CONSTRUCTION AND TESTING REPORT
SOUTHEAST POLK COUNTY DEEP EXPLORATORY WELL
FROSTPROOF, FLORIDA

WATER WELL CONSTRUCTION PERMIT No. SF081408B

PREPARED FOR

POLK COUNTY UTILITIES

AND

SFWMD

PREPARED BY

PBSJ
4030 W. Boyscout Blvd.
Tampa, FL 33607

APRIL 2010

Certification Page

This report on the construction and testing of the Southeast Deep Exploratory Well SE-DEW for Polk County Utilities, Winter Haven, Florida was prepared by or under the direction of a Registered Professional Geologist in the State of Florida.

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April 22, 2010
Date

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Executive Summary

The 2005-2006 Kissimmee Basin Water Supply Plan concluded that traditional groundwater sources used in the Central Florida region may be limited over the twenty year planning horizon. This conclusion was, however, based upon a limited amount of information and it was identified that there is a need to gather additional hydrologic information and to look for new potential sources of potable water. In particular, hydrogeologic and geologic information for the upper and lower portions of the Floridan Aquifer System (FAS) in Osceola and Polk Counties was identified for future collection efforts.

This report documents the results of the construction and testing of a Lower Floridan aquifer deep exploratory well (SE-DEW), which is located on a 10.3 acre outparcel of the FX-Bar ranch property east of the City of Frostproof, in southeast Polk County, Florida. SE-DEW was drilled to a depth of 2,521 feet below land surface (bls) for testing purposes. It was completed with casing to 1,400 ft bls and open hole to 2,140 ft bls to allow the withdrawal of groundwater from the uppermost permeable zone of the Lower Floridan Aquifer. Three additional wells were also constructed at the site to collect hydrogeologic data and to monitor water levels during aquifer performance testing of the SE-DEW.

The main findings of the exploratory drilling and testing program at this site are:

Hydrogeologic units identified during construction and testing of the SE-DEW included the surficial aquifer system (SAS), the intermediate confining unit (ICU), the middle semi-confining unit – upper part (MC1), the Avon Park permeable zone (APPZ), the middle semi-confining unit – lower part (MC2), the Lower Floridan aquifer –uppermost permeable zone (LF1), a confining unit within the LFA (LC), and a deeper permeable zone within the LFA (LF2).

Packer and aquifer performance testing yielded an estimated transmissivity of 308,700 gallons per day per foot or 41,270 feet squared per day for the APPZ, at 870 to 1,250 ft bls.

Aquifer performance testing of LF1 yielded a transmissivity of approximately 121,900 gallons per day per foot or 16,300 feet squared per day, a storage coefficient of 3.6e-04 and a leakage factor (r/B) of 0.1 with a calculated leakance of 4.07 $x10^{-3}$ per day.

Laboratory analysis of water samples collected from packer tests showed that the TDS concentration of water below approximately 2,370 ft bls was greater than 10,000 mg/L and therefore the LFA below this depth is not a potential source of drinking water as defined in Chapter 62-520 of the Florida Administrative Code, which defines an Underground Source of Drinking Water (USDW) as an aquifer with a TDS concentration of less than 10,000 mg/L.

An assessment of potential drawdown impacts to “Ridge Lakes” and Stressed Lakes” within the Southwest Florida Water Management District, and Lake Kissimmee resulting from a new withdrawal of 30 MGD from LF1 at the SE-DEW site was conducted by applying the Hantush-

Jacob equation for a semi-confined aquifer. The modeling results show that the drawdown in the potentiometric surface of LF1 is less than 0.01 feet at these lakes.

1.0 Introduction

1.1. Background

The 2005-2006 Kissimmee Basin Water Supply Plan concluded that traditional groundwater sources used in the Central Florida region may be limited over the twenty year planning horizon. This conclusion was, however, based upon a limited amount of information and it was identified that there is a need to gather additional hydrologic information and to look for new potential sources of potable water. In particular, hydrogeologic and geologic information for the upper and lower portions of the Floridan Aquifer System (FAS) in Osceola and Polk Counties was identified for future collection efforts.

In July 2008, Polk County and the South Florida Water Management District (SFWMD) entered into a cooperative agreement to investigate the hydrogeologic conditions of the FAS in southeast Polk County to answer questions regarding the extent and vertical connection of the FAS and to provide data on the regional extent of the freshwater portion of the FAS in central Florida. The investigation involves the construction and testing of one Upper Floridan aquifer (UFA) and one Lower Floridan aquifer (LFA) exploratory wells, the collection of lithologic and geophysical logs, the collection and analysis of rock cores, conducting packer test, the analysis of water quality samples, and the conducting and analysis of aquifer performance tests (APTs) conducted in the upper and lower portions of the FAS. In addition, the investigation included the construction of a shallow monitor well to monitor impacts to the water table of the surficial aquifer during the APTs. During construction of the LFA exploratory well, Polk County authorized the construction of a dual-zone monitor well to monitor impacts to water levels in the upper and lower portions of the FAS during the APTs. This report summarizes the construction and testing of the LFA exploratory well, herein referred to as the Southeast Deep Exploratory Well or SE-DEW.

Technical specifications for the construction and testing of the SE-DEW were prepared by PBS&J and submitted to Polk County Utilities (PCU) for incorporation into contract documents. The contract for the construction and testing of the SE-DEW was awarded to Rowe Drilling Company, Inc. (RDC) of Polk City, Florida. After obtaining the required Well Construction Permits (WCPs) from the SFWMD, RDC mobilized to the construction site on September 3, 2008. Construction and testing operations at the SE-DEW began on October 16, 2008 following construction of the shallow monitor well, and after initiating the construction of the Upper Floridan exploratory well SE-UFA-MW1. A copy of the WCP is presented in **Appendix A**. Although SE-DEW was permitted for testing, observation and monitoring purposes, it was constructed to meet the construction standards for public water system wells per Chapter 62-532 of the Florida Administrative Code (FAC) for future use as a production well following modification of the construction permit to reflect the change in use from observation to public water supply, a satisfactory sanitary site inspection, and issuance of a Water Use Permit by the SFWMD.

1.2. SE-DEW Location

As depicted on **Figure 1**, SE-DEW is located at the southeast Polk County Deep Exploratory Well site, which is located east of the City of Frostproof, Florida within Section 21, Township 31 South, Range 29 East, on property leased by Polk County Utilities. The Deep Exploratory well site is a 10.3 acre outparcel of the FX-Bar ranch property that is bordered on the west by a drainage ditch and County Road (C.R.) 630 on the south. The SE-DEW is geographically located at 27.7670259 North Latitude and 81.428103 West Longitude.

1.3. Regional Hydrogeologic Framework

The hydrogeologic system in the area consists of a series of clastic deposits underlain by a thick sequence of carbonate rocks. The stratigraphic units underlying the area form a layered sequence of aquifers and confining units. Principal hydrogeologic units consist of the surficial aquifer system (SAS), the intermediate aquifer system (IAS) or intermediate confining unit (ICU), and the Floridan Aquifer System (FAS), which are further subdivided into secondary aquifers, confining units and permeable zones. These hydrogeologic units, associated geologic units, and brief lithologic descriptions are presented on **Figure 1-2**, which is a reproduction of Figure 8 of the U.S. Geological Survey (USGS) Scientific Investigations Report (SIR) 2007-5207 by R. S. Reese and E. Richardson (2007).

Excerpts from the USGS SRI reports 2007-5207 and 2006-5320 by Rick M. Spechler and Sharon E. Kroening on the hydrology of Polk County, Florida are presented below to provide further details on the hydrogeologic units, geologic units, and lithology for the region, which includes the SE-DEW site. The approximate thicknesses of the hydrogeologic units at the SE-DEW site based on information presented in Hydrogeologic sections X-X' (Figure 17g) of the USGS SIR report 2007-5207 are also presented. Hydrogeologic sections X-X' trends north to south and is offset westward of the SE-DEW site by approximately 4 miles.

The SAS is unconfined and consists of unconsolidated clastic deposits that range in age from Holocene to Pliocene. The unit is primarily composed of fine to medium grained quartz sand near land surface that grades with depth to silty and clayey sands. The lithology of the sediments within the SAS can vary considerably both vertically and laterally. The base of the SAS is defined by the first persistent beds of Miocene or Pliocene age sediments containing a substantial increase in clay or silt (Spechler and Kroening, 2006). The approximate thickness of the SAS expected at the SE-DEW site based on hydrogeologic sections X-X' is 120 feet.

The SAS overlies the ICU or IAS of late Oligocene to Pliocene age. Water-bearing rocks in the IAS of west-central and southwestern Florida grade or pinch out to the east and, in east-central and southeastern Florida, the IAS becomes the ICU. The ICU is present throughout much of northern and eastern Polk County (Spechler and Kroening, 2006). The ICU serves as a confining layer that restricts the vertical movement of water between the SAS and the underlying Upper Floridan aquifer (UFA). The lithology of the ICU is variable and includes fine-grained sediments, such as clay, marl, micritic limestone, and silt, of the Hawthorne Group which provide good confinement. The approximate thickness of the ICU expected at the SE-DEW site based on hydrogeologic sections X-X' is 130 feet.

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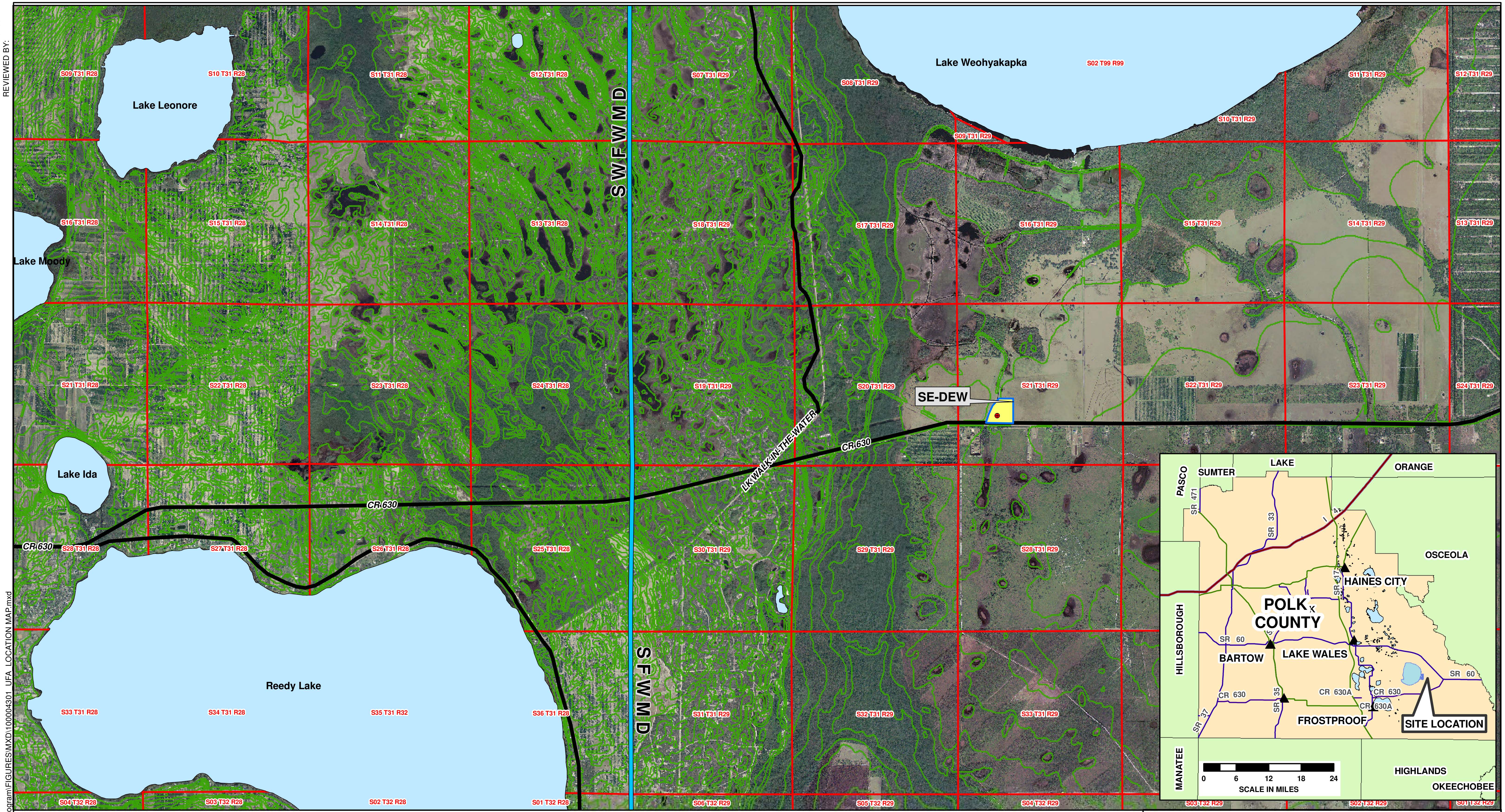

LEGEND:

- Southeast Deep Exploratory Well
- Topographic Contours - 5 Foot Intervals
- Major Roads
- Southeast Polk County Deep Exploratory Well Site
- Section , Township, Range
- Water Management Distric Boundry

NOTES:

1. THIS FIGURE IS GENERATED IN COLOR. PHOTOCOPYING IN BLACK AND WHITE WILL RESULT IN THE LOSS OF THE PRESENTED DATA.
2. AERIAL PHOTOGRAPH PROVIDED BY THE SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT (03-2006).
3. SHAPEFILES PROVIDED BY POLK COUNTY, THE FLORIDA DEPARTMENT OF TRANSPORTATION AND SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT.

N W E S

1 INCH = 3,000 FT

0 1,500 3,000 4,500 6,000
Feet

Polk County Utilities

SOUTHEAST DEEP EXPLORATORY WELL SITE LOCATION MAP FROSTPROOF, POLK COUNTY, FLORIDA

SCALE: AS SHOWN
APRIL 2010

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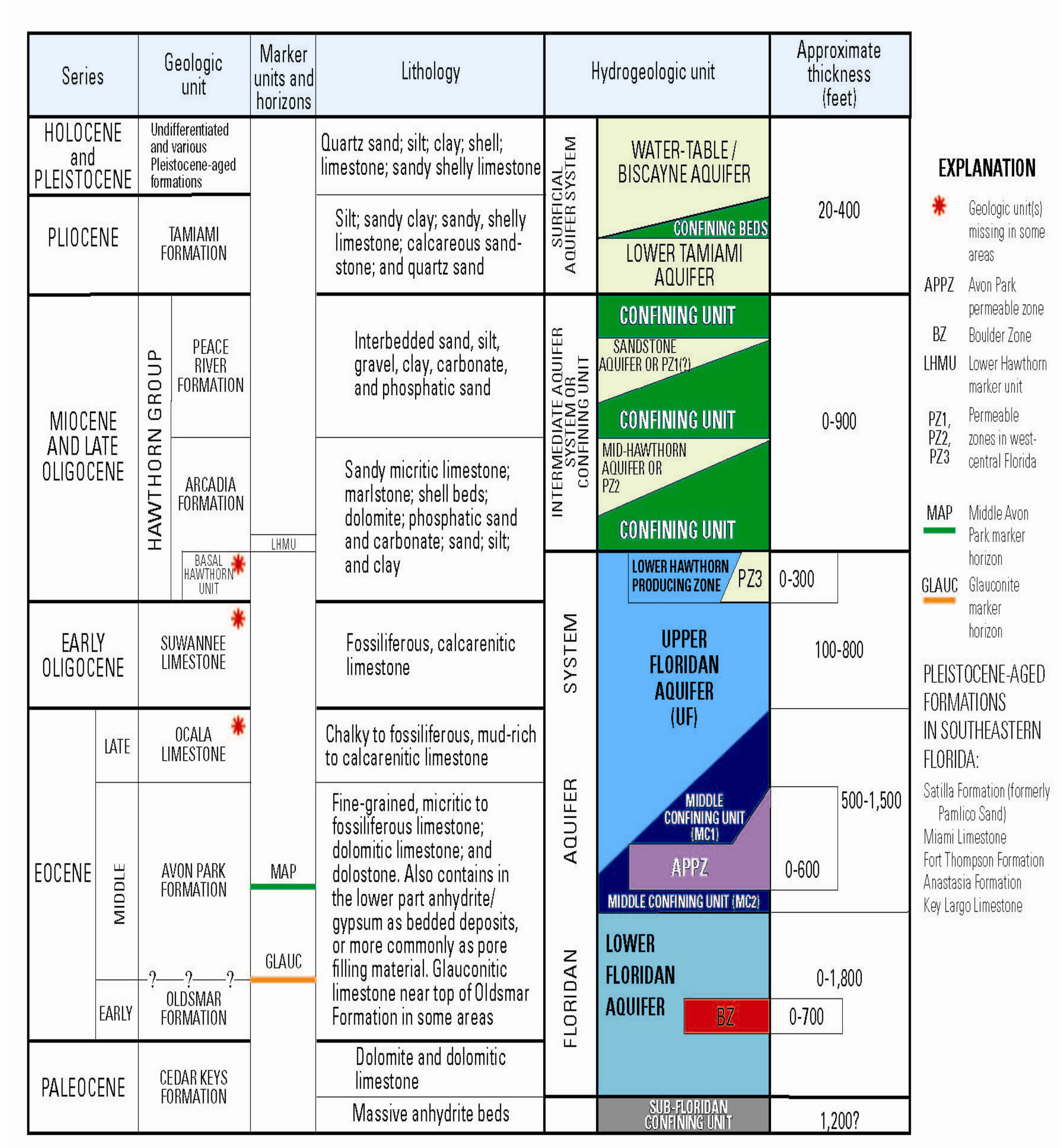
FIGURE 1

FILE PATH: F:\COMMON\Hydrogeological Program\FIGURES\MXD\100004301 UFA LOCATION MAP.mxd

Figure 1-2. Chart Showing Relation of Hydrogeologic to Geologic Units and their Lithology in Central and Southern Florida
From Reese, R.S. and E. Richardson (2007)



The geologic units that compose the UFA include the Suwannee Limestone, the Ocala Limestone and the upper part of the Avon Park Formation. The surface of the UFA is the remnant of an ancient karst plain, and generally exhibits considerable irregularity throughout Polk County. Sink-hole type depressions on the surface of the aquifer are common. (Spechler and Kroening, 2006).

In much of Polk County where the Suwannee Limestone is present, the uppermost permeable zone of the UFA coincides with the Suwannee Limestone (Spechler and Kroening, 2006). Underlying the Suwannee Limestone is a semiconfining unit that generally corresponds stratigraphically to all or parts (mostly the upper pat) of the Ocala Limestone, but in some areas, also may include the extreme upper part of the Avon Park Formation (Spechler and Kroening, 2006). The unit is composed of a soft, chalky, fine gained foraminiferal calcilutite and calcarenite limestone (Spechler and Kroening, 2006). As identified in the report by Spechler and Kroening (2006), the lowermost permeable zone of the UFA occurs in the hard, fractured dolostone within the Avon Park Formation, and is the major source of water in the UFA. However, as identified in R. S. Reese and E. Richardson (2007), this permeable zone is considered a regional production zone within the middle confining unit referred to as the Avon Park permeable zone (APPZ) and is not considered part of the UFA. The approximate thickness of the UFA that would be expected at the SE-DEW site based on hydrogeologic sections X-X' is 100 feet.

Transmissivity of the UFA is highest in west-central Florida where it is greater than 100,000 feet squared per day (ft^2/ day). A region of low transmissivity (less than 10,000 ft^2/ day) exists in a large central peninsular area that extends from southeastern Polk to northwestern Miami-Dade Counties.

The Suwannee Limestone predominantly consists of pale-orange to tan, fossiliferous, medium grained calcarenite with minor amounts of quartz sand and rare-to-absent phosphate mineral grains. Characteristic porosity and permeability in the Suwannee Limestone is interparticular to moldic or vuggy. This formation is mapped as being absent by truncation in virtually all of east-central Florida.

The Ocala Limestone consists of micritic or chalky limestone, calcaenitic limestone and coquinoid limestone. The limestone is characterized by abundant large foraminifera, such as *Operculinoides* sp., *Camerina* sp., and *Lepidocyclina* sp. These characteristic foraminifera, where present, have been used by various workers to distinguish the Ocala Limestone from the overlying Suwannee Limestone and the underlying Avon Park Formation.

The Avon Park Formation consists principally of micritic to fossiliferous limestone, dolomitic limestone, and dolostone or dolomite. Fine- to medium- grained calcarenite that is moderately to well sorted is intermittently present. Dolomite ranges from light brown to orangish brown to dark brown or even black and from sucrosic to dense. The cone-shaped *Dictyoconus* sp. is the foraminifera characteristic of the Avon Park Formation.

The middle confining unit (MCU) of the FAS underlies the UFA, and in most of the study area, is divided into upper (MC1) and lower (MC2) parts that are separated by the APPZ. Despite the name, in most of the study area the middle confining unit is semiconfining or leaky in nature and generally consists of micritic limestone, dolomitic limestone, and dolomite or dolostone. In most of west-central Florida including Highlands County and parts of southwestern Florida, where the Ocala Limestone is fine grained and micritic in nature, the upper boundary of the middle confining unit is placed at or near the upper contact of the Ocala Limestone. The approximate thickness of the MC1 expected at the SE-DEW site based on hydrogeologic sections X-X' is 485 feet.

The APPZ usually lies between the Upper and Lower Floridan aquifers and within the MCU, within the Avon Park Formation. This formation characteristically contains thick beds or units of dolostone with interbedded limestone and dolomitic limestone; micritic to dolomitic limestone is most common in the upper part of the stratigraphic unit. Permeability in the Avon Park Permeable Zone is primarily associated with fracturing, but cavernous or karstic, intergrain, and intercrystalline permeability can also be present. The dolomite in this zone varies from poorly to moderately consolidated and sucrosic to dense, hard, and massive, with a gradation from the former to the later commonly occurring with increasing depth. The approximate thickness of the APPZ expected at the SE-DEW site based on hydrogeologic sections X-X' is 300 feet.

Separating the APPZ and the LFA is the MC2. It separates the UFA from the LFA in this area and is also the transition from the Avon Park Formation into underlying Oldsmar Formation (Spechler and Kroening, 2006). The lower MCU, can vary greatly in thickness and composition, it is comprised of crystalline dolomite, which can either be source of good confinement when un-fractured or prove only semi-confining when fracturing in present. The approximate thickness of the MC2 expected at the SE-DEW site based on hydrogeologic sections X-X' is 200 feet.

The LFA is a thick sequence of carbonate rocks that contains several permeable zones separated by thick semiconfining units. The semiconfining units trend to be much thicker than the permeable zones, with the exception of the underlying Boulder Zone in the lower part of the aquifer. The permeable zones or subaquifers in the LFA above the Boulder Zone are listed from the highest to lowest, beginning with LF1 and continuing with LF2, LF3, and so forth. In some areas inly LF1 is present. The confining unit below LF1 and the ones between deeper permeable zones are referred to as LC. The approximate thickness of the LF1 expected at the SE-DEW site based on hydrogeologic sections X-X' is 120 feet.

The LFA generally is present within the lower part of the Avon Park Formation, the Oldsmar Formation, and the upper part of the Cedar Keys Formation (Spechler and Kroening, 2006).The Oldsmar Formation primarily consists of a sequence of white to gray, micritic limestone and interbedded tan to light-brown dolomite. Anydrite and gypsum are common lithologic components of the Oldsmar Formation in west-central Florida. The top of the Oldsmar Formation in east-central Florida is marked by glauconitic limestone. Dolomite, dolomitic limestone, and anhydrite constitute the Cedar Keys formation. The anhydrite is present as thick massive beds in the lower part of the formation, and the top of these beds mark the base of the FAS.

1.4. Site-Specific Hydrogeologic and Geologic Units

Hydrogeologic units identified during construction and testing of the SE-DEW included the SAS, the ICU, MC1, the APPZ, the MC2, an uppermost permeable zone in the LFA (LF1), a confining unit with the LFA (LC), and a deeper permeable zone within the LFA (LF2). The UFA was not identified at the site due to the absence of the Suwannee Limestone and the low permeability of the Ocala Limestone that was identified during the construction and testing of the SE-DEW.

The depth from land surface to the base of the SA/ top of the ICU at the SE DEW was identified at approximately 130 ft bls or 60 ft below the National Geodetic Vertical Datum of 1929 (NGVD) based on a change in lithology from fine quartz sand to a gray-green clay. At the SE-UFA-MW1 the contact between the two units was identified at a depth of 80 ft bls based on a change in lithology from fine quartz sand to a gray-green phosphatic clay.

The base of the ICU/ top of MC1 at the SE-DEW was identified at approximately 290 ft bls or 360 ft below NGVD based on a change in lithology from a phosphatic, fine quartz sand to a white, moderately indurated, fossiliferous limestone. At the SE-UFA-MW1 the contact between the two units was identified at a depth of approximately 250 ft bls based on a decrease in gamma ray emissions from 160 to 20 GAPI on the natural gamma log between 250 and 255 ft bls and a change in lithology from a phosphatic, gray clay to a white, moderately indurated, fossiliferous limestone at 250 to 260 ft bls. The thickness of the ICU at the SE-DEW therefore is approximately 160 feet.

The base of the MC1 / top of the APPZ was identified at approximately 870 ft bls or 800 ft below NGVD based on the testing conducted during the construction of well SE-UFA-MW1 and the SE-DEW. The thickness of MC1 at the SE-DEW therefore is approximately 580 feet. The UFA was not identified at the SE-DEW.

The base of the APPZ/ top of MC2 was identified at approximately 1,250 ft bls or 1,180 ft below NGVD based on the static water level measurements, groundwater sampling and air-lift specific capacity testing during drilling activities, and the geophysical logging results. The thickness of the APPZ therefore is approximately 380 feet.

The open borehole section of SE-UFA-MW1 intercepted an uppermost permeable zone within the APPZ between approximately 870 and 930 ft bls. An estimated transmissivity of 30,040 ft^2/ day was calculated for this permeable zone based on data obtained from an aquifer performance test at SE-UFA-MW1 in December 2009.

The base of the MC2/ top of LF1 was identified at approximately 1,420 ft bls or 1,350 ft below NGVD based on static water level measurements, groundwater sampling and air-lift specific capacity testing during drilling activities, and the geophysical logging results. The thickness of the MC2 therefore is approximately 170 feet.

The base of the LF1/ top of the LC was identified at approximately 1,870 ft bls or 1,800 ft below NGVD based on static water level measurements, groundwater sampling and air-lift specific capacity testing during drilling activities, and the geophysical logging results. The thickness of the LF1 therefore is 450 feet.

The base of the LC/ top of the LF2 was identified at approximately 2,280 ft bls or 2,100 ft below NGVD based on static water level measurements, groundwater sampling and air-lift specific capacity testing during drilling activities, and the geophysical logging results. The thickness of the LC therefore is 410 feet.

Figure 1-3 provides the thicknesses of the hydrogeoloic units from land surface through LF1 that were identified at the SE-DEW site based on data obtained during the construction and testing of the SE-DEW and the estimated expected thicknesses based on hydrogeologic sections X-X' for comparison.

Figure 1-3 Hydrogeologic Unit Thicknesses at the SE-DEW Site

Hydrogeologic Unit	Unit Thickness (ft) From SE-DEW Data	Expected Unit Thickness (ft) From Section X-X'
SAS	130	120
ICU	160	130
UFA	0	100
MC1	580	485
APPZ	380	300
MC2	170	200
LF1	450	120

Geologic units identified during construction and testing of the SE-DEW included unconsolidated clastic deposits of Holocene to Pliocene age that comprised the SAS, the Hawthorn group that comprised the ICU, and the Ocala Limestone, the Avon Park Formation and the Oldsmar Formation that comprise the FAS. The Suwannee Limestone was not encountered at the site. The contact between the Ocala Limestone and the Avon Park Formation was estimated to be at approximately 690 ft bls based on a change in lithology from a moderately indurated, fossiliferous limestone to a well indurated, dolomitic limestone. The contact between the Avon Park Formation and Oldsmar Formation was estimated to be at approximately 1,930 ft bls based on an increase in the natural gamma ray emissions noted on the geophysical logs at this depth.

2.0 Well Construction

Drilling operations during the construction of the SE-DEW were conducted with a Gardner Denver 3000 trailer mounted drilling rig incorporating a Kelly drive table rotary system. The table rotary is located approximately 4.3 feet above land surface. The nominal sizes of the drilling bits used were 12, 18, 24, 30, 36 and 42 inches in diameter. The drill rods were 7-inch outside diameter and ranged from approximately 30 to 32 feet in length. Photographs of the drilling equipment and selected well construction activities are presented in **Appendix B.**

The drilling operations, which are further described in the following Sections 2.1 and 2.2, utilized mud-rotary drilling to a depth of approximately 620 feet below land surface (bls) followed by reverse-air drilling to a depth of 2,521 ft bls. Formation samples were collected at 10-foot intervals during pilot-hole drilling and examined, identified and catalogued on-site by a PBS&J geologist. The formation samples were utilized to prepare a lithologic log for the SE-DEW, which is presented in **Appendix C**. In general, formation materials encountered at the site included unconsolidated sands that comprise the surficial aquifer system (SAS) to approximately 130 ft bls, clay and limestone that comprises the intermediate confining unit (ICU) to approximately 290 ft bls, and limestone and dolostone of the Floridan aquifer system to the drilled depth of 2,521 feet bls.

Steel casings were installed and grouted in place at various depths as drilling proceeded to prevent collapse of the borehole and to prevent the interchange of water between hydrogeologic units. Installation and grouting of the casing are further described in the following Sections 2.3 through 2.8

2.1. Mud Rotary Drilling

Mud rotary drilling is utilized to drill through unconsolidated or poorly consolidated sediments that generally are unstable, have a tendency to collapse into the borehole and yield relatively low quantities of groundwater. The drilling mud stabilizes the borehole and removes the drill cuttings during the drilling operations. The mud rotary drilling operations at the site utilized bentonite drilling mud as the drilling fluid, which was mixed in an earthen pit approximately 10,000 gallons in volume.

During mud rotary drilling, the drilling mud is pumped through the drill rods and exits out the drill bit. The viscous drilling fluid suspends the cuttings and circulates back up the borehole to land surface. The returning mud, laden with formation cuttings, is routed back into the open pit, which is tiered and baffled allowing the formation cuttings to settle out. The drilling fluids are collected in another tier and re-circulated back down the drill rod. Following completion of the well, the cuttings and drilling mud were removed from the 10,000-gallon dug pit and transported to a private landowner for fill purposes. The 10,000 gallon pit was then backfilled with clean sand and compacted.

