# ENGINEERING REPORT
FOR THE
CONSTRUCTION AND TESTING
OF THE
CITY OF SARASOTA
DEEP INJECTION WELL SYSTEM

FLORIDA DEPARTMENT OF
ENVIRONMENTAL PROTECTION
CLASS I TEST INJECTION WELL

PERMIT NO.0298881-001-UC/1X

**PREPARED FOR**

CITY OF SARASOTA

**PREPARED BY**

ATKINS

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TAMPA, FLORIDA 33607

**SEPTEMBER 2012**

**Certification Page**

## Professional Geologist Certification

The hydrogeological evaluations and interpretations contained in the "Engineering Report for the Construction and Testing of the City of Sarasota Deep Injection Well" for the City of Sarasota dated September 2012, were prepared by, or reviewed by, a Registered Professional Geologist in the State of Florida.

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8/30/12
Date

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# 1.0 Introduction

## 1.1. Project Background

The City of Sarasota (City) owns and operates a Reverse Osmosis (RO) Water Treatment Plant (WTP), which generates a brine waste stream that is currently discharged to Sarasota Bay via a surface water outfall at Hog Creek. Due to exceedances of surface water discharge standards, the Florida Department of Environmental Protection (FDEP) requested that an alternative disposal option is implemented. The City entered into a Consent Order (CO) and implementation schedule with the FDEP on December 19, 2008 (OGC File No. 08-2097). One of the key components of the CO directed the City to investigate the feasibility of utilizing a deep injection well (DIW) for the disposal of RO brine. If deep injection was feasible, the CO also directed the City to move forward with implementing a deep injection well program.

To comply with the CO and implementation schedule, a Class I injection well was proposed by the City to dispose of brine reject water generated from the RO WTP. The primary purpose of the injection well will be for brine disposal; however, the well will also be designed and permitted for additional capacity in order to serve as a wet weather back-up disposal option for excess reclaimed water from the Waste Water Treatment Facility (WWTF). The primary utilization of the treated reclaimed water is through the reclaimed water supply system. The test deep injection well (DIW) is a tubing and packer design which will accommodate both brine and excess reclaimed water. The tubing and packer consists of an 18-inch diameter fiberglass reinforced pipe (FRP) injection tubing.

The City's Class I DIW system (DIW-1) is located on City owned property north of the RO WTP at 1750 12th Street in Sarasota (**Figure 1-1**). A site aerial is provided as F**igure 1-2.** The DIW-1 was permitted as a Class I test injection well designed to be completed with a final casing depth of 1,100 feet below land surface (bls) and a final open hole interval to 1,700 feet bls. Two monitor wells were also permitted as part of the DIW system and include an upper zone monitor well (UZMW-1) planned for a total depth of 850 feet bls and a lower zone monitor well (LZMW-1) with a planned final depth of 950 feet bls.

Design and permitting of the DIW system was initiated by the City in 2009 with the assistance of Atkins (formerly PBS&J), the Engineer of Record. On February 13, 2011, the FDEP issued the test well construction permit (FDEP Permit No. 0298881-001-UC/1X) to the City. A copy of the FDEP well construction permit is presented in **Appendix A**.

Initially four shallow water table monitoring wells (SMW-1, SMW-2, SMW-3 and SMW-4) were used to monitor the water quality and water levels within the Surficial aquifer during well construction activities. A fifth replacement shallow water table monitor well (SMW-5), was installed during the course of construction. As the drilling rig and containment pad were moved around the site to facilitate drilling of the deeper monitor wells, SMW-(?) was covered by the containment pad, The Southwest Florida Water Management District (SWFWMD) issued well construction permits for the four shallow water table monitor wells (814184) on July 11, 2011, for the lower and upper zone monitor wells (814633) on July 28, 2011, and for the test injection well (814796) on August 4, 2011. Copies of the well construction permits are presented in **Appendix A**.

Technical specifications and contract documents were prepared and released for bid by the City (Bid No. 11-19W) in April 2011 and opened on May 17, 2011. Youngquist Brothers, Inc. (YBI) of Fort Myers, Florida was selected as the lowest responsible bidder for the construction and testing of the test injection well system. Following verification of the bid submittal and execution of the contract documents, a notice-to-proceed was issued by the City to YBI on August 1, 2011. Site preparation work including construction of a site access road began in August 2011. Pilot-hole drilling for the DIW was initiated on August 21, 2011. Atkins provided inspection and construction management services during construction and testing activities of the deep injection well system.

## 1.2. Site Description

The City's DIW system is located at 1330 North Osprey Ave, which is north of the City WWTF in Sarasota County, Florida (see **Figure 1-1**). Topography at the site is low and flat, with elevations averaging approximately 13 feet above National Geodetic Vertical Datum (NGVD). The DIW test site is bordered on the north by an empty lot, on the west by Osprey Ave and the City of Sarasota Recycling Center and to the east and south by the City vehicle storage yard.

The DIW test site is located in the northwest corner of the City vehicle storage yard in an open area at the approximate latitude of 27° 21′ 00.90″ North and longitude 82° 32′ 03.49″ West. The lower zone monitor well is located approximately 37 feet southeast of the injection well. The upper monitor well was constructed approximately 35 feet northeast of the injection well. **Figures 1-1** and **1-2** depict the site location and the site layout. The shallow water table monitor wells SMW-1, SMW-2, SMW-3, SMW-4 and SMW-5 are located around the steel drill rig containment pad.

## 1.3. Purpose and Scope

The purpose of this report is to present a description of the well construction activities and the hydrogeologic testing program completed during the construction of DIW-1. A summary of the findings and appropriate recommendations are presented at the end of this report. The report is prepared in compliance with FDEP requirements contained in Chapter 62-528 of the Florida Administrative Code (F.A.C.) and the FDEP well construction permit.

Well construction information provided in this report includes a description of drilling procedures, the type and quantity of materials used to complete the injection well system, and the chronology of major construction and testing events. A chronology of critical decisions made requiring Technical Advisory Committee (TAC) concurrence is also provided. Unless otherwise specified, all depths given in this report refer to feet below land surface (bls).

Hydrogeologic testing data presented in this report includes the results of formation sampling, drilling and packer test water quality analyses, rock core descriptions and analyses, geophysical logging, packer hydraulic tests and mechanical integrity testing (MIT). The report also includes a description of the data and methods used in the identification of the base of the Underground Source of Drinking Water (USDW), water quality at the project location and an analysis of the hydraulic characteristics of confining units overlying the proposed injection zone.

### 1.4. Acknowledgements

The successful completion of the City of Sarasota RO WTP injection well project was the result of close cooperation by numerous agencies and individuals. The FDEP Technical Advisory Committee provided valuable agency support and technical assistance throughout the project. Key TAC individuals include:

Mr. Bill Kelsey, P.G., FDEP/Tampa
Ms. Rommy Lahera, FDEP/Tampa
Mr. James Alexander, P.G., FDEP/Tallahassee
Mr. Joe Haberfeld, P.G., FDEP/Tallahassee
Mr. David Arnold, P.G., SWFWMD/Brooksville

City of Sarasota personnel were also helpful in providing guidance and logistical support towards the successful completion of the project. Key City individuals include:

Mr. Peter Perez
Mr. Roger Maikranz
Mr. Gerald Boyce

# 2.0 Well Construction

This section describes the construction and testing history of the shallow pad monitoring wells, SMW-1 through SMW-5, the deep injection well, the LZMW-1, and the UZMW-1 at the City's RO WTP site. For each of these wells, an in-depth description is provided for the well drilling methodology used, casing installation and cementing procedures and the quantity of materials used in the wells. Specifically in the case of the DIW-1, a description of the tubing and packer assembly system and its installation is presented in detail. Hydrogeological data collected during the construction of DIW-1, LZMW-1 and UZMW-1 are presented and discussed in **Section 3.0** of this report.

Shallow monitor wells SMW-1 through SMW-5 were constructed prior to the initiation of construction activities of the injection well and monitor wells. During well construction activities, TAC members were provided weekly summary reports. The weekly TAC construction summary reports, daily construction activity logs and well completion reports generated during the course of this project are included in **Appendices B, C** and **D,** respectively.

## 2.1. Drilling Operation Methodology

The five shallow pad monitor wells for the injection well system were drilled with a truck-mounted mud rotary drilling rig **(Figure 2-1)**. The shallow monitor wells were installed with a 10-foot screened interval to depths of 17 to 20 feet bls. The wells were completed with a concrete pad and three protective bollards **(Figure 2-2).**

An electric top-head drive rotary drilling rig was utilized in the construction of the test injection well (DIW-1) and two monitor wells (LZMW-1 and UZMW-1) as shown in **Figure 2-3**. The drill rods utilized were steel, approximately 45 feet in length and 6.8–inch inside diameter. Additional drilling rods onsite, necessary for other drilling operations, such as coring and packer testing, were approximately 30 feet in length. Various drill bit sizes were used during well construction for the injection well and two monitor wells ranging in diameter from 9.8 inches to 58 inches (**Figures 2-4** and **2-5).**

The drilling operations for the deep injection well and two monitor wells consisted initially of mud rotary drilling techniques until an approximate depth of 300 feet followed by reverse-air drilling methods. The mud drilling technique was primarily used to drill through sand and unconsolidated or poorly consolidated deposits that generally are unstable and produce little water. These deposits have a tendency to collapse into the borehole. The drilling mud stabilizes the hole and removes the drill cuttings during drilling operations. Reverse-air drilling techniques are used primarily to drill in competent, generally water-bearing, rock. Water produced by the formation serves as the drilling fluid. Reverse-air drilling techniques allow for the collection of formation water samples during drilling operations.

Both drilling techniques were utilized at the site under a closed circulation system (no discharge). The water in the aquifers encountered during drilling of the deep injection well and two monitor wells is brackish to saline water and would contaminate the water table aquifer at the site if discharged to land surface. In addition, the FDEP construction permit 0298881-001-UC/1X states that disposal of drilling fluids and formation water must be in a sound environmental manner that avoids violation of surface and ground water quality standards.

### 2.1.1. Mud Drilling Method

The mud drilling operations at the site used bentonite drilling mud with approved additives as the drilling fluid. The drilling mud was mixed in an approximately 12,000 gallon mud slurry tank that was connected to a 90,000 gallon steel tank which was located on a temporary secondary steel pad constructed directly south of the drill rig area. This fluid was pumped through an 8-inch inside diameter (I.D.) PVC mud line to the drill rig and ultimately down the drill rods, exiting out the drilling bit. The viscous drilling fluid suspends the cuttings and circulates back up the borehole to land surface where the drilling fluid was routed through a 10-inch I.D. PVC return line back to the mud tank onto vibrating screens, known as shale shakers, suspended over the mud tank (**Figures 2-6** and **2-7)**. The screen generally separates the cuttings from the drilling fluid and directs the cuttings to the 90,000 gallon steel storage tank and the mud to the 12,000 gallon slurry tank. The drilling fluids were collected in the mud tank and re-circulated back down the drill rod. Cuttings were removed from the storage tank with a track hoe and disposed of along with excess drilling fluids at the FDEP approved Dejonge borrow pit disposal site located at 305 S. Jackson Road in Venice, Florida.

### 2.1.2. Reverse-Air Drilling Method

The reverse-air drilling method utilizes water as the drilling fluid. Small diameter steel tubing is suspended down inside the 6.8-inch I.D. drill rod assembly and connected to a high capacity electric-powered air compressor. The bottom of the 2⅜-inch outside diameter (O.D.) steel airline was generally set to a depth between 200 and 400 feet bls. Compressed air is piped down the tubing that aerates the water inside the drill pipe above the end of the tubing. This aeration causes a pressure differential, which in turn causes upward flow of the water inside the drill pipe. The drill rod in effect becomes an airlift pump. Water and cuttings at the bottom of the borehole and at the drill bit face are drawn into the drilling bit and conveyed up the drill rod to the surface. The water and cuttings from the drill rod are then routed to the storage tank system and the cuttings settle out of suspension. The water flows into the storage tank where it is pumped back into the well through a port on the wellhead.

For the duration of the construction of the injection well, the well and drilling rig were located within a steel containment pad with approximately five-foot walls to contain potential spills. As a primary flow control devise on the well, a backflow preventor was installed at the top of the wellhead. In addition, the supplies required to create a hyper saline solution, called a "salt kill" were also stored on-site in the event that water levels needed to be suppressed.

## 2.2. Pad Monitor Well Construction

On August 9, 2011 prior to the start of any drilling activities, monitor wells SMW-1 through SMW-4 were installed around the perimeter of the temporary drilling pad. The shallow wells were used to monitor the water quality of the Surficial Aquifer during drilling operations of the deep injection well. A fifth monitor well (SMW-2B) that replaced SMW-2, was installed in closer proximity to the LZMW-1 on November 4, 2011 in order to more effectively monitor groundwater quality on the northeast side of the drilling operations. Weekly water quality samples collected from the shallow monitor wells were analyzed for dissolved oxygen, pH, specific conductance, temperature and turbidity in the field by a laboratory representative and the chloride levels were determined in the laboratory. The sampling results are discussed in **Section 3** of the report.

YBI installed the shallow monitor wells using a small truck-mounted drilling rig. All of the monitor wells were installed by mud-rotary drilling techniques using nominal 7 ⅞-inch diameter bit. The wells were drilled to a total depth ranging from approximately 17 to 20 feet; after which, 10 feet of a 2-inch O.D. diameter Schedule 40 PVC casing with a 10-foot PVC screen (0.01-inch slot size) were installed to the total depth. The annulus was backfilled with 20/30 graded silica sand to a depth of approximately two feet above the top of the screen and then was topped with approximately one foot of bentonite pellets. The remainder of the annulus was filled with Type II neat cement grout to land surface, shown in as-built diagram (**Figure 2-8**). Each completed well was developed in preparation for water quality sampling prior to and during injection well construction activities and equipped with a PVC cap. Well completion reports for the pad monitor wells are contained in **Appendix D**.

## 2.3. Test Injection Well Construction

Construction and subsequent testing of DIW-1 commenced on August 21, 2011 and was completed on June 1 2012. A chronology of the significant injection well construction and testing activities is presented in **Table 2-1**.

The pilot hole for the well was drilled to a total depth of approximately 1,762 feet. Hydrogeologic testing and data collected during the construction indicated that the proposed injection zone was located between approximately 1,200 and 1,762 feet. Casing diameters of the well varied and included the following: a 52-inch diameter surface casing (**Figure 2-9**), a 40-inch intermediate casing (**Figure 2-10**) a 28-inch final casing (**Figures 2-11**), and an 18-inch FRP tubing (**Figure 2-12**). A mill certificate is a steel industry document that is used to certify the manufacturing standards of the steel casing produced by the mill. Copies of the mill certificates for all the casings used in the construction of the DIW are presented in **Appendix E**.

### 2.3.1. Drilling and Casing Installation

#### 2.3.1.1. Surface Casing (52-Inch)

A 12.25-inch diameter mud-rotary drilled borehole was advanced to an approximate depth of 300 feet on August 22, 2011. The pilot hole was then reamed with a 58-inch diameter reamer bit to a depth of 314 feet on August 30, 2011, in preparation for installation of the 52-inch surface casing. Drift indicator surveys are conducted in order to verify the alignment of the well throughout construction. The deviation surveys were collected in the pilot hole and in the reamed borehole of the injection well at 90-foot intervals. **Table 2-2** presents a summary of the borehole deviation surveys conducted on both the pilot and reamed diameters. The maximum allowable borehole deviation is one degree and a maximum allowable difference between any two successive survey points is 0.5 degrees. All of the deviation surveys were within the allowable limits of less than 1-degree deviation over the tested interval.

The surface casing of DIW-1 consisted of nominal 39 to 50-foot sections of 0.375-inch wall, 52-inch diameter steel casings that were butt-welded together as the casing was installed (**Figures 2-13** and **2-14**). Steel centralizers at 90-degrees orientation were placed 38 feet from the bottom of the casing and approximately every 78 feet thereafter. The casing was installed to a total depth of approximately 310 feet on August 30, 2011 without encountering any obstructions.

The contractor cemented the 52-inch surface casing with one pressure grout stage completed on August 31, 2011. The pressure grout stage consisted of pumping 120 barrels of Portland Type II neat cement with 6% bentonite additive followed by 100 barrels of Portland Type II neat cement, which resulted in a visible cement return at land surface. A total volume of 220 barrels of cement were pumped, which was slightly less than the theoretical cement volume of 279 barrels estimated for the annulus of the surface casing. Cement quantities from all of the grouting stages during construction of DIW-1 are presented in **Table 2-3**.

#### 2.3.1.2. Intermediate Casing (40-Inch)

The cemented 52-inch diameter surface casing was allowed to cure for a period of two days prior to resuming drilling activities on September 2, 2011 due to preparations required to switch the rig drilling techniques from mud rotary to reverse-air drilling. A 12.25-inch diameter pilot hole was advanced to approximately 1,232 feet using reverse-air drilling techniques and subsequently completed on September 11, 2011. Drilling was stopped at 1,232 feet based upon the detection of the base of the USDW. Lithology, groundwater quality data, geophysical evaluations and recommendations for an intermediate casing depth of 1,120 feet were submitted and approved by the TAC on September 22, 2011. Detailed discussion of the determination of the base of the USDW is presented in **Section 3** of this report.

YBI proceeded to ream the 12.25-inch diameter pilot hole to a nominal diameter of 48.5-inches and to an approximate depth of 1,123 feet bls. The reamed borehole was completed on September 26, 2011 in preparation for the installation of the 40-inch diameter intermediate casing. A geophysical logging suite consisting of gamma ray and caliper logs was completed on September 27, 2011, in order to verify borehole dimensions and estimate cement quantities.

The intermediate casing of DIW-1 consisted of nominal 50-foot sections of 0.375-inch wall, 40-inch diameter steel casing that were butt-welded together as the casing was installed. Centralizers at 90-degrees orientation were placed at 5, 20, 40 and 100 feet from the bottom of the casing and approximately every 80 feet thereafter. The intermediate casing was installed on September 27 and 28, 2011 to a depth of 1,120 feet without encountering any obstructions.

Cementing of the intermediate casing was completed in six cementing stages (**Table 2-3**) consisting first of a pressure grout stage and then five tremie grout stages from September 28, 2011 through October 1, 2011 (**Figures 2-15** and **2-16**). The pressure grout stage consisted of pumping 325 barrels of Portland Type II neat cement in the annular space of the intermediate casing. The shut-in pressure at the header of the casing following the pressure grout stage reached eight pounds per square inch (psi). After a 10-hour waiting period, the cement was tagged in the annulus at a depth of 790 feet bls. A temperature log confirmed the cement depth of 810 feet. Stage two consisted of pumping 239 barrels of neat cement with 6% bentonite gel additive via the tremie pipe method. The cement was tagged at a depth of 651 feet bls in the annulus. A temperature log indicated the cement at a depth of 654 feet bls.

The third stage consisted of pumping 258 barrels of neat cement with 6% bentonite gel additive. The temperature log completed after stage 3 indicated a cement top of 580 feet and the physical tag demonstrated the top of cement at 590 feet. The fourth stage consisted of pumping 204 barrels of neat cement with 6% bentonite additive via the tremie method into the annular space of the 40-inch diameter intermediate casing. The temperature log conducted after approximately eight hours had elapsed indicated a cement top of 447 feet, with the physical tag encountering the cement top at 451 feet bls. On September 30, 2011, the fifth and final stage of grouting the intermediate casing was conducted utilizing 227 barrels of neat cement with 6% bentonite additive, resulting in a cement top tag of 215 feet bls confirmed by the temperature log indicating a cement top at 210 feet bls. The final stage of cement, stage 6 was installed on October 1, 2011, consisting of 217 barrels of neat Portland Type II cement, delivered via tremie pipe, and resulting in a full cement return at land surface.

The total volume of cement pumped was 1,470 barrels, which was greater than the theoretical cement volume of 1,060 barrels estimated for the annulus of the intermediate casing, potentially due to some degree of wash-out in the borehole and varying permeability.

#### 2.3.1.3. Final Casing (28-inch)

Following an approximate 24-hour cure period for the cement pumped during the final stage of the 40-inch diameter intermediate casing installation, reverse-air drilling of a 12.25-inch diameter pilot hole commenced on October 1, 2011 and was completed on October 7. During drilling of the pilot hole to an approximate depth of 1,762 feet, collection of four rock cores (**Figures 2-17** through **2-20**), ground water quality data c, geophysical logging and hydraulic packer testing were completed. Based upon a review of the geologic and hydrogeologic data, a semi-confining unit exists between the base of the USDW located at approximately 1,120 feet bls and the purposed casing setting depth of 1,197 feet. Packer testing and core testing results are presented in **Section 3.**

The FDEP issued approval of the final casing setting depth of 1,197 feet on October 26, 2011. Following approval of the casing setting depth, YBI continued preparations for casing delivery and installation.

In preparation for the installation of the 28-inch diameter final casing, reaming of the pilot hole to a nominal diameter of 38 inches was initiated on October 12, 2011. The borehole was reamed to a diameter of 38 inches to a depth of 1,197 feet. The reaming bit was changed to a 24-inch diameter bit at 1,197 feet, after which reaming continued with the 24-inch bit to a total depth 1,762 feet which was completed on October 22, 2011. A geophysical logging suite consisting of gamma ray and caliper logs was completed on December 21, 2011 to verify borehole dimensions and estimate cement quantities.

The final casing of the DIW-1 consisted of 40 joints of 28-inch diameter, 0.5-inch steel pipe, ranging in length from 26 to 38 feet, with an average length of 29 feet and one additional joint, a 5 foot section of 30- inch, 0.5-inch wall steel casing was installed below the final FRP tubing in the first string of the steel casing which was installed near the bottom of the casing string in order to make up for a shortage of 28-inch casing. Prior to installation, a casing modification request was submitted to and approved by FDEP for the alteration to the casing configuration. The final casing has a wall thickness of 0.5-inches and an outside diameter of 28-inches (inside diameter of 27-inches), exception was the 5-foot, 30-inch OD, 29-inch ID section. The final steel casing was butt-welded together as the casing was installed. The bottom of the 28-inch casing was fitted with three rubber packer assemblies to prevent cement from entering the 24-inch open borehole interval (1,197 to 1,762 feet) during the remaining grouting operations (**Figure 2-21**).

Centralizers at 90 degree orientations were placed at 5, 20, 40 and 100 feet from the bottom of the final casing and every 60 feet thereafter. The final casing was installed to an approximate depth of 1,197 feet without encountering any obstructions. Youngquist Brothers, Inc. (YBI) conducted a pressure test on the installed casing to confirm casing integrity.

The polished bore receptacle (PBR) of the YBI packer was installed as part of the 28-inch final casing (**Figure 2-22)** and was located seventeen feet above the bottom and inside the 28-inch final casing. The packer is designed to seal the annulus between the final casing and the injection tubing. The YBI packer consists of two thick tapered sections of machined steel pipe that join together to form the annular seal. The female end of the YBI packer, also referred to as the PBR, was welded near the end of the final casing. The male end of the YBI packer, also referred to as the stinger assembly, was installed on the 18-inch injection tubing string as shown in **Figure 2-23**.

The final casing was grouted in 7 stages consisting of two small tremie shots and 5 larger volume tremie grout stages (**Table 2-3**). Stages A and B consisted of a total of 2 barrels of neat cement that were pumped into the bottom of the casing annulus and tagged at a depth of 1,185 feet. Stage 1 consisted of 47 barrels pumped into the annulus using a tremie pipe. The cement was tagged by tremie pipe at a depth of 1,107 feet after approximately 18 hours. Temperature logs were run after each large grouting stage (stages 1-5) to confirm cement coverage. Temperature logs are described in **Section 3**. Stage 2 consisted of 220 barrels of neat cement. After approximately 8 hours the cement was tagged at a depth of 818 feet. Stage 3 consisted of 232 barrels of neat cement that was tagged at a depth of 511 feet after 13 hours. Stage 4 consisted of 186 barrels of neat cement and resulted in a cement top of 255 feet. Following stage 4, a cement bond log (CBL) was conducted which indicated that the cement had bonded properly around the final casing from 255 to 1,197 feet. The remaining 255 feet of final casing was tremie grouted (stage 5) with 193 barrels neat cement. Cement returns at land surface were observed during stage 5 on January 27, 2012. The total volume of cement pumped was 880 barrels, which exceeded the theoretical cement volume of 824 barrels estimated for the annulus of the final casing. The caliper log indicated an increase in fractures and voids from approximately 1,120 to 1,200 feet bls, which may have contributed to the excess cement volumes.

A casing pressure test was conducted on the final casing on February 2, 2012 in accordance with permit regulations. A single inflatable packer assembly was installed to a depth of 1,170 feet bls isolating the casing from the open monitor interval. The casing was then pressurized to 160 psi and monitored for changes in the system. Over the 60 minute test there was a 0.5 decrease in pressure from 160 psi to 159.5 psi. This signifies a 0.31% deviation which is within the 5% tolerance as mandated by FDEP. The results from the pressure test on DIW-1 are presented in **Table 2-4**.

#### 2.3.1.4. DIW-1 Injection Tubing (18-Inch)

After completing the cementing of the 28-inch steel casing, YBI began the installation of the 16.6-inch inside diameter (18-inch outside diameter) fiberglass reinforced pipe (FRP) into the well. The stinger assembly of the YBI packer was threaded to the end of the injection tubing (**Figure 2-23**), which was lowered to a depth of 1,180 feet. The FRP injection tubing string consisted of 41 sections of FRP pipe each with an average length of 30 feet attached to a top piece (4-foot above ground section) of 18-inch stainless steel pipe. As part of the installation procedure of the tubing string, male and female threaded ends of tubing joints were joined together using threaded couplings at land surface. A thread sealing compound, composed of rubber based adhesive, was added to all threads to ensure the integrity of each tubing connection. Each connection was initiated by hand-tightening until at least 50% of the thread had been secured and then a power tong was used to complete the threaded connection. Joints were tightened to an average of 195 psi. Specifications for the FRP tubing are included in **Appendix E**.

The final joint of injection tubing was lowered into the well until the stinger assembly was just above the PBR. Then YBI utilized a video camera inside the injection tubing to confirm that the PBR was ready to receive the stinger assembly. After seating the tubing and stinger assembly, approximately 19,000 gallons of a 1.0 percent mix of Baracor 100 corrosion inhibitor and fresh water was pumped down the annular space between the 28-inch final casing and the 18-inch injection tubing. This quantity displaced native fluids and completely filled the annular space with the corrosion inhibitor fluid. The YBI packer assembly was fully seated on February 4, 2012 with approximately 6,000 pounds of compressive weight as part of securing the tubing to the packer assembly. A schematic of the YBI packer assembly is shown in **Figure 2-24**.

### 2.3.2. Injection Zone Development

The injection zone was developed for approximately eight hours at a pumping rate of 150 gpm. A total of approximately 65,000 gallons of groundwater was discharged to the onsite storage tank during development which equated to approximately three casing volumes prior to sample collection. The discharge water was clear and free of any sediment or particulate matter.

At the end of development, field water quality measurements indicated specific conductivity had stabilized at approximately 52,000 µmhos/cm, which was representative of native background conditions. On February 10, 2012, personnel from Benchmark Laboratories, Inc. were onsite to collect the background water sample at the end of well development. A discussion of sample results is presented in **Section 3.** An as-built drawing of the DIW-1 in addition to the geologic formations is depicted in **Figure 2-25**. The completed DIW-1 wellhead is shown in **Figure 2-26**.

A pressure test was conducted on the annular space between the 28-inch final casing and the 18-inch tubing on February 8, 2012 in accordance with permit regulations. After seating the tubing in the PBR and filling the annular space with the mixture of Baracor (1%) and fresh water as a corrosion inhibitor, the annulus was closed in and pressurized to 153 psi and monitored for changes. During the 60 minute test there was a 1 psi decrease in pressure from 153 psi to 152 psi. This represented a 0.65% change, which is within the 5% tolerance as mandated by FDEP. The results from the annular pressure test on DIW-1 are presented in **Table 2-5**.

## 2.4. Lower Zone Monitor Well Construction

The LZMW-1 was the second well completed at the site. Construction began on October 27, 2011. Casing sizes of the well included a 16-inch intermediate casing installed to a depth of 304 feet and a 6-inch final casing completed to a depth of 1,115 feet. The open interval monitor zone extends from the bottom of the final casing at a depth of 1,115 to 1,141 feet. Copies of the mill certificates for all the casings used in the construction of the LZMW-1 are presented in **Appendix E**. A chronology of the significant LZMW-1 construction and testing activities are summarized in **Table 2-6**.

### 2.4.1. Drilling and Casing Installation

#### 2.4.1.1. LZMW-1 Intermediate Casing (16-Inch)

Beginning on October 27, 2011, a 12.25-inch diameter pilot hole was advanced to an approximate depth of 312 feet using mud-rotary drilling methods. Formation samples were collected every 10 feet during the drilling of the pilot hole. Based on lithologic data collected from the pilot hole, relatively competent rock was found to occur approximately between 285 and 300 feet. Geophysical evaluations conducted in the LZMW-1 pilot hole also confirmed that competent rock occurred at 300 feet, which was selected as the casing setting depth. A complete discussion of all geophysical surveys completed on the LZMW-1 is presented in **Section 3.6.2**.

The 12.25-inch pilot hole was reamed to a nominal 24 inches in diameter to a depth of approximately 304 feet using mud-rotary drilling methods. The borehole was prepared for casing installation by circulating with mud until mud returns were free from cuttings. Several "wiper trips" were made by rotating the bit in and out of the borehole, prior to the installation of the 16-inch intermediate casing.

Borehole deviation surveys, using a "sure-shot tool," were collected in both the pilot-hole and reamed hole at 90-foot intervals throughout the entire length of the well. A summary of the deviation surveys collected on the pilot hole and reamed hole are presented in **Table 2-7**. All of the deviation surveys were within the allowable deviation of one degree over the tested interval of 90 feet.

The intermediate casing of the LZMW-1 consisted of seven, nominal 42-foot sections of 0.375-inch wall, 16-inch diameter steel casing, which were butt-welded together as they were installed into the reamed borehole on November 2, 2011. Steel strap centralizers were placed at 5, 20 and 40 feet from the bottom of the casing and every 100 feet thereafter. The casing was installed to a total depth of 300 feet without encountering any obstructions.

YBI cemented the 16-inch intermediate casing with one pressure grout stage consisting of pumping 110 barrels of neat cement. Cement returns visible at land surface at the end of the stage.

The cemented 16-inch casing was allowed to cure for a period of approximately 18 hours prior to resuming drilling activities. The total volume of cement pumped was 110 barrels, which was comparable to the theoretical cement volume of 93 barrels estimated based upon the caliper geophysical log for the annulus of the intermediate casing. Cementing information from all of the grouting stages during construction of the LZMW-1 is presented in **Table 2-8**.

#### 2.4.1.2. LZMW-1 Final Casing (6-Inch)

From November 4 through November 8, 2011 the pilot hole was drilled with a 12.25 inch diameter tricone bit under reverse-air drilling methodology to an anticipated casing depth of 1,114 feet bls. The drilling bit was then changed out for a 9⅞ tricone bit to finish drilling the open borehole section of the well. Upon completing the pilot hole to a total depth of 1,141 feet bls, a full suite of static and dynamic geophysical logs were conducted, which included X-Y caliper and gamma ray, temperature, fluid conductivity, flow meter, BHC sonic VDL, dual induction and a televiewer. These geophysical logs were conducted on the completed borehole to verify casing setting depth as well as geologic confirmation of the open monitor interval.

Following completion of the geophysical logging, a single inflatable packer assembly was installed just above the casing seating depth, isolating the monitoring interval below from the open borehole above. A packer test was conducted across the interval 1,114 feet to 1,141 feet bls, at a pumping rate of 43 gpm with a maximum drawdown of 136 feet, resulting in a specific capacity of the isolated zone of 0.32 gpm/ft. The water quality showed a specific conductivity of 26,400 µS/cm after four hours of pumping. The test is discussed in greater detail and the hydraulic data are presented in **Section 3**.

At the conclusion of the packer test on November 9, 2011, YBI reamed the open bore hole from 300 to 1,114 feet bls with a 14.75-inch reamer bit in preparation for installation of the final 6-inch casing. The reaming activities were completed on November 11, 2011 and followed by a geophysical logging run, consisting of XY-caliper and gamma ray to confirm the reamed borehole depth and diameter as well as estimate annular grout quantities necessary for the installation of the final casing.

The final casing of the LZMW-1 consisted of thirty-eight nominal 29-foot sections of 6.7-inch O.D. FRP casing and a 10-foot section of stainless steel riser casing, which were joined together by threaded couplings that were taped and sealed. Centralizers at 90-degree orientation were placed at 5, 20 and 40 feet from the bottom of the casing and every 100 feet thereafter. The bottom of the casing was seated at a depth of approximately 1,115 feet. After the casing was lowered into place on November 15, 2011, four small grout shots, two one barrel, a two barrel and a five barrel stage, totaling 9 barrels of neat cement and 4 cubic feet of gravel, were pumped into the annulus to assure that the rubber packers utilized for seating the casing and isolating the monitor interval from the annular space were secure. A hard tag of the cement inside the annulus following the fourth stage was at approximately 1,075 feet. The remaining portion of the final casing (from approximately 1,075 feet to land surface) was tremie grouted in five cement stages utilizing a total of 388 barrels of neat cement. Theoretical volume to fill the annular space was 201.2 barrels. A CBL was conducted prior to initiating stage 5 which brought the cement top to land surface. Details of the five cement stages are shown in **Table 2-8**.

#### 2.4.1.3. Monitoring Zone Development

Development of the open borehole interval (approximately 1,115 to 1,141 feet below land surface) of the LZMW-1 was initiated following the disinfection of the open interval. Approximately 3,500 gallons of chlorine hydroxide, with an approximate concentration of 225 ppm, was pumped down to the monitor interval and allowed to remain in the well for approximately 12 hours and was subsequently developed out of the well. The discharge water was monitored for residual chlorine, without any detection. The open interval was developed at an average rate of approximately 35 gpm (total of approximately 12,000 gallons of ground water discharged). The discharge water at the end of well development appeared to be clear and free of any sediment or particulate matter. At the end of development, the specific conductivity of the discharge water was 27,800 µS/cm and the temperature was 29.8 degrees Celsius. The well was considered stabilized and development complete after a minimum of three well volumes were discharged. Personnel from Benchmark Laboratories, Inc. collected the background water sample at the end of well development on November 21, 2011. Laboratory results from the background sample are presented in **Section 3**.

A casing pressure test was conducted on the final casing on December 22, 2011 in accordance with permit regulations. A single inflatable packer assembly was installed to a depth of 1,105 feet bls isolating the casing from the open monitor interval. The casing was then pressurized to 61 psi and monitored for changes in the system. Over the 60 minute test there was a 2.5 increase in pressure, from 61 psi to 63.5 psi. This is within the 5% tolerance as mandated by FDEP. The results from the pressure test on LZMW-1 are presented in **Table 2-9**.

After development of the monitoring zone, the wellhead was completed (**Figure 2-27**). **Figure 2-28** depicts an as-built drawing of the LZMW-1 in addition to the various geologic formations that were encountered during the drilling of the well.

## 2.5. Upper Zone Monitor Well Construction

The UZMW-1 was the third well completed at the site. Construction began on November 27, 2011. Casing sizes of the well included a 16-inch intermediate steel casing installed to a depth of 300 feet bls and a 6-inch final FRP casing set at 1,040 feet. The open interval monitor zone was extended to a total well depth of 1,075 feet. A chronology of significant construction activities is shown in **Table 2-10.** Copies of the mill certificates for all the casings used in the construction of the UZMW-1 are presented in **Appendix E**.

### 2.5.1. Drilling and Casing Installation

#### 2.5.1.1. UZMW-1 Intermediate Casing (16-Inch)

Beginning on November 27, 2011, the 12.25- inch diameter pilot hole was advanced to an approximate depth of 310 feet using mud-rotary drilling methods. Formation samples were collected every 10 feet during the drilling of the pilot hole. The pilot hole was advanced to a depth of 310 feet on November 29, 2011. Based on lithologic data collected from the pilot hole, relatively competent rock was found to occur approximately between 290 and 300 feet. Geophysical evaluations conducted in the UZMW-1 pilot hole confirmed that competent rock occurred at 300 feet, which was selected as the casing setting depth. A complete discussion of all geophysical surveys completed on the UZMW-1 is presented in **Section 3.6.2**.

The nominal 12.25-inch diameter pilot hole was reamed to a nominal 24 inches in diameter to a depth of approximately 300 feet using mud-rotary drilling methods. The borehole was prepared for casing installation by circulating with mud until mud returns were free from cuttings. Several "wiper trips" were made by rotating the bit in and out of the borehole, prior to the installation of the 16-inch intermediate casing.

Borehole deviation surveys, using a "sure-shot tool," were collected in both the pilot hole and reamed hole at 90-foot intervals throughout the entire length of the well. A summary of the deviation surveys collected on the pilot hole and reamed hole are presented in **Table 2-11**. All of the deviation surveys were well within the allowable deviation of one degree over the tested interval of 90 feet.

The intermediate casing of the UZMW-1 consisted of seven, nominal 42-foot sections of 0.375-inch wall, 16-inch diameter steel casing, which were butt-welded together as they were installed into the reamed borehole on December 1, 2011. Steel strap centralizers were placed at 5, 20 and 40 feet from the bottom of the casing and every 100 feet thereafter. The casing was installed to a total depth of 300 feet without encountering any obstructions.

YBI cemented the 16-inch intermediate casing with one pressure grout stage consisting of pumping 118 barrels of neat cement. Cement returns were noted at land surface by Atkins personnel.

The cemented 16-inch casing was allowed to cure for a period of approximately 18 hours prior to resuming drilling activities. The total volume of cement pumped was 118 barrels, which was comparable to the theoretical cement volume of 93.4 barrels estimated for the annulus of the intermediate casing. Cementing information from all of the grouting stages during construction of the UZMW-1 is presented in **Table 2-12**.

#### 2.5.1.2. UZMW-1 Final Casing (6-Inch)

After the drilling rig was switched over to reverse air drilling methodology the 12.25-inch pilot hole was advanced to a total depth of 1,040 feet bls, the bit was changed out to a 9⅞-inch bit and continued drilling to a total depth of 1,075 feet bls. A full suite of both static and dynamic geophysical log were conducted in the completed borehole, including XY-caliper, gamma ray, dual induction, BHC sonic VDL, temperature and fluid conductivity. Following the completion of the geophysical logs, an off-bottom packer test was conducted to confirm the water quality over the interval from 1,040 feet to 1,075 feet bls. Laboratory water quality data indicated the total dissolved solids concentration was 4,700 mg/L. At the conclusion of the packer test on December 7, 2011, YBI reamed the open bore hole from 300 to 1,040 feet bls with a 14.75-inch reamer bit in preparation for installation of the final 6-inch casing. The reaming activities were completed on December 8, 2011 and were followed by a geophysical logging run, that consisted of XY-caliper and gamma ray to confirm the reamed borehole depth and diameter as well as estimate annular grout quantities necessary for the installation of the final casing.

The final casing of the UZMW-1 consisted of thirty-six nominal 29-foot sections of 6-inch O.D. FRP casing and a 10-foot stainless steel riser, which were joined together by threaded couplings that were taped and sealed. Centralizers at 90-degree orientation were placed at 5, 20 and 40 feet from the bottom of the casing and every 100 feet thereafter. The bottom of the casing was seated at a depth of approximately 1,040 feet on December 12, 2011. Two initial small cement shots, totaling 2 barrels of neat cement, were pumped in the annulus to seat the casing. A hard tag of the cement inside the annulus following the second stage was at approximately 1,033 feet. The remaining portion of the final casing (from approximately 1,033 feet to land surface) was tremie grouted in 5 cement stages utilizing a total of 270 barrel cement. The theoretical volume to fill the annular space was 207 bbls. The first large cement stage consisted of 5 barrels of neat cement resulting in the cement top indicated on a temperature log at approximately 1,013 feet. A physical tag with a tremie pipe at approximately 1,022 feet confirmed the temperature log. The second stage was comprised of 55 barrels of neat cement. A temperature log indicated a cement top at approximately 813 feet, which was confirmed by a physical tag. The third stage was comprised of 72 barrels of neat cement with a 6% bentonite gel additive. A temperature log indicated a cement top at approximately 618 feet, which was confirmed by a physical tag. The fourth stage was comprised of 71 barrels of neat cement with a 6% bentonite gel additive. A temperature log indicated a cement top at approximately 310 feet, which was confirmed by a physical tag at 304 feet bls. A CBL was conducted prior to initiating stage 5 which brought the cement top to land surface. Stage 5 brought the cement top to land surface utilizing 67 barrels of neat cement. Grout return was witnessed by Atkins personnel. Details of the five cement stages are shown in **Table 2-12**.

#### 2.5.1.3. Monitoring Zone Development

A casing pressure test was conducted on the final casing December 23, 2011 in accordance with permit regulations. A single inflatable packer assembly was installed to a depth of 1,021 feet bls isolating the casing from the open monitor interval. The casing was then pressurized to 59 psi and monitored for changes in the system. Over the 60 minute test there was a 1 psi increase in pressure, from 59 psi to 60 psi. This is well with in the 5% tolerance as mandated by FDEP. The results from the pressure test on UZMW-1 are presented in **Table 2-13.**

Development of the open borehole interval (approximately 1,040 to 1,075 feet below land surface) of the UZMW-1 was initiated following the disinfection of the open interval. Approximately 4,000 gallons of chlorine hydroxide with an approximate concentration of 250 ppm, was pumped down to the monitor interval and allowed to remain in the well for approximately 12 hours and then developed out of the well. Residual chlorine was not detected in the discharge water. The open interval was developed at an average rate of approximately 75 gpm (total of 9,000 gallons of groundwater discharged). The discharge water at the end of well development appeared to be clear and free of any sediment or particulate matter. At the end of development, the specific conductivity of the discharge water was 9,700 µS/cm, and the temperature was 29.4 degrees Celsius. The well was considered stabilized and development complete after the minimum three well volumes were discharged. Personnel from Benchmark Laboratories, Inc. collected the background water sample at the end of well development on January 4, 2012. Laboratory results from the background sample are presented in **Section 3**.

After development of the monitoring zone, the wellhead was completed (**Figure 2-29**). **Figure 2-30** depicts an as-built drawing of the UZMW-1 in addition to the various geologic formations that were encountered during the drilling of the well.

## 2.6. Mechanical Integrity Testing (MIT)

As part of the mechanical integrity testing (MIT) of the wells, casing pressure tests were performed on the 6-inch final casings of LZMW-1 and UZMW-1 and the 28-inch final casing of the DIW-1. Additionally, a pressure test was conducted on the annulus between the 28-inch steel casing and the 18-inch injection tubing. YBI conducted a radioactive tracer survey (RTS) on the injection well to demonstrate the external mechanical integrity of the injection well.

### 2.6.1. Casing Pressure Tests

#### 2.6.1.1. LZMW-1 and UZMW-1

In fulfillment of the permit requirements for the monitoring wells, the 6-inch final casings of LZMW-1 and UZMW-1 were pressure tested as part of the installation procedures. LZMW-1 and UZMW-1 final casings were pressure tested on December 22 and December 23, 2011, respectively. A temporary header assembly was attached to the final stainless steel flange to seal in the top of the wells. The inflatable packer was installed near the bottom of the 6-inch casing in both wells. The packer was inflated to approximately 165 psi to isolate the casing from the open-hole section of each well. The inside of the final casings were pressurized with water to 61 pounds per square inch (psi) for the LZMW-1 and 59 psi for the UZMW-1 and then shut-in for a period of one hour (**Tables 2-9** and **2-13**). After 60 minutes, the pressure changed by 2.5 psi (4.1 percent) at LZMW-1 and 1.0 psi (1.7 percent) at UZMW-1, which were both within the range of the test tolerance limit of +/- 5 percent as established by FDEP guidelines. Both final well casing pressure tests were performed under the observation of Atkins personnel.

#### 2.6.1.2. DIW-1

The 28-inch final casing of DIW-1 was pressure tested as a condition of the construction permit. The pressure test of the 28-inch final casing was conducted on February 1, 2012 with a 17-inch inflatable packer (expandable to 24 inches) set to approximately 1,170 feet. The top of the 28-inch casing was sealed with a temporary header assembly and the test was conducted by pressurizing the inside of the 28-inch casing to 160 psi for 60 minutes (**Table 2-4)**. After 60 minutes, the pressure had decreased to 159.5 psi. The 0.5-psi decrease represents a 0.31% pressure change, which is within the 5% allowable pressure change during the test. Mrs. Rommy Lahera-Aument (FDEP) of the TAC was on-site to witness the successful performance of the casing pressure test. The external mechanical integrity of the injection well was demonstrated.

The annular space between the 28-inch steel casing and the 18-inch FRP tubing was pressure tested on February 7, 2012. The annulus was pressured up using water to 153.0 psi. After 60 minutes, the pressure dropped to 152 psi, a loss of 0.65%, which is well within the 5% range allowable by FDEP. Mrs. Rommy Lahera-Aument (FDEP) witnessed the pressure test and concurred that the test passed. The annular pressure test results are included in **Table 2-5.**

### 2.6.2. Radioactive Tracer Survey (RTS)

#### 2.6.2.1. Introduction

External mechanical integrity (MI) testing consists of conducting a dynamic radioactive tracer survey (RTS). External MI testing typically consists of positioning the logging tool at the bottom of the tubing with the ejector port located approximately five feet inside the final casing. A tracer is then ejected while chase water is being injected into the well at a rate of approximately four feet per minute. The logging tool remains stationary and tracer movement is monitored for a period of one-hour (time log mode). If upward tracer movement is not observed, then the test is deemed successful and a repeat test (30 minute duration) is performed for verification. A detailed description of the logging tool and procedures used during the external RTS are presented in the following sections.

YBI performed the RTS and background geophysical logs, which consisted of a temperature log and a gamma log. Copies of all the geophysical logs for the external MIT are included in **Appendix N**.

#### 2.6.2.2. Background Logs

A background gamma ray (GR) log was conducted on February 23, 2012 to establish baseline conditions of the well prior to conducting the RTS survey. The GR log was run from the bottom of the well to land surface. The gamma counts observed on the log ranged from approximately 5 to 35 API counts which are the units used by the American Petroleum Institute (API).

#### 2.6.2.3. External MI Test Results

The external MI test was conducted on February 23, 2012, with Miguel Martinez of YBI operating the logging unit. The RTS logging tool used is approximately 25.5 feet long and contains multiple logging capabilities including GR, casing collar locator (CCL), temperature and tracer ejector. The general configuration of the RTS tool is presented at the top of the RTS log. The RTS tool contains three gamma ray detectors - gamma ray bottom (GR#1), gamma ray middle (GR#2), and gamma ray top (GR#3). The GR detector is located 1.2 feet from the bottom of the tool, while the GR#2 and the GR#3 are located 10.5 feet and 24.0 feet from the tool bottom, respectively. The tracer ejector port is located 13.5 feet from the bottom, which places the tracer ejector port 12.3 feet above the GR#1, 3 feet above the GR#2 and 10.5 feet below GR#3.

#### 2.6.2.4. First External RTS

For the first external test, the RTS tool was positioned at the bottom of the 27-inch ID casing with the ejector port at 1,192 feet bls (5 feet above the bottom of the 27-inch ID casing). A fresh water line was attached the wellhead with an in-line flow meter. Copies of the flow meter certification and radioactive assay of the tracer are attached. Flow to the well was regulated at 53 gpm (approximately 4 feet down hole velocity). One minute of pre-ejection time logging was conducted after which one millicurie of tracer (Iodine 131) was ejected at 1192 feet bls. Tracer was first observed at GR#2 detector after approximately 25 seconds. Tracer was observed at GR#1 detector approximately 3 minutes and 10 seconds after ejection, which correlates to a down hole velocity of 3.9 feet/min (12.3 feet in 3.16 minutes). Throughout the course of the one hour external MI test, no tracer was observed on the GR#3 detector indicating no upward movement of tracer occurred inside or outside the casing. Readings at the GR#1 and GR#2 detectors returned to near background levels by the end of the test. The first dynamic RTS was considered successful.

The RTS tool was then logged out of position up to approximately 975 feet bls. Gamma counts on all three detectors returned to background levels and a minor amount of staining was apparent at 1,192 feet bls. The well was flushed with fresh water at a rate of 115 gpm, for approximately 120 minutes, for a total of approximately 14,000 gallons.

#### 2.6.2.5. Second External MI Test

The second dynamic test was begun by re-positioning the ejector port again to 1,192 feet bls and regulating the flow to the well at 56 gpm. One minute of pre-ejection time logging was conducted after which one millicurie of tracer was ejected. Tracer was first observed at GR#2 detector after approximately 25 seconds. Tracer was observed at GR#1 detector approximately 2.5 minutes after ejection, which correlates to a down hole velocity of 4.9 feet/min (12.3 feet in 2.5 minutes). No tracer was observed at GR#3 detector throughout the course of the 30-minute verification test and readings at all three detectors returned to near background levels by the end of the test. The second external MI was considered successful.

The RTS tool was then logged out of position up to approximately 975 feet bls and the well was flushed with approximately 14,000 gallons of fresh water. The tool was then lowered to approximately 1,450 feet near the bottom of the open borehole and the remaining tracer was dumped. A final gamma log was run and the GR#1, GR#2 and GR#3 detectors mimicked the background GR log. No evidence of tracer was noted throughout the well except some minor casing staining at the point of ejection at 1,192 feet bls demonstrating the external integrity of the injection well.

# 3.0 Hydrogeologic Data and Analysis

An extensive hydrogeologic data collection program was undertaken during construction of the wells with the objective of obtaining the hydrogeologic information necessary to identify an acceptable injection zone and injection monitoring system in the area of interest. The hydrogeologic data consisted of the following: formation (lithologic) sampling, water quality sampling, hydraulic testing (packer tests), rock coring and geophysical logging. Regional and site-specific data are presented in the sections below.

## 3.1. Regional Hydrogeology

The regional hydrogeologic framework has been described in numerous studies conducted along the west central portion of the Florida coast. **Table 3-1** presents a general summary and description of the geologic and hydrogeologic framework in the vicinity of the site based on data published by the United States Geological Survey (USGS). **Figures 3-1** and **3-2** present a generalized hydrogeologic cross section for the region, including the approximate location of the City of Sarasota RO WTP DIW-1 well site.

The hydrogeologic framework of the area is composed of Tertiary and Quaternary-aged sediments and sedimentary rocks that comprise the Surficial aquifer system, Intermediate aquifer system and the Floridan aquifer system (Knochenmus, 1998). Stratigraphic units found at the site consist of (in descending order), Terrace or Undifferentiated Deposits followed by the Caloosahatchee Marl and Tamiami Formation. Next is the Hawthorn Formation that contains the Tampa Member of the Arcadia Formation, followed by the Suwannee Limestone, Ocala Limestone and the Avon Park Formation.

The Caloosahatchee Marl and Tamiami Formations are considered as confining units separating the Surficial Aquifer System (SAS) from the underlying Intermediate Aquifer System (IAS). The IAS is composed primarily of the geologic units of the Hawthorn Group and is separated from the underlying Upper Floridan Aquifer System (UFAS) by the Tampa Member. The Tampa Member is often the basal confining unit for the IAS, especially in areas south of Manatee County where it is generally thicker. In Sarasota County, three major permeable zones (uppermost zone PZ1, PZ2 and lowermost zone PZ3) separated by clay layers are recognized by the USGS (1996) within the IAS.

Underlying the Hawthorn Group are thick sequences of marine deposited carbonates, which comprise the Suwannee Limestone, the Ocala Limestone, the Avon Park Formation and the Oldsmar and Cedar Keys Formations. These carbonate units comprise the Floridan Aquifer System. The targeted injection zone occurs in the upper permeable zone of the Avon Park Formation.

The Suwannee Limestone is the uppermost permeable unit within the UFA and is confined above by clayey carbonate rocks within the IAS and below by low-permeability limestone in the upper part of the Ocala Limestone (Hutchinson, 1992). The Suwannee Limestone is approximately 310 feet thick (490 feet to 800 feet) at the DIW-1 site. It is a fossiliferous and vuggy, white to tan to grey limestone, which is moderately hard with sections of more friable units and lenses of silty, white clays. Shell casts and fragments are common throughout, whereas, the most represented are echinoderms. Dolomitized limestone occurs in the lower portions of the unit. Water production units are typically found at the top and bottom of the hydrogeologic unit. The transmissivity of the Suwannee Limestone generally ranges from 5,000 to 50,000 $ft^2/d$ with storage coefficients averaging $1.0 \times 10^{-4}$. The Suwannee Limestone is confined on the top by the Hawthorn Group and on the bottom by the Ocala Limestone.

The top of the Ocala Limestone, a semi-confining unit, occurs below a dolomitic limestone marker bed (800 feet at the DIW-1) that is distinguished by high activity on gamma-ray logs. The Ocala unit itself exhibits low gamma radiation and is a fine-grained, soft to partially indurated, micritic limestone containing abundant disk fossil remains and scattered large foraminifera that were identified over a wide area of southwest Florida through drilling and testing at injection-well sites in the 1980's (Hutchinson, 1992). The predominant genus of fossils present in the Ocala Limestone is the Lepidocyclina.

The Avon Park Formation underlies the Ocala Limestone, at approximately 1028 feet bls, and is comprised of fossiliferous limestone and dolostone units, crystalline in nature and highly fractured (dolostone units). Gypsum and anhydrite occur in the lower part of the formation as intergranular filled vugs in the carbonate rock and the top of these beds generally designate the base of the Upper Floridan aquifer. The thickness of the formation ranges from 900 to greater than 1,600 feet (Reese, 2007). The Avon Park Formation contains highly mineralized water (as a result of intrusion and upconing) in the vicinity of the study area. The Avon Park Formation is the major water-bearing zone of the Upper Floridan aquifer.

The Avon Park permeable zone, a subaquifer, is contained within the Avon Park Formation and characteristically consists of units of dolostone and interbedded limestone in its upper part. Transmissivity for the Avon Park permeable zone is generally an order of magnitude higher than transmissivity in the Upper Floridan aquifer and has been determined to range from less than 100,000 to greater than one million $ft^2/day$ (Reese, 2007). This zone generally provides geophysical signatures of high resistivity on the dual induction log and cycle skipping (cyclic high-amplitude velocity measurements) on the sonic log (Hutchinson, 1992).

