CONSTRUCTION AND TESTING SUMMARY REPORT

CITY OF PORT ST. LUCIE,
LTC INJECTION WELL SYSTEM,
LTC WATER TREATMENT PLANT
MARCH 2004

VOLUME I

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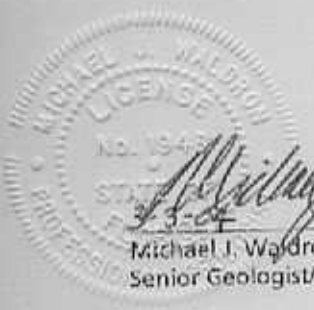

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Construction and Testing Summary Report

City of Port St. Lucie
LTC Injection Well System
LTC Water Treatment Plant

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Date:
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1. Introduction

This document provides the construction and testing results of the Class I injection well (IW1) and associated Floridan-aquifer, dual-zone deep monitor well (MW1) at the City of Port St. Lucie, Western (LTC) Water Treatment Plant (WTP) in St. Lucie County, Florida. The LTC Water Treatment Plant is located in Section 2, Township 36 South, Range 39 East. A site location map is presented as Figure 1. A site layout map showing the location of the injection well system is presented as Figure 2.

The LTC WTP intends to utilize Floridan-aquifer water supply wells and treat the raw water by reverse osmosis to drinking water standards; the potable-water treatment by-product will be disposed by Class I deep well injection (the primary disposal method). IW1 has been designed and constructed to accept up to 12 million gallons per day (mgd) of a mixed effluent waste stream, including primary disposal of potable water treatment by-product from the Prineville WTP and the LTC WTP (not yet completed) and secondarily-treated domestic wastewater from the Northport Wastewater Treatment Facility.

A dual-zone, deep monitor well (MW1) was constructed to monitor for potential upward migration of fluids injected into IW1. The upper monitor zone, (installed from 1,555 feet to 1,607 feet below pad level [bpl]) was installed above the lowermost regional Underground Source of Drinking Water (USDW), the interface defined by the depth at which the total dissolved solids (TDS) concentration of the formation water exceeds 10,000 milligrams per liter (mg/L). The lower monitor zone (installed from 1,780 feet to 1,830 feet bpl) was installed in the first sufficiently transmissive interval below the USDW. The MW1 construction details (with geologic and hydrogeologic columns) are presented as Figure 3.

IW1 was constructed with a 24-inch outside diameter (O.D.), 0.500-inch wall thickness seamless-steel casing installed to a depth of 2,764 feet bpl and was lined with a 20-inch O.D., 0.438-inch wall thickness, internally-coated steel (threaded and coupled) injection tubing. The total depth of IW1 is 3,350 feet bpl. The construction details for IW1 (with geologic and hydrogeologic columns) are presented as Figure 4. Construction and testing of the wells was performed in accordance with Chapter 62-528, Florida Administrative Code (FAC), the recommendations of the Underground Injection Control (UIC) Technical Advisory Committee (TAC), and the provisions of Florida Department of Environmental Protection (FDEP) Construction Permit No. 188679-001-UC. A copy of the construction permit is provided in Appendix A. The monitor well, injection well and appurtenances were constructed in accordance with

the contract documents for the work ("Technical Specifications – City of Port St. Lucie, LTC Injection Well System", prepared by Reese, Macon and Associates, Inc., 2002).

Youngquist Brothers, Inc. (Contractor) began construction of MW1 on May 23, 2002. The construction of MW1 was completed on August 5, 2002 and the Contractor began mobilizing to the IW1 location. Construction of IW1 began on August 8, 2002. The construction and testing of both MW1 and IW1 were completed by January 24, 2003. A summary of the construction and testing activities is presented as Table 1.

2. Findings

The results of the construction and testing of MW1 and IW1 led to the following conclusions:

- The base of the lowermost regional USDW is located at a depth of approximately 1,670 feet bpl.

