Polk Regional Water Cooperative

Technical Memorandum
SOUTHEAST LFA WATER PRODUCTION FACILITY
TEST WELL 3 COMPLETION REPORT

FINAL | May 6, 2024

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Southwest Florida Water Management District

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Contents

Appendices

Tables

Figures

Abbrevations

ACS	A.C. Schultes
AWS	Alternative water supply
APT	Aquifer performance test
APHPZ	Avon Park high permeability zone
bls	Below land surface
°C	Degrees Celsius
CY	Cubic yard
d	Day
DIL	Dual-induction laterolog
e.g.	Exempli gratia (Latin for "for example")
et al	Et alia (Latin for "and others)
FAS	Floridan aquifer system
FRP	Fiberglass reinforced plastic
Ft	Feet
GAPI	American Petroleum Institute (API) gamma ray units
gpm	Gallons per minute
GMU	Glauconite marker unit
HCU	Hawthorn confining unit
ID	Inner diameter
i.e.	Id est (Latin for "that is")
in	Inch
K	Hydraulic conductivity
K_z	Vertical hydraulic conductivity
$K_{x,y}$	Hydraulic conductivity in the horizontal (x and y) directions
LFA	Lower Floridan aquifer
LFAWPF	Lower Floridan Aquifer Water Production Facility
max	Maximum
MCU	Middle confining unit
MGD	Million gallons per day
Mg	Million gallons
mg/L	Milligrams per liter
min	Minimum
MLLW	Mean Lower Low Water
µ	Theis dimensionless time parameter
µS/cm	MicroSiemens per centimeter
NAVD	North American Vertical Datum of 1988
OBI	Optical borehole imaging
OD	Outer diameter
PRWC	Polk Regional Water Cooperative
Psi	Pounds per square inch
pC/L	PicoCuries per liter
PVC	Polyvinyl chloride
PW	Production well
Q	Pumping rate
RO	Reverse osmosis
RWSP	Regional Water Supply Plan
(s) ft	Drawdown in feet
s'	Residual drawdown

SA	Surficial Aquifer
SC	Specific conductance
SDT	Step-drawdown test
SE-DEW	Southeast deep exploratory well
SE-TPW	Southeast test production well (at SELFA WPF)
SE-TPW3	Southeast test production well 3
SELFA WPF	Southeast Lower Floridan Aquifer Water Production Facility
SFWMD	South Florida Water Management District
SI	Saturation index
SP	Spontaneous potential
std units	Standard units
SWFWMD	Southwest Florida Water Management District
t	Time
t'	Residual time
T	Transmissivity
TDS	Total dissolved solids
TPW3	Test production well 3
TPW3-LFA	Test production well 3 Lower Floridan Aquifer monitor well
TPW3-SA	Test production well 3 surficial aquifer monitor well
TPW3-UFA	Test production well 3 Upper Floridan aquifer monitor well
µmhos/cm	Micromhos per centimeter
UFA	Upper Floridan aquifer
USDW	Underground source of drinking water
W(µ)	Theis well function

1 INTRODUCTION

1.1 Background

Polk County has traditionally relied on fresh groundwater from the Upper Floridan aquifer (UFA) as its primary water source for urban, agricultural, and industrial uses. Previous central Florida planning efforts and the South Florida Water Management District (SFWMD) and Southwest Florida Water Management District (SWFWMD) water supply planning and assessment investigations have documented that the rate of groundwater withdrawal in certain areas of Polk County is either rapidly approaching, or has surpassed the maximum rate that can be sustained without causing harm or adverse impacts to the water resources and related natural systems, as documented in the Central Florida Water Initiative (CFWI) 2020 Regional Water Supply Plan (RWSP).

The SWFWMD's November 2015 RWSP for the Heartland Planning Region identified that an increase in water supply will need to be developed to meet demands in Polk County from 2010 through 2035. Brackish groundwater from the Lower Floridan aquifer (LFA) has been identified as a potential key alternative water supply (AWS) source for public supply.

The Polk Regional Water Cooperative (PRWC) was formed to respond to Polk County's water supply challenge. The Cooperative was created by an interlocal agreement to provide a mechanism for innovative regional cooperation amongst local governments. This regional cooperation includes developing, recovering, storing, and supplying water for county and municipal purposes to reduce adverse environmental effects of excessive withdrawals of water from concentrated areas. The intent of the Cooperative is to encourage the development of fully integrated robust public water supply systems comprised of diverse sources managed in a manner that takes full advantage of Florida's intense climatic cycles to ensure reliable, sustainable and drought resistant systems, and which maximizes the use of AWSs to the greatest extent practicable. To accomplish this effort, the Cooperative intends to access State funds and other private or public funding sources to develop AWSs.

The PRWC has elected to pursue two LFA brackish groundwater desalination projects: the Southeast Lower Floridan Aquifer Water Production Facility (SELFA WPF) and the West Polk Lower Floridan Aquifer Water Production Facility.

Data on the hydrogeology and water quality of the SELFA WPF wellfield are available from a deep exploratory well program conducted in 2008-2009 at the south end of the planned wellfield alignment (SE-DEW site) and from a test well program at the planned SELFA WPF site (SE-TPW site) in 2018-2019 (TeamOne 2019). Data from an additional site along the proposed SELFA WPF wellfield was determined to be needed by the SWFWMD, its third party peer-reviewer (CDM Smith) and the PRWC consultants (TeamOne). Test production well 3 (SE-TPW3) was installed to obtain hydrogeological data to support the design of the SELFA WPF and to serve as a production well for the facility. The locations of test production well 3 (SE-TPW3) and other LFA test wells in its vicinity are mapped in **Figure 1-1**.

1.1 Purpose

The primary purpose of this project is to obtain additional hydrogeological data at the wellfield for the SELFA WPF.

The SE-TPW3 program is intended to increase our understanding of the LFA in the central part of the SELFA WPF wellfield. A key issue is whether hydrogeological conditions and aquifer water quality extrapolated between the SE-DEW and SE-TPW site are appropriate for the central part of the wellfield. This information is needed for the final design of the wellfield and water treatment system. Specific objectives of the TPW3 drilling and testing program include:

1) Confirmation of raw water productivity (potential well yields) within the LFA,
2) Obtaining data on the water chemistry of the LFA production zone and adjoining strata,
3) Evaluating the hydraulic properties of the LFA production zone and adjoining confining strata;
4) Quantitatively evaluating the degree of confinement between the UFA and LFA and within the LFA.

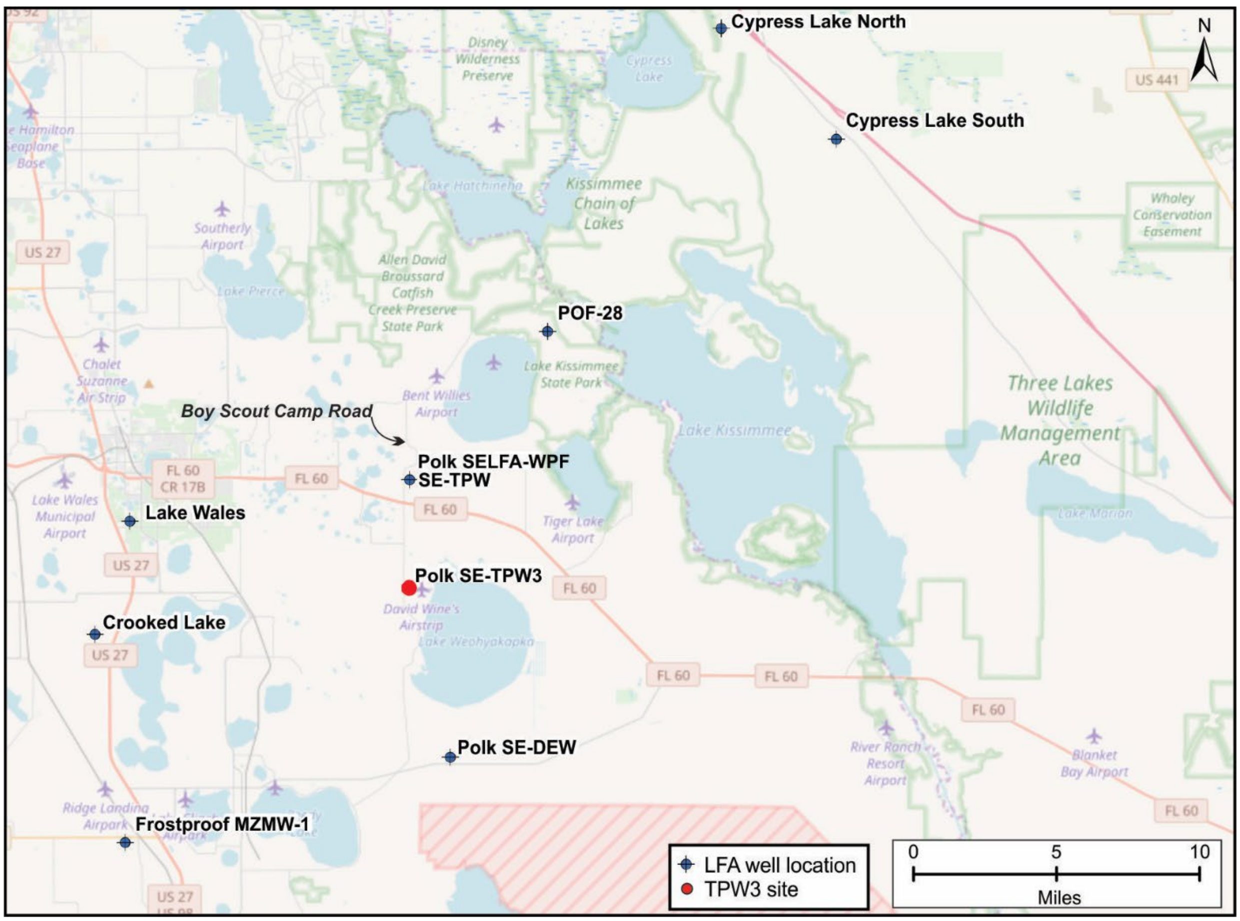

Figure 1-1 Map showing locations of the project site and nearest LFA wells

SE-TPW3 will serve as one of the initial production wells for the SELFA WPF and is designated as production well no. 12 (PW-12).

1.3 Project Description

The drilling program at the TPW3 site included construction of the following test/monitor wells:

1) Surficial aquifer monitor well TPW3-SA to monitor surficial aquifer water level fluctuations during the APT.

2) Upper Floridan aquifer well TPW3-UFA to monitor UFA water levels. TPW3-UFA was finished as an UFA monitor well open to the Ocala Limestone.

3) Lower Floridan Test/Monitor Well, TPW3-LFA, served as the exploratory well for the project. The primary purpose of this well is to obtain data on water quality-versus depth profile and variations in transmissivity within the LFA. TPW3-LFA served as a production zone monitor well for the constant rate discharge test (aquifer performance test or APT). Lithologic samples were collected during advancement of the pilot hole and water quality samples obtained to track how water quality (salinity) changes with depth. Five packer tests were performed during the drilling of the pilot hole in the LFA. Geophysical logging was also conducted within the pilot hole and used for the characterization of aquifers and confining strata.

4) Lower Floridan Production Well, TPW3, was constructed as a production well for the SELFA WPF (PW-12) and as the pumped well for the APT. The use of a monitor well open to the same interval as the test/production well allowed for analytical solutions for transmissivity, storativity, and leakance.

The well design and construction sequencing plans were documented in Technical Specifications prepared by TeamOne in December of 2021, which were incorporated into the bid package.

The TPW3 site is located near the intersection of Walk-in-Water Road and Cypresswood Drive, approximately 9 miles southeast of the Lake Wales city center and 2.5 miles south of State Route 60 (**Figure 1-1**). Well TPW3 is located south of Cypresswood Drive and the LFA monitor well is located north of Cypresswood Drive (**Figure 1-2**).

The TPW3 is located near the eastern edge of the Lake Wales Ridge physiographic unit. The land surface in the project site area slopes to the east, first relatively steeply to small lakes located immediately to the east, and then toward Lake Weohyakapka, which is located approximately 0.8 to 1.0 miles to the east. The land surface elevation at the well sites is approximately 103 to 105 ft NAVD.

The land use in the TPW3 vicinity is mixed agricultural and residential. The Walk-in-Water Estates community is located between Walk-in-Water Road and Lake Weohyakapka to the east. Orange groves and cattle pasture are located on the west side of Walk-in-Water Road.

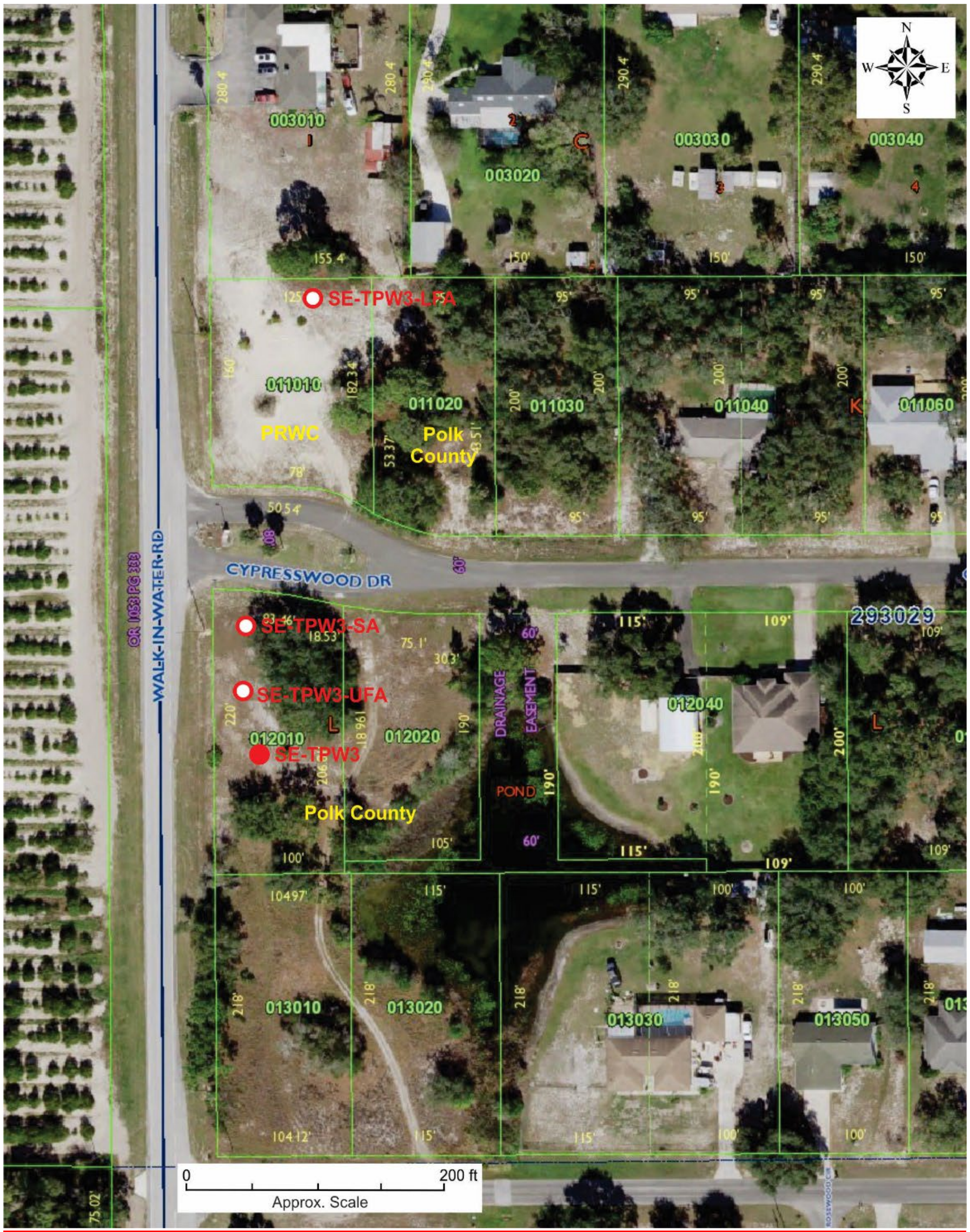

Figure 1-2 Aerial photograph of the TPW3 site showing well locations and property lines

2 EXPLORATORY DRILLING AND WELL CONSTRUCTION

Technical specifications for the SE-TPW3 drilling and testing plans were prepared by TeamOne. A.C. Schultes of Florida Inc. (ACS) was contracted by the PRWC to construct the four wells at the TWP3 site. The contract with ACS was executed on September 21, 2022. A notice to proceed was issued on November 7, 2022. Construction of wells SE-TPW3-LFA and SE-TPW3 began in late November. Construction oversight was provided by WSP USA and ASRUs LLC. The project was substantially complete on February 29, 2024.

Wells SE-TPW3-UFA, SE-TPW3-LFA, and SE-TPW3 have open-hole completions. Well SE-TPW3-SA has a screened completion. Copies of the well construction permits are provided in **Appendix A**. A casing summary is provided in **Table 2-1** and copies of the casing mill certificates are provided in **Appendix B**. Detailed construction chronologies for the four wells are provided in **Appendix C**.

Table 2-1 Casing summary

Casing depth (ft bls)	Material	Inner Diameter (in)	Wall thickness (in)
SE-TPW3-SA			
75	PVC, Sch. 40, Certa-Lok	4	0.237
SE-TPW3-UFA			
220	Carbon steel, ASTM A53B, Sch. 40	12	0.375
290	Carbon steel, ASTM A53B, Sch. 40	6	0.28
SE-TPW3			
58	Carbon steel, ASTM A53B, Sch. 40	43.25	0.375
102	Carbon steel, ASTM A53B, Sch. 40	35.25	0.375
310	Carbon steel, ASTM A53B, Sch. 40	29.25	0.375
1,400	Redbox 1000 Fiberglass reinforced plastic	16.37	0.59
SETPW3-LFA			
106	Carbon steel, ASTM A53B, Sch. 40	23.25	0.375
350	Carbon steel, ASTM A53B, Sch. 40	17.25	0.375
1,400	Carbon steel, ASTM A53B, Sch. 40	12	0.375
Carbon steel: API 5L Grade B, ASTM A 53 Grade B or Spiral Weld A 139 Grade B.			

2.1 Surficial Aquifer Well TPW3-SA

The surficial aquifer monitor well (TWP3-SA) was installed using a dual-rotary (DR) rig, which was mobilized on-site on April 5, 2023. An 8-inch I.D. steel casing was advanced to 75 feet below land surface (ft bls), total depth. The casing was then conditioned to remove internal sediment in preparation for setting the casing and screen. On April 17, 2023, a 4-inch I.D. Certa-Lok PVC casing with 20 ft of 0.020" slot screen was installed and the following day 15 bags of 20/30 filter sand, 5 bags of 40F fine sand, and 5 bags (94-lbs each) of cement were emplaced. The casing was cemented to land surface on April 20, 2023. The temporary steel casing, used to stabilize the borehole, was progressively lifted as the filter pack, sand, and cement were added. TWP3-SA was developed for 4 hours on April 21, 2023, completing the well construction (the wellhead was installed later). An as-built well construction diagram is provided as **Figure 2-1.**

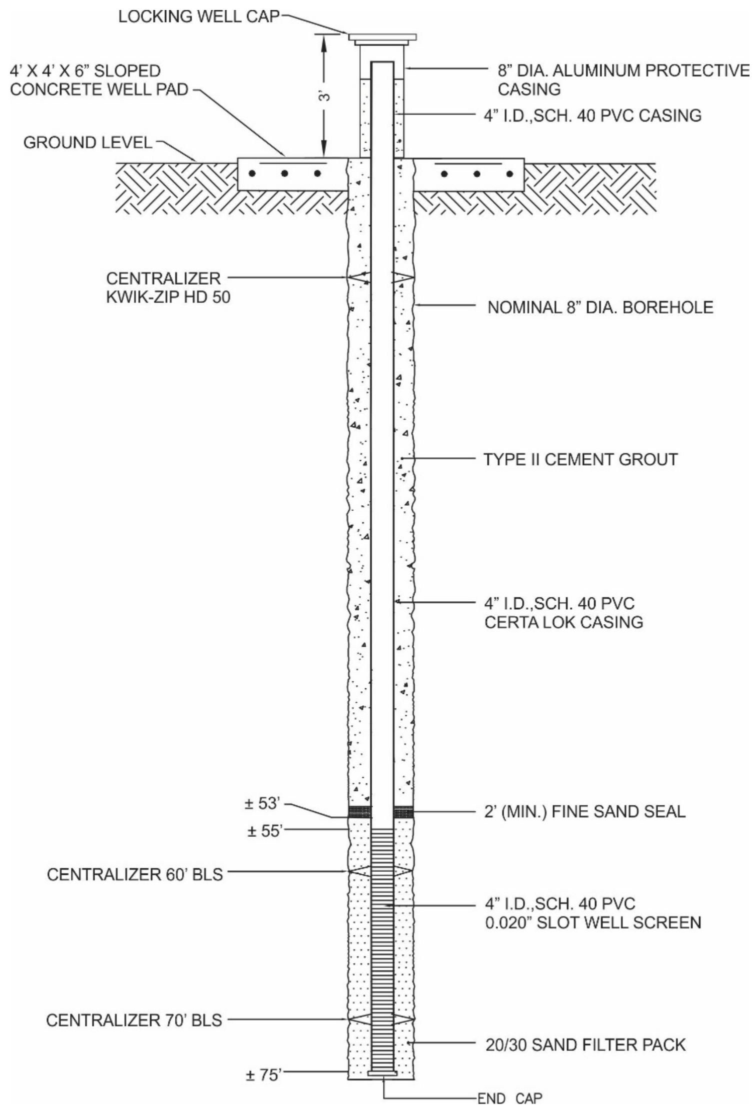

Figure 2-1 SE-TPW3-SA as-built diagram

2.2 Upper Floridan Aquifer Construction Water/Monitor Well WP-UFA

Construction of Upper Floridan aquifer supply/monitor well WP-UFA began on April 24, 2023. A 12-inch I.D. (12.75-inch O.D.) carbon steel casing was driven in place to 220 ft bls. A nominal 12-inch borehole was then drilled to 400 ft bls (total depth) using the reverse-air rotary method. A 6-inch I.D. carbon steel casing with two cement baskets was installed to 290 ft bls. The bottom of the casing was cemented in place using a total of 14 sacks (94 lbs) of neat Type II cement. The remaining annulus was cemented in placed with 11 cubic yards of neat Type 1L cement slurry.

