traveled to a receptor (and the greater the time of travel), the lower the risk. Distance and the associated travel time is also a risk factor that can be manipulated by risk managers.

Natural attenuation processes can significantly reduce risks in all of the options. The type and opportunity for attenuation is very specific to the particular disposal option and the local conditions under which it is used. Natural attenuation processes include filtration by geologic media, dispersion by groundwater or ocean currents, biological degradation, adsorption, and photo-oxidation. The distance between the receptors and stressors and the resulting travel times are important factors that can further enhance attenuation.

Depending on the geographic location, there are significant differences in hydrogeology, coastal hydrology, and water quality in South Florida. These site-specific and regional characteristics can determine whether there is a very low risk or a significant risk. For example, deep-well disposal in Dade and Brevard counties have long travel times in comparison to Pinellas County. However, this potential increased risk for Pinellas County is ameliorated by providing a higher level of wastewater treatment in Pinellas County. As another example, the coastal conditions off southeast Florida are favorable for ocean disposal because the local currents result in rapid dispersion and dilution, whereas the circulation and water-quality conditions along Florida's Gulf Coast would probably preclude placement of outfalls.

The relative risk assessment identified major data and knowledge gaps for all of the disposal options. This is particularly the case for how natural processes may influence attenuation in deep-well injection and in the extent and nature of ecological impacts. The relative risk assessment relied on existing information and data and some modeling of that data. It is clear that for deep-well injection, many issues have never been addressed because of the belief that there would be no movement of the effluent into USDWs once the fluid was injected. The confirmation of fluid movement, even in the few cases reported, reveals that there is much about the pathways, flow, attenuation, and so forth that is little understood, given the fact that injected fluid can reach USDWs in some cases.

For all options, there is very limited information concerning ecological health effects. Water-quality standards do not exist for this area, and in many cases, the numbers and types of receptors may not be known. Also, compared to human health effects, there is little information on the impacts of specific stressors on specific populations (such as zooplankton, fisheries, marine mammals, birds).

Definitive studies are needed to track stressors back to their origins or sources because there are many potential sources other than wastewater disposal for the same stressors. It is important to identify and recognize the contributions of various sources of stressors. Cumulative effects are not well understood for either human or ecological receptors and may go unrecognized. As more demand develops for additional wastewater treatment capacity in South Florida, these data and information gaps will likely need to be addressed so that new facilities can be designed, constructed, operated and maintained with full confidence that public health and the environment are protected.

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DESCRIPTION OF APPENDIX TABLES 1-1 AND 1-2.

1.0 General

Appendix Table 1-1 includes data collected from various sources. These sources include information compiled in reports by the Florida Water Environment Association Utility Council and by SEFLOE, as well as sampling data sent directly from the Miami-Dade North District Wastewater Treatment Plant and the Brevard County South Beaches Wastewater Treatment Facility. KEMRON Environmental Services, Inc. provided sampling data from the Albert Whitted Water Reclamation Facility in St. Petersburg. The Florida Department of Environmental Protection provided sampling results for the wastewater treatment facility in the City of Cape Canaveral and the Howard Curren Wastewater Treatment Plant in Tampa Bay.

1.1 Florida Water Environment Association Utility Council

The Florida Water Environment Association Utility Council (FWEAUC) report (Englehardt et al., 2001) provided analysis of sampling and monitoring results of effluent that had been treated to different standards (advanced wastewater treatment, secondary treatment, and advanced secondary treatment) as well as "native" ambient water in injection zones and monitoring zones in target aquifers. In all, eight (8) categories of sampling data were summarized in the Florida Utility Council report. The data that we present in Appendix Table 1-1 represents "digested" data that has already been processed by the FWEAUC authors. Those authors include raw concentration data for each of the sampling stations in appendices B and C of their report. For each of the sampling dates for each of the stations, the authors provide two lists of monitoring data; the first list includes the concentrations of all detected constituents and sets each of the "non-detect" values to zero (0), and the second list duplicates the first, but sets "non-detect" values at their detection limit. For Each of these two lists, the average concentration of each parameter was calculated from all of the sampling results at all of the stations within a category (e.g., advanced wastewater treatment), resulting in average values for each constituent with non-detects as zero and non-detects at the detection limit, respectively. Processing the data in this manner has the same effect as assigning values one-half of the detection limit to all non-detects, a standard approach not inconsistent with risk assessment methodologies (US EPA. 1998).

The Florida Utility Council study processed all of the raw data in this manner. The utilities that supplied monitoring data to the authors of the report include:

- City of Hollywood
- City of Boca Raton
- City of Fort Lauderdale
- City of Sunrise
- City of Boynton Beach
- City of West Palm Beach
- Broward County North Regional Wastewater Treatment Plant
- Miami-Dade County North and South District Wastewater Treatment Plants
- Seacoast Utilities

- South Central Regional Wastewater Treatment Plant
- Florida Governmental Utility Authority (FGUA) Sarasota plants (Southgate and Gulf Gate Wastewater Treatment Plants)
- The FGUA Golden Gate Plant

1.2 Miami-Dade North District Wastewater Treatment Facility, Dade County

Sampling results from one round of tests characterizing a full suite of waste contaminants in screen effluent were obtained from the Miami-Dade Water and Sewer (North District) utility directly (Miami-Dade Water/Sewer Submission # 9903001041). This facility provides secondary treatment for wastewater effluent before discharging through an ocean outfall to the Atlantic Ocean. The sampling date for these results is March 19, 1999; this is the same sampling date as the results used in the Florida Utility Council report; a comparison of the raw data sent by the facility to the data in the Florida Utility Council report confirms that this is the same data set. Data from this set were entered into Appendix Table 1-1 directly; no processing of the data was performed except for the conversion of values from mg/L to μg/L (or vice versa). Constituents that were below the detection limit are indicated in Table 11 with a less than (<) sign preceding the reported detection limit.