- The primary confining interval above the injection zone occurs between approximately 2,280 feet and 2,638 feet bpl. The top of the injection zone is located at a depth of approximately 2,638 feet bpl.

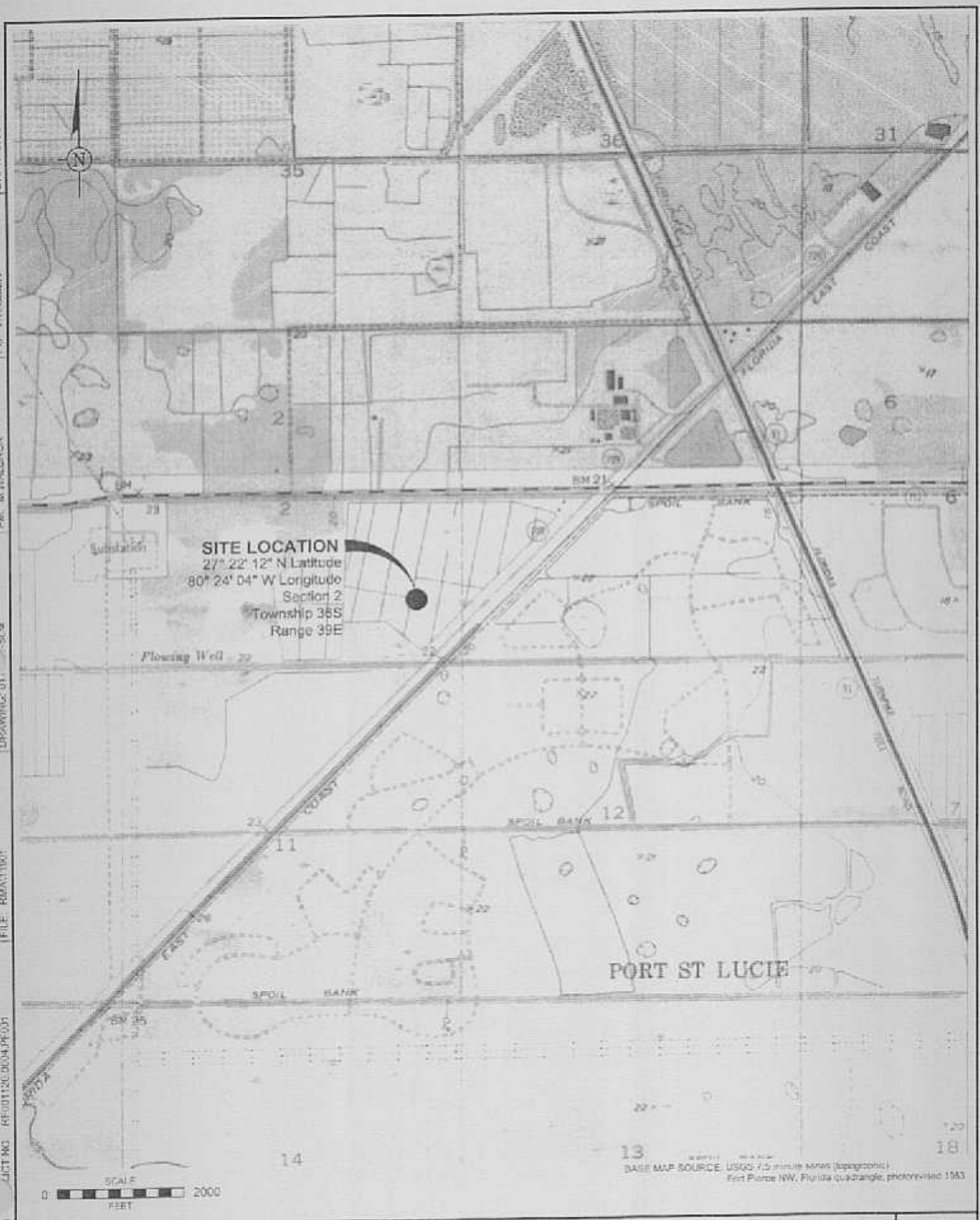
- As determined by core sample analysis, the average horizontal and vertical hydraulic conductivities of the primary confining interval (2,280 feet and 2,638 feet bpl) are 0.75 gallons per day per square foot (gpd/ft^2) and 0.73 gpd/ft^2, respectively.