The hydraulic characteristics of the Avon Park Formation, in addition to the low permeable units situated above and below this unit thus resulting in vertical confinement by impermeable strata, support it as a potential injection zone.

### 3.2. Formation Sampling

Formation (lithologic) samples were obtained during the drilling operations of the three wells (DIW-1, LZMW-1 and UZMW-1). These samples were collected at ten-foot intervals throughout the total depth of each well. The formation samples were collected from the discharge line during mud rotary and reverse-air drilling. YBI provided one set of formation samples to the engineer and stored a second set of samples on-site for the FDEP, which were shipped to the Florida Geological Survey upon well completion.

Formation samples were described on the basis of composition, color, texture, visible porosity, fossil content and structure. Analyses of the formation samples were used to prepare a lithologic log of the wells at the site. A copy of the complete lithology logs for wells DIW-1, LZMW-1 and UZMW-1 are presented in **Appendix F**.

Estimates of geologic formation and aquifer unit contacts were made from the lithologic logs and geophysical logging data (**Section 3.6**) collected from the DIW-1 well pilot hole. The Hawthorn Group unit extends from a depth of 30 feet to 548 feet. During the utilization of the mud rotary drilling techniques during the initial 300 feet of the well pilot hole construction, water quality samples are not collected due to the presence of mud within the samples. The top of the Suwannee Limestone and the bottom of the Upper Floridan aquifer occurs at an approximate depth of 548 feet, with the formation extending to 800 feet. The top of the Ocala Limestone, and subsequent top of the Floridan Aquifer, are estimated to be at approximately 800 feet, with the formation extending to 1,028 feet. The top of the Avon Park Formation was encountered at an approximate depth of 1,0`28 feet and extended to the bottom of the pilot hole at 1,762 feet, where anhydrates, namely calcite and gypsum were encountered in the cuttings. The targeted injection zone from the bottom of the final casing at 1,197 feet to the final depth of 1,762 feet is located entirely within the Avon Park permeable zone. Overall, the hydrogeology encountered at the DIW-1 site is similar to the published regional geologic data and to the geology observed at the Sarasota County Central County WRF deep exploratory well (Atkins, 2011).

### 3.3. Rock Cores

A total of four rock core samples were collected while advancing the DIW-1 pilot hole. Targeted coring depths were determined from the regional geologic information and data collected during the construction of the USGS Deep Test Well, which is located at the City of Sarasota WWTF approximately 750 feet south of the site. The cores were collected using a 20-foot long core barrel with a 4-inch receiver sleeve inside the barrel. The rock cores were collected by advancing the pilot hole to the targeted coring depth and attaching the coring tool to the drilling rod. The core barrel was lowered to the proposed coring depth and was drilled into the rock formation at a constant rotation and penetration rate. After the core barrel was advanced approximately 10 to 12 feet, it was withdrawn from the pilot hole. Rock core samples were extracted from the inner core barrel sleeve and placed directly into wooden core boxes. Core sample boxes were labeled with the core number, core interval, date and time. Four core extractions were conducted between the depths of 1,023 to 1,178 feet bls. The core samples to be analyzed in the laboratory were collected from the following depth intervals: 1,135 to 1,143 feet and 1,163 to 1,178 feet. **Table 3-2** presents a summary of each coring event and the resultant hydraulic data from the laboratory analyses.

Representative sections of the core samples, which had pieces greater than four inches in length, were submitted to the Ardaman and Associates, Inc. Geotechnical Laboratory in Orlando, Florida for analysis of selected physical and hydraulic parameters (**Figures 3-3** and **3-4**) including specific horizontal and vertical permeability, porosity, specific gravity, elastic modulus and compressive strength. According to the laboratory report, the permeability tests were performed in general accordance with ASTM Standard D 5084 using the constant head method. The unconfined compression tests were performed in general accordance with ASTM Standard D 7012 using the unconfined test method. The specific gravity tests were performed in general accordance with ASTM Standard D 854 using 50 to 60 gram specimens.

A total of four rock sections from the DIW-1 were analyzed. Samples were submitted to the geotechnical laboratory from the following coring intervals; 1,135 to 1,143 feet (segment 1: 1,135 feet); 1,163 to 1,178 feet (segment 2: 1,163 feet, segment 3: 1,173 feet, segment 4: 1,177 feet). The coring intervals were located just above and within the proposed injection zone from 1,197 to 1,762 feet. The horizontal and vertical hydraulic conductivity values from the sample collected from an approximate depth of 1,135 feet (segment 1) were determined to be 0.0.0116 and 0.0002 feet/day, respectively, indicating relatively low permeability. The compressive strength and the elastic modulus testing were not tested on segment 1 due to an insufficient quantity of core sample remaining following the hydraulic conductivity test. The porosity values from the sample ranged from 0.86 to 0.88 (dimensionless).

The horizontal and vertical hydraulic conductivity values from the sample collected from an approximate depth of 1,163 feet (segment 2) were determined to be 0.0396 and 0.0235 feet/day, respectively. The compressive strength and the elastic modulus testing were not conducted on Segment 2 due to an insufficient quantity of core sample remaining following the hydraulic conductivity test. The porosity values from the sample ranged from 0.23 to 0.227 (dimensionless).

The horizontal and vertical hydraulic conductivity values from the sample collected from an approximate depth of 1173 feet (Segment 3) were determined to be 0.027 and 0.022 feet/day, respectively. The porosity values from the sample ranged from 0.227 to

0.229 (dimensionless). The compressive strength and the elastic modulus of Segment 3 were determined to be 2,990 lb/in$^2$ and 1.2 x $10^6$ lb/in$^2$ at 50 percent of the ultimate axial stress, respectively.

The horizontal and vertical hydraulic conductivity values from the sample collected from an approximate depth of 1,177 feet (segment 4) were determined to be 0.079 and 0.079 feet/day, respectively. The compressive strength and the elastic modulus of segment 4 were determined to be 3,350 lb/in$^2$ and 1.4 x $10^6$ lb/in$^2$ at 50 percent of the ultimate axial stress, respectively. The porosity values from the sample were determined to be 0.224 and 0.227 (dimensionless).

The low hydraulic conductivity values determined from the analyzed rock cores indicate the potential for low formation permeability. A copy of the complete laboratory report is presented in **Appendix G**.

## 3.4. Hydraulic Testing

Hydraulic testing performed during the well construction project consisted of seven packer tests on the DIW-1. Discharge water generated during the packer tests was pumped to the mud tanks for temporary storage and subsequently hauled off-site for proper disposal at DeJonge Excavating Contractors disposal site. The tests were conducted utilizing straddle packer assemblies and generally consisted of pumping the testing interval for four hours followed by three hours of recovery.

### 3.4.1. Packer Tests

Seven packer tests were performed during pilot-hole drilling of the DIW-1 in order to obtain hydraulic data across selected intervals to verify native water quality conditions, identify the base of the Underground Source of Drinking Water (USDW), evaluate potential confining characteristics of the rock formations and determine the final proposed injection interval of the DIW-1 and the monitoring intervals for the LZMW and the UZMW. Packer tests were run in the pilot hole of the injection well at the following approximate intervals: 1,200 to 1,232 feet, 1,157 to 1,188 feet, 1,119.5 to 1,150.5 feet, 1,044.5 to 1,075.5 feet, 1,501 to 1,762 feet, 1,276 to 1,307 feet and 1,446.5 to 1,477.5 feet. A packer test was conducted in the lower zone monitor well to test the open interval between 1,114 to 1,141 feet and within the upper zone monitor well to isolate the zone between 1,037 to 1,075 feet.

The injection well straddle packer assembly consisted of upper and lower packer units separated by 31 feet of perforated pipe for the injection well packer tests number 2, 3, 4, 6 and 7. The first packer test was an off-bottom packer that isolated a 32-foot interval and the fifth packer test was also an off-bottom packer that tested a 261-foot interval. The straddle packer assembly was lowered to the selected depth using drill rods. The perforated pipe between the packers allowed native water produced from the pilot-hole test interval to be pumped out through the drill pipe. The straddle packer assembly was inflated using water pressure in order to isolate the selected test interval (**Figures 3-5** and **3-6**).

Immediately prior to each packer test, the isolated interval was developed via a combination of airlifting and pumping until the development water was clear and specific conductivity levels were stabilized. The submersible pump was lowered into the drill rod assembly and background water level data were collected until the water levels became relatively stable. Water was pumped through the drill rod assembly for the packer tests, which were generally four hours in duration. Discharge rates were measured with an in-line flow meter installed in the discharge line assembly. An In-situ Hermit 3000 data logger was installed within the drill pipe that maintained connectivity to the testing interval in order to measure changes in water level during the packer test related to pumping. A water level indicator was installed within the annular space above the top packer in order to monitor changes in water level that would potentially indicate a breach in the packer seat. **Table 3-3** summarizes the hydraulic test results of the packer tests conducted within the injection and monitor wells. The data collected during the packer tests are included in **Appendix I**.

#### 3.4.1.1. DIW-1 Packer Test No. 1 (1,200 – 1,232 feet)

Following the drilling of the 12.25-inch diameter pilot hole to a depth of 1,232 feet packer test no. 1 was conducted on September 12, 2011 in order to verify the base of the USDW through isolation of the depth interval from 1,200 to 1,232 feet. During the drilling of the pilot hole the reverse-air groundwater samples indicated that an increase in specific conductance was noted at depths of 1,220 and 1,230 feet where the specific conductance increased to 10,560 µS/cm and 13,490 µS/cm, respectively, thus indicating the possible presence of the base of the USDW. In addition to the change in water quality, a change in formation from dolomitic limestone to dolomite was observed at an approximate depth range from 1,210 to 1,220 feet bls. The depth of the base of the USDW using reverse-air groundwater samples is an estimate due to the mixing of the groundwater throughout the open and contiguous pilot hole. Water quality data from a packer test is typically used to confirm the depth of the base of the USDW. By isolating discrete depth intervals during packer tests, more representative water quality measurements can be obtained.

Prior to initiating the packer test, the following geophysical logs were conducted under static conditions: X-Y caliper, gamma ray, borehole compensated sonic (which was utilized to determine the log-derived total dissolved solids), dual induction and temperature. The results of the caliper log were utilized to verify the borehole dimensions and to determine the exact packer setting depths. The logs indicated that the first off-bottom packer test could be successfully conducted across the interval 1,200 to 1,232 feet bls. The off-bottom packer assembly was lowered to approximately 1,200 feet and inflated to 380 psi in preparation for the first packer test. The pressure was maintained at 380 psi on the packer throughout the testing. There were no significant changes in the water levels within the annulus throughout the duration of the test, thus indicating that the packers were firmly set in the borehole and an effective seal was maintained.

The open borehole interval was developed with a five horsepower submersible pump to establish native water quality conditions within the test interval. Approximately 18,000 gallons of water were pumped during the four hour test at an average pump rate of 75 gallons per minute (gpm). The laboratory determined TDS concentration of the water sample collected at the end of the test was 35,640 mg/L, indicating that the test interval is well below the base of the USDW. The well was allowed to recover for a total of three hours in order to collect recovery water levels before the pump was removed from the well (**Figure 3-7**).

The drawdown observed at the end of the packer test was 79 feet. The water level in the well approached the background water level during the recovery phase within ten minutes after the end of pumping. Based on a pumping rate of 75 gpm and a drawdown of 79 feet, the specific capacity, the well production per unit decline in head, for this interval was approximately 0.95 gpm/ft (**Table 3-3**). The hydraulic conductivity values for this interval calculated using the Cooper-Jacob solution on the drawdown and the Theis recovery analysis method on the recovery data were estimated to be 1.4 and 1.1 feet/day, respectively (**Figures 3-8** and **3-9**). The low hydraulic conductivity values indicate relatively low permeability and confining characteristics of the limestone and dolomite.

#### 3.4.1.2. DIW-1 Packer Test No. 2 (1,157 to 1,188 feet)

The second packer test was conducted on September 14, 2011 to verify the base of the USDW. A straddle packer assembly was deployed to isolate the interval from 1,157 to 1,188 feet. The straddle packer assembly was set up with the mid-point of the packers separated by 31 feet of 6-inch perforated pipe. A five horsepower submersible pump was set to approximately 180 feet below land surface inside the pipe assembly. Each packer was inflated through a single water line with an approximate pressure of 395 psi maintained on the packer assembly throughout the testing.

The tested interval was developed in order to establish native water quality conditions within the test zone. Following the pre-test development, the discharge water appeared to be clear and free of particulate matter. The water level in the isolated zone was allowed to recover to the static water level before initiating the pumping test. The test interval was initially pumped at an approximate rate of 9 gpm for the first hour yielding a drawdown of approximately 134 feet, which was approaching the submersible pump. Therefore, the packer test pumping rate was reduced to approximately 4 gpm for four additional hours resulting in a drawdown of 100 feet, which was then followed by a six-hour recovery period (**Figure 3-10**).

The specific capacity of the interval from 1,157 to 1,188-foot was determined during the packer test to be approximately 0.04 gpm/ft of drawdown at a pumping rate of 4 gpm. The hydraulic conductivity values for this interval calculated using the Cooper-Jacob solution on the drawdown and the Theis recovery analysis method on the recovery data were estimated to be 0.08 and 0.05 feet/day, respectively (**Figures 3-11** and **3-12**). The low hydraulic conductivity values indicate low permeability and confining characteristics of the limestone. The laboratory determined TDS value for this interval was 2,092 mg/L. Based upon a comparison of water quality data collected during the packer tests, the water quality data from the second packer test indicated that this test interval of low permeability limestone contained relic fresh water trapped between two zones of more saline groundwater.

#### 3.4.1.3. DIW-1 Packer Test No. 3 (1,119.5 to 1,150.5 feet)

The third packer test was conducted on September 15, 2011, in order to confirm a production zone for the lower zone monitor well, which is designed to monitor the first permeable zone above the injection zone. A straddle packer assembly was deployed to isolate the interval from 1,119.5 to 1,150.5 feet. The mid-point of the straddle packer assembly was separated by 31 feet of 6-inch perforated pipe. A five horsepower submersible pump was set to approximately 180 feet below land surface inside the pipe assembly. Each packer was inflated through a single water line with pressures of approximately 400 psi maintained on the packer assembly throughout the testing.

Approximately 6,500 gallons of groundwater were developed out of the test interval to establish native water quality conditions. Water levels in the isolated zone were allowed to recover back to static before initiating the pumping test. The test interval was pumped for four hours at a rate of 42 gpm, resulting in a drawdown of 102.6 feet, which was followed by a three-hour recovery period (**Figure 3-13**). The specific capacity of the 1,119.5 to 1,150.5-foot interval was determined to be approximately 0.41 gpm/ft of drawdown at a pumping rate of 42 gpm. The hydraulic conductivity values for the test interval calculated using the Cooper-Jacob solution on the drawdown and the Theis recovery analysis method on the recovery data were estimated to be 0.42 and 0.46 feet/day, respectively (**Figures 3-14** and **3-15**). The laboratory determined TDS value for this interval was 16,428 mg/L.

#### 3.4.1.4. DIW-1 Packer Test No. 4 (1,044.5 to 1,075.5 feet)

The fourth packer test was conducted on September 16, 2011, in order to determine the aquifer characteristics and water quality of the proposed monitor zone for the upper zone monitor well, which is designed to monitor within and near the base of the USDW. The straddle packer assembly was deployed to isolate the interval from 1,044.5 to 1,075.5 feet. The mid-point of the straddle packer assembly was separated by 31 feet of 6-inch perforated pipe. A five horsepower submersible pump was set to approximately

180 feet below land surface inside the pipe assembly. During the packer test, the packer pressure was maintained within the range of 390 to 400 psi.

The tested interval was initially developed as previously discussed and the discharge water appeared to be clear and free of sediment. The water level in the isolated zone recovered to static level prior to initiating the pumping test. The test interval was pumped for four hours at an average rate of 86 gpm resulting in a drawdown of approximately 47 feet, which was subsequently followed by a three-hour recovery period.

The specific capacity of the tested interval was estimated to be 1.84 gpm/ft of drawdown at a pumping rate of 86 gpm. The water level data file collected during the packer test was compromised and the transmissivity and the hydraulic conductivity values were estimated. Transmissivity is the rate in which water is transmitted horizontally through an aquifer under a unit width and a unit hydraulic gradient and in general. Based upon the Cooper-Jacob (1946) solution for flow to a well in a confined aquifer, the specific capacity is determined by dividing the flow rate by the drawdown and the transmissivity can be estimated from the specific capacity of a confined aquifer. The hydraulic conductivity value of 15.8 feet/day for this interval was estimated as follows:

- Transmissivity (gpd/ft) = 2,000 x Specific Capacity = 2,000 x 1.84 gpm/ft = 3,674 gpd/ft or 3,674 gpd/ft ÷ 7.48 gallon/$ft^3$ = 491.2 $ft^2$/day
- Hydraulic Conductivity (ft/day) = Transmissivity ($ft^2$/day) /aquifer thickness (feet) = 491.2 $ft^2$/day ÷ 31 ft = 15.8 ft/day

The laboratory determined TDS value for this interval was 6,204 mg/L.

The base of the USDW is defined as the depth where groundwater quality of 10,000 milligrams per liter total dissolved solids is first intercepted. Reverse-air drilling water quality samples were collected during pilot-hole drilling from 330 feet to 1,762 feet and analyzed for specific conductance in the field. Reverse-air lifted groundwater samples indicated that specific conductance values slowly increased from 3,330 microsiemens per centimeter (µS/cm) at a depth of 330 feet to 6,800 µS/cm at a depth of 1,200 feet. An abrupt increase in specific conductance was noted at depths of 1,230 feet and 1,260 feet where the specific conductance increased to 13,730 µS/cm and 23,300 µS/cm, respectively. The base of the USDW at the injection well was determined to be approximately 1,120 feet based on water quality data from two straddle packer tests and confirmation from geophysical logs. The intermediate 40-inch diameter casing setting at depth of 1,120 feet was approved by the Department of Environmental Protection on September 22, 2011.

### 3.4.1.5. DIW-1 Packer Test No. 5 (1,501 to 1,762 feet)

The fifth packer test was conducted on October 9, 2011, in order to confirm the permeability of the injection zone. The off-bottom packer assembly was deployed to isolate the interval from 1,501 to 1,762 feet. The mid-point of the straddle packer assembly was separated by 261 feet of 6-inch perforated pipe. The five horsepower submersible pump was set to approximately 180 feet below land surface. A packer pressure of 400 psi was maintained throughout the test.

The tested interval was initially developed as previously discussed and the water level in the isolated zone recovered to static level before initiating the pumping test. The test interval was pumped for three hours at a rate of 90 gpm resulting in a drawdown of approximately 3 feet, followed by a two hour recovery period (**Figure 3-16)**.

The specific capacity of the test interval was determined to be approximately 30 gpm/ft of drawdown at a pumping rate of 90 gpm. The greater the transmissivity, the more prolific the aquifer and the less drawdown that will be observed in the well. Due to the more transmissive properties of the permeable test interval, the pump was unable to stress the aquifer enough to generate representative drawdown conditions. A significant amount of the observed drawdown was primarily due to friction loss within the pump and the drill rod assembly. Therefore, as previously discussed, the hydraulic conductivity value for this interval was calculated to be 30.7 feet/day based upon an estimated transmissivity of 8,021.4 $ft^2$/day. The laboratory determined TDS value for this interval was 36,752 mg/L.

### 3.4.1.6. DIW-1 Packer Test No. 6 (1,276.5 to 1,307.5 feet)

The sixth packer test was conducted on October 10, 2011, in order to verify the permeability within the test interval and determine the capacity of a fracture within the injection zone. The straddle packer assembly was deployed to isolate the 31-foot interval from 1,276.5 to 1,307.5 feet. A five horsepower submersible pump was set to approximately 180 feet below land surface.

The tested interval was initially developed until the water quality stabilized and was representative of native groundwater. Following development, water levels in the isolated zone were recovered to static prior to initiating the pumping test. The test interval was pumped for two hours at a rate of 92 gpm resulting in a drawdown of approximately 1.1 feet and was followed by a one-hour recovery period.

The specific capacity of the interval between 1,276.5 and 1,307.5 feet was determined to be approximately 83.6 gpm/ft of drawdown at a pumping rate of 92 gpm. Due to the permeability of the zone, the hydraulic conductivity value for this interval was calculated to be 721.4 feet/day based upon an estimated transmissivity of 22,363 $ft^2$/day. The laboratory determined TDS value for this interval was 36,424 mg/L.

#### 3.4.1.7. DIW-1 Packer Test No. 7 (1,446.5 to 1,477.5 feet)

The seventh packer test was conducted on October 11, 2011, in order to verify the permeability within the test interval and determine the capacity of a fracture within the injection zone. The straddle packer assembly was deployed to isolate the 31-foot interval from 1,446.5 to 1,477.5 feet. A five horsepower submersible pump was set to approximately 180 feet below land surface. During the packer test, the packer pressure was maintained within the range of 380 to 390 psi.

The tested interval was initially developed until the water quality stabilized and was representative of native groundwater. The test interval was pumped for three hours at a rate of 92 gpm resulting in a drawdown of approximately 2.87 feet and was followed by a one-hour recovery period.

The specific capacity of the interval between 1,446.5 and 1,477.5 feet was determined to be approximately 31.4 gpm/ft of drawdown at a pumping rate of 92 gpm. Due to the permeability of the zone, the hydraulic conductivity value for this interval was calculated to be 271 feet/day based upon an estimated transmissivity of 8396 $ft^2$/day. The laboratory determined TDS value for this interval was 36,268 mg/L.

#### 3.4.1.8. DIW-1 Packer Test Summary

Seven packer tests were conducted within the injection well in order to determine ground water quality and aquifer characteristics. The depths tested through the use of the packer tests ranged from 1,044.5 to 1,762 feet bls. Packer tests 1, 5, 6 and 7 were conducted within the injection well injection zone from 1,197 to 1,762 feet and thus tests 2 through 4 were conducted above the final casing depth. Packer test 3 was utilized to evaluate the LZMW-1 monitor zone and packer test 4 was more representative of the conditions within the UZMW-1 monitor zone. The water quality and aquifer characteristics as determined through the packer tests 3 and 4 indicate that the depth from 1,040 to 1,075 feet and 1,115 through 1,141 feet appear to be suitable for the open interval within the upper zone and lower zone monitor wells, respectively.

The injection well packer test hydraulic data from tests 2 and 3 indicate that the rock formations between 1,119.5 to 1,188 feet, which are located above the final casing setting depth of 1,197 feet, demonstrate low formation permeability and confinement characteristics with hydraulic conductivity values ranging from of 0.05 to 0.4 feet/day.

It was determined through packer tests 5 through 7 that the zone from 1,276 to 1,762 feet had greater permeability with estimated hydraulic conductivity values ranging from 31 to 721 feet/day. This zone is located below the USDW and the final casing depth in the injection zone within the Avon Park Formation of the Upper Floridan aquifer. **Table 3-3** summarizes the injection well packer test parameters and results.

### 3.4.1.9. LZMW Packer Test No. 1 (1,114 to 1,141 feet)

Following the drilling of the lower zone monitor well 9⅞-inch diameter pilot hole to a depth of 1,141 feet an off-bottom packer test was conducted on November 9, 2011 to test the hydraulic properties of the 27-foot interval from 1,114 to 1,141 feet and determine water quality. Prior to initiating the packer test, the following geophysical logs were conducted under static conditions: X-Y caliper, gamma ray, temperature, fluid conductivity, flow meter, borehole compensated sonic with VDL, dual induction and televiewer. The fluid conductivity, temperature and flow meter logs were also conducted under dynamic conditions with a pumping rate range from 110 to 116 gallons per minute.

A five horsepower submersible pump and a data transducer were deployed within the drill pipe that is contiguous with the test interval and an additional transducer was installed within the annular space in order to monitor water levels. Development by pumping was conducted and a total of three well volumes were evacuated prior to returning the well to static condition and recording background water levels. The interval was pumped at an approximate rate of 43.5 gpm for approximately 260 minutes with a maximum drawdown of 136 feet, resulting in an estimated specific capacity of 0.32 gpm/ft (**Figure 3-17**). During the packer test, the packer pressure was maintained within the range of 380 to 400 psi. Water quality samples were collected at the end of the packer test and the total dissolved solids value as determined by the laboratory was 17,892 mg/L. The well was allowed to recover for two hours in order to collect recovery water levels before the pump was removed from the well.

The hydraulic conductivity values for the test interval calculated using the Cooper-Jacob solution on the drawdown and the Theis recovery analysis method on the recovery data were estimated to be 0.56 and 0.55 feet/day, respectively (**Figures 3-18** and **3-19**).

### 3.4.1.10. UZMW Packer Test No. 1 (1,037 to 1,075 feet)

Following the drilling of the upper zone monitor well 9⅞-inch diameter pilot hole to a depth of 1,075 feet an off-bottom packer test was conducted on December 7, 2011 to test the hydraulic properties of the 38-foot interval from 1,037 to 1,075 feet and determine water quality. Prior to initiating the packer test, the following geophysical logs were conducted in the completed pilot hole under static conditions: X-Y caliper, gamma ray, dual induction, borehole compensated sonic with VDL, temperature, flow meter and fluid conductivity. The temperature, flow meter and fluid conductivity logs were also conducted under dynamic, pumping conditions. The geophysical logs were utilized to determine the packer setting depth and support the determination of the monitored interval and subsequent casing seating for the final 6⅝-inch FRP casing.

The off-bottom packer test was conducted in the anticipated monitor interval from a depth of 1,037 feet to 1,075 bls. The packer was inflated to approximately 400 psi and the test interval was pump developed, tested for stabilization and then instrumented with down hole pressure transducers in the pump column to monitor the pumped interval and in the annular space to monitor the competency of the packers connection to the borehole wall. A five horsepower submersible pump was utilized to evacuate the monitor interval at an average rate of 88 gpm for four hours, yielding a drawdown of approximately 27.5 feet and resulting in an estimated specific capacity of 3.2 gpm/ft (**Figure 3-20**). The water levels were monitored for two hours during the recovery phase of the test. The laboratory determined TDS concentration of the water sample collected at the end of the test was 6,284 mg/L, thus indicating that the monitor zone is above the base of the USDW.

The hydraulic conductivity values for the test interval calculated using the Cooper-Jacob solution on the drawdown and the Theis recovery analysis method on the recovery data were estimated to be 2.5 and 2.9 feet/day, respectively (**Figures 3-21 and 3-22**).

## 3.5. Water Quality Sampling

The water quality sampling program implemented during the injection well construction project consisted of four sampling types. The Surficial Aquifer was monitored during construction by sampling four shallow water table monitor wells located near the drilling pad. During reverse-air drilling operations, grab samples were collected of the discharge water in order to monitor potential changes in aquifer water quality during drilling. Water quality samples were also collected from isolated testing intervals during packer testing. After the completed wells were developed, final background water quality samples were collected from DIW-1, the LZMW-1, and UZMW-1.

### 3.5.1. Surficial Aquifer Water Quality

The four Surficial Aquifer monitoring wells (SMW-1 through SMW-5) located around the drill pad were sampled weekly to monitor for any potential water quality changes resulting from the drilling operation. The pad wells were installed and initially sampled prior to any deep drilling activities in order to establish ambient groundwater conditions.

Benchmark Laboratory personnel, who were subcontracted to YBI during the execution of the project, collected and analyzed weekly water levels and water quality samples. Each well was purged and sampled using a peristaltic pump. Discharge water was collected after a minimum of three well volumes had been purged. The water samples were analyzed at the laboratory for the following parameters: chloride, dissolved oxygen, specific conductance, pH, temperature and turbidity (**Table 3-4)**. **Figures 3-23** through **3-27** graphically present the results of the water quality analyses for specific conductance and chloride. Well SMW-2 showed a sharp increase in chloride beginning, with a corresponding response in specific conductance in October 2011, which indicated a possible leak of formation water from the containment pad near this well. The well was pumped by the contractor until chloride levels returned to near background conditions. Copies of the laboratory reports for the wells are included in **Appendix J**.

### 3.5.2. Airlift Water Quality Samples

During the reverse-air drilling phase of the DIW-1, LZMW-1, and UZMW-1, water samples were collected at approximately every 30 feet. These samples were collected to provide indicators of water quality changes at depth during drilling activities and to help identify the base of the USDW (10,000 mg/L TDS interface). The samples were collected by the contractor in two, 1-liter bottles and labeled with the well ID, depth, date, and collection time. Samples were submitted to Atkins personnel for field testing of specific conductance, total dissolved solids, salinity and temperature with a HACH field instrument and pH was measured with an Oakton field meter. The duplicate samples were submitted to Benchmark Laboratories in Palmetto, Florida for analysis of pH, specific conductance, total dissolved solids, sulfate, and chloride. Below the intermediate casing of DIW-1, additional samples were collected every 60 feet and analyzed for total Kjeldahl nitrogen and ammonia. Airlift water quality data are included in **Appendix K**.

#### 3.5.2.1. DIW-1 Airlift Water Quality

Due to the drilling technique of re-circulating discharge water back to the well and due to the contiguous open-hole section of the pilot hole, airlift water quality results at specific depths are not considered very accurate; however, relative changes in water quality with depth were used in evaluating changes in formation hydraulic capacity and groundwater quality. The drilling technique was modified from mud rotary to reverse-air at a depth of 310 feet, which lead to the initiation of the collection of airlift ground water quality samples. Airlift water quality results were obtained from the DIW-1 below an approximate depth of 330 feet. TDS concentration increased sharply from 4,672 mg/L at 1,200 feet to 25,052 mg/L at 1,290 feet, which correlates with the USDW defined by packer tests and log derived TDS depth of 1,120 feet. TDS values continued to increase to a maximum of 37,300 mg/L at the bottom of the hole at a depth of 1,762 feet (**Table 3-5**).

Based on the laboratory analyzed airlift water quality samples, throughout the proposed injection zone (1,197 to 1,762 feet), the specific conductivity, TDS and chloride concentrations averaged 42,930 µS/cm, 29,713 mg/L and 16,000 mg/L, respectively. The average sulfate and pH values within the injection zone interval were 2,615 mg/L and 7.18 standard units (s.u.), respectively. **Figures 3-28** through **3-30** depict the laboratory determined airlift water quality analysis results versus depth measured during the drilling of the injection well for specific conductivity, chloride, ammonia, and TKN, respectively. Changes in specific conductivity and chloride water quality are noted at depths of 1170-1350 feet. The ammonia and TKN values show no apparent correlation with depth.

#### 3.5.2.2. LZMW-1 Airlift Water Quality

Due to the drilling technique of recirculating discharge water back into the well and the large section of open hole, the airlift water quality are not considered very accurate and are used as relative indicators of water quality changes. Laboratory water quality data from airlift samples collected during the drilling of LZMW-1 from a depth of 330 feet to 1,140 feet indicated a gradual increase in TDS concentrations from 2,360 mg/L at 330 feet to 3,924 mg/L at the bottom of the borehole at 1,140 feet. The average TDS value within the monitor zone from 1,115 to 1,141 feet was 3,834 mg/L. The chloride values ranged from 764 mg/L at 330 feet to 1,203 mg/L at 1,140 feet, with an average value of 1,164 mg/L within the monitor zone. The airlift laboratory water quality data for the LZMW-1 is presented in **Table 3-6**. Water quality data are included in **Appendix K**.

#### 3.5.2.3. UZMW-1 Airlift Water Quality

Laboratory water quality data from airlift samples collected during the drilling of UZMW-1 from a depth of 330 to 1,075 feet bls generally shows a gradual increase in specific conductivity, chloride, sulfate, and TDS values with depth. Chloride values increased from 813 mg/L at a depth of 330 feet to 1,290 mg/L at the final depth of 1,075 feet bls. The average chloride value within the monitor zone from 1,040 to 1,075 feet was 1,196 mg/L. The specific conductance values throughout the drilling of the pilot hole ranged from 3,510 µS/cm at 330 feet to 5,660 µS/cm at 1,075 feet bls with an average of 5,200 µS/cm within the monitor zone. The total dissolved solids values ranged from 2,392 mg/L at 330 feet to 3,792 mg/L at a depth of 1,075 feet, with an average value of 3,460 mg/L within the monitor zone. **Table 3-7** contains a summary of the airlift laboratory water quality data for UZMW-1.

### 3.5.3. DIW-1 Packer Test Water Quality Samples

The water quality results determined during the packer tests are deemed more reliable than the estimated water quality measurements conducted during the airlift water quality sampling events. Water samples collected from packer tests completed on the DIW-1 were submitted to Atkins personnel for field testing in conjunction with duplicate samples submitted by the Contractor to Benchmark Laboratories for analysis of chloride, pH, specific conductivity, TDS and sulfate. The packer tests that were conducted in the proposed injection zone, which included packer tests 5, 6 and 7, ammonia and total Kjeldahl nitrogen were also analyzed. **Table 3-8** summarize the field and laboratory water quality analysis results from the injection well and monitor well packer tests. Copies of the laboratory reports for the DIW-1 packer tests are included in **Appendix L**.

The isolated zone during each packer test was thoroughly developed with a minimum volume equivalent to the test interval and the drill rod pumped prior to initiating the test, thus resulting in discharge water samples that were more representative of the isolated formation water quality. In addition, to provide additional assurance that the water quality samples were representative, the samples to be analyzed at the laboratory were collected at the end of the packer test pumping phase.

The discharge sample collected at the end of packer test 1 indicated that the TDS concentration was 35,640 mg/L for the interval between 1,200 to 1,232 feet bls, which is below the base of the USDW. Packer test 2 indicated a TDS concentration of 2,002 mg/L across the interval 1,157 to 1,188 feet bls, which was attributed to relic or connate fresh groundwater. The TDS value determined during packer test 3, which was performed across the interval 1,119.5 to 1,150.5 feet bls was 16,428 mg/L. Packer test 4 was performed across the interval from 1,044.5 to 1,075.5 feet bls and resulted in a TDS concentration of 6,204 mg/L.

Based upon the results of packer tests 3 and 4, the base of the USDW was estimated at an approximate depth of 1,120 feet bls. The base of the USDW as confirmed with the geophysical log derived TDS, which indicated a TDS greater than 10,000 mg/L at a depth of 1,120 feet bls.

The depth interval from 1,501 to 1,762 feet was isolated during packer test 5 and resulted in a TDS concentration of 36,752 mg/L. Packer Tests 6 and 7 were performed across the intervals from 1,276.5 to 1,307.5 feet and 1,446.5 to 1,477.5, respectively, with resultant TDS concentrations of 36,424 and 36,268 mg/L, respectively.

Based upon a comparison of the water quality data that was collected during the airlift sampling events and the results from the packer tests above and below the injection zone, the elevated TDS values within the formation water in the injection zone is considered of lower quality and conducive to receiving the proposed injectate.

### 3.5.4. Background Water Quality Sampling

Following installation of the injection tubing at the injection well and the final casing at the monitor wells, background water quality conditions were established for the DIW-1, LZMW-1, and UZMW-1. The open borehole interval at each well was pumped as part of well development until the discharge water was free and clear of sediment and a minimum of three borehole volumes and one casing volume had been removed from the well. Immediately following the conclusion of well development procedures, a YBI submersible pump was used by Benchmark Laboratories personnel to draw a representative discharge water sample from each well. Each representative water sample was transferred to labeled sample bottles and transported by laboratory personnel to Benchmark Laboratories for analyses. The DIW-1 was sampled on February 10, 2012, the LZMW-1 was sampled on November 21, 2011, and the UZMW-1 was sampled on January 4, 2012.

The water quality analyses were conducted in order to establish the background water quality concentrations prior to the operation of the injection well. All background water samples were analyzed for parameters that have established primary and secondary drinking water standards, in addition to other water quality constituents, although the well will not be utilized for drinking water purposes. **Table 3-9** presents a comparison of the background water samples with the maximum contaminant limits (MCLs) of the drinking water standards. Primary standard exceedances for the DIW-1 included fluoride, sodium and thallium. Secondary standard exceedances included chloride, iron, manganese, sulfate, odor, TDS and surfactants for well DIW-1. The LZMW-1 background sample primary standard exceedances included arsenic, thallium, tetrachlorethene and radium 226. The LZMW-1 secondary exceedances included chloride, iron, color, odor, sulfate, and TDS. The UZMW-1 background sample primary exceedances included sodium, gross alpha and radium 226. The UZMW-1 secondary exceedances included chloride, sulfate, odor and TDS. The laboratory reports that contain the analytical results of the background water quality analyses are included in **Appendix M**.

## 3.6. Geophysical Logging

A geophysical logging program was conducted throughout the construction of the injection well system. The logging program included collection of geophysical data for use in the interpretation of the hydrogeologic conditions beneath the site, identifying the depth of the USDW, and to aid in the estimation and verification of the construction details of the wells. YBI provided all geophysical logging services during construction activities. The geophysical logging truck is shown in **Figure 3-31** and a geophysical logging tool is shown in **Figure 3-32.**

### 3.6.1. DIW-1 Logging Runs

The geophysical logging series conducted on the DIW-1 consisted of nine individual logging events that were performed during the course of the well construction, along with a tenth event for the Radioactive Tracer Survey Test at the completion of well construction. Geophysical logging was completed on all pilot and reamed portions of the borehole in addition to selected stages of well construction. Logging operations in the 12.25-inch diameter pilot hole were conducted primarily to verify hydrogeologic conditions and to determine casing setting depths and the packer test intervals. Logs conducted in the reamed portion of the borehole were primarily run to verify the diameter of the borehole and estimate cement quantities. A summary of all geophysical logging of DIW-1 is presented in **Table 3-10**. Copies of individual logs for DIW-1 are included in **Appendix N**.

Various geophysical logging tools were utilized during the construction of the well. The caliper log provides a continuous record of average borehole diameter in addition to being utilized to identify fractures and possible water-bearing flow zones. Gamma ray logs record the natural-gamma radiation emitted from rocks penetrated by the borehole, which is utilized to identify lithologic units. Fluid temperature logs record the vertical water temperature variations in the borehole and are generally utilized to identify water-producing and water-receiving zones. Temperature logs are also utilized to delineate the cement top depths following casing grouting procedures. Electromagnetic-induction logs record the electrical conductivity or resistivity of the formation and the water within the borehole and are affected by the porosity, permeability and clay content of the formation and by the dissolved solids concentration of the water within the formation. The borehole compensated (BHC) sonic log measures the transit time of an elastic wave created by an acoustic signal after passing through the formation. The sonic log is used to delineate lithology and to estimate the intergranular porosity of a rock formation.

***DIW-1 Run 1*** was a combination gamma ray and X-Y caliper log, as well as dual induction and BHC sonic logs, run inside the 12.25-inch diameter mudded pilot hole to a depth of 300 feet to verify the geologic characteristics of the formation exposed within the borehole and to select the casing setting depth for the 56-inch diameter surface casing. The pilot hole is gauged and round with no apparent fracturing or void space, with an average diameter within the range of 12.5 to 14.5 inches, with a maximum of 15.8-inches. The gamma ray log shows several sharp increases or spikes to the right concentrated in the upper 2/3 of the pilot hole. The increases in gamma ray counts correlate with formations that are higher in clays containing radioactive isotopes of potassium. The dual induction log indicates that resistive limestone occurs at the bottom of the borehole and is suitable for casing installation.

***DIW-1 Run 2*** was run on the 58-inch diameter reamed mudded borehole from land surface to 314 feet bls. The logs conducted were X-Y caliper, and gamma ray utilized to confirm casing placement and estimate grout quantity for the installation of the 56-inch diameter surface casing to a depth of 310 feet bls. The caliper log showed a larger than gauge borehole that was fairly uniform with no significant fractures or voids and with an average diameter within the range of 61 and 64 inches. The formation appeared most competent in the bottom 50 feet of the borehole. The gamma ray log response was very subdued, most likely due to the large diameter of the reamed hole.

***DIW-1 Run 3*** was run on the 12.25-inch pilot hole from land surface to 1232 feet in order to verify the pilot hole geology, determine hydrogeologic characteristics and determine the appropriate setting depth for the intermediate casing and settings for the targeted packer tests utilized to identify the base of the USDW. The geophysical logs included the X-Y caliper, gamma ray, dual induction, temperature, BHC sonic, and log derived TDS.

Based upon the results of the caliper log, the pilot-hole diameter ranged from 13 to 18 inches from 300 to 582 feet and two fractures present at 493 feet and 535 feet, which were shown to have a diameter of 19.5 and 27 inches respectively. The pilot-hole diameter was greater than the bit gauge with an average diameter of approximately 16 inches from 300 to 582 feet, 19 inches from 582 to 792 feet, and 17 inches from 804 to 1,020 feet, which may be related to the presence softer limestone beds washed out to a larger diameter. Below 1020 feet bls the hole diameter averages 13.5 inches due to with no apparent fracturing or voids, due to harder lithology and the presence of more dolomitic limestone.

Higher gamma ray counts were detected at 400 feet, 548 feet, and 790 feet bls, with the over-all gamma ray signature decreasing in variability with depth. The combination of significant gamma ray peaks and corresponding smaller caliper diameters at a depth of 548 feet is inferred as the top of the Suwannee Limestone formation.

The temperature log did not show a marked increase in temperature but rather a gradual increase with depth.

The maximum porosity values were measured at depths of 490 and 585 feet. A general decrease in the porosity values began at a depth of 620 feet and continued to the base of the pilot hole at 1232 feet, which correlates to the presence of dolomite.

The dual induction log showed resistivity values ranging from 6 to 60 ohm-meters. Resistivity peaks were noted at depths of 870 feet and 885 feet, which typically correspond to higher density rock types.

An analysis of the sonic and dual induction resistivity logs by YBI was used to create the log derived TDS values for the logged interval. This analysis used porosity values derived from the sonic log to determine the formation factor, F, which is the ratio of the rock resistivity to that of its water content, using Archie's second equation:

$$F = \frac{a}{\Phi^m}$$

Where: a = Constant derived from core data
m = Constant derived from core data
$\Phi$ = Porosity from sonic log

The resistivity of the formation water was derived using another Archie equation:

$$Rw = \frac{Ro}{F}$$

Where: Rw = resistivity of the formation water
Ro = resistivity value from dual induction log
F = Formation factor

The log derived TDS was not a clear indicator in identifying the base of the USDW, due in part to a unique combination of water quality and geologic factors. The TDS spikes over 10,000 mg/L at a depth of 1,040 ft bls then again at 1,055 ft and 1,065 -1,072 ft bls. The TDS decreases below 10,000 mg/L between 1,075 ft and 1,120 ft bls, which is followed quickly by another increase in TDS much greater than 10,000 mg/L. The decreases in TDS or freshening water quality below or at the base of the USDW could be related to a change in porosity of the formation that would trap relic water of varying TDS concentrations with in them. Then through airlift drilling, and the resulting mixing and dilution of the formation waters, identifying the base of the USDW is an estimate.

Based on this analysis, the depth where the TDS value of the formation water becomes consistently greater than 10,000 mg/L was determined to be 1120 feet bls. The geophysical logs and water quality data from the packer tests were submitted to the TAC along with recommendations for the 28-inch final casing setting depth. Following review of the submittals and correspondence with the TAC, a 28-inch casing depth of 1,197 feet was accepted by the TAC. The TAC also concurred with the identification of the base of the USDW at approximately 1,120 feet.

A televiewer log was conducted of the open pilot hole from land surface to 1,232 feet. The log indicated that the open-hole interval below the casing was comprised of friable micritic limestone with little fracturing intermixed with dolomitic layers.

***DIW-1 Run 4*** was run on the 56-inch diameter reamed borehole from land surface to 1,120 feet bls. The logs conducted were X-Y caliper and gamma ray and were utilized to confirm casing placement and estimate grout quantity for the installation of the 40-inch intermediate casing to a depth of 1,120 feet bls. The caliper log showed a gauged borehole that was fairly round. No significant fractures or voids were noted between 310 feet and 580 feet bls. From 580 feet to 675 feet, the borehole is larger than gage and indicates possible fractures with diameters of 62 to 66 inches. The formation appeared most competent in the bottom 150 feet of the borehole. The gamma ray log was uniform and the amplitude of the signature was decreasing with depth. Several isolated gamma ray increases were noted at depths of 395 feet and 545 feet bls.

***DIW-1 Run 5*** consisted of five temperature logs that were conducted following the preceding cement stage during the grouting of the 40-inch intermediate casing to a depth of 1,120 feet bls. Six cementing stages were required to bring the cement to land surface. The results of the individual temperature logs were collectively displayed on the final stage cement log conducted on September 28, 2011. The temperature log (#1) completed after the first cementing stage delineated the top of the cement at a depth of 800 feet. The physical tag of the cement top was at a depth of 790 feet. The temperature log (#2) completed after the second cementing stage indicated that the top of the cement was located at approximately 650 feet, which was confirmed with a physical tag at a depth of 651 feet. The temperature log (#3) completed after the third cementing stage indicated a cement top at 594 feet and the physical tag indicated a cement top depth of 590 feet. The temperature log (#4) completed after the fourth cementing stage indicated an approximate cement top depth of 432 feet, which was confirmed with a physical tag at a depth of 451 feet. The temperature log (#5) completed after the fifth cementing stage indicated an approximate cement top depth of 214 feet, which was confirmed with a physical tag at a depth of 215 feet. The remainder of the annulus was grouted to land surface in cementing stage 6. In general, there was a strong correlation between the cement top depth determined via the temperature logs and the physical cement tags.

***DIW-1 Run 6*** was run on the 12.25-inch pilot hole from 1,080 to 1,752 feet in order to verify the pilot hole geology, determine hydrogeologic characteristics and the appropriate setting depth for the final casing and settings for the packer tests. The geophysical logs included the X-Y caliper, gamma ray, dual induction, temperature, flow meter, BHC sonic and video survey.

The caliper log delineated a fairly gauged pilot hole with an approximate diameter of 13 inches from a depth of 1,122 feet to 1,752 feet. The pilot hole diameter varies at depths from 1,450 to 1,480 feet, thus signifying potential caverns and flow zones and apparent fractures at 1,284 feet bls. From the base of the intermediate casing at 1,120 feet to 1,190 feet, the diameter of the pilot hole was slightly washed out, with a maximum diameter of 14 inches.

The gamma ray counts are generally low within areas consisting of carbonates and dolomite. Therefore, the gamma ray values, which ranged from 10 to 40 American Petroleum Institute gamma ray units (GAPI), were generally consistent throughout the logged interval from 1,080 to 1,752 feet. A slight increase in the gamma ray values within the range of 20 to 40 GAPI was noted from approximately 1290 to 1,310 feet bls.

In general, the temperature of the water within aquifer zones increases with depth as a result of the naturally occurring geothermal gradient. The static temperature log indicates that the groundwater temperature gradually increased from 89 degrees Fahrenheit (°F) at 1,080 feet to 92.5 °F at 1,752 feet.

The dual induction log measures the shallow, medium and deep resistivity values and indicates variations in the dissolved solids concentrations and thus is utilized to delineate flow zones. Geophysical log indicators of the Avon Park permeable zone are higher resistivity values and cyclic high-amplitude velocity measurements visible on the sonic log. A decreasing shift in the resistivity value was detected at a depth of 1,380 feet continuing to 1,510 feet, which correlates to the beginning of fracturing in the borehole, thus indicating a potential influence of higher conductance water due to flow zones. A general increase in the resistivity values was delineated from approximately 1,520 to 1,640 feet which correlates to decreasing porosity in the formation, and decreasing fracture related flow.

The BHC sonic log utilizes acoustic signals to measure travel times through the various matrices. In general, the travel time of a formation depends on the elastic properties of the formation which are related to porosity and lithology. Therefore, a faster travel time correlates to a denser material and an increase in the porosity would lead to a slower travel time. The travel time of water ranges from 189 to 210 µsec/ft, whereas it is generally 44 and 49 µsec/ft for dolomite and limestone, respectively. An increase in the travel time and the porosity to a maximum of 240 porosity units was delineated at the depths of 1,280 feet, 1,410 feet, and 1,450 feet to 1,480 feet bls which both correlate to fractures and potential flow zones. The lowest porosity values were measured from 1,340 to 1,370 feet, thus indicating the presence of a more dense formation.

The variable density log, when conducted in conjunction with a sonic log is generally utilized to detect fractures and formation density. Decreases in the density were delineated from 1,210 feet to 1,480 feet bls which correlates with fractured areas and potential flow zones. The density increases beginning at a depth of approximately 1,150 feet to 1,200 feet, is related to the presence of crystalline dolomite and low apparent permeability.

A televiewer survey was conducted of the open pilot hole from 1,080 feet to 1,752 feet. The televiewer showed the intermediate casing, 40-inch steel, landed at 1,120 feet bls. The open-hole interval is comprised of micritic limestone and dolomitic limestone with pitting and fracturing visible at 1,220 feet to 1,350 feet bls. Fracturing increases again at a depth of 1,375 feet to approximately 1,500 feet bls. At the bottom of the borehole, several small fractures are encountered.

***DIW-1 Run 7*** combination gamma ray and X-Y caliper log run in the 38.5-inch reamed hole from 1,020 to 1,197 feet, then in the 24-inch reamed borehole from 1,197 to 1,762 feet bls. The shelf that the casing will seat on at 1,197 feet is evident. The caliper log indicated the borehole extended to a total depth of 1,762 feet bls, with very little fracturing or washouts. The borehole below 1,480 feet to a total depth of 1,762 feet was out of gage possibly related to a divergent pilot hole. The 38.5-inch section of the borehole was used to estimate the cement quantity required to grout the 28-inch final casing in addition to verifying the integrity of the borehole wall at the final casing setting depth.

***DIW-1 Run 8*** consisted of a composite of four temperature logs completed during the cementing of the 28-inch final casing. The temperature log (#1) completed after the first cementing stage showed the top of the cement at a depth of approximately 1,110 feet. The physical tag of the cement was at a depth of 1,107 feet. The temperature log (#2) completed after the second cementing stage delineated the top of the cement at a depth of 806 feet. The physical tag of the cement top was at an approximate depth of 818 feet. The temperature log (#3) completed after the third cementing stage indicated that the top of the cement was located at 508 feet, which was confirmed with a physical tag at 511 feet. The temperature log (#4) completed after the fourth cementing stage indicated a cement top at 256 feet, which was confirmed with a physical tag at 255 feet. In general, there was an excellent correlation between the temperature log cement top determinations and the physical tags.

***DIW-1 Run 9*** following the completion of the fourth stage of cement, a cement bond log was conducted, after which the cement was brought to land surface. An acoustic cement bond log was conducted on the 28-inch casing in order to detect the presence of the cement, and thus verify the integrity of the cement placement and seal. The log indicated that the cementation appeared complete (bond of integrity) from casing to cement to formation. Additionally, the cement appeared dense throughout the entire length of the cemented casing from 1,197 feet to the top of cement (at the time of log run) at a depth of 255 feet below land surface.

A video survey was conducted of the final steel casing from land surface to 1,180 feet. The forty 28-inch final steel casing weld joints were visually inspected and there appeared to be no visible signs of misalignment and the welds appeared continuous. The receiver for the permanent packer looked clean and intact with no apparent defects.

A video survey was also conducted after the installation of the 16.6-inch ID FRP tubing. The video survey confirmed that all of the FRP joints were intact and the FRP was firmly seated in the packer. The open borehole was also inspected and found to be open and clear to 1,760 feet bls

### 3.6.2. LZMW-1 Logging Runs

A total of six individual logging events were performed during the construction of LZMW-1 (**Table 3-11**). Electronic copies of the geophysical logs are presented in **Appendix N**.

***LZMW-1 Run 1*** was a combination gamma ray and X-Y caliper log, as well as dual induction and BHC sonic logs, run inside the 12.25-inch diameter mudded pilot hole to a depth of 310 feet to verify the geologic characteristics of the formation exposed within the borehole and to select the casing setting depth for the 16-inch diameter surface casing. The pilot hole is gauged and round with no apparent fracturing or void space, with an average diameter within the range of 13 to 14.5 inches, with a maximum of 14.8 inches. The gamma ray log shows several sharp increases or spikes to the right concentrated in the upper 2/3 of the pilot hole. The increases in gamma ray counts correlate with formations that are higher in clays containing radioactive isotopes of potassium.

The dual induction log showed resistivity values ranging from 10 to 200 ohm-meters. Resistivity peaks were noted at depths of 65 feet and 90 feet, which typically correspond to higher density rock types.

The porosity values are generally high in this section of the bore hole, 70 to 100 SU due to the unconsolidated make up of the Hawthorn Formation. The porosity of the borehole decreased with depth indicating a more competent formation.

***LZMW-1 Run 2*** was run on the 24-inch diameter reamed mudded borehole from land surface to 314 feet bls. The logs conducted were X-Y caliper and gamma ray utilized to confirm casing placement and estimate grout quantity for the installation of the 16-inch diameter surface casing to a depth of 300 feet bls. The caliper log showed a larger than gauge borehole that was fairly uniform with no significant fractures or voids and with an average diameter within the range of 25 and 28.5 inches. The formation appeared most competent in the bottom 50 feet of the borehole. The gamma ray log response was very subdued, most likely due to the large diameter of the reamed hole.

***LZMW-1 Run 3*** was run on the 12.25-inch pilot hole from land surface to 1,114 feet and 9.8-inch 1,141 feet bls in order to verify the pilot hole geology, determine hydrogeologic characteristics and determine the appropriate setting depth for the final casing and settings for the targeted packer tests utilized to identify the base of the USDW. The geophysical logs included the X-Y caliper, gamma ray, dual induction, temperature and BHC sonic.

Based upon the results of the caliper log, the pilot-hole diameter ranged from 13 to 21 inches from 300 to 1,114 feet and two fractures were present at 425 feet and 535 feet, which were shown to have a diameter of 16 and 18.5 inches respectively. The pilot hole diameter was greater than the bit gauge with an average diameter of approximately 21 inches from 600 to 790 feet, an average of 18 inches, from 800 to 960 feet, which may be related to the presence softer limestone beds washed out to a larger diameter. Below 1,020 feet bls the hole diameter averages 13.5 inches due to with no apparent fracturing or voids, due to harder lithology and the presence of more dolomitic limestone.

Higher gamma ray counts were detected at 400 feet, 548 feet and 790 feet bls, with the over-all gamma ray signature decreasing in variability with depth. The combination of significant gamma ray peaks and corresponding smaller caliper diameters at a depth of 548 feet is inferred as the top of the Suwannee Limestone formation.

The maximum porosity values were measured at depths of 300 feet to 650 feet bls. A general decrease in the porosity values began at a depth of 680 feet and continued to the base of the pilot hole at 1,142 feet, which correlates to the presence of dolomite.

