Well Construction and Testing Report:

Paradise Run Aquifer Storage and Recovery Test-Monitor Well HIF - 42

Prepared for:

South Florida Water Management District

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
PROTECTOR OF THE EVERGLADES SINCE 1949

Prepared by:

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Executive Summary

The South Florida Water Management District (SFWMD) constructed Aquifer Storage and Recovery (ASR) Test-Monitor Well HIF-42 to evaluate the development of ASR in the general vicinity of northern Lake Okeechobee. This work was undertaken by SFWMD to demonstrate:

1. The feasibility of a large-scale ASR well system for diversion of excess surface waters to storage
2. The use of natural systems for pre-treatment of surface water delivered to ASR wells
3. That combining ASR with constructed wetlands could achieve water load and water quality improvements
4. Improved habitat management

At the Paradise Run Site, a "stacked" ASR well system has been envisioned by SFWMD, including paired ASR wells to provide subsurface storage of treated surface water within the upper Floridan aquifer and the middle Floridan aquifer and capable of operating with a storage/recovery capacity of 50 million gallons per day (mgd).

The successful completion and testing of the Paradise Run ASR Test-Monitor Well (HIF-42) provides the initial evaluation of site-specific hydrogeology. The results of the exploratory drilling, aquifer testing, and water quality analyses are favorable for development of ASR targeting subsurface storage zones within the upper Floridan and middle Floridan aquifers. The approximate depths of hydrogeologic units and the permeable and confining zones in these two aquifers were observed during the construction of the Paradise Run ASR Test-Monitor Well HIF-42, and are summarizes in Exhibit ES-1.

EXHIBIT ES-1
Hydrogeologic Units, Permeable Zones, and Confining Zones
Paradise Run ASR Test-Monitor Well (HIF-42)

Hydrostratigraphic Unit	Depth Interval
Surficial aquifer	Water table to 140 feet bls
Intermediate aquifer/Upper confining unit	140 feet to 550 feet bls
Upper Floridan aquifer	550 feet to 790 feet bls
Middle confining unit - Upper Zone	790 feet to 950 feet bls
Middle Floridan aquifer	950 feet to 1,480 feet bls
Middle confining unit - Lower Zone	1,480 feet to 1,720 feet bls
Lower Floridan aquifer	1,720 feet to 1,802 feet bls (and deeper)

Notes:
bls = below land surface

The Paradise Run ASR Test-Monitor Well (HIF-42) was completed as a dual-zone monitor well for use during operational testing of a future ASR well system. An upper monitoring interval is an open annular monitor zone that extends below the 24-inch casing at 560 feet below land surface (bls) to the top of the 14-inch casing cement grout at 1,049 feet bls. This upper monitor zone is open to the upper Floridan aquifer and middle Floridan aquifer upper permeable zone. The lower monitor zone is an open-hole that extends below the 14-inch casing at 1,310 feet bls to the bottom of the completed well at 1,530 feet bls. The exploratory/pilot hole for the well was drilled to 1,802 feet bls, but was back plugged to complete the well within the two referenced monitoring intervals.

Underground sources of drinking water (USDW), defined as groundwater having a total dissolved solids (TDS) concentration of 10,000 milligrams per liter (mg/L) or less, are present to a depth of approximately 1,600 feet at the Paradise Run ASR site. The concentration of dissolved minerals gradually increases with depth throughout the upper Floridan aquifer. Below approximately 1,300 feet bls within the middle Floridan aquifer, dissolved mineral concentrations increase rapidly.

Estimates of transmissivity, based on the aquifer testing, suggest values of approximately 2,000 to 3,000 feet squared per day (ft^2/day) for the upper Floridan aquifer and 10,000 to 20,000 ft^2/day for the middle Floridan aquifer. These values are considered low for ASR. However, improvement in transmissivity may be achieved by acidizing the completed open-hole storage zone following ASR well construction. This post-completion technique was used successfully at the Kissimmee River ASR (Well EXKR-1) site located approximately 7 miles southeast of the Paradise Run site. Acidization of well EXKR-1 improved the functional transmissivity of the well by approximately 40 percent. Similar improvement in transmissivity could be expected for post-completion acidization of future Paradise Run ASR wells.

For the 50-mgd pilot ASR system, the conceptual design included five pairs of stacked wells, with each pair of wells providing a storage/recovery capacity of roughly 10 mgd. Future ASR wells would be completed with a shallow storage zone in the interval from approximately 550 feet to 1,150 feet bls within the upper Florida aquifer and middle Floridan aquifer upper permeable zone. The deeper storage zone would target the interval from approximately 1,300 feet to 1,500 feet bls within the middle Florida aquifer lower permeable zone. The data show that transmissivity values are low. The combined storage and recovery capacity for each pair of ASR wells may be in the range of 5.3 mgd to 7.4 mgd, with the higher rate occurring as a result of post-completion formation acidization. Using these estimates, 10 to 15 wells may be required to achieve the planned 50 mgd ASR system capacity.

Pending the construction and successful cycle testing of the first pair of ASR wells, modular expansion of the ASR system could commence.

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Appendices

List of Exhibits

Acronyms and Abbreviations

APT	Aquifer Performance Test
ASR	Aquifer Storage and Recovery
BFA	Barnes Ferland & Associates
BHCS/VDL	Borehole Compensated Sonic/Variable Density Display Log
bls	Below Land Surface
BMP	Below Measuring Point
C	Roughness Coefficient
Cal	Caliper
CBL	Cement Bond Log
CBL/VDL	Cement Bond Log/Variable Density Display Log
CD	Compact Disk
DIL	Dual Induction Log
FAS	Floridan Aquifer System
FC	Fluid Conductivity
FDD	Florida Design Drilling Corporation
FDEP	Florida Department of Environmental Protection
FGS	Florida Geological Survey
FM	Flowmeter
ft^2/day	Feet Squared per Day
gpm	Gallons per Minute
gpm/ft	Gallons per Minute per Foot
GR	Gamma Ray
hh:mm	Hours and Minutes
IA/UC	Intermediate Aquifer/Upper Confining Unit
LFA	Lower Floridan Aquifer
LOER	Lake Okeechobee Estuary Recovery
MAP	Middle Avon Park Correlation Marker
MCU	Middle Confining Unit
MFA	Middle Florida Aquifer
mgd	Million gallons per day
mg/L	Milligrams per Liter
mV	milliVolt

NGVD	National Geodetic Vertical Datum
POD	Point of Discharge
psi	Pounds per Square Inch
PZ1	Production Zone 1
PZ2	Production Zone 2
RO	Reverse Osmosis
(s, d)	Log Run under Static and Dynamic Conditions
SAS	Surficial Aquifer System
SFWMD	South Florida Water Management District
SWS	Schlumberger Water Services
TDS	Total Dissolved Solids
Temp	Temperature
TMDL	Total Maximum Daily Load
UFA	Upper Florida Aquifer
USACE	U.S. Army Corps of Engineers
USDW	Underground Source of Drinking Water
USGS	U.S. Geological Survey
µg/L	Micrograms per Liter
µmhos/cm	Micromhos per Centimeter
µS/cm	MicroSiemens per Centimeter
^{o}F	Degrees Fahrenheit

SECTION 1

Introduction

The South Florida Water Management District (SFWMD) is conducting multi-phased studies to develop a pilot-scale demonstration of an Aquifer Storage and Recovery (ASR) well system. ASR involves collection and treatment of water during periods of low demand or high supply, storage of this excess water in a suitable underground zone or aquifer, and subsequent recovery during periods of high demand or low supply using ASR wells. Beginning in the early 1990s, the SFWMD and U.S. Army Corps of Engineers (USACE) conceived an ASR solution to the problems of maintaining year-round positive flow and reducing the phosphorus load in Lake Okeechobee (CH2M HILL, 1996). More recent Lake Okeechobee Estuary Recovery (LOER) initiatives led to the implementation of the Paradise Run Restoration and ASR Demonstration Project.

This report documents the results of the construction and testing of the ASR Test-Monitor Well HIF-42. The work described herein was accomplished under *Phase 2 Services for the Paradise Run Restoration and ASR Demonstration Project Site* (SFWMD Contract No. C-C13201P/3600000285).

The preparatory work for the ASR system demonstration was accomplished under Phase 1 services, and included planning, system siting, and conceptual designing that was necessary prior to the construction and testing of Test-Monitor Well HIF-42. As proposed, the completed Paradise Run ASR pilot system will store treated surface water underground during periods of water availability, with recovery during dry periods. The conceptual design capacity of the proposed ASR demonstration system is 50 million gallons per day (mgd). The project as initially envisioned will include the construction and operation of surface water intake and pumping facilities; surface water treatment for suspended solids filtration and water disinfection; construction of approximately 10 Class V, Group 7 Injection Wells and associated pumps, pipelines and controls; recovered water management facilities and discharge structure; and construction of approximately six Floridan aquifer monitor wells, including well HIF-42. The successful outcome of the demonstration project will help meet Total Maximum Daily Loads (TMDL) for pollutants entering Lake Okeechobee, demonstrate the sufficiency of constructed wetlands for surface water pretreatment, and reestablish base flow through upper Paradise Run to achieve habitat restoration.

Construction of ASR Test-Monitor Well HIF-42 provides the initial subsurface data required for the eventual design and construction of the Class V injection wells for the ASR well system. The objectives for construction and testing of Test-Monitor Well HIF-42 were twofold:

1. Evaluation of the Floridan aquifer at the project site to assess the potential for a stackable ASR well system using storage zones in the upper Floridan and middle Floridan (proposed hydrostratigraphic unit) aquifers. The concept of a stackable ASR system is predicated on storage of injected water in several discrete vertically separated and hydraulically isolated storage zones. The benefits of a stackable ASR system are

primarily related to the reduction in land required for ASR system development. The conceptual design includes construction of pairs of ASR wells, one completed to a shallow depth and one completed to a deeper depth, with each storage zone hydraulically separated, while allowing independent operation of each ASR well.

2. Conversion of the exploratory well (HIF-42) for use as a monitor well for future ASR system operation associated with the pilot scale demonstration.

Test-Monitor Well HIF-42 was constructed under SFWMD-issued permit No. 28-59-00519 and is located in Highlands County, Florida, within Section 31, Township 37 South, Range 34 East; geospatial coordinates are Latitude 27° 13′ 12″ North and Longitude 80° 57′ 23″ West. This site is just north of the town of Buckhead Ridge and west of the City of Okeechobee, as shown in **Exhibit 1**. The primary study area where the well was constructed encompasses approximately 1,400 acres and is situated on the west bank of the C-38 canal in a spoil area that was produced during the dredging and straightening of the Kissimmee River. A Florida Department of Environmental Protection (FDEP) Generic Permit for Discharge of Produced Groundwater, No. FLG070461, was issued. A copy of this permit is provided in **Appendix A.**

The following sections of this report describe the hydrogeologic setting; HIF-42 well construction; the results of drilling and testing; and an evaluation of data collected to determine the viability of and select subsurface zones for development of an ASR well system. The report is structured as follows:

- Section 1: Introduction
- Section 2: Hydrogeologic Framework
- Section 3: Well Construction Summary
- Section 4: Well Testing and Evaluation
- Section 5: Summary and Conclusions
- Section 6: References

CH2M HILL and its subconsultant (Barnes, Ferland and Associates [BFA] and ASR*us*) served as the engineer of record for the design, permitting, and construction activities for well drilling and testing. Florida Design Drilling Corporation (FDD) submitted the lowest bid and was selected as the project's well drilling contractor. Geophysical logging services were provided by MV Geophysical under subcontract to FDD. Specialty geophysical logging services were provided by Schlumberger Water Services under contract to SFWMD.

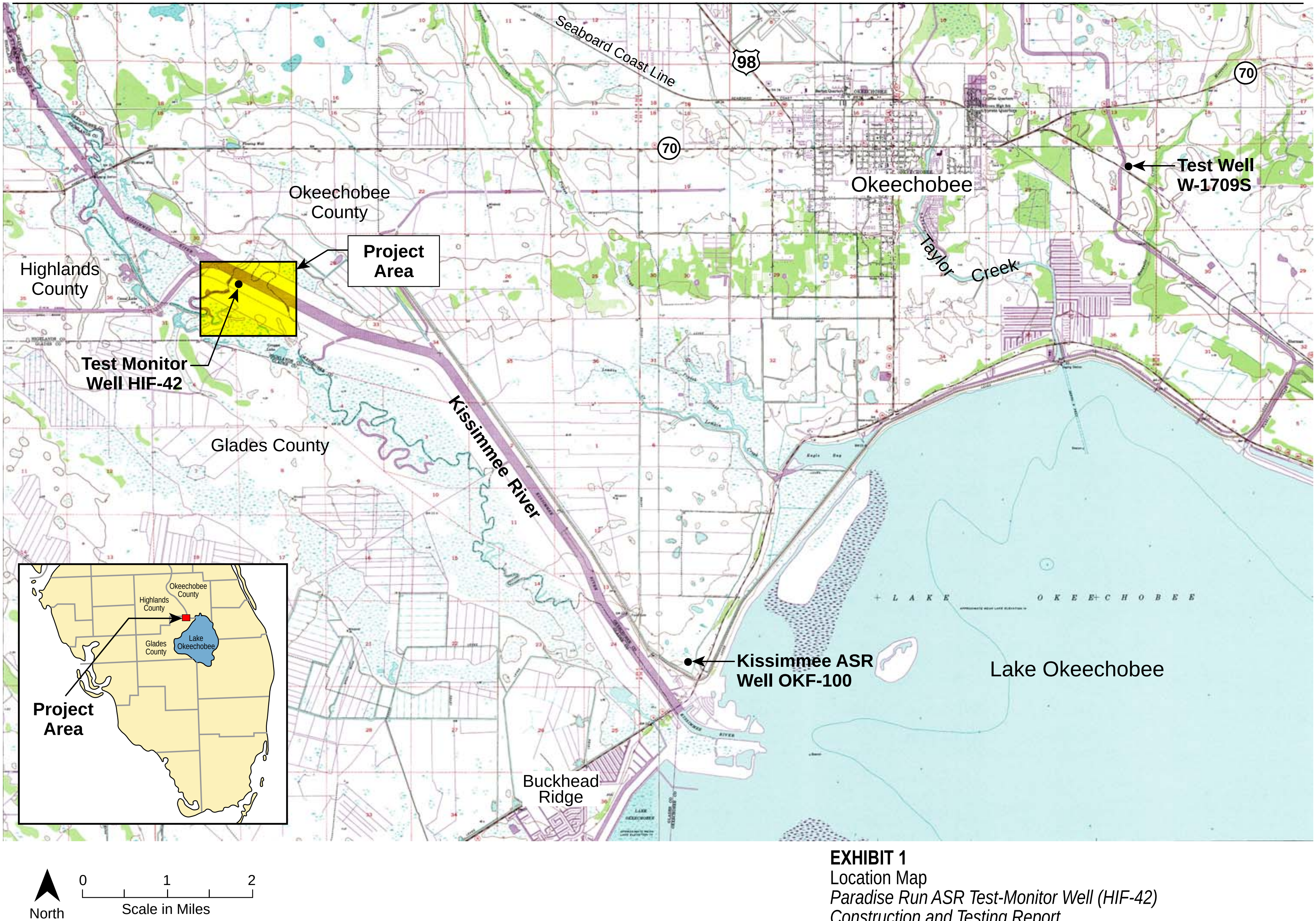

EXHIBIT 1
Location Map
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

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SECTION 2

Hydrogeologic Framework

The hydrogeologic framework for the groundwater resources in the vicinity of the Paradise Run project site include the surficial aquifer system (SAS), intermediate aquifer/upper confining unit (IA/UC), and the Floridan aquifer system (FAS) (Florida Geological Survey [FGS], 1986). The FAS is further divided into upper and lower aquifers separated by a semi-confining unit. The semi-confining unit that divides the upper and lower Floridan aquifers has discrete production zones that have prompted the naming and adoption of a new "informal" aquifer described as the middle Floridan aquifer (MFA) (Reese and Richardson, 2004). The permeable zones within the upper Floridan aquifer (UFA) and the MFA were identified as potential zones for ASR, and were investigated through the drilling and testing of Well HIF-42 described in this report.

Exhibit 2 presents a hydrogeologic section that identifies the various geologic formations and associated aquifer systems.

2.1 Overview of Aquifers and Confining Units

2.1.1 Surficial Aquifer System

The SAS is the principal source of potable water within the Kissimmee River basin in Highlands and Okeechobee counties. The SAS contains freshwater that is easily obtainable for low-cost domestic supply (Bradner, 1994), but the majority of use is for agricultural supply. The SAS may also discharge to surface water bodies that are pumped and used for irrigation. Surface water/SAS supplies are also blended with saline water from the upper Floridan aquifer, which produces water quality suitable for crop irrigation.

The SAS includes all saturated sediment and rock from the water table to the top of the confining unit that isolates the SAS from deeper artesian aquifers of the FAS. This SAS is predominantly unconfined, but some deeper permeable zones can be semi-confined (Bradner, 1994). The undifferentiated Pleistocene and Pliocene age unconsolidated sands, Pamlico, and Anastasia formations, along with part of the late Miocene age Tamiami formation, generally make up the SAS and are composed primarily of sand interbedded with thin lenses of limestone, sandstone, or shell (SFWMD, 1998). Water producing zones in the SAS and their productivity vary laterally and vertically because of variations in the rock and unconsolidated sediments.

The thickness of permeable limestone, sandstone, and shell strata within the SAS increases toward the coast (east) and southward, generally with improving water quality (SFWMD, 1998). Throughout most of Okeechobee County (including adjacent Highlands County), SAS water quality meets potable standards; near Lake Okeechobee, however, chloride concentrations typically exceed potable water standards (Bradner, 1994).

Series	Geologic Unit	Approximate thickness (feet)	Lithology	Hydrogeologic unit	Approximate thickness (feet)
HOLOCENE	PAMLICO SAND	0-50	Quartz sand with shelly intervals	SURFICIAL AQUIFER SYSTEM	150-380
PLEISTOCENE	ANASTASIA FORMATION	0-200	Quartz sand, shell, and coquina		
	FT. THOMPSON FORMATION	0-40	Alternating marine molluscan limestone and freshwater marl		
PLIOCENE	TAMIAMI FORMATION	0-200	Sandy, shelly limestone, calcareous sandstone, quartz sand, and clayey sand		
MIOCENE AND LATE OLIGOCENE	HAWTHORN GROUP	600-800	Clay, marl, dolosilt, micritic limestone, clayey sand, silt, and phosphate grains	INTERMEDIATE CONFINING UNIT	600-700
	MARKER UNIT	90-130	Micritic limestone to marl, chert nodules, some phosphate grains		
	BASAL HAWTHORN UNIT	30-355	Limestone, dolomite, shell, sand, sandstone, and calcareous clay or silt, abundant phosphate grains in places	FLORIDAN AQUIFER SYSTEM — LOWER HAWTHORN PRODUCING ZONE	10-180
EARLY OLIGOCENE	SUWANNEE LIMESTONE	0-150	Fossiliferous, calcarenitic limestone	UPPER FLORIDAN AQUIFER	500-700 ?
EOCENE — LATE	EOCENE GROUP — OCALA LIMESTONE	0-300	Chalky to fossiliferous, calcarenitic limestone		
EOCENE — MIDDLE	AVON PARK FORMATION	900-1,200	Fine-grained, micritic to fossiliferous limestone and dolomite	MIDDLE CONFINING UNIT *	0?-900
EOCENE — EARLY	OLDSMAR FORMATION (DOLOMITE UNIT 0-900)	1,100-1,500	Fine-grained, micritic to fossiliferous limestone, dolomitic limestone, and dense dolomite	LOWER FLORIDAN AQUIFER ** (BOULDER ZONE 300-650)	1,800
PALEOCENE	CEDAR KEYS FORMATION	500-600	Dolomite and dolomitic limestone		
		1,500?	Massive anhydrite beds	SUB-FLORIDAN CONFINING UNIT	1,500?

* Includes proposed Middle Floridan aquifer where present

** Includes Lower Floridan Permeable Zone 1 located above the Boulder Zone

Modified from:
Reese and Memberg, 2000
USGS Water-Resources Investigation Report 99-4061

EXHIBIT 2
Generalized Hydrogeologic Section
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

Changes in water quality in the SAS may result from upward leakage from the underlying Floridan aquifer through damaged or corroded well casings, improperly placed or cemented casings, or improperly abandoned Floridan aquifer wells. The higher head of the FAS can force groundwater into the SAS, which may result in localized areas of poor water quality.

2.1.2 Intermediate Aquifer/Upper Confining Unit

The IA/UC between the unconfined SAS and semi-confined artesian aquifers of the FAS is comprised of the relatively impermeable sequence of phosphatic clays, silts, and limestones of the Miocene age Hawthorn Group. Discrete zones within the unit are suitable for water supply; over-pumping in many areas, however, has degraded water quality in IA/UC producing zones over time, especially along the west coast of Florida.

The top of the IA/UC occurs near land surface in the central areas of the state near Polk County. In the vicinity of the project site, the IA/UC dips to the southeast toward the Atlantic coast, where its depth is more than 300 feet. The thickness of the IA/UC also varies, and may exceed 600 feet in areas further south from the project site.

2.1.3 Floridan Aquifer System

The FAS underlies all of Florida and portions of southern Georgia and Alabama. Parker et al. (1955) defined the FAS to include parts of the middle Eocene (Avon Park and Lake City Limestone), upper Eocene (Ocala Limestone), Oligocene (Suwannee Limestone), and Miocene (Tampa Limestone, and permeable parts of the Hawthorn formation that are in hydrologic contact with the rest of the aquifer) formations. Miller (1986) defined the Floridan aquifer as a vertically continuous sequence of carbonate rocks of generally high permeability hydraulically connected in varying degrees and whose permeability is an order to several orders of magnitude greater than that of those rocks that bound the system above and below. Lithologically, the FAS is composed mainly of limestone and dolostone.

The FAS is present near land surface in the center of the state and ranges in thickness from approximately 200 feet to nearly 3,000 feet. Near the north end of Lake Okeechobee, the top of the FAS occurs at depths of approximately 600 feet below land surface (bls) and dips to the southeast to more than 900 feet bls. Within the FAS, water-producing zones may be isolated (semi-confined) by interbedded low permeability strata. The permeable intervals are associated with solution cavities and unconformities at formation boundaries, the latter of which can be correlated throughout the region. Water quality deteriorates to the south and with depth, increasing in hardness and salinity. The FAS is subdivided into two aquifers based on the vertical occurrence of two highly permeable zones. These are the upper Floridan and lower Floridan aquifers, which are separated by a low permeability interval named the middle confining unit (MCU). Both the upper and lower Floridan aquifers can be further subdivided into hydrostratigraphically discrete, but locally and regionally extensive production zones.

2.1.3.1. Upper Floridan Aquifer

The UFA may reach a thickness of 500 feet and is characterized by two distinct and continuous producing zones. These two zones occur along the unconformities which serve as the lithologic contacts between 1) the Hawthorn Group and the Suwannee Formation, where present, or the Ocala Group, and 2) the Ocala Group and the Avon Park formation.