- The transmissivity of the injection zone penetrated by the open hole (from 2,764 feet to 3,350 feet bpl) is estimated as 2,103,751 gallons per day per foot (gpd/ft), and the hydraulic conductivity of the injection zone is estimated at 3,583 gpd/ft^2.

- The injection zone is sufficiently transmissive to accept combined effluent at the anticipated buildout rate of 12 mgd.

3. Data Collection Methods and Results

During well construction, data were collected and interpreted to determine the geologic and hydrogeologic characteristics of the strata intercepted by the borehole. These data were used to determine the optimal subsurface design of MW1 and IW1. Data also were collected to ensure both wells were being constructed in accordance with the



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SITE LOCATION MAP

CITY OF PORT ST. LUCIE
LTC WATER PLANT
ST. LUCIE COUNTY, FLORIDA

FIGURE
1

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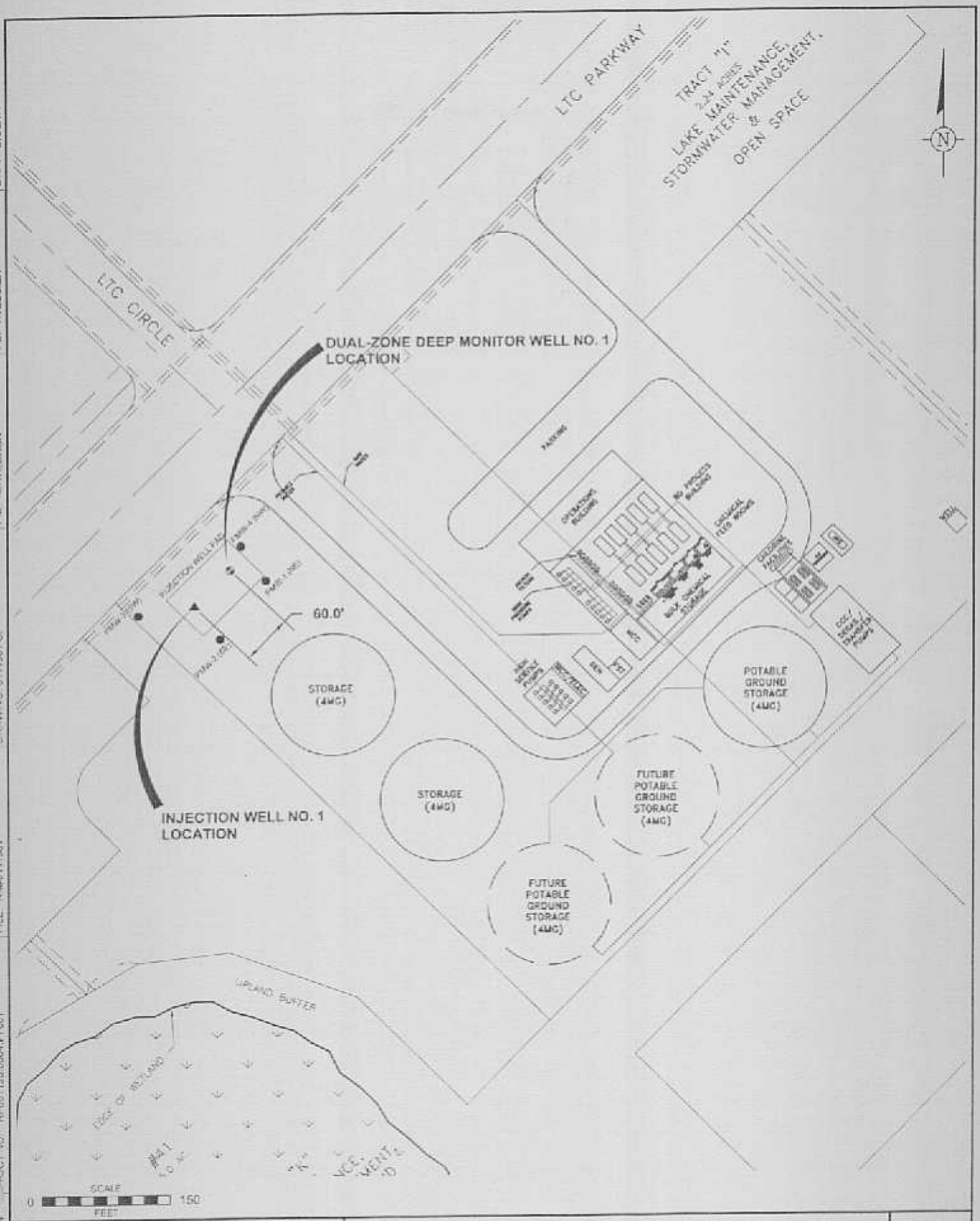