An as-built well construction diagram is provided as **Figure 2-2.** The construction of TPW3-UFA was completed on May 24, 2023.

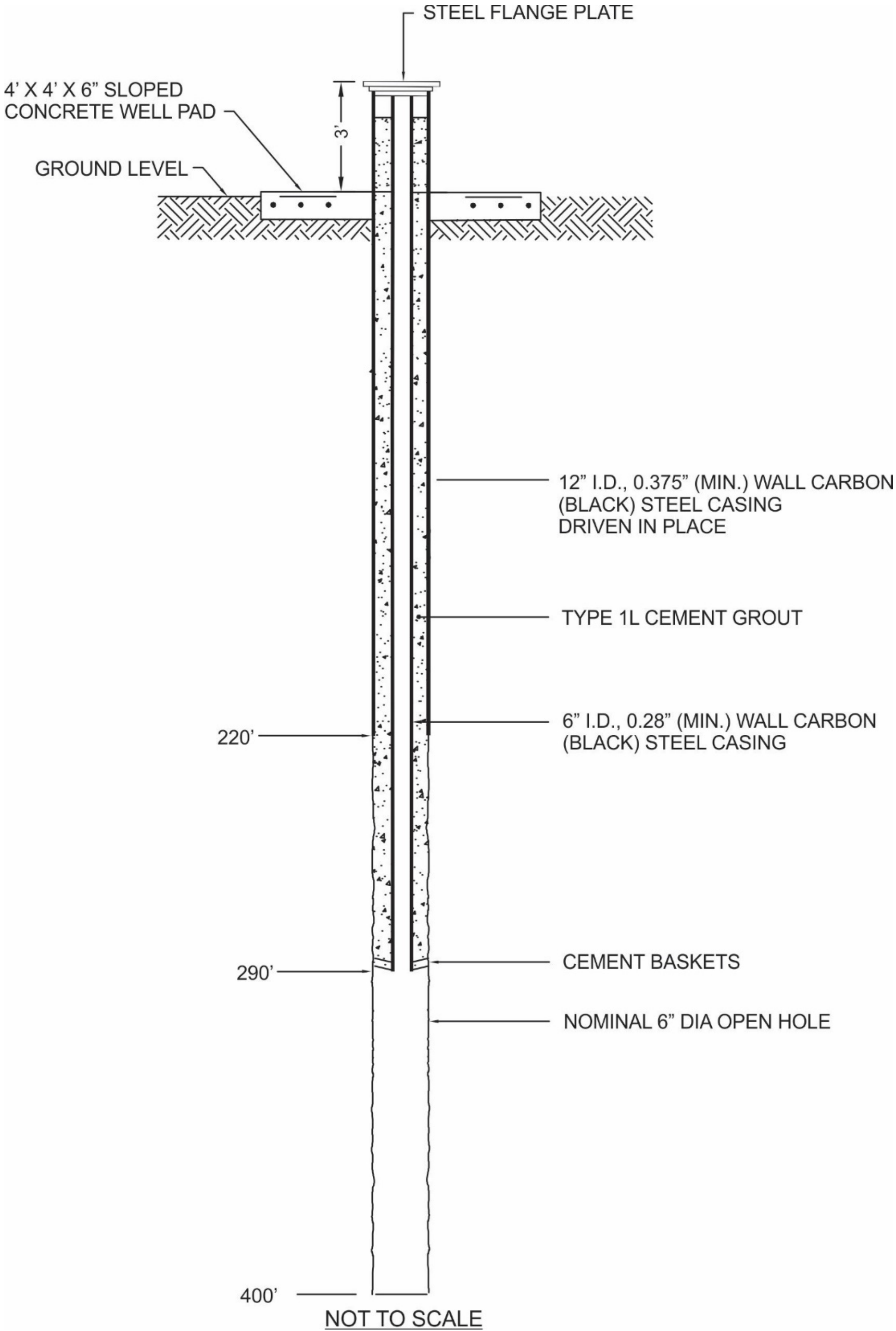

Figure 2-2 SE-TPW3-UFA as-built diagram

2.3 Lower Floridan Aquifer Test Production Well SE-TPW3

RW Harris was subcontracted to auger a nominal 50-inch diameter borehole to 58 ft bls, which was completed on November 22, 2023. A 44-inch O.D., 0.375-inch wall pit casing was installed and cemented to land surface.

A nominal 44-inch borehole was then augered to 103 ft bls and a 36-inch O.D. conductor casing was installed to 102 ft bls and cemented in placed with 13 cubic yards of neat cement.

A 12 ¼-inch diameter pilot hole was drilled to 350 ft bls using the mud-rotary method, which was then reamed to a nominal 36-inches. Geophysical logging was attempted but the tool was blocked by an obstruction at about 150 ft bls. The drill string was tripped back in and the hole cleared to total depth. A caliper and gamma ray log was successful run on April 26, 2023.

An attempt was made to install the 30-inch O.D. (0.375-in wall) surface casing to 350 ft bls. The casing could not be lowered past 310 ft bls, which was deemed to be satisfactory based on the site-specific hydrogeology. The casing was cemented to land surface with 20 cubic yards of neat cement.

A center punch was performed and the pilot hole for the production casing was drilled to 1,400 ft bls using the reverse-air rotary method. The pilot hole was geophysically logged on July 7, 2023, and then reamed to 1,400 ft bls. The reamed hole was geophysically logged on September 22, 2023.

A nominal 18-inch diameter FRP casing was installed to 1,400 ft bls. Multiple cement drinking zones were encountered during grouting, which were bridged using pea gravel. The FRP casing was cemented to land surface using 69 cubic yards of neat Type 1L cement, 108 cubic yards of 6% bentonite type 1L cement, and approximately 174 linear feet of gravel. Grouting was completed on October 23, 2023.

A nominal 16-inch diameter open hole (15 ¾-inch diameter bit) was drilled to 1,900 ft bls from November 2, 2023 to December 12, 2023. An as-built construction diagram is provided as **Figure 2-3**. The open hole was geophysically logged on February 21, 2024.

The bore hole video survey and caliper log run on February 21, 2024, revealed that a good grout seal is present at the base of the casing, that the open hole is clear to total depth (1,900 ft bls), and that there is no evidence that would indicate the casing lacks mechanical integrity.

2.4 Lower Floridan Aquifer Monitor Well SE-TPW3-LFA

TPW3-LFA was drilled as the exploratory well for the project. A 24-inch steel diameter pit/conductor casing was installed through the surficial sands to 106 ft bls using a dual-rotary drilling rig. A rotary rig was then mobilized and a pilot hole (12 ¼-inch diameter) was drilled to 350 ft bls using the mud-rotary method. The pilot hole was then reamed with a 23-inch diameter bit to 353 ft bls and geophysically logged on January 18, 2023. An 18-inch diameter surface casing was set to 350 ft bls and cemented in place to land surface with 21 cubic yards of neat Type 1L cement on January 19, 2023.

A center punch was performed and then the drilling system was then converted to the reverse air reverse-air rotary method. A nominal 12 ¼-inch diameter pilot hole was drilled to 1,400 ft bls from January 30 to February 10, 2023. The pilot hole was geophysically logged on February 14, 2023, and then reamed with a 17-inch diameter bit to 1,407 ft bls from February 14 to 23, 2023.

After geophysically logging the reamed hole, a 12-inch diameter steel casing was installed to 1,400 ft bls. The 12-inch diameter steel casing was cemented to land surface using 56.65 cubic yards of neat Type 1L cement and 54 cubic yards of 8% bentonite type 1L cement. Approximately 3 cubic yards of gravel was used to bridge a flow zone at about 910 ft bls.

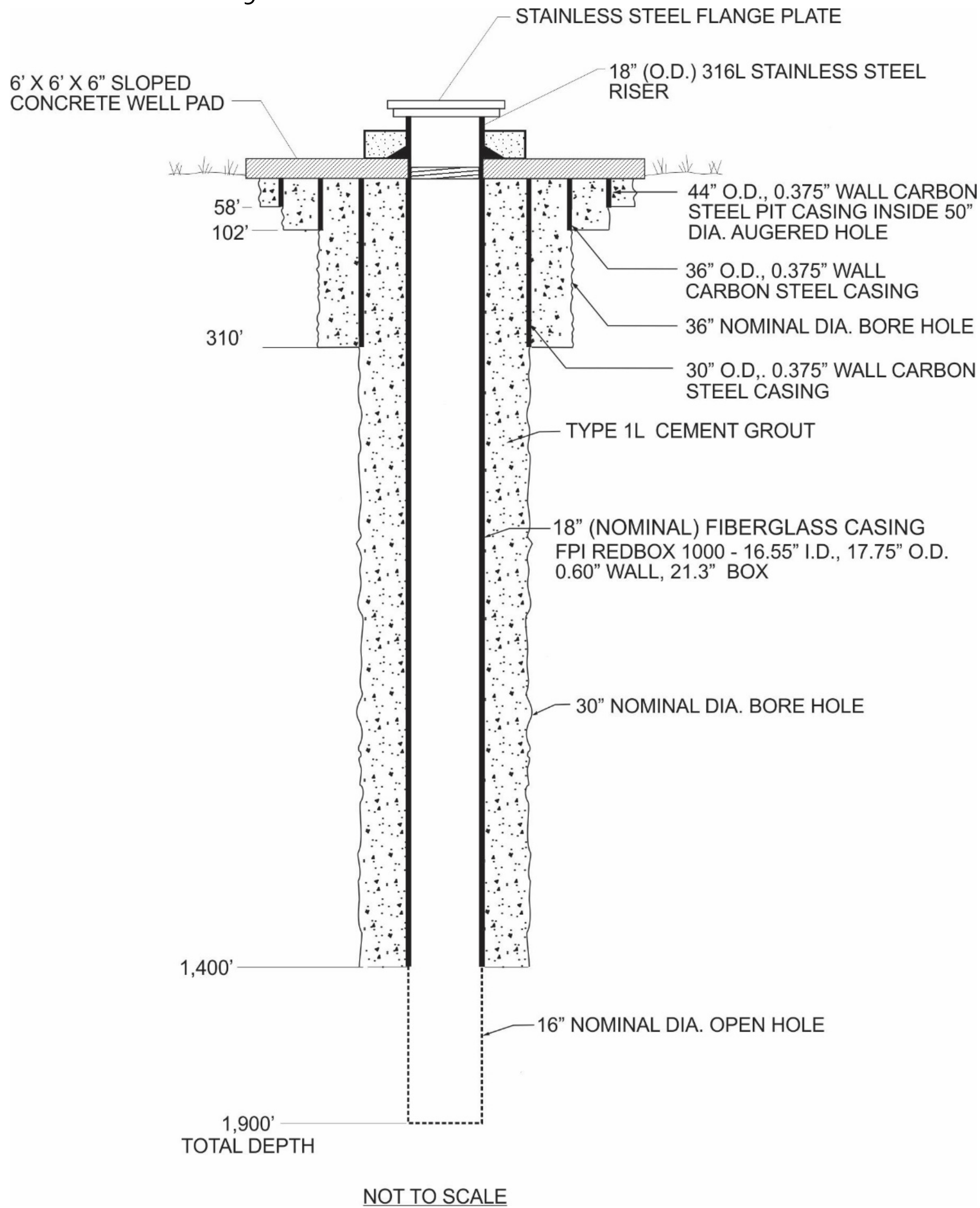

Figure 2-3 SE-TPW3 as-built diagram

An open hole was drilled with an 11 7/8-inch diameter bit to 2,558.6 ft bls from March 31, 2023, to May 3, 2023. The open hole was geophysically logged including an optical bore imaging log (OBI) run by the U.S. Geological Survey. Five packer tests were performed to obtain data on aquifer hydraulics and water quality.

After testing was completed, the open-hole was back-plugged with cement to 1,908.6 ft bls, the base of the production zone.

An as-built construction diagram of SE-TPW3-LFA is provided as **Figure 2-4**.

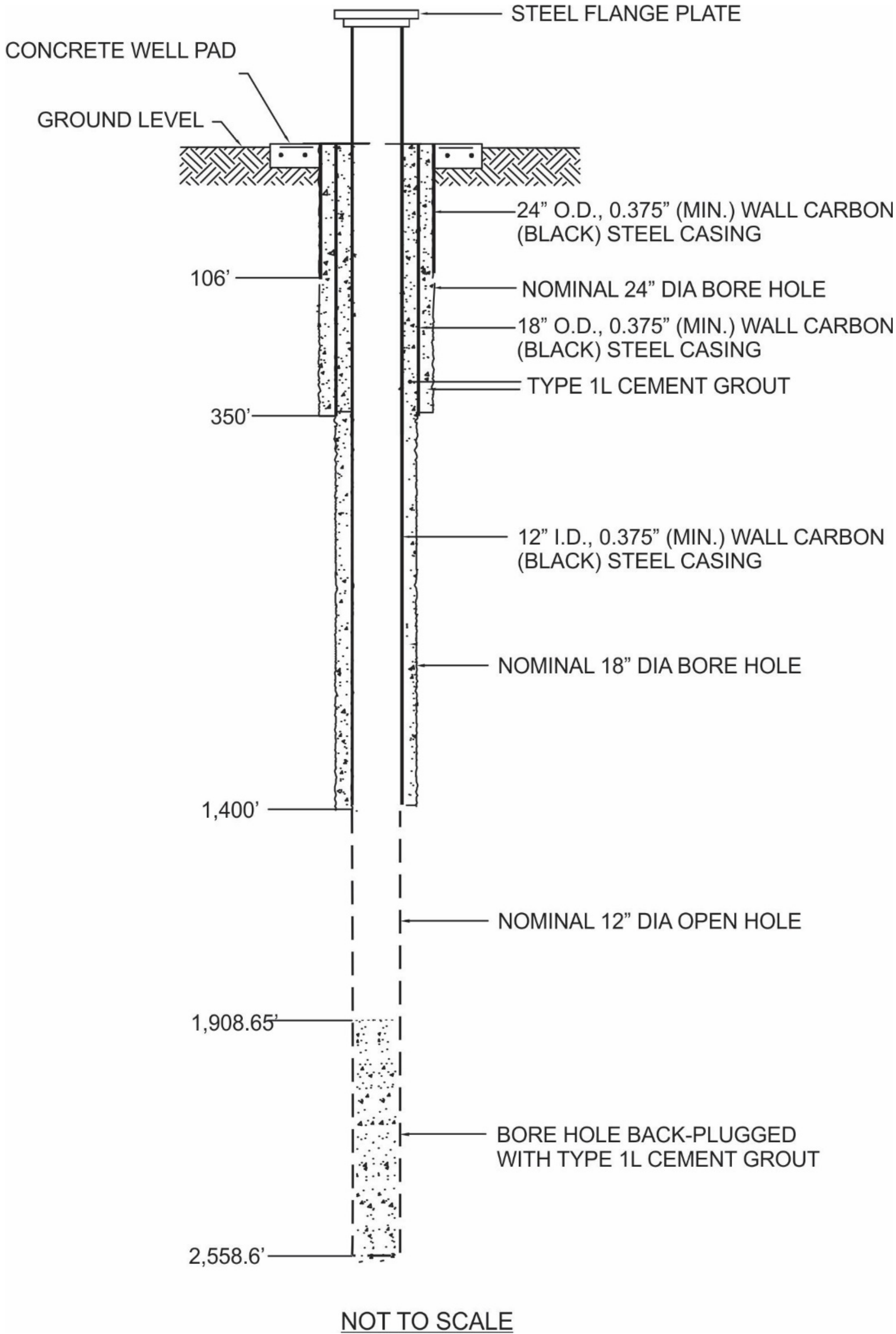

Figure 2-4 SE-TPW3-LFA as-built diagram

3 STRATIGRAPHIC FRAMEWORK

Representative formation samples were collected at 10 ft intervals during advancement of pilot holes at the TPW3 site. The samples were described by their lithology color, their degree of induration and texture. The geologic units encountered at the site include, in descending order: undifferentiated sand and clay deposits, Hawthorn Group, Ocala Limestone, Avon Park Formation, Oldsmar Formation and the Cedar Keys Formation. A stratigraphic column detailing the hydrogeology and hydrostratigraphy encountered at the TPW3 site is presented below in **Figure 3.1**. Lithologic logs for SE-TPW3 LFA and SE-TPW3 are provided in **Appendix D**. Textural terms used to characterize siliclastic sediments are based on the Unified Classification System. Textural terms used to characterize carbonate rocks in lithologic log descriptions are based on the classification system of Dunham (1962). Geophysical logs were also used in describing the geologic formations encountered.

Well TPW3-LFA penetrates strata of Holocene to Paleocene age, which can be divided into three main intervals. The upper strata from land surface to approximately 220 ft bls consists of mixed siliciclastic and carbonate strata of Holocene to Miocene age that constitute the surficial aquifer system and Hawthorn confining unit (also referred to as the intermediate confining unit or aquifer system). The strata from 220 to 2,540 ft bls consists predominantly of carbonate rocks (limestone, dolomites, and dolomitic limestones) of Late Eocene to Early Eocene age that constitute the Floridan aquifer system. The underlying evaporitic (mixed dolomite and bedded anhydrite) Cedar Keys Formation (Paleocene) constitutes the Sub-Floridan confining unit.

Stratigraphic formations are, by definition, mappable bodies of rock that are lithologically distinct from adjoining strata (i.e., have different rock types). However, the formations that constitute most of the Floridan aquifer system (Suwannee Limestone, Ocala Limestone, Avon Park Formation, and Oldsmar Formation) are defined based on their age (i.e., are biostratigraphic units) rather than their lithology (Miller 1986). For example, the Avon Park Formation is now commonly defined as carbonate rocks of Middle Eocene age in peninsular Florida (Miller 1986), although the Middle Eocene strata were originally subdivided, in ascending order, into the Lake City Limestone and the Avon Park Limestone (Applin and Applin 1944). Formation boundaries have historically been placed at positions in wells or exposures at the nearest lithological change to a biostratigraphic transition. In practice, locating the depths of formation boundaries in the Floridan aquifer system can be very difficult from well cuttings and geophysical logs. Indeed, Reese and Memberg (2000) proposed that individual formation names of the Eocene strata be abandoned for the Floridan aquifer system in the subsurface and the strata combined in an "Eocene Group."

Formation boundaries were identified in the evaluation of the TPW3 data based on typical lithologies, fossil types, and geophysical characteristics of each unit. The formation boundary determinations considered previous U.S. Geological Survey stratigraphic analyses for or including Polk County (Spechler & Kroening 2007; Reese and Richardson 2008).

3.1 Holocene, Pleistocene, and Pliocene Series

The Pliocene and younger aged surficial sediments are mainly comprised of varying percentages of undifferentiated sand at the TPW3 site and are present from land surface to 100 feet bls. The sands are generally clean through about 60 ft. bls. The underlying sands from 60 to 100 have increasing clay and silt contents and tend to be cohesive .

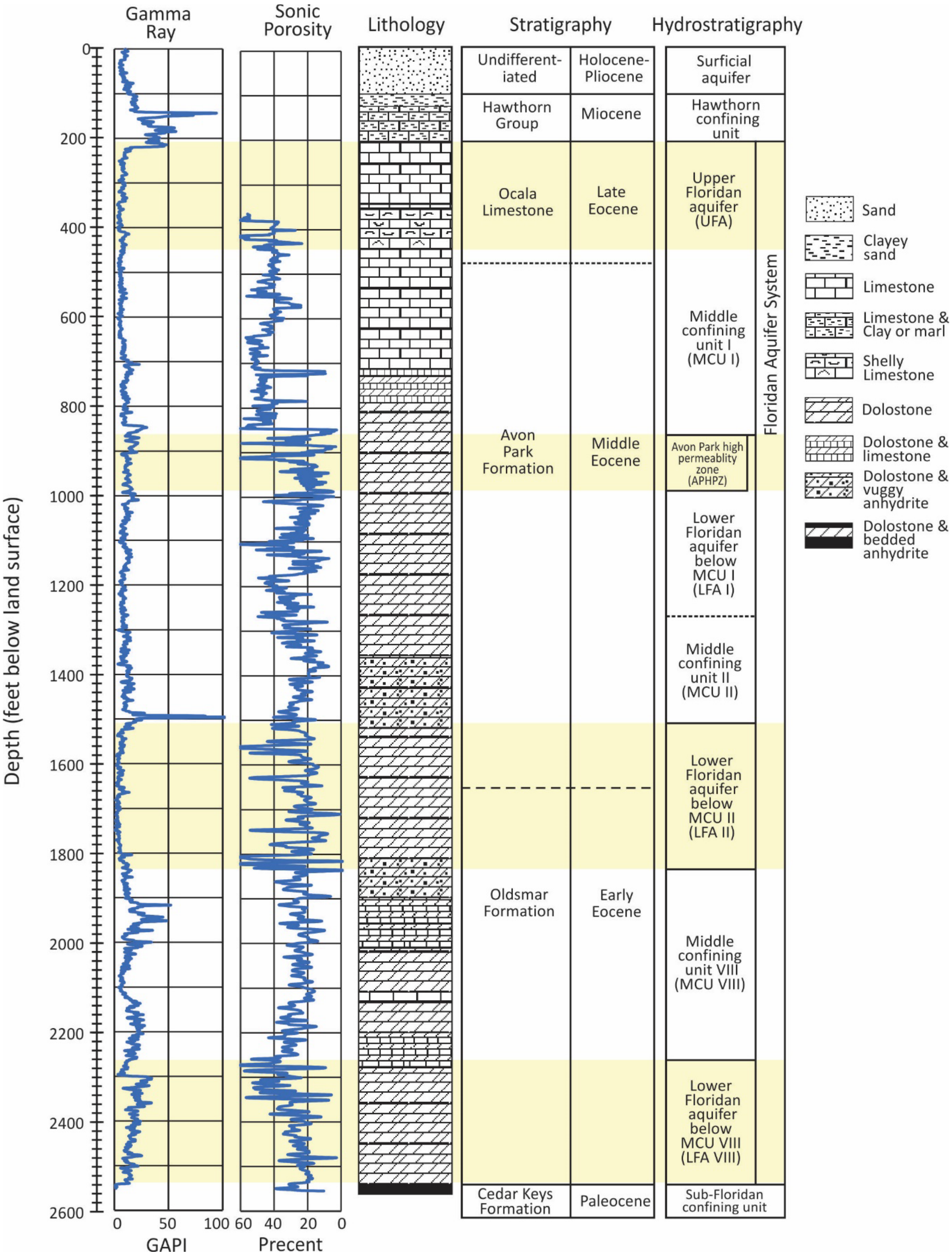

Figure 3-1 TPW3-LFA hydrostratigraphic diagram

3.2 Miocene Series

The Hawthorn Group of Miocene age includes the lower Arcadia Formation and the upper Peace River Formation and consists of widely varying lithologies and components that include limestone, mudstone, dolostone, dolosilt, shell, quartz sand, clay, and phosphate grains. The strata from 100 to 140 ft bls consists mostly of clay. Limestone with variable amounts of clay or marl are present to the base of the Hawthorn Group at about 220 ft bls. The high clay and phosphate content of the Hawthorn Group gives the unit a relatively high natural radioactivity as measured on the gamma geophysical ray log. The bottom of the unit is clearly evident on the gamma ray log by a sharp drop in activity at 220 ft bls.

