TRANSMITTAL

MWH Cape Coral FLORIDA

MWH Americas Inc.
2503 Del Prado Blvd. S., Suite 430
Cape Coral, Florida 33904
Tel: (239) 573-5959
Fax: (239) 573-6007

To: Bill Peak
P.O. Box 150027
Cape Coral, FL
33915-0027

Attn: Bill Peak

From: Ed Rectenwald

Date: June 25, 2009

Subject: IRR-6C.1 Horseshoe ASR Exploratory Well Completion Report

Project: IRR-6C.1 Phase II ASR Exploratory Wells

Job No: 3220289. 864704

The following items are:

- [ ] Requested
- [X] Report
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Transmittal Items

Item No.	Copies	Description
1	8	IRR-6C.1 Horseshoe ASR Exploratory Well Completion Report

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Gordon Kennedy
File: 3220289. 3.1.2/6.10

Program Management at Risk Services for Water, Wastewater, & Irrigation Facilities

Project Title: **IRR-6C.1 Phase II ASR EXW**

Document Title: **Horseshoe ASR Exploratory Well Completion Report**

June 2009

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Document Control Sheet

Document Information

Client:	**City of Cape Coral**
Project Title:	IRR-6C.1 Phase II ASR EXW
Document Title:	Horseshoe ASR EXW Completion Report
Project Number:	3220289
File Name:	IRR-6C.1 Construction Report
File Reference:	3220289

Inter-Discipline Review

Discipline	Checked by (Reviewer)
Hydrogeology	Mike Weatherby

Document Control

V-1		Internal Review	Ed Rectenwald, Greg Young	Gordon Kennedy, Mike Weatherby, Brooke Fait	Ron Cass
Rev	Date	Revision Description	Prepared (Lead Author)	Reviewed	Approved

Distribution

Name	Name	Name
Bill Peak – CCC	Bill Steckroat - CCC	Shawn Kopko- CCC
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GLOSSARY

Term	Definition
als	Above Land Surface
ASR	Aquifer Storage and Recovery
ASTM	American Society For Testing And Materials
bls	Below Land Surface
°C	Degrees Celsius
cm/sec	Centimeters per Second
EPA	Environmental Protection Agency
FAS	Floridan Aquifer System
FDEP	Florida Department of Environmental Protection
ft	Feet
gpd	Gallons Per Day
gpd/ft	Gallons Per Day Per Foot
gpm	Gallons Per Minute
gpm/ft	Gallons Per Minute Per Foot
HDPE	High Density Polyethylene
IAS	Intermediate Aquifer System
ID	Inside Diameter
LFA	Lower Floridan Aquifer
mgd	Million Gallons Per Day
mg/L	Milligrams per Liter
NGVD	National Geodetic Vertical Datum
psi	Pounds per Square Inch
PtCo	Platinum-Cobalt
PVC	Polyvinyl Chloride
RIDS	Regional Irrigation Distribution System
SAS	Surficial Aquifer System
SFWMD	South Florida Water Management District
TDS	Total Dissolved Solids
EXW	Test Production Well
UFA	Upper Floridan Aquifer
µS/cm	Microsiemens per Centimeter
USDW	Underground Source of Drinking Water
WTMW	Water Table Monitor Well

Executive Summary

This report summarizes the construction and testing of the Aquifer Storage and Recovery Exploratory Well (ASR EXW) at the Horseshoe Canal site; one of three ASR EXWs constructed in Northern Cape Coral to test the Upper Floridan Aquifer for the use of ASR technology. The well construction results are summarized below:

- On November 30, 2007, the FDEP issued Construction Permit No. 272886-002 UC/5X for a Class V ASR EXW. The well was designed to meet the requirements of the Florida Department of Environmental Protection Class V Injection Well standards and the specific conditions of the Underground Injection Control permits.

- Construction of the ASR EXW began on March 26, 2008 and was substantially complete on September 15, 2008.

- The ASR EXW was drilled and tested to 910 feet below land surface (bls). The well was back plugged to 694 feet bls with neat cement and completed with 8.625 OD PVC set to 523 feet bls.

- Water quality of the completed monitoring interval is brackish, and contains a chloride and TDS concentration of approximately 1,610 mg/L and 3,060 mg/L, respectively.

- Geophysical logs were conducted in the pilot hole after each stage of pilot hole drilling, prior to packer testing and before casing installation. The logs provide a continuous record of the physical properties of the subsurface formations and/or their water quality within the borehole.

- Packer tests were not performed because of unfavorable borehole conditions which prevented the packer to properly seal off a selected interval.

- Rock cores were collected and sent to Ardaman and Associates for petrophysical analysis to determine the following parameters; vertical and horizontal hydraulic conductivity, vertical and horizontal porosity and specific gravity. Four rock cores were retrieved from the Floridan Aquifer System from the following intervals; 640 to 650, 800 to 810, 849 to 859, and 892 to 902 feet bls.

- During drilling and testing to 910 feet bls, it was concluded that this site is unfeasible for ASR technology because of bulk conduit flow in the lower Hawthorn aquifer and minimal confinement above the Suwannee Limestone (storage zone).

- A request to cease drilling was sent and approved by the FDEP on August 4, 2008 (Appendix E) with an alternate plan to complete the well in the LHA for use as a monitor well and to potentially be utilized as an RO production well if the North Water Treatment plant allows. The alternate use plan was submitted in fulfillment of Specific Condition 1.g. (2).

- An aquifer test was conducted at a constant rate of 1,900 gpm for 3 hours on the completed Horseshoe ASR EXW on October 13, 2008. The estimated transmissivity is 146,900 gpd/ft and was calculated from recovery data using the Hantush early time method.

1.0 Introduction

This report summarizes the drilling and testing of a Class V Aquifer Storage and Recovery (ASR EXW) Exploratory well constructed at the Coral Oaks Golf Club property proximal to the Horseshoe Canal. The following information is included this report:

- Well construction methods,
- Data collection and testing procedures,
- Geological and hydraulic interpretation of data collected,
- Documentation of the FDEP approved casing setting depths for monitoring the potential storage zone
- Identification of hydrogeologic conditions favorable for potential underground storage, and
- Recommendations on the future well utility and suitability of the site for ASR.

The well was constructed under FDEP Construction Permit No. 272886-002 UC/5X and the applicable regulations of Chapter 62-528, Florida Administrative Code (FAC).

1.1 Background

In 2004, the City of Cape Coral selected MWH Americas, Inc. (MWH) as the Program Manager at Risk for the expansion of the Water, Wastewater, Irrigation Facilities, and Phase 2 Utility Extension Services. The MWH Facilities Master Plan (2004) estimates the average daily irrigation demands at build-out to be 132 million gallons per day (MGD). The water available from existing and planned sources (approximately 50 MGD reclaimed water, and 47 MGD freshwater canal system during the dry season) is approximately 97 mgd, leaving a potential irrigation water supply deficit of 35 mgd.

Several studies have identified ASR as having a high potential to provide the City with the additional supply of irrigation water (Missimer & Associates, 1989; Dames & Moore, 1998; Camp Dresser & McKee, 2005). Additionally, the City is a stakeholder in a Regional Irrigation Distribution System (RIDS) investigated by the South Florida Water Management District (SFWMD). The RIDS Master Plan for the Lower West Coast area (SFWMD, 2002) and Feasibility Study for the Cape Coral area (SFWMD, 2004) identified significant volumes of surface water and reclaimed water could be available to Cape Coral for ASR wells during the wet season. The Horseshoe Canal is identified in the latter report as a potential surface water ASR location. The RIDS studies are incorporated into the Lower West Coast Water Supply Plan Update (SFWMD, 2006). As such, construction of the ASR facilities is eligible to receive funding from the SFWMD Alternative Water Supply Program.

The Horseshoe Canal site is listed as a permitted ASR well facility (ASR-2) in the City's SFWMD Irrigation Water Use Permit (No. 36-00998-W). The permit, which was issued by the SFWMD Governing Board on March 8, 2006, allows the withdrawals of approximately 720 MG from eight (8) ASR wells withdrawing from the freshwater canal system. The Irrigation WUP has a duration of 20 years.

An Application to Construct a Class V Injection Well System for the Horseshoe Canal Exploratory Well was prepared and submitted by MWH to the Florida Department of Environmental Protection (FDEP) on January 12, 2007 under the IRR-2 Work Authorization. The FDEP issued Construction Permit No. 272886-002 UC/5X on November 30, 2007. A copy of the FDEP permit is included as Appendix A.

The Cape Coral City Council authorized MWH Americas to design, permit and supervise the construction and testing of three ASR Exploratory Wells in Northern Cape Coral. Design and construction was conducted under the IRR-6 and IRR-6C.1 Work Authorizations, respectively. Notice to Proceed was issued to the drilling subcontractor on January 28, 2008.

1.2 Purpose

Several locations in Cape Coral adjacent to freshwater canals having high wet season discharge were identified in the consultant and RIDS reports noted above. The Horseshoe Canal was cited in several publications as having a high potential for supplying abundant surface water.

A vicinity map of the Horseshoe ASR EXW is shown in Figure 1-1. A map showing the location of the ASR EXW and associated monitor wells is shown in Figure 1-2. The project site is located adjacent to the Southwest corner of the Coral Oaks Golf Course driving range along the Azara Canal. The physical address of the Golf Courses is 1800 NW 28th Avenue, Cape Coral, Lee County, Florida.

1.3 Scope of Services

Rowe Drilling Corporation of Tampa, FL, as the contractor, conducted the drilling, construction, and testing activities of the Horseshoe ASR EXW. MWH Americas, Inc. was the City's onsite representative, providing construction observation and technical services required to comply with the construction permit. Construction management was provided by MWH Constructors, Inc.

Construction and testing of the well was performed and reported weekly in accordance with Chapter 62-528 F.A.C., recommendations of the FDEP, the Technical Advisory Committee (TAC), and requirements of the Permit (272886-002 UC/5X). The TAC includes members of local, state, and federal agencies, including state and local representatives of the FDEP, the South Florida Water Management District, and the U.S. Environmental Protection Agency (EPA). Construction and testing activities were conducted in accordance with Specific Condition 3 of the Permit. This report was prepared in fulfillment of Specific Condition 5 of the Permit.