Numerous locally occurring high permeability zones also exhibit secondary porosity in the form of fractures and caverns that typically are associated with dolomitized zones. These high permeability zones are not stratigraphically controlled and occur irregularly throughout the region. Water quality varies throughout the UFA and with increasing depth of the production zones. In the upper portion of the FAS, common values for total dissolved solids (TDS) range from less than 500 milligrams per liter (mg/L) to greater than 2,000 mg/L, and chloride ranges from less than 100 mg/L to greater than 1,000 mg/L. The UFA is utilized across the state for water supply.

2.1.3.2. Middle Confining Unit/Middle Floridan Aquifer

The MCU corresponds stratigraphically to the upper portion of the Avon Park Formation, and is composed of very fine grained limestone interbedded with coarser limestones and dolostones. Few private or municipal water supply wells in the vicinity of the project fully penetrate this unit, so data are limited to several exploratory wells funded by the SFWMD or other agencies. Data from test wells in the Lake Okeechobee area place the thickness of the MCU at 200 feet to 400 feet (Lukasiewicz, 1992).

Permeable zones within the MCU have been informally referred to as the MFA, which usually occurs within a thick section of the Avon Park Formation composed primarily of dolostone or dolomitic limestone. Interbedded limestone can also be present in the upper section of the MFA. The permeability in the MFA occurs primarily through fractures, but solutions cavities can also be present (Reese and Richardson, 2004).

2.1.3.3. Lower Floridan Aquifer

The deeper producing zones of the FAS are associated with lower Avon Park Formation (formerly identified as the Lake City Limestone) and the Oldsmar Formation. The upper portion of this aquifer is composed of hard, porous, crystalline dolomitic limestone, with stringers of chalky fossiliferous limestone. Two distinct flow zones are present and generally correspond to: 1) the contact between the former Lake City Limestone, a biostratigraphic unit, and the Avon Park Formation, and, 2) the Lake City Limestone (now included in the Avon Park Formation) and underlying Oldsmar Formation. These flow zones have been referred to as lower Floridan aquifer (LFA) Production Zones 1 and 2 (PZ1 and PZ2). The permeability within these two zones is controlled by the degree of secondary porosity and may be cavernous in nature. The zones are separated by approximately 250 feet of low permeability material. The two producing zones may also be distinguished by a significant difference in water quality (SFWMD, 1998).

A thick confining interval of dense limestones and dolostones separate the LFA PZ2 from a cavernous and highly transmissive zone referred as the Boulder Zone. Water quality within the Boulder Zone has salinities approaching seawater concentrations. The Boulder Zone is present to the south of a line extending roughly from Volusia County to Lee County and has been used for disposal of treated industrial or municipal wastewater effluent and concentrate produced from reverse osmosis (RO) water treatment facilities.

2.2 Hydrogeologic Framework at the Paradise Run ASR Site

The Paradise Run ASR site is located in the lower Kissimmee River floodplain approximately 7 miles northwest of the northern shore of Lake Okeechobee. Ground surface elevation is approximately 24 feet National Geodetic Vertical Datum (NGVD). Mucky soil is present in the vicinity of the site, consisting of the Kaliga/Tequesta/Gator series (Lewis et al., 1989).

At the Paradise Run site, all regional aquifers and confining units previously described are present. The water table occurs near land surface and the base of the SAS is approximately 140 feet bls. At the project site, the SAS contains fine to medium sand, yellow to light gray with alternating shell beds and fossil fragments.

The IA/UC is present from approximately 140 to 550 feet bls. It is composed largely of interbedded sand, silt, and clay in the upper portion, grading with increased depth to phosphatic clays, micritic limestone, and shell beds of late Miocene to Oligocene age typical of the Hawthorn Group.

The UFA is present from 550 to 790 feet bls and is composed of fossiliferous limestone with some dolostone. The MCU, inclusive of the proposed MFA, is present from 790 to 1,720 feet bls. The upper zone of the MCU is present from 790 to 950 feet bls, the lower zone of the MCU is present from 1,480 to 1,720 feet bls. The proposed MFA occurs between the depths of approximately 950 and 1,480 feet bls. The most permeable/transmissive zone within the MFA occurs between the depths of 1,280 and 1,480 feet bls, where fractured dolostone is present. The top of the LFA may be correlated at a depth of 1,720 feet bls and extend to depths greater than the 1,802 feet bls well completion depth. The sub-Floridan confining unit was not penetrated during the drilling and testing of Test-Monitor Well HIF-42.

Lithostratigraphic and hydrostratigraphic boundaries based on interpretation of well cuttings, rock cores, and geophysical logs collected throughout drilling of the Paradise Run ASR Test-Monitor Well (HIF-42) are summarized in **Exhibit 3.**

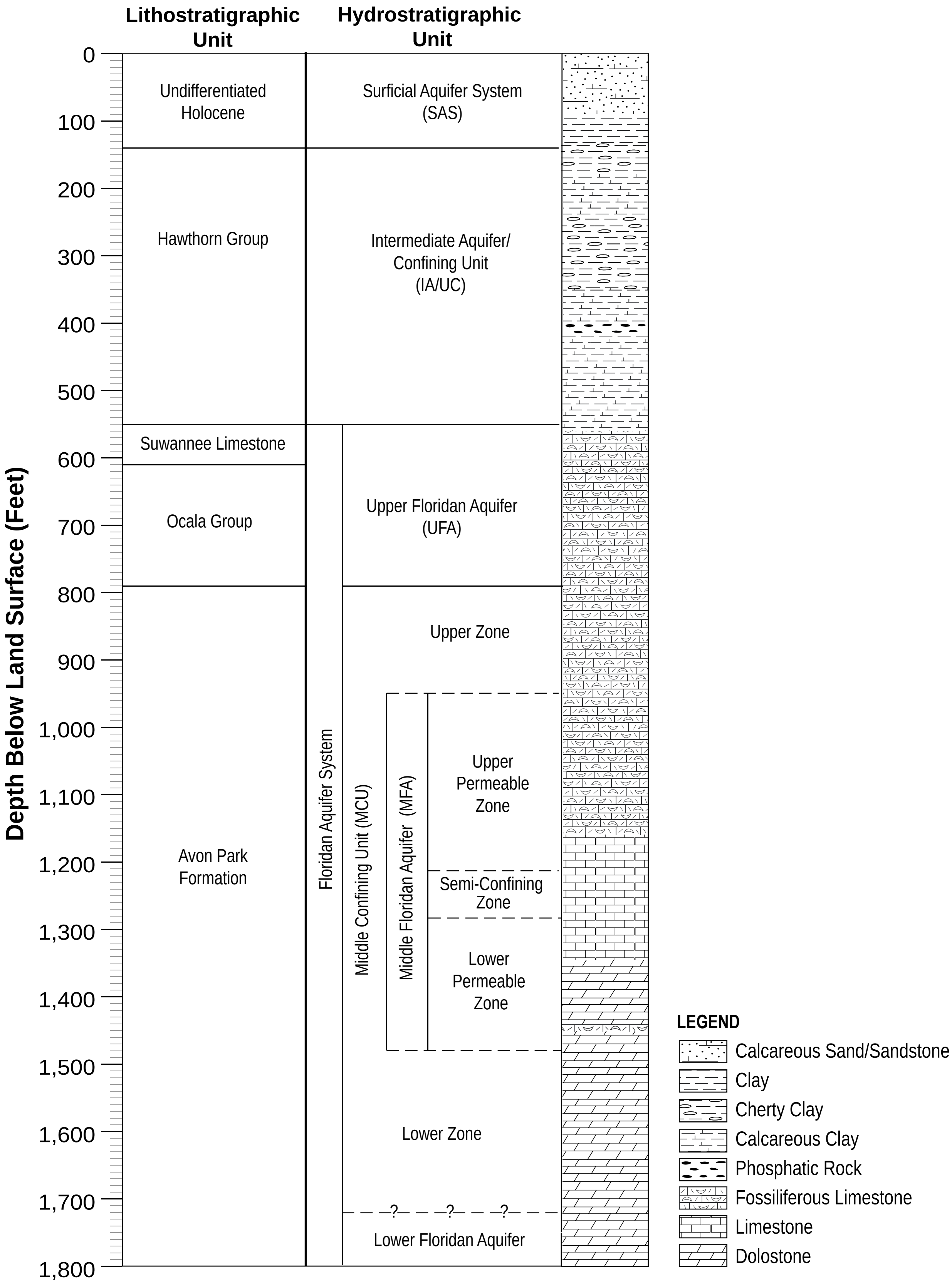


EXHIBIT 3
Identified Lithostratigraphic and Hydrostratigraphic Contacts
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

SECTION 3

Well Construction Summary

3.1 Well Construction Summary

Test-Monitor Well HIF-42 was constructed by FDD of West Palm Beach, Florida, under contract to the SFWMD. Drilling operations commenced upon FDD mobilization in September 2007, and were completed in April 2008.

Well construction and testing were conducted in accordance with plans and specifications titled "Floridan Aquifer Test-Monitor Well Construction (Paradise Run) Highlands County, Florida" and well construction permit No. 28-59-00319, issued by the SFWMD. Disposal of water produced during drilling operations was conducted in accordance with the requirements of an FDEP-issued Generic Permit for Discharge of Produced Groundwater, FLG070461-001-IWPT/GE. Construction permits are provided in **Appendix A**.

Prior to commencing drilling operations related to Test-Monitor Well HIF-42, four shallow groundwater monitor wells were installed to evaluate any potential water quality impacts to the SAS resulting from the drilling and testing. The layout of the drill site, including the location of the shallow groundwater monitor wells is shown in **Exhibit 4**. Water quality including chloride concentration and specific conductance were analyzed and monitored throughout drilling. Water quality for the shallow monitor wells ranged from 8 mg/L to 870 mg/L for chloride and 117 to 3,347 micromhos per centimeter (µmho/cm) for specific conductance. Maximum reported values for chloride and specific conductance occurred in the southwest monitor well closest to Test-Monitor Well HIF-42. Water quality data collected during the project are provided in **Appendix B**.

Drill cuttings drilling mud were collected and stored throughout the drilling operations. Periodically, these materials were hauled to a pre-approved disposal site in a rural area of Buckhead Ridge, Florida, in accordance with the project specifications.

3.2 Formation Evaluation and Well Construction

A nominal 10-inch pilot hole was advanced in stages to obtain rock cuttings, water quality and geophysical data. These data were used to select the casing depths necessary to isolate and protect the SAS, isolate the unconsolidated material and swelling clays found in the IA/UC, and to isolate the artesian FAS from the aquifers above.

North

0 250
Scale in Feet

☐ Water Quality Monitoring Station

SW ● Surficial Aquifer Monitor Well

EXHIBIT 4
Site Layout
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

CH2MHILL

WB092008003TPA 345660.TW.03

The pilot hole was drilled to a total depth of 1,802 feet bls (-1,777 feet NGVD). Mud rotary drilling methods were used to progress the borehole through the SAS and IA/CU. Reverse-air drilling methods were used below the 24-inch intermediate casing depth of 560 feet bls where consolidated formations and the flowing artesian conditions were present. While drilling through the FAS, a rotating flow control header was provided to maintain drilling fluids and water produced under flowing artesian conditions; salt and other weight control additives were also required to suppress the artesian head during well construction.

3.3 Casing Installation

A steel pit casing 42 inches in diameter was installed once the drilling rig was positioned and the derrick was raised. The pit casing was driven to 42 feet bls. For subsequent casing installation, the nominal 10-inch pilot hole was progressively enlarged using a stepped bit reamer. Casings were then installed by butt welding and the annular space surrounding the casing was cemented.

A steel surface casing 36 inches in diameter with a 0.375-inch wall thickness was set at 180 feet bls to isolate the SAS. An intermediate steel casing 24 inches in diameter with 0.375-inch wall thickness was set at a depth of 560 feet bls to isolate the unconsolidated material and swelling clays of the Hawthorn Group present within the IA/CU; the bottom of the 24-inch casing penetrated the UFA. A 14-inch-diameter steel casing with 0.375-inch wall thickness was installed at a depth of 1,310 feet bls, penetrating the MCU. The 14-inch casing was partially cemented to provide two monitoring zones upon completion of the well. Casing installation and cement grout placement are summarized in **Exhibit 5** and mill certificates for the installed casings are provided in **Appendix C**.

Completion of Test-Monitor Well HIF-42 allowed for water sampling and pressure measurement in two discrete zones. The upper monitoring zone is accessible through the annular space between the 14-inch and 24-inch casings. The upper monitor zone is open to groundwater within the UFA and the MFA lower permeable zone present from the bottom of the 24-inch casing at 560 feet bls to the top of the 14-inch casing cement grout at 1,049 feet bls. The lower monitor zone is open to groundwater within the MFA lower permeable zone. The lower monitor zone is a nominal 13-inch diameter open-hole extending from the bottom of the 14-inch casing at 1,310 feet bls to 1,530 feet bls; the 10-inch pilot hole was back plugged with cement grout between 1,802 feet bls and 1,530 feet bls following completion of logging and testing, and selection of the lower monitoring interval. Formation and aquifer testing conducted during drilling is discussed in detail in Section 4, Well Testing and Evaluation.

Following installation of the 24-inch and 14-inch casings, three methods were employed to evaluate the mechanical integrity of the well:

1. Pressure testing
2. First cement stage temperature log
3. A cement bond log (CBL).

The mechanical integrity testing and results are discussed in Section 3.4, Well Casing Integrity Evaluation. **Exhibit 6** shows the construction details of Well HIF-42, while **Exhibit 7** provides a chronological summary of drilling and testing activities**.**

EXHIBIT 5
Casing Installation and Cement Grout Summary
Paradise Run ASR Test-Monitor Well (HIF-42)

Casing Size	Borehole	Date	Cement Stage	Interval Cemented		Casing OD (In)	Hole Dia. (Inches)	Fillup (LF)	Calc. Volume (CF)	Est. Yield (CF/SK)	Cement Reqd. (SK)	Field Observations
				Bottom (Ft bls)	Top (Ft bls)							
42"	None	10/2/2007	Driven	0	0	42	n/a	n/a	n/a	n/a	n/a	Pit casing was driven; no cement grout was required.
36"	Mudded	10/18/2007	1	185	60	36	42	125	319	1.50	213	8 CY delivered from Cemex; wt. 13.9 - 14.1 lb/gal; max. header pressure was 25 psi.
		10/19/2007	2	60	0	36	42	60	153	1.50	102	3.5 CY mixed and placed by FDD; wt. 12.9 - 14.2 lb/gal pumped. Cement returns 13.4 lb/gal.
							36" Total:	**185**	**472**	**1.50**	**315**	
24"	Mudded	11/16/2007	1	560	348	24	35	212	750	1.20	625	20 CY delivered from Cemex; max. header pressure 18 psi
		11/17/2007	2	348	0	24	35	348	1232	1.20	1027	29 supersacks of cement mixed and placed by FDD; wt. 14.7 lb/gal
							24" Total:	**560**	**1982**	**1.20**	**1652**	
14"	Rev-Air	2/4/2008	1	1310	1142	14	23	168	305	1.20	254	12 supersacks of cement mixed and placed by FDD
			2	1142	1049	14	23	93	169	1.20	141	1 Super SackpPlus 200 sacks of cement mixed and placed by FDD
							14" Total:	**261**	**474**	**1.20**	**395**	
								Estimated Well Cementing Totals	**2929**	**1.30**	**2362**	Total cement placed by FDD was 2671 sacks

Notes:
API Class B Equivalent (Halliburton Red Book):

Bentonite by Weight:	0%	2%	4%	6%
Water Reqmt. (gal/sk):	5.2	6.5	7.8	9.1
Slurry Vol.(CF/Sk):	1.18	1.36	1.55	1.73
Slurry Density (lb/gal):	15.6	14.7	14.1	13.5

1 Sack = 94 lb
1 Super Sack = 3,300 lb
est. = Estimated
Mudded = Borehole maintained with bentonite drilling mud
Rev-Air = Reverse-Air drilling, minimal bentonite added

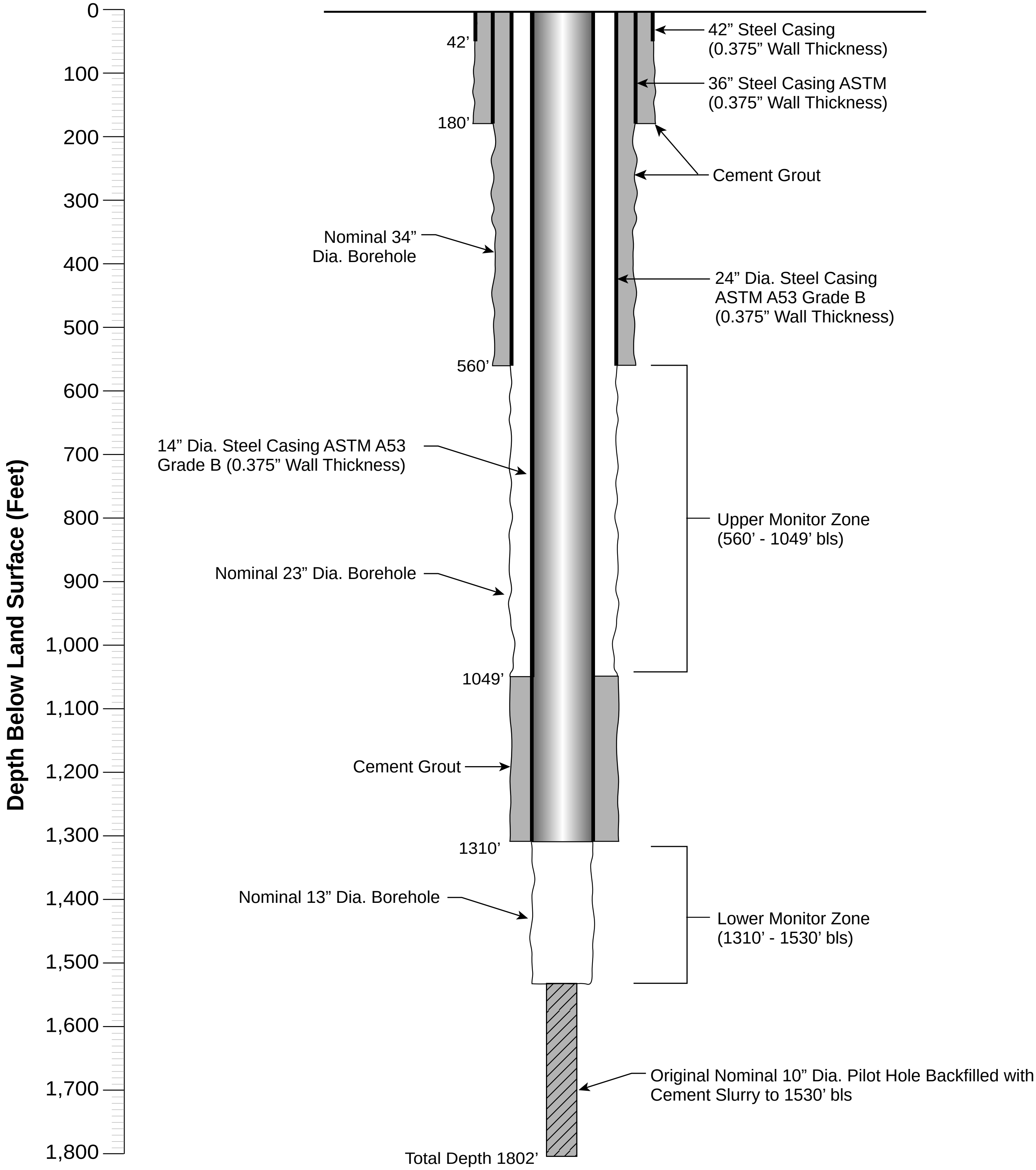


EXHIBIT 6
Well Construction Schematic
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

EXHIBIT 7
Drilling And Testing Chronology
Paradise Run ASR Test-Monitor Well (HIF-42)

Date	Activity
9/4/07 – 10/16/07	Mobilized drilling rig and equipment. Installed 42-inch pit casing and drilled 10-inch diameter pilot hole to 180 ft bls
10/17/07 – 10/17/07	Performed Caliper and gamma log. Selected surface casing installation depth.
10/17/07 –10/18/07	Installed and cemented 180 feet of 36-inch diameter surface steel casing.
10/19/07 – 10/26/07	Drilled pilot hole from 180 ft to first core interval starting at 454 ft bls
10/27/07 – 10/27/07	Collected 10 foot rock core at starting at 456 feet bls
10/29/07 – 11/5/07	Drilled pilot hole to 1,252 ft on mud rotary and collect 10 foot rock cores at 798 feet bls, 1,110 feet bls and 1,252 feet bls.
11/6/07 – 11/6/07	The well was made available to the SFWMD for their geophysical logging contractor, Schlumberger, to perform specialty logs on open hole from 180 ft to 1,262 ft; these logs are not included in this contract and evaluation will be performed by SFWMD.
11/7/07- 11/7/07	Backfilled pilot hole from 1,262 feet to 500 feet bls using limestone pea gravel
11/7/07 – 11/13/07	Reamed pilot hole from 180 feet to 560 feet bls using a 34-inch bit.
11/14/07 – 11/14/07	Performed X-Y caliper and natural gamma logs on 34-inch diameter borehole.
11/14/07 – 11/17/07	Installed 560 feet of 24-inch diameter steel casing and cement to surface. Ran Temp log to determine top of cement.
11/19/07 – 11/27/07	Successfully conducted a pressure test on the 24-inch casing.
11/28//07 – 12/15/08	Changed from mud-rotary to reverse-air drilling methods. Drilled out gravel backfill from pilot hole on using reverse-air drilling. Drilled nominal 10-inch diameter pilot hole to 1,802 ft bls and collect 10 foot rock cores at 1,520 feet and 1,750 feet bls.
12/17/07- 1/2/08	Ran geophysical logs on the open-hole section from 560 ft to 1,802 ft bls. Performed 4 packer tests within the open section of borehole at the following intervals: 1,320 feet to 1,380 feet, 1,420 feet to 1,445 feet, 1,470 feet to 1,530 feet, and 1,703 feet to 1,763 feet bls.
1/2/08 – 1/17/08	Permanently back plugged the nominal 10-inch bore hole from the total drilled depth of 1,802 to 1,550 feet bls. Temporarily back plugged the borehole with gravel and bentonite-cement slurry from 1,540 to 880 feet bls. Reamed nominal 10-inch bore hole with nominal 22-inch diameter bit from 560 feet to 880 feet bls.
1/18/08 – 1/21/08	Ran geophysical logs on the open-hole section from 560 to 880 feet bls. Conducted step drawdown pumping test on the open-hole section.
1/21/08 – 1/28/08	Reamed nominal 10-inch diameter borehole from 880 to 1,110 feet bls with nominal 22-inch diameter bit. Ran geophysical logs and conducted 2nd interval step drawdown pumping test and constant rate pumping test on the open-hole section from 560 to 1,110 feet bls.
1/28/08 –2/5/08	Reamed nominal 10-inch diameter borehole from 1,110 to 1,320 feet bls with nominal 22-inch diameter bit. Ran caliper log following reaming. Installed 14-inch casing to 1,320 feet bls. Cemented casing from 1,320 feet to 1,049 feet bls.

EXHIBIT 7
Drilling And Testing Chronology
Paradise Run ASR Test-Monitor Well (HIF-42)

Date	Activity
2/6/08 – 3/3/08	Successfully conducted a pressure test on the 14-inch casing. Reamed nominal 13-inch diameter borehole from 1,310 to 1,530 feet bls. Ran geophysical logs. Conducted step drawdown pumping test on the open-hole section. Began demobilization of drilling rig and equipment.
3/3/08 – 4/4/08	Complete wellhead and site cleanup. Collected water quality samples from the upper and lower monitor zones in the well.