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SITE LAYOUT MAP

CITY OF PORT ST. LUCIE
LTC WATER PLANT
ST. LUCIE COUNTY, FLORIDA

FIGURE
2

testing of IW1 commenced on April 10, 2003. During operational testing, permit conditions applicable to monitoring the physical and chemical characteristics of injected fluids, MW1 monitor-zone fluids, and operational performance of the injection well were satisfied to provide information to submit the operating permit application for the injection well system. Operational testing of IW1 was performed in accordance with Chapter 62-528, FAC, and the provisions of the FDEP Construction Permit No. 188679-001-UC. Available IW1 operational and effluent water-quality data with graphical plots are presented in Appendix G. Available MW1 monitor-zone water-quality and wellhead pressure data (upper and lower zone) with graphical plots also are presented in Appendix G.

The data collected from operational testing demonstrate that the injection well system has mechanical integrity and that an adequate degree of confinement exists between the injection zone and the base of the lowermost regional USDW.

5. Geology and Hydrogeology

5.1 Regional Geologic Setting

The Surficial Aquifer is composed mainly of unconsolidated sand, silt and shell with varying amounts of limestone, sandstone, shell and clay. This aquifer contains the water table and water within it exists under mainly unconfined conditions. Between land surface and approximately 130 feet deep, the Pleistocene sediments correspond to descriptions of the Pamlico Sand and Anastasia Formation in St. Lucie County. Below 130 feet deep (to approximately 185 feet or more), the sediments are mainly composed of clay, shell, sands and silt. These descriptions correspond to the Post-Miocene Ft. Thompson, Caloosahatchee Marl and the Tamiami Formations. The base of the Tamiami Formation is not well defined in St. Lucie County; however, the lower limit of the Surficial Aquifer coincides with the top of laterally extensive and vertically persistent beds of much lower permeability and varies in depth from about 100 feet to more than 175 feet below land surface in the County.

Underlying the Surficial Aquifer are the Miocene clays and marls that form a confining sequence between the Surficial Aquifer and the Oligocene to Eocene limestones and dolomites of the Floridan Aquifer. These sediments form a confining sequence referred to as the Hawthorn Group. The Hawthorn Group sediments overlie the Floridan Aquifer, which exists under artesian conditions with a potentiometric level above land surface. In south Florida, the dense Miocene clays of the overlying Hawthorn Group sediments provide good confinement for the Floridan Aquifer.

The Floridan Aquifer includes the thick carbonate sequence of all or part of the Paleocene to lower Miocene Series and, in south Florida, serves as a regionally significant water-yielding unit under confined conditions. The Floridan Aquifer underlies all of Florida and southern Georgia and includes all of middle and upper Eocene Ocala Group, Avon Park Formation and Lake City Limestone, and the Oligocene Suwannee Limestone and those permeable Hawthorn Group beds in contact with the rest of the aquifer.