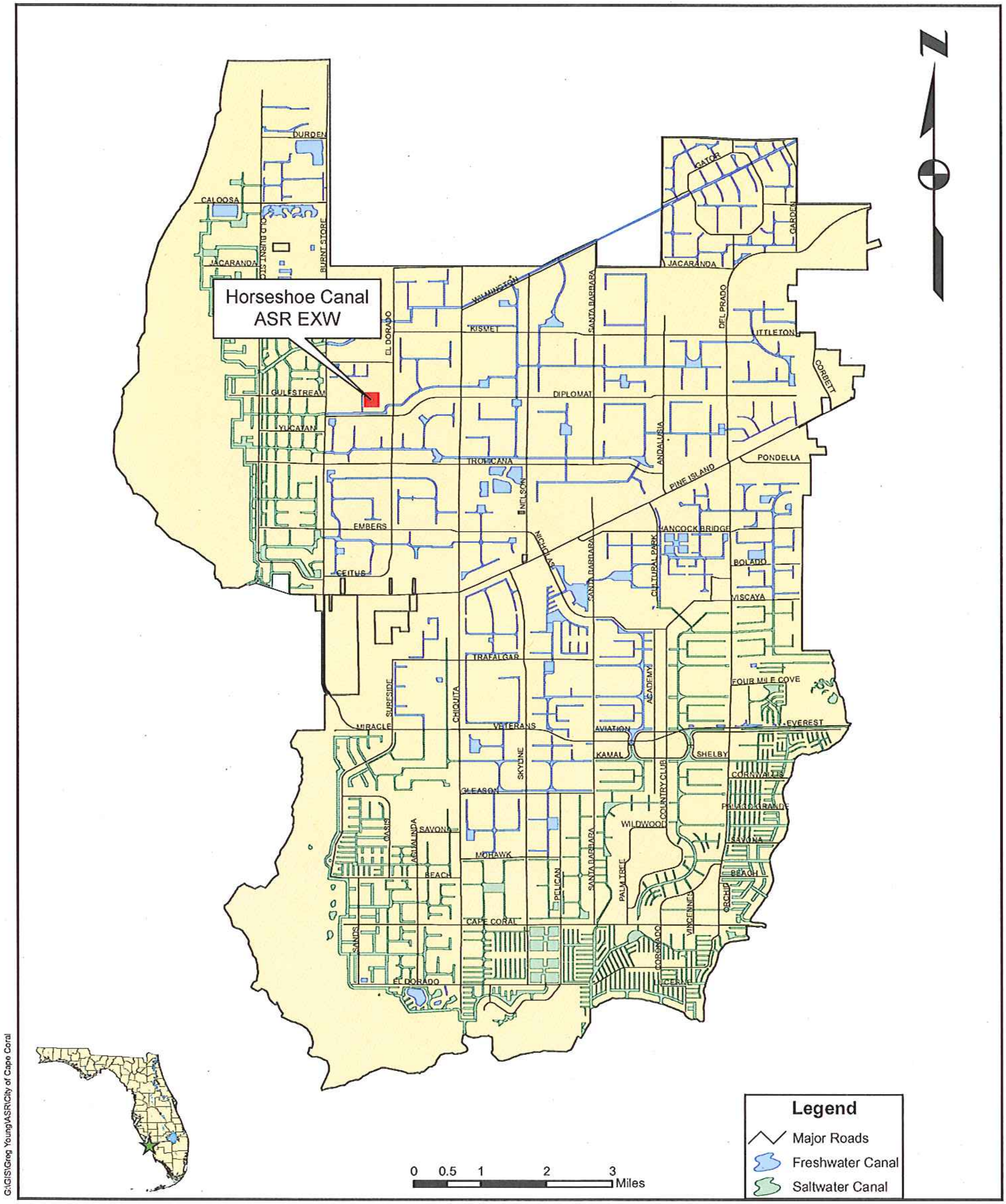

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Figure 1-1 Horseshoe ASR EXW Vicinity Map

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Figure 1-2 Horseshoe ASR EXW Site Map

2.0 Geology and Hydrogeology

Northwestern Lee County is underlain by rocks of Cenozoic age to a depth of about 5,000 feet (Meyer, 1989). These rocks are composed of carbonates, with minor amounts of evaporates in the lower portion and clastics in the upper portion (Reese, 2000). In this section, the stratigraphy and identified aquifer systems encountered during drilling and testing operations for the Horseshoe ASR EXW will be discussed from youngest to oldest in age.

2.1 Geology

Sediments encountered during the construction of the ASR EXW range in age from Late Pleistocene to Oligocene. MWH Americas collected geologic formation samples (well cuttings) from the pilot hole during drilling operations and described them based on their dominant lithologic and textural characteristics using the Folk (1959) carbonate rock classification system. A detailed lithologic log is provided in Appendix B. A detailed description of the lithostratigraphy and its relationship to the hydrostratigraphy of the study area is provided below. A stratigraphic and hydrostratigraphic column of the site is shown in Figure 2-1.

2.1.1 Pliocene - Pleistocene Series

The undifferentiated deposits encountered include predominately siliciclastic and carbonate deposits of the Pamlico Sand Formation and the Undifferentiated Fort Thompson/Caloosahatchee Formation. Undifferentiated Plio-Pleistocene surficial deposits consisted primarily of unconsolidated sand, marine bivalvia and gastropoda shell. This unit was observed at the Horseshoe ASR EXW to a depth of approximately 20 feet.

2.1.2 Miocene Series

The Hawthorn Group unconformably underlies undifferentiated Pliocene-Pleistocene deposits, and is a lithologically complex sequence of silt, clay, calcareous clay, dolosilt, quartz sand, phosphate, limestone, and dolomite (Scott, 1988). It is a regional stratigraphic unit of early Pliocene to Miocene age that underlies all of South Florida. The Hawthorn Group is comprised of an upper, primarily siliciclastic unit (Cape Coral Clay Member of the Peace River Formation), and a lower, primarily carbonate unit (Arcadia Formation) (Scott, 1988). The two formations are separated by a major regional disconformity (Scott, 1988, and Cunningham, et al, 2001). Locally, the Lehigh Acres Sandstone member is occasionally present at the base of the Peace River Formation. At the Horseshoe ASR site, the Hawthorn Group occurs from approximately 20 to 760 feet bls.

The lower 500 feet of the unit consists of 3 to 4 large scale, transgressive-regressive cycles. Each cycle consists of a lower thick limestone unit and an upper mixture of minor carbonate and clastic units (Missimer and Associates, 1985).

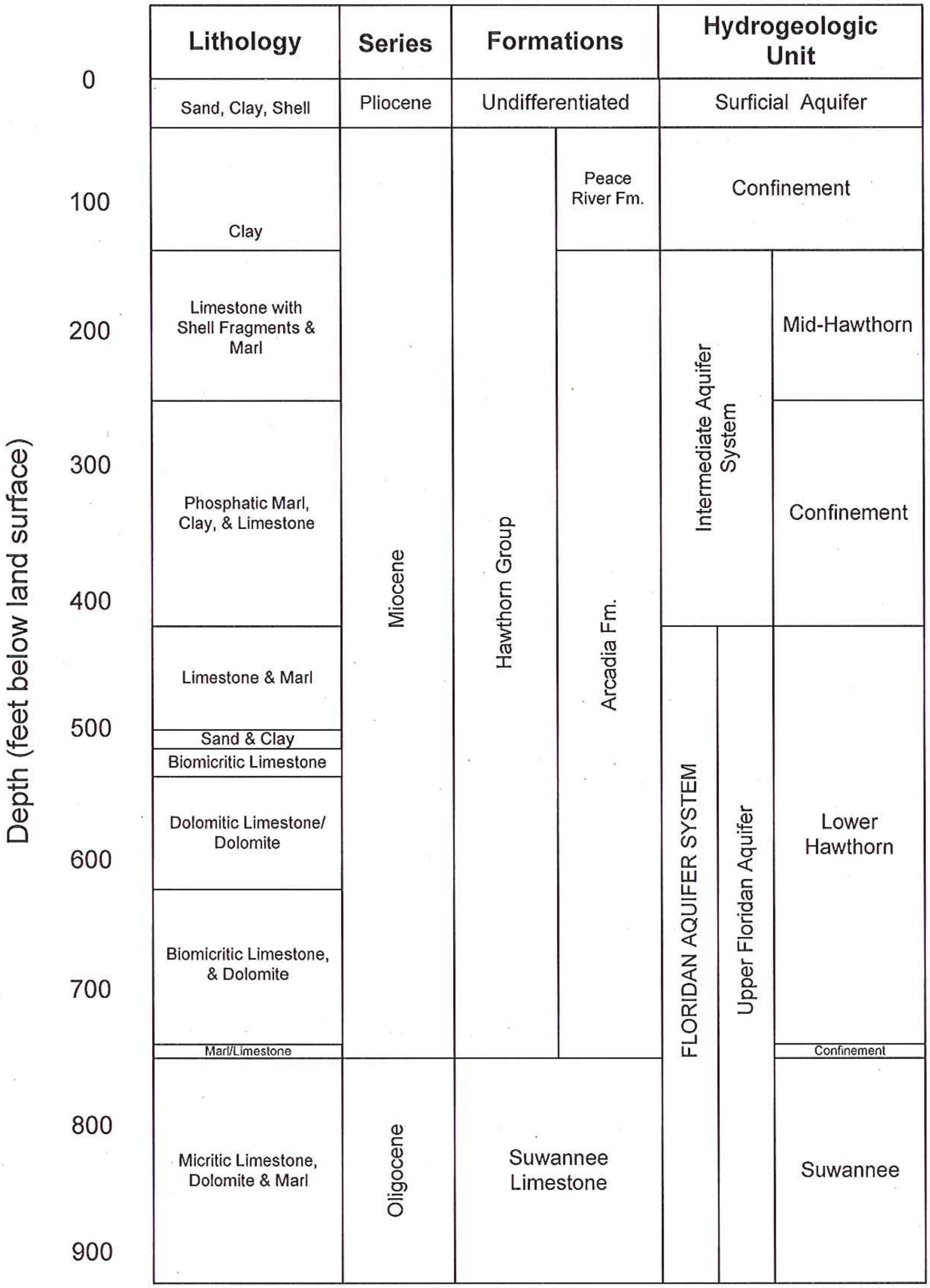

Figure 2-1 Stratigraphic and Hydrostratigraphic Column

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Peace River Formation

The Peace River Formation of the Hawthorn Group consists of sandstones, sands, sandy limestones, dolomitic clays or dolosilts, and fossilized shell material (Scott, 1988 and Bennett and Rectenwald, 2004). The formation occurs from approximately 20 to 140 feet bls. The Peace River formation is usually subdivided into two named members, the Cape Coral Clay member and the Lehigh Acres Sandstone member (Missimer and Associates, 1985).

The Cape Coral Clay is predominantly a greenish gray to dark greenish gray, soft to moderately soft, semi-cohesive clay with trace amounts of silt. The Lehigh Acres Sandstone member was not present.

Arcadia Formation

The lower part of the Hawthorn Group, the Arcadia formation, consists predominately of limestone and dolostone containing varying amounts of quartz sand, clay, and phosphate grains. The Arcadia Formation is important from a resource viewpoint as a water supply source for the City of Cape Coral for both domestic and public water supply uses. Hydrologically, it incorporates several aquifers and confining units identified within the Hawthorn Group.

The Arcadia Formation occurs from approximately 140 to 760 feet bls at the Horseshoe ASR Site. The formation is lithologically complex, containing limestone and dolosilt beds of varying thickness. The limestones are light to yellowish gray micrites and biomicrites with moderate to good porosity. The formation is interbedded with light gray marl or lime mud and occasional light olive gray dolomitic silty clay and dolomite are present. Phosphate granules are abundant throughout the Arcadia Formation. The base of the Arcadia Formation is identified by light gray marl, an immediate decrease in phosphate content in lithologic samples, and attenuation of gamma ray activity on geophysical logs. Lithologic logs are available in Appendix B and geophysical logs are available in Appendix C.

2.1.3 Oligocene Series

The top of the Oligocene Age Suwannee Limestone occurs at 760 feet bls and continued to the total depth of the well at 910 feet bls. The contact between the Hawthorn Group and the Suwannee Limestone was identified based on interpretations from the lithology, geophysical logs and video surveys (Appendices B, C and D). A disconformity separates the Hawthorn Group from the Suwannee Limestone (Reese, 2000).

The contact between these two formations is described as a moderately consolidated limestones interbedded with lime mud or marl. The Suwannee Limestone is typically a very pale orange biomicrite having a trace of phosphate and medium-grained calcarenitic texture. The contact between the Hawthorn Group and the Suwannee Limestone is also marked by a change in the lithology and an attenuation of the natural gamma activity, as depicted in the geophysical logs (Appendix C), primarily because of the decrease in phosphate content in the upper Suwannee Limestone. In addition, the Suwannee

Limestone is characterized by higher sonic transit times as compared to the bottom portion of the Arcadia Formation.

2.2 Hydrogeology

Three major aquifer systems underlie the study area of Cape Coral, Florida: the Surficial Aquifer System (SAS), the Intermediate Aquifer System (IAS), and the Floridan Aquifer System (FAS). These aquifer systems are composed of multiple, discrete aquifers separated by low permeability confining units that occur throughout this Tertiary/Quaternary age sequence.

2.2.1 Surficial Aquifer System

The SAS consists of the water-table aquifer and hydraulically connected units above the top of the first occurrence of laterally extensive and vertically persistent beds of much lower permeability (Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986). At the Horseshoe ASR Site, the SAS occurs within the undifferentiated Plio-Pleistocene water saturated sediments of the Pamlico Sand Formation, and Undifferentiated Fort Thompson/Caloosahatchee strata. The base of the surficial aquifer system occurs at contact with the Cape Coral Clay Member of the Hawthorn Group at a depth of 20 feet bls. The aquifer is unconfined and in direct contact with atmospheric pressure. Recharge to the aquifer originates principally from rainfall, with some secondary recharge originating from leakage from surface water bodies and as movement of groundwater flows up gradient through the site. Discharge from the surficial aquifer occurs mainly through evapotranspiration, drainage to surface water bodies, downward leakance to deeper aquifers, and lateral groundwater flow.

