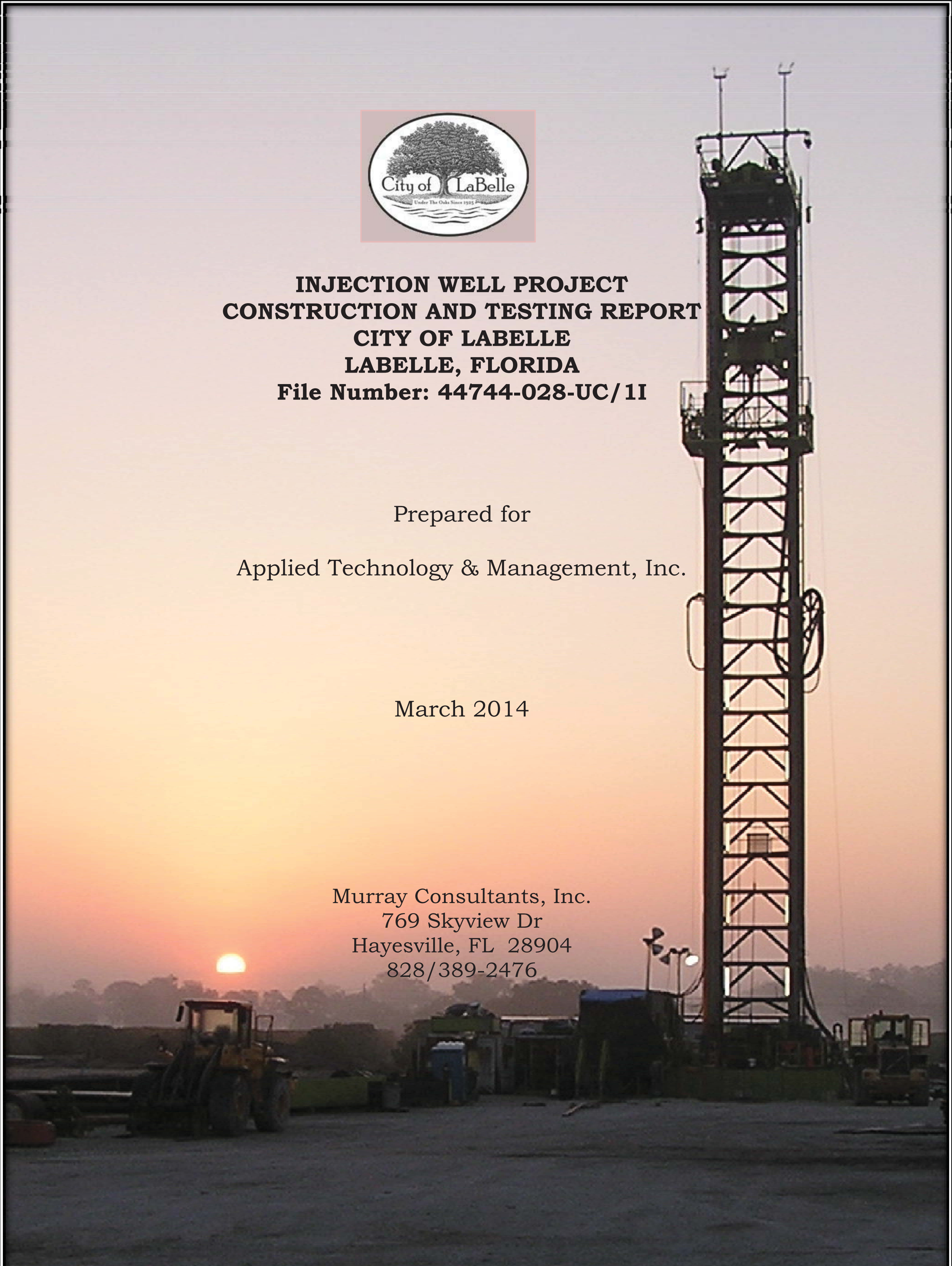

INJECTION WELL PROJECT
CONSTRUCTION AND TESTING REPORT
CITY OF LABELLE
LABELLE, FLORIDA
File Number: 44744-028-UC/1I

Prepared for

Applied Technology & Management, Inc.

March 2014

Murray Consultants, Inc.
769 Skyview Dr
Hayesville, FL 28904
828/389-2476

PROFESSIONAL GEOLOGIST CERTIFICATION AND APPROVAL

"In accordance with Rule 62-528.340(4), F.A.C., I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based upon my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations." In accordance with Chapter 492, Florida Statutes

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Date: March 17, 2014

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INJECTION WELL PROJECT
CONSTRUCTION AND TESTING REPORT
CITY OF LABELLE
LABELLE, FLORIDA
File Number: 44744-028-UC/1I

1.0 Introduction

The City of LaBelle (LaBelle) is constructing a Reverse Osmosis (RO) Water Treatment Plant (WTP), just south of the City on part of what was the Bob Paul Grove. The non-potable source of water will be from the Upper Floridan Aquifer. Murray Consultants Inc., was retained by Applied Technology & Management to provide hydrogeologic consulting services to design, and oversee the construction of an injection well system for the RO plant reject brine (concentrate) and ultimately, wet-season treated effluent.

This report summarizes the construction and testing of the Class I injection well (IW-1) and the dual zone monitoring well (DZMW-1) at the future LaBelle WTP (#2) site in LaBelle, Hendry County, Florida. A location map is provided as **Figure 1-1**. The location of the injection well system on the WTP site is provided as **Figure 1-2**.

The wells were constructed to meet the requirements of the FDEP Class I Injection Well standards and the specific conditions of the UIC construction permit (44744-028-UC/1I) issued by FDEP on January 12, 2010 and modified on January 17, 2013. A copy of the permit and minor modification are included in **Appendix A**.

The purpose of the injection well (IW-1) is to dispose of a volume of up to 7.39 million gallons per day (MGD) of RO concentrate generated by the future LaBelle RO WTP and ultimately, wet-season treated effluent generated by an existing wastewater treatment plant. RO concentrate is classified as an industrial waste by the United States Environmental Protection Agency (USEPA) and therefore requires a discharge permit. Underground injection, via a tubing and packer injection well, must be into a permeable zone isolated by overlying confinement from the base of any underground source of drinking water (USDW). The USDW is defined as aquifers having a total dissolved solids (TDS) concentration less than 10,000 milligrams per liter (mg/1).

Well construction operations, for the subsurface portion of the injection well system, commenced on March 1 and were completed on October 6, 2013. Youngquist Brothers, Inc. (YBI) of Fort Myers, Florida, installed the wells. Well site geology, construction oversight, and regulatory compliance were provided by Murray Consultants Inc., and supported by Cardno ENTRIX.

In conformance with the limiting conditions of the FDEP construction permit, weekly construction progress reports were submitted to the FDEP and members of the Technical Advisory Committee (TAC), USEPA composed of the, FDEP, South Florida Water Management District (SFWMD), and the United States Geological Survey (USGS). FDEP personnel were notified of significant testing events during construction of both the IW and the DZMW, and were present for casing pressure testing events. Weekly construction progress reports are included as **Appendix B**.

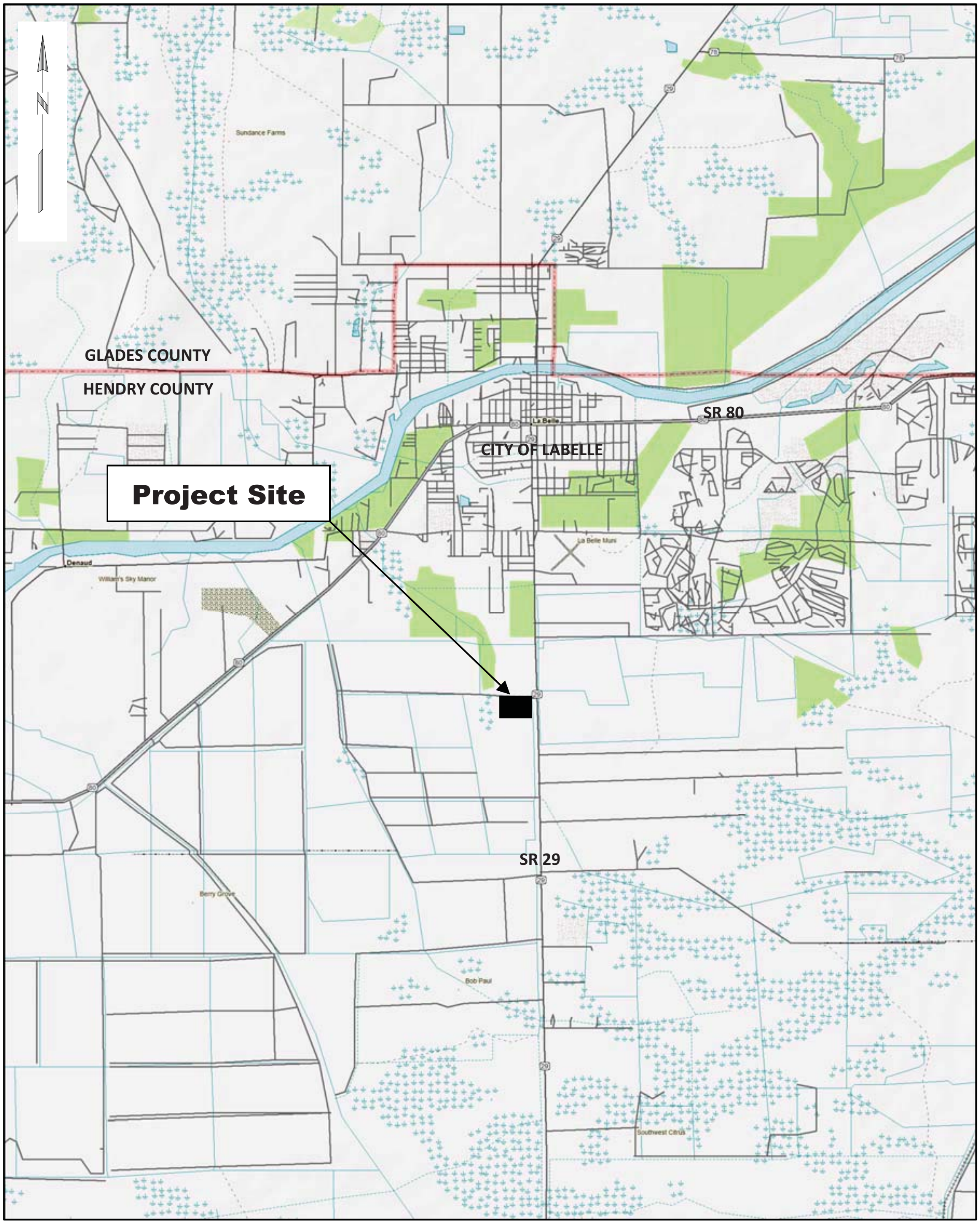
In accordance with regulatory requirements, the following items were addressed during the construction and testing of both IW-1 and DZMW-1:

- Confinement
- Mechanical integrity
- Well performance under operating conditions
- Background water quality in the injection zone and monitoring zones

The following is a summary of the drilling activities performed at the LaBelle WTP #2 site:

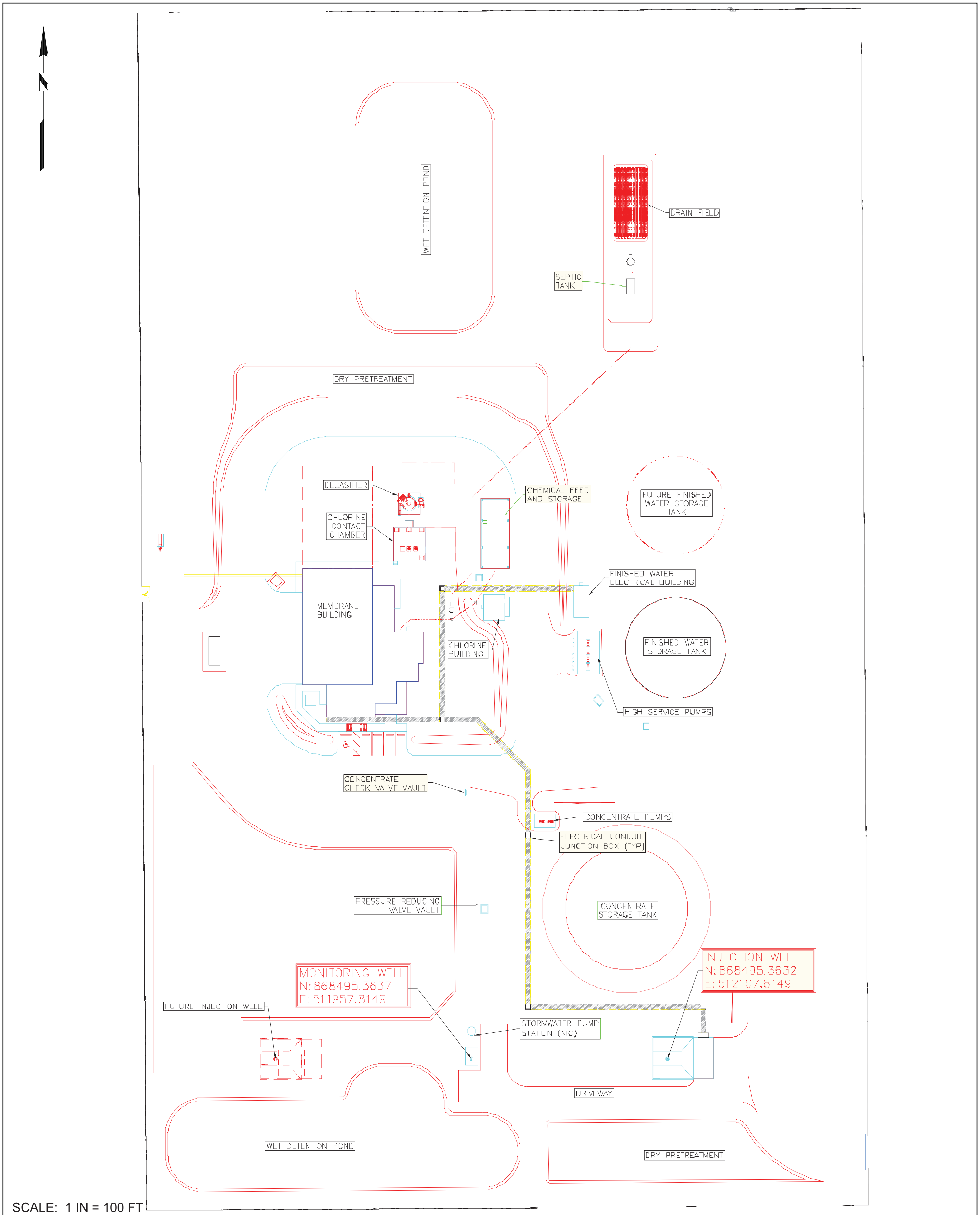
- IW-1 was constructed with a 24-inch outside diameter, 0.500-inch wall thickness, steel injection casing, a positive-seal packer and mandrel assembly (YBI Triple Seal Packer), and a 16-inch outside diameter fiberglass (FRP) tubing, with a final casing at a depth of 2,552 feet below pad level (bpl).
- A corrosion-inhibitor fluid (Baracor) was emplaced in the annulus between the FRP tubing and the steel injection casing.
- Total depth of the injection well is 3,300 feet bpl; the open hole extends from 2,552 feet to the 3,300 feet bpl.
- The injection zone is within the permeable "Boulder Zone" of the Oldsmar formation. The only permeable zone is from 3,040 to 3,240 feet bpl.
- The open-hole transmissivity is estimated at about 450,000 gallons per day per foot (gpd/ft), calculated from injection test results.
- The base of the USDW at the site was determined to be at a depth of approximately 1,710 feet bpl.
- The two zones to be monitored by the dual zone monitoring well are in the Avon Park formation between the depths of 1,648 and 1,695 feet bpl (approximately 860 feet above the top of the injection zone) and between the depths of 1,900 and 1,938 feet bpl (approximately 600 feet above the top of the injection zone).

The details of the site activities, including the pilot-hole drilling, well construction, lithologic descriptions, geophysical logging and groundwater characterization, are presented in the following sections of this document.



SCALE: 1 IN = 8,000 FT

FIGURE 1-1 **SITE LOCATION MAP**	CITY OF LABELLE LABELLE, FL DATE: 3/17/14	Murray Consultants, Inc. Water Resource Consulting 769 Skyview Dr. Hayesville, NC 828-389-2476



SCALE: 1 IN = 100 FT

FIGURE 1-2
SITE MAP

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2.0 Injection Well IW-1 Construction

2.1 Containment Pad/Pit Casing Installation

Prior to commencement of drilling operations for IW-1, a limerock sub-base for the steel containment pad was installed at the site. A temporary steel-containment pad was constructed for use during the drilling of the wells to provide support for drilling equipment and to contain all fluids from the borehole and/or construction activities. Following completion of Well IW-1, the containment pad was moved to the site of DZMW-1.

The pad was designed to support the greatest possible load that might be placed on it during well construction, and has dimensions of approximately 45 feet by 25 feet with a 4-foot high retaining wall on the perimeter. The retaining wall was designed as a sealed system to protect the surficial aquifer by containing any fluid spills within the limits of the pad. The surficial aquifer was protected by the pad principally from saline formation water encountered during the drilling of Well IW-1. A pump was installed into the containment pad to remove fluids from the pad to an on-site storage system and/or for transmission to the approved off-site disposal location.

Pit casings were pile driven at IW-1 and DZMW-1 locations, **Figure 1-2**. The IW-1 pit casing is constructed of 66-inch diameter steel casing installed to a depth of 34 feet. The DZMW-1 pit casing is a 48-inch diameter steel casing installed to a depth of 39 feet.

2.2 Pad Monitoring Wells

Four (4) shallow groundwater monitoring wells (MW-1, MW-2, MW-3, and MW-4) were installed with two (2) wells at the eastern corners of the IW containment pad and two (2) wells at the western corners of the DZMW containment pad. The four (4) pad monitoring wells were installed on February 1, 2013 and sampled by Benchmark Analytic Laboratory on February 14, 2013 for baseline background water quality. Construction details for the four (4) pad monitoring wells are summarized on **Table 2-1**, a schematic illustration of a typical pad monitoring well is provided as **Figure 2-1**, and a site map showing the location of the pad monitoring wells is provided as **Figure 2-2**.

A registered land surveyor surveyed the measuring point of each of the pad monitoring wells relative to National Geodetic Vertical Datum (NGVD 29). For purposes of this report, all measurements are referenced to NGVD. Upon completion of the project and for reporting purposes, all measurement will be referenced to NAVD 88. The purpose of the pad monitoring wells was to provide a means of assessing any potential impacts to the shallow surficial aquifer at the site resulting from uncontrolled leaks or spills of saltwater emanating from deep saline aquifers during the drilling operations or from equipment fueling.