3.3 Oligocene Series

The Suwannee Limestone was not present at this location.

3.4 Eocene Series

The Eocene Series in peninsular Florida consists, in descending order, the Ocala Limestone (Late Eocene), Avon Park Formation (Middle Eocene), and Oldsmar Formation (Early Eocene).

3.4.1 Ocala Limestone

The Ocala Limestone typically consists of light-colored (commonly very pale orange), often chalky appearing limestone that is relatively pure, as manifested by low gamma ray activities. The formation is characterized by the presence of large (several millimeter-sized) flat, discoidal foraminifera belonging to the genus *Lepidocyclina*. The upper part of the formation from about 220 to 350 ft bls is somewhat marly. *Lepidocyclina* constitutes most of the cuttings between approximately 350 and 420 ft bls. The base of the Ocala Limestone occurs at roughly 450 ft bls based on the transition to more typical Avon Park Formation fossils and a bioclast grainstone (cemented carbonate sand) lithology.

3.4.2 Avon Park Formation

The Middle Eocene aged Avon Park Formation consists primarily of fossiliferous limestone interbedded with dolomitic limestone and vuggy dolostone. The Avon Park Formation varies from a wackestone to grainstone with minor mudstone. At the TPW3 site, the Avon Park Formation extends from approximately 450 to 1,914 feet bls. The upper part of the Avon Park Formation is characterized by common small echinoids belong to the genus *Neolaganum*. The foraminifera fauna is often dominated by millimeter-sized cone-shaped foraminifera belong to the genus *Dictyoconus* and similar genera. However, cone-shaped "dictyoconid" foraminifera are not particularly common at the TPW3 site and were first detected in trace amounts in the 480 to 490 ft bls cutting sample from TPW3-LFA

The Avon Park Formation in TPW is composed mostly of light gray to pale yellowish brown to brown dolostones and calcareous dolostones, and subsidiary limestones and dolomitic limestones. The most common lithology is bioclast grainstone that is replaced by finely crystalline dolomite. Darker brown, very dense (low porosity) dolostones are present.

A lithological changes occurs at about 840 ft bls downhole to much better indurated dolostones, which is evident in the well cuttings and in the caliper log by decrease in borehole diameter to close to bit size. The caliper log indicates generally softer rock is present between about 990 and 1,290 ft bls, followed downhole by return in harder, better indurated rock.

Anhydrite in the form of nodules of various size was originally common throughout the Avon Park Formation. Anhydrite appears in cuttings as clear crystals and opaque white masses and is present below about 1,340 ft bls. Between approximately 1510 to 1,850 ft bls, the anhydrite has been largely dissolved, leaving open cavities of various sizes and degrees of interconnection (**Figure 3-2**).

Figure 3-2 Borehole video of cavities formed by complete (top) and partial (bottom) dissolution of anhydrite nodules.

3.4.3 Oldsmar Formation

The Early Eocene-aged Oldsmar Formation consists primarily of dolomitic recrystallized microcrystalline limestone in the upper section and crystalline, low porosity, dolostones in the lower section. The Oldsmar Formation varies from a packstone to wackestone to grainstone. Anhydrite is locally present as small nodules. The boundary between the Avon Park Formation and Oldsmar Formation is lithologically indistinct. Reese and Richardson (2008) mapped across South Florida a marker unit, referred to as the "glauconite marker horizon," which approximately marks the top of the Oldsmar Formation. The "glauconite marker horizon" is marked by a pronounced increase in gamma ray activity (Reese and Richardson 2008). Based on the gamma ray log, known thickness of the Avon Park Formation in Polk County and the Reese and Richardson's map of the top of glauconite marker horizon, the top of the Oldsmar Formation is placed at approximately 1,914 ft bls in TPW-LFA.

3.5 Paleocene Series - Cedar Keys Formation

The Oldsmar Formation is underlain by the late Paleocene-aged Cedar Keys Formation. The top of the Cedar Keys Formation is usually placed at the top of first thick bedded anhydrite unit below the Oldsmar Formation, which occurs at 2540 ft bls in well TPW3-LJA, as evident by first occurrence of abundant anhydrite in the cuttings.

The Cedar Keys Formation consists primarily of dolostone and evaporites (gypsum and anhydrite) with less abundant limestone. Based on data from oil and gas wells in the eastern Polk County region, the Cedar Keys Formation is estimated to be between 1,000 and 1,200 ft thick in the SE LFAWPF wellfield vicinity.

4 HYDROGEOLOGIC FRAMEWORK

Traditionally, the hydrogeology of peninsular Florida has been divided into three main units, the Surficial Aquifer System (SAS), intermediate confining unit or aquifer system, and the Floridan aquifer system (FAS, Miller 1986). The nomenclature and naming conventions used in this report are consistent with the SWFWMD current understanding of the regional hydrostratigraphy (LaRoche and Horstman 2023).

Three major hydrostratigraphic units occur in west-central Florida: the surficial aquifer (SA), confining units within the Hawthorn Group and intermediate aquifers referred to as the Hawthorn confining unit or aquifer system, and the FAS. The FAS is divided into two zones of higher permeability: the Upper Floridan aquifer (UFA) and the Lower Floridan aquifer (LFA), which are separated by one or more regional confining units (middle confining units I and/or II). The hydrostratigraphic units at the TPW3 site are described below and the hydrostratigraphy of the site is summarized in **Figure 3-1** and **Table 4-1.**

Table 4-1 Summary of hydrostratigraphy of the SE-TPW3-LFA

Unit	Abbreviation	Depth (ft bls)		Thickness (ft)	Approximate elevation (ft NAVD)	
		Top	Bottom		Top	Bottom
Surficial aquifer	SA	0	102	102	105	3
Hawthorn confining unit	HCU	102	220	118	3	-115
Upper Floridan aquifer	UFA	220	450	230	-115	-345
Middle confining unit I	MCU I	450	875	425	-345	-770
Avon Park high-permeability zone	APHPZ	875	1120	245	-770	-1002
Lower Floridan aquifer below MCU I	LFA I	1120	1269	149	-1002	-1167
Middle confining unit II	MCU II	1269	1520	251	-1167	-1415
Lower Floridan aquifer below MCU II	LFA II	1520	1850	330	-1415	-1745
Middle confining unit VIII	MCU VIII	1850	2270	420	-1745	-2165
Lower Floridan aquifer below MCU VIII	LFA VIII	2270	2540	270	-2165	-2435
Sub-Floridan confining unit	SFCU	2540			-2435	

4.1 Surficial Aquifer

The surficial aquifer system in Florida is defined as the "permeable hydrogeologic unit contiguous with land surface that is comprised principally of unconsolidated clastic deposits" (Southeastern Geological Society Ad Hoc Committee, 1986). The surficial aquifer system comprises all materials from the water table to the top of the Hawthorn confining unit. The SAS in Polk County consists of a single aquifer referred to as the surficial aquifer or water table aquifer. In Polk County, the base of the surficial aquifer system is marked by a transition to the low hydraulic conductivity clayey strata of the Hawthorn Group.

The surficial aquifer (SA) at the TPW3 site consists predominantly of unconsolidated quartz sands. The base of the SA is marked by a transition to the more clay-rich strata of the Hawthorn confining unit (HCU). The base of the SAS occurs at roughly 102 ft bls.

4.2 Hawthorn Confining Unit

The Hawthorn confining unit, also referred to as the intermediate confining unit, is defined as including "all rocks that lie between and collectively retard the exchange of water between the overlying surficial aquifer system and the underlying Floridan aquifer system" (Southeastern Geological Society Ad Hoc Committee, 1986). The Hawthorn confining unit at well TPW3-LFA consists of the Hawthorn Group and is present from 102 to 220 ft bls. The base of the Hawthorn confining unit is marked by a downhole transition to the lighter-colored and more transmissive fossiliferous limestones of the Ocala Limestone.

4.3 Floridan Aquifer System

The FAS is one of the most productive aquifers in the United States and underlies all of Florida and parts of Georgia and South Carolina for a total area of about 100,000 square miles (Miller, 1986). The FAS consists of an extensive sequence of thickly bedded Tertiary-aged limestones and, less abundant dolostones that are connected to varying degrees. The FAS is quite heterogeneous as far as hydraulic conductivity. Flowmeter log data show that the aquifer consists of a number of zones with very high hydraulic conductivities, which are commonly solution-riddled or fractured, separated by confining or semi-confining intervals of rock with low hydraulic conductivities (Miller, 1986). Confining units within the FAS in South Florida vary greatly in thickness and vertical continuity. An important factor controlling transmissivity within the FAS in PRWC SE wellfield area is whether secondary porosity features, particularly vugs and small cavities, are open or filled with anhydrite. High transmissivity flow zones are characterized by the presence of a network of dissolutional cavities that are apparently interconnected with considerable areal extent.

The middle confining unit is traditionally defined as the interval of lesser transmissivity strata that hydraulically separates the UFA from the Lower Floridan aquifer (LFA). In southeastern Polk County, the middle confining unit contains two separate confining units referred to, respectively as "middle confining unit I" (MCU I) and "middle confining unit II" (MCU II). MCU I and MCU II are separated by a more transmissive interval referred to by the SWFWMD as "LFA below MCU I" (LFA I). LFA below MCU-I has also been referred to the Middle Floridan aquifer. MCU II is absent in the eastern part of the state where the top of the LFA in considered the base of MCU I. A very high transmissivity interval or secondary porosity, called the "Avon Park high-permeability zone" (APPZ), is present at the top of the LFA below MCU I in southeastern Polk County.

The division of the FAS into aquifers and confining units is less distinct at the TPW3 site than at other sites in Polk County, as was also the case at the Deep Exploratory Well (DEW), located about 5 ½ mile to the south (PBS&J, 2010).

4.3.1 Upper Floridan Aquifer

The Upper Floridan aquifer is interpreted to be present from 220 to 450 ft bls in well TPW3 LFA. The UFA includes most of the Ocala Limestone and extends downward to the base of the fossiliferous limestones in which large foraminifera (particularly *Lepidocyclina*) constitute most of the recovered cuttings. No hydraulic testing or open-hole borehole geophysical logging were performed on the aquifer.

4.3.2 Middle Confining Unit I

MCU I consists of lower hydraulic conductivity strata that provides hydraulic separation between the UFA and APHPZ. MCI extends from 450 to 875 ft bls, which corresponds to a thickness of 425 ft. MCU I is more appropriately described as a semi-confining unit as the strata does not have a particularly low transmissivity. Rather the transmissivity of MCU I is markedly less than that of the overlying UFA and underlying APHPZ.

4.3.3 Avon Park High-Permeability Zone

The Avon Park high-permeability Zone, as the names implies, is a high transmissivity interval that is located with the middle part of the Avon Park Formation. The APHPZ consists mostly of relatively low permeability dolostones in which its high transmissivity is due to secondary porosity flow zones. The Optical Borehole Imaging (OBI) log run at the SE-TPW site shows that the enhanced permeability of the zone is due to dissolutional features (apparently of evaporite minerals) rather than fracturing. The APHPZ is interpreted to occur between 875 and 1,120 ft bls in TPW3-LFA. The proposed APHPZ depth interval includes several secondary porosity zones indicated by borehole enlargement on the caliper log and increase transit times and porosity on the sonic log. The APHPZ contains freshwater. The unit was not hydraulically tested at TPW3.

4.3.4 Lower Floridan Aquifer Below MCU I

The Lower Floridan aquifer below MCU I (LFA I) consists of the strata between MCU I and the lower porosity and permeability anhydrite-bearing strata of MCU II. MCU I at the TPW3 site consists of the high transmissivity APHPZ and an underlying unit that lacks the secondary porosity flow zones of the APHPZ. LFA I below the APHPZ is composed mostly of dolostones with low apparent porosities and appears to be more of a (semi) confining zone than aquifer (i.e., an interval that produces significant quantities of water). The base of LFA-I is placed at 1,269 ft bls.

4.3.5 Middle Confining Unit II

Middle confining unit II is less permeable and thus a more effective confining unit that MCU I. There is not a distinct down-hole break in rock properties between LFA I and MCU II in TPW3-LFA.

A characteristic feature of MCU II is the presence of calcium sulfate minerals (anhydrite and/or gypsum; referred to herein as just anhydrite). Anhydrite formerly present in the overlying strata was dissolved to form secondary porosity (vugs). Within the lower MCU II much of the anhydrite/gypsum is still intact resulting in lower porosities. The top of the MCU II is placed at 1,269 ft bls, at which depth there is a down-hole decrease in overall porosity on the TPW3-LFA sonic log. Trace anhydrite was first present in the cuttings from 1340 to 1350 ft bls in TPW3. The base of MCU II occurs at approximately 1520, below which depth secondary porosity intervals are evident on the sonic, caliper, and OBI log. Anhydrite was last observed in the 1,510 to 1,520 ft bls sample from SE-TPW3-LFA and was last observed at about 1,550 ft bls in the SE-TPW3 OBI log and borehole video.

4.3.6 Lower Floridan Aquifer Below MCU II (LFA II)

Lower Floridan aquifer below MCU II is the planned production zone for the SE Wellfield. Water production from LFA II is primarily through secondary porosity (fractured or cavity intervals). LFA II is bounded above and below by strata in which secondary porosity horizons are much less well developed.

The flowmeter interpretation log from the SE-TPW3 LFA well log shows production from LFA II but the log response is dominated by the major flow zone from 2,310 to 2,325 ft bls (**Figure 4-1**).

The base of LFA II is placed at 1,850 ft bls, below the deepest secondary porosity zones evident on the sonic and caliper logs and at the base of the main flow zone indicated by the TPW3 open hole flowmeter log. Anhydrite is also present in the 1,830-1,840 ft bls and deeper cuttings samples.

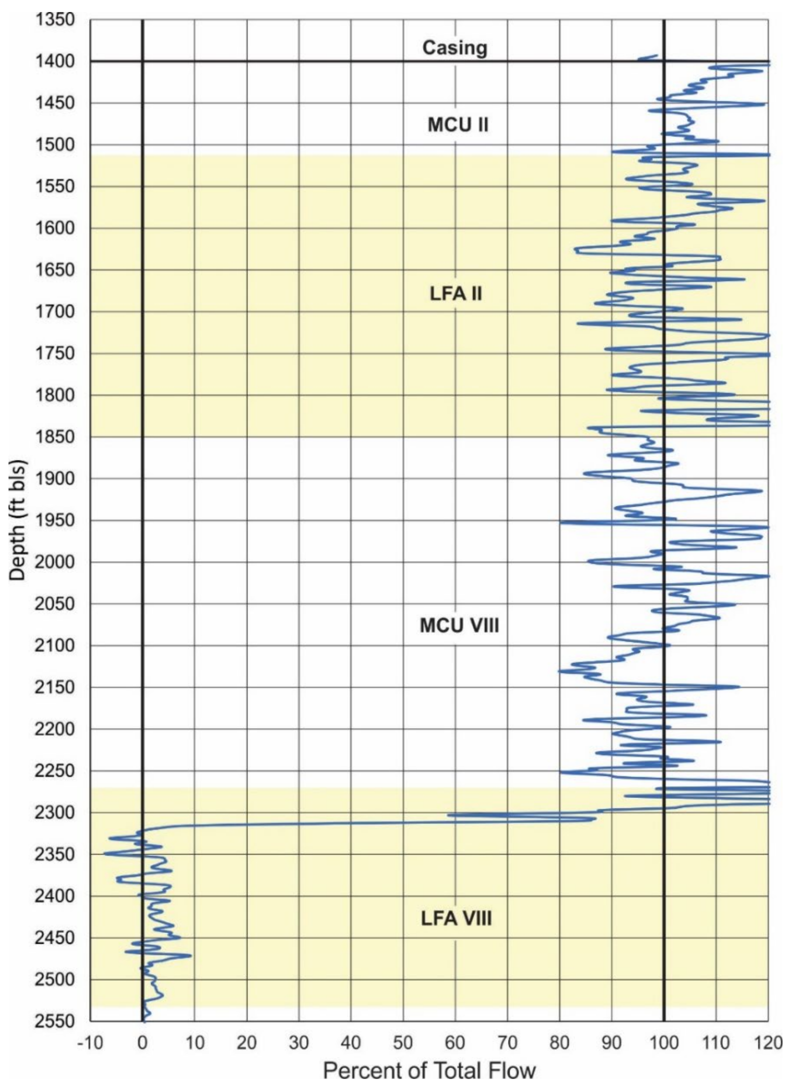

Figure 4-1 Flowmeter interpretation log (3 ft trailing moving average)

4.3.7 Middle Confining Unit VIII

The Lower Floridan aquifer below MCU II is divided into two aquifers that are separated by a confining unit, which is now referred to as middle confining unit VIII (MCU VIII), as defined by Miller (1986, p. B69). MCU VIII, was previously referred to as the “Glauconite Marker Unit” (GMU) is some reports (e.g., Williams and Kuniansky, 2016), but the use of GMU name is unsatisfactory because the unit as a whole is generally not noticeably glauconitic (glauconite is a greenish, iron-rich phyllosilicate mineral) and the glauconitic marker horizon occurs at different hydrostratigraphic positions in the FAS. Elevated gamma ray activity that appears to correlate with the MCU VIII is present between 1,914 and 1,980 ft bls at the SE-TPW3 site.

MCU VIII hydraulically separates LFA II and LFA VIII. The base of MCU VIII is placed at the top of the uppermost secondary porosity zone of LFA VIII. MCU VIII consists predominantly of dolomitic strata with an overall lower transmissivity than that of the overlying and underlying aquifer units and a much lesser development of secondary porosity intervals that could act as flow zones. MCU VIII occurs between approximately 1,850 ft bls and 2,270 ft bls in TPW3-LFA.

4.3.8 Lower Floridan Aquifer below MCU VIII

The Lower Floridan aquifer below MCU VIII (LFA VIII) is the basal aquifer of the Floridan aquifer system. The outstanding feature of LFA VIII at the TPW3 site is a major flow zone from 2,310 to 2,325 ft bls, which contains open fractures and large cavities on the OBI log. The flowmeter log from 1,400 ft bls to 2,560 ft bls shows that 95% of the flow entered the well in this major flow zone. Static and dynamic fluid conductivity rapidly increase downhole from about 3,200 to about 60,000 µS/cm in the flow zone. The LFA VIII strata below the major flow is much less transmissive.

4.3.9 Sub-Floridan Confining Unit

The Sub-Floridan confining unit consists of low permeability carbonate and anhydrite beds belonging to the Cedar Keys Formation.

4.4 Hydrostratigraphic Correlation between SE-DEW, SE-TPW3-LFA and SE-TPW

A correlation diagram (south to north) using the merged caliper and sonic logs for the SE-DEW, SE-TPW3-LFA, and SE-TPW is provided as **Figure 4-2.** The main hydrostratigraphic units are continuous across the proposed SELFA WPF wellfield. However, there is considerable variation in the number and depth of secondary porosity flow zones, which are evident by their long sonic transit times.

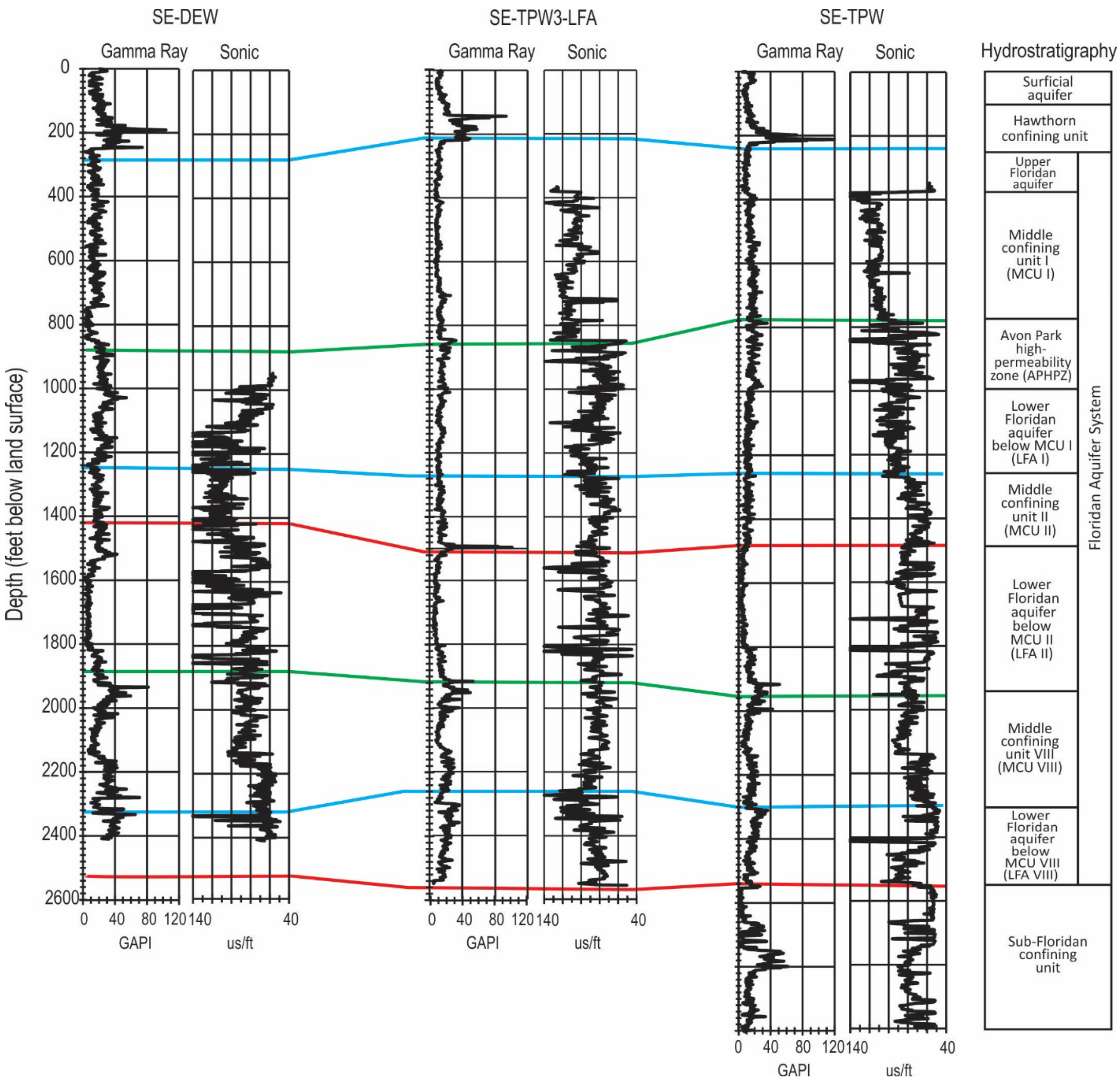

Figure 4-2 SE-DEW, SE-TPW3-LFA, and SE-TPW geophysical and hydrostratigraphic correlation diagram.