1.3 South Beaches Wastewater Treatment Facility, Brevard County

Sampling results from one round of tests characterizing a full suite of waste contaminants were obtained from the Brevard County Water Resources Department (South Beaches Wastewater Treatment Facility, 2001) for effluent analyses conducted on December 7 and 28, 2000. This facility discharges effluent via a Class I deep injection well, reuse, or surface water discharge. Wastewater that is discharged through deep well injection receives secondary treatment. Water that is reused receives secondary treatment and high level disinfection with chlorine. Finished water destined for reuse has a concentration of 1 ppm chlorine and is filtered to reduce the concentration of total suspended solids to less than 5 ppm. Effluent is occasionally discharged directly to the Indian River during heavy rain and hurricanes. This effluent receives secondary treatment, plus chlorination and dechlorination as well as nutrient removal to lower the concentration of nitrogen, phosphorus and chlorine (Chuck Caron, personal communication).

These data represent single (not averaged) results. Data from this set were entered into Appendix Table 1-1 directly; no processing of the data was performed except for the conversion of values from mg/L to μg/L (or vice versa). Constituents that were below the detection limit are indicated in Appendix Table 1-1 with a less than (<) sign preceding the reported detection limit.

1.4 City of St. Petersburg, Albert Whitted Water Reclamation Facility, Pinellas County

Sampling results from the Albert Whitted Water Reclamation Facility were obtained by KEMRON Environmental Services, Inc. The records supplied by Kemron include effluent monitoring data from a range of dates, as well as minimum, maximum, and average concentrations for each constituent; not all constituents were tested for on all the dates. Sampling and analysis occurred on September 16, 1998, January 4, 1999, April 6, 1999, June 29, 1999, July 1, 1999, September 26, 2000, and January 24, 2001.

Volatile organic constituents, synthetic organic constituents, secondary drinking water standard regulated constituents, and inorganic constituents were all sampled in September 1998, January and April 1999, September 2000, and January 2001. Radionuclides were sampled in September 1998, April and June 1999, and September 2000. Trihalomethanes were sampled in September 2000, and microbes were sampled in January 1999 and January 2001. Kemron provided constituent concentration data in two sets: one set of data included data qualifiers to indicate concentrations that were below detection limits, and the other set of data had the qualifiers removed in order to calculate the average concentration of each constituent. The average concentration of each constituent was entered directly into Appendix Table 1-1 from the Kemron table lacking qualifiers. Then, if any of the values used in the calculation had actually been below the detection limit, a "less than" (<) sign was added to the value entered into Appendix Table 1-1. For this reason, a "less than" sign preceding a concentration value **does not** indicate that the numeric value is the detection limit. The "less than" sign simply means that the average concentration of the constituent in question is less than the value reported in the table.

Ammonia, total nitrogen, total Kjeldahl nitrogen, orthophosphate, and water temperature were sampled in November 2000; those results were obtained from a Reclamation Facility Monitor Well and Effluent Study Report dated December 26, 2000 that was also provided by Kemron. These single sampling values were added to Appendix Table 1-1. No processing of the data was performed except for the conversion of values from mg/L to µg/L (or vice versa).

1.5 City of Cape Canaveral

The Cape Canaveral treatment plant serves the City of Cape Canaveral. In the mid 1990s, the plant was upgraded to an advanced wastewater treatment facility. The plant is part of a reclaimed water system that supplements the City of Cocoa Beach's reclaimed water supply. Discharge to the Banana River, a segment of the Indian River Lagoon, occurs during wet weather or other periods when reclaimed water demands are low.

The Florida Department of Environmental Protection, Central District, supplied comprehensive sampling results from a round of sampling at the Cape Canaveral Wastewater Treatment Plant conducted on October 1, 1999. The City of Cape Canaveral provided comprehensive sampling results from analyses conducted on April 3, 2001. These sampling results were entered into Appendix Table 1-1 directly without processing other than conversion of concentration units to be compatible with the other records in the table (i.e., conversion of values from mg/L to µg/L or vice versa).

In addition, the Florida Department of Environmental Protection (DEP) provided weekly, monthly, and annual sampling results for constituents that were monitored as part of Cape Canaveral's compliance with its National Pollution Discharge Elimination System (NPDES) permit. These constituents include total nitrogen, total phosphorus, and total suspended solids. These data were provided for calendar years 1999 through 2001. To supplement the other sampling results for Cape Canaveral (dated October 1999 and April 2001), the annual average of each of the three constituents were calculated from monthly averages provided in the Florida DEP spreadsheet. Twelve monthly average records were used to calculate the annual average for each constituent in 1999; however, May and June 2001 data were unavailable. For this reason, only ten monthly averages were used to calculate the annual average of each constituent in 2001. Annual averages for each of these three constituents were included in Appendix Table 1-1 in the Cape Canaveral 1999 and 2001 columns; superscripted footnote numbers distinguish these average values from the comprehensive raw data.