2.2.2 Intermediate Aquifer System

Aquifers that lie beneath the SAS and above the FAS in southwestern Florida are grouped within the IAS (Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition, 1986). The IAS does not outcrop and contains water under confined conditions (Miller, 1986).

A productive horizon, locally called the Mid-Hawthorn Aquifer, occurs from 140 to 250 feet bls. The Mid-Hawthorn aquifer occurs within limestones in the upper portion of the Arcadia Formation of the Hawthorn Group (Missimer and Associates, 1985, Knapp *et al.*, 1986 and Miller, 1986). This aquifer is currently the major source of water supply to residents served by domestic self-supply wells in Cape Coral, Florida.

2.2.3 Floridan Aquifer System

The FAS is defined as a vertically continuous sequence of permeable carbonate rocks of Tertiary age that are hydraulically connected in varying degrees, and whose permeability is generally several orders of magnitude greater than that of the rocks that bound the system above and below (Miller, 1986). The system is subdivided into the upper Floridan Aquifer (UFA), middle confining unit (MCU) and the lower Floridan Aquifer (LFA) based on hydraulic characteristics. The FAS in the City of Cape Coral, Florida is composed predominately of limestone with dolomitic limestone and dolomite. The FAS occurs within the lower Arcadia Formation, Suwannee Limestone, Ocala Limestone, Avon Park Formation, and Oldsmar Formation.

At the Horseshoe Canal site, the UFA occurs from 410 to the total depth of the well, 910 feet bls. The aquifer consists of two predominant permeable zones in the Lower Hawthorn Group and Suwannee Limestone. These productive zones were identified using lithologic descriptions, dual induction and borehole compensated sonic geophysical logs, and a borehole video survey.

The first transmissive horizon includes the lower portion of the Basal Hawthorn Unit (Reese, 2000), and occurs from 410 to 740 feet bls. This aquifer is locally named the Lower Hawthorn Aquifer. The predominant lithologies present are interbedded yellowish-gray fossiliferous limestones and light gray dolomitic limestones. The limestones are generally moderately hard and have a moderate to high porosity. The Lower Hawthorn aquifer's dolomitic limestones have a very hard microsucrosic texture with variable porosities. The borehole compensated sonic and video logs identified bulk conduit flow from approximately 520 to 710 feet bls. The Lower Hawthorn aquifer is the major source for public water supply to the residents in Cape Coral, Florida.

The second productive interval within the UFA was identified from 760 to the total depth of the well, 910 feet bls in the Suwannee Limestone, locally named the Suwannee Aquifer. A thin, semi-confining bed between the Suwannee and Lower Hawthorn Aquifer is approximately 20 feet thick and consists of yellowish gray marls. It is composed of interbedded moderately hard biomicritic limestones and marls. The aquifer becomes less permeable with depth because of interbedding with increased lime mud and fine-grained material.

3.0 Well Construction

3.1 Introduction

This section describes the construction activities of the Horseshoe ASR EXW. The site location map is provided as Figure 1-2. A summary report of the construction activities were submitted to the Department on a weekly basis as required by Specific Condition 5b. FDEP weekly reports and correspondence are provided in Appendix E.

3.2 Site Development

The construction site is essentially flat with elevations varying less than one foot from the average 12.5 feet above the North American Vertical Datum of 1988 (NAVD 88) for the site. The boundary surveys are provided in Appendix F.

Two Water Table Monitoring Wells (WTMWs) were installed prior to the start of drilling activities. The WTMWs monitored the water quality of the surficial aquifer during construction and development of the ASR system. WTMW-1 was located approximately 30 feet southeast of the EXW and WTMW-2 was located approximately 20 feet west of the EXW, along the Azara Canal. The locations of the WTMWs are shown in Figure 1-2.

Each WTMW was constructed to a depth of approximately 20 feet bls. The wells were completed with 10 feet of 4-inch diameter 10-slot Schedule 40 polyvinyl chloride (PVC) casing at the base and approximately 10 feet of 4-inch diameter Schedule 40 PVC riser casing from the top of screen to land surface. The annulus of the WTMW's were backfilled with silica sand to approximately one foot above the screen interval with a bentonite seal above the sand and grouted to land surface.

The WTMWs were developed for approximately 30 minutes following their construction and water quality tests to measure conductivity, chloride, pH, and temperature were conducted to obtain initial background measurements of the parameters. The WTMWs were sampled on a weekly basis for those water quality parameters along with water level measurements. Figure 3-1 shows a schematic diagram of a typical WTMW.

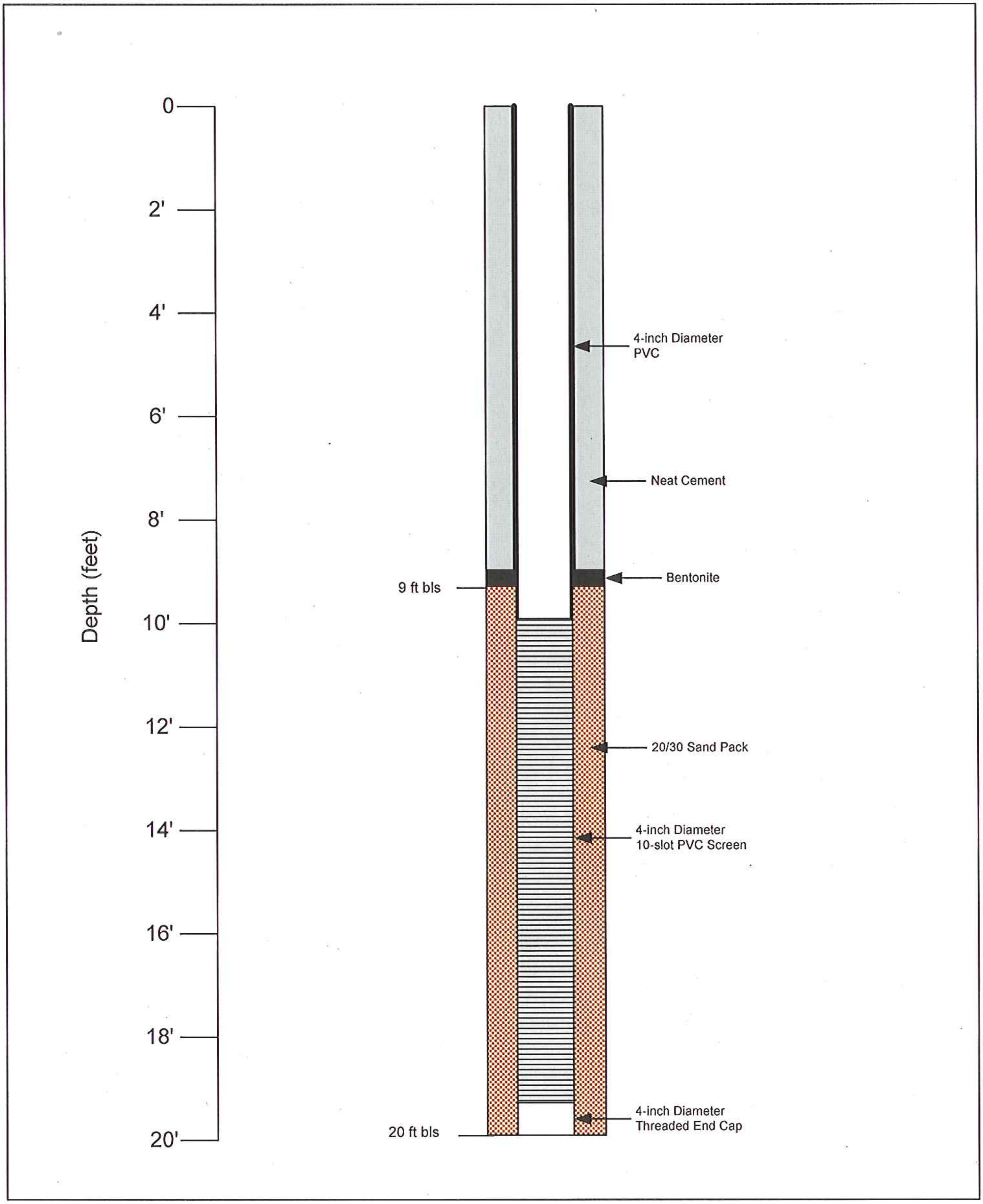

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Figure 3-1 Water Table Monitor Well Schematic

3.3 Containment Pad

A temporary containment pad consisting of a crushed limestone berm approximately 2.5 feet high overlain by HDPE material was constructed to contain and remove drilling fluids produced during construction activities of the Horseshoe ASR EXW. Following completion, the HDPE material and limestone were removed from the site.

The containment pad was designed to protect the surficial aquifer by containing fluid spills and brackish formation water encountered during drilling operations. A pump was installed into the containment pad to remove fluids from the pad to an onsite storage system for removal to the approved off site disposal location.

3.4 Well Construction

The drilling and construction operations for the Horseshoe ASR EXW began March 26, 2008 and well construction activities were substantially complete on September 15, 2008. Well construction activities concluded on October 21, 2008 with final geophysical logging and video survey. Drilling operations were normally conducted 8 hours per day, 5 days per week. A schematic diagram of the completed well is presented in Figure 3-2. An As-Built diagram is available in Appendix G. A summary of well construction and testing activities at the ASR EXW is included in Table 3-1.

The surficial aquifer and the upper portion of the Hawthorn Group were drilled using the mud rotary and reverse air drilling methods to a depth of 523 feet bls. During mud rotary drilling operations, all drilling fluid was contained in a closed circulation system. Intermediate casing was set at 523 feet bls. The well was drilled to a total depth of 910 feet bls using reverse air drilling techniques. Following the evaluation of potential storage zones, the well was backplugged with neat cement to 694 feet bls and completed by installing 8-inch diameter Schedule 40 PVC final casing to 520 feet bls.

The diameter of the drill bits used and depths to which the bits penetrated were a function of geology, well design, and regulatory requirements for the project. Extensive sampling and testing was conducted on the borehole to evaluate the potential for aquifer storage and to aid in the final design of the exploratory well. Specifics of the testing program and data obtained from testing are presented in Section 4.

Table 3-1 Construction Chronology

Start Date	End Date	Description of Activities
3-12-08	3-25-08	Mobilized equipment and prepared site.
3-26-08	3-27-08	Drilled 12¼-inch pilot hole to depth of 83 ft bls.
3-31-08	4-1-08	Reamed 25-inch diameter borehole to depth of 82 ft bls.
4-1-08	4-2-08	Set and grouted 80-feet of 18-inch diameter steel surface casing.
4-7-08	4-10-08	Drilled 12¼-inch pilot hole to 438-ft with direct mud rotary drilling method.
4-11-08	4-15-08	Switched to reverse air drilling method because of loss of circulation
4-16-08	4-18-08	Drilled 12¼-inch pilot hole to 515-ft bls with reverse air drilling method.
4-21-08	4-23-08	Quartz sand backfilled borehole to 480-ft bls. Switched drilling method back to mud rotary method with gorilla mud to regain circulation.
4-28-08	5-1-08	Reamed pilot hole with 17-inch bit to 425-ft bls with reverse air method.
4-29-08	4-29-08	Conducted geophysical logging on borehole to 515-ft bls.
5-1-08	5-1-08	Switched to mud rotary drilling method using weighted mud to control high artesian flow.
5-6-08	5-7-08	Reamed pilot hole with 17-inch bit to 460-ft bls with mud rotary method using weighted mud.
5-8-08	5-12-08	Performed cement squeeze job with 24-cuyd neat cement to control high artesian flow and quartz sand backfill.
5-13-08	5-13-08	Tagged cement from squeeze job at 198-ft bls.
5-13-08	5-20-08	Reamed borehole to 523-ft bls using mud rotary drilling method.
5-20-08	5-20-08	Geophysical Logging: XY Caliper, Gamma Ray.
5-22-08	5-23-08	Set and grouted 12-inch intermediate casing to 523-ft bls.
5-27-08	6-5-08	Drilled nominal 11¾-inch diameter pilot hole to 620-ft bls using reverse air
6-10-08	7-2-08	Drilled nominal 9⅞-inch diameter pilot hole to 910-ft bls using reverse air
6-19-08	6-19-08	Cored Interval 640 to 650 ft bls – Core #1.
6-24-08	6-24-08	Cored Interval 800 to 810 ft bls – Core #2.
6-27-08	6-27-08	Cored Interval 849 to 859 ft bls – Core #3.
7-1-08	7-1-08	Cored Interval 892 to 902 ft bls – Core #4.
7-8-08	7-8-08	Video survey
7-10-08	7-10-08	Video survey
7-14-08	7-14-08	Geophysical Logging: XY Caliper, Gamma Ray, Dual Induction, Spontaneous Potential, Sonic.
7-31-08	8-4-08	Backplugged well from 910 ft bls to 694 ft bls.
8-8-08	8-8-08	Set 520 feet of 8-inch diameter PVC final casing.
8-8-08	8-18-08	Grouted 8-inch diameter PVC final casing.
8-27-08	8-27-08	Video survey
9-4-08	9-4-08	Geophysical Logging: XY Caliper and Video survey.
9-30-08	10-2-08	Well Development.
10-13-08	10-13-08	Conducted Step Test and Constant Rate Aquifer Test. Final water quality sampling was conducted during testing.
10-21-08	10-21-08	Final Geophysical Logging: XY Caliper and Video survey.
12-23-08	12-23-08	Disinfected well.