The pad monitoring wells were sampled each week for water levels, temperature, conductivity, dissolved chloride concentrations, and pH during the drilling operations. Copies of the weekly monitoring reports and a summary table for the four (4) pad monitoring wells' water-quality results are included in **Appendix C**. No significant changes in water quality in the surficial aquifer were recorded during the installation of IW-1 and DZMW-1.

Table 2-1: Pad Monitoring Well Construction Details

Well #	Total Depth (ft BPL)	Casing Length (ft)	Screened Interval (ft)	Casing Diameter (in)	Top of Casing Measuring Point Elevation (NGVD 29)	Casing Material
MW-1	17.3	7.3	7.3-17.3	2	22.58	Sch 40 PVC
MW-2	17.3	7.3	7.3-17.3	2	22.60	Sch 40 PVC
MW-3	16.0	6.0	6-16	2	22.69	Sch 40 PVC
MW-4	17.3	7.3	7.3-17.3	2	22.66	Sch 40 PVC

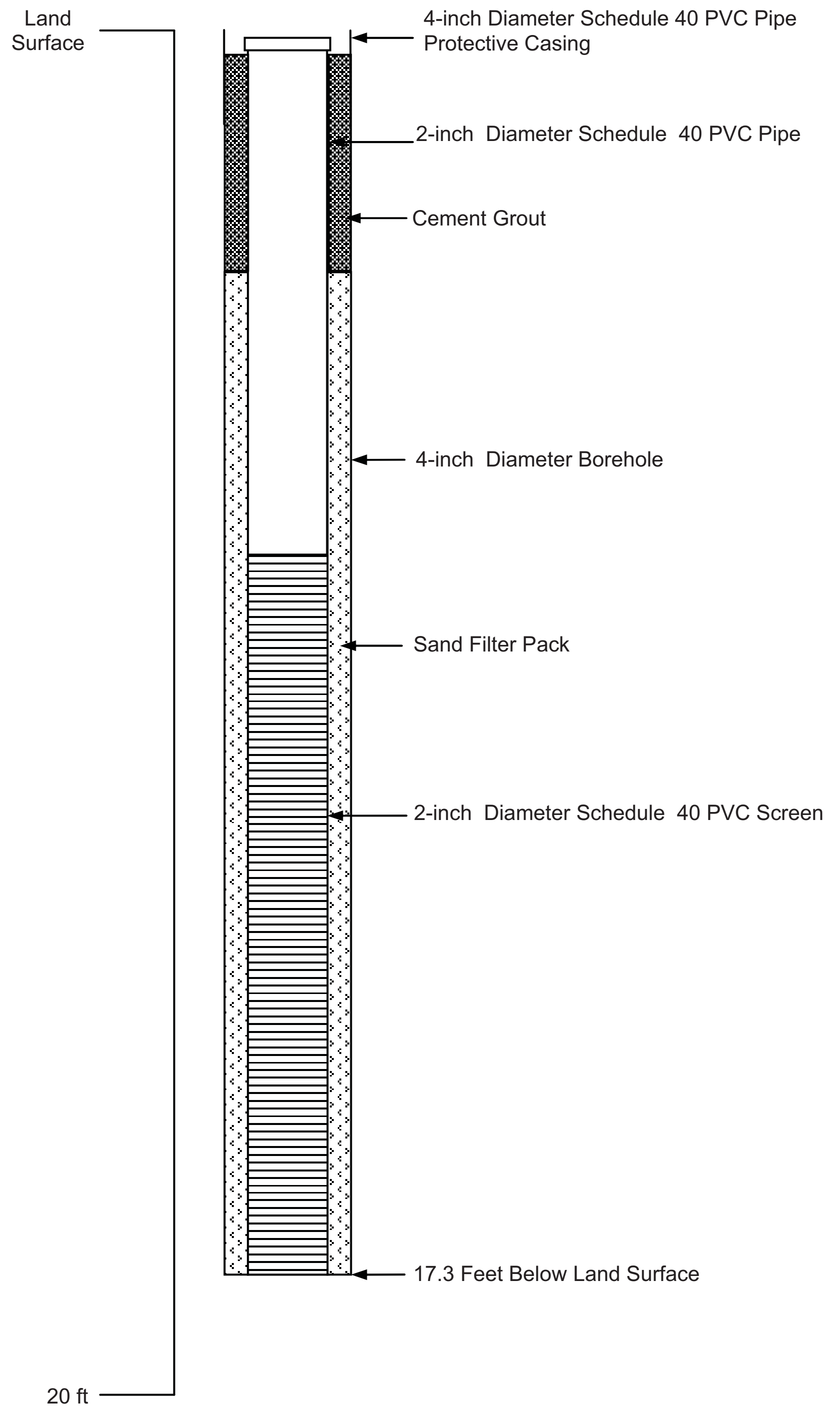

FIGURE 2-1
PAD MONITORING WELL TYPICAL CONSTRUCTION DETAILS

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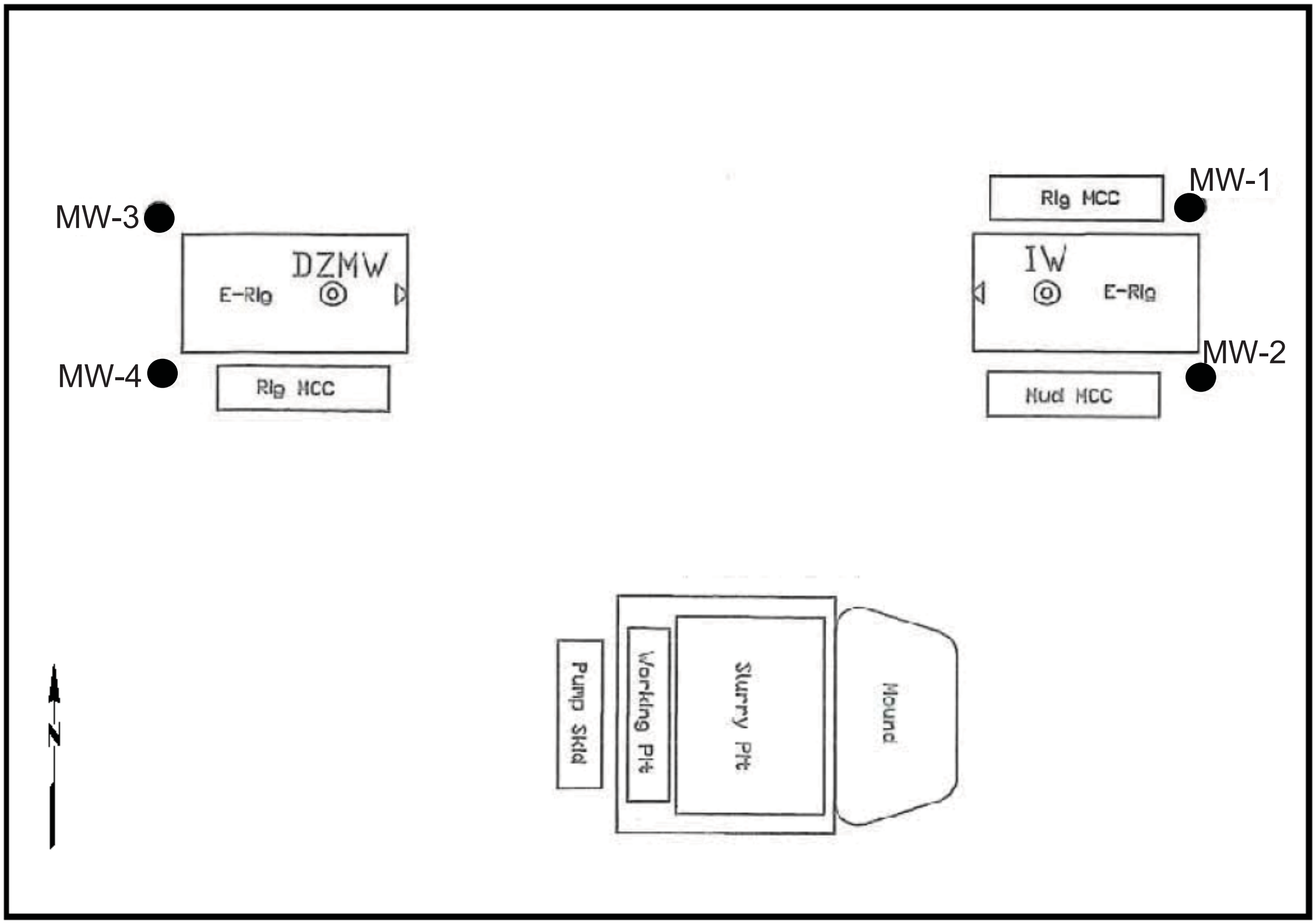

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FIGURE 2-2
PAD MONITORING WELL LOCATION MAP

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2.3 Injection Well

Drilling and construction of IW-1 began on March 3, 2013. Drilling operations were generally conducted on a 24 hours a day, 7 days per week schedule. Major construction and testing activities were completed on July 25, 2013.

Well construction was in accordance with the FDEP construction permit. A copy of the FDEP Construction permit (File Number: 44744-028-UC/1I) is provided in **Appendix A**. The drilling of IW-1 proceeded generally as identified in the project specifications and as approved by FDEP.

The project specifications outlined a drilling plan that was adjusted based on site-specific conditions. The plan included setting steel casing at selected depths in order to maintain the formation during drilling and to facilitate testing. To consistently record downhole depth, all well measurements were recorded in terms of depth below pad level (bpl). The pad elevation was approximately 27 feet NGVD.

Injection well IW-1 was generally constructed as follows:

- Drill a 12.25-inch diameter pilot hole to approximately 200 feet bpl using the mud rotary method.
- Drill a nominal 64.5-inch diameter borehole to approximately 150 feet bpl using the mud rotary method.
- Set and cement 54-inch diameter steel casing to a depth of 145 feet bpl.
- Drill a 14.75-inch diameter pilot hole to approximately 900 feet bpl using the mud rotary method.
- Drill a nominal 52.5-inch diameter borehole to approximately 765 feet bpl using the mud rotary method.
- Set and cement 42-inch diameter steel casing to a depth of 760 feet bpl.
- Drill a 12.25-inch diameter pilot hole to approximately 2,010 feet bpl using the reverse air method.
- Back-plug pilot hole with cement to 1,127 feet bpl.
- Drill a nominal 40.5-inch diameter borehole to approximately 1,815 feet bpl using the reverse air method.
- Set and cement 34-inch diameter steel casing to a depth of 1,798 feet bpl.
- Drill a 12.25-inch diameter pilot hole to approximately 3,740 feet bpl using the reverse air method and core at selected depths.
- Back-plug pilot hole with cement from 2,000 to 2,503 feet bpl.
- Drill a nominal 32.5-inch diameter borehole to approximately 2,552 feet bpl using the reverse air method.
- Set and cement 24-inch diameter steel casing to a depth of 2,552 feet bpl.
- Set 16-inch OD FRP tubing and packer assembly at 2,542 feet bpl.

The pilot hole was drilled to a total depth of 3,737 feet bpl; however, because the water temperature and specific conductance started increasing below 3,350 feet bpl and due to the presence of massive anhydrite, the pilot hole was back-plugged to 3,300 feet bpl.

A summary of the construction sequence for the IW is provided as **Table 2-2** and a schematic, as-built illustration of IW-1 is presented as **Figure 2-3**. A summary of the construction details for IW-1 is provided as **Table 2-3**. The lithologic log for the IW is included in **Appendix D**.

A closed-circulation drilling fluid system was used for drilling of both IW-1 and DZMW-1: the mud-rotary method to the upper casing setting depth of 765 feet, with the reverse-air rotary method below that depth.

IW-1 was permitted and constructed with a tubing and packer design. The tubing installed is 16-inch outside-diameter, fiberglass reinforced plastic (FRP) manufacture, Red Box 1500. The external casing packer installed is a permanent positive-seal packer and mandrel assembly (YBI Triple Seal Packer). The annular fluid emplaced between the tubing and the 24-inch outside diameter steel injection casing is Halliburton Baracor 100. Copies of the mill certificates are included in **Appendix E**, casing logs in **Appendix F**, cement records in **Appendix G**, cement logs in **Appendix H**, and tubing manufacturer's information in **Appendix I**.

After the tubing was set, a video was performed on the entire tubing and open-hole section of the well.

Table 2-2: Summary of IW-1 Construction Sequence

Date	Significant Activities
01/15/13	Began site preparation.
01/24/13	Pile drove pit casings: 66-inch diameter for IW-1 to 34 feet and 48-inch diameter for DZMW-1 to 39 feet.
01/29/13	Setting up drill pad and mud system.
02/01/13	Completed installation of four (4) shallow pad monitoring wells.
02/27/13	Begin moving rig on-site.
03/03/13	Drilled 12.25-inch diameter pilot hole to 200 feet below pad level (bpl).
03/05/13	Reamed a 64.5-inch diameter hole to 150 feet bpl.
03/06/13	Ran caliper/gamma ray log. Set 145 feet of 54-inch diameter by 0.0375-inch wall thickness steel casing. Pressure grouted with 214 barrels neat cement.
03/11/13	Drilled 14.75-inch diameter pilot hole to 900 feet below pad level (bpl). Ran caliper/gamma ray, BHC Sonic w/VDL display, and DIL logs.
03/21/13	Reamed a 52.5-inch diameter hole to 765 feet bpl. Ran caliper/gamma ray log. Set 760 feet of 42-inch diameter by 0.375-inch wall thickness steel casing.
03/22/13	Pressure grouted first stage with 126 barrels of 6% bentonite cement and 285 barrels neat cement, and second stage with 150 barrels 12% bentonite cement and 198 barrels 6% bentonite cement.
03/25/13	Switched to reverse air drilling.
03/31/13	Drilled 12.25-inch diameter pilot hole to 2,010 feet below pad level (bpl).
04/01/13	Ran caliper/gamma ray, BHC Sonic w/VDL display, DIL, FRT, BHTV, and Flow logs.
04/02/13	Ran straddle packer test #1 from interval 1,957 to 1,974 feet bpl.
04/03/13	Ran straddle packer test #2 from interval 1,915 to 1,932 feet bpl.
04/04/13	Ran straddle packer test #3 from interval 1,832 to 1,846 feet bpl.
04/06/13	Ran straddle packer test #4 from interval 1,661 to 1,678 feet bpl.
04/07/13	Ran straddle packer test #5 from interval 1,797 to 1,814 feet bpl.
04/08/13	Completed back-plugging of pilot hole to 1,127 feet bpl with 12% bentonite cement.

Table 2-2: Summary of IW-1 Construction Sequence

Date	Significant Activities
04/18/13	Reamed a 40.5-inch diameter hole to 1,813 feet bpl.
04/19/13	Ran caliper/gamma ray logs.
04/21/13	Set 1,798 feet 34-inch diameter by 0.375-inch wall thickness steel casing. Ran cement bond log.
04/25/13	Completed cementing 34-inch diameter casing in six (6) stages with 150 barrels neat cement and 933 barrels 6% bentonite cement.
04/26/13	Performed pressure test on the 34-inch diameter casing with 3.2% change in pressure.
04/30/13	Drilled 12.25-inch diameter pilot hole to 2,118 feet bpl. Cut core #1 from 2,118 to 2,138 feet bpl.
05/01/13	Drilled 12.25-inch diameter pilot hole to 2,196 feet bpl. Cut core #2 from 2,196 to 2,213 feet bpl.
05/03/13	Drilled 12.25-inch diameter pilot hole to 2,322 feet bpl. Cut core #3 from 2,322 to 2,337 feet bpl.
05/04/13	Drilled 12.25-inch diameter pilot hole to 2,400 feet bpl. Cut core #4 from 2,400 to 2,410 feet bpl.
05/05/13	Drilled 12.25-inch diameter pilot hole to 2,477 feet bpl. Cut core #5 from 2,477 to 2,487 feet bpl.
05/06/13	Drilled 12.25-inch diameter pilot hole to 2,487 feet bpl. Cut core #6 from 2,487 to 2,498 feet bpl.
05/08/13	Drilled 12.25-inch diameter pilot hole to 2,586 feet bpl. Cut core #4 from 2,586 to 2,596 feet bpl.
05/17/13	Drilled 12.25-inch diameter pilot hole to 3,737 feet bpl.
05/18/13	Ran caliper/gamma ray, BHC Sonic w/VDL display, DIL, FRT, and Flow logs.
05/19/13	Ran video survey.
05/20/13	Ran straddle packer test #6 from interval 2,489 to 2,506 feet bpl.
05/21/13	Ran straddle packer test #7 from interval 2,641 to 2,658 feet bpl.
05/22/13	Ran straddle packer test #8 from interval 2,278 to 2,295 feet bpl.
05/23/13	Completed back-plugging of pilot hole to 3,315 feet bpl with neat cement.

Table 2-2: Summary of IW-1 Construction Sequence

Date	Significant Activities
05/25/13	Completed back-plugging of pilot hole from 2,530 to 2,000 feet bpl with neat cement.
06/08/13	Reamed 32.5-inch diameter hole to 2,552 feet bpl.
07/01/13	Reamed 22.0-inch diameter open hole to 3,289 feet bpl.
07/02/13	Ran caliper/gamma ray log.
07/08/13	Set 2,552 feet 24-inch diameter by 0.500-inch wall thickness steel casing.
07/09/13	Ran cement bond log.
07/13/13	Completed seven (7) cementing stages for the 24-inch diameter casing with 154 barrels neat cement and 1,185 barrels 6% bentonite cement.
07/15/13	Ran cement bond log.
07/16/13	Performed pressure test on the 24-inch diameter casing with 2.25% change in pressure. Witnessed by FDEP. Complete cementing stage 8 with 182 barrels 6% bentonite cement. Ran video survey.
07/19/13	Set 2,542 feet bpl 16-inch diameter by 0.800-inch wall thickness FRP tubing.
07/25/13	Installed annular fluids, Baracor. Ran video survey.
07/26/13	Started moving the rig to the Dual Zone Monitoring Well site.
07/30/13	Rig moved and ready to drill.
08/21/13	Performed pressure test on the casing annulus with 0.30% change in pressure. Witnessed by FDEP.
09/26/13	Conducted Radioactive Tracer Survey.
10/06/13	Completed injection test (background, injection & recovery).

