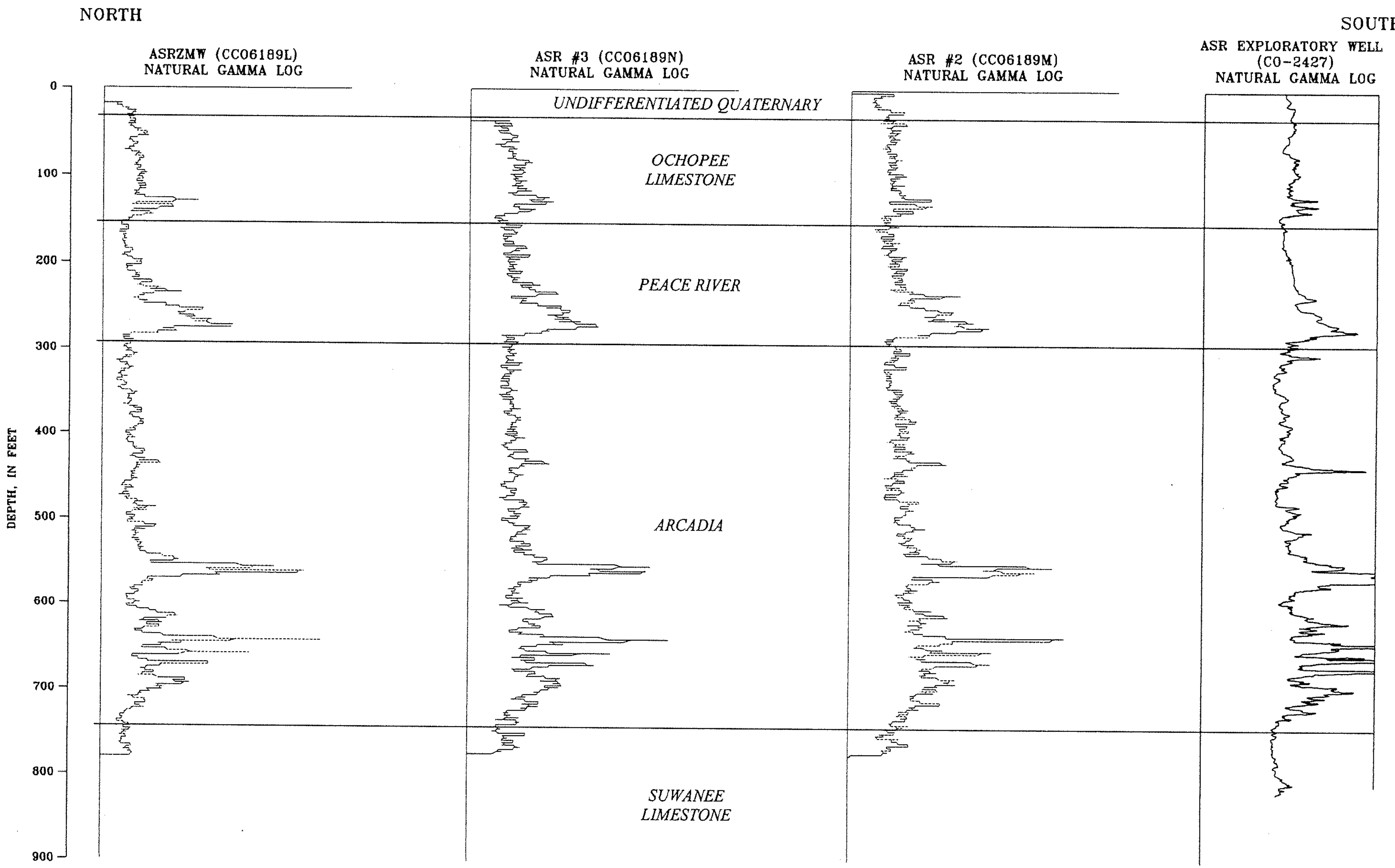
Water Resource Solutions	PROJECT NAME: MARCO ISLAND UTILITIES	DWG. NUMBER: A-014773E3
	PROJECT NUMBER: 01-04773.02	DATE: 11/22/04

FIGURE 1-2. MARCO LAKES SITE LOCATION.



Water Resource Solutions	PROJECT NAME: MARCO ISLAND UTILITIES — DWG. NUMBER: A-014773E3
	PROJECT NUMBER: 01-04773.02 — DATE: 11/22/04

FIGURE 2-1. GENERAL HYDROSTRATIGRAPHIC COLUMN MARCO LAKES EXPLORATORY WELL CO-2427.



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DATE: 11/22/04

FIGURE 2-2. NORTH-SOUTH GEOLOGIC CROSS-SECTION THROUGH SITE BASED ON GEOPHYSICAL LOGS.