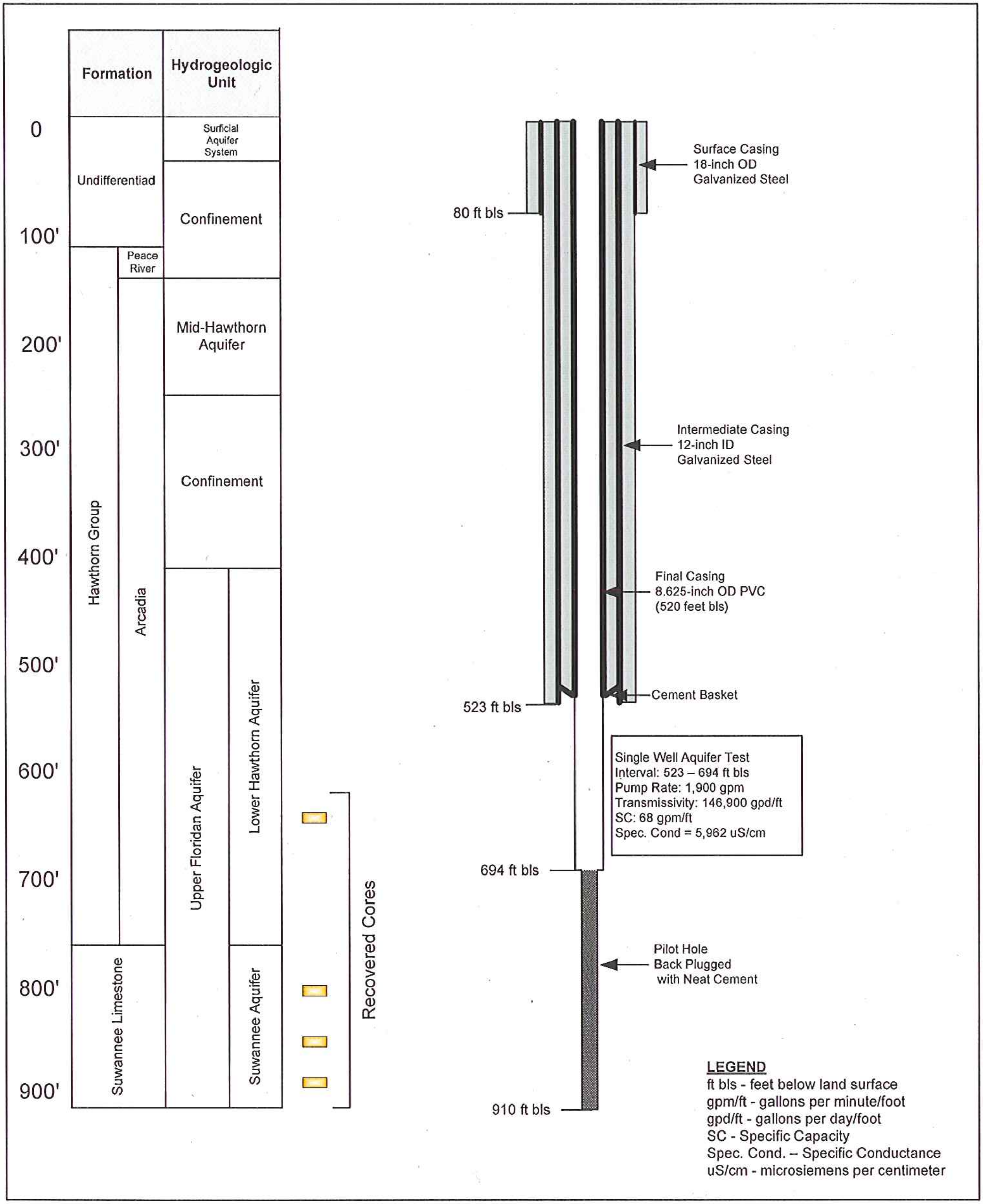

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Figure 3-2 Horseshoe Canal ASR EXW Schematic and Hydrogeologic Summary

3.4.1 Surface Casing

A 12 ¼ inch diameter pilot hole was initially drilled to a depth of 83 ft bls and a 25-inch diameter reamed borehole was drilled to a depth of 82 feet bls. Eighty feet of 18-inch diameter steel casing was then installed and grouted in place. The purpose of the surface casing was to prevent surficial material from falling into the borehole during drilling operations, maintain the strength and integrity of the surficial material from the weight and vibration of the drill rig, and to protect the surficial aquifer from drilling materials and fluids used in the construction of the well.

3.4.2 Pilot Hole Drilling and Reaming Operations

A 12 ¼-inch diameter pilot hole was drilled to determine an intermediate casing depth. The construction of a pilot hole minimizes attenuation effects of large diameter boreholes on geophysical logs and maintains the vertical alignment of the borehole during reaming activities.

Lithologic samples were collected at 10-foot intervals and at changes in the lithology during pilot hole drilling operations (Appendix B). Lithologic samples were used to help determine formation changes and the hydrologic and physical properties of the aquifers. Geophysical logging consisted of XY Caliper, Gamma Ray, Dual Induction, Spontaneous Potential, Borehole Compensated Sonic and Video. Lithologic sampling and geophysical logging are described in Section 4, Data Collection and Analysis. Geophysical logs and video descriptions are available in Appendices C and D.

Drilling operations were challenging because of unusual subsurface conditions encountered, primarily in the LHA of the Arcadia Formation, and to a lesser extent in the underlying Suwannee aquifer. The unusual conditions encountered from approximately 438 to 710 feet bls included unusually high artesian flow, poorer quality water originating from cavernous or fractured zones, unconsolidated sand, and interbedded very hard dolomite.

The upper portion of the Hawthorn Group to 438 feet bls, was drilled using mud rotary with a 12 ¼ -inch diameter bit. Because of a loss of circulation, reverse air drilling method was employed from 438 to 480 feet bls. An unconsolidated sand interval was then encountered at approximately 485 feet bls which continued to backfill into the borehole when the drilling contractor attempted to advance the bit. The drilling contractor elected to switch back to mud rotary and use a much heavier drilling fluid (i.e. gorilla mud) for sand control and drilled to 515 feet bls.

During reaming operations, a 17-inch diameter bit was used to drill through the pilot hole to 523 feet bls. Because of bulk flow characteristics in the LHA, the drilling contractor employed wash rotary method (drill with formation water) to 425 feet bls and then switched to gorilla mud in an attempt to control sand and flow to a depth of 470 feet bls. The drilling contractor elected to perform a cement squeeze job (i.e. backplugging) to better control sand and high artesian flow. The cement squeeze job was completed to a depth of 198 feet bls and was then successfully reamed to a depth of 523 feet bls. The borehole was reamed 8 feet below the pilot to better seal the sands encountered from approximately 480-510 ft bls.

The 12-inch diameter intermediate steel casing was set at 523 feet bls as approved by the FDEP. Mill certificates for the steel casing are provided in Appendix I. Prior to placement of the intermediate casing, geophysical logging was performed consisting of an XY Caliper and Gamma Ray log. The XY Caliper log was used to determine the physical properties of the borehole and provide annular volume information for cementing operations. Intermediate casing grouting operations are summarized in Table 3-2.

Table 3-2 Intermediate Casing Grout Summary

Date	Stage	Cement Type	Density (lbs/gal)	Total Volume (Barrels)	Total Volume (cuft)	Theoretical Tag (ft bls)	Actual Tag (ft bls)
5/22/08	1A	2%	14.5	30	168	-	-
5/22/08	1B	Neat	15.1	38	213	103	109
5/23/08	2	Neat	15.2	26	146	0	0

Prior to reverse air drilling and discharging into the Azara Canal, Sanders Laboratory of Nokomis, Florida collected groundwater samples from the ASR EXW on May 29, 2008 to fulfill the requirements of the Generic Discharge Permit as required by the FDEP. The water produced from the ASR EXW was sampled and analyzed by Sanders Laboratory at initial discharge into the Azara Canal and 30 days after the initial sampling. The results from the Generic Discharge Permit sampling are presented in Appendix J.

Since the adjacent Coral Oaks Golf Course utilizes the canal for irrigation, additional steps in water quality monitoring were taken because of the anomalously high artesian flow encountered during pilot hole drilling operations from 580 to the total depth of 910 feet bls. During any discharge event, water quality (temperature, pH, and specific conductivity) were collected at five different locations in the canal; the discharge point, 100 meters downstream, 300 meters downstream, 100 meters upstream, and 200 meters upstream. The enhanced sampling was conducted to minimize any potential impacts to the golf course.

The groundwater produced from the ASR EXW was also filtered through a settling tank before entering the canal. In addition, a silt curtain was installed in the canal to provide an additional measure of containment.

Pilot hole drilling resumed following generic discharge sampling using reverse air drilling techniques to a total depth of 910 feet bls. Drilling was slow because of encountering very hard dolomite and controlling the high artesian flow. During pilot hole drilling, four rock cores measuring 4-inches in diameter were obtained at various depths as discussed in Section 4.2. The rock cores were sent to Ardaman and Associates of Orlando, Florida for additional analyses. Results of the analyses are presented in Section 4.

3.4.3 Request to Cease Drilling Activities

The well was drilled to 910 feet bls and not to the planned depth of 1,200 feet bls because the unusual subsurface conditions present at this location are unsuitable for aquifer storage and recovery. A request to cease drilling was sent and approved by the FDEP on August 4, 2008 (Appendix E), with an alternate plan to complete the well in the LHA for use as a monitor well and for potential future use as an RO production well if the North Water Treatment plant allows. The alternate use plan was submitted in fulfillment of Specific Condition 1.g. (2).

3.4.4 Back Plugging

The open hole was back plugged from 910 to 694 feet bls and completed in the LHA because of the unusual subsurface conditions identified during drilling and testing. The back plugging was completed in two stages, with a total of 70 barrels of neat cement as shown in Table 3-3.

Table 3-3 Backplug Summary

Date	Stage	Cement Type	Density (lbs/gal)	Total Volume (Barrels)	Total Volume (cuft)	Theoretical Tag (ft bls)	Actual Tag (ft bls)
7/31/08	1	Neat	15.4	36	202	740	820
8/4/08	2	Neat	15.0	34	191	700	694

3.4.5 Final Casing

Because of unfavorable geologic conditions for aquifer storage and recovery, the well was completed in the LHA. On August 8, 2008, following backplug operations, the final casing, 8 inch PVC, was installed to 520 feet bls. The casing was grouted in place in eight stages as summarized in Table 3-4.