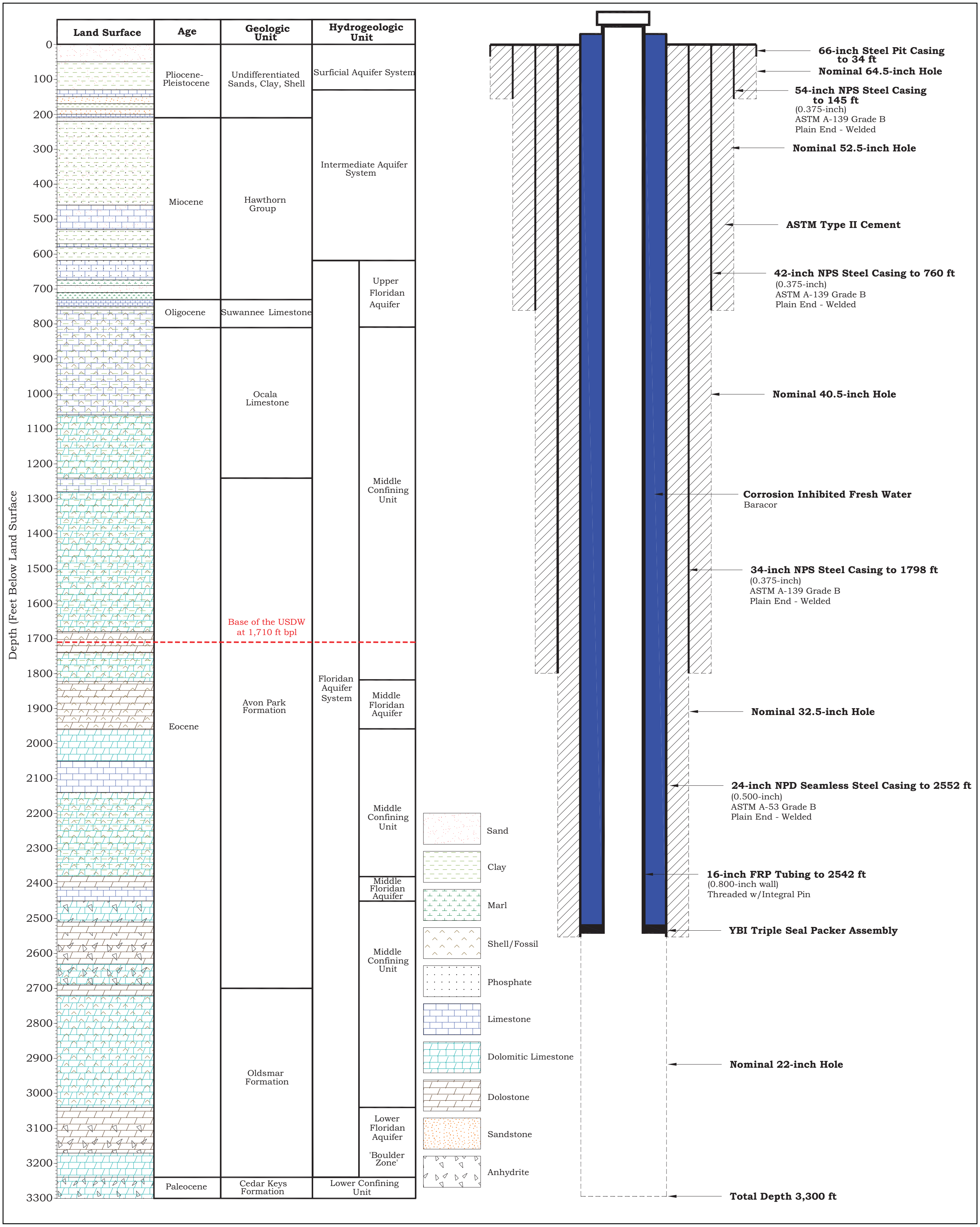

FIGURE 2-3

IW-1 AS-BUILT DIAGRAM

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Table 2-3: IW-1 Well Construction Details

Casing	Casing OD Diameter (in)	Casing ID Diameter (in)	Casing Material	Setting Depth (ft BPL)
Pit	66		Steel	34
Conductor	54	53.25	Spiral weld carbon steel	145
Surface	42	41.25	Spiral weld carbon steel	760
Intermediate	34	33.25	Spiral weld carbon steel	1,798
Injection	24	32	Seamless carbon Steel	2,552
Tubing	16	14.48	FRP	2,542

3.0 Dual Zone Monitoring Well Construction (DZMW-1)

Drilling and construction of DZMW-1 started on August 1, 2013 and was completed on September 18, 2013. The drilling of DZMW-1 proceeded generally as identified in the project specifications. The monitor zones depths were based on data collected during the drilling and testing of IW-1 and DZMW-1. The selection of the monitor zone depths is discussed later in the report. DZMW-1 was installed at the site using the same YBI drilling rig.

Monitoring well DZMW-1-1 was generally constructed as follows:

- Drill a nominal 42.5-inch diameter borehole to approximately 150 feet bpl using the mud rotary method.
- Set and cement 36-inch diameter steel casing to a depth of 145 feet bpl.
- Drill a 12.25-inch diameter pilot hole to approximately 800 feet bpl using the mud rotary method.
- Drill a nominal 34.5-inch diameter borehole to approximately 770 feet bpl using the mud rotary method.
- Set and cement 36-inch diameter steel casing to a depth of 765 feet bpl.
- Drill a 12.25-inch diameter pilot hole to approximately 1,950 feet bpl using the reverse air method.
- Back-plug pilot hole with cement to 840 feet bpl.
- Drill a nominal 22.0-inch diameter borehole to approximately 1,652 feet bpl using the reverse air method.
- Set and cement 16-inch diameter steel casing to a depth of 1,648 feet bpl.
- Drill a 12.25-inch diameter pilot hole to approximately 1,950 feet bpl using the reverse air method.
- Set 6.625-inch diameter FRP casing to a depth of 1,900 feet bpl and cement from 1,695 to 1,900 feet bpl.

The upper monitor zone (UMZ) was established between 1,648 and 1,695 feet bpl and the lower monitor zone (LMZ) between 1,900 and 1,938 feet bpl. A brief summary of the construction sequence for the DZMW is provided as **Table 3-1**. A schematic illustration of the DZMW is provided as **Figure 3-1**. A summary of the construction details is provided as **Table 3-2**. The lithologic log for the DZMW is included in **Appendix D**. Copies of the mill certificates are included in **Appendix E**, casing logs in **Appendix F**, cement records in **Appendix G**, cement logs in **Appendix H**, and tubing manufacturer's information in **Appendix I**.

Table 3-1: Summary of DZMW-1 Construction Sequence

Date	Significant Activities
07/30/13	Rig moved and ready to drill.
08/01/13	Reamed a 42.5-inch diameter hole to 150 feet bpl. Ran caliper/gamma ray log. Set 145 feet of 36-inch diameter by 0.0375-inch wall thickness steel casing.
08/02/13	Pressure grouted with 109 barrels neat cement.
08/05/13	Drilled 12.25-inch diameter pilot hole to 800 feet below pad level (bpl).
08/06/13	Ran caliper/gamma ray, BHC Sonic w/VDL display, and DIL logs.
08/10/13	Reamed a 34.5-inch diameter hole to 770 feet bpl. Ran caliper/gamma ray log.
08/11/13	Set 765 feet of 26-inch diameter by 0.375-inch wall thickness steel casing. Pressure grouted with 320 barrels of 6% bentonite cement and 103 barrels neat cement.
08/13/13	Switched to reverse air drilling.
08/17/13	Drilled 12.25-inch diameter pilot hole to 1,950 feet below pad level (bpl).
8/182013	Ran caliper/gamma ray, BHC Sonic w/VDL display, DIL, FRT, BHTV, Flow logs and video survey.
08/19/13	Ran straddle packer test #1 from interval 1,905 to 1,935 feet bpl.
08/20/13	Ran straddle packer test #2 from interval 1,760 to 1,790 feet bpl and #3 from 1,700 to 1,730 ft bpl.
08/21/13	Ran straddle packer test #4 from interval 1,660 to 1,690 feet bpl.
08/24/13	Completed back-plugging of pilot hole to 840 feet bpl with 12% bentonite cement.
08/29/13	Reamed a 22.0-inch diameter hole to 1,652 feet bpl. Ran caliper/gamma ray logs.
08/30/13	Set 1,647.7 feet 16-inch diameter by 0.375-inch wall thickness steel casing. Ran pre-cement bond log.
09/03/13	Completed cementing 16-inch diameter steel casing in five (5) stages with 70 barrels neat cement and 503 barrels 6% bentonite cement. Performed pressure test on the 16-inch diameter casing with 0.3% change in pressure.
09/05/13	Reamed a 12.25-inch diameter hole to 1,950 feet bpl.

Table 3-1: Summary of DZMW-1 Construction Sequence

Date	Significant Activities
09/07/13	Ran video survey of the 16-inch diameter steel casing.
09/08/13	Set 1,900 feet 6.625-inch diameter by 0.34-inch wall thickness FRP casing. Ran pre-cement bond log.
09/11/13	Completed cementing 6.625-inch diameter FRP casing in five (5) stages with 74 barrels of neat cement.
09/12/13	Performed pressure test on the 6.625-inch diameter FRP casing with 5.0% change in pressure. Ran CBL and video survey.
09/13/13	Re-ran CBL and video on lower portion and open hole of lower monitor zone.
09/18/13	Completed development and water quality sample collected for primary and secondary drinking water standards.

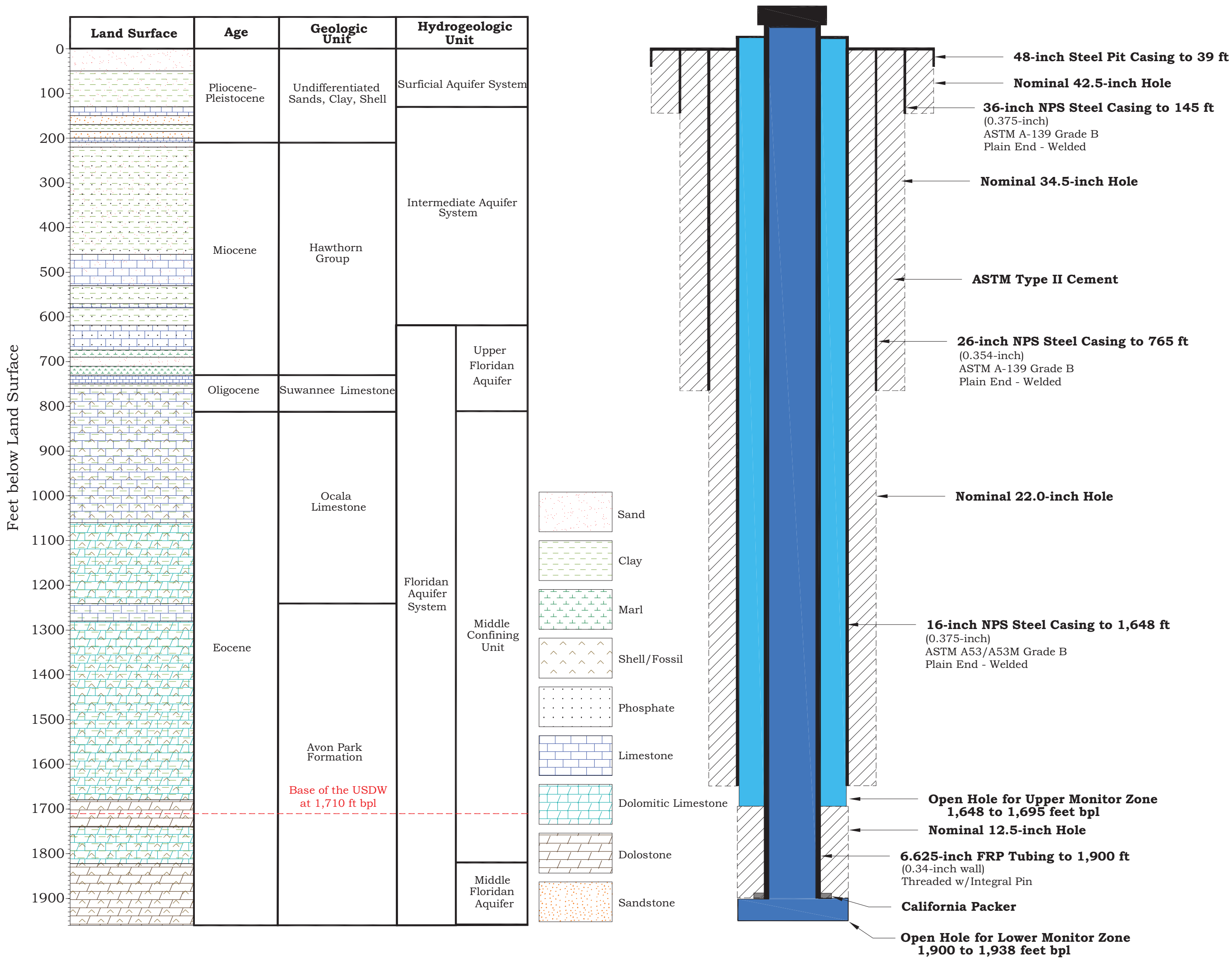

FIGURE 3-1
DZMW-1 AS-BUILT DIAGRAM

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DATE: 3/17/14

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Water Resource Consulting
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Hayesville, NC
828-389-2476

Table 3-2: DZMW-1 Well Construction Details

Casing	Casing OD Diameter (in)	Casing ID Diameter (in)	Casing Material	Setting Depth (ft bpl)
Pit	48		Steel	39
Conductor	36	35.25	Spiral weld carbon steel	145
Surface	26	25.29	Spiral weld carbon steel	765
Upper Zone	16	15.25	Seamless carbon steel	1,648
Lower Zone	6.10	5.43	FRP	1,900

Other Construction Details:

Total Depth of Well: 1,950 feet

Upper Monitoring Zone: 1,648 - 1,695 feet bpl

Lower Monitoring Zone: 1,900 - 1,938 feet bpl

4.0 Data Collection and Analysis

Data were collected during the construction of the wells using various methods and procedures as described in this Section. YBI Geophysical Logging Division performed the geophysical logging. Subcontractors of YBI included the following: Benchmark Analytic Laboratory, which performed water quality analyses and Ardaman & Associates, Inc., which performed the rock core analyses. Depth measurements in the wells are referenced to pad level. The elevations of the IW-1 and DZMW-1 drilling pads were approximately 27 feet NGVD 29. Final pad elevations will be surveyed to NAVD 88. The Geologist and the Contractor prepared independent daily-progress reports during well construction. In addition to recording daily drilling progress, the reports included the following:

- Pertinent drilling information such as weight-on-bit, penetration rates, and relative hardness of the formations,
- Problems encountered during drilling,
- Activities related to the installation of well casings, cementing activities and/or placement of other materials, and their quantities,
- Detailed descriptions of test procedures and data collection, and
- The length and configuration of tools introduced into the borehole.

Copies of the daily and weekly progress reports were transmitted to the TAC members on a weekly basis. Copies of the weekly reports, which include the daily drillers' log, are provided in **Appendix B.**

4.1 Geologic Samples

Samples of formation cuttings were collected and analyzed during the drilling of the IW and DZMW. Circulation time (the time required for drilled cuttings to reach the surface) was calculated regularly to ensure that accurate sample depths were recorded. After initial examination, the on-site Geologist described the samples. A geologic description of each sample was entered into a lithology log. These logs are presented in **Appendix D**. Formation cuttings were bagged in 10-foot intervals and sent to the Florida Geological Survey in Tallahassee, Florida.

4.2 Geophysical Logging Program

Geophysical logging of boreholes was completed after each pilot hole was drilled in both the IW and DZMW of each stage of drilling. The purpose of these logs was to assist in casing seat selection, identify potential confining sequences and flow zones, and track water quality and lithologic changes. The suite of open-hole geophysical logs performed included the following: XY caliper, gamma ray (GR), dual induction log (DIL), and borehole-compensated (BHC) sonic with variable density log (VDL) display. In addition to these logs, below the surface casing (and at total depth), fluid resistivity and temperature (FRT) (static and dynamic) and flowmeter (static and dynamic) logs were performed. Cased-hole logs performed in IW-1 and DZMW-1 included temperature and cement-bond log (CBL) with VDL display (before and after cementing). A digital borehole televiewer (BHTV) was used in place of a video survey when water visibility was poor. A brief description of the information provided by each logging tool is as follows:

XY Caliper - the XY caliper log measures the diameter of a borehole in two planes perpendicular to each other. The caliper log can provide information on structural features of a lithology, the consistency of the borehole diameter, washouts, swelling clays, and rock obstructions. Secondary porosity features, such as fractures and solution features may be apparent on the caliper log. This log may also provide information concerning the general mechanical strength of the formation.

Gamma Ray - The gamma ray log measures natural gamma radiation produced by the decay of uranium daughter products in formation material. Rock formations that typically contain these products include clay and phosphate. These components are important to identifying geologic formations and stratigraphic correlations.

Dual Induction Log - The dual induction log is used to measure the electrical properties of the formation. The electrical resistivity of the formation is affected by the formation porosity and water chemistry. These logs give important information concerning the water quality in the formation (particularly the transition found at the base of the USDW), porosity of the formation, water producing, and confining zones, and mixing of formation water with drilling fluid in the borehole. The log consists of three resistivity traces:

> **Deep Resistivity (ILD):** Measures resistivity of the formation material with a wide receiver spacing that penetrates deep into the formation.
>
> **Medium Resistivity (ILM):** Measures resistivity of the formation with a medium receiver spacing that examines the formation material close to the borehole, where drilling fluids may have invaded the formation.
>
> **Shallow Resistivity (LL3):** This log reads the lateral resistivity with closely spaced electrodes that measure resistivity primarily within the borehole and on the borehole wall.

Borehole Compensated Sonic Variable Density Log - The BHC sonic log uses sonic pulses to determine competency of the borehole. This log is strongly affected by porosity and the mechanical strength of the formation. The more porous the borehole wall, the faster the travel time of the acoustic signal. The VDL provides a visual representation of the borehole along with important information about fractures and solution features.

Flow Meter Surveys - The fluid velocity log measures the rate of fluid movement in the borehole. The flowmeter can detect "cross-flow" or water moving from one aquifer to another due to pressure differentials, as well as, identify producing intervals when the well is being pumped.

Fluid resistivity - Fluid resistivity logs reflect changes in the dissolved solids of the well water.

Temperature - The temperature log measures the temperature of the fluid that fills the borehole. The log is used to measure characteristics of the formation fluid under static and dynamic flow conditions, and provides information about the movement of the fluids within the borehole, along with the source of fluids.

Digital Borehole Televiewer (BHTV) - A digital borehole televiewer produces a 360 degree ultrasonic image from measurement of the acoustic properties around the borehole wall. This log is similar to the BHC sonic log, but has a much higher frequency of measurement with more complete coverage of the circumference of the borehole. Due to the high resolution of this tool, it can be used to identify bedding and fractures.

Cement Top Temperature - The temperature log was used for verification of the annular space fill-up after each cementing stage.