Upon completion of drilling and testing, a permanent wellhead was installed. The wellhead valves and piping are shown in **Exhibit 8**. The upper and lower monitor zones discharge piping are joined together by manifold to discharge groundwater to the C-38 canal during purging and sampling as previously shown in Exhibit 4. Shut-in pressures for the upper and lower monitor zones are 7.6 pounds per square inch (psi) (hydraulic head of 46 feet NGVD) and 5.6 psi (hydraulic head of 43 feet NGVD), respectively.

3.4 Well Casing Integrity Evaluation

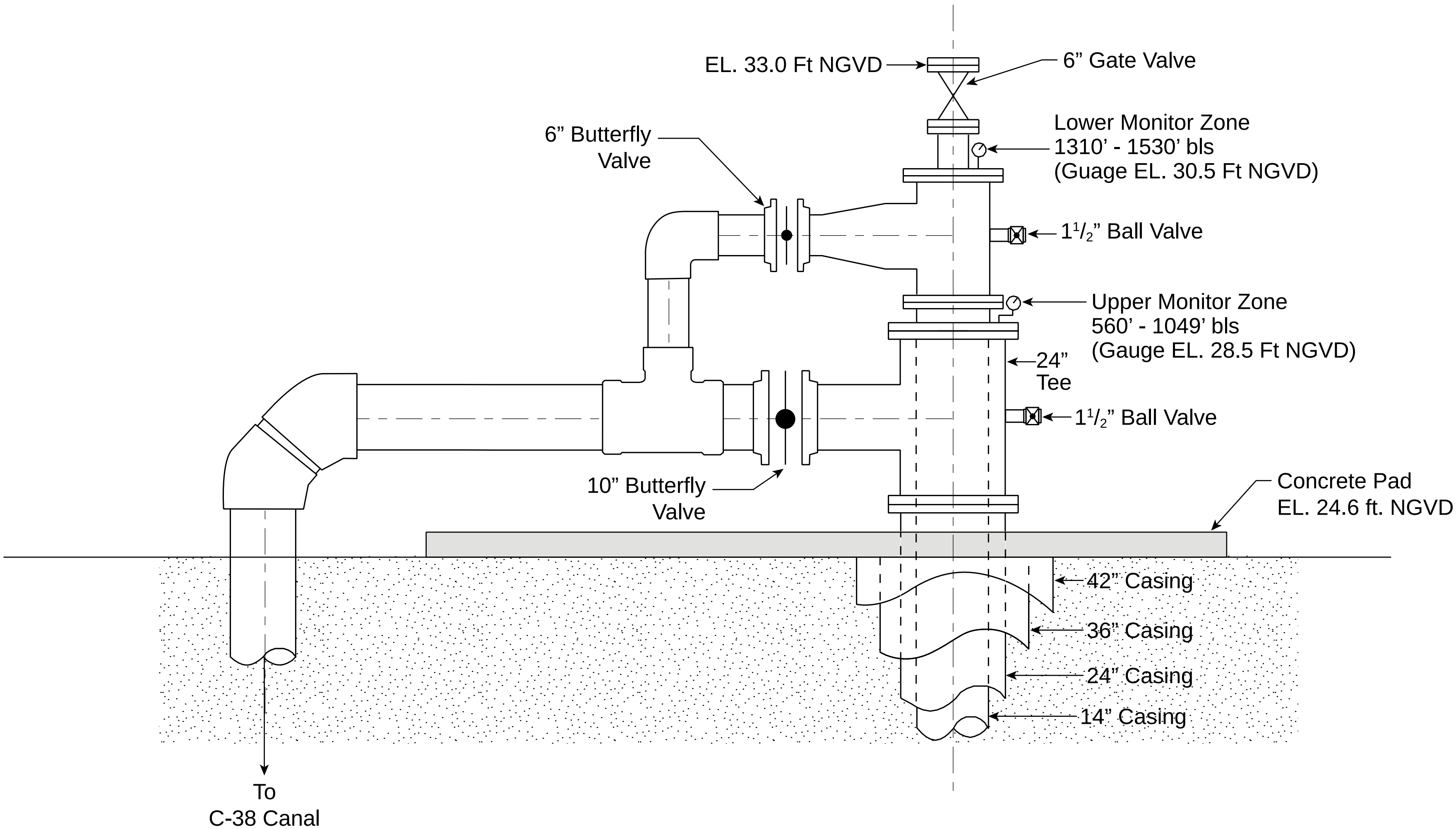
Following installation, the 24-inch and 14-inch well casings were evaluated for mechanical integrity using pressure testing, and temperature and cement bond logging. These testing methods and their results are described below.

3.4.1 Pressure Testing

Casing pressure tests were performed in accordance with Specification Section 2550-Casing (CH2M HILL and LBFH, Inc., 2007) to verify post-installation casing integrity. Pressure testing was accomplished by installing a pressure-tight temporary wellhead on the casing tested. The bottom of the casing was sealed by cement grout from the preceding grouting operations. Successful testing was demonstrated by maintaining a pressure of 50 psi for a period of 60 minutes with not more than ± 5 percent deviation in pressure. Following testing, the cement plug was drilled from the casing and the well construction proceeded.

3.4.1.1. 24-inch Casing Pressure Test

On November 27, 2007, a successful casing pressure test was performed on the 24-inch casing installed to 560 feet bls. Prior to pressurizing the well casing for testing, the drilling mud inside was displaced with water. Subsequently, the well was pressurized to 50 psi and shut-in for a period of 60 minutes. The pressure test was conducted by FDD and witnessed by BFA and SFWMD. The pressure within the casing dropped to 48.5 psi over the 60 minute period. This loss of 1.5 psi was within the allowable deviation.



Not to Scale

EXHIBIT 8
Wellhead Schematic
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

3.4.1.2. 14-inch Casing Pressure Test

On February 6, 2008, a successful casing pressure test was performed on the 14-inch casing installed to 1,310 feet bls to verify post-installation casing integrity. Following installation of a pressure tight header, the casing was completely filled with water. The casing was pressurized to 50 psi and shut-in for a period of 60 minutes. During this time, the pressure was observed and no change in pressure occurred. The pressure test was conducted by FDD and witnessed by BFA and the SFWMD.

3.4.2 Temperature and Cement Bond Logging

In conjunction with the casing pressure tests on the 24-inch and 14-inch steel casings, temperature and cement bond logs (CBLs) were run to confirm the presence of the cement in the annular space between the casing and formation. As cement grout cures, its heat of hydration causes an elevation in fluid temperature within the well casing. A significant variation in fluid temperature within the casing may occur adjacent to the top of the cement in the annulus, thus confirming the top of the cement. A hard tag on the top of the cement using the cementing pipe(s) further confirms the top of cement identified on the temperature log.

Acoustical logging techniques referred to as a CBL are also appropriate for determining the presence of cement, and may provide qualitative data to evaluate the cement bond to both pipe and formation. The CBL measures the loss of acoustic energy as it propagates through casing. This loss theoretically can be related to the fraction of the casing perimeter covered with cement (“Bond Index”).

Geophysical logs used to evaluate the integrity of the casing are provided in **Appendix D**.

3.4.2.1. 24-inch Casing Temperature and CBL Evaluation

On November 14, 2007, 8 hours after placement of the first stage of cement grout, a temperature log was run inside the 24-inch steel casing. The abrupt change in temperature from 85 degrees Fahrenheit (°F) to 120°F within the depth interval from 320 to 345 feet bls indicated that the top of cement was at approximately 345 feet bls. The top of cement was confirmed by a hard tag with the cementing pipe at 348 feet bls prior to placing the second stage of cement.

On December 5, 2007, 22 days after cementing operations, a CBL was run through the 24-inch casing from its setting depth at 560 feet bls to land surface. The acoustical amplitude ranged from nearly 0 millivolts (mV) to a high of 3 mV and the variable density display showed the presence of annular cement throughout the entire length of the casing. This CBL was interpreted to reflect a fully cemented casing from bottom to land surface.

3.4.2.2. 14-inch Casing Temperature and CBL Evaluation

On February 5, 2008, 10 hours after placement of the first stage of cement grout, a temperature log was run inside the 14-inch steel casing. A gradual change in temperature was measured from 85°F to 130°F across the depth interval of 1,130 feet to 1,190 feet. The maximum incremental change in recorded temperature (Delta Temperature) was at a depth of approximately 1,142 feet bls. The top of the first stage of cement was confirmed at

1,142 feet bls by a hard tag with the cementing pipe prior to placing the second stage of cement. The top of the second cement stage was confirmed by a hard tag at 1,049 feet bls.

A CBL was run on December 12, 2008, 7 days after completing cementing operations. The CBL was run inside the 14-inch casing from its setting depth at 1,310 feet bls to 975 feet bls. The acoustical amplitude ranged from 25 mV to 35 mV in uncemented casing; for the cemented casing, the amplitude ranged from 1 mV to 15 mV in. The variable density display on the CBL indicated the presence of annular cement from the bottom of the casing at 1,310 feet bls to the top of the cemented interval at 1,049 feet bls, as determined from an abrupt change in the recorded two-way travel time. The top of cement was confirmed by a hard tag with the cementing pipe at 1,049 feet bls. This CBL was interpreted to reflect a fully cemented casing from bottom to the top of the cemented interval at 1,049 feet bls.

3.4.3 Hydrogeologic Testing

Additional discussion of the details and results from the collection of rock cores, geophysical logging, aquifer pumping tests, straddle packer testing, and water quality analyses are included in Section 4, Well Testing and Evaluation.

SECTION 4
Well Testing and Evaluation

During the construction of Test-Monitor Well HIF-42, testing was conducted to evaluate the subsurface lithology, aquifer parameters, and water quality at the site. These data were obtained to identify potential zones for design of the proposed ASR system. Testing data collection and analyses included:

- Drill cuttings from the pilot hole every 10 feet to a depth of 1,802 feet bls
- Six 10-foot-long, 4-inch-diameter rock cores
- Geophysical logs
- Four straddle packer pumping tests and water analyses
- Reverse-air drilling water sample analyses
- Open-hole aquifer pumping tests
- Completed Monitoring zones water sample analyses

The following section describes the data collected and the results of the testing conducted.

4.1 Drill Cuttings Analysis

A nominal 10-inch pilot hole was drilled using a 9.875-inch drill bit from land surface to a depth of 1,802 feet bls, and rock cuttings were collected every 10 feet. **Exhibit 9** is the lithologic log, and describes the materials penetrated during drilling. The borehole was advanced using closed-circulation mud rotary techniques from 180 feet to 1,262 feet bls. Reverse-air circulation was conducted from 1,262 feet bls to the total drilled depth of 1,802 feet bls. **Exhibit 10** presents a generalized description of the unconsolidated sediments and rock penetrated**,** and also shows the well completion and a summary of test intervals.

4.2 Rock Cores

Rock cores measuring a nominal 4 inches in diameter were collected using a 10-foot-long double-tube core barrel (N&N Drilling) at various depths during pilot hole drilling. Upon reaching the coring depth, the pilot hole was increased in diameter using a 12.25-inch drill bit and the borehole was conditioned. Six core runs were made within the following intervals: 456 to 466 feet, 798 to 808 feet, 1,100 to 1,110 feet, 1,252 to 1,262 feet, 1,510 to 1,520 feet, and 1,750 to 1,760 feet bls. Five cores were recovered, meeting the minimum 50 percent recovery requirement. The basic core analysis data, total gamma data, ultrasonic velocity data, X-ray diffraction mineralogy, section photomicrographs, and descriptions of the samples are presented in the "Petrographic Evaluation of the Avon Park Formation, Ocala Limestone, and Arcadia Formation from the W-18812 Well," prepared by Core Laboratories Inc. Advanced Technology Center, and provided as **Appendix E. Exhibit 11** summarizes the permeability, porosity, grain size and density analyses for selected core intervals.

EXHIBIT 9
Lithologic Log
Paradise Run ASR Test-Monitor Well (HIF-42)

Depth (Feet bls)		Pilot Hole Lithologic Descriptions Visual Observation of Rock Cuttings and Cores
Top	**Bottom**	
40	90	Sand; yellow gray to light gray; medium porosity; intergranular; very fine to fine grain; unconsolidated; shell 40% est.; fossil fragments
90	110	Packstone; light gray; medium porosity; medium grained; unconsolidated; trace shell
110	140	Packstone; light gray; medium porosity; medium grained; unconsolidated; quartz sand; trace shell
140	180	Silty limestone and chert; light olive gray; low porosity; poor induration; clay matrix; quartz sand; some shell
180	240	Wackestone; light olive gray; intergranular; low porosity; fossils; grain size medium to granular
240	350	Silty limestone and chert; light olive gray; low porosity; poor induration; clay matrix; quartz sand; some shell
350	400	Wackestone; light olive gray; intergranular; low porosity; fossils; medium to coarse grain
400	420	Phosphorite; dark brown; intergranular; calcite matrix; medium to coarse grain; quartz sand
455	465	**Core No. 1** -Wackestone; light olive gray; intergranular; low porosity; fossils; medium to coarse grain
420	500	Wackestone; light olive gray; intergranular; low porosity; fossils; medium to coarse grain
500	560	Wackestone; white to light gray; intergranular; Calcilutite; fine to medium grain
560	800	Packstone; yellowish gray; fine grain; moldic; pin-point vugs; high porosity; calcilutite; mollusk
798	808	**Core No. 2**- Packstone; yellowish gray; fine to coarse grain; moldic pin-point vugs; high porosity; calcilutite; mollusk
800	840	Grainstone; yellowish gray; intergranular; pin-point vugs; fine to medium grain; calcilutite; mollusk
840	1,040	Packstone; yellowish gray; fine to coarse grain; moldic; pin-point vugs; high porosity; calcilutite; mollusk
1,040	1,100	Packstone; yellowish gray; fine to coarse grain; moldic; pin-point vugs; high porosity; calcilutite; mollusk
1,100	1,110	**Core No. 3** - Packstone; yellowish gray; fine to coarse grain; moldic pin-point vugs; high porosity; calcilutite; mollusk
1,100	1,150	Packstone; yellowish gray; fine to coarse grain; moldic; pin-point vugs; high porosity; calcilutite; mollusk
1,150	1,160	Grainstone; yellowish gray; intergranular; pin-point vugs; fine to medium grain; calcilutite; mollusk

EXHIBIT 9
Lithologic Log
Paradise Run ASR Test-Monitor Well (HIF-42)

Depth (Feet bls)		Pilot Hole Lithologic Descriptions Visual Observation of Rock Cuttings and Cores
Top	Bottom	
1,160	1,250	Wackestone; yellowish gray; intergranular; pin-point; calcilutite; fine to coarse grain; some dolostone
1,250	1,260	**Core No. 4** - Wackestone; yellowish gray; intergranular; pin-point; calcilutite; fine to coarse grain: some dolostone
1,250	1,270	No Sample
1,270	1,347	Wackestone; yellowish gray; intergranular; pin-point; calcilutite; fine to coarse grain; some dolostone
1,347	1,440	Dolostone; yellowish brown; intergranular; pin-point vugs; dolomitic cement; fine to medium grain.
1,440	1,450	Wackestone; Yellowish gray; intergranular; pin-point; calcilutite; fine to coarse grain; some dolostone
1,450	1,490	Dolostone; yellowish brown; intergranular; pin-point vugs; dolomitic cement; fine to medium grain.
1,490	1,500	Dolostone; dark yellowish brown; intergranular; pin-point vugs; dolomitic cement; fine to medium grain.
1,500	1,510	**Core No. 5** - dark yellowish brown; intergranular; pin-point vugs; dolomitic cement; fine to medium grain.
1,510	1,520	**Core No. 6** - dark yellowish brown; intergranular; pin-point vugs; dolomitic cement; fine to medium grain
1,520	1,610	Dolostone; dark yellowish brown; intergranular; pin-point vugs; dolomitic cement; fine to medium grain.
1,610	1,750	Dolostone; yellowish brown; intergranular; pin-point vugs; dolomitic cement; fine to medium grain; trace gypsum
1,750	1,760	**Core No. 7** - dark yellowish brown; intergranular; pin-point vugs; dolomitic cement; fine to medium grain; some gypsum
1,760	1,800	Dolostone; dark yellowish brown; intergranular; pin-point vugs; dolomitic cement; fine to medium grain.

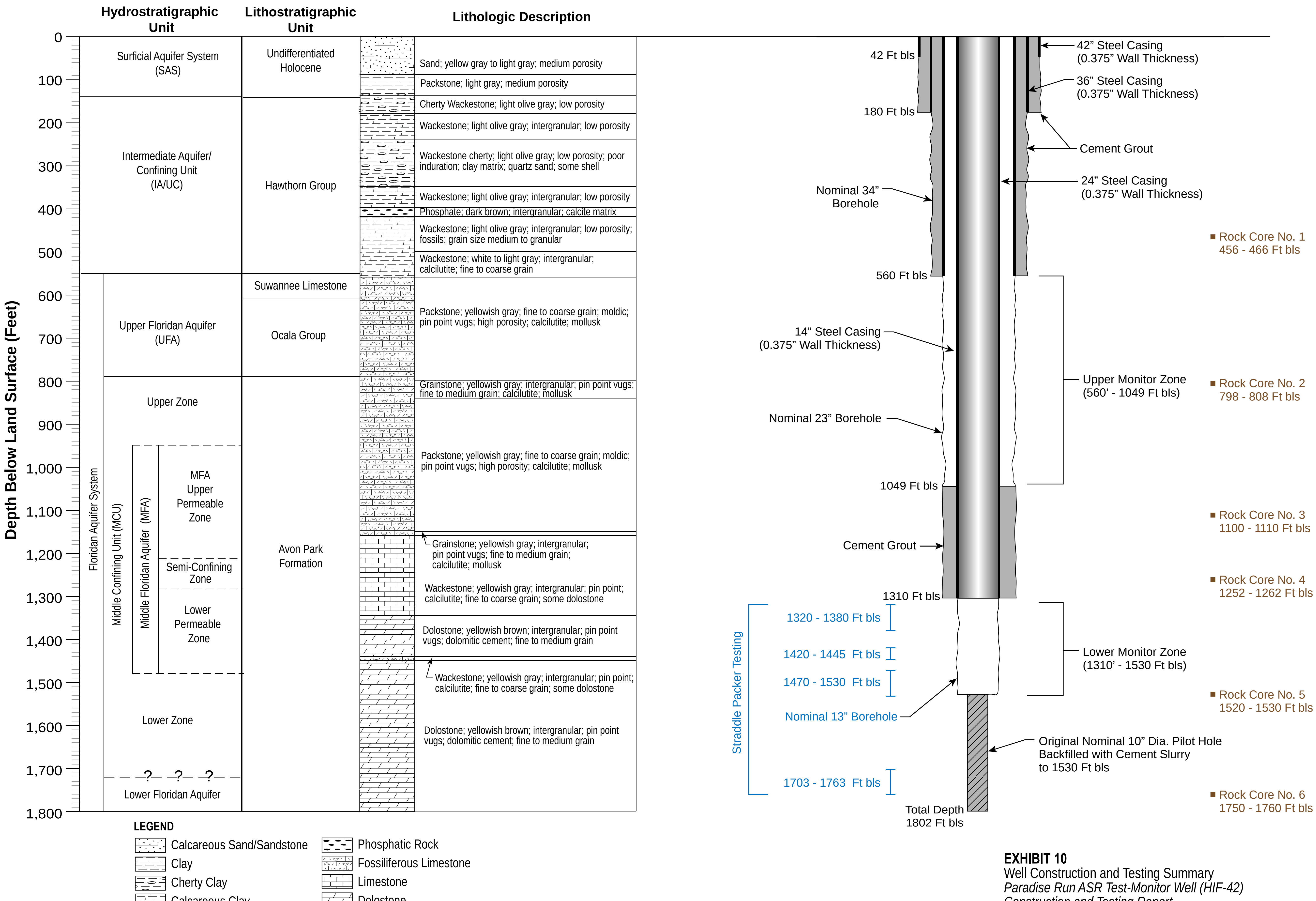


EXHIBIT 10
Well Construction and Testing Summary
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

EXHIBIT 11
Well HIF-42 Rock Core Laboratory Data
Paradise Run ASR

Drilling Data						Laboratory Data								
Core No.	Core Date	Depth Top (Ft bls)	Depth Bot. (Ft bls)	Recovery (Ft)	Core Dia. (In)	Depth Top (Ft bls)	Depth Bot. (Ft bls)	Max. Horiz. k (md)	90 Degrees to Max. k (md)	Vertical k (md)	Porosity (%)	Grain Density (gm/cc)	Lithologic Description
1	10/27/2007	456	466	6	4	460.0	461.0	2.265	1.641	0.105	43.5	2.64	Sandstone, Gray, very fine to fine grain size, calcite
1	10/27/2007	456	466	6	4	463.5	464.5	225.772	225.772	68.472	40.9	2.71	Conglomerate, limey, sandy
2	10/31/2007	798	808	10.5	4	799.5	801.0	24.559	24.136	16.970	39.4	2.68	Limestone, silt to chalky crystalline size, slight pin point moldic
2	10/31/2007	798	808	10.5	4	805.0	806.0	275.211	275.211	104.304	36.1	2.68	Limestone, silt to chalky crystalline size, slight pin point moldic porosity
3	11/02/2007	1100	1110	10	4	1104.0	1105.0	2629.744	1752.234	1731.354	37.7	2.69	Limestone, very fine to silty crystalline size, pin point porosity, intergranular porosity
4	11/05/2007	1252	1262	10	4	1261.0	1262.0	159.449	133.401	59.284	35.6	2.67	Limestone, slity to chalky crystalline size, pin point moldic porosity
5	12/10/2007	1510	1520	2	4	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d
6	12/13/2007	1750	1760	10	4	1756.0	1757.0	0.806	0.446	1.336	17.4	2.83	Dolomite, silty to very fine crystalline size, trace fracture, trace gypsum, slight pin point moldic porosity
6	12/13/2007	1750	1760	10	4	1757.5	1758.5	40.792	6.212	2.489	16.4	2.80	Dolomite, fine to very fine crystalline size, trace gypsum, pin poin moldic porosity
6	12/13/2007	1750	1760	10	4	1759.0	1760.0	30.363	22.773	10.743	23.7	2.79	Dolomite, fine to very fine crystalline size, gypsum, pin point moldic porosity

Notes:
n/d - Not determined
md - milli-darcys
k - Permeability
gm/cc - grams per cubic centimeter
Ft bls - Feet below land surface

4.3 Reverse-Air Drilling Water Sample Analyses

A nominal 10-inch pilot hole was drilled from land surface to a total depth of 1,802 feet bls. The drilling contractor changed from direct mud-rotary to reverse-air drilling methods upon penetration of water producing zones within the upper Floridan aquifer. Reverse-air drilling began at the depth of 1,264 feet bls and collection and analysis of water samples occurred as drill pipe was added, approximately at 30-foot intervals. The water samples were analyzed in the field for specific conductance, chlorides, and pH. **Exhibit 12** shows the results of the reverse-air water quality analyses. **Exhibit 13** provides a graphical depiction of the variability in chloride concentration and specific conductance as a function of pilot hole depth.