5 HYDROGEOLOGIC TESTING

The hydrogeologic testing program was designed to obtain information on the hydraulic properties of the proposed production and injection zones and intervening and overlying confining strata. The TPW3 hydrogeologic testing program included the following elements:

- Description of well cuttings
- Geophysical logging
- Packer testing
- An aquifer performance test

5.1 Geophysical Logging Program

Borehole geophysical surveys are performed by lowering sensing devices (sondes) attached to a wireline into a borehole and recording various physical properties of the penetrated strata. The geophysical logging program implemented during the construction of SE-TPW3-LFA was designed to collect information on the geology and hydrogeology of penetrated strata, particularly the location and properties of high transmissivity intervals that are suitable for raw water production zones, and confining strata that would impede vertical flow of water into the proposed production zone.

The geophysical logs were run by MV Geophysical Surveys, Inc. and Lee Logging LLC. The type of logs run and the information they provided are summarized in **Table 5-1.** The SE-TPW3 logging program is summarized in **Table 5-2.** Copies of geophysical logs are provided in **Appendix E**.

Table 5-1 Geophysical logs run and the types of information provided

Geophysical Log	Information provided
Caliper	Borehole diameter (X and Y directions). Used to identify differences in rock hardness and the presence of fractured or cavernous intervals, and to estimate annulus (required cement) volumes for grouting of casings.
Spontaneous potential	Variations in salinity. The SP log is typically run as it is on the same tool as the DIL, but it usually does not provide much useful information in carbonate rocks.
Gamma ray	Natural radioactivity of rock. Used for lithological identification and correlation.
Sonic	Travel time of sound wave in the formation. Used to determine porosity and identify fractured zones.
Dual induction laterolog (DIL)	Resistivity of the formation. Used to identify rock types, determine formation water salinity, and identify permeable zones.
Temperature (static and dynamic)	Water temperature within casing and borehole. Used to evaluate continuity of cement and zones of water flow into the well.
Fluid conductivity (static and dynamic)	Salinity of water inside well. Used to evaluate changes in formation water salinity and the location of flow zones.
Flowmeter (static and dynamic)	Relative transmissivity of strata; identification of flow zones.
Video survey	Optical images of the inner surface of the production casing and the production zone strata.

Table 5-2 TPW3 site geophysical logging summary

Borehole	Geophysical Logs
TPW3-LFA	
0 to 350 ft, bls reamed	Caliper and gamma ray
250 to 1,400 ft bls, pilot	Caliper, gamma ray, dual induction laterolog, sonic.
0 to 1,400 ft bls, ,reamed	Caliper and gamma ray
1,400 to 2,560 ft bls, open hole	Caliper, gamma ray, dual induction laterolog, sonic, and static and dynamic flowmeter, fluid conductivity, and temperature. Optical borehole imager (USGS)
TPW3	
0 to 350 ft bls, reamed	Caliper and gamma ray
0 to 1,400 ft bls, pilot	Caliper, gamma ray, dual induction laterolog, sonic.
1,400 to 1,900 ft bls, reamed.	Caliper, gamma ray, resistivity (dual Induction), , borehole compensated sonic. Borehole video (entire well)

A summary of the SE-TPW3-LFA geophysical log interpretation is provided in **Table 5-3**.

Table 5-3 SE-TPW3 geophysical log interpretation

Depths (ft bls)		Description
Top	Bottom	
0	140	Low gamma ray activity (< 30 GAPI).
140	220	Distinctly higher gamma ray activity (> 40 GAPI) indicative of the clayey and phosphatic strata of the Hawthorn Group.
130	350	Low gamma ray (< 20 GAPI) indicative of the cleaner (purer) limestones of the Ocala Limestone.
350		Casing seat.
350	716	High sonic porosities (35 to 55%) and considerable borehole enlargement (mostly < 25" for 12.5" bit) are indicative of soft, porous rock.
716	728	Hard bed (dolostone) with borehole diameter close to bit size and sonic porosity decreasing to about 10%.
728	849	Soft, porous rock with sonic porosities mostly between 40 and 55% and considerable borehole enlargement.
849	875	Abrupt downhole change in hard, less porous dolostones. Borehole is close to bit size and sonic porosities are less than 10% from 850 to 860 ft bls.

875	1,120	Avon Park high-permeability Zone. Borehole is mostly close to gauge, with some increase below 900 ft bls. Sonic porosity is variable, between 5 and 30%. Secondary porosity intervals, as manifested by long sonic transit times and borehole expansion, are present, with peaks at 878, 910, 994, 1009, 1104, and 1117 ft bls.
1,120	1,174	Hard, low porosity dolostone. Borehole close to gauge and majority of interval has a sonic porosity below 25%. Second porosity intervals are not evident.
1,174	1,269	Variable sonic porosities. Tighter beds with porosities between 10 and 20%, and more porous beds with porosities between 25 and 50%. Modest borehole enlargement decreasing with depth.
1,269	1,510	MCU II. A modest overall decrease in porosity below 1269 and borehole close to gauge. Sonic porosities are between 10 and 30% from 1137 to 1,400 ft bls. The dual induction log and log-derived specific conductance indicates an increase in groundwater salinity below 1,280 ft bls. Secondary porosity features are not evident. Intact anhydrite nodules are commonly visible in the video survey.
1,510	1,850	LFA II. Low to moderate porosity rock (predominantly dolostones) with sonic porosities mostly between 15% and 30%. Static fluid conductivity is between 3,613 and 3,230 µS/cm. LFA interval is characterized by the presence of secondary porosity features indicated by borehole enlargement, increased sonic transmit times, and washouts on VDL log. Vugs and cavities that formed by anhydrite nodules dissolution are present throughout, with larger cavities common between 1,652 and 1,6622 ft bls. Intact anhydrite is rare. The flowmeter interpretation log of the entire LFA does not show significant flow, but the log is dominated by a deeper flow zone. The flowmeter log for the TPW3 open hole indicates that the main flow zone pf the production is located between 1,800 and 1,850 ft bls.
1,850	2,270	MCU VIII. Low-porosity dolostones with sonic porosities between 15 and 30 percent. Similar to overlying strata except that well-developed secondary intervals are absent. Static fluid conductivity between 3,163 and 3,194 µS/cm. Anhydrite-filled nodules and cavities formed by their complete or partial dissolution are commonly evident in the video survey.
2,270	2,310	LFA VIII. Secondary porosity is evident on sonic log but the flowmeter and fluid conductivity logs do not show evidence for significant flow.
2,310	2,325	Major flow zone, which dominates the flowmeter interpretation log. Static and dynamic fluid conductivity rapidly increase downhole from about 3,200 to about 60,000 µS/cm. Secondary porosity zone. Fluid temperature increases downhole from 80.9 to 86.7 °F. The flow zone is producing water with a conductivity of about 3,200 µS/cm. The 10,000 mg/L isopleth occurs at the base of the flow zone.
2,325	2,540	Secondary porosity intervals are present down to 2,350 ft bls, but negligible flow is evident on the flowmeter interpretation log. Strata below 2,2350 ft bls have porosities between 20 and 30% with minimal development of large secondary porosity features (except small feature at about 2,477 ft bls). High salinity groundwater is indicated by static and dynamic fluid conductivities between about 45,500 and 62,500 µS/cm.
2,540	2,560	Cedar Keys Formation – Sub-Floridan confining unit. Abundant anhydrite in cuttings.

5.2 Packer Testing

Five packer tests were performed on TPW3-LFA using an inflatable packer system. Tests PT-2 through PT-5 were straddle pack tests with a packer spacing of 50 feet. Test TP-1 was performed using a single packer set below the 12-inch diameter casing seated at 1,400 ft. The tests were performed in reverse-order with the deepest of the planned tests PT-5 performed first.

Test depths were selected based on water quality and aquifer hydraulic information goals and borehole conditions. The objective of the latter was to seat each packer in a borehole interval that was round, had a diameter close to gauge (12-inches), and was not apparently fractured.

The tested intervals were pumped with a submersible pump and water-level versus time data were automatically collected using pressure transducers and manually measured using a water level probe as a back-up. After an initial purging and testing to determine the optimal pumping rate, the well was allowed to recover. The packer tests had a single pumping phase with a target duration of two hours and a minimum pumping amount of one packer system water volume. The pumping phase was followed by a recovery period of at least two hours or until water levels recovered back to static level. Longer pumping phases were constrained by brackish and saline water disposal considerations.

The time-drawdown data were analyzed using standard methods. The preferred method, which is deemed most accurate, is a Theis-based, curve-match technique such as the Hantush-Walton method for leaky aquifers (Hantush and Jacob 1955; Walton 1962). The Cooper and Jacob (1946) method (aka the straight-line method) is a simplified approximation of the Theis method.

Transmissivity (T) was also estimated from specific capacity (pumping rate divided by drawdown; Q/s) using the equation:

$$T = 2000(Q/s)$$

where the units for transmissivity, pumping rate, and drawdown, are gallons per day/ft, gallons/min, and feet, respectively (Driscoll 1986, p. 1021). The Driscoll method provides rough estimates of transmissivity and is considered the least accurate technique.

Interpretation of packer test data from high transmissivity zones is complicated by pipe frictional head losses being a significant component of measured drawdowns and oscillatory time-drawdown curves, which are referred to as underdamped responses. Oscillatory recovery data from packer tests recovery phase were interpreted as a slug test using the Butler and Garnett (2000) method for analysis of slug tests in formations of high-hydraulic conductivity. The Butler and Garnett (2000) method is a spreadsheet curve-matching technique that considers underdamped responses.

The packer test hydraulic data are summarized in **Table 5-3** and discussed below.

Table 5-4 Summary of packer test results

Test/Parameter	PT-1	PT-2	PT-3	PT-4	PT-5
Depths (ft bls)	1400-1,628	1792 - 1842	2142-2192	2,319-2,369	2,488-2,538
Unit	LFA II	LFA II	MCU VIII	LFA VIII	LFA VIII
Type	Single	Straddle	Straddle	Straddle	Straddle
Date	7/31/23	7/13/23	7/10/23	6/30/23	6/26/2023
Average pumping rate (gpm)	100	101.5	61.1	94.5	14.1
Pumping duration	148	158 min	153 min	100 min	473 min
Drawdown (ft)	1.53	4.2	156.2	2.0	125.1
Specific capacity (gpm/ft)	65.3	24.2	0.39	47.2	0.113
Estimated transmissivity (ft^2/d)	77,800 (B&G) >17,470 (D)	**28,600 (B&G)** >6,470 (D)	**131 (H-W)** 170 (C&J) 104.3 (D)	**38,150 (B&G)** >12,620 (D)	**7.8 (H-W)** 5.4 (C&J) 30.2 (D)
Laboratory specific conductance (µS/cm)	2,910	2,830	3,090	43,200	24,200

B&G: Butler and Garnett (2000) method
C&J: Cooper and Jacob (1946) Method
D: Driscoll (1986) method
H-W: Hantush-Walton method
Most reliable value is in bold text.

Packer Test No. 1

Packer Test No. 1 was a single packer test with the packer set at 1,626 ft bls. The tested interval was thus from 1,400 to 1,626 ft bls. There was not enough room in the annulus to install a pump. Instead, a perforated segment of drill pipe was added to the packer column pipe above the packer. The pipe was capped below the packer.

The pumping rate was a constant 100 gpm from the start of the test until the end. The total pumping time was 148 minutes at a 100 gpm rate. The drawdown was approximately 1.5 feet within the drill pipe. The time-drawdown data showed a strong oscillatory (underdamped) response at the start of pumping and then quickly reached final drawdown. Most of the drawdown was frictional losses in the pipe.

The annulus data also showed oscillatory responses at the beginning and end of pumping, but not a comparable drawdown as observed in the packer column, consistent with the latter being predominantly frictional losses.

The estimated minimum transmissivity obtained from the Driscoll (1986) method is 17,470 ft^2/d. The Butler and Garnett (2000) method curve match (**Figure 5-1**) is of moderate quality and gives a hydraulic conductivity of 345 ft/d, which corresponds to a transmissivity 78,000 ft^2/d.

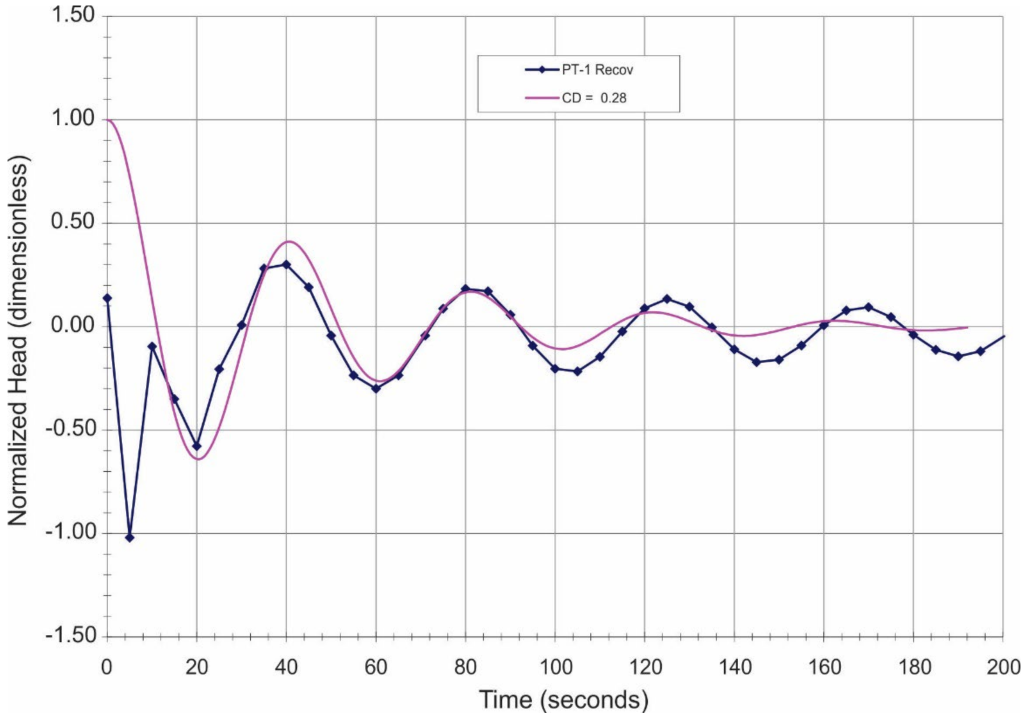

Figure 5-1 PT-1 Butler and Garnett method curve match

Packer test No. 2

Packer Test No. 2 was a straddle packer test performed from 1,792 to 1,842 ft bls, at the base of LFA II. The interval includes secondary porosity intervals, as indicated by long sonic transit times. The drawdown was about 4.2 ft, which can be attributed mostly to frictional pipe losses.

The time-drawdown plots for the both the pumping and drawdown phases has a strong oscillatory, underdamped response (**Figure 5-2**) that precludes the use of the Hantush-Walton and Cooper and Jacob methods.

A transmissivity of 6,470 ft^2/d was calculated from the specific capacity of 24.2 gpm/ft using the Driscoll (1986) method, which should be considered a minimal value due to the pipe friction contribution to the drawdown.

The early recovery data was analyzed using the Butler and Garnett (2000) method (**Figure 5-3**), from which a hydraulic conductivity of 572 ft/d was obtained, which corresponds to a transmissivity for the 50 ft packer interval is 28,600 ft^2/d.

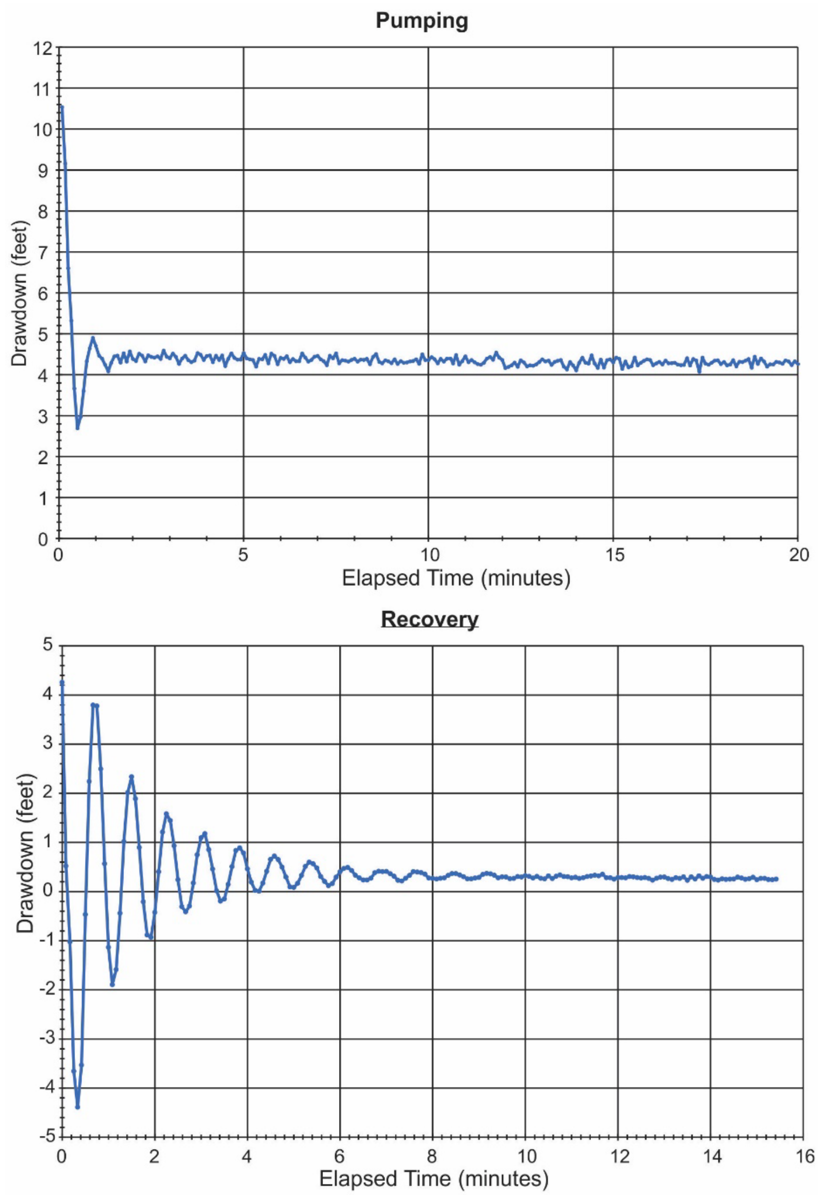

Figure 5-2 PT-2 Early time-drawdown plots

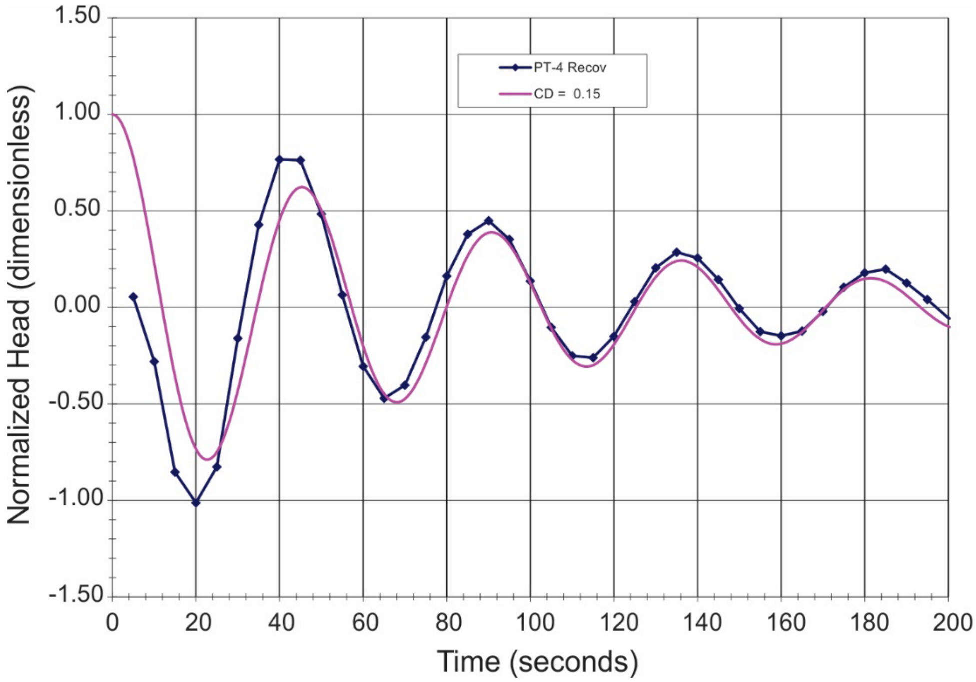

Figure 5-3 PT-2 Butler and Garnett method curve match

Packer Test No. 3

Packer test No. 3 was a straddle packer test performed from 2,142 to 2,192 ft bls, within MCU VIII.

The Hantush-Williams and Cooper and Jacob methods gave transmissivities of 131 and 170 ft²/d, respectively (**Figure 5-4**). A transmissivity of 104.3 ft²/d was calculated from the specific capacity of 0.39 gpm/ft using the Driscoll (1986) method. The 131 ft²/d transmissivity corresponds to an average horizontal hydraulic conductivity of 2.6 ft/d.