Cement Bond Log - This log detects potential voids in the grout sheath around the casing by measuring the acoustic properties of the cemented casing. The CBL aids in the determination of the external mechanical integrity of the well, and provides an indication of the quality of the hydraulic seal between the final casing and the well bore. The CBL records amplitude, in millivolts (mV), of the first arrival of a wave signal at a 3-foot receiver created by a calibrated, 1,000 mV output signal. Amplitude is at a maximum in unsupported pipe and a minimum in well-cemented casing. The amplitude is a function of the attenuation of the transmitted signal due to the coupling of cement to casing. Attenuation rates depend on the cement compressive strength, the casing diameter, casing thickness, and the degree of cement bonding.

During the geophysical logging and testing of each well, the on-site Geologist witnessed the logging and verified quality-control procedures. The quality control maintained during the testing program was largely provided by YBI Geophysical Logging Division and documented. Industry standard quality control measures were observed and are documented on the logs.

After reaming of each hole for the installation of a casing, both caliper and gamma ray logs were conducted. These were used to help determine the amount of cement needed for each casing. Downhole video surveys were conducted in the injection well and the dual zone monitoring well. Generally, these were done after the pilot holes were drilled and of the injection and monitoring well casings. A BHTV was used on the pilot hole below the IW surface casing, due to poor visibility during video logging.

A summary of the geophysical logs run in IW-1 and the DZMW-1 are provided on **Table 4-1**. Copies of the logs in both *.pdf* and *.las* format and the video surveys are included in **Appendix J.**

Table 4-1: Summary of Geophysical Logs for IW-1 and DZMW-1

Date	Log Type	Depth (ft bpl)
Injection Well		
March 6, 2013	GR, Caliper, DIL, BHC w/VDL	0 - 150
March 12, 2013	GR, Caliper, DIL, BHC w/VDL	150 - 900
March 21, 2013	GR, Caliper	50 - 750
March 22, 2013	Temperature	0 -750
April 1, 2013	GR, Caliper, DIL, BHC w/VDL, FRT (Static & Dynamic), Flow (Static & Dynamic), BHTV	750 - 2,010
April 19, 2013	GR, Caliper	750 - 1,810
April 21, 2013	CBL, before cementing	30 - 1,780
April 22 - 24, 2013	Temperature	0 - 1,780
April 25, 2013	CBL, after cementing	0 - 1,770
May 18, 2013	GR, Caliper, DIL, BHC w/VDL, FRT (Static & Dynamic), Flow (Static & Dynamic)	1,730 - 3,738
May 19 - 20, 2013	Video Survey	1,780 - 3,713
July 2, 2013	GR, Caliper, Flow (Static & Dynamic)	1,710 - 3,290
July 9, 2013	CBL, before cementing	0 - 2,518
July 11 - 14, 2013	Temperature	0 - 2,518
July 15, 2013	CBL, after cementing	100 - 2,526
July 16, 2013	Video Survey	18 - 2,545
July 25, 2013	Video Survey	0 - 3,244
Dual Zone Monitoring Well		
August 1, 2013	GR, Caliper	0 - 150
August 5, 2013	GR, Caliper, DIL, BHC w/VDL	100 - 800
August 10, 2013	GR, Caliper	42 - 750
August 17, 2013	GR, Caliper, DIL, BHC w/VDL, FRT (Static & Dynamic), Flow (Static & Dynamic)	700 - 1,950
August 18, 2013	Video Survey	756 - 1,933
August 29, 2013	GR, Caliper	750 - 1,650
August 30, 2013	CBL, before cementing	0 - 1,630
August 31 - September 2, 2013	Temperature	0 - 1,630
September 3, 2013	CBL, after cementing	0 - 1,630
September 7, 2013	Video Survey	35 - 1,653
September 7, 2013	GR, Caliper	1,600 - 1,950
September 8, 2013	GR, Caliper	1,730 - 1,950
September 8, 2013	CBL, before cementing	1,630 - 1,865
September 10 - 12, 2013	Temperature	0 - 1,880
September 12, 2013	CBL, after cementing	1,630 - 1,872
September 12, 2013	Video Survey	0 - 1,911
September 14, 2013	CBL, after cementing	1,800 - 1,920
September 14, 2013	Video Survey	1,896 - 1,938

GR=Gamma Ray, DIL=Dual Induction Log, BHC w/VDL=Borehole Compensated Sonic with Variable Density Log, FRT=Fluid Resistivity and Temperature, CBL=Cement Bond Log, BHTV=Borehole Televiewer Log

4.3 Packer Testing

Packer tests were conducted to delineate the base of the underground source of drinking water (USDW), evaluate the confinement above the injection zone, and to determine approximate depths for the upper and lower monitoring zones. Four (4) straddle-packer tests in IW-1 were performed for water quality and four (4) for confinement. Four (4) straddle-packer tests in DZMW-1 were performed to isolate appropriate monitoring zones.

Water samples were procured from the isolated test intervals by pumping. The water samples obtained from the test zones were analyzed on-site for conductivity. In addition, groundwater samples obtained from the test intervals were transported to an analytical laboratory for analyses of calcium, magnesium, potassium, sodium, dissolved chloride, sulfate, ammonia nitrogen, bicarbonate alkalinity, and total dissolved solids concentrations. The samples were placed on ice immediately upon collection and kept cool in route to the laboratory. A complete chain-of-custody was maintained throughout the sampling, transport and analytical operations. A summary of the intervals tested and the data obtained is presented on **Tables 4-2 and 4-3**. The complete packer-test hydraulic data and graphical analyses are provided in **Appendix K**. More complete water quality analyses for the packer test intervals are contained in **Appendix L**.

Based upon the results of the packer testing program, and utilizing data from analyses of the open-hole geophysical logs, the base of the USDW was determined to occur at an approximate depth of 1,710 feet bpl at the site. An upper monitoring zone from 1,648 to 1,695 feet was selected. A lower monitoring zone from 1,900 to 1,938 feet was selected as the first zone with appreciable permeability above the injection zone.

Table 4-2: Summary of Packer Test Data for IW-1

Packer Test No.	Depth Interval (ft bpl)	TDS (mg/l)	Field Conductivity (µmhos/cm)	Chlorides (mg/l)	Hydraulic Conductivity Recovery Analysis (cm/sec (ft/d))
1	1,957-1,974	N/A	N/A	N/A	3.0e-06 (8.4e-03)
2	1,915-1,932	33,708	52,000	20,343	2.5e-02 (7.1e+01)
3	1,832-1,849	14,352	23,720	14,352	1.1e-02 (3.0e+01)
4	1,661-1,678	5,556	10,150	3,116	1.0e-04 (2.9e-01)
5	1,797-1,814	20,912	33,700	11,641	3.7e-05 (1.1e-01)
6	2,489-2,506	N/A	N/A	N/A	3.3e-06 (9.5e-03)
7	2,641-2,658	N/A	N/A	N/A	5.1e-06 (1.5e-02)
8	2,278-2,295	N/A	N/A	N/A	2.9e-06 (8.1e-03)

Table 4-3: Summary of Packer Test Data for DZMW-1

Packer Test No.	Depth Interval (ft bpl)	TDS (mg/l)	Field Conductivity (µmhos/cm)	Chlorides (mg/l)	Hydraulic Conductivity based on Specific Capacity (cm/sec (ft/d))
1	1,905-1,935	35,616	49,600	19,388	N/A
2	1,760-1,790	20,652	30,820	10,873	6.0e-04 (1.7)
3	1,700-1,730	18,352	27,800	9,587	6.0e-04 (1.7)
4	1,660-1,690	7,608	10,500	4,051	N/A

4.4 Coring Program

A whole-rock coring program was conducted for quantifying confinement between the base of the USDW and the proposed injection zone. Seven (7) four-inch diameter cores were taken in IW-1 pilot hole. A summary of the cored intervals, generalized lithologic descriptions, and vertical permeability ranges is provided on **Table 4-4**.

Representative portions of each core were sent to a geotechnical laboratory for analyses. The laboratory analyses included general lithologic descriptions and determination of porosity and horizontal and vertical permeabilities. Complete core analyses are included in **Appendix M**. All unused portions of each core were transported to the Florida Geological Survey (FGS) core laboratory in Tallahassee, FL.

The coring program substantiated that significant confinement exists at the site between the base of the USDW and the selected injection zone. **Figure 4-1** is a schematic of packer testing and coring done for IW-1.

Table 4-4: Summary of Cored Intervals in IW-1

Core #	Interval Cored (ft)	Recovery (ft)	Sections sent to Laboratory (ft)	Average Vertical Permeability (ft/d)	Lithology
1	2118-2138	20	2124.1-2125.3 2128.3-2129.2	8.00E-02	Limestone, grainstone to packstone, moderate to well indurated, moderate to good intergranular and moldic porosity, mostly biogenic debris (foraminifera, bryozoa, moderate apparent permeability.
2	2196-2213	10	2208.2-2209	3.12E-01	Limestone, packstone, well indurated, mostly biogenic debris including foraminifera (Dictyoconus americanus), peloids, bryozoans, echinoids, good to moderate intergranular and moldic intragranular porosity, good apparent permeability.
3	2322-2337	15	2325.8-2326.8	3.68E-02	Limestone, packstone, well indurated, mostly biogenic debris including foraminifera, peloids, bryozoans, echinoid, good to moderate intergranular and intragranular porosity, good apparent permeability, vuggy porosity in part with vugs from 2 - 3 cm in diameter often filled with euhedral dolomite crystals.
4	2400-2410	8.8	2401.7-2402.1 2407.5-2408.4	5.24E-02	Dolostone, grainstone, moderately to well indurated, vuggy, very high porosity and apparent vugular permeability, some vugs contain poorly cemented dolomite crystals; and Limestone, mudstone to packstone, well indurated, poor apparent intergranular porosity and permeability.
5	2477-2487	10	2482.3-2483.2	1.67E-02	Dolomitic limestone, very well indurated, common fracture and pore/vug filling anhydrite/dolomite, common fossil (echinoid Neolaganum dalli) replacement with dolomite, very poor apparent porosity and permeability.
6	2487-2498	10.8	2488.2-2488.9 2495.2-2496.2	5.69E-03	Dolomitic limestone, grainstone, well indurated, with anhydrite, poor porosity and apparent permeability; and Dolostone, pin point vugularity, low permeability and porosity.
7	2585.7-2596	10.3	2588.8-2589.5	5.39E-05	Dolostone, moderately to well indurated, pin point vugularity, with anhydrite.

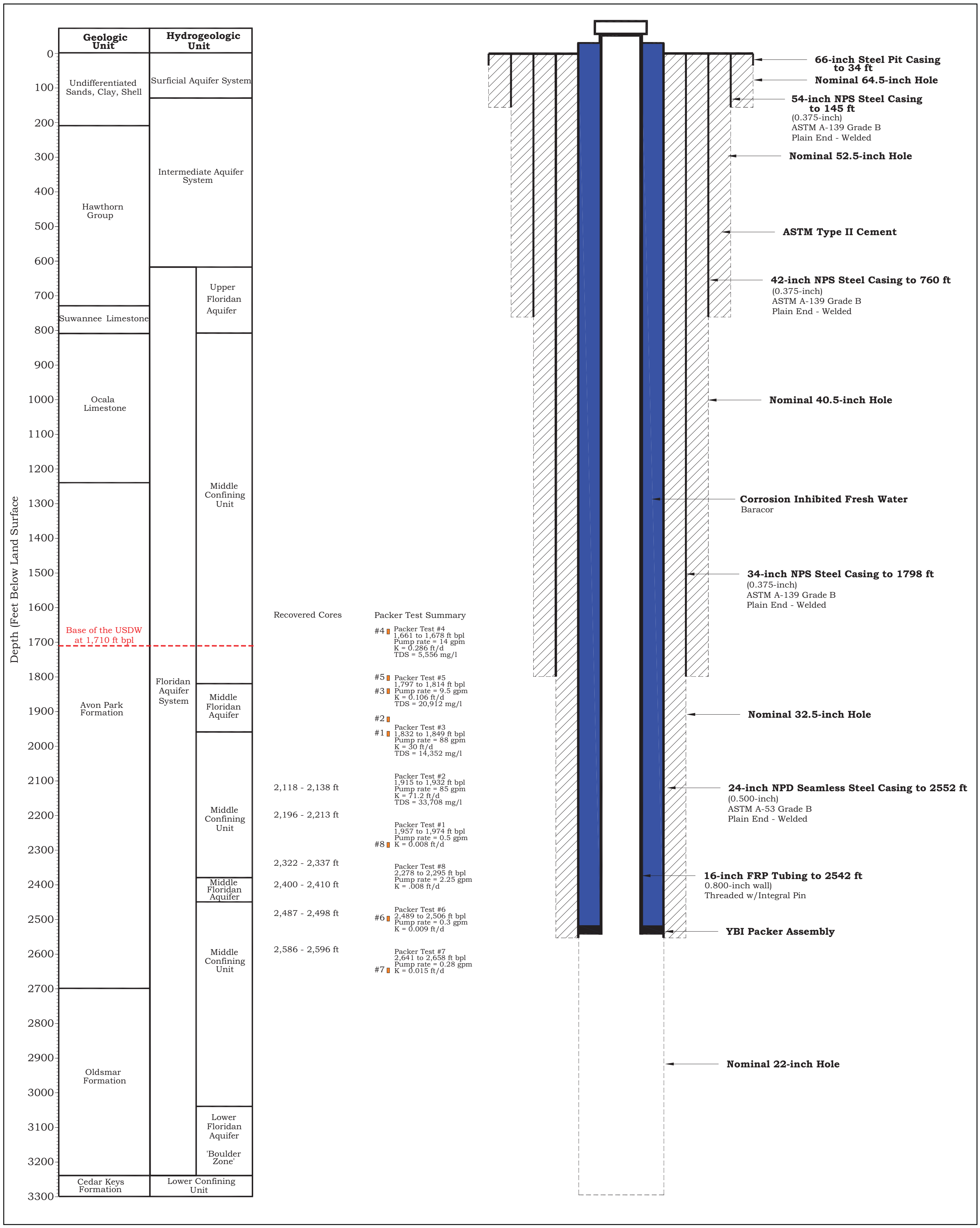

FIGURE 4-1
SCHEMATIC OF PACKER TESTING AND CORING FOR IW-1

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4.5 Water Quality Analyses

Water samples were procured during IW-1 and DZMW-1 construction from the reverse-air drilling fluid return stream, packer testing, and pumping the open-hole section below the final casings.

During reverse-air drilling, fresh water (i.e. water with dissolved chlorides less than 250 mg/I) was often added to the pits to replace fluid lost during the drilling operations. This resulted in a constant dilution of the return water stream and generally rendered the reverse-air water quality analyses non-representative, particularly when significant lengths of open-hole section were present. In shorter open-hole sections (generally after setting a string of casing) and in intervals where permeabilities and formation yields were high, more representative formation samples could be obtained from the reverse air return stream. Reverse-air water quality analyses were performed on-site and included determination of conductivity and a few dissolved chloride concentrations. Reverse-air water quality samples were obtained at 10 foot intervals to a depth of about 2,000 feet bpl during the drilling of IW-1. Seven of the water samples collected were sent for laboratory analysis and tested for total dissolved solids, sodium, sulfate, bicarbonate alkalinity, and chloride concentrations. The reverse-air water quality analyses are contained in **Appendix L**.

Water quality analyses from the packer test intervals were significantly more accurate than the reverse-air water quality analyses. The packer testing procedure, intervals tested, and analytical results were described in a previous section of this report. The water quality analytical results from the packer test intervals are contained in **Appendix L**.

Representative water samples were obtained from the injection zone in IW-1 and from the upper and lower monitoring zones in DZMW-1 by pumping. Water samples from each of these three zones were transported to an analytical laboratory for Primary and Secondary Drinking Water analyses. A condensed summary of the inorganic analyses, secondary contaminants, and radionuclide's for each of the three (3) zones is presented on **Table 4-5**. The complete water quality analytical results are included in **Appendix L**.

Table 4-5: Condensed Summary of Primary and Secondary Drinking Water Analyses for IW-1 and DZMW-1

Parameter	Injection Zone	Lower Monitoring Well	Upper Monitoring Well	Units	MCL	MDL
Aluminum	0.147	0.157	0.277	mg/l	0.2	0.023
Chloride	20,343	19,103	2,852	mg/l	250	0.353
Copper	0.006	0.004	0.004	mg/l	1	0.004
Fluoride	0.872	0.534	0.533	mg/l	2	0.03
Iron	2.19	0.076	0.421	mg/l	0.3	0.029
Manganese	0.029	0.089	0.022	mg/l	0.05	0.00098
Silver	0.01	0.007	0.003	mg/l	0.1	0.0005
Sulfate	3,161	2,125	509	mg/l	250	0.339
Zinc	0.019	0.007	0.037	mg/l	5	0.0014
Odor	1	1	4	ton	3	1
pH	7.25	8.33	9.91	units	6.5-8.5	
Total Dissolved Solids	35,508	33,472	5,776	mg/l	500	7.26
Surfactants	2.01	1.742	0.311	mg/l	0.5	0.03
Potassium	375	383	46.1	mg/l		0.169
Ammonia Nitrogen	0.01	0.107	0.252	mg/l		0.008
Total Kjeldahl Nitrogen	0.203	0.124	0.434	mg/l		0.05
Arsenic	0.036	0.007	0.005	mg/l	0.01	0.00138
Barium	0.055	0.503	4.01	mg/l	2	0.06
Cadmium	0.0009	0.0009	0.0009	mg/l	0.005	0.0009
Chromium	0.004	0.016	0.006	mg/l	0.1	0.002
Cyanide	0.005	0.005	0.005	mg/l	0.2	0.005
Lead	0.00134	0.0027	0.0027	mg/l	0.015	0.00134
Mercury	0.000198	0.000198	0.000198	mg/l	0.002	0.000198
Nickel	0.005	0.00118	0.004	mg/l	0.1	0.00118
Selenium	0.00157	0.00628	0.00628	mg/l	0.05	0.00157
Sodium	10,600	10,800	1,450	mg/l	160	0.034
Antimony	0.00452	0.00904	0.00904	mg/l	0.006	0.00452
Beryllium	0.000078	0.000078	0.000078	mg/l	0.004	0.000078
Thallium	0.000981	0.00392	0.00392	mg/l	0.002	0.000981
Gross Alpha	22.6+/-4.1	18.2+/-3.2	8.6+/-7.2	pCi/l	15	1.0
Radium-226	20.9+/-0.2	16.7+/-1.1	1.0+/-0.3	pCi/l	5	0.8
Radium-228	1.0	1.0+/-0.6	0.8	pCi/l	5	1.0

MCL = Maximum Contaminant Limit
MDL = Method Detection Limit NA = Not Analyzed
mg/I = milligrams per liter
pc/1 = picocuries per liter

4.6 Deviation Surveys

Deviation surveys were performed at approximate 90-foot intervals in all pilot and reamed holes for both IW-1 and DZMW-1. The deviation surveys were performed by YBI using Totco Sure-Shot instruments. A tabulation of the deviation surveys for IW-1 and DZMW-1 are provided in **Appendix N.** No deviations greater than 0.50 degrees were recorded in any portion of either well.