1.6 SEFLOE II Data

Concentrations of several parameters in effluent from four wastewater treatment plants (Broward County North Regional Wastewater Treatment Plant, City of Hollywood, Miami-Dade North District WWTP, and Miami-Dade Central District WWTP) were provided in the SEFLOE II report (Appendix Table 1-2) (Hazen and Sawyer, 1994). Data for ammonia, total Kjeldahl nitrogen, total phosphorus, nitrate, nitrite, and oil and grease were supplied in that report as arithmetic averages for each utility. These average values were collected from separate tables and entered into Appendix Table 1-2 in columns labeled with the utility names (SEFLOE data for Miami-Dade North District are in a different column than the monitoring data provided by the utility directly). For the remaining parameters that were analyzed, raw sampling data were provided for each facility. For example, results from one round of sampling were reported for the City of Hollywood, results from two sampling dates were reported for each of the Miami-Dade facilities (February 27, 1991 and February 18, 1992 for North District and February 22, 1991 and September 20, 1991 for Central District), and results from four sampling dates were reported for Broward County (February 13, 1991, September 20, 1991, February 11, 1992, and March 24, 1992). The average concentration for each parameter at each utility was calculated using these concentration data and excluding data points that were identified by the SEFLOE authors as "questionable" (i.e., single values for arsenic, copper, and zinc in Broward County; total silver in the City of Hollywood and Miami-Dade Central; and heptachlor in Miami-Dade North). In instances where the reported concentration was "BDL" (Below Detection Limit), no detection limit was reported; for this reason, a value of zero (0) was used in the calculation of average concentrations.

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Appendix Table 1-1. Drinking Water Standards and Sampling Results for Treated Wastewater and Native Water in South Florida

		Advanced Wastewater Treatment				Reclaimed Water Treatment		Secondary Effluent		Native Water Monitoring Zones				
		Various Counties	Brevard County			Various Counties	Pinellas County	Various Counties	Dade County	Florida Utility Council[2] - Various Counties				
			South Beaches	Cape Canaveral WWTP										
Parameter Name	Drinking Water MCL[1]	Florida Utility Council[2]	South Beaches WWTF[3]	Sample Date 10/1/99[4]	Sample Date 4/3/01[5]	Florida Utility Council[2]	Albert Whitted WRF, St. Petersburg[6]	Florida Utility Council[2]	Miami-Dade North District[7]	Effluent Injection Zone	Lower Monitoring Zone	Upper Monitoring Zone	ASR Injection Zone	Biscayne Monitoring Zone
Inorganic Analysis														
Arsenic (mg/L)	0.050	0.001	< 0.0050	< 0.005	< 0.0045	0.003	<0.00314	0.003	< 0.01	0.010	0.007	0.005	0.002	0.015
Barium (mg/L)	2.000		0.031		0.0070	0.094	<0.0103	0.023	< 0.05	0.184	0.363	0.089	0.404	0.244
Cadmium (mg/L)	0.005	0.000	< 0.0010	< 0.0001	< 0.00005	0.001	<0.0022	0.001	< 0.005	0.004	**0.012**	**0.065**	0.003	0.001
Chromium (mg/L)	0.100	0.001	< 0.0050	< 0.005	< 0.0009	0.003	<0.00625	0.005	< 0.005	0.014	0.023	0.006	0.010	0.004
Cyanide (mg/L)	0.200				< 0.006	0.002	<0.025800	0.015	< 0.004	0.006	0.009	0.004	0.002	0.004
Fluoride (mg/L)	4.000	0.940	0.080		0.505	0.420	0.73700	0.790	0.75	0.700	0.860	1.470	1.580	0.190
Lead (mg/L)	A.L.=0.015	0.000	< 0.0010	< 0.003	0.0014	0.001	<0.00255	0.004	< 0.005	**0.069**	**0.108**	**0.022**	0.002	0.009
Mercury (mg/L)	0.002	0.000	< 0.00020	0.0004	0.00021	0.000	<0.0002	0.000	< 0.001	0.000	0.001	0.001	0.000	0.000
Nickel (mg/L)	0.100	0.002		< 0.03	0.0031	0.005	<0.008	0.011	< 0.005	0.023	0.036	0.025	0.004	0.003
Nitrate (mg/L)	10.00		9.6		0.0620	3.690	0.28000	3.820	0.64	0.420	0.070	0.040	0.030	0.190
Nitrite (mg/L)	1.000				< 0.0035	0.013	0.18000	0.575	< 0.05	0.009	0.025	0.012	0.006	0.005
Selenium (mg/L)	0.050	0.001	< 0.0020	< 0.005	< 0.0026	0.004	<0.00388	0.004	< 0.01	**0.637**	0.007	0.004	0.005	0.001
Sodium (mg/L)	160.0	64.00	**230**		121.0	75.00	28.03500	114.0	181	**8062**	**5514**	**1357**	**1215**	80.0
Antimony (mg/L)	0.006			0.011	0.0034	**0.142**	<0.002175	**0.013**	< 0.005	0.003	**0.019**	**0.010**	0.004	0.001
Beryllium (mg/L)	0.004			< 0.004	< 0.0001	0.004	<0.000525	0.001	< 0.002	0.008	**0.010**	**0.005**	0.001	0.000
Thallium (mg/L)	0.002			< 0.002	< 0.0010	0.001	<0.0012	0.002	< 0.002	**0.305**	**0.013**	**0.007**	0.001	0.001
Secondary Analysis														
Aluminum (mg/L)	0.200				0.0992	0.050	<0.1135	0.074	< 0.1	0.20	**0.917**	**0.744**	0.163	**0.823**
Chloride (mg/L)	250.0	82.20	160		165	116.9	189	151.85	218	**15302.5**	**9897.0**	**2203.3**	**2448.4**	176.2
Copper (mg/L)	A.L.=1.3	0.003	< 0.01	< 0.01	< 0.0005	0.021	0.0086	0.004	< 0.01	0.21	0.032	0.132	0.010	0.005
Iron (mg/L)	0.300	0.000	< 0.040		0.0225	0.177	0.0963333	0.183	0.209	**3.151**	**4.450**	**19.294**	**1.079**	**0.420**
Manganese (mg/L)	0.050		0.0058		0.0185	0.024	0.012567	0.018	< 0.05	0.038	0.046	0.027	0.043	0.013
Silver (mg/L)	0.100		< 0.010	< 0.01	0.0040	0.001	<0.00392	0.002	< 0.001	0.037	0.008	0.005	0.004	0.003
Sulfate (mg/L)	250.0	179.5	110		111	76.20	41.7	56.623	71.9	**2379.2**	**1117.9**	**401.0**	**521.8**	38.80
Zinc (mg/L)	5.000	0.000	0.037	< 0.03	0.0676	0.023	0.036500	0.014	0.02	0.008	0.015	0.059	0.082	0.025
Color (PtCo units)	15.00				5	**33.00**	**30**	**43.91**		7.400	6.300	12.60	12.00	**21.90**
Color (APHA units)									50					
Odor (TON)	3.000				2	2.500	**10**	**10.95**	**75**	1.200	**3.300**	2.100	**13.50**	0.700
pH	6.5-8.5		7.42		6.99	7.000	7.0775	6.863	6.93	7.700	7.900	7.700	7.500	8.100
TDS (mg/L)	500.0		**1200**		648	**528.0**	**557**	**550.71**	**610**	**28682**	**18328**	**4128**	**5240**	**533.0**
TSS (mg/L)				1.066 [9]	0.868 [9]									
Foaming Agents (mg/L)	1.500		0.13			0.143	0.305	**2.518**		0.080	0.253	0.118	0.074	0.193
Trihalomethane Analysis														
Bromodichloromethane (µg/L)				6.4	10.200				< 0.5					
Dibromochloromethane (µg/L)				40.9	10.700				< 0.5					
Tribromomethane (Bromoform; µg/L)				122	< 0.31000				< 0.5					
Trichloromethane (Chloroform; µg/L)				1.2	3.6900				7.18					
Total THMs (µg/L)	80.00		**230**		24.600	26.850	6.7	61.584	7.18	0.167	0.650	0.500	2.607	0.026