Groundwater quality data from reverse-air water samples show that water quality generally deteriorates with increased depth. Higher concentrations of dissolved minerals with increased depth, as reflected by the increasing chloride concentration and specific conductance values, are generally related to the higher residence time of the water within the aquifer. Remnant seawater (Bradner, 1994) may also be present in the FAS that has not been sufficiently mixed or flushed as groundwater moves through the aquifer. Other variations in reverse-air water sample quality may also be attributed to the addition of freshwater from C-38 canal, prolonged downtime during repairs to essential drilling equipment, or the addition of salt to control artesian flow.

EXHIBIT 12
Test-Monitor Well HIF-42 Pilot Hole Reverse-Air Water Quality
Paradise Run ASR Test-Monitor Well

Depth (Feet bls)	Chloride (mg/L)	Specific Cond. (uS/cm)	pH
1297	186	1,207	8.36
1328	90	1,230	8.36
1360	252	1,315	8.35
1390	254	1,321	8.14
1,552	2,500	8,261	n/a
1583	2,330	7,484	n/a
1,614	2,440	7,677	n/a
1,680	2,380	10,881	7.86
1,709	3,009	11,992	7.84
1,740	3,890	19,152	7.77
1,770	6,000	13,844	7.81
1,800	2,420	9,747	7.94

Notes:
n/a – not analyzed
uS/cm – microSiemens per centimeter

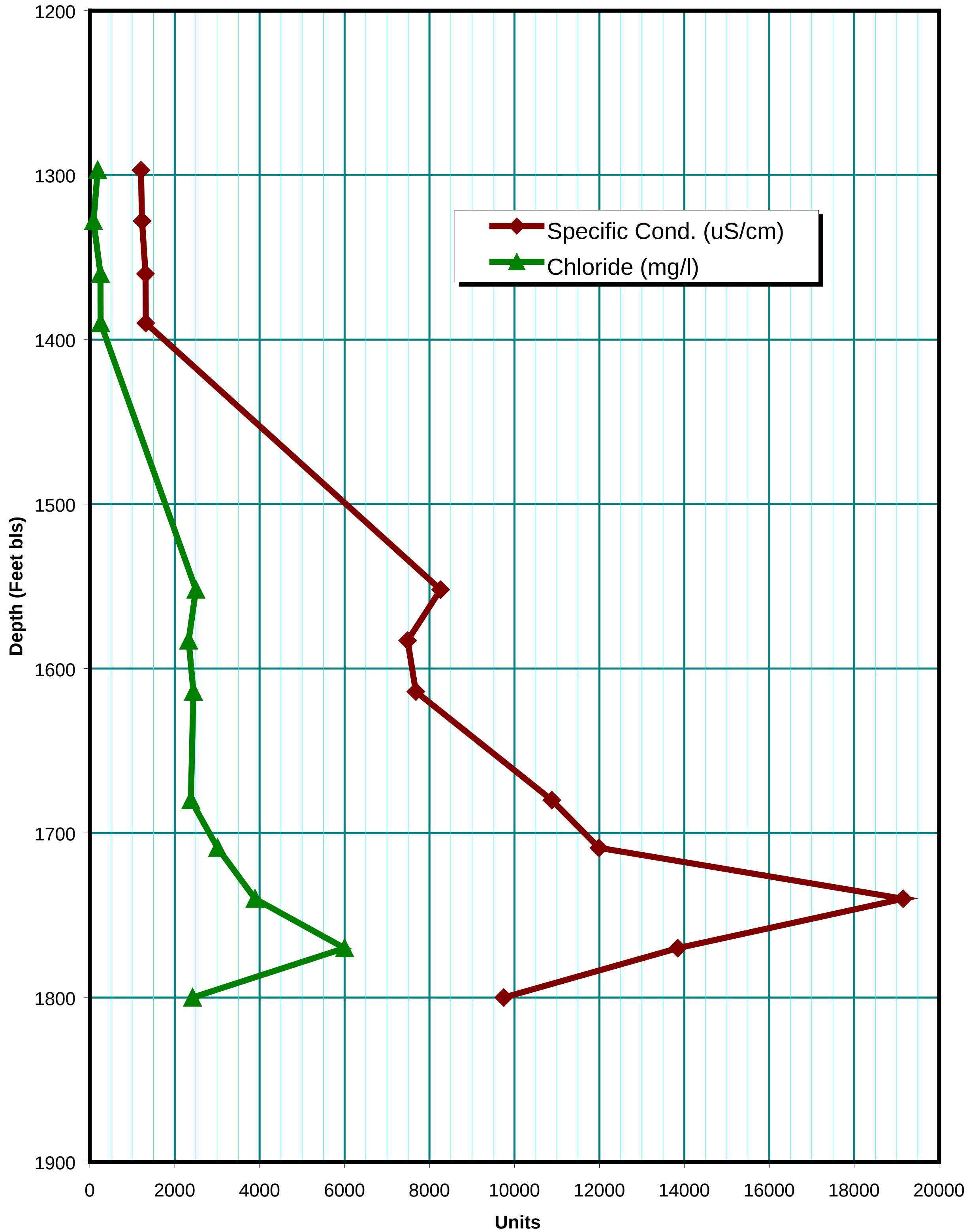


EXHIBIT 13
Reverse-Air Drilling Water Quality
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

4.4 Geophysical Logs

The geophysical logging program was planned for collection of information on the hydrogeology of the strata penetrated, evaluation of borehole geometry for setting and cementing of well casings, identification of straddle packer testing intervals, and identification and evaluation of potential ASR storage and confining zones. Geophysical logs were performed as listed in **Exhibit 14**. Geophysical logging was performed by MV Geophysical Corporation of Fort Myers Florida. Schlumberger Water Services (SWS), under contract to SFWMD, provided advanced geophysical logging data and interpretations on the depth intervals from 180 to 1,262 feet bls. The SWS logs provided supplemental data on borehole conditions, aquifer properties, fractures and bedding, lithology, and groundwater salinity. **Appendix D** provides a copy of the SWS document, "Advanced Geophysical Logging of Paradise Run Well HIF-42, Summary Report."

4.4.1 Description of Geophysical Logs

Borehole geophysical logging involves lowering measuring devices (sondes) on a wireline into a borehole or well to record various parameters related to the borehole geometry and the physical properties of the rock penetrated, pore fluids, and borehole fluid. Geophysical log data is presented graphically to depict the various measurements with depth. The following provides a brief description of the various geophysical logs run during the drilling and testing of Test-Monitor Well HIF-42:

- Caliper: measures casing and borehole diameter; indicates the degree of consolidation and fractures within the rock.
- Natural Gamma-Ray: measures naturally produced gamma radiation found in soil and rock; used to correlate litho-stratigraphic boundaries.
- Dual-Induction: measures the electrical conductivity of rock and pore fluids; used to evaluate formation porosity and variations in the quality of pore-filling water.
- Spontaneous Potential: measures natural potentials that develop between the borehole fluid and surrounding rock; often used to delineate permeable beds and formation boundaries.
- Fluid Resistivity: measures resistivity of the borehole fluids; used to indicate water producing zones within the open borehole.
- Fluid Temperature: measures temperature of the borehole fluids; used to indicate water producing zones within the open borehole. Also, because of the heat of hydration produced by curing cement grout, the temperature log may be used to estimate the top of cement behind the casing.

EXHIBIT 14
Test-Monitor Well HIF-42 Summary of Geophysical Logging
Paradise Run ASR Test-Monitor Well

Logging Run	1		2		3		4		5		6		7		8		9		10	
Date	**10/17/07**		**11/14/07**		**11/14/07**		**12/5/07**		**12/17/07**		**1/18/08**		**1/25/08**		**1/30/08**		**1/31/08**		**2/12/08**	
	Log	**Depth (ft)**	**Log**	**Depth (ft)**	**Log**	**Depth (ft)**	**Log**	**Depth (ft)**	**Log**	**Depth (ft)**	**Log**	**Depth (ft)**	**Log**	**Depth (ft)**	**Log**	**Depth (ft)**	**Log**	**Depth (ft)**	**Log**	**Depth (ft)**
	Cal	0-180'	Cal	0-598	Temp (CT)	0-548	Cal	495-1,236	Cal	0-1,802	Cal	0-878	Cal	495-1,097,'	Cal	0-1,310	Cal	0-1,310	Cal	0-1,530
	GR	0-180'	GR	0-598	GR	0-548	GR	495-1,236	GR	0-1,802	GR	0-878	GR	495-1,097	GR	0-1,310	GR	0-1,310	GR	0-1,530
							FC(s,d)	495-1,236	FC(s,d)	495-1,802	FC(s,d)	495-880	FC(s,d)	495-1,097					FC(s,d)	1,195-1,530
							Temp (s,d)	495-1,236	Temp (s,d)	495-1,802	Temp (s,d)	495-880	Temp (s,d)	495-1,097					Temp (s,d)	1,195-1,530
							FM(s,d)	495-1,236	FM(s,d)	495-1,802	FM(s,d)	495-880	FM(s,d)	495-1,097					FM(s,d)	1,255-1,530
							CBL/VDL	495-560	BHCS/VDL	525-1,794									CBL/VDL	995-1,310
									DIL	560-1,800										

Notes:
Geophysical Log Legend:
- Cal – Caliper
- GR – Gamma Ray
- FC – Fluid Conductivity
- Temp – Temperature
- Temp (CT) – Temperature, Cement Top
- FM – Flowmeter
- DIL – Dual-Induction
- BHCS/VDL – Borehole Compensated Sonic with Variable Density Display
- CBL/VDL – Cement Bond Log with Variable Density Display
- (s,d) – Log run during static (s) and dynamic (d) conditions; pumping or flowing the well

- Flowmeter: measures flow velocity of borehole fluids; typically run at constant velocities up and down the well; provides a means for estimating the contribution of flow from various production intervals.
- Borehole Compensated Sonic with Variable Density Display: measures the two-way travel time and attenuation of an acoustical energy (sound) produced by the sonde through the formation. The measured travel time of the sound wave is affected by the rock matrix and the pore water; the data may be used to evaluate the relative porosities of the rock penetrated.
- Cement Bond Log with Variable Density Display: measures the acoustical energy attenuation to determine the degree of cement bonding to the casing and the formation.

For a description of advanced geophysical logs, refer to the SWS report provided in **Appendix D**.

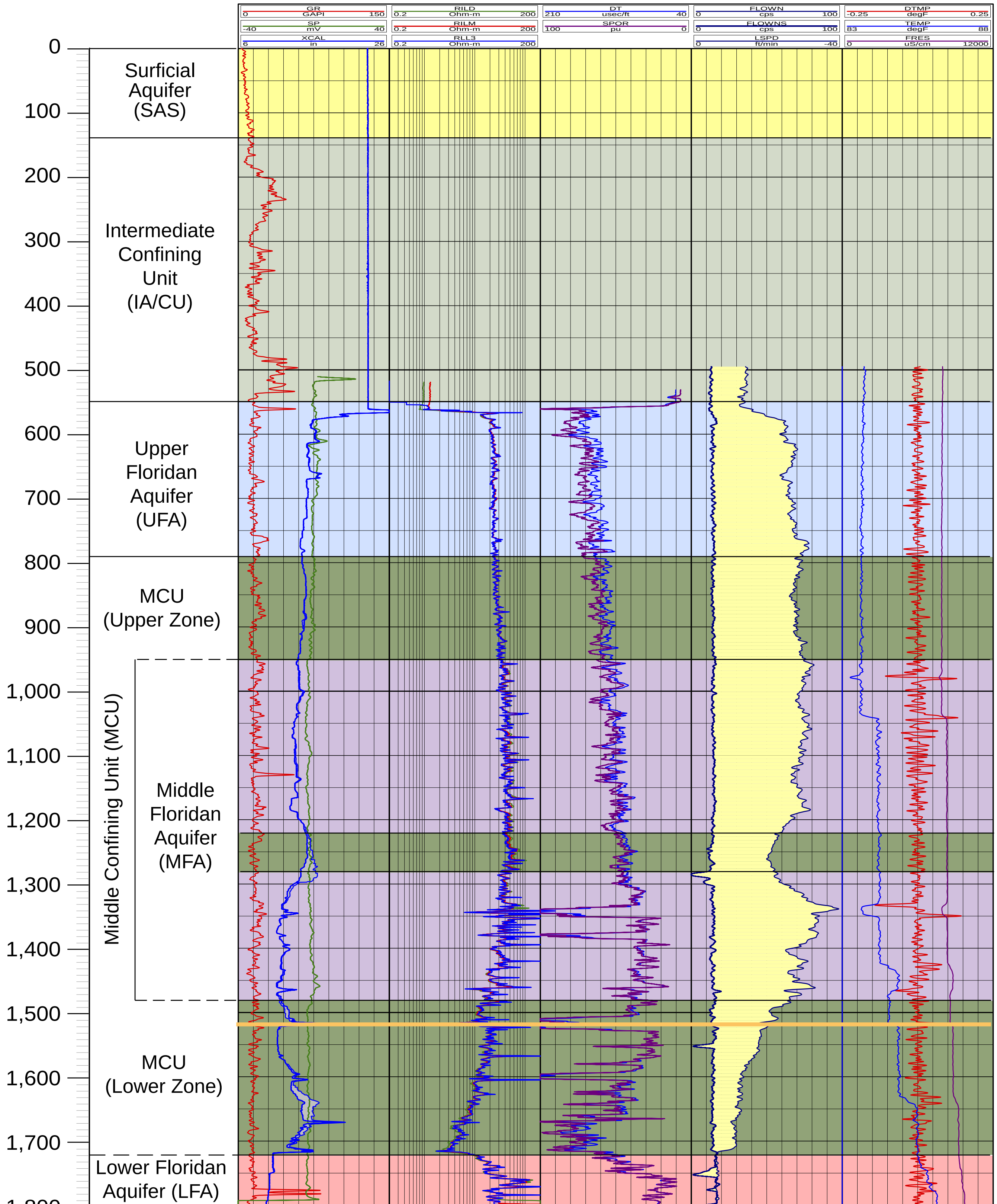
4.4.2 Pilot Hole Geophysical Logging Summary

A nominal 10-inch-diameter borehole was drilled in stages to 1,802 feet bls and conditioned for geophysical logging to evaluate the properties of the formation and aquifers penetrated. **Exhibit 15** presents a composite of geophysical logs run from land surface to the well completion depth and depicts the major hydrostratigraphic units.

Evaluation of the dual-induction log shows that the lithology within the UFA and MCU-upper zone are fairly uniform. The resistance values are generally increasing within these units, and the trace for the three conductors becomes more divergent as the salinity of the formation water increases. The increasing salinity with depth was also established through analysis of reverse-air pilot hole water quality samples referenced in Section 4.3. Harder fractured dolostone and dolomitic limestone become more prevalent within and below the proposed MFA.

Within the MCU's upper and lower zones, the XY caliper reveals an out-of-round borehole indicative of the softer, and possibly less permeable, limestone or dolomitic limestone.

The middle Avon Park correlation marker (MAP) as described by Reese and Richardson (2004) is present near the base of the proposed MFA. The MAP can be correlated with geophysical logging data from wells W-17095 and OKF-100 in the vicinity of the Paradise Run site. The MAP was identified at wells W-17095 and OKF-100 at the approximate depths of 1,620 feet bls and 1,530 feet bls, respectively (Reese and Richardson, 2004). However, the distinct gamma-ray kick was not observed within this well or those referenced. The glauconite marker bed found near the top of the Oldsmar Limestone was not present, and is anticipated to be several hundred feet deeper than the 1,802 foot completion depth of this well.



HIF-42 Geophysical Log Run No.5 (0 to 1,800 feet)

- Surficial Aquifer System
- Intermediate Confining Unit
- Upper Floridan Aquifer
- Middle Floridan Aquifer
- Middle Confining Unit
- Lower Floridan Aquifer
- Middle Avon Park Formation Marker Bed

EXHIBIT 15
Summary and Analysis of Pilot Hole Geophysical Logs
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

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Geophysical logging was also conducted on the pilot hole while pumping the well at a rate of 1,000 gallons per minute (gpm). Flowmeter, temperature, and fluid resistivity logs conducted under pumping (dynamic) conditions were used to identify flow zones within the borehole. Generally, little flow was obtained from the bottom of the borehole. Major points of water entry were identified at the following depths based on observed changes in fluid temperature and fluid resistivity while pumping the well: 1,650 feet bls, 1,530 feet bls, 1,430 feet bls, 1,350 feet bls, and 1,040 feet bls.

Exhibits 16 and 17 summarize the flow contribution from the major subdivisions of the FAS. The flowmeter log was run on the 10-inch pilot hole .

EXHIBIT 16
Sources of Flow Entering ASR Test Well within Florida Aquifer
Paradise Run ASR Test-Monitor Well (HIF-42)

Hydrostratigraphic Unit	Flow Contribution
UFA	67 Percent
MCU – Upper Zone	5 Percent
MFA	14 Percent
MCU – Lower Zone and Deeper Units	4 Percent
LFA	10 Percent

Although the calculated flow contribution from the MFA was comparatively low, discrete flow zones were evaluated further during aquifer performance testing on intervals within the enlarged borehole. The results of these tests are discussed in Section 4.6, Aquifer Performance Testing.

4.5 Straddle Packer Testing

Following analysis of the borehole geophysical logs and consideration of the reverse-air water sample data, four straddle packer tests were performed. The straddle packer tests isolated zones for evaluation of water quality and aquifer hydraulic properties. The test intervals were chosen in areas where, based on examination of the caliper logs, the borehole was relatively smooth and uniform in diameter to permit proper packer element seating. All of the straddle packer tests were performed using a TAM LI inflatable straddle packer assembly. The packer assembly was run on 5-inch drill pipe (4.5-inch-diameter, internally flush), and packer separation varied from 25 feet to 60 feet. Johnson V-wire well screen was installed between the packers to reduce friction losses as groundwater is pumped from the isolated depth interval. The straddle packers were inflated with water through an external 0.25-inch stainless steel tubing extending to land surface.

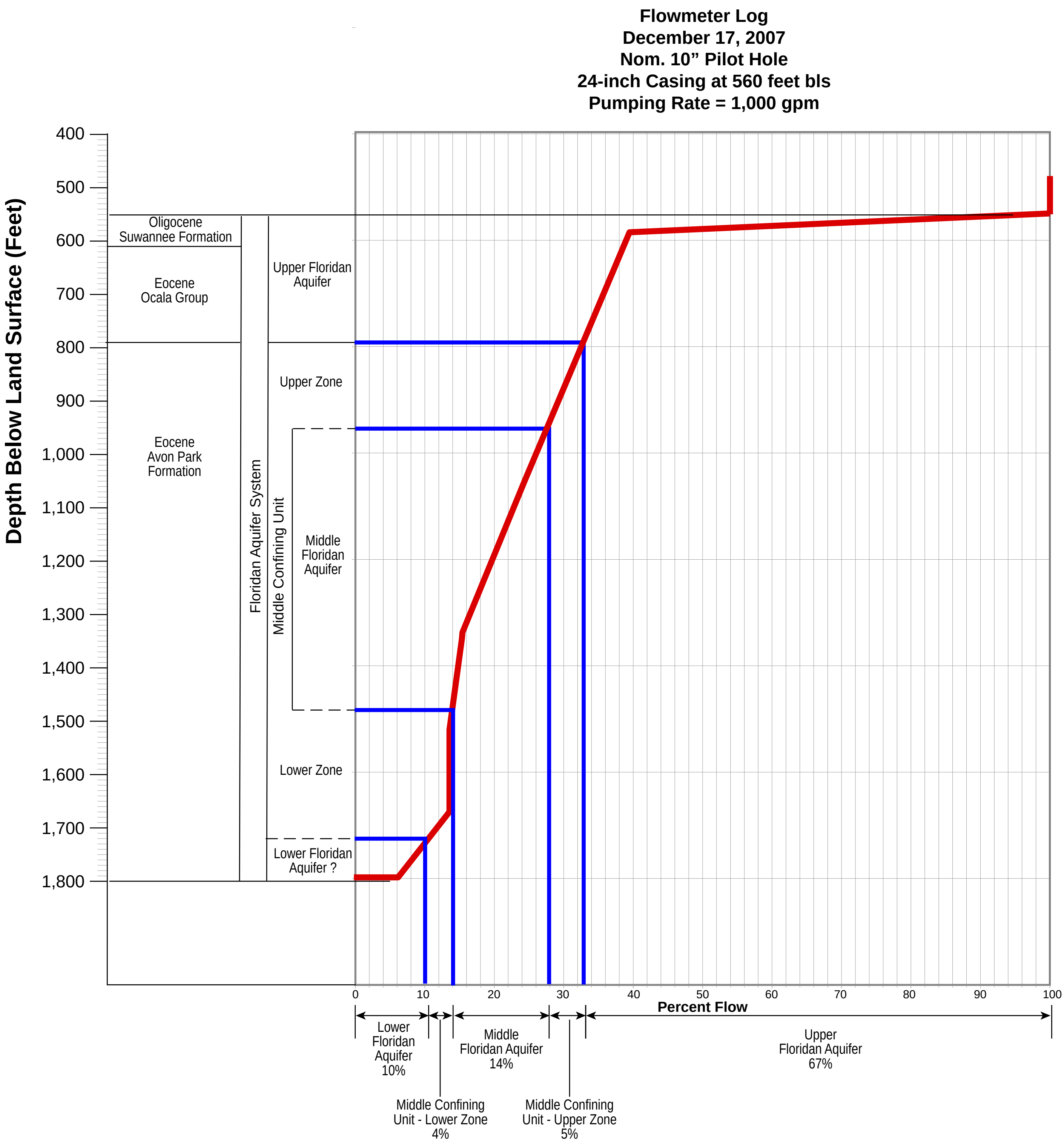

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EXHIBIT 17
Pilot Hole Flowmeter Log Summary
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

Approximately 150 feet of 7.625-inch oil field casing was connected to the drill pipe to allow installation of a 6-inch submersible pump for specific capacity testing. The pump capacity was approximately 400 gpm. Water levels within the drill pipe were measured with a pressure transducer and measurements recorded on an In-Situ water level data logger (Level Troll®700). At the bottom of the lower packer, a 1,000 psi pressure transducer was run in with the assembly to record absolute pressure during testing. The reference point for all measurements was the top of the drill pipe at an approximate elevation of 30 feet NGVD. The top of the drill pipe was 5 feet above the pad level elevation of approximately 24 feet NGVD. The four straddle packer testing intervals are described in **Exhibit 18**, while **Exhibit 19** shows a schematic representation of the straddle packer assembly used for testing.