The dual induction log showed resistivity values ranging from 6 to 90 ohm-meters. Resistivity peaks were noted at depths of 370 feet to 410 feet, 470 feet to 520 feet and 790 feet, and 980 feet to 1,110 feet bls, which typically correspond to higher density rock types.

A set of static and dynamic geophysical logs were conducted that including fluid conductivity, temperature and flow meter. The fluid conductivity log showed an increase in both static and dynamic conductivity values starting at a depth of 1,030 feet to a depth of 1,080 feet bls, increasing from 8,500 µS/cm to 21,500 µS/cm. The only decrease in dynamic conductivity is below the base of the surface casing at 300 feet bls and extending down to 380 feet bls, which indicates an increase in fresh water flow under dynamic conditions. This decrease also correlated to the only decrease observed in the dynamic temperature log as well. In the static logs a gradual increase is seen in both temperature and fluid conductivity, mirroring the trend of the dynamic logs. The only decrease in static temperature and static fluid conductivity is exhibited at a depth of 410 feet to 420 feet bls.

The flow meter log showed an increase in flow at depths of 580, 795, and 1,035 feet bls. The increases in flow rate at 580 to 795 feet bls may be related to constriction in borehole diameter.

A televiewer log conducted of open pilot hole from land surface to 1,141 feet. The log indicated that the open hole interval below the casing is comprised of friable micritic limestone with little fracturing intermixed with dolomitic layers. Fracturing and pitting is seen from a depth of 330 to 484 feet, 493 to 509 feet, 519 to 526 feet, 534 to 690 feet, 706 to 735 feet, 762 to 775 feet, 789 feet, 803 to 828 feet, 1,017 to 1045 feet and 1,104 feet to 1,115 feet bls.

***LZMW-1 Run 4*** was run on the 15-inch diameter reamed borehole from land surface to 1,114 feet and the 9.8-inch borehole to the base of the monitor interval at 1,142 feet bls. The logs conducted were X-Y caliper and gamma ray and were utilized to confirm casing placement and estimate grout quantity for the installation of the 6-inch intermediate casing to a depth of 1,115 feet bls. The caliper log showed a gauged borehole that was fairly rounded. Fractures were noted between 400 feet and 600 feet bls. From 600 feet to 800 feet the borehole is larger than gauge and washed out with an average diameter of 20 inches. The formation appeared most competent in the bottom 50 feet of the borehole. The gamma ray log showed the highest signatures between 350 feet to 400 feet bls, whereas the remainder of the log was uniform and the amplitude of the signature was decreasing with depth. Several isolated increases in the gamma ray signature were noted at depths of 550 feet and 800 feet bls.

***LZMW-1 Run 5*** consisted of five temperature logs that were conducted following the preceding cement stage during the grouting of the 16-inch intermediate casing to a depth of 1,114 feet bls. Five cementing stages were required to bring the cement to land surface. The results of the individual temperature logs were collectively displayed on the final stage cement log conducted on November 17, 2011. The temperature log (#1) completed after the first cementing stage delineated the top of the cement at a depth of 772 feet. The physical tag of the cement top was at a depth of 773 feet. The temperature log (#2) completed after the second cementing stage indicated that the top of the cement was located at approximately 620 feet, which was confirmed with a physical tag at a depth of 617 feet. The temperature log (#3) completed after the third and fourth cementing stage indicated a cement top at 304 feet and the physical tag indicated a cement top depth of 303 feet. The remainder of the annulus was grouted to land surface in cementing stage 5 after conducting the CBL log. In general, there was a good correlation between the cement top depth determined via the temperature logs and the physical cement tags.

***LZMW-1 Run 6*** following the completion of the fourth stage of cement, a cement bond log was conducted, after which the cement was brought to land surface.

An acoustic cement bond log was conducted on the 6-inch casing in order to detect the presence of the cement, and thus verify the integrity of the cement placement and seal. The log indicated that the cementation appeared complete (good bond) from casing to cement to formation. Additionally, the cement appeared dense throughout the entire length of the cemented casing from 1,115 feet to the top of cement (at the time of log run) at a depth of 303 feet below land surface.

### 3.6.3. UZMW-1 Logging Runs

A total of four individual logging events were performed during the construction of UZMW-1 (**Table 3-12)**. Copies of geophysical logs run on UZMW-1 are presented in **Appendix R**.

***UZMW-1 Run 1*** was a combination gamma ray and X-Y caliper log, as well as dual induction and BHC sonic logs, run inside the 12.25-inch diameter mudded pilot hole to a depth of 310 feet to verify the geologic characteristics of the formation exposed within the borehole and to select the casing setting depth for the 16-inch diameter surface casing. The pilot hole is gauged and round with no apparent fracturing or void space, with an average diameter within the range of 13 to 14 inches, with a maximum of 14.8-inches. The gamma ray log shows several sharp increases or spikes to the right concentrated in the upper 2/3 of the pilot hole. The increases in gamma ray counts correlate with formations that are higher in clays containing radioactive isotopes of potassium.

The dual induction log showed resistivity values ranging from 20 to 100 ohm-meters. Resistivity peaks were noted at depths of 70 feet and 90 feet, which typically correspond to higher density rock types.

The porosity values are generally high in this section of the bore hole, 70-100 (pu) due to the unconsolidated make up of the Hawthorn Formation. The porosity of the borehole decrease with depth indicating a more competent formation.

***UZMW-1 Run 2*** was run on the 24-inch diameter reamed mudded borehole from land surface to 304 feet bls. The logs conducted were X-Y caliper and gamma ray utilized to confirm casing placement and estimate grout quantity for the installation of the 16-inch diameter surface casing to a depth of 300 feet bls. The caliper log indicated a larger than gauge borehole that was fairly uniform with no significant fractures or voids and with an average diameter within the range of 25 and 26.5 inches. The formation appeared most competent in the bottom 50 feet of the borehole. The gamma ray log response was very subdued, most likely due to the large diameter of the reamed hole.

***UZMW-1 Run 3*** was run on the 12.25-inch pilot hole from land surface to 1,040 feet and 9.8-inch from 1,040 to 1,070 feet bls in order to verify the pilot hole geology, determine hydrogeologic characteristics and determine the appropriate setting depth for the final casing and settings for the targeted packer tests utilized to test the monitored interval. The geophysical logs included the X-Y caliper, gamma ray, dual induction, temperature and BHC sonic.

Based upon the results of the caliper log, the pilot hole diameter ranged from 13 to 21 inches from 300 to 1,040 feet and indicated a fracture present at 535 feet, which had a diameter of 18.5 inches. The pilot-hole diameter was greater than the bit gauge with an average diameter of approximately 17 inches from 600 to 790 feet, an average of 18 inches from 800 to 960 feet, which may be related to the presence of softer limestone beds washed out to a larger diameter. Below 1,020 feet bls the average hole diameter is 13.5 inches with no apparent fracturing or voids, due to harder lithology and the presence of more dolomitic limestone.

Higher gamma ray counts were detected at 400 feet, 548 feet and 790 feet bls, with the over-all gamma ray signature decreasing in variability with depth. The combination of significant peaks and corresponding smaller caliper diameters at depths of 400 feet and 548 feet are typically used to determine the depth of the top and bottom of the Suwannee Limestone formation.

The maximum porosity values were measured at depths of 300 feet to 450 feet, from 520 feet to 540 feet and from 575 feet and 610 feet bls. A general decrease in the porosity values began at a depth of 630 feet and continued to the base of the pilot hole at 1,070 feet, which correlates to the presence of dolomite.

The dual induction log showed resistivity values ranging from 6 to 90 ohm-meters. Resistivity peaks were noted at depths of 470 feet to 540 feet and 790 feet, which typically correspond to higher density rock types.

A set of static and dynamic geophysical logs were conducted including; fluid conductivity, temperature and flow meter. The fluid conductivity log indicated an increase in both static and dynamic conductivity values starting at a depth of 1,020 feet to a depth of 1,060 feet bls, increasing from 8,900 µS/cm to 14,191 µS/cm in the dynamic log and 17,800 µS/cm to 27,800 µS/cm in the static log. According to the static and dynamic temperature logs an increase in temperature with depth is indicated. The static temperature increases from 81.8 °F at 610 ft bls to 85.9 °F at 640 feet bls.

The flow meter log indicated an increase in flow at depths of 598 feet, 668 feet and 804 feet bls. The increases in flow rate at 804 feet bls may be related to constriction in borehole diameter.

***UZMW-1 Run 4*** was run on the 15-inch diameter reamed borehole from land surface to 1,040 feet and the 9.8-inch borehole to the base of the monitor interval at 1,070 feet bls. The X-Y caliper and gamma ray logs conducted were utilized to confirm casing placement and estimate grout quantity for the installation of the 6-inch intermediate casing to a depth of 1,040 feet bls. The caliper log indicated a gauged borehole that was fairly rounded. Fractures were noted between 400 feet and 600 feet bls. From 600 feet to 800 feet, the borehole is larger than gauge and washed out with an average diameter of 20 inches and from 800 feet to 970 feet the borehole is an average diameter of 19 inches due to a degree of washout. The formation appeared most competent in the bottom 50 feet of the borehole. The gamma ray log indicated the highest signatures between 350 feet to 400 feet bls and the remainder of the log was uniform and the amplitude of the signature was decreasing with depth. Several isolated gamma ray increase kicks were noted at depths of 550 feet and 800 feet bls.

***UZMW-1 Run 5*** consisted of four temperature logs that were conducted following the preceding cement stage during the grouting of the 6-inch FRP final casing to a depth of 1,040 feet bls. Five cementing stages were required to bring the cement to land surface. The results of the individual temperature logs were collectively displayed on the final stage cement log conducted on December 13, 2011. The temperature log (#1) completed after the first cementing stage delineated the top of the cement at a depth of 1,010 feet. The physical tag of the cement top was at a depth of 1,013 feet. The temperature log (#2) completed after the second cementing stage indicated that the top of the cement was located at approximately 812 feet, which was confirmed with a physical tag at a depth of 813 feet. The temperature log (#3) completed after the third cementing stage indicated that the top of the cement was located at approximately 630 feet, which was confirmed with a physical tag at a depth of 618 feet. The temperature log (#4) completed after the fourth cementing stage indicated that the top of the cement was located at approximately 316 feet, which was confirmed with a physical tag at a depth of 310 feet. The remainder of the annulus was grouted to land surface in cementing stage 5.

### 3.7. Injection Test

In compliance with the DIW-1 Well Construction permit stipulations, testing requirements and FDEP approved injection test protocol, a short term, high rate injection test was completed on the DIW-1 between May 3 and 7 of 2012. The purpose of the test was to demonstrate the ability of the well to assimilate high rate flows. Atkins personnel along with City staff coordinated the testing activities (valves and plant operations) and observed the injection test. Contractor personnel (YBI) were also present on site to monitor equipment performance and ensure instrumentation and controls were working properly.

The approved injection testing program is presented in **Appendix O** and consists of a two step approach. Water was injected from the WWTF for a period of four hours (at a low rate) which is then immediately stepped to a sustained high rate. The actual rates were determined in the field based on water availability and system hydraulics. Prior to and during the injection test, operational and system response data would be collected from the onsite flow meters, pressure gauges and ancillary instrumentation. Additionally, down hole pressure data, barometric data and tidal data would be collected 24-hours before the test, during the 8-hour injection test, and 24-hours after the test.

On May 3, 2012, a pre-test was conducted to ensure logistics were in place to convey water to the well and that instrumentation and pressure gauges were operating properly prior to initiating the injection test. The preliminary testing protocol followed that of the approved testing plan but was shorter in duration. **Figures 3-33, 3-34, 3-35, and 3-36** illustrate the wellhead configurations and location of flow meters, pressure gauges, flow meter digital readouts and valves.

During the preliminary test, flow reached a high of 3,600 gallons per minute (gpm) and stabilized between 2,900 and 3,000 gpm according to the total flow sonic meter digital readout (see **Figure 3-35**). Pressure gauges and digital transducer readouts were checked for the injection well, annulus system and monitor wells and all were operating properly. All Injection Test data are included on a compact disk in **Appendix O**.

### 3.7.1. 8-Hour Injection Test - Step 1

Background data collection for the injection test was initiated at about 12:00 PM on May 4, 2012. At 19:40 PM on May 5, 2012, the injection test was initiated and flow from the City WWTF was injected down the well at a rate of approximately 3,600 gpm. All pressure and flow data collected manually during the eight hour injection test is presented in **Table 3-13**.

The step 1 rate remained relatively constant at about 3,600 gpm between 19:53 PM and 23:37 PM (4 hours) as per the approved injection testing program.

Pressure at the injection wellhead for the entire injection test is shown in **Figure 3-37**. Static wellhead pressure was approximately 0 psi (gauge) and increased immediately to about 18 psi when injection commenced. This equates to a wellhead pressure increase of approximately 18 psi at a flow rate of 3,200 gpm. The low wellhead pressure increase is indicative of a highly efficient injection well.

**Figure 3-38** illustrates the annular pressure throughout the course of the entire injection tests. Annular pressure was approximately 91 psi at the beginning of Step 1 injection and remained relatively constant throughout the 4-hour step.

The pressure observed from downhole pressure transducers during step 1 of the injection test for the UZMW-1 and the LZMW-1 are presented in **Figure 3-39**. Both wells responded to the initial pressure wave resulting from the initiation of injection and stabilized relatively quickly. The LZMW-1 well pressure increased on the order of 0.76 psi while the UZMW-1 well pressure increased on the order of 1.27 psi.

### 3.7.2. 8-Hour Injection Test – Step 2

Step 2 of the injection test began at 23:43 PM, the flow rate from the City WWTF was increased to approximately 6200 gpm and then decreasing to 5900 gpm for the remainder of the test.

The maximum flow rate reached a high of 6,350 gpm (9.2 million gallons per day) and averaged about 6000 gpm (8.6 million gallons per day) over the last four hours of the test. The flow rate was sustained at a rate of 6000 gpm for approximately 2 hours (from 00:45 AM to 2:40 AM) and consistently at 5900 in the last hour of the test.

Pressure at the injection wellhead for the entire injection test is shown in **Figure 3-37**. As previously discussed, pressure towards the end of step 1 was approximately 17 psi. Within the first hour of step 2 injection, injection wellhead pressures rose to a high of 53.5 psi, with a final pressure of 50 psi and averaging about 51 psi during high rate injection. Total wellhead pressure increase over the course of the injection test was about 50 psi at an average maximum flow rate of 6000 gpm.

Annular pressure increased over the course of the injection tests, to a maximum of approximately 93psi during step 1. With the initiation of Step 2, the annular pressure rose above the tolerance of the transducer probe (100psi), and it became necessary for the contractor to bleed off the system to approximately 95psi to preserve data integrity of the recorder. Ultimately the pressure increased to a maximum of approximately 96 psi during step 2. The increases in annular pressure with the initiation of each step directly correlates to the increase in injection rate as the test progressed.

The pressure observed during step 2 of the injection test for the UZMW-1 and the LZMW-1 are also presented in **Figure 3-39**. Both wells responded to the step 2 increase in injection flows. The LZMW-1 well pressure increased on the order of 0.7 psi while the UZMW-1 well pressure increased on the order of 0.62 psi. Overall, the maximum increase in well pressures for both the UZMW-1 and the LZMW-1 over the course of the injection tests was 1.2 psi and 1.45 psi, respectively.

### 3.7.3. Background Barometric, Tidal, and Downhole Data

Background data were obtained for 24-hours before the injection test, during the 8-hour injection test, and for 24-hours after the test. Transducers were installed in the DIW-1, UZMW-1, LZMW-1, annulus, and at the bottom of the well casing. Additionally, barometric data were measured throughout the testing period. Tidal data were obtained for a three day period (May 3 – May 7) from the nearest NOAA station at Port Manatee in Bradenton, Fl.

**Figure 3-40** shows pressure data for the DIW-1, UZMW-1, and LZMW-1 as well as barometric data and tidal data for the entire testing period (24-hours before the test, during the 8-hour injection test and 24-hours after the injection test). Barometric pressure remained relatively stable over the course of the injection test and has no significant impact on well pressures observed during the eight hour injection test.

Down hole pressure was monitored before, during and after the test using an oilfield pressure transducer deployed at the bottom of the well casing (approximately 1,250 feet bls). The downhole pressure data are shown in **Figure 3-41**. The downhole pressure was measured at approximately 552 psi before the test. During the injection test, downhole pressure increased to approximately 607.2 psi, or a total pressure increase of 55.2 psi. Tidal data was plotted against the formation pressure for the duration of the testing period. The tidal fluctuations showed no correlation with pressures measured in the DIW or monitor wells.

### 3.7.4. Injection Test Results

1. A two step, high rate injection test was completed on the DIW-1 deep well on May 6, 2012 following an approved 2 step injection process.

2. Step 1 of the test consisted raw groundwater conveyed to the well at a rate of about 3,600 gpm for a period of four hours.
3. Well head pressure on the injection well increased by 18 psi at the sustained flow injection rate of 3,600 gpm indicating a highly efficient injection well.
4. Barometric pressure was monitored and showed no appreciable changes that would significantly affect well pressure readings.
5. In Step 2 the flow was increased to approximately 6000 gpm for the last four hours.
6. Total flow rate averaged approximately 6000 gpm for the last four hours of the test at an average injection pressure of 51psi.
7. Pressures in the LZMW and the UZMW increased a total of 1.46 and 1.84 respectively.
8. A transducer placed below the bottom of the well casing showed an increase in pressure of 55.2 psi.
9. Tidal data was obtained and plotted along with the formation pressure data and no correlation was observed.

### 3.7.5. Injection Test Recommendations

1. Authorize a maximum sustained injection rate not to exceed 6000 gpm during operational testing of the well.
2. Set the maximum sustained injection pressure at 105 psi based on the MIT completed on the well.
3. Finalize the monitoring requirements and frequencies in addition to formatting FDEP Monthly Operating Reporting (MOR's) forms.

## 3.8. Vertical Travel Time Calculations

The vertical travel time of a freshwater injectate plume was calculated between the top of the injection zone (1197 feet) and the base of the USDW (1120 feet). The USDW during the drilling of the injection well was estimated at a depth of 1120 feet, below which, the background water quality TDS concentration was 35,056 mg/L. **Table 3-14** summarizes the calculation for vertical travel time using the Darcy equation and incorporating injection well core permeability and porosity data, injection pressure, fresh water head differences, and buoyancy factors. Vertical upward flow migration is dependent upon the static head differences between the injection zone and overlying units, the pressure directly caused by injection, and the buoyancy of the fresher injectate in a saline injection zone. The static head within the upper monitoring zone, which is near the location of the base of the USDW, was selected as the lower reference point some 122 feet above the injection zone.

Water levels (heads) and injection pressures were obtained during the injection test and post monitoring period conducted at the DIW-1 site on from May 3 through May 7, 2012. For the analysis, static injection well and UZMW-1 heads were referenced to feet from land surface. The injection well water level (29.44 feet NGVD) measured on May 4, 2012 before the injection test was selected as the static equivalent fresh water head. The UZMW-1 water level (8.42 feet NGVD) measured at the same point in time was selected as the static equivalent fresh water head because the TDS concentration of this well (5,440 mg/l) suggests that the measured water level is not significantly affected by salt water density differences.

Using the static head differential, an aquifer pressure increase of 41.5 feet during injection at the maximum anticipated brine injection rate and a buoyancy pressure displacement of 1.88 feet, the total differential pressure between the top of the injection zone and the upper monitoring zone is calculated to be 64.4 feet. The vertical head gradient between the two zones, which are separated by 122 feet, is then 0.53 feet per foot. Incorporating the vertical permeability (0.009 feet per day based on core data) and porosity (0.2 dimensionless) of the formation along with the head gradient into Darcy's equation yields a linear travel time of 0.02 feet per day. It then follows that the estimated travel time for a brine injectate from the top of the injection zone to the base of the UZMW (distance of 122 feet) is on the order of 14 years.

# 4.0 Wellhead Configuration

The currently completed construction well consists of the DIW wellhead terminating in an 18-inch diameter stainless steel flange, the monitor wells finished with a stainless steel riser and flange, and Surficial monitor wells completed at land surface protected by a steel meter box and concrete pad. The top of the flange at the DIW has an elevation of 29.27 ft NGVD, and has been fitted with a temporary 3-inch ball valve to allow access to the well for future planned construction activities. The DIW-1 wellhead, final site layout and surveyed elevations of DIW-1, LZMW & UZMW, and the four Surficial Aquifer monitor wells SMW-1, SMW-2, SMW-4 and SMW-5 are shown in **Figure 4-1**. Photographs of the completed well pad and DIW well system are shown in **Figure 4-2**.

# 5.0 Summary and Recommendations

## 5.1. Summary

A Class I Industrial deep injection well and two deep monitor wells were successfully constructed and tested at the City of Sarasota WWTF site in Sarasota County. DIW-1 was completed with a 28-inch steel casing to an approximate depth of 1,197 feet with an open-hole section (injection zone) extending to an approximate depth of 1,762 feet. The injection well is a tubing and packer designed system. An 18-inch diameter FRP tubing was installed with a stainless steel packer system inside the 28-inch steel casing. The annulus between the tubing and steel casing is fluid filled and the annulus pressure is monitored as an early warning leak detection system.

LZMW-1 was constructed with a monitoring zone interval of approximately 1,115 to 1,141 feet below land surface and UZMW-1 with a monitoring zone interval of approximately 1,040 to 1,075 feet below land surface. Four shallow water table monitoring wells were installed around the deep wells to monitor the Surficial Aquifer water quality during construction activities. All drilling operations were conducted under construction permits issued by the FDEP and the SWFWMD.

A hydrogeologic testing program was approved by the FDEP and stipulated as part of the injection well construction permit. The testing program was performed on DIW-1 system during construction activities and included the following: formation sampling, rock coring, open-hole packer hydraulic testing, water quality sampling, geophysical logging, and a short-term (8-hour) injection test.

Data collected from the hydrogeologic testing program were used to define the hydrogeologic framework beneath the City of Sarasota site and aid in developing the final construction details for the deep wells. Formation sampling and geophysical logging were used to verify the geology of the site. Geophysical logging and water quality sampling (airlift and packer test) were used to determine the occurrence of the USDW, which was identified at approximately 1120 feet.

Water quality samples also allowed a characterization of the background water quality conditions within the injection zone and monitoring intervals. Rock cores and packer tests were used to estimate the hydraulic characteristics of confining units overlying the injection zone. The geometric average of vertical permeability of the overlying geologic units tested was 0.009 feet per day. Based on this vertical permeability, the estimated vertical travel time from the top of the injection zone (1,200 feet) to the base of the UZMW (1075 feet) is approximately 14 years.

A short-term (8-hour) injection test was performed on DIW-1 following completion of a successful MIT. An average flow rate of approximately 3,600 gpm and a maximum flow rate of 6,000 gpm were sustained for the final 4 hours of the test with a maximum wellhead pressure change of 51 psi. A down-hole memory pressure transducer was utilized to directly measure pressure in the formation below the base of the casing. The formation pressure increase resulting from injection was 55.2 psi above static conditions. This injection test demonstrated that a suitable injection zone exists between 1,200 and 1,762 feet.

The flow rate during the injection test was limited by the existing pumping and temporary piping infrastructure at the treatment plant, which did not allow injection pressures to rise above 51 psi at the wellhead. The City is currently designing a new, permanent pumping and piping injection system that will allow higher flow rates to be sent to the injection well.

## 5.2. Recommendations

An operational testing program will be performed in compliance with the injection well construction permit for DIW-1 and in support of the injection well operating permitting process. The proposed operational testing program will consist of injecting brine reject water and/or reuse water initially at a rate of up to 6,000 gpm (9 MGD) at a maximum wellhead pressure not to exceed 105 psi. The City anticipates requesting a greater injection rate for operational testing once the construction of the permanent pumping and piping infrastructure is completed and the higher rate can be demonstrated through a short-term rerate test. Operational monitoring will consist of recording flows, injection wellhead pressures, monitor well pressures, and water quality sampling.

The operational testing period for DIW-1 will not exceed two years from the date of authorization and cannot extend beyond the current construction permit which expires on January 31, 2016. Data collected during operational testing will be submitted to the FDEP on a monthly basis as required by the operating permit. After a minimum testing period of one year, the test data will be reviewed and incorporated into a summary report for the FDEP, in support of the operating permit application.

# 6.0 References


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*Hutchinson, C. B., 1992, Assessment of hydrogeologic conditions with emphasis on water quality and wastewater injection, southwest Sarasota and west Charlotte Counties, Florida: U.S. Geological Survey Water-Supply Paper 2371, 74 p.*

*Knochenmus, Lari A. and Bowman, Geronia, 1998. Transmissivity and Water Quality of Water-Producing Zones in the Intermediate Aquifer System, Sarasota County, Florida. U.S. Geological Survey Water-Resources Investigations Report 98-4091.*

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# Section 2 Tables

# CITY OF SARASOTA RO WATER TREATMENT FACILITY
# DEEP INJECTION WELL

## TABLE 2-1
## CHRONOLOGY OF DIW-1 SIGNIFICANT CONSTRUCTION AND TESTING ACTIVITIES

| DATE | ACTIVITY |
|---|---|
| 7/13/11 | Preconstruction meeting on site at the City of Sarasota Water Treatment FACILITY (WTF) property (future site of the injection well system). Youngquist Brothers, Inc. (YBI) is authorized to begin mobilization of drilling equipment and supplies. |
| 7/26/11 | Notice to Proceed issued by the City of Sarasota |
| 8/9/11 | Install Surficial aquifer monitor well (SMW) 1-4 around the deep injection well (DIW) pad and installed the supply well for drilling operations. The supply well was drilled to 200 feet and casing was set to a depth of 85 feet below land surface (bls) |
| 8/18/11 | The City of Sarasota conducted all site inspections |
| 8/19/11 | Electric power is turned on by Florida Power and Light (FPL) |
| 8/21/11 | YBI initiated mud rotary drilling of the injection well pilot hole with a 12.25-inch diameter tricone bit |
| 8/22/11 | Complete injection well pilot hole drilling to a depth of 300 feet bls. The formation consisted primarily of clay but solid limestone geologic formations were encountered below 290 feet bls |
| 8/23/11 | Conduct RUN 1 geophysical logging suite: XY caliper, gamma, dual induction, borehole compensated (BHC) sonic with Variable Density Log (VDL). Initiated reaming with a 58.5-inch complex reamer bit in support of the surface casing installation |
| 8/24/11 | Continue reaming; 52-inch diameter casing was delivered to the site |
| 8/25/11 | Continue reaming to approximate depth of 100 ft bls |
| 8/26/11 | Reaming continued to an approximate depth of 150 feet bls |
| 8/27/11 | Reaming continued to an approximate depth of 194 feet bls |
| 8/28/11 | Reaming continued to an approximate depth of 260 feet bls |
| 8/29/11 | Reaming was completed to 314 feet bls (14 feet beyond the pilot hole, due to lithology) |
| 8/30/11 | Conducted XY caliper and gamma ray geophysical logs of the reamed borehole to a depth of 314 ft bls. Estimated annular borehole volume is 340 bbls, cement plan and casing tally submitted in prep for 52-inch casing install. Will install to 310 ft bls with the surface pipe (only pay for 300 feet of pipe due to YBI over drill). Begin installation of the injection well 52-inch surface casing. |
| 8/31/11 | Pressure grout the casing to land surface using 100 barrels of neat cement and 120 barrels of cement with a 6% bentonite added gel; Total of 220 barrels of grout. Close-in pressure is 65 psi. Possibility that caliper log was out of calibration thus leading to the discrepancy in grout quantities; will re-calibrate and resubmit logs |
| 9/1/11 | Prepare for reverse-air drilling, dispose of the drilling mud from the pits off-site |
| 9/2/11 | Continue preparations and mud disposal. Tripped in the drilling assembly and |

| DATE | ACTIVITY |
|---|---|
| | drilling through the cement plug at the bottom of the injection well surface casing. Began reverse-air drilling of the pilot hole to a depth of 480 ft bls. Airlift water quality samples were collected every 30 ft beginning at 330 ft bls. The samples were analyzed and sent to the lab for analysis of pH, chloride, specific conductivity, sulfate and total dissolved solids |
| 9/3/11 | Continued injection well pilot hole reverse-air drilling to a depth of 750 ft bls |
| 9/4/11 | Continue pilot hole drilling to a depth of approximately 960 ft bls |
| 9/5/11 | Continued pilot hole drilling to a depth of 1023 ft bls and cut CORE 1 from 1023 ft bls to 1038 ft bls. The core sample consisted of approximately 70% recovery, 11 ft of formation material, with several sections suitable for testing. Conducted drift inclination survey at 940 feet (< 0.25º) |
| 9/6/11 | Continue pilot hole drilling with 12.25-inch drill bit via reverse-air methods; collecting water quality samples for field and laboratory analysis. Drilled to a depth of 1050 ft bls and began cutting CORE 2 from 1050 to 1065 feet bls. Conducted a drift inclination survey at 1,030 feet (0.25º). |
| 9/7/11 | Completed cutting CORE 2 to a depth of 1062 feet bls (12 ft attempt), resulted in 5 ft of recovered formation material, approximately 30% recovery, possible sections for testing, resume pilot hole drilling to a depth of 1085 feet by the end of the day |
| 9/8/11 | Conduct a drift inclination survey at 1,120 feet (< 0.25º). In support of determining the depth of the base of the underground source of drinking water (USDW), field water quality samples were collected every five feet beginning at 1,400 feet. Reverse-air drilling of the 12.25-inch pilot hole continued until a depth of 1,135 feet (Specific Conductance = 5,010 µS/cm). |
| 9/9/11 | CORE 3 was collected from 1135 to 1142 feet bls; approximately 5 ft of material returned, with over three testable sections. Trip back in with the 12.25-in tricone bit, continue drilling to 1163 ft bls, collecting field water quality samples every 5 ft in an attempt to locate the USDW. |
| 9/10/11 | CORE 4 was collected from 1163 to 1178 ft bls and resulted in a full recovery. Resume pilot hole drilling with 12.25-inch bit. The water level in the pilot hole was approximately 17 ft bls. Drilled to 1218ft bls, continue collecting field water quality every 5 ft and lab samples every 30 ft. |
| 9/11/11 | Continued pilot hole drilling to 1231 ft bls, collecting water quality along the way. The specific conductivity increased to 15,190 µS/cm (in closed circulation). The following geophysical logs of the pilot hole were conducted: XY caliper, gamma, temperature, dual induction, BHC sonic VDL with log derived TDS and televiewer from the base of the pilot hole at 1,231 ft to the bottom of the surface casing at 310 feet. |
| 9/12/11 | Conduct PACKER Test No. 1 across the interval between 1200 to 1232 ft bls. Pumped for 4 hours (2 hour of recovered background, 2 hours recovery) and a maximum drawdown of 79.4 ft occurred at a pumping rate of 75 gpm, resulting in a specific capacity of 0.94 gpm/ft of drawdown. The groundwater specific conductivity was 51,500 µS/cm and water quality samples were collected for lab analysis. |
| 9/13/11 | Development |
| 9/14/11 | Conduct PACKER Test No. 2 across the interval between 1157 to 1188 ft bls. |

| DATE | ACTIVITY |
|---|---|
| | Pumped for 5 hours (2 hour recovered background, 6 hours recovery) and a maximum drawdown of 100 ft occurred at a pumping rate of 4 gpm, resulting in a specific capacity of 0.04 gpm/ft of drawdown. The groundwater specific conductivity was 2,600 µS/cm and water quality samples were collected for lab analysis. |
| 9/15/11 | Conduct PACKER Test No. 3 across the interval between 1119.5 to 1150.5 ft bls. Pumped for four hours (2 hours background, 3 hours recovery) and a maximum drawdown of 102.6 ft occurred at a pumping rate of 42 gpm, resulting in a specific capacity of 0.41 gpm/ft of drawdown. The groundwater specific conductivity was 24,200 µS/cm and water quality samples were collected for lab analysis at the fourth hour. |
| 9/16/11 | Conduct PACKER Test No. 4 across the interval from 1044.5 to 1075.5 ft bls. Pumped the interval for four hours (2 hours background, 3 hours recovery) and a maximum drawdown of 47 ft occurred at a pumping rate of 86.3 gpm, resulting in a specific capacity of 1.86 gpm/ft of drawdown. The groundwater specific conductivity was 8,960 µS/cm and water quality samples were collected for lab analysis at the fourth hour of pumping. |
| 9/17/11 | With packer tests complete, begin back plugging the pilot hole in preparation for reaming in support of the installation of the intermediate casing. Gravel back from 1231 ft to 1158 ft bls with approximately 75 $ft^3$ of gravel. Add two shots of cement (12%) 102 barrels and 124 barrels, bringing the top of cement to approximately 500 ft bls. Begin preparations for reverse-air reaming |
| 9/18/11 | Begin reaming the injection well borehole. |
| 9/20/11 | Continue reaming at 470 ft bls (at AM shift change) |
| 9/21/11 | Continue reaming at 551 ft bls (at AM shift change); packer test water quality report delivered (preliminary) |
| 9/22/11 | Continue reaming at 781 ft bls (at AM shift change). Atkins submitted a request for approval for the intermediate casing seat to FDEP for a recommended casing setting depth of 1,120 ft bls. |
| 9/23/11 | Continue reaming at 1021 ft bls (at AM shift change) |
| 9/24/11 | Reaming continued, to apx 1042 ft bls; drift indicator surveys continue to be conducted every 90 ft bls, have not exceeded .25deg |
| 9/25/11 | Reaming continued to 1116 ft bls |
| 9/26/11 | Reaming completed to a depth of 1123 ft bls and borehole was prepped for the installation of the intermediate casing |
| 9/27/11 | Geophysical logging RUN4, consisting of XY caliper, gamma confirm borehole for casing prep and estimate grout quantities. SWM sampled. Intermediate casing, 40-inch .375-inch steel wall installed to a depth of 1120 ft bls. 23 pieces of casing apx 40 ft in length |
| 9/28/11 | STAGE 1; pressure grouted with 325 bbls neat cement. temp tag and physical tag apx 790 ft bls (theo 740 ft bls). STAGE 1; tremmie grouted 239 bbls 6% gel cement. cement top 651 ft bls (theo 600 ft bls) |
| 9/29/11 | STAGE 3; tremmie grouted 300bbls 6% gel cement, tag is 590 ft bls (theo 350 ft bls). STAGE 4; tremmie grouted 204 bbls 6% gel cement, tag is 451 ft bls (theo 350 ft bls) |
| 9/30/11 | STAGE 5; tremmie grouted 227 bbls 6% gel cement, tag 215 ft bls (theo 200 ft bls). |

| DATE | ACTIVITY |
|---|---|
| | STAGE 6; tremmie grouted 217 bbls 6% gel cement, cement return at LS |
| 10/1/11 | Drill out cement plug and continue 12.25 inch pilot hole to a depth of 1160 ft bls on reverse air, conduct deviation surveys every 90 ft, collect lithology samples every 10 and water quality samples every 30 feet for lab and field analysis |
| 10/2/11 | Continue pilot hole drilling to 1215 ft bls |
| 10/3/11 | Continue pilot hole drilling to 1267 ft bls |
| 10/4/11 | Continue pilot hole drilling to a depth of 1334 ft bls |
| 10/5/11 | Continue pilot hole drilling to a depth of 1423 ft bls |
| 10/5/11 | Continue pilot hole to a depth of 1560 ft bls |
| 10/7/11 | Completed pilot hole drilling to a depth of 1762 ft bls; evaporites found at 1760 ft; hole prepped for logging |
| 10/8/11 | Conduct geo logging RUN6; full suite of static and dynamic across 1120-1762 ft bls; xy caliper, gamma, dual induction, sonic, video (didn't work to cloudy cant stress the bottom of the hole enough) |
| 10/9/11 | Continue logging RUN 6; televiewer log. PACKER TEST 5; packer assembly was tripped in to center line at 1501 ft bls, isolated zone is off bottom. 1762 to 1501 ft bls. Install 5 hp sub pump and run at 90 gpm with a max drawdown of 3 ft. Spec Cap is 30 gpm/ft of DRAWDOWN. Test was over 4 hr and final water quality sample showed 52,600 us/cm field conductivity. Samples were sent to the lab for analysis |
| 10/10/11 | PACKER TEST 6; 31 ft straddle, interval 1276-1307 ft bls. Pumped at 92 gpm with 1.1 ft of max drawdown for 2.5 hrs. Spec Cap 83.6 gpm/ft of DRAWDOWN. Final water quality sample showed 51,600 us/cm field conductivity. Samples were sent to the lab for analysis |
| 10/11/11 | PACKER TEST 7; 31 ft straddle, interval 1446-11477 ft bls. Pumped at 92 gpm with max drawdown of 2.87 ft. Spec Cap 31.4 gpm/ft of DRAWDOWN. Test was over 3 hrs and the final water quality sample showed 51,000 us/cm conductivity. Samples were sent to the lab for analysis |
| 10/12/11 | Began reaming the borehole to 38-inch diameter to a depth of 1153 ft bls, on reverse air |
| 10/13/11 | Completed reaming of the borehole to a depth of 1197 ft bls (anticipated 28-inch final casing seating). |
| 10/14/11 | Began reaming with a 24-inch bit reverse air in the pilot hole below the proposed casing seat at 1197 ft to 1214 ft bls |
| 10/20/11 | Continue reaming borehole to a depth of 1692ft |
| 10/22/11 | Completed the reamed 24-inch borehole to a depth of 1762 ft bls under reverse air, cleared the bottom of the borehole and began demobilization of the IW drilling rig. Will now drill the monitors and await 28-inch casing delivery |
| 12/16/11 | After completion of the monitor wells, remobilization back to the IW site begins |
| 12/21/11 | Mobilization complete, geophysical logging RUN7; XY caliper to check the depth and condition of the borehole, all good |
| 1/9/12 | First delivery of 28-inch final casing delivered to the site. Casing is steel .5-inch wall |
| 1/11/12 | Second delivery of 28-inch final casing delivered to the site. Total on site is 1193 ft . a 30-inch diameter, apx 7 ft long section of casing will be sandwiched into the bottom 10 ft of the casing run to extend the full casing length to 1197 ft . the positive seal packer assembly will be located at apx 1185 ft bls |

| DATE | ACTIVITY |
|---|---|
| 1/13/12 | Submit casing modification request for the installation of the piece of 30-inch casing. |
| 1/17/11 | FDEP approves the modification request, continued prepping casing for installation |
| 1/19/12 | Began installation of the 28 inch, 0.5-inch wall steel final casing, 40 sections of pipe with an average length of 30 ft were installed to a depth of 338 ft bls, centralizers were attached as per the spec |
| 1/20/12 | Continued casing installation to a depth of appx 800 ft bls |
| 1/21/12 | Completed casing installation and landed the casing at 1197 ft bls |
| 1/22/12 | Began installation of gravel into the bottom of the annular space to help secure the bottom of the casing and isolate the annular space from the injection zone below. Approximately 50 gallons of gravel were installed. |
| 1/23/12 | An additional 75 gallons of gravel were installed in the annular space making the combined gravel top 1189 ft bls as determined with a physical tag. Small grout shots are used to seat the bottom of the casing. STAGE A ; 1 bbl neat cement via tremmie. Yielded a 2 ft lift, cement top at 1187 ft bls by physical tag. STAGE B ; 1bbl neat cement via tremmie, yielded 6 ft of lift, cement top at 1181 ft bls by physical tag. |
| 1/24/12 | Installed STAGE 1; 47 bbls neat cement, yielded 78 ft of fill, cement top at 1107 ft bls (inside of the intermediate casing bottom at 1120 ft bls) as verified by agreement between the cement top temperature log and the physical tag by tremmie pipe. STAGE 2; 220 bbls of neat cement via tremmie, yielding 289 ft of lift and a cement top of 818 ft bls, as verified by temp log and physical tag |
| 1/25/12 | STAGE 3; 232 bbls of neat cement, yielded 307 ft of fill and a cement top of 511 ft bls as confirmed by agreement between temp log and physical tag. STAGE 4; 186 bbls neat cement, resulted in 256 ft of lift and a cement top of 255 ft bls, confirmed by temp log and physical tag. |
| 1/27/12 | Conduct CBL in the final casing to show quality of annular cementing behind the casing. STAGE 5; 193 bbls neat cement, yielding 255 ft of lift and bringing the cement top to land surface with a full grout return. |
| 1/30/12 | Weld on casing header in preparation for casing pressure test. FDEP was alerted to the possibility of a casing pressure test on 1/31 or 2/1. Initial preliminary pressure test conducted by the contractor passed, and the contractor pressure testes the casing prior to beginning cementing work, which also passed |
| 1/31/12 | Continuing to work on the system to get it to pass an hour long preliminary casing pressure test. ` |
| 2/1/12 | Casing pressure test conducted on 28-inch steel casing, packer set at 1170 ft bls, system pressurized to 160 psi; loss of 0.5 psi over the 60 minute test. passed by FDEP Rommy |
| 2/2/12 | Prep to install 18-inch FRP |
| 2/3/12 | Install 18-inch FRP to a depth of 1180; PBR stinger installed on the bottom of the leading pipe; 41 joints made up with glue and torqued to 195 psi. |
| 2/4/12 | FRP was landed at 1180 ft bls while the annular volume was replaced with a 1% Baracor solution (approx 19,000 gal) |
| 2/7/12 | Conduct annular pressure test at 153 psi; loss of 1psi over 60 minutes. Test passed by FDEP Rommy |
| 2/8/12 | Begin development of the DIW for background water quality sampling. Estimated 62000 Gal will be evacuated |

| DATE | ACTIVITY |
|---|---|
| 2/10/12 | Benchmark sampled the well for primary and secondary water quality standards; final video survey was conducted inside the tubing(observing all seams) then proceeded to view the open interval and the bottom at 1754 ft bls. (video in preparation for RTS) |
| 2/23/12 | Conduct RTS test on the completed well. |

**TABLE 2-2**

**City of Sarasota RO Water Treatment Plant Test Injection Well**

**DIW-1 DRIFT INCLINATION SURVEY RESULTS**

| Date | Depth (ft) | Deviation (degrees) | Drilling Status |
|---|---|---|---|
| 8/22/2011 | 90 | <0.25 | 12.25-inch pilot hole |
| 8/22/2011 | 180 | 0.25 | 12.25-inch pilot hole |
| 8/22/2011 | 270 | 0.25 | 12.25-inch pilot hole |
| | | | |
| 8/25/2011 | 90 | <0.25 | 58.5-inch reamed borehole |
| 8/25/2011 | 180 | 0.25 | 58.5-inch reamed borehole |
| 8/25/2011 | 270 | 0.25 | 58.5-inch reamed borehole |
| | | | |
| 9/2/2011 | 400 | <0.25 | 12.25-inch pilot hole |
| 9/3/2011 | 490 | <0.25 | 12.25-inch pilot hole |
| 9/3/2011 | 580 | 0.25 | 12.25-inch pilot hole |
| 9/3/2011 | 670 | 0.25 | 12.25-inch pilot hole |
| 9/4/2011 | 760 | 0.25 | 12.25-inch pilot hole |
| 9/4/2011 | 850 | 0.25 | 12.25-inch pilot hole |
| 9/5/2011 | 940 | <0.25 | 12.25-inch pilot hole |
| 9/6/2011 | 1,030 | 0.25 | 12.25-inch pilot hole |
| 9/8/2011 | 1,120 | <0.25 | 12.25-inch pilot hole |
| | | | |
| 9/19/2011 | 400 | 0.25 | 48.5-inch reamed hole |
| 9/20/2011 | 490 | 0.25 | 48.5-inch reamed hole |
| 9/20/2011 | 580 | 0.25 | 48.5-inch reamed hole |
| 9/21/2011 | 670 | 0.25 | 48.5-inch reamed hole |
| 9/21/2011 | 760 | 0.25 | 48.5-inch reamed hole |
| 9/23/2011 | 850 | 0.25 | 48.5-inch reamed hole |
| 9/24/2011 | 940 | 0.25 | 48.5-inch reamed hole |
| 9/25/2011 | 1,030 | 0.25 | 48.5-inch reamed hole |
| 9/26/2011 | 1,120 | 0.25 | 48.5-inch reamed hole |
| | | | |
| 10/3/2011 | 1,210 | 0.25 | 12.25-inch pilot hole |
| 10/4/2011 | 1,300 | <0.25 | 12.25-inch pilot hole |
| 10/5/2011 | 1,390 | 0.25 | 12.25-inch pilot hole |
| 10/5/2011 | 1,480 | <0.25 | 12.25-inch pilot hole |
| 10/6/2011 | 1,570 | <0.5 | 12.25-inch pilot hole |
| 10/7/2011 | 1,660 | <0.25 | 12.25-inch pilot hole |
| 10/8/2011 | 1,750 | 0.50 | 12.25-inch pilot hole |
| | | | |
| 10/16/2011 | 1180 | 0.25 | 24-inch reamed hole |
| 10/14/2011 | 1,210 | <0.25 | 24-inch reamed hole |
| 10/15/2011 | 1,300 | <0.25 | 24-inch reamed hole |
| 10/16/2011 | 1,390 | 0.25 | 24-inch reamed hole |
| 10/17/2011 | 1,480 | 0.25 | 24-inch reamed hole |
| 10/18/2011 | 1,570 | <0.25 | 24-inch reamed hole |
| 10/21/2011 | 1,660 | <0.25 | 24-inch reamed hole |
| 10/22/2011 | 1,750 | 0.25 | 24-inch reamed hole |
| | | | |

Note: Sure-shots were utilized for the drift inclination surveys and are designed in 0.25 degree increments.

**TABLE 2-3**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**SCHEDULE OF GROUT PLACEMENT FOR DIW-1**

| Date | Stage No. | Interval Filled (feet) | Volume Pumped (barrels) | Actual Linear Fill (feet) | Theoretical Linear Fill (feet) | Theoretical Cement Top Depth (feet) | Method of Emplacement | Additives to Cement |
|---|---|---|---|---|---|---|---|---|
| **52-inch Surface Casing** | | | | | | | | |
| 8/31/2011 | 1 | 310-0 | 220.0 | 310 | 250 | 60 | pressure | 120 bbls 6%, 100 bbls neat |
| **Totals** | | | **220** | **310** | | | | |
| **40-inch Intermediate Casing** | | | | | | | | |
| 9/28/11 2:30 | 1 | 1,120 - 790 | 325 | 330 | 384 | 736 | pressure | Neat |
| 9/28/2011 | 2 | 790-651 | 239 | 139 | 190 | 600 | tremie | 6% |
| 9/29/2011 | 3 | 651-590 | 258 | 61 | 251 | 400 | tremie | 6% |
| 9/29/2011 | 4 | 590-451 | 204 | 139 | 240 | 350 | tremie | 6% |
| 9/30/2011 | 5 | 451-215 | 227 | 236 | 251 | 200 | tremie | 6% |
| 10/1/2011 | 6 | 215-ls | 217 | 215 | 215 | LS | tremie | Neat |
| **Totals** | | | **1470** | **1120** | | | | |
| **28-inch Final Casing** | | | | | | | | |
| 1/22/2012 | | 1198-1193 | 125 G | 5 | 10 | 1188 | tremie | Gravel |
| 1/23/2012 | A | 1193-1191 | 1 | 2 | 5 | 1188 | tremie | Neat |
| 1/23/2012 | B | 1191-1185 | 1 | 6 | 5 | 1186 | tremie | Neat |
| 1/24/2012 | 1 | 1185-1107 | 47 | 78 | 65 | 1120 | tremie | Neat |
| 1/24/2012 | 2 | 1107-818 | 220 | 289 | 300 | 807 | tremie | Neat |
| 1/25/2012 | 3 | 818-511 | 232 | 307 | 312 | 506 | tremie | Neat |
| 1/25/2012 | 4 | 511-255 | 186 | 256 | 255 | 256 | tremie | Neat |
| 1/27/2012 | 5 | 255-LS | 193 | 255 | 255 | LS | tremie | Neat |
| **Totals** | | | **880** | **1198** | | | | |

**TABLE 2-4**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**INJECTION WELL FINAL 28-INCH STEEL CASING PRESSURE TEST**

| Date | Elapsed Time min | Pressure psi | Pressure Change psi | % Deviation |
|---|---|---|---|---|
| 2/1/12 | 0 | 160.00 | 0.00 | 0.00 |
| 2/1/12 | 5 | 160.00 | 0.00 | 0.00 |
| 2/1/12 | 10 | 160.00 | 0.00 | 0.00 |
| 2/1/12 | 15 | 160.00 | 0.00 | 0.00 |
| 2/1/12 | 20 | 160.00 | 0.00 | 0.00 |
| 2/1/12 | 25 | 160.00 | 0.00 | 0.00 |
| 2/1/12 | 30 | 160.00 | 0.00 | 0.00 |
| 2/1/12 | 35 | 160.00 | 0.00 | 0.00 |
| 2/1/12 | 40 | 160.00 | 0.00 | 0.00 |
| 2/1/12 | 45 | 160.00 | 0.00 | 0.00 |
| 2/1/12 | 50 | 160.00 | 0.00 | 0.00 |
| 2/1/12 | 55 | 160.00 | 0.00 | 0.00 |
| 2/1/12 | 60 | 159.50 | 0.50 | 0.31 |

**TABLE 2-5**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**INJCETION WELL FINAL 18-INCH FRP TUBING ANNULAR PRESSURE TEST**

| Date | Elapsed Time min | Pressure psi | Pressure Change psi | % Deviation |
|---|---|---|---|---|
| 2/8/12 | 0 | 153.00 | 0.00 | 0.00 |
| 2/8/12 | 5 | 153.00 | 0.00 | 0.00 |
| 2/8/12 | 10 | 153.00 | 0.00 | 0.00 |
| 2/8/12 | 15 | 152.50 | 0.50 | 0.33 |
| 2/8/12 | 20 | 152.50 | 0.50 | 0.33 |
| 2/8/12 | 25 | 152.00 | 1.00 | 0.65 |
| 2/8/12 | 30 | 152.00 | 1.00 | 0.65 |
| 2/8/12 | 35 | 152.00 | 1.00 | 0.65 |
| 2/8/12 | 40 | 152.00 | 1.00 | 0.65 |
| 2/8/12 | 45 | 152.00 | 1.00 | 0.65 |
| 2/8/12 | 50 | 152.00 | 1.00 | 0.65 |
| 2/8/12 | 55 | 152.00 | 1.00 | 0.65 |
| 2/8/12 | 60 | 152.00 | 1.00 | 0.65 |

**CITY OF SARASOTA RO WATER TREATMENT FACILITY**
**DEEP INJECTION WELL**

**TABLE 2-6**
**CHRONOLOGY OF SIGNIFICANT LZMW-1**
**CONSTRUCTION AND TESTING ACTIVITIES**

| DATE | ACTIVITY |
|---|---|
| 10/27/11 | Mobilization of the drilling rig is complete; begin mud rotary drilling of the pilot hole with a 12.25 inch tricone bit. Lithology samples are collected every 10 ft and deviation surveys are conducted every 90 ft |
| 10/28/11 | Continued pilot hole drilling utilizing mud rotary drilling techniques to a depth to 118 ft bls. |
| 10/29/11 | Continued pilot hole drilling to apx depth of 288 ft bls |
| 10/30/11 | Completed the mudded pilot hole, 12.25-inch diameter to a depth of 312 ft bls. Conducted geophysical logging RUN 1; logs conducted xy caliper, gamma ray, temp, sonic, and dual induction |
| 10/31/11 | Began reaming of the pilot hole with a 24-inch reamer bit, mud rotary to a depth of 220 ft bls |
| 11/1/11 | Completed reaming of the pilot hole to a depth of 304 ft bls, and a diameter of 24-inches. Conducted geophysical logging RUN2; logs conducted xy caliper, gamma ray (confirm reamed hole, anticipate grout quantities ) |
| 11/2/11 | Installed 16-inch; .375-inch wall surface casing to a depth of 300 ft bls; grouted to LS in one stage; pressure grout with 110 bbls neat cement with full grout return at LS |
| 11/3/11 | Prep rig for reverse air drilling; began pilot hole drilling below the base of the surface casing, 12.25 inch tricone bit under reverse air conditions |
| 11/4/11 | Continue pilot hole drilling to a depth of 537 ft bls; sampling lithology every 10 ft, formation water quality for lab and field analysis every 30 ft and drift survey every 90 ft. |
| 11/5/11 | Continue pilot hole drilling to a depth of 797 ft |
| 11/6/11 | Continue pilot hole drilling to a depth of 1,077 ft |
| 11/7/11 | Completed pilot hole drilling to a depth of 1114 ft bls with the 12.25 inch tricone bit under reverse air conditions. Trip in with a 9⅞ tricone bit and continue pilot hole drilling under reverse air methodology to a depth of 1128 ft bls |
| 11/8/11 | Completed pilot hole drilling to a depth of 1141 ft bls with 9⅞ bit. Conduct geophysical logging RUN 3; full suite of static and dynamic logs including; XY caliper, gamma ray, temp, fluid conductivity, flow meter, sonic, dual induction and televiewer. Pumping rate was 110 while dynamic logging was conducted. After logs were complete, inflatable packer was installed with centerline at 1114 ft bls; isolated interval 1114 ft to 1141 ft bls(the anticipated monitor interval) |
| 11/9/11 | PACKER TEST 1; isolated interval 1114 ft to 1141 ft bls, pumped at 43 gpm with max drawdown of 136 ft, resulting in a Spec Cap of 0.32 gpm/ft of dd. After 4 hours of pumping the final water quality was sampled, field testing showed 26,400 us/cm, samples were sent to the lab for analysis. After 2 hours of recovery data was collected, packer assembly was tripped out and a 14.75-inch reamer bit was |

| | |
|---|---|
| | installed, reaming the pilot hole from 12.25 inch to 14.75 inch began and continued to 717 ft bls |
| 11/10/11 | The reaming of the pilot hole was completed to 1114 ft bls in preparation for install of 6-inch FRP final casing install |
| 11/11/11 | Conduct geophysical logging RUN 4; logs conducted: XY caliper/ gamma ray, for confirmation of the borehole and estimation of grout quantities |
| 11/14/11 | Atkins submitted final casing seat proposal to FDEP for approval; proposed seat for final 6-inch FRP casing is 1115 ft bls |
| 11/15/11 | FDEP confirms casing seat of 1115 ft bls; begin installation of 6-inch final casing. 38 sections, of 29.5 ft long, 6⅝ OD FRP installed to seating depth. Several rubber packers were installed in the bottom 3 ft of the casing to ensure good connection between the base of the casing and the borehole wall. Joints were taped and sealed when tightened. Centralizers were installed at regular intervals per spec. a casing seating cement shot (STAGE A) was pumped down via tremie; consisted of 1 bbl of neat cement, resulting return is apx 3 ft of lift, cement top in the annular space is 1112 ft bls |
| 11/16/11 | Second casing seating shot was installed into the annulus (STAGE B); 1 bbl of neat cement, yielded no significant return; installed 30 gal of gravel to bridge and got 7 ft of lift, gravel top at 1109 ft bls. Third small shot (STAGE C) installed via tremie, 2 bbls neat cement, brought a 3 ft return and cement top at 1106 ft bls. STAGE D, 5 bbls neat cement installed via tremie, resulting in 31 ft of lift and a cement top of 1075 ft bls. STAGE 1; 90 bbls of neat cement installed via tremie, resulting in 302 ft of lift and a cement top of 773 ft bls as verified by agreement between a cement top temperature log and a physical tag of the cement top in the annular space |
| 11/17/11 | STAGE 2; 92 bbls of neat cement via tremie, resulting in 156 ft of lift and a cement top of 617 ft bls, as confirmed by agreement between temp log and physical tag. STAGE 3; 71 bbls of neat cement, resulting in 35 ft of vertical lift in the annular space and a cement top of 582 ft bls, as confirmed by agreement between temp log and physical tag. STAGE 4; 75 bbls neat cement resulting in 279 ft of lift and a cement top of 303 ft bls, as confirmed by agreement between temp log and physical tag |
| 11/18/11 | Conduct CBL |
| 11/19/11 | STAGE 5; 60 bbls neat cement, resulting in 303 ft of lift and bringing a full grout return to land surface. Pump installed to begin cooling the casing in anticipation of pressure test |
| 11/20/11 | Continued to develop out the well to alleviate the temperature gradient produced by the curing annular grout. Development stopped, well is then disinfected with apx 3500 gal of 225 ppm chlorine solution, pumped in via tremie and then allowed to set for 12 hrs, then pumped out and disposed of. Discharge water was monitored for residual chlorine, none detected |
| 11/21/11 | Utilizing the development from the disinfection; well was sampled for background water quality parameters by Benchmark personnel. |
| 12/22/11 | Casing pressure test conducted; packer set at 1105 ft bls and well head sealed in, well pressurized to 61 psi and over 60 minutes gained 2.5 psi to read 63.5 psi at the end of the test. |