2.2. Reverse-Air Drilling

Reverse-air drilling techniques are primarily used to drill competent water-bearing formations. Water produced by the formation during the drilling operations serves as the drilling fluid. Compressed air is piped down a 1-inch diameter air-line inside the drill pipe that aerates the water. This aeration causes a pressure differential, which in turn causes upward flow of the water inside the drill pipe. The drill pipe in effect becomes an air-lift pump. Water and cuttings at the bottom of the borehole are drawn into the drilling bit and conveyed up the drill rod to land surface.

The water and cuttings from the drill rod were routed to a series of coffered earthen pits with turbidity mitigation controls installed. The discharge water, saturated with cuttings, was directed through six pits of varying size and construction, in an effort to allow the cuttings and suspended solids to settle, leaving the discharge water clearer with very low turbidity. The final pit was a lined over-land-flow, burmed area that allowed the velocity of the discharge to slow significantly, reducing the sediment transport ability of the water. To further decrease the turbidity in the final pit, Jute mats were placed on the bottom of the approximately 400 square feet area, and dusted with an anionic polymer that, when in solution increases the mass of the suspended solids by coagulation causing them to settle out of suspension. The discharge water was continually monitored for Specific Conductance, Turbidity and pH, prior to being releasing into a county drainage ditch that parallels the north side of C.R. 630. All field sample results of discharged water fell within acceptable limits as required by the FDEP Generic Permit for the Discharge of Produced Ground Water from any Non-Contaminated Site Activity.

Reverse-air drilling techniques allows for the collection of formation water samples through the drill rod for water quality analyses and the performance of air-lift specific capacity tests to evaluate borehole formation hydraulics during drilling operations. These activities are described in **Sections 4.4** and **4.5**.

2.3. Pit Casing Installation

Construction of SE-DEW was initiated by Rowe Drilling Company, Inc. (RDC) with the installation of a nominal 42-inch diameter steel pipe to a depth of 27 ft bls on October 21, 2008. This casing was installed to prevent unconsolidated, near-surface sediments at the site from collapsing into the borehole during drilling activities.

2.4. 36-Inch Casing Installation

Due to the non-cohesive nature of the SAS, which is comprised predominantly of quartz sands at the site, A nominal 36-inch diameter steel casing was installed on October 28, 2008 to an approximate depth of 86 ft bls into sandy clay of the ICU to prevent potential borehole collapse during continued construction activities. The nominal 12-inch diameter pilot hole was reamed to a nominal 42-inch diameter to a depth of approximately 86 feet in preparation for installation of the casing. Two sections of steel pipe, which were approximately 43 feet in length, were welded together and rotated by hand as they were lowered into the borehole to ensure that the casing hung free of obstructions and plumb within the borehole (photos in **Appendix B**). Steel centralizers, which were positioned at 0, 90, 180, and 270 degrees around the casing, were welded in place five feet above the bottom of the casing, 60 above that, and 5 feet below the top of the casing. Tremmie pipe was temporarily installed between the casing and borehole wall to approximately 5 feet from the bottom of the borehole in preparation for grouting of the annulus. Mill certificates for the casing are included in **Appendix D.**

2.5. 36-Inch Casing Grouting

Cement grouting of the surface casing was completed utilizing tremmie grouting methods. Tremmie grouting is performed by pumping grout through a tremmie pipe, which is installed into the annular space from the surface, to a depth just above the intended grout application.

RDC conducted cementing operations at the SE-DEW with manufactured cement from CEMEX of Lake Wales, Florida. RDC cemented the nominal 36-inch diameter surface casing in place with two tremmie grout stages utilizing Portland Type II cement mixed with 5.2 gallons of water per 94 pounds of cement (1 sack). The theoretical volume to fill the annulus between the nominal 42-inch diameter borehole and the 36-inch O.D., 86 feet long casing, was approximately 294 sacks of neat cement grout. RDC utilized a grout mix with a quantity of sand incorporated to add strength for improved borehole stability.

The first grout stage was performed on October 28, 2008 and consisted of pumping 294 sacks of neat cement grout. On October 29, 2008, an additional 84 sacks of neat cement grout was installed in the annular space by tremmie pipe, which resulted in a return of grout to land surface. The total quantity of grout used was 378 sacks.

2.6. 30-Inch Casing Installation

Following the completion of the pilot hole to a depth of 280 feet bls, the nominal 12-inch diameter pilot hole was reamed utilizing mud-rotary techniques to a nominal 36-inch diameter to a depth of approximately 275 feet in preparation for the installation of the 30-inch diameter casing by RDC on November 7, 2008.

The 30-inch casing consisted of seven sections of butt-welded nominal 30-inch diameter, 3/8-inch thick wall, carbon steel pipe totaling approximately 273 feet in length. Steel centralizers, which were positioned at 0, 90, 180, and 270 degrees around the casing, were welded in place five feet above the bottom of the casing and every 60 feet thereafter with the final centralizer placed 20 feet below the top of the casing. After the bottom of the welded casing string was landed in a moderately indurated limestone of the UFA, it was rotated by hand to demonstrate that it hung free of obstructions and plumb in the borehole. A temporary steel pressure head was welded onto the top of the casing in preparation for pressure grouting of the annulus between the casing and borehole wall. Casing mill certificates for the nominal 30-inch diameter intermediate casing are included in **Appendix D**.

2.7. 30-Inch Casing Grouting

The 30-inch diameter casing installation required a pressure grout for the first stage of grouting, ensuring a seal at the bottom of the casing to the surrounding lithology. Pressure grouting is performed by pumping grout inside the casing through a pipe that is sealed using a header assembly welded to the top of the casing, the casing is then pressurized. The grout is pumped down the tremmie pipe and forced around the bottom of the casing and up the outside, filling the annular space between the casing and reamed borehole wall. Tremmie grouting is performed by pumping grout through a tremmie pipe, which is installed into the annular space from the surface, to a depth just above the intended grout application.

RDC conducted grouting operations at the SE-DEW on November 7, 2008, utilizing manufactured cement from CEMEX of Lake Wales, Florida. RDC cemented the 30-inch diameter casing in place with one tremmie grout stage utilizing Portland Type II cement mixed with 5.2 gallons of water per 94 pounds of cement (1 sack). The theoretical volume to fill the annulus between the nominal 36-inch diameter borehole and the 30-inch O.D., 273 foot long casing, was approximately 450 sacks of neat cement grout. RDC pumped 484 sacks of neat cement. On November 10, 2008 a physical tag of the grout top revealed the grout had risen to with in four feet of land surface. RDC brought the grout up to land surface during the well head completion phase of construction.

2.8. 24-Inch Casing Installation

After the completion of the pilot hole to a depth of 990 feet, the nominal 12-inch pilot hole was reamed to a nominal 30-inch diameter, utilizing reverse-air drilling techniques, in preparation for the installation of the 24-diameter casing. Geophysical logging of the reamed borehole was conducted by Aquifer Data Systems (ADS) of Ft. Myers, Florida on December 15, 2008. The initial geophysical logging event (**Run No. 1**) was conducted in preparation for installation of the nominal 24-inch diameter casing and is discussed further in **Section 4.2**. The bottom of the nominal 24-inch diameter casing was landed at approximately 980 ft bls, below the uppermost permeable zone of the Avon Park permeable zone (APPZ).

The 24-inch casing was installed on December 18, 2008 and consisted of twenty-four sections of butt-welded nominal 30-inch diameter, 3/8-inch thick wall, carbon steel pipe totaling approximately 981 feet in length. Steel centralizers, which were positioned at 0, 90, 180, and 270 degrees around the casing, were welded in place five feet above the bottom of the casing and every 60 feet thereafter with the final centralizer placed 20 feet below the top of the casing. After the bottom of the welded casing string was landed in limestone of the APPZ, it was rotated by hand to demonstrate that it hung free of obstructions and plumb in the borehole. A temporary steel pressure head was welded onto the top of the casing in preparation for pressure grouting of the annulus between the casing and borehole wall. Casing mill certificates for the nominal 24-inch diameter intermediate casing are included in **Appendix D**.

2.9. 24-Inch Casing Grouting

Cement grouting of the 24-inch diameter casing was completed using both pressure grouting and tremmie grouting methods. RDC conducted grouting operations at the SE DEW beginning on December 20, 2008, with manufactured cement from CEMEX of Lake Wales, Florida. RDC cemented the nominal 24-inch diameter surface casing in place with a pressure grout stage, and 13 subsequent tremmie grout stages utilizing Portland Type II cement mixed with 5.2 gallons of water per 94 pounds of cement (1 sack). The theoretical volume to fill the annulus between the nominal 30-inch diameter borehole and the 24-inch O.D., along the 981 foot long casing, was approximately 3,270 sacks of 12% bentonite gel additive cement grout. The theoretical volume of the annulus is inordinately high due to a extensive amount of washed out borehole along the entire length of the open hole section. The total quantity of grout used was 1,080 sacks.

The pressure grout stage was performed on December 20, 2008 and consisted of pumping 180 sacks of Portland Type II neat cement grout. The pressure gauge installed on the header assembly read 40 pounds per square inch (psi) at the end of the pressure grouting operation and maintained that pressure reading for approximately four hours until the grout set. On December 21, 2008, a physical tag revealed that the cement top was located at an approximate depth of 970 ft bls, an 11 foot lift for the first grout stage. The second stage was a delivered via tremmie grouting procedures, 88 sacks of Portland Type II neat cement grout were pumped into the annular space, resulting in a vertical lift of 35 feet and a physical cement top tag of 945 feet bls. Next a gravel bridge was installed across a highly transmissive zone of the UFA. Twenty cubic yards of gravel were installed from 945 feet to 848 feet bls to fill the highly permeable and fractured zone between approximately 870 and 930 ft bls. A grout cap was laid over top of the gravel to in effect seal in the gravel, decreasing its vertical porosity to future overlying grout stages. The cap was comprised of 40 sacks of Portland Type II neat cement grout delivered via tremmie method, this yielded a return of 42 feet, resulting in a grout top tag of 806 feet bls.

Between the dates of January 7, 2009 and January 27, 2009, thirteen additional stages, identical in their composition, were pumped into the annular space of the intermediate-2 casing. The grout mix consisted of 4 cubic yards, (88 sacks), of manufactured Portland Type II neat cement, combined with 900lbs of hydrated bentonite gel additive, making a total volume of 9 cubic yards (198 sacks) of grout mix at a 12% bentonite concentration. On January 27, 2009 during grout stage 13 of the 24-inch diameter casing installation, a full cement return was witnessed at land surface. After only pumping 1,080 sacks of the theoretical 3,270 sacks of grout needed to fill the annular space, it was determined that RDC had miscalculated the grout tags throughout the grouting process, that at some point bridging or channeling had occurred resulting in the premature return of grout at land surface. RDC conducted a Cement Bond Log (CBL) on February 2, 2009 (**Run No. 2**), in an attempt to determine the extent of cement fill behind the casing, if voids existed or if channeling could be detected. The CBL indicated a good cement bond from the bottom of the casing to approximately 945 ft bls and at 865 to 870 ft bls where neat cement was installed, but apparently due to the gravel and high concentration of bentonite gel additive in the remaining grout, making the grout mix less dense, the CBL was inconclusive above 865 ft bls. To address any concerns over the increased potential for casing failure due to accelerated corrosion that might result from the lack of cement over an apparently large section of the annulus, the final 18-inch diameter casing was telescoped from 250 to 1,400 ft bls instead of 850 to 1,400 ft bls.

2.10. Back-Plugging of Pilot Hole

After geophysical logging and packer testing of the pilot hole between 980 and 2,521 ft bls was completed, the pilot hole was back-plugged to 2,141 ft bls with a 4% bentonite gel and Portland Type II cement grout mix except for the interval between 2,371 and 2,172 feet bls, which was backfilled with clean gravel. Tremmie grouting for the back-plugging required seven stages that were initiated on April 15, 2009. The purpose of the gravel bridge was to decrease the amount of cement required to fill two large horizontal fractures identified during geophysical logging at 2,335 ft bls and 2,367 ft bls and to maintain the permeability of these fractures in the eventuality that the SE-DEW is deepened in the future to include these fractures as a part of the open borehole interval.

2.11. Final 18-Inch Casing Installation

After back-plugging was completed, a section of the remaining 12-inch pilot hole from the bottom of the 24-inch diameter casing to a depth of 1,403 feet bls was reamed to a nominal 24-inch diameter, utilizing reverse-air drilling techniques, in preparation the installation of the 18-inch diameter final casing. The drill cuttings from reaming the pilot hole and gravel were used to temporarily backfill the section of the remaining pilot hole between 1,403 and 2,141 ft bls to prevent grout from filling what would be the open borehole section of the completed well.

Geophysical logging of the reamed borehole was conducted by MV Geophysical of Ft. Myers, Florida on May 8, 2009. The initial geophysical logging event (**Run No. 4**) was conducted in preparation for installation of the nominal 18-inch diameter final casing and is discussed further in **Section 3.6: Geophysical Logging**. The bottom of the nominal 18-inch diameter final casing was landed at approximately 1,400 ft bls in dolomitic limestone of middle confining unit 2.

The final casing was installed on May 29, 2009 and consisted of 28 sections of nominal 18-inch diameter, 3/8-inch thick wall, butt-welded carbon steel pipe, totaling 1,153 feet in length. After the telescoped casing string was landed at a depth of approximately 1,403 ft bls with the top of the casing extending to 250 feet bls, it was rotated to demonstrate that it hung free of obstructions and plumb in the borehole Steel centralizers, which were positioned at 0, 90, 180, and 270 degrees around the casing, were welded in place five feet above the bottom of the casing and every 60 feet thereafter with the final centralizer placed 20 feet below the top of the casing. The casing was suspended on drill rod utilizing a left-hand threaded back-off tool, which was affixed to the end of the drill rod and screwed onto the casing. After the casing was cemented in place, the drill rod was turned free of the casing and pulled out of the borehole. A temporary steel pressure head assembly was welded onto the top of the drilling pipe at land surface, in preparation for pressure grouting of the annulus between the casing and borehole wall. Casing mill certificates for the nominal 18-inch diameter final casing are included in **Appendix D**.

2.12. Final Casing Grouting

RDC cemented the nominal 18-inch diameter final casing in place with one pressure grout stage and five tremmie grout stage. The grout installed during both stages consisted of Portland Type II manufactured cement from CEMEX with 5.2 gallons of water per 94 pounds of cement (1 sack) ratio. The theoretical volume of grout required to fill the annulus between the nominal 24-inch diameter borehole and the nominal 18-inch diameter final casing from the bottom of the casing to the land surface was approximately 1,342 sacks of neat cement grout. However, additional quantities of grout were needed to fill the annulus since the borehole diameter was larger than 24 inches as demonstrated on the caliper log of the reamed borehole. The total quantity of cement installed during the grouting of the nominal 18-inch diameter final casing was 1,396 sacks.

The pressure grout stage was completed on June 2, 2009 and consisted of pumping 420 sacks of neat cement grout. The pressure gauge installed on the header assembly read 60 psi at the end of the pressure grouting operation. The top of the cement in the annular space between the borehole and the steel final casing was tagged at an approximate depth of 1248 ft bls and confirmed by a temperature tag of 1,240 feet bls approximately fifteen hours after the completion of the pressure grouting stage (**Run No. 5**).

The tremmie grouting stages were completed between June 3 and 8, 2009. Approximately 976.5 sacks of neat cement grout were pumped into the annular space through a 1.5-inch diameter tremie pipe set within the annulus. Of the 976.5 sacks tremmie grouted, 588 sacks were neat grout and 388 sacks contained 4% hydrated bentonite by weight. The second stage directly proceeding the pressure grouting consisted of approximately 336 sacks of neat cement grout, resulting in a tag of 1,044 feet bls, confirmed by a temperature tag of 1,042 feet bls. The third stage consisted of 252 sacks of neat cement grout, resulting in a tag of 795 feet bls, which was confirmed by a temperature logging tag at 810 feet bls (**Run No. 6**). In the fourth stage of cementing, hydrated bentonite gel was added to the grout, in the amount of 4% by weight. Approximately 158 sacks of the 4% bentonite and cement grout were installed, resulting in a physical tag of 550 feet bls. The use of temperature logging was discontinued after the third stage of cement due to the fact that the log showed the top of cement was above the base of the 24-inch diameter casing. The remainder of the annulus was filled in two more cementing stages. The fifth stage was comprised of 158 sacks of 4% bentonite and cement grout resulting in a physical tag of the top of the cement at 340 feet bls. The sixth stage of 74 sacks of 4% bentonite and cement grout brought the top to approximately 250 feet bls at the top of the telescoped 18-inch casing.

2.13. Open Hole Interval

Following installation of the nominal 18-inch diameter final casing, the nominal 12-inch diameter pilot hole below the final casing was cleared of gravel and drill cuttings and reamed to a nominal 18-inch diameter to approximately 2,141 ft bls utilizing reverse-air drilling between June 12 and July 9, 2009.

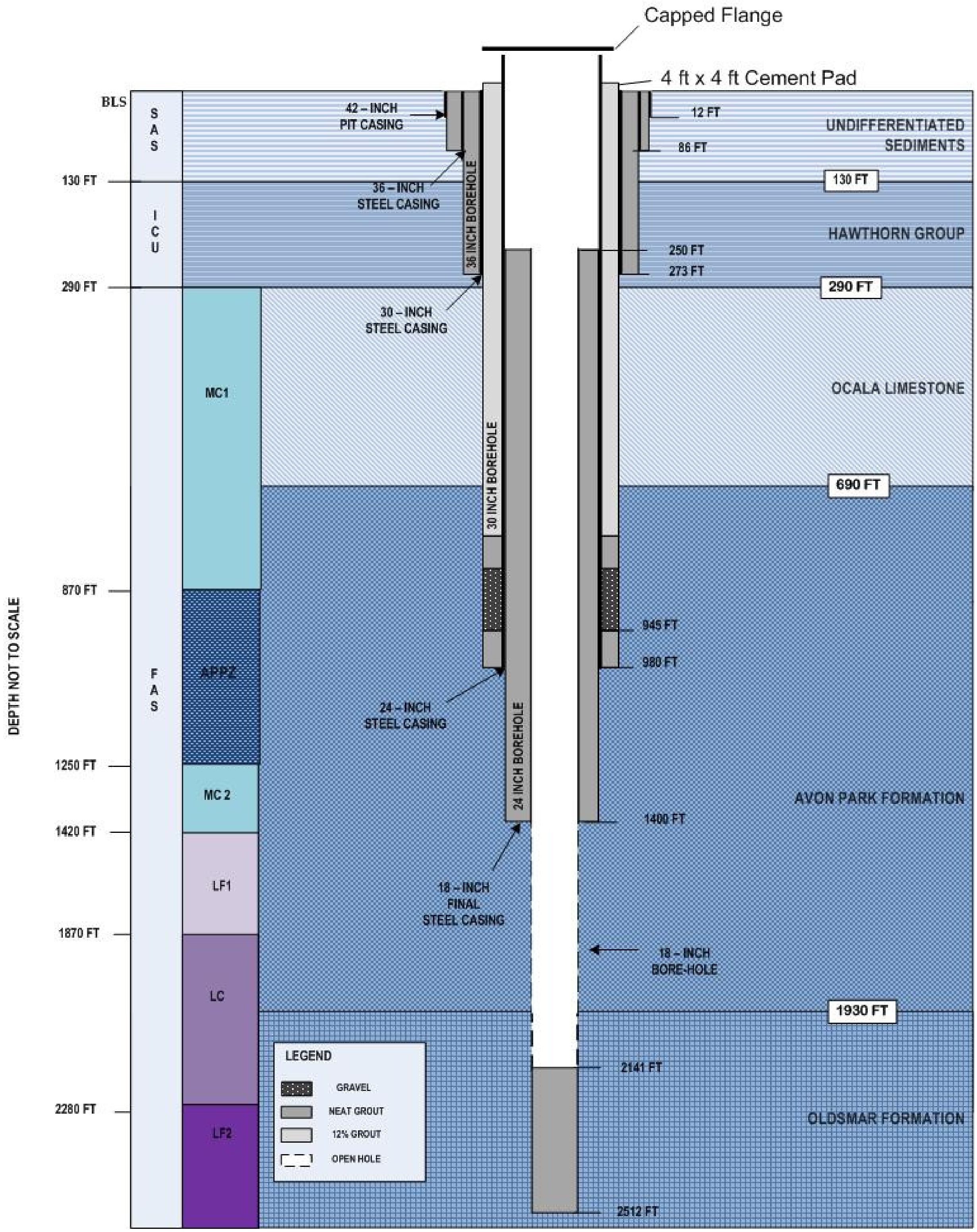
After clearing and reaming, the borehole was logged under pumped and static flow conditions on July 28, 2009 to evaluate the hydrogeologic and physical characteristics of the open borehole section of the completed well between 1,400 and 2,141 ft bls, which intercepted the uppermost permeable zone of the LFA. Discussion of these geophysical logs (**Run No. 7**) is presented in **Section 3.6: Geophysical Logging**. The as-built diagram of the completed SE-DEW and estimated depths of the geologic and hydrogeologic units that were encountered during the drilling of the well are depicted in **Figure 2-1**.

2.14. Well Development

Development of the open borehole interval of SE-DEW to remove drill cuttings was conducted on July 24, 2009 by pumping the well utilizing a 75 h.p. 8-inch vertical turbine pump that tested at a maximum pumping rate of approximately 2,100 gpm after installation. Following a 15 to 30 minute period of pumping, the pump was stopped and the water level in the well was allowed to recover for 5 to 10 minutes after which the pump was operated again at a rate of 2,100 gpm. The production well was intermittently pumped and allowed to recover for a period of approximately eight hours at which point the discharge water was visibly clear and free of solids and the turbidity measurements utilizing a calibrated LaMotte 2020 turbidity meter were approximately 1 Nephelometric Turbidity Unit.

Figure 2-1 As-built Drawing of SE-DEW

Including Geologic and Hydrogeologic Units



3.0 Hydrogeologic Testing

Hydrogeologic testing during the construction of the SE-DEW included the following activities, which are further detailed in the sections below.

- Collection of lithologic samples at 10-ft intervals from land surface to 2,521 ft bls during pilot hole drilling;
- Measuring water levels in the pilot hole during shift changes to provide static water levels at depths during reverse-air drilling from 1,033 to 2,521 ft bls;
- Performance of air-lift specific capacity tests and collection of air-lift water samples for laboratory analysis at 30-ft intervals during reverse-air drilling of the pilot hole from 1,033 to 2,417 ft bls;
- Collection of rock cores between 997 and 2,420 ft bls during reverse-air drilling of the pilot hole for analyses of vertical and horizontal permeability, porosity, and specific gravity.
- Geophysical logging and video surveying during drilling and construction operations to 2,410 ft bls;
- Conducting packer tests in the pilot hole between 270 and 2,521 ft bls;
- Performance of a variable rate step-drawdown test and a 14-day aquifer performance test, which included laboratory analysis of a discharge sample to establish baseline water quality, following installation of the final casing to 1,400 ft bls and back-plugging of the borehole to 2,140 ft bls

3.1. Lithology Sampling

Lithologic samples were collected at 10 ft depth intervals from land surface to 2,521 ft bls and examined on-site by a PBS&J geologist during pilot-hole drilling at the SE-DEW. The formation samples were used to prepare a lithologic log for the well, which is presented in **Appendix C**. The formation samples were collected by the Contractor from the discharge line during mud-rotary and reverse-air drilling, bagged and labeled and submitted to the Engineer.

Formation samples were described on the basis of composition, color, texture, visible porosity, fossil content, and structure. In general, the lithology consisted of unconsolidated quartz sands of the surficial aquifer system (SAS) to 85 ft bls, clay and limestone of the intermediate confining unit (ICU) from 85 to 250 ft bls, and limestone, dolomitic limestone, and dolostone of the Floridan aquifer system (FAS) from 250 to 2,521 ft bls including traces of quartz and gypsum between 1,860 and 1,990 ft bls.

3.2. Daily Water Level Measurements

Depth to water was measured in the pilot hole with a water level meter from a fixed measuring point, which was referenced to land surface, at shift changes during reverse-air drilling operations to identify changes in the formation water levels as the borehole was advanced. A change in the formation water level generally indicates a change in formation permeability and / or change in the pilot hole fluid density as a result of a change in water quality. **Table 3-1** presents daily static water level depths and elevations measured during reverse-air drilling of the pilot hole from approximately 1,033 to 2,521 ft bls. **Figure 3-1** presents a plot of the static water level elevations versus depth.

Table 3-1 Daily Static Water Level Measurements

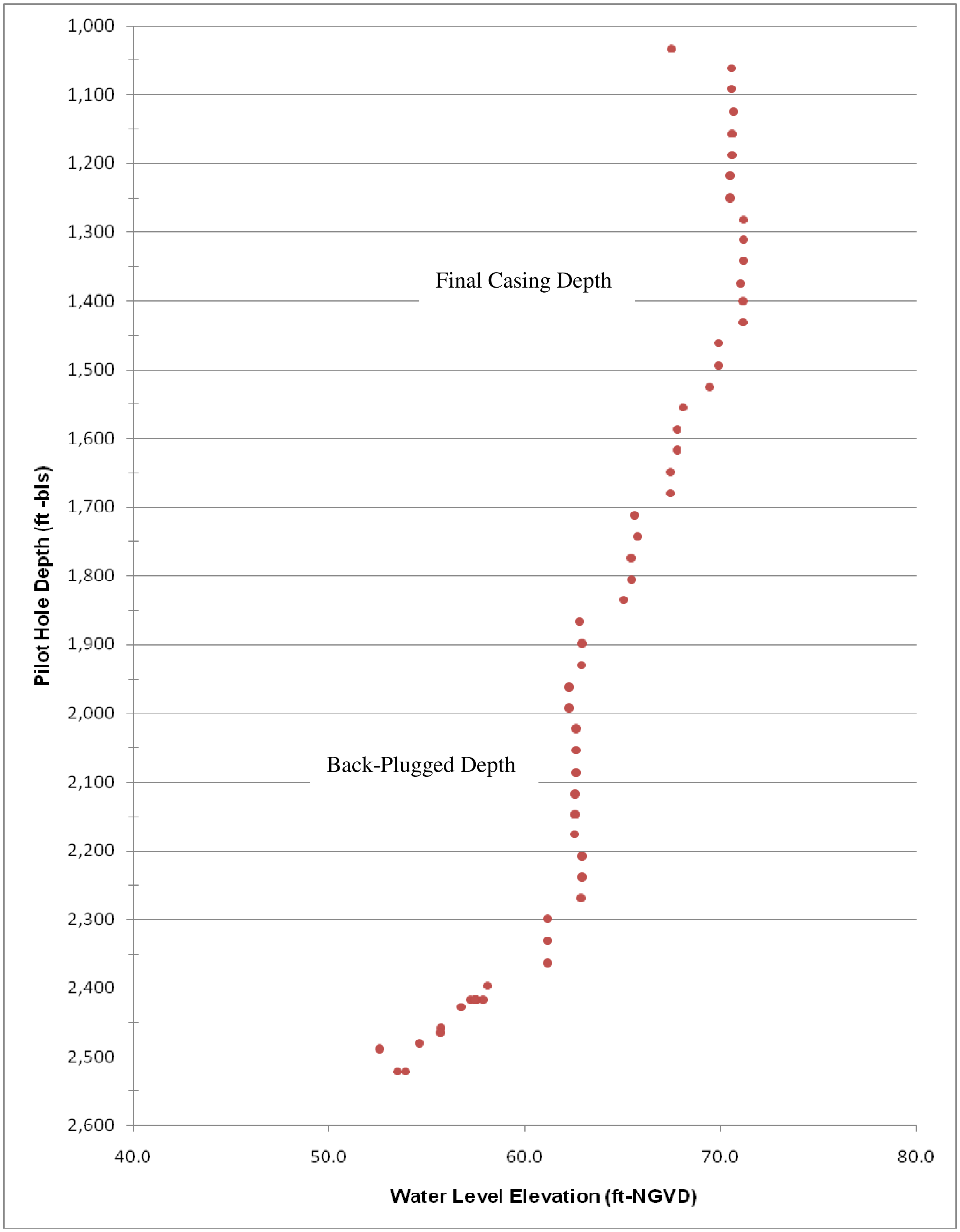
Date (D/M/Y)	Time (Hr:Min)	Drilled Borehole Depth (ft bls)	Static Water Level Depth (ft bmp)	Static Water Level (ft reference to LS)		Static Water Level Elevation (ft-NGVD)
1/27/2009	22:27	1,033	4.54	2.54	bls	67.5
1/28/2009	9:23	1,062	1.43	0.57	als	70.6
1/28/2009	14:30	1,092	1.45	0.55	als	70.6
1/28/2009	22:01	1,124	1.33	0.67	als	70.7
1/29/2009	21:52	1,157	1.41	0.59	als	70.6
1/29/2009	3:25	1,188	1.41	0.59	als	70.6
1/30/2009	18:18	1,218	1.52	0.48	als	70.5
1/30/2009	22:04	1,250	1.51	0.49	als	70.5
2/3/2009	2:20	1,282	0.84	1.16	als	71.2
2/3/2009	4:15	1,311	0.84	1.16	als	71.2
2/3/2009	6:02	1,342	0.84	1.16	als	71.2
2/3/2009	10:32	1,374	1.00	1.00	als	71.0
2/4/2009	3:10	1,400	0.86	1.14	als	71.1
2/4/2009	23:10	1,431	0.86	1.14	als	71.1
2/5/2009	4:10	1,461	2.10	0.10	bls	69.9
2/5/2009	16:00	1,494	2.10	0.10	bls	69.9
2/5/2009	19:12	1,525	2.55	0.55	bls	69.5
2/6/2009	6:25	1,555	3.91	1.91	bls	68.1
2/9/2009	10:15	1,587	4.25	2.25	bls	67.8
2/9/2009	15:25	1,617	4.25	2.25	bls	67.8
2/9/2009	20:28	1,649	4.57	2.57	bls	67.4
2/10/2009	4:05	1,680	4.57	2.57	bls	67.4
2/12/2009	20:03	1,712	6.40	4.40	bls	65.6
2/17/2009	14:00	1,743	6.25	4.25	bls	65.8
2/17/2009	21:54	1,774	6.56	4.56	bls	65.4
2/18/2009	1:43	1,806	6.55	4.55	bls	65.5
2/18/2009	6:25	1,835	6.93	4.93	bls	65.1
2/19/2009	3:05	1,866	9.22	7.22	bls	62.8

Date	Time	Drilled Borehole Depth	Static Water Level Depth	Static Water Level		Static Water Level Elevation
2/20/2009	0:57	1,898	9.10	7.10	bls	62.9
2/20/2009	10:22	1,930	9.12	7.12	bls	62.9
2/23/2009	15:00	1,962	9.76	7.76	bls	62.2
2/24/2009	0:52	1,992	9.76	7.76	bls	62.2
2/24/2009	8:45	2,022	9.40	7.40	bls	62.6
2/25/2009	6:38	2,054	9.40	7.40	bls	62.6
2/25/2009	13:45	2,086	9.40	7.40	bls	62.6
2/25/2009	21:17	2,117	9.46	7.46	bls	62.5
2/26/2009	4:05	2,147	9.46	7.46	bls	62.5
2/26/2009	10:05	2,176	9.47	7.47	bls	62.5
2/26/2009	15:35	2,208	9.10	7.10	bls	62.9
2/28/2009	5:47	2,238	9.10	7.10	bls	62.9
2/28/2009	11:35	2,269	9.15	7.15	bls	62.9
3/2/2009	19:36	2,299	10.84	8.84	bls	61.2
3/3/2009	13:30	2,331	10.83	8.83	bls	61.2
3/4/2009	3:10	2,363	10.83	8.83	bls	61.2
3/4/2009	14:48	2,396	13.92	11.92	bls	58.1
3/5/2009	2:35	2,417	14.15	12.15	bls	57.9
3/5/2009	10:42	2,417	14.50	12.50	bls	57.5
3/5/2009	13:22	2,417	14.51	12.51	bls	57.5
3/6/2009	8:00	2,417	14.50	12.50	bls	57.5
3/10/09	15:07	2,417	14.52	12.52	bls	57.5
3/11/2009	7:00	2,417	14.50	12.50	bls	57.5
3/12/2009	8:05	2,417	14.76	12.76	bls	57.2
3/13/2009	8:12	2,417	14.58	12.58	bls	57.4
3/13/2009	15:16	2,417	14.51	12.51	bls	57.5
3/16/2009	9:00	2,417	14.56	12.56	bls	57.4
3/17/2008	8:00	2,417	14.56	12.56	bls	57.4
3/18/2009	7:14	2,417	14.58	12.58	bls	57.4
3/18/2009	14:32	2,428	15.25	13.25	bls	56.8
3/18/2009	18:12	2,458	16.27	14.27	bls	55.7
3/18/2009	20:04	2,464	16.30	14.30	bls	55.7
3/19/2009	8:55	2,480	17.38	15.38	bls	54.6
3/19/2009	14:32	2,488	19.40	17.40	bls	52.6
3/19/2009	18:30	2,521	18.51	16.51	bls	53.5
3/20/2009	9:00	2,521	18.11	16.11	bls	53.9

Notes:

1. ft-bmp = feet below measuring point; ft-bls = feet below land surface; als = above land surface
2. ft-NGVD = feet above/below the National Geodetic Vertical Datum of 1929. The elevation is based on an estimated land surface elevation of 70 ft-NGVD from USGS topographic contours.