The water was mildly brackish with a SC of about 3,000 µS/cm , which is consistent with the fluid conductivity log value of about 3,200 µS/cm.

Packer Test No. 4

Packer Test No. 4 was performed from 2,319 to 2,369 ft bls which includes the base of the major flow zone located from approximately 2,310 to 2,325 ft bls. Minimal drawdown (≤ 2 ft) was measured, which fluctuated and was likely accentuated by frictional losses with the 3.5-inch ID packer pipe. Hence, calculation of a transmissivity value using the Hantush-Walton and Cooper and Jacob methods was not possible. A transmissivity of 12,620 ft²/d was calculated from the specific capacity of 47.2 gpm/ft using the Driscoll (1986) method, which should be considered a minimal value due to the pipe friction contribution to the drawdown.

The recovery data has an extreme oscillatory (underdamped) response (**Figure 5-5**), from which a hydraulic conductivity of 763 ft/d was obtaining using the Butler and Garnett (2000) method. The corresponding transmissivity for the 50 ft packer interval is 38,150 ft²/d. The calculated transmissivity may be too high but, nevertheless, the test interval is highly transmissive.

The water sample was saline. Based on the geophysical log and reverse-air water quality data, PT-4 appears to have been run a very short distance below the base of the USDW (10,000 mg/L TDS isopleth). The TDS of the sample of 34,440 mg/L is very close to that of average seawater.

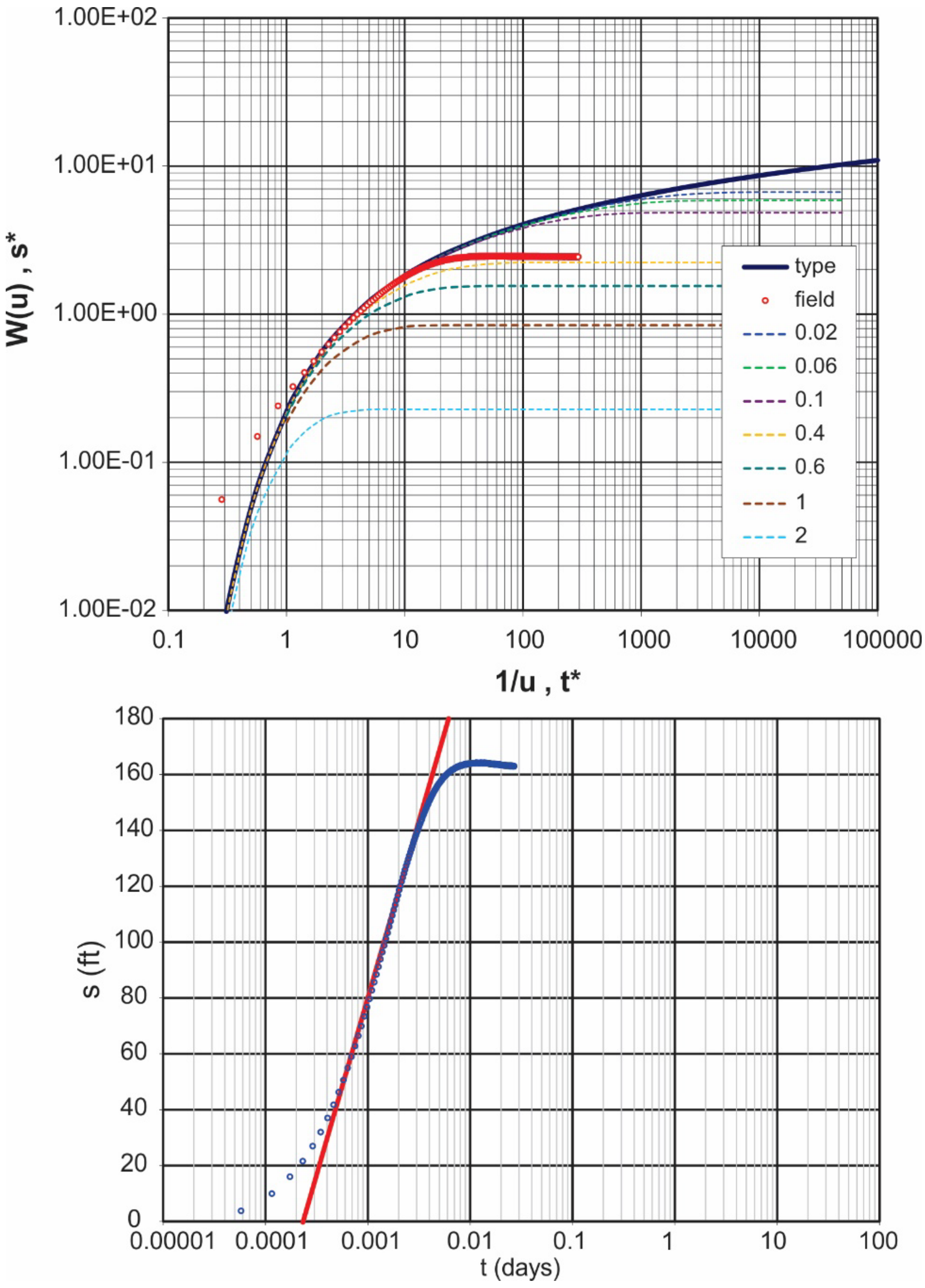

Figure 5-4 PT-3 Pumping phase interpretation graphs

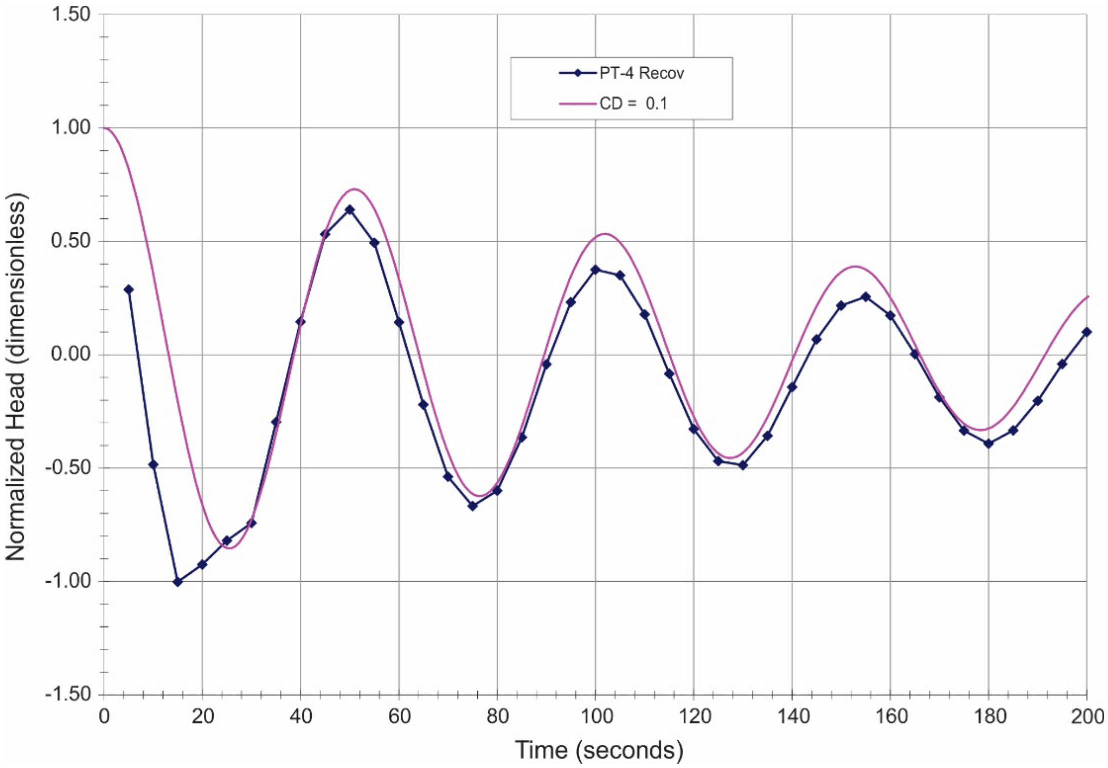

Figure 5-5 PT-4 Butler and Garnett method curve match

Packer Test No. 5

Packer Test No. 5 was performed from 2,488 to 2,538 ft bls, within LFA below MCU VIII (LFA VIII). The transducer data was not recoverable, but sufficient time-drawdown data was manually collected during the test. Over 125 feet of drawdown was recorded. The average pumping rate was 14.1 gpm. The instantaneous pumping rate gradually shifted downward during the test from an initial value of 27 gpm, presumably due to the increasing drawdown.

A good Hantush-Walton curve match was obtained for the first hour of the test (**Figure 5-6**), which gives a very low transmissivity of 7.8 ft^2/d using an average pumping rate for this time period.

The water sample from PT-5 was saline with a laboratory specific conductance of 24,200 µS/cm and a TDS of 17,600 mg/L. These values are about 50% lower than anticipated based on the fluid conductivity geophysical log. It is possible that there was a freshening of the water due to bypass flow around the packer, which may occur when there is a large drawdown, such as occurred during PT-5.

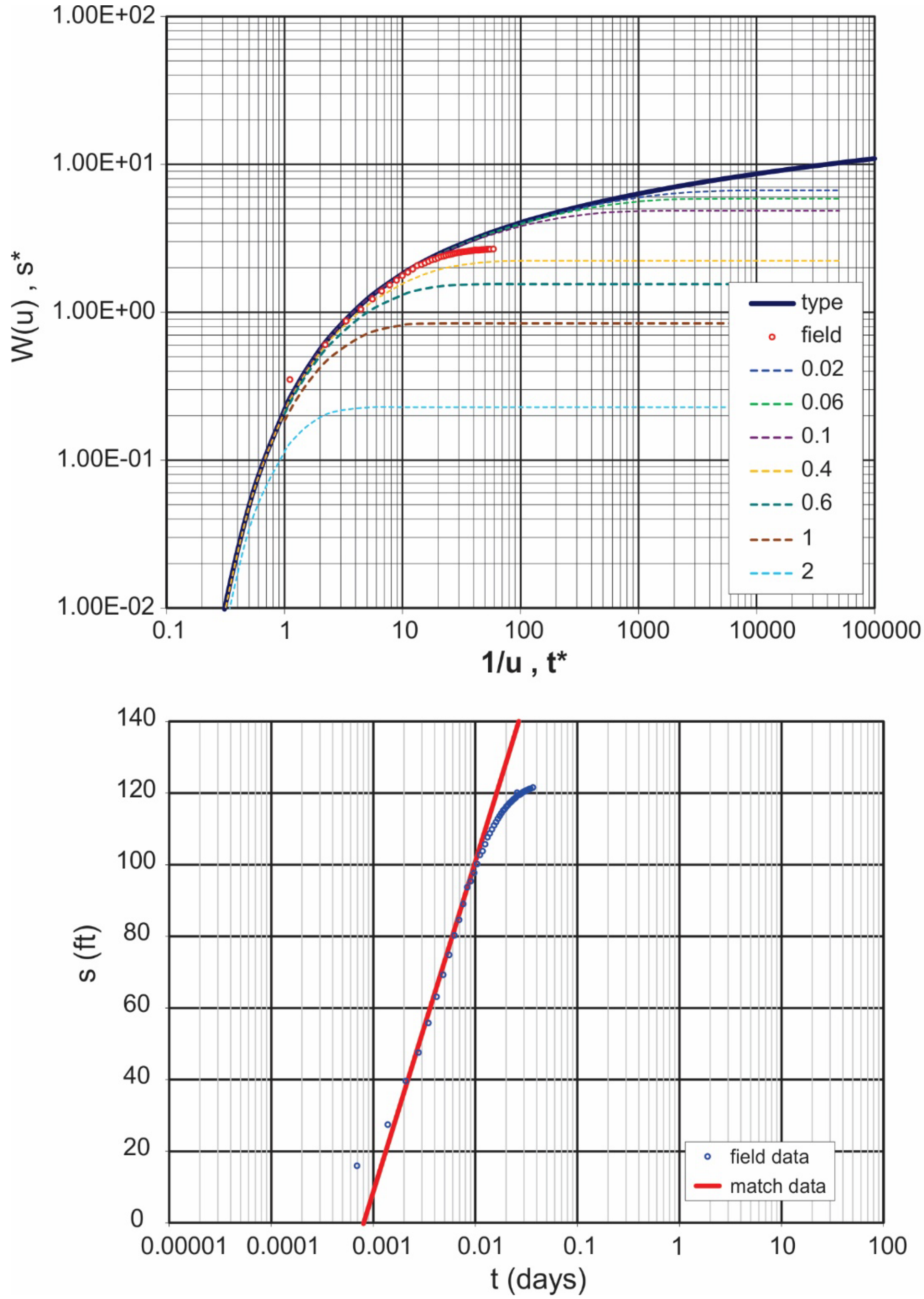

Figure 5-6 PT-5 Pumping phase interpretation graphs

5.3 Step-Drawdown Test

A step-drawdown test was performed on TPW3 (located 340 feet south of TPW3-LFA) on January 22, 2024. The test consisted of four, two-hour minimum long tests at progressively increasing pumping rates. The total pumping duration was 565 minutes. The drawdown data are plotted in Figure 5-7 and summarized in Table 5-3. The maximum end of test drawdown in TPW3 was 51.26 ft. The maximum drawdown in the production zone monitor well (TPW3-LFA) was approximately 7 feet. Test related drawdown was not detected in the UFA monitor well (SE-TPW3-UFA).

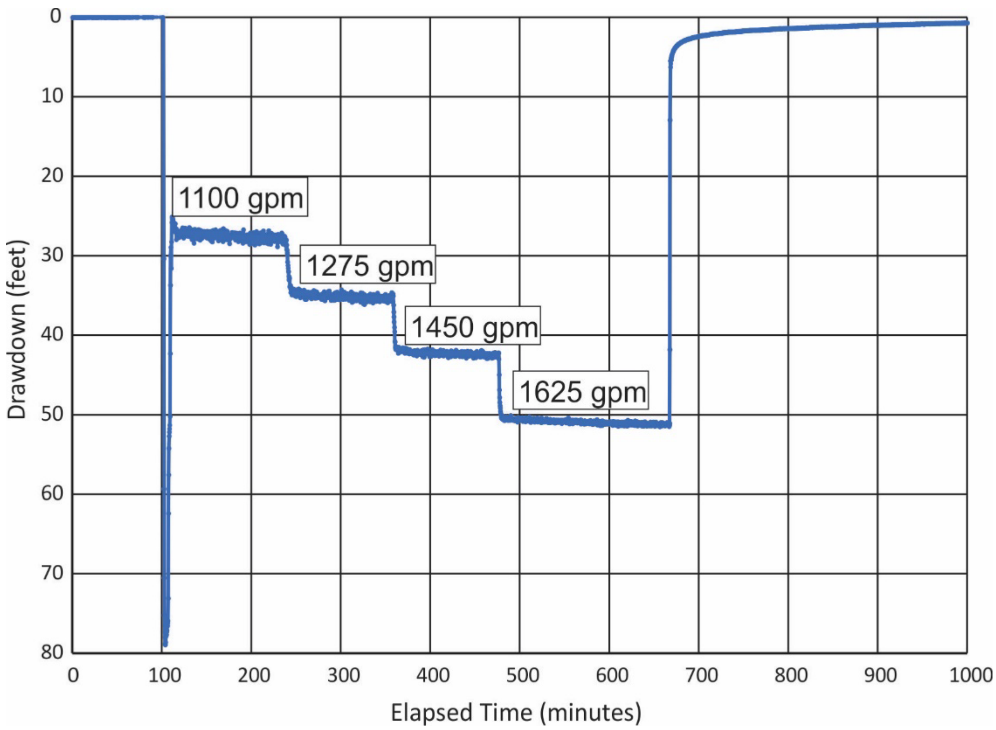

Figure 5-7 Plot of step-drawdown test results

Table 5-5 Step-drawdown test results

Step Number	Pumping rate (gpm)	TPW3 Drawdown (end of step, feet)	Specific capacity (gpm/ft)
1	1,100	27.97	39.3
2	1,275	35.35	36.1
3	1,450	42.55	34.1
4	1,625	51.26	31.7

5.4 Aquifer Performance Test

5.4.1 Introduction

A constant-rate aquifer performance test (APT) was initiated on January 30, 2024, starting at 10:00 A.M. at a rate of approximately 1,500 gpm. The pumping phase was preceded by seven days of background water level monitoring following the step-drawdown test. The produced water was disposed of in a spray field located on the west side of Walk-in-Water Road (**Figure 5-8**).

Water levels were recorded in the pumped well (SE-TPW3), the production zone (upper LFA monitor well SE-TPW3-LFA), the Upper Floridan aquifer monitor (SE-TPW3-UFA), and the surficial aquifer monitor well (SE-TPW3-SA) using downhole data logger systems. Transducers were also placed in the SE-DEW LFA zones and the TPW-LFA wells. Pumping rates were recorded hourly using a flowmeter.

Several challenges were faced during the running of the APT. Water disposal had to be monitored to prevent potential impacts to the orange grove located to the south of the spray field. The pumping duration was originally planned for 14 days, however due to water ponding near the grove, the decision was made to terminate the APT on February 6, 2024, at about 4:30 PM after approximately 7 days of pumpage. After recovery was completed, the well was pumped for another two hours and water samples collected for analysis for primary and secondary drinking water standards. Water quality was consistent throughout the test (Section 5.4.4).

The APT was interrupted from approximately 7:20 A.M. to 11:20 A.M. on February 1, 2024 due to a discharge pipe leak. Generator malfunctions impacting the pumping rate starting at approximately 8:30 P.M. on February 3, 2024, and a replacement generator was installed at about 5:55 PM on February 5, 2024.

Water disposal constraints precluded repeating of the APT. There was only approximately 4.3 days of fairly consistent discharge usable for quantifying hydraulic parameters. Nevertheless, the collected data were sufficient for achieving the key goals of the APT: (1) determination of aquifer hydraulic parameters, (2) evaluation of well yield (specific capacity), and (3) obtaining representative production zone water chemistry data.

Figure 5-8 Photograph of APT spray field.

5.4.2 Test Data

The water depth data from the SE-TPW3 site monitoring wells for the step-drawdown test through APT recovery are plotted in **Figure 5-9**. The data illustrate the difference in water elevations between the wells and the absence of any significant long-term water level trends over the duration of the monitoring period, except for a minor downward trend in the UFA.

Background water depth data from the SE-DEW LFA II wells are plotted in **Figure 5-10**. The difference in water depths between the two wells presumably reflects a difference in land surface elevation. The data show a minor rise in water levels toward the end of the test . There is no evident impact from the APT pumping.

Drawdown data from the SE-TPW3 site are plotted in **Figure 5-11**. From the early test data, there was approximately 47.5 feet of drawdown at a pumping rate of 1,500 gpm, for a specific capacity of 31.6 gpm/ft. During the period when the pumping rate increased to 1,600 gpm, the drawdown increased to 52.0 feet (specific capacity = 30.8 gpm/ft). The drawdown in the Lower Floridan aquifer monitor well (SE-TPW3-LFA), located 340 feet from the production well, was approximately 7.7 ft at a pumping rate of 1,500 gpm.

Water levels in the UFA monitor well (SE-TPW3-UFA) varied with time, with drawdown peaking at 1.24 ft on February 1, 2024, at 4:40 PM. However, the UFA drawdown pattern does not coincide with that of TPW3 or TPW3-LFA and there was an overall minor increase in water levels over the duration of the pumping phase of the APT. Review of water level data from UFA wells in eastern Polk County included in the SWFWMD Environmental Data Portal revealed no consistent regional water level trends during the APT. Hence, there is no suggestion that the LFA impacted water levels in the UFA.

Water levels in the SA had an overall minor upward drift over the duration of the pumping period with no response to the LFA pumping (Figure 5-11).