The middle to upper Eocene limestones, dolomitic limestones and dolomites of the Avon Park Formation and Lake City Limestone overlie the lower Eocene sediments of the Oldsmar Formation. Much of the Oldsmar Formation can be characterized by the vuggy texture of the dolomite drilled cutting samples and large-scale dissolution features noted on caliper logs. The lower portion of this formation contains a section of highly permeable dolomite with highly mineralized water referred to as the "Boulder Zone" that is used throughout south Florida for the disposal of wastewater.

5.2 Local Hydrogeology and Underground Sources of Drinking Water

A brief review of the regional hydrogeologic setting for the vicinity of the injection well system follows to indicate the general vertical and lateral limits of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement (where known) in each USDW that may be affected by the proposed injection.

A north-south hydrostratigraphic cross section of the geologic formations containing the underground sources of drinking water in the area of the project site is presented as Figure 6. In addition, a west-east (southwest to northeast) hydrostratigraphic cross section of the same geologic formations in the area of the project site is presented as Figure 7. The general vertical limits of the USDWs are shown with their position relative to the injection formation (injection zone). Formation names and boundaries of the confining intervals and injection zone are also shown.

5.2.1 Surficial Aquifer

In the local area of the project site, the Surficial Aquifer is composed mainly of unconsolidated sand and shell with varying amounts of limestone, sandstone and clay between land surface and 130 feet. The aquifer is used as the main source of drinking water throughout St. Lucie County.

The water table is shown (from Technical Publication 95-01, South Florida Water Management District, 1995) at an elevation of between 12 and 16 feet (based on the National Geodetic Vertical Datum [NGVD] adjustment of 1929) in the vicinity of the LTC Injection Well System. Based upon a review of the 1970 U. S. Geological Survey topographic map, and the final survey of the project site, the land surface elevation shows little slope in the vicinity of the site and appears to be between approximately 20 and 24 feet above NGVD. The groundwater flow direction in the Surficial Aquifer appears to be to the south or southeast toward the St. Lucie River. The base of the Surficial Aquifer in the area of the site is approximately 160 feet below NGVD or approximately 185 feet below land surface.

5.2.2 Intermediate Aquifer

Underlying the Surficial Aquifer are approximately 430 feet of Miocene clays and marls with some limestones forming a sequence of confining beds between the sediments of the Surficial Aquifer and the Eocene limestones and dolomites of the Floridan Aquifer System. This Miocene-age sequence is found throughout south Florida and has been redesignated (from the Hawthorn, Peace River and Arcadia Formations) to the Hawthorn Group based on extensive work to define the areal extent of the several formations comprising these sediments in Florida. Although permeable beds exist within the Intermediate Aquifer System, the Hawthorn Group formations generally form a confining sequence (or aquiclude) in St. Lucie County and the water quality is poor in comparison to the upper and middle Surficial Aquifer. The dense clays of the Miocene Hawthorn Group sediments provide good confinement for the underlying Floridan Aquifer.

5.2.3 Floridan Aquifer

The Floridan Aquifer underlies all of Florida and southern Georgia and includes parts or all of middle and upper Eocene Ocala Group (Avon Park) Formations and the Oligocene Suwannee Limestone, as well as portions of the Miocene Tampa Formation and those permeable Hawthorn Group beds in contact with the rest of the aquifer.

Water quality in the Floridan Aquifer is poor in comparison to the Surficial Aquifer. Water from the Floridan Aquifer in the area contains TDS concentrations that exceed drinking water standards. Although the desalination treatment required results in higher consumer costs, limited use of Floridan Aquifer water has become an established necessity in St. Lucie County in order to reduce pumping of the better-quality water from the Surficial Aquifer System (both to mitigate potential impacts to environmentally sensitive wetlands and to reduce the potential for saltwater intrusion in

the Surficial Aquifer). The Floridan Aquifer generally exists under artesian conditions with a potentiometric level above land surface. The Floridan Aquifer is artesian in all parts of St. Lucie County, except in eastern St. Lucie County where land surface is more than 50 feet above mean sea level. In areas where the Floridan Aquifer has not experienced significant withdrawals, the potentiometric water level varies from 30 to 50 feet above mean sea level (Bearden, H. W., Report of Investigations No. 62, United States Geological Survey, 1972, p. 10). The principal recharge areas for the artesian Floridan Aquifer in southern Florida are centered in Polk and Lake Counties. The potentiometric surface slopes gently toward the east and southeast, except where locally affected by withdrawals.