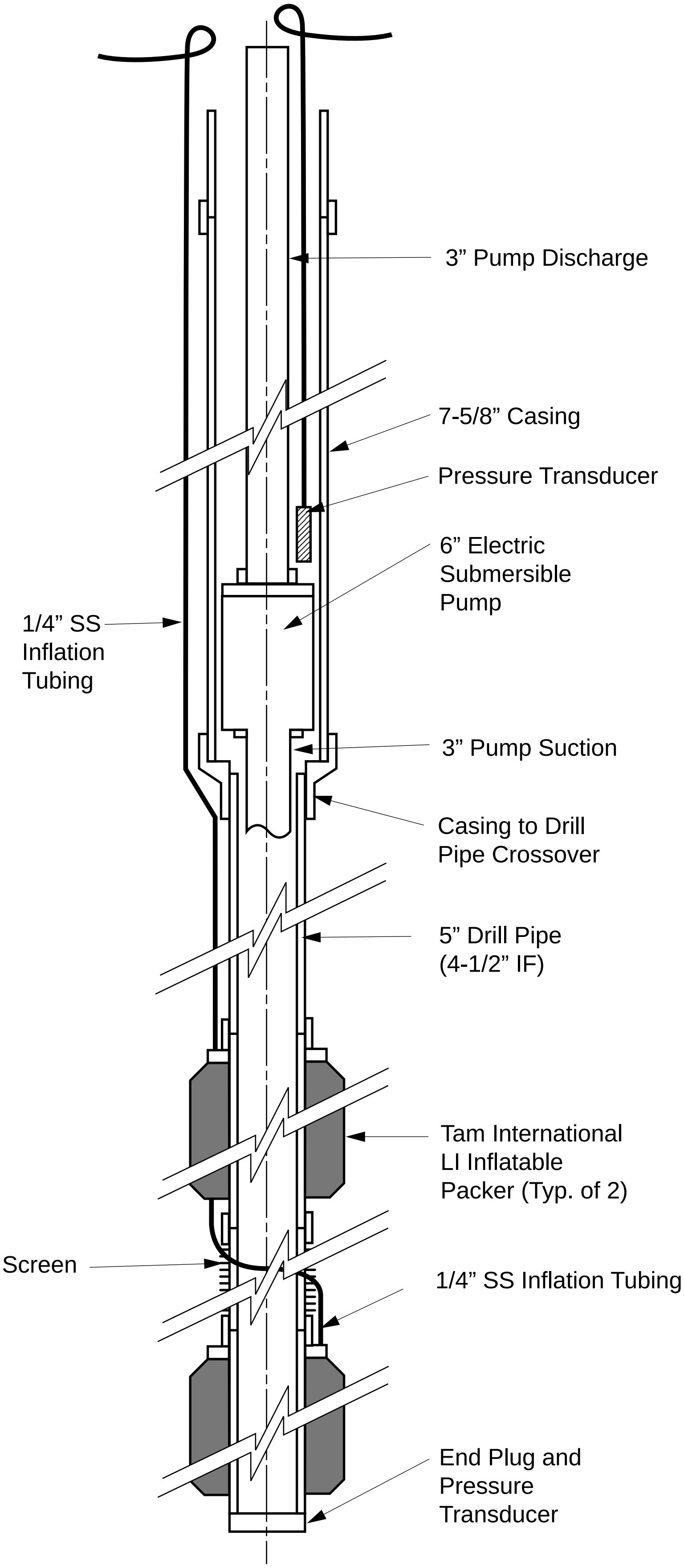
EXHIBIT 18
Packer Tests and Depth Intervals
Paradise Run ASR Test-Monitor Well (HIF-42)

Packer Test Number	Depth Interval
1	1,703 feet – 1,763 feet bls
2	1,470 feet – 1,530 feet bls
3	1,320 feet – 1,380 feet bls
4	1,420 feet – 1,445 feet bls

Exhibit 20 summarizes the straddle packer testing results. Correction to the specific capacity testing data was based on calculated friction losses using the Hazen-Williams empirical formula for drill pipe with a 4.5-inch internal diameter and a roughness coefficient (C) of 100. The resulting head losses were subtracted from the measured drawdown to provide a better estimate of the formation specific capacity for each interval tested. Because of the high flow rates for straddle packer tests 1, 2, and 3, friction head losses within the drill pipe amounted to almost half of the measured drawdown. The results of each straddle packer test are discussed further in following sections. The water level data for the four straddle packer tests are contained in **Appendix F.**

4.5.1 Packer Test No. 1 (Depth Interval 1,703 to 1,763 feet bls)

On December 21, 2007, the first packer test was run in the nominal 10-inch pilot hole on the interval from 1,703 to 1,763 feet bls. The test was conducted for 2 hours at a constant discharge rate of 210 gpm. This interval was selected to evaluate the specific capacity of the lower portion of the pilot hole and to obtain a representative water quality sample. The straddle packer assembly isolated the flow zone identified at approximately 1,716 feet bls. Prior to pumping during straddle packer placement through inflation, water flowed from the drill pipe and a static water level was not obtained during zone testing. However, using the static elevations of the two monitor zones upon completion of Well HIF-42, an estimated static head of approximately 41 feet NGVD is projected as shown in **Exhibit 21**. At a flow rate of 210 gpm, the water level in the drill pipe dropped 46 feet to an approximate elevation of -16 feet NGVD. The drawdown is estimated at 51 feet and the resulting specific capacity is 4.1 gpm per foot (gpm/ft). A correction for 18.4 feet for friction losses within the drill pipe, however, places the formation specific capacity at approximately 6.4 gpm/ft. Water level measurements during pumping are shown in **Exhibit 22**.



Not to Scale

EXHIBIT 19
Straddle Packer Assembly for Specific Capacity Testing
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

EXHIBIT 20
Well HIF-42 Straddle Packer Testing Summary
Paradise Run ASR Test-Monitor Well

Test Date	Test ID	Length of Test (hh:mm)	Test Interval (feet)	Length of Open Interval (feet)	Pumping Rate (gpm)	Static Water Elev. (feet NGVD)	Pumped Water Elev. (feet NGVD)	Drawdown (feet)	Hazen-William Estimate Friction Loss; C=100 (feet of water)	Corrected Specific Capacity (gpm/ft)
12/21/07	PT-1	2:46	1,703-1,763	60	210	41	-10	51	18.4	6.4
12/26/07	PT-2	2:49	1,470-1,530	60	225	43	-3	46	17.7	8.0
12/27/07	PT-3	1:59	1,320-1,380	60	300	43	-43	86	26.8	5.0
1/2/08	PT-4	3:29	1,420-1,445	25	11	43	-20	63	0.1	0.2

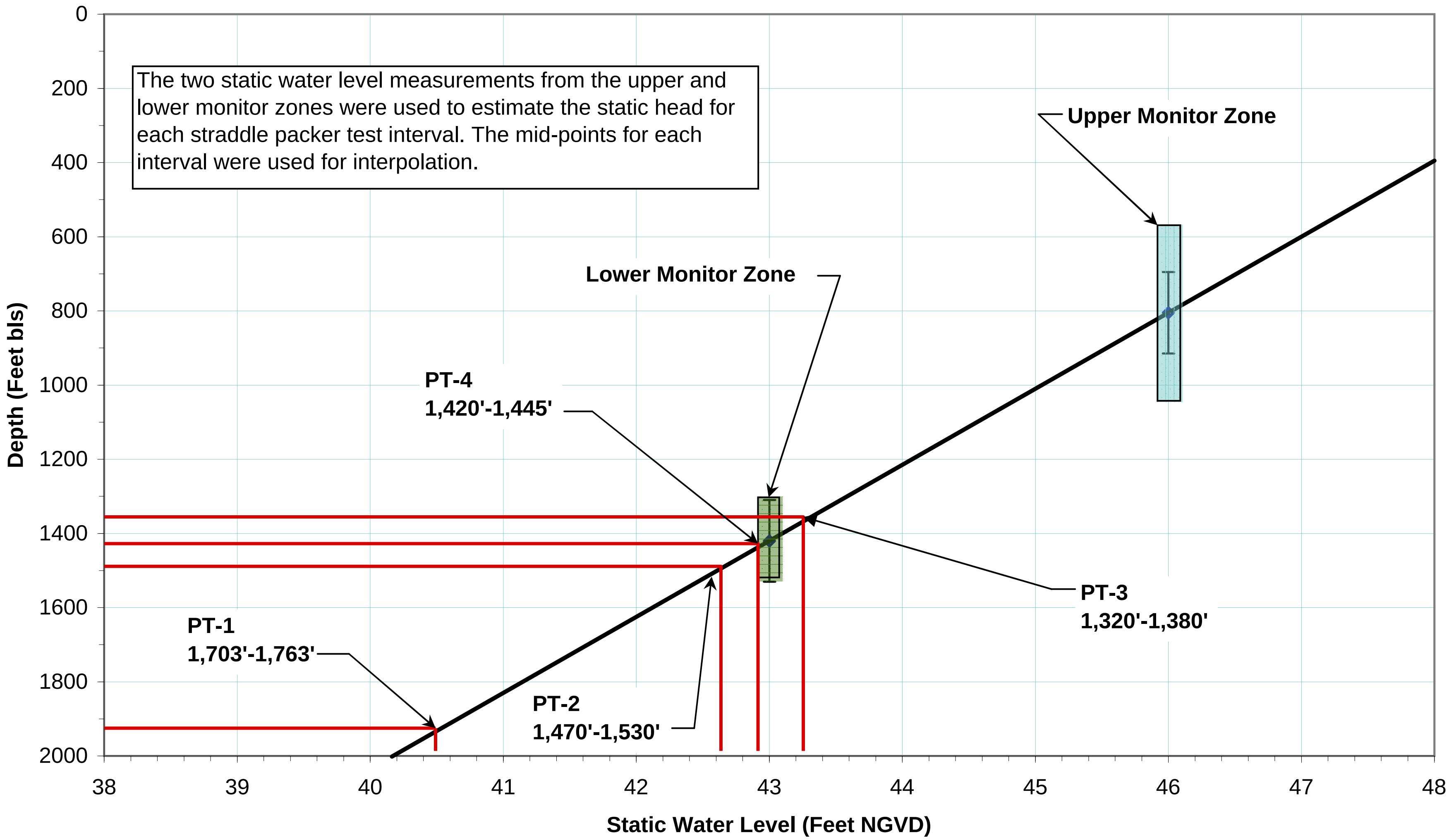


EXHIBIT 21
Interpolation of Floridan Aquifer Static Hydraulic Head for Straddle Packer Testing
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

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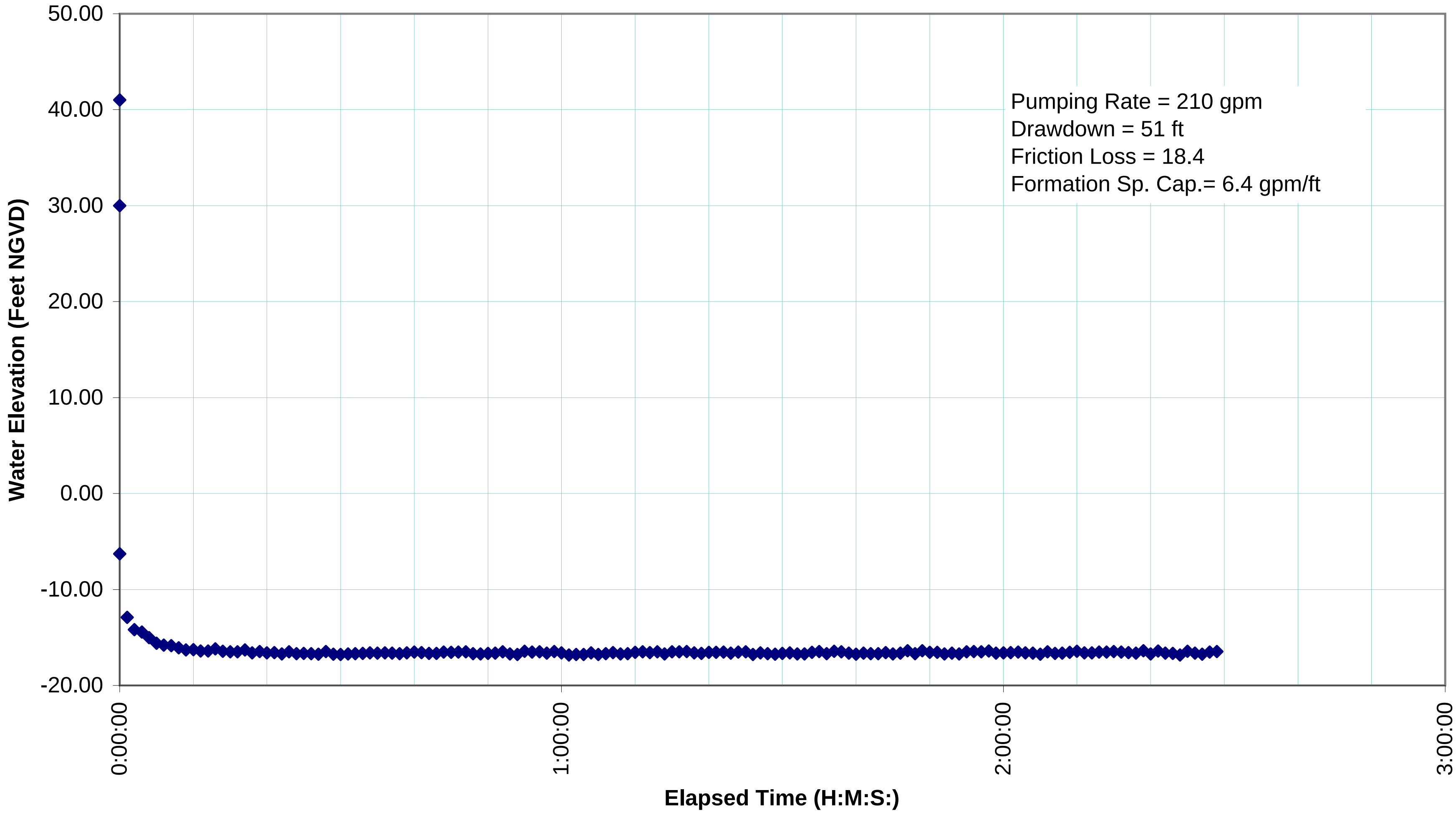

EXHIBIT 22
Straddle Packer Pumping Test No. 1
Depth 1,703-1,763 Feet bls, December 21, 2007
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

4.5.2 Packer Test No. 2 (Depth Interval 1,470 to 1,530 feet bls)

On December 26, 2007, the second packer test was performed at a pumping rate of 225 gpm for 2.5 hours. The straddle packer was positioned and inflated to isolate the interval from 1,470 to 1,530 feet bls. This interval was selected to obtain water quality and specific capacity data from the lower portion of the MFA proposed by Reese and Richardson (2004). As shown in Exhibit 21, an estimated static head of approximately 43 feet NGVD is projected. The depth to water from the top of the drill pipe (Elevation 30± NGVD) was measured at 38.8 feet, at approximate elevation -3 feet NGVD. The drawdown is estimated at 46 feet, which results in a specific capacity of 4.9 gpm/ft. A correction for 17.7 feet for friction losses within the drill pipe, however, places the formation specific capacity at approximately 8.0 gpm/ft. The depth to water remained constant shortly after the test began. Water level measurements during pumping are shown in **Exhibit 23.**

4.5.3 Packer Test No. 3 (Depth Interval 1,320 to 1,380 feet bls)

On December 27, 2007, the third packer test was performed at a pumping rate of 300 gpm for 2 hours. The straddle packer was positioned and inflated to isolate the interval from 1,320 to 1,380 feet bls. This interval was selected to obtain water quality and production data from the upper portion of the proposed MFA. As shown in Exhibit 21**,** an estimated static head of approximately 43 feet NGVD is projected. The depth to water from the top of the drill pipe (Elevation 30± NGVD) was measured at 77.7 feet, at approximate elevation -43 feet NGVD. The drawdown is estimated at 86 feet, which results in a specific capacity of 3.5 gpm/ft. A correction for 26.8 feet for friction losses within the drill pipe, however, places the formation specific capacity at approximately 5.0 gpm/ft. The depth to water remained constant shortly after the test began. Water level measurements during pumping are shown in **Exhibit 24.**

4.5.4 Packer Test No. 4 (Depth Interval 1,420 to 1,445 feet bls)

On January 2, 2008, the fourth packer test was performed at a pumping rate of 11 gpm for 4 hours. The straddle packer was positioned and inflated to isolate the interval from 1,420 to 1,445 feet bls. This interval was selected to obtain water quality and production data from a low permeability interval between the upper and lower permeable zones of the proposed MFA. As shown in Exhibit 21**,** an estimated static head of approximately 43 feet NGVD is projected. The depth to water from the top of the drill pipe (Elevation 30± NGVD) was measured at 54.6 feet, approximate elevation -20 feet NGVD. The drawdown is estimated at 63 feet, which results in a specific capacity of 0.2 gpm/ft. A correction for 0.1 feet for friction losses within the drill pipe, however, has negligible effect on the specific capacity. The depth to water remained constant shortly after the test began. Water level measurements during pumping are shown in **Exhibit 25.**

4.5.5 Straddle packer Testing Water Quality

Water quality sampling was conducted at the conclusion of pumping for each of the four straddle packer tests described above. Water samples were collected at the conclusion of the of each straddle packer test prior to pump shutoff and after field parameters (pH, temperature, turbidity and specific conductance) had stabilized.

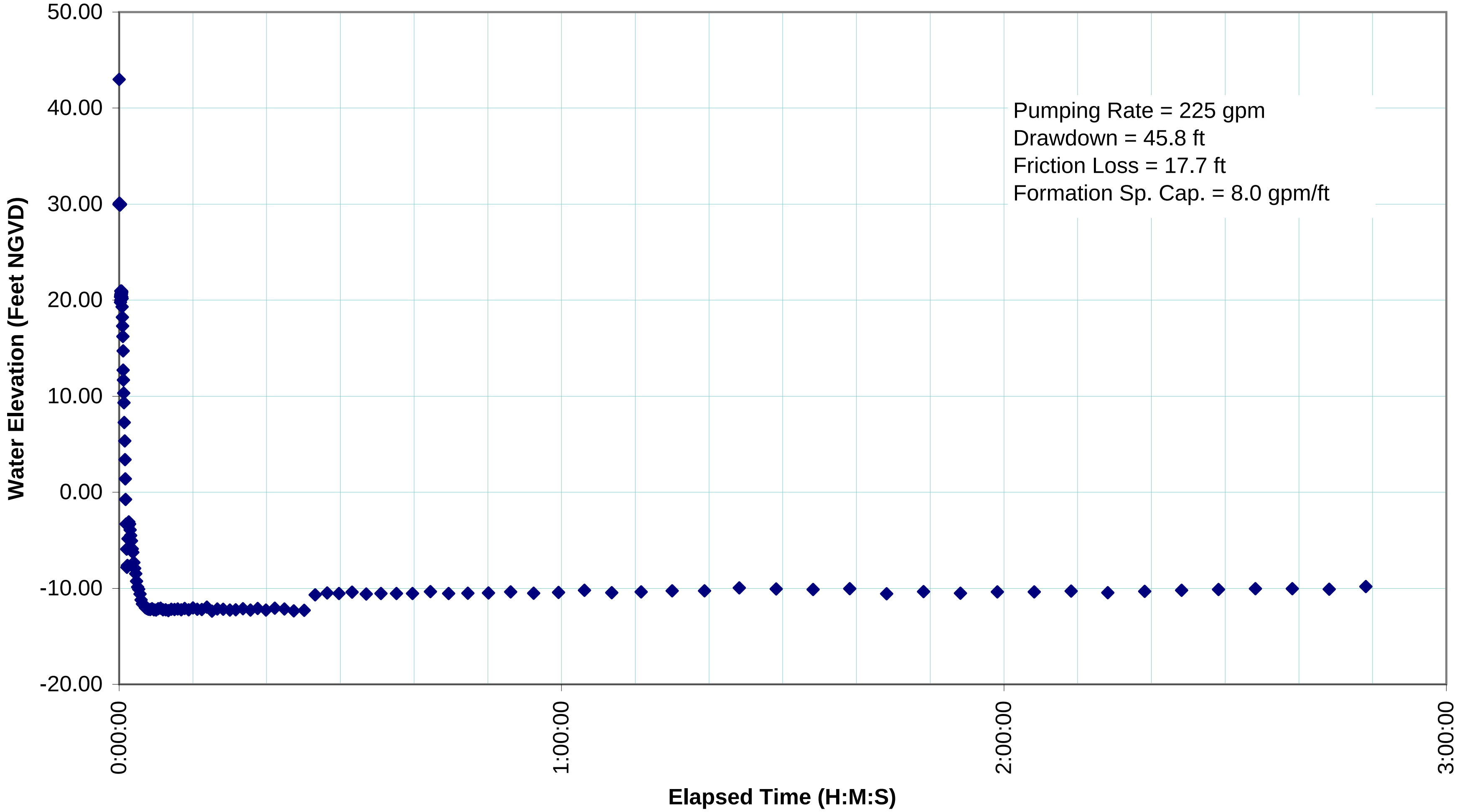

EXHIBIT 23
Straddle Packer Pumping Test No. 2
Depth 1,470-1,530 Feet bls, December 26, 2007
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

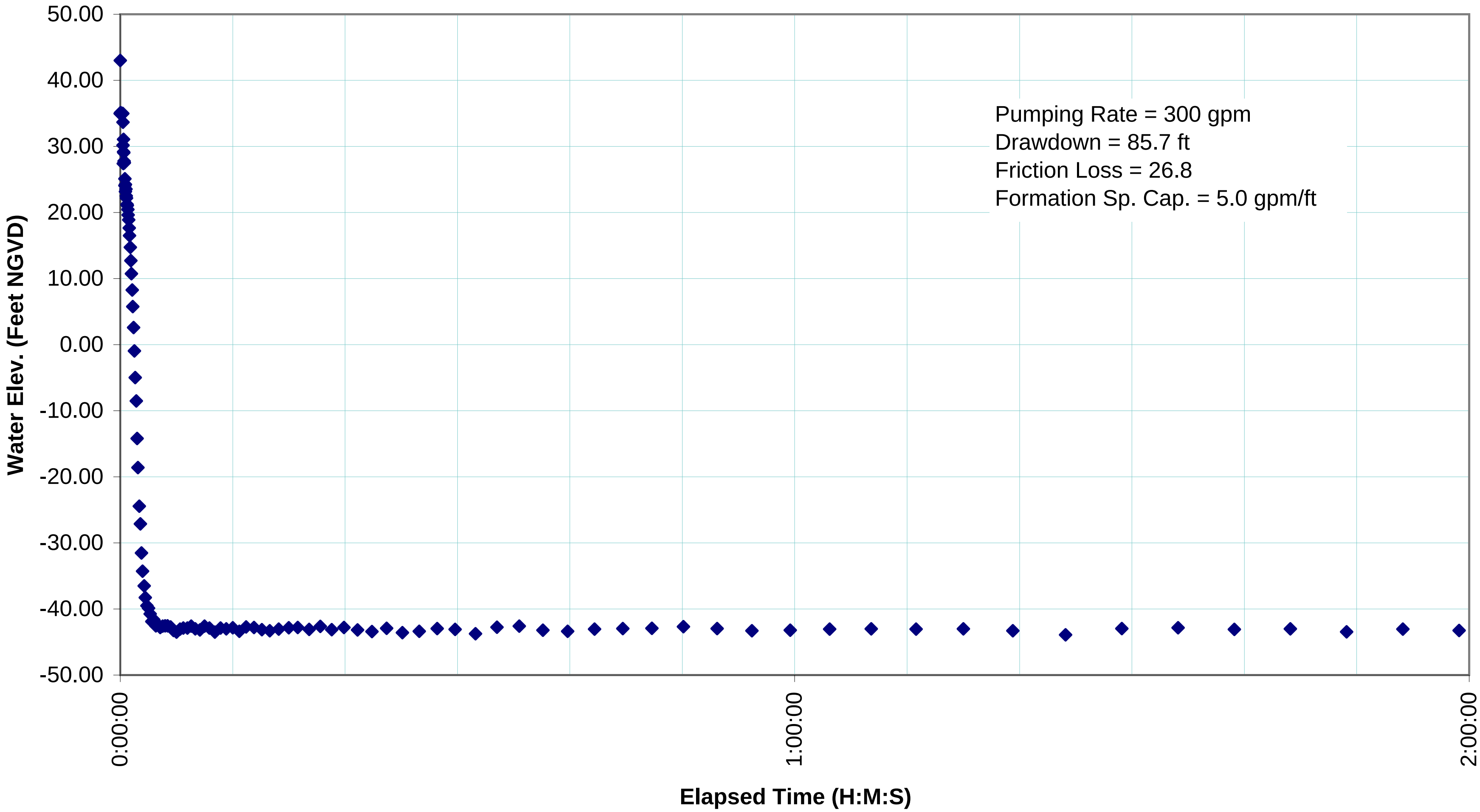

EXHIBIT 24
Straddle Packer Pumping Test No. 3
Depth 1,320-1,380 Feet bls, December 27, 2007
Paradise Run ASR Test/Monitor Well (HIF-42)
Construction and Testing Report