Table 3-4 Final Casing Grout Summary

Date	Stage	Cement Type	Density (lbs/gal)	Total Volume (Barrels)	Total Volume (cuft)	Theoretical Tag (ft bls)	Actual Tag (ft bls)
8/8/08	1	Neat	15.2	1.1	5.6	509	*
8/9/08	2	Neat	15.0	1.9	10.7	*	515
8/11/08	3	Neat	15.0	1.1	6.2	501	505
8/12/08	4	Neat	15.1	1.3	7.3	488	468
8/13/08	5	6%	14.7	7.0	39.3	379	379
8/14/08	6	6%	14.4	9.0	50.5	265	279
8/15/08	7	6%	13.5	8.0	44.9	178	141
8/18/08	8	6%	14.0	8.0	44.9	40	0

* Contractor unable to hard tag Stage 1

3.4.6 Well Development

After drilling operations were complete, the well was initially developed with reverse air. Because of the high flow characteristics, final development was completed by both allowing the well to flow naturally and with the use of a submersible pump. Water samples were collected periodically during development for field parameters. Water samples were obtained and tested for specific conductivity, dissolved oxygen, pH, and temperature. Well development water quality measurements are available in Section 4.5.

4.0 Hydrogeological Testing/Data Collection

Data collected during the drilling and construction of the Horseshoe ASR EXW included lithologic samples, geophysical logging, and water quality sampling. Analysis of collected data was used to characterize the lithology, water quality, and relative permeability of the sediments encountered. Cores were collected during drilling operations at selected depths to determine discrete hydraulic properties of the aquifer and in identification of possible storage zones.

4.1 Inclination Surveys

Inclination surveys were conducted on the borehole during both pilot hole and reamed hole operations to ensure the borehole did not deviate significantly from plum and prevent, hinder, or interfere with casing and cement grout placement. Surveys were performed every 60 feet during drilling operations. In accordance with vertical drift specifications for the well, each inclination measurement was less than one degree and consecutive survey measurements differed no more than 0.5 degrees. The survey results were recorded with a Sure-Shot tool. The average inclination during construction of the ASR EXW was 0.68 degrees for the pilot hole and 0.51 degrees for the reamed hole. The results of the inclination surveys conducted during drilling operations are presented in Appendix H.

4.2 Lithologic Sampling and Coring

Formation cuttings were collected during drilling operations every 10 feet from surface to the total depth of the pilot hole. Samples were characterized for rock type, color, consolidation, texture, cementation, hardness/induration, fossil type, and porosity/permeability. Lithologic sampling aided in identifying the contacts between formations, selection of core intervals, and understanding the overall physical characteristics of formations penetrated by the borehole. Detailed descriptions of the lithology encountered during pilot hole drilling of the Horseshoe ASR EXW is presented in electronically in Appendix B and as a hard copy in the report supplement.

During drilling of the Horseshoe ASR EXW, conventional cores were collected using a 4-inch diameter, 10-foot long, diamond-tipped core barrel. Four rock cores were retrieved from the Arcadia Formation and Suwannee Limestone between 640 and 902 feet bls with core recoveries between 8 and 90 percent. A summary of the full-diameter coring program conducted at this site is presented in Table 4-1.

Table 4-1 Coring Program Summary

Core #	Date Cored	Cored Interval (ft bls)	Recovered (ft)	Recovered (%)
1	6/19/08	640 - 650	0.8	8
2	6/24/08	800 - 810	9.0	90
3	6/27/08	849 - 859	4.4	44
4	7/1/08	892 - 902	7.7	77

MWH, Americas sent five sections of the rock cores obtained during drilling operations to Ardaman and Associates, Inc., located in Orlando, Florida to determine the following parameters: vertical and horizontal hydraulic conductivity, vertical and horizontal porosity and specific gravity. Hydraulic conductivity and porosity were measured in general accordance with ASTM Standard D 5084 "Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter" using constant head (Method A). Specific gravity measurements were made in general accordance with ASTM Standard D 854 "Specific Gravity of Soil Solids by Water Pycnometer" using approximately 50 gram specimens ground to pass the U.S. Standard No. 40 sieve. Unconfined compression tests were performed in general accordance with ASTM Standard D 7012 "Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures" using the unconfined test method (Method C). The core analyses results are summarized in Table 4-2. Full laboratory reports from Ardaman and Associates, Inc are available in Appendix K.

Table 4-2 Core Sample Petrophysical Analyses Summary

Core No.	Sample Depth (ft)	Vertical Hydraulic Conductivity (cm/sec)	Horizontal Hydraulic Conductivity (cm/sec)	Vertical Porosity (%)	Horizontal Porosity (%)	Specific Gravity
2	801.8	$1.7x10^{-3}$	$1.9x10^{-3}$	45.8	44.9	2.75
2	804.8	$3.7x10^{-4}$	$2.5x10^{-4}$	46.8	45.2	2.70
3	849.7	$4.1x10^{-4}$	$8.9x10^{-6}$	36.8	35.9	2.71
4	895.3	$9.2x10^{-9}$	$1.7x10^{-8}$	32.5	32.9	2.70
4	899.2	$2.6x10^{-6}$	$1.9x10^{-5}$	41.9	41.7	2.67

* Core #1 was not analyzed because of low recovery

4.3 Geophysical Logging and Analysis

Geophysical logs were conducted in the pilot hole after each stage of drilling. The logs provide a continuous record of the petrophysical properties of the subsurface formations and/or their water quality adjacent to the borehole. Analysis of the logs were used to assist in the interpretation of stratigraphy, to provide estimates of permeability, porosity, bulk density, resistivity, and to determine the total dissolved solids of the groundwater. Geophysical logs are presented (PDF and LAS format) in Appendix C.

The geophysical logs were compared to lithologic cuttings that aided in identifying geologic contacts, and were used to obtain specific hydrogeologic data pertaining to the formations. The geophysical data, in conjunction with water quality, specific capacity testing during drilling, and lithology were utilized in determining aquifer properties and optimum casing depths.

Geophysical logs were run in the pilot hole, reamed hole, total depth pilot hole, and final open borehole of the Horseshoe Canal ASR EXW. The geophysical logging sequence during drilling is summarized in Table 4-3. Geophysical logs were used to provide support of casing depth requests, and final open hole interval.

Table 4-3 Geophysical Summary

Date	Logged Interval (ft bls)	XY Caliper	Gamma Ray	Spontaneous Potential	Dual Induction	Sonic Porosity	Comments
4-29-08	0-492	X	X	X	X	X	12.25-inch pilot hole
5-20-08	0-523	X	X				17-inch reamed hole
7-14-08	0-910	X	X	X	X	X	12.25-inch borehole
9-4-08	0-694	X	X				Logging to a rock obstruction at 653 feet bls.
10-21-08	0-650	X					Final logging to obstruction after attempts were made to clear it from the borehole

4.4 Video Surveys

Video surveys were conducted for borehole and casing inspections. The videos provide a continuous record of the visual characteristics of the subsurface formations. Video surveys and descriptions are presented in Appendix D. The video survey sequence during drilling is summarized in Table 4-4.

Table 4-4 Video Survey Summary

Date	Interval (ft bls)	Comments
7-8-08	0-710*	Attempted video of borehole, salt brine obstruction at 710 feet bls
7-10-8	0-910	Video to total depth of borehole
8-27-08	0-694*	Attempted video of borehole, salt brine obstruction at 611 feet bls
9-4-08	0-694*	Video to a rock obstruction at 653 feet bls.
10-21-08	0-650	Final video to obstruction after attempts were made to clear it from the borehole

* Video is not provided in the Appendices

The video survey on September 4, 2008 showed the borehole to be partially blocked with loose rock at a depth of 650 ft bls. Several attempts were made, however, the borehole geometry and unusual subsurface conditions made it unfeasible to clear the obstruction.

The blockage is not anticipated to interfere with the utility of the well as either a monitoring well or a production well.

4.5 Water Quality Sampling and Analysis

4.5.1 Water Quality during Drilling Operations

Water quality samples were collected at 30-foot intervals in the pilot hole during reverse-air drilling. Sampling started at a depth of 483 feet bls and continued to the depth of 902 feet bls. Samples were collected from the discharge point of the fluid circulation system. The samples were analyzed on-site for dissolved oxygen, temperature, pH, conductivity, and chloride. These data indicated a general increase in chloride concentrations from 483 to 800 feet bls and a decrease in these concentrations from 800 to 902 feet bls. Specific conductivity values fluctuated slightly up and down throughout the borehole to 902 feet bls. Pilot hole water quality measurements are presented in Table 4-4.

Table 4-5 Reverse Air Drilling Water Quality with Depth

Date	Depth (ft bls)	Specific Conductivity (µS/cm)	Dissolved Oxygen (%)	pH	Temperature (°C)	Chloride (mg/L)
4-17-08	483	3,520	63.41	7.40	24.2	875
4-18-08	502	3,780	67.5	6.80	25.6	950
5-29-08	560	4,175	24.7	7.70	29.44	1,325
5-30-08	579	5,910	29.0	7.21	29.7	1,600
6-2-08	583	6,706	31.3	7.21	27.3	1,600
6-9-08	620	7,791	43.0	7.62	26.2	1,600
6-10-08	620	8,161	41.7	8.40	26.5	1,750
6-13-08	620	7,375	22.8	7.60	26.2	2,000
6-16-08	635	7,488	19.1	7.74	27.5	2,050
6-17-08	640	7,262	32.6	7.84	27.0	2,050
6-20-08	660	5,484	45.1	7.32	26.3	1,700
6-20-08	680	5,475	56.2	7.53	24.8	1,700
6-21-08	680	6,143	48.2	7.32	25.7	1,800
6-23-08	720	7,194	54.7	7.49	27.3	2,150
6-23-08	740	7,110	58.1	7.42	26.9	2,150
6-23-08	760	6,792	59.8	7.46	25.9	2,100
6-23-08	780	6,774	64.2	7.60	27.8	2,200
6-23-08	800	6,734	45.3	7.17	25.5	2,200
6-24-08	800	7,213	47.1	7.01	25.5	2,150
6-26-08	820	6,015	31.1	7.20	26.5	1,888
6-26-08	840	6,036	49.0	7.13	25.5	1,850
6-27-08	859	6,151	35.9	7.13	26.6	1,900
6-27-08	879	6,119	40.7	7.19	25.9	1,800
7-1-08	902	5,449	34.8	7.31	26.1	1,612

4.5.2 Well Development

Prior to back plugging, the well was developed with artesian flow on July 31, 2008 for approximately 4 hours. A pump was not initially used because of the unusual high artesian flow. Water quality samples were collected and tested for specific conductivity, dissolved oxygen, pH and temperature.

The well was also developed with a vacuum assisted pump prior to performing a step rate drawdown test and a constant rate aquifer test. The well was pump developed at approximately 1,850 gpm for approximately 10 hours from September 30, 2008 to October 2, 2008. The artesian flow was measured to be approximately 1,500 gpm with both a manometer and a mechanical flow meter. The artesian flow was less than previously estimated at approximately 3,000 gpm during reverse air drilling operations. The latter was calculated by measuring the vertical drop of the stream of water and the distance the stream travels parallel to the pipe to provide that drop (Anderson, 1998). Water quality samples were collected and tested for specific conductivity, dissolved oxygen, pH and temperature. Well development water quality measurements are available in Table 4-6.