Figure 3-1. Water Level Elevations vs. Depth



Changes in water level elevations as depicted in **Figure 3-1** indicate that flow in the borehole is downward and changes in formation permeability, and /or changes in water quality occur at approximately 1,250 ft bls, 1,430 ft bls, 1,550 ft bls, 1,700 ft bls, 1,860 ft bls, 2,290 ft bls and 2,390 ft bls.

3.3. Air-Lift Specific Capacity Tests

Short-term air-lift specific capacity tests were conducted at every drill rod change (approximately every 30 feet) during reverse-air drilling of the nominal 12-inch diameter pilot hole between the depths of 1,033 and 2,417 ft bls. Specific capacity testing was discontinued after encountering high chloride concentrations in the air-lift sample at 2,417 ft bls and drilling operations went to closed circulation to prevent discharge of high-chloride water to the surface water system. The capacity of the drilled pilot hole to produce water at a specific depth was calculated by measuring the discharge rate during reverse-air drilling and the resulting drop in water level from the static water level measured before the start of drilling. The specific capacity values, which are reported in gallons per minute per foot of drawdown (gpm/ft), can subsequently be utilized to estimate relative permeability of the formation materials encountered during drilling. The water level, drawdown, and pumping rate measurements and calculated specific capacity values from each air-lift specific capacity test are summarized in **Table 3-2.**

Table 3-2. Air-Lift Specific Capacity Test Data and Results

Date mm/dd/yyyy	Time hr:min	Depth (ft bls)	Static Water Level (ft)		Pumping Water Level (ft)		Drawdown (ft)	Rate (gpm)	Specific Capacity (gpm/ft)
1/27/2009	22:27	1,033	4.54	bmp	14.20	bmp	9.66	142.8	14.8
1/28/2009	9:23	1,062	1.43	bmp	5.08	bmp	3.65	135.7	37.2
1/28/2009	14:30	1,092	1.45	bmp	4.97	bmp	3.52	166.7	47.4
1/28/2009	22:01	1,124	1.33	bmp	4.90	bmp	3.57	133.9	37.5
1/29/2009	21:52	1,157	1.41	bmp	4.60	bmp	3.19	137.8	43.2
1/29/2009	3:25	1,188	1.41	bmp	4.38	bmp	2.97	137.2	46.2
1/30/2009	18:18	1,218	1.52	bmp	4.45	bmp	2.93	153.8	52.5
1/30/2009	22:04	1,250	1.51	bmp	4.35	bmp	2.84	99.9	35.2
2/3/2009	2:20	1,282	0.84	bmp	3.38	bmp	2.54	132.9	52.3
2/3/2009	4:15	1,311	0.84	bmp	3.44	bmp	2.60	142.5	54.8
2/3/2009	6:02	1,342	0.84	bmp	3.65	bmp	2.81	150.1	53.4
2/3/2009	10:32	1,374	1.00	bmp	3.81	bmp	2.81	169.5	60.3
2/4/2009	3:10	1,400	0.86	bmp	3.52	bmp	2.66	147.8	55.6
2/4/2009	23:10	1,431	0.86	bmp	3.50	bmp	2.64	133.2	50.5
2/5/2009	4:10	1,461	2.10	bmp	4.29	bmp	2.19	130.4	59.6
2/5/2009	16:00	1,494	2.10	bmp	4.35	bmp	2.25	158.7	70.5
2/5/2009	19:12	1,525	2.55	bmp	4.90	bmp	2.35	163.9	69.7
2/6/2009	6:25	1,555	3.91	bmp	6.20	bmp	2.29	131.4	57.4

Date mm/dd/yyyy	Time hr:min	Depth (ft bls)	Static Water Level (ft)		Pumping Water Level (ft)		Drawdown (ft)	Rate (gpm)	Specific Capacity (gpm/ft)
2/9/2009	10:15	1,587	4.25	bmp	6.50	bmp	2.25	178.4	79.3
2/9/2009	15:25	1,617	4.25	bmp	6.65	bmp	2.40	146.4	61.0
2/9/2009	20:28	1,649	4.57	bmp	6.79	bmp	2.22	126.1	56.8
2/10/2009	4:05	1,680	4.57	bmp	7.80	bmp	3.23	129.9	40.2
2/12/2009	20:03	1,712	6.40	bmp	8.11	bmp	1.71	112.2	65.6
2/17/2009	14:00	1,743	6.25	bmp	6.32	bmp	0.07	118.3	1690.6
2/17/2009	21:54	1,774	6.56	bmp	8.48	bmp	1.92	116.7	60.8
2/18/2009	1:43	1,806	6.55	bmp	8.40	bmp	1.85	126.1	68.1
2/18/2009	6:25	1,835	6.93	bmp	8.84	bmp	1.91	130.0	68.1
2/19/2009	3:05	1,866	9.22	bmp	10.30	bmp	1.08	120.0	111.1
2/20/2009	0:57	1,898	9.10	bmp	9.70	bmp	0.60	125.9	209.9
2/20/2009	10:22	1,930	9.12	bmp	10.75	bmp	1.63	132.3	81.2
2/23/2009	15:00	1,962	9.76	bmp	11.02	bmp	1.26	114.2	90.6
2/24/2009	0:52	1,992	9.76	bmp	11.17	bmp	1.41	119.0	84.4
2/24/2009	8:45	2,022	9.40	bmp	11.00	bmp	1.60	120.2	75.2
2/25/2009	6:38	2,054	9.40	bmp	10.80	bmp	1.40	124.5	88.9
2/25/2009	13:45	2,086	9.40	bmp	10.74	bmp	1.34	138.2	103.1
2/25/2009	21:17	2,117	9.46	bmp	10.80	bmp	1.34	121.4	90.6
2/26/2009	4:05	2,147	9.46	bmp	10.89	bmp	1.43	120.0	83.9
2/26/2009	10:05	2,176	9.47	bmp	10.93	bmp	1.46	119.5	81.8
2/26/2009	15:35	2,208	9.10	bmp	10.84	bmp	1.74	127.7	73.4
2/28/2009	5:47	2,238	9.10	bmp	10.60	bmp	1.50	122.6	81.7
2/28/2009	11:35	2,269	9.15	bmp	10.72	bmp	1.57	120.7	76.9
3/2/2009	19:36	2,299	10.84	bmp	12.01	bmp	1.17	119.4	102.1
3/3/2009	13:30	2,331	10.83	bmp	12.25	bmp	1.42	120.5	84.9
3/4/2009	3:10	2,363	10.83	bmp	13.17	bmp	2.34	124.8	53.3
3/4/2009	15:05	2,394	13.92	bmp	14.44	bmp	0.52	129.0	248.1
3/5/2009	2:30	2,417	14.15	bmp	14.40	bmp	0.25	116.3	465.0

NOTE: ft bls: Feet Below Land Surface;
als: Above Land Surface

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Changes in the air-lift specific capacity values as identified in **Table 3-2** indicate the permeabilities of the formation materials at 1,712 to 1,743 ft bls, at 1,835 to 1,898 ft bls, and 2,369 to 2,417 ft bls are significantly higher than the permeabilities of the formation material in the remainder of the pilot hole.

3.4. Air-Lift Water Quality Sampling

Groundwater samples were collected at approximately every drill rod length at the end of the air-lift specific capacity test during reverse-air drilling of the nominal 12-inch pilot hole between 1,033 and 2,522 ft bls. The water quality samples were analyzed in the field for specific conductance and temperature using a calibrated Hach sensION5 conductivity meter, and chloride concentration for samples collected below 1,587 ft bls using a Hach test kit. Duplicate air-lift water samples were collected below 1,150 ft bls and submitted to a laboratory for analysis of calcium, chloride, hardness, specific conductance, sulfate, pH and total dissolved solids. The field water quality measurements are summarized in **Table 3-3**. The analytical water quality results are summarized in **Table 3-4** and plotted with respect to increasing depth in **Figures 3-2** through **3-8**. The laboratory analytical water quality reports are provided in **Appendix E**.

Table 3-3. Air-Lift Field Water Quality Measurements

Date	Time	Depth (ft bls)	Conductivity (µS/cm)	Temperature (°C)	Chloride (mg/L)
11/18/2008	10:00	657	207.0	22.8	--
11/19/2008	0:45	657	212.0	21.0	--
1/27/2009	22:26	1,033	193.2	27.0	--
1/28/2009	7:52	1,062	194.0	24.6	--
1/28/2009	14:29	1,092	213.0	24.3	--
1/28/2009	22:00	1,124	191.2	25.5	--
1/29/2009	21:52	1,157	195.6	24.7	--
1/29/2009	3:20	1,188	193.6	25.3	--
1/30/2009	22:08	1,250	192.4	22.4	--
2/3/2009	2:17	1,282	191.1	24.6	--
2/3/2009	4:17	1,311	191.4	24.8	--
2/3/2009	6:06	1,342	189.1	24.7	--
2/3/2009	10:32	1,374	188.4	23.2	--
2/4/2009	3:03	1,400	189.0	20.1	--
2/4/2009	23:00	1,431	189.4	16.5	--
2/5/2009	4:06	1,461	190.9	19.4	--
2/5/2009	16:00	1,494	195.3	22.7	--
2/5/2009	19:12	1,525	209.0	19.7	--
2/6/2009	6:30	1,555	192.3	21.8	--
2/9/2009	10:15	1,587	225.0	24.1	30
2/9/2009	15:25	1,617	192.1	20.7	30
2/9/2009	20:28	1,649	189.2	19.0	20
2/10/2009	4:05	1,680	190.9	22.5	35
2/12/2009	20:03	1,712	192.8	24.6	25
2/17/2009	14:00	1,743	203.0	24.7	30

Date	Time	Depth (ft bls)	Conductivity (µS/cm)	Temperature (°C)	Chloride (mg/L)
2/17/2009	21:54	1,774	208.3	19.3	25
2/18/2009	1:43	1,806	197.6	21.1	25
2/18/2009	6:25	1,835	193.1	20.9	20
2/19/2009	3:05	1,866	196.2	22.4	25
2/20/2009	0:57	1,898	195.8	23.3	25
2/20/2009	10:22	1,930	241.0	24.5	25
2/23/2009	15:00	1,962	197.9	22.3	25
2/24/2009	0:52	1,992	206.0	21.1	30
2/24/2009	8:45	2,022	204.0	21.7	30
2/25/2009	6:38	2,054	197.7	24.1	25
2/25/2009	13:45	2,086	207.0	24.8	30
2/25/2009	21:17	2,117	200.0	21.3	30
2/26/2009	4:05	2,147	203.0	23.7	30
2/26/2009	10:05	2,176	205.0	23.8	25
2/26/2009	15:35	2,208	201.0	24.6	30
2/28/2009	5:47	2,238	198.2	24.1	25
2/28/2009	11:35	2,269	203.0	25.0	35
3/2/2009	19:36	2,299	196.9	21.2	20
3/3/2009	13:30	2,331	201.0	25.1	20
3/4/2009	3:10	2,363	196.3	21.6	20
3/4/2009	15:05	2,394	205.0	23.7	20
3/5/2009	2:30	2,417	8,250	21.7	>400

Table 3-4. Laboratory Analytical Results for Air-Lift Water Quality Sampling

Date	Time (HH:MM)	Depth (ft-bls)	Chloride (mg/L)	Sp. Cond. (µmhos/cm)	Total Hardness (mg/L)	TDS (mg/L)	SO_4 (mg/L)	Ca (mg/L)	pH S.U.
1/27/2009	22:26	1,033	NA	NA	NA	NA	NA	NA	NR
1/28/2009	7:52	1,062	NA	NA	NA	NA	NA	NA	NR
1/28/2009	14:29	1,092	NA	NA	NA	NA	NA	NA	NR
1/28/2009	22:00	1,124	NA	NA	NA	NA	NA	NA	NR
1/29/2009	21:52	1,157	6.8	189.9	100	130	4.5	23	NR
1/29/2009	3:20	1,188	6.7	187.5	95	120	4.1	22	NR
1/30/2009	18:18	1,218	8.1	191.7	85	120	4.4	20	NR
1/30/2009	22:08	1,250	7.1	188.0	97	110	4.1	22	NR
2/3/2009	2:17	1,282	16.0	187.8	93	130	5.1	20	NR

Date	Time (HH:MM)	Depth (ft-bls)	Chloride (mg/L)	Sp. Cond. (µmhos/cm)	Total Hardness (mg/L)	TDS (mg/L)	SO_4 (mg/L)	Ca (mg/L)	pH S.U.
2/3/2009	4:17	1,311	13.0	190.9	180	130	4.6	39	NR
2/3/2009	6:06	1,342	8.2	188.1	110	110	4.0	26	NR
2/3/2009	10:32	1,374	7.9	190.7	110	130	4.5	23	NR
2/4/2009	3:03	1,400	7.6	189	140	110	4.3	30	NR
2/4/2009	23:00	1,431	7.9	190	90	78	4.0	19	NR
2/5/2009	4:06	1,461	8.0	190	120	74	4.1	25	NR
2/5/2009	16:00	1,494	8.0	190	170	66	4.2	36	NR
2/5/2009	19:12	1,525	8.1	210	180	74	4.3	38	NR
2/6/2009	6:30	1,555	8.1	190	100	86	4.2	22	NR
2/9/2009	10:15	1,587	8.9	220	190	106	7.5	44	NR
2/9/2009	15:25	1,617	8.6	190	110	78	4.4	24	NR
2/9/2009	20:28	1,649	8.0	190	80	74	4.1	18	NR
2/10/2009	4:05	1,680	8.0	190	92	82	4.0	21	NR
2/12/2009	20:03	1,712	7.8	190	78.0	40	5.5	17	7.6
2/17/2009	14:00	1,743	8.6	192	100	88	4.5	21	7.7
2/17/2009	21:54	1,774	7.8	190	75.0	82	4.6	17	7.8
2/18/2009	1:43	1,806	7.7	193	140	54	4.1	30	7.9
2/18/2009	6:25	1,835	7.6	191	130	100	4.0	28	7.8
2/19/2009	3:05	1,866	7.7	192	100	120	4.1	22	7.8
2/20/2009	0:57	1,898	7.8	192	110	110	4.5	25	7.7
2/20/2009	10:22	1,930	8.0	239	210	210	23.0	50	NR
2/23/2009	15:00	1,962	8.0	194	85	180	5.4	20	NR
2/24/2009	0:52	1,992	8.2	202	150	160	8.1	41	NR
2/24/2009	8:45	2,022	8.3	197	220	180	6.3	52	NR
2/25/2009	6:38	2,054	7.9	195	100	170	5.1	24	NR
2/25/2009	13:45	2,086	8.8	210	130	100	7.7	30	7.6
2/25/2009	21:17	2,117	8.3	200	150	92	7.1	37	7.7
2/26/2009	4:05	2,147	8.3	200	170	100	8.3	41	8.0
2/26/2009	10:05	2,176	8.5	200	140	104	8.7	36	7.4
2/26/2009	15:35	2,208	8.5	200	170	94	6.9	42	7.6
2/28/2009	5:47	2,238	8.3	200	140	84	5.7	31	8.0
2/28/2009	11:35	2,269	8.8	200	150	110	6.4	36	7.6
3/2/2009	19:36	2,299	8.4	190	140	94	5.4	39	7.8
3/3/2009	13:30	2,331	8.5	200	240	98	6.2	59	7.8
3/4/2009	3:10	2,363	8.1	196	130	104	4.9	29	7.7
3/4/2009	14:48	2,396	8.5	200	130	108	5.1	29	7.8

Date	Time (HH:MM)	Depth (ft-bls)	Chloride (mg/L)	Sp. Cond. (µmhos/cm)	Total Hardness (mg/L)	TDS (mg/L)	SO_4 (mg/L)	Ca (mg/L)	pH S.U.
3/5/2009	2:35	2,417	2,800	8,150	930	4,400	380	130	8.0
3/18/2009	13:10	2,428	130	600	15	320	28.0	2.9	7.6
3/18/2009	20:04	2,458	1,300	4,000	50	2,100	210	7.6	7.6

NOTE: mg/L = milligrams per Liter; µS/cm = micro Siemens per centimeter; NA = Not Available; NR = Not Reported