5.3 Local Geologic Structures

Based upon the data collected during pilot-hole construction, the hydrology and geologic structures near the site have been summarized. In the local area of the project site, the Surficial Aquifer is composed mainly of unconsolidated sand, clay and shell, with varying amounts of limestone, sandstone and clay between land surface and 130 feet bpl. These Pleistocene sediments correspond to descriptions of the Pamlico Sand and underlying Anastasia Formation in St. Lucie County.

Between 130 and 185 feet bpl, the sediments consist of grayish-olive clays with varying amounts of sand, shell, and some interbedded limestone. These descriptions correspond to Post-Miocene Ft. Thompson, Caloosahatchee Marl and Tamiami Formation sediments.

Between 185 and 390 feet bpl, the sediments consist predominantly of dark olive-gray, slightly plastic clay with sand and shell. Marl predominates from 390 to 620 feet bpl, consisting of a light olive-gray, soft, plastic carbonate mud with some quartz and phosphate sands. Below 550 feet bpl, limestones are present, interbedded with the marl. These formations correspond to descriptions of the Hawthorn Group and the underlying Suwannee Limestone. Between 620 feet and 1,420 feet bpl, sediments consisting of a moderately soft, fossiliferous, white to very pale orange limestone that contain foraminifera. The limestone corresponds to descriptions of the upper Eocene Ocala Group. From 850 feet to 1,420 feet bpl, sediments consist of very-fine grained, hard, highly fractured dolomite.

The middle to upper Eocene limestones, dolomitic limestones and dolomites of the Avon Park Formation and Lake City Limestone are encountered between 1,420 and 2,280 feet deep. The existence of the Lake City Limestone in this area is inferred from the literature. Typically, there is insufficient microfossil evidence in samples from

Table 1. Average Injection Wellhead Pressures and Daily Flows, City of Port St. Lucie LTC Injection Well System

Date	Average Daily Volume (mgd)	Monthly-Average Injection Pressure (psi)	Total Volume to Injection Well (mg)	Days In Service (Days/Month)
Mar-03	0.721	16.2	28.5	19
Apr-03	0.612	13.5	18.4	30
May-03	2.430	26.2	43.7	18
Jun-03	2.363	18.0	70.9	30
Jul-03	2.093	19.0	65.1	30
Aug-03	2.282	19.8	71.8	31
Sep-03	2.698	19.0	80.9	30

"mgd" denotes rate in units of "million gallons per day"
"psi" denotes pressure in units of "pounds per square inch"
"mg" denotes volume in "million gallons."

Table 2. Summary of Deep Monitor-Well Upper Monitor-Zone Water Quality and Pressure Data from Port St. Lucie LTC Injection Well System