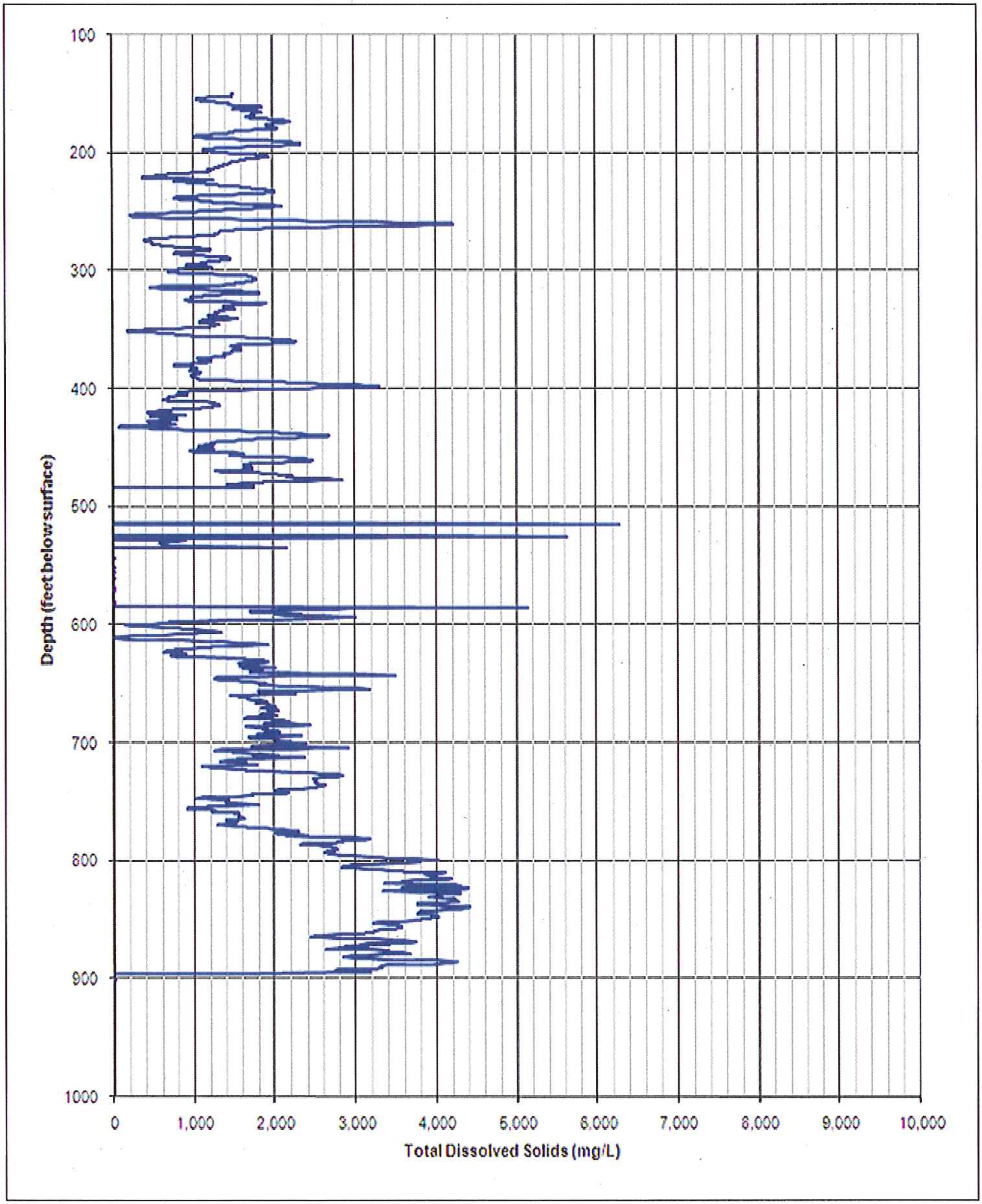
Table 4-6 Well Development Water Quality with Depth

Date	Time	Specific Conductivity (µS/cm)	Temperature (°C)	pH	D.O. (%)
9-30-08	1110	5,642	25.2	8.40	19.4
9-30-08	1210	5,721	25.7	8.31	21.4
9-30-08	1315	5,861	24.9	7.82	29.8
9-30-08	1405	5,848	25.5	8.09	26.7
9-30-08	1520	5,997	25.9	8.16	27.5
10-1-08	1150	5,967	26.9	7.84	36.2
10-2-08	0955	5,811	25.8	7.77	17.3

4.5.3 Total Dissolved Solids Analysis with Depth

The Sonic Porosity and Dual Induction logs were used to calculate a log-derived Total Dissolved Solids (TDS) plot for the ASR EXW based on the method developed by Callahan (1996) using empirical data from South Florida compiled by Reese (1994).

TDS ranged between approximately 500 and 4,500 mg/L with generally increased salinity to 800 ft bls and a slight decrease from 800 to 910, the total depth of the well (Figure 4-1). Erroneous TDS values were calculated from approximately 500 to 600 feet bls because of the unusual subsurface conditions. The plot indicates that the base of the Underground Source of Drinking Water (USDW) was not encountered during drilling and testing activities. The accuracy of the calculated TDS is supported by specific conductivity data collected while drilling.



MWH BUILDING A BETTER WORLD

Figure 4-1 Horseshoe Canal ASR EXW Log Derived Total Dissolved Solids Plot

4.5.4 Water Quality During Testing

Water quality from the ASR EXW was collected during the constant rate aquifer test conducted on October 13, 2008 of the completed open interval, 523-694 feet bls. During the drawdown phase, the water quality samples were obtained approximately every hour and measurements of specific conductivity, dissolved oxygen, pH, temperature and chloride were collected. Results of the water quality measurements for the aquifer test are shown in Table 4-7.

Table 4-7 Step Drawdown/Constant Rate Aquifer Test Water Quality

Time	**Specific Conductivity** (µS/cm)	**D.O.** (%)	**pH**	**Temperature** (°C)	**Cl^-** (mg/L)
1150	5,628	34.7	7.07	23.7	1,850
1240	5,696	39.5	7.08	25.4	1,850
1400	5,795	40.0	7.04	26.4	1,960
1505	5,962	47.2	7.92	26.4	1,900

4.5.5 Final Water Quality

The ASR EXW was pump developed until at least three well volumes of water had been evacuated from the well and the chloride concentration, temperature, pH and specific conductivity measurements stabilized. Water samples were collected by Sanders Laboratories, Inc. on October 13, 2008 during the constant rate aquifer test. Results of primary, secondary, bacteriological, and radionuclide water quality parameters are listed in Table 4-5. The volatile and synthetic organics analyses resulted in below detection limits and therefore are not listed in Table 4-8. Complete results are available in Appendix L.

Table 4-8 Completed Well Primary & Secondary Water Quality

Parameter		ASR EXW (523 – 694 ft bls)
Primary Inorganics	Aluminum (mg/L)	0.044
	Antimony (mg/L)	BDL
	Arsenic (mg/L)	BDL
	Barium (mg/L)	0.069
	Berylium (mg/L)	BDL
	Cadmium (mg/L)	BDL
	Chromium (mg/L)	BDL
	Fluoride (mg/L)	1.0
	Mercury (mg/L)	BDL
	Nickel (mg/L)	BDL
	Nitrate (mg/L)	BDL
	Nitrite (mg/L)	BDL
	Selenium (mg/L)	BDL
	Sodium (mg/L)	880
	Thallium (mg/L)	BDL
Secondary Inorganics	Color (PtCo Color Units)	5
	Copper (mg/L)	BDL
	Chloride (mg/L)	1,610
	Iron (mg/L)	0.054
	Manganese (mg/L)	BDL
	Silver (mg/L)	BDL
	Specific Conductance (umhos/cm)	5,570
	Sulfate (mg/L)	274
	Total Dissolved Solids (mg/L)	3,060
	Zinc (mg/L)	BDL
Bacteriological	Total Coliform (CFU/100ml)	BDL
Radionuclides	Gross Alpha (pCi/l)	130
	Radium-226 (pCi/l)	19
	Radium-228 (pCi/l)	1.1
Additional Parameters	Dissolved Oxygen (mg/L)	1.81
	Turbidity (NTU)	8.6
	Sand (ppm)	<1.8
	SDI	2.76

4.6 Well Testing and Analysis

4.6.1 Specific Capacity Testing while Drilling

The unusual subsurface conditions and bulk flow characteristics encountered during drilling operations made it difficult to accurately determine specific capacity with depth. Specific capacity testing was performed at two intervals to a depth of 600 feet bls during reverse air drilling operations before suspending any additional testing do to the high flow characteristics.

Drilling operations were halted while each test was conducted to determine static water level in the pilot hole and the flow rate developed during airlifting. The resultant specific capacity measurement is an indication of the flow in that section of the pilot hole, relative to the rest of the pilot hole, and not an absolute value of that section of pilot hole. During initial drilling activities, specific capacity values were calculated at 560 and 600 feet bls recording measurements of 3.5 and 39.5 gpm/ft, respectively.

4.6.2 Packer Testing

Packer testing was not conducted because of the unusual subsurface conditions during drilling operations. The borehole was irregular, cavernous, and highly fractured in such a way that a packer would have been unable to properly isolate and test an interval to characterize aquifer parameters and determine water quality.

4.6.3 Step Drawdown Testing

A step drawdown test was conducted on October 13, 2008. The Horseshoe ASR EXW was pumped at 1,100, 1,750 and 1,850 gpm using a vacuum assisted pump. The step drawdown test yielded an average specific capacity of 77.2 gpm/ft. Results for the step drawdown test are summarized in Table 4-9. Theoretical transmissivity was calculated using the standard multiplier of 2,000 for each step during the test. Transmissivity based on each of the three steps during the step drawdown test are 180,400 gpd/ft, 147,000 gpd/ft, and 136,000 gpd/ft, respectively.

Table 4-9 Step Drawdown Test

Step	Pump Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)
1	1,100	12.2	90.2
2	1,750	23.8	73.5
3	1,850	27.2	68.0

4.6.4 Constant Rate Aquifer Testing

A single well constant rate aquifer test was conducted on the ASR EXW to determine the hydraulic characteristics of the completed open interval, 523-694 feet bls. The interval is completed in the most productive interval of the LHA at this location. The aquifer test consisted of three phases: a background phase was conducted to determine ambient static water level conditions; a pumping phase to determine water level drawdown in the well associated with pumping and a recovery phase to determine the return to static water level conditions. Water level data was collected in feet and PSI using an Insitu pressure transducer. During the pumping phase, water quality samples were collected approximately every hour and measurements of specific conductivity, dissolved oxygen, pH, temperature and chloride were documented. The constant rate aquifer test yielded an average specific capacity of 70.4 gpm/ft.

The background phase consisted of recording water level measurements in the well for a period of 43 hours, a plot of the background data is shown in Figure 4-2. The pumping phase consisted of pumping water from the well with a vacuum assisted pump at constant-rate of 1,900 gpm for three hours while recording water level changes in the ASR EXW as shown in Figure 4-3. The pumping phase conducted on October 13, 2008 was followed by a 24-hour recovery period, where pumping stopped and water levels were allowed to return to background condition. Transmissivity was calculated from the recovery data. A semi-log plot of the recovery data is shown in Figure 4-4.