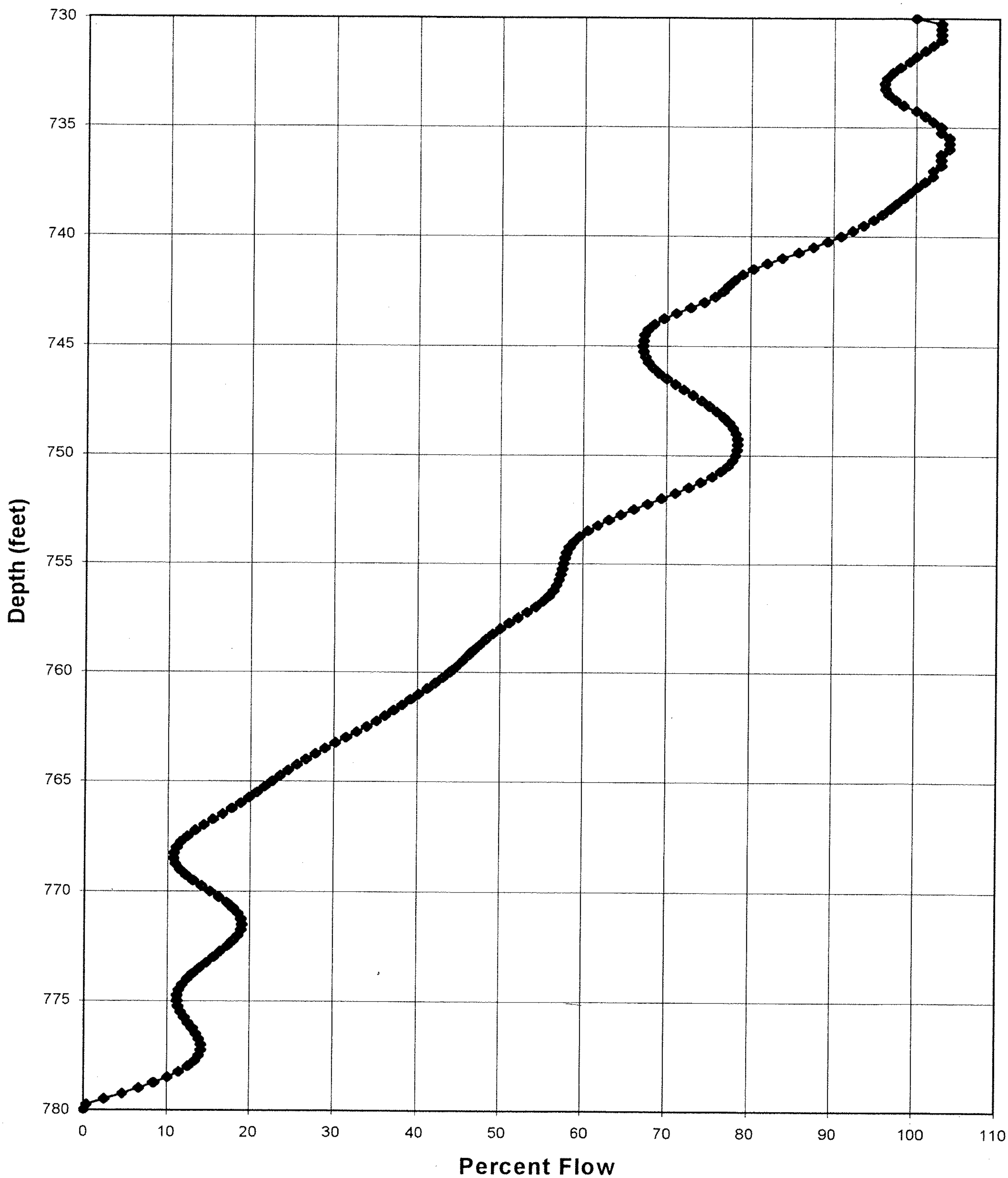

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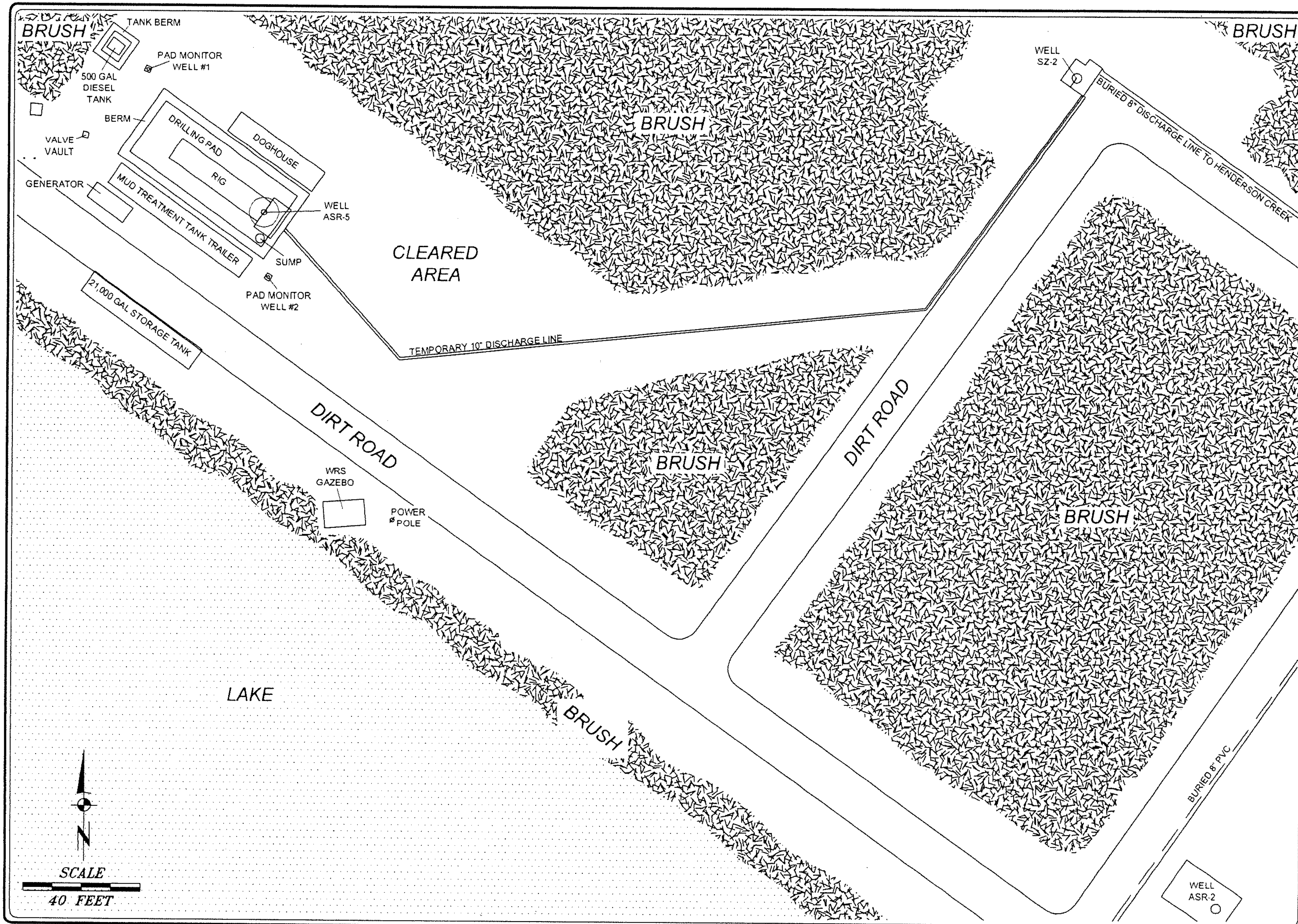
Figure 2.3 Flow Log Diagram



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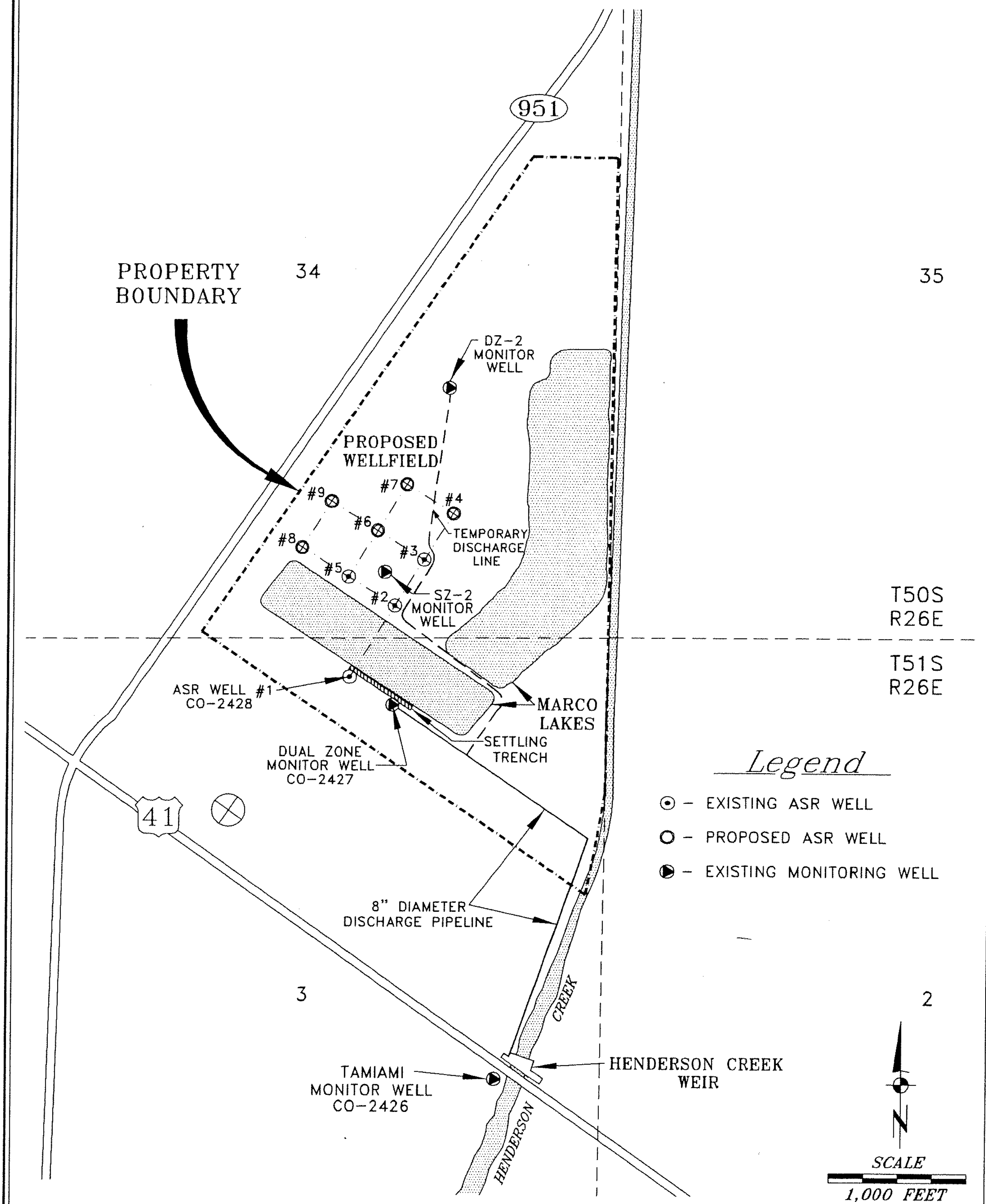
	PROJECT NUMBER: 01-04773.02	DATE: 12/15/04

FIGURE 3.1 ASR-5 CONSTRUCTION SITE LAYOUT.