5.0 Geology and Hydrogeology

5.1 Regional Geologic Setting

The anticipated subsurface geology of the City site was described in the Area of Review portion of the FDEP construction permit application supporting documentation (Sims, 2009). The actual stratigraphy, as encountered in IW-1 and DZMW-1, is described below. A generalized hydrostratigraphic column for the LaBelle area is provided on **Figure 5-1**. A regional cross-section was developed to identify the subsurface features that would be encountered at the well site. **Figure 5-2** is a plan view map showing the east-west trace for the cross-section presented in **Figure 5-3**. An updated formation top table is provided in **Table 5-1**. The cross-section and the formation tops were updated to reflect the subsurface conditions actually encountered during the drilling process.

5.2 Stratigraphy

Sediments encountered during the construction of the LaBelle injection well system range in age from Pliocene-Pleistocene to Paleocene. Lithologic descriptions are based on formation samples (cuttings) collected from IW-1 and DZMW-1 at 10-foot intervals during drilling of the pilot holes. The lithology is described based on the dominant rock type, physical and textural characteristics, such as porosity and color, using the scheme of Geological Society of America Munsell color chart. Lithologic descriptions for IW-1 and DZMW-1 are provided in **Appendix D**.

5.2.1 Holocene-Pleistocene

Undifferentiated Sediments

The undifferentiated Holocene-Pleistocene age deposits at the site consist of unconsolidated clay, shell beds, and fine to very coarse-grained quartz sand lenses and are approximately 125 feet thick. The interval from 125 to 210 feet bpl consists of limestone identified as the Ochopee Limestone member of the Tamiami Formation.

5.2.2 Miocene-Pliocene Series

Arcadia Formation - Hawthorn Group

At the site, the sediments of the Arcadia Formation-Hawthorn Group were identified between a depth interval of 210 and 730 feet bpl. From 210 to 460 feet bpl, the sediments were primarily olive green to greenish gray phosphatic sandy, and silty clays.

At 460 feet bpl, 10 feet of dolostone was encountered. The lithology from 470 feet to 674 feet bpl was predominately a sequence of limestone (packstone)

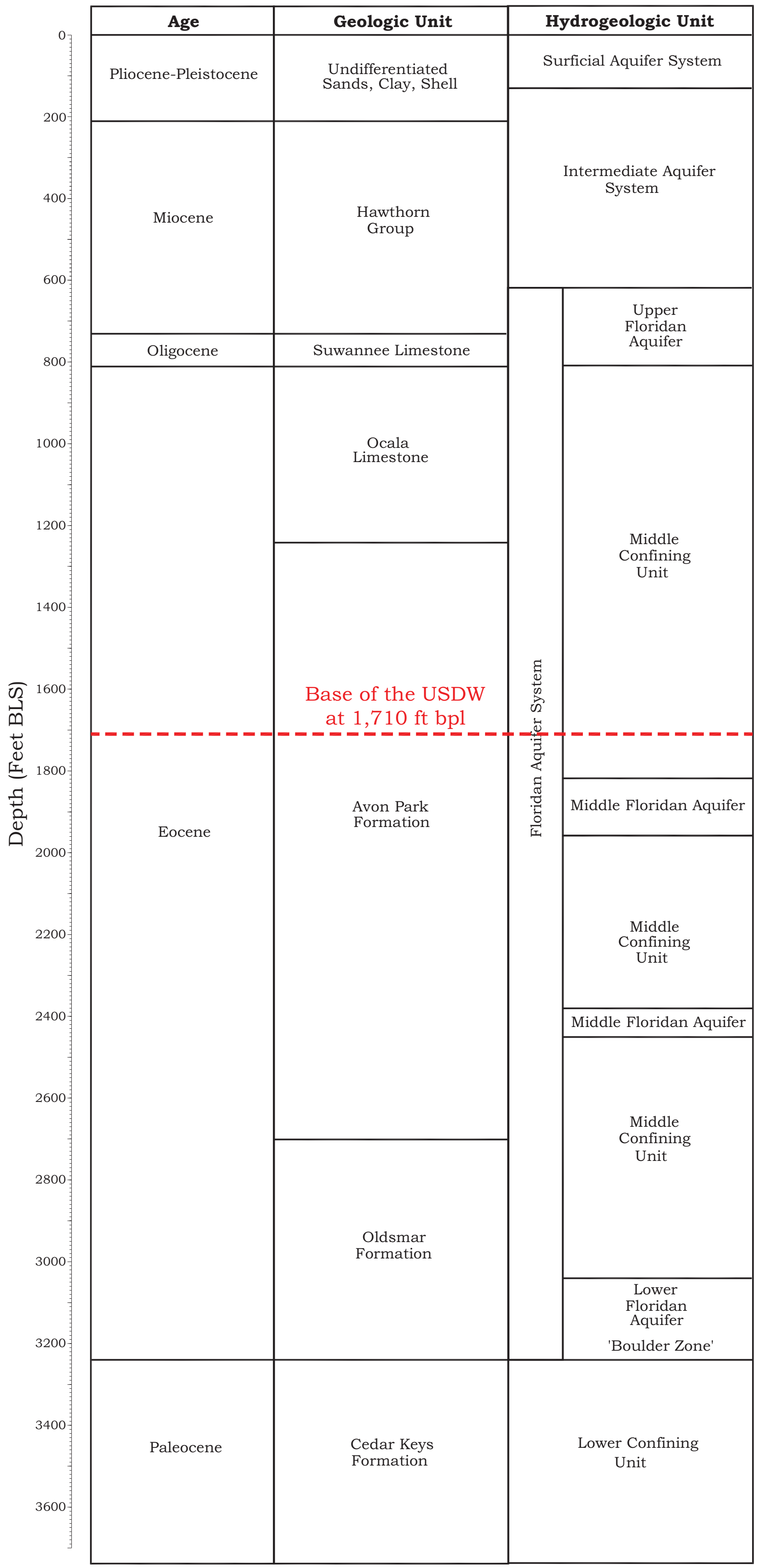

FIGURE 5-1
GENERALIZED HYDROSTRATIGRAPHIC COLUMN

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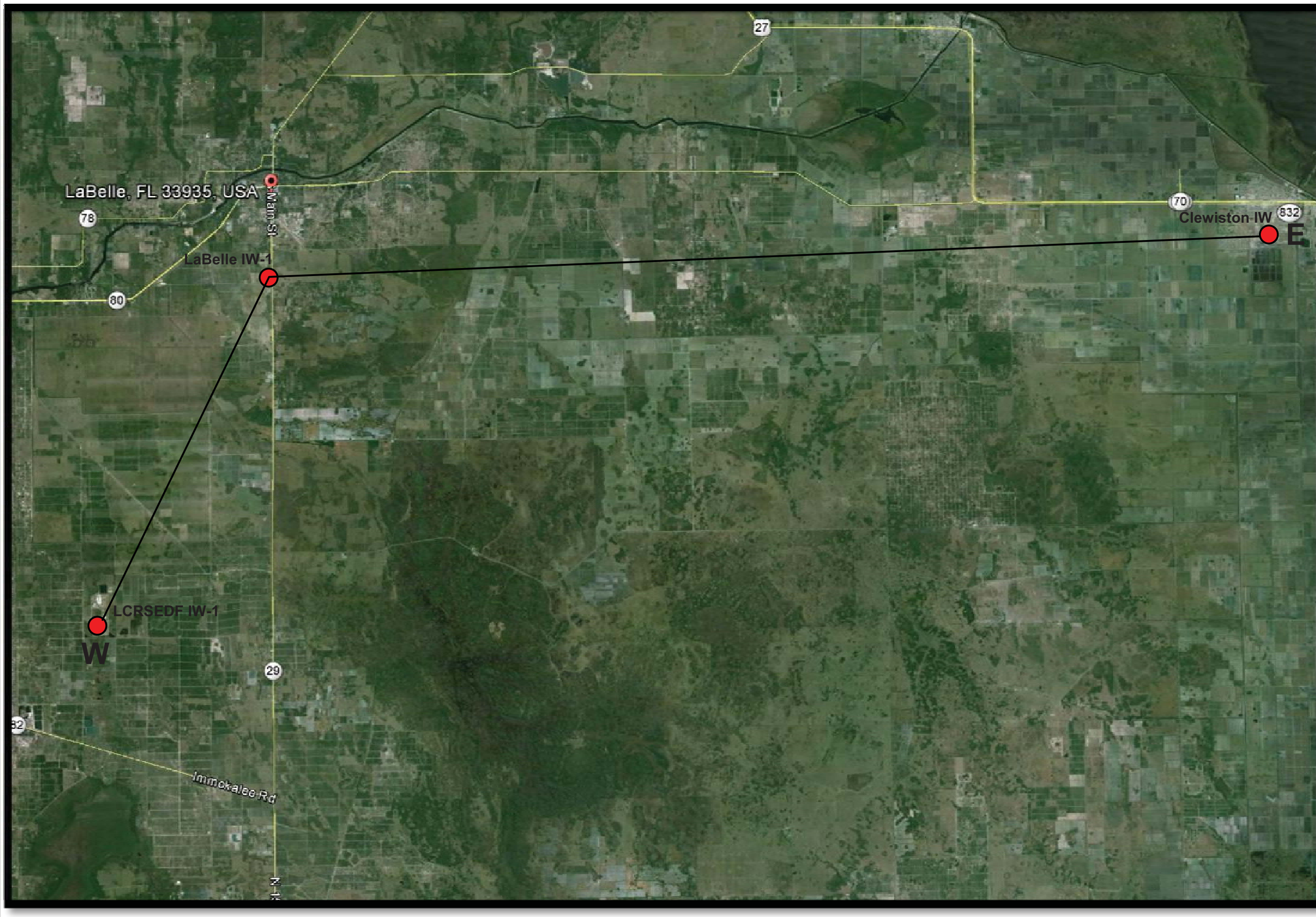

SCALE: 1 in = 5.6 mi

FIGURE 5-2
STRATIGRAPHIC CROSS-SECTION LOCATION MAP

CITY OF LABELLE
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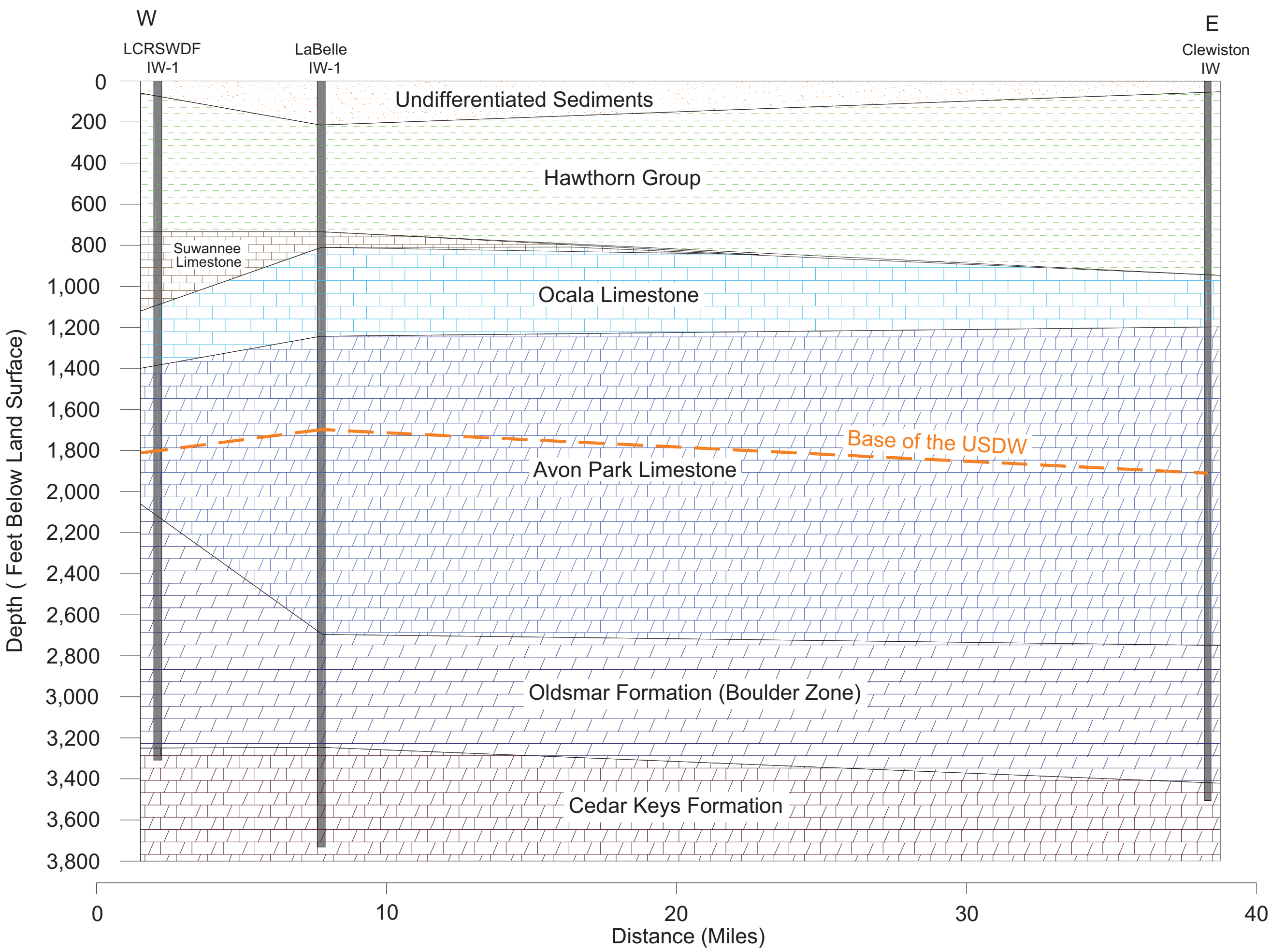

NOTE: LCRSWDF denotes Lee County Regional Solid Waste Disposal Facility

FIGURE 5-3 **WEST-EAST STRATIGRAPHIC CROSS-SECTION**	CITY OF LABELLE LABELLE, FL DATE: 3/17/14	Murray Consultants, Inc. Water Resource Consulting 769 Skyview Dr. Hayesville, NC 828-389-2476

Table 5-1: Depth of Formation Tops and Major Features at City of LaBelle IW-1 Compared to a Nearby Injection Well

Formation	Projected Depths at LaBelle IW-1 (feet bpl)	Actual Depths at LaBelle IW-1 (feet bpl)	LCRSWDF* (feet bpl)
Pliocene-Pleistocene	0	0	0
Hawthorn Group	200	210	60
Suwannee Limestone	750	730	730
Ocala Limestone	850	810	1,120
Avon Park Formation	1,140	1,240	1,400
Oldsmar Formation	2,500	2,700	2,060
Cedar Keys Formation		3,240	3,240
Additional Information			
Base of USDW	1,680	1,710	1,810
Boulder Zone	3,400	3,040	2,400
Final Casing Depth	3,400	2,542	2,396

* LCRSWDF denotes Lee County Regional Solid Waste Disposal Facility

and light to medium gray clays. The basal portion of the Arcadia Formation consists of yellowish gray carbonate sand and minor clays that occur from 674 to 730 feet bpl.

5.2.3 Oligocene

Suwannee Limestone

The Suwannee formation unconformably underlies the Hawthorn Group at 730 feet bpl. The Suwannee Limestone consists primarily of grayish orange to yellowish gray packstones. The base of the Suwannee Limestone is a well-indurated phosphate-free packstone. The total thickness of the Suwannee formation at the site is about 80 feet.

5.2.4 Eocene Series

Ocala Limestone

The Ocala Limestone was encountered at a depth of 810 feet bpl. This stratigraphic unit unconformably underlies the Suwannee formation. It consists primarily of yellowish gray to very pale orange, poorly to moderately indurated wackestones and packstones. The Ocala formation is marked by the first appearance of the Ocala index fossil, Lepidocyclina ocalana; other foraminifera, particularly *Nummulites* sp. and *Amphistegina* sp. are present. The base of the Ocala Limestone consists of dolomitic limestone and was picked at 1,240 feet bpl due to the lack of index fossils below that depth. The Ocala formation is about 430 feet thick at the site.

Avon Park Formation

The top of the Avon Park Formation is identified at a depth of 1,240 feet bpl. At this depth, a lithologic change occurred with a change in fossil assemblage and an increase in natural gamma-ray activity. The first observed diagnostic microfossil (*Dictyoconus* sp.) in formation samples was noted at a depth of 1,400 feet bpl. The Avon Park Formation from 1,240 to 1,680 feet bpl consists predominantly of moderately indurated, yellowish gray to very pale orange wackestone and packstone units with minor to moderate crystallization. At a depth of 1,680 feet to 1,960 feet bpl, a brownish crystalline dolostone was encountered. Below 1,960 feet bpl a limestone sequence containing layers of moderately indurated grainstones, dolostone, and dolomitic limestones were observed. At a depth of 2,475 feet bpl, anhydrite was observed in the drilled cutting samples. *Dictyoconus* sp., a diagnostic microfossil of the Avon Park Formation, was noted throughout the Avon Park formation samples to a depth of 2,700 feet bpl.

Oldsmar Formation

The Oldsmar formation unconformably underlies the Avon Park formation at the site. It was encountered at a depth of 2,700 feet bpl. The upper 340 feet consists of relatively low porosity to vugular porosity, very pale orange dolomitic limestones. At the depth of 3,040 feet bpl, the lithology changes to a predominately pale-yellowish brown dolostone and some dolomitic limestone, with minor anhydrite from 3,220 to 3,240 feet bpl. The total thickness of the Oldsmar formation at the site is 540 feet.

A characteristic 'boulder zone' of massively-bedded dolomite with extensive fracturing, solution features and cavities was not encountered. Minor fractures and solution features are present from 3,100 to 3,260 feet bpl. This zone is considered the injection zone. The geophysical logs also indicate that the major flow zone is within this same area.

5.2.5 Paleocene

Cedar Keys Formation

The Cedar Keys Formation was encountered at 3,240 feet bpl and consists predominately of white to light gray anhydrite and light olive gray dolomitic limestone. This continued to the total depth of the hole at 3,737 feet bpl.

5.3 Hydrogeology

As indicated on **Figure 5-1**, those zones which serve as water supply sources in the LaBelle area include the undifferentiated Holocene-Pleistocene deposits (water-table aquifer), and the Hawthorn Group (Sandstone, Mid and Lower Hawthorn aquifers). Of these, the water-table, the Sandstone aquifer, and the Lower Hawthorn aquifer, are the most important sources of supply. All of these aquifers are separated from the injection zone by intervening confining zones of significant thickness.