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		Advanced Wastewater Treatment				Reclaimed Water Treatment		Secondary Effluent		Native Water Monitoring Zones				
		Various Counties	Brevard County			Various Counties	Pinellas County	Various Counties	Dade County	Florida Utility Council[2] - Various Counties				
				Cape Canaveral WWTP										
Parameter Name	Drinking Water MCL[1]	Florida Utility Council[2]	South Beaches WWTF[3]	Sample Date 10/1/99[4]	Sample Date 4/3/01[5]	Florida Utility Council[2]	Albert Whitted WRF, St. Petersburg[6]	Florida Utility Council[2]	Miami-Dade North District[7]	Effluent Injection Zone	Lower Monitoring Zone	Upper Monitoring Zone	ASR Injection Zone	Biscayne Monitoring Zone
Radiological Analysis														
Gross Alpha (pCi/L)	15				< 1.60	3.167	<6.775 +/-1.4	0.400	< 1+/-0.5	9.675	7.300	4.100	**24.660**	5.550
Gross Alpha excl. radon & uranium (pCi/L)			< 4.0+/-2.3											
Radium-226 (pCi/L)					< 0.30		0.4 +/-0.15							
Radium-228 (pCi/L)					< 0.90		<0.75 +/-0.45							
Radium-226 and Radium-228			0.5+/-0.1											
Microbiological Analysis														
Total Coliform (col/100ml)	1, or 5%[8]							**394.071**		**33.50**	**7.000**	**0.500**	**6.000**	
Fecal Coliform (cfu/100ml)	0						<1							
Miscellaneous Analysis														
Ammonia-N (mg/L)							18.0	8.753		3.766	0.561	0.644	0.575	
Nitrogen, total (mg/L)				0.752 [9]	0.97 [9]	13.30	18.3	17.000		9.350	0.881	1.330		
Nitrogen, organic (mg/L)								1.584		0.998	0.374	0.432	0.307	
Nitrogen, total Kjeldahl (mg/L)						4.075	17.9	9.783		5.528	0.474	0.678	0.830	
Nitrate/Nitrite (as N; mg/L)					0.062		0.426667		0.64					
Ortho-phosphate (mg/L)							2.18	1.431		0.234	0.045	0.023	0.133	
Phosphorus, total (mg/L)				0.152 [9]	0.119 [9]	1.375		1.327		0.271	0.261	0.129	0.255	
BOD (mg/L)								8.300		4.300	5.400	7.000	1.400	
CBOD 5 (mg/L)														
Hormonally Active Agents														
Oil and Grease (mg/L)														
Hazardous Algal Bloom including aerosol dist.														
Water Temperature (°C)							26.6	25.333		22.80	23.50	24.30		24.40
Turbidity (NTU)							2.515		11.59					
MBAS Surfactants (mg/L)					< 0.020				0.063					
Synthetic Organic Constituent and Volatile Organic Constituent Analysis														
1,2-Dibromo-3-Chloropropane (DBCP; µg/L)	0.2				< 0.02000		<0.14		< 0.02					
Ethylene Dibromide (EDB; µg/L)	0.05		< 0.01		< 0.01000		<0.02		< 0.02					
Hexachlorocyclopentadiene (µg/L)	50			< 10	< 0.0200		<1.94		< 0.01					
Hexachlorobenzene (µg/L)	1			< 10	< 0.0100		<0.233		< 0.01					
v-BHC (Lindane; µg/L)	0.2		< 0.023	< 0.05	< 0.0240		<0.01		< 0.01					
Alachlor (µg/L)	2				< 0.0625		<1.17		< 0.01					
Heptachlor (µg/L)	0.4			< 0.05	< 0.0540		<0.045		< 0.01					
Heptachlor epoxide (µg/L)	0.2			< 0.05	< 0.0245		<0.035		< 0.01					
Endrin (µg/L)	2		< 0.023	< 0.1	< 0.0100		<0.13		< 0.01					
Methoxychlor (µg/L)	40		< 0.023	< 0.1	< 0.250		<0.21		< 0.01					
Arochlor 1016 (µg/L)				< 1.0					< 0.01					
Arochlor 1221 (µg/L)				< 1.0					< 0.01					
Arochlor 1232 (µg/L)				< 1.0					< 0.01					
Arochlor 1242 (µg/L)				< 1.0					< 0.01					
Arochlor 1248 (µg/L)				< 1.0					< 0.01					
Arochlor 1254 (µg/L)				< 1.0					< 0.01					