Figure 3-2. Calcium Concentration (mg/L) vs. Depth

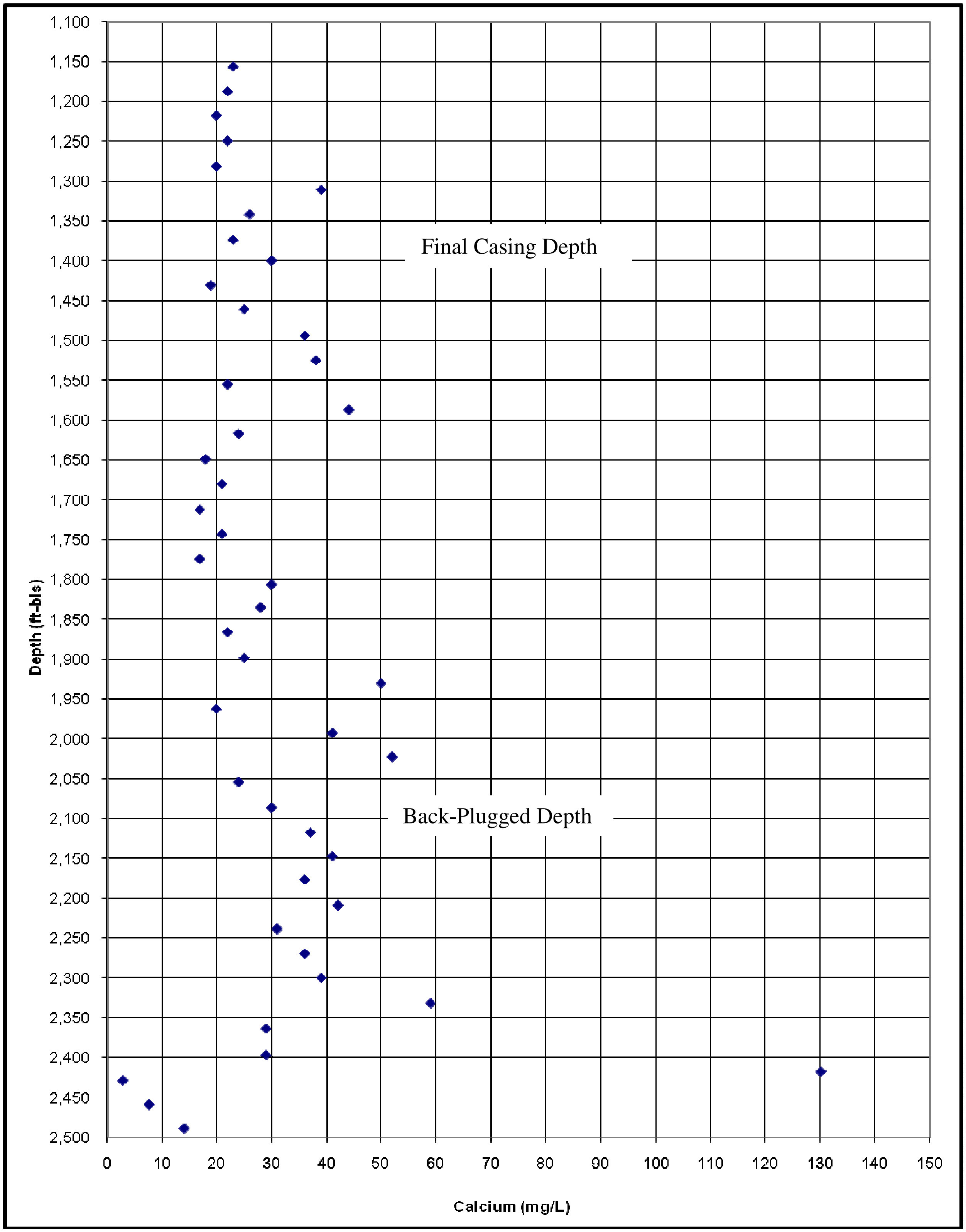


Figure 3-3. Hardness Concentration (mg/L) vs. Depth

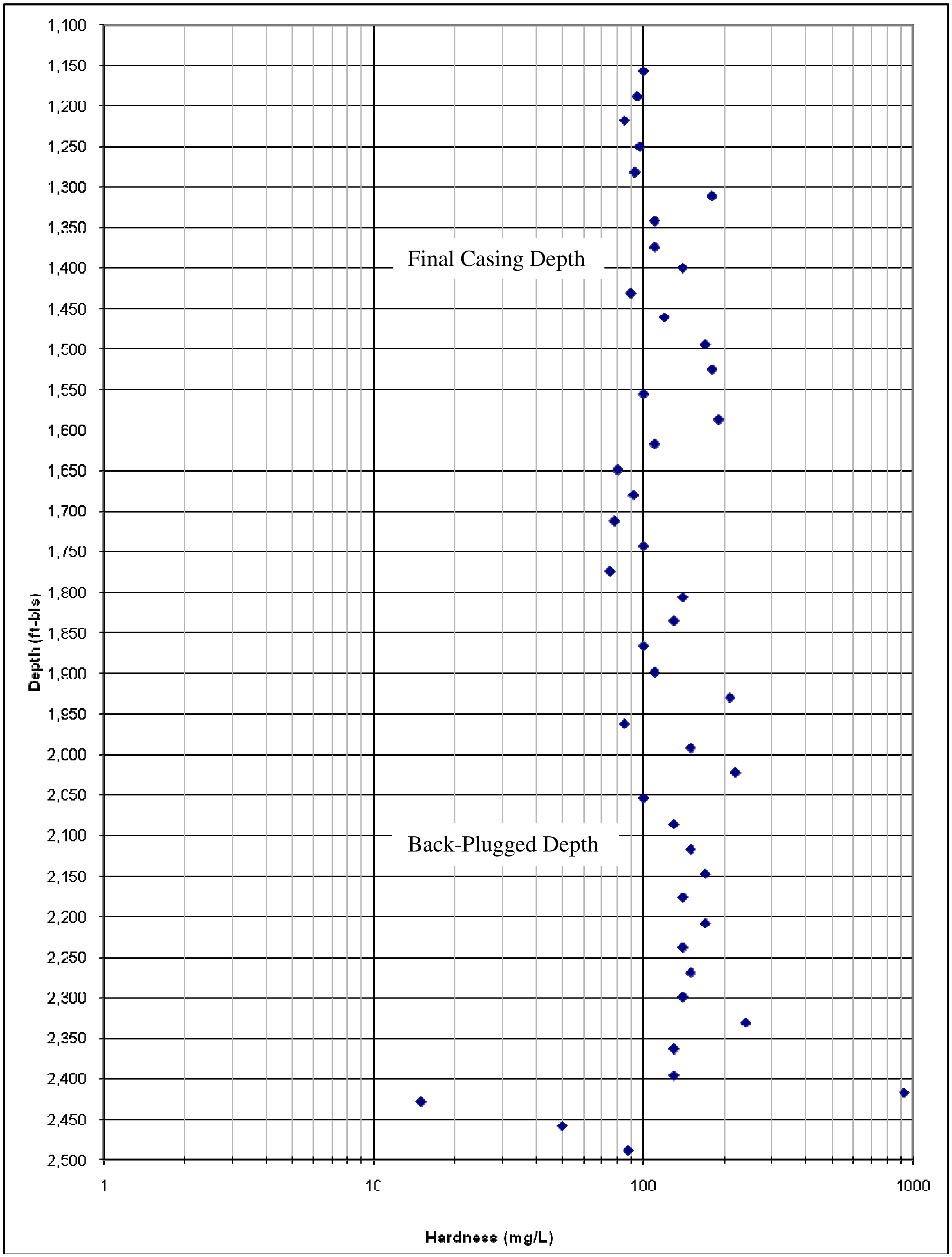


Figure 3-4. Total Dissolved Solids Concentration (mg/L) vs. Depth

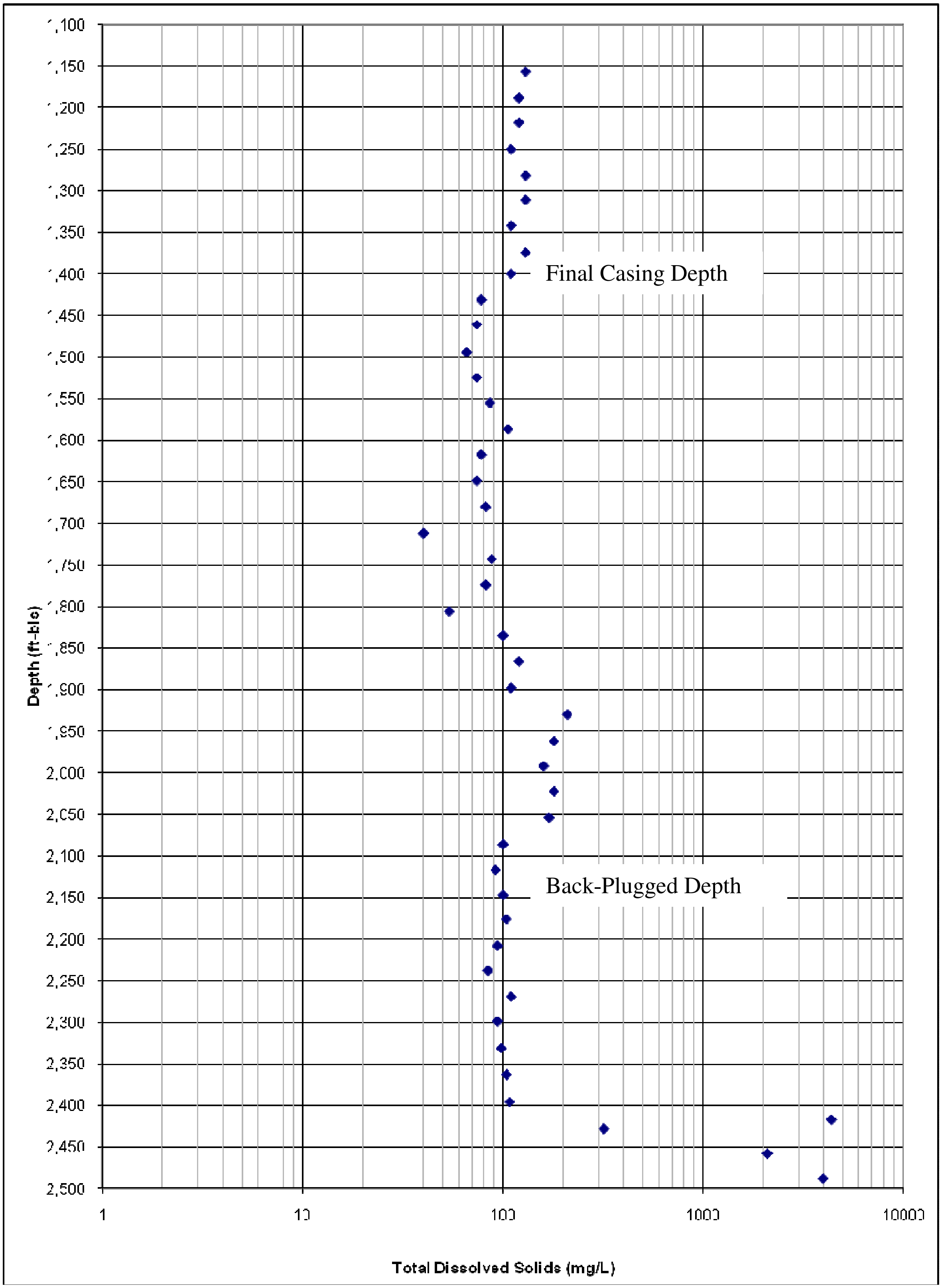


Figure 3-5. Chloride Concentration (mg/L) vs. Depth

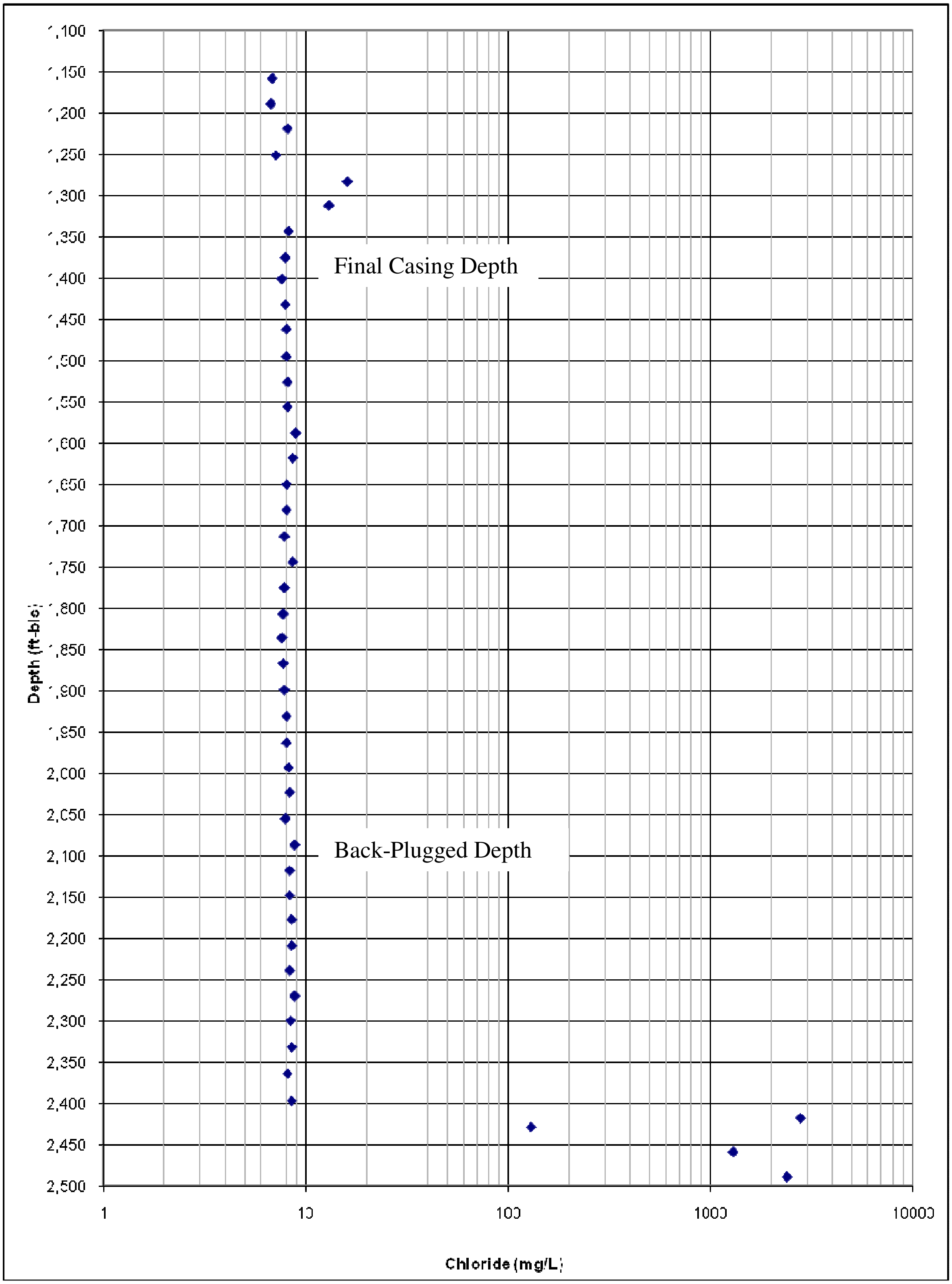


Figure 3-6.Sulfate (mg/L) vs. Depth

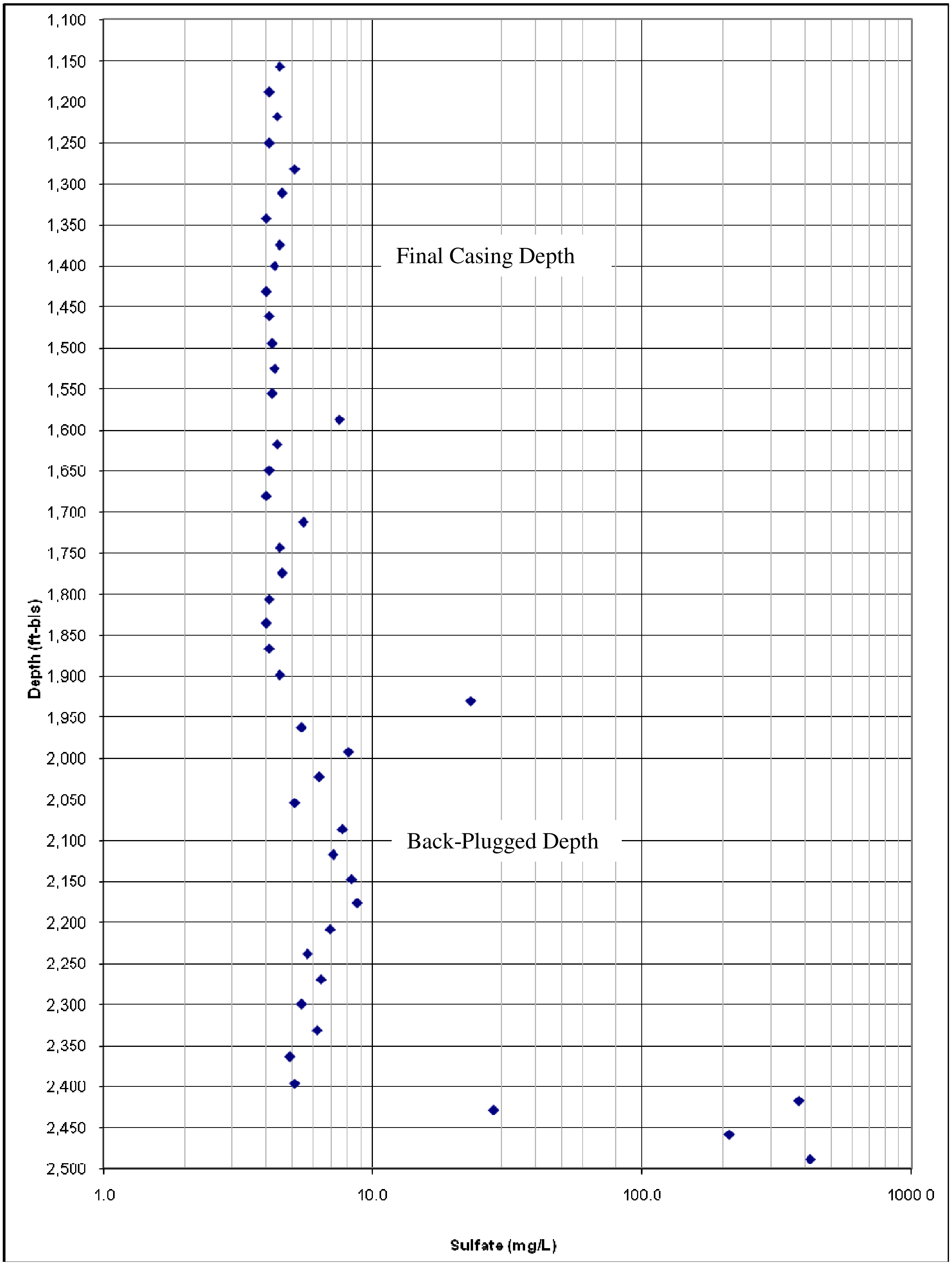


Figure 3-7. Field Specific Conductance (µmhos/cm) vs. Depth

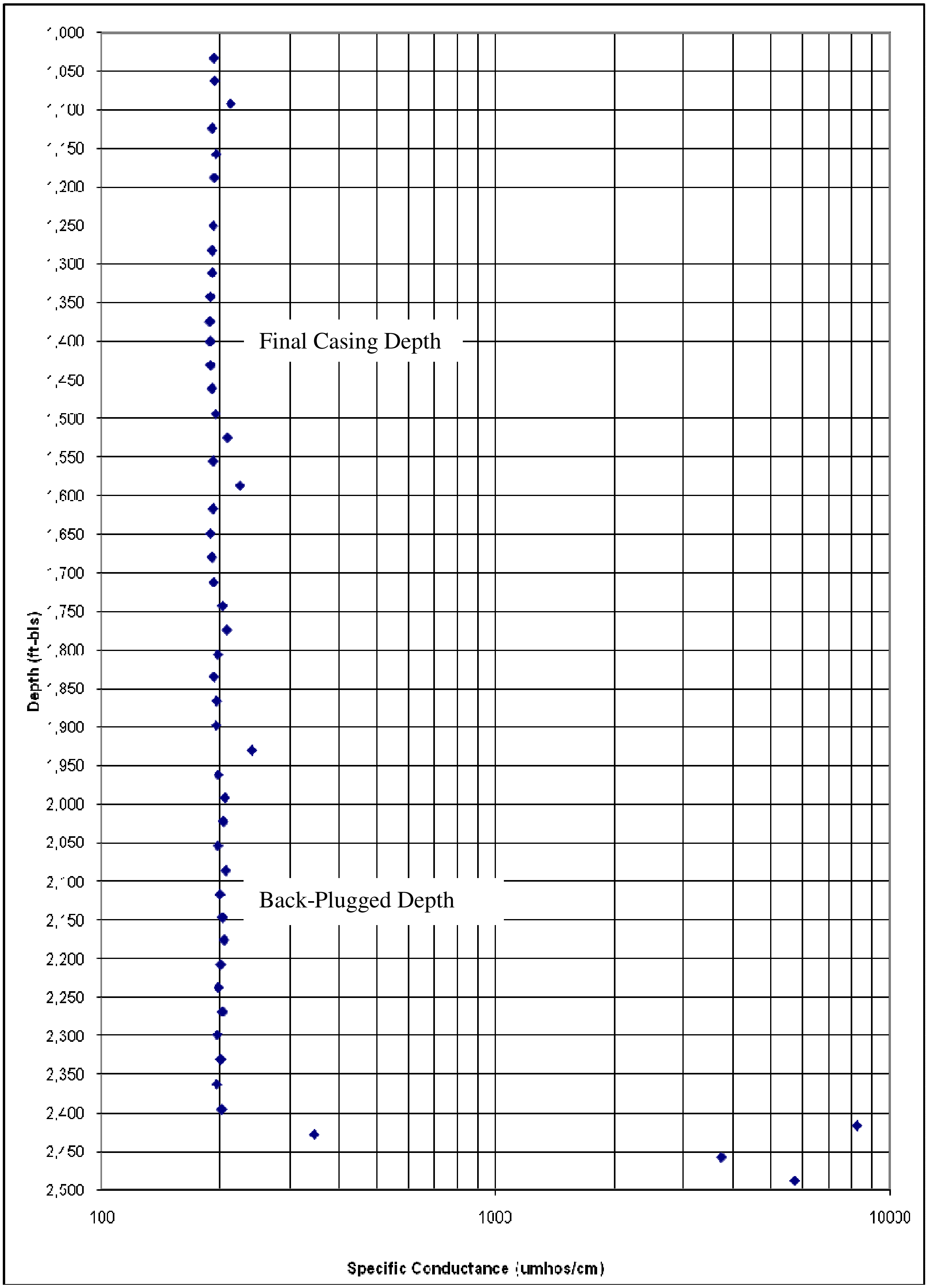
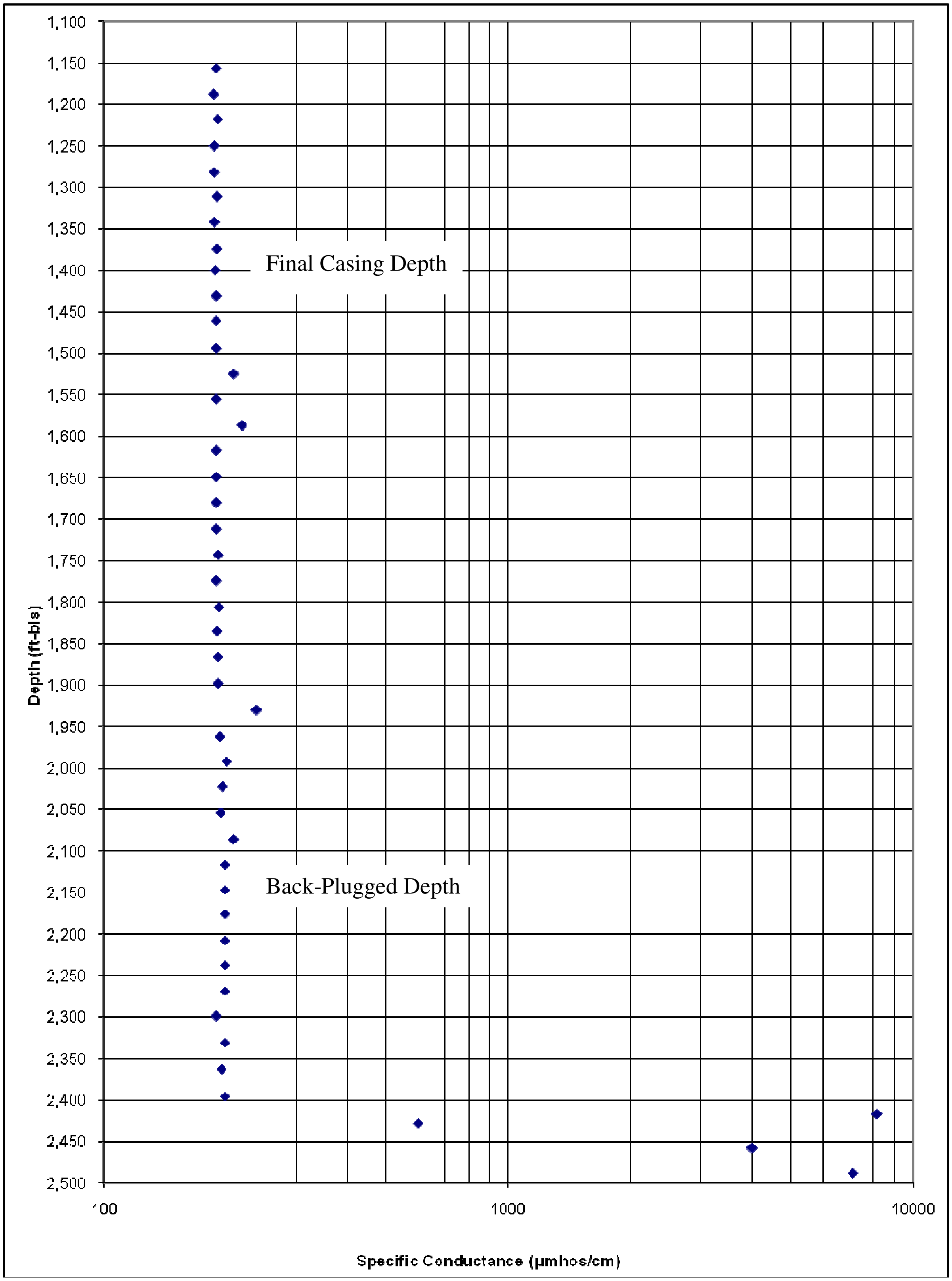


Figure 3-8. Laboratory Specific Conductance (µmhos/cm) vs. Depth



Figures 3-2 through 3-8 in general show relatively constant water quality concentrations from 1,157 ft bls to approximately 2,400 ft bls. Below approximately 2,400 ft bls, chloride, sulfate and TDS concentrations increase by one to two orders of magnitude, and calcium and hardness concentrations decrease substantially. Intervals of relatively higher concentrations of calcium, hardness, sulfate and particularly TDS at approximately 1,300 to 1,400 ft bls, 1,500 to 16,00 ft bls and 1,900 to 2,050/ 2,200 indicate relatively lower formation permeability at these intervals. Low formation permeability relative to higher formation permeability can result in longer residence times as water moves through the aquifer allowing more opportunity for the chemical composition of the water to be altered and for chemical reactions between the water and aquifer material to reach equilibrium.

3.5. Rock Core Sampling and Analysis

A total of ten rock cores were collected while advancing the SE DEW pilot-hole from 997 to 2,420 ft bls. In general, targeted coring depths were determined from the regional geologic information and lithology encountered during pilot-hole drilling. **Table 3-5** identifies the dates and depth intervals of the ten rock cores. Rock coring attempts while drilling the pilot hole between 400 and 500 ft bls and 1,250 and 1,350 ft bls, which would have provided cores from the UFA and MCU2 were unsuccessful. Based on the hydrogeologic unit depths at the SE-DEW site identified in **Figure 2-1 of Section 2.0**, rock cores 1 and 2 are from the APPZ, rock cores 3, 4, 5, and 6 are from the uppermost permeable zone within the LFA, rock cores 7, 8, and 9 are from a confining unit within the LFA and core 10 is from a deeper permeable zone within the LFA.

Table 3-5. Rock Core Summary

Core No.-Segment Date Cored	Percent Recovery	Interval Cored		Lithology Description	Core Depth (ft)	Total Porosity	Vertical K ft/day	Horizon K ft/day	Sg
		Begin	End						
1-A 1-12-09	70%	997	1007	Brown Dolomitic Limestone	1,003	0.064	1.05E-04	1.22E-05	2.84
1-B 1-12-09	70%	997	1007	Brown Dolomitic Porous Limestone	1,005	0.156	5.10E-01	1.11E-01	2.83
2-A 1-29-09	56%	1121	1131	Brown Dolomitic Limestone	1,126	0.185	4.54E-02	2.58E-03	2.83
2-B 1-29-09	56%	1121	1131	Brown Dolomitic Limestone	1,123	0.270	5.67E-01	8.79E-01	2.83
3-A 2-4-09	55%	1420	1430	Light Brown Dolomitic Limestone	1,428	0.316	1.53E-01	1.11	2.83

Core No.- Segment Date Cored	Percent Recovery	Interval Cored		Lithology Description	Core Depth (ft)	Total Porosity	Vertical K ft/day	Horizon K ft/day	Sg
		Begin	End						
4-A 2-6-09	100%	1555	1565	Brown Dolomitic Limestone	1,558	0.109	3.12E-04	5.39E-06	2.84
4-C 2-6-09	100%	1555	1565	Brown Dolomitic Limestone	1,562	0.22	1.02	1.05	2.82
5-A 2-10-09	74%	1680	1690	Light Brown Limestone	1,684	0.203	1.39E-02	8.79E-02	2.76
5-B 2-10-09	74%	1680	1690	Light Brown Dolomitic Limestone	1,687	0.15	2.32E-04	1.64E-03	2.81
6-A 2-18-09	74%	1835	1845	Brown Dolomitic Limestone	1,843	0.064	1.50E-06	5.10E-06	2.82
6-B 2-18-09	74%	1835	1845	Brown Dolomitic Limestone with vugs	1,841	0.13	8.79E-05	5.10E-02	2.83
7-A 2-19-09	62%	1889	1899	Brown Dolomitic Limestone	1,892	0.298	1.76E-02	3.12E-02	2.80
7-B 2-19-09	62%	1889	1899	Brown Dolomitic Limestone	1,897	0.11	2.75E-05	1.87E-05	2.82
8-A 2-24-09	88%	2037	2042	Brown Limestone	2,038	0.012	1.93E-05	1.30E-05	2.71
9-A 2 -27-09	100%	2208	2218	Brown Dolomitic Limestone	2,211	0.03	2.83E-07	2.10E-06	2.80
9-B 2-27-09	100%	2208	2218	Brown Dolomitic Limestone	2,215	0.070	2.24E-05	8.79E-07	2.82
9-C 2-27-09	100%	2208	2218	Brown Dolomitic Limestone	2,216	0.08	6.24E-03	7.65E-06	2.83
10-A 3-13-09	66%	2410	2420	Light Brown Dolomitic Limestone	2,413	0.102	6.80E-05	4.82E-04	2.85

Core No.- Segment Date Cored	Percent Recovery	Interval Cored		Lithology Description	Core Depth (ft)	Total Porosity	Vertical K ft/day	Horizon K ft/day	Sg
		Begin	End						
10-B 3-13-09	66%	2410	2420	Brown Dolomitic Limestone	2,417	0.270	8.22E-02	5.67E-01	2.85

3.5.1. Rock Coring Methodology

The cores were collected using a 10-ft core barrel with a 4-inch diameter 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 water pressure. 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 for submittal to a laboratory for analysis.

3.5.2. Rock Core Analyses

Representative sections of the core, longer than 4-inches in length, were submitted to Ardaman & Associates, Inc., of Orlando, Florida, for analysis of vertical and horizontal permeability, total porosity, and specific gravity (S_g), which is the ratio of the density of the material to the density of water. Formation permeability, which was reported in centimeters per second, was converted to hydraulic conductivity for **Table 3-5**. A copy of the laboratory reports are presented in **Appendix F**. Upon arriving at the laboratory, samples were dried using a convection oven to remove all fluids from rock pore spaces. Once the samples were completely dried they were then tested for porosity by direct pore volume measurement using Boyle's law. Bulk Volume was then measure by Archimedes Principles. The specific gravity tests were performed in general accordance with ASTM Standard D 854 "Specific Gravity of Soil Solids by Water Pyconometer" using 50 to 100 grams specimens ground to pass the U.S. Standard No. 40 sieve. The permeability tests were performed in general accordance with ASTM Standard D 5084 "Measurement of Hydraulic Conductivity of Saturated Porous Material Using a Flexible Wall Permeameter" using the constant head test method. Total porosity (n) was back-calculated for the permeability test specimens using the measured dry density (γd), based on the specimen measured dry mass and measured total volume, the measured mineral specific gravity (Gs) of the specimen, and the following relationship between dry density and total porosity:

$n = [1-(\gamma d/Gs\gamma w)]$ where γw is the unit weight of water.

3.5.3. Rock Core Analyses Results

Results of analyses of the ten cores are summarized in **Table 3-5**. A plot of depth versus vertical hydraulic conductivity and horizontal hydraulic conductivity is provided as **Figure 3-9**. Vertical hydraulic conductivity values ranged between 1.02 and 2.83 X 10^{-7} ft/d and averaged 0.127 ft/d. The horizontal hydraulic conductivity values ranged between 1.11 and 8.79 X 10^{-7} ft/d and averaged 0.20 ft/d. In general, rock core analyses indicated three zones of permeability in the borehole. Zones of relatively high permeability were detected between 1,005 ft bls and 1,562 ft bls, and at 2,417 ft bls. A zone of relatively low permeability was detected between 1,684 ft bls and 2,413 ft bls.

A plot of depth versus total porosity is provided as **Figure 3-10**. Total porosity values of the ten cores ranged between 0.32 and 0.012 and averaged 0.15. Total porosity values greater than 0.25 were measured in cores collected at 1,123 ft bls, 1,428 ft bls, 1,892 ft bls, and 2,417 ft bls. Total porosity values less than 0.10 were detected at cores collected at 1,843 ft bls, 2,038 ft bls, 12,211 ft bls, 2,215 ft bls, and 2,216 ft bls.

Figure 3-9. Depth vs. Vertical and Horizontal Conductivity

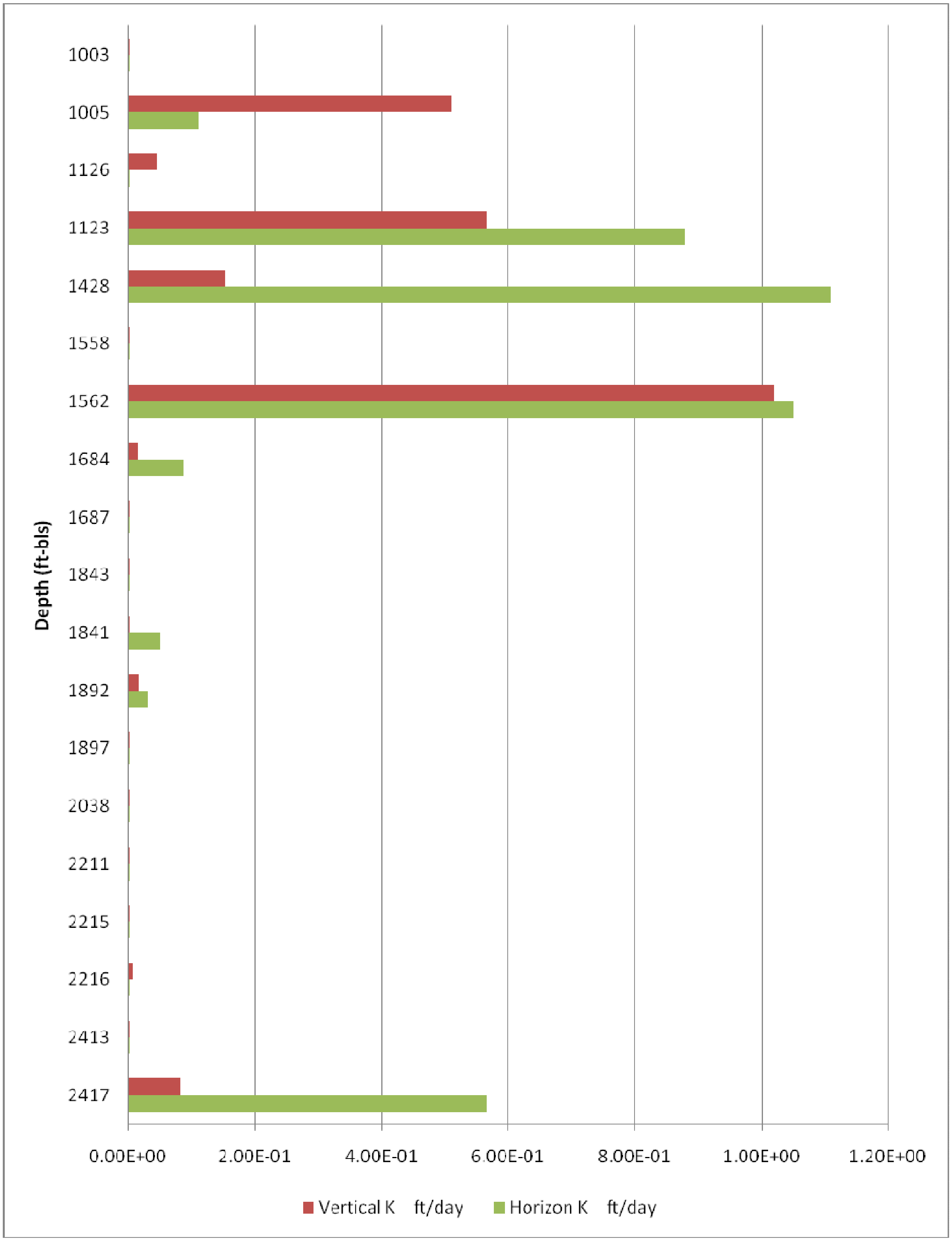
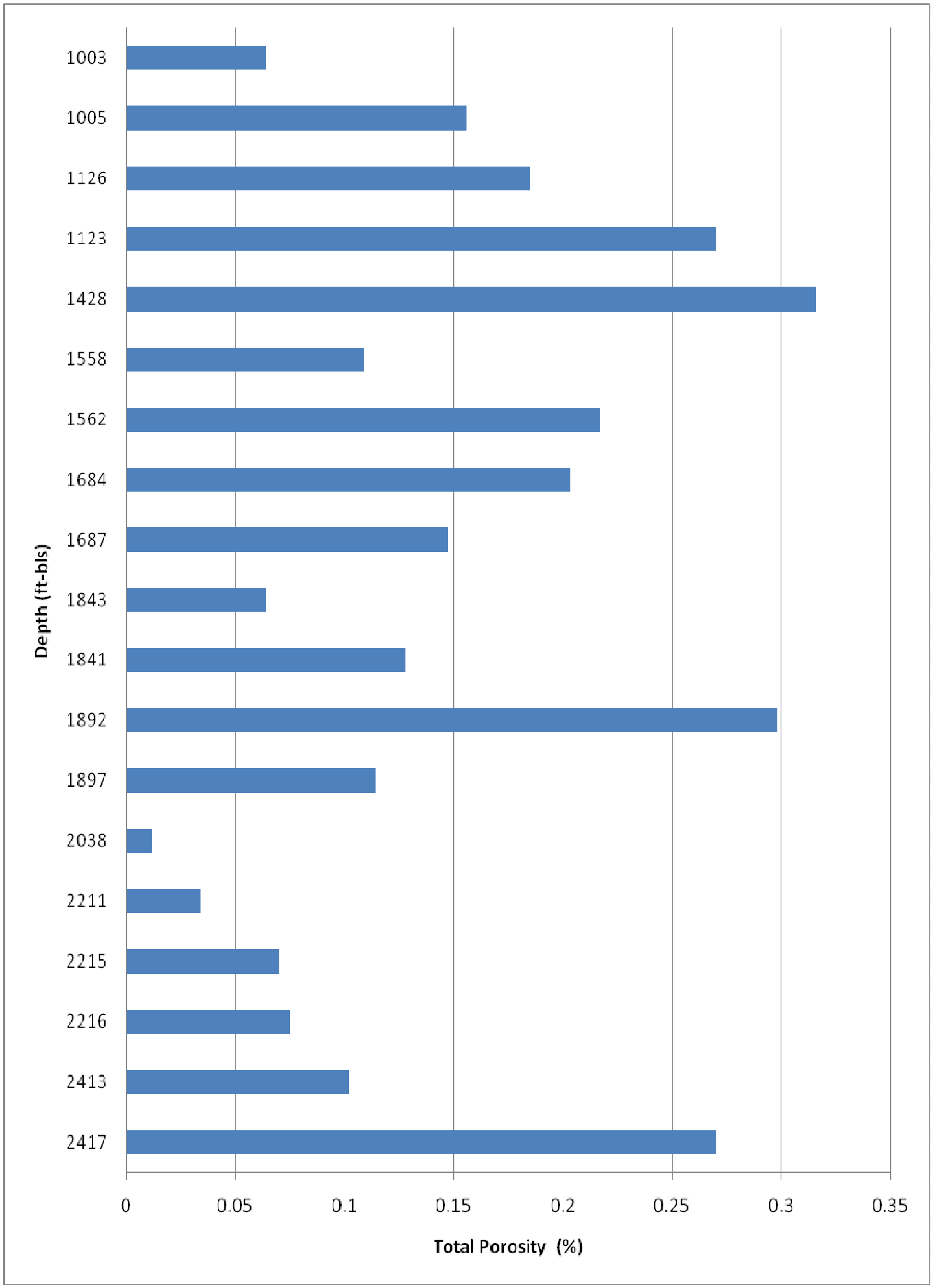


Figure 3-10. Depth vs. Total Porosity



3.6. Geophysical Logging

Geophysical logging during the construction of the SE-DEW was performed by MV Geophysical Surveys, Inc. (MV) of Fort Meyers Florida and Aquifer Data Systems (ADS) of Ruskin Florida. Geophysical logging is conducted to determine general hydrogeologic characteristics of the formation encountered including, but not limited to; formation thickness, lithologies, flow zones and water quality characteristics. In addition, geophysical surveys are also used to determine borehole and grout conditions to assist in well construction. The logging program included collection of geophysical data under static (non-pumping) and dynamic (pumping) conditions. The pumping rate during the suite of dynamic geophysical logs was approximately 2,000 gpm for Run No. 4 and 2,100 gpm for Run No. 7. Copies of the geophysical logs are presented in **Appendix G**. **Table 3-6** summarizes the geophysical logging events performed at the SE-DEW.