Water Resource Solutions	PROJECT NAME: MARCO ISLAND UTILITIES	DWG. NUMBER: A-014773E3
	PROJECT NUMBER: 01-04773.02	DATE: 12/15/04

FIGURE 3-2. MARCO LAKES ASR EXPANSION SITE DETAIL.

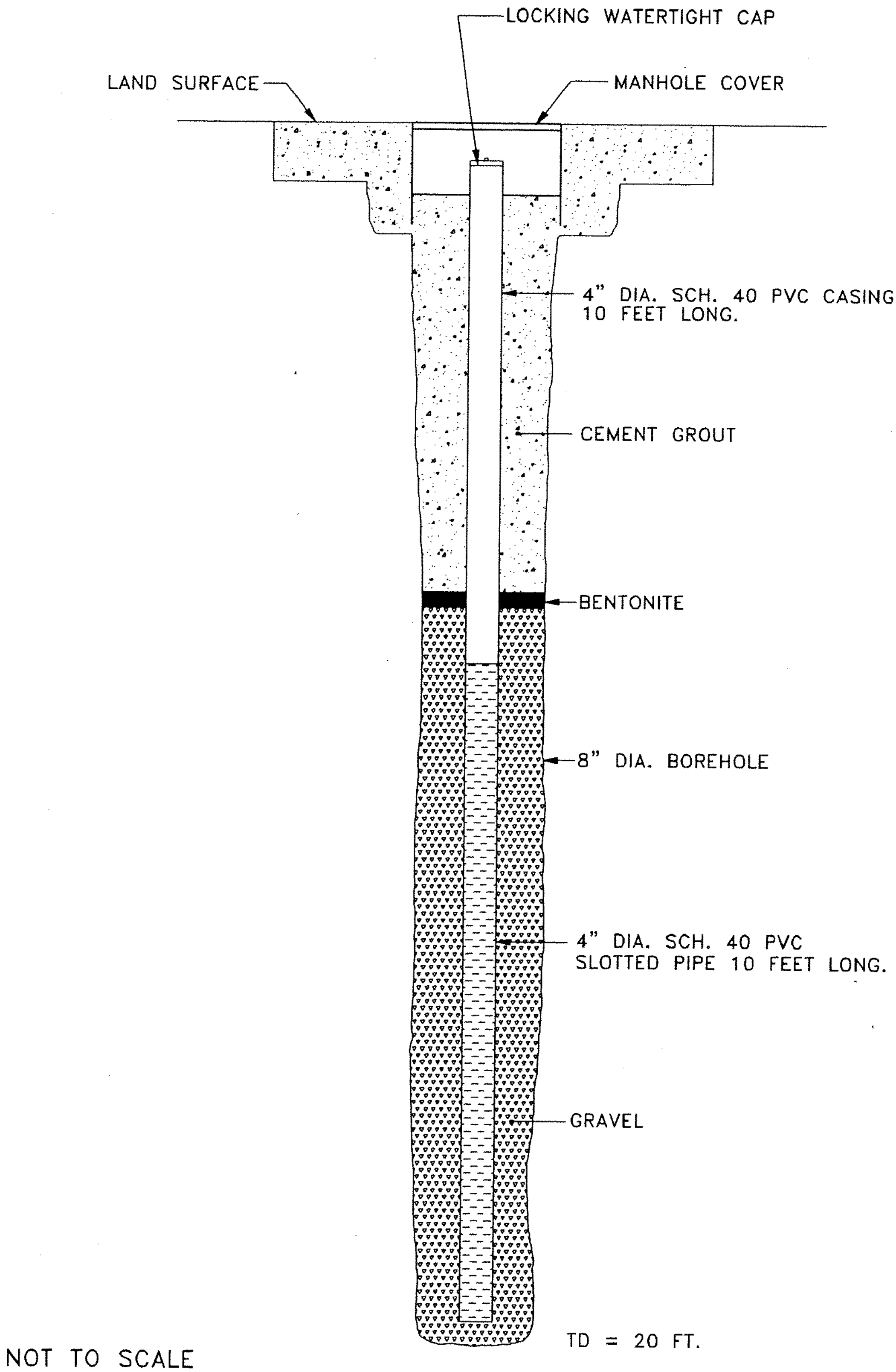


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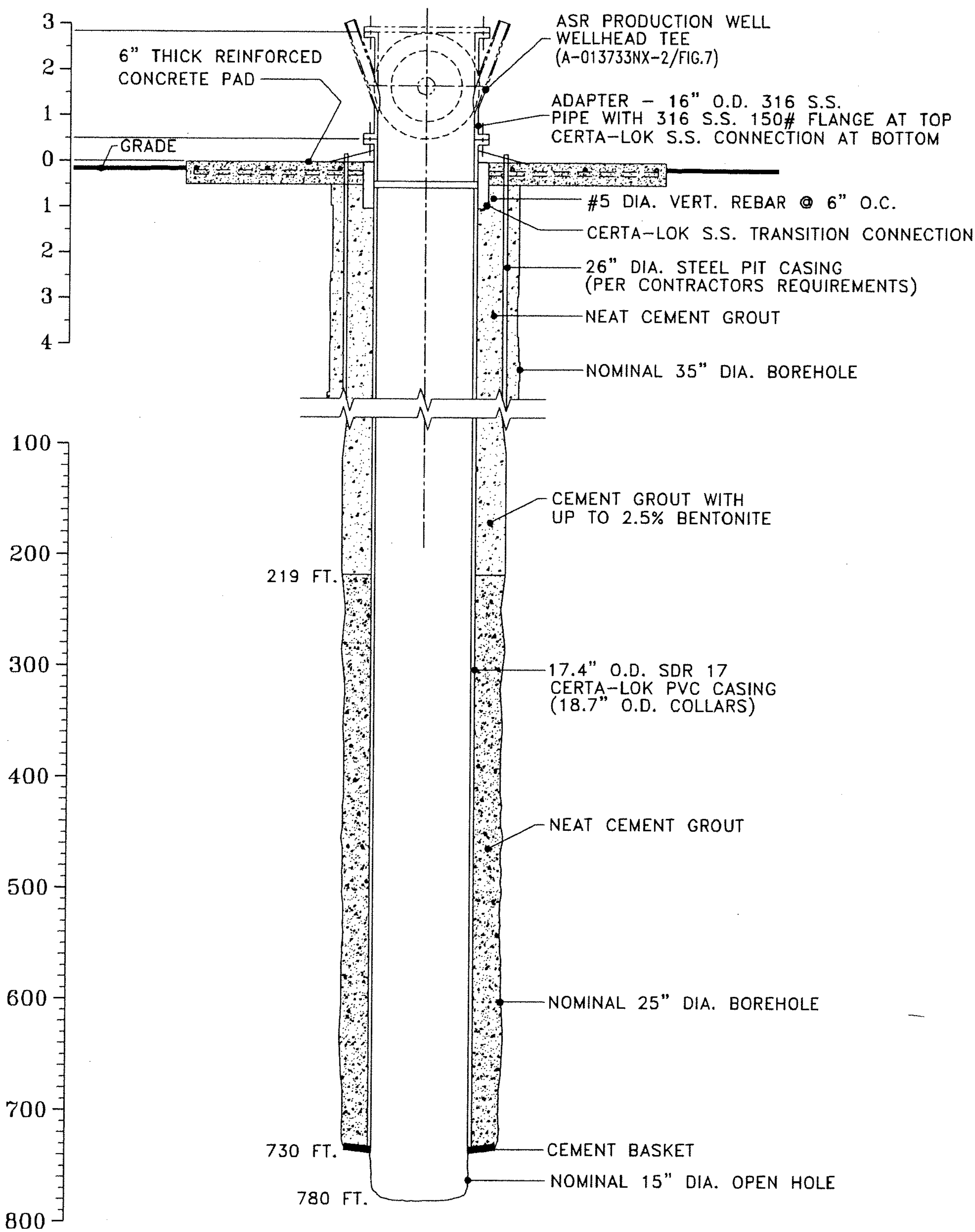
FIGURE 3-3. PAD MONITOR WELL CONSTRUCTION SCHEMATIC.