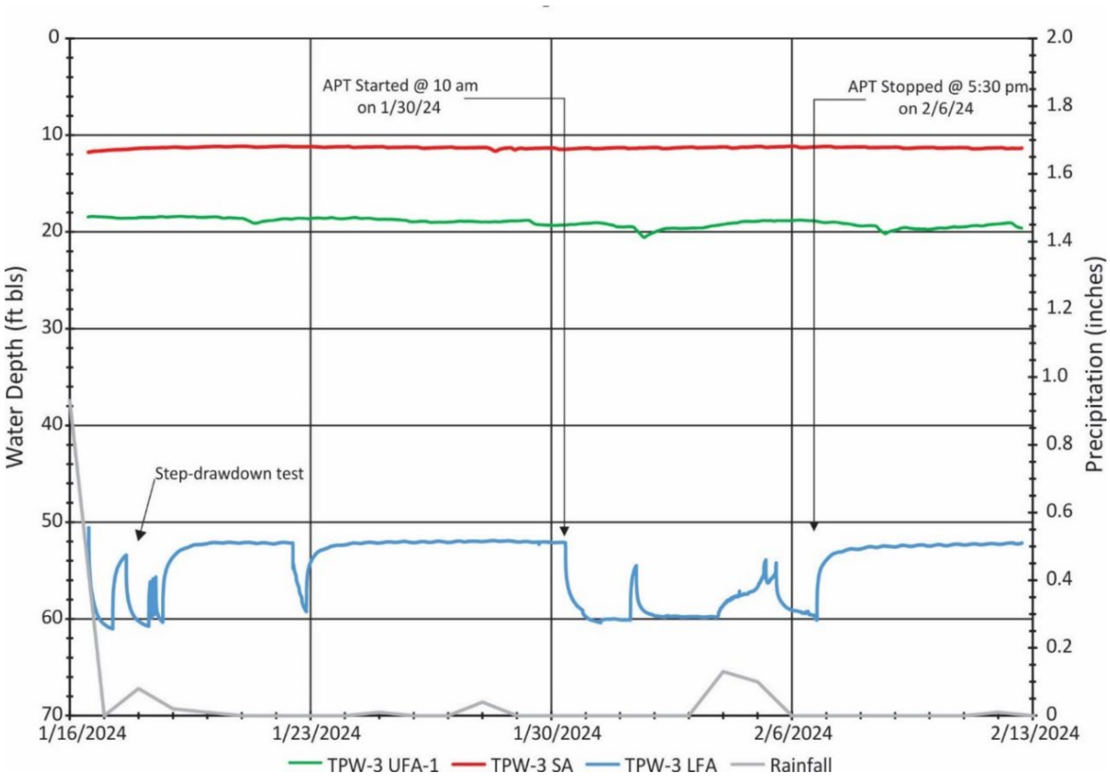

Figure 5-9 TPW3 monitoring wells water depth data

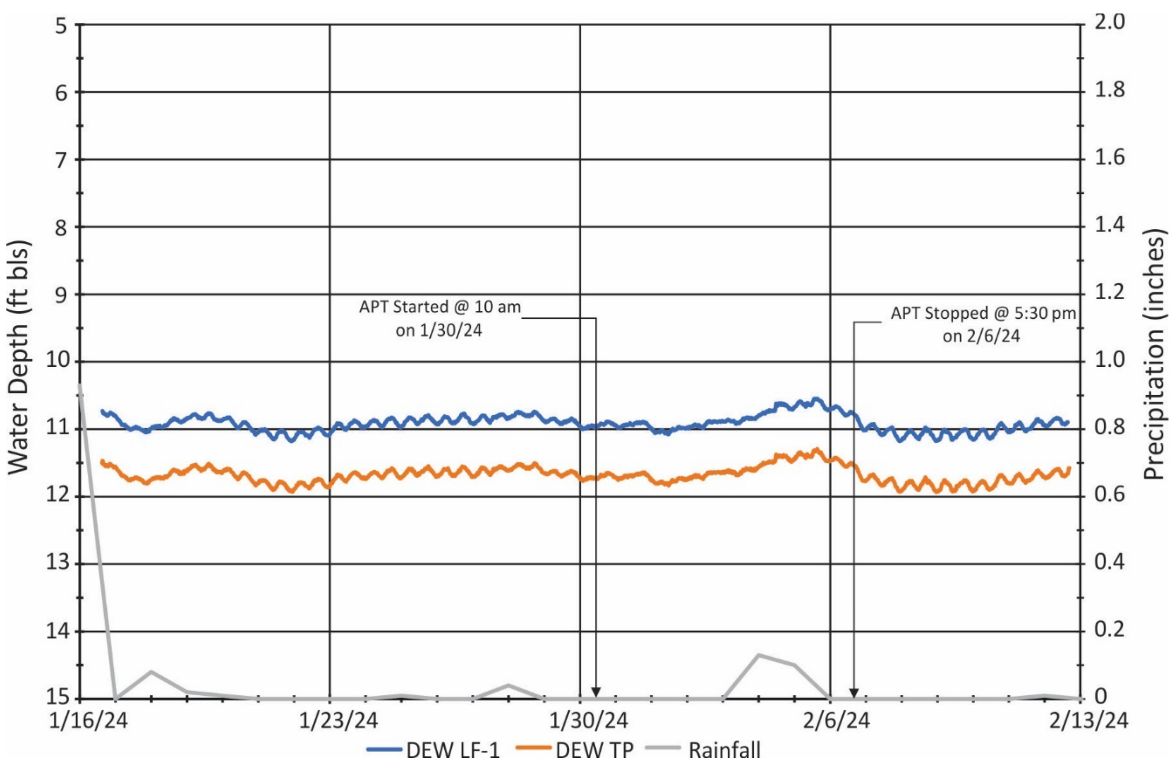

Figure 5-10 Water depth data from the SE-DEW LFA-II wells

5.4.3 APT Data Interpretation

The time-drawdown data from the production zone (SE-TPW3-LFA) were evaluated using the Hantush-Walton (Hantush and Jacob 1955; Walton 1962) modification of the Theis (1953) method for leaky aquifers and the Cooper and Jacob (1946) straight-line method. The APT analysis results are summarized in **Table 5-6**.

The Hantush-Walton and Cooper and Jacob interpretative plots for the LFA monitor (observation) well from the pumping phase are provided as **Figure 5-12**. Although the time-drawdown data are irregular, there is sufficient data from the first day of the test that plot on the Theis curve to allow for the calculation of aquifer hydraulic parameters. Transmissivity values of 20,900 and 19,100 ft^2/d were obtained.

The recovery data from the first shut-down (February 1, 2024) was interpreted using the Cooper and Jacob recovery method (**Figure 5-13**). The early data (highest t/t') values is subject to a small time error as the 5-minute readings do not accurate capture the moment the pump was turned off. Nevertheless, the calculated transmissivity of 21,150 ft^2/d agrees with the pumping phase data.

The end of test data from SE-TPW3-LFA gives two plausible straight-line plots, which give transmissivities of 20,800 and 26,450 ft^2/d (**Figure 5-14**).

The early (first day) time-drawdown from the production well are suitable for interpretation using the Cooper and Jacob method (**Figure 5-15**). The transmissivity value obtained from the pumped well (21,150 ft^2/d) is close to that obtained from the observation well.

Five of the six transmissivity values cluster around an average of 20,300 ft^2/d.

Table 5-6 Summary of APT LFA II hydraulic parameters

Method	Transmissivity (ft^2/d)	Storativity	Leakance (d^{-1})
Observation well (SE-TPW3-LFA			
Hantush-Walton (curve match)	20,900	5.6×10^{-4}	7.2×10^{-5}
Cooper & Jacob (straight-line)	19,100	7.2×10^{-4}	-
Cooper & Jacob recovery (intermediate)	21,150	-	-
Cooper & Jacob recovery (intermediate)	20,800, 26,450		
Pumped well (SE-TP3)			
Cooper & Jacob (straight-line)	19,600	-	-

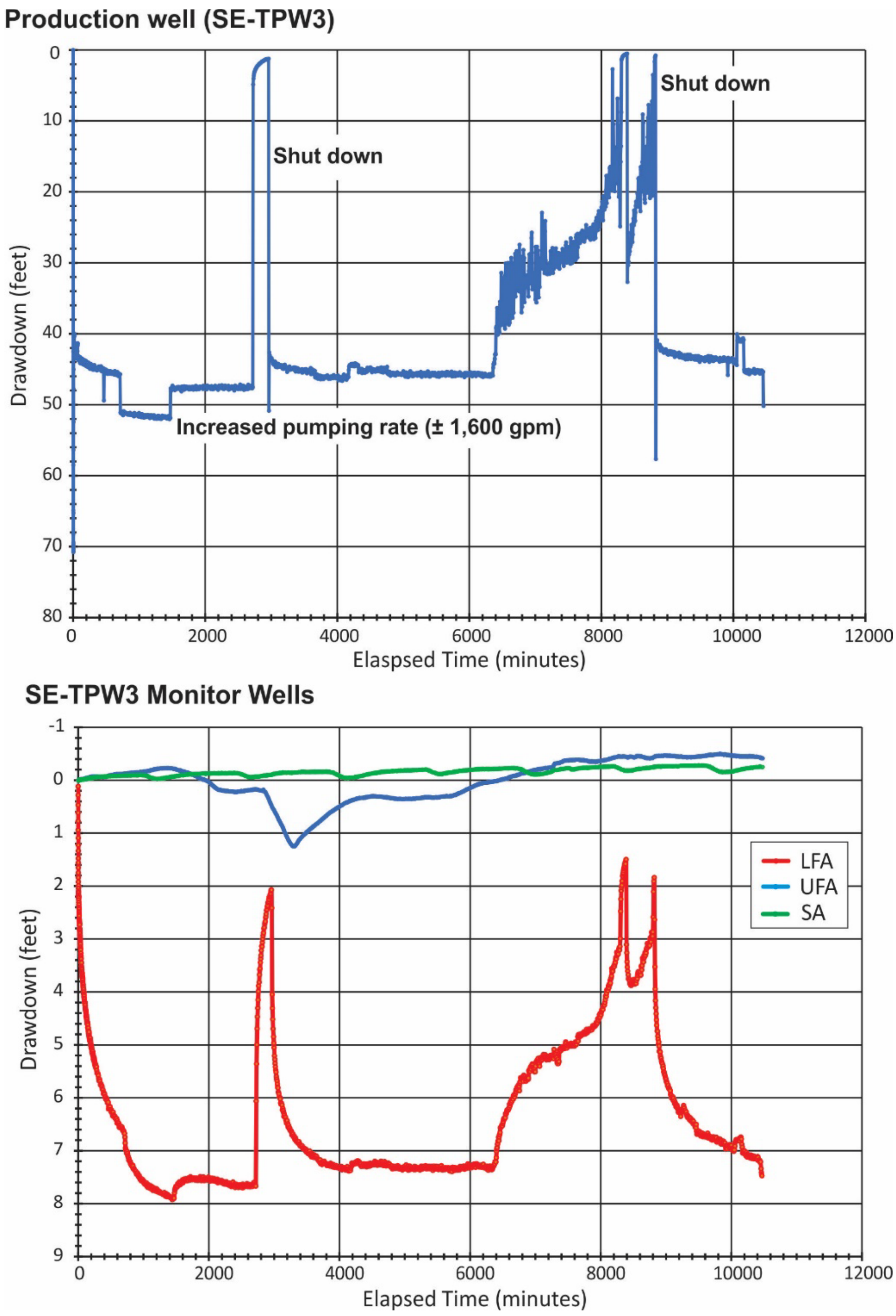

Figure 5-11 APT pumping phase drawdown data

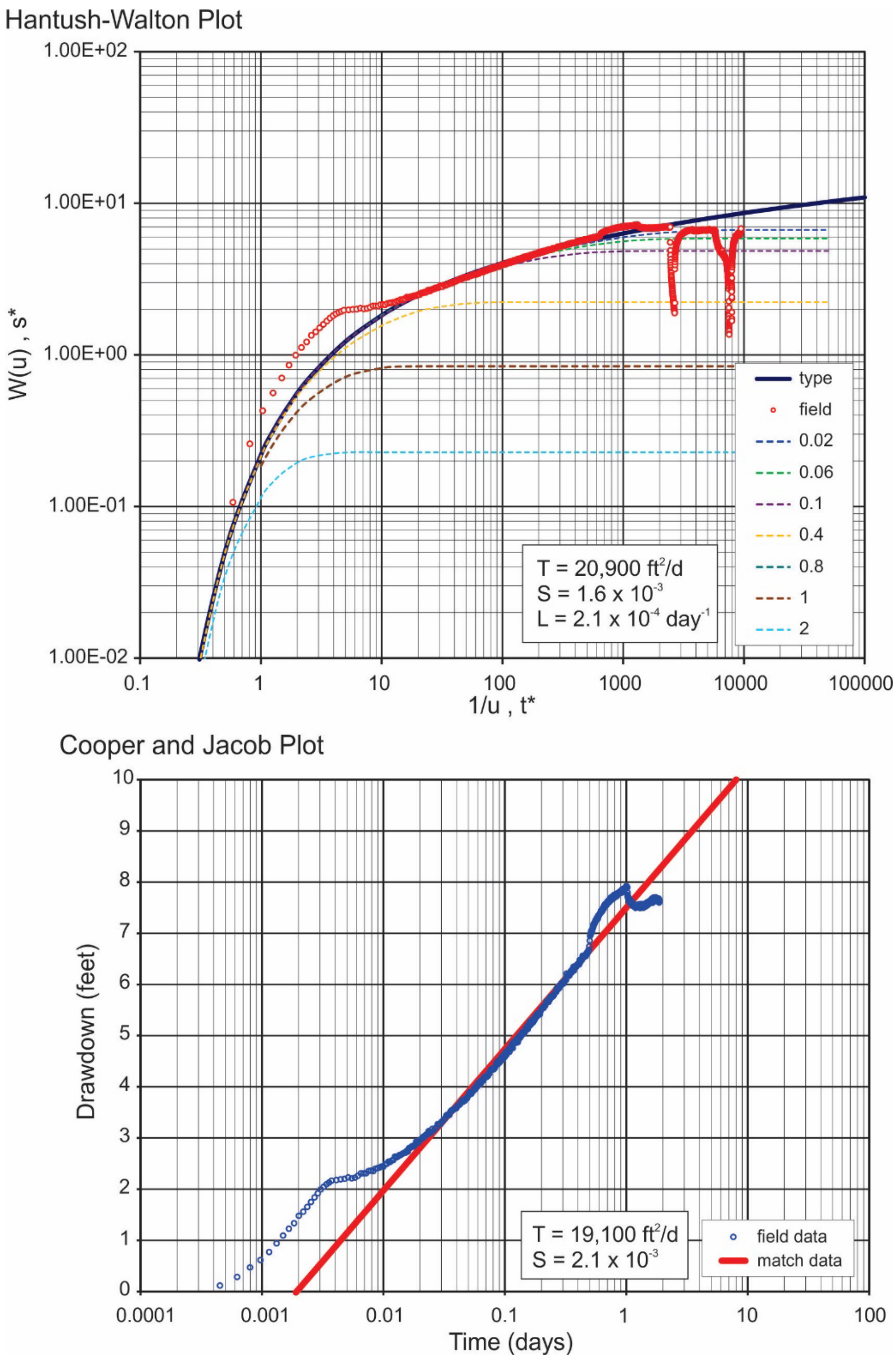

Figure 5-12 APT interpretative plots - SE-TPW3-LFA observation well pumping phase.

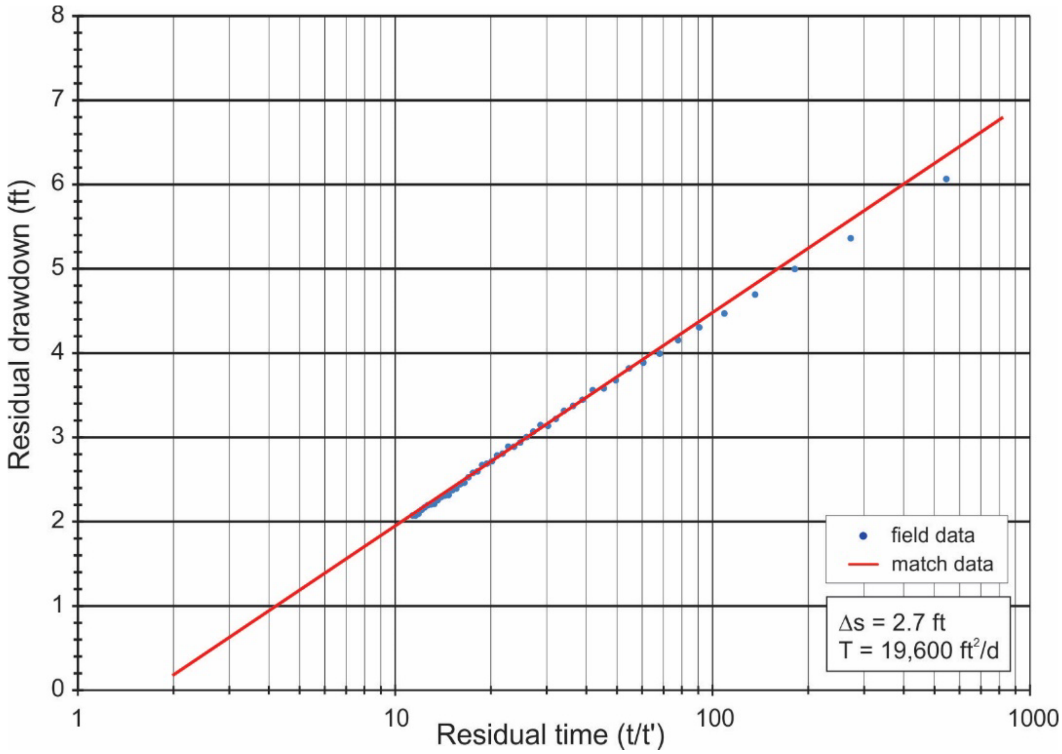

Figure 5-8 Interpretive plot SE-TPW3-LFA intermediate recovery

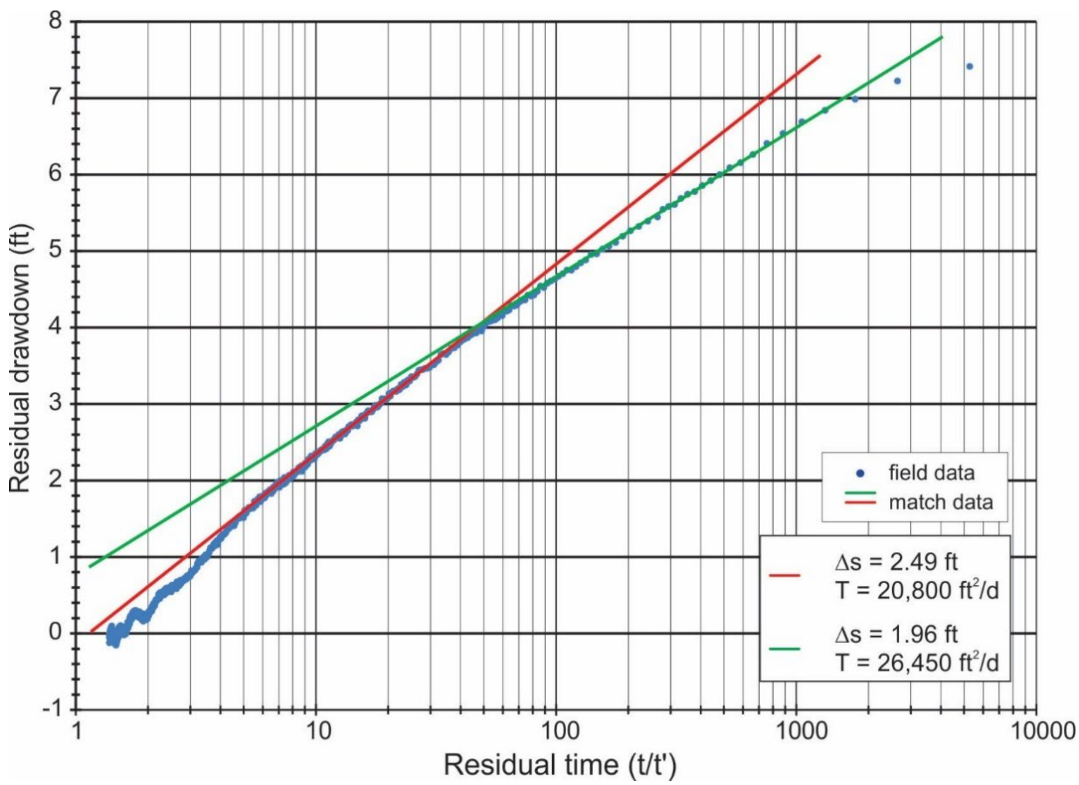

Figure 5-9 Interpretative plot of SE-TPW3-LFA end of test recovery data

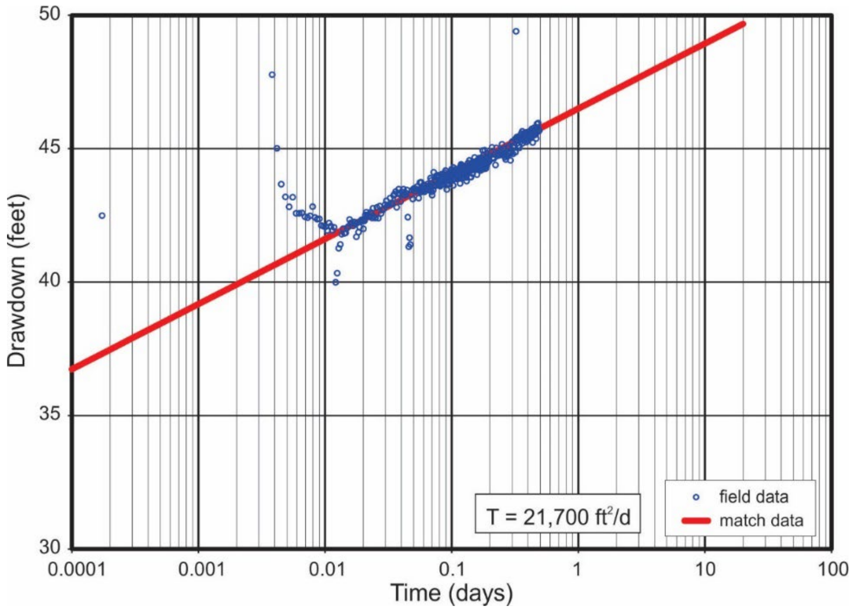

Figure 5-10 APT interpretative plot - SE-TPW3 early pumping phase

5.4.4 APT discharge water quality

Samples of the discharge from the APT were periodically collected and analyzed daily for specific conductance, TDS, chloride, sulfate, chloride, and calcium. The laboratory data are summarized in **Table 5-7** and copies of the laboratory reports are included in **Appendix F**.

The discharge water chemistry data considered as a whole does not show a change in water quality over time. The specific conductance and total dissolved solids (TDS) data show a slight increase over the duration of the test, but an increase in salinity is not confirmed by the sulfate and calcium concentration data, the main anions and cations.

Table 5-7 APT discharge laboratory data

Date and Time	Specific conductance (µS/cm)	Total Dissolved Solids (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Calcium (mg/L)	Sodium (mg/L)
1/31/24 10:00	2,780	2,980	11.0	1,990	537	14.8
2/1/24 14:00	2,780	3,080	11.1	1,960	547	15.0
2/2/24 10:00	2,790	748*	11.1	1,980	525	14.8
2/3/24 10:00	2,790	3,120	11.6	1,990	533	15.2
2/4/24 10:00	2,790	3,200	11.6	2,010	532	15.0
2/5/24 10:00	2,800	3,250	12.1	1,990	551	15.3
2/6/24 10:00	2,800	3,210	11.7	1,970	531	15.3

* Spurious laboratory value

5.5 Hydraulic Heads

Static depths to water in the TPW3-LFA borehole below the 1,400 ft bls casing were measured each morning during well drilling. The depth to water data are plotted in Figure 5-16. The data show an increase in the depth to water (decrease in water elevation) below 2,306 ft bls, which corresponds to a major flow zone and an abrupt down-hole increase in salinity. The greater depth to water below 2,306 ft bls is due to the greater salinity, and thus density, of the water in the borehole and casing.