There are three major aquifer systems that underlie the project site: the Surficial Aquifer System (SAS), the Intermediate Aquifer System (IAS), and the Floridan Aquifer System (FAS). These aquifer systems are composed on multiple, discrete aquifers separated by low permeability "confining" units that occur throughout this Tertiary/Quaternary age sequence. Generalized hydrostratigraphic columns were presented in **Figures 2-3**, **3-1**, and **5-1**. The aquifers found at the site are briefly described below.

5.3.1 Surficial Aquifer System

The SAS consists of the water table aquifer and extends from land surface to about 130 feet bpl. An unconfined, water table aquifer was present within the upper 50 feet of unconsolidated material. From 50 feet to 130 feet bpl, pale olive to dark greenish gray clay was encountered forming a low permeablilty aquifer base.

The SAS is the main source of drinking water in Hendry County. Water level elevations and flow direction of groundwater within the system generally conform to the topography, flowing from higher to lower elevations. Ponds, lakes, and canals in the area act as discharge points for the water table aquifer.

5.3.2 Intermediate Aquifer System

The IAS was encountered between depths of 130 to 620 feet bpl. The IAS is comprised of the Sandstone Aquifer and Mid-Hawthorn Aquifer, mostly within the Hawthorn Group. The Sandstone Aquifer is semi-confined above from the overlying SAS by low permeable layers of sandy clay. The Sandstone Aquifer is a major source of water for irrigation and domestic self-supply in Western Hendry County. The Sandstone Aquifer was encountered from approximately 130 to 210 feet bpl. The Mid-Hawthorn Aquifer was not apparent at the site. Overall, the Hawthorn Group sediments in the area act as a confining unit overlying the highly productive zones of the Upper Floridan Aquifer (UFA).

5.3.3 Floridan Aquifer System

The term “Floridan Aquifer” was established by Parker et al. (1955) to describe water-bearing rocks associated with the Avon Park Formation, Ocala Limestone, Suwannee Limestone, Tampa Limestone, and permeable parts of the Hawthorn Group which are in hydrologic contact with the underlying units. Miller (1986) defined the FAS as “a vertically continuous sequence of carbonate rocks of generally high permeability that are mostly of middle and late Tertiary age and hydraulically connected in varying degrees and whose permeability is in general, an order to several orders of magnitude greater than that of those rocks that bound the system above and below.” At the site the FAS consists of a thick sequence of Tertiary limestone and dolostones within the lower Arcadia Formation-Hawthorn Group, Suwannee Limestone, Ocala Limestone, Avon Park Formation, and the Oldsmar Formation. The FAS was encountered between depths of approximately 620 to 3,240 feet bpl. It is comprised of several distinct producing zones and confining units.

Upper Floridan Aquifer

At the site, the top of the FAS was identified at a depth of 620 feet bpl, within the basal portion of the Arcadia Formation. The UFA was identified in the interval from 620 to 810 feet bpl. Two zones of high permeability were identified within the Upper Floridan. The first zone occurred from 635 to 675 feet bpl within the lower Arcadia Formation-Hawthorn Group. A second transmissive zone was noted from 730 to 760 feet bpl within the Suwannee Limestone.

Middle Confining Zone/Floridan Aquifer

The Middle Confining Zone is sometimes described as an inter-aquifer confining unit that contains several transmissive areas that are called the Middle Floridan Aquifer. This zone lies from 810 to 3,040 feet bpl. Between 810 to 1,820 feet bpl, there is the first low permeability carbonate section with confining properties. This section consists of poorly indurated mudstone and wackestone and is part of the Middle Confining Zone. From approximately 1,820 to 1,960 feet bpl, a sequence of fractured cryptocrystalline dolostone is present and is part of the Middle Floridan Aquifer. This transmissive zone is underlain by another dense, low permeable, microcrystalline, dolomitic limestone zone. This dolomitic sequence between 1,960 to 2,380 feet bpl is also part of the Middle Confining. Another transmissive area occurs from 2,380 to 2,450 feet bpl. The final confining area lies from 2,450 to 3,040 feet bpl. Minor amounts of anhydrite and gypsum are present from 2,475 to 2,690 feet bpl. The Middle Confining Zone confines the upper permeable aquifers from the Lower Floridan Aquifer (LFA).

Lower Floridan Aquifer

Below the Middle Confining Zone, between 3,040 to 3,240 feet bpl, is the LFA. This aquifer occurs in the lower part of the Oldsmar Formation. Groundwater in the LFA compares to the chemical nature of modern seawater. Minor to moderate fracturing was encountered during drilling and some horizons exhibited vuggy porosity. The BHC w/VDL logs supported the visual observations recorded on the video survey indicating higher porosity at 3,040 to 3,240 feet bpl. There were no 'cavities' encountered that is normally seen in the 'Boulder Zone." The LFA is the 'injection zone' for this well.

Below the LFA, massive anhydrite was encountered from 3,240 to 3,340 feet bpl. This marks the top of the Lower Confining Unit (Miller, 1986) that occurs in the Cedar Keys Formation. Dolostone, dolomitic limestone, and anhydrite comprised the remainder of the drilled hole to 3,737 feet bpl.

5.4 Groundwater Quality

Based upon the water quality analyses performed on groundwater samples obtained from packer testing, as well as from geophysical log interpretation data, the base of the USDW was found at an approximate depth of 1,710 feet bpl in DZMW-1. **Tables 4-2 and 4-3** present a summary of TDS, conductivity, and dissolved chloride concentrations versus depth for the packer test intervals, the monitoring intervals in DZMW-1, and the injection zone in IW-1. **Table 4-5** presents a summary of the inorganic portion of the Primary and Secondary Drinking Water analyses conducted on groundwater samples obtained from the monitoring zones in DZMW-1 and the injection zone in IW-1. The complete Primary and Secondary Drinking Water analyses are contained in **Appendix L**.

Water samples were collected at 10-foot intervals from the reverse-air discharge stream during the drilling of the IW to about 2,000 feet bpl. These water samples were analyzed for conductivity, with some analyzed for chloride concentration and TDS. However, as previously described, because fresh water was added to the rig fluid circulation tanks at various rates throughout most of the drilling operations, the water samples obtained from the reverse air discharge stream tend to be non-representative of the native water in the formations penetrated. A complete set of water quality analyses for samples obtained from the reverse-air discharge stream is also contained in **Appendix N**.

5.5 Injection Zone

As described in previous sections of this report, the injection zone selected for the LaBelle injection well is the interval from 3,040 to 3,240 feet bpl. The 16-inch diameter injection tubing was set at a depth of 2,542 feet bpl in IW-1. The top of the first permeable zone below the casing is at 3,040 feet bpl. The native water quality in the injection zone has a TDS concentration of 35,508 mg/l. The injection zone is overlain by low permeability confining units of considerable thickness. A quantification of the transmissivity of the injection zone is provided in a subsequent section of this report (6.3).

5.6 Monitoring Zones

Based on the lithology and water quality encountered during the drilling of DZMW-1, the two monitoring zones were constructed as follows:

Upper Zone: 1,648 to 1,695 feet bpl

Lower Zone: 1,900 to 1,938 feet bpl

The upper monitoring zone is in the middle part of the Avon Park formation. The un-cemented annulus between the nominal 16-inch intermediate casing and the 6.625-

inch OD lower tubing allows groundwater emanating from the upper monitoring zone to be sampled at the surface. Hydrostatic pressure in the relatively fresh upper monitoring zone is sufficient to allow the well to flow at approximately 20 gallons per minute (gpm).

The lower monitoring zone is also within the Avon Park Formation. The open-hole section of the DZMW below the 6.625-inch OD lower tubing allows for groundwater entering the well to be sampled from inside the 6.625-inch diameter tubing. This zone can be pumped at a rate of approximately 10 gpm.

5.7 Confinement Analysis

Documentation of confinement is required by Specific Condition 6.c.(5) of the FDEP Construction Permit, and provides reasonable assurance that the injected water will not migrate into overlying sources of drinking water. Confinement is provided by strata having low vertical hydraulic conductivity, the physical property indicating the ability of the rock to transmit water. Confinement is evaluated qualitatively based on observed physical characteristics of the rocks and quantitatively based on mechanical and geophysical properties of the rocks. The direct measurement of vertical hydraulic conductivity is obtained from core analysis. The location and thickness of confining units which overly the injection zone were evaluated by a variety of methods discussed below to demonstrate that the injection zone is hydraulically separated from the USDW. The presence of satisfactory confining sequences located between approximately 2,550 and 3,315 feet bpl was initially documented in the IW-1 Final Casing Seat Selection Request letter submitted to the Technical Advisory Committee (TAC) on May 31, 2013.

5.7.1 Criteria Used for Identification of Confining Units

Confining beds or rock intervals that are likely to offer good vertical confinement were identified using the following criteria:

- Lithology consisting of dense, low permeability dolomite or limestone having low macro-porosity (i.e., visible pore spaces) and a high degree of cementation (hardness) as observed in examination of cuttings and core samples.
- Relatively gauge borehole diameters observed on the video and documented on caliper logs, indicating solid competent formation materials. Fractured dolomite and limestone is commonly manifested by an enlarged borehole.
- Absence of fractures on the video survey or borehole televiewer log.
- Absence of flow indicators on the flowmeter logs.
- Low sonic transit times (DT) and derived sonic porosities.
- Variable Density Logs (VDL) having consistent, parallel, banded or chevron pattern reflections.

- Low transmissivities calculated from the Packer Test data.
- Low hydraulic conductivities determined from Core Analyses.

The confinement properties of the strata between the base of the USDW (approximately 1,710 feet bpl) and 2,550 feet bpl were evaluated using the above criteria and data. Additionally, confinement between the bottom of the casing and the injection zone (3,040 feet bpl) was encountered and evaluated with the same criteria. In general, the criteria listed above starts with generally qualitative data (lithologic, video, and core descriptions) and ends with available quantitative data (geophysical logs, core laboratory analysis, and packer testing) for this evaluation. Lithologic logs are presented in **Appendix D**, core descriptions and analyses are presented in **Appendix M**, geophysical logs are presented in **Appendix J,** and packer test flow data is presented in **Appendix K**. A summary of the confining units identified at the project site is provided in **Table 5-2,** including depth interval, thickness, and hydraulic properties determined from geophysical logs, packer tests, and core analysis that indicate confinement.

Table 5-2: Description of Confinement

Unit	Depth Interval (feet bpl)	Thickness (feet)	Packer Test Hydraulic Conductivity (cm/sec (ft/d)) and Test Number	Sonic Porosity (p.u.)	Sonic Transit Time (µsec/ft)	Core Data		
						Core Number	Porosity (%)	Vertical Hydraulic Conductivity (cm/sec (ft/d))
A	1,850 to 1,910	60	-	5	52	-	-	-
B	2,118 to 2,138	219	-	33	95	1	28-33	2.8e-05 (8.0e-02)
	2,196 to 2,213		-	20	80	2	32.5	1.1e-04 (3.1e-01)
	2,278 to 2,295		3.0e-06 (8.1e-03) PT 8	29	85	-	-	-
	2,322 to 2,337		-	25	84	3	24.8	1.3e-05 (3.7e-02)
C	2,400 to 2,410	10	-	22	80	4	22-30	1.9e-05 (5.2e-02)
D	2,477 to 2,487	29	-	7	65	5	21.8	5.9e-06 (1.7e-02)
	2,487 to 2,498		-	15	70	6	11-25	2.0e-06 (5.7e-03)
	2,489 to 2,506		3.3e-06 (9.5e-03) PT 6	15	70	-	-	-
Total		**318**						
E	2,586 to 2,596	10	-	12	70	7	5.5	1.9e-08 (5.4e-05)
F	2,641 to 2,658	17	5.1e-06 (1.5e-02) PT 7	20	75	-	-	-

The confining units are identified by letter designation A through F. Units A through D comprise the total confinement above the injection zone, while Units E and F represents a confining unit between the bottom of the casing and the injection zone. The total thickness of the confining units above the injection zone is approximately 318 feet.

5.7.2 Confinement Analysis

Examination of the drill cuttings indicates the presence of a moderately to well indurated, low to medium porosity, dolomitic limestone with occurrences of dolostone over the entire interval between the intermediate casing seat at 1,798 feet and the final casing depth at 2,552 feet bpl. In this interval, the lithology is generally fine to microcrystalline, vuggy, low permeability dolomitic limestone and dolostone (Units A through G), with minor interbedded low porosity limestone. Core samples collected from Core No. 7 (2,586 feet to 2,596 feet bpl) consists of dense dolostone, as described in **Appendix M**. Low vertical hydraulic conductivity values were obtained from these cores during core analysis as discussed below.

Competent, gauge borehole is indicated on the XY caliper log between 1,850 to 1,910 feet bpl (Unit A), 1,990 to 2,020 feet bpl, 2,400 to 2,410 feet bpl (part of Unit B), 2,477 to 2,506 feet bpl (Unit C), 2,530 to 2,580 feet bpl, 2,586 to 2,600 feet bpl (Unit D), and 2,670 to 2,720 feet bpl. The borehole video survey confirms the presence of dense dolomitic limestone and dolostone intervals between 1,950 and 2,500 feet bpl. The intervals appear as a generally gauge hole (XY caliper) with a smooth to rough texture as a result of a moderate to high occurrence of vugs. The video log also indicates that rock intervals between the confining sequences described in **Table 5-2** contains some fractured and vuggy horizons. Anhydrite infilling started at about 2,530 feet bpl. Fractured or minor cavernous intervals are present from 2,250 to 2,260 feet bpl, 2,380 to 2,400 feet bpl, and 2,550 to 2,600 feet bpl. Vertical fissures and bedding plane features appear to be localized and should not impact the overall integrity of the confining sequences identified.

The flowmeter log indicates that no significant contributions to flow occur above 3,040 feet bpl. The significant flow zone is present from 3,040 to 3,200 feet bpl, and a minor flow zone is present at approximately 2,700 feet. Between 2,550 and 2,700 feet bpl, there do not appear to be any zones present that are contributing flow to the borehole.

Sonic transit times (DT) ranging from 50 to 90 μs/ft are indicated in the BHCL over much of the interval between the base of the Intermediate Casing and the Final Casing setting depth. Transit times less than 60 μs/ft are present in the intervals from 1,860 to 1,910 feet bpl (Unit A), 1,920 to 1,940 feet bpl, 2,022 to 2,024 feet bpl, and 2,525 to 2,540 feet bpl for a total of 87 feet. A transit time of less than 60 μs/ft is indicative of dense, low permeability dolomite. Consistent parallel reflections on the VDL track were most notable from 2,220 to 2,240 feet bpl (Unit B), 2,250 to 2,300 feet bpl (Unit B), 2,480 to 2,500 feet bpl (Unit C), and 2,610 to 2,700 feet bpl. The major geophysical logs of IW-1 are presented in **Figure 5-4**.

Straddle-packer tests were conducted from 2,278 to 2,295 feet bpl (Packer Test No. 8) and 2,489 to 2,506 feet bpl (Packer Test No. 6) to determine the hydraulic properties of the isolated intervals and quantify discrete-horizon water quality. Packer Test No. 8, conducted in Unit A and Packer Test No. 6 conducted in Unit C, yielded low hydraulic conductivity values of 8.1e-3 and 9.5e-3 ft/d, respectively, as shown in the packer test data listed in **Tables 4-2** and **5-2**. Straddle-packer testing data with water sample analyses are included in **Appendix K**.

Conventional cores were recovered in confining Units B, C, and D, and provide direct measurements of porosity and vertical permeability. The cores were collected at the depth intervals of 2,118 to 2,138 feet bpl, 2,196 to 2,213 feet bpl, 2,322 to 2,337 feet bpl, 2,400 to 2,410 feet bpl, 2,477 to 2,487 feet bpl, 2,487 to 2,498 feet bpl, and 2,586 to 2,596 feet bpl, and confirmed the presence of well-indurated dolostone and limestone with low visible permeability. Vertical hydraulic conductivities measured from cores recovered within the confining sequences ranged from 1.1e-4 cm/sec to 1.9e-8 cm/sec (3.1e-1 to 5.4e-5 ft/d).

5.7.3 Confinement Summary

The combined hydrogeological, geological and geophysical data provide reasonable assurance that confinement exists between the base of the USDW and the top of the injection zone. The summary of confinement presented in **Table 5-2** lists six units of variable thickness, having a total thickness of 345 feet. The units exhibit hydraulic properties that are characteristic of sediments that act as confinement and restrict the vertical movement of water.

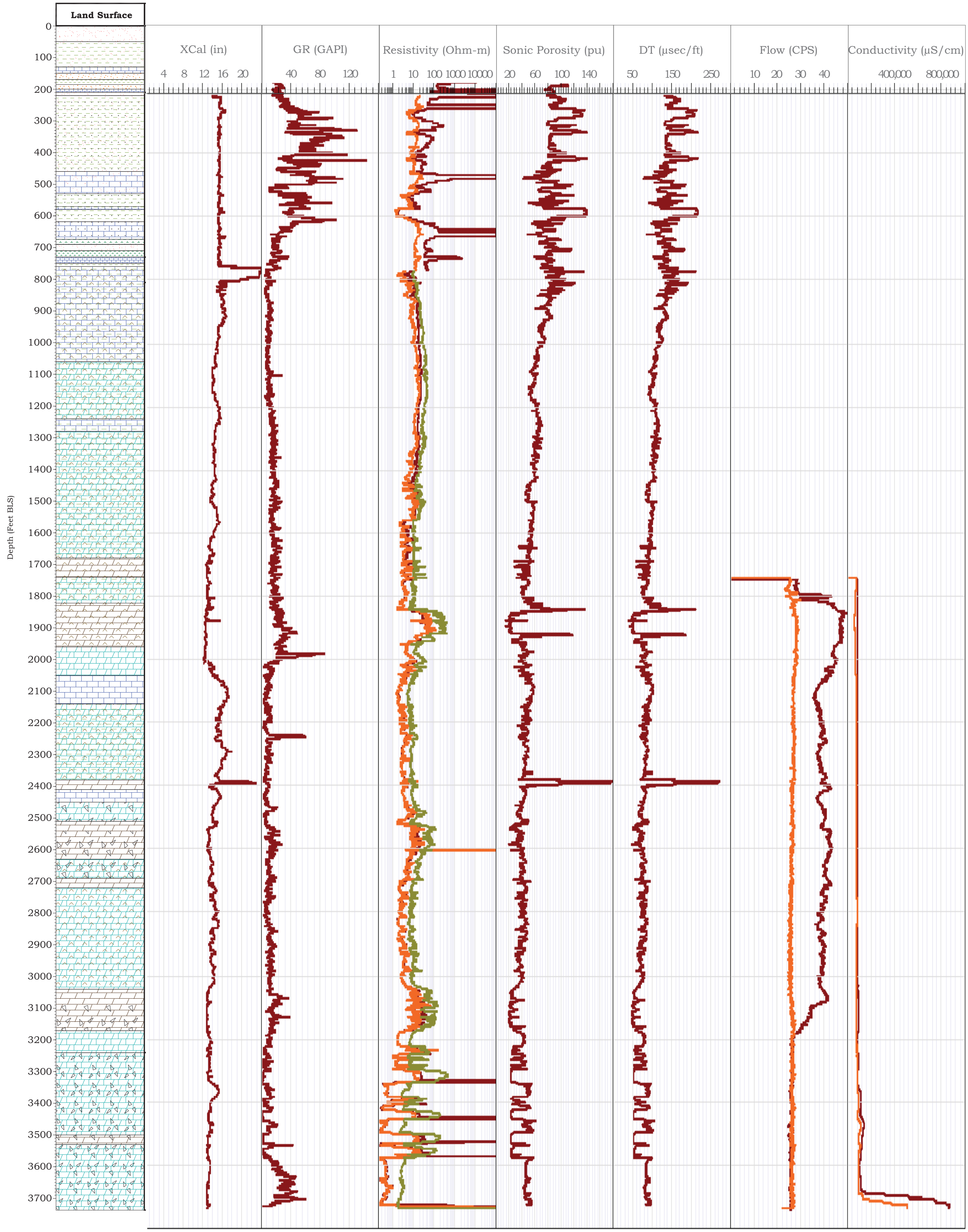

FIGURE 5-4
MAJOR GEOPHYSICAL LOGS OF IW-1

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6.0 Well Testing Program

6.1 Casing Pressure Tests

Pressure tests were conducted in the IW on the following occasions:

- On the 34-inch OD steel intermediate casing on April 26, 2013, at 105.2 psi.
- On the 24-inch OD steel injection casing on July 16, 2013, at 155.5 psi.
- On the 16-inch FRP tubing /24-inch OD injection casing annulus on August 21, 2013, at 152 psi.