Water Resource Solutions	PROJECT NAME: MARCO ISLAND UTILITIES	DWG. NUMBER: A-014773E2
	PROJECT NUMBER: 01-04773.02	DATE: 11/17/04

FIGURE 3-4. ASR #5 WELL CONSTRUCTION SCHEMATIC.

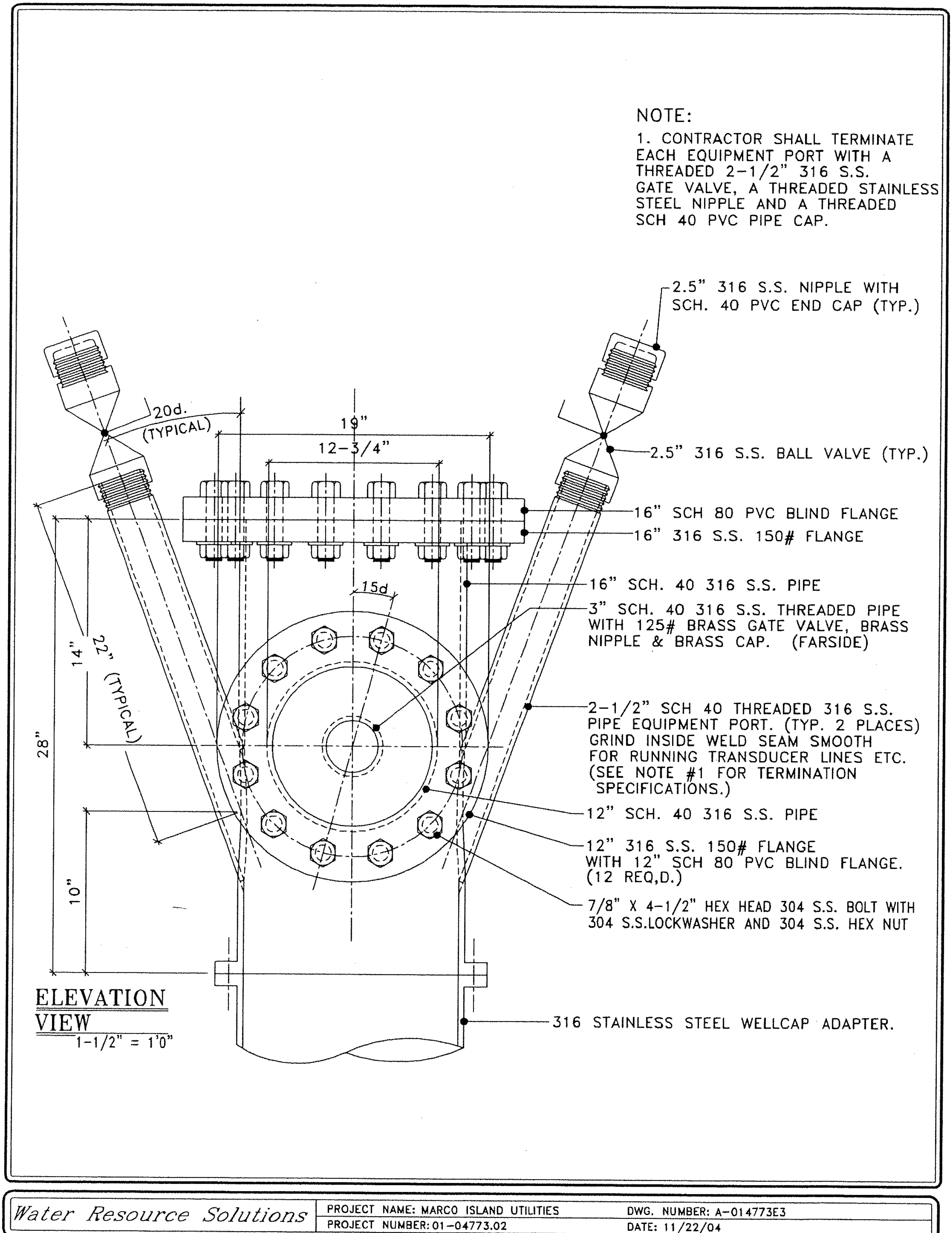
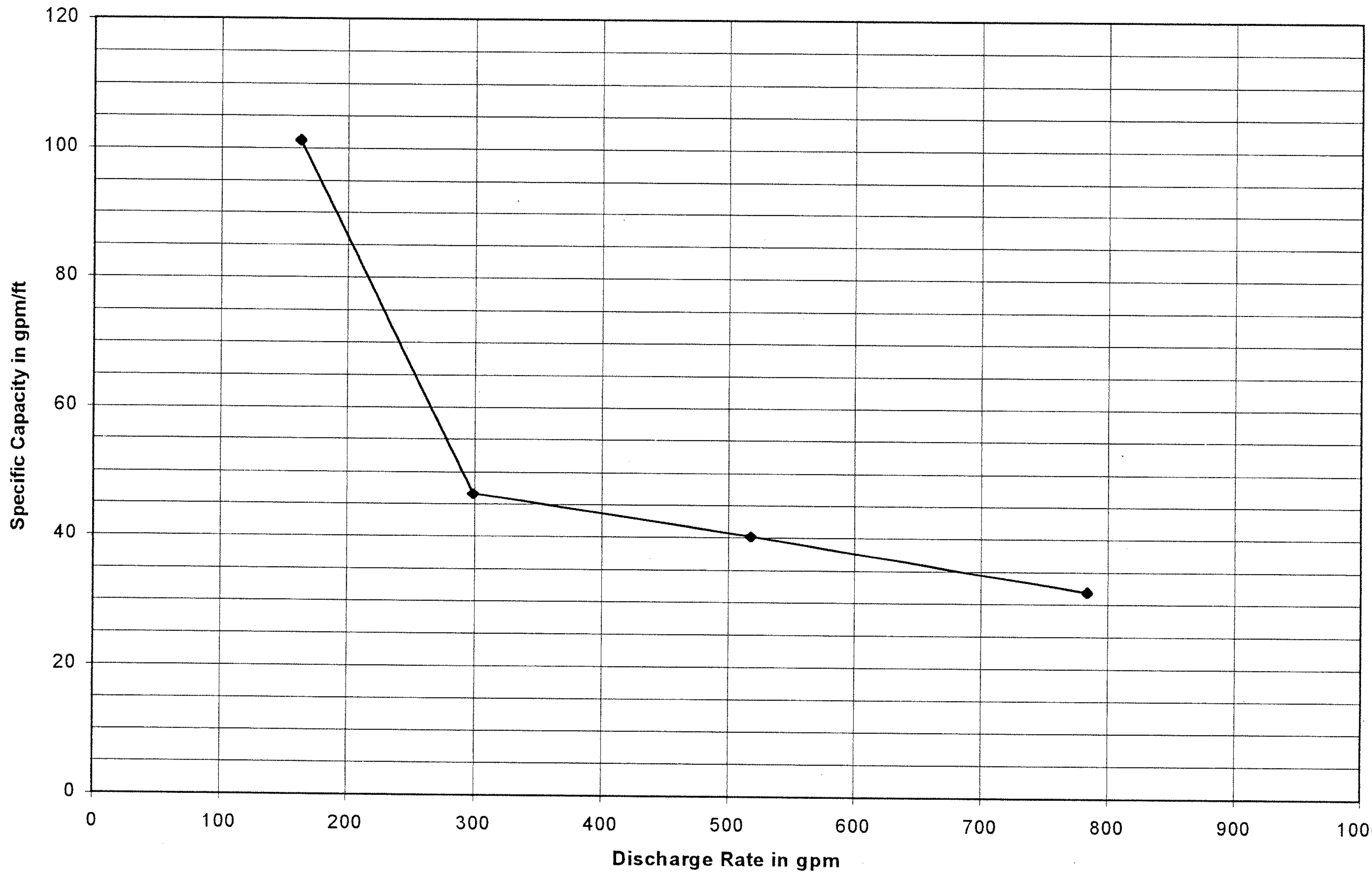