**TABLE 2-7**
**City of Sarasota RO Water Treatment Facility Deep Injection Well System**
**LOWER ZONE MONITOR WELL DRIFT INDICATOR SURVEY RESULTS**

| Date | Depth (ft) | Deviation (degrees) | Drilling Status |
|---|---|---|---|
| 10/29/2011 | 90 | <0.25 | 12.25" Pilot hole |
| 10/29/2011 | 180 | <0.25 | 12.25" Pilot hole |
| 10/30/2011 | 270 | <0.25 | 12.25" Pilot hole |
| | | | |
| 10/31/2011 | 90 | <0.25 | 24" Reamed hole |
| 11/1/2011 | 180 | <0.25 | 24" Reamed hole |
| | | | |
| 11/4/2011 | 360 | 0.25 | 12.25" Pilot hole |
| 11/4/2011 | 450 | <0.25 | 12.25" Pilot hole |
| 11/4/2011 | 540 | <0.25 | 12.25" Pilot hole |
| 11/5/2011 | 630 | <0.25 | 12.25" Pilot hole |
| 11/5/2011 | 720 | 0.25 | 12.25" Pilot hole |
| 11/5/2011 | 810 | <0.25 | 12.25" Pilot hole |
| 11/6/2011 | 900 | 0.25 | 12.25" Pilot hole |
| 11/6/2011 | 990 | <0.25 | 12.25" Pilot hole |
| 11/6/2011 | 1105 | <0.25 | 12.25" Pilot hole |
| 11/6/2011 | 1080 | <0.25 | 9-⅞" Pilot hole |
| | | | |
| 11/9/2011 | 390 | 0.25 | 14.75" Reamed hole |
| 11/10/2011 | 480 | 0.25 | 14.75" Reamed hole |
| 11/10/2011 | 570 | 0.25 | 14.75" Reamed hole |
| 11/10/2011 | 660 | <0.25 | 14.75" Reamed hole |
| 11/10/2011 | 750 | <0.25 | 14.75" Reamed hole |
| 11/10/2011 | 840 | 0.25 | 14.75" Reamed hole |
| 11/10/2011 | 930 | 0.25 | 14.75" Reamed hole |
| 11/10/2011 | 1020 | <0.25 | 14.75" Reamed hole |
| 11/10/2011 | 1110 | <0.25 | 14.75" Reamed hole |

**TABLE 2-8**
**City of Sarasota RO Water Treatment Facility Deep Injection Well System**
**SCHEDULE OF GROUT PLACEMENT FOR LOWER ZONE MONITOR WELL**

| Date | Stage No. | Interval Filled (feet) | Volume Pumped (barrels) | Actual Linear Fill (feet) | Theoretical Linear Fill (feet) | Method of Emplacement | Additives to Cement |
|---|---|---|---|---|---|---|---|
| **16-inch Surface Casing** | | | | | | | |
| 11/7/2011 | 1 | 300-LS | 110 | 300 | 300 | pressure | neat |
| **Total** | | | **110** | **300** | | | |
| | | | | | | | |
| **6⅝- inch Final Casing** | | | | | | | |
| 11/15/2011 | A | 1115-1112 | 1 | 3 | 7 | tremie | neat |
| 11/16/2011 | B | 1112-1112.2 | 1 | 0 | 7 | tremie | neat |
| 11/16/2011 | *GRAVEL* | *1112-1109* | *~30 gallon* | *7* | | *tremie* | *GRAVEL* |
| 11/16/2011 | C | 1109-1106 | 2 | 3 | 10 | tremie | neat |
| 11/16/2011 | D | 1106-1075 | 5 | 31 | 25 | tremie | neat |
| 11/16/2011 | 1 | 1075-773 | 90 | 302 | 367 | tremie | neat |
| 11/17/2011 | 2 | 773-617 | 92 | 156 | 325 | tremie | neat |
| 11/17/2011 | 3 | 617-582 | 71 | 35 | 300 | tremie | neat |
| 11/17/2011 | 4 | 582-303 | 75 | 279 | 352 | tremie | neat |
| 11/19/2011 | 5 | 303-LS | 60 | 303 | 303 | tremie | neat |
| **Total** | | | 397 | 1115 | | | |

**TABLE 2-9**
**City of Sarasota RO Water Treatment Facility Deep Injection Well**
**LOWER ZONE MONITOR WELL FRP CASING PRESSURE TEST**

| Elapsed Time (min) | Casing Pressure (psi) | Pressure Change (psi) | Pressure Change (%) |
|---|---|---|---|
| 0.0 | 61.0 | 0.0 | 0.0 |
| 5.0 | 61.5 | 0.5 | 0.8 |
| 10.0 | 62.0 | 1.0 | 1.6 |
| 15.0 | 62.5 | 1.5 | 2.5 |
| 20.0 | 63.0 | 2.0 | 3.3 |
| 25.0 | 63.5 | 2.5 | 4.1 |
| 30.0 | 62.0 | 1.0 | 1.6 |
| 35.0 | 62.0 | 1.0 | 1.6 |
| 40.0 | 62.0 | 1.0 | 1.6 |
| 45.0 | 62.5 | 1.5 | 2.5 |
| 50.0 | 63.0 | 2.0 | 3.3 |
| 55.0 | 63.5 | 2.5 | 4.1 |
| 60.0 | 63.5 | 2.5 | 4.1 |

## CITY OF SARASOTA RO WATER TREATMENT FACILITY
## DEEP INJECTION WELL

### TABLE 2-10
### CHRONOLOGY OF SIGNIFICANT UZMW-1
### CONSTRUCTION AND TESTING ACTIVITIES

| DATE | ACTIVITY |
|---|---|
| 11/27/11 | Initiate pilot hole drilling with a 12.25 inch tricone bit under mud rotary drilling techniques to approximately 30 ft bls; lithology samples are collected every 10 ft and deviation surveys are conducted every 90 ft |
| 11/28/11 | Continued pilot hole drilling to a depth of 240 ft bls |
| 11/29/11 | Completed pilot hold drilling at a depth of 310 ft bls; conduct geophysical logging on the pilot hole; logs include xy caliper, gamma, dual induction, and sonic; logging completed trip in with a 24 inch reaming bit and begin reaming to prep for surface casing installation, reamed down to a depth of 65 ft bls |
| 11/30/11 | Completed reaming to a depth of 300 ft bls utilizing mud rotary drilling |
| 12/1/11 | Geophysical logging RUN 1, conducted on the completed borehole; logs include xy caliper/ gamma to confirm bore hole and estimate grout quantities. Install the 16-inch,0.375 wall steel surface casing to a depth of 300 ft bls and grout to land surface in one stage (STAGE 1); consisting of 118 bbls neat cement |
| 12/3/11 | Continued pilot hole drilling to a depth of 537 ft bls with a 12.25 inch tricone bit, under reverse air drilling methods, Lithology samples are collected every 10 ft, water quality samples for lab and field analysis are collected every 30 ft and deviation surveys are collected every 90 ft. |
| 12/4/11 | Pilot hole drilling continued to a depth of 897 ft bls |
| 12/5/11 | 12.25 inch pilot hole was completed to a depth of 1040 ft bls and a 97/8 tricone bit was advanced to 1075 ft bls |
| 12/6/11 | Conducted a full suite of static and dynamic geophysical logs, RUN 2; logs conducted included, xy caliper, gamma, dual induction, sonic, temperature, fluid conductivity. Dynamic logs were performed under pumping conditions; pump rate was apx 125 gpm. |
| 12/7/11 | PACKER TEST 1, packer assembly center line installed to a depth of 1037 ft bls with pumped interval isolated below, extending to 1075 ft bls. The test was conducted at 88 gpm with a max drawdown of 27.5 ft, resulting in a Spec Cap of 3.2 gpm/ft of drawdown. The test lasted for 4 hours and the final water quality sample showed a field conductivity reading of 9,500 us/cm, the sample was also sent to the lab for further analysis. |
| 12/8/11 | Began reaming with 14.75 inch reamer bit to a depth of 1040 ft bls and then cleared the open interval of drilling debris with a 9⅞ bit to 1075 ft bls |
| 12/9/11 | Conducted geophysical logging RUN 3, logs included xy caliper / gamma and a repeat of the static fluid conductivity log from RUN 2. Proposed casing seat depth for the 6-inch FRP final casing to FDEP for their approval |
| 12/12/11 | Approval granted for casing seating depth of 1040 ft bls by FDEP, begin installation of 6-inch FRP final casing. 36 sections of 6 5/8 OD FRP installed to 1040 ft bls, |

| | |
|---|---|
| | average length is 29 ft, joints were taped and sealed and centralizers were attached at regular intervals as per the spec. |
| 12/13/11 | Begin annular grouting of the final casing; first shot, STAGE A was 1 bbl neat cement via tremmie pipe, yielding a 4 ft return and a cement top of 1036 ft bls, second small shot was STAGE B, 1 bbl neat cement via tremmie pipe, 3 ft return and cement top at 1033 ft bls. STAGE 1, 5 bbls neat cement via tremmie, yielding a 20 ft lift, and a resulting cement top of 1013 ft bls, which is verified by the agreement between the cement top temperature log and a physical tag of the cement top with the tremmie pipe |
| 12/14/11 | STAGE 2; 55 bbls neat cement via tremmie, resulting in 200 ft of vertical lift and a cement top of 813 ft bls, verified by agreement between temp log and physical tag. STAGE 3; 72 bbls 6% gel cement via tremmie, resulting in 195 ft of lift and a cement top of 618 ft bls. STAGE 4; 71 bbls 6% gel cement via tremmie, resulting in 308 ft of lift and a cement top of 310, as verified by agreement between the temp log and the physical tag |
| 12/15/11 | STAGE 5; 67 bbls neat cement, resulting in 310 ft of lift and bringing the cement top to land surface with a full grout return |
| 12/19/11 | Begin demobilization of rig from UZ and mobilization to DIW |
| 12/23/11 | Conduct casing pressure test with packer set at 1021 ft bls. Casing system was pressurized to 59 psi and only increased 1 psi to 60 psi over the course of the 1 hour test. This represents a less than 5% change in pressure; as a result pressure test is approved. |
| 1/3/12 | Disinfection of the monitor zone of the well. Approximately 4000 gal of 250 ppm chlorine solution was pumped down the hole and allowed to set for 12 hours then pumped out, monitored for residual chlorine and then disposed of. There was no detection of residual chlorine. |
| 1/4/12 | Utilizing the development post disinfection, the well was sampled for background water quality parameters by Benchmark personnel |

**TABLE 2-11**
**City of Sarasota RO Water Treatment Facility Deep Injection Well System**
**UPPER ZONE MONITOR WELL DRIFT INDICATOR SURVEY RESULTS**

| Date | Depth (ft) | Deviation (degrees) | Drilling Status |
|---|---|---|---|
| 11/28/2011 | 90 | <0.50 & >0.25 | 12.25-inch pilot |
| 11/28/2011 | 180 | <0.50 & >0.25 | 12.25-inch pilot |
| 11/29/2011 | 270 | <0.50 & >0.25 | 12.25-inch pilot |
| | | | |
| 11/30/2011 | 90 | <0.50 & >0.25 | 24-inch ream |
| 11/30/2011 | 180 | 0.25 | 24-inch ream |
| 12/1/2011 | 270 | <0.50 & >0.25 | 24-inch ream |
| | | | |
| 12/3/2011 | 390 | <0.25 | 12.25-inch pilot |
| 12/3/2011 | 480 | <0.25 | 12.25-inch pilot |
| 12/3/2011 | 570 | <0.25 | 12.25-inch pilot |
| 12/4/2011 | 660 | 0.25 | 12.25-inch pilot |
| 12/4/2011 | 750 | 0.25 | 12.25-inch pilot |
| 12/4/2011 | 840 | 0.25 | 12.25-inch pilot |
| 12/5/2011 | 930 | <0.25 | 12.25-inch pilot |
| 12/5/2011 | 1020 | 0.25 | 12.25-inch pilot |
| | | | |
| 12/8/2011 | 390 | 0.25 | 14.75-inch ream |
| 12/8/2011 | 480 | <0.25 | 14.75-inch ream |
| 12/8/2011 | 570 | <0.25 | 14.75-inch ream |
| 12/8/2011 | 660 | <0.25 | 14.75-inch ream |
| 12/8/2011 | 750 | <0.25 | 14.75-inch ream |
| 12/8/2011 | 840 | <0.25 | 14.75-inch ream |
| 12/8/2011 | 930 | <0.25 | 14.75-inch ream |
| 12/8/2011 | 1040 | <0.25 | 14.75-inch ream |

**TABLE 2-12**
**City of Sarasota RO Water Treatment Facility Deep Injection Well**
**UPPER ZONE MONITOR WELL SCHEDULE OF GROUT PLACEMENT**

| Date | Stage No. | Interval Filled (feet) | Volume Pumped (barrels) | Actual Linear Fill (feet) | Theoretical Linear Fill (feet) | Method of Emplacement | Additives to Cement |
|---|---|---|---|---|---|---|---|
| **16-inch Surface Casing** | | | | | | | |
| | 1 | 300-LS | 118 | 300 | 297 | Pressure | Neat |
| **Total** | | | **118** | **300** | | | |
| | | | | | | | |
| **6-inch Final Casing** | | | | | | | |
| | A | 1040-1036 | 1 | 4 | 7 | Tremie | Neat |
| | B | 1036-1033 | 1 | 3 | 7 | Tremie | Neat |
| | 1 | 1033-1013 | 5 | 20 | 30 | Tremie | Neat |
| | 2 | 1013-813 | 55 | 200 | 223 | Tremie | Neat |
| | 3 | 813-618 | 72 | 195 | 313 | Tremie | 6% |
| | 4 | 618-310 | 71 | 308 | 350 | Tremie | 6% |
| | 5 | 310-LS | 67 | 310 | 310 | Tremie | Neat |
| **Total** | | | 272 | 1040 | 1240 | | |

**TABLE 2-13**
**City of Sarasota RO Water Treatment Facility Deep Injection Well**
**UPPER ZONE MONITOR WELL FIANL FRP CASING PRESSURE TEST**

| Test Date | Elapsed Time (min) | Casing Pressure (psi) | Pressure Change (psi) | Pressure Change (%) |
|---|---|---|---|---|
| 12/23/2011 | 0 | 60.00 | 5.00 | 0.0 |
| 12/23/2011 | 5 | 60.00 | 5.00 | 0.0 |
| 12/23/2011 | 10 | 60.00 | 5.00 | 0.0 |
| 12/23/2011 | 15 | 60.00 | 5.00 | 0.0 |
| 12/23/2011 | 20 | 60.00 | 5.00 | 0.0 |
| 12/23/2011 | 25 | 60.00 | 5.00 | 0.0 |
| 12/23/2011 | 30 | 60.50 | 5.50 | 0.8 |
| 12/23/2011 | 35 | 60.50 | 5.50 | 0.8 |
| 12/23/2011 | 40 | 60.50 | 5.50 | 0.8 |
| 12/23/2011 | 45 | 60.50 | 5.50 | 0.8 |
| 12/23/2011 | 50 | 61.00 | 6.00 | 1.7 |
| 12/23/2011 | 55 | 61.00 | 6.00 | 1.7 |
| 12/23/2011 | 60 | 61.00 | 6.00 | 1.7 |

# Section 3 Tables

| System | Series | Stratigraphic Unit | General Lithology | Major Lithologic Unit | Hydrogeologic Unit | |
|---|---|---|---|---|---|---|
| Quaternary | Holocene and Pleistocene | Surficial sand, terrace sand, phosphorite | Predominantly fine sand; interbedded clay, marl, shell and phosphorite | Sand | Surficial Aquifer | |
| Tertiary | Pliocene | Undifferentiated deposits[1] | Clayey and pebbly sand; clay, marl and phosphorite | Clastic | upper confining unit | Intermediate Aquifer System |
| | Miocene | Hawthorn Group: Peace River Formation | Dolomite, sand, clay and limestone, silty, phosphatic | Carbonate and Clastic | aquifer | |
| | | Hawthorn Group: Arcadia Formation | | | | |
| | | Hawthorn Group: Tampa Member / Nocatee Member | Limestone, sandy, phosphatic, fossiliferous; sand and clay in lower part in some areas | | lower confining unit | |
| | Oligocene | Suwannee Limestone | Limestone, sandy limestone, fossiliferous | Carbonate | Upper Floridan Aquifer | Floridan Aquifer System |
| | Eocene | Ocala Limestone | Limestone, chalky, foraminiferal, dolomitic, near bottom | | | |
| | | Avon Park Formation | Limestone and hard brown dolomite; intergranular evaporite in lower part in some areas | | Upper Floridan Aquifer / Middle Confining Unit | |
| | Eocene / Paleocene | Oldsmar and Cedar Keys Formations | Dolomite and limestone with intergranular gypsum and anhydrite | Carbonate / Carbonate with Evaporites / Evaporites | Middle Confining Unit / Lower Floridan Aquifer / Sub-Floridan Confining Unit | |

[1] Includes all or parts of Caloosahatchee and Bone Valley Member

# Hydrogeologic Framework

(Reprinted from Metz, P.A. and Brendle, D.L., 1996)

ATKINS

Table 3-1

**TABLE 3-2**
**City of Sarasota RO Water Treatment Plant**
**TEST INJECTION WELL FORMATION CORES SUMMARY**

| Segment Number | Core Number | Collection Date | Interval Cored | | Segment Depth (ft) | Segment Length (inch) | Remarks | Specific Gravity ($g/cm^3$) | Vertical Hydraulic Conductivity (ft/day) | Horizontal Hydraulic Conductivity (ft/day) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | BEGIN | END | | | | | | |
| 1 | 3 | 9/9/11 | 1,135 | 1,143 | 1,135 | 7.5 | Limestone, dolomitic, tan with brown banding | 2.83 | 0.00016 | 0.012 |
| 2 | 4 | 9/10/11 | 1,163 | 1,178 | 1,163 | 6.5 | Limestone, micritic, hard, tan; bottom 7 feet dolomitic | 2.71 | 0.024 | 0.040 |
| 3 | 4 | 9/10/11 | 1,163 | 1,178 | 1,173 | 15.3 | Limestone, micritic, hard, tan; bottom 7 feet dolomitic | 2.71 | 0.022 | 0.027 |
| 4 | 4 | 9/10/11 | 1,163 | 1,178 | 1,177 | 11.5 | Limestone, micritic, hard, tan; bottom 7 feet dolomitic | 2.77 | 0.079 | 0.079 |

**TABLE 3-3**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**PACKER TEST HYDRAULIC PROPERTIES**

| Well | Date | Test No. | Interval (ft bls) | Pump Rate (gpm) | Drawdown (ft) | Specific Capacity (gpm/ft) | Transmissivity Cooper-Jacob (Drawdown) (ft²/day) | Transmissivity Theis Method (Recovery) (ft²/day) | Hydraulic Conductivity Cooper-Jacob (Drawdown) (ft/day) | Hydraulic Conductivity Theis (Recovery) (ft/day) | Transmissivity Estimate (Drawdown) (ft²/day) | Hydraulic Conductivity Estimate (Drawdown) (ft/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIW-1 | 9/12/2011 | 1 | 1200 - 1232 | 75 | 79.4 | 0.94 | 46.20 | 35.60 | 1.40 | 1.10 | - | - |
| DIW-1 | 9/14/2011 | 2 | 1157 - 1188 | 4 | 100.0 | 0.04 | 1.60 | 2.30 | 0.05 | 0.07 | - | - |
| DIW-1 | 9/15/2011 | 3 | 1119.5 - 1150.5 | 42 | 102.6 | 0.41 | 12.90 | 17.90 | 0.40 | 0.60 | - | - |
| DIW-1 | 9/16/2011 | 4 | 1044.5 - 1075.5 | 87 | 46.9 | 1.86 | - | - | - | - | 491.2 | 15.8 |
| DIW-1 | 10/10/2011 | 5 | 1501 - 1762 | 90 | 3.0 | 30.00 | - | - | - | - | 8,021.4 | 30.7 |
| DIW-1 | 10/10/2011 | 6 | 1276.5 - 1307.5 | 92 | 1.1 | 83.60 | - | - | - | - | 22,362.7 | 721.4 |
| DIW-1 | 10/11/2011 | 7 | 1446 - 1477 | 92 | 2.9 | 31.40 | - | - | - | - | 8,571.0 | 276.5 |
| LZMW-1 | 11/9/2011 | 1 | 1,114 - 1,141 | 43.5 | 136.0 | 0.32 | 15.10 | 14.80 | 0.56 | 0.55 | - | - |
| UZMW-1 | 12/7/2011 | 1 | 1,037-1,075 | 88 | 27.5 | 3.20 | 94.10 | 109.70 | 2.50 | 2.90 | - | - |

In areas of confinement, the transmissivity and hydraulic conductivity values were calculated from packer test pumping drawdown data using the Cooper-Jacob Straight Line solution.
The values were estimated in the more permeable zones since the aquifer was not stressed enough to produce a representative drawdown curve, except test 4, which resulted in

**TABLE 3-4**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**SHALLOW WATER TABLE MONITOR WELL MONITORING DATA**

| | | | | Laboratory Measurement | Field Measurements | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Well** | **Well Location** | **Date** | **Time** | **Chloride (mg/L)** | **Dissolved Oxygen (mg/L)** | **pH (s.u.)** | **Specific Conductance (µmhos/cm)** | **Turbidity (NTU)** | **Temperature (°C)** | **Water Level (ft TOC)** | **Remarks** |
| SMW-1 | MW NW | 8/11/2011 | 9:17 | 26.8 | 0.47 | 6.50 | 1,040 | 3.7 | 27.9 | 5.19 | background |
| SMW-1 | MW NW | 8/16/2011 | 13:26 | 7.6 | 0.21 | 6.60 | 1,300 | 1.3 | 27.8 | 5.59 | |
| SMW-1 | MW NW | 8/23/2011 | 10:57 | 40.6 | 0.41 | 6.60 | 1,320 | 0.7 | 28.0 | 5.41 | |
| SMW-1 | MW NW | 8/30/2011 | 15:25 | 42.4 | 0.16 | 6.70 | 1,290 | 0.8 | 28.0 | 5.10 | |
| SMW-1 | MW NW | 9/13/2011 | 11:35 | 46.6 | 0.24 | 6.60 | 1,250 | 1.0 | 27.7 | 4.91 | |
| SMW-1 | MW NW | 9/20/2011 | 10:41 | 43.8 | 0.14 | 6.60 | 1,292 | 0.8 | 27.7 | 5.28 | |
| SMW-1 | MW NW | 9/27/2011 | 17:31 | 42.9 | 0.20 | 6.70 | 1,273 | 1.1 | 27.6 | 5.02 | |
| SMW-1 | MW NW | 10/5/2011 | 17:07 | 46.7 | 0.23 | 6.70 | 1,276 | 0.8 | 27.5 | 5.73 | |
| SMW-1 | MW NW | 10/11/2011 | 9:27 | 40.8 | 0.17 | 6.50 | 1,290 | 2.7 | 27.0 | 5.68 | |
| SMW-1 | MW NW | 10/18/2011 | 10:42 | 44.5 | 0.33 | 6.8 | 1331 | 3.1 | 26.8 | 6.62 | |
| SMW-1 | MW NW | 10/28/2011 | 10:53 | 48.8 | 0.24 | 7.00 | 1,411 | 7.1 | 26.2 | 5.97 | |
| SMW-1 | MW NW | 11/1/2011 | 11:08 | 55.6 | 0.65 | 6.70 | 1,320 | 1.6 | 26.0 | 10.17 | |
| SMW-1 | MW NW | 11/8/2011 | 10:09 | 47.5 | 0.25 | 6.60 | 1,320 | 1.6 | 25.7 | 6.04 | |
| SMW-1 | MW NW | 11/15/2011 | 14:55 | 51.1 | 0.30 | 6.60 | 1,321 | 7.6 | 25.5 | 6.29 | |
| SMW-1 | MW NW | 11/21/2011 | 13:22 | 48.2 | 0.29 | 6.70 | 1,353 | 3.4 | 25.4 | 6.23 | |
| SMW-1 | MW NW | 11/29/2011 | 14:38 | 47.6 | 0.63 | 6.80 | 1,332 | 3.7 | 25.0 | 6.51 | |
| SMW-1 | MW NW | 12/6/2011 | 10:41 | 59.1 | 0.43 | 6.70 | 1,325 | 4.6 | 24.8 | 6.29 | |
| SMW-1 | MW NW | 12/13/2011 | 10:13 | 54.3 | 0.44 | 6.50 | 1,441 | 1.6 | 24.4 | 6.55 | |
| SMW-1 | MW NW | 12/22/2011 | 10:10 | 60.5 | 0.62 | 6.70 | 1,296 | 2.5 | 24.2 | 6.71 | |
| SMW-1 | MW NW | 12/28/2011 | 15:21 | 55.1 | 0.34 | 6.70 | 1,350 | 8.0 | 24.0 | 7.08 | |
| SMW-1 | MW NW | 1/3/2012 | 15:02 | 53.4 | 1.08 | 7.30 | 1,312 | 5.3 | 23.4 | 6.79 | |
| SMW-1 | MW NW | 1/12/2012 | 13:41 | 57.8 | 0.29 | 6.50 | 1,350 | 1.1 | 23.5 | 6.25 | |
| SMW-1 | MW NW | 1/18/2012 | 11:52 | 53.4 | 0.29 | 6.40 | 1,350 | 0.5 | 23.2 | 6.46 | |
| SMW-1 | MW NW | 1/25/2012 | 15:48 | 59.0 | 0.37 | 6.60 | 1,330 | 0.8 | 23.0 | 7.21 | |
| SMW-1 | MW NW | 2/1/2012 | 11:07 | 59.3 | 0.29 | 6.60 | 1,336 | 2.7 | 22.8 | 7.23 | |
| SMW-1 | MW NW | 2/8/2012 | 13:55 | 77.3 | 1.02 | 6.60 | 1,430 | 0.3 | 22.8 | 6.96 | |
| SMW-1 | MW NW | 2/15/2012 | 11:26 | 64.2 | 0.42 | 6.70 | 1,350 | 5.5 | 22.8 | 6.74 | |
| SMW-1 | MW NW | 2/22/2012 | 12:21 | 54.5 | 0.29 | 6.70 | 1,308 | 2.0 | 22.5 | 6.63 | |
| SMW-1 | MW NW | 2/29/2012 | 13:52 | 64.2 | 0.30 | 6.80 | 1,370 | 0.4 | 22.9 | 7.11 | |
| SMW-1 | MW NW | 3/8/2012 | 11:52 | 61.8 | 0.52 | 6.50 | 1,340 | 0.2 | 23.3 | 6.85 | |
| | | | | | | | | | | | |
| SMW-2A | MW NE | 8/11/2011 | 9:30 | 49.5 | 0.23 | 6.60 | 1,280 | 1.1 | 27.8 | 5.72 | background |

**TABLE 3-4**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**SHALLOW WATER TABLE MONITOR WELL MONITORING DATA**

| | | | | Laboratory Measurement | Field Measurements | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Well | Well Location | Date | Time | Chloride (mg/L) | Dissolved Oxygen (mg/L) | pH (s.u.) | Specific Conductance (µmhos/cm) | Turbidity (NTU) | Temperature (°C) | Water Level (ft TOC) | Remarks |
| SMW-2A | MW NE | 8/16/2011 | 13:14 | 10.2 | 0.13 | 6.60 | 1,330 | 0.8 | 27.8 | 6.47 | |
| SMW-2A | MW NE | 8/23/2011 | 11:07 | 49.4 | 0.12 | 6.60 | 1,360 | 0.7 | 28.0 | 6.04 | |
| SMW-2A | MW NE | 8/30/2011 | 15:03 | 51.1 | 0.31 | 6.80 | 1,360 | 0.6 | 27.9 | 5.78 | |
| SMW-2A | MW NE | 9/13/2011 | 12:05 | 40.6 | 0.11 | 6.60 | 1,410 | 0.4 | 27.8 | 5.59 | |
| SMW-2A | MW NE | 9/20/2011 | 9:57 | 48.9 | 0.21 | 6.70 | 1,540 | 0.6 | 27.7 | 5.95 | |
| SMW-2A | MW NE | 9/27/2011 | 17:52 | 76.5 | 0.26 | 6.70 | 1,700 | 1.4 | 27.5 | 5.71 | |
| SMW-2A | MW NE | 10/4/2011 | 17:24 | 72.0 | 0.19 | 6.70 | 1,600 | 2.6 | 27.3 | 6.42 | |
| SMW-2A | MW NE | 10/11/2011 | 10:14 | 116.0 | 0.12 | 6.60 | 1,770 | 3.0 | 26.8 | 6.42 | |
| SMW-2A | MW NE | 10/18/2011 | 11:02 | 76.5 | 0.22 | 6.90 | 1,700 | 2.0 | 26.6 | 7.30 | |
| SMW-2A | MW NE | 10/28/2011 | 11:13 | 37.4 | 0.21 | 7.00 | 1,500 | 9.1 | 26.1 | 6.81 | |
| SMW-2A | MW NE | 11/1/2011 | 12:23 | 44.1 | 0.78 | 6.60 | 1,320 | 2.7 | 26.2 | 11.08 | |
| SMW-2A | MW NE | 11/8/2011 | 10:32 | 45.8 | 0.36 | 6.60 | 1,317 | 2.8 | 25.8 | 6.89 | |
| SMW-2A | MW NE | 11/15/2011 | 15:22 | 45.6 | 0.32 | 6.70 | 1,287 | 3.8 | 25.5 | 7.08 | |
| SMW-2A | MW NE | 11/21/2011 | 12:44 | 44.4 | 0.24 | 6.60 | 1,297 | 1.7 | 25.4 | 7.13 | |
| SMW-2A | MW NE | 11/29/2011 | 14:58 | 41.1 | 0.21 | 6.60 | 1,272 | 8.1 | 25.0 | 7.19 | |
| SMW-2A | MW NE | 12/6/2011 | 10:22 | 46.6 | 0.49 | 6.70 | 1,262 | 2.3 | 24.7 | 7.07 | |
| SMW-2A | MW NE | 12/13/2011 | 10:34 | 43.1 | 0.17 | 6.60 | 1,349 | 1.4 | 24.3 | 7.65 | |
| SMW-2A | MW NE | 12/22/2011 | 9:51 | 45.1 | 0.42 | 6.70 | 1,194 | 1.7 | 24.1 | 7.59 | |
| SMW-2A | MW NE | 12/28/2011 | 15:38 | 40.1 | 0.20 | 6.70 | 1,210 | 9.2 | 23.7 | 8.00 | |
| SMW -2B | MW NE R | 1/3/2012 | 15:21 | 39.1 | 1.20 | 6.60 | 1,205 | 4.0 | 23.1 | 7.68 | |
| SMW -2B | MW NE R | 1/12/2012 | 13:57 | 43.1 | 0.21 | 6.60 | 1,230 | 0.8 | 23.1 | 7.02 | |
| SMW -2B | MW NE R | 1/18/2012 | 12:12 | 44.7 | 0.17 | 6.40 | 1,240 | 1.0 | 22.8 | 7.27 | |
| SMW -2B | MW NE R | 1/25/2012 | 16:05 | 44.3 | 0.16 | 6.60 | 1,250 | 0.9 | 22.5 | 8.11 | |
| SMW -2B | MW NE R | 2/1/2012 | 10:42 | 45.2 | 0.23 | 6.50 | 1,269 | 5.1 | 22.4 | 8.19 | |
| SMW -2B | MW NE R | 2/8/2012 | 14:16 | 45.9 | 0.44 | 6.50 | 1,250 | 0.4 | 22.5 | 7.63 | |
| SMW -2B | MW NE R | 2/15/2012 | 10:10 | 42.9 | 0.71 | 6.70 | 1,274 | 2.0 | 22.5 | 7.45 | |
| SMW -2B | MW NE R | 2/22/2012 | 12:39 | 51.1 | 0.41 | 6.60 | 1,315 | 1.6 | 22.3 | 7.53 | |
| SMW -2B | MW NE R | 2/29/2012 | 14:22 | 51.5 | 0.17 | 6.70 | 1,340 | 0.5 | 22.5 | 7.92 | |
| SMW -2B | MW NE R | 3/7/2012 | 12:08 | 53.1 | 0.52 | 6.50 | 1,400 | 0.8 | 23.0 | 8.03 | |
| | | | | | | | | | | | |
| SMW-3 | MW SE | 8/11/2011 | 10:12 | | 0.32 | 6.70 | 1,110 | 29.0 | 29.9 | 6.30 | background |
| SMW-3 | MW SE | 8/16/2011 | 12:41 | 40.7 | 0.23 | 6.60 | 1,360 | 4.1 | 29.8 | 6.46 | |
| SMW-3 | MW SE | 8/23/2011 | 11:51 | 37.5 | 0.13 | 6.70 | 1,390 | 0.8 | 29.9 | 6.65 | |
| SMW-3 | MW SE | 8/30/2011 | 14:03 | 51.7 | 0.55 | 6.70 | 1,710 | 5.8 | 29.5 | 6.46 | |
| SMW-3 | MW SE | 9/13/2011 | 14:02 | 46.7 | 0.13 | 6.70 | 1,430 | 1.1 | 29.2 | 7.38 | |

**TABLE 3-4**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**SHALLOW WATER TABLE MONITOR WELL MONITORING DATA**

| | | | | Laboratory Measurement | Field Measurements | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Well** | **Well Location** | **Date** | **Time** | **Chloride (mg/L)** | **Dissolved Oxygen (mg/L)** | **pH (s.u.)** | **Specific Conductance (µmhos/cm)** | **Turbidity (NTU)** | **Temperature (°C)** | **Water Level (ft TOC)** | **Remarks** |
| SMW-3 | MW SE | 9/20/2011 | 9:26 | 45.9 | 0.20 | 6.60 | 1,610 | 2.5 | 28.7 | 7.30 | |
| SMW-3 | MW SE | 9/27/2011 | 16:36 | 36.9 | 0.24 | 6.80 | 1,438 | 3.6 | 28.4 | 7.09 | |
| SMW-3 | MW SE | 10/4/2011 | 16:19 | 47.2 | 0.21 | 6.50 | 1,570 | 7.6 | 28.1 | 7.99 | |
| SMW-3 | MW SE | 10/11/2011 | 10:49 | 38.6 | 0.19 | 6.70 | 1,480 | 6.6 | 27.6 | 8.49 | |
| SMW-3 | MW SE | 10/18/2011 | 9:54 | 37.3 | 0.25 | 6.40 | 1,530 | 3.7 | 27.2 | 9.08 | |
| SMW-3 | MW SE | 10/28/2011 | 11:54 | 38.1 | 0.48 | 7.10 | 1,466 | 2.7 | 26.4 | 7.64 | |
| SMW-3 | MW SE | 11/1/2011 | 13:09 | 40.2 | 2.18 | 6.60 | 1,450 | 11.5 | 26.2 | 8.45 | |
| SMW-3 | MW SE | 11/8/2011 | 11:28 | 40.1 | 0.25 | 6.70 | 1,485 | 4.8 | 26.1 | 7.75 | |
| SMW-3 | MW SE | 11/15/2011 | 15:46 | 36.4 | 0.46 | 6.70 | 1,386 | 5.7 | 25.5 | 7.91 | |
| SMW-3 | MW SE | 11/21/2011 | 11:56 | 34.4 | 0.30 | 6.80 | 1,420 | 3.4 | 25.5 | 8.42 | |
| SMW-3 | MW SE | 11/29/2011 | 15:36 | 32.8 | 0.40 | 6.80 | 1,387 | 5.3 | 24.7 | 7.71 | |
| SMW-3 | MW SE | 12/6/2011 | 9:57 | 41.1 | 1.14 | 6.60 | 1,453 | 6.2 | 24.5 | 8.38 | |
| SMW-3 | MW SE | 12/13/2011 | 11:17 | 34.0 | 1.70 | 6.70 | 1,475 | 4.5 | 24.0 | 9.65 | |
| SMW-3 | MW SE | 12/22/2011 | 10:54 | 33.6 | 0.53 | 7.00 | 1,309 | 4.1 | 24.0 | 9.21 | |
| SMW-3 | MW SE | 12/28/2011 | 16:22 | 35.3 | 0.22 | 6.80 | 1,330 | 2.2 | 23.4 | 9.13 | |
| SMW-3 | MW SE | 1/3/2012 | 15:48 | 35.0 | 1.04 | 7.00 | 1,297 | 6.7 | 22.6 | 8.40 | |
| SMW-3 | MW SE | 1/12/2012 | 14:26 | 32.6 | 0.33 | 6.80 | 1,310 | 1.5 | 23.1 | 7.50 | |
| SMW-3 | MW SE | 1/18/2012 | 12:32 | 32.5 | 0.19 | 6.50 | 1,300 | 0.7 | 23.2 | 7.69 | |
| SMW-3 | MW SE | 1/25/2012 | 16:25 | 32.0 | 0.13 | 6.80 | 1,290 | 0.7 | 22.7 | 10.16 | |
| SMW-3 | MW SE | 2/1/2012 | 9:54 | 32.3 | 0.89 | 6.40 | 1,295 | 4.1 | 22.5 | 8.70 | |
| SMW-3 | MW SE | 2/8/2012 | 14:35 | 29.4 | 0.26 | 6.60 | 1,300 | 3.7 | 22.6 | 9.97 | |
| SMW-3 | MW SE | 2/15/2012 | 11:47 | 33.1 | 0.43 | 6.80 | 1,300 | 7.1 | 22.7 | 9.33 | |
| SMW-3 | MW SE | 2/22/2012 | 11:30 | 34.1 | 1.10 | 6.80 | 1,277 | 2.3 | 22.9 | 8.20 | |
| SMW-3 | MW SE | 2/29/2012 | 14:45 | 30.2 | 0.12 | 6.80 | 1,290 | 0.4 | 22.7 | 9.48 | |
| SMW-3 | MW SE | 3/7/2012 | 12:38 | 32.0 | 0.16 | 6.60 | 1,260 | 1.3 | 23.2 | 10.18 | |
| | | | | | | | | | | | |
| SMW-4 | MW SW | 8/11/2011 | 10:20 | 40.0 | 0.38 | 6.70 | 1,240 | 1.4 | 27.9 | 5.15 | background |
| SMW-4 | MW SW | 8/16/2011 | 12:41 | 40.7 | 0.23 | 6.60 | 1,360 | 4.1 | 29.8 | 6.46 | |
| SMW-4 | MW SW | 8/23/2011 | 12:04 | 36.7 | 0.13 | 6.60 | 1,280 | 0.7 | 27.9 | 5.36 | |
| SMW-4 | MW SW | 8/30/2011 | 14:35 | 37.2 | 0.18 | 6.70 | 1,300 | 0.5 | 28.0 | 5.02 | |
| SMW-4 | MW SW | 9/13/2011 | 12:31 | 41.1 | 0.18 | 6.60 | 1,250 | 3.3 | 27.7 | 5.03 | |
| SMW-4 | MW SW | 9/20/2011 | 10:21 | 35.0 | 0.20 | 6.60 | 1,610 | 2.5 | 28.7 | 7.30 | |
| SMW-4 | MW SW | 9/27/2011 | 17:07 | 35.2 | 0.23 | 6.70 | 1,324 | 1.0 | 27.7 | 4.70 | |
| SMW-4 | MW SW | 10/4/2011 | 16:41 | 38.4 | 0.53 | 6.70 | 1,314 | 0.6 | 27.6 | 5.56 | |

**TABLE 3-4**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**SHALLOW WATER TABLE MONITOR WELL MONITORING DATA**

| | | | | Laboratory Measurement | Field Measurements | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Well | Well Location | Date | Time | Chloride (mg/L) | Dissolved Oxygen (mg/L) | pH (s.u.) | Specific Conductance (µmhos/cm) | Turbidity (NTU) | Temperature (°C) | Water Level (ft TOC) | Remarks |
| SMW-4 | MW SW | 10/11/2011 | 9:52 | 34.5 | 0.14 | 6.60 | 1,280 | 1.7 | 27.3 | 5.63 | |
| SMW-4 | MW SW | 10/18/2011 | 10:21 | 35.1 | 0.5 | 6.7 | 1338 | 2 | 27 | 6.52 | |
| SMW-4 | MW SW | 10/28/2011 | 11:32 | 37.4 | 0.31 | 7.10 | 1,388 | 3.1 | 26.3 | 5.79 | |
| SMW-4 | MW SW | 11/1/2011 | 11:30 | 32.9 | 0.46 | 6.60 | 1,200 | 19.7 | 26.4 | 13.12 | |
| SMW-4 | MW SW | 11/8/2011 | 11:01 | 35.0 | 0.40 | 6.70 | 1,311 | 3.9 | 25.6 | 5.84 | |
| SMW-4 | MW SW | 11/15/2011 | 14:35 | 36.8 | 0.45 | 6.40 | 1,312 | 9.7 | 25.2 | 6.07 | |
| SMW-4 | MW SW | 11/21/2011 | 13:46 | 33.2 | 0.46 | 6.90 | 1,342 | 3.8 | 25.2 | 6.23 | |
| SMW-4 | MW SW | 11/29/2011 | 14:22 | 33.5 | 0.35 | 6.60 | 1,310 | 2.7 | 24.8 | 6.35 | |
| SMW-4 | MW SW | 12/6/2011 | 11:04 | 37.2 | 1.43 | 6.80 | 1,308 | 4.3 | 24.4 | 6.02 | |
| SMW-4 | MW SW | 12/13/2011 | 10:53 | 34.8 | 0.34 | 6.70 | 1,423 | 3.6 | 23.5 | 6.08 | |
| SMW-4 | MW SW | 12/22/2011 | 10:28 | 37.0 | 0.19 | 6.80 | 1,265 | 2.3 | 23.8 | 6.59 | |
| SMW-4 | MW SW | 12/28/2011 | 16:41 | 33.4 | 0.15 | 6.80 | 1,280 | 3.7 | 23.4 | 6.89 | |
| SMW-4 | MW SW | 1/3/2012 | 16:09 | 33.4 | 0.52 | 6.90 | 1,288 | 8.7 | 22.9 | 6.43 | |
| SMW-4 | MW SW | 1/12/2012 | 14:51 | 35.9 | 0.15 | 6.80 | 1,290 | 2.9 | 23.3 | 6.79 | |
| SMW-4 | MW SW | 1/18/2012 | 12:52 | 32.4 | 0.15 | 6.50 | 1,280 | 0.8 | 23.0 | 5.99 | |
| SMW-4 | MW SW | 1/25/2012 | 16:43 | 36.2 | 0.40 | 6.70 | 1,300 | 0.8 | 22.8 | 6.74 | |
| SMW-4 | MW SW | 2/1/2012 | 10:16 | 36.5 | 0.35 | 6.50 | 1,306 | 5.1 | 22.8 | 6.96 | |
| SMW-4 | MW SW | 2/8/2012 | 14:55 | 36.2 | 0.22 | 6.60 | 1,310 | 0.6 | 23.1 | 6.63 | |
| SMW-4 | MW SW | 2/15/2012 | 12:11 | 36.1 | 0.33 | 6.70 | 1,301 | 5.3 | 23.1 | 6.45 | |
| SMW-4 | MW SW | 2/22/2012 | 11:59 | 35.8 | 0.41 | 6.60 | 1,315 | 1.6 | 22.3 | 7.53 | |
| SMW-4 | MW SW | 2/29/2012 | 15:07 | 35.0 | 0.12 | 6.90 | 1,290 | 0.4 | 23.3 | 6.89 | |
| SMW-4 | MW SW | 3/7/2012 | 12:47 | 34.8 | 0.16 | 6.70 | 1,260 | 1.2 | 23.9 | 6.90 | |

1. The groundwater samples were analyzed by Benchmark Laboratories, Inc.
2. TOC indicates the measurement was recorded from the top of the well casing.

**TABLE 3-5**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**DIW-1 ANALYTICAL REVERSE-AIR DRILLING AIRLIFT WATER QUALITY RESULTS**

| Date | Time | Depth (ft bls) | Chloride (mg/L) | Sulfate (mg/L) | Specific Conductance (µS/cm) | TDS (mg/L) | pH (s.u.) | | TKN (mg/L) | Ammonia (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 9/2/2011 | 6:00 | 330 | 776 | 611 | 3,330 | 2,320 | 8.77 | Q | | |
| 9/2/2011 | 12:00 | 360 | 765 | 605 | 3,350 | 2,172 | 8.41 | Q | | |
| 9/2/2011 | 14:55 | 390 | 791 | 639 | 3,350 | 2,016 | 8.15 | Q | | |
| 9/2/2011 | 18:20 | 420 | 800 | 652 | 3,340 | 2,064 | 8.04 | Q | | |
| 9/2/2011 | 21:30 | 450 | 777 | 641 | 3,330 | 2,052 | 7.93 | Q | | |
| 9/2/2011 | 23:30 | 480 | 785 | 654 | 3,300 | 2,020 | 7.88 | Q | | |
| 9/3/2011 | 3:30 | 510 | 705 | 540 | 3,300 | 2,076 | 7.91 | Q | | |
| 9/3/2011 | 6:10 | 540 | 765 | 646 | 3,290 | 2,120 | 7.92 | Q | | |
| 9/3/2011 | 8:20 | 570 | 752 | 660 | 3,280 | 2,068 | 7.88 | Q | | |
| 9/3/2011 | 11:40 | 600 | 1,041 | 925 | 4,280 | 2,732 | 7.64 | Q | | |
| 9/3/2011 | 14:30 | 630 | 1,211 | 1,078 | 4,880 | 3,288 | 7.66 | Q | | |
| 9/3/2011 | 16:30 | 660 | 1,207 | 1,095 | 4,930 | 3,332 | 7.67 | Q | | |
| 9/3/2011 | 19:00 | 690 | 1,240 | 1,148 | 5,020 | 3,296 | 7.65 | Q | | |
| 9/3/2011 | 21:15 | 720 | 1,226 | 1,134 | 5,010 | 3,396 | 7.69 | Q | | |
| 9/3/2011 | 23:30 | 750 | 1,304 | 1,053 | 5,650 | 3,784 | 7.72 | Q | | |
| 9/4/2011 | 4:10 | 780 | 1,303 | 1,168 | 5,250 | 3,568 | 7.71 | Q | | |
| 9/4/2011 | 8:15 | 810 | 1,381 | 1,101 | 5,770 | 3,916 | 7.80 | Q | | |
| 9/4/2011 | 10:00 | 840 | 1,452 | 1,234 | 5,680 | 3,852 | 7.82 | Q | | |
| 9/4/2011 | 13:00 | 870 | 1,442 | 1,252 | 5,620 | 3,852 | 7.82 | Q | | |
| 9/4/2011 | 16:40 | 900 | 1,418 | 1,254 | 5,530 | 3,812 | 7.93 | Q | | |
| 9/4/2011 | 19:40 | 930 | 1,409 | 1,268 | 5,500 | 3,784 | 7.80 | Q | | |
| 9/5/2011 | 23:25 | 960 | 1,409 | 1,268 | 5,500 | 3,784 | 7.80 | Q | | |
| 9/5/2011 | 3:00 | 990 | 1,307 | 1,225 | 5,340 | 3,712 | 7.93 | Q | | |
| 9/5/2011 | 6:25 | 1,020 | 1,315 | 1,266 | 5,220 | 3,656 | 7.88 | Q | | |
| 9/6/2011 | 16:15 | 1,050 | 991 | 1,058 | 4,730 | 3,248 | 7.86 | Q | | |
| 9/7/2011 | 22:30 | 1,080 | 962 | 1,141 | 4,610 | 3,232 | 7.91 | Q | | |
| 9/8/2011 | 2:25 | 1,110 | 1,019 | 1,174 | 4,790 | 3,376 | 7.78 | Q | | |
| 9/9/2011 | 17:00 | 1,140 | 1,299 | 1,249 | 5,600 | 3,904 | 7.83 | Q | | |
| 9/10/2011 | 13:30 | 1,170 | 1,518 | 1,187 | 6,350 | 4,376 | 7.73 | Q | | |
| 9/10/2011 | 17:25 | 1,200 | 1,662 | 1,203 | 6,800 | 4,672 | 7.74 | Q | | |
| 9/11/2011 | 6:35 | 1,230 | 4,127 | 1,417 | 13,730 | 8,864 | 7.80 | Q | | |
| 10/3/2011 | 14:40 | 1,260 | 7,486 | 1,690 | 23,300 | 14,980 | 7.76 | Q | 0.781 | 0.398 |
| 10/4/2011 | 6:00 | 1,290 | 13,545 | 2,231 | 37,800 | 25,052 | 7.64 | Q | | |
| 10/4/2011 | 14:50 | 1,320 | 17,832 | 2,615 | 47,200 | 31,504 | 7.52 | Q | 1.070 | 0.635 |
| 10/5/2011 | 2:15 | 1,350 | 19,366 | 2,745 | 50,900 | 36,276 | 7.50 | Q | | |
| 10/5/2011 | 12:10 | 1,380 | 19,665 | 2,767 | 51,100 | 35,300 | 7.43 | Q | 0.897 | 0.755 |
| 10/5/2011 | 16:40 | 1,410 | 19,042 | 2,721 | 50,000 | 34,456 | 7.58 | Q | | |
| 10/5/2011 | 23:00 | 1,440 | 19,217 | 2,900 | 50,100 | 35,728 | 7.23 | Q | 0.826 | 0.757 |
| 10/6/2011 | 3:00 | 1,470 | 19,480 | 3,138 | 50,900 | 35,668 | 7.42 | Q | | |
| 10/6/2011 | 0:00 | 1,500 | 19,733 | 3,204 | 51,600 | 36,060 | 7.41 | Q | 0.851 | 0.736 |
| 10/6/2011 | 12:08 | 1,530 | 19,156 | 3,084 | 51,400 | 35,348 | 7.54 | Q | | |
| 10/6/2011 | 18:18 | 1,560 | 18,754 | 2,871 | 50,700 | 35,004 | 7.53 | Q | 0.766 | 0.534 |
| 10/7/2011 | 5:30 | 1,590 | 19,278 | 3,071 | 51,900 | 35,644 | 7.52 | Q | | |
| 10/7/2011 | 11:35 | 1,620 | 19,377 | 3,064 | 51,500 | 35,764 | 7.45 | Q | 0.854 | 0.770 |
| 10/7/2011 | 17:40 | 1,650 | 19,343 | 3,096 | 52,100 | 36,304 | 7.56 | Q | | |

**TABLE 3-5**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**DIW-1 ANALYTICAL REVERSE-AIR DRILLING AIRLIFT WATER QUALITY RESULTS**

| Date | Time | Depth (ft bls) | Chloride (mg/L) | Sulfate (mg/L) | Specific Conductance (µS/cm) | TDS (mg/L) | pH (s.u.) | | TKN (mg/L) | Ammonia (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 10/8/2011 | 2:30 | 1,680 | 19,275 | 3,009 | 52,000 | 36,388 | 7.48 | Q | 0.787 | 0.763 |
| 10/8/2011 | 6:00 | 1,710 | 19,759 | 3,282 | 52,700 | 36,744 | 7.57 | Q | | |
| 10/8/2011 | 10:25 | 1,740 | 19,723 | 3,345 | 52,600 | 36,908 | 7.47 | Q | 0.770 | 0.633 |
| 10/8/2011 | 16:07 | 1,762 | 19,832 | 3,466 | 53,200 | 37,308 | 7.61 | Q | 0.889 | 0.808 |

1. Groundwater samples were collected every 30 feet during drilling for field and laboratory analysis and every 60 feet for laboratory analysis of TKN and ammonia after a depth of 1,260 feet.
2. NC denotes not collected
3. Q: Denotes that the sample was held beyond acceptable holding time. pH is to be analyzed immediately in the field, therefore, pH levels analyzed in the lab will exceed holding time.