A FDEP representative witnessed the injection casing and annular pressure tests. No significant pressure decreases were noted during the one-hour tests (less that 5% change). The pressure test data for IW-1 is contained in **Appendix O**.

Pressure tests were conducted in the DZMW on the following occasions:

- On the 16-inch OD steel casing for the upper monitoring zone on September 3, 2013, at 150 psi.
- On the 6.625-inch OD RFP casing for the lower monitoring zone on September 12, 2013, at 100 psi.

No significant pressure decreases were noted during either one-hour tests (less that 5% change). The pressure test data for the DZMW is included in **Appendix O**. FDEP declined to witness the pressure tests on the DZMW.

6.2 Radioactive Tracer Survey

A radioactive tracer survey (RTS) was conducted in IW-1 on September 26, 2013. The test was conducted by YBI in accordance with the permitted specifications. No upward movement of the tracer slugs was noted during the various portions of the test. A copy of the geophysical log for the tracer survey is contained in **Appendix P.** In addition, copies of the radioactive solution laboratory calibration record and flowmeter calibration record are also provided in **Appendix P**.

6.3 Injection Test

A 24-hour injection test was conducted by YBI in IW-1 between 6:25 PM on October 4, 2013 and 6:25 PM on October 5, 2013. Prior to conducting the test, approximately 24 hours of background IW-1 wellhead and annulus pressure data and DZMW-1 (upper and lower zones) water level data were collected using pressure transducers and an automated data logger. The barometric pressure was recorded during background, injection, and recovery. Throughout the injection test, and for the first two hours of recovery, a geologist was on site to manually record the injection rate, injection pressure, and annular pressure for the injection well; and record the water levels in the DZMW and atmospheric temperature.

The source of water for the injection test was two RO Flordian Aquifer wells. These wells were tested for Primary and Secondary Drinking Water standards prior to the injection test, results in **Appendix L**. The RO wells pump at a rate of 1,500 gpm each. The wells discharge into the 16-inch diameter PVC raw water line that feeds into the RO plant. From the plant, YBI installed PVC pipe that connected to the injection well. YBI provided an in-line pump that could pump at least 5,000 gpm. An in-line recently calibrated flowmeter was installed in the pipe to the injection well with manual read capabilities. The installed gate valve on the injection well had to be manually opened and closed at the start and end of the injection test. It took three minutes to fully open and close the gate valve; consequently, at the start of the injection test the pumping rate was about 1,550 gpm. Based on the total gallons pumped, the average injection rate was 1,625 gpm.

The average injection rate for the injection test was 1,625 gpm. The injection wellhead pressure started at 21.5 psi and reached 64 psi within three minutes of injection. A maximum wellhead pressure increase of 43.42 psi (approximately 100.2 feet) was recorded during the injection test. No changes in water level were noted in either monitoring zone during the injection test. The pressure within the annulus appeared to increase or decrease depending on a combination of the water temperate and atmospheric temperature.

Recovery data was recorded in IW-1 for a period of approximately 12 hours after the injection test had been completed. Approximately 12 hours of water level data was also recorded in the two monitoring zones of the DZMW after the injection test had been completed. All water level data for the injection test is included in **Appendix Q**.

The pressure data for the injection well and DZMW from background through recovery and tidal height from Fort Myers are graphically represented in **Figure 6-1**. The DZMW water level data, barometric pressure, and tidal height are shown in **Figure 6-2**. IW-1 pressure changes and injection rate during the injection portion of the test are presented in **Figure 6-3**.

Formation transmissivity, based on the average injection rate, analysis of injection test data is in the range of 450,000 gpd/ft. The semi-logarithmic plot used to calculate a transmissivity value of 206,250 gpd/ft during injection is presented as **Figure 6-4**. The semi-logarithmic plot used to calculate a transmissivity value of 692,000 gpd/ft during recovery is presented as **Figure 6-5**. Averaging the transmissivity results for the injection portion of the test with the results of the recovery part of the test, an average transmissivity for the injection zone is approximately 450,000 gpd/ft.

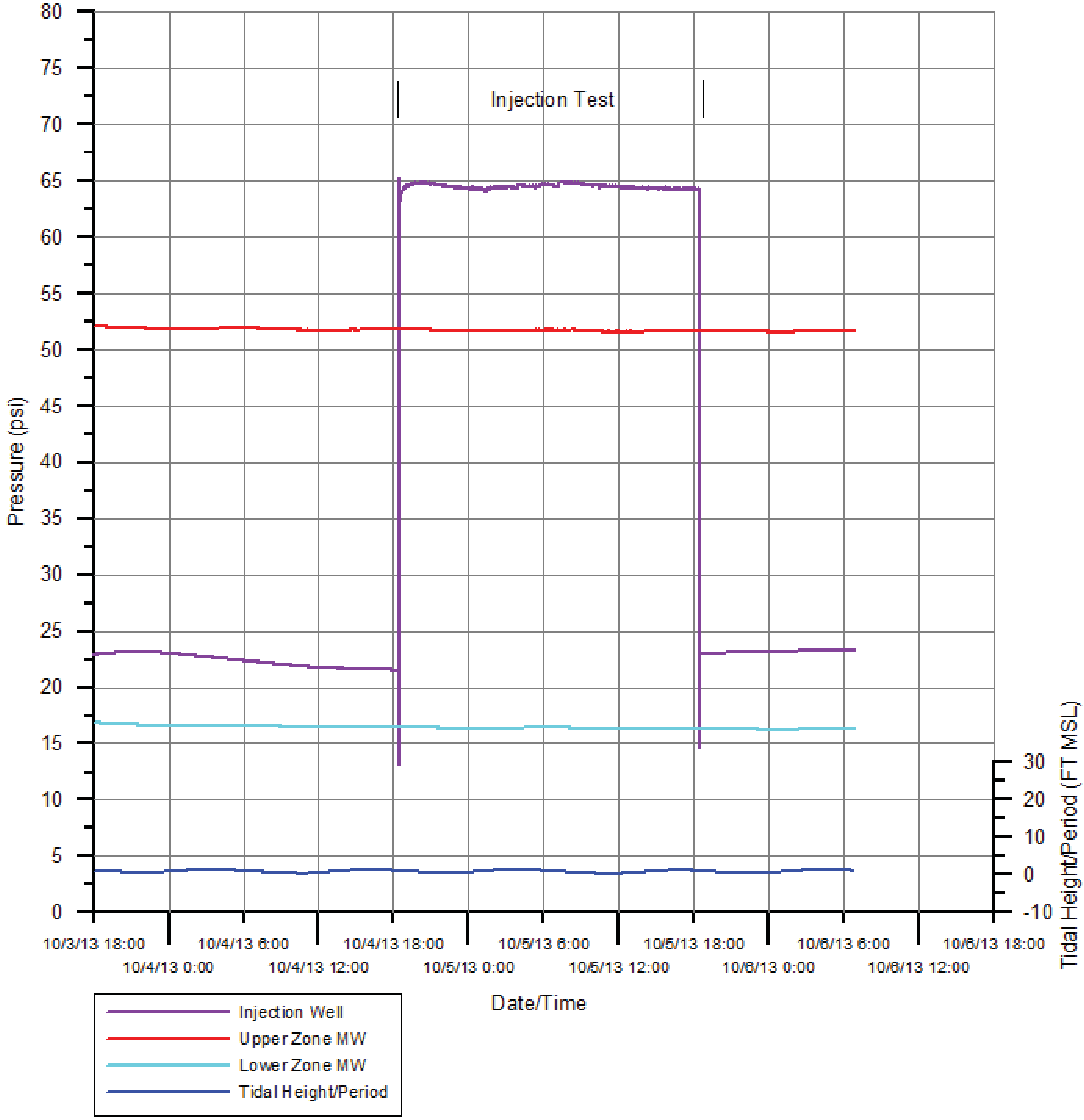

FIGURE 6-1
INJECTION TEST
PRESSURE DATA BACKGROUND THROUGH RECOVERY

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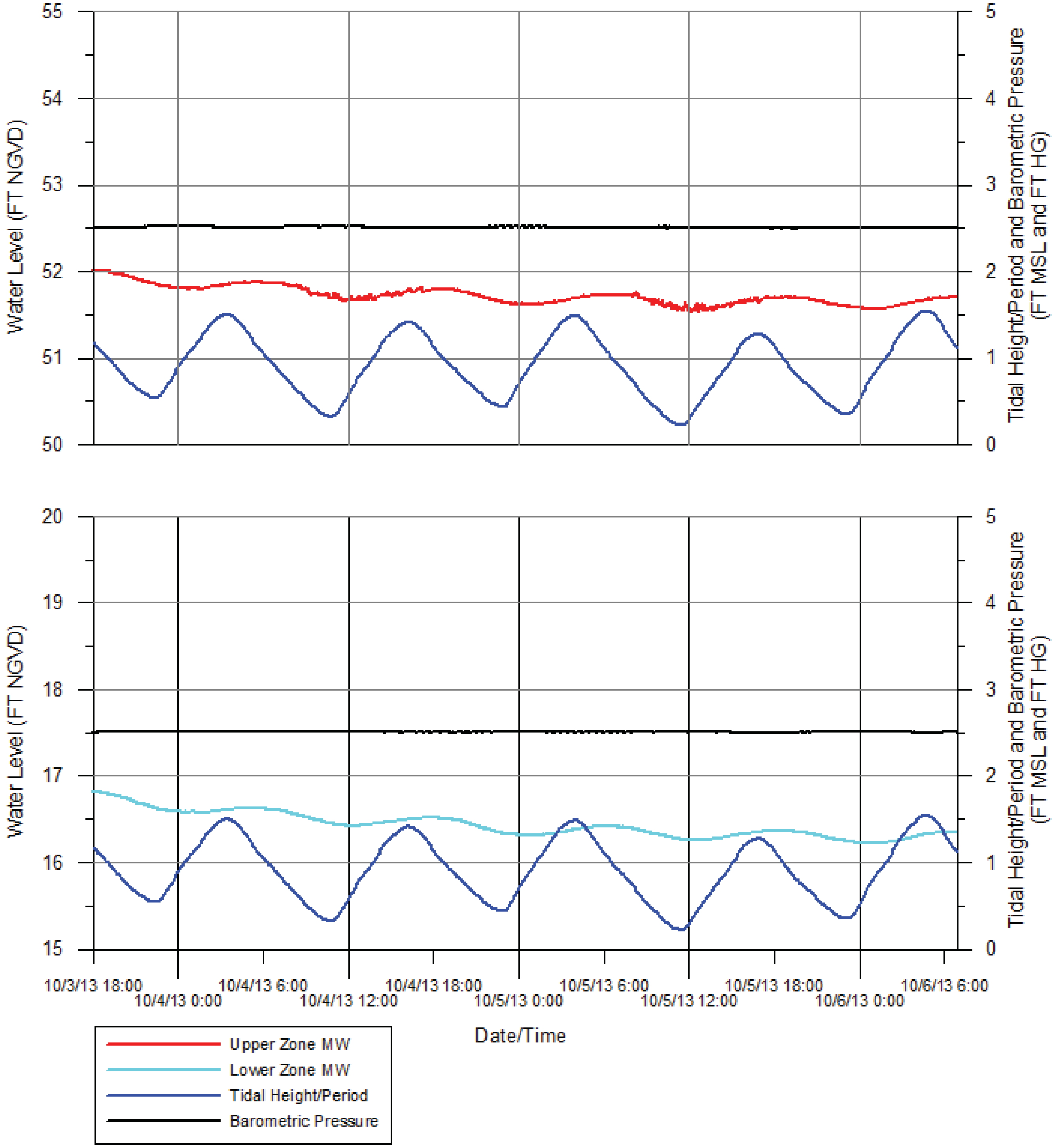

FIGURE 6-2
INJECTION TEST
DZMW WATER LEVEL, TIDAL HEIGHT, BAROMETRIC PRESSURE

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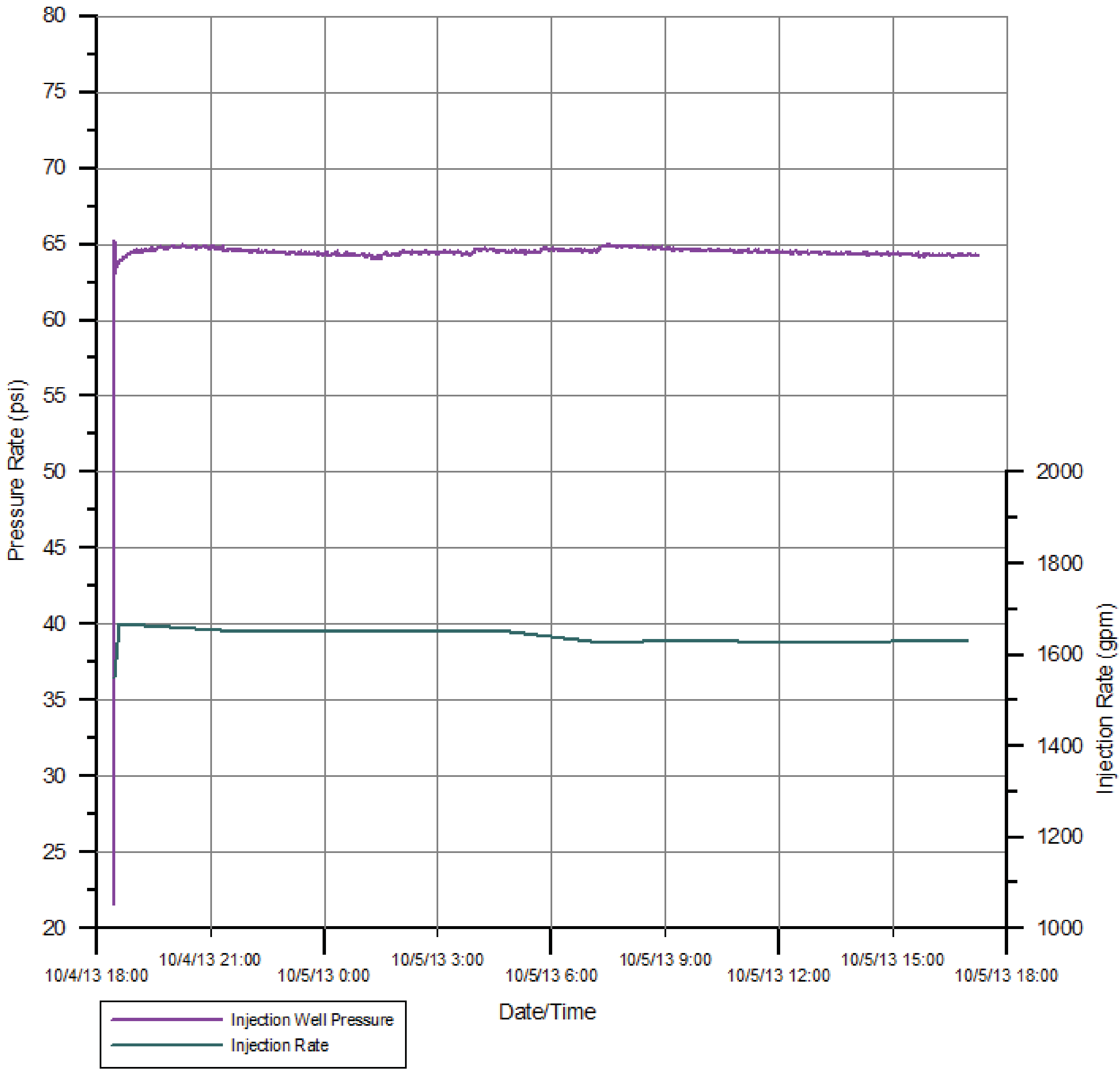