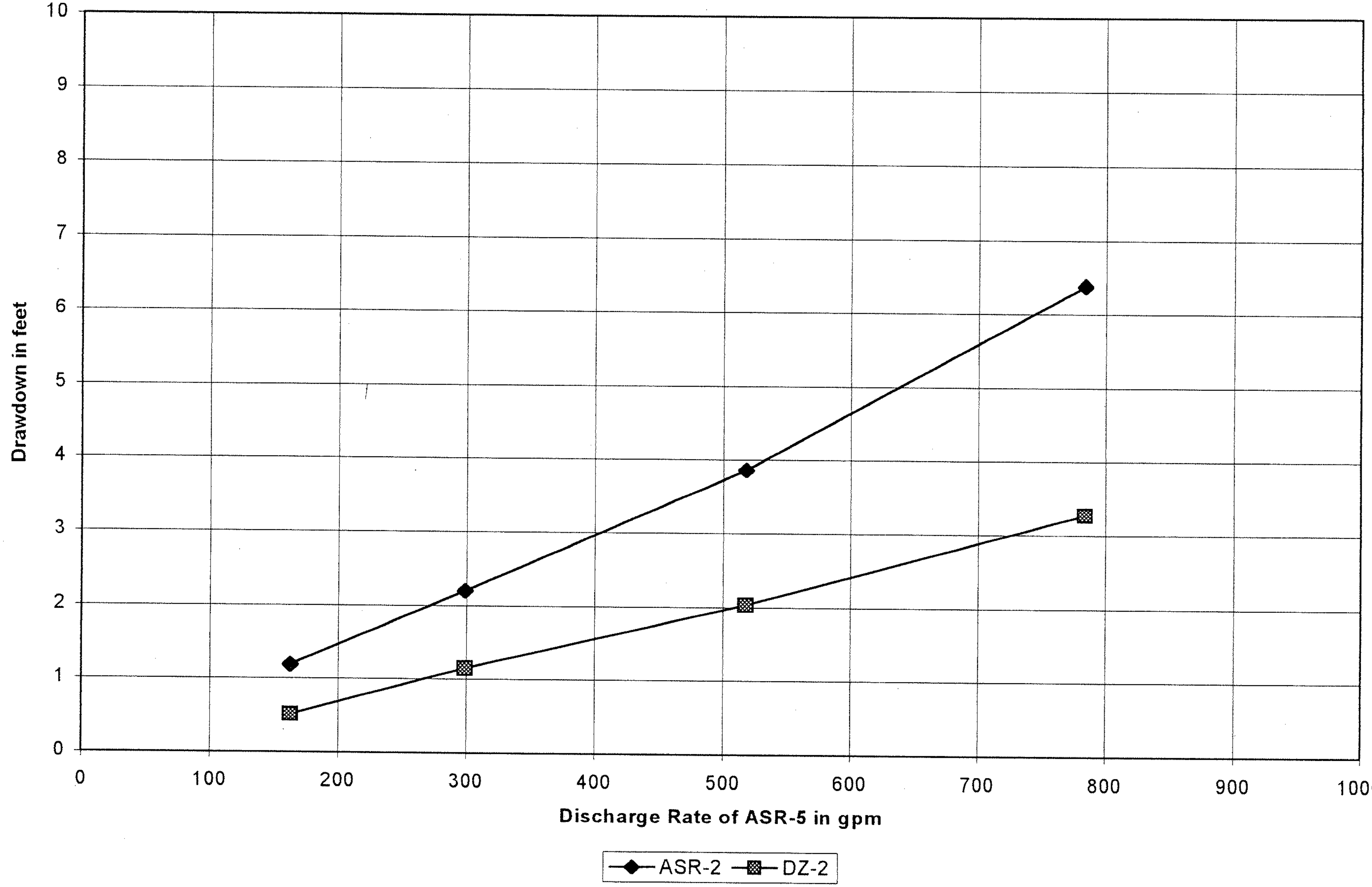
FIGURE 3-5. ASR PRODUCTION WELLHEAD DIAGRAM.