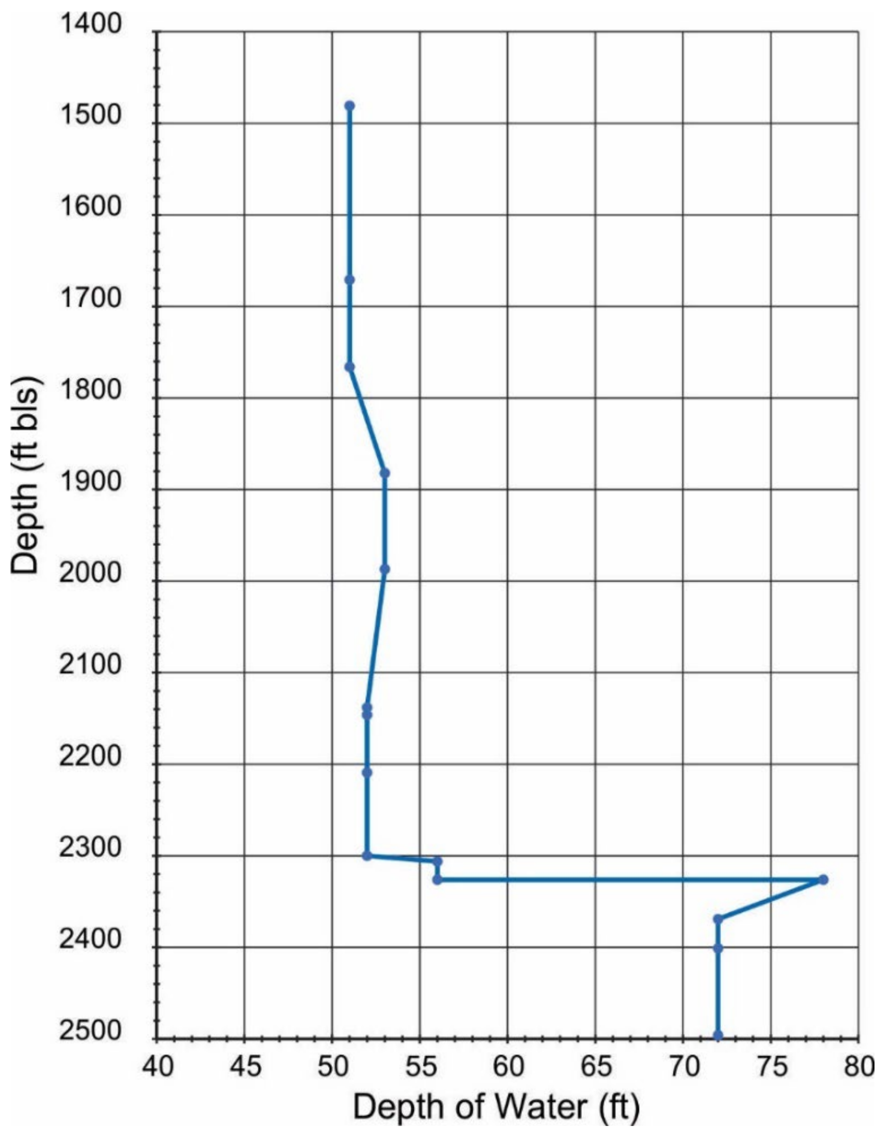

Figure 5-11 TPW3-LFA plot of depth to water versus depth

Depth to water and water elevation data from the completed TPW3 site wells are provided in Table 5-7.

Table 5-7 Depth to water and water elevations in TPW3 site wells

Well	SE-TPW3	SE-TPW3-LFA	SE-TPW3-UFA	SE-TPW3-SA
Top of flange/casing elevation (ft NAVD)	104.87	109.39	105.96	106.74
Concrete pad elevation (ft NAVD)	104.01	106.59	103.35	104.09
Depth to water (ft below TOC on (2/26/2023)	49.23	55.23	22.30	14.18
Groundwater elevation (ft NAVD)	55.64	54.16	83.66	92.56

6 WATER QUALITY

Data on groundwater quality were obtained from analyses of water samples from the reverse-air discharge, packer tests, step-drawdown tests, and aquifer performance test, and from the borehole geophysical logging.

6.1 Borehole Geophysical Logging

Geophysical logs can provide information on groundwater salinity in two main manners. The fluid conductivity log directly measures the conductivity of the water within the borehole. Where there is minimal flow within a well, the chemistry of water within a borehole tends to equilibrate with the water in the adjoining formation. A static fluid conductivity log can thus provide information on changes in salinity with depth. The dynamic fluid conductivity (performed while the well is being pumped) also provides information on changes in salinity with depth.

A segment of the fluid conductivity and temperature log of TPW3-LFA is provided as **Figure 6-1**. Downhole across the flow zone between 2,310 and 2,325 ft bls, fluid conductivity increases from about 3,200 µS/cm to over 60,000 µS/cm. Fluid temperature increases from 80.9 °F to 86.9 °F. The water produced from the flow zone is this much less saline and cooler than the underlying groundwater, which has a salinity close to seawater values.

The fluid conductivity log of the open hole of TPW3 gives a value of 2,912 µS/cm at 1,790 ft bls, just above the main LFA II flow zone. The log shows decreasing salinity with depth from 1,800 to 1,900 ft bls, which may reflect the presence of stagnant, fresher water.

Formation water fluid conductivity can be estimated from porosity obtained from the sonic log and formation resistivity obtained from the deep induction log in accordance with the Archie (1942) equation. Raw log-derived specific conductance (SC, conductivity at 25°C) versus depth plots have considerable noise. Peaks in specific conductance tend to be correlated with low porosity dolomite beds, which could either be an artifact of the method or perhaps reflect more saline water retained in the tight units. The profiles can be smoothed by plotting moving averages (e.g., 3 or 4 ft) to more clearly show overall trends with depth.

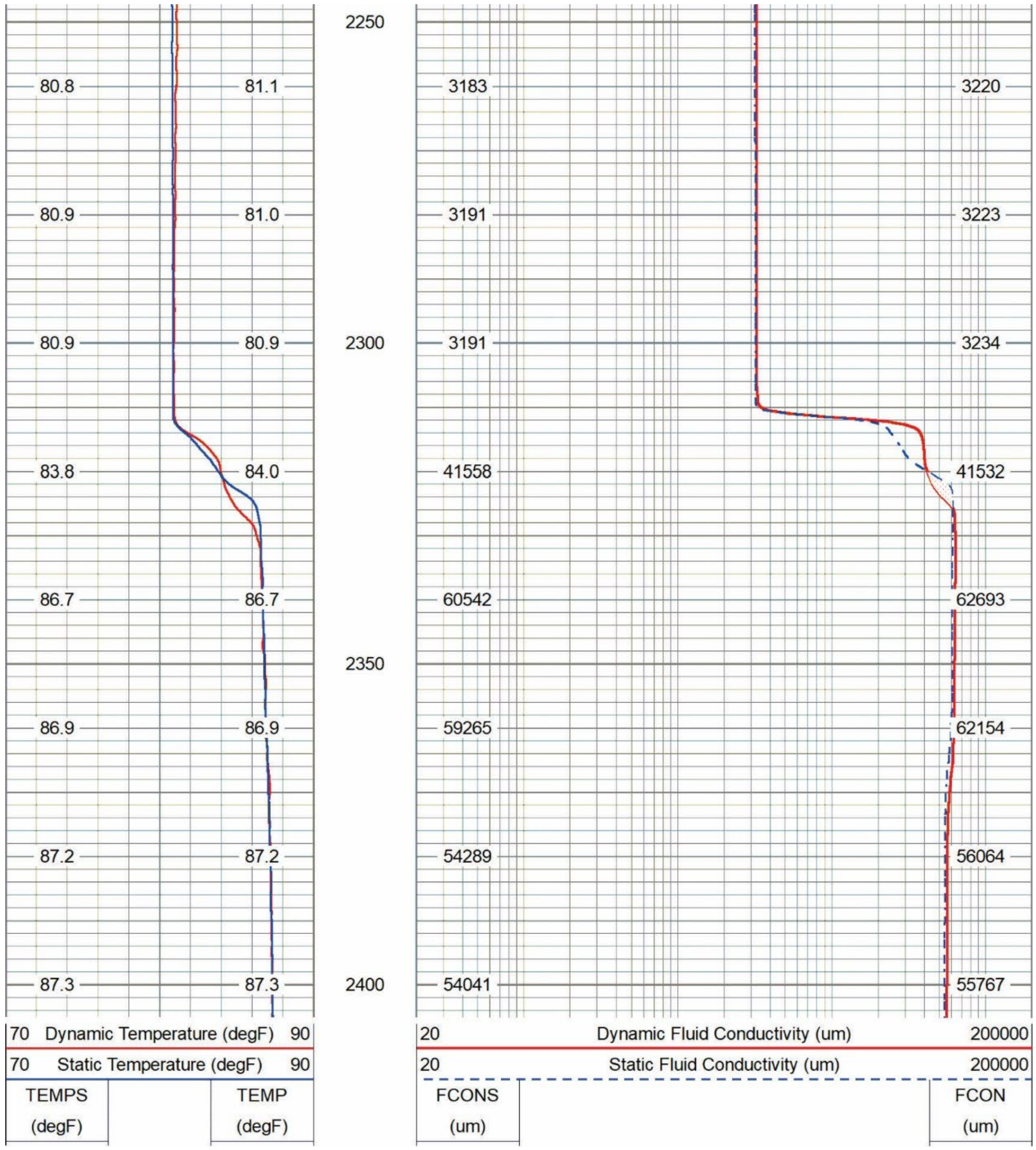

Figure 6-1 Fluid conductivity and temperature log of TW3-LFA around main flow zone

The log-derived specific conductance versus depth profile for the TPW3-LFA pilot hole from 350 to 1,400 ft bls, indicates that the groundwater is fresh (SC < 500 µmhos/cm) down to about 1,280 ft bls (**Figure 6-2**). Below 1,280 ft bls, the water is mildly brackish.

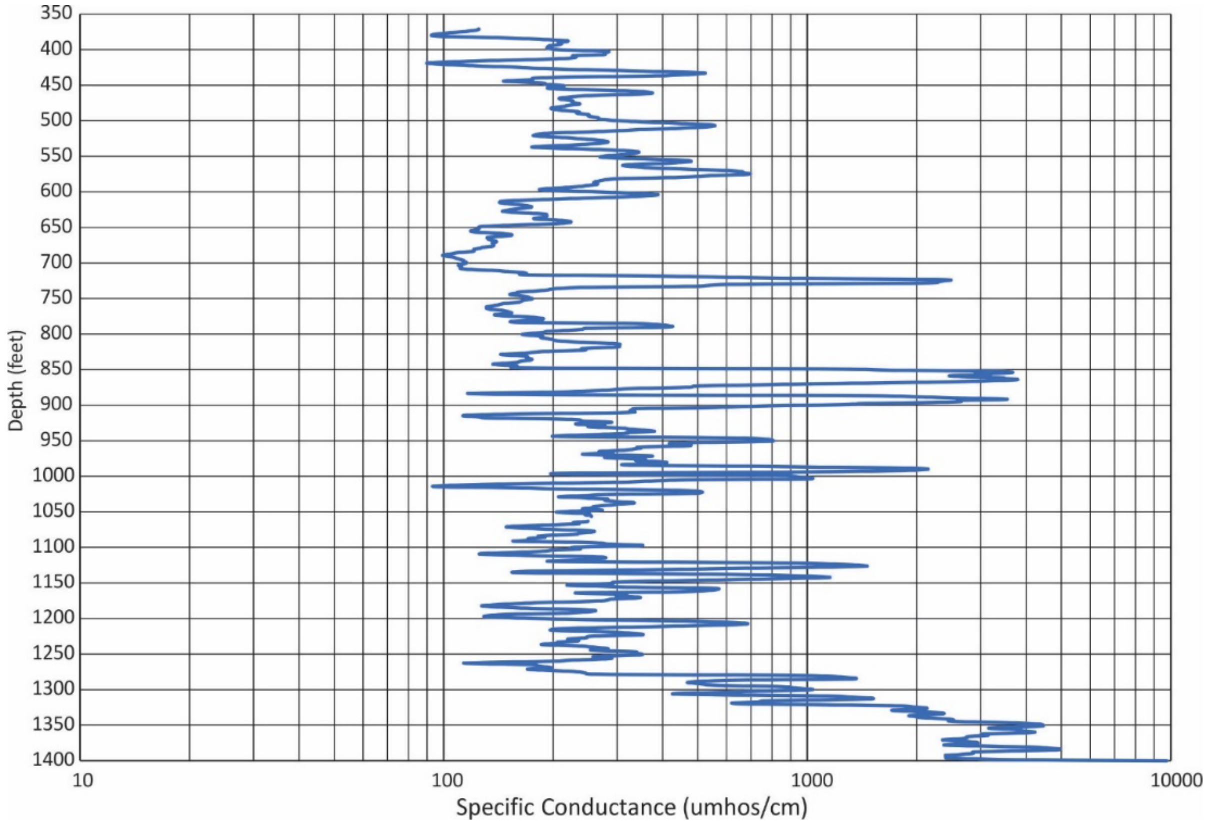

Figure 6-2 Log-derived SC versus depth profile to 1,400 ft bls (4 ft trailing moving average)

The log-derived specific conductance versus depth profile for the TPW3-LFA pilot hole from 1,400 to total depth (2, 560 ft bls) is provided as **Figure 6-3.** The plot has considerable scatter but shows a pronounced down-hole increase in salinity at about 2,320 ft bls to, or close to, sea water values. This increase in salinity is also evident in the fluid conductivity log and reverse-air discharge water quality data. The presence of a major flow zone at 2,310 to 2,325 ft bls is evident on the flowmeter log.

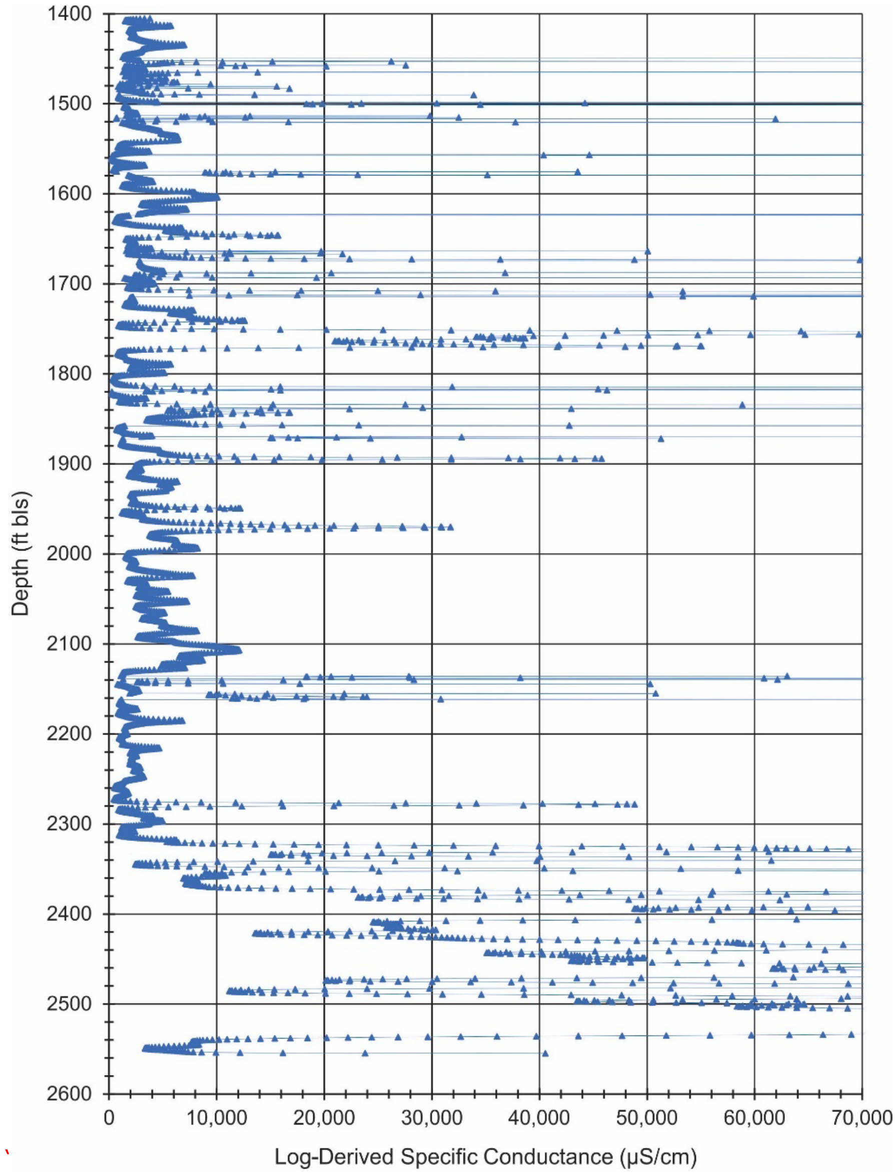

Figure 6-3 Log-derived SC versus depth profile from 1,400 to 2,560 ft bls (3 ft trailing moving average)

6.2 Reverse-Air Discharge

Samples of the reverse air discharge were collected every 90 feet (3rd drill rod addition) and analyzed for a suite of major and minor cations and anions. The laboratory reverse air discharge data are compiled in **Table 6-1** and the laboratory reports are provided in **Appendix G**.

The reverse-air discharge water quality data for a given depth is not necessarily representative of the formation water quality at that depth because of mixing with water produced higher in the borehole and the addition of fresh (UFA) groundwater to the water being circulated in the borehole. However, changes in the composition of the reverse-air discharge can provide qualitative information on formation water quality and water production.

A plot of specific conductance, TDS, chloride, sulfate, calcium, and sodium concentrations versus depth is provided as **Figure 6-4.** The concentrations of all parameters show little change down through 2,272 ft bls. There is a very large increase in the concentration of salinity correlated parameters between the 2,272 and 2,371 ft bls samples, reflecting the larger increase in salinity below the 2,310 to 2,325 ft bls major flow zone.

Table 6-1 Reverse-air discharge data summary

Parameter	Unit/ Sample (ft bls)	1547	1640	1730	1820	1925	2020	2110	2177	2272	2371	MDL	PQL
Turbidity	NTU	70	240	700	55	50	70	750	55	140	80	0.050	0.15
Total alkalinity	mg/L	77.2	76.5	80.6	84.6	83.4	84.4	79.8	79.3	78.2	70.5	3.74	10.0
Ammonia as N	mg/L	0.102	0.107	0.110	0.101	0.099	0.057	0.030	0.050	0.099	0.058	0.0062	0.0200
Ammonium as NH4	mg/L	0.093	0.102	0.288	0.094	0.006	0.054	0.029	0.047	0.092	0.055	0.0062	0.0200
Bicarbonate	mg/L	76.1	76	79.8	78.6	79.6	84	79.4	78.6	77.5	70.2	3.74	10.0
Bromide	mg/L	0.069	ND	ND	ND	ND	ND	0.218	ND	ND	65.3	.124	0.250
Carbonate	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.74	10.0
Chloride	mg/L	10.5	10.3	10.4	10.3	10.3	10.2	10.1	9.99	52.6	18,000	0.252	1.00
Specific conductance	µmos/cm	2,840	2,760	2,850	2,780	2,800	2,850	2,860	2,840	2,910	42,100	1.00	1.00
Dissolved organic carbon	mg/L	-	-	-	-	-	1.23	0.965	0.865	0.936	ND	0.135	0.500
Fluoride	mg/L	2.59	2.5	2.52	2.46	2.45	2.56	2.52	2.55	2.39	1.61	0.0104	0.0500
Hydrogen sulfide	mg/L	ND	0.142	0.126	0.098	0.136	0.072	0.216	0.129	0.050	0.005	0.0021	0.0100
Ferric iron	mg/L	0.92	1.34	2.19	1.46	1.17	1.71	3.15	3.01	1.56	1.54	-	-
Ferrous iron	mg/L	ND	ND	0.5	0.4	ND	ND	ND	ND	ND	ND	0.200	0.600
Nitrate/nitrite as N	mg/L	0.216	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0144	0.150
Orthophosphate as P	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0486	0.100
Phosphorous-total	mg/L	0.356	0.17	0.106	0.175	0.12	0.138	0.211	0.211	0.155	0.144	0.0666	0.200
Silica, total	mg/L	14.5	14	14.3	14.4	14.3	14.9	13.7	14	14.2	7.75	0.0396	0.119
Sulfate	mg/L	2,240	2,190	2,260	2,130	2,870	2,080	2,100	2,080	2,070	3,050	4.76	25.0
Total dissolved solids	mg/L	3,560	3,480	3,390	3,290	3,240	3,400	3,500	3,470	3,550	33,700	40.0	120
Total organic carbon	mg/L	1.00	1.00	-	1.17	1.08	0.919	-	0.865	0.936	ND	0.135	0.500
pH	S.U.	8.09	8.05	7.91	8	8.03	7.71	7.69	8.03	8.08	7.56	0.1	0.1
Aluminum	mg/L	0.097	0.148	0.320	0.081	0.051	0.068	0.386	0.012	0.009	0.019	0.00294	0.0100
Barium	mg/L	0.013	0.013	0.015	0.013	0.013	0.012	0.014	0.018	0.013	0.040	0.000109	0.0010
Boron	mg/L	0.043	0.044	0.043	0.044	0.043	0.042	0.043	0.040	0.050	4.510	0.000903	0.0100

Calcium	mg/L	629	670	741	679	662	592	963	582	589	924	0.120	1.25
Copper	mg/L	0.008	0.0046	0.013	0.014	0.024	0.006	0.015	0.011	0.003	0.027	0.00129	0.0050
Total hardness	mg/L	2,480	2,650	2,970	2,670	2,550	2,350	3,370	2,320	2,340	6,280	0.0101	0.200
Magnesium	mg/L	221	237	272	236	218	211	234	212	213	964	1.22	10.0
Manganese	mg/L	0.013	0.017	0.031	0.021	0.017	0.020	0.056	0.028	0.018	0.029	0.000193	0.00100
Potassium	mg/L	3.00	3.02	3.15	2.90	2.81	2.78	3.15	2.72	4.34	449	0.0333	0.0500
Sodium	mg/L	17.7	18.4	19.9	17.6	17.4	16.3	22.2	15.7	44.4	8,770	0.730	2.00
Strontium	mg/L	10.3	10.8	10.7	10.9	10.5	10.1	10.2	10.0	10.0	27.2	0.0152	0.0250

ND = not detected
MDL = method detection limit; PQL = practical quantification limit