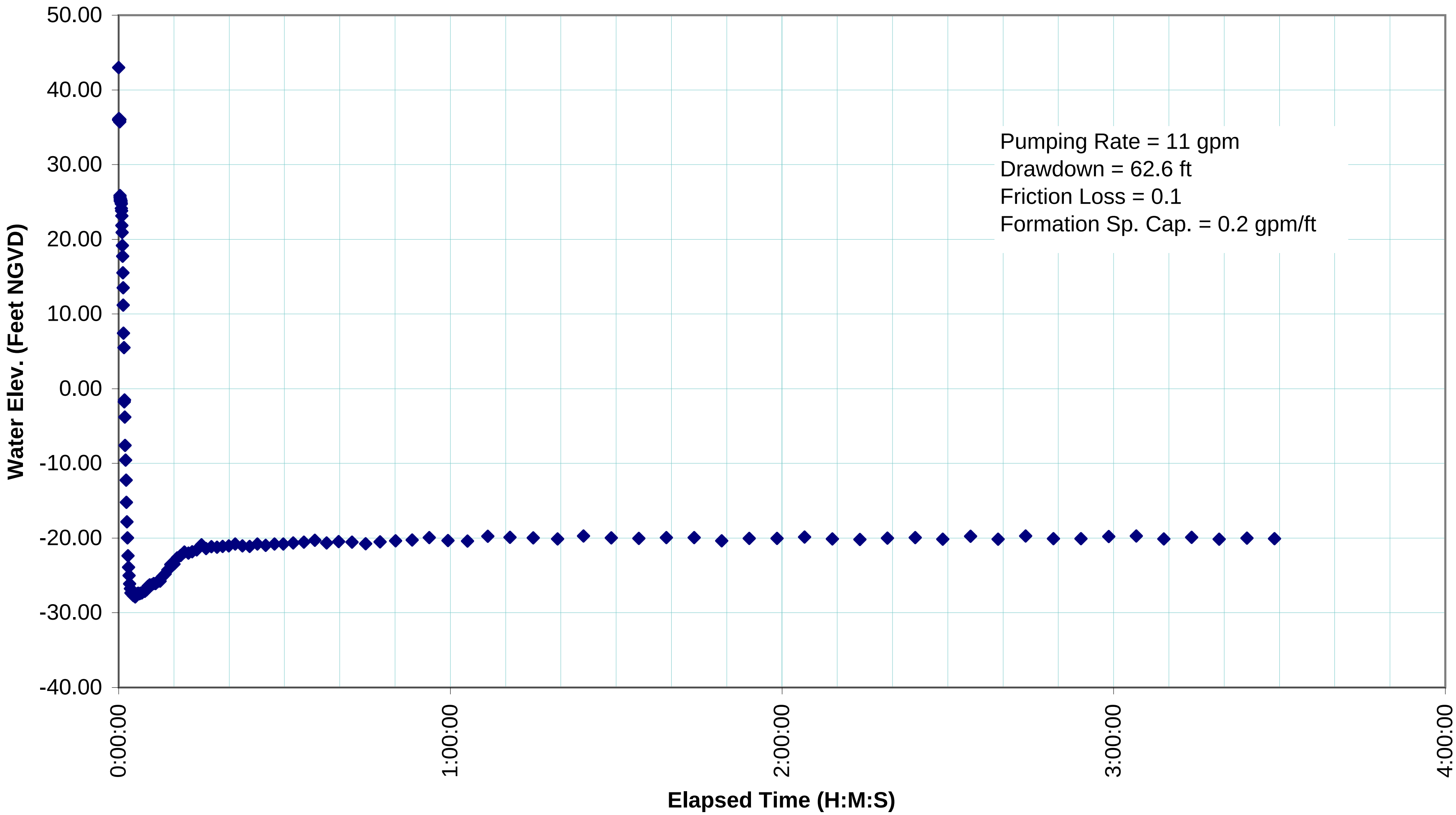

EXHIBIT 25
Straddle Packer Pumping Test No. 4
Depth 1,420-1,445 Feet bls, January 2, 2008
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

Following collection, each water sample was shipped to Columbia Analytical Services Laboratory for analysis of metals and selected inorganic parameters. **Exhibit 26** presents the results of the water quality analyses; analytical reports are contained in Appendix B. **Exhibit 27** shows chloride, sulfate and TDS concentrations for the four straddle packer testing intervals. An increase in concentration of these constituents with depth indicates that the groundwater becomes more mineralized. Drinking Water Standards were exceeded for the constituents listed in **Exhibit 28**.

4.6 Aquifer Performance Testing

Following geophysical logging of the pilot hole and straddle packer testing, aquifer performance tests (APT) were conducted to determine the hydraulic properties of the formation within three depth intervals. Prior to conducting the APTs, the nominal 10-inch pilot hole was back plugged from the bottom at 1,802 feet to 880 feet bls with cement grout. The pilot hole below the bottom of the 24-inch casing at 560 feet bls and the back plugged pilot hole between 880 feet and 1,310 feet bls were enlarged using a 22.5-inch bit. Two UFA/MFA upper zone intervals were developed for testing: 560 to 880 feet bls, and 560 to 1,110 feet bls. Subsequently, the interval from 1,310 to 1,530 feet bls (consistent with the lower zone of the proposed MFA) was developed for testing following the installation of the 14-inch casing set at 1,310 feet bls. The open-hole testing interval below the 14-inch casing was enlarged using a 12.25-inch bit to a depth of 1,530 feet bls.

The depth intervals selected to perform the APTs were based on evaluation of the geophysical logs and water quality data collected from the straddle packer tests. The testing intervals were selected to better evaluate the hydraulic characteristics of the UFA, MCU-Upper Unit, and the upper and lower zones of the MFA.

For each APT, a 6-inch electric submersible pump with a capacity of 1,500 gpm was installed. A temporary fabricated flanged header was installed on the 24-inch and 14-inch casings to support the pump and prevent the well from flowing. The flange elevations for the installed headers were 6.5 feet above pad level. A temporary 12-inch-diameter pipeline 280 feet in length was installed to convey produced water from the well to a point of discharge on the west bank of the C-38 canal. Flow measurements were made using a totalizing impeller flowmeter except for the final constant rate pumping test, which used a sonic flowmeter.

Water level measurements within the well during the APTs were made using an In-Situ Level Troll®700 pressure transducer. The pressure transducer was installed in the well and packed-off to maintain pressure at the header. The header flanges for the 24-inch and 14-inch casings were the reference points for water level measurement. The elevation of the header flange(s) was approximately 30.5 feet NGVD.

EXHIBIT 26
Well HIF-42 Straddle Packer Testing Water Quality Analyses
Paradise Run ASR Test-Monitor Well

Analyte	Drinking Water Standards (mg/L)	Packer Test 1 Depth 1,703-1,763 ft Date 12/21/2007	Packer Test 2 Depth 1,470-1,530 ft Date 12/26/2007	Packer Test 3 Depth 1,320-1,380 ft Date 12/27/2007	Packer Test 4 Depth 1,420-1,425 ft Date 1/2/2008
Antimony	0.006	0.00061	U	U	U
Arsenic	0.01	U	U	U	U
Barium	2	0.0056	0.04	0.0473	0.033
Beryllium	0.004	U	U	U	U
Cadmium	0.005	U	U	U	U
Chromium	0.1	0.0019	0.00057	0.0014	0.00048
Copper	1	0.0057	0.0024	0.003	U
Fluoride	2.0	**5.3**	0.24	0.69	0.61
Lead	0.015	0.00033	0.00043	0.0007	U
Manganese	0.05	0.0087	0.0034	0.0017	0.039
Nickel	0.1	0.0075	0.0025	0.0015	0.0012
Selenium	0.05	U	U	U	U
Silver		U	U	U	U
Sodium	160	**2,990**	**1,180**	**420**	**666**
Strontium		20.4	41.8	40.5	54.7
Thallium	0.002	U	U	U	U
Tin		U	U	U	U
Zinc	5	0.084	0.081	0.0133	0.0024
Aluminum	0.2	U	0.12	0.08	0.06
Calcium		1,010	279	103	143
Iron	0.3	**0.58**	0.21	0.08	**0.66**
Magnesium		412	188	72	105
Potassium		101	33	12	19
Alkalinity		98	80	120	89
Carbon, Dissolved Organic		1.4	1.4	1.8	1.4
Carbon, Total Organic		1.9	1.6	2.6	1.5
Chloride	250	**5,300**	**2,380**	**730**	**1,200**
Silica		12	12	14	14
Solids, Total Dissolved	500	**14,000**	**4,900**	**1,900**	**2,600**
Sulfate	250	**2,800**	**670**	**300**	**350**
Turbidity		4.3	4.9	0.34	2.8

Notes
U= Analyzed but not detected

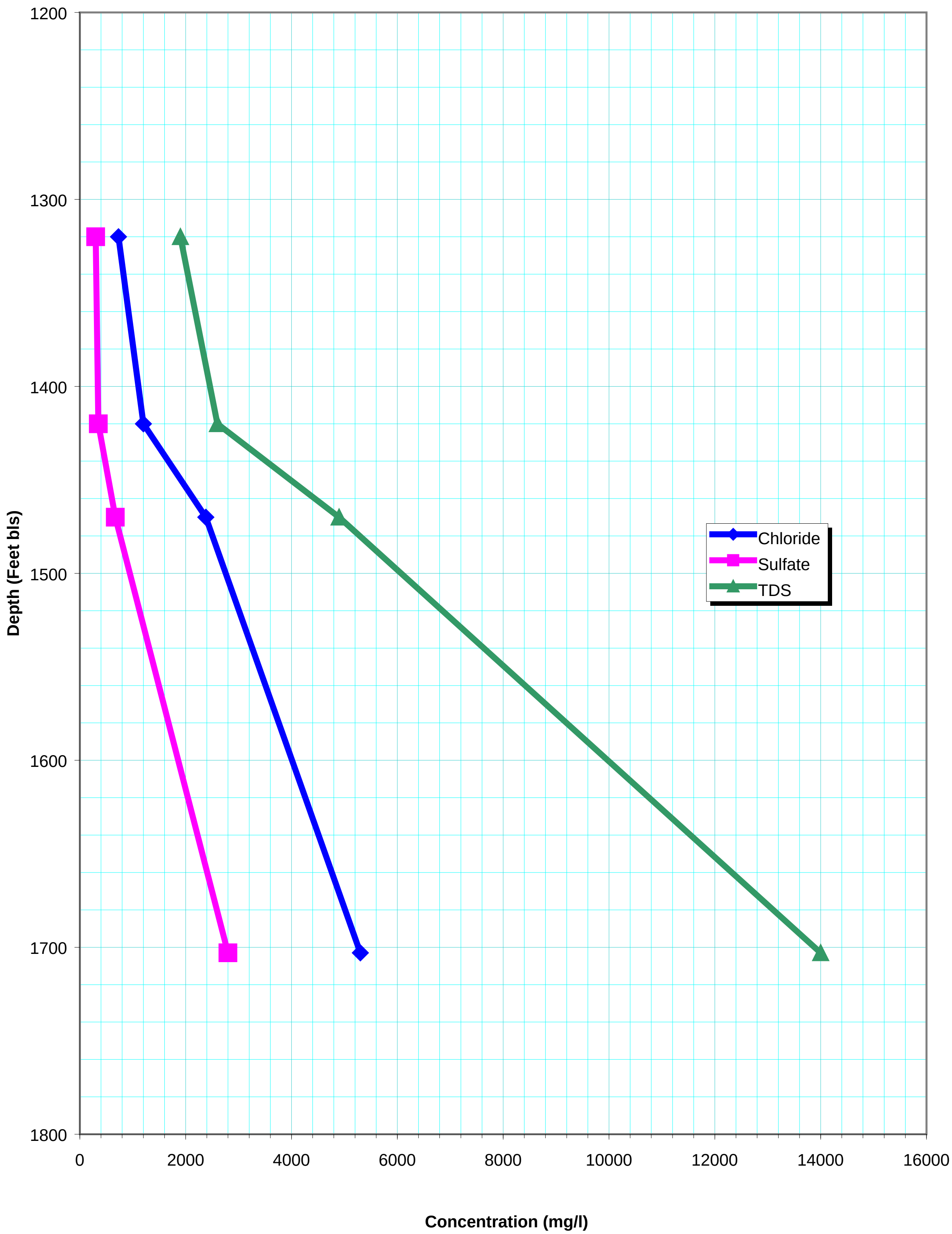

EXHIBIT 27
Straddle Packer Testing Water Quality
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

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EXHIBIT 28
Exceedances of Drinking Water Standards in Samples Collected During Straddle Packer Tests
Paradise Run ASR Test-Monitor Well (HIF-42)

Constituent	Drinking Water Standard	PT-1 1,703-1,763 feet bls	PT-2 1,470-1,530 feet bls	PT-3 1,320-1,380 feet bls	PT-4 1,420-1,425 feet bls
Fluoride	2.0 mg/L	5.3 mg/L	--	--	--
Sodium	160 mg/L	2,990 mg/L	1,180 mg/L	420 mg/L	666 mg/L
Iron	0.3 mg/L	0.58 mg/L	--	--	--
Chloride	250 mg/L	5,300 mg/L	2,380 mg/L	730 mg/L	1,200 mg/L
TDS	500 mg/L	14,000 mg/L	4,900 mg/L	1,900 mg/L	2,600 mg/L
Sulfate	250 mg/L	2,800 mg/L	670 mg/L	300 mg/L	350 mg/L

APTs included step-drawdown and constant rate pumping tests. Step-drawdown tests were conducted by pumping the well at three incrementally higher flow rates, each for a period of 1 hour. Water level recovery in the well was measured for a period of 2 hours once the pump was stopped. **Exhibit 29** presents the specific capacity data for each of the step-drawdown pumping tests. Following evaluation of the step-drawdown data, constant rate pumping tests were also conducted. The constant rate pumping durations were approximately 8 hours, followed by a period of water level recovery for at least 8 hours. Specific capacity was measured, and transmissivity and hydraulic conductivity were estimated using the Cooper-Jacob method (U.S. Geological Survey [USGS], 2002). The results of the APTs are summarized in **Exhibit 30** and testing details are described in the following sections. The data collected during the APTs are provided in **Appendix G** and include the pumping test analyses.

4.6.1 Testing Interval 560 to 880 feet bls

On January 21, 2008, a step-drawdown pumping test was performed on the 22.5-inch open-hole in the interval from 560 to 880 feet bls within the UFA. The pre-test static water level was approximately 46 feet NGVD. Stepped pumping rates were maintained for a period of approximately 1 hour each. The pumping rates were 180 gpm, 350 gpm, and 525 gpm. Water level drawdown at these flow rates were 33 feet, 63 feet, and 114 feet, respectively. Water level recovery data were collected for a period of approximately 5 hours. **Exhibit 31** shows the water levels throughout the pumping and recovery cycle.

4.6.2 Testing Interval 560 feet to 1,110 feet bls

On January 26, 2008, a step-drawdown pumping test was performed on the 22.5-inch open-hole in the interval from 560 to 1,110 feet bls within the UFA. The pre-test static water level was approximately 42 feet NGVD, and may have been low because of salt added to the well to control flow during pump installation. Stepped pumping rates were maintained for a period of approximately 1 hour each. The pumping rates were 500 gpm, 1,000 gpm, and 1,500 gpm. Water level drawdown at these flow rates were 34 feet, 59 feet, and 102 feet, respectively. **Exhibit 32** shows the water levels for the three pumping rates provided during the step-drawdown test.

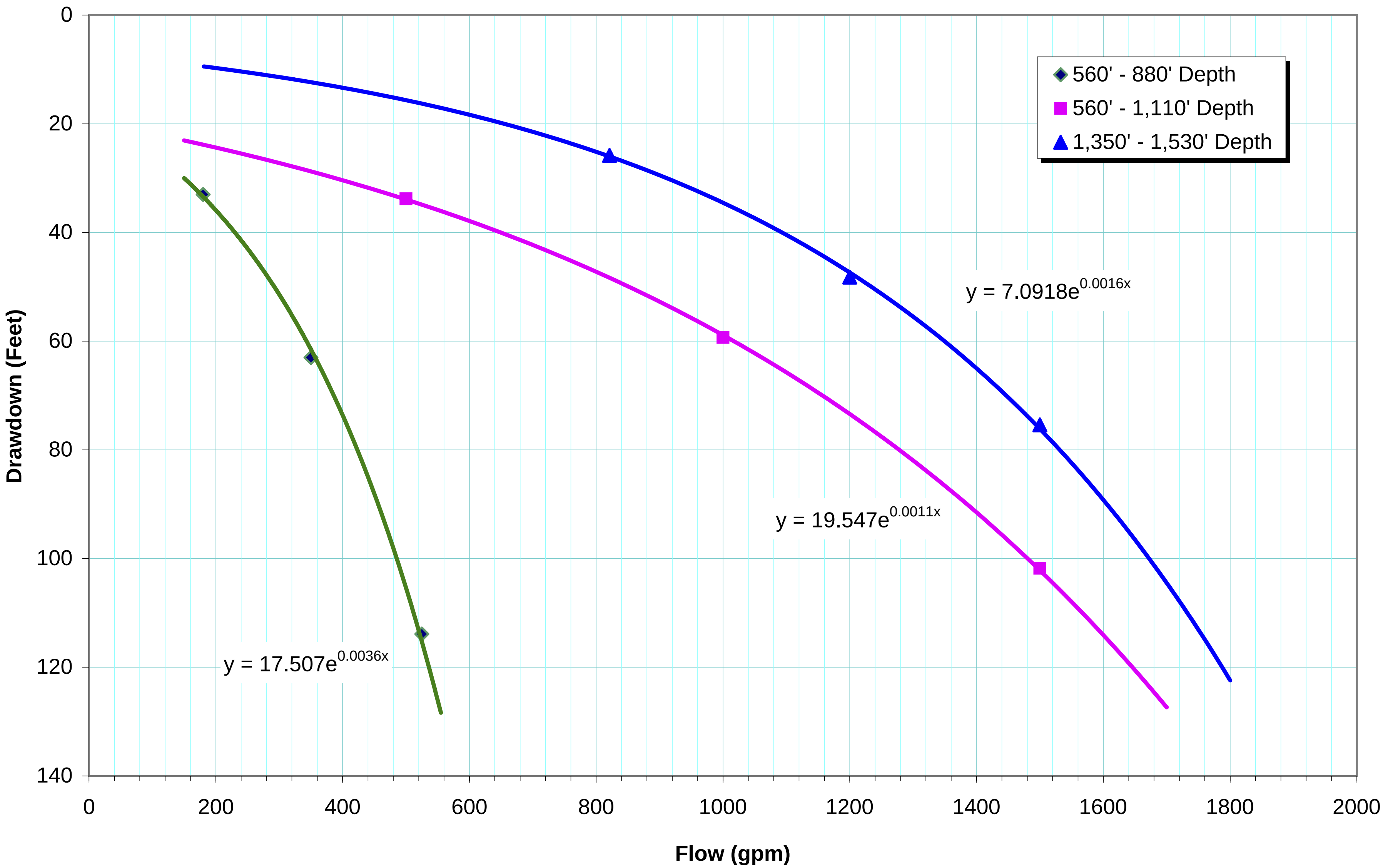

EXHIBIT 29
Step-Drawdown Testing Comparison
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

EXHIBIT 30
Well HIF-42 Aquifer Performance Test Summary
Paradise Run ASR Test-Monitor Well

Test Date	Test ID	Type of Test	Length of Test (hours)	Open Interval (feet bls)	Pumping Rate (gpm)	Drawdown (feet BMP)	Specific Capacity (gpm/ft)	Estimated Transmissivity (ft^2/day)		Estimated Hydraulic Conductivity (ft/day)	
								Drawdown	Recovery	Drawdown	Recovery
(1/21/2008	ST-1	Step-Drawdown		560-880				2,000		5	
		Step 1	1:29		180	33.0	5.4				
		Step 2	1:06		350	63	5.5				
		Step 3	1:02		525	113.9	4.6				
1/26/2008	ST-2	Step-Drawdown		560-1,110				3,000		5	
		Step 1	1:03		500	33.8	14.7				
		Step 2	1:02		1,000	59.3	16.8				
		Step 3	0:59		1,500	101.8	14.7				
1/26/2008	CRT-1	Constant	8:04	560-1,110	1,470	122.8	11.9	12,000	11,000	22	20
2/29/2008	ST-3	Step-Drawdown		1,310-1,530				2,000		10	
		Step 1	1:04		821	25.8	31.7				
		Step 2	1:00		1,200	48.2	24.8				
		Step 3	0:50		1,500	75.4	19.8				
3/3/2008	CRT-2	Constant	8:06	1,310-1,530	1,450	82.7	4700	18,000	5,600	81	25