Water Resource Solutions

Project : Marco Lakes ASR-5
Project Number: 01-04773.HO Date: 12/07/04

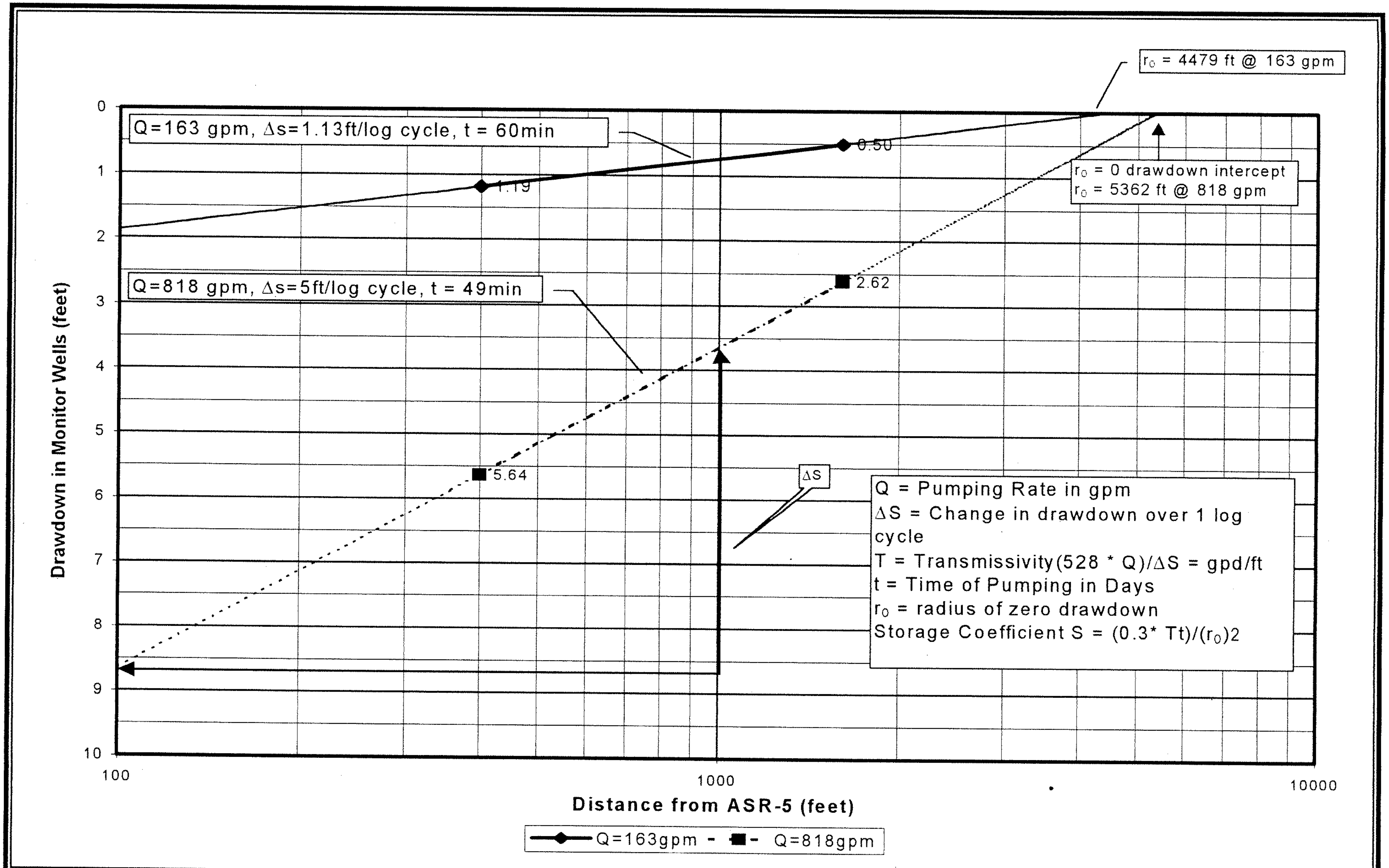
Figure 4-1 Specific Capacity vs. Discharge at ASR-5



Water Resource Solutions

Project : Marco Lakes ASR-5
Project Number: 01-04773.HO Date: 12/07/04

Figure 4-2 Drawdown at ASR-2 and DZ-2 vs Discharge Rate of ASR-5



Water Resource Solutions	Project : Marco Lakes ASR-5 Project Number: 01-04773.HO Date: 12/07/04

Figure 4-3 Drawdown vs. Distance from ASR-5

Table 2-1

Formation Water Conductivity Analysis

Sample Date	Sample Time	Depth of 15-inch Bit (feet bpl)	CONDUCTIVITY (μmhos/cm)
10/19/04	8:35	740	1860
10/19/04	8:40	750	1640
10/19/04	9:45	760	1245
10/19/04	9:55	770	1168
10/19/04	10:05	780	1053

Table 3-1

Pad Monitor Well Construction Details

WELL NUMBER:	MW #1	MW #2
LOCATION	NW CORNER	SE CORNER
ELEVATION OF TOC (NGVD)	6.17	6.37
TOTAL DEPTH (FEET BELOW TOC)	17.4	18.8
DIAMETER (INCHES)	4 PVC	4 PVC
CASING LENGTH (FEET)	7.4	8.8
SCREEN LENGTH (FEET)	10	10
SCREEN SIZE	0.010-inch slot	0.010-inch slot
GRAVEL PACK DEPTH (FEET)	7 - 20	7 - 20
GRAVEL PACK TYPE	20/30 silica sand	20/30 silica sand
SEAL DEPTH (FEET)	6-7	6-7
SEAL TYPE	Bentonite Chips ~ ¼ "	Bentonite Chips ~1/4"
GROUT DEPTH (FEET)	0-6	0-6
GROUT TYPE	Neat portland cement	Neat portland cement

Table 3-2

Pad Well No. 1 Weekly Monitoring Summary

Sample Date	Depth to Water Below Top of Casing (ft.)*	Elevation of Water Level (NGVD)	CHLORIDE (mg/l)	CONDUCTIVITY (μmhos/cm)	pH (standard units)	TEMPERATURE (°C)
7/22/2004	2.55	3.62	44	615	7.42	24.8
7/29/2004	2.75	3.42	42	611	7.18	25.7
8/5/2004	1.03	5.14	36	571	6.84	24.9
8/12/2004	0.94	5.23	34	749	6.92	26.3
8/19/2004	0.87	5.3	36	711	6.85	25.3
8/26/2004	0.77	5.4	34	648	6.78	25.7
9/2/2004	1.26	4.91	32	770	6.75	25.5
9/9/2004	1.07	5.1	30	806	6.64	25.4
9/16/2004	1.93	4.24	30	768	6.79	25.6
9/23/2004	1.86	4.31	28	786	6.69	25.8
9/30/2004	2.31	3.86	32	759	6.79	25.7
10/7/2004	2.99	3.18	34	771	6.76	25.7
10/14/2004	3	3.17	26	774	6.61	25.5
10/21/2004	3.21	2.96	32	742	6.75	25.7
10/28/2004	3.52	2.65	30	735	6.76	26.6
11/4/2004	3.92	2.25	52	754	6.9	25.9
11/11/2004	3.95	2.22	38	733	6.02	26
11/17/2004	4.09	2.08	20	717	6.73	25.3
11/24/2004	4.38	1.79	22	735	6.79	25.8

*Top of Casing Elevation = 6.17 Feet NGVD

Table 3-3

Pad Well No. 2 Weekly Monitoring Summary

Sample Date	Depth to Water Below Top of Casing (ft.)*	Elevation of Water Level (NGVD)	CHLORIDE (mg/l)	CONDUCTIVITY (µmhos/cm)	pH (standard units)	TEMPERATURE (°C)
7/22/2004	2.67	3.7	32	588	7.26	25
7/29/2004	2.8	3.57	34	568	6.88	26.2
8/5/2004	1.16	5.21	30	559	6.75	27
8/12/2004	1.08	5.29	28	718	6.83	28.3
8/19/2004	1.09	5.28	32	664	6.68	29.2
8/26/2004	0.98	5.39	26	609	6.76	26.1
9/2/2004	1.38	4.99	28	730	6.72	25.9
9/9/2004	1.22	5.15	16	785	6.67	26.4
9/16/2004	2.08	4.29	34	750	6.88	26.6
9/23/2004	1.96	4.41	34	770	6.83	26.5
9/30/2004	2.44	3.93	34	725	6.87	26.7
10/7/2004	3.13	3.24	88	787	6.87	27
10/14/2004	3.15	3.22	40	746	6.79	26.6
10/21/2004	3.38	2.99	54	754	6.82	26.8
10/28/2004	3.51	2.86	86	871	6.69	27.5
11/4/2004	3.93	2.44	142	1165	6.84	27.3
11/11/2004	4.13	2.24	120	955	6.84	26.4
11/17/2004	4.25	2.12	110	1080	6.82	25.6
11/24/2004	4.56	1.81	98	1088	6.90	27.4

*Elevation = 6.37 Feet NGVD

Table 3-4

Inclination Survey Log

Date	Bit Diameter (inches)	Depth (feet bpl)	Inclination (degrees)
08/05/04 & 08/16/04	12.5	90	0.75
8/17/04	12.5	180	0.00
8/18/04	12.5	270	0.75
8/19/04	12.5	360	0.00
8/19/04	12.5	450	0
8/19/04	12.5	540	0.5
8/20/04	12.5	630	0.25
8/20/04	12.5	720	0.50
8/26/04	25.00	90	0.25
8/27/04	25.00	180	0.50
8/30/04	25.00	270	0.25
8/31/04	25.00	360	0.50
9/1/04	25.00	450	0.50
9/1/04	25.00	540	0.60
9/8/04	25.00	630	0.50
9/9/04	25.00	720	0.00