FIGURE 6-3
INJECTION TEST
INJECTION PRESSURE AND INJECTION RATE

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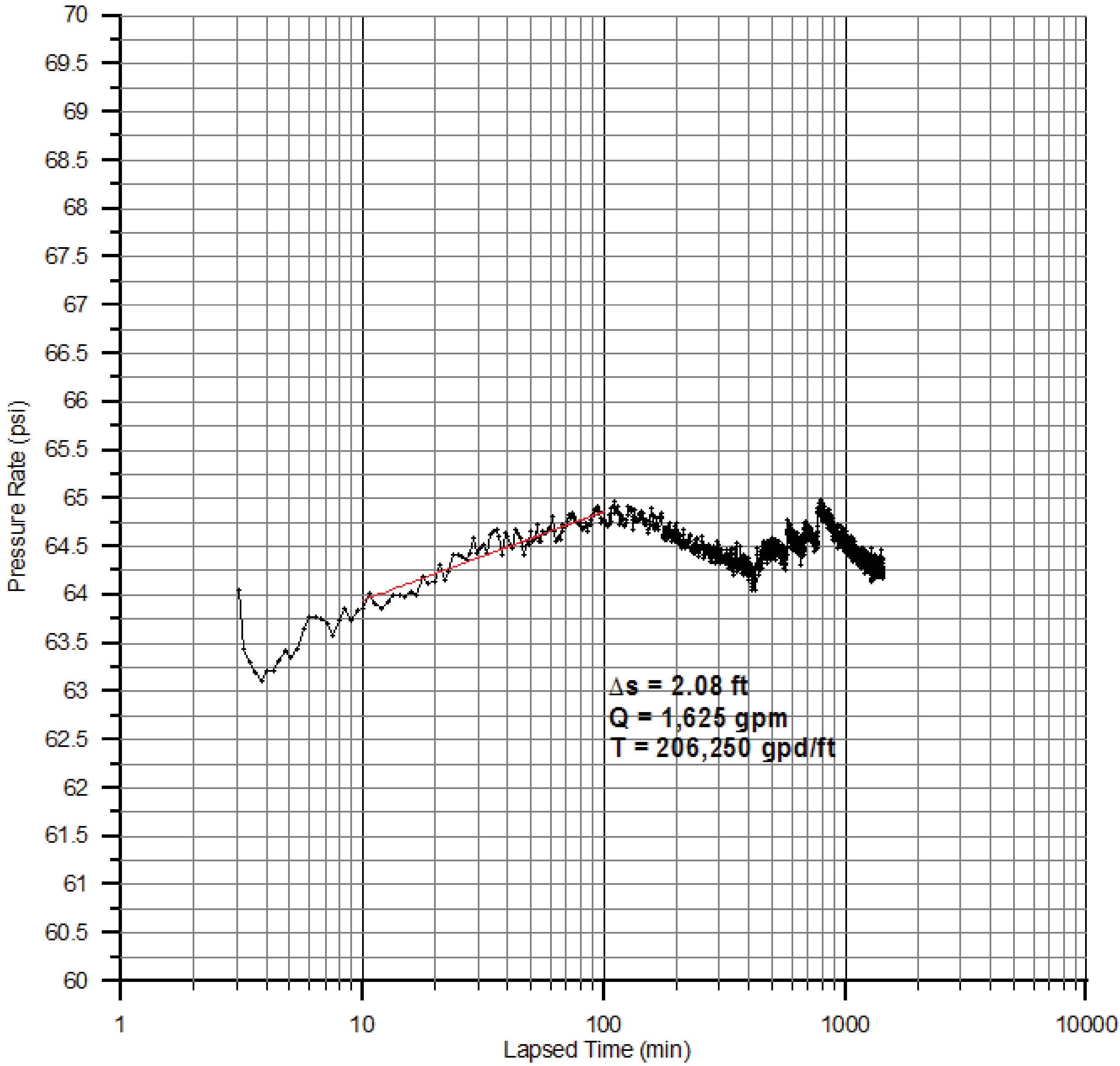

FIGURE 6-4
INJECTION TEST
SEMI-LOG PLOT OF INJECTION PRESSURE CHANGE VERSUS TIME

CITY OF LABELLE
LABELLE, FL
DATE: 3/17/14

Murray Consultants, Inc.
Water Resource Consulting
769 Skyview Dr.
Hayesville, NC
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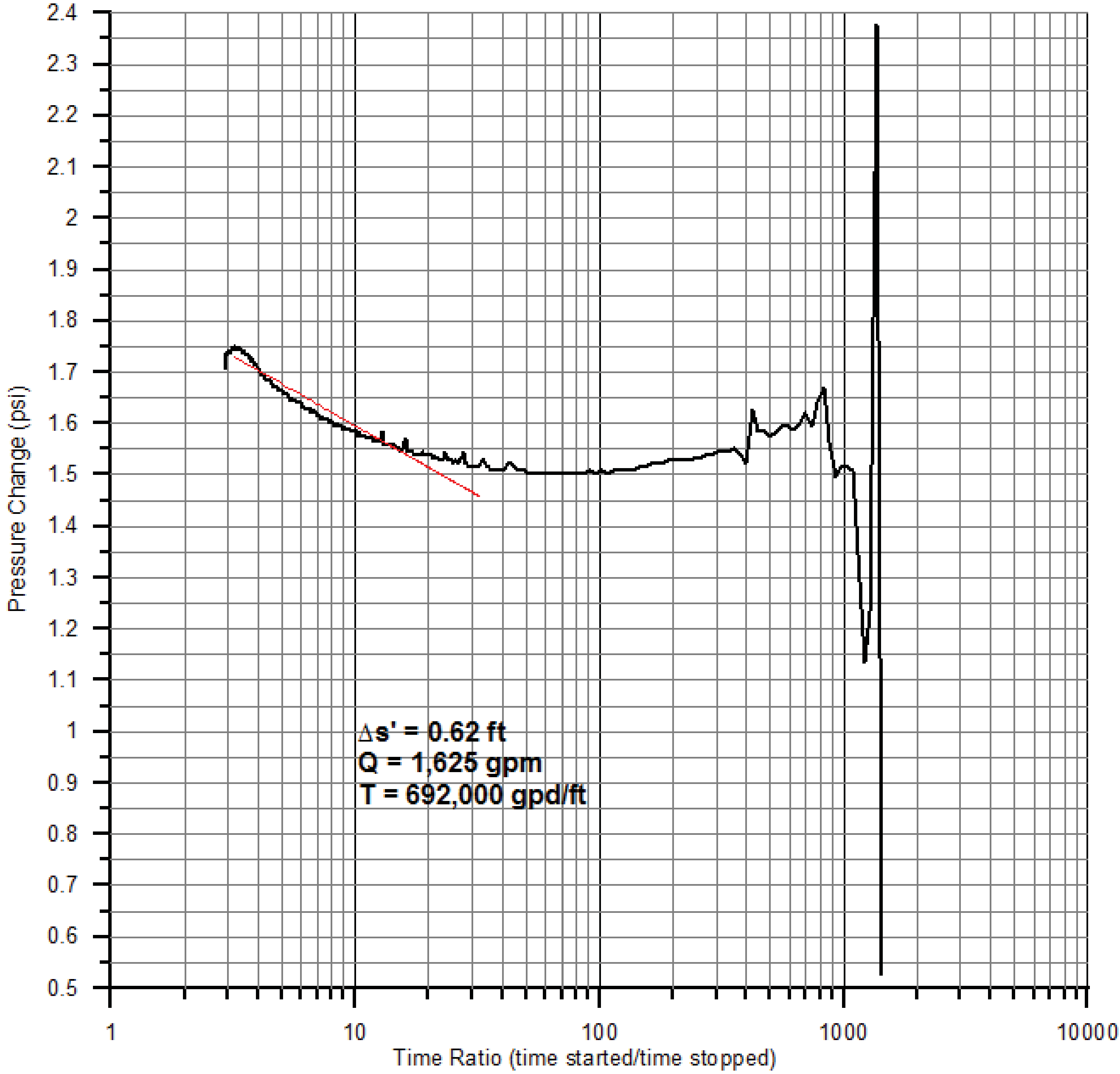

FIGURE 6-5 **INJECTION TEST** **SEMI-LOG PLOT OF RECOVERY VERSUS TIME STARTED/TIME STOPPED**	CITY OF LABELLE LABELLE, FL DATE: 3/17/14	Murray Consultants, Inc. Water Resource Consulting 769 Skyview Dr. Hayesville, NC 828-389-2476

7.0 Conclusions and Recommendations

7.1 Conclusions

The following list summarizes the findings identified during the construction of the LaBelle Deep Injection Well System.

- The base of the USDW, where the groundwater exceeds 10,000 mg/L TDS, occurs at 1,710 feet bpl at IW-1.
- The confining sequence above the injection zone occurs between 1,850 feet and 2,658 feet bpl, consisting of six primary confing units having a total thickness of approximately 345 feet.
- Vertical hydraulic conductivity determined from core analyses within the confining sequences ranges from 1.1e-4 to 1.9e-8 cm/sec or 3.1e-1 to 5.4e-5 ft/d.
- Hydraulic conductivities determined from packer testing within the confining sequences range from 1.5e-2 to 8.1e-3 ft/d.
- A moderately transmissive injection zone, containing highly saline water, occurs between approximately 3,040 and 3,240 feet bpl.
- The IW-1 final casing (24-inch diameter) was successfully pressure tested at 155.5 psi. The IW-1 FRP tubing (16-inch outer diameter) was successfully pressure tested at 152 psi.
- The Radioactive Tracer Survey, temperature log, and pressure testing results demonstrate that IW-1 has mechanical integrity.
- An injection test was performed on IW-1 at a rate of 1,625 gpm (3.2 ft/sec, 2.34 MGD) with an average injection pressure of 64 psi.
- The injection zone is capable of accepting a flow rate equivalent to a velocity of 3.2 feet per second in IW-1 at an injection pressure that will not initiate fractures in the injection zone or confining sequences.
- One dual-zone monitor well was drilled with an Upper Monitor Zone from 1,650 to 1,690 feet bpl, and a Lower Monitor Zone from 1,900 to 1,950 feet bpl.
- The presence of favorable geologic conditions, a moderately transmissive injection zone filled with water having greater than 10,000 mg/L TDS, suitable confining sequences, and suitable monitor zones will permit the use of the injection well for disposal of non-hazardous reverse osmosis concentrate water at the LaBelle WTP #2 in accordance with existing state and federal underground injection control regulations.

7.2 Recommendations

The following recommendations are in accordance with the requirements of FAC Rule 62-528 for the safe operation of an injection well system. These procedures should be carried out conscientiously to ensure compliance with the injection well construction permit (**Appendix A**) and all regulatory requirements and to ensure successful operation of the well. Additional information on monitoring and reporting data is discussed in **Section 7.3**.

- Dual-zone monitor well pressure is to be continuously monitored.
- Injection wellhead pressure is to be continuously monitored. The maximum pressure the well can be operated at is 103 psi, which is two-thirds the pressure at which the final casing was hydrostatically pressure tested (155.5 psi).
- Annular pressure to be continuously monitored.
- Flow to the injection well is to be continuously monitored. The maximum rate the well can be operated at is 1,625 gpm (2.34 MGD), based on the average pumping rate used during the injection test.
- Total volume injected to be monitored daily.
- Dual-zone monitor well water quality is to be monitored weekly/monthly.
- Injectate water quality is to be monitored monthly.
- Injection well injectivity tests are to be performed monthly.
- A complete analysis of the injectate is to be performed yearly.
- Injection well mechanical integrity tests are to be performed every five years.

7.3 Well Operation, Maintenance and Future Testing

When the injection well is operational, a variety of data will be collected to satisfy statutory/permit requirements and to assist in managing the system. This section discusses the basic requirements for data collection to maintain permit compliance during both the initial testing and long-term operation of the injection well system. Initially, the injection well will be operating under the construction permit. A minimum of six months of operation are required before the City can apply for an operating permit. The construction permit for IW-1 expires January 11, 2015. It is essential that the performance data collection begin upon operational startup to establish baseline information that both satisfies regulatory requirements and serves for future data comparison and performance analyses. These records should be permanently maintained.

7.3.1 Injection Well Data Collection

Records starting from FDEP's authorization to begin operational testing should be maintained to evaluate injection well performance. The pressure at the injection wellhead is to be continuously monitored and recorded. Daily, monthly average, maximum and minimum pressures are to be reported to FDEP monthly.

The flow rate into the injection well is to be continuously monitored and recorded. Daily average, maximum, and minimum flow rates, as well as the total volume of fluid pumped into the well are to be reported to the FDEP on a monthly basis. The pressure and flow monitoring requirements are listed in **Table 7.1** and in the construction permit.

During operational testing the injectate stream water quality is to be monitored through monthly sampling. Samples are to be collected from the injectate concentrate stream and analyzed as shown in **Table 7-1.** The results of these analyses are to be sent to the FDEP monthly.

Table 7-1: IW-1 Monitoring Requirements

Parameter	Units	Reporting Frequency
IW-1		
Injection Pressure	psi	Daily/Monthly
Maximum Injection Pressure	psi	Daily/Monthly
Minimum Injection Pressure	psi	Daily/Monthly
Average Injection Pressure	psi	Daily/Monthly
Annular Pressure	psi	Daily/Monthly
Maximum Annular Pressure	psi	Daily/Monthly
Minimum Annular Pressure	psi	Daily/Monthly
Average Annular Pressure	psi	Daily/Monthly
Flow rate	gpm	Daily/Monthly
Maximum Flow Rate	gpm	Daily/Monthly
Minimum Flow Rate	gpm	Daily/Monthly
Average Flow Rate	gpm	Daily/Monthly
Total Volume WTP Concentrate Injected	gallons	Daily/Monthly
Fluid added to/removed from Annulus	gallons	Daily/Monthly
Pressure added to/removed from Annulus	psi	Daily/Monthly
WTP Concentrate Water Quality		
Specific Conductance	µmhos/cm	Monthly
Total Dissolved Solids	mg/L	Monthly
pH	std units	Monthly
Chloride	mg/L	Monthly
Sulfate	mg/L	Monthly
Field Temperature	°C	Monthly
Total Kjeldahl Nitrogen (TKN)	mg/L	Monthly
Sodium	mg/L	Monthly
Calcium	mg/L	Monthly
Potassium	mg/L	Monthly
Magnesium	mg/L	Monthly
Iron	mg/L	Monthly
Bicarbonate	mg/L	Monthly
Radium 226	pCi/L	Monthly
Radium 228	pCi/L	Monthly
Gross Alpha	pCi/L	Monthly

Sampling is only required during those months in which the WTP concentrate is injected

7.3.2 Monitor Well Data Collection

The purpose of monitor zone data collection is to detect changes in water quality attributable to the injection activities into the associated injection well. To collect the water quality samples, the monitor zones at the dual-zone monitoring well will be equipped with two sampling pumps, one for each zone. Interconnection of piping from the different zones and wells is not permitted by FDEP. Prior to collecting water samples for analysis, at least three well volumes are to be pumped from the monitor zone.

Dual-zone monitor well water quality is to be monitored through weekly and monthly samples collected from the two dual-zone monitor well zones. Samples are to be collected and analyzed as shown in **Table 7-2.** The results of these analyses are to be sent to the FDEP monthly. The pressure in both zones of the dual-zone monitor well is to be continuously monitored and recorded relative to feet NAVD 88 or psi. Daily and monthly average, maximum and minimum pressures are to be reported to FDEP monthly (**Table 7-2**).

Table 7-2: DZMW-1 Monitoring Requirements

Parameter	Units	Reporting Frequency
DZMW-1		
Maximum Water Level or Pressure	ft NAVD or psi	Daily/Monthly
Minimum Water Level or Pressure	ft NAVD or psi	Daily/Monthly
Average Water Level or Pressure	ft NAVD or psi	Daily/Monthly
Water Quality		
Specific Conductance	µmhos/cm	Weekly
Ammonia as N	mg/L	Weekly
Total Dissolved Solids	mg/L	Weekly
pH	std units	Weekly
Chloride	mg/L	Weekly
Sulfate	mg/L	Weekly
Field Temperature	°C	Weekly
Total Kjeldahl Nitrogen (TKN)	mg/L	Weekly
Sodium	mg/L	Monthly
Calcium	mg/L	Monthly
Potassium	mg/L	Monthly
Magnesium	mg/L	Monthly
Iron	mg/L	Monthly
Bicarbonate	mg/L	Monthly
Radium 226*	pCi/L	Monthly
Radium 228*	pCi/L	Monthly
Gross Alpha*	pCi/L	Monthly

*Lower Zone Only

7.3.3 Injectivity Testing

Periodic determination of the injectivity of a well is used as a measure of the efficiency of a well and is a permit requirement as a management tool for the injection well system. The injectivity test involves injecting fluid into a well at three (or more) injection rates and recording the injection pressure for each rate. The shut-in pressure of the injection well is to be measured before each different injection rate. The injectivity is calculated by dividing the injection rate by the required injection pressure (wellhead injection pressure minus shut-in wellhead pressure). The result is expressed as gallons per minute per pounds per square inch (gpm/psi).

Factors affecting the injection wellhead pressure are a function of the following:

- The density differential between the injected fluid and the formation water in the injection zone,
- The friction loss in the casing, and
- The bottom hole pressure (injection zone transmissivity).

The density differential should be fairly constant as long as the temperature and density of the injection and formation fluids remain constant. Friction loss in the casing and bottom hole pressure can vary as a result of changes in the flow rate, physical condition of the injection zone and physical condition of the casing. In general, pressure builds slowly with time (for a given pumping rate) as the casing "ages". Similarly, plugging of an injection zone can cause a gradual pressure build-up over time. The testing rates for injectivity testing should be established when the well is placed in operation. A specific injectivity test is required to be performed monthly. Flow to the well and wellhead pressures are to be recorded during this period. Pressure fall off is to be recorded as part of the monthly specific injectivity test.

7.3.4 Mechanical Integrity

An injection well has mechanical integrity when there is no injection fluid movement horizontally into the adjacent formation through the well injection casing or vertically up from the bottom of the injection casing. Mechanical integrity testing includes a pressure test, a radioactive tracer survey, a high-resolution temperature log, and a television survey. This testing will be used, along with the monitoring data of the upper and lower monitor zones, to demonstrate the absence of fluid movement above the injection zone.

The injection well is to be tested for mechanical integrity every five years in accordance with FAC Rule 62-528. Based on the date of testing during construction, the first mechanical integrity test (MIT) is to be performed before August 21, 2018, which is 5 years following the Radioactive Tracer Survey.

The proposed MIT plan must be approved by FDEP prior to performing the testing. Request for approval should be made approximately six months prior to the required completion date.

7.4 Plugging and Abandonment Plan/Financial Responsibility

In the event that the injection well has to be abandoned, the well must be effectively sealed (or plugged) to prevent upward migration of the injection zone fluid or the interchange of formation water through the borehole or along the casing. The plugging program will require the services of a qualified drilling contractor with equipment capable of pumping neat cement to a depth of 3,300 feet.

The following procedures would be followed to abandon the injection well:

- Obtain a permit from the FDEP.
- Suppress the wellhead pressure with drilling mud.
- Remove the wellhead assembly.
- Remove the YBI packer and FRP Injection tubing.
- Fill the open hole with crushed limestone to 15 feet below the final casing, confirming the depth of fill with a tremie pipe or wire line.
- Place a sand cap on the crushed limestone to 10 feet below the bottom of the 16-inch casing.
- Fill the open hole and 16-inch diameter casing to land surface with neat cement.

The following procedures would be followed to abandon the dual-zone monitor well:

- Obtain a permit from the FDEP.
- Suppress the wellhead pressure with drilling mud.
- Remove the wellhead assembly.
- Fill the lower zone open hole with crushed limestone and the 6.625-inch diameter casing with neat cement grout.
- Fill the upper zone open hole with crushed limestone and the 16-inch diameter casing with neat cement grout.

Cost estimates for plugging and abandoning the injection well and monitor well zones were presented in the application materials. The cost estimate for plugging and abandoning the injection well system should be updated annually, according to Specific Condition 10 of the Construction Permit.

8.0 References

Miller, J.A., 1986. Hydrogeologic framework of the Floridan aquifer system in Florida and in parts of Georgia, Alabama, and South Carolina, *USGS Professional Paper 1403-B.*

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