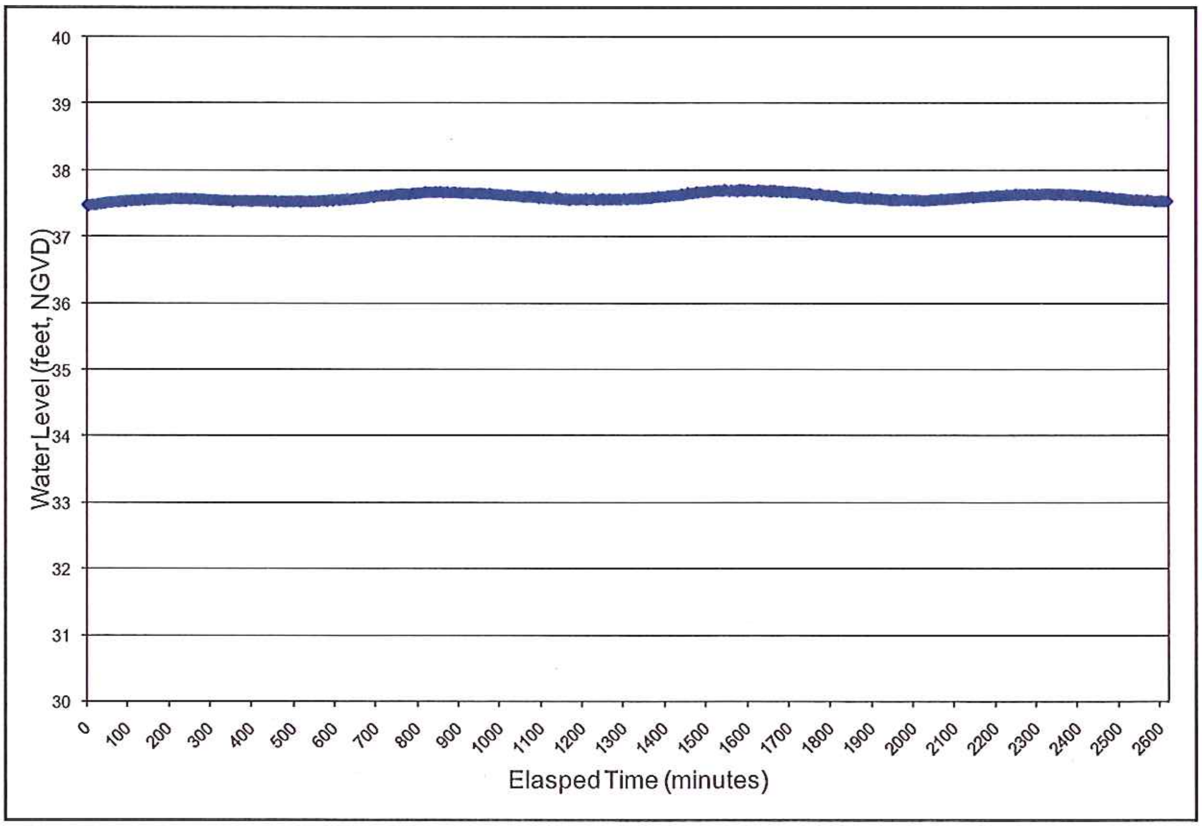


Figure 4-2 Constant Rate Aquifer Test Background Water Level

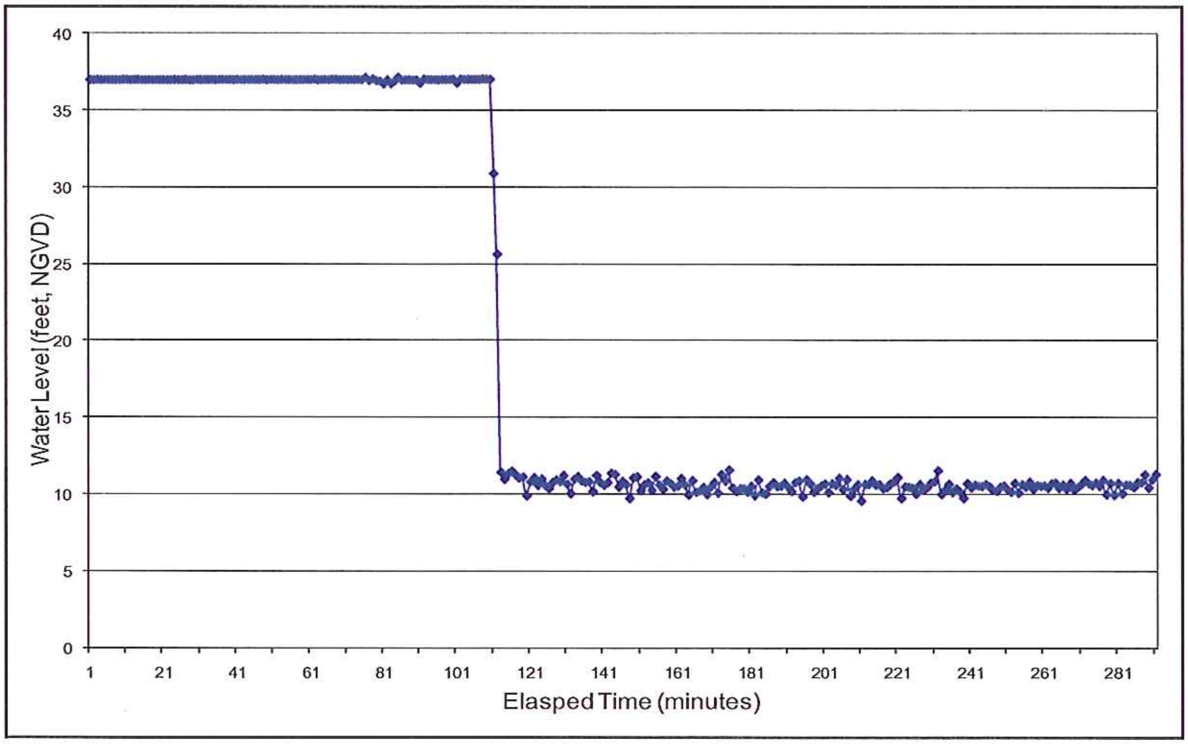


Figure 4-3 Constant Rate Aquifer Test Drawdown Water Level

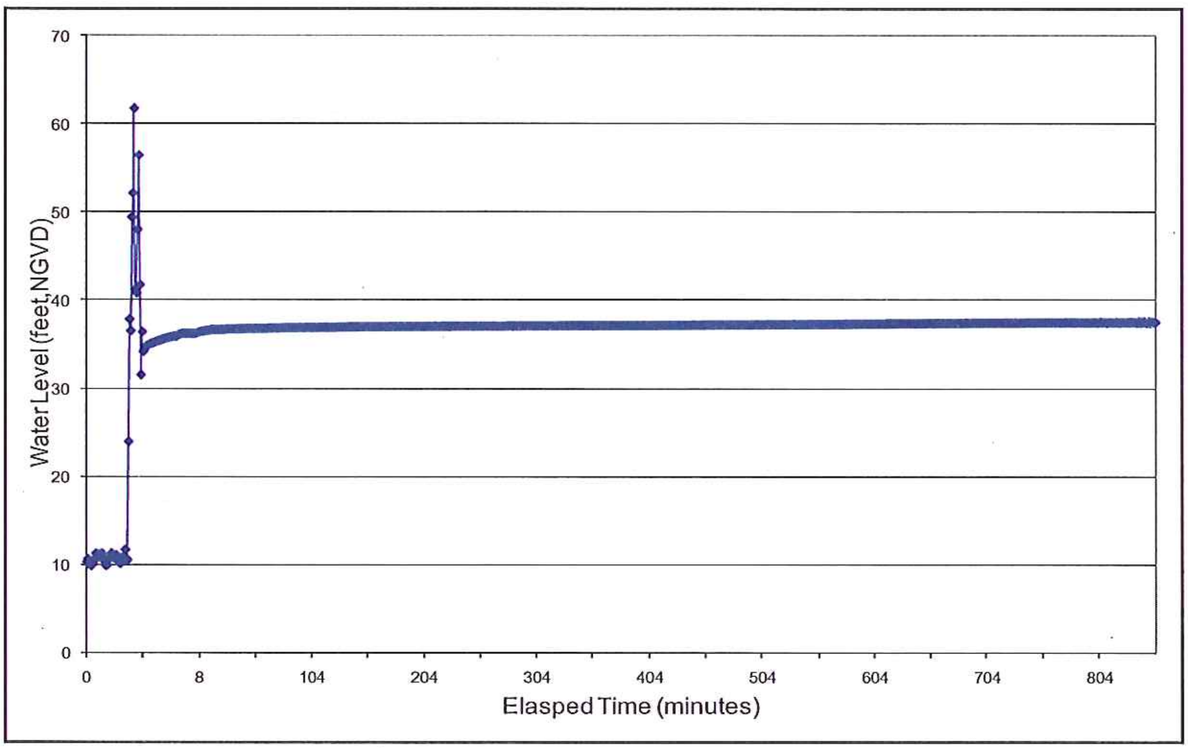


Figure 4-4 Constant Rate Aquifer Test Recovery Water Level

Recovery data from the ASR EXW was used to calculate transmissivity of the aquifer using three solution methods. These three methods were: the Hantush (1960) method for semi-confined aquifers with aquitard storage, the Hantush early time method (1960), and the Moench (1985) constant head method. A summary of the transmissivity results are presented in Table 4-10.

Table 4-10 Transmissivity Values from Constant Rate Aquifer Test

Transmissivity (gpd/ft)		
Hantush$_1$ (1960)	**Hantush**$_2$ (1960)	**Moench** (1985)
135,200	146,900	170,600

1 - With Aquitard Storage
2- Early Time

The transmissivity measured with the Hantush Early Time analysis is comparable to the average of all three aquifer test analysis methods used as shown in Table 4-9. A log/log plot of drawdown versus time, utilizing the Hantush Early Time solution, for the pumped interval is provided in Figure 4-5. The results of this solution yielded a transmissivity value of 146,900 gpd/ft, a storage coefficient of 3.9 x 10-7. The log/log plots of drawdown versus time for the Hantush with aquitard storage solution and the Moench solution are provided in Appendix M.

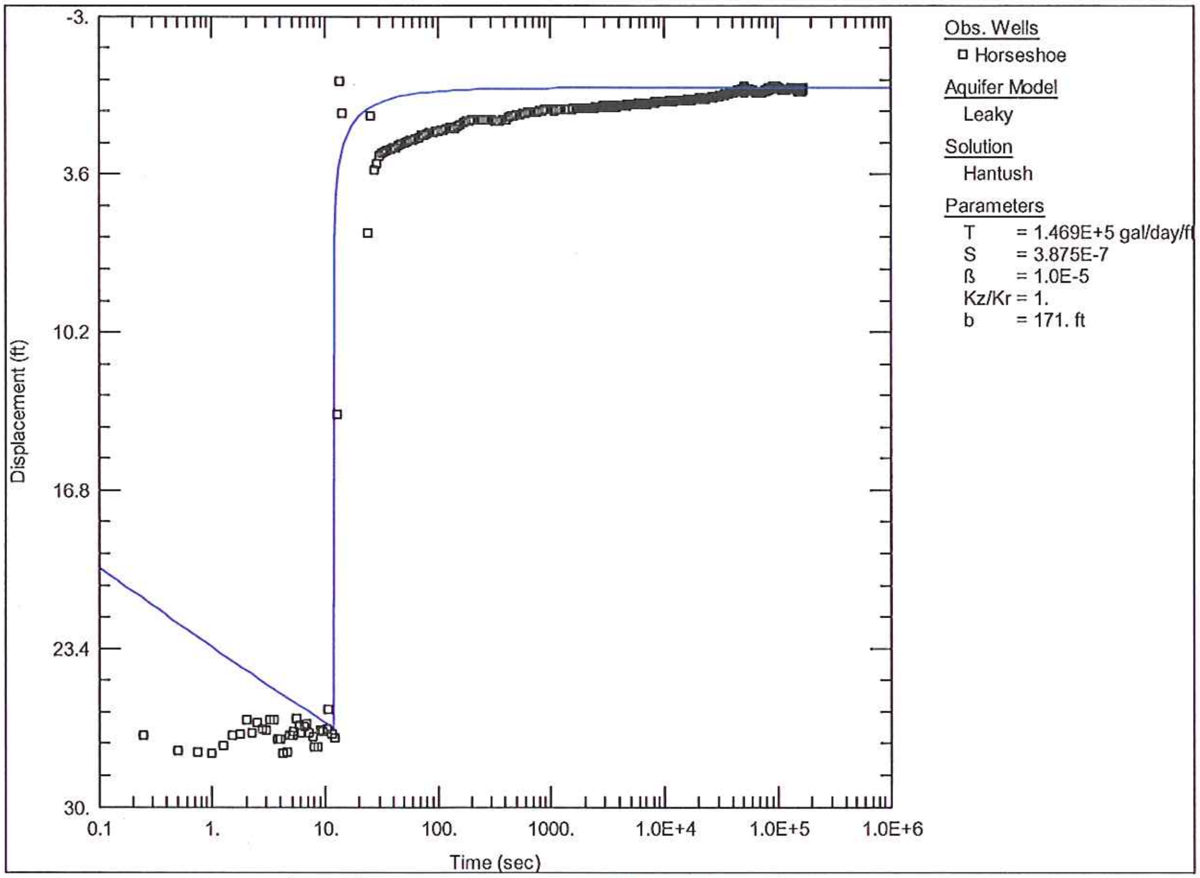


Figure 4-5 Hantush Early Time Log-Linear Plot of Drawdown vs. Time

5.0 Conclusions and Recommendations

The drilling and construction operations for the Horseshoe ASR EXW began March 26, 2008 and well construction activities were substantially complete on September 15, 2008. Well construction activities concluded on October 21, 2008 with final geophysical logging and video survey. The ASR EXW was drilled and tested to 910 ft bls. The well was then back plugged to 694 feet bls with neat cement and completed with 8.625 OD PVC set to 520 feet bls and is now ready for installation of monitoring equipment. The well was constructed to the requirements specified under FDEP permit No. 272886-002 UC/5X.