Table 3-5

Rate of Penetration Log for 12.5-Inch Pilot Hole

Date	Drill From (feet bpl)	Drill To (feet bpl)	Total Length (feet)	Minutes	Rate (feet/min.)
8/17/04	102.00	130.10	28.10	17	1.65
8/17/04	130.10	135.00	4.90	7	0.7
8/17/04	135.00	140.00	5.00	1	5
8/17/04	140.00	148.00	8.00	2	4
8/17/04	148.00	150.00	2.00	2	1
8/17/04	150.00	155.00	5.00	6	0.83
8/17/04	155.00	159.40	4.40	1	4.4
8/17/04	159.40	186.50	27.10	16	1.7
8/17/04	186.50	218.80	32.30	8	4.04
8/17/04	218.80	250.50	31.70	26	1.22
8/18/04	250.50	282.15	31.65	19	1.67
8/18/04	282.15	313.65	31.50	24	1.31
8/18/04	313.65	345.35	31.70	11	2.88
8/18/04	345.35	376.70	31.35	26	1.21
8/18/04	376.70	407.95	31.25	9	3.47
8/18/04	407.95	439.25	31.30	19	1.65
8/18/04	439.25	469.95	30.70	42	0.73
8/19/04	469.95	500.95	31.00	23	1.35
8/19/04	500.95	531.85	30.90	25	1.24
8/19/04	531.85	563.20	31.35	30	1.05
8/19/04	563.20	594.85	31.65	17	1.86
8/19/04	594.85	626.20	31.35	31	1.01
8/19/04	626.20	656.85	30.65	Rain Delay	NA
8/20/04	656.85	686.95	30.10	30	1.00
8/20/04	686.95	717.90	30.95	35	0.88
8/20/04	717.90	745.00	27.10	Delay	NA

Table 3-6

Drill String Tally for 12.5-Inch Pilot Hole Drilling

Description	Unit Length (feet)	Total String Length (feet)	TD (ft) w/Kelly Down 35' BPL
Bit	1.00	1.00	36.00
Sub	2.20	3.20	38.20
DC 1	30.40	33.60	68.60
DC 2	30.30	63.90	98.90
DC 3	29.00	92.90	127.90
Sub	2.20	95.10	130.10
DC 4	29.30	124.40	159.40
DC 5	27.40	151.80	186.80
Pipe 1	32.00	183.80	218.80
Pipe 2	31.70	215.50	250.50
Pipe 3	31.65	247.15	282.15
Pipe 4	31.50	278.65	313.65
Pipe 5	31.70	310.35	345.35
Pipe 6	31.35	341.70	376.70
Pipe 7	31.25	372.95	407.95
Pipe 8	31.30	404.25	439.25
Pipe 9	30.70	434.95	469.95
Pipe 10	31.00	465.95	500.95
Pipe 11	30.90	496.85	531.85
Pipe 12	31.35	528.20	563.20
Pipe 13	31.65	559.85	594.85
Pipe 14	31.35	591.20	626.20
Pipe 15	30.65	621.85	656.85
Pipe 16	30.10	651.95	686.95
Pipe 17	30.95	682.90	717.90
Pipe 18	31.00	713.90	748.90

Table 3-7

Drill String Tally for 25-Inch Reamed Hole Drilling

Description	Unit Length (feet)	Total String Length (feet)	TD (ft) w/Kelly Down 35' BPL
12" Bit	1.00	1.00	36.00
25" Hole Opener	5.60	6.60	41.60
Sub	2.10	8.70	43.70
Stabilizer-23"	4.65	13.35	48.35
DC 1 - 8"	29.00	42.35	77.35
Stabilizer-23"	7.00	49.35	84.35
DC 2 - 8"	30.30	79.65	114.65
DC 3 - 8"	30.40	110.05	145.05
Sub	2.00	112.05	147.05
DC 4 - 6.9"	29.30	141.35	176.35
DC 5 - 6.9"	27.40	168.75	203.75
Pipe 1	31.60	200.35	235.35
Pipe 2	31.40	231.75	266.75
Pipe 3	31.55	263.30	298.30
Pipe 4	31.35	294.65	329.65
Pipe 5	32.00	326.65	361.65
Pipe 6	31.80	358.45	393.45
Pipe 7	31.50	389.95	424.95
Pipe 8	31.40	421.35	456.35
Pipe 9	30.60	451.95	486.95
Pipe 10	31.30	483.25	518.25
Pipe 11	31.30	514.55	549.55
Pipe 12	31.25	545.80	580.80
Pipe 13	30.70	576.50	611.50
Pipe 14	31.70	608.20	643.20
Pipe 15	30.95	639.15	674.15
Pipe 16	31.35	670.50	705.50
Pipe 17	30.10	700.60	735.60

Table 3-8

Production Casing Tally 17.4-Inch PVC

Sequence No.	Length (ft)	Total Depth (feet)	Spline In Place	Time Submerged	Centralizers
*Tailpiece 1	10.00	10.00	7:40	7:42	729'
2	19.97	29.97	7:50	7:53	
3	19.96	49.93	7:57	8:10	
4	19.96	69.89	8:19	8:21	650'
5	19.95	89.84	8:25	8:28	
6	19.97	109.81	8:31	8:35	
7	19.98	129.79	8:36	8:40	
8	20.00	149.79	8:44	8:46	
9	19.95	169.74	8:49	8:52	
10	19.97	189.71	8:55	8:58	
11	19.97	209.68	9:02	9:04	
12	19.99	229.67	9:08	9:13	
13	19.96	249.63	9:18	9:19	
14	19.97	269.6	9:23	9:25	
15	19.97	289.57	9:32	9:35	
16	19.98	309.55	9:39	9:44	
17	19.98	329.53	9:49	9:52	
18	19.97	349.5	10:05	10:07	370'
19	19.99	369.49	10:09	10:14	
20	19.98	389.47	10:15	10:19	
21	19.98	409.45	10:25	10:27	
22	19.97	429.42	10:30	10:35	
23	19.99	449.41	10:38	10:43	
24	20.00	469.41	10:48	10:52	
25	20.00	489.41	10:55	10:58	
26	19.98	509.39	11:02	11:07	
27	19.98	529.37	11:11	11:15	
28	19.99	549.36	11:18	11:21	
29	19.97	569.33	11:25	11:28	
30	19.98	589.31	11:30	11:33	
31	20.00	609.31	11:39	11:42	
32	19.98	629.29	11:52	11:55	
33	19.98	649.27	11:59	12:02	
34	19.99	669.26	12:14	12:18	665'
35	19.95	689.21	12:21	12:25	
36	20.00	709.21	12:30	12:35	
37	20.00	729.21			