Table 3-6. Geophysical Logging Events

SOUTHEAST DEEP EXPLORATORY WELL							
DATE		15-Dec-08	02-Feb-09	11-Mar-09	08-May-09	03 & 04-Jun-09	28-Jul-09
LOGGING RUN NUMBER		1	2	3	4	5,6	7
BOREHOLE or CASING		30-inch reamed hole	24-inch casing	12-inch pilot hole	24-inch reamed hole	18-inch Casing	18-inch reamed
INTERVAL	BEGIN (FT BLS)	270	0	980	980	1100 –R1 900-R2	1400
LOGGED	END (FT BLS)	984	980	2410	1403	1350-R1 1250-R2	2102
BOREHOLE FLOW CONDITIONS		Static	Static	Static/ Dynamic	Static	Static	Static/ Dynamic
LOGS CONDUCTED	CEMENT BOND		X				
	SONIC w/ VARIABLE DENSITY			X			X
	NATURAL GAMMA RAY	X		X	X		X
	CALIPER	X		X	X		X
	SPONTANEOUS POTENTIAL			X			X
	FLUID RESISTIVITY			X			X
	DUAL INDUCTION			X			X
	TEMPERATURE			X		X	X
	FLOW METER			X			X
	VIDEO			X			X
COMMENTS		Indication of casing placement and grout volume	Indication of grout placement	Data Collection	Indication of casing placement and grout volume	Indication of grout placement	Data Collection

NOTE: FT BLS: Feet Below Land Surface

The geophysical logging series conducted on the SE-DEW consisted of seven individual logging events, herein referred to as "Runs," that were performed during the course of well construction. **Run No. 1**, which was performed by ADS, consisted of an X-Y caliper log and a natural gamma log conducted on the reamed portion of the 30-inch diameter borehole between 270 and 984 ft bls in preparation for installation of the 24-inch casing. **Run No. 2**, which was performed by MVGS, consisted of a cement bond with variable density log on the installed 24-inch casing from land surface to 980 ft bls. **Run No. 3**, which was performed by MVGS, consisted of a suite of geophysical logs including a video survey conducted in the 12-inch pilot extending from 980 ft to 2410 ft bls under static and dynamic flow conditions. **Run No. 4** consisted of an X-Y caliper log and a natural gamma log conducted on the reamed portion of the 24-inch diameter borehole between 980 and 1403 ft bls in preparation for installation of the 18-inch casing. **Run Nos. 5 and 6**, which was performed by ADS, consisted of temperature logs to identify the depth to grout following two grouting events during the grouting of the 18-inch casing **Run No. 7**, which was performed by MVGS, consisted of a suite of geophysical logs including a video survey conducted in the 18-inch reamed hole extending from 1400 ft to 2102 ft bls under static and dynamic flow conditions. A more detailed description of the individual geophysical logging events and video survey are presented in the following sections. Copies of individual geophysical logs and video surveys for the SE-DEW are presented in **Appendix G** and **Appendix H**, respectively.

Run No. *1* consisted of running a combination gamma-ray and X-Y Caliper tool on the reamed portion of the nominal 30-inch borehole between 272 and 984 ft bls in preparation for the installation of the 24-inch diameter casing to a depth of 980 ft bls. The logs were completed on December 15 2008. The X-Y caliper log was used to verify the 30-inch diameter casing setting depth, identify borehole dimensions that may affect casing installation and grouting, and provide the annular hole volume between the 24-inch casing and nominal 30-inch borehole. The gamma-ray log, which provides a continuous record of the total gamma radiation detected in the borehole, was primarily utilized to verify that the bottom of the casing was not being set in a clayey zone.

Review of the caliper log, which provides a continuous profile of borehole diameter, shows the borehole diameter was 40 inches to 73 inches from the base of the 30-inch casing to approximately 685 ft bls, 34 inches to 71 inches from 685 to 890 ft bls and relatively gauged hole at approximately 32-inches in diameter from 890 to 984 ft bls. Based upon the caliper log, the diameter of the reamed borehole interval provided an annulus substantially greater than the nominal 2-inch annulus between the borehole wall and casing required under Chapter 62-532 of the Florida Administrative Code. As a result of the large annulus, the drilling contractor submitted a request to the SFWMD, which was approved, to allow up to 12% bentonite by weight to be added to the cement grout to reduce the volume of cement needed to grout the annulus.

Run No. 2 consisted of running a cement bond log on the grouted 24-inch casing to evaluate the effectiveness of the grouting operations. Physical tags by the drilling contractor of the top of cement during the grouting stages and the volume of grout utilized indicated the potential for channels or intervals with only partial bonds in the annulus between the borehole and 24-inch casing. The cement bond log indicated a good cement bond from approximately 945 to 980 ft bls and at 865 to 870 ft bls where the grout did not contain bentonite (gravel was placed between these two intervals), but did not show a good cement bond on most of the remaining annulus, which could have been due to the large diameter of the casing in combination with the low density of the bentonite-cement grout. The movement of water along any unsealed annular space either from the surface to the aquifer or between aquifers was not a concern because of the grouted 30-inch casing, which separated the annulus from the IAS and the surface. However, the increased potential for casing failure due to accelerated corrosion that might result from the lack of cement over an apparently large section of the annulus was a concern. This was addressed by extending the 18-inch casing farther uphole to 250 ft bls, instead of the originally planned depth of 850 ft bls.

Run No. 3 consisted of conducting a video survey and a suite of geophysical logs under static and dynamic flow conditions on March 11, 2009. The geophysical logging was conducted on the 12-inch nominal pilot hole which extended from the base of the 24-inch casing at 980 ft bls to 2,410 ft bls. Logs that were conducted under static flow conditions consisted of: gamma-ray, X-Y caliper, flow meter, spontaneous potential, electric dual induction/ laterolog resistivity log (LL3) combination, temperature, fluid resistivity/conductivity, and borehole compensated sonic with variable density. Logs that were conducted under dynamic flow conditions consisted of: temperature, fluid resistivity/conductivity and flowmeter, and the video survey under pumping conditions of approximately 2,000 gpm.

The gamma-ray log indicated changes in lithology at approximately 1,590 ft bls, 1,820 ft bls, 1,930 ft bls, 2,070 ft bls, and 2,150 ft bls. Review of the lithologic log shows dolostone and dolomitic limestone at these depths with traces of quartz and gypsum identified at depths between 1,860 and 1,990 ft bls.

The caliper log showed the bottom of the 24-inch casing at approximately 980 ft bls and a relatively gauged pilot hole below the casing to 1,060 ft bls. Below 1,060 ft bls, the pilot hole diameter was greater than a nominal 12-inches to a depth of 1,480 ft bls with a maximum diameter of approximately 30 inches at 1,243 ft bls within an interval of apparent fractures between 1,212 ft bls and 1,250 ft bls. Below 1,480 ft bls, the borehole diameter was relatively gauged to a depth of 1,930 ft bls with a maximum diameter of approximately 22 inches at a depth of 1,698 ft within an interval of apparent fractures between 1,670 ft bls and 1,700 ft bls. The caliper log indicated softer material between 1930 ft bls and 2,170 ft bls, particularly from 2,080 ft bls to 2,170 ft bls where the pilot hole diameter ranged between 14 and 22 inches. The pilot hole diameter was relatively gauge below 2,080 ft to the bottom of the hole at 2,410 ft bls except for two apparent fractures at 2,330 ft bls and 2,365 ft bls.

A static flow meter log was conducted in the well to determine if inter-borehole flow was occurring. The borehole flow was logged from the bottom of the casing at 980 ft bls to 2,420 ft bls under non-pumping conditions with the logging speed held relatively constant at 115 feet per minute (ft/min). The flow log indicated down hole flow from approximately 1,000 ft bls to 2,365 ft bls with flow exiting the borehole into the formation at the apparent fractures at 2,330 ft bls and 2,365 ft bls. The flow meter was held stationary at various depths along the borehole where the static flow log indicated changes in flow rate and the caliper log showed borehole diameters were relatively gauged at 12 to 13 inches. The spinning rate of the impeller was recorded at these stationary depths to identify the relative rate of downhole flow in the borehole. The impeller spin rates in counts per second (cps) and station depths in ft bls are provided in the following **Table 3-7**.

Table 3-7. Flow Log Station Depths and Readings

Station Depth (ft-bls)	Spin Rate (cps)
1010	0
1035	10
1055	15-16
1535	27-28
1897	19-20
2025	19
2230	20-21
2280	20
2323	19
2360	14
2370	0

The spin rates indicate flow rates increase down hole to a depth between 1,535 and 1,897 ft bls where some of the flow exits the borehole and enters the formation. Flow rates below 1,897 ft bls appear to remain relatively constant, which indicates no additional flow into our out of the formation, until the flow enters the formation at the apparent fractures at 2,330 ft bls and 2,365 ft bls.

The Spontaneous Potential (SP) log is a passive log that measures the natural electrical potential of rock units. The potential is negative if fluids in the permeable rock are more conductive (greater concentration of dissolved solids) than fluid in the borehole. Conversely, the potential is positive if the formation fluid is lower in dissolved solids than fluid in the borehole. The potential measured in the borehole is relatively constant at 1 to 2 millivolts from 980 to approximately 1,750 ft bls where it decreases at a relatively constant rate to the bottom of the borehole with values becoming negative below approximately 2,200 ft bls. The decreasing potentials below 1,750 ft bls likely indicate increasing concentration of dissolved solids in the formation relative to the borehole fluid, which is influenced by up-hole water quality due to the down hole flow.

The dual induction-LL3 resistivity log measures the ability of the borehole material including fluids to oppose the flow of electricity. A decrease in the resistivity of a section of limestone can indicate an increase in the porosity of the limestone due to a greater quantity of groundwater, which is less resistant than limestone. Water quality also affects resistivity. In general, the resistivity of the formation will vary inversely with the TDS contained in the groundwater. If all other conditions remain the same, resistivity decreases as TDS increases. Deflection on the dual induction-LL3 resistivity log at approximately 1,850 ft bls indicates a change in formation material/ porosity and/or water quality at this depth. The lithologic log shows the addition of traces of gypsum and quartz in the dolomitic limestone between 1,860 and 1,990 ft bls.

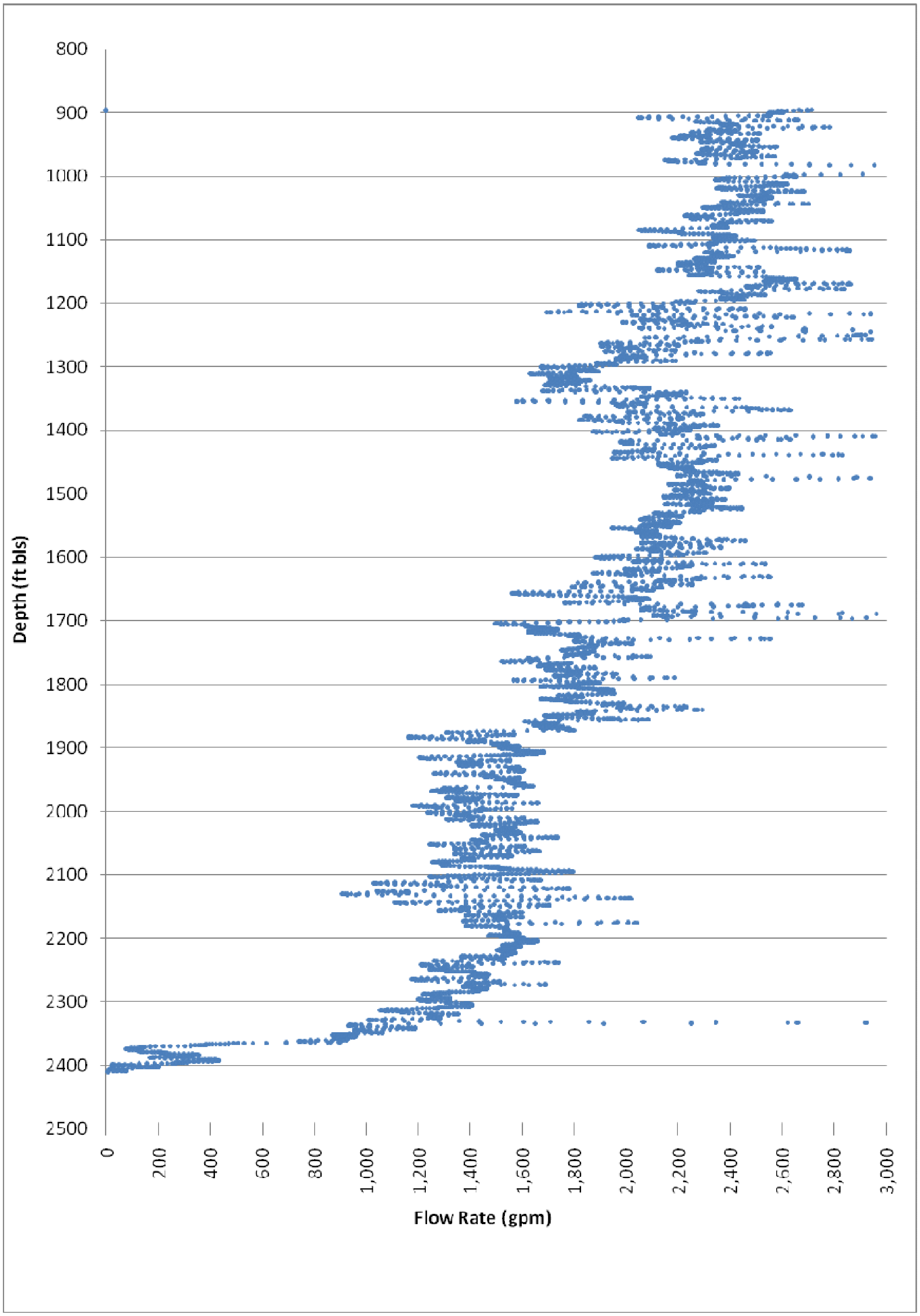
Temperature logs can provide useful information on the movement of water through a borehole including the location of depth intervals that produce or accept water. Fluid Resistivity/ Conductivity logs present a qualitative measurement of TDS in the borehole fluid. The static temperature log shows little change in borehole temperature and the fluid resistivity/conductivity log shows slightly increasing fluid conductivity from the base of the 24-inch casing to the bottom of the borehole, which is consistent with the presence of down-hole flow in the borehole.

Sonic logs, also called acoustic logs, use a transducer to transmit an acoustic wave through the fluid in the borehole and in the surrounding rocks and can be used to provide data on porosity, lithology, cement, and the location and character of fractures. The borehole compensated sonic with variable density log indicates intervals of greater porosity at approximately 1,130 to 1,250 ft bls, 1,420 to 1,440, ft bls, 1,570 to 1,600 ft bls, 1,670 to 1,700 ft bls, 1,830 to 1,860 ft bls, and 2,330 to 2,365 ft bls.

Geophysical logs that were conducted under dynamic flow conditions include flow meter, temperature and fluid resistivity/conductivity, which were run down the borehole at a constant rate while pumping the well/ borehole at approximately 2,000 gpm.

The calculated flow rates in the open borehole from 980 to 2,410 ft bls during pumping are plotted in the following **Figure 3-11**. The flow rates in gallons per minute were calculated utilizing the borehole diameters from the caliper log and a conversion of 3.4 ft/min per cps, which was based on the calibration run information provided at the end of the flow log.

Figure 3-11. Pilot Hole Flow Rates during Pumping – Open Interval 980 to 2,410 ft bls



Inspection of the plotted flow rates indicates that flow in the borehole:

- increased from 0 to approximately 1,400 gpm between the bottom of the borehole at 2,410 ft bls and approximately 2,300 ft bls;
- remained relatively constant from 2,300 to 1,890 ft bls;
- increased to approximately 2,200 gpm between 1,890 and 1,420 ft bls, and;
- increased to approximately 2,400 gpm between 1,420 ft bls and the bottom of the 24-inch casing at 980 ft bls.

Review of the dynamic fluid resistivity/conductance log and temperature log showed significant changes in water quality and temperature at 2,365 ft bls and between 2,390 ft bls and 2,410 ft bls. These logging runs were limited to the borehole interval between 2,000 ft bls and 2,410 ft bls due to the increasing specific conductivity and apparent chloride concentration of the discharge water.

Run No. 4 consisted of running a combination gamma-ray and X-Y Caliper tool on the reamed portion of the nominal 12-inch pilot hole between 980 and 1,405 ft bls in preparation for the installation of the 18-inch diameter casing to a depth of 1,400 ft bls. The logs were completed on May 8, 2009. The X-Y caliper log was used to identify borehole dimensions that may affect casing installation and grouting, and provide the annular hole volume between the 18-inch casing and the nominal 24-inch reamed borehole. The gamma-ray log was primarily utilized to verify that the bottom of the casing was not being set in a clayey zone.

Run Nos. 5 and 6 consisted of running a temperature tool inside the 18-inch casing following the initial pressure grouting on June 2, 2009 and first tremie grouting on June 3, 2009 to assist in verifying grout placement in the annulus between the casing and the nominal 24-inch borehole. The temperature logs verified the physical grout tags of 1,248 ft bls on the initial pressure grouting stage and 1,044 ft bls on the first tremie grout stage.

Run No. 7 consisted of conducting a video survey and a suite of geophysical logs under static and dynamic flow conditions on February 11, 2009 after the final 18-inch casing had been installed and the 12-inch pilot hole, which was reamed to a nominal 18-inch diameter, had been back-lugged with either grout or gravel to 2,140 ft bls. The geophysical logging was conducted on the nominal 18-inch borehole which extended from the base of the 18-inch casing at 980 ft bls to 2,140 ft bls. Logs that were conducted under static flow conditions consisted of: gamma-ray, X-Y caliper, flow meter, spontaneous potential, electric dual induction/ laterolog resistivity log (LL3) combination, temperature, fluid resistivity/conductivity, borehole compensated sonic with variable density, and the video survey. Logs that were conducted under dynamic flow conditions consisted of: temperature, fluid resistivity/conductivity and flow meter under pumping conditions of approximately 2,000 gpm.

The gamma-ray log, which was similar to the log run on February 11, 2009, again indicated changes in lithology at approximately 1,590 ft bls, 1,820 ft bls, 1,930 ft bls, 2,070 ft bls, and 2,150 ft bls as well as 250 ft bls.

The caliper log, in general, indicated that fracturing was more prevalent between 1400 ft bls and 1,870 ft bls where the borehole diameter extended to approximately 30 inches at 1,685 ft bls in comparison to the interval between 1,870 ft bls and 2,140 ft bls where the borehole diameter was less than 19-inches.

The static flow log was conducted in the nominal 18-inch borehole between 1,400 ft bls and 2,140 ft bls on August 3, 2009 under non-pumping conditions with the logging speed held relatively constant at 50 ft/min. Continuous flow meter surveys run up and down the borehole under non-pumping conditions yield information as to the direction of groundwater flow in the borehole. If the water is moving downward, then the up run will show a higher count over the interval where the water is moving. Conversely, if the water is moving up then the down run will show a higher count rate. As with the February 11, 2009 static flow log, the log indicates down-hole flow, but at a substantially reduced rate.

The SP log showed little change in the electrical potential of the formation material from the bottom of the casing to the bottom of the borehole at 2,140 ft bls. This may be due to the relatively large diameter of the reamed hole at 18 inches.

The dual induction-LL3 resistivity log, like the February 11 2009 log, shows a deflection at approximately 1,850 ft bls, which indicates a change in formation material/ porosity and/or water quality at this depth.

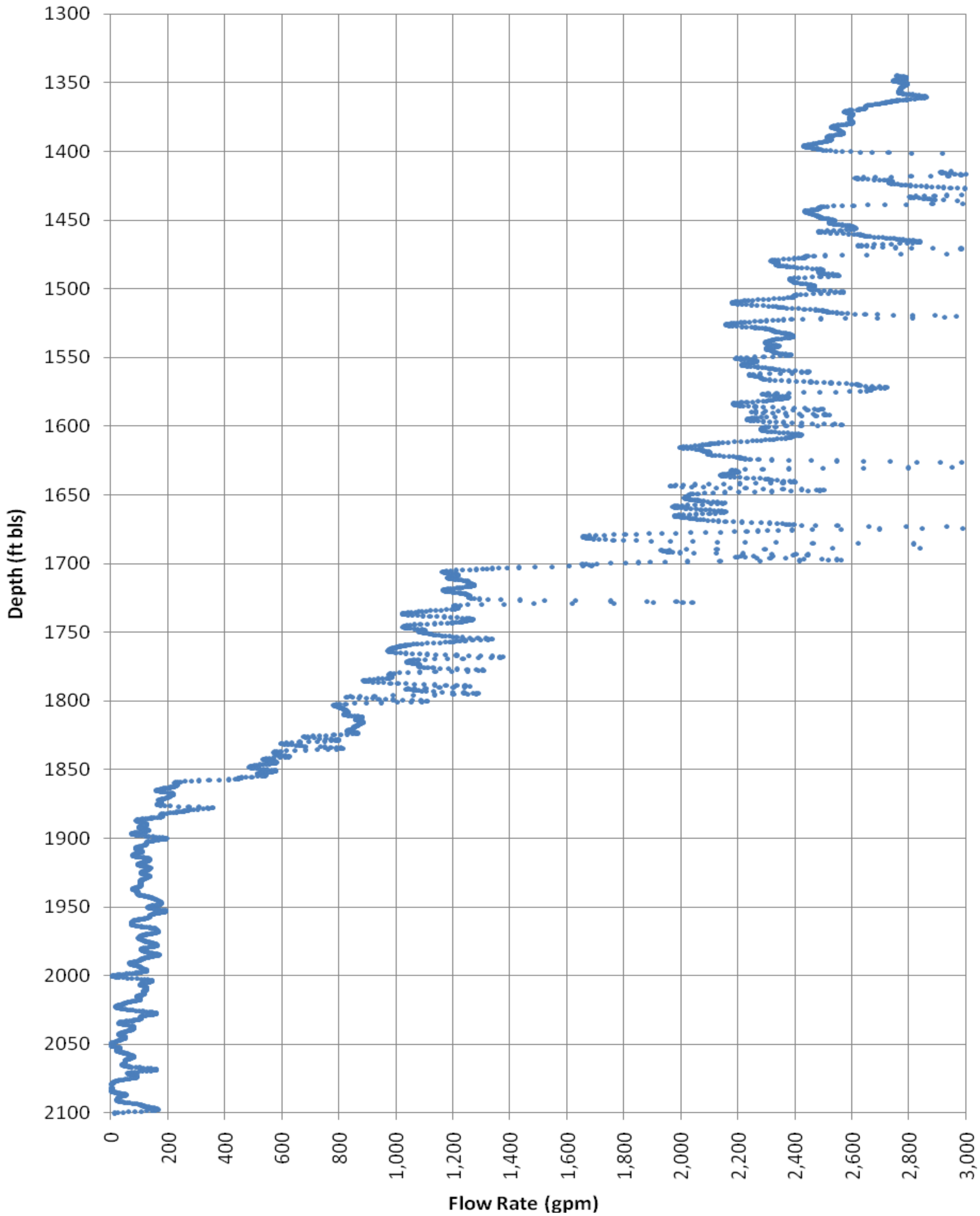
The static temperature log and the fluid conductivity log, unlike the logs conducted on February 11, 2009, showed a substantial increase in temperature and fluid conductivity starting at approximately 1,875 ft bls and continuing to 2,000 ft bls where temperature and fluid conductivity remained relatively constant to the bottom of the borehole at 2,140 ft bls. The change in the temperature and fluid conductivity is attributed to the substantial reduction in down hole flow that resulted from back-plugging the borehole from 2,520 to 2140 ft bls, which allows the borehole fluid to better reflect background water quality and temperature conditions.

The sonic log show similar results to the February 11 2009 results, but like the SP log may have been affected by the larger diameter of the borehole.

Geophysical logs that were conducted under dynamic flow conditions include flow meter, temperature and fluid conductivity, which were run down the borehole at a constant rate while pumping the well/ borehole at approximately 2,100 gpm.

The calculated flow rates in the open borehole from 1,400 to 2,100 ft bls during pumping are plotted in the following **Figure 3-12**. The flow rates in gallons per minute were calculated utilizing the borehole diameters from the caliper log and a conversion of 3.3 ft/min per cps, which was based on the calibration run information provided at the end of the flow log.

Figure 3-12. Borehole Flow Rates during Pumping – Open Interval 1,400 to 2,100 ft bls



Inspection of the plotted flow rates indicates that flow in the borehole:

- increased from 0 to approximately 200 gpm between the bottom of the borehole at 2,140 ft bls and approximately 1,860 ft bls, which accounted for 8% of the total flow;

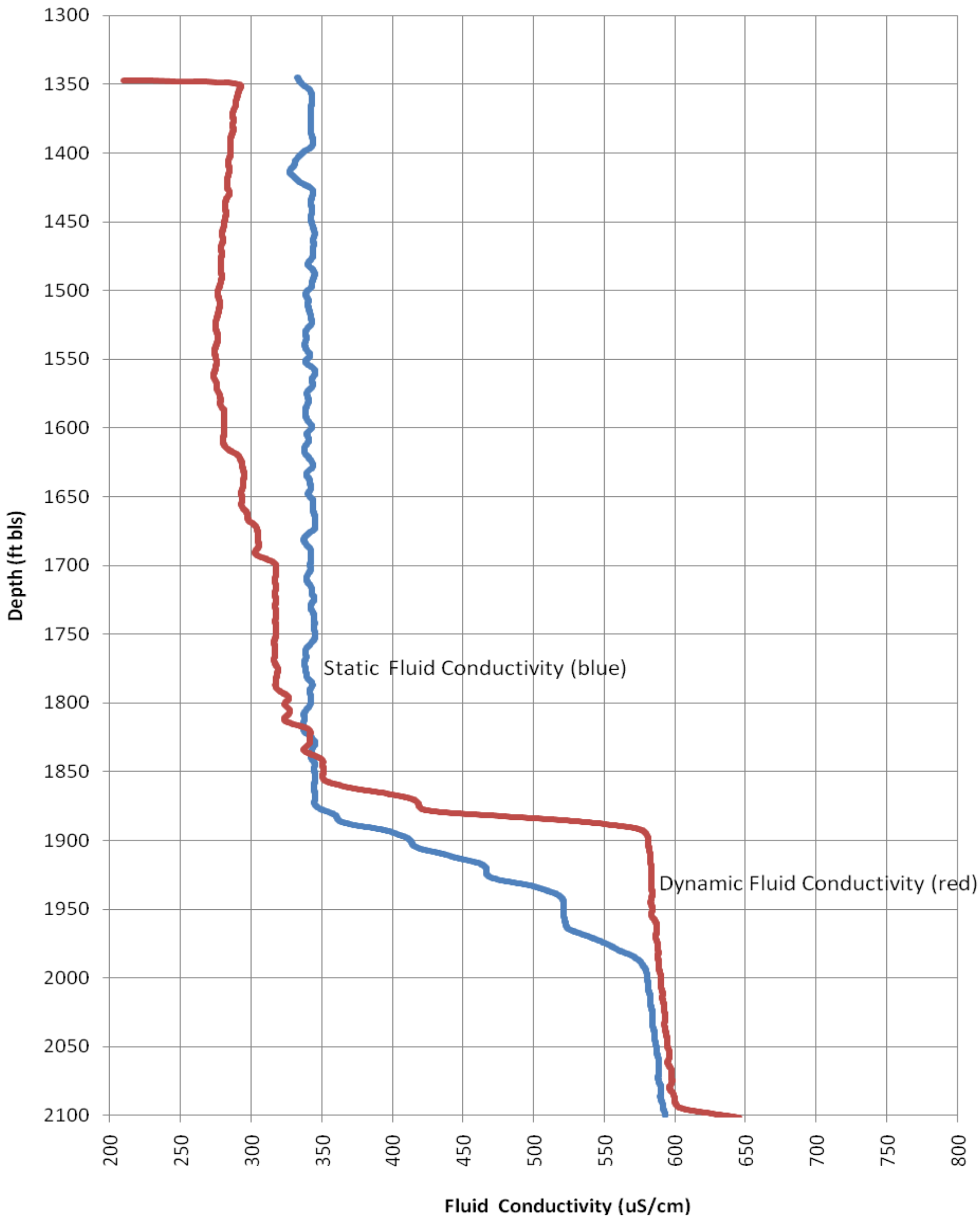
- increased from 200 gpm to approximately 1,200 gpm between 1,860 and 1,710 ft bls, which accounted for 40% of the total flow;

- increased from 1,200 gpm to approximately 2,100 gpm between 1,710 and 1,690 ft bls, which accounted for 36% of the total flow;

- and increased to approximately 2,500 gpm between 1,690 ft bls and the bottom of the 18-inch casing at 1,400 ft bls, which accounted for 16% of the total flow.