**TABLE 3-6**

**City of Sarasota RO Water Treatment Plant Test Injection Well**

**Lower Zone Monitor Well Reverse-Air Drilling Airlift Water Quality Results**

| Laboratory Measurements | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Date | Time | Depth (ft bls) | Chloride (mg/L) | Sulfate (mg/L) | Specific Conductance (µS/cm) | TDS (mg/L) | pH (s.u.) | Lab Qual |
| 11/4/2011 | 8:45 | 330 | 764 | 561 | 3,570 | 2,360 | 9.60 | Q |
| 11/4/2011 | 11:50 | 360 | 771 | 569 | 3,590 | 2,404 | 9.20 | Q |
| 11/4/2011 | 15:15 | 390 | 779 | 574 | 3,590 | 2,372 | 8.61 | Q |
| 11/4/2011 | 17:20 | 420 | 777 | 573 | 3,600 | 2,456 | 8.38 | Q |
| 11/4/2011 | 20:30 | 450 | 745 | 571 | 3,520 | 2,320 | 8.03 | Q |
| 11/4/2011 | 21:50 | 480 | 762 | 584 | 3,540 | 2,372 | 7.94 | Q |
| 11/5/2011 | 0:05 | 510 | 732 | 572 | 3,470 | 2,264 | 7.98 | Q |
| 11/5/2011 | 2:00 | 540 | 731 | 576 | 3,490 | 2,344 | 7.90 | Q |
| 11/5/2011 | 3:30 | 570 | 712 | 591 | 3,450 | 2,200 | 7.88 | Q |
| 11/5/2011 | 6:30 | 600 | 850 | 726 | 4,050 | 2,620 | 7.77 | Q |
| 11/5/2011 | 8:30 | 630 | 888 | 838 | 4,270 | 2,792 | 7.76 | Q |
| 11/5/2011 | 10:19 | 660 | 899 | 913 | 4,380 | 2,924 | 7.75 | Q |
| 11/5/2011 | 14:52 | 690 | 901 | 987 | 4,500 | 3,076 | 7.80 | Q |
| 11/5/2011 | 17:30 | 720 | 972 | 1,020 | 4,730 | 3,288 | 7.77 | Q |
| 11/5/2011 | 19:42 | 750 | 990 | 1,039 | 4,760 | 3,308 | 7.79 | Q |
| 11/5/2011 | 22:00 | 780 | 1,330 | 1,088 | 5,750 | 3,852 | 7.84 | Q |
| 11/6/2011 | 2:40 | 810 | 1,345 | 1,098 | 5,730 | 3,780 | 7.85 | Q |
| 11/6/2011 | 4:45 | 840 | 1,412 | 1,115 | 5,980 | 3,856 | 7.86 | Q |
| 11/6/2011 | 6:00 | 870 | 1,414 | 1,124 | 5,970 | 3,940 | 7.88 | Q |
| 11/6/2011 | 8:25 | 900 | 1,388 | 1,129 | 5,910 | 3,956 | 7.84 | Q |
| 11/6/2011 | 10:20 | 930 | 1,365 | 1,135 | 5,840 | 3,884 | 7.86 | Q |
| 11/6/2011 | 12:47 | 960 | 1,318 | 1,122 | 5,720 | 3,820 | 7.84 | Q |
| 11/6/2011 | 15:30 | 990 | 1,309 | 1,130 | 5,670 | 3,888 | 7.84 | Q |
| 11/6/2011 | 17:25 | 1,020 | 1,276 | 1,127 | 5,600 | 3,900 | 7.97 | Q |
| 11/6/2011 | 21:45 | 1,050 | 1,199 | 1,135 | 5,450 | 3,720 | 7.98 | Q |
| 11/7/2011 | 2:45 | 1,080 | 1,145 | 1,163 | 5,320 | 3,764 | 7.92 | Q |
| 11/7/2011 | 5:30 | 1,110 | 1,125 | 1,177 | 5,230 | 3,744 | 7.80 | Q |
| 11/8/2011 | 4:05 | 1,140 | 1,203 | 1209 | 5510 | 3924 | 7.84 | Q |

Q: Denotes that the sample was held beyond acceptable holding time. pH is to be analyzed immediately in the field, therefore, pH levels analyzed in the lab will exceed holding time.
* Indicates that the water quality sample was refrigerated prior to field analysis.

**TABLE 3-7**

**City of Sarasota RO Water Treatment Plant Test Injection Well**

**UPPER ZONE MONITOR WELL REVERSE-AIR DRILLING ANALYITICAL WATER QUALITY**

| Laboratory Measurements | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | Time | Depth (ft bls) | Chloride (mg/L) | Sulfate (mg/L) | Specific Conductance (µS/cm) | TDS (mg/L) | pH (s.u.) |
| 12/3/2011 | 6:00 | 330 | 813 | 585 | 3,510 | 2,392 | 9.49 |
| 12/3/2011 | 9:21 | 360 | 814 | 562 | 3,510 | 2,304 | 9.39 |
| 12/3/2011 | 12:00 | 390 | 818 | 589 | 3,520 | 2,372 | 9.29 |
| 12/3/2011 | 14:36 | 420 | 782 | 554 | 3,410 | 2,296 | 8.95 |
| 12/3/2011 | 17:00 | 450 | 796 | 596 | 3,480 | 2,204 | 8.83 |
| 12/3/2011 | 18:30 | 480 | 784 | 550 | 3,470 | 2,228 | 8.88 |
| 12/3/2011 | 21:20 | 510 | 802 | 600 | 3,490 | 2,252 | 8.75 |
| 12/3/2011 | 23:31 | 540 | 809 | 604 | 3,520 | 2,304 | 8.42 |
| 12/4/2011 | 1:10 | 570 | 800 | 595 | 3,480 | 2,200 | 8.23 |
| 12/4/2011 | 4:30 | 600 | 812 | 579 | 3,610 | 2,256 | 7.99 |
| 12/4/2011 | 6:40 | 630 | 978 | 745 | 4,080 | 2,596 | 7.87 |
| 12/4/2011 | 7:45 | 660 | 996 | 861 | 4,370 | 2,768 | 7.69 |
| 12/4/2011 | 12:00 | 690 | 937 | 737 | 4,460 | 2,824 | 7.75 |
| 12/4/2011 | 13:45 | 720 | 1,191 | 1,049 | 5,230 | 3,340 | 7.65 |
| 12/4/2011 | 15:45 | 750 | 1,215 | 1,037 | 5,080 | 3,264 | 7.66 |
| 12/4/2011 | 17:20 | 780 | 1,373 | 1,048 | 5,650 | 3,636 | 7.67 |
| 12/4/2011 | 20:00 | 810 | 1,405 | 1,052 | 5,750 | 3,668 | 7.63 |
| 12/4/2011 | 20:50 | 840 | 1,381 | 1,125 | 5,580 | 3,600 | 7.69 |
| 12/4/2011 | 22:20 | 870 | 1,290 | 906 | Not included in lab report | | |
| 12/4/2011 | 23:30 | 900 | Not included in lab report | | | | |
| 12/5/2011 | 0:20 | 930 | Not included in lab report | | | | |
| 12/5/2011 | 2:15 | 960 | 1,276 | 1,120 | 5,350 | 3,464 | 7.71 |
| 12/5/2011 | 4:00 | 990 | 1,289 | 1,130 | 5,480 | 3,484 | 7.71 |
| 12/5/2011 | 5:45 | 1,020 | 1,242 | 1,124 | 5,280 | 3,360 | 7.83 |
| 12/5/2011 | 17:00 | 1,050 | 1,103 | 1,192 | 4,740 | 3,128 | 7.77 |
| 12/5/2011 | 21:20 | 1,075 | 1,290 | 1,189 | 5,660 | 3,792 | 7.81 |

The laboratory results for pH were qualified with Q, which denotes that the sample was held beyond acceptable holding time. pH is to be analyzed immediately in the field, therefore, pH levels analyzed in the lab will exceed

* Indicates that the water quality sample was refrigerated prior to field analysis.

**TABLE 3-8**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**PACKER TEST WATER QUALITY RESULTS**

| Laboratory Measurements | | | | | | | | | | | | Field Measurements | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well | Date | Test No. | Interval (ft bls) | Chloride (mg/L) | Sulfate (mg/L) | Specific Conductance (µS/cm) | TDS (mg/L) | pH (s.u.) | | Ammonia (mg/L) | TKN (mg/L) | Specific Conductance (µS/cm) | TDS (mg/L) | Salinity (‰) | Temperature (°C) | pH (s.u.) |
| DIW-1 | 9/12/2011 | 1 | 1,200 - 1,232 | 20,037 | 2,942 | 51,500 | 35,640 | 7.02 | Q | NA | NA | 51,300 | 25,700 | 33.8 | 29.4 | 6.67 |
| DIW-1 | 9/14/2011 | 2 | 1,157 - 1,188 | 242 | 917 | 2,600 | 2,002 | 7.58 | Q | NA | NA | 2740 | 1550 | 1.3 | 28.5 | 7.50 |
| DIW-1 | 9/15/2011 | 3 | 1,119.5 - 1,150.5 | 7,767 | 1,693 | 24,200 | 16,428 | 7.10 | Q | NA | NA | 24,100 | 12,050 | 15 | 30.6 | 7.04 |
| DIW-1 | 9/16/2011 | 4 | 1,044.5 - 1,075.5 | 2,427 | 1,354 | 8,960 | 6,204 | 7.22 | Q | NA | NA | 8,930 | 4,460 | 5.0 | 31.0 | 7.08 |
| DIW-1 | 10/10/2011 | 5 | 1,501 - 1,762 | 19,432 | 3,187 | 52,600 | 36,752 | 6.85 | Q | 0.709 | 0.886 | 52,600 | 26,300 | 35 | 29.6 | 7.12 |
| DIW-1 | 10/10/2011 | 6 | 1,276.5 - 1,307.5 | 19,600 | 3,191 | 52,000 | 36,424 | 7.31 | Q | 0.620 | 0.667 | 51,600 | 25,800 | 34 | 30.7 | 7.26 |
| DIW-1 | 10/11/2011 | 7 | 1,446.5 - 1,477.5 | 19,854 | 3,297 | 51,700 | 36,268 | 6.94 | Q | 0.689 | 0.684 | 51,000 | 25,500 | 33.5 | 30.7 | 6.85 |
| | | | | | | | | | | | | | | | | |
| LZMW-1 | 11/9/2011 | 1 | 1,114 - 1,141 | 8,556 | 1,991 | 26,400 | 17,892 | 7.16 | Q | 0.578 | 0.778 | 26,400 | 13,200 | 16.1 | 30.7 | 7.00 |
| | | | | | | | | | | | | | | | | |
| UZMW-1 | 12/7/2011 | 1 | 1,037-1,075 | 2,696 | 1,406 | 9,520 | 6,284 | 7.39 | Q | NA | NA | 9,580 | 4,790 | 5.3 | 22.6 | 7.82 |

NA denotes that an analysis for the parameter was not conducted
Q denotes that the sample was held beyond the accepted holding time

**TABLE 3-9**
**City of Sarasota RO Water Treatment Facility Test Injection Well**
**BACKGROUND WATER QUALITY:**
**PRIMARY and SECONDARY DRINKING WATER ANALYSES**

| Parameter | Units | MCL | DIW-1 | | LZMW-1 | | UZMW-1 | |
|---|---|---|---|---|---|---|---|---|
| **Primary Drinking Water Standards** | | | **2/10/2011** | | **11/21/2011** | | **1/4/2012** | |
| **Inorganic Compounds** | | | | | | | | |
| Antimony | mg/L | 0.006 | 0.00452 | U | 0.00226 | U | 0.00226 | U |
| Arsenic | mg/L | 0.01 | 0.03 | U | **0.018** | **X** | 0.008 | |
| Barium | mg/L | 2 | 0.02 | | 0.027 | | 0.018 | |
| Beryllium | mg/L | 0.004 | 0.000078 | U | 0.000078 | U | 0.000078 | U |
| Cadmium | mg/L | 0.005 | 0.0009 | U | 0.0009 | U | 0.0009 | U |
| Chromium | mg/L | 0.1 | 0.002 | U | 0.004 | I | 0.002 | U |
| Cyanide | mg/L | 0.2 | 0.005 | U | 0.005 | U | 0.005 | U |
| Fluoride | mg/L | 4 | 0.291 | | 1.25 | | 0.689 | |
| Lead | mg/L | 0.015 | **0.023** | **X** | 0.00067 | U | 0.002 | I |
| Mercury | mg/L | 0.002 | 0.000198 | U | 0.000198 | U | 0.000198 | U |
| Nickel | mg/L | 0.1 | 0.00118 | U | 0.005 | | 0.00118 | U |
| Nitrate | mg/L | 10 | 0.06 | U | 0.06 | U | 0.06 | U |
| Nitrite | mg/L | 1 | 0.041 | U | 0.041 | U | 0.041 | U |
| Total Nitrate and Nitrite | mg/L | 10 | 0.06 | U | 0.012 | I | 0.06 | U |
| Selenium | mg/L | 0.05 | 0.03 | | 0.00157 | U | 0.00157 | U |
| Sodium | mg/L | 160 | **10,600** | **X** | 116 | | **690** | **X** |
| Thallium | mg/L | 0.002 | **0.031** | **X** | **0.011** | **X** | 0.000981 | U |
| **Pesticides** | | | | | | | | |
| 1,2-Dibromo-3-chloropropane | µg/L | 0.2 | 0.014 | U | 0.014 | U | 0.014 | U |
| 1,2-Dibromoethane | µg/L | 0.02 | | | 0.01 | U | 0.01 | U |
| Aldrin | µg/L | - | | | 0.0062 | U | | |
| Chlordane | µg/L | 2.0 | 0.047 | U | 0.044 | U | 0.045 | U |
| Dieldrin | µg/L | - | | | 0.0051 | U | | |
| Endrin | µg/L | 2.0 | 0.002 | U | 0.0019 | U | 0.0019 | U |
| gamma-BHC (Lindane) | µg/L | 0.2 | 0.003 | U | 0.0028 | U | 0.0029 | U |
| Heptachlor | µg/L | 0.4 | 0.006 | U | 0.0056 | U | 0.0057 | U |
| Heptachlor epoxide | µg/L | 0.2 | 0.003 | U | 0.0028 | U | 0.0029 | U |
| Methoxychlor | µg/L | 40 | 0.014 | U | 0.013 | U | | |
| PCB | µg/L | 0.5 | 0.1 | U | 0.094 | U | 0.096 | U |
| Toxaphene | µg/L | 3.0 | 0.61 | U | 0.57 | U | 0.013 | U |
| 2,4,5-TP (Silvex) | µg/L | 50 | 0.035 | U | 0.035 | U | 0.0356 | U |
| 2,4-D | µg/L | 70 | 0.017 | U | 0.017 | U,J | 0.017 | U |
| Dalapon | µg/L | 200 | 0.38 | U | 0.38 | U | 0.58 | U |
| Dinoseb | µg/L | 7.0 | 0.05 | U | 0.05 | U | 0.05 | U |
| Pentachlorophenol | µg/L | 1.0 | 0.009 | U | 0.009 | U | 0.009 | U |
| Picloram | µg/L | 500 | 0.05 | U | 0.05 | U | 0.05 | U |

**TABLE 3-9**
**City of Sarasota RO Water Treatment Facility Test Injection Well**
**BACKGROUND WATER QUALITY:**
**PRIMARY and SECONDARY DRINKING WATER ANALYSES**

| Parameter | Units | MCL | DIW-1 | | LZMW-1 | | UZMW-1 | |
|---|---|---|---|---|---|---|---|---|
| **Volatile Organic Compounds** | | | | | | | | |
| 1,1,1-Trichloroethane | µg/L | 200 | 0.1 | U | 0.1 | U | 0.1 | U |
| 1,1,2-Trichloroethane | µg/L | 5 | 0.14 | U | 0.14 | U | 0.14 | U |
| 1,1-Dichloroethene | µg/L | 7 | 0.11 | U | 0.11 | U | 0.11 | U |
| 1,2,4-Trichlorobenzene | µg/L | 70 | 0.15 | U | 0.15 | U | 0.15 | U |
| 1,2-Dichlorobenzene | µg/L | 600 | 0.11 | U | 0.11 | U | 0.11 | U |
| 1,2-Dichloroethane | µg/L | 3 | 0.16 | U | 0.56 | I | 0.16 | U |
| 1,2-Dichloropropane | µg/L | 5 | 0.15 | U | 0.15 | U | 0.15 | U |
| 1,4-Dichlorobenzene | µg/L | 75 | 0.1 | U | 0.1 | U | 0.1 | U |
| Benzene | µg/L | 1 | 0.12 | U | 0.12 | U | 0.12 | U |
| Bromodichloromethane | µg/L | - | | | 1.61 | | | |
| Carbon tetrachloride | µg/L | 3 | 0.2 | U | 0.2 | U | 0.2 | U |
| Chlorobenzene | µg/L | 100 | 0.1 | U | 0.1 | U | 0.1 | U |
| Chloroethane | µg/L | - | | | 0.15 | U | | |
| cis-1,2-Dichloroethene | µg/L | 70 | 0.11 | U | 0.11 | U | 0.11 | U |
| Dibromochloromethane | µg/L | - | | | 6.84 | | | |
| Ethylbenzene | µg/L | 700 | 0.35 | I | 0.11 | U | 0.11 | U |
| Methylene chloride | µg/L | 5 | 0.2 | U | 0.2 | U | 0.2 | U |
| Styrene | µg/L | 100 | 0.71 | | 0.1 | U | 0.1 | U |
| Tetrachlorethene | µg/L | 3 | 0.2 | U | **16.5** | **X** | 0.2 | U |
| Toluene | µg/L | 1000 | 0.26 | I | 0.11 | U | 0.11 | U |
| Xylenes, Total | µg/L | 10,000 | 1.01 | | 0.13 | U | 0.13 | U |
| trans-1,2-Dichloroethene | µg/L | 100 | 0.12 | U | 0.12 | U | 0.12 | U |
| Trichloroethene | µg/L | 3 | 0.12 | U | 0.12 | U | 0.12 | U |
| Vinyl chloride | µg/L | 1 | 0.15 | U | 0.15 | U | 0.15 | U |
| **Semi-Volatile / Synthetic Organic Compounds** | | | | | | | | |
| 2,3,7,8-TCDD (Dioxin) | ng/L | 0.03 | ND | | N D | | ND | |
| Alachlor | µg/L | 2 | 0.034 | U | 0.032 | U | 0.033 | |
| Atrazine | µg/L | 3.0 | 0.021 | U | 0.02 | U | 0.02 | U |
| Benzo(a)pyrene | µg/L | 0.2 | 0.021 | UJ | 0.019 | U | 0.019 | U,J |
| bis(2-ethylhexyl)phthalate | µg/L | 6.0 | 0.54 | U | 0.51 | U | 0.5 | U |
| Di(2-ethylhexyl)adipate | µg/L | 400 | 0.42 | U | 0.39 | U | 2.1 | U |
| Hexachlorobenzene | µg/L | 1.0 | 0.011 | U | 0.01 | U | 0.011 | U |
| Hexachlorocyclopentadiene | µg/L | 50 | 0.012 | U | 0.011 | U | 0.011 | U |
| Simazine | µg/L | 4.0 | 0.044 | U | 0.041 | U | 0.042 | U |
| Carbofuran | µg/L | 40 | 0.32 | U,J | 0.32 | U | 0.32 | U |
| Oxamyl | µg/L | 200 | 0.41 | U,J | 0.41 | U | 0.41 | U |
| Glyphosate | µg/L | 700 | 2.1 | U | 2.1 | U | 2.7 | U,J |

**TABLE 3-9**
**City of Sarasota RO Water Treatment Facility Test Injection Well**
**BACKGROUND WATER QUALITY:**
**PRIMARY and SECONDARY DRINKING WATER ANALYSES**

| Parameter | Units | MCL | DIW-1 | | LZMW-1 | | UZMW-1 | |
|---|---|---|---|---|---|---|---|---|
| Endothall | µg/L | 100 | 2.7 | U | 2.7 | U | 0.15 | U,J |
| Diquat | µg/L | 20 | 0.15 | U | 0.15 | U | 0.38 | U |
| **Radionuclides** | | | | | | | | |
| Gross Alpha | pCi/L | 15 | 4.3+/-1.5 | | 9.9 +/- 2.3 | | **45.7 +/- 5.8** | |
| Radium-226 | pCi/L | 5 | 3.4+/-0.3 | | **7.8 +/- 0.4** | | **6.2 +/- 0.6** | |
| Radium-228 | pCi/L | | 0.9 | U | 0.9 +/- 0.5 | | 1.4 +/- 0.5 | |
| **Secondary Drinking Water Standards** | | | | | | | | |
| Aluminum | mg/L | 0.2 | 0.084 | | 0.1 | | 0.027 | I |
| Chloride | mg/L | 250 | **21,463** | **X** | **10,095** | **X** | **2399** | **X** |
| Copper | mg/L | 1 | 0.007 | I | 0.006 | I | 0.004 | U |
| Iron | mg/L | 0.3 | **3.1** | **X** | **0.88** | **X** | 0.164 | |
| Manganese | mg/L | 0.05 | **0.057** | **X** | 0.026 | | 0.00098 | U |
| Silver | mg/L | 0.1 | 0.0005 | U | 0.0005 | U | 0.0005 | U |
| Sulfate | mg/L | 250 | **3,173** | **X** | **1,932** | **X** | **1356** | **X** |
| Zinc | mg/L | 5 | 0.179 | | 0.049 | | 0.0014 | U |
| Color | C.U. | 15 | 7.5 | | **80** | **X** | 7.29 | |
| Odor | TON | 3 | **16** | **X** | **8** | **X** | **8** | **X** |
| pH - Field | s.u. | 6.5 - 8.5 | 7 | | 7.07 | Q | 7.34 | |
| Total Dissolved Solids | mg/L | 500 | **35,056** | **X** | **19,184** | **X** | **5440** | **X** |
| Surfactants-MBAS | mg/L | 0.5 | **1.84** | **X** | 0.03 | U | 0.244 | |
| **Additional Parameters** | | | | | | | | |
| Ammonia | mg/L | - | | | 0.543 | | | |
| Nitrogen, Total Kjeldahl | mg/L | - | | | 0.643 | | | |
| Nitrogen, Organic | mg/L | - | | | 0.1 | I | | |
| Phosphorus, Total | mg/L | - | | | 0.13 | | | |

**Notes:**
ng/L denotes nanograms/liter
pCi/L denotes picocuries/liter
**Bold** denotes that the result is greater than the water quality standards as established in Rule 62.550, Florida

**Qualifiers:**
I: Denotes that the reported value is between the laboratory method detection limit and the laboratory practical

U: The compound was analyzed for but not detected.

X: Denotes exceedance of MCL

Q: Sample beyond acceptable hold time.

**TABLE 3-10**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**DIW-1 GEOPHYSICAL LOGGING SCHEDULE**

| DIW-1 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DATE** | | **23-Aug-11** | **30-Aug-11** | **11-Sep-11** | **27-Sep-11** | **28-Sep-11** | **9-Oct-11** | **21-Dec-11** | **27-Jan-12** | **27-Jan-12** | | |
| **LOGGING RUN** | | **RUN-1** | **RUN -2** | **RUN -3** | **RUN -4** | **RUN -5** | **RUN -6** | **RUN -7** | **RUN-8** | **RUN-9** | **RUN-10** | **RUN-11** |
| **BOREHOLE** | | **12.25" Pilot** | **58.5" Ream** | **12.25" Pilot** | **48.5" Ream** | **40" Casing** | **12.25" Pilot** | **12.25" Pilot** | **28" Casing** | **28" Casing** | | |
| **INTERVAL LOGGED** | **BEGIN (FT BLS)** | **SURFACE** | **5** | **310** | **5** | **0** | **1,120** | **1,120** | **LS** | **LS** | | |
| | **END (FT BLS)** | **299** | **314** | **1,232** | **1,123** | **1,088** | **1,762** | **1,762** | **1,170** | **1,170** | | |
| **LOGS CONDUCTED** | **GAMMA RAY** | **x** | **x** | **x** | **x** | | **x** | | | | | |
| | **CALIPER** | **x** | **x** | **x** | **x** | | **x** | **x** | | | | |
| | **DUAL INDUCTION** | **x** | | **x** | | | **x** | | | | | |
| | **TEMPERATURE** | | | **x** | | **x** | **x** | | **x** | | | |
| | **FLOW METER** | | | | | | | | | | | |
| | **BHC SONIC** | **x** | | **x** | | | **x** | | | | | |
| | **LOG DERIVED TDS** | | | **x** | | | | | | | | |
| | **SECTOR BOND LOG** | | | | | | | | | | | |
| | **VIDEO** | | | **x Televiewer** | | | **x Televiewer** | | | | | |
| **RTS** | | | | | | | | | | | | |
| **COMMENTS** | | Geologic confirmation / Indication of casing placement | Geologic confirmation/ Indication of casing placement | Confirmation of pilot hole, USDW & packer setting depths | Confirmation of pilot hole, USDW & casing setting depth | Merged Cement Temperature Log | Geologic confirmation / Indication of packer setting/casing seating | RE-RUN | Cement stage top | Survey of grout integrity and cement stage top | Survey of grout integrity and cement stage top | MIT of FRP Liner |

**TABLE 3-11**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**LOWER ZONE MONITOR WELL GEOPHYSICAL LOGGING SCHEDULE**

| LZMW-1 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DATE | | | 8-Oct-11 | 15-Oct-11 | 8-Nov-11 | 11-Nov-11 | 17-Nov-11 | 18-Nov-11 |
| LOGGING RUNS | | | RUN-1 | RUN -2 | RUN -3 | RUN -4 | RUN -5 | RUN -6 |
| BOREHOLE | | | 12.25-inch Pilot | 24-inch Ream | 12.25-inch Pilot & 9⅞-inch Pilot | 14.5-inch Ream | 6-inch Final Casing | 6-inch Final Casing |
| INTERVAL LOGGED | | BEGIN (FT BLS) | LS | LS | 300 | 300 | LS | LS |
| | | END (FT BLS) | 300 | 300 | 1,141 | 1,140 | 1,115 | 1115 (1141) |
| LOGS CONDUCTED | GAMMA RAY | | X | X | X | X | | X |
| | CALIPER | | X | X | X | X | | X |
| | DUAL INDUCTION | | X | | X | | | |
| | TEMPERATURE | | X | | X | | X | |
| | FLOW METER | | | | X | | | |
| | BHC SONIC | | X | | X | | | |
| | CEMENT BOND LOG | | | | | | | X |
| | VIDEO | | | | TELEVIEWER | | | |
| COMMENTS | | | Geologic confirmation / Indication of casing placement | Geologic confirmation/ Indication of casing placement | Confirmation of pilot hole, USDW & casing setting depth | Confirmation of pilot hole, USDW & casing setting depth | Merged Cement Temperature Log | Open Interval Confirmation / CBL |

**TABLE 3-12**
**City of Sarasota RO Water Treatment Plant Test Injection Well**
**UPPER ZONE MONITOR WELL GEOPHYSICAL LOGGING SCHEDULE**

| UZMW-1 | | | | | |
|---|---|---|---|---|---|
| DATE | | 29-Nov-11 | 1-Dec-11 | 6-Dec-11 | 9-Dec-11 |
| LOGGING RUNS | | RUN-1 | RUN -2 | RUN -3 | RUN -4 |
| BOREHOLE | | 12.25-inch Pilot | 24-inch Ream | 12.25-inch to 9⅞-inch Pilot | 14.75-inch to 9⅞-inch Ream |
| INTERVAL LOGGED | BEGIN (FT BLS) | LS | LS | LS | LS |
| | END (FT BLS) | 310 | 310 | 1,040 / 1,075 | 1,040 / 1,075 |
| LOGS CONDUCTED | GAMMA RAY | X | X | X | X |
| | CALIPER | X | X | X | X |
| | DUAL INDUCTION | X | | X | |
| | TEMPERATURE | | | X | |
| | FLUID CONDUCTIVITY | | | X* | X* |
| | FLOW METER | | | X* | |
| | BHC SONIC | | | X | |
| | LOG DERIVED TDS | | | | |
| | CEMENT BOND LOG | | | | |
| | VIDEO | | | | |
| COMMENTS | | Geologic confirmation/ Indication of casing placement | Geologic confirmation/ Indication of casing placement | Confirmation of pilot hole,indication for packer setting depth | Geologic confirmation/ Indication of casing placement & verify conductivity |

* Indicates that the log was also conducted under dynamic conditions.

# TABLE 3-13
## City of Sarasota RO WTF Deep Injection Well
### INJECTION TEST MANUAL DATA

DIW Well ID: COS DIW INJ Test
Location: COS WTF RO Facility 12th St Sarasota
Target Pumping Rate: 9000 gpm
Start Pumping Date: 5/5/2012 Time: 19:40
Flow Meter Reading Start: 0 gallons

Monitor Well ID: UZ & LZ
Distance between Monitor & Pumped Wells:
Ref. Pt. for Depth to Water: Top of Riser
End Pumping Date: 5/6/2012 3:40
Flow Meter Reading End: 2287500 gallons

| Date mm/dd/yy | Clock Time hh:mm:ss | Elapsed Time (min) | Injection Rate (gpm) | Well Head Pressure (psi) | Well Head Pressure Dial | Annular Pressure (psi) | Annular Pressure Dial | WL/Pressure UZMW (ft/psi) | WL/Pressure LZMW (ft/psi) | Totalizer (Gal) |
|---|---|---|---|---|---|---|---|---|---|---|
| 5/5/2012 | 21:30 | 110 | 3630 | | 13 | 92.37 | | | | |
| 5/5/2012 | 21:45 | 125 | 3560 | | 13 | | | | | |
| 5/5/2012 | 21:57 | 137 | 3546 | | 13 | 91.92 | | 13.33psi | 11.43 psi | |
| 5/5/2012 | 22:26 | 166 | 3550 | | 13 | | | | | 609378 |
| 5/5/2012 | 22:35 | 175 | 3568 | | 13 | 91.7 | | 19.31 ft/13.36 psi | 23.21ft/ 11.47 psi | |
| 5/5/2012 | 23:02 | 202 | 3552 | | 13 | | | | | 736216 |
| 5/5/2012 | 23:20 | 220 | 3550 | | 13 | 91.29 | | 13.39psi | 11.51 psi | |
| 5/5/2012 | 23:32 | 232 | 3547 | | 13 | | | | | 838679 |
| 5/5/2012 | 23:37 | 237 | 3504 | | 13 | | | | | |
| 5/5/2012 | 23:40 | 240 | 4210 | | | | | | | |
| 5/5/2012 | 23:41 | 241 | 4560 | | | | | | | |
| 5/5/2012 | 23:42 | 242 | 4640 | | | | | | | |
| 5/5/2012 | 23:43 | 243 | 5720 | | | | | | | |
| 5/5/2012 | 23:44 | 244 | 6152 | 50.46 | 41 | 96 | 95.3 | 13.47 psi | 11.66 psi | |
| 5/5/2012 | 23:48 | 248 | 6350 | | 47 | | | | | |
| 5/5/2012 | 23:51 | 251 | 6276 | 51.21 | 48 | 96 | 95.9 | 13.57 psi | 11.77 psi | 929234 |
| 5/5/2012 | 23:57 | 257 | 6230 | | 48 | 96 | | | | |
| 5/6/2012 | 0:02 | 262 | 6202 | | 47 | | | | | |
| 5/6/2012 | 0:04 | 264 | 6160 | 51.7 | 48 | 96 | 95.7 | | | |
| 5/6/2012 | 0:26 | 286 | 6104 | 52.14 | 49 | 96 | 95.7 | 13.7 psi | 11.94 psi | 1152043 |
| 5/6/2012 | 0:45 | 305 | 6025 | 52.14 | 49 | 96 | 95.46 | 19.41 ft/ 13.7 psi | 22.04ft / 11.99psi | |
| 5/6/2012 | 0:57 | 317 | 6024 | | | | | | | |
| 5/6/2012 | 0:58 | 318 | 6012 | | | | | | | |
| 5/6/2012 | 1:00 | 320 | 6031 | | | | | | | 1355786 |

## TABLE 3-13
## City of Sarasota RO WTF Deep Injection Well
### INJECTION TEST MANUAL DATA

DIW Well ID: COS DIW INJ Test

Location: COS WTF RO Facility 12th St Sarasota

Target Pumping Rate: 9000 gpm

Start Pumping Date: 5/5/2012 Time: 19:40

Flow Meter Reading Start: 0 gallons

Monitor Well ID: UZ & LZ

Distance between Monitor & Pumped Wells:

Ref. Pt. for Depth to Water: Top of Riser

End Pumping Date: 5/6/2012 3:40

Flow Meter Reading End: 2287500 gallons

| Date mm/dd/yy | Clock Time hh:mm:ss | Elapsed Time (min) | Injection Rate (gpm) | Well Head Pressure (psi) | Well Head Pressure Dial | Annular Pressure (psi) | Annular Pressure Dial | WL/Pressure UZMW (ft/psi) | WL/Pressure LZMW (ft/psi) | Totalizer (Gal) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 20.82 top of riser | 25.0 Top of riser | 0 |
| 5/5/2012 | 19:30 | | | 0.073 | 0 | | 83.076 | | | 0 |
| 5/5/2012 | 19:40 | 0 | 1700 | 12.5 | | | | | | |
| 5/5/2012 | 19:42 | 2 | 4100 | | | | | | | |
| 5/5/2012 | 19:43 | 3 | 4370 | 12.7 | | | | | | |
| 5/5/2012 | 19:44 | 4 | 4500 | 12.5 | 18 | | 90 | | | |
| 5/5/2012 | 19:44 | 4 | 4550 | 13.8 | 11 | | | | | |
| 5/5/2012 | 19:45 | 5 | 4000 | 13.87 | 12 | | | | | |
| 5/5/2012 | 19:46 | 6 | 3750 | 14.2 | 12 | 91.85 | | | | |
| 5/5/2012 | 19:47 | 7 | 3720 | 32.2 | 12 | | 92 | | | |
| 5/5/2012 | 19:48 | 8 | 3730 | 38.7 | 13 | 92.16 | | | | |
| 5/5/2012 | 19:50 | 10 | 3720 | 44.1 | 13 | | | | | |
| 5/5/2012 | 19:53 | 13 | 3690 | 43.8 | 13 | | | | | |
| 5/5/2012 | 19:55 | 15 | 3670 | 51.6 | 13 | | | | | |
| 5/5/2012 | 19:57 | 17 | 3650 | 51 | 13 | | | | | |
| 5/5/2012 | 20:00 | 20 | 3710 | 52.2 | 13 | | | | | |
| 5/5/2012 | 20:02 | 22 | 3720 | 52.4 | 13 | | | | | |
| 5/5/2012 | 20:04 | 24 | 3720 | | 13 | 92.3 | | 13.073 psi | 11.18 psi | |
| 5/5/2012 | 20:16 | 36 | 3650 | | 14 | | | | | |
| 5/5/2012 | 20:22 | 42 | 3680 | | 13 | | | | | |
| 5/5/2012 | 20:30 | 50 | 3670 | | 13 | | | | | 182700 |
| 5/5/2012 | 20:40 | 60 | 3670 | | 13 | | | | | 219500 |
| 5/5/2012 | 21:00 | 80 | 3680 | | 14 | 92.54 | 94 | 19.62ft /13.25 psi | 23.55ft /11.36psi | |
| 5/5/2012 | 21:15 | 95 | 3670 | | 14 | | | | | 358126 |

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# TABLE 3-13
## City of Sarasota RO WTF Deep Injection Well
### INJECTION TEST MANUAL DATA

DIW Well ID: COS DIW INJ Test
Location: COS WTF RO Facility 12th St Sarasota
Target Pumping Rate: 9000 gpm
Start Pumping Date: 5/5/2012 Time: 19:40
Flow Meter Reading Start: 0 gallons

Monitor Well ID: UZ & LZ
Distance between Monitor & Pumped Wells:
Ref. Pt. for Depth to Water: Top of Riser
End Pumping Date: 5/6/2012 3:40
Flow Meter Reading End: 2287500 gallons

| Date mm/dd/yy | Clock Time hh:mm:ss | Elapsed Time (min) | Injection Rate (gpm) | Well Head Pressure (psi) | Well Head Pressure Dial | Annular Pressure (psi) | Annular Pressure Dial | WL/Pressure UZMW (ft/psi) | WL/Pressure LZMW (ft/psi) | Totalizer (Gal) |
|---|---|---|---|---|---|---|---|---|---|---|
| 5/6/2012 | 1:08 | 328 | 5990 | | 49 | 96 | | | | |
| 5/6/2012 | 1:17 | 337 | 5980 | | | | | | | |
| 5/6/2012 | 1:18 | 338 | 5960 | | | | | | | 1469172 |
| 5/6/2012 | 1:21 | 341 | 6008 | 52.1 | 49 | 96 | 95.5 | | | |
| 5/6/2012 | 1:48 | 368 | 5964 | 53.04 | 49 | 96 | 94.7 | | | 1645602 |
| 5/6/2012 | 2:02 | 382 | 5953 | 53.12 | 50 | 96 | 94.7 | | | |
| 5/6/2012 | 2:40 | 420 | 6004 | 53.02 | 50 | 96 | 94.1 | 13.9 psi | 12.16 psi | 1957021 |
| 5/6/2012 | 2:58 | 438 | 5923 | 53.01 | 50 | 96 | 94.03 | 18.03 ft/ 13.9 psi | 21.6ft 12.18 psi | |
| 5/6/2012 | 3:12 | 452 | 5963 | | 50 | 96 | | | | 2151634 |
| 5/6/2012 | 3:24 | 464 | 5870 | 52.49 | 50 | 96 | 93.71 | 13.96 psi | 12.21 psi | |
| 5/6/2012 | 3:35 | 475 | 5925 | | 50 | 96 | | | | 2281502 |
| 5/6/2012 | 3:40 | 480 | 5950 | 52.3 | 50 | 96 | 93.6 | 13.8 psi | 12.2 psi | 2287500 |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| Step 1 average | | | 3688.0 | 31.8 | 13.1 | 92.0 | 92.0 | | | 2044.9 |
| | | | | | | | | | | |
| Step 2 average | | | 5976.6 | 52.2 | 48.6 | 96.0 | 94.9 | | | 7050.7 |
| | | | | | | | | | | |
| | | | | | | | | | | |

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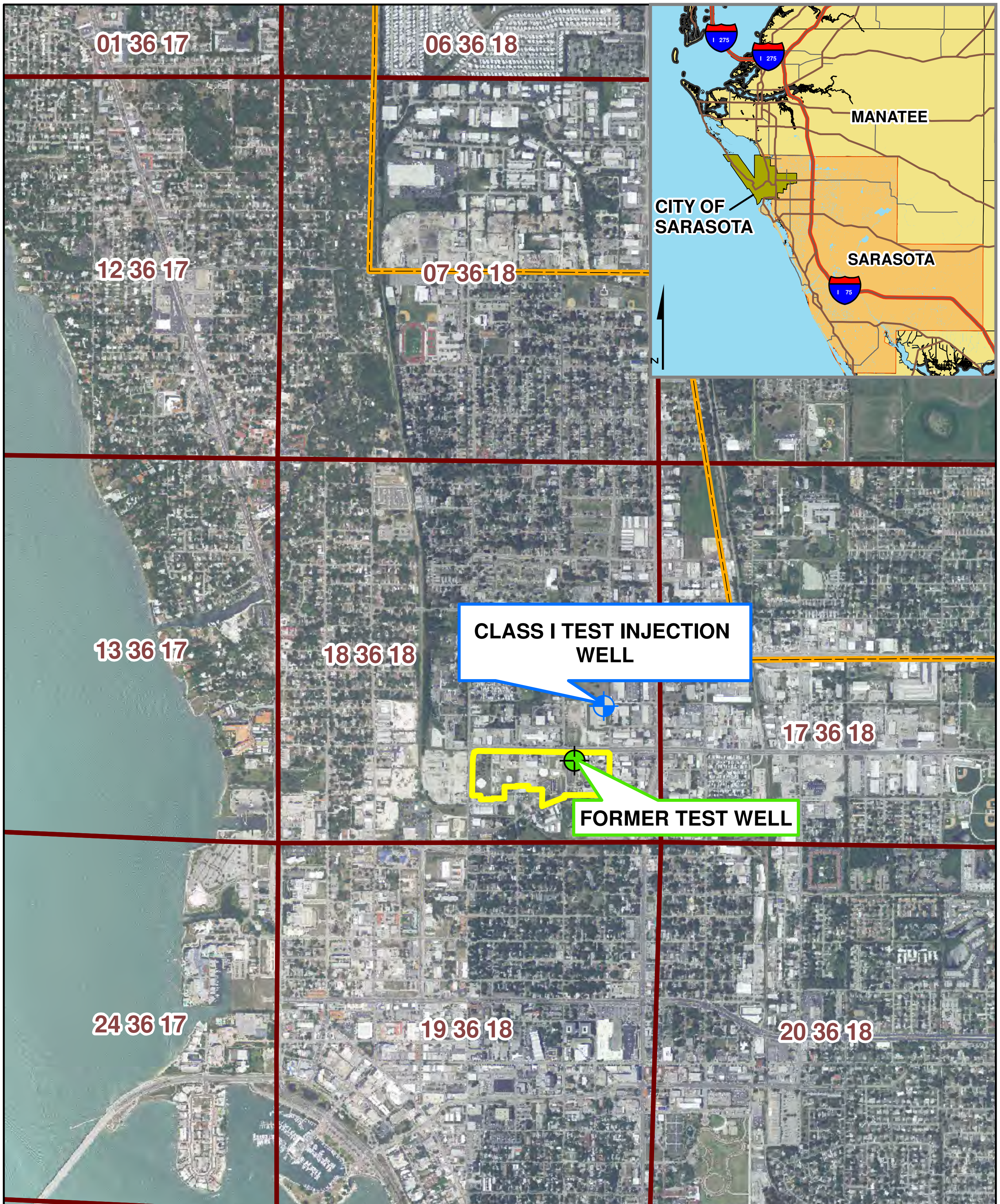
# TABLE 3-14
# SUMMARY OF VERTICAL TRAVEL TIMES

| | |
|---|---|
| Vertical travel distance to UZMW, near base of USDW (122 feet bls):<br>D= Distance = 1197'- 1075' = 122 feet | Dist = 122 feet |
| Geometric averages of vertical permeability (Kv) and apparent Porosity (N)<br>(From Rock Core Lab data) | |
| a. Kv (avg) = Geometric average of vertical permeability | Kv avg = 0.009 feet/day |
| b. N (avg) = Average apparent porosity. | N avg = 0.2 dimensionless |
| Pressure difference between 10,000 mg/l TDS and injection plume:<br>(Note pad elevation of ~27.9 feet; all elevations referenced from NGVD) | |
| a. Natural Pressure (Head) Difference (Hd):<br>Injection Well head (Iwh) – UZMW head (Mwh) | |
| Equiv fresh water head on injection well: | Iwh = 29.44 feet (NGVD) |
| Equiv fresh water head on UZMW: | Mwh = 8.42 feet (NGVD) |
| Difference between adjusted heads: | Hd = 21.02 feet |
| b. Aquifer (Formation) Pressure Increase during injection (Api): | Api = 41.5 feet |
| c. Buoyancy Pressure (Bp):<br>Displacement distance (plume height) of injectate multiplied by<br>Difference in specific gravity. Assume worst case of a SG difference<br>of 0.025 (sea water – fresh water). Assume plume height of 75 feet. | |
| 0.025 * 75 = Bp | Bp = 1.88 feet |
| d. Total Differential Pressure = Hd+Api+Bp=Tp | Tp = 64.4 feet |
| 4. Vertical travel time (Tv) based on Darcy Equation:<br>$T_v$.=D/$V_x$<br>where D distance and $V_x$ is darcian velocity (Vd) or Linear Velocity (Vl) | |
| a. Vd=Kv*lv, Where lv is the vertical head gradient<br>lv = Tp/D = 64.4/122 | lv = 0.53 feet/feet |
| :.Vd = Kv*lv (0.009 x 0.53) | Vd = 0.00477 ft/day |
| b. Linear Velocity (Vl) = Darcian Velocity (Vd)/ Apparant Porosity (N)<br>0.00477/0.2 | Vl = 0.0238 ft/day |
| c. Travel time = separation from USDW interface to injectate/Vl | |
| Tt = s/Vl = 122 feet/0.0238 feet/day | Tt = 5,126 days |
| Travel time (Tt) to USDW | Tt ~ 14 years |

# Section 1 Figures

CREATED BY: 22601
REVIEWED BY: 14133




**LEGEND:**

- TEST INJECTION WELL
- USGS MONITOR WELL
- CITY BOUNDARY
- CITY OF SARASOTA RO WTP
- SECTION, TOWNSHIP, RANGE

**NOTES:**

1. THIS FIGURE IS GENERATED IN COLOR. PHOTOCOPYING IN BLACK AND WHITE WILL RESULT IN THE LOSS OF THE PRESENTED DATA.
2. AERIAL IMAGERY PROVIDED BY THE USDA (2010).

0 335 670 1,340 2,010
SCALE IN FEET

CITY OF SARASOTA
1565 1ST STREET
SARASOTA, FLORIDA 34236

**CITY OF SARASOTA**
**CLASS I TEST INJECTION WELL SYSTEM**
**SITE LOCATION MAP**

JUNE 2012

ATKINS

**FIGURE 1-1**

F:\COMMON\Hydrogeological Program\FIGURES\MXD\100017693-Site_Location_Map.mxd


**LEGEND:**

- Fire Hydrants
- Water Mains 2009
- Water Service Lines 2009
- Sewer Mains 2010
- Sewer Manhole 2010
- Private Reuse 2010
- Reuse Main 2010
- Roadways
- COS DIW Approximate Site Boundary

1 in = 200 ft

0 50 100 200 300 400

SCALE IN FEET

CITY OF SARASOTA PUBLIC WORKS/UTILITIES DIVISION
1761 12TH STREET
SARASOTA, FLORIDA 34236

# CITY OF SARASOTA DEEP INJECTION WELL WATER AND REUSE UTILITY MAP

JUNE 2012

ATKINS

**FIGURE 1-2**

F:\Hydrogeological Program\FIGURES\MXD\100017693_COS_DIW_Utility_Map.mxd

# Section 2 Figures

FIGURE 2-1
TRUCK MOUNTED DRILLING RIG
FOR INSTALLATION OF SURFICIAL AQUIFER MONITOR WELLS


Figure 2-2 Surficial Aquifer Monitor Wells

FIGURE 2-3
INJECTION WELL DRILLING RIG – YBI E2

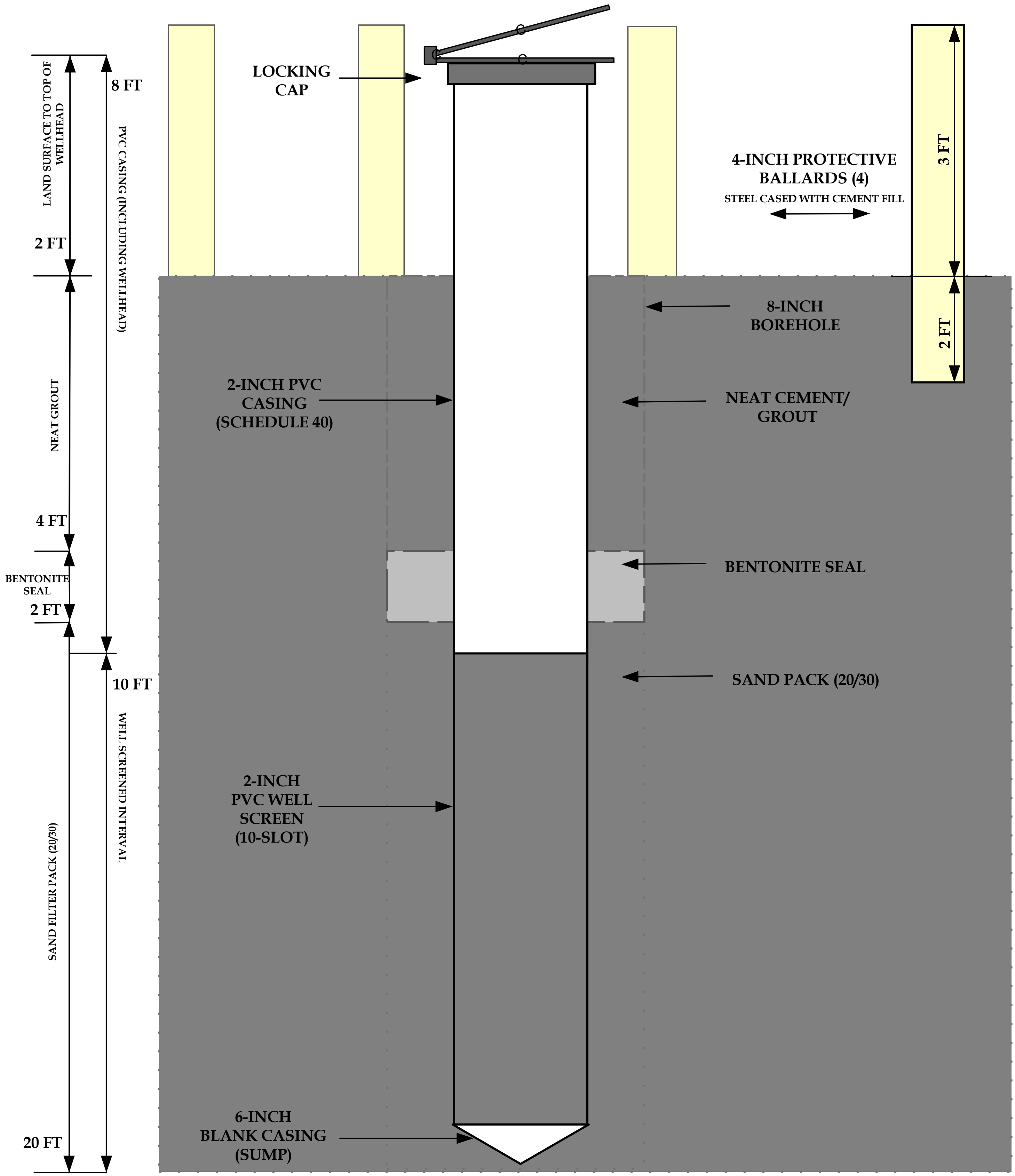
FIGURE 2-4: 12-INCH TRICONE DRILLING BIT

FIGURE 2-5: 56-INCH REAMING BIT

FIGURES 2-6 and 2-7

SHALE SHAKERS AND DESANDERS DURING MUD DRILLING

FIGURE 2-8
SURFICIAL AQUIFER MONITOR WELL
AS-BUILT DIAGRAM




NOT TO SCALE

MARCH 2012

FIGURE 2-9: 52-INCH SURFACE CASING

FIGURE 2-10: 40-INCH INTERMEDIATE CASING

FIGURE 2-11: 28-INCH INJECTION WELL FINAL CASING

FIGURE 2-12: 18-INCH INJECTION WELL FRP TUBING

FIGURE 2-13
52-INCH SURFACE CASING INSTALLATION

FIGURE 2-14
40-INCH DIW INTERMEDIATE CASING INSTALLATION

FIGURE 2-15: TREMIE GROUT

FIGURE 2-16: PRESSURE HEAD ASSEMBLY FOR GROUTING

FIGURE 2-17: CORE BARREL

FIGURE 2-18: CORE BARREL BIT

FIGURE 2-19: RETRIEVING CORE SAMPLE


FIGURE 2-20: INJECTION WELL CORE SAMPLES

FIGURE 2-21:
CEMENTING PACKER FOR INJECTION WELL 28-INCH CASING

FIGURE 2-22: FEMALE PACKER PBR WELDED INSIDE 28-INCH CASING

FIGURE 2-23:
INJECTION WELL POLISH BORE RECEPTICLE
"STINGER" ASSEMBLY AND FRP

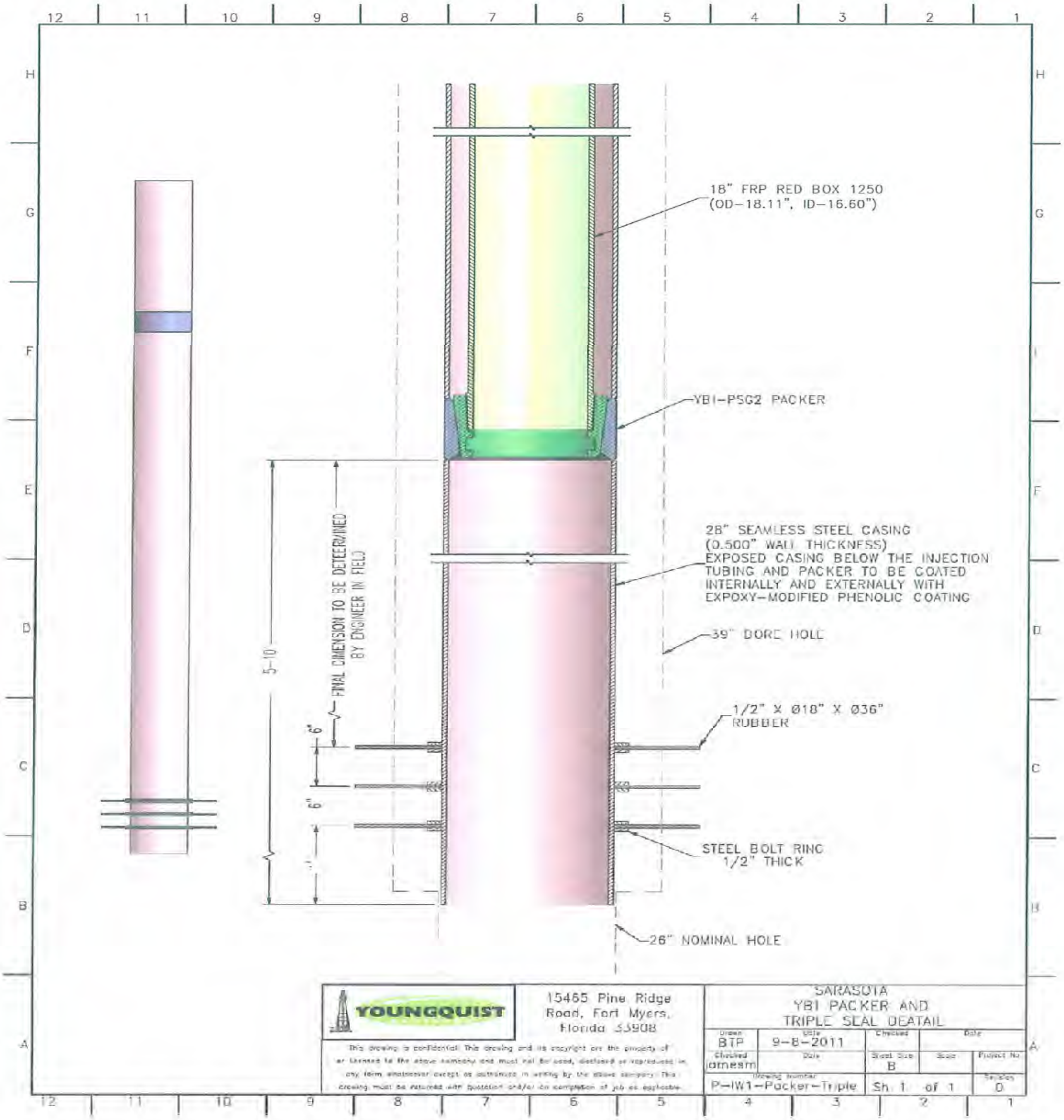



FIGURE 2-24:
YBI PACKER ASSEMBLY SCHEMATIC

FIGURE 2-25
CITY OF SARASOTA DEEP INJECTION WELL PROJECT
AS-BUILT DRAWING OF DEEP INJECTION WELL
INCLUDING ESTIMATES OF GEOLOGIC AND HYDROGEOLOGIC UNITS