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		Advanced Wastewater Treatment				Reclaimed Water Treatment		Secondary Effluent		Native Water Monitoring Zones				
		Various Counties	Brevard County			Various Counties	Pinellas County	Various Counties	Dade County	Florida Utility Council[2] - Various Counties				
				Cape Canaveral WWTP										
Parameter Name	Drinking Water MCL[1]	Florida Utility Council[2]	South Beaches WWTF[3]	Sample Date 10/1/99[4]	Sample Date 4/3/01[5]	Florida Utility Council[2]	Albert Whitted WRF, St. Petersburg[6]	Florida Utility Council[2]	Miami-Dade North District[7]	Effluent Injection Zone	Lower Monitoring Zone	Upper Monitoring Zone	ASR Injection Zone	Biscayne Monitoring Zone
Arochlor 1260 (µg/L)				< 1.0					< 0.01					
Toxaphene (µg/L)	3		< 0.57	< 1.0	< 0.500		<1.77		< 0.01					
Chlordane (µg/L)	2			< 0.05	< 0.500		<0.64		< 0.01					
Simazine (µg/L)	4				< 0.176		<2.67		< 0.5					
Atrazine (µg/L)	3				< 0.625		<1.4		< 0.2					
Dalapon (µg/L)	200				< 0.802		<1.0		< 1.3					
2,4-D (µg/L)	70		< 0.1		< 0.362		<0.1		< 0.2					
Pentachlorophenol (µg/L)	1			< 50	< 0.0545		<0.04		< 0.2					
Phenols (total; µg/L)														
2,4,5-TP (silvex; µg/L)	50		< 0.2		< 0.0250		<0.2		< 0.2					
Dinoseb (µg/L)	7				< 0.125		<0.2		< 0.2					
Picloram (µg/L)	500				< 0.250		<0.1		< 0.2					
Vinyl Chloride (µg/L)	2		< 1	< 10	< 0.29000		<0.625		< 0.5					
1,1-Dichloroethene (µg/L)	7			< 5	< 0.02000		<0.625		< 0.5					
Methylene Chloride (µg/L)				< 5	< 0.31000				< 0.5					
Trans-1,2-Dichloroethene (µg/L)	100			< 5	< 0.12000		<2.5		< 0.5					
Cis-1,2-Dichloroethene (µg/L)	70				< 0.03000		<0.625		< 0.5					
1,1,1-Trichloroethane (µg/L)	200		< 1	< 5	< 0.21000		<2.5		< 0.5					
Carbon Tetrachloride (µg/L)	5		< 1	< 5	< 0.29000		<0.625		< 0.5					
Benzene (µg/L)	5		< 1	< 5	< 0.05000		<0.625		< 0.5					
1,2-Dichloroethane (µg/L)	5		< 1	< 5	< 0.02000		<0.625		< 0.5					
Trichloroethene (µg/L)	5		< 1	< 5	< 0.02000		<0.875		< 0.5					
1,2-Dichloropropane (µg/L)	5			< 5	< 0.33000		<0.625		< 0.5					
Toluene (µg/L)	1000			< 5	< 0.41000		<2.5		< 0.5					
1,1,2-Trichloroethane (µg/L)	5			< 5	< 0.23000		<0.625		< 0.5					
Tetrachloroethene (µg/L)	5		< 1	< 5	< 0.21000		<0.625		4.66					
Chlorobenzene (µg/L)	100			< 5	< 0.23000		<0.625		< 0.5					
Ethylbenzene (µg/L)	700			< 5	< 0.47000		<2.5		< 0.5					
m & p-Xylene (µg/L)									< 0.5					
o-Xylene (µg/L)									< 0.5					
Xylenes (total; µg/L)	10000				< 0.24000		<0.5							
Styrene (µg/L)	100				< 0.47000		<0.5		< 0.5					
1,4-Dichlorobenzene (para) (µg/L)	75		< 1	< 5	< 0.02000		<0.517		< 0.5					
1,2-Dichlorobenzene (ortho) (µg/L)	600			< 5	< 0.05000		<0.5		< 0.5					
1,2,4-Trichlorobenzene (µg/L)	70			< 10	< 0.22000		<10.9		< 0.5					
Di(2-Ethylhexyl)phthalate (µg/L)	6			< 10	< 1.32		<1.25		< 5					
Di(2-Ethylhexyl)adipate (µg/L)	400				< 0.600		<1.12		< 5					
Benzo(a)pyrene (µg/L)	0.2			< 10	< 0.0400		<0.1		< 0.2					
Carbofuran (µg/L)	40				< 0.900		<2		< 10					
Oxamyl (vydate; µg/L)	200				< 1.13		<2		< 50					
Glyphosate (µg/L)	700				< 2.4		<6		< 10					
Endothall (µg/L)	100				< 3.00		<9.0		< 10					