Review of the dynamic fluid conductivity log and temperature log showed a substantial increase in temperature and fluid conductivity starting at approximately 1,860 ft bls and continuing to 1,890 ft bls where temperature and fluid conductivity remained relatively constant to the bottom of the borehole at 2,140 ft bls. **Figure 3-13** presents static and dynamic fluid conductivity that was measured during the geophysical logging of the borehole between 1,400 and 2,100 ft bls.

Figure 3-13. Static and Dynamic Fluid Conductivity – Open Interval 1,400 to 2,100 ft



3.7. Video Surveys

Video surveys were conducted during Run No. 3 and Run No. 7. Copies of the surveys are included on DVD in **Appendix H**.

The nominal 24-inch diameter well casing, casing welds, and the open-hole interval of the SE-DEW from 980 to 2,420 ft bls were examined during the first video camera survey conducted on March 11, 2009. Water in the well was clear through the length of the video assessment. Visual inspection of the nominal 24-inch diameter final well casing and casing welds from land surface to approximately 980 ft bls, showed no visible signs of cracks or deformities in the casing and the casing welds appeared continuous.

The nominal 18-inch diameter well casing, casing welds, and the open-hole interval of the SE-DEW from 1,400 to 2,102 ft bls were examined during the first video camera survey conducted on July 28, 2009. Water in the well was clear through the length of the video assessment. Visual inspection of the nominal 24-inch diameter final well casing and casing welds from 250 ft bls to approximately 1,400 ft bls, showed no visible signs of cracks or deformities in the casing and the casing welds appeared continuous.

The video surveys of open borehole intervals generally showed vuggy, "pocketed" walls from approximately 1,000 to 1,890 ft bls with no large horizontal or vertical fractures. Below 1,890 the borehole walls were relatively smooth with the exception of two horizontal fractures at 2,335 ft bls and 2,367 ft bls.

3.8. Packer Testing

Packer tests were conducted to characterize the water quality and hydraulics of specific intervals of the nominal 12-inch pilot hole that was drilled from 270 to 2,521 ft bls. Packer test intervals were selected using information obtained from the static water level, water quality, and lithologic data obtained during reverse-air drilling, and the geophysical logs. Ten packer tests were conducted in the pilot hole. The tests dates, test intervals, pumping rates and durations are provided in **Table 3-8**.

Table 3-8. Packer Test Events

Test Date	Packer Test #	Test Interval (ft bls)	Open Interval Length (ft)	Zone Pumped	Pumping Rate (gpm)	Pumping Duration (min)
11/19/2008	1	270 – 657	387	Open hole	89.6	247
3/25/2009	2	981 – 2,373	1392	Above Packer	2000	270
3/26/2009	3	2,373 – 2,521	148	Below Packer	20	131
3/30/2009	4	981 – 2,188	1207	Above Packer	2000	240
3/31/2009	5	981 – 1,915	934	Above Packer	2000	251
4/1/2009	6	981 – 1,712	731	Above Packer	2000	277
4/2/2009	7	981 – 1,535	554	Above Packer	2000	285
4/3/2009	8	981 – 1,324	343	Above Packer	2000	228
4/6/2009	9	981 – 1,128	147	Above Packer	1000	240
4/9/2009	10	2,373 – 2,395	22	Straddle	10.6	480

Packer test #1 was conducted after casing was installed to 270 ft bls and the pilot hole was drilled to 657 ft bls. The lithology of the open hole interval consisted of chalky, moderately indurated, biogenic limestone within the Upper Floridan aquifer (UFA). A packer was not installed for this test. The test procedure consisted of:

- Installing a submersible pump in the casing/ open pilot hole to 89 ft bls. Measure the pumping rate during the test using an in-line flow meter;
- Installing an F65/ M30 Solinst Levelogger in the well to 63 ft bls to measure and record water level changes during the test;
- Pumping the pilot hole at a constant rate while monitoring and recording water level, temperature, and specific conductivity changes until stable;

- Collecting a discharge sample for laboratory analysis;
- Shutting pump off and recording water level recovery.

Packer tests #2 through 10 were conducted after casing was installed to 981 ft bls and the pilot hole was drilled to 2,521 ft bls. The lithology of the open hole interval, in general, consisted of limestone and dolostone of the Avon Park permeable zone (APPZ) and the Lower Flordan aquifer (LFA).

The test procedure for packer tests #2 and #4 through #9 consisted of:

- Lowering the packer assembly to the selected depth then inflating the packer;
- Installing a submersible pump in the casing/ pilot hole to 80 ft bls. The pumping rate during the test was measured using an in-line flow meter;
- Installing a F30 Solinst Levelogger in the UFA monitor well SE-UFA-MW1to monitor water level changes during a test;
- Installing a F30 Solinst Levelogger in the drill pipe and a F65 Solinst Levelogger in the casing/ pilot hole to monitor water level changes below the pumped zone and in the pumped zone, respectively, during a test;
- Monitoring the water level changes in the two zones until stable.
- Pumping the pilot hole at a constant rate while monitoring water level, temperature, and specific conductivity changes until stable;
- Collecting a discharge sample for laboratory analysis;
- Shutting the pump off and recording water level recovery.

The test procedure for packer test #3 was similar to the above except a small submersible pump was installed inside the 4.5-inch diameter drill pipe and the zone below the packer was pumped. The test procedure for packer test #10 was similar to the procedure for packer test #3, except two coupled packers were installed in the pilot hole and the zone between the two packers was pumped. Water level changes below the bottom packer were not monitored during packer test #10.

The calculated specific capacities of the ten packer test intervals, which is the pumping rate in gallons per minute divided by the drawdown in feet are provided in **Table 3-9**. The Table also includes the changes in water levels either above or below the test intervals during the packer tests, which were measured to identify potential leakance of groundwater into the tested interval and the changes in water levels at SE-UFA-MW1, which were measured to identify any hydraulic connection between the pilot hole interval and the uppermost production zone of the APPZ.

In order to account for the change in water levels in the test intervals of packer tests 3 and 10 that resulted from the change in water density as fresher water from uphole was pumped out and replaced by formation waters from within the test interval, the drawdown from these packer tests were calculated as the difference between the water level at the end of pumping and the recovered water level after pumping was stopped.

Water levels measured below the packers during packer tests #2, #4, #5, #6, #7, #8, and #9 indicated that upward leakance into the pumped zone was insignificant during these tests. Water levels measured at SE-UFA-MW1 during these packer tests showed that the uppermost permeable zone of the APPZ and the open hole interval below 981 ft bls are hydraulically connected.

Table 3-9. Packer Tests Specific Capacity Results

Test #	Test Interval (ft bls)	Static WL of Test Interval (ft from LS)	Total DD in Test interval (ft)	Specific Capacity of Test Interval (gpm/ft)	Change in WL above/ below Test Interval (ft)	Change in WL at SE-UFA –MW1 (ft)
1	270 – 657	+ 1.94	52.88	1.7	not applicable	52.88
2	981 – 2,373	- 15.03	16.95	118.0	0.23	0.31
3	2,373 – 2,521	- 15.70	1.65	12.1	0.09	0.03
4	981 – 2,188	- 12.40	21.55	92.8	0.21	0.83
5	981 – 1,915	- 10.98	23.36	85.6	0.09	1.33
6	981 – 1,712	- 7.73	31.93	62.6	0.16	1.61
7	981 – 1,535	- 3.98	45.90	43.6	0.18	1.50
8	981 – 1,324	- 5.50	47.59	42.0	0.56	1.5+
9	981 – 1,128	- 2.96	51.40	19.5	0.12	2.11
10	2,373 – 2,395	- 44.57	32.58	0.3	0.21	0.10

Notes: DD = Drawdown, LS = Land Surface, gpm/ft = gallons per minute per foot of drawdown; WL = Water Level. Red text denotes gaining water levels. **Black** text denotes dropping water levels.

An estimate of the transmissivities of the test intervals, which are provided in **Table 3-10**, can be derived from specific capacity utilizing empirical equations based on the Jacob's equation. The empirical equations simplify to the following equation for most cases.

$$T = \left(\frac{Q}{s}\right)2000$$

Where: **T** equals transmissivity in gallons per day per foot;

s equals well drawdown in feet; and
Q equals well yield in gallons per minute.

Well efficiency losses are not a factor in calculating the estimated transmissivities for the packer tests results because of the large diameter of the casing (24-inch) while pumping for packer tests #1, #3, and #4 through #9 and the low pumping rates while pumping through the 4.5-inch drill rod for packer tests #2 and #10.

Table 3-10. Estimated Transmissivities of the Packer Test Intervals

Test #	Test Interval (ft bls)	Specific Capacity of Test Interval (gpm/ft)	Transmissivity (gpd/ft)	Transmissivity (ft2/day)
1	270 – 657	1.7	3,400	450
2	981 – 2,373	118.0	236,000	31,550
3	2,373 – 2,521	12.1	24,200	3,240
4	981 – 2,188	92.8	185,600	24,810
5	981 – 1,915	85.6	171,200	22,890
6	981 – 1,712	62.6	125,200	16,740
7	981 – 1,535	43.6	87,200	11,660
8	981 – 1,324	42.0	84,000	11,230
9	981 – 1,128	19.5	39,000	5,210
10	2,373 – 2,395	0.3	600	80

The estimated transmissivities of the packer test intervals for packer tests #2 and #4 through #9 were used to estimate transmissivities for intervals of the pilot hole that are associated with various hydrogeologic units as defined in Reese, R.S. and E. Richardson, 2007. The pilot hole intervals, estimated transmissivities and associated hydrogeologic units are provided in **Table 3-11**.The transmissivity for a pilot hole interval was calculated by subtracting the transmissivity of the overlying packer test interval from the underlying packer test interval that included the pilot hole interval.

Table 3-11. Estimated Transmissivities and Associated Hydrogeologic Units of Specific Pilot Hole Intervals

Pilot hole Interval (ft bls)	Pilot hole Interval Length (ft)	Transmissivity (gpd/ft)	Transmissivity (ft2/day)	Associated Hydrogeologic Unit
980 – 1,128	148	38,900	5,200	lower APPZ
1,128 – 1,324	196	45,100	6,030	lower APPZ
1,324 – 1,535	211	3,100	414	MC2
1,535 – 1,712	177	38,100	5,090	LF1
1,712 – 1,915	203	45,900	6,140	LF1
1,915 – 2,188	273	14,400	1,920	LC
2,188 – 2,373	185	51,600	6,900	LF2

Notes: APPZ = Avon Park Permeable Zone; MC2 = Middle semiconfining unit, lower part
LF1 = Lower Floridan aquifer, uppermost permeable zone
LC = Confining unit within the Lower Floridan aquifer
LF2 = Deeper permeable zone within the Lower Floridan aquifer

An estimated transmissivity of 41,270 ft^2/day or 308,700 gpd/ ft for the APPZ (870 to 1,250 ft bls) is obtained by adding the sum of the estimated transmissivities of the two pilot hole intervals between 980 and 1,324 ft bls, which equals 11,230 ft^2/day or 84,000 gpd/ft, and the estimated transmissivity of 30,040 ft^2/day or 224,700 gpd/ ft for the uppermost permeable zone of the APPZ that was calculate from data collected during the APT of SE-UFA-MW1.

The estimated transmissivity of the open hole interval of the completed SE-DEW, which is cased to 1,400 ft bls and open hole to 2,140 ft bls, based on the packer test results for the pilot hole intervals from 1,535 to 2,188 ft bls is 13,150 ft^2/day or 98,400 gpd/ft.

Discharge water samples were collected from the tested intervals at the end of the packer tests. The samples were transported to either Florida Analytical, Inc. of Lakeland, Florida – FL certification #E84098 or Southern Analytical Laboratories, Inc of Oldsmar, Florida – FL certification #E84129 for analysis of chloride, sulfate, calcium, magnesium, TDS, specific conductivity and hardness. The laboratory analytical results are presented in **Table 3-12**. Copies of the Laboratory reports are included in **Appendix I.**

Table 3-12. Packer Tests Water Quality Analysis Results

Date	Test #	Interval (ft bls)	Chloride (mg/L)	Specific Conductivity (µS/cm)	Total Hardness (mg/L)	Sulfate (mg/L)	TDS (mg/L)	Calcium (mg/L)
11/18/2008	1	270-657	6.3	212	111	7	90	30.2
3/25/2009	2	981 - 2,373	1,200.0	4,190	510	190	2,200	69.0
3/26/2009	3	2,373 - 2,521	15,000.0	38,600	5500	2,600	26,000	790.0
3/30/2009	4	981 - 2,188	8.6	210	100	11	108	22.0
3/31/2009	5	981 - 1,915	8.2	200	95	11	110	20.0
4/1/2009	6	981 - 1,712	8.1	200	89	7.6	110	19.0
4/2/2009	7	981 - 1,535	7.8	190	88	7.2	100	19.0
4/3/2009	8	981 - 1,324	8.2	190	81	5.2	100	19.0
4/6/2009	9	981 - 1,128	8.0	190	80	5.3	96	18.0
4/9/2009	10	2,373 - 2,395	6,200	19,000	2,200	1,100	10,800	290

Water quality analysis results from packer test #1 reflect the low TDS concentrations typically associated with groundwater from the UFA in the area. The water sample collected from packer test #2 is a composite sample from the hydrogeologic units intercepted by the open borehole interval including the APPZ, LF1, LC and LF2. Water quality analysis results from packer tests #4 through # 9, which did not include water from LF2, showed relatively constant concentrations for each parameter regardless of the packer test interval that are significantly lower than the concentrations from packer test #2. This would indicate that the differences in water quality parameter concentrations between packer test #2 and packer tests #4 through #9 is the water being contributed from the LF2 interval between approximately 2,188 and 2,373 ft bls, and in particular, the two large horizontal fractures at 2,335 ft bls and 2,367 ft bls. The water sample from packer test # 2, which was collected after pumping over 18 well volumes and the increase in field specific conductivity measurements over the last three well volumes averaged less than 3%, had a TDS concentration of 2,200 mg/L. Inspection of **Figure 3-13**, which presents the pilot hole flow rates measured during the dynamic flow logging that was conducted along the open pilot hole interval between 980 and 2,410 ft bls while pumping at approximately 2,100 gpm, indicates that approximately 60% of the total flow from the well was being contributed from the LF2 interval and in particular from the two horizontal fractures. Based on the estimated flow distribution between LF2 and the overlying units and the TDS concentrations from the packer tests, the estimated TDS concentration from the LF2 interval and in particular from the two horizontal fractures is 3,600 mg/L. This estimated TDS concentration should be considered a minimum value because field specific conductivity measurements, although approaching stability, were still increasing slightly at the time the water sample was collected for packer test #2.

Laboratory analysis of water samples collected from packer tests 3 and 10 shows that the TDS concentration of water below 2,370 ft bls was greater than 10,000 mg/L and therefore the LFA below this depth is not a potential source of drinking water as defined in Chapter 62-520 of the Florida Administrative Code, which defines an Underground Source of Drinking Water (USDW) as an aquifer with a TDS concentration of less than 10,000 mg/L.

3.9. Variable Rate Step Drawdown Pumping Test

A variable rate step-drawdown pumping test (step test) was performed on the SE-DEW on July, 27, 2009 to identify the drawdown in the well at various pumping rates for use in designing the pump capacity in the event that the well is permitted as a production well in the future and to establish the pumping rate for the 14-day aquifer performance test. Additional data collected during pumping of the SE DEW included water level measurements at SE-UFA-MW1 to identify potential effects on water levels in the overlying APPZ from pumping and water samples from a spigot on the SE DEW discharge pipe at the end of each pumping time step. The water samples were submitted to Southern Analytical Laboratories, Inc. and analyzed for chloride, sulfate, TDS, calcium, total hardness, specific conductivity, and pH.

An 8-inch diameter submersible pump powered by a 75 horsepower motor with the intake set at approximately 107 ft bls was utilized for this pumping test. The pumping rate was measured with a calibrated in-line flowmeter. A calibration certification for the flow meter is included as **Appendix J**. Water levels in the SE-DEW were measured with a Geo-Tech 100-foot water level indicator at a 1.5-inch diameter “stilling” pipe that extended to approximately 100 ft below the top of the well casing. Groundwater was discharged to a ditch located approximately 200 feet south of the well via 12-inch diameter PVC pipe. Flow in the ditch discharges into Lake Weohyakapka, which is located approximately 1.7 miles north of the SE-DEW.

The well was initially pumped at a rate of 700 gpm until the water level in the well stabilized. The pumping rate was subsequently increased in successive time steps to rates of 1,400 and 2,500 gpm following stabilization of the water level at each time step. The static water level in the SE-DEW prior to pumping was approximately 12.0 ft bls. **Table 3-13** summarizes the pumping test measurements and the calculated specific capacity for each pumping rate.

Table 3-13. Step-Drawdown Pumping Test Capacity Results

Date	Elapsed Pumping Time (min)	Static Water Level (ft bls)	Pumping Water Level (ft bls)	Drawdown (ft)	Pumping Rate (GPM)	Specific Capacity (GPM/ft)
7/27/09	120	12.0	25.1	13.1	700	53.4
7/27/09	240	12.0	41.2	29.2	1,400	47.9
7/27/09	480	12.0	67.8	55.8	2,100	37.6

The water level in the SE-UFA-MW1 well did not change appreciably after the initial drawdown for the 120 minutes that the SE-DEW was pumping at 700 gpm. Four minutes after increasing the pumping rate to 1,400 gpm, the water level dropped by 0.01-foot and then dropped another 0.01-foot 100 minutes later. The water level dropped another 0.01-foot five minutes after increasing the pumping rate to 2,100 gpm and stayed at that level until the end of the pumping test for a total water level drop of 0.03 –foot.

Table 3-14 summarizes the results of the laboratory analyses of the water samples collected from the SE-DEW at the end of each pumping time step. The laboratory analytical reports are included in **Appendix K**.

Table 3-14. Step-Drawdown Pumping Test Water Quality Analysis Results

Elapsed Pumping Time (min)	Pumping Rate (GPM)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)	Calcium (mg/L)	Total Hardness (mg/L)	pH	SP. COND. (umhos/cm)
114	700	9.8	27	110	24	110	7.6	270
232	1,400	10	43	130	27	130	8.3	292
470	2,100	11	77	180	37	180	8.4	365

With the exception of chloride, the water quality parameters show a marked increase in concentration with each increase in pumping rate. Based on the static and dynamic fluid conductivity logs which showed high conductivity fluids in the borehole between approximately 1,890 and 2,140 ft bls, possible explanations for the increase in concentrations include;

- Flow from the borehole interval between 1,890 and 2,140 ft bls is providing a greater percentage of the total flow from the well as the pumping rate is increased and/ or;
- Groundwater from the APPZ and LF1 with a lower TDS concentration, which has flowed into the borehole interval between 1,890 and 2,140 ft bls due to the downward flow, is being purged from the lower interval during pumping.

3.10. Aquifer Performance Test

A 14-day aquifer performance test (APT) of SE-DEW was initiated in October 2009 to assess the hydraulic properties of the uppermost permeable zone of the LFA. The principle of an APT is rather simple (Krusman, G.P. and N.A. De Ridder, 1983). From a well that is completed in the aquifer to be tested, groundwater is pumped during a certain time and at a certain constant rate. The effect of the pumping well on the water level of the aquifer is measured in the pumped well and observation wells in the vicinity. The hydraulic characteristics of the aquifer are then determined by substituting the drawdowns measured in the observation wells, their distance from the pumped well, and the well pumping rate in an appropriate formula.

The APT was comprised of three phases. During Phase 1 from October 06, 2009 to the start of pumping of SE-DEW at 12:30 p.m. on October 19, 20009, rainfall, barometric pressure and pre-pumping water levels were monitored at the onsite wells including the SA monitor well SE-SA-MW1, the UFA monitor well SE-UFA-MW1, the dual zone monitor well DZMW, and the production well SE-DEW. During phase 2 from 12:30 p.m. on October 19, 2008 to 1:05 p.m. on November 2, 2009, monitoring of water levels and barometric pressure continued while pumping SE-DEW at an average constant rate of 2,013 gallons per minute (gpm). During Phase 3 from 1:00 p.m. on November 2, 2009 to November 17, 2009, pumping of SE-DEW was stopped and water levels at the on-site wells, rainfall, and barometric pressure were monitored.

3.10.1. Aquifer Performance Test Setup and Data Collection

Construction specifications and relative elevations of the monitor wells and the SE-DEW that were used for the APT are provided in the following **Table 3-15**. All of the wells were surveyed by a licensed professional surveyor on October 6, 2009 for elevation relative to an estimated land surface elevation of 70 feet above the National Geodetic Vertical Datum of 1929 (NGVD) at SE-SA-MW1.

Table 3-15. SE DEW APT Well Specifications

Well	Measuring Point	Measuring Point Elevation* (Ft-NGVD)	Casing Diameter (inches)	Casing Depth (ft-bls)	Total Depth (ft- bls)	Aquifer monitored	Distance from Pumping Well (ft)
SE-DEW	Top of casing flange	74.70	24	1,400	2,140	--	--
SE-UFA-MW1	Top of steel capping plate	73.36	18	270	950	Uppermost permeable zone of APPZ	100
SE-SA-MW1	Top of metal ring on casing	72.68	6	40	80	SA	95
SE-DZMW APPZ Zone	Top of 14-inch capping plate	71.52	14	270	1,250	APPZ	200
SE-DZMW LF1 Zone	Top of 8-inch casing flange	72.95	8	1,400	2,140	Uppermost permeable zone of LFA	200

* Measuring point elevation for depth to water measurements.

The SE-DEW was temporarily equipped with an 8-inch diameter vertical turbine pump powered by a 100 horsepower motor with intake bowls set at approximately 100 ft bls for the APT. The pumping rate was measured with a calibrated in-line flow meter and a circular orifice weir at the end of the discharge pipe to verify the flow meter. The circular orifice weir consisted of an 8-inch diameter orifice plate, a level 10-inch diameter pipe, and a manometer tube. The flow rate from the SE DEW was controlled utilizing an inline gate valve. Instantaneous flow rates, totalizer readings, and weir readings were manually recorded during Phase 2 of the APT. Tabulated instantaneous flow rate readings, totalizer readings, and weir readings are included as electronic files on CD in **Appendix L**. The total volume of water pumped during Phase 2 was 40,652,950 gallons, which resulted in an average pumping rate of 2,013 gpm over the 20,195 minute pumping period. The average manometer reading at the circular orifice weir was 45.5 inches, which equates to 2,040 gpm.

Groundwater was discharged through 12-inch diameter PVC pipe to a ditch located approximately 650 feet northwest of the SE-DEW. Flow in the ditch discharges into Lake Weohyakapka, which is located approximately 1.7 miles north of the site. Prior to discharging to the ditch, a water sample was collected from the well on October 07, 2008 and submitted to Southern Analytical Laboratories, Inc. for analysis of those parameters listed in Table 1 of the Florida Department of Environmental Protection Generic Permit for the discharge of produced ground water from any non-contaminated site activity. The results of the analysis, which is included in **Appendix M**, showed that the concentrations of the parameters were below their respective screening value.

Solinst Leveloggers, which are water level recording devices that combine a data logger, battery, pressure transducer and temperature sensor in a small, stainless steel housing, were temporarily installed in SE-DEW-1, SE-UFA-MW1, SE-SA-MW1 and SE-DZMW prior to the start of Phase 1 of the APT. The data loggers were programmed to measure and record water level data at linear rates during Phase 1 and at logarithmic rates during Phases 2 and 3. The water level in the wells were also manually measured during the APT from an established measuring point with an electronic water level indicator and at temporary manometers, which were installed at SE-UFA-MW1 and the DZMW-UFA zone due to water levels that were above the top of their respective casings at the start of Phase 1 of the APT. Electronic copies of the water level field data sheets for SE-DEW, SE-UFA-MW1, SE-SA-MW1 and the DZMW are included on CD in **Appendix L**. A Solinst Barologger was also installed onsite to measure changes in barometric pressure during the APT and to compensate the Leveloggers, which measures the water and air column above them, for atmospheric pressure fluctuations. The Levelogger and Barologger electronic files are included on CD in **Appendix L.**

Rainfall at the site during the APT was measured utilizing a standard range gauge, which was attached to a fence post in an open area on the east side of the site, and manually recorded on a daily basis. Rainfall amounts measured at the site were 0.15-inch on October 16, 2009 and 0.20-inch on November 10, 2009. There was no rainfall at the site during pumping Phase 2 of the APT.

Water quality testing to monitor changes in water quality during pumping Phase 2 of the APT included the collection of discharge water samples twice a day for laboratory analysis and field measurements of specific conductivity utilizing a calibrated Hach sensION5 conductivity meter. A discharge sample was also collected at the end of Phase 2 for laboratory analysis of secondary and select primary drinking water standards parameters and operational water quality parameters.

3.10.2. Aquifer Performance Test Data Analysis

The changes in water levels and barometric pressure measured and recorded by the Solinst Levelogger were compensated for barometric pressure utilizing barometric pressure readings measured and recorded at an on-site Solinst Barologger and elevation relative to NGVD utilizing manual depth to water measurements from the surveyed measuring points on the wells. The compensated water level elevations were then graphed utilizing an electronic spreadsheet.

Figure 3-14 is a time series plot of water level elevations relative to NGVD at the on-site monitor wells including SE-SA-MW1, SE-UFA-MW1, and SE-DZMW during the APT. Pre-pumping water levels were near land surface at SE-SA-MW1, approximately 5 feet above land surface at SE-UFA-MW1 and the APPZ zone of SE-DZMW, and approximately 12 feet below land surface at the SE-DEW and the LF1 zone of SE-DZMW. Water levels at all wells showed declining trends at relatively constant rates during the pre-pumping and recovery phases of the APT, which are assumed to reflect the regional trends in water levels of the SA, APPZ and the

LFA. The rates of decline were approximately 0.07 ft/day at the LF1 and UFA zones of the SE-DZMW and at SE-UFA-MW1. The rate of decline at SE-SA-MW1 was less at approximately 0.04 ft/ day.

Figure 3-15 is a time series plot of water level elevations relative to NGVD at the SE-DEW during the APT. The water level elevation changed from a pre-pumping level of approximately 58.0 feet NGVD to approximately 4.5 feet NGVD at the end of pumping for a total measured drawdown of 53.5 feet. Approximately 1 foot of the drawdown can be attributed to the regional decline in the LFA water level. The water level recovered to approximately 56.0 feet NGVD within 1 hour after pumping was stopped.

Figure 3-16 is a time series plot of water level elevations relative to NGVD during the APT at the LFA zone of the SE-DZMW, which is located 200 feet east of SE-DEW. The water level elevation changed from a pre-pumping level of approximately 58.0 feet NGVD to approximately 47.5 feet NGVD at the end of pumping for a total measured drawdown of 10.5 feet of which 9.5 feet is attributed to pumping at the SE-DEW after accounting for the regional trend. The water level recovered to approximately 56.0 feet NGVD within 1 hour after pumping was stopped.

Figure 3-17 is a time series plot of water level elevations relative to NGVD during the APT at the APPZ zone of the SE-DZMW, which is located 200 feet east of SE-DEW, and the uppermost permeable zone of the APPZ at SE-UFA-MW1, which is located 100 feet east of SE-DEW. The water level decline at both wells during the pumping phase of the APT appears to be similar to the regional decline in water levels, which indicates that impacts to the overlying UFA and APPZ water levels at the site are minimal from pumping the LFA. Water levels in the two wells do begin to separate after the start of pumping with water levels in the deeper SE-DZMW UFA zone obtaining a maximum separation of approximately 0.15 feet below the water level in SE-UFA-MW1 approximately 7 days after the start of pumping. The water level separation continued for approximately 2 days after pumping was stopped. Drawdown “spikes” from an 8-inch diameter, 960-feet deep irrigation well located approximately 3,500 feet southwest of the SE-DEW are visible in the water level elevations plot.

Figure 3-18 is a time series plot of water level elevations relative to NGVD that were recorded by Leveloggers during the APT at SE-SA-MW1, which is located 95 feet northwest of SE-DEW. There are two trends in the rate of water level decline separated by the rainfall event of October 16, 2009, which has a visible impact on the water level. The rate of water level decline after the rainfall event from October 18 2009 through the pumping and recovery phase of the APT is constant, which indicates that there was no drawdown to the water table of the SA at the site from pumping the LF1.