Notes:
BMP = Below measuring point

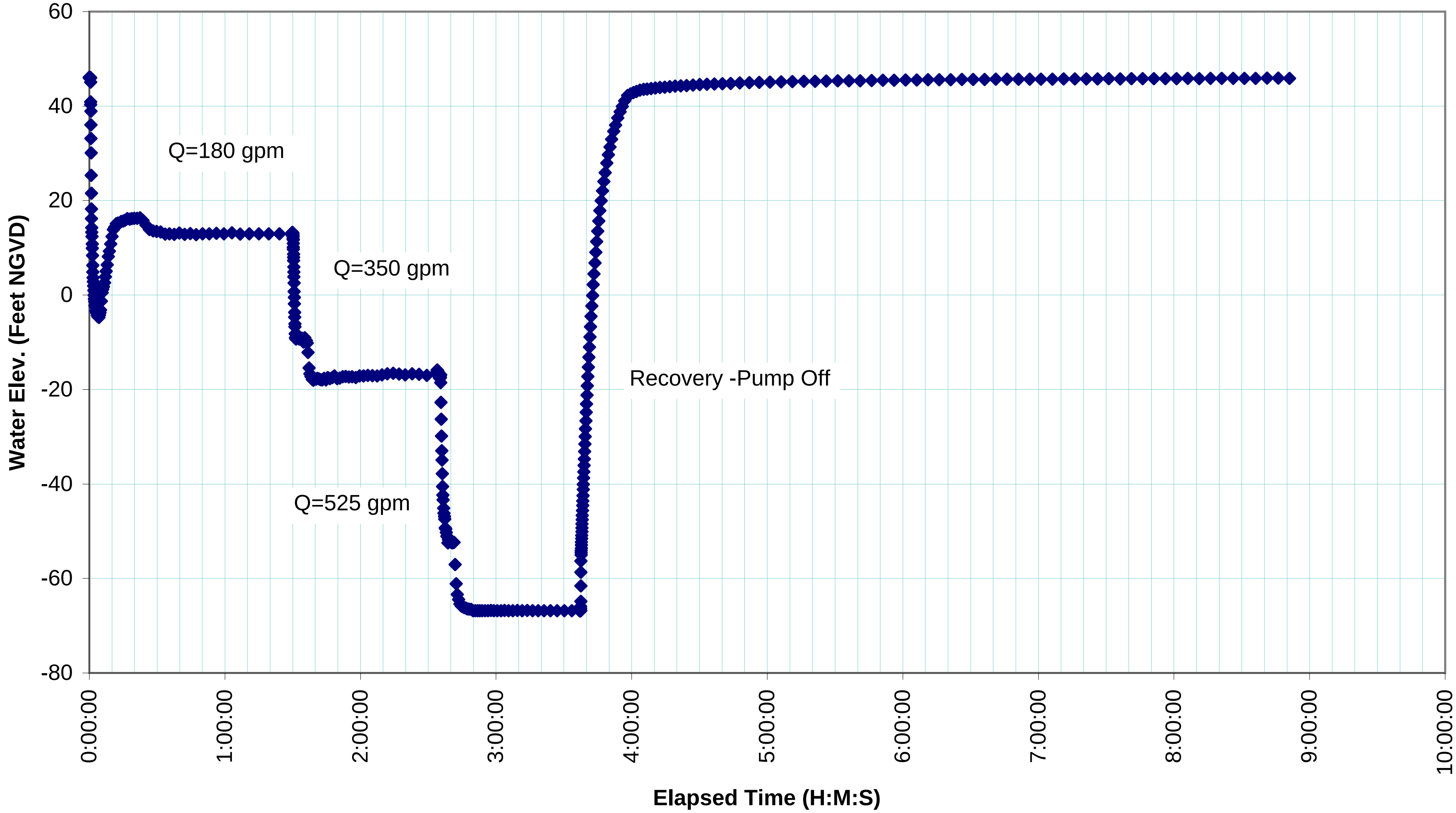

EXHIBIT 31
Step-Drawdown Pumping Test
Depth 560-880 Feet bls, January 21, 2008
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

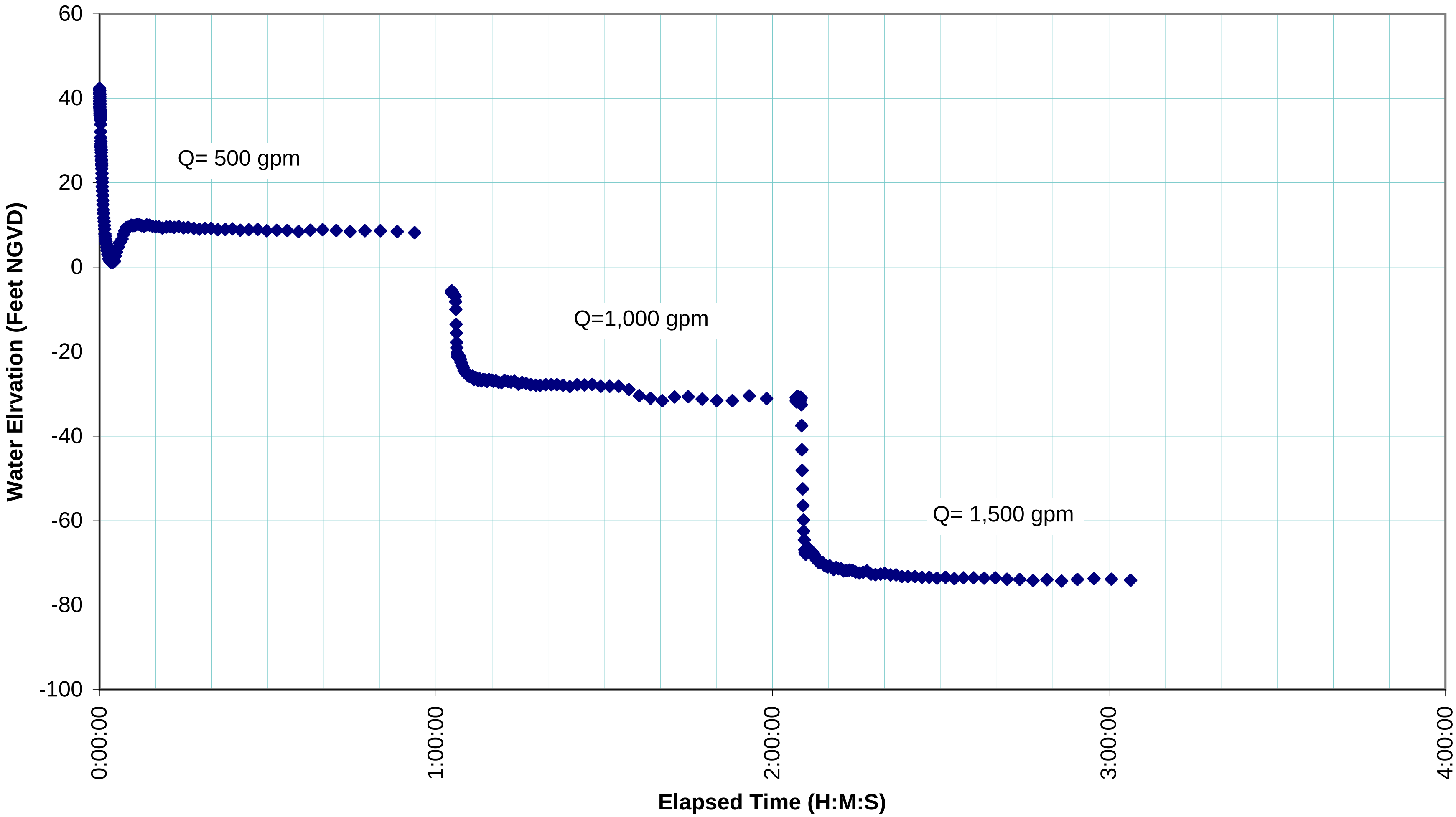

EXHIBIT 32
Step-Drawdown Pumping Test
Depth 560-1,110Feet bls, January 26, 2008
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

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On January 28, 2008, an 8-hour constant rate pumping test was performed on the 22.5-inch open-hole at a flow rate of 1,470 gpm. Water level drawdown at this flow rate was approximately 123 feet. **Exhibit 33** shows the water level data for the constant rate pumping test.

4.6.3 Testing Interval 1,310 feet to 1,530 feet bls

On February 29, 2008, a step-drawdown pumping test was performed on the 22.5-inch open-hole in the interval from 1,310 feet to 1,530 feet bls within the UFA. The pre-test static water level was approximately 37 feet NGVD. The static level was observed at approximately 42 feet NGVD during well recovery. The variance in head and may have been related to residual saltwater in the formation as a result of adding salt to the well to stop the flow during test pump installation. Stepped pumping rates were maintained for a period of approximately 1 hour each. The pumping rates were 821 gpm, 1,200 gpm, and 1,500 gpm. Water level drawdown at these flow rates were 26 feet, 48 feet, and 75 feet, respectively. **Exhibit 34** shows the water levels for the three pumping rates provided during the step-drawdown test.

On March 3, 2008, an 8-hour constant rate pumping test was performed on the 22.5-inch open-hole at a flow rate of 1,450 gpm; water level drawdown at this flow rate was approximately 83 feet. **Exhibit 35** shows the water level data for the constant rate pumping test.

4.7 Discharge of Produced Groundwater to the C-38 Canal

Groundwater from the Floridan aquifer that was produced during drilling and testing of the Paradise Run ASR Test-Monitor Well was conveyed through a 12-inch pipeline to the point of discharge (POD) located on the west bank of the C-38 canal. Discharge to surface water was conducted in accordance with General Permit FLG070461, Generic Permit for Discharge of Produced Groundwater.

Produced water was settled in baffled holding tanks prior to discharge into the C-38 canal to remove suspended solids. Two monitoring stations were established in the C-38 canal 150 meters north (upstream) and south (downstream) of the POD as previously shown on Exhibit 4. YSI meters with turbidity and specific conductance sensors were provided and installed by SFWMD at the two monitoring stations. The turbidity and specific conductance measurements were reported to be generally within the permit limits; however, turbidity was observed to increase as a result of boat traffic in the vicinity of the monitoring stations.

A sample of the produced water was analyzed by Jupiter Environmental Laboratories, Inc. for permit-required constituents. Except for total recoverable mercury and total recoverable lead, all other constituents met permit requirements. The values for lead and mercury were both reported to be less than the method reporting limits of 0.0020 micrograms per liter (µg/L) and 0.0020 mg/L, respectively; however, the laboratory method reporting limits exceed the permit limits for mercury and lead which are 0.000012 µg/L and 0.00003 mg/L, respectively. A copy of the water quality report is provided in **Appendix B**. The produced water quality data is presented in **Exhibit 36.**

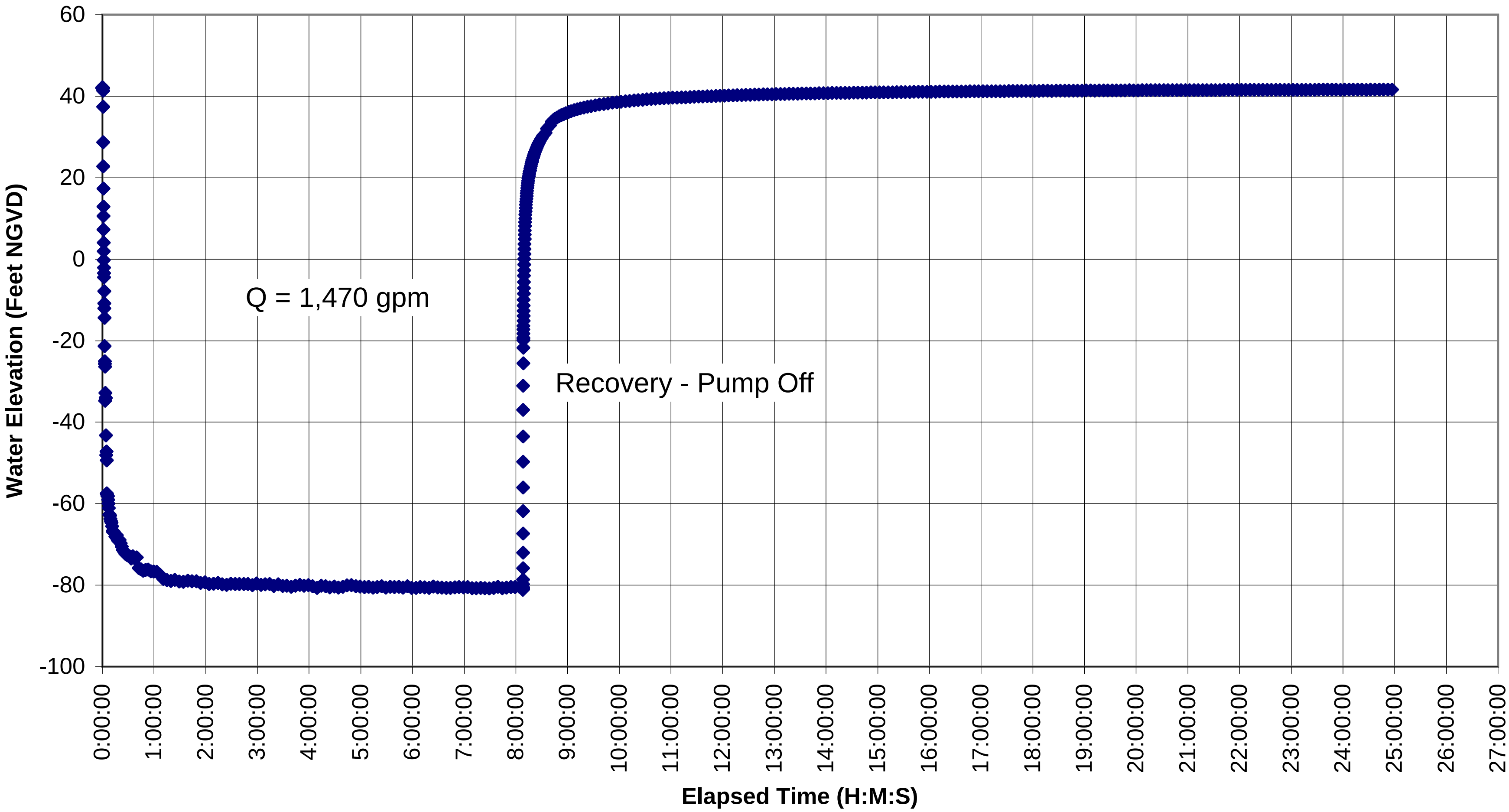

EXHIBIT 33
Constant Rate Pumping Test
Depth 560-1,110Feet bls, January 28, 2008
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

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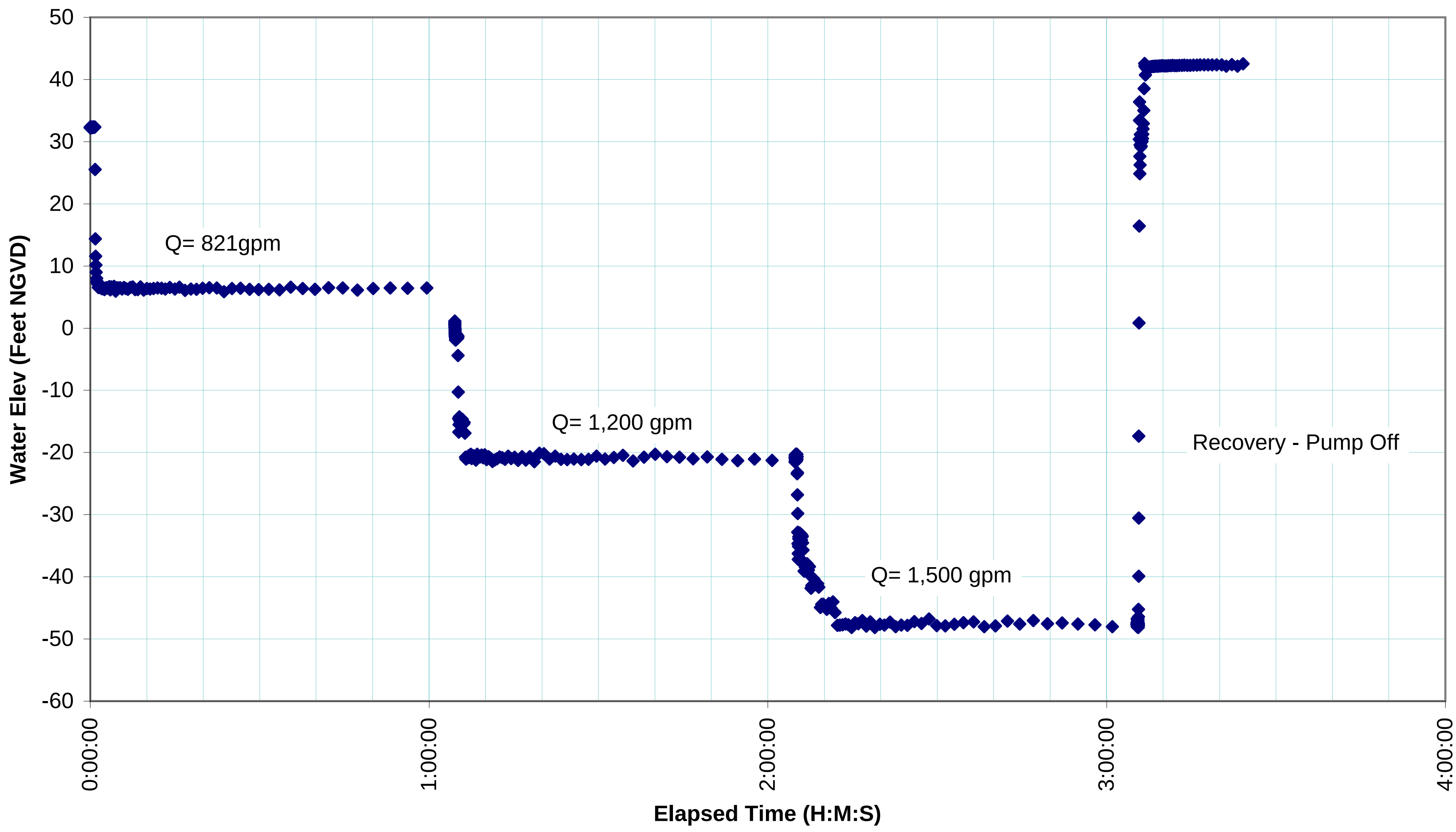


EXHIBIT 34
Step-Drawdown Test
Depth 1,310-1,530 Feet bls, February 29, 2008
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

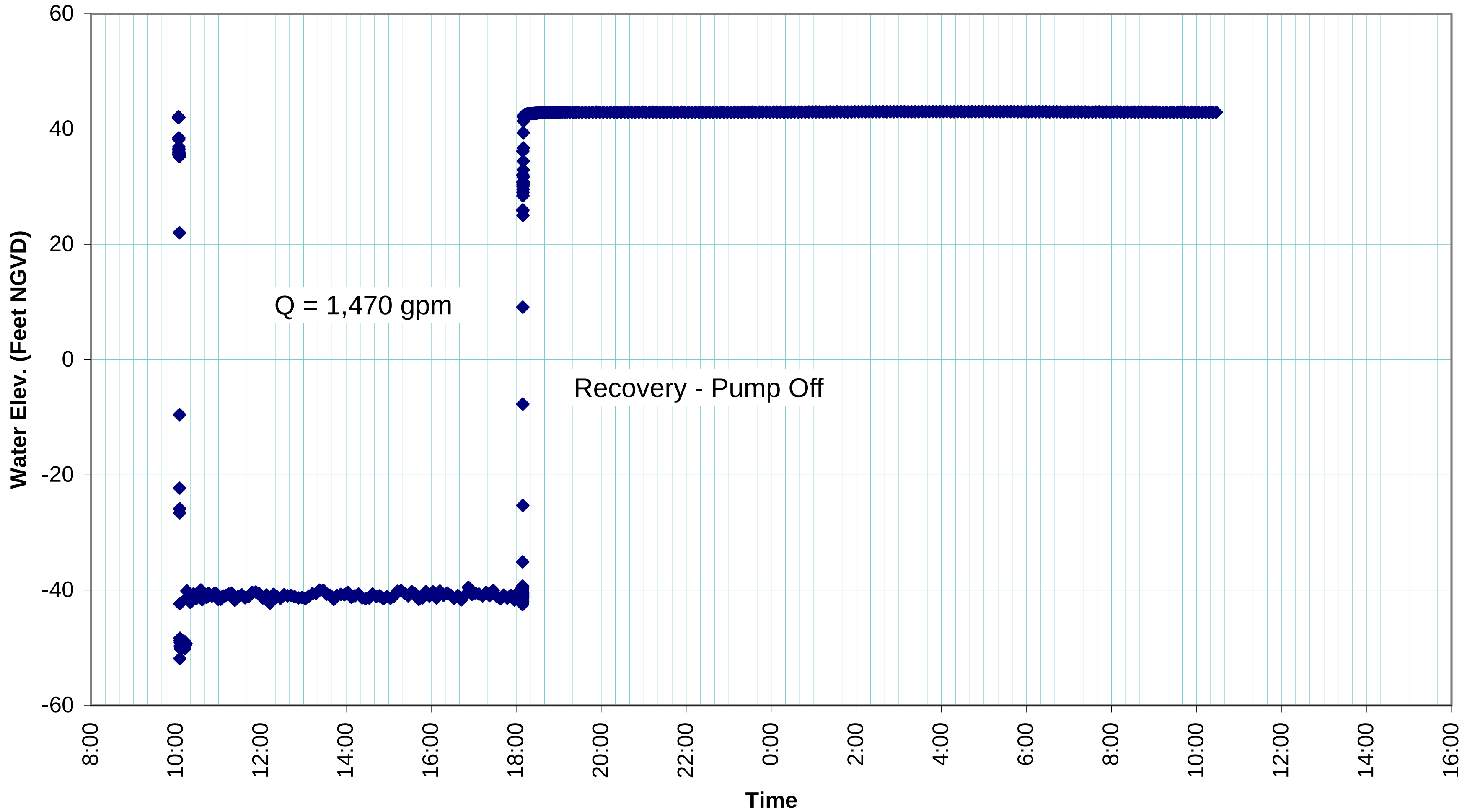


EXHIBIT 35
Constant Rate Pumping Test
Depth 1,310-1,530 Feet bls, March 3, 2008
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

EXHIBIT 36

Water Quality Monitoring for Produced Groundwater Discharge to the C-38 Canal
Paradise Run ASR Test Monitor Well (HIF-42)

Well HIF-42 Produced Groundwater Quality (November 30, 2007)

	Screening Values for Discharges into Freshwater		Result	
Total Organic Carbon (TOC)	10	mg/l	32	V
pH	6.0-8.5	SU	8.31	Q1
Total Recoverable Mercury	0.000012	µg/l	0.00091	i
Total Recoverable Cadmium	0.0093	mg/l	<0.0020	U
Total Recoverable Copper	0.0029	µg/l	<0.0020	U
Total Recoverable Lead	0.00003	mg/l	<0.0020	U
Total Recoverable Zinc	0.086	mg/l	<0.0020	U
Total Recoverable Chromium (Hex.)	0.011	mg/l	<0.010	Q1
Benzene	0.001	µg/l	<1	U
Napthalene	0.1	µg/l	<1	U
Chloride		mg/l	350	
Sulfate		mg/l	260	J4
Alkalinity		mg/l	130	J4
Total Dissolved Solids		mg/l	1000	
Sodium		mg/l	320	
Magnesium		mg/l	29	
Potassium		mg/l	17	
Calcium		mg/l	77	

Notes:

J4=MS/MSD recovery exceeded control due to matrix interference. LCS/LCSD recovery was within acceptable range

Q1=Sample received past/too close to the accepted holding time

V=Indicates that the analyte was detected in both the sample and the associated method

U=Analyte was not detected

4.8 Upper and Lower Monitoring Zone Water Quality

On April 4, 2008, following 48-hours of purging, background water quality samples were collected from the upper (560 to 1,049 feet bls) and lower (1,310 to 1,530 feet bls) monitor intervals of completed dual-zone well HIF-42. The flow rate from the upper and lower monitor zones were estimated at 500 gpm and 200 gpm, respectively. The casing volumes associated with the upper and lower monitoring zones are 7,917 gallons and 9,333 gallons, respectively. Typically, three casing volumes are purged prior to sample collection. The estimated volume of water purged from the upper and lower monitoring zones prior to sampling are estimated at approximately 1.4 million gallons and 0.6 million gallons, respectively.

The water samples were analyzed for primary and secondary drinking water standards by Columbia Analytical Services, Inc. The analytical results are presented in **Exhibit 37.** Constituents exceeding primary and secondary drinking water standards are summarized in **Exhibit 38**.