Appendix Table 1-1. Drinking Water Standards and Sampling Results for Treated Wastewater and Native Water in South Florida

		Advanced Wastewater Treatment				Reclaimed Water Treatment		Secondary Effluent		Native Water Monitoring Zones				
		Various Counties	Brevard County			Various Counties	Pinellas County	Various Counties	Dade County	Florida Utility Council[2] - Various Counties				
Parameter Name	Drinking Water MCL[1]	Florida Utility Council[2]	South Beaches WWTF[3]	Cape Canaveral WWTP Sample Date 10/1/99[4]	Cape Canaveral WWTP Sample Date 4/3/01[5]	Florida Utility Council[2]	Albert Whitted WRF, St. Petersburg[6]	Florida Utility Council[2]	Miami-Dade North District[7]	Effluent Injection Zone	Lower Monitoring Zone	Upper Monitoring Zone	ASR Injection Zone	Biscayne Monitoring Zone
Diquat (μg/L)	20				< 4.00		<0.4		< 0.5					
Paraquat (μg/L)									< 1					
1,1-dichloroethane (μg/L)			< 1	< 5	< 0.10000									
PCB-1242 (mg/L)							<0.00075							
PCB-1254 (mg/L)							<0.00075							
PCB-1221 (mg/L)							<0.00125							
PCB-1232 (mg/L)							<0.00075							
PCB-1248 (mg/L)							<0.00075							
PCB-1260 (mg/L)							<0.00075							
PCB-1016 (mg/L)							<0.00075							
Polychlorinated byphenyls (PCBs; mg/L)	0.0005				< 0.250 mg/L		<0.00023							
2,3,7,8-TCDD (Dioxin; mg/L)	$3x10^{-8}$													
Dichloromethane (mg/L)	0.005						<0.000625							

1 National Primary Drinking Water Regulations, 40 CFR 141 et seq.
2 Englehardt et. al. 2001. Comparative Assessment of Human and Ecological Impacts from Municipal Wastewater Disposal Methods in Southeast Florida, Table 2. Numbers are the average of the means of the measurements calculated with non-detects as zero and non-detects at their detection limit values.
3 South Beaches Wastewater Treatment Facility, Melbourne Beach, FL. 2001. Reclaimed Water or Effluent Analysis Report, Report Period 1/1/2000 - 12/31/2000. If monitoring result below the detection limit, this was indicated by showing a less than (<) sign preceding the detection limit.
4 Florida Department of Environmental Protection. 1999. Annual Reclaimed Water/Effluent Analysis for Primary and Secondary Drinking Water Standards, Cape Canaveral Wastewater Treatment Plant. Samples collected October 1, 1999. Laboratory Order Number B9-10-019.
5 City of Cape Canaveral. 2001. Laboratory Order Number 11926.
6 City of St. Petersburg, Public Utilities Department, Albert Whitted Water Reclamation Facility. Values are the average of sampling results from 9/98, 1/99, 4/99, 9/00, and 1/01, except values for ammonia, total nitrogen, total Kjeldahl nitrogen, orthophosphate, and water temperature, which are actual values measured 11/9/00. Values that were non-detects with a detection limit greater than the MCL were excluded from the calculation of the averages. A "less than" sign preceding a value indicates that at least one of the annual sampling results was below the detection limit. It does not necessarily indicate that all annual sampling results were below the detection limit for any given constituent.
7 Miami Dade Water/Sewer, North District. 1999. Submission #9903001041, pp. 47-52. Screen effluent collected 3/19/99. Monitoring results below detection limits are indicated by showing a less than (<) sign preceding the reported detection limit.
8 For systems that collect >40 samples per month, MCL is 5% monthly samples are positive; for systems that collect <40 samples per month, MCL is 1 positive sample.