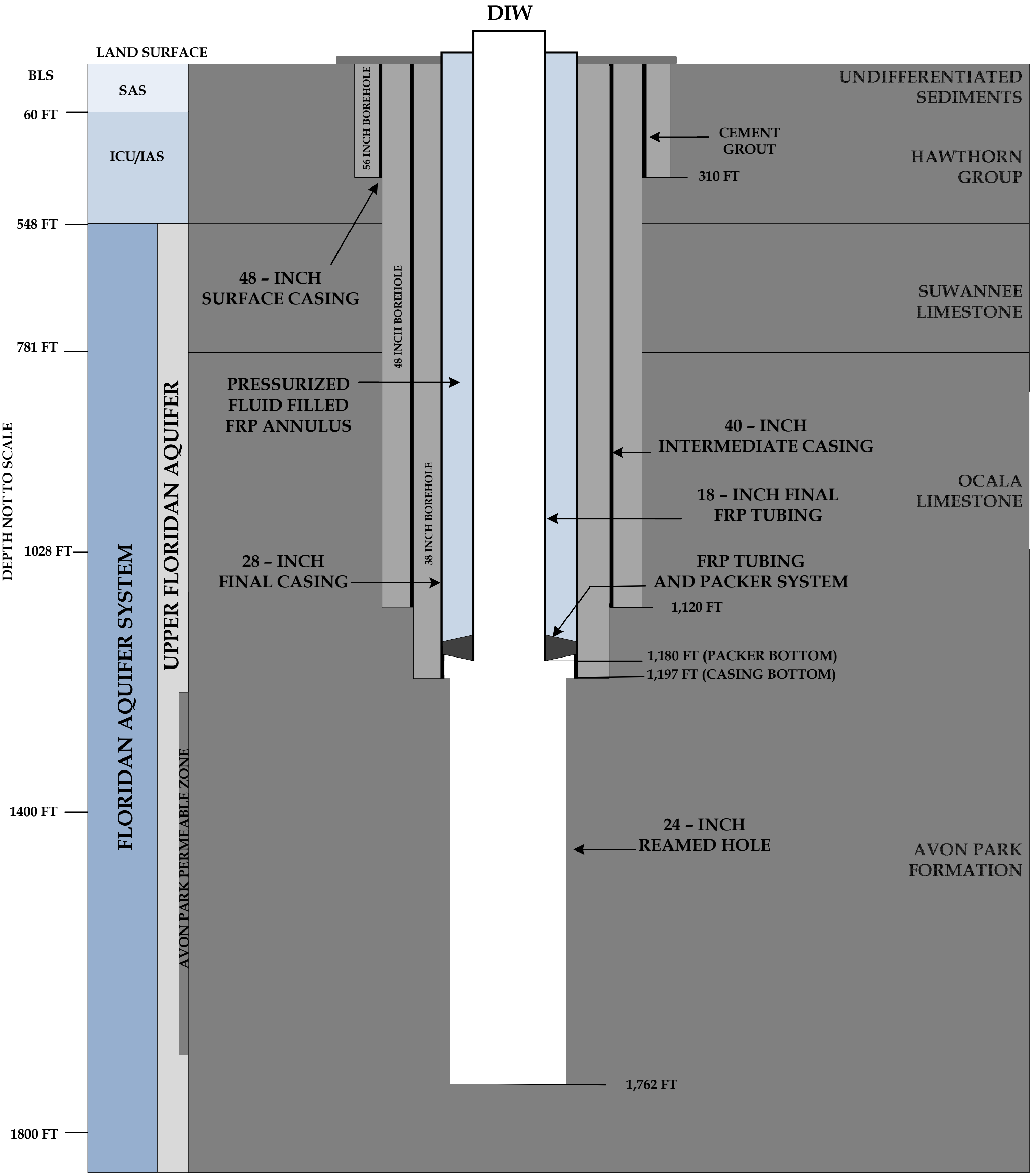


Figure 2-26 DIW Wellhead

Figure 2-27 LZMW Wellhead

FIGURE 2-28
CITY OF SARASOTA DEEP INJECTION WELL PROJECT
AS-BUILT DRAWING OF LOWER ZONE MONITOR WELL
INCLUDING ESTIMATES OF GEOLOGIC AND HYDROGEOLOGIC UNITS

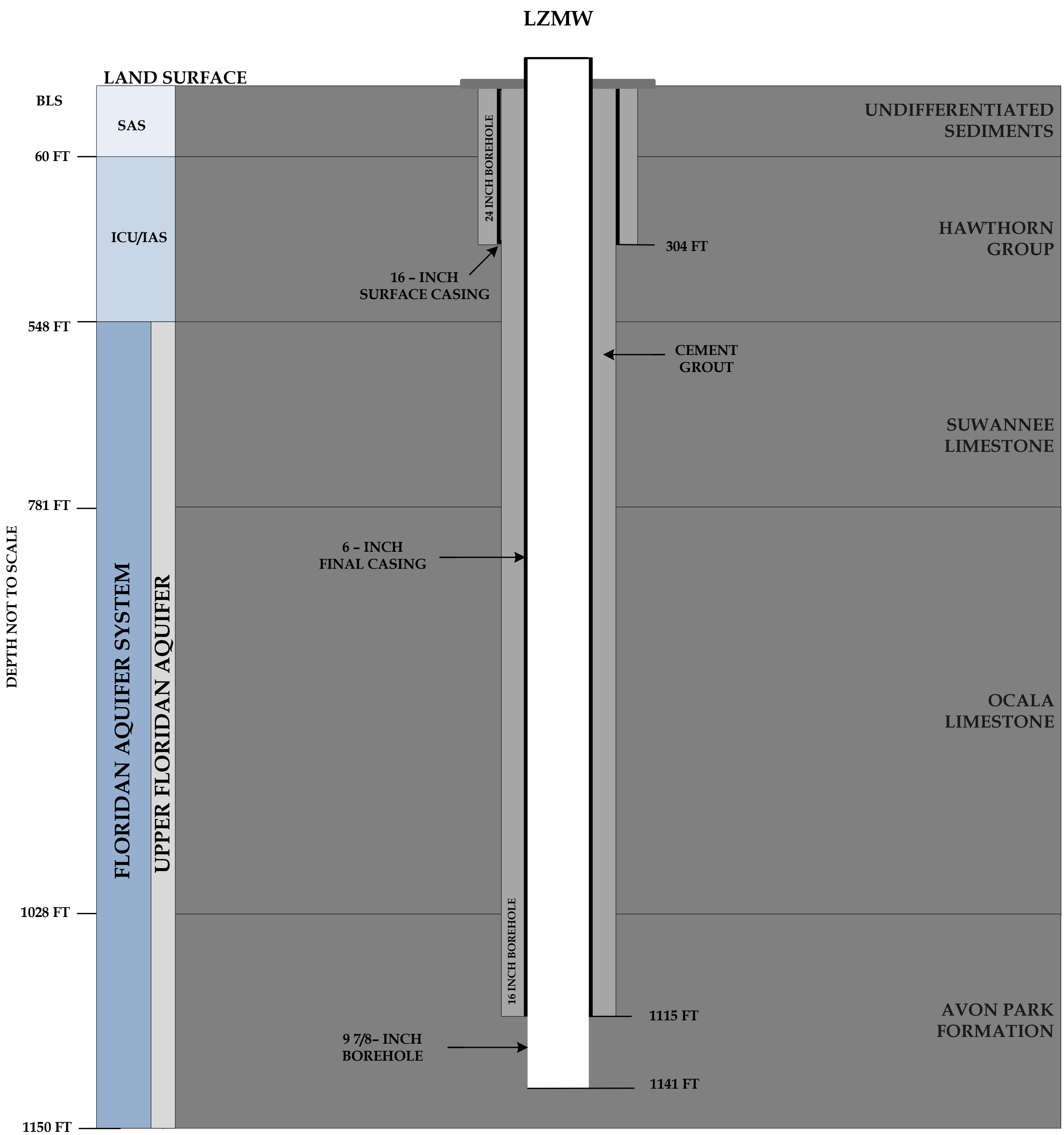
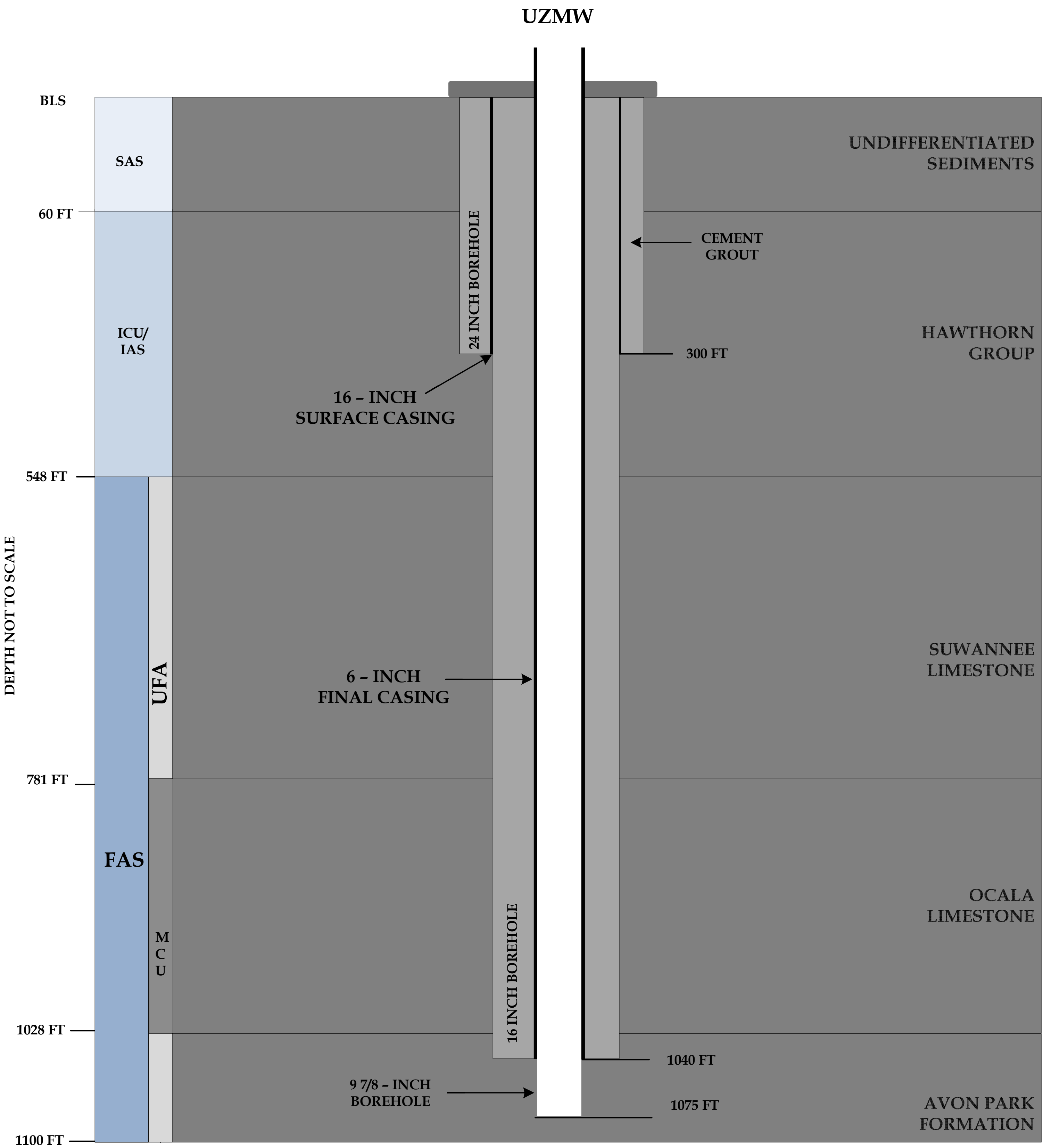


Figure 2-29 UZMW Wellhead

FIGURE 2-30
CITY OF SARASOTA DIW PROJECT
AS-BUILT DRAWING OF UZMW
INCLUDING ESTIMATES OF GEOLOGIC AND HYDROGEOLOGIC UNITS



# Section 3 Figures

F:\COMMON\Hydrogeological Program\FIGURES\MXD\100017693_COS-DIW-1_FGS_NS_TRANSECT.mxd

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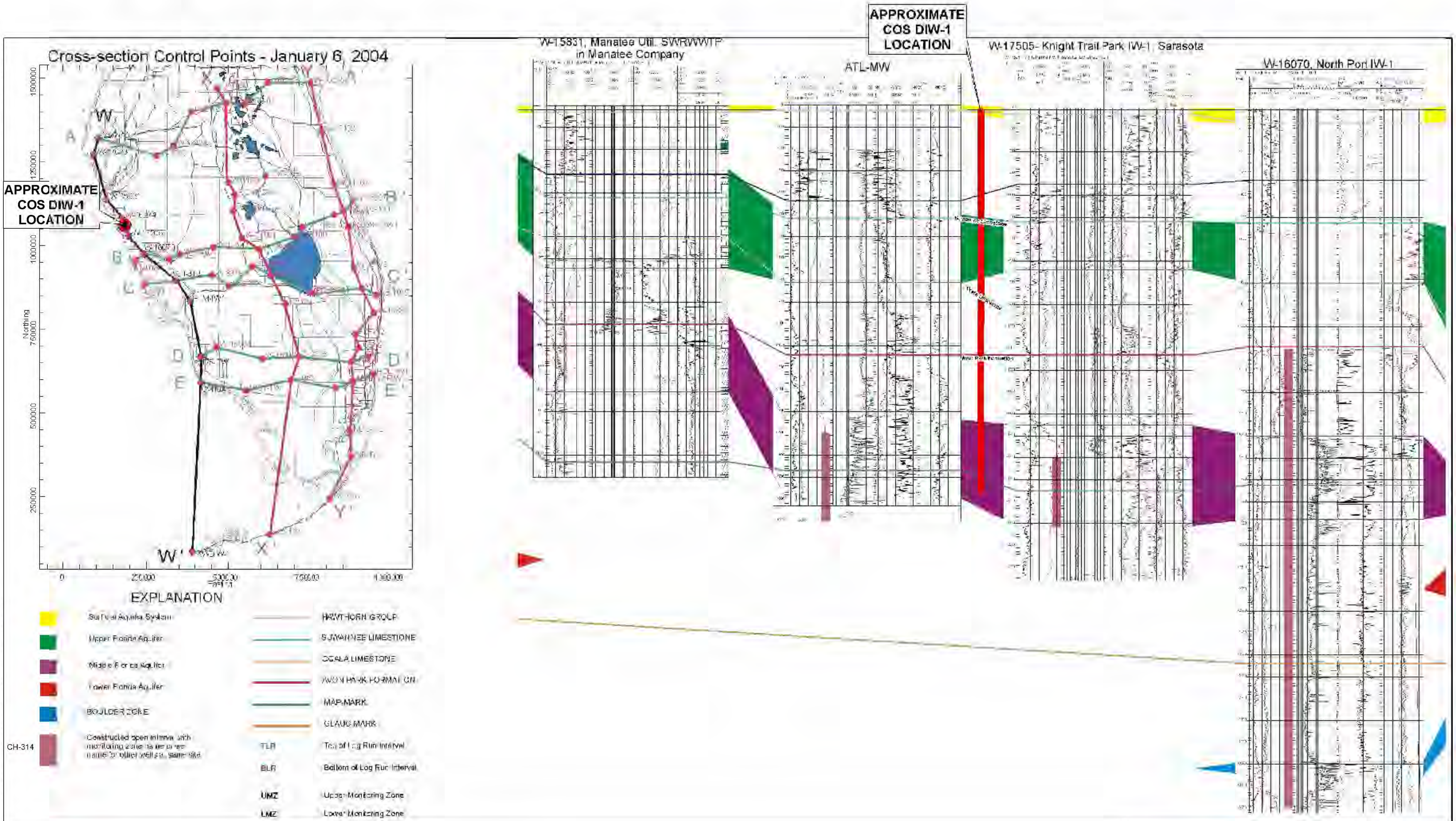
REVIEWED BY: 14133




**NOTES:**

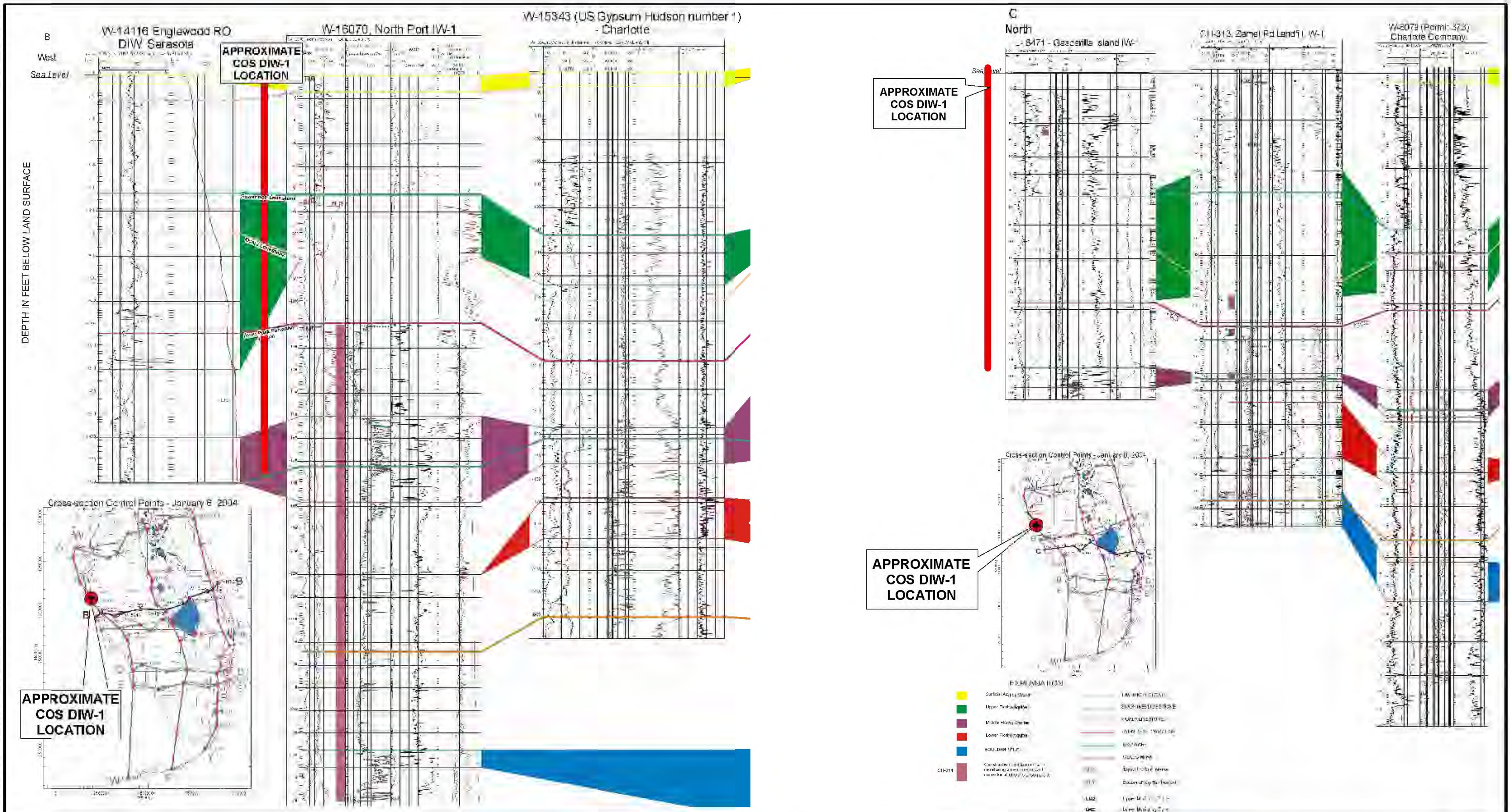
1. THIS FIGURE IS GENERATED IN COLOR. PHOTOCOPYING IN BLACK AND WHITE WILL RESULT IN THE LOSS OF THE PRESENTED DATA.
2. GEOLOGIC/HYDROGEOLOGIC CROSS-SECTION PROVIDED BY THE FLORIDA GEOLOGICAL SURVEY. REPRINTED FROM: ARTHUR, J.D., FISCHLER, C. KROMHOUT, J. CLAYTON, C.M. KELLEY, R.A LEE, L. LI, M. O'SULLIVAN, R.C. GREEN, AND C.L. WERNER, 2008. HYDROGEOLOGIC FRAMEWORK OF THE SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT. FLORIDA GEOLOGICAL SURVEY BULLETIN 68 (DRAFT VERSION).

FDEP CLASS I INJECTION WELL CONSTRUCTION AND TESTING PERMIT
CITY OF SARASOTA RO WTP TEST INJECTION WELL
SARASOTA COUNTY, FLORIDA

**REGIONAL GEOLOGY AND HYDROGEOLOGY**
**FLORIDA GEOLOGICAL SURVEY**
**NORTH-SOUTH TRANSECT**

SCALE AS SHOWN
MARCH 2012

ATKINS FIGURE 3-1




**NOTES:**

1. THIS FIGURE IS GENERATED IN COLOR. PHOTOCOPYING IN BLACK AND WHITE WILL RESULT IN THE LOSS OF THE PRESENTED DATA.
2. GEOLOGIC/HYDROGEOLOGIC CROSS SECTION PROVIDED BY THE FLORIDA GEOLOGICAL SURVEY. REPRINTED FROM: ARTHUR, J.D., C. FISCHLER, C. KROMHOUT, J. CLAYTON, G.M. KELLEY, R.A. LEE, L. LI, M. O'SULLIVAN, R.C. GREEN, AND C.L. WERNER. 2007. HYDROGEOLOGIC FRAMEWORK OF THE SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT. FLORIDA GEOLOGICAL SURVEY BULLETIN 68 (DRAFT VERSION).

FDEP CLASS I INJECTION WELL CONSTRUCTION AND TESTING PERMIT
CITY OF SARASOTA ROWTP TEST INJECTION WELL
SARASOTA COUNTY, FLORIDA

**REGIONAL GEOLOGY AND HYDROGEOLOGY**
**FLORIDA GEOLOGICAL SURVEY**
**EAST-WEST TRANSECTS**

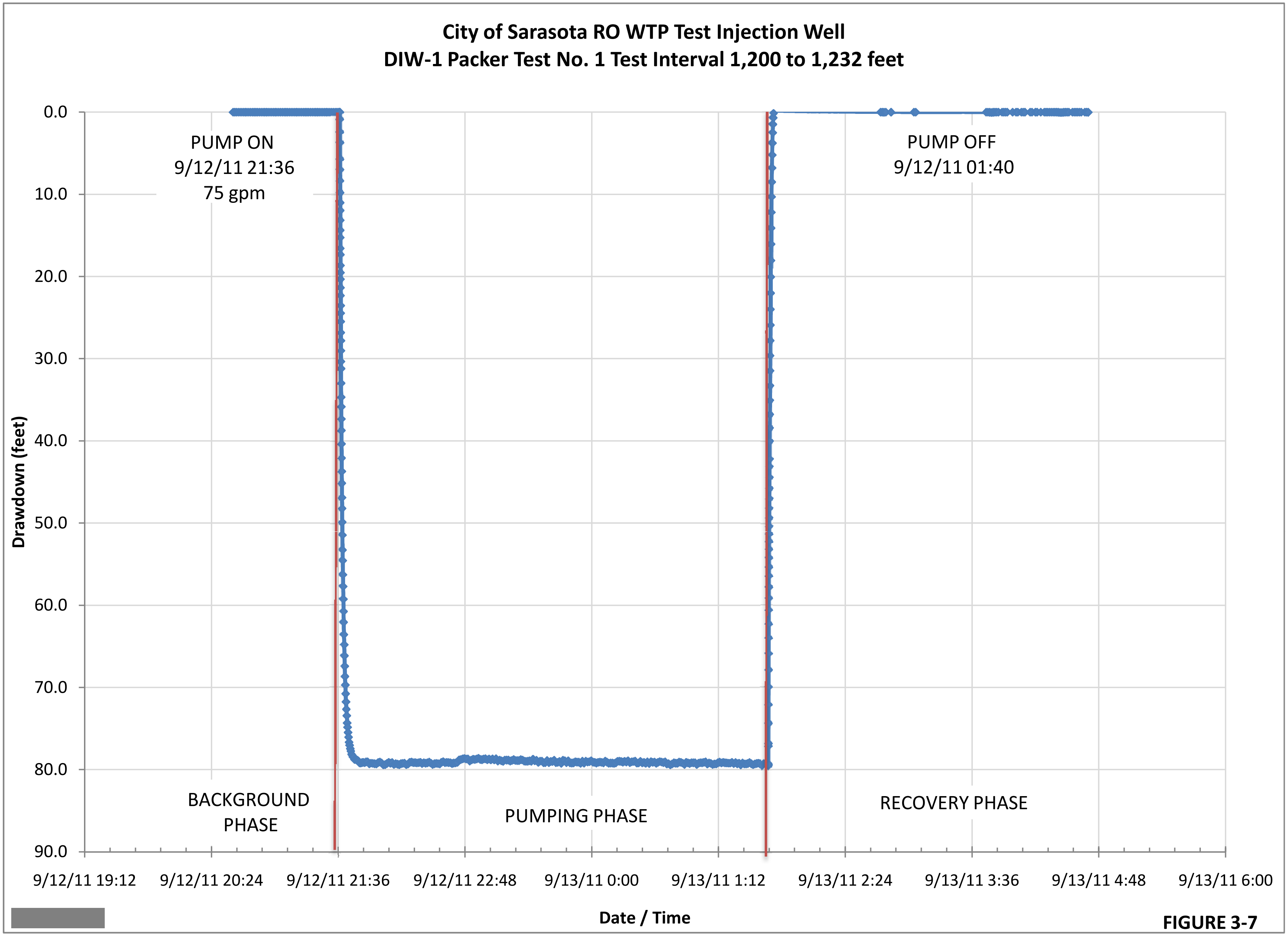
SCALE AS SHOWN
MARCH 2012

ATKINS **FIGURE 3-2**

FIGURES 3-3 and 3-4 CORE SAMPLES

FIGURE 3-5 INFLATABLE PACKERS

FIGURE 3-6 PACKER TEST SET-UP



City of Sarasota RO WTP Test Injection Well
DIW-1 Packer Test No. 1 Test Interval 1,200 to 1,232 feet
Drawdown (feet)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
PUMP ON
9/12/11 21:36
75 gpm
PUMP OFF
9/12/11 01:40
BACKGROUND
PHASE
PUMPING PHASE
RECOVERY PHASE
9/12/11 19:12
9/12/11 20:24
9/12/11 21:36
9/12/11 22:48
9/13/11 0:00
9/13/11 1:12
9/13/11 2:24
9/13/11 3:36
9/13/11 4:48
9/13/11 6:00
Date / Time


**FIGURE 3-7**

**City of Sarasota RO WTP Test Injection Well**
**DIW-1 Packer Test No. 1 Test Interval 1,200 to 1,232 feet**
**Log/Linear Cooper Jacob Drawdown Analysis**

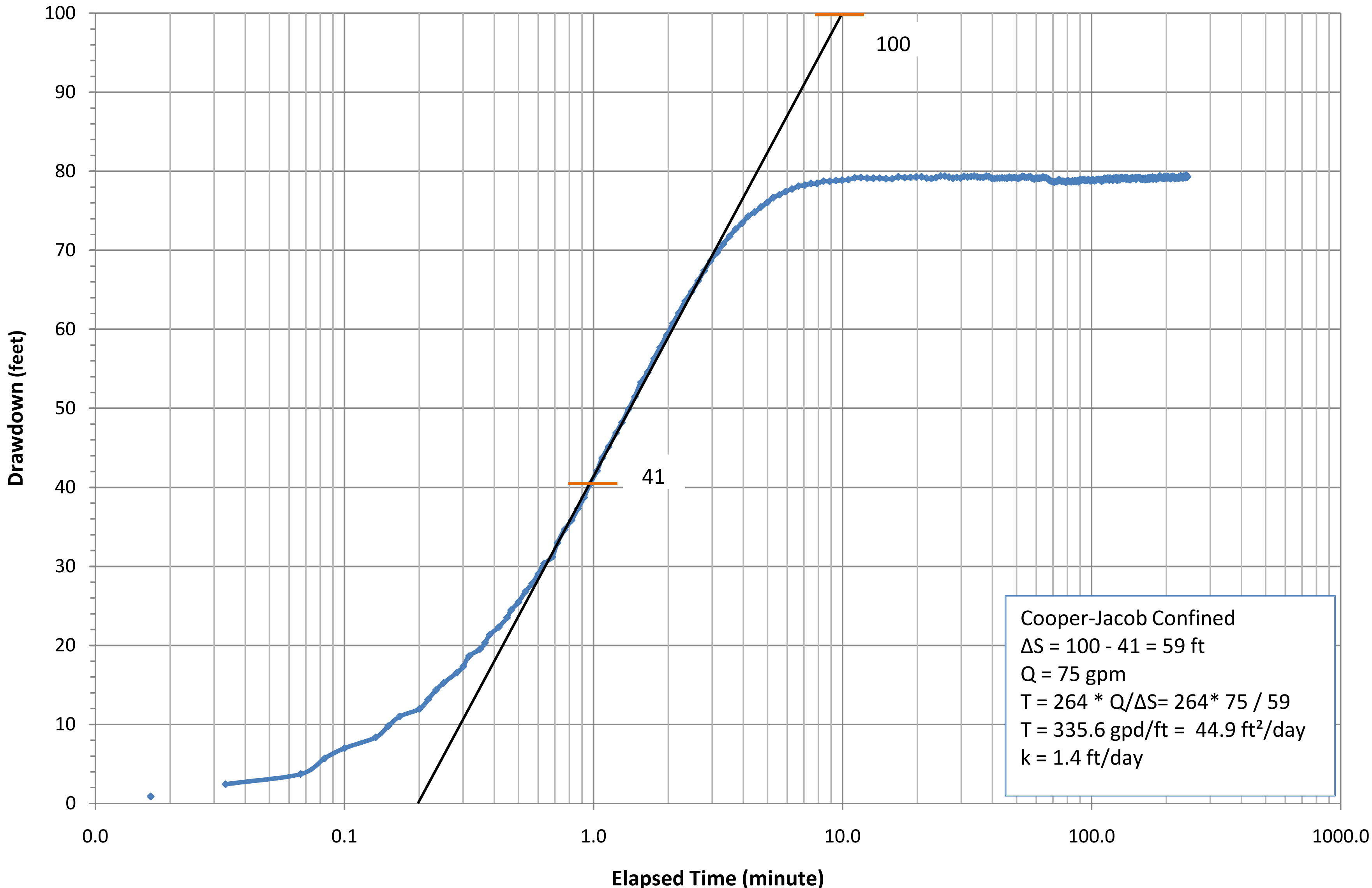



**FIGURE 3-8**

**City of Sarasota RO WTP Test Injection Well**
**DIW-1 Packer Test No. 1 Test Interval 1,200 to 1,232 feet**
**Log/Linear Theis Recovery Analysis**

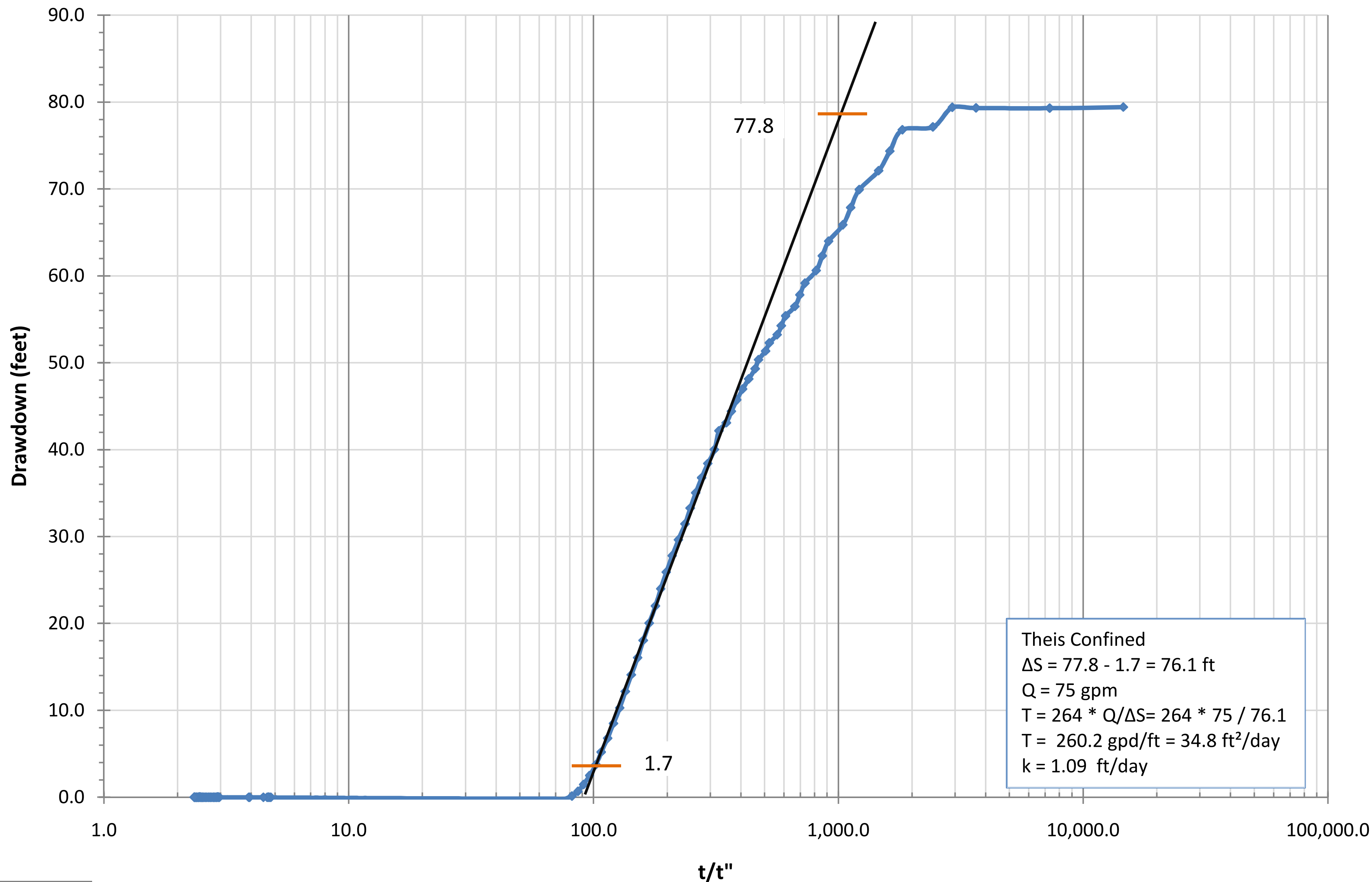
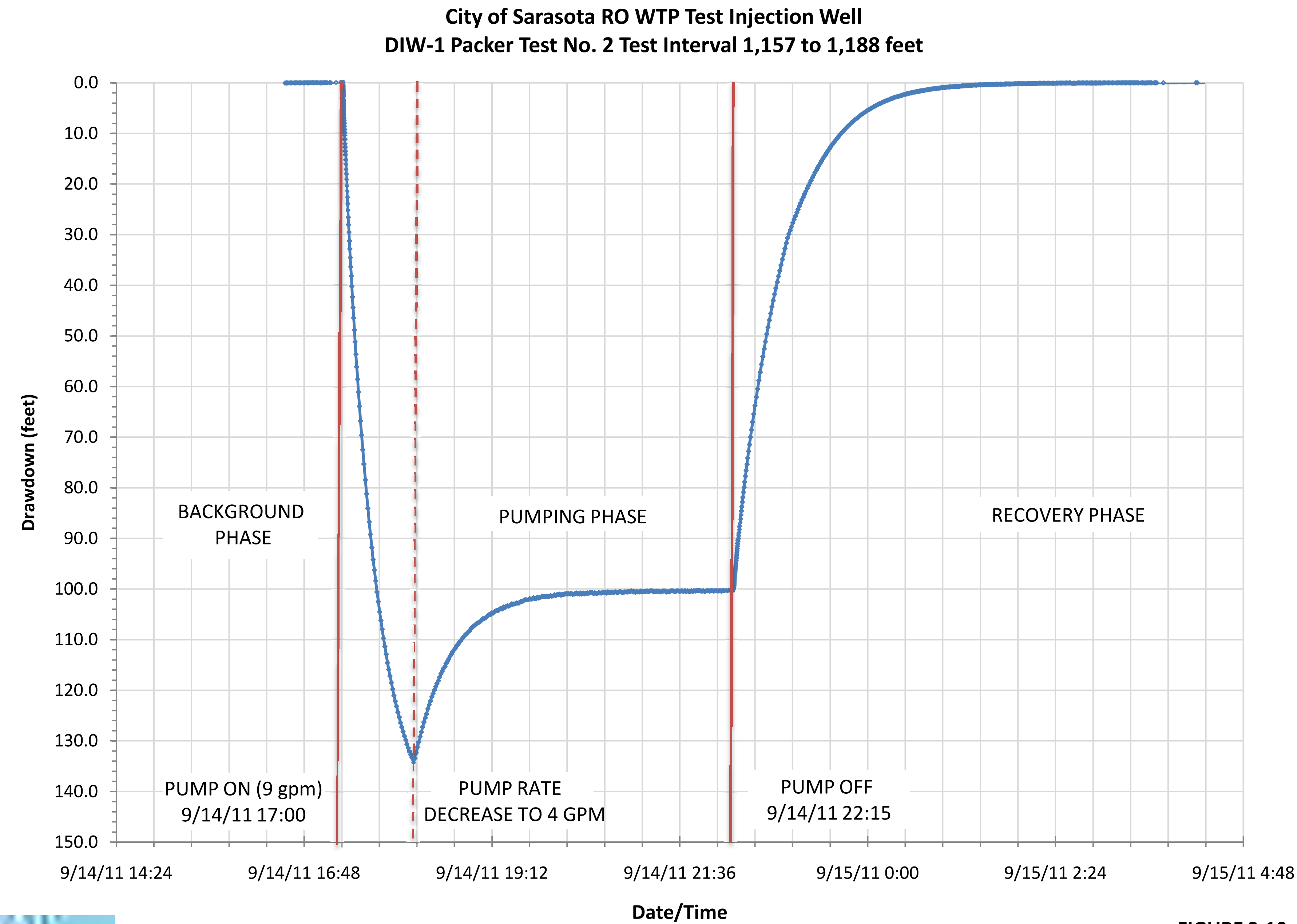



**FIGURE 3-9**



City of Sarasota RO WTP Test Injection Well
DIW-1 Packer Test No. 2 Test Interval 1,157 to 1,188 feet
Drawdown (feet)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0
150.0
BACKGROUND PHASE
PUMPING PHASE
RECOVERY PHASE
PUMP ON (9 gpm)
9/14/11 17:00
PUMP RATE DECREASE TO 4 GPM
PUMP OFF
9/14/11 22:15
9/14/11 14:24
9/14/11 16:48
9/14/11 19:12
9/14/11 21:36
9/15/11 0:00
9/15/11 2:24
9/15/11 4:48
Date/Time


FIGURE 3-10

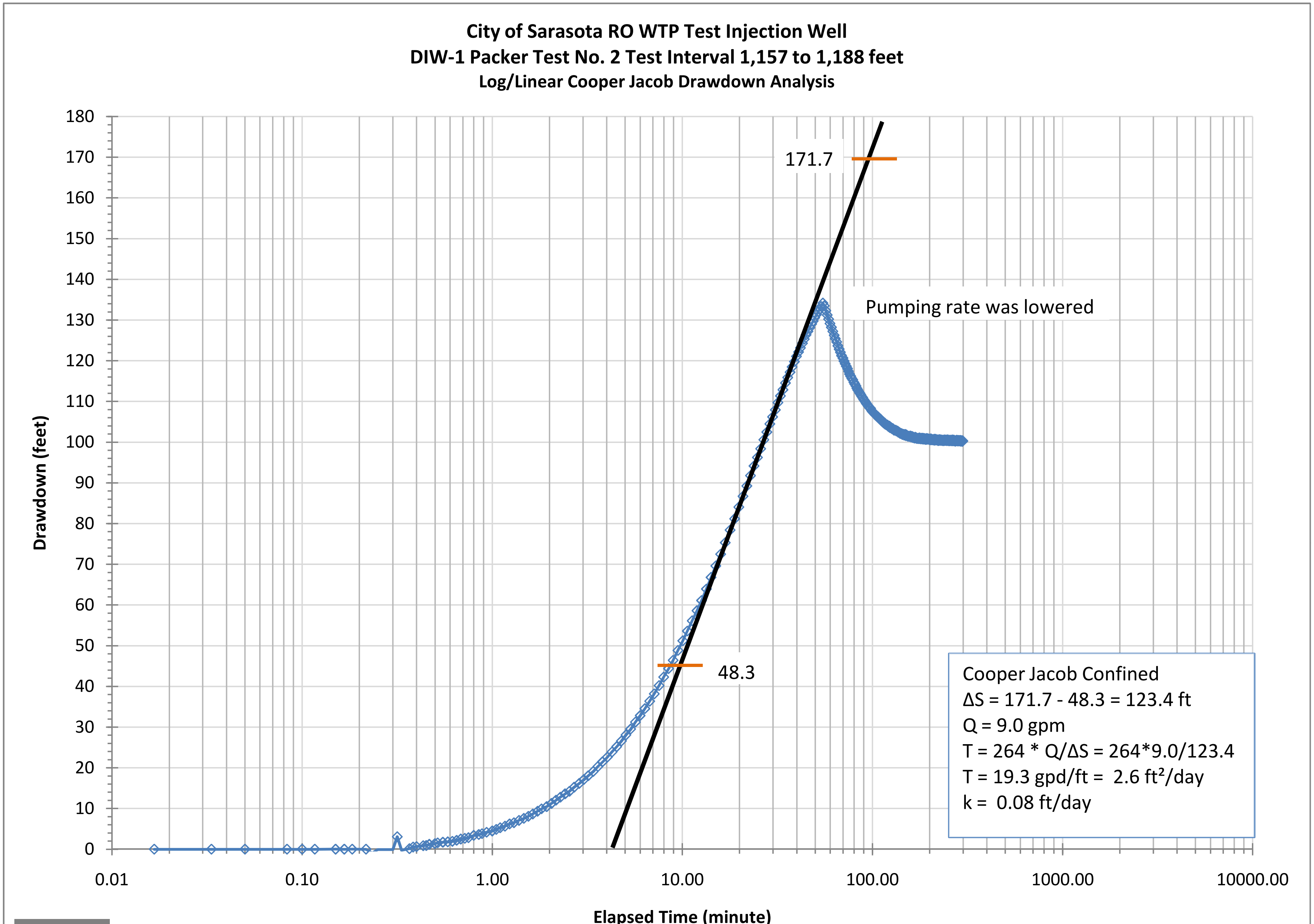

City of Sarasota RO WTP Test Injection Well
DIW-1 Packer Test No. 2 Test Interval 1,157 to 1,188 feet
Log/Linear Cooper Jacob Drawdown Analysis
Drawdown (feet)
Elapsed Time (minute)
171.7
48.3
Pumping rate was lowered
Cooper Jacob Confined
ΔS = 171.7 - 48.3 = 123.4 ft
Q = 9.0 gpm
T = 264 * Q/ΔS = 264*9.0/123.4
T = 19.3 gpd/ft = 2.6 ft²/day
k = 0.08 ft/day

**FIGURE 3-11**

**City of Sarasota RO WTP Test Injection Well**
**DIW-1 Packer Test No. 2 Test Interval 1,157 to 1,188 feet**
**Log/Linear Theis Recovery Analysis**

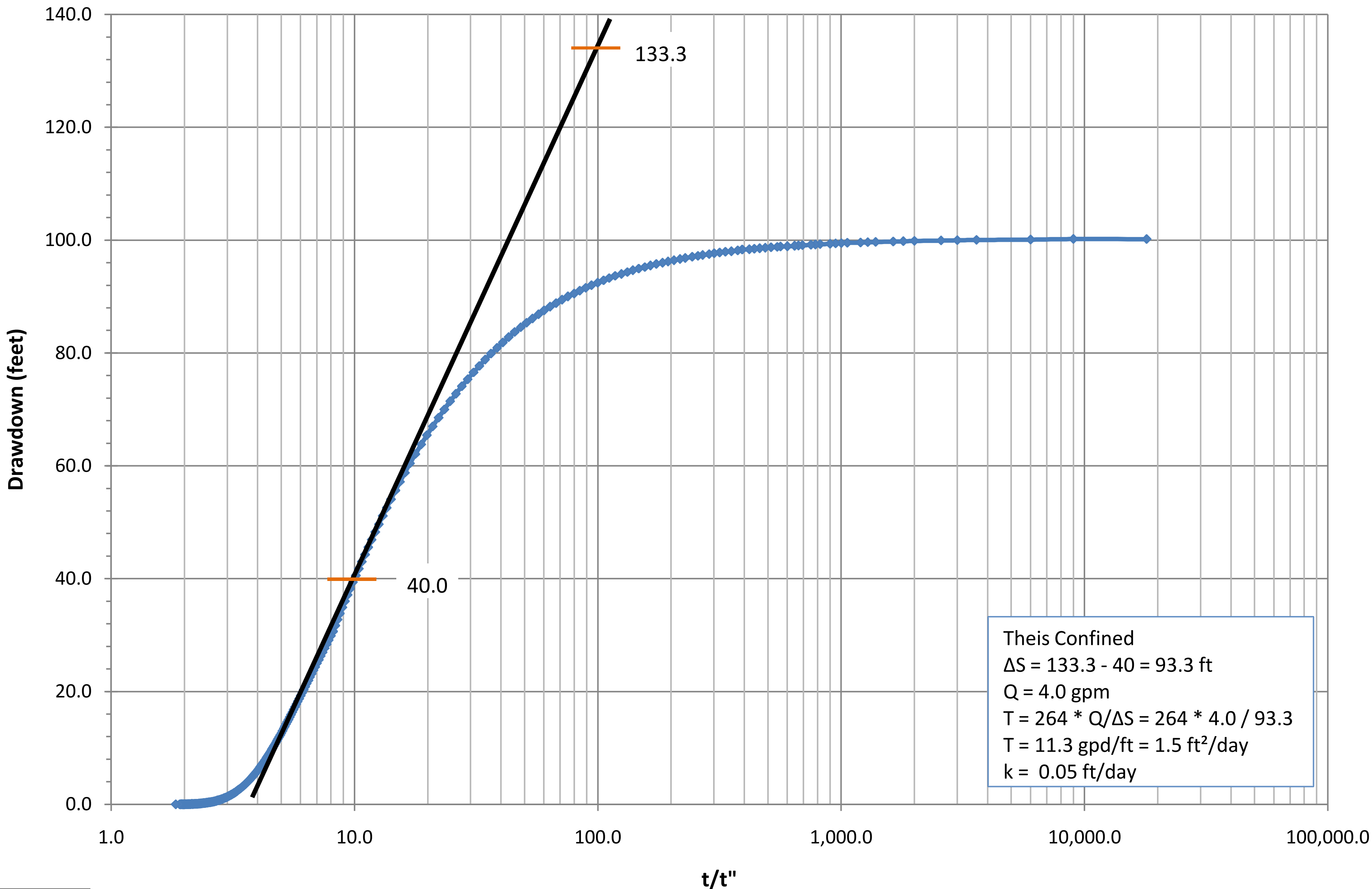



**FIGURE 3-12**

**City of Sarasota RO WTP Test Injection WellD**
**DIW-1 Packer Test No. 3 Test Interval 1,119.5 to 1,150.5 feet**

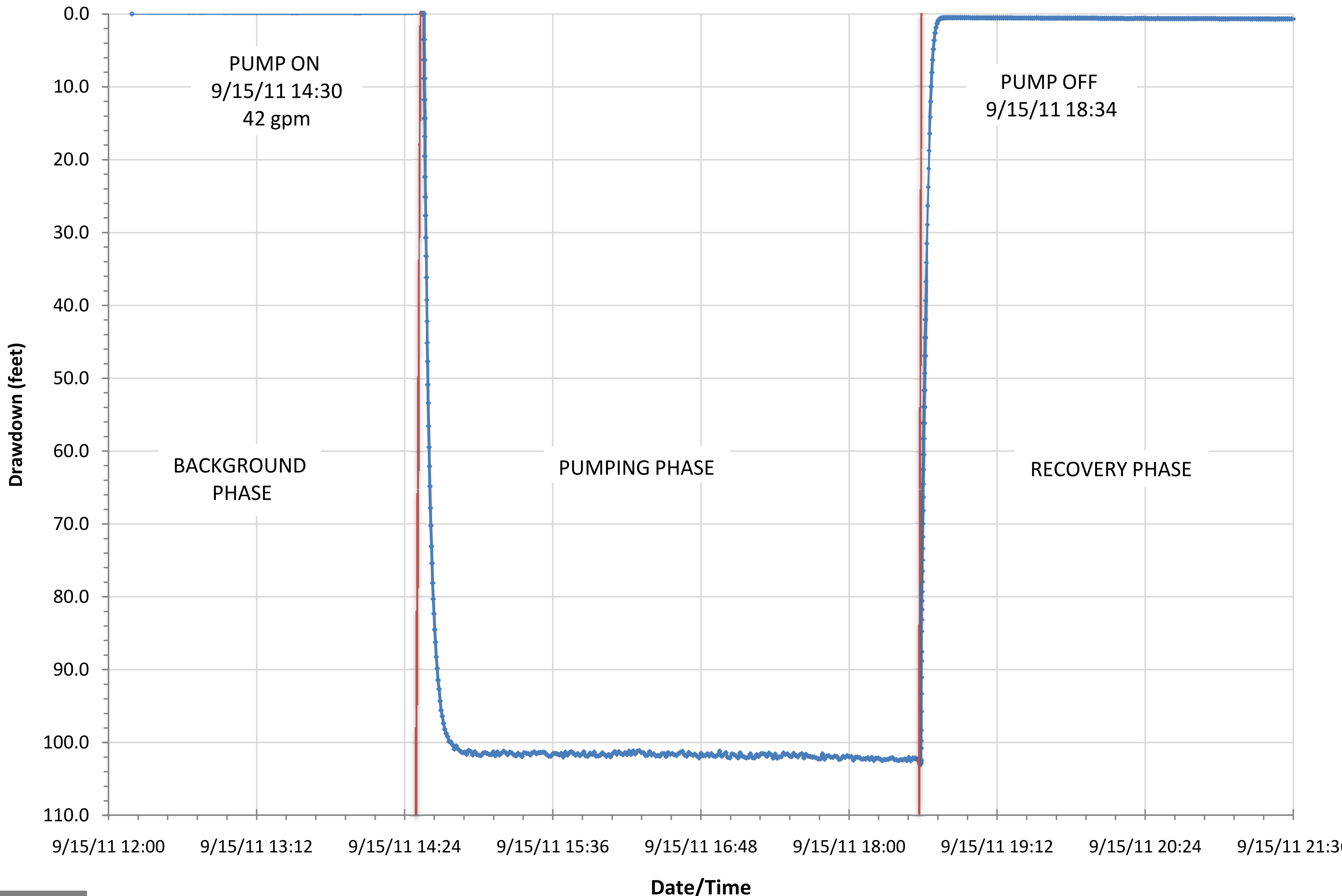



**FIGURE 3-13**

**City of Sarasota RO WTP Test Injection Well**
**DIW-1 Packer Test No. 3 Test Interval 1,119.5 to 1,150.5 feet**
**Log/Linear Cooper Jacob Drawdown Analysis**