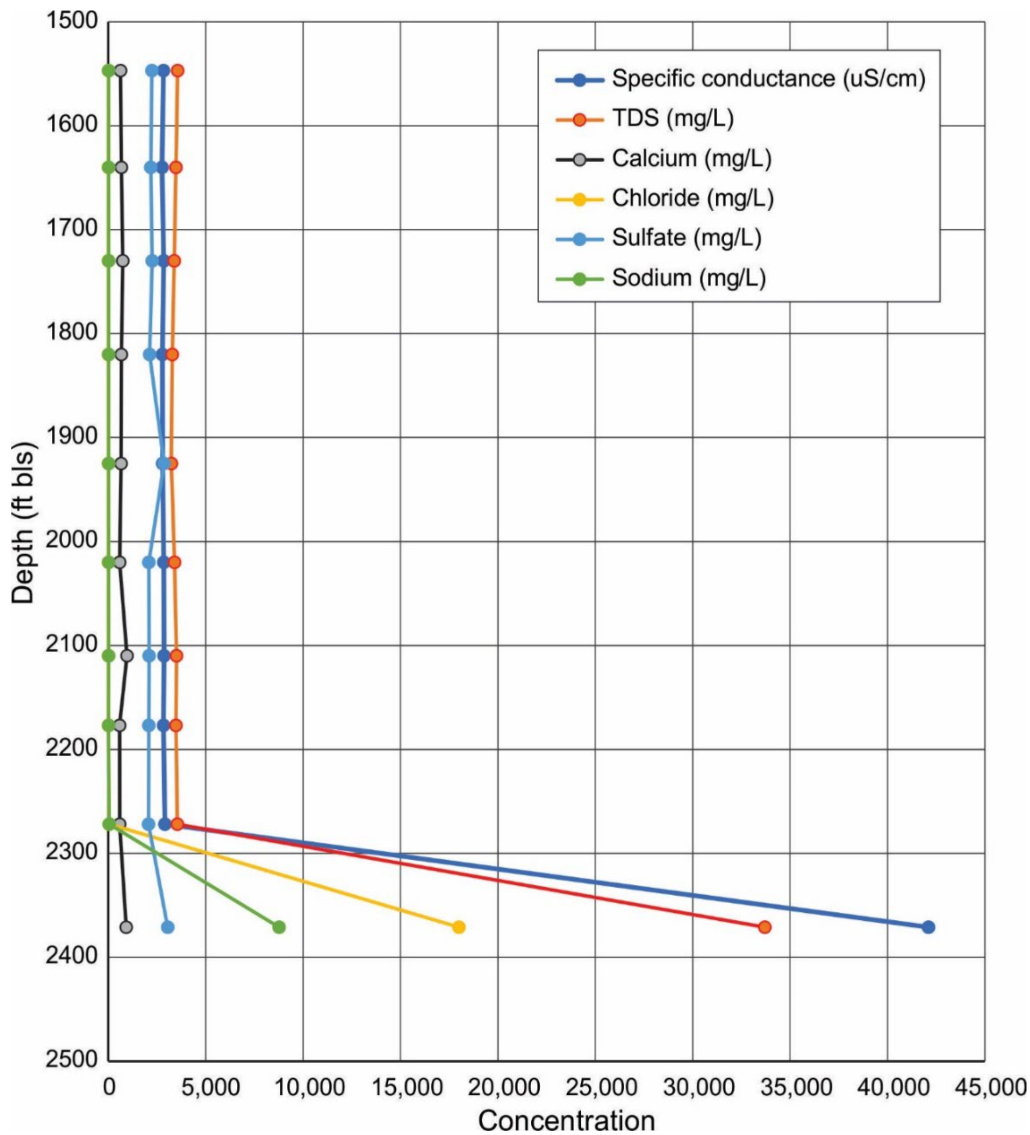

Figure 6-4 Reverse-air discharge water quality data

6.3 Pumping and Packer Tests

Water samples were collected at the end of the packer tests and aquifer performance test for laboratory analyses for major and minor cations and anions and some additional water quality parameters. The aquifer performance test discharge was analyzed for Florida primary and secondary drinking water standards, major cations and anions, and reverse-osmosis design parameters. The laboratory chemistry data from the packer test and APT samples are shown in **Table 6-2**. Copies of the laboratory reports are provided in **Appendices H and I.**

Table 6-2 Summary of packer test and APT water chemistry data

Test/Parameter	PT-1	PT-2	PT-3	PT-4	PT-5	APT	MDL	PQL
Depths (ft bls)	1400-1,628	1792 - 1842	2142-2192	2,319-2,369	2,488-2,538	1,400-1,900		
Unit	LFA II	LFA II	MCU VIII	LFA VIII	LFA VIII	LFA II		
Specific conductance (µS/cm)	2,910	2,830	3,090	43,200	24,200	2,991	1.00	1.00
TDS Lab (mg/L)	3,560	3,220	3,630	34,440	17,600	2,640	40	120
TDS Calculated (mg/L)	2,985	2,503	2,785	30,757	16,927	2,837	-	-
Chloride (mg/L)	11.2	10.9	230	16,900	7,810	9.94	0.306	0.500
Sulfate (mg/L)	2,080	1,620	1,680	3,090	3,310	1,970	3.64	5.00
Bicarbonate (mg/L)	81.9	77.8	79.6	70.6	75.9	93.0	-	-
Fluoride (mg/L)	2.5	2.28	1.18	1.82	3.96	2.52	0.0158	0.0250
Sodium (mg/L)	15.5	15	125	8,140	3,940	14.8	0.160	2.00
Potassium (mg/L)	2.56	2.39	11.4	678	263	2.01	0.010	0.050
Calcium (mg/L)	538	562	465	907	970	521	0.130	2.00
Magnesium (mg/L)	228	187	168	864	491	198	0.094	1.00
Strontium (mg/L)	10.9	10.7	8.70	30.3	19.5	9.87	0.00030	0.00500
pH (std units)	7.47	7.34	7.49	7.18	7.07	7.46	0.100	0.300
Barium (mg/L)	0.0112	0.0122	0.0221	0.0380	ND	0.0111	0.000106	0.00100
Boron (mg/L)	0.0501	0.0412	0.0900	3.94	2.37	0.041	0.001	0.020
Bromide (mg/L)	ND	ND	0.766	61.1	27.6	ND	0.0248	0.0500
Dissolved organic carbon (mg/L)	0.931	0.916	0.313	ND	ND	1.26	0.135	0.500
Hydrogen sulfide (mg/l)	0.575	0.179	0.279	0.0469	0.0914	0.870	0.0105	0.0500
Ferric iron (mg/L)	0.465	0.268	0.473	1.57	1.54	0.02449	-	-
Ferrous iron (mg/L)	ND	ND	ND	ND	0.90	ND	0.200	0.600
Silica, total (mg/L)	13.4	13.7	14.4	8.69	11.4	13.4	0.0396	0.119

ND = not detected; MDL = method detection limit; PQL = practical quantification limit

There is some discrepancy between TDS values reported using method SM2540C-2015 (evaporation at 180°C) and values calculated as the sum of dissolved constituent concentrations. The later are more consistent with the specific conductance values and are thus interpreted to be more accurate. The TDS concentration of the production zone is estimated to be 3,000 ± 200 mg/L.

6.4 Base of the Underground Source of Drinking Water

The base of the regulatory Underground Source of Drinking Water (USDW) is defined as the 10,000 mg/L total dissolved solids (TDS) isopleth.

The log-derived conductivity plot, fluid conductivity logs, reverse-air discharge data and packer test results from the TWP3-LFA well show that the base of the USDW (10,000 mg/L TDS isopleth) occurs close to the top of LFA VII at about 2,320 ft bls. This depth is comparable to that determined at the SE-DEW site (2,370 ft bls) and the SE-TPW site (2,320 ft bls).

The USGS Geological Survey regional map of the base of the USDW (**Figure 6-5**; Williams and Kuniansky 2016) shows it occurring between -2,300 and -2,400 ft NGVD (≈ 2,400 to 2,500 ft bls) in the TPW3 vicinity.

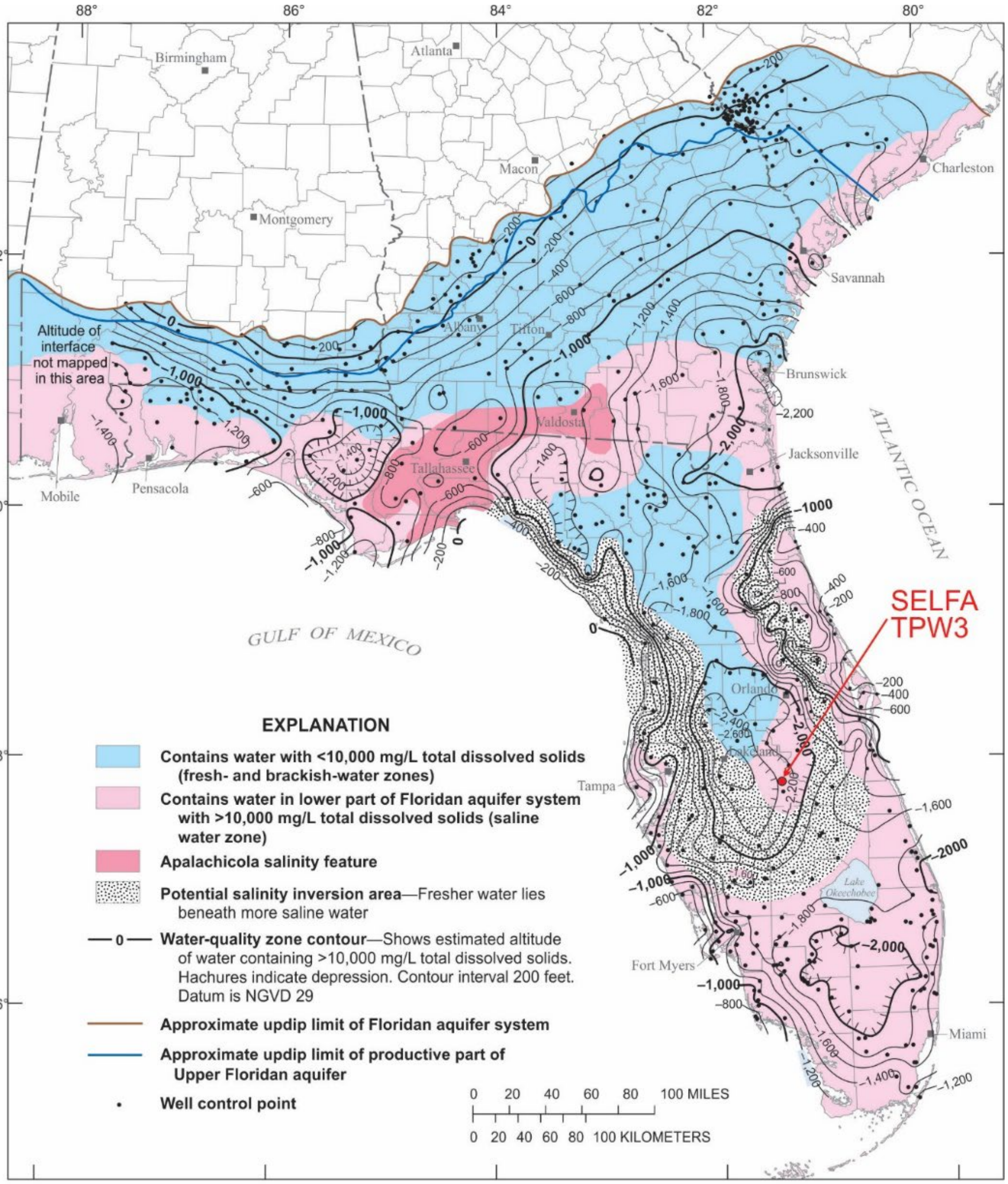

Figure 6-5 Map of base of the USDW in Florida

6.5 Groundwater Chemistry

A piper plot of the packer tests and APT data show that two distinct water types are present (**Figure 6-6**). The upper LFA production zone water samples (APT, PT-1, PT-2, and PT-3) are calcium-sulfate type in which the dissolved solids were derived primarily from the dissolution of gypsum and/or anhydrite present in the formation. The lower LFA water samples (PT-4 and PT-5) are sodium chloride type in which the dissolved solids were derived mainly from seawater, which composition is also plotted.

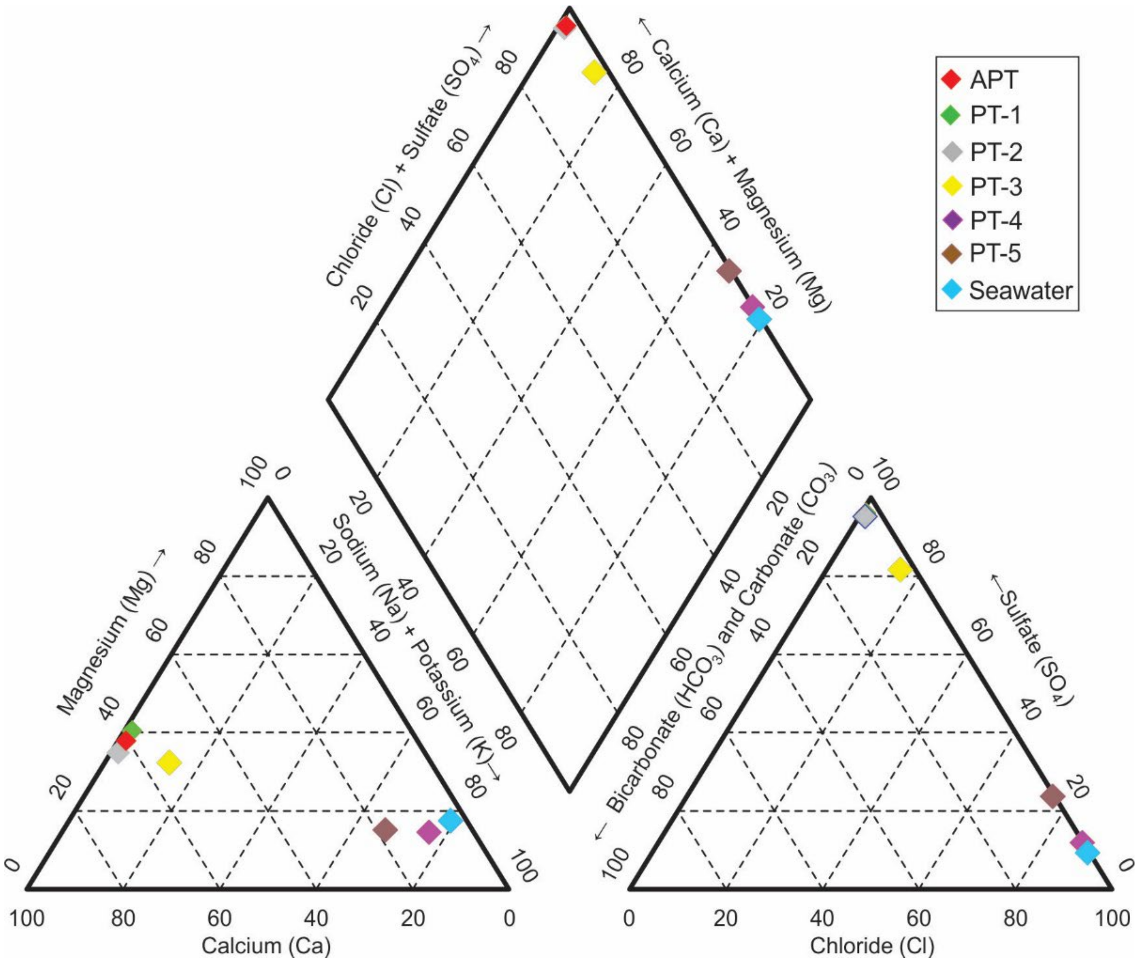

Figure 6-5 Piper diagram of SE-TPW3 APT and packer tests water samples.

The saturation state of waters with respect to the calcium sulfate (anhydrite and gypsum), carbonate, and some other ionic minerals (barite and fluorite) were calculated using the USGS PHREEQC (Parkhurst and Appelo 1999) code. Saturation indices of solutions for minerals is defined as the $\log_{10}$ of the ratio of the ion activity production and solubility product. Saturation indices of less than zero indicate unsaturated conditions, whereas values greater than zero indicate supersaturated conditions (**Table 6-3**).

The production zone water samples from the SE-TPW3 site (PT-1, PT-2, and APT) are at about saturation with respect to gypsum (a hydrated calcium sulfate) and undersaturated with respect to the more soluble calcium sulfate mineral anhydrite. The MCU VIII and LFA VIII samples are also at about gypsum saturation. Calcium sulfate concentrations in the LFA are being controlled by interaction with calcium sulfate minerals in the aquifer.

Table 6-3 Calculated saturation state of packer test and APT water samples

Test/Parameter	PT-1	PT-2	PT-3	PT-4	PT-5	APT
Depths (ft bls)	1400-1,628	1792 - 1842	2142-2192	2,319-2,369	2,488-2,538	1,400-1,900
Unit	LFA II	LFA II	MCU VIII	LFA VIII	LFA VIII	LFA II
Mineral	Saturation Index					
Calcite ($CaCO_3$)	0.13	0.04	0.11	-0.24	-0.24	0.22
Aragonite ($CaCO_3$)	-0.01	-0.10	-0.03	-0.39	-0.38	0.08
Dolomite ($CaMg(CO_3)_2$)	0.21	-0.06	0.11	-0.11	-0.41	0.37
Gypsum ($CaSO_4 \cdot H_2O$)	-0.05	-0.10	-0.15	-0.18	0.02	-0.07
Anhydrite ($CaSO_4$)	-0.27	-0.32	-0.37	-0.39	-0.20	-0.27
Barite ($BaSO_4$)	-0.03	-0.08	0.21	0.16	-	-0.12
Fluorite (CaF_2)	0.08	-0.08	-0.57	-0.52	0.37	0.06

Calculated calcite saturation states are highly sensitive to pH and measured pH values have large potential for errors if careful sampling and analysis procedures are not followed. Degassing of CO_2 upon exposure of water to the atmosphere, decreases CO2 levels resulting in an increase in pH and thus the saturation state of carbonate minerals. Hence, the calculated supersaturation with respect to calcite may not reflect *in situ* aquifer conditions. The APT sample has a saturation index (SI) of 0.22 at the field pH of 7.46 and an SI of -0.14 at the laboratory pH of 7.17.

Nevertheless, the production zone samples are close to saturation with respect to calcite, aragonite and dolomite, which is to be expected in deep groundwaters with long contact times with aquifer carbonate minerals.

7 COMPARISON OF SELFA WPF TEST WELLS

Three test production wells for the SELFA WPF have been constructed and tested, SE-DEW, SE-TPW, and SE-TPW3 (Figure 1.1), which are all completed in the same aquifer, LFA II. SE-TPW3 will be used as a production well for Phase I of the SELFA WPF project (production well PW-12). The SE-DEW may be incorporated into a later project phase. SE-TPW will be converted to a monitor well for the SELFA WPF deep injection well system.

The aquifer hydraulic properties and production zone water quality for the three sites are summarized in **Table 7-1**. SE-TPW3 has a similar transmissivity as the SE-DEW, which suggests that the proposed wellfield area is more productive (has higher specific capacities) than at the SE-TPW site. The wellfield area appears to also have a lower leakance than to the north at the SW-TPW site.

LFA II at the SE-TPW and SE-TPW3 sites contains water with a TDS concentration of 3,000 ± 300 mg/L. The LFA II zone at the Crooked Lake dual-zone monitor well (located approximately 11 miles to west; Figure 1-1) also has a TDS concentration of about 3,000 m/L (WSP 2023). The low salinity measured at the SE-DEW site thus appears to be anomalous, possibly related to a downward flow of fresher water during well construction. LFA II contains a calcium sulfate water type at all three sites.

Table 7-1 Summary of SELFA WPF test production well data

Well	Transmissivity (ft^2/d)	Storativity (unitless)	Leakance (day^{-1})	Specific capacity (gpm/ft)	Laboratory total dissolved solids (mg/l)	Laboratory Specific Conductance (µS/cm)
SE-DEW	16,300	3.6×10^{-4}	4.07×10^{-3}	37.6	1,100	1,447
SE-TPW	3,830	1.5×10^{-3}	1.1×10^{-2}	13.8	3,220	3,030
SE-TPW3	20,900	5.6×10^{-4}	7.2×10^{-5}	31.6	2640 – 2837	2,991

Notes: Hantush-Walton (Jacob) method hydraulic parameters are provided
Water chemistry data are from end of APT sample.

The SE-TPW3 data confirms the water quality and hydraulic properties incorporated into the Southeast Wellfield design.

8 CONCLUSIONS

The SE-TPW3 hydrogeologic testing program completed in 2024 resulted in the following findings:

- The LFA II production zone at the TPW3 site is sufficiently transmissive for the planned raw water production. Five of the six transmissivity values obtained from the APT cluster around an average of 20,300 ft^2/d. Well TPW3 was pumped at 1,625 gpm during the step-drawdown test with a drawdown of about 51.3 ft, which gives a specific capacity of 31.7 gpm/ft.

- The transmissivity of the LFA II is greater than that encountered at the SE-TPW site (3,810 ft^2/d and at the SE-DEW site (15,300 ft^2/d).

- The main flow zone in the LFA II production zone (1,400 to 1,900 ft bls) is located between 1,800 and 1,850 ft bls.

- The low leakance value of 2.1×10^{-4} day^{-1} calculated from the APT test data indicates that the production zone has very good underlying and overlying confinement.

- The base of the regulatory Underground Source of Drinking Water (USDW), defined as the 10,000 mg/L total dissolved solids (TDS) isopleth, is placed at approximately 2,320 ± 20 ft bls.

- LFA II production zone contains groundwater with a TDS of 3,000 ± 200 mg/L, comparable or slightly fresher than the TPW production zone value.

- Water chemistry data from the production zones (LFA II) indicates the native groundwater is a calcium sulfate-type. The sulfate concentration is an order or magnitude greater than both the chloride and bicarbonate concentrations indicating that the TDS is derived mainly from calcium sulfate mineral dissolution.

- The groundwater in both the LFA II and LFA VIII units is slightly undersaturated with respect to gypsum and anhydrite (calcium sulfate minerals) and at or near saturation with respect to calcium carbonate minerals (calcite, aragonite, and dolomite).

- The shortened duration and unsteady pumping rates of the APT reduced the value of the analysis of aquifer boundary conditions within the test site's vicinity (from faults, conduits, or other non-homogeneous features). Opportunities may exist to use the completed production and monitor wells for a longer-duration APT in the future once a production pump is installed and the raw water line to the SE treatment facility is constructed. If that opportunity presents itself and funds are available, future testing is recommended to confirm leakance, aquifer homogeneity, and consistency of water quality.

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