Date	TDS (mg/L)	Chlorides (mg/L)	Conductivity (µmhos/cm)	Ammonia (mg/L)	TKN (mg/L)	Nitrate (mg/L)	Phosphorus (mg/L)	pH	Sulfate (mg/L)	Sodium (mg/L)	Gross α (pCi/L)	^{226}Ra (pCi/L)	^{228}Ra (pCi/L)	Pressure (psi)
03/17/03	3700	1900	4370	12.00	18.00	*0.018*	0.180	7.81	470	1000				3.29
03/24/03	2700	1600	5200	0.37	0.36	*0.160*	0.005	8.01	190	740				2.86
03/31/03	3100	1700	5300	0.34	0.58	*0.080*	0.009	7.28	180	840				2.71
04/09/03	3600	1800	6200	0.40	0.64	*0.080*	*0.008*	7.88	170	860	*13.8 +/- 8*	3.7 +/- 0.3	0.9 +/- 0.5	2.94
04/15/03	3700	1600	5870	0.39	1.30	*0.080*	*0.008*	7.72	220	680				2.71
04/24/03	5500	2100	8130	18.00	19.00	*0.016*	*0.008*	7.65	710	1500				2.75
04/30/03	3600	2000	4680	0.43	0.43	*0.250*	*0.010*	7.85	230	890				4.07
05/08/03	4900	3100	6020	0.45	0.44	*0.016*	0.010	7.52	230	1300				3.19
05/14/03	4100	1900	4830	0.45	0.49	*0.016*	0.009	7.76	200	950	17.4 +/- 11	3.9 +/- 0.3	*<0.9*	3.18
05/20/03	4700	2100	5920	0.46	0.60	*0.160*	0.012	7.75	210	730				3.83
05/28/03	3900	1900	4370	0.45	0.65	*0.080*	*0.008*	7.80	230	880				4.56
06/04/03	4000	2000	6260	0.46	0.60	*0.080*	0.008	7.80	230	740	*<13.4 +/- 8*	4.5 +/- 0.3	<0.7+/- 0	4.50
06/11/03	4600	2000	6670	0.45	0.54	*0.16*	0.011	7.60	240	980				4.50
06/17/03	4400	2100	5240	0.38	0.58	*0.16*	0.008	7.60	210	970				4.50
06/24/03	4100	2300	6620	0.47	1.80	*0.016*	0.012	7.75	230	1200				3.10
07/01/03	4400	1500	6210	0.46	0.65	0.16	0.018	7.85	190	800	<10.7+/-6	3.7+/-0.6	<0.9+/-0	2.9
07/08/03	4500	2300	6070	0.41	0.68	0.16	0.014	7.93	200	750				2.5
07/14/03	4600	2200	6230	0.42	0.42	0.16	0.120	7.80	200	890				3.6
07/22/03	4200	2300	5980	0.44	0.55	0.16	0.019	7.80	220	840				2.7
07/29/03	4500	2100	6969	0.33	0.52	0.16	0.008	7.71	210	1200				3.0
08/06/03	4400	2300	6990	0.51	0.74	0.18	0.008	7.90	240	1000	<15.4+/-8	3.8+/-0.5	<1.0+/-0	2.8
08/12/03	5400	2500	7250	0.44	0.79	0.09	0.110	7.68	240	1200				3.1
08/19/03	4500	2300	7120	0.53	0.63	0.18	0.009	7.90	190	1200				4.0
08/26/03	4500	2200	7100	0.40	0.62	0.18	0.008	7.50	200	1100				3.5
09/04/03	4700	2800	7400	0.28	0.70	0.18	0.008	7.74	210	1100	<12.6+/-7	4.5+/-0.7	<0.8+/-0	0.1
09/09/03	4900	2400	7630	0.34	0.64	0.18	0.008	7.84	260	1200				3.1
09/16/03	3300	1300	6340	0.43	0.43	0.18	0.008	7.93	200	980				4.4
09/23/03	4500	2400	7530	0.40	0.40	0.01	0.009	7.76	230	1100				2.9

Shaded areas indicate data was not collected on that date
Italicized data indicate values are reported as "less than" the method detection limit
"mg/L" denotes concentration in milligrams per liter
"umhos/cm" denotes micromhos per centimeter
"pCi/L" denotes picoCuries per liter
"psi" denotes pounds per square inch
"TDS" denotes total dissolved solids
"TSS" denotes total suspended solids
"TKN" denotes total Kjeldahl nitrogen
"Gross α" denotes gross alpha
"^{226}Ra and ^{228}Ra" denotes radium-226 and radium-228, respectively

Table 3. Summary of Deep Monitor Well Lower-Monitor Zone Water Quality and Pressure Data, City of Port St. Lucie LTC Injection Well System