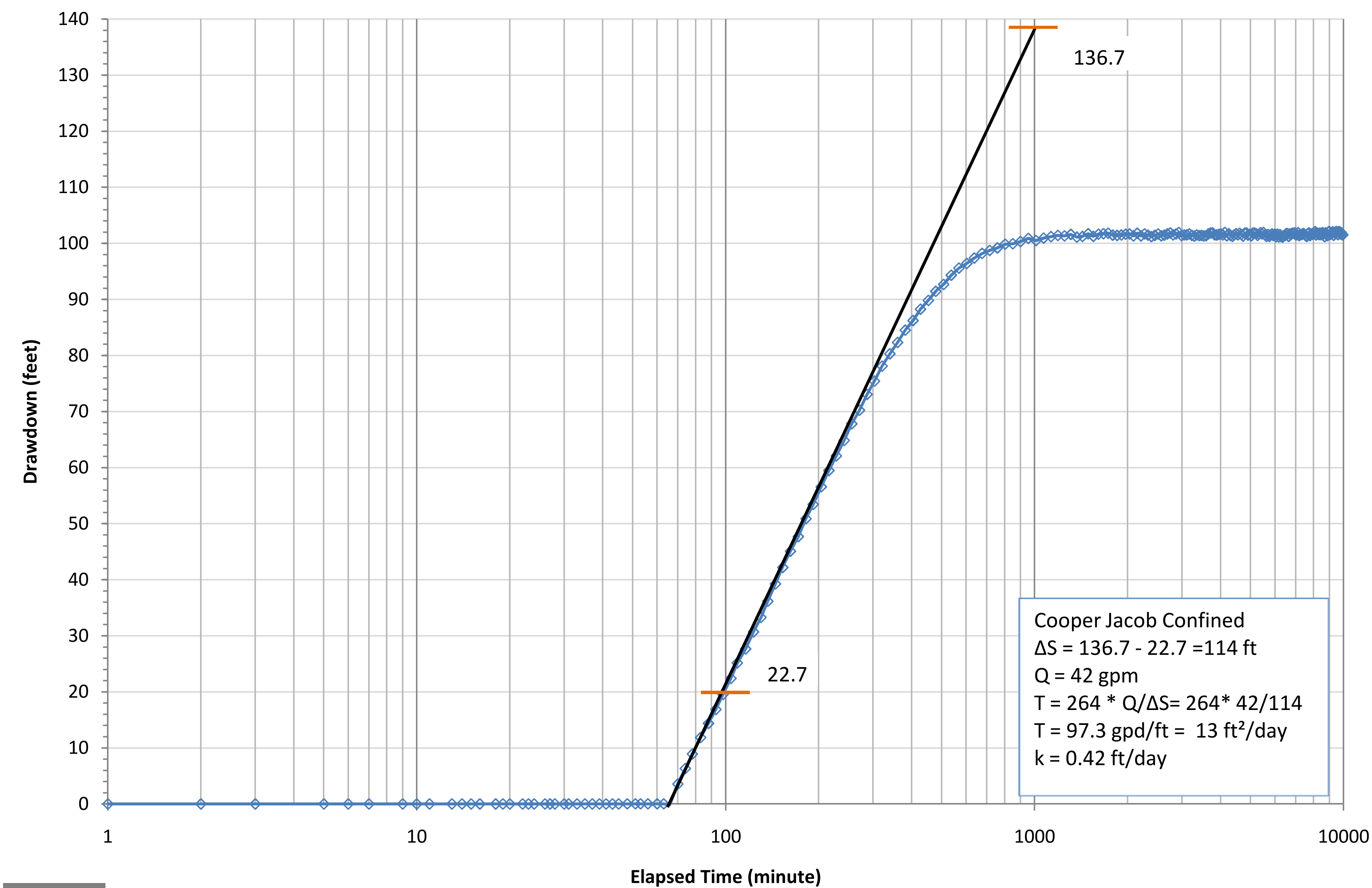



**FIGURE 3-14**

**City of Sarasota RO WTP Test Injection Well**
**DIW-1 Packer Test No. 3 Test Interval 1,119.5 to 1,150.5 feet**
**Log/Linear Theis Recovery Analysis**

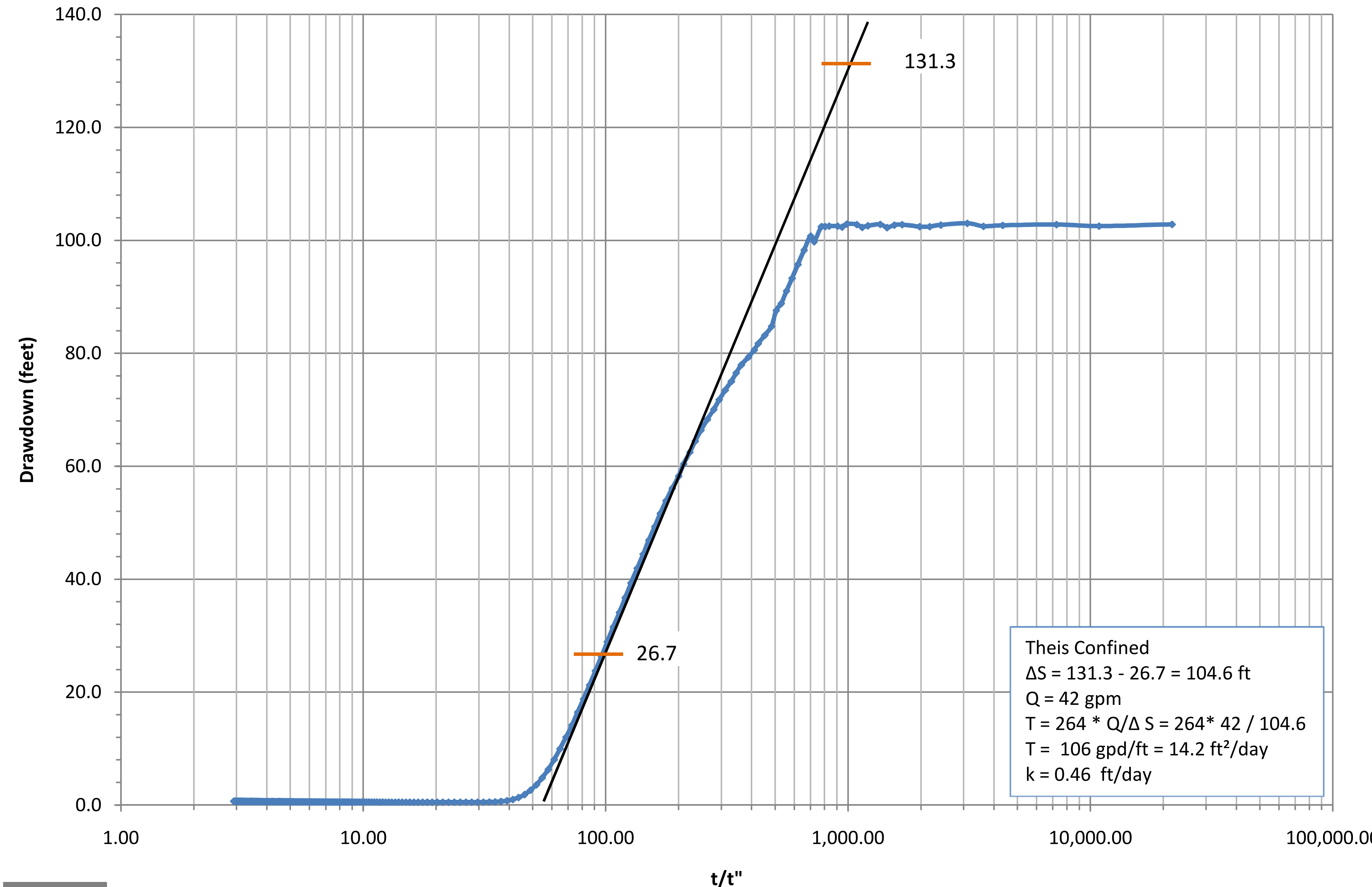



**FIGURE 3-15**

**City of Sarasota RO WTP Test Injection Well**
**DIW-1 Packer Test No. 5 Test Interval 1,501 to 1,762 feet**

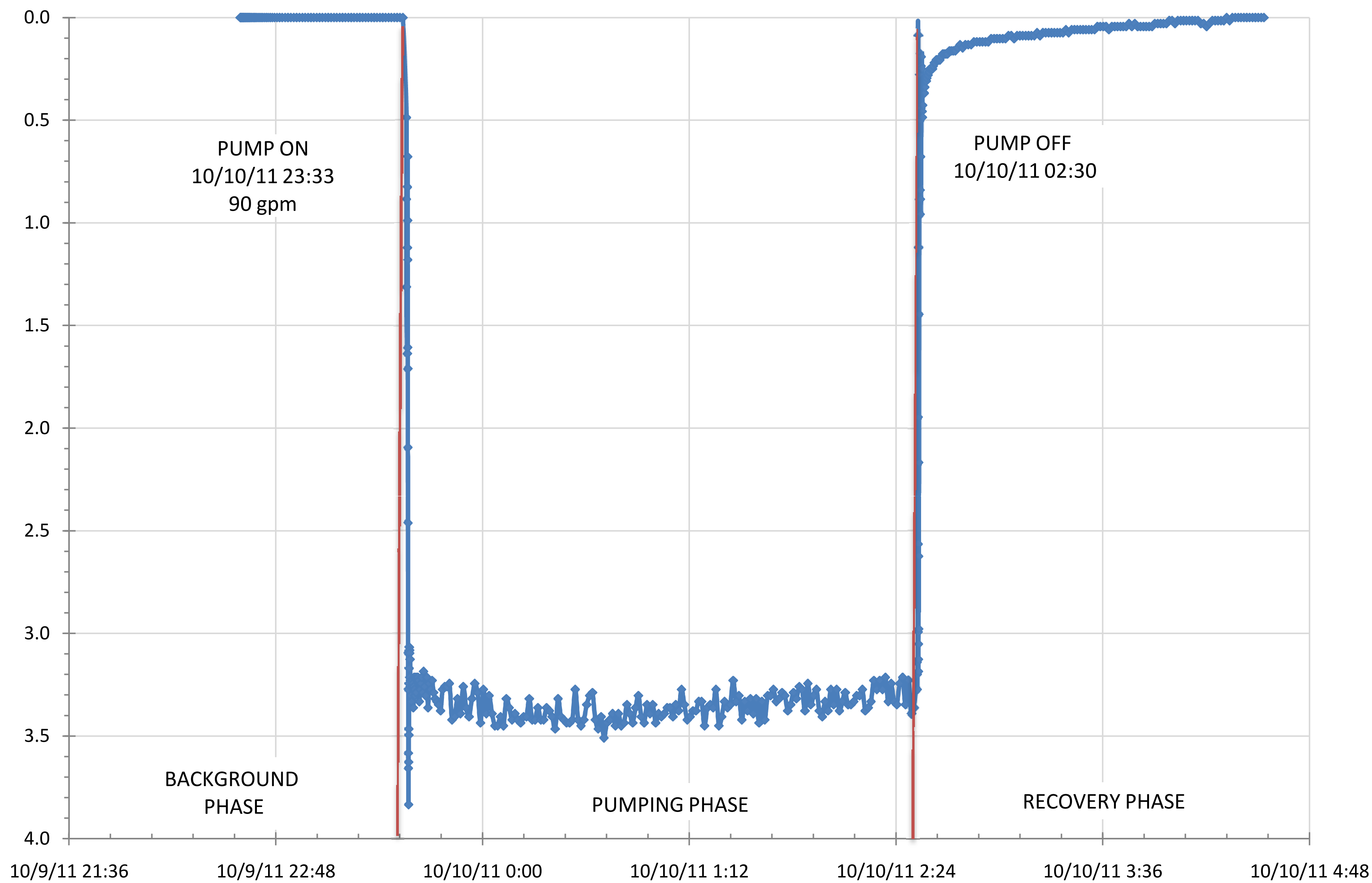
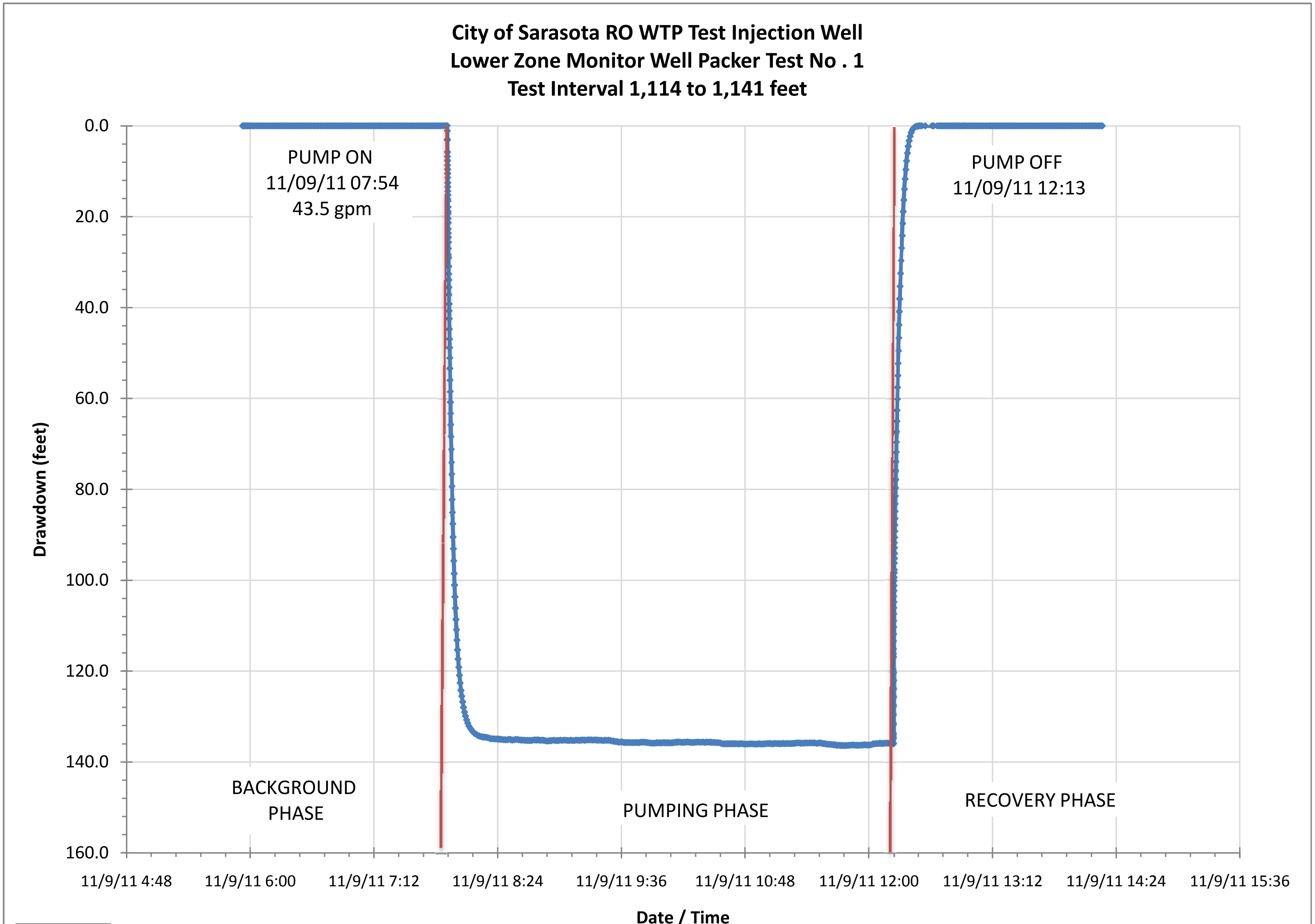



**FIGURE 3-16**



City of Sarasota RO WTP Test Injection Well
Lower Zone Monitor Well Packer Test No . 1
Test Interval 1,114 to 1,141 feet
Drawdown (feet)
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
PUMP ON
11/09/11 07:54
43.5 gpm
PUMP OFF
11/09/11 12:13
BACKGROUND PHASE
PUMPING PHASE
RECOVERY PHASE
11/9/11 4:48
11/9/11 6:00
11/9/11 7:12
11/9/11 8:24
11/9/11 9:36
11/9/11 10:48
11/9/11 12:00
11/9/11 13:12
11/9/11 14:24
11/9/11 15:36
Date / Time


FIGURE 3-17

**City of Sarasota RO WTP Test Injection Well**
**Lower Zone Monitor Well Packer Test No. 1 Test Interval 1,114 to 1,141 feet**
**Log/Linear Cooper-Jacob Drawdown Analysis**

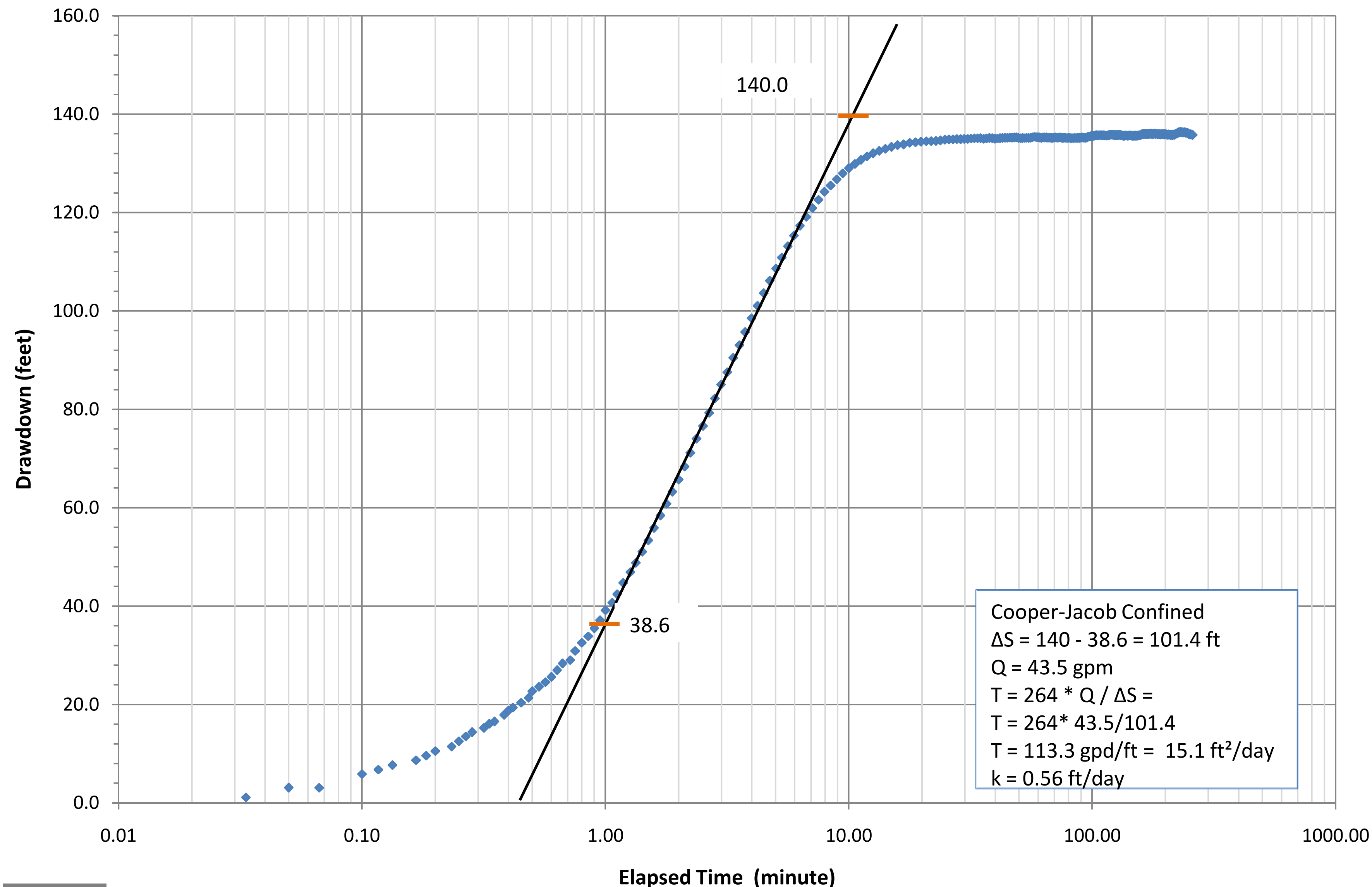



**FIGURE 3-18**

**City of Sarasota RO WTP Test Injection Well**
**Lower Zone Monitor Well Packer Test No. 1 Test Interval 1,114 to 1,141 feet**
**Log/Linear Theis Recovery Analysis**

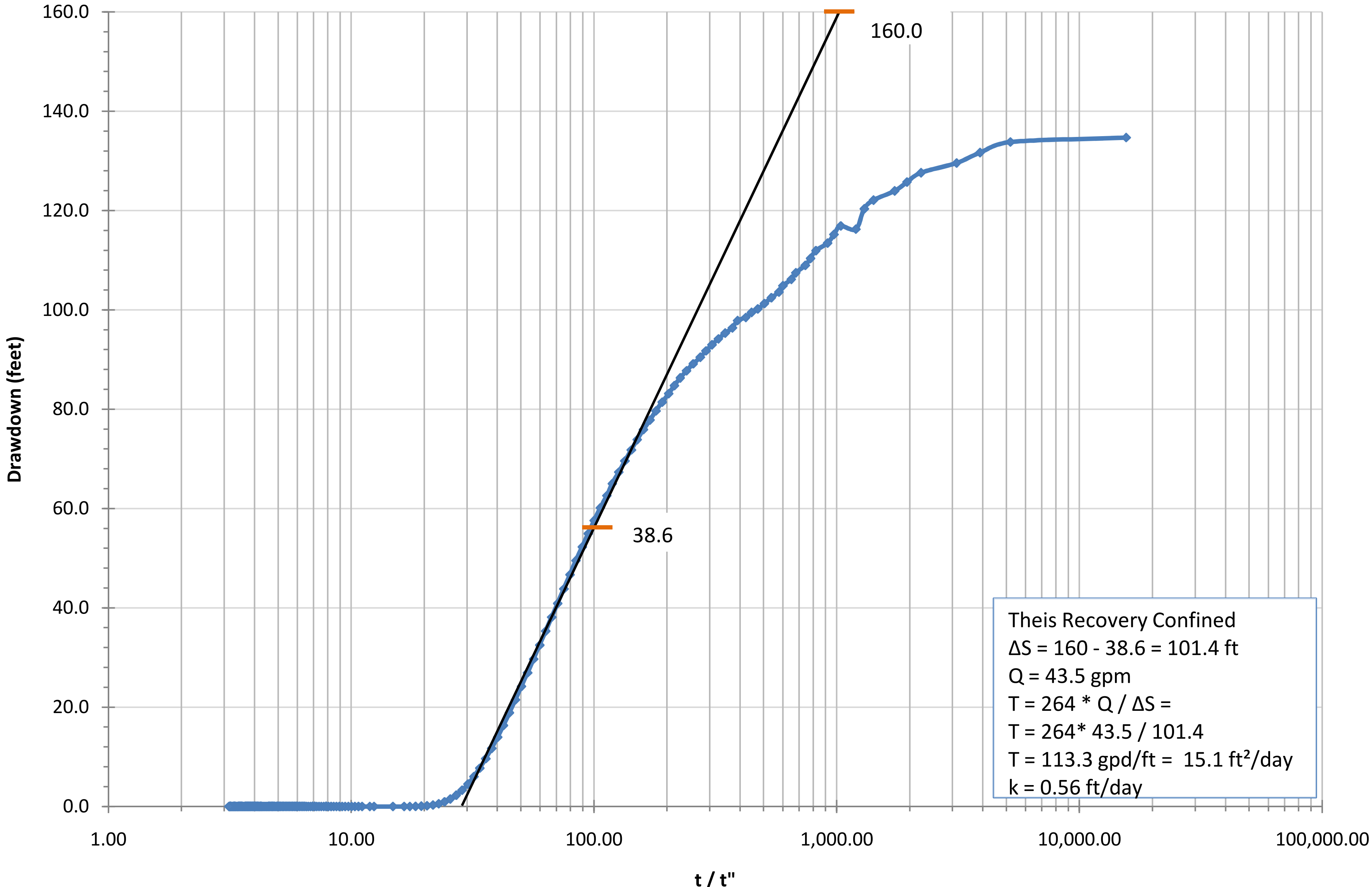



**FIGURE 3-19**

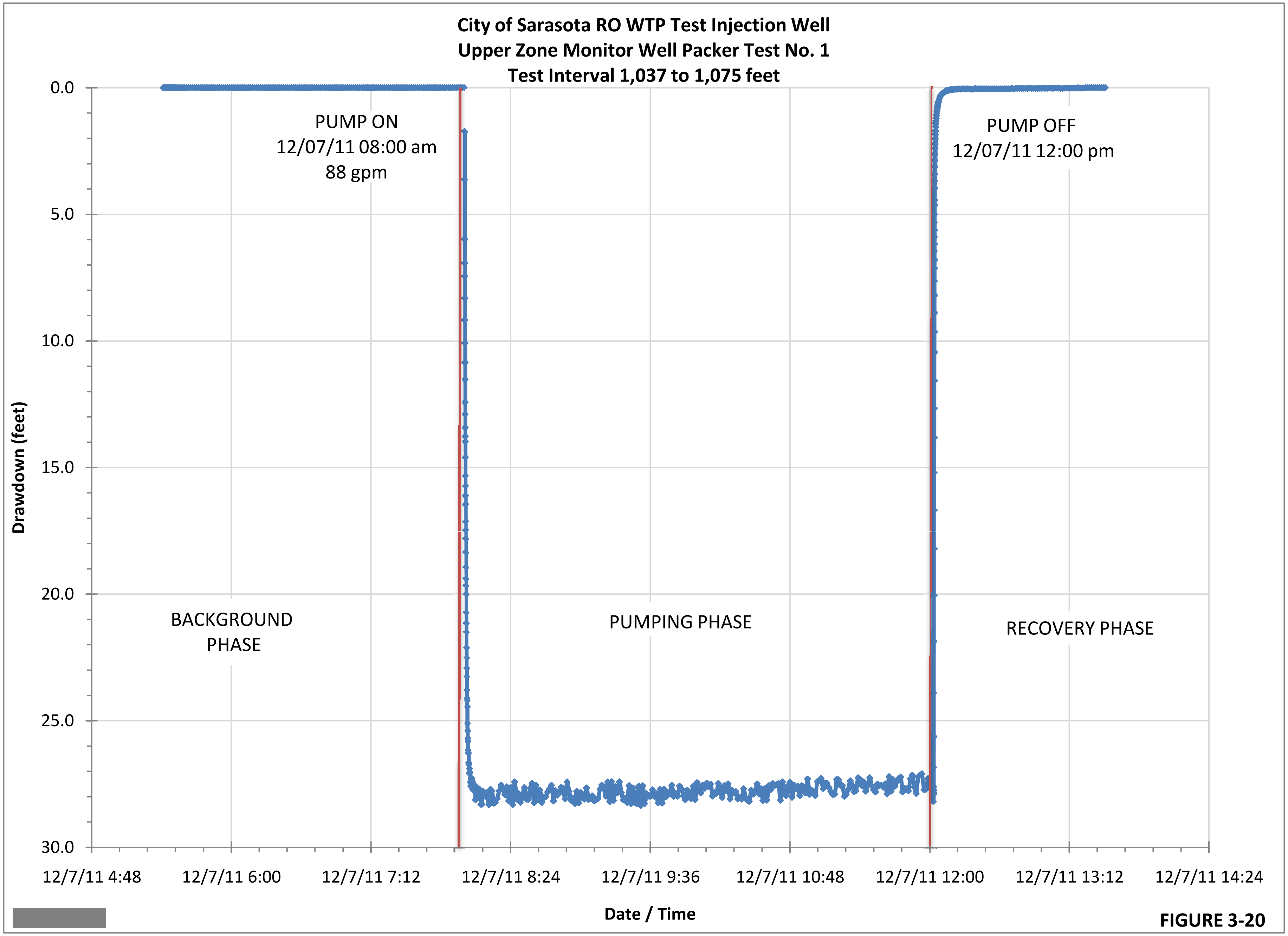

City of Sarasota RO WTP Test Injection Well
Upper Zone Monitor Well Packer Test No. 1
Test Interval 1,037 to 1,075 feet
PUMP ON
12/07/11 08:00 am
88 gpm
PUMP OFF
12/07/11 12:00 pm
BACKGROUND PHASE
PUMPING PHASE
RECOVERY PHASE
Drawdown (feet)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
12/7/11 4:48
12/7/11 6:00
12/7/11 7:12
12/7/11 8:24
12/7/11 9:36
12/7/11 10:48
12/7/11 12:00
12/7/11 13:12
12/7/11 14:24
Date / Time

**FIGURE 3-20**

**City of Sarasota RO WTP Test Injection Well System**
**Upper Zone Monitor Well Packer Test No. 1 Test Interval 1,037 to 1,075 feet**
**Log/Linear Cooper Jacob Drawdown Analysis**

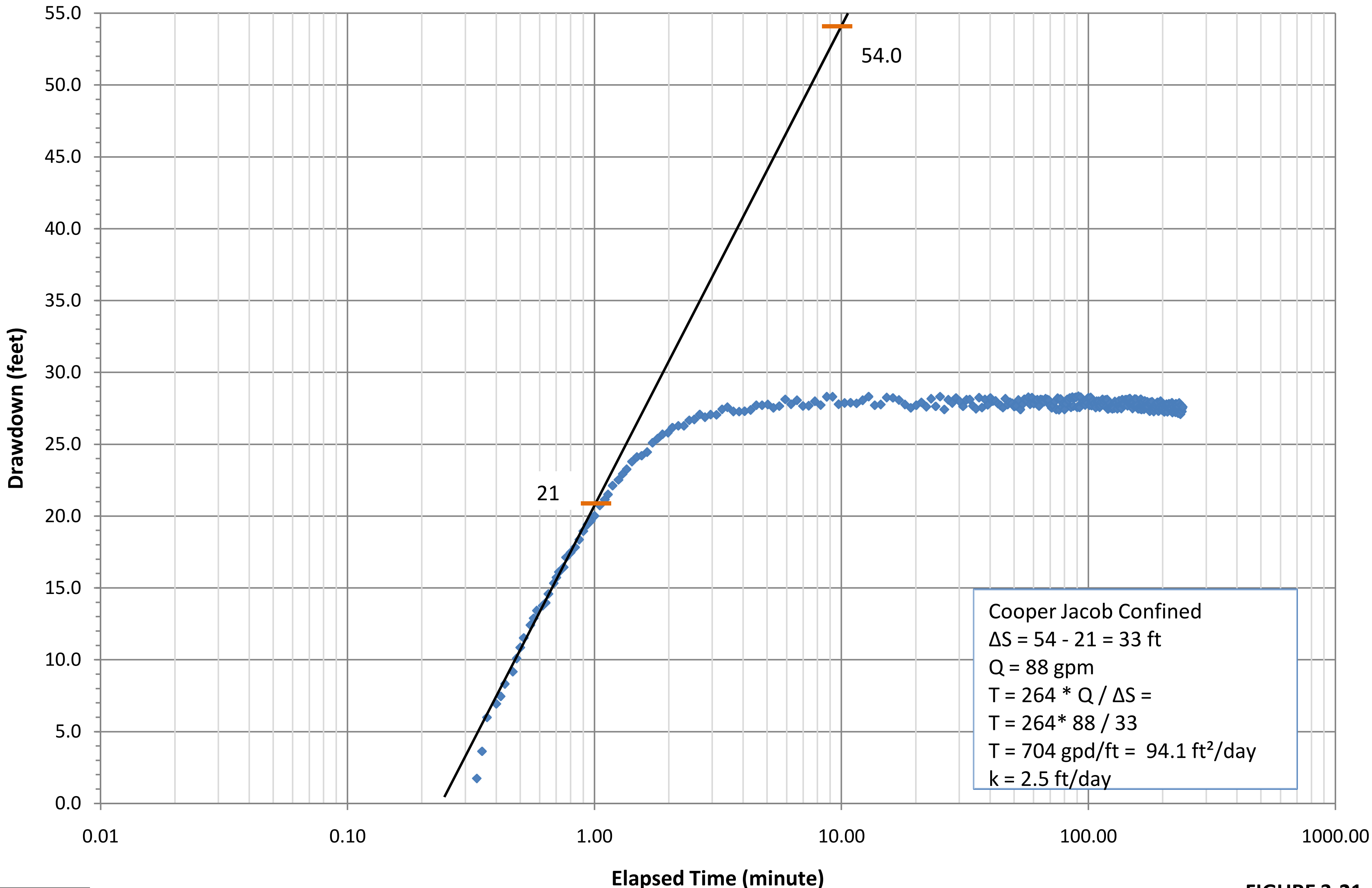



**FIGURE 3-21**

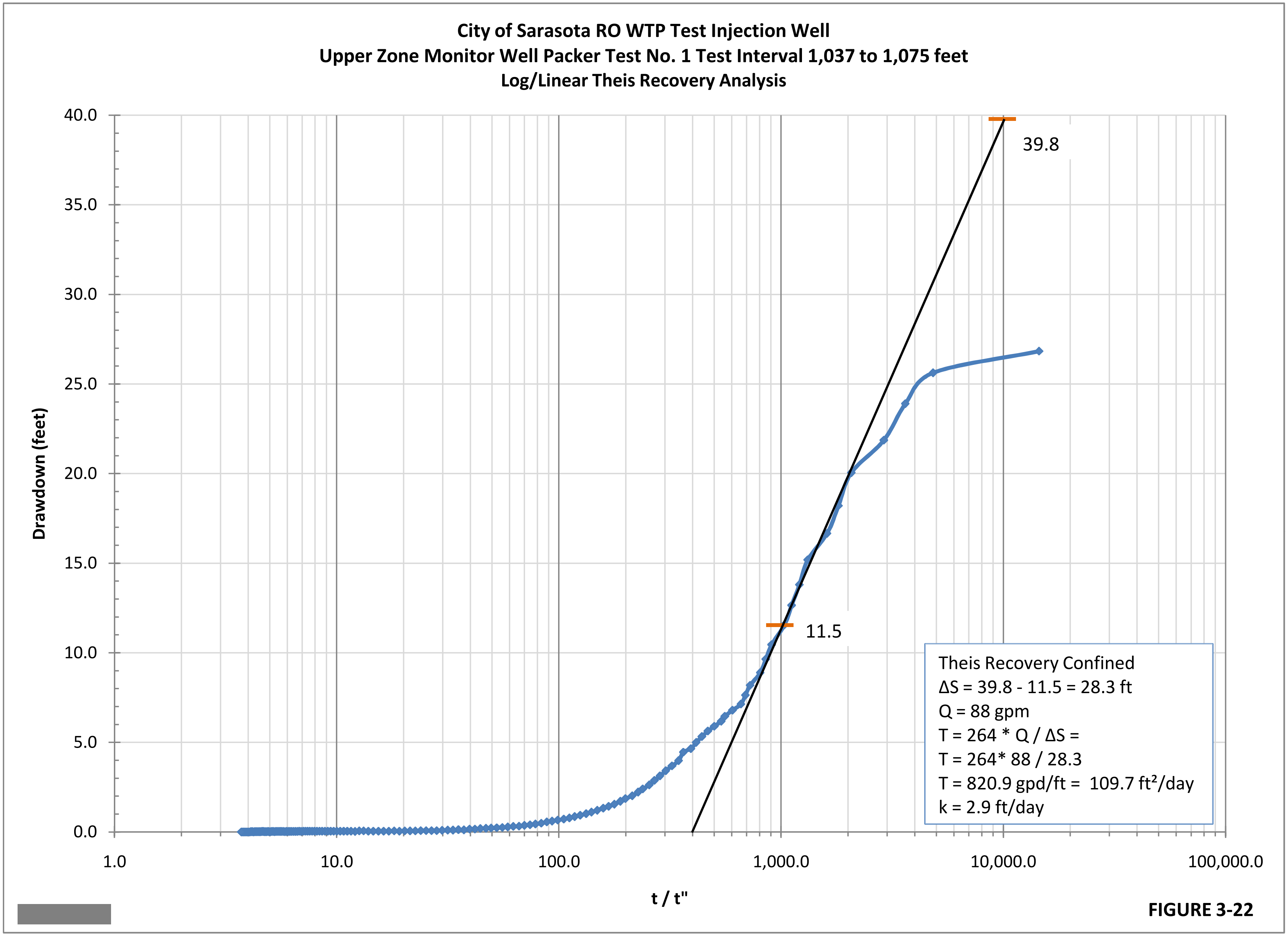

City of Sarasota RO WTP Test Injection Well
Upper Zone Monitor Well Packer Test No. 1 Test Interval 1,037 to 1,075 feet
Log/Linear Theis Recovery Analysis
Drawdown (feet)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1.0
10.0
100.0
1,000.0
10,000.0
100,000.0
t / t"
39.8
11.5
Theis Recovery Confined
ΔS = 39.8 - 11.5 = 28.3 ft
Q = 88 gpm
T = 264 * Q / ΔS =
T = 264* 88 / 28.3
T = 820.9 gpd/ft = 109.7 ft²/day
k = 2.9 ft/day

FIGURE 3-22

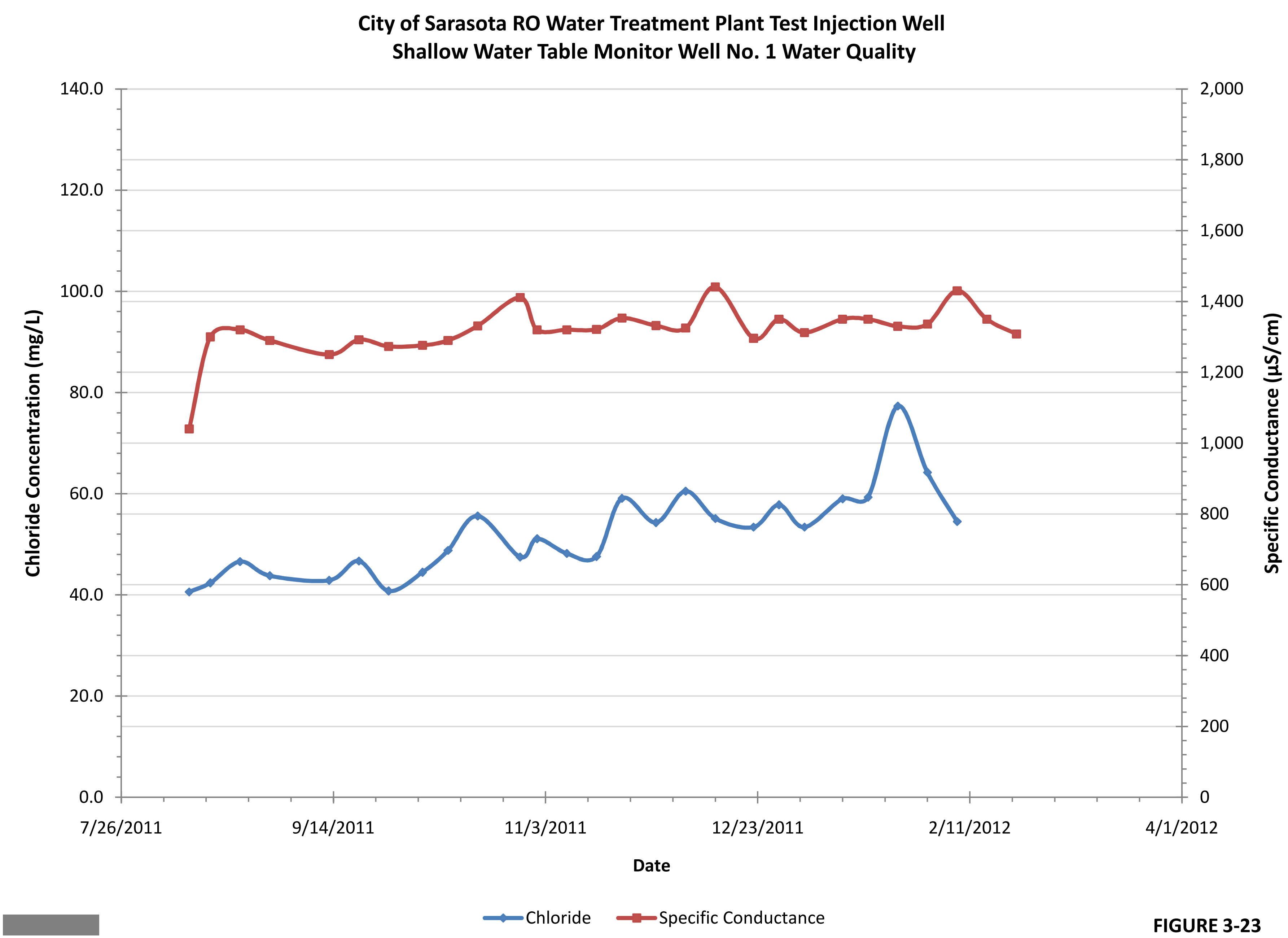

City of Sarasota RO Water Treatment Plant Test Injection Well
Shallow Water Table Monitor Well No. 1 Water Quality
Chloride Concentration (mg/L)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Specific Conductance (µS/cm)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
7/26/2011
9/14/2011
11/3/2011
12/23/2011
2/11/2012
4/1/2012
Date
Chloride
Specific Conductance

**FIGURE 3-23**

**City of Sarasota RO Water Treatment Plant Test Injection Well**
**Shallow Water Table Monitor Well No. 2 Water Quality**

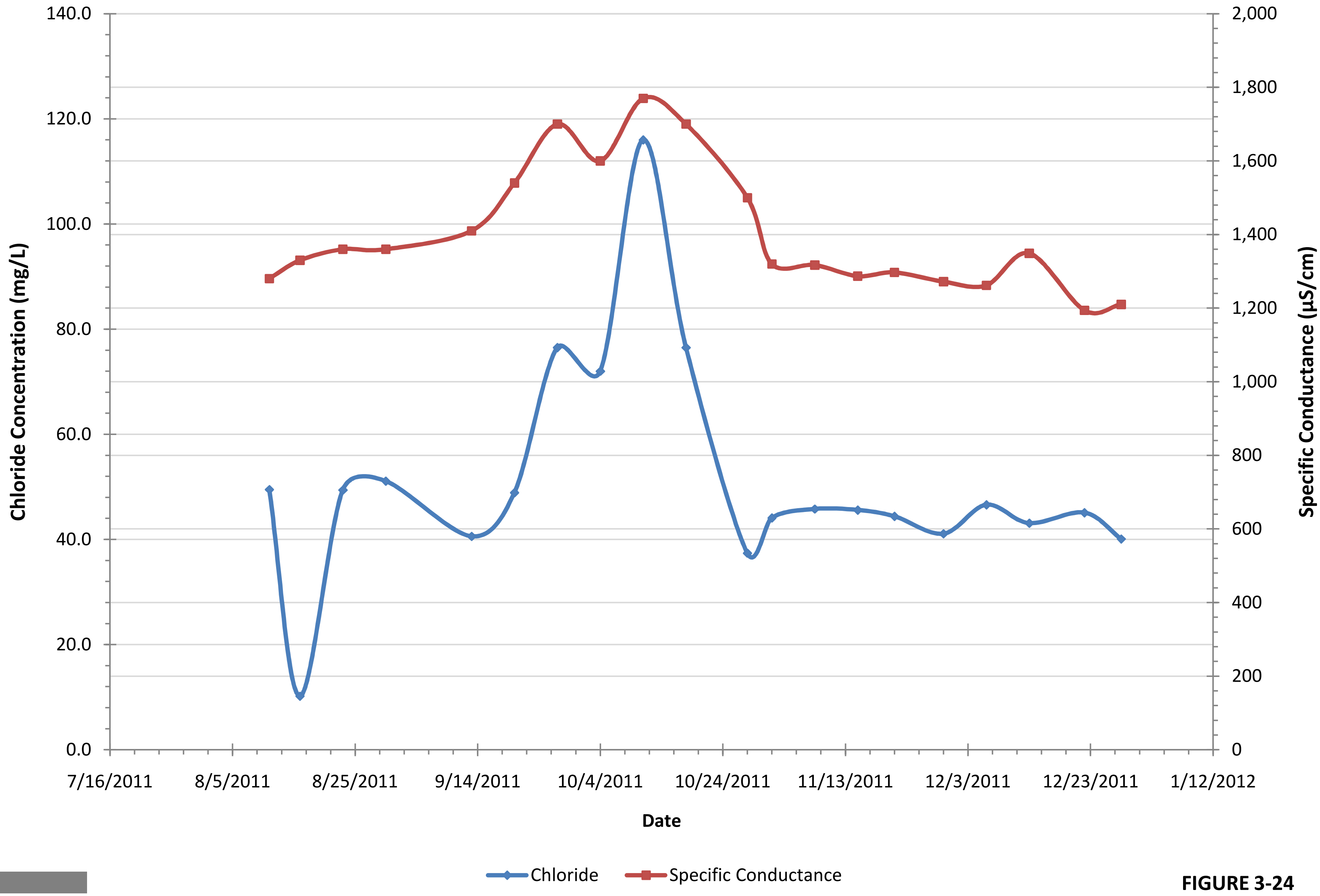



**FIGURE 3-24**

**City of Sarasota RO Water Treatment Plant Test Injection Well**
**Replacement Shallow Water Table Monitor Well No. 2B Water Quality**

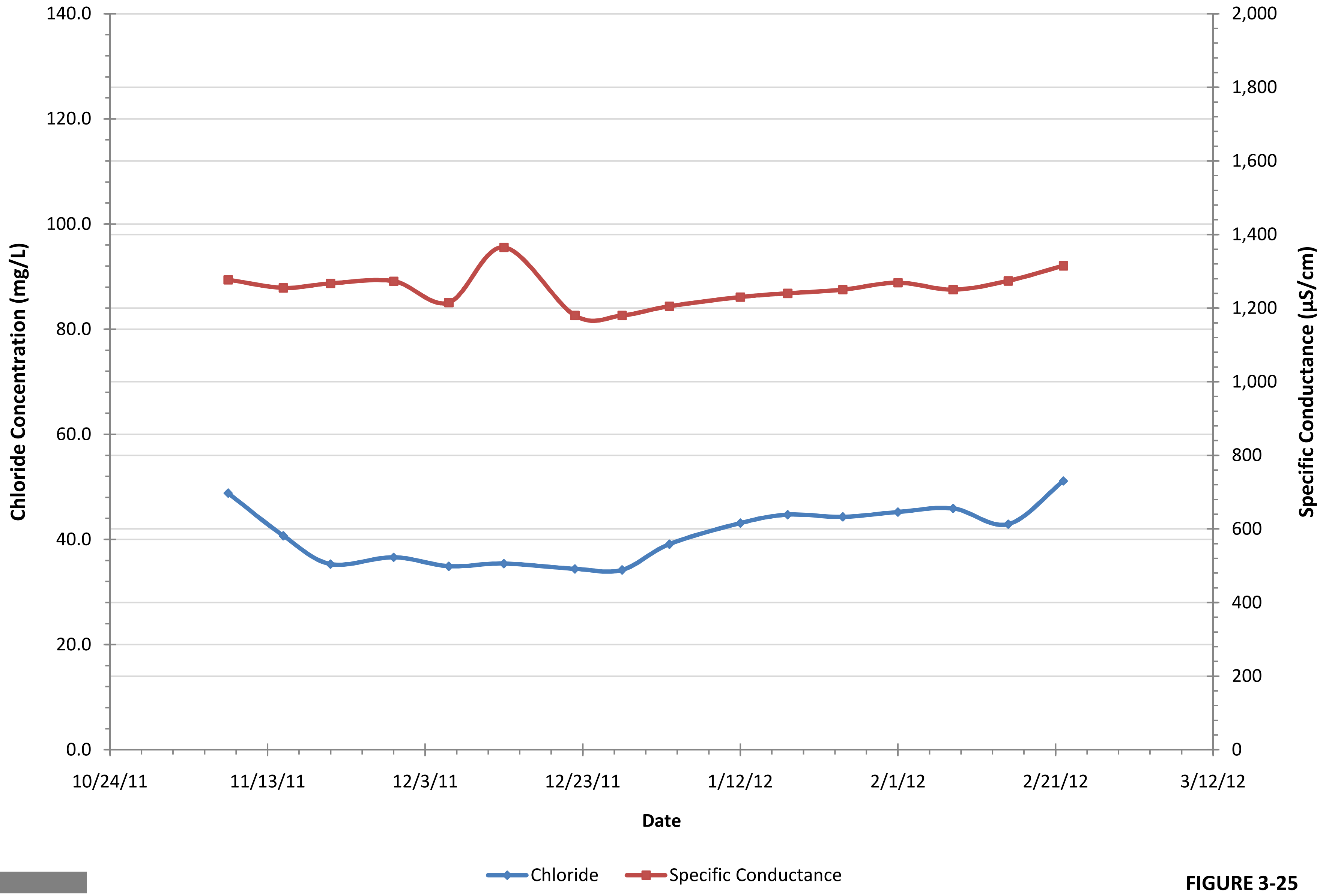



**FIGURE 3-25**

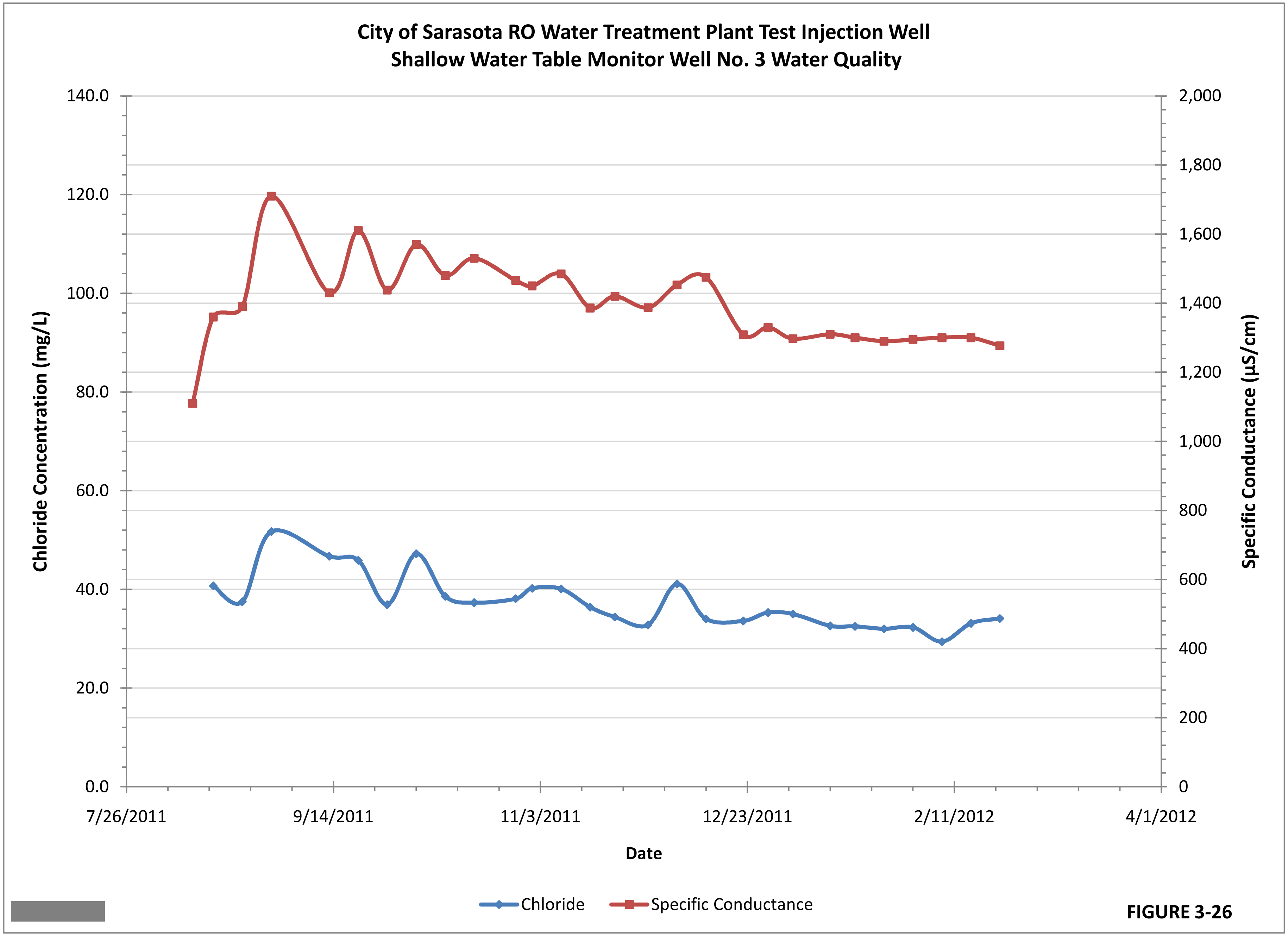
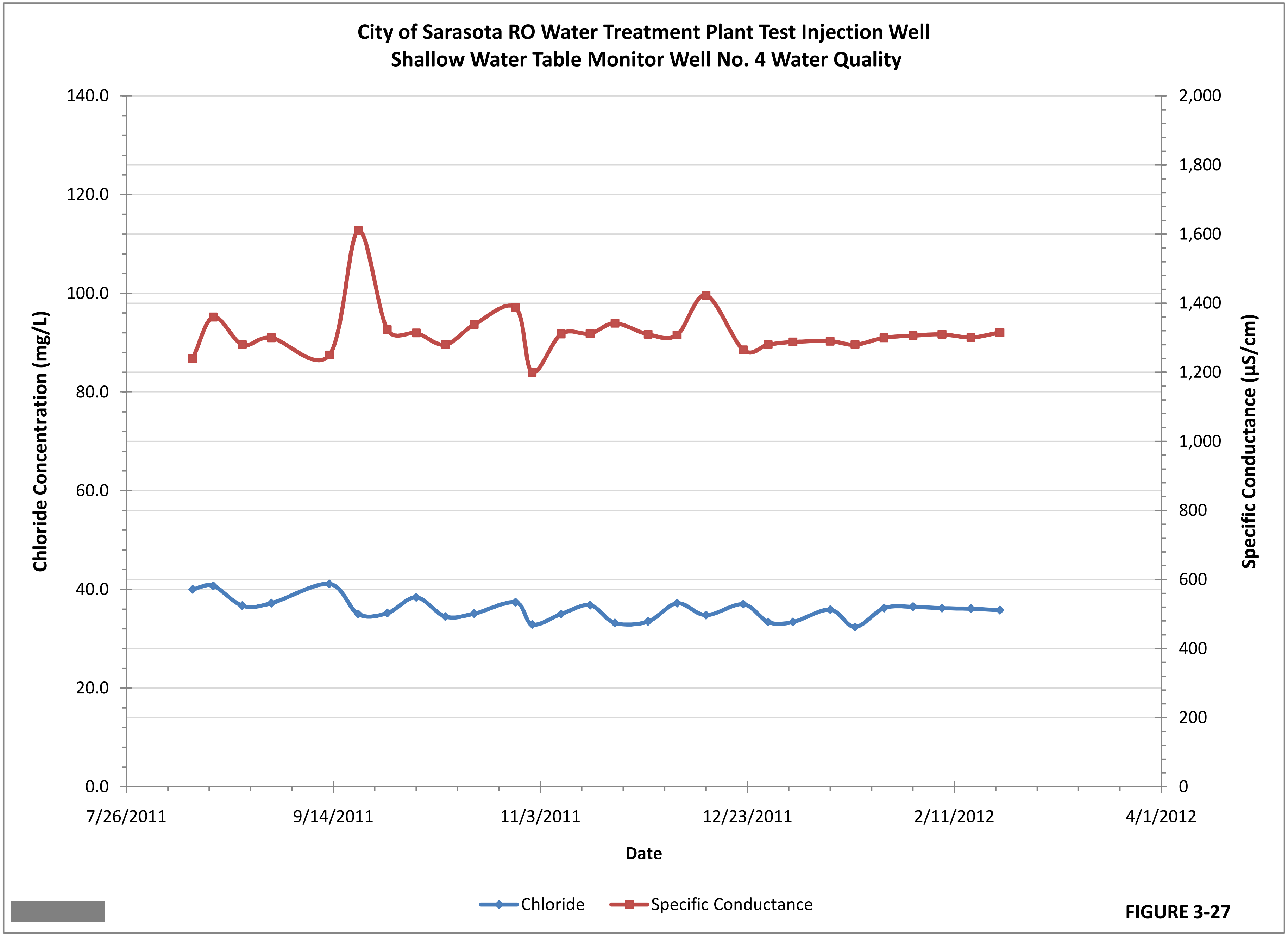