Figure 3-14. Aquifer Performance Test Monitor Well Water Levels

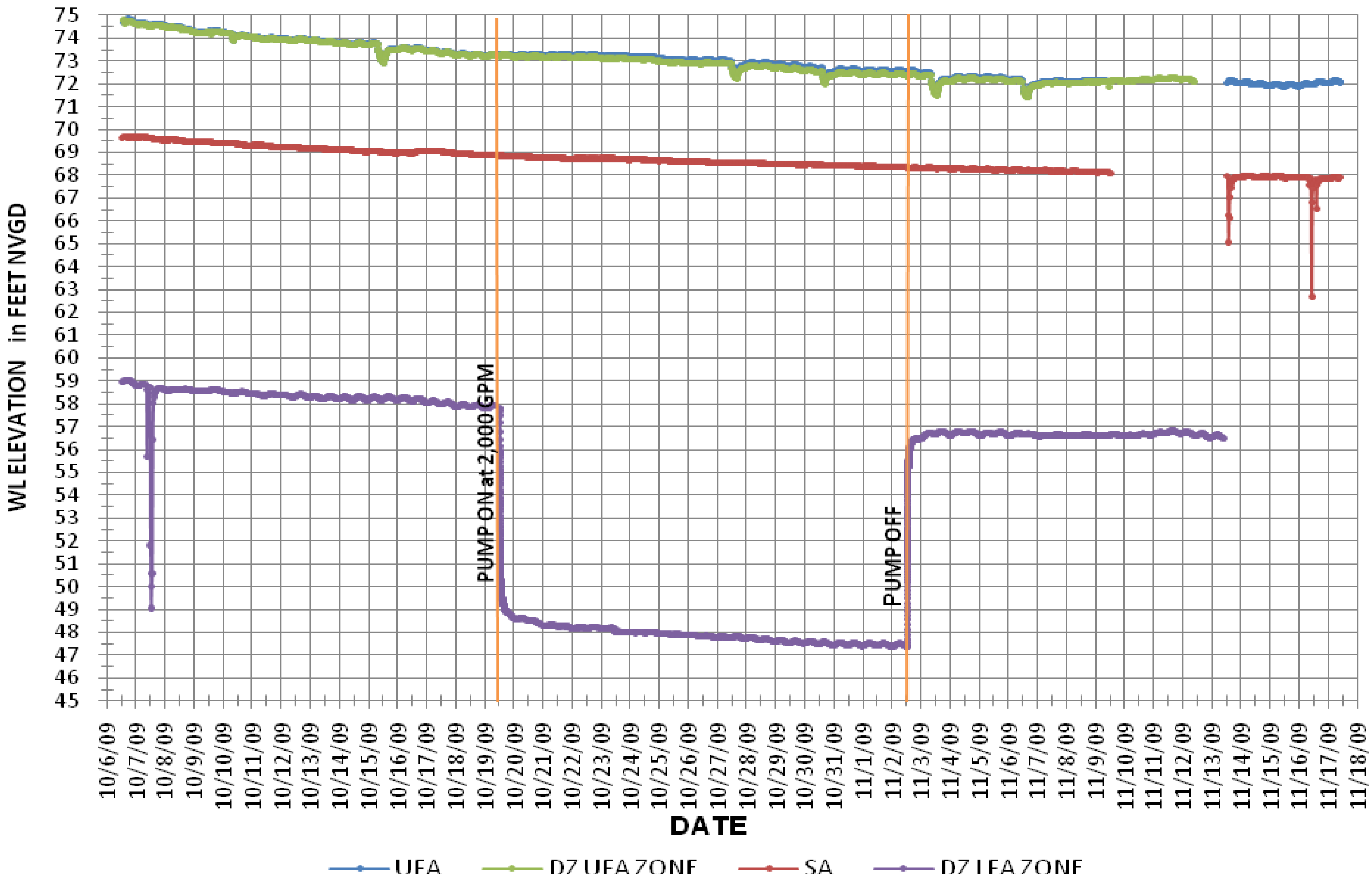


Figure 3-15. Aquifer Performance Test SE-DEW Water Levels

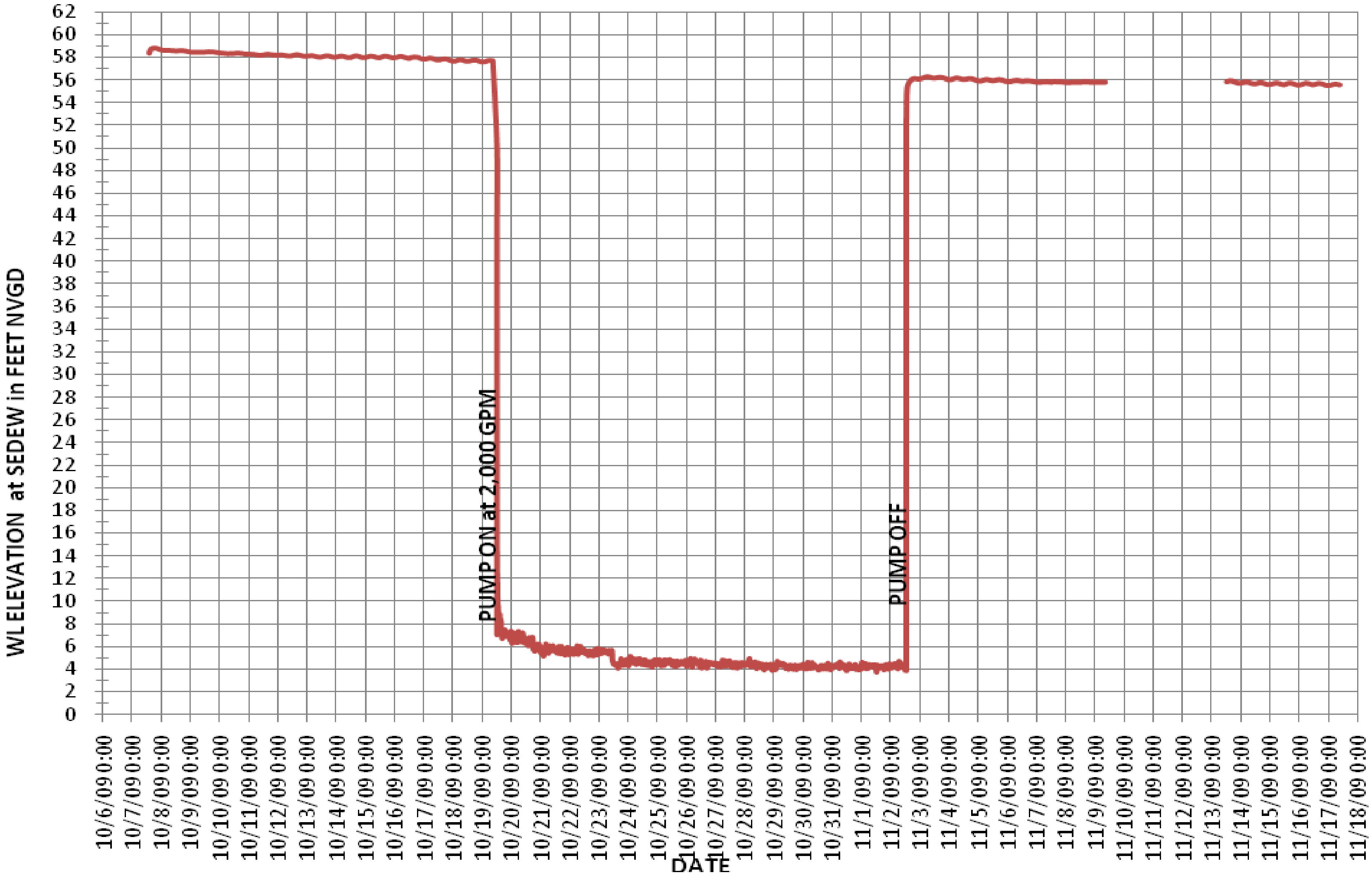


Figure 3-16. Aquifer Performance Test DZ LFA Zone Water Levels

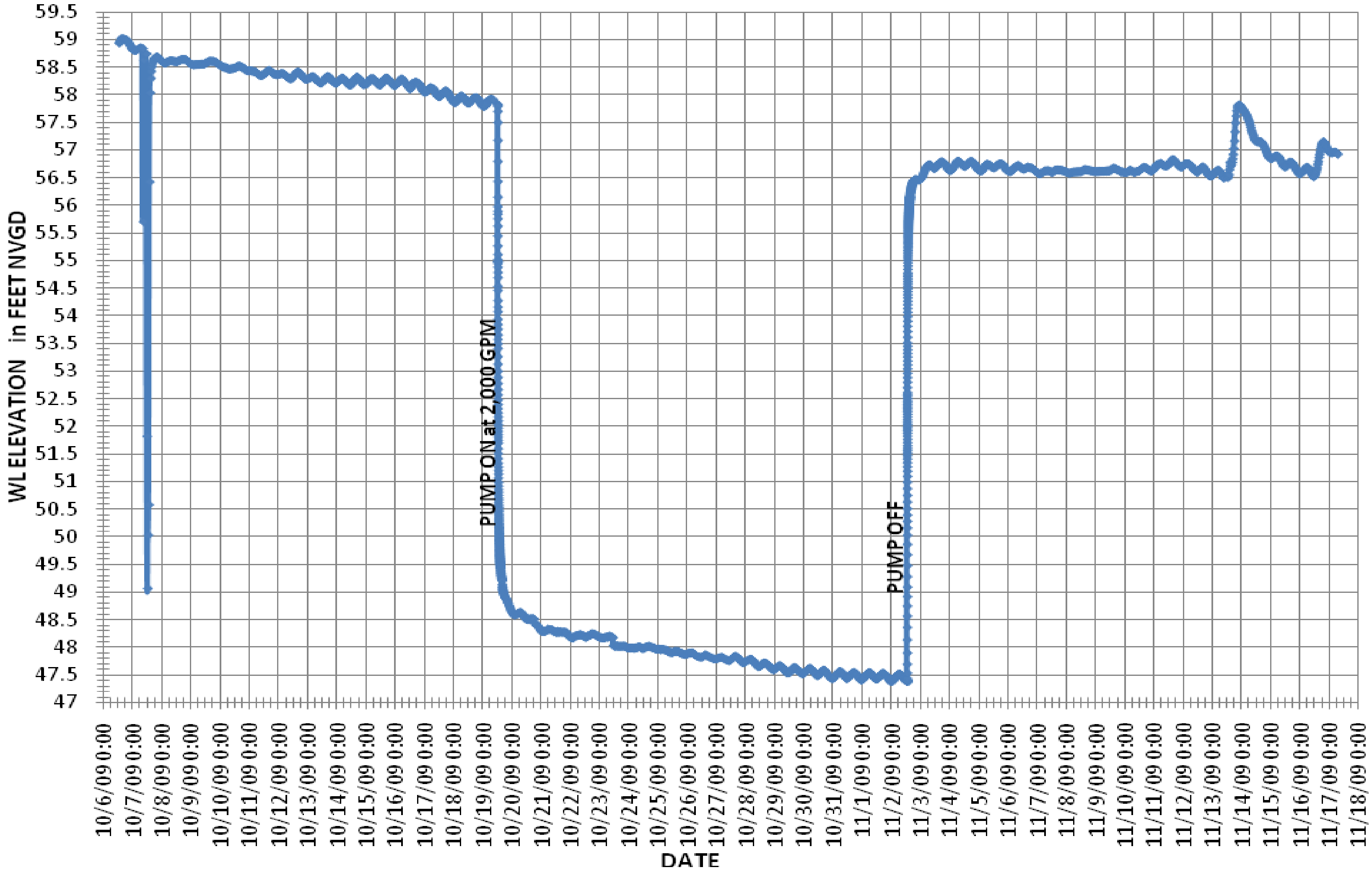


Figure 3-17. Aquifer Performance Test SE-UFA-MW1 and DZ-UFA Zone Water Levels

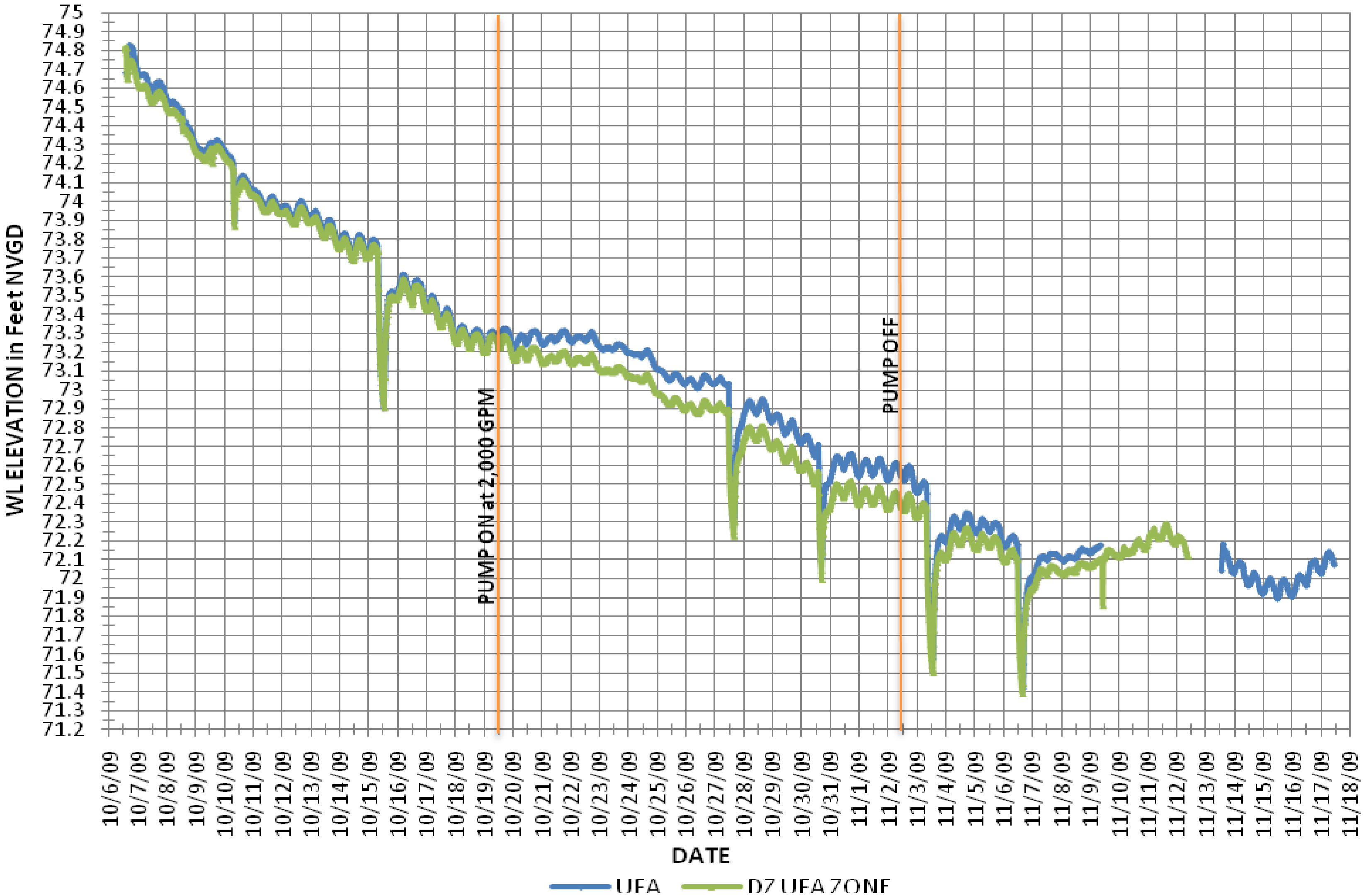


Figure 3-18. Aquifer Performance Test SE-SA-MW1 Water Levels

3.11. Aquifer Performance Test - Corrections to Drawdown Data

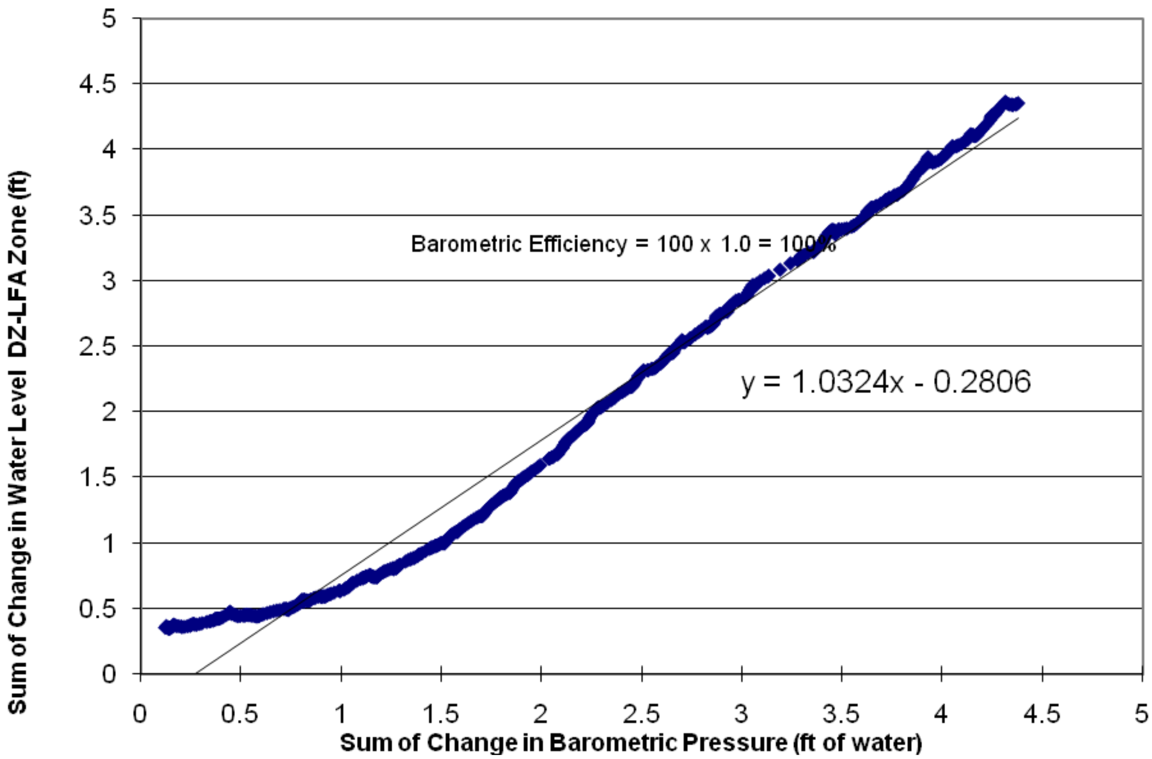
The observed drawdowns resulting from pumping a well during an APT may be influenced by elements for which no allowance is made in the analytical methods that are used to calculate the hydraulic characteristics of the aquifer. When these influences are identifiable and significant, the APT drawdowns can be corrected for these influences as needed. These influences include but are not limited to: natural recharge or drainage of the aquifer, changes in barometric pressure, influence of tide or aquifer pressure, earth tides, water level fluctuations in a river hydraulically connected to the aquifer, differences between day and night evapo-transpiration, and rainfall. The LFA water level data recorded during the pumping Phase 2 of the APT at the LFA zone of SE-DZMW were evaluated for barometric pressure corrections and corrections for regional changes in water levels (recharge or drainage of the aquifer).

3.11.1. Barometric Pressure and Regional Trend Correction

In wells penetrating confined and leaky aquifers, the water levels are continuously changing as the atmospheric pressure changes. When the atmospheric pressure decreases, the water level rises in compensation. When the atmospheric pressure increases, the water level decreases in compensation. By comparing the atmospheric changes, expressed in terms of a column of water, with the actual changes in water levels observed during the (phase 1 period), it is possible to calculate the barometric efficiency of the aquifer (Clark,1967).

The barometric efficiency (BE) is a parameter of the aquifer, and specifies how it reacts to change in atmospheric pressure. The BE value usually ranges between 0.2 and 0.75. High barometric efficiencies reflect high strength and rigid test formations, while low efficiencies indicate highly compressible formations (Spane, 1993). The BE is defined as the ratio of change in water level in a well to the corresponding change in atmospheric pressure. **Figure 3-19** provides the BE of 1.0 that was calculated utilizing the method described by Clark (1967) as applied to the pre-pumping Phase 1 changes in barometric pressure and water levels elevations in feet of water. The BE was applied to the water level data measured at the LFA Zone of the SE-DZMW during pumping Phase 2 utilizing the Solinst software. At a BE of 1.0, the water level corrected for barometric pressure is the same as the water level compensated for barometric pressure. The electronic spreadsheet file SE DEW_APT _BE Calc.xls, which is included in **Appendix L** on CD, includes the calculations of the BE for the barometric pressure correction to the LFA Zone of the SE-DZMW water level elevations.

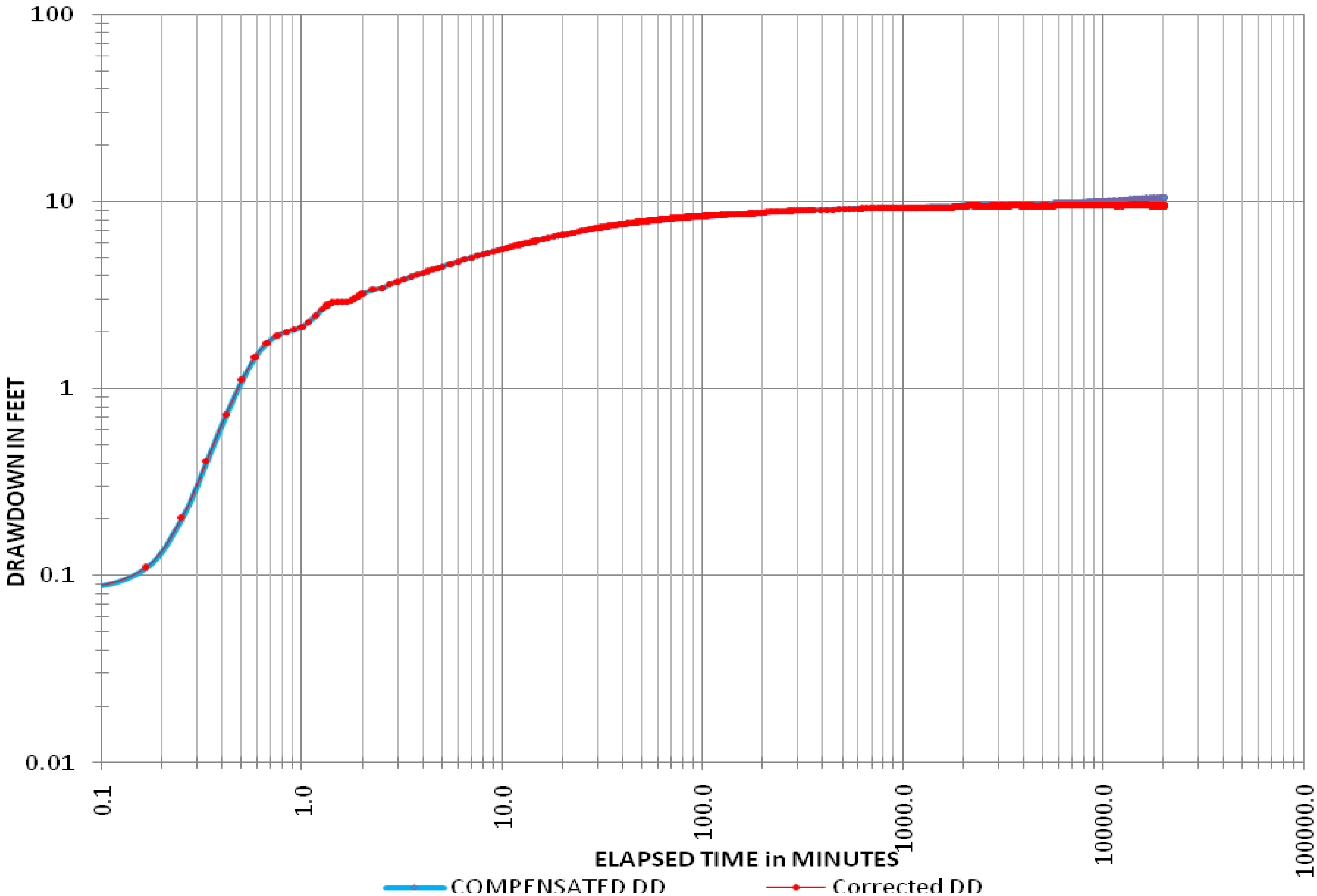
Figure 3-19. Aquifer Performance Test – Barometric Efficiency Calculation



The regional decline of 0.07 ft/ day that was identified from the time series plot of water level elevations for the SE DEW and the LFA zone of SE- DZMW was subtracted from the drawdown calculated from the pumping Phase 2 compensated water level data recorded at the LFA zone of SE- DZMW utilizing an electronic spreadsheet.

Figure 3-20 is a log-log time series plot of the compensated and the corrected drawdown at the LFA zone of SE- DZMW during Phase 2 of the APT. The shape of the drawdown curve when compared to the type curves for a confined aquifer and semi-confined aquifer indicate the uppermost permeable zone of the LFA is semi-confined.

Figure 3-20. Aquifer Performance Test Log-Log Plot of Drawdown at LFA zone of SE-DZMW



The drawdown data measured at the LFA zone of SE-DZMW1 were analyzed utilizing AQTESOLV, which is a software package for the analysis of aquifer tests developed by HydroSOLVE, Inc. (2002). AQTESOLVE was utilized to solve for aquifer parameters by the Theis (1935) and Cooper-Jacob (1946) analytical methods for a pumping test in a confined aquifer, by the Theis (1935) analytical method for a recovery test in a confined aquifer, and by the Hantush-Jacob analytical method (1955) for a pumping test in a leaky aquifer assuming no storage in the aquitard(s) .

The four methods identified above assume:

- Aquifer has infinite areal extent
- Aquifer is homogeneous, isotropic, and of uniform thickness
- Aquifer potentiometric surface is initially horizontal
- Flow to the well is unsteady (transient)
- The aquifer is pumped at a constant discharge rate
- Pumping well is fully or partially penetrating
- Flow to pumping well is horizontal when pumping well is fully penetrating
- Water is released instantaneously from storage with decline of hydraulic head
- Diameter of pumping well is very small so that storage in the well can be neglected

The Theis Method also assumes:

- The aquifer is confined

The Cooper-Jacob Method and the Theis Method for a recovery test also assume:

- The aquifer is confined
- Values of u are small (i.e., distance from the pumping well is small and time since start of pumping is large).

Hantush-Jacob's Method (1955) also assumes:

- The aquifer is semi-confined (leaky)
- Confining bed(s) has infinite areal extent, uniform vertical hydraulic conductivity and uniform thickness
- Confining bed(s) is overlain or underlain by an infinite constant-head source
- Flow in the aquitard(s) is vertical

The AQTESOLVE test results are provided in **Appendix N**. The calculated transmissivity in feet squared per day (ft^2/day) and gallons per day per foot (gpd/ft) and storativity value for the uppermost permeable zone of the LFA and the Leakance in units of per day (day^{-1}) between this zone and overlying and/or underlying units utilizing the four methods where applicable are provided in **Table 3-16**.

Table 3-16. Aquifer Performance Test Hydraulic Properties

Analytical Method	Calculated Transmissivity (ft^2/day)	Calculated Transmissivity (gpd/ft)	Calculated Storativity (unitless)	Leakance (day-1)
Theis	15,300	114,400	0.00030	Not Applicable
Cooper Jacob	19,200	143,600	0.00023	Not Applicable
Theis Recovery	15,700	117,400	Not Applicable	Not Applicable
Hantush Jacob	16,300	121,900	0.00036	4.07E-03

The Leakance (k'/b') was calculated from the Hantush-Jacob leakage factor r/B where: $B = \sqrt{Tb'/k'}$ and k'/b' or Leakance = T/B^2 and:

r = Distance from pumping well
B = Hantush Leakage Factor (L^{-1})
T = Transmissivity of the aquifer (ft^2/day)
k' = hydraulic conductivity of the aquitard overlying aquifer (L/t)
b' = thickness of the overlying aquitard

The corrected measured drawdown of 52.5 feet at SE-DEW while pumping at an average constant rate of 2,013 gpm results in a specific capacity of 38.3 gallons per minute per foot of drawdown (gpm/ft). An estimate of the transmissivity of the uppermost permeable zone of the LFA can be derived from specific capacity utilizing empirical equations based on the Jacob's equation. The empirical equations simplify to the following equation for most cases.

$$T = \left(\frac{Q}{s}\right)2000$$

Where: **T** equals transmissivity in gallons per day per foot;
s equals well drawdown in feet; and
Q equals well yield in gallons per minute.

Well efficiency losses must be accounted for and removed from the drawdown prior to using the above equation. Loss of head in steel pipe from friction is reported in Appendix 17.A Table 1 of *Groundwater and Wells* by Driscoll (1986). Total head loss from pipe friction while pumping 2,000 gpm through 1,150 ft of 18-inch diameter casing is approximately 1.6 ft, which results in a formation head loss of approximately 50.9 ft (52.5 ft – 1.6 ft). Based on this analysis, the transmissivity of the uppermost permeable zone of the LFA is approximately 79,100 gpd/ft or 10,600 ft^2/day.

3.11.2. SE-DEW APT Water Quality Sampling and Results

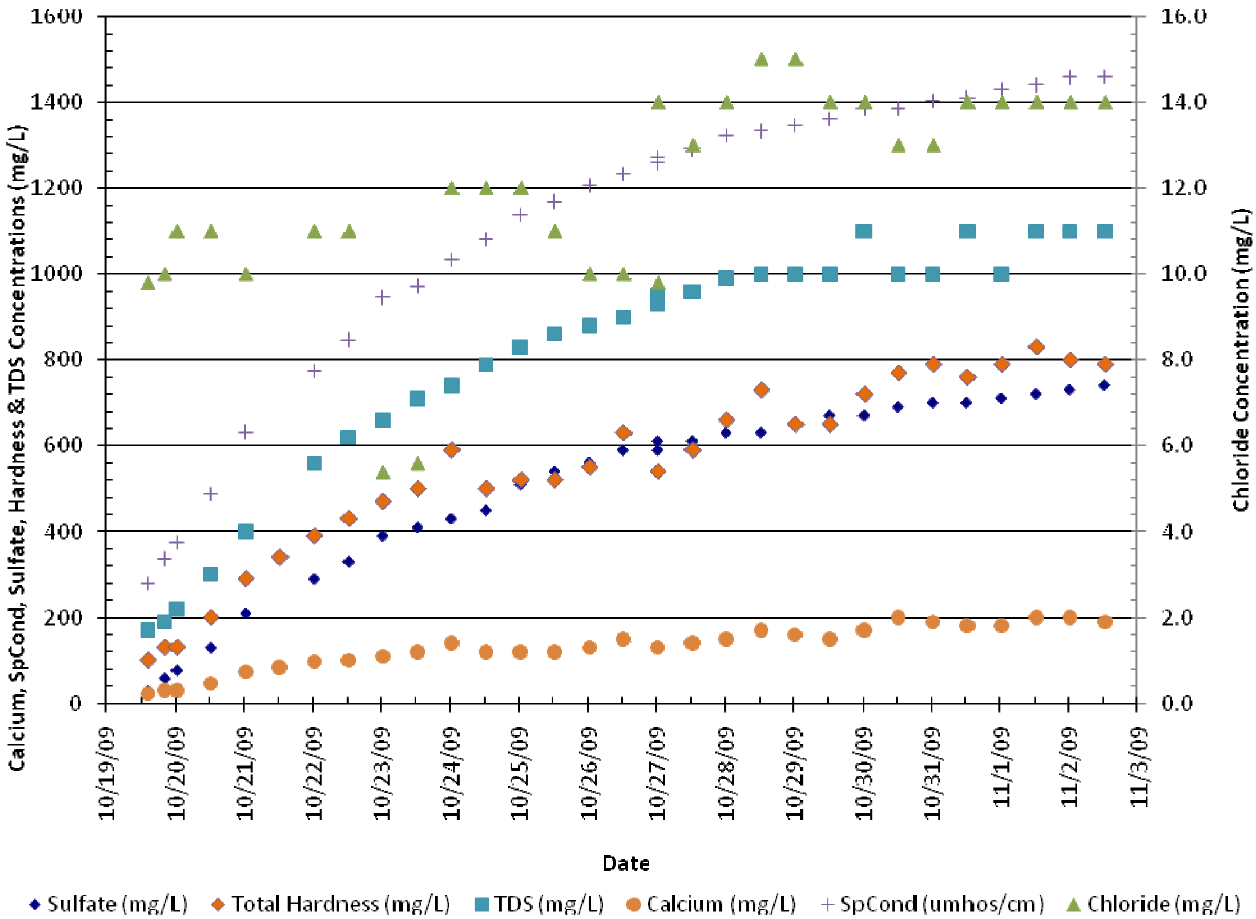
Discharge water samples were collected from a sampling tap at the wellhead twice daily during the pumping phase of the APT to evaluate changes in water quality during pumping. The samples were transported to Southern Analytical Laboratories, Inc of Oldsmar, Florida – FL certification #E84129 for analysis of chloride, sulfate, calcium, magnesium, TDS, specific conductivity and hardness. The laboratory analytical results are presented in **Table 3-17**.