*Cement basket located 4" above bottom around outside of casing

Table 3-9

Cementing Log

Stage	Date	Time	Rate (bbls/min)	Weight (ppg)	Volume Pumped (sks)	Casing Pressure (psi)	Comments
1	9/19/04	17:00					Tag cement basket at 730' bpl.
1	9/19/04	17:33					Begin freshwater pre-flush. Tremie bottom at 729 'bpl
1	9/19/04	17:35					End preflush. (10 bbls). Mixing cement.
1	9/19/04	17:40		13.80			Begin pumping cement
1	9/19/04	17:42		14.8			
1	9/19/04	17:46			50		Stop pumping with tremie at 729 ft bpl
1	9/19/04	17:52					Pull 1 double, tremie at 687 ft bpl
1	9/19/04	17:58					Begin mixing
1	9/19/04	18:00		15.0			Begin pumping cement
1	9/19/04			15.4			
1	9/19/04	18:05			50		Finish pumping cement
1	9/19/04	18:08					Pull 2 doubles, tremie at 603 ft bpl
1	9/19/04	18:14					Pump 1 bbl flush
1	9/19/04	18:16					Pull 3 doubles, bottom at 477 ft. bpl
1	9/19/04	18:30					Finish, leave 1 double above pad level
2	9/20/04	16:30					Tag cement at 623 ft. bpl
2	9/20/04	16:50					Begin freshwater pre-flush.Tremie at 623
2	9/20/04	17:00					End pre-flush (10 bbls.). Begin mixing neat cement.
2	9/20/04	17:02		14.7			Begin pumping cement
2	9/20/04	17:06		15.2			
2	9/20/04	17:08			50		Stop pumping cement
2	9/20/04	17:10					Pull 1 double of tremie. Bottom at 581
2	9/20/04	17:13		15			Begin pumping cement
2	9/20/04	17:19		15.2			
2	9/20/04	17:22			50		Stop pumping
2	9/20/04	17:24					Pull 1 double, tremie bottom at 539
2	9/20/04	17:30		15.3			Begin pumping cement
2	9/20/04	17:32		14.8			
2	9/20/04	17:37		15.4	100		Finish cementing
2	9/20/04	17:40					Pull 1 double, tremie bottom at 397
2	9/20/04	17:46					Pump freshwater displacement (4bbls)
2	9/20/04	17:48					Pull tremie, tremie bottom at 252

Table 3-9

Cementing Log

Stage	Date	Time	Rate (bbls/min)	Weight (ppg)	Volume Pumped (sks)	Casing Pressure (psi)	Comments
3	9/21/04	8:45					Tag cement at 375 ft. bpl
3	9/21/04	9:05					Pump freshwater flush, tremie at 375
3	9/21/04	9:08					Begin mixing cement
3	9/21/04	9:10		15.3			Begin pumping cement
3	9/21/04	9:12		15.4			
3	9/21/04	9:14			100		Stop Cementing
3	9/21/04	9:21					Pull 1 double, tremie at 333
3	9/21/04	9:25					Mixing cement.
3	9/21/04	9:27		15.2			Begin freshwater pre-flush.
3	9/21/04	9:29		15.2			
3	9/21/04	9:32		15.3	100		End cementing, flush 1 bbl water.
3	9/21/04	9:40					Pull all tubing from borehole
3	9/21/04	10:00					Finish pulling all tubing.
4	9/22/04	9:22					Tag cement at 219 ft. bpl
4	9/22/04	9:25					Raise tremie bottom to 208 ft bpl
4	9/22/04	10:20					Pressure guage connected to casing, run pressure test at 30 psi.
4	9/22/04	11:51					Pressue up casing to 40 psi
4	9/22/04	12:19					Begin freshwater pre-flush.
4	9/22/04	12:20					Begin mixing cement and bentonite
4	9/22/04	12:22					Begin pumping cement with 2.5% bentonite. 10 sacks bent./200 sacks cement
4	9/22/04	12:23		13.7			
4	9/22/04	12:24		13.8			
4	9/22/04	12:26		14.2			
4	9/22/04	12:28		13.8			
4	9/22/04	12:30		12.6			
4	9/22/04	12:33		11.8			
4	9/22/04	12:34		11.8			
4	9/22/04	12:35		11.8	200		Finish pumping cement, begin chase.
4	9/22/04	13:00					Trip out all tremie pipe. Well at 31 psi.
5	9/23/04	6:40					Tag cement at 95.5 ft. bpl
5	9/23/04	6:58					Pressure up casing
5	9/23/04	7:06					Begin freshwater flush (10 bbls)
5	9/23/04	7:08					Hose problem delay
5	9/23/04	8:18					Begin pumping neat cement.
5	9/23/04	8:20		13.3	28		Finish pumping neat move to bentonite cement pumping
5	9/23/04	8:22		12.8			
5	9/23/04	8:23		12.3			
5	9/23/04	8:25		11.7			
5	9/23/04	8:26			137		Cement returns at surface. Stop pumping cement. 5 sacks bentonite had been
5	9/23/04	8:37					All tremie tripped from annulus.

Table 3-10

Cement Stage and Volume Summary

Stage	Date	Cement additives	Yield (cf/sk)	Theoretical Fill			Actual Fill			Tag Depth (ft bpl)	Percent Filled (I/Fx100)	Cum. Total (cu ft)	Observer Init.
				Interval	Footage	Volume (cf)	Interval	Footage	Volume (cf)				
1	9/19/04	Neat	1.28	730 to 645	85	128	730 to 623	107	173	623	126%	173	AWM
2	9/20/04	Neat	1.28	623 to 485	138	257	623 to 375	248	467	375	180%	643	AWM
3	9/21/04	Neat	1.28	375 to 240	135	257	375 to 219	156	300	219	116%	943	AWM
4	9/22/04	2.5% Bentonite	1.41	219 to 110	109	282	219 to 95.5	123.5	350	95.5	113%	1293	AWM
5a	9/23/04	2% Bentonite	1.38	95.5 to 49.5	46	189							
5b	9/23/04	Neat	1.28	49.5 to 31	18.5	36							
5	9/23/04	a+b		95.5 to 31	64.5	225	95.5 to 1.5	94	282	1.5	146%	2875	AWM

Table 3-11

Drill String Tally for 15-Inch Open Hole Drilling

Description	Unit Length (feet)	Total String Length (feet)	TD (ft) w/Kelly Down 35' BPL
12" Lead Bit	1.80	1.80	36.80
15" Hole Opener	1.90	3.70	38.70
Sub	2.13	5.83	40.83
DC 1	29.07	34.90	69.90
DC 2	30.30	65.20	100.20
DC 3	30.17	95.37	130.37
Pipe 1	31.40	126.77	161.77
Pipe 2	31.24	158.01	193.01
Pipe 3	30.70	188.71	223.71
Pipe 4	30.93	219.64	254.64
Pipe 5	31.30	250.94	285.94
Pipe 6	31.70	282.64	317.64
Pipe 7	31.40	314.04	349.04
Pipe 8	30.60	344.64	379.64
Pipe 9	31.35	375.99	410.99
Pipe 10	31.53	407.52	442.52
Pipe 11	31.33	438.85	473.85
Pipe 12	31.77	470.62	505.62
Pipe 13	31.60	502.22	537.22
Pipe 14	31.50	533.72	568.72
Pipe 15	30.65	564.37	599.37
Pipe 16	31.36	595.73	630.73
Pipe 17	31.34	627.07	662.07
Pipe 18	31.00	658.07	693.07
Pipe 19	31.67	689.74	724.74
Pipe 20	31.20	720.94	755.94
Pipe 21	32.00	752.94	787.94

Table 4-1

Specific Capacity Data Table for ASR-5

Time	Time since start of Pumping	Drawdown in ASR-5 (ft.)	Totalizer in Gallons	Average flow rate per Step (gpm)*	Specific Capacity in gpm/ft. of drawdown	Notes
8:00	0	0.000	69842000			Initial Meter No Flow
9:00	60	1.610	69852700	163	101.2	Artesian flow only
10:00	120	6.418	69872250	299	46.6	"
11:00	180	12.901	69906100	518	40.2	Pump running
12:00	240	24.643	69957340	784	31.8	"

* Flow data corrected to compensate for 108.9 % accuracy of meter.

Table 4-2

Distance Drawdown Data

Well Name	Distance from ASR5 (ft.)	Elapsed time of Pumping (minutes)	Flow Rate (gpm)	Drawdown from static level (ft.)	Transmissivity (gpd/ft)	Storage Coefficient
ASR 2	400	60	163	1.19	76124	4.74E-05
DZ-2	1607		"	0.50		
ASR 2	400	49	818	5.64	86380	3.07E-05
DZ-2	1607		"	2.62		