City of Sarasota RO Water Treatment Plant Test Injection Well
Shallow Water Table Monitor Well No. 3 Water Quality
Chloride Concentration (mg/L)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Specific Conductance (µS/cm)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
7/26/2011
9/14/2011
11/3/2011
12/23/2011
2/11/2012
4/1/2012
Date
Chloride
Specific Conductance

**FIGURE 3-26**



City of Sarasota RO Water Treatment Plant Test Injection Well
Shallow Water Table Monitor Well No. 4 Water Quality
Chloride Concentration (mg/L)
Specific Conductance (µS/cm)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
7/26/2011
9/14/2011
11/3/2011
12/23/2011
2/11/2012
4/1/2012
Date
Chloride
Specific Conductance


FIGURE 3-27

# City of Sarasota RO Water Treatment Plant
# Specific Conductivity During Reverse-Air Drilling of DIW-1

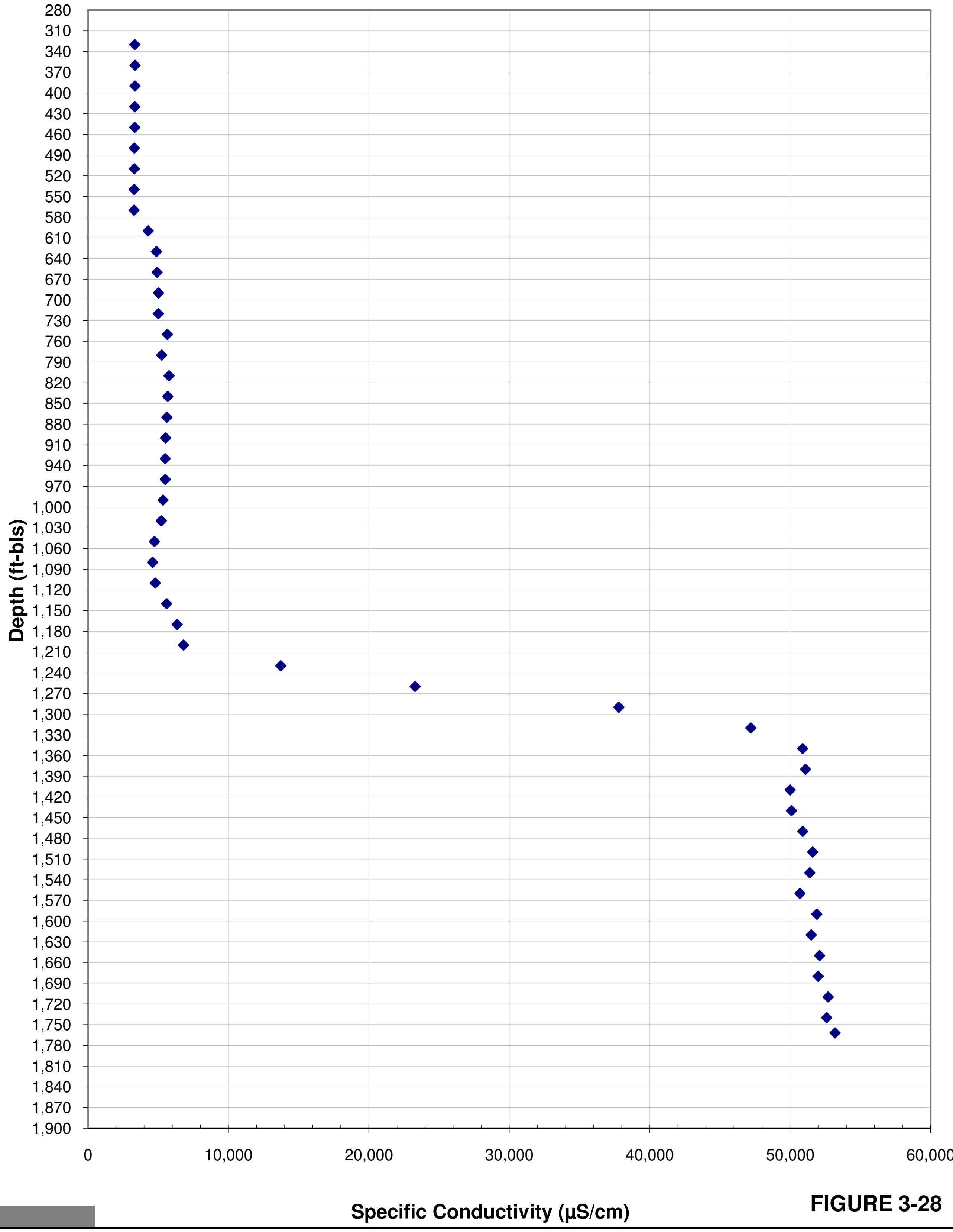



**FIGURE 3-28**

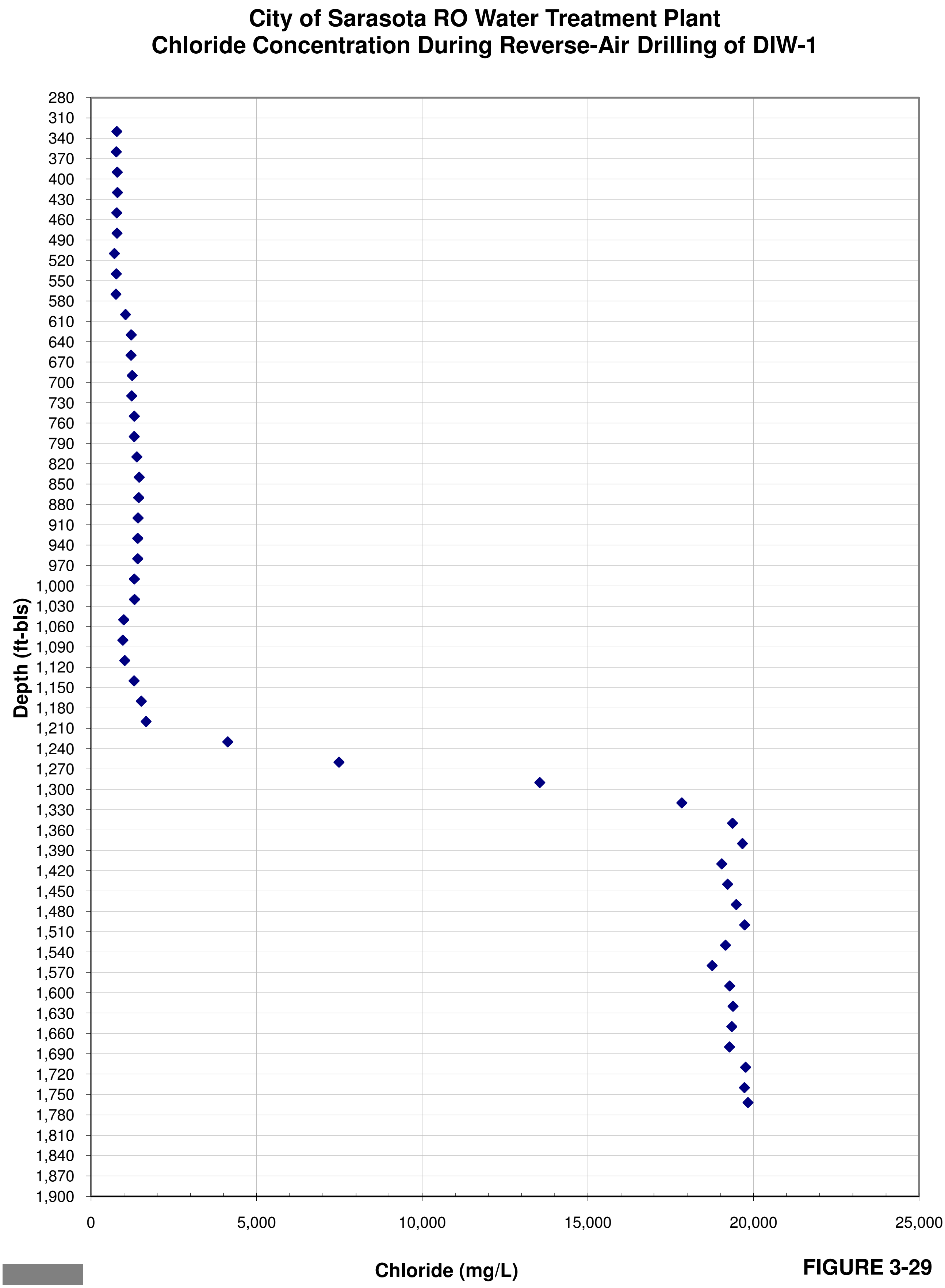

City of Sarasota RO Water Treatment Plant
Chloride Concentration During Reverse-Air Drilling of DIW-1
Depth (ft-bls)
280
310
340
370
400
430
460
490
520
550
580
610
640
670
700
730
760
790
820
850
880
910
940
970
1,000
1,030
1,060
1,090
1,120
1,150
1,180
1,210
1,240
1,270
1,300
1,330
1,360
1,390
1,420
1,450
1,480
1,510
1,540
1,570
1,600
1,630
1,660
1,690
1,720
1,750
1,780
1,810
1,840
1,870
1,900
0
5,000
10,000
15,000
20,000
25,000
Chloride (mg/L)

FIGURE 3-29

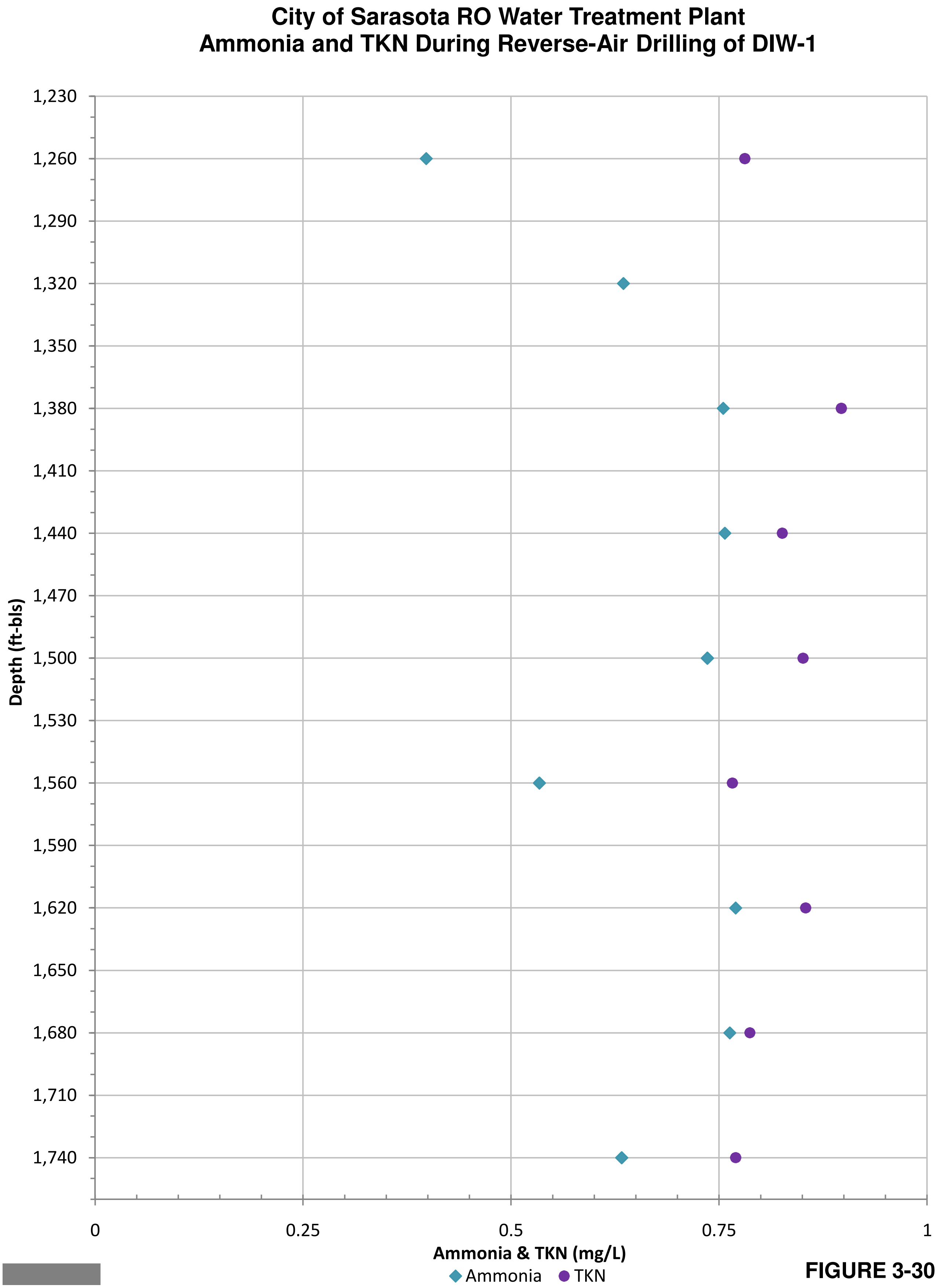

City of Sarasota RO Water Treatment Plant
Ammonia and TKN During Reverse-Air Drilling of DIW-1
Depth (ft-bls)
1,230
1,260
1,290
1,320
1,350
1,380
1,410
1,440
1,470
1,500
1,530
1,560
1,590
1,620
1,650
1,680
1,710
1,740
0
0.25
0.5
0.75
1
Ammonia & TKN (mg/L)
Ammonia
TKN

**FIGURE 3-30**


FIGURE 3-31 GEOPHYSICAL LOGGING TRUCK

FIGURE 3-32 LOGGING TOOL


FIGURE 3-33 Injection Test Well head


FIGURE 3-34 Pressure Gages at the DIW Wellhead


FIGURE 3-35 Strap-on Sonic Flowmeter

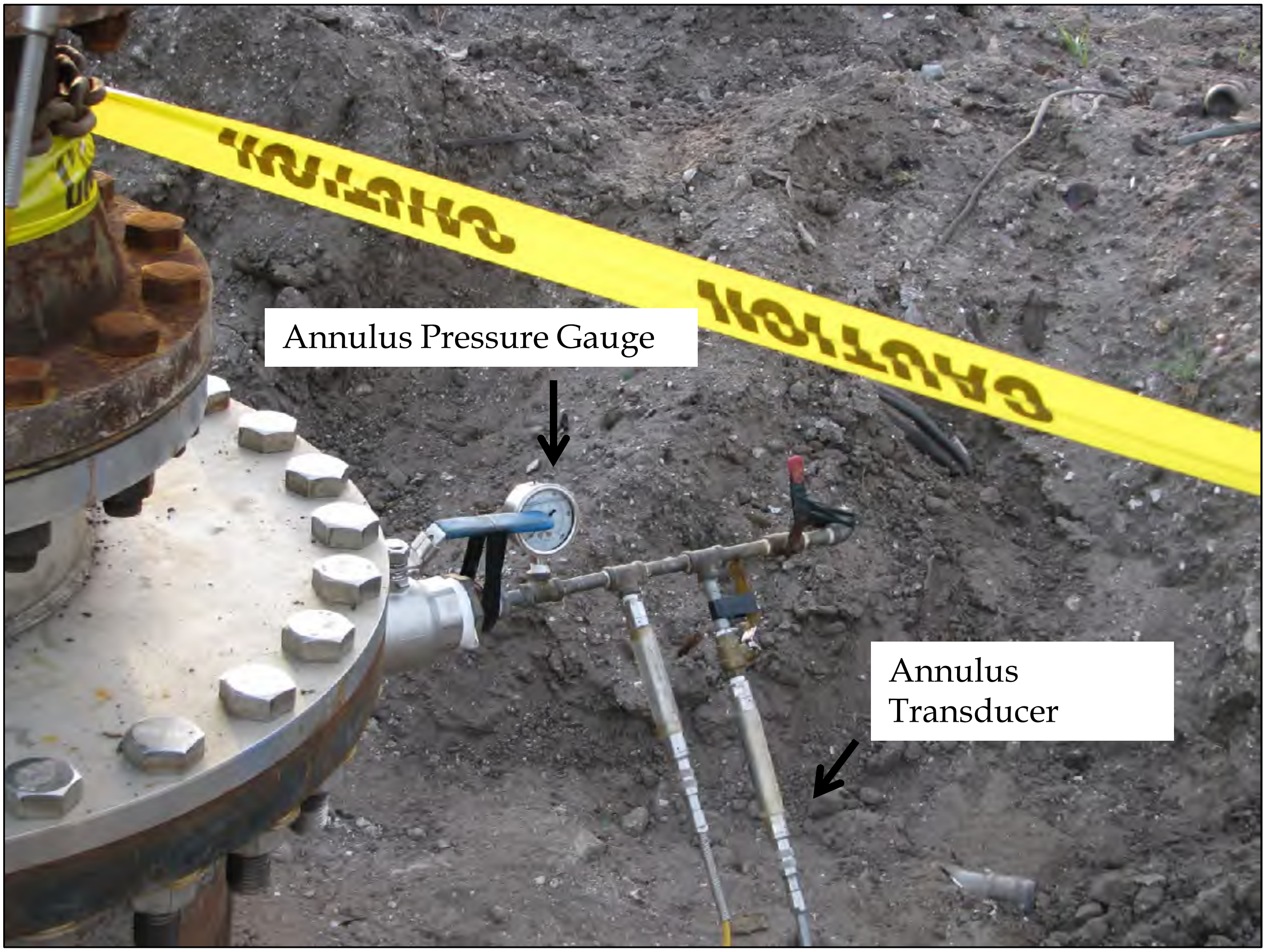
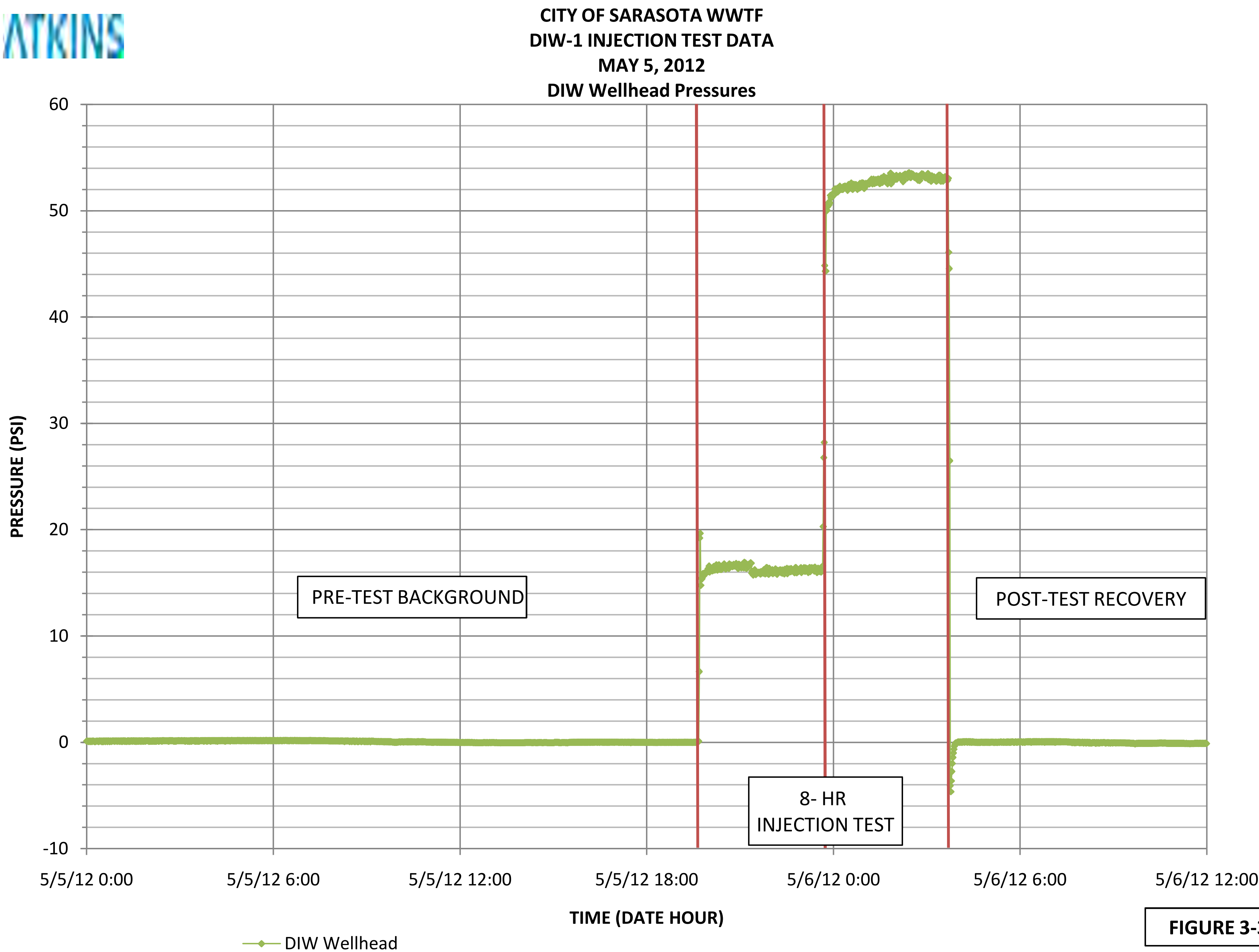
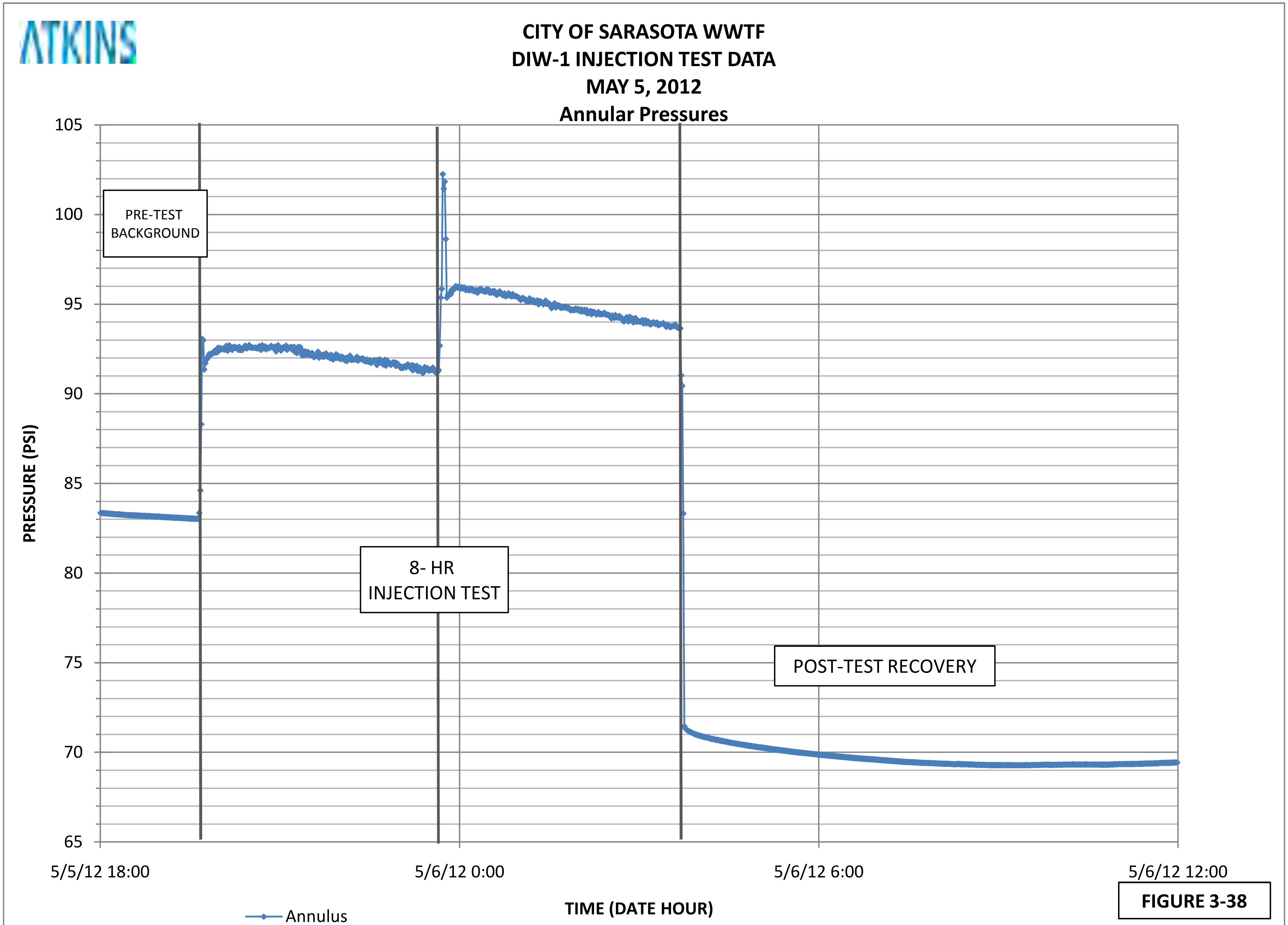



FIGURE 3-36 –Annulus Gauges



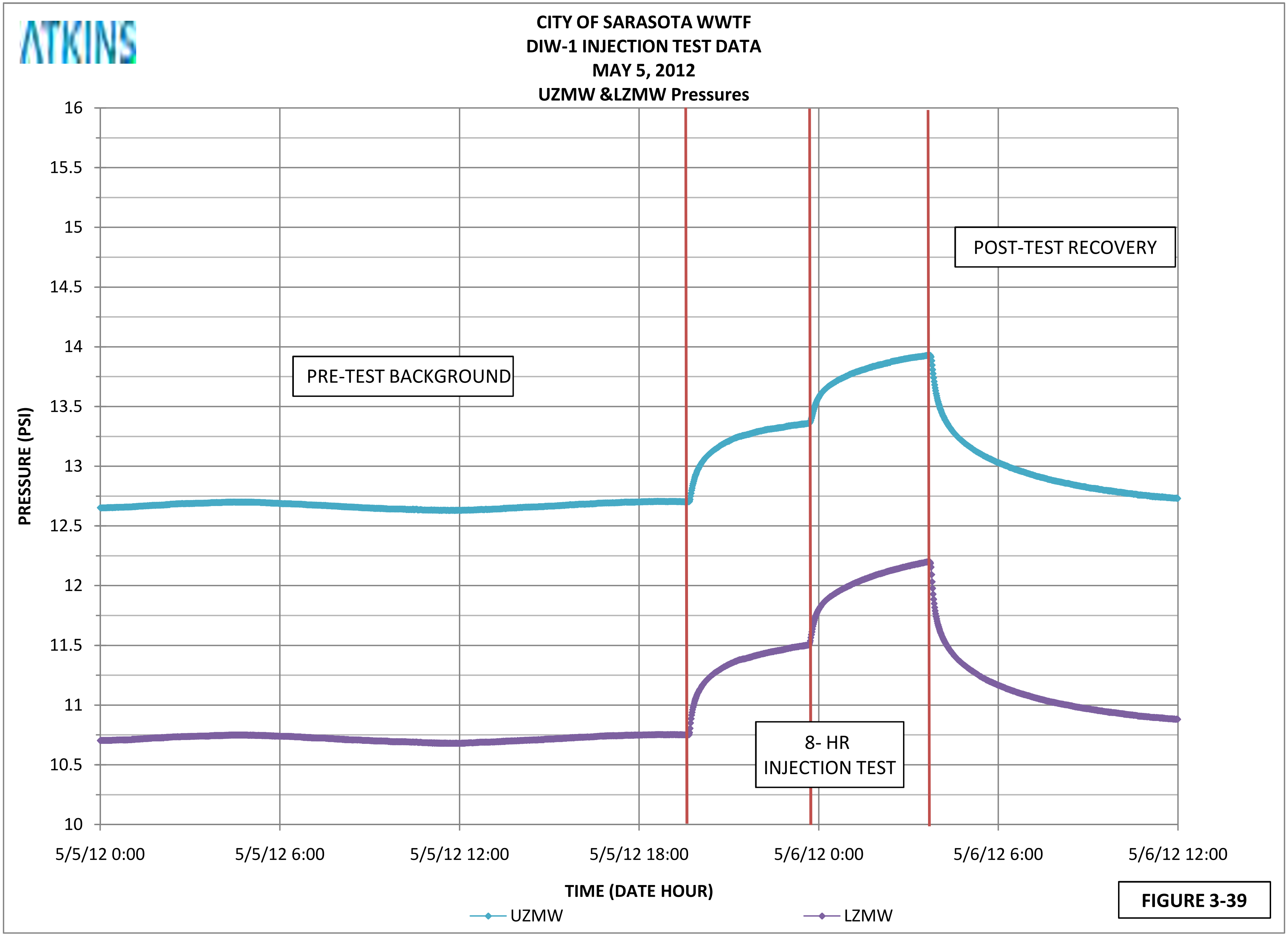
CITY OF SARASOTA WWTF
DIW-1 INJECTION TEST DATA
MAY 5, 2012
DIW Wellhead Pressures
PRESSURE (PSI)
60
50
40
30
20
10
0
-10
PRE-TEST BACKGROUND
8- HR
INJECTION TEST
POST-TEST RECOVERY
5/5/12 0:00
5/5/12 6:00
5/5/12 12:00
5/5/12 18:00
5/6/12 0:00
5/6/12 6:00
5/6/12 12:00
TIME (DATE HOUR)
DIW Wellhead

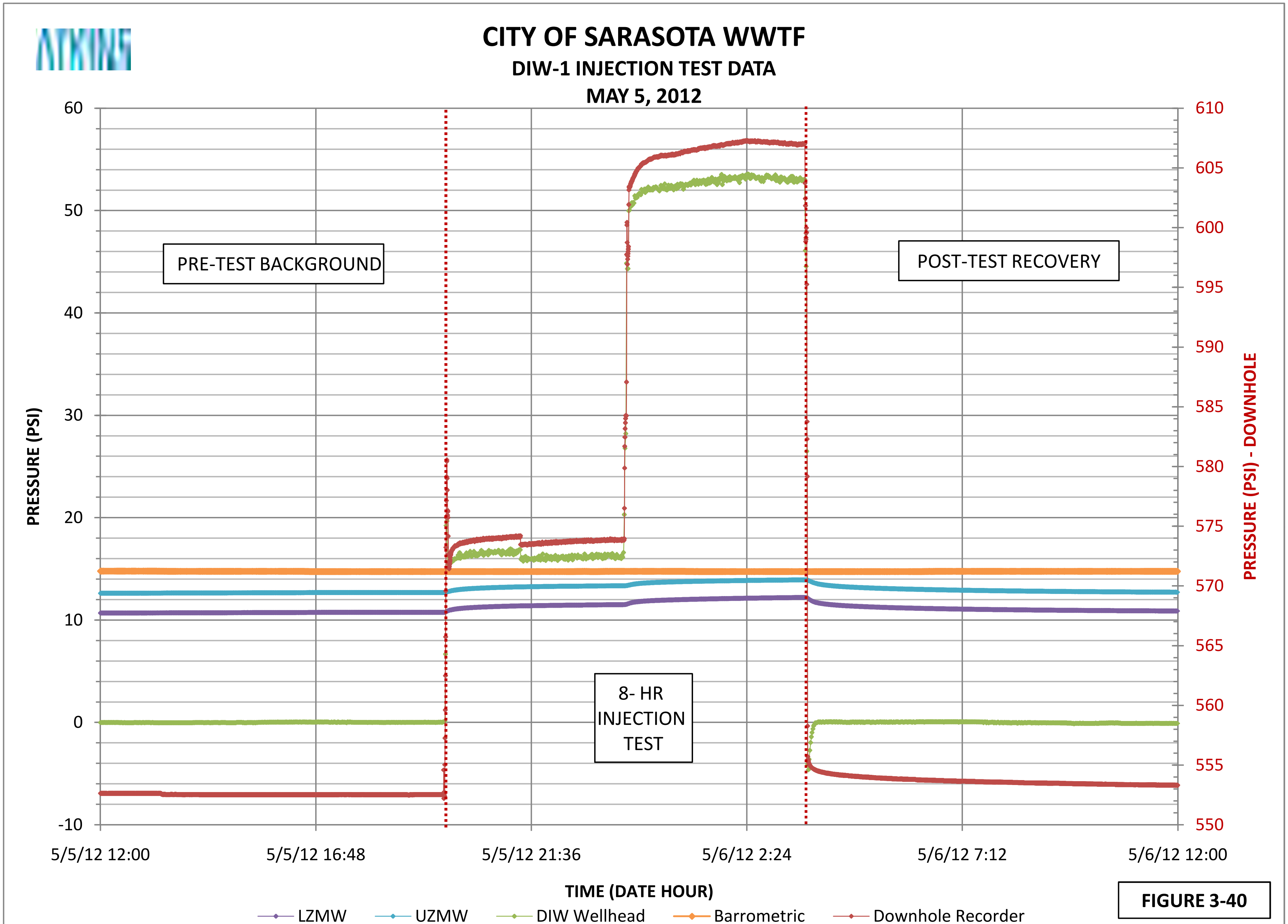

**FIGURE 3-37**



CITY OF SARASOTA WWTF
DIW-1 INJECTION TEST DATA
MAY 5, 2012
Annular Pressures
105
100
95
90
85
80
75
70
65
PRESSURE (PSI)
PRE-TEST BACKGROUND
8- HR INJECTION TEST
POST-TEST RECOVERY
5/5/12 18:00
5/6/12 0:00
5/6/12 6:00
5/6/12 12:00
TIME (DATE HOUR)
Annulus


FIGURE 3-38


ATKINS
CITY OF SARASOTA WWTF
DIW-1 INJECTION TEST DATA
MAY 5, 2012
UZMW &LZMW Pressures
16
15.5
15
14.5
14
13.5
13
12.5
12
11.5
11
10.5
10
PRESSURE (PSI)
PRE-TEST BACKGROUND
POST-TEST RECOVERY
8- HR
INJECTION TEST
5/5/12 0:00
5/5/12 6:00
5/5/12 12:00
5/5/12 18:00
5/6/12 0:00
5/6/12 6:00
5/6/12 12:00
TIME (DATE HOUR)
UZMW
LZMW
FIGURE 3-39



CITY OF SARASOTA WWTF
DIW-1 INJECTION TEST DATA
MAY 5, 2012
PRE-TEST BACKGROUND
POST-TEST RECOVERY
8- HR
INJECTION
TEST
PRESSURE (PSI)
PRESSURE (PSI) - DOWNHOLE
60
50
40
30
20
10
0
-10
610
605
600
595
590
585
580
575
570
565
560
555
550
5/5/12 12:00
5/5/12 16:48
5/5/12 21:36
5/6/12 2:24
5/6/12 7:12
5/6/12 12:00
TIME (DATE HOUR)
LZMW
UZMW
DIW Wellhead
Barrometric
Downhole Recorder


FIGURE 3-40

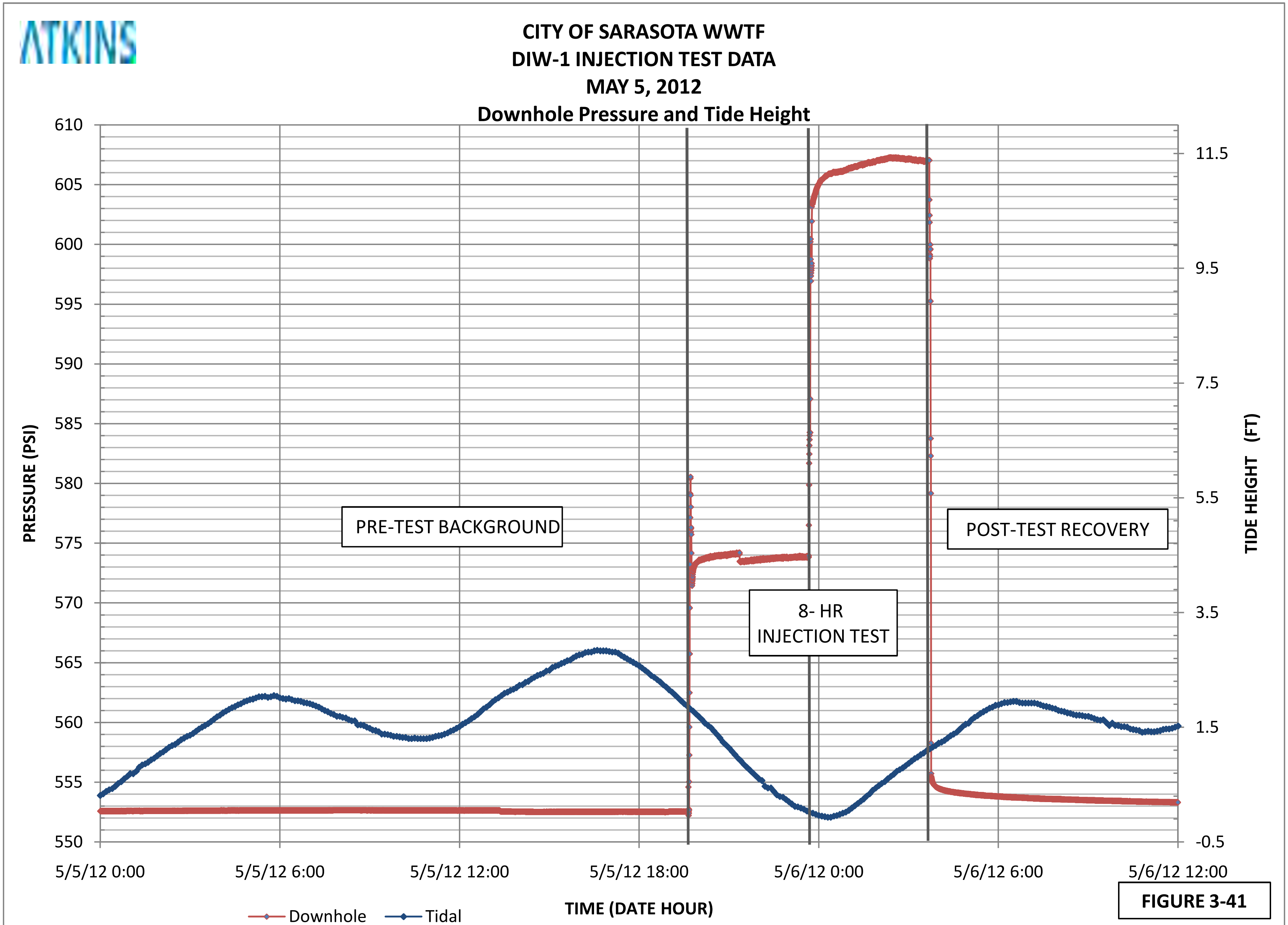
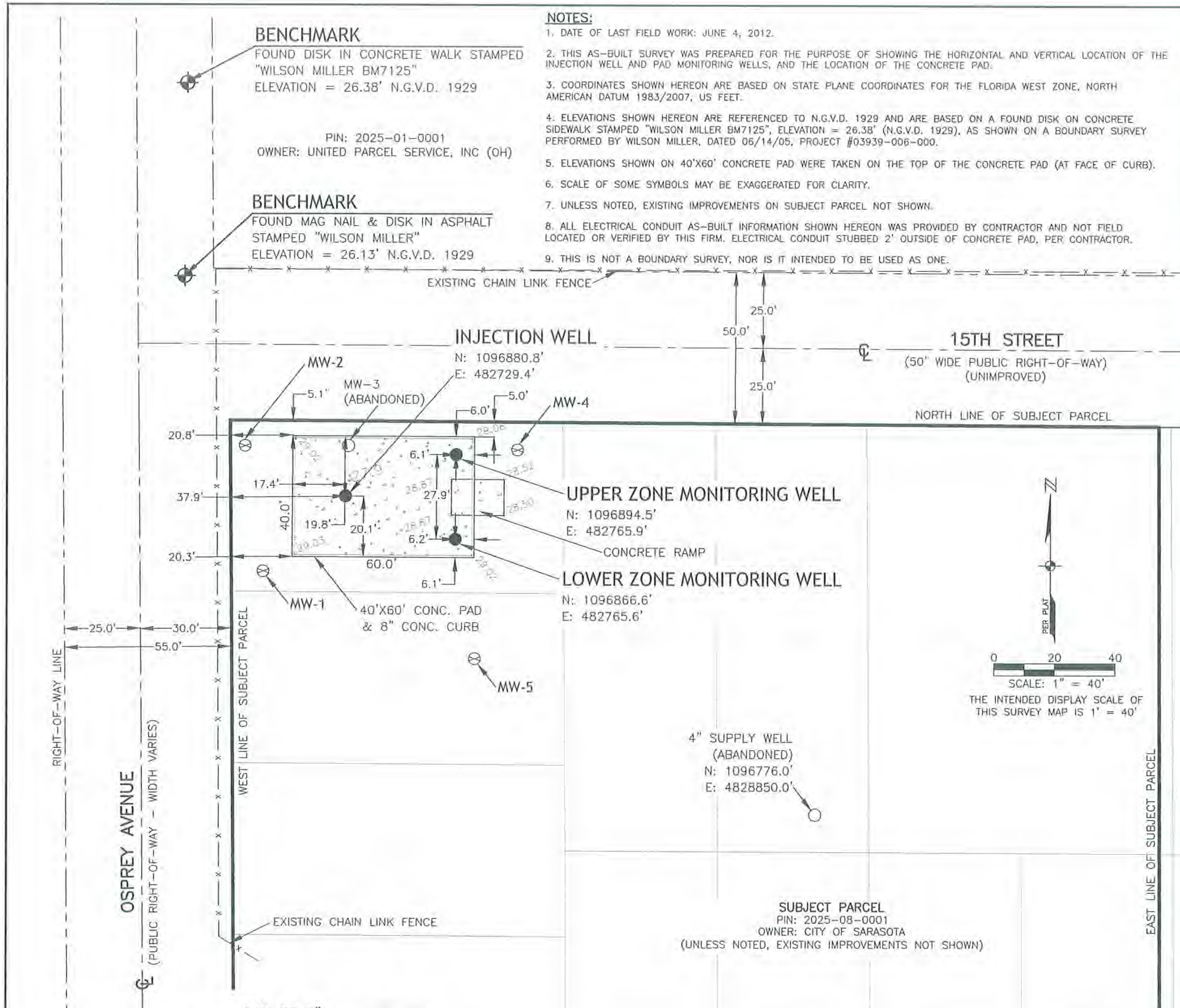

ATKINS
CITY OF SARASOTA WWTF
DIW-1 INJECTION TEST DATA
MAY 5, 2012
Downhole Pressure and Tide Height
PRESSURE (PSI)
610
605
600
595
590
585
580
575
570
565
560
555
550
TIDE HEIGHT (FT)
11.5
9.5
7.5
5.5
3.5
1.5
-0.5
PRE-TEST BACKGROUND
8- HR
INJECTION TEST
POST-TEST RECOVERY
5/5/12 0:00
5/5/12 6:00
5/5/12 12:00
5/5/12 18:00
5/6/12 0:00
5/6/12 6:00
5/6/12 12:00
TIME (DATE HOUR)
Downhole
Tidal

**FIGURE 3-41**

# Section 4 Figures

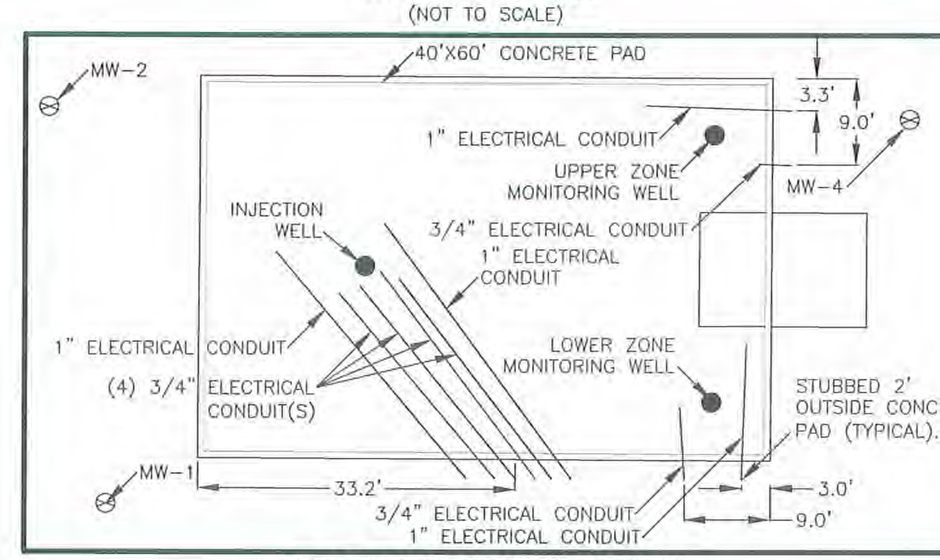
NOTES:

1. DATE OF LAST FIELD WORK: JUNE 4, 2012.
2. THIS AS-BUILT SURVEY WAS PREPARED FOR THE PURPOSE OF SHOWING THE HORIZONTAL AND VERTICAL LOCATION OF THE INJECTION WELL AND PAD MONITORING WELLS, AND THE LOCATION OF THE CONCRETE PAD.
3. COORDINATES SHOWN HEREON ARE BASED ON STATE PLANE COORDINATES FOR THE FLORIDA WEST ZONE, NORTH AMERICAN DATUM 1983/2007, US FEET.
4. ELEVATIONS SHOWN HEREON ARE REFERENCED TO N.G.V.D. 1929 AND ARE BASED ON A FOUND DISK ON CONCRETE SIDEWALK STAMPED "WILSON MILLER BM7125", ELEVATION = 26.38' (N.G.V.D. 1929), AS SHOWN ON A BOUNDARY SURVEY PERFORMED BY WILSON MILLER, DATED 06/14/05, PROJECT #03939-006-000.
5. ELEVATIONS SHOWN ON 40'X60' CONCRETE PAD WERE TAKEN ON THE TOP OF THE CONCRETE PAD (AT FACE OF CURB).
6. SCALE OF SOME SYMBOLS MAY BE EXAGGERATED FOR CLARITY.
7. UNLESS NOTED, EXISTING IMPROVEMENTS ON SUBJECT PARCEL NOT SHOWN.
8. ALL ELECTRICAL CONDUIT AS-BUILT INFORMATION SHOWN HEREON WAS PROVIDED BY CONTRACTOR AND NOT FIELD LOCATED OR VERIFIED BY THIS FIRM. ELECTRICAL CONDUIT STUBBED 2' OUTSIDE OF CONCRETE PAD, PER CONTRACTOR.
9. THIS IS NOT A BOUNDARY SURVEY, NOR IS IT INTENDED TO BE USED AS ONE.





INJECTION WELL
(NOT TO SCALE)




ELECTRICAL CONDUIT DETAIL

SCALE: 1" = 20'

GENERAL LEGEND

N.G.V.D. 1929 = NATIONAL GEODETIC VERTICAL DATUM OF 1929
℄ = CENTERLINE
EL. = ELEVATION
CONC. = CONCRETE
O.R. = OFFICIAL RECORDS
PIN: = PARCEL IDENTIFICATION NUMBER
NO. = NUMBER
PG = PAGE
P.B. = PLAT BOOK
LB 7777 = LICENSED SURVEY BUSINESS FLORIDA CERTIFICATE NO. 7777
⊖ = 2" PAD MONITORING WELL
MW = MONITORING WELL
+29.08 = AS-BUILT ELEVATION

IN MY PROFESSIONAL OPINION, AS A LICENSED FLORIDA PROFESSIONAL SURVEYOR AND MAPPER, THIS PLAT IS A TRUE AND CORRECT REPRESENTATION OF A SURVEY MADE AND PLATTED UNDER MY DIRECTION, DATED AS SHOWN IN NOTE 1 ABOVE AND MADE IN ACCORDANCE WITH CHAPTER 472.027, FLORIDA STATUTES.

ROBBY J. WALKER (FOR THE FIRM LB #7777)
PROFESSIONAL SURVEYOR AND MAPPER
FLORIDA CERTIFICATE NO. 6629

DATE SIGNED:

NOT VALID WITHOUT THE SIGNATURE AND THE ORIGINAL RAISED SEAL OF A FLORIDA LICENSED SURVEYOR AND MAPPER. THIS CERTIFICATION IS TO THE DATE OF LAST FIELD WORK AS SHOWN AND NOT THE SIGNATURE DATE.

| CODE | NORTHING | EASTING | TOP OF 2" PVC EL. | DESCRIPTION |
|---|---|---|---|---|
| MW-1 | 1096856.1 | 482702.3 | 26.9' | 2" PAD MONITORING WELL |
| MW-2 | 1096897.4 | 482696.2 | 26.8' | 2" PAD MONITORING WELL |
| MW-3 | 1096897.5 | 482730.3 | – | 2" PAD MONITORING WELL (ABANDONED) |
| MW-4 | 1096896.2 | 482786.2 | 27.6' | 2" PAD MONITORING WELL |
| MW-5 | 1096827.2 | 482772.1 | 27.0' | 2" PAD MONITORING WELL |

| NO. | REVISION | DATE |
|---|---|---|
| (2) | ADDED ELECTRICAL CONDUIT AS-BUILTS BY CONTRACTOR | 07/30/12 |
| (1) | ADDED FINAL IMPROVEMENTS/AS-BUILT ELEVATIONS | 06/06/12 |

THIS SURVEY IS ONLY FOR THE BENEFIT OF:
YOUNGQUIST BROTHERS, INC

NO OTHER PERSON OR ENTITY MAY RELY ON THIS SURVEY.

YOUNGQUIST BROTHERS, INC

PARCEL OF LAND LYING IN
SECTION 18, TOWNSHIP 36 SOUTH, RANGE 18 EAST
PARCEL IDENTIFICATION NO. 2025-08-0001
SARASOTA COUNTY, FLORIDA


WALKER SURVEYING & MAPPING
3375 NW COUNTY ROAD 661A
ARCADIA, FL 34266
PHONE (863) 244-9609
FAX (863) 993-0962
LB #7777


AS-BUILT SURVEY

| DATE | PROJECT NO. | FILE NO. | SCALE | SHEET |
|---|---|---|---|---|
| 04/02/12 | 20110036 | 18-36-18 | 1" = 40' | 1 OF 1 |

FIGURE 4-1

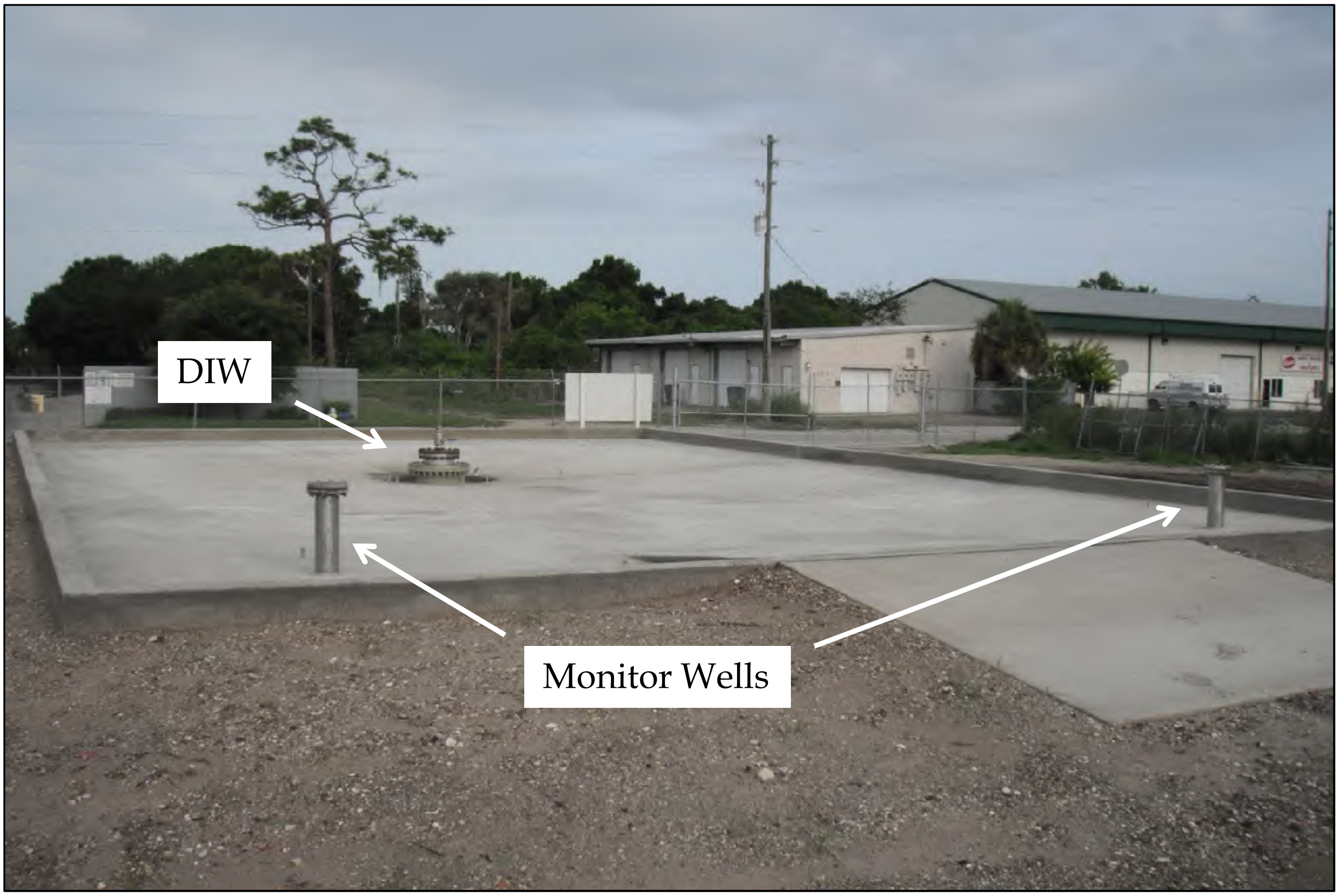



Figure 4-2 City of Sarasota Deep Injection Well System