Date	TDS (mg/L)	Chlorides (mg/L)	Conductivity (µmhos/cm)	Ammonia (mg/L)	TKN (mg/L)	Nitrate (mg/L)	Phosphorus (mg/L)	pH	Sulfate (mg/L)	Sodium (mg/L)	Gross α (pCi/L)	^{226}Ra (pCi/L)	^{228}Ra (pCi/L)	Pressure (psi)
03/17/03	2700	1400	27400	0.38	0.67	*0.08*	0.01	6.88	160	700				38.0
03/24/03	21000	2700	30000	1.30	1.60	*0.02*	0.03	7.18		7300				38.9
03/31/03	19000	15000	28500	1.50	1.70	*0.08*	0.05	7.02	780	6900				39.0
04/09/03	24000	15000	27100	1.40	1.80	*0.08*	*0.04*	7.06	700	6800	103 +/- 56	3.7 +/- 0.3	0.9 +/- 0.5	39.00
04/15/03	22000	15000	28200	1.40	2.10	*0.08*	*0.04*	7.08	830	5900				39.00
04/24/03	26000	13000	29300	1.4	1.6	*0.016*	0.044	7.13	890	7100				37.10
04/30/03	21000	14000	19800	1.40	1.60	*0.25*	0.05	7.14	770	5800				38.80
05/08/03	2600	16000	23100	1.50	1.60	*0.016*	0.05	6.83	810	8200				38.6
05/14/03	25000	14000	21800	1.5	1.7	*0.016*	0.042	6.93	730	5800	57.7 +/- 3	57.7 +/- 0.3	<1.0 +/- 0	30.3
05/20/03	24000	15000	24200	1.5	1.6	*0.16*	0.059	6.99	740	3500				37.5
05/28/03	26000	15000	20200	1.5	1.9	*0.08*	0.036	7.06	720	5300				38.0
06/04/03	23000	15000	25500	1.5	1.9	*0.080*	0.046	7.00	940	3400	<53.8+/-3	7.1+/-0.4	*<0.7+/-0*	39.0
06/11/03	27000	15000	23600	1.4	2.0	*0.160*	0.046	7.00	850	6300				39.2
06/17/03	20000	16000	23600	1.3	2.0	*0.160*	0.048	7.00	820	5800				39.2
06/24/03	24000	14000	35200	1.5	2.5	*0.016*	0.015	7.00	830	7000				28.3
07/01/03	25000	21000	33400	1.50	1.8	*0.100*	0.06	7.05	950	5500	<40.6+/-2	4.1+/-0.6	<0.9+/-0	33.5
07/08/03	25000	18000	32400	1.50	1.6	0.16	0.03	6.72	780	5100				30.8
07/14/03	24000	15000	31900	1.40	1.5	0.16	0.02	7.07	840	6700				36.6
07/22/03	24000	15000	31300	1.60	2.10	0.16	0.02	7.01	840	7000				33.9
07/29/03	25000	17000	37900	1.40	1.50	0.16	0.01	6.94	800	7100				34.4
08/06/03	24000	16000	34700	1.60	1.20	0.18	0.02	7.00	830	6600	<67.5+/-3	3.6+/-0.5	<1.0+/-0	33.9
08/12/03	29000	15000	36100	1.60	1.70	0.09	0.12	6.95	810	6300				34.2
08/19/03	24000	14000	35200	1.60	1.40	0.18	0.02	7.05	740	7300				39.0
08/26/03	27000	16000	35700	1.30	2.00	0.18	0.11	7.18	680	6200				35.7
09/04/03	25000	15000	34400	1.30	1.50	0.18	0.01	7.10	810	6600	36.8+/-21	5.3+/-0.8	<0.7+/-0	23.0
09/09/03	24000	14000	37950	1.30	1.70	0.18	0.04	7.12	890	6300				34.0
09/16/03	25000	14000	37710	1.40	1.40	0.18	0.02	7.12	810	6900				35.8
09/23/03	24000	14000	37570	1.30	1.40	0.03	0.02	7.01	720	6600				33.0

Shaded areas indicate data was not collected on that date

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