Figures 3-21 is a graph of the changes in the water quality parameters over time. Copies of the laboratory analytical reports are included in **Appendix O**. Specific Conductance and sulfate concentrations showed increasing trends for the duration of the APT. Chloride, total hardness, TDS and calcium concentrations showed increasing trends to some degree, but generally stabilized by the eleventh day of pumping and remained relatively constant for the duration of the APT. The increase in concentrations of sulfate, calcium, magnesium, TDS, specific conductivity and hardness is attributed to flow from the borehole interval open to the LC (1,870 to 2,140 ft bls) that was being purged of fresher water that had flowed into the interval prior to the APT as a result of down hole flow, and possibly from upward migration of water from the LC below 2,140 ft bls. Chloride concentrations remained low during the APT ranging from 10 to 15 mg/L, which is evidence that the LC restricts the flow of high chloride concentration water from LF2 to LF1.

Table 3-17. Aquifer Performance Test Water Quality Changes During Pumping

Date (DD/MM/YR)	**Time** (Hr:Min)	**Chloride** (mg/L)	**Specific Conductance** (µmhos/cm)	**Total Hardness** (mg/L)	**Sulfate** (mg/L)	**TDS** (mg/L)	**Calcium** (mg/L)
10/19/2009	14:30	9.8	280	100	30	170	23
10/19/2009	20:30	10.0	337	130	59	190	30
10/20/2009	0:30	11.0	374	130	78	220	30
10/20/2009	12:30	11.0	488	200	130	300	47
10/21/2009	0:30	10.0	632	290	210	400	73
10/21/2009	12:30	NS	NS	340	NS	NS	84
10/22/2009	0:30	11.0	774	390	290	560	98
10/22/2009	12:30	11.0	847	430	330	620	100
10/23/2009	0:30	5.4	946	470	390	660	110
10/23/2009	12:30	5.6	972	500	410	710	120
10/24/2009	0:30	12.0	1033	590	430	740	140
10/24/2009	12:30	12.0	1081	500	450	790	120
10/25/2009	0:30	12.0	1139	520	510	830	120
10/25/2009	12:30	11.0	1169	520	540	860	120
10/26/2009	0:30	10.0	1206	550	560	880	130
10/26/2009	12:30	10.0	1234	630	590	900	150
10/27/2009	0:30	9.8	1259	540	610	950	130
10/27/2009	0:30	14.0	1273	NS	590	930	NS
10/27/2009	12:30	13.0	1292	590	610	960	140
10/28/2009	0:30	14.0	1323	660	630	990	150
10/28/2009	12:30	15.0	1334	730	630	1000	170
10/29/2009	0:30	15.0	1347	650	650	1000	160
10/29/2009	12:30	14.0	1361	650	670	1000	150
10/30/2009	0:30	14.0	1387	720	670	1100	170
10/30/2009	12:30	13.0	1385	770	690	1000	200
10/31/2009	0:30	13.0	1403	790	700	1000	190
10/31/2009	12:30	14.0	1411	760	700	1100	180
11/1/2009	0:30	14.0	1431	790	710	1000	180
11/1/2009	12:30	14.0	1441	830	720	1100	200
11/2/2009	0:30	14.0	1459	800	730	1100	200
11/2/2009	12:30	14.0	1461	790	740	1100	190
Secondary DW Standard		250	N/A	N/A	250	500	N/A

Figure 3-21. Aquifer Performance Test Water Quality Changes During Pumping



A sample of the discharge water from SE-DEW was collected near the end of the pumping phase of the APT on November 2, 2009 for laboratory analyses to provide a record of the baseline water quality. Water quality samples were collected from a sampling tap at the wellhead by Southern Analytical Laboratories, Inc. of Oldsmar, Florida, while the well was being pumped at a rate of approximately 2,000 gpm. The bottled samples were analyzed for select primary drinking water standards, secondary drinking water standards, and operational parameters including sulfide, magnesium, calcium, dissolve iron, total alkalinity, specific conductance, and turbidity. The laboratory analytical report is included in **Appendix P**.

The results of the laboratory analysis, which are summarized in **Table 3-18,** show that water quality of the uppermost permeable zone of the LFA below the site meets the select Primary Drinking Water Standards including inorganic compounds, volatile organic contaminants, synthetic organic contaminants, and radionuclides, and the Secondary Drinking Water Standards with the exception of Odor, Sulfate and TDS. The detected threshold odor number (TON) of 8 exceeded the Maximum Contaminant Levels (MCL) per Rule 62-550.320 FAC of 3 TON, the detected sulfate concentration of 720 mg/L exceeded the MCL of 250 mg/L, and the detected TDS concentration of 1,100 mg/L exceeded the MCL of 500 mg/L.

Table 3-18. APT Discharge Baseline Sample Laboratory Analytical Results

Primary Drinking Water Standards: Inorganics				
Parameter	**MCL**	**Units**	**Analytical Results**	**Qualifier**
Antimony	0.006	mg/L	0.001	U
Arsenic	0.01	mg/L	0.001	U
Asbestos	7	MFL	0.2	U,S4
Barium	2.0	mg/L	**0.071**	--
Beryllium	0.004	mg/L	0.0001	I
Cadmium	0.005	mg/L	0.0013	U
Chromium	0.10	mg/L	0.004	U
Cyanide	0.20	mg/L	0.005	U
Fluoride	4.0	mg/L	**0.54**	--
Lead	0.015	mg/L	0.001	U
Mercury	0.002	mg/L	0.0001	U
Nickel	0.1	mg/L	0.001	U
Nitrate	10 (as N)	mg/L	0.01	U
Nitrite	1 (as N)	mg/L	0.01	U
Selenium	0.05	mg/L	0.001	U
Sodium	160	mg/L	**6.9**	**--**
Thallium	0.002	mg/L	0.001	U
Primary Drinking Water Standards: Organics				
Parameter	**MCL**	**Units**	**Analytical Results**	**Qualifier**
1,1,1-Trichloroethane	0.2	mg/L	0.0003	U
1,1,2-Trichloroethane	0.005	mg/L	0.0003	U
1,1-Dichloroethene	0.007	mg/L	0.0005	U
1,2,4-Trichlorobenzene	0.07	mg/L	0.0005	U
1,2-Dichloropropane	0.005	mg/L	0.0003	U
2,3,7,8-TCDD (Dioxin)		ng/L	0.0012	U,S18
2,4,5-TP (Silvex)	0.05	mg/L	0.00025	U
2,4-D	0.07	mg/L	0.001	U
Alachlor	0.002	mg/L	0.0002	U
Atrazine	0.003	mg/L	0.00006	U
Benzene	0.001	mg/L	0.0005	U
Benzo(a)pyrene	0.0002	mg/L	0.0001	U
Carbofuran	0.04	mg/L	0.0005	U
Carbon Tetrachloride	0.003	mg/L	0.0003	U
Chlordane	0.002	mg/L	0.00005	U
Cis-1,2-Dichloroethene	0.07	mg/L	0.0002	U
Dalapon	0.2	mg/L	0.001	U
Di(2-ethylhexyl)adipate	0.4	mg/L	0.0003	U
Di(2-ethylhexyl)phthalate	0.006	mg/L	0.001	U
Dibromochloropropane	0.0002	mg/L	0.000005	U
Dichloromethane (Methylene Chloride)	0.005	mg/L	0.0005	U
Dinoseb	0.007	mg/L	0.0005	U
Diquat	0.02	mg/L	0.001	U
Endothall	0.1	mg/L	0.02	U
Endrin	0.002	mg/L	0.0001	U
Ethylbenzene	0.7	mg/L	0.0005	U
Ethylene Dibromide (1,2-Dibromoethane)	2E-05	mg/L	0.000005	U
Glyphosate (Roundup)	0.7	mg/L	0.01	U

Primary Drinking Water Standards: Inorganics				
Heptachlor	0.0004	mg/L	0.00008	U
Heptachlor Epoxide	0.0002	mg/L	0.0001	U
Hexachlorobenzene	0.0001	mg/L	0.00005	U
Hexachlorocyclopentadiene	0.05	mg/L	0.00005	U
Lindane	0.0002	mg/L	0.00006	U
Methoxychlor	0.04	mg/L	0.00005	U
Monochlorobenzene (Chlorobenzene)	0.1	mg/L	0.0005	U
Oxamyl (Vydate)	0.2	mg/L	0.0005	U
p-Dichlorobenzene (1,4-Dichlorobenzene)	0.075	mg/L	0.0005	U
Pentachlorophenol	0.001	mg/L	0.0001	U
Picloram	0.5	mg/L	0.00075	U
Polychlorinated Biphenyl (PCB)	0.0005	mg/L	0.0002	U
Simazine	0.004	mg/L	0.00007	U
Styrene	0.1	mg/L	0.0005	U
Tetrachloroethene	0.003	mg/L	0.0002	U
Toxaphene	0.003	mg/L	0.0005	U
Trans-1,2-Dichloroethene	0.1	mg/L	0.0005	U
Trichloroethene	0.003	mg/L	0.0002	U
Vinyl Chloride	0.001	mg/L	0.0005	U
Xylenes (Total)	10	mg/L	0.0005	U
Primary Drinking Water Standards: Radionuclides				
Parameter	**MCL**	**Units**	**Analytical Results**	**Qualifier**
Radium 226	5	pCi/L	1.3	--
Radium 228	5	pCi/L	0.6	--
Gross Alpha (Incl. Uranium)	15	pCi/L	5.3	--
Radium 226/228 Combined		pCi/L	1.9	--

Primary Drinking Water Standards: Microbiological				
Parameter	**MCL**	**Units**	**Analytical Results**	**Qualifier**
Total Coliform	Absent	Cts/ 100 ml	1	U

Secondary Drinking Water Standards				
Parameter	**MCL**	**Units**	**Analytical Results**	**Qualifier**
Aluminum	0.2	mg/L	0.05	I
Chloride	250	mg/L	**13**	--
Copper	1.0	mg/L	0.003	U
Fluoride	2.0	mg/L	**0.54**	--
Iron	0.3	mg/L	**0.19**	--
Color	15	Color Units	5	U
Foaming Agents (MBAS)	0.5	mg/L	0.05	U
Manganese	0.05	mg/L	0.0027	**I**
Odor	3	TON	**8**	U
pH	6.5 – 8.5	S.U.	**7.5**	--
Silver	0.1	mg/L	0.001	U
Sulfate	250	mg/L	**720**	--
Total Dissolved Solids (TDS)	500	mg/L	**1,100**	--
Zinc	5.0	mg/L	0.003	U

Operational Parameters				
Parameter	**MCL**	**Units**	**Analytical Results**	**Qualifier**
Calcium	DNA	mg/L	**200**	--
Magnesium	DNA	mg/L	**75**	--
Sulfide	DNA	mg/L	**2.0**	--
Dissolve Iron	DNA	mg/L	**0.043**	I
Total Alkalinity	DNA	mg/L	**110**	--
Specific Conductance	DNA	umhos/cm	**1,447**	--
Turbidity	DNA	NTU	**3.9**	--

Notes
Analyses conducted by Southern Analytical Laboratories, Inc. FDOH Cert. No. E84129
Maximum Contaminant Level (MCL) per Rules 62-550.310 and 62-550.320, FAC.

Definitions/ Qualifiers
mg/L = milligrams per Liter
ng/L = nanograms per Liter
pCi/L = Picocurries/Liter
DNA = Does Not Apply
TON: Threshhold Odor Number
umhos/ cm = Micro-mhos per centimeter
NTU: Nephelometric Turbidity Units
S4 = Analysis subcontracted to EMSL, FDOH Cert. No. E86795
U = Analyte was not detected. Indicated concentration is method detection limit.
S18 = Analysis subcontracted to Summit Environmental Technologies, FDOH Cert. No. E87688
I = The reported value is between the laboratory method detection limit and the laboratory practical quantification limit

4.0 Wellhead Completion, Surveying, and Disinfection

4.1. Wellhead Completion

The wellhead of the SE-DEW was completed by cutting the 24-inch diameter casing to a height of approximately three feet above ground surface. A 30-inch diameter flat-face, hub type flange was welded to the casing, which was capped with 1/4-inch thick steel plate with two 1 1/4-inch threaded ports with plugs installed near the center of the plate to allow access to the well for water level monitoring equipment. The steel plate was secured to the flange with a gasket, steel bolts and nuts. Casing, flange, cap, nuts and bolts were coated with a black epoxy to inhibit rust. A square cement pad approximately four feet in diameter and 4-inches thick was poured around the casing. The Well Completion Report is included in **Appendix Q**.

On February 4, 2010, PBS&J installed a Solinst Levelogger Gold Model 3001 water level data transducer and recorder in the SE-DEW at one of the 1 1/4-inch ports. The Levelogger was programmed to record water levels every hour on the hour. Additional information on the Logger and installation setup is provided in **Table 4-1**. A photograph of the completed wellhead is included in **Appendix B**.

Table 4-1 SE-DEW Levelogger Data

Make	Water Fluctuation Range (ft)	Serial Number	Installed Depth Below cap (ft)	Communication Type
F30	29.5	1015841	25 ft	Direct Read Cable

4.2. Surveying

The SE-DEW was surveyed in on February 23, 2010, by a registered professional Florida land surveyors, Accuright Surveys of Orlando, Inc. The survey data shows the land surface, well head, and measuring point elevations referenced to the National Geodetic Vertical Datum of 1929 (NGVD), as well as the exact location of the well based on latitude and longitude on the state plane coordinate system. The Survey Report is included in **Appendix R**. The results of the surveying are listed in **Table 4.2** below.

Table 4-2 SE-DEW Survey Data

Part A – Elevation Data in Feet above NGVD

Land Surface	Top of Pad	Top of Flange	Top of 11/4-inch ports
77.46	78.01	81.23	81.29

Part B – Location Data

NORTHING, FL W	EASTING, FL W	LATITUDE	LONGITUDE
1248435.64	841109.3	27.7670259	-81.428103

4.3. Well Disinfection

Laboratory analysis of the discharge sample collected on November 2, 2009 from the SE-DEW near the end of the aquifer performance test showed that Total Coliform was absent, which indicated that disinfection of the well was not necessary. To confirm the results of the analysis, the drilling contractor collected two additional water samples from the SED-EW On February 04, 2010 using a clean bailer. The samples were transported to Southern Analytical Laboratories, Inc of Oldsmar, Florida for analysis of Total Coliform. The results of the analysis confirmed that Total Coliform was absent, and therefore disinfection of the SE-DEW was not conducted. The Laboratory analytical Report is included in **Appendix S**.

5.0 Summary, Recommendation, and Discussion

5.1. Summary

Construction and testing of the Southeast Deep Exploratory Well (SE-DEW) was initiated on October 8, 2008 and substantially completed on November 17, 2010. Three additional monitoring wells were also constructed at the site to collect hydrogeologic data and to monitor water levels during aquifer performance testing of the SE-DEW. These wells included SE-SA-MW1, which was cased to 40 feet below land surface (ft bls) and screened to 80 ft bls; SE-UFA-MW1, which was cased to 270 ft bls and open hole to 950 ft bls; and SE-DZMW, which was constructed with two open hole intervals – 270 to 1,250 ft bls, which monitored the Avon Park permeable zone and 1,400 to 2,140 ft bls, which monitored the uppermost permeable zone of the Lower Floridan aquifer.

The SE-DEW is located at latitude 27.7670259, longitude -81.428103 in Section 21, Township 31 South, Range 29 East, within Polk County, Florida, east of the City of Frostproof approximately 200 feet north of C.R. 630 and approximately 6,500 feet east of Walk-In-Water Road.

The SE-DEW was constructed to meet construction standards for public water system wells per Chapter 62-532 of the Florida Administrative Code. SE-DEW was constructed to allow the withdrawal of groundwater from the uppermost permeable zone of the Lower Floridan Aquifer through a series of carbon steel casings including 24-inch diameter casing from land surface to 980 feet below land surface (ft bls) and a telescoped 18-inch diameter casing from 250 to 1,400 ft bls. The open borehole section of the SE-DEW was drilled to a depth of 2,512 ft bls, and then back-plugged with cement grout to 2,140 ft bls and reamed to a nominal 18-inch diameter from 1,400 to 2,140 ft bls after packer testing and geophysical logging was completed.

Hydrogeologic units identified during construction and testing of the SE-DEW included the surfical aquifer system (SA), the intermediate confining unit (ICU), the middle semi-confining unit – upper part (MC1), the Avon Park permeable zone (APPZ), the middle semi-confining unit – lower part (MC2), the Lower Floridan aquifer –uppermost permeable zone (LF1), a confining unit with the LFA (LC), and a deeper permeable zone within the LFA (LF2).

The depth from land surface to the base of the SA/ top of the ICU at the SE-DEW was identified at approximately 130 ft bls or 60 ft below the National Geodetic Vertical Datum of 1929 (NGVD) based on a change in lithology from fine quartz sand to a gray-green clay. At the SE-UFA-MW1 the contact between the two units was identified at a depth of 80 ft bls based on a change in lithology from fine quartz sand to a gray-green phosphatic clay.

The base of the ICU/ top of MC1 at the SE-DEW was identified at approximately 290 ft bls or 360 ft below NGVD based on a change in lithology from a phosphatic, fine quartz sand to a white, moderately indurated, fossiliferous limestone. At the SE-UFA-MW1 the contact between the two units was identified at a depth of approximately 250 ft bls based on a decrease in gamma ray emissions from 160 to 20 GAPI on the natural gamma log between 250 and 255 ft bls and a change in lithology from a phosphatic, gray clay to a white, moderately indurated, fossiliferous limestone at 250 to 260 ft bls. The thickness of the ICU at the SE-DEW therefore is approximately 160 feet.

The base of the MC1/ top of the APPZ was identified at approximately 870 ft bls or 800 ft below NGVD based on the testing conducted during the construction of well SE-UFA-MW1 and the SE-DEW. The thickness of MC1 therefore is approximately 580 feet.

The base of the APPZ/ top of MC2 was identified at approximately 1,250 ft bls or 1,180 ft below NGVD based on the static water level measurements, groundwater sampling and air-lift specific capacity testing during drilling activities, and the geophysical logging results. The thickness of the APPZ therefore is approximately 380 feet.

The base of the MC2/ top of LF1 was identified at approximately 1,420 ft bls or 1,350 ft below NGVD based on static water level measurements, groundwater sampling and air-lift specific capacity testing during drilling activities, and the geophysical logging results. The thickness of the MC2 therefore is approximately 170 feet.

The base of the LF1/ top of the LC was identified at approximately 1,870 ft bls or 1,800 ft below NGVD based on static water level measurements, groundwater sampling and air-lift specific capacity testing during drilling activities, and the geophysical logging results. The thickness of the LF1 therefore is 450 feet.

The base of the LC/ top of the LF2 was identified at approximately 2,270 ft bls or 2,210 ft below NGVD based on static water level measurements, groundwater sampling and air-lift specific capacity testing during drilling activities, and the geophysical logging results. The thickness of the LC therefore is 410 feet.

Testing at the SE-DEW consisted of:

- The collection of lithologic samples during drilling operations;
- Measuring static water levels, groundwater sampling, and air-lift specific capacity testing during drilling activities;
- Collection of rock cores for analyses of vertical and horizontal permeability, porosity, and specific gravity;
- Geophysical logging and video surveying during drilling and construction operations;
- Performance of a variable rate step-drawdown test and a 14-day aquifer performance test, which included laboratory analysis of a discharge sample to establish baseline water quality.

Changes in the formations water levels as the pilot hole was advanced from 1,000 to 2,521 ft bls during reverse-air drilling indicate that the vertical component of groundwater flow in the formations is downward and changes in formation permeability, and /or changes in water quality occur at approximately 1,250 ft bls, 1,430 ft bls, 1,550 ft bls, 1,700 ft bls, 1,860 ft bls, 2,290 ft bls and 2,390 ft bls.

Air-lift specific capacity tests results during reverse-air drilling of the nominal 12-inch diameter pilot hole between the depths of 1,033 and 2,417 ft bls indicate significant increases in the permeabilities of the formation materials at 1,712 to 1,743 ft bls, 1,835 to 1,898 ft bls, and 2,369to 2,417 ft bls.

In general, analysis of rock core samples collected between 997 and 2,420 ft bls indicated three zones of permeability in the borehole. Zones of relatively high permeability were detected between 1,005 ft bls and 1,562 ft bls, and at 2,417 ft bls. A zone of relatively low permeability was detected between 1,684 ft bls and 2,413 ft bls.

The gamma-ray log indicated changes in lithology at approximately 250 ft bls, 1,590 ft bls, 1,820 ft bls, 1,930 ft bls, 2,070 ft bls, and 2,150 ft bls. Review of the lithologic log shows dolostone and dolomitic limestone at these depths with traces of quartz and gypsum identified at depths between 1,860 and 1,990 ft bls.

Below 1,480 ft bls, the borehole diameter was relatively gauged to a depth of 1930 ft bls with a maximum diameter of approximately 22 inches at a depth of 1,698 ft within an interval of apparent fractures between 1,670 ft bls and 1,700 ft bls. The caliper log indicated softer material between 1,930 ft bls and 2,170 ft bls, particularly from 2,080 ft bls to 2,170 ft bls where the pilot hole diameter ranged between 14 and 22 inches. The pilot hole diameter was relatively gauged below 2,080 ft to the bottom of the hole at 2,410 ft bls except for two horizontal fractures at 2,330 ft bls and 2,365 ft bls.

The borehole compensated sonic with variable density log indicates intervals of greater porosity at approximately 1,130 to 1,250 ft bls, 1,420 to 1,440, ft bls, 1,570 to 1,600 ft bls, 1,670 to 1,700 ft bls, 1,830 to 1,860 ft bls, and 2,330 to 2,365 ft bls.

The static flow log conducted in the nominal 18-inch borehole between 1,400 ft bls and 2,140 ft bls indicated downhole flow. The dynamic flow log of the same open hole interval, which was pumped at 2,000 gpm indicated:

- 8% of the pumped flow was from the open hole section between 2,140 and 1,860 ft bls;
- 40% of the pumped flow was from the open hole section between 1,860 and 1,710 ft bls;
- 36% of the pumped flow was from the open hole section between 1,710 and 1,690 ft bls, and;
- 16% of the pumped flow was from the open hole section between 1,690 and 1,400 ft bls.

The static temperature log and the fluid conductivity log of the open hole borehole between 1,400 ft bls and 2,140 ft bls showed a substantial increase in temperature and fluid conductivity starting at approximately 1,875 ft bls and continuing to 2,000 ft bls where temperature and fluid conductivity remained relatively constant to the bottom of the borehole at 2,140 ft bls.

The dynamic fluid conductivity log and temperature log of the open hole borehole between 1,400 ft bls and 2,140 ft bls showed a substantial increase in temperature and fluid conductivity starting at approximately 1,860 ft bls and continuing to 1,890 ft bls where temperature and fluid conductivity remained relatively constant to the bottom of the borehole at 2,140 ft bls.

Based upon a visual inspection of the 24-inch diameter casing, the 18-inch diameter final casing, and exposed casing welds via the video survey conducted from land surface to approximately 1,400 ft bls, there were no visible signs of misalignment, cracks or deformities in the well casing and the casing welds appeared continuous.

The sum of the estimated transmissivities from packer tests of the two pilot hole intervals between 980 and 1,324 ft bls, which equals 11,230 feet squared per day (ft^2/day) or 84,000 gallons per day per foot (gpd/ft), added to the estimated transmissivity of 30,040 ft^2/day or 224,700 gpd/ ft for the uppermost permeable zone of the APPZ that was calculated from data collected during the APT of SE-UFA-MW1 provides an estimated transmissivity of 41,270 ft^2/day or 308,700 gpd/ ft for the APPZ (870 to 1,250 ft bls).

The estimated transmissivity of the open hole interval of the completed SE-DEW (1,400 to 2,140 ft bls) based on the packer test results for the pilot hole intervals from 1,535 to 2,188 ft bls is 13,150 ft^2/day or 98,400 gpd/ft.

The estimated transmissivity of the LC based on the packer test results is 1,920 ft^2/day or 14,400 gpd/ ft.

The estimated transmissivity of the LF2 interval from approximately 2,180 to 2,372 ft bls based on the packer test results is 6,900 ft^2/day or 51,600 gpd/ ft.

The estimated Total Dissolve Solids (TDS) concentration from the LF2 interval between 2,280 and 2,373 ft bls and in particular the two horizontal fractures at 2,330 ft bls and 2,365 ft bls, based on geophysical logs and packer tests, is approximately 3,600 mg/L.

Laboratory analysis of water samples collected from packer tests showed that the TDS concentration of water below approximately 2,370 ft bls was greater than 10,000 mg/L and therefore the LFA below this depth is not a potential source of drinking water as defined in Chapter 62-520 of the Florida Administrative Code, which defines an Underground Source of Drinking Water (USDW) as an aquifer with a TDS concentration of less than 10,000 mg/L.

The specific capacity of the SE-DEW was calculated to be 38.3 gallons per minute per foot of drawdown while pumping the well at a rate of 2,013 gallons per minute (gpm) for the14-day APT.

Water levels measured at the on-site wells during the APT of the SE-DEW showed declining trends at relatively constant rates during the pre-pumping and recovery phases of the APT, which are assumed to reflect the regional trends in water levels of the SA, APPZ and the LFA. The rates of decline were approximately 0.07 ft/day at the LF1 and UFA zones of the SE-DZMW and at SE-UFA-MW1. The rate of decline at SE-SA-MW1 was less at approximately 0.04 ft/ day.

Monitor of water levels at SE-SA-MW1 during the 14-day APT showed that there was no discernable impact to the water table of the SA at the site from pumping LF1 at average constant pumping rate of 2,013 gpm.

Monitor of the APPZ water levels at SE-DZMW, which is located 200 feet from SE-DEW, during the 14-day APT showed a measured drawdown of approximately 0.2 feet in the potentiometric surface of the APPZ that is attributed to pumping LF1 at average constant pumping rate of 2,013 gpm.

The drawdown measured during the APT at the LFA zone of the DZMW, which is located approximately 200 feet east of SE-DEW was utilized to solve for hydraulic parameters of LF1 by the Theis (1935) and Cooper-Jacob analytical methods (1946) for a pumping test in a confined aquifer, the Theis analytical method (1935) for a recovery test in a confined aquifer, and the Hantush-Jacob analytical method (1955) for a pumping test in a leaky aquifer assuming no storage in the aquitards. The results of the analyses indicated that the transmissivity of LF1 ranges between 114,000 and 143,600 gpd/ft or 15,300 and 19,200 ft^2/day. The calculated storativity values ranged between 3.6 $\times 10^{-4}$ and 2.3 $\times 10^{-4}$. The leakance value calculated from the Hantush-Jacob analytical method is 4.07 $\times 10^{-3}$ per day.

Discharge water samples were collected twice daily during the pumping phase APT for analysis of chloride, sulfate, calcium, magnesium, TDS, specific conductivity and hardness by a certified laboratory. Specific Conductance and sulfate concentrations showed increasing trends for the duration of the APT. Chloride, total hardness, TDS and calcium concentrations showed increasing trends to some degree, but generally stabilized by the eleventh day of pumping and remained relatively constant for the duration of the APT. The increase in concentrations of sulfate, calcium, magnesium, TDS, specific conductivity and hardness is attributed to flow from the borehole interval open to the LC (1,870 to 2,140 ft bls) that was being purged of fresher water that had flowed into the interval prior to the APT as a result of down hole flow and possibly from upward migration of water from the LC below 2,140 ft bls. Chloride concentrations remained low during the APT ranging from 10 to 15 mg/L, which is evidence that the LC restricts the flow of high chloride concentration water from LF2 to LF1.

The results of the laboratory analysis of the baseline water quality sample show that water quality of LF1 below the site meets select Primary Drinking Water Standards including inorganic compounds, volatile organic contaminants, synthetic organic contaminants, and radionuclides and the Secondary Drinking Water Standards with the exception of Odor, Sulfate and TDS. The detected threshold odor number (TON) of 8 exceeded the Maximum Contaminant Levels (MCL) per Rule 62-550.320 FAC of 3 TON, the detected sulfate concentration of 720 mg/L exceeded the MCL of 250 mg/L, and the detected TDS concentration of 1,100 mg/L exceeded the MCL of 500 mg/L.

5.2. Recommendation

In the eventuality the SE-DEW is used as a water supply well, PBS&J recommends back-plugging the LS section between 1,870 and 2,140 ft bls with cement grout to reduce the flow of high calcium and sulfate concentration water from that depth during pumping.

5.3. Discussion

An assessment of potential drawdown impacts to "Ridge Lakes" within the Southwest Florida Water Management District (SWFWMD) resulting from a new withdrawal of 30 MGD from the uppermost permeable zone of the Lower Floridan aquifer (LF1) at the SE-DEW site was conducted by applying the Hantush-Jacob equation for a semi-confined aquifer utilizing an analytical model that simulates two-dimensional transient groundwater flow. A Technical Memorandum that provides details on the assessment method and background information is included in **Appendix T**.

Aquifer parameters of transmissivity, storage coefficient, and leakage for LF1 utilized in the equation were calculated from water level drawdown data obtained during the 14-day aquifer performance test of the SE-DEW while being pumped at a constant rate of 2,000 gpm.

For the purposes of an impact assessment, any lowering (>0.0 feet) of the potentiometric surface of the Floridan aquifer below a "Ridge Lake" is considered an impact. The modeling results show that the drawdown in the potentiometric surface of LF1 is less than 0.01 feet at the SWFWMD "Ridge Lakes. Therefore, based on the modeling results and the 0.0 feet drawdown criterion, a new withdrawal of 30 MGD from LF1 at the SE-DEW site would not impact "Ridge Lakes" in the SWFWMD.

In addition, the modeling results show that the drawdown in LF1 from a withdrawal of 30 MGD at the SE-DEW site is less than 0.01 feet at Stressed Lakes within the Southern Water Use Caution Area of the SWFWMD and Lake Kissimmee.

6.0 References

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