9 Annual Average calculated from monthly averages in 1999 and 2001 supplied by Florida Department of Environmental Protection (Cape Canaveral NPDES constituent data). Data from May and June 2001 are unavailable; therefore, annual averages for 2001 are calculated from 10 monthly averages.

Appendix Table 1-2. Summary of Treated Wastewater Effluent Characteristics - Southeast Florida Outfall Experiment (SEFLOE)

Arithmetic Average

Parameter Name	Broward	Hollywood	Dade-North	Dade-Central
Ammonia (mg/L)	12.48	5.96	10.46	
Nitrogen, total Kjeldahl (mg/L)	14.31	9.38	13.4	
Phosphorus, Total (mg/L)	1.66	0.97	1.6	
Nitrates (mg/L)	0.42	1.70		
Nitrites (mg/L)	2.01			
Nitrates + Nitrites (mg/L)	2.07			
Oil & Grease (mg/L)	2.17	19.24	3.27	2.54

	Broward		Hollywood	Dade-North		Dade-Central	
	Arithmetic Average of data from four sampling dates		Data from one sampling date	Arithmetic Average of data from two sampling dates		Arithmetic Average of data from two sampling dates	
Parameter Name	Average	Average, excluding "questionable" data points	Sampling Data	Average	Average, excluding "questionable" data points	Average	Average, excluding "questionable" data points
1,1,1 Trichloroethane (µg/L)	1.1	1.1					
Antimony Total (mg/L)				0.013	0.013	0.022	0.022
Arsenic Total (mg/L)	0.032	0.001		0.0004	0.0004		
Cadmium Total (mg/L)	0.002	0.002		0.002	0.002	0.005	0.005
Chloroform (µg/L)	1.65	1.65	10	9.01	9.01		
Chromium Total (mg/L)	0.047	0.047					
Copper Total (mg/L)	0.037	0.012		0.018	0.018	0.023	0.023
Cyanide Total (mg/L)				0.008	0.008	0.005	0.005
Dichlorobromomethane (µg/L)	0.615	0.615					
Ethylbenzene (µg/L)				0.25	0.25		
Heptachlor (µg/L)				0.092	0		
Lead Total (mg/L)	0.004	0.004		0.010	0.010	0.02	0.02
Nickel total (mg/L)	0.015	0.015		0.003	0.003	0.003	0.003
Phenols, Total (µg/L)			70			11	11
Selenium Total (mg/L)	0.007	0.007		0.0005	0.0005		
Silver Total (mg/L)	0.0005	0.0005	0.010 (ques)			0.007	0
Tetrachloroethylene (µg/L)						3	3
Thallium Total (mg/L)				0.019	0.019	0.007	0.007
Toluene (µg/L)				1.07	1.07		
Zinc Total (mg/L)	0.054	0.036	0.015	0.015	0.015	0.041	0.041

1 Hazen and Sawyer, Inc. 1994. SEFLOE II Final Report. pp. III-182-185; III-202-205; and III-210-213. Average values represent 7-43 sampling records from Broward County North Regional Wastewater Treatment Plant, the Miami-Dade North District and Central District Wastewater Treatment Plants, and the City of Hollywood Wastewater Treatment Plant.

Appendix Table 1-2. Summary of Treated Wastewater Effluent Characteristics - SEFLOE data[1] Continued

Broward

Parameter	2/13/1991	9/20/1991	2/11/1992	3/24/1992	average	average -ques points
Dichlorobromomethane (μg/L)	n/a	n/a	0	1.23	0.615	0.615
Chloroform (μg/L)	1.7	0.0	2.72	2.18	1.65	1.65
1,1,1 Trichloroethane (μg/L)	1.5	0.0	2.68	0	1.0525	1.0525
Arsenic Total (μg/L)	0.0	124.0	1.7	2.3	32	1.333333333
Cadmium Total (μg/L)	0.0	8.3	0	0.3	2.15	2.15
Chromium Total (μg/L)	2.8	3.3	3.2	179	47.075	47.075
Copper Total (μg/L)	2.1	20.0	111.3	14.4	36.95	12.16666667
Lead Total (μg/L)	0.0	5.0	4.8	6.7	4.125	4.125
Nickel total (μg/L)	4.2	44.0	6.8	6.7	15.425	15.425
Selenium Total (μg/L)	0.0	23.3	1	2	6.575	6.575
Silver Total (μg/L)	0.0	0.5	0.9	0.5	0.475	0.475
Zinc Total (μg/L)	20.0	52.5	111	34	54.375	35.5

Hollywood

Parameter	sampling point (11/25/91)
Chloroform (μg/L)	10
Silver, Total (μg/L)	10 (ques)
Zinc, Total (μg/L)	15
Phenols, Total (μg/L)	70