The monitoring interval of the ASR EXW is completed within the Lower Hawthorn aquifer of the Upper Floridan aquifer. The ASR EXW has a specific capacity of 90.2 gpm/ft at a pump rate 1,100 gpm. The ambient water within the monitoring zone is brackish, and contains a chloride and TDS concentration of approximately 1,610 mg/L and 3,060 mg/L, respectively.

Unusual subsurface conditions were encountered during drilling activities, primarily in the Lower Hawthorn aquifer of the Arcadia Formation, and to a lesser extent in the underlying Suwannee aquifer. The conditions included unusually high artesian flow and poorer quality water originating from cavernous or fractured zones in the interval from approximately 535 to 710 feet.

Video and geophysical logging confirmed the presence of cavernous areas and enlarged wellbore that are characteristic of injection zones normally encountered much deeper, typically below 2,500 feet. Although the unusual conditions were not encountered in the underlying planned storage zone (Suwannee aquifer); there was limited confinement present, and evidence of fissures and cracks that might be connected to the cavernous zones encountered above. The presence of these bulk flow features are generally considered not suitable for aquifer storage and recovery.

Based on the information obtained from this well, we would not recommend locating an ASR production well within 1,000 to 1,500 feet of this well. Therefore, MWH do not recommend drilling of an ASR test production well and completing this well as a Storage Zone Monitor Well as planned. The well was completed as a test/production well with current utility to monitor the LHA and potential future utility as a raw water production well for the North RO treatment plant.

6.0 References

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Report Supplement
Hard Copy Lithologic Logs

MWH

LITHOLOGY

IRR-6C.1 ASR Exploratory Well
Horseshoe Canal

Well Number	002 (L-1041)
Permit Number	272886-002-UC/5X
Job Number	3220289.864702
Owner	City of Cape Coral

Depth (ft bls)	Description
0-5	Sand: moderate yellowish brown 10YR 5/4; fine; well sorted; silica; (fill).
5-20	Shell Fragments (90%): medium light gray N6 and light gray N7; predominantly bi-valves. Limestone (10%): light gray N7; weathered; high porosity.
20-30	Clay (70%): dark greenish gray 5GY 4/1; moderately soft; trace of silt. Limestone (30%): light gray N7; micrite; weathered; high porosity.
30-40	Limestone (70%): light gray N7; micrite; weathered; high porosity. Clay (30%): dark greenish gray 5GY 4/1; moderately soft; trace of silt.
40-50	Clay (80%): dark greenish gray 5GY 4/1; moderately soft; trace of silt. Limestone (20%): light gray N7; micrite; weathered; high porosity.
50-60	Clay: greenish gray 5GY 6/1; moderately soft; 2-3% fine sand.
60-80	Clay: greenish gray 5GY 6/1; soft; 2-3% fine sand/silt.
80-90	Clay: greenish gray 5GY 6/1; soft; silty.
90-140	Clay: greenish gray 5GY 6/1; soft; 2-3% fine sand/silt.
140-150	Limestone (50%): white N9 and very light gray N8; biomicrite; friable; high porosity; 5-10% very fine phosphate. Marl (50%): very light gray N8; very soft.
150-180	Marl (80%): very light gray N8; very soft. Limestone (20%): white N9 and very light gray N8; biomicrite; friable; high porosity; 5-10% very fine phosphate.
180-190	Limestone (70%): very light gray N8; biomicrite; friable; high porosity; 5-10% very fine phosphate. Marl (30%): very light gray N8; very soft.
190-210	Limestone (80%): very light gray N8; biomicrite; friable; high porosity; ~5% fine phosphate. Marl (20%): very light gray N8; very soft.

Depth (ft bls)	Description
210-220	Marl (60%): very light gray N8; very soft. Limestone (40%): very light gray N8; biomicrite; friable; high porosity; ~5% fine phosphate.
220-250	Limestone (70%): very light gray N8; biomicrite; friable; high porosity; 2-3% fine phosphate. Marl (30%): very light gray N8; very soft.
250-260	Clay: greenish gray 5GY 6/1; moderately soft; silty.
260-270	Clay (50%): greenish gray 5GY 6/1; soft; silty. Marl (50%): very light gray N8; soft.
270-290	Marl: very light gray N8; very soft; 5-10% very fine phosphate.
290-300	Marl (90%): very light gray N8; very soft; 5-10% very fine phosphate. Limestone (10%): very light gray N8 to light gray N7; micrite; moderate porosity; friable.
300-310	Marl (70%): very light gray N8; very soft; 5-10% very fine phosphate. Limestone (30%): very light gray N8 to light gray N7; micrite; high porosity; friable.
310-320	Marl: very light gay N8; very soft; ~5% very fine phosphate.
320-340	Limestone (60%): very light gray N8; biomicrite; moderate porosity; friable; 5-10% very fine phosphate. Marl (40%): very light gray N8; soft.
340-360	Marl (90%): very light gray N8; soft; 5-10% very fine phosphate. Limestone (10%): very light gray N8; biomicrite; high porosity; friable.
360-380	Marl (90%): very light gray N8 and greenish gray 5GY 6/1; soft; 5-10% very fine phosphate. Limestone (10%): very light gray N8; biomicrite; high porosity; friable.
380-390	Marl (90%): very light gray N8; soft; 5-10% very fine phosphate. Limestone (10%): very light gray N8; biomicrite; high porosity; friable.
390-400	Marl: mottled very light gray N8 and greenish gray 5GY 6/1; soft; ~5% very fine phosphate.
400-410	Limestone (50%): very light gray N8; biomicrite; high porosity; friable; 5-10% very fine phosphate. Marl (50%): very light gray N8; soft.
410-420	Limestone (70%): yellowish gray 5Y 8/1 and light gray N7; biomicrite; moderately high porosity; moderately friable; 2-3% fine phosphate. Marl (30%): light greenish gray 5GY 8/1; moderately soft.
420-440	Limestone (50%): yellowish gray 5Y 8/1 and light gray N7; biomicrite; moderately high porosity; moderately friable; 2-3% fine phosphate. Marl (50%): light greenish gray 5GY 8/1; moderately soft.
440-460	Clay: pale olive 10YR 6/2; moderately stiff; plastic; trace of fine sand and silt.
460-480	Limestone: yellowish gray 5Y 8/1; biomicrite; high intergranular porosity; moderately hard; 2-3% fine phosphate.

Depth (ft bls)	Description
480-500	Limestone (80%): yellowish gray 5Y 8/1; biomicrite; high intergranular porosity; moderately hard. Clay (20%): light olive gray 5Y 6/1 to light gray N7; moderately soft; sandy; 3-4% fine phosphate.
500-510	Sand: medium light gray N6; fine grained quartz; well sorted; ~5% fine phosphate; trace of clay; trace of shell fragments.
510-520	Limestone: greenish gray 5GY 6/1; micrite; moderate porosity; friable; trace of shell fragments.
520-540	Limestone: yellowish gray 5Y 8/1; biomicrite; moderate intergranular and moldic porosity; friable; 2-3% very fine phosphate.
540-570	Dolomitic Limestone: yellowish gray 5Y 8/1; biomicrite; moderate intergranular and vuggy porosity; hard; 5-6% very fine phosphate.
570-590	Dolomitic Limestone: yellowish gray 5Y 8/1 and very pale orange 10YR 8/2; biomicrite; high intergranular and vuggy porosity; moderately hard; 2-3% very fine phosphate.
590-610	Dolomite: light gray N7; possibly high fracture porosity; hard; 1-2% very fine phosphate.
610-620	Dolomite: light gray N7; possibly high fracture porosity; very hard
620-640	Limestone: white N9 to very light gray N8; biomicrite; high moldic porosity; moderately hard; fossiliferous; bivalves and gunteri.
640-660	Limestone: white N9 to very light gray; biomicrite; high moldic porosity; moderately soft; fossiliferous; bivalves and gunteri.
660-670	Limestone: very light gray N8 to yellowish gray 5Y 8/1; biomicrite; high moldic and vuggy porosity; friable; fossiliferous.
670-680	Limestone (50%): very light gray N8 to yellowish gray 5Y 8/1; biomicrite; high moldic and vuggy porosity; friable; fossiliferous. Marl (50%): white N9 to very light gray N8; soft.
680-690	Limestone: very light gray N8 and yellowish gray 5Y 8/1; biomicrite; high moldic and vuggy porosity; friable; 2-3% very fine phosphate.
690-710	Limestone: very light gray N8 and yellowish gray 5Y 8/1; biomicrite; high moldic and vuggy porosity; moderately hard; 2-3% very fine phosphate.
710-730	Limestone (80%): yellowish gray 5Y 8/1; biomicrite; high moldic and vuggy porosity; moderately hard; 2-3% very fine phosphate. Dolomite (20%): light olive gray 5Y 6/1; hard.
730-740	Limestone: very light gray N8 and yellowish gray 5Y 8/1; biomicrite; high moldic and vuggy porosity; moderately hard; 2-3% very fine phosphate.

Depth (ft bls)	Description
740-760	Limestone (70%): yellowish gray 5Y 8/1 and pale orange brown 10YR 7/2; biomicrite; high moldic and vuggy porosity; moderately hard; 1-2% very fine phosphate. Marl (30%): light gray N7; soft; trace of very fine phosphate.
760-780	Limestone: pale orange brown 10YR 7/2 and yellowish gray 5Y 8/1; biomicrite; high moldic and vuggy porosity; moderately friable.
780-790	Limestone: pale orange brown 10YR 7/2, yellowish gray 5Y 8/1 and very pale orange 10YR 8/2; biomicrite; moderate moldic porosity; moderately hard.
790-800	Limestone (90%): pale orange brown 10YR 7/2 and very pale orange 10YR 8/2; biomicrite; moderate moldic porosity; moderately hard. Marl (10%): yellowish gray 5Y 8/1; soft.
800-810	Limestone (90%): very pale orange 10YR 8/2 and grayish orange 10YR 7/4; biomicrite; high moldic and vuggy porosity; moderately friable. Dolomite (10%): light gray N7; hard.
810-820	Limestone (90%): very pale orange 10YR 8/2 and yellowish gray 5Y 7/2; biomicrite; high moldic and vuggy porosity; moderately friable. Dolomite (10%): light gray N7; hard.
820-830	Limestone (90%): very pale orange 10YR 8/2; biomicrite; high moldic and vuggy porosity; moderately friable. Dolomite (10%): light gray N7; hard.
830-840	Limestone (50%): very pale orange 10YR 8/2; biomicrite; high moldic and vuggy porosity; moderately friable. Marl (50%): pale yellowish brown 10YR 6/2; soft.
840-850	Limestone: very pale orange 10YR 8/2; micrite; moderate intergranular porosity; friable.
850-860	Limestone (70%): yellowish gray 5Y 8/1; micrite; moderate intergranular porosity; friable. Marl (30%): yellowish gray 5Y 8/1; soft.
860-890	Limestone: very pale orange 10YR 8/2 and yellowish gray 5Y 8/1; biomicrite; calcarenitic; moderately high moldic and vuggy porosity; 1-2% very fine phosphate.
890-892	Dolomite: light gray N7 and medium light gray N6; crystalline; hard.
892-900	Limestone (90%): pale grayish orange 10YR 8/4; micrite; moderate intergranular porosity; hard. Clay (10%): mottled yellowish gray 5Y 8/1 and very light gray N8; very hard; low plasticity.
900-910	Limestone: pale grayish orange 10YR 8/4; micrite; moderate intergranular porosity; hard.

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