Copies of the laboratory reports are provided in **Appendix B.**

The upper monitor zone water samples had chloride, sulfate, and TDS concentrations of 190, 200, and 680 mg/L, respectively. The lower monitor/storage zone water samples had chloride, sulfate, and TDS concentrations of 860, 520, and 3,600 mg/L, respectively. The lower zone chloride concentration of 8,600 mg/L reported by the laboratory is inconsistent with chloride concentrations from straddle packer water samples. Although the laboratory confirmed the accuracy of the result, resampling and analysis should be conducted.

The initial water quality data appear favorable for ASR development within Floridan aquifer zones between the depths of approximately 560 and 1,500 feet bls. Cycle testing will be needed, however, to determine whether leaching of metals and radionuclides or saline water upconing are problematic.

4.9 Evaluation of Underground Sources of Drinking Water

During the drilling and testing of the Paradise Run ASR Test-Monitor Well (HIF-42), water quality samples were collected from four straddle packer testing intervals and from the two monitoring zones following completion of the well. The water quality data indicate that the approximate depth to the base of underground sources of drinking water (USDW), defined as groundwater containing a TDS concentration of less than or equal to 10,000 mg/L, occurs at approximately 1,600 feet bls. **Exhibit 39** shows the distribution of the TDS data as a function of depth.

EXHIBIT 37
Background Water Quality - Upper and Lower Monitor Zones
Paradise Run ASR Test-Monitor Well (HIF-42)

State Primary Drinking Water Standards: Inorganic

Parameter	MCL[1] (mg/L)	Upper Zone 560 - 1,050 Feet bls (mg/L)	Lower Zone 1,310 - 1,530 Feet bls (mg/L)
Antimony	0.006	U	U
Arsenic	0.01	U	U
Barium	2	0.037	0.044
Beryllium	0.004	U	U
Cadmium	0.005	U	U
Chromium	0.1	U	1.3 i
Cyanide	0.2	U	U
Fluoride	4	0.56	0.0013 i
Lead	0.015	U	U
Mercury	0.002	U	U
Nickel	0.1	0.0031 i	0.0015 i
Nitrate (as N)	10	0.11 i	U
Nitrite (as N)	1	U	U
Selenium	0.05	U	U
Sodium	160	140	**778**
Thallium	0.002	U	U

State Primary Drinking Water Standards: Volatile Organics

Parameter	MCL[1] (mg/L)	Upper Zone 560 - 1,050 Feet BLS (mg/L)	Lower Zone 1,310 - 1,530 Feet BLS (mg/L)
1,1-Dichloroethene	0.007	U(J3)	U (J3)
1,1,1-Trichloroethane	0.2	U	U
1,1,2-Trichloroethane	0.005	U	U
1,2-Dichloroethane (EDC)	0.003	U	U
1,2-Dichloropropane	0.005	U	U
1,2,4-Trichlorobenzene	0.07	U(J3)	U (J3)
Benzene	0.001	U	U
Carbon Tetrachloride	0.003	U	U
Cis-1,2-Dichloroethylene	0.07	U	U
Dichloromethane (Methylene Chloride)	0.005	U	U
Ethylbenzene	0.7	U	U
Monochlorobenzene (Chlorobenzene)	0.1	U	U
o-Dichlorobenzene (1,2-Dichlorobenzene)	0.6	U	U
p-Dichlorobenzene (1,4-Dichlorobenzene)	0.075	U	U
Styrene	0.1	U	U
Tetrachloroethylene	0.003	U	U
Toluene	1	U	U
Trans-1,2-Dichloroethylene	0.1	U	U
Trichloroethylene	0.003	U	U
Vinyl Chloride	0.001	U	U
Xylenes (Total)	10	U	U

State Primary Drinking Water Standards: Pesticides and PCB's

Parameter	MCL[1] (mg/l)	Upper Zone 560 - 1,050 Feet bls (mg/l)	Lower Zone 1,310 - 1,530 Feet bls (mg/l)
2,4-D	0.07	U	U
2,3,5-TP (Silvex)	0.05	U	U
Alachlor	0.002	U	U
Atrazine	0.003	U	U
Benzo(a)pyrene	0.002	U	U
Carbofuran	0.0002	U	U
Chlordane	0.04	U	U
Dalapon	0.2	U	0.0002 I
Di(2-ethylhexyl)adipate	0.4	U	U
Di(2-ethylhexyl)phthalate	0.006	0.00015 I	0.00015 I
Dibromochloropropane	0.0002	U	U
Dinoseb	0.007	U	U
Diquat	0.02	U	U
Endothall	0.1	U	U
Endrin	0.002	U	U
1,2-Dibromoethane (Ethylene Dibromide – EDB)	0.00002	U	U
Glyphosate (Roundup)	0.7	U	U
Heptachlor	0.0004	U	U
Heptachlor Epoxide	0.0002	U	U
Hexachlorobenzene	0.001	U	U
Hexachlorocyclopentadiene	0.05	U	U
Lindane (G-BHC)	0.0002	U	U
Methyoxychlor	0.04	U	U
Oxamyl (Vydate)	0.2	U	U
Pentachlorophenol	0.001	U	U
Picloram	0.5	U	U
Polychlorinated Biphenyl (PCB)	0.0005	U	U
Simazine	0.004	U	U
Toxaphene	0.003	U	U

State Primary Drinking Water Standards: Radionuclides

Parameter	MCL[1] (pCi/L)	Upper Zone 560 - 1,050 Feet bls (pCi/L)	Lower Zone 1,310 - 1,530 Feet bls (pCi/L)
Radium 226[2]	5 pCi/L3[2]	1.9	**9.0**
Radium 228[2]	5 pCi/L3[2]	1.2 U	1.1 U
Gross Alpha	15 pCi/L	4.3	**29.2**

EXHIBIT 37
Background Water Quality - Upper and Lower Monitor Zones
Paradise Run ASR Test-Monitor Well (HIF-42)

State Secondary Drinking Water Standards

Parameter	MCL[1] (mg/L)	Upper Zone 560 - 1,050 Feet bls (mg/L)	Lower Zone 1,310 - 1,530 Feet bls (mg/L)
Aluminum	0.2	U	U
Chloride	250	190	**8600**
Copper	1	U	0.00037 i
Fluoride	2	0.56	1.3 i
Iron	0.3	0.036 i	0.044 i
Manganese	0.05	0.0024	0.0011
Silver	0.1	U	U
Sulfate	250	200	520
Zinc	5	U	U
Color	15 PCU	U	U
Odor	3 TON	4	4 Q
pH	6.5-8.5	7.9 Q	7.6 Q
Total Dissolved Solids (TDS)	500	680	3600
Foaming Agents (MBAS)	0.5	0.054 i	0.052 i

Microbiological

Parameter	MCL[1] (CFU)	Upper Zone 560 - 1,050 Feet bls (CFU)	Lower Zone 1,310 - 1,530 Feet bls (CFU)
Total Coliform	4	U	U
Fecal Coliform	1	U	U

EXHIBIT 37
Background Water Quality - Upper and Lower Monitor Zones
Paradise Run ASR Test-Monitor Well (HIF-42)

Other Parameters

Parameter		Upper Zone 560 - 1,050 Feet bls	Lower Zone 1,310 - 1,530 Feet bls
Alkalinity as CaCO3, Total	mg/L	110	95
Aroclor 1016	mg/L	U	U
Aroclor 1221	mg/L	U	U
Aroclor 1232	mg/L	U	U
Aroclor 1242	mg/L	U	U
Aroclor 1248	mg/L	U	U
Aroclor 1254	mg/L	U	U
Aroclor 1260	mg/L	U	U
Bicarbonate as CaCO3	mg/L	110	95
Bromoform	mg/L	U	U
Calcium	mg/L	39	186
Carbon, Total Organic	mg/L	1.5	1
Chloroform	mg/L	U	U
Cyanide, Total	mg/L	U	U
Dibromochloromethane	mg/L	U	U
Disolved Organic Carbon	mg/L	1.2	0.79 i
Iron	mg/L	0.036 i	0.044 i
m,p-Xylenes	mg/L	U	U
Magnesium	mg/L	30	126
Methylene Blue Active Substances	mg/L	0.054 i	0.052 i
Nitrate+Nitrite as Nitrogen	mg/L	0.11	U
o-Xylene	mg/L	U	U
Potassium	mg/L	6	22
Silica	mg/L	18	17 J3
Sulfide, Total Dissolved	mg/L	U	U

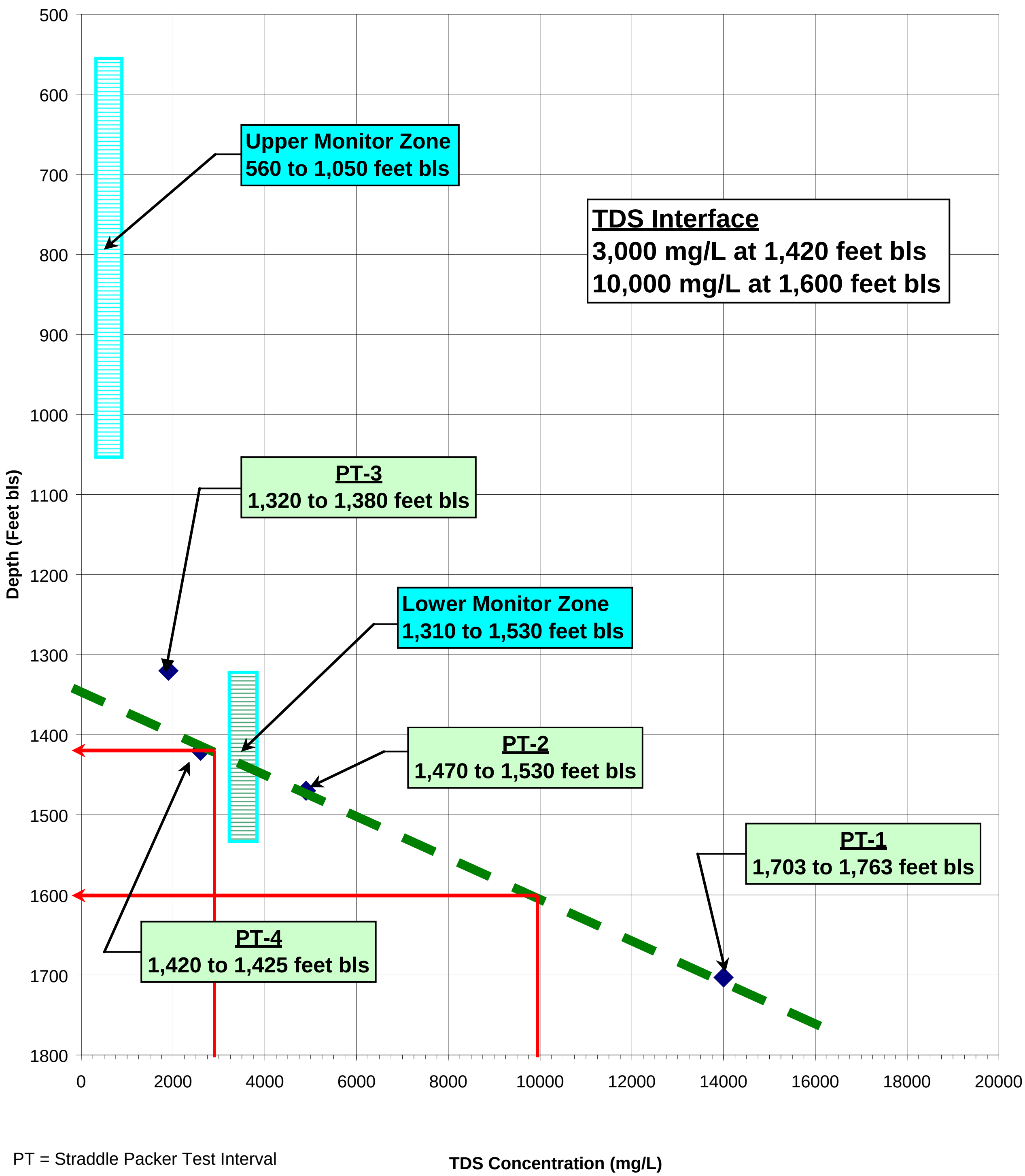
Notes:
1 Maximum Contaminant Level (MCL) per Rules 62-550.310, FAC.
2 The MCL for Radium 226 and Radium 228 combined is 5 pCi/L

Abbreviations and Acronyms:
pCi/L: Picacurries/liter
MDL: Minimum Detection Limit
mg/L: Milligrams per liter
µg/L: Micrograms/Liter
N/A: Not Analyzed
TON: Threshold Odor Number
PCU: Platinum Cobalt Units
CFU: Colony Forming Units/100 mL
MCL: EPA Maximum Contaminant Level

Qualifiers:
i: The reported value is between the laboratory method detection
J3: The report value failed to meet the established quality control criteria.
Q: Sample held beyond the accepted holding time.
U: Analyte was not detected; indicated concentration is MDL

EXHIBIT 38
Constituents Exceeding Drinking Water Standards in Upper and Lower Monitor Zones
Paradise Run ASR Test-Monitor Well (HIF-42)

Parameter	Drinking Water Standard	Upper Zone 560-1,049 feet bls	Lower Zone 1,310-1,530 feet bls
Sodium	160 mg/L	--	778 mg/L
Gross Alpha	15 pCi/L	--	29.2 pCi/L
Chloride	250 mg/L	--	8,600 mg/l
Sulfate	250 mg/L	--	520 mg/L
Total Dissolved Solids	500 mg/L	680 mg/L	3,600 mg/L



PT = Straddle Packer Test Interval

EXHIBIT 39
TDS Concentrations
Paradise Run ASR Test-Monitor Well (HIF-42)
Construction and Testing Report

SECTION 5

Summary and Conclusions

The SFWMD constructed ASR Test-Monitor Well HIF-42 to evaluate the development of ASR in the general vicinity of northern Lake Okeechobee. This work was undertaken by the SFWMD to support its mission of water supply planning, flood protection, water quality improvements, and ecosystem restoration. At the Paradise Run Site, a "stacked" ASR well system has been envisioned by the SFWMD, including paired ASR wells to provide subsurface storage of treated surface water within the UFA and the MFA. CH2M HILL and its subconsultants, ASR*us* and BFA, supported the SFWMD by providing design, permitting, and construction services for the drilling and testing of ASR Test-Monitor Well HIF-42. FDD was contracted to construct and test the well; these activities occurred between September 2007 and April 2008, in accordance with design specifications provided by the SFWMD.

Geophysical logging required for well construction and formation evaluation was conducted by MV Geophysical. Schlumberger Water Services under contract to the SFWMD provided advanced geophysical logging data and interpretations on the depth interval from 180 feet to 1,262 feet bls. The Schlumberger logs provided supplemental data on borehole conditions, aquifer properties, fractures and bedding, lithology, and groundwater salinity.

The principal hydrogeologic units identified at the Paradise Run site include the SAS of south-central Florida, the IA/UC, and the FAS. The UFA and proposed MFA of the FAS were evaluated at the Paradise Run site for the potential development of an ASR well system. The LFA may have been penetrated during drilling, and extends deeper than the 1,802 foot well completion depth. Following all formation and aquifer evaluation, the well was completed as a dual-zone monitor well with open intervals from 560 to 1,049 feet bls (upper monitor zone) and 1,310 to 1,530 feet bls (lower monitor zone).

The UFA is most often used for ASR systems in southern Florida primarily because groundwater is less mineralized, although its yield may be limited in some areas. It extends from approximately 560 to 790 feet bls at the Paradise Run site. The UFA is well-confined above by thick clayey units of the Hawthorn Group; the static artesian head in the aquifer is approximately 12 feet above land surface.

The MCU, which includes the proposed MFA, extends from the base of the UFA at 790 feet to 1,720 feet bls. The MFA is present from approximately 950 to 1,480 feet bls. The top of the LFA may occur at a depth of 1,720 feet, and the unit extends below the exploratory pilot hole completed at a depth of 1,802 feet bls.

Exhibit 40 summarizes the approximate depths of hydrogeologic units observed during the construction of the Paradise Run ASR Test-Monitor Well HIF-42.

EXHIBIT 40
Site Specific Hydrogeologic Units
Paradise Run ASR Test-Monitor Well (HIF-42)

Hydrostratigraphic Unit	Depth Interval
Surficial aquifer	Water table to 140 feet bls
Intermediate aquifer/Upper confining unit	140 feet to 550 feet bls
Upper Floridan aquifer	550 feet to 790 feet bls
Middle confining unit - Upper Zone	790 feet to 950 feet bls
Middle Floridan aquifer	950 feet to 1,480 feet bls
Middle confining unit - Lower Zone	1,480 feet to 1,720 feet bls
Lower Floridan aquifer	1,720 feet to 1,802 feet bls (and deeper)

Notes:
bls = below land surface

Within the UFA, moderately brackish formation water appears to be present throughout the interval as indicated by the fluid conductivity logs (Logging Runs 4 and 5). Groundwater increases in mineral content with depth. **Exhibit 41** summarizes the TDS and chloride water quality data from the completed monitoring zones.

EXHIBIT 41
TDS and Chloride Concentrations in Monitor Zones
Paradise Run ASR Test-Monitor Well (HIF-42)

Groundwater Constituent	Upper Monitor Zone (560 feet to 1,049 feet bls)	Lower Monitor Zone (1,310 feet to 1,530 feet bls)
Total dissolved solids	680 mg/L	3,600 mg/L
Chloride	190 mg/L	8,600 mg/L (1)

Notes:
bls = below land surface
mg/L = milligrams per liter
TDS = total dissolved solids
1 – Laboratory result was confirmed; however, the expected chloride concentration would be in the range of 800 to 1,600 mg/L. A reanalysis was not available and would be needed for confirmation.

Groundwater TDS concentrations less than 3,000 mg/L extend from the SAS to a depth of approximately 1,420 feet bls within the FAS. The USDW extends to a depth of approximately 1,600 feet bls at the site.

Estimates of transmissivity, based on the aquifer testing, suggest values of approximately 2,000 to 3,000 ft^2/day for the UFA and 10,000 to 20,000 ft^2/day for the MFA. Excessively high transmissivity values associated with large intervals of secondary porosity (fractures and cavities) were not observed. The estimated transmissivity values are generally considered low for ASR. For this reason, construction of ASR wells at this site would likely require post-completion formation acidization to improve well performance. Although the transmissivity values of the targeted ASR zones are low, dispersive mixing is also expected to be low, and may be beneficial to the recovery of low salinity stored water as measured by recovery efficiency.

At the Kissimmee River ASR well (EXKR-1) located approximately 7 miles southeast of the Paradise Run site, the transmissivity within the UFA is roughly twice that observed at Paradise Run ASR Test-Monitor Well HIF-42, based on APT data. The Kissimmee River ASR well (EXKR-1) was acidized following completion to improve its performance. Aquifer testing of the UFA storage zone after acidization indicated an improvement in transmissivity of approximately 40 percent. Similar results could be expected for storage zones in future ASR wells constructed at the Paradise Run ASR site. As such, acidizing is considered necessary and recommended for all future ASR wells constructed at the Paradise Run site.

Hydraulic separation appears to exist between the two monitoring zones in the Paradise Run ASR Test-Monitor Well based on evaluation of the porosity and permeability reflected on the geophysical logs (sonic and dual induction logs [DIL]). This confinement is further demonstrated by an estimated 1 foot difference in hydraulic head, as corrected for temperature and salinity, between the upper and lower monitor zones in the Paradise Run ASR Test-Monitor well.

Based on testing data, future ASR well pairs would be constructed with one well completed at a shallow depth and the other well at a deeper depth. The shallow storage zone would target the interval from approximately 600 to 1,100 feet bls within the UFA and MFA upper permeable zone. The deeper storage zone would target the interval from approximately 1,300 to 1,500 feet bls within the MFA lower permeable zone. Water quality data obtained from straddle packer testing at the Paradise Run site, indicate that significantly more mineralized formation water is present at 1,500 feet bls and deeper. Extending the ASR storage zones below 1,500 feet bls could be problematic if significant upconing of deeper saline water occurred during recovery cycles, reducing water recovery efficiency.

Pretreatment will be critical to implementation of ASR because of the lower than anticipated transmissivity values and the predominance of intergranular porosity. Using a combination of both natural treatment systems and conventional filtration, reduction of total suspended solids (TSS) will be necessary for surface water introduced into the ASR wells. Disinfection will also be required to meet current groundwater protection standards and to reduce concentrations of microbial constituents that may cause formation plugging and biofouling within the well.

5.1 Future ASR Development

The successful completion of ASR Test-Monitor Well HIF-42 provides basic information for development and testing of an ASR well system at the Paradise Run site. Consistent with SFWMD objectives, a stacked ASR well system appears to be feasible for implementation of ASR with an ultimate capacity of 50-mgd. In accordance with the SFWMD's implementation plan, the first segment of work will include the construction of a two-well ASR system to provide a storage/recovery capacity of 10 mgd. For each pair of wells, it is anticipated that one well would be completed in the UFA and MFA upper permeable zone, and the other well would be completed in the MFA lower permeable zone, in accordance with the concept of a stacked ASR well system. In addition to the ASR well construction, during the first segment, at least one monitor well, intake and discharge structures, conveyances, and filtration and disinfection systems would be constructed. The design concept would provide for modular expansion of the ASR system to achieve the 50-mgd capacity.

The conceptual plan for the ASR system included five pairs of ASR wells to provide 50 mgd of storage and recovery capacity. The results of aquifer testing conducted during the construction of the Paradise Run ASR Test-Monitor Well HIF-42 indicate that the likely capacity of ASR wells operating at a 50 psi injection/115-foot recovery drawdown will be less than the planned 10 mgd for the stacked ASR well pairs. Wells constructed in the UFA/MFA upper permeable zone and MFA lower permeable zone may have injection capacities on the order of 2.4 mgd to 3.1 mgd and recovery capacities of 2.9 mgd to 3.8 mgd. The combined storage and recovery capacity for each pair of ASR wells may be in the range of 5.3 mgd to 7.4 mgd, with the higher rate occurring as a result of an assumed 40 percent improvement in the well capacity following formation acidization. Using these estimates, 10 to 15 wells may be required to achieve the planned 50 mgd ASR system capacity.

Subsequent phases of the project may be conducted consistent with SFWMD funding to complete the construction and testing of a 50 mgd ASR system. CH2M HILL recommends that the SFWMD proceed with implementation of the first segment of the project to include the construction and testing of the first pair of ASR wells and the associated conveyance and treatment facilities. The following future tasks will be required in support of the continued development of ASR at the Paradise Run site:

- ASR well design and permitting
- Surface water intake and recovered water discharge structure design and permitting
- Surface water treatment/filtration and disinfection systems design and permitting, including pre-treatment using natural wetland systems
- Preparation of bid documents for civil work and well construction, solicitation of bids and contracting
- Construction of the first pair of stacked ASR wells and associated reporting
- Commencement of operational testing and evaluation of the stacked ASR wells including injection/recovery cycle testing to demonstrate the differences in recharge and recovery rates in the two storage zones
- Phased expansion of modular components of the 50-mgd ASR system

Pending construction and successful cycle testing of the first pair of ASR wells, modular expansion of the ASR system could commence. The ultimate goal will be implementation of a 50-mgd of ASR system that demonstrates:

1. The feasibility of a large-scale ASR well system for diversion of excess surface waters to storage
2. The use of natural systems for pre-treatment of surface water delivered to ASR wells
3. The combination of ASR with constructed wetlands to achieve water load and water quality improvements to meet TMDL requirements
4. The advantages of a multiple well ASR systems to supporting habitat management

SECTION 6
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