Dade-North

Parameter	2/27/1991	2/18/1992	average	ave - ques points
Chloroform (μg/L)	10.01	8.0	9.005	9.005
Ethylbenzene (μg/L)	0.5	0	0.25	0.25
Toluene (μg/L)	2.14	0	1.07	1.07
Heptachlor (μg/L)	0.183	0	0.0915	0
Antimony Total (μg/L)	26.3	0	13.15	13.15
Arsenic Total (μg/L)	0.83	0	0.415	0.415
Cadmium Total (μg/L)	3.0	0	1.5	1.5
Copper Total (μg/L)	19.0	16.0	17.5	17.5
Lead Total (μg/L)	20.2	0	10.1	10.1
Nickel total (μg/L)	5	0	2.5	2.5
Selenium Total (μg/L)	0.91	0	0.455	0.455
Thallium Total (μg/L)	38.9	0	19.45	19.45

Dade-Central

Parameter	2/22/1991	9/20/1991	average	ave - ques points
Tetrachloroethylene (μg/L)	0	6	3	3
Antimony Total (μg/L)	44.8	0	22.4	22.4
Cadmium Total (μg/L)	9	0	4.5	4.5
Copper Total (μg/L)	35	10	22.5	22.5
Lead Total (μg/L)	40	0	20	20
Nickel total (μg/L)	5	0	2.5	2.5
Silver, Total (μg/L)	14	0	7	0
Thallium Total (μg/L)	13	0	6.5	6.5
Zinc Total (μg/L)	82	0	41	41
Cyanide Total (μg/L)	9.6	0	4.8	4.8
Phenols, Total (μg/L)		11	11	11

Appendix Table 1-3. Microbial Standards and Concentrations in Treated Wastewater.

Microbial Standards

<u>Microbial Pathogens and Sewage Indicators</u>	Drinking Water Maximum Containment Level[1]	Florida Department of Environmental Protection Recommended Limits[2]		Summary of Requirements For Disinfection Used in South Florida		
		Average	Maximum	Basic disinfection	Intermediate disinfection	High-Level disinfection
Total Coliform (col/100ml)	1, or 5%					
Fecal Coliform (cfu/100ml)	0			≤ 200	≤ 14	BDL
Enterovirus (mpn/100 L)						
Enterovirus (PFU/100 L)[2a]		0.044	0.165			
Enterovirus (PFU/100 L)[2b]		14	50			
Cryptosporidium (oocysts/100 L)		5.8	22	5	5	5
Giardia lamblia (cysts/100 L)		1.4	5			
Enterococci (cfu/100 mL)						
Clostridium perfringens (cfu/100 mL)						
Coliphages (pfu/100 mL)						
Enterovirus (PFU/100L)						
Coliphages Host E. coli (pFamp) (PFU/100 mL)						
Coliphages Host E. coli C (PFU/100 mL)						

BLD = Below Detection Limit

Microbial Surface Water Concentrations (1)

<u>**Microbial Pathogens and Sewage Indicators**</u>	**Surface Water**							
	Sarasota County						**Hillsborough County**	
	5 Streams in the vicinity of Sarasota[1]		Sarasota Bay [1]		Phillippi Creek[1]		Tampa Bypass Canal[1]	
	Average	Range	Average	Range	Average	Range	Average	Range
Total Coliform (col/100ml)								
Fecal Coliform (cfu/100ml)								
Enterovirus (mpn/100 L)								
Cryptosporidium (oocysts/100 L)	6.6	ND-157	ND	ND	3.1	ND-11	3.1	ND-11
Giardia lamblia (cysts/100 L)	ND	ND	ND	ND	0.42	ND-2.9	0.42	ND-2.9
Enterococci (cfu/100 mL)								
Clostridium perfringens (cfu/100 mL)								
Coliphages (pfu/100 mL)								
Enterovirus (PFU/100L)								
Coliphages Host E. coli (pFamp) (PFU/100 mL)								
Coliphages Host E. coli C (PFU/100 mL)								

ND= Nondetect

Microbial Surface Waters Concentrations (2)

Microbial Pathogens and Sewage Indicators	**Surface Waters**
	Brevard County
	Duda Ditches[2]
	single sampling date
Total Coliform (col/100ml)	
Fecal Coliform (cfu/100ml)	100.9
Enterovirus (mpn/100 L)	
Cryptosporidium (oocysts/100 L)	
Giardia lamblia (cysts/100 L)	
Enterococci (cfu/100 mL)	
Clostridium perfringens (cfu/100 mL)	
Coliphages (pfu/100 mL)	
Enterovirus (PFU/100L)	
Coliphages Host E. coli (pFamp) (PFU/100 mL)	
Coliphages Host E. coli C (pfu/100 mL)	

Microbial Concentrations in Untreated and Treated Wastewater (1)

Microbial Pathogens and Sewage Indicators	Raw Wastewater	Secondary Treated Wastewater	Secondary Treated Wastewater					
	United States	Dade County	Broward County					
	Urban Communities within the United States[1]	MDWSD North District IW3[2]	City of Fort Lauderdale[3]	City of Hollywood[3]	Sunrise (IW1 and IW2)[3]	Sunrise (IW3)[3] Sawgrass	Hollywood WTP (reuse filter)[3]	Broward County Regional WWTP (Reuse Composite Sampler)[4]
	sampling dates unknown	sampling date 3/19/99	sampling date 4/25/96	sampling date 4/25/96	sampling date 2/11/00	sampling date unknown	sampling date 7/9/99	average of 30 values taken in September 2001
Total Coliform (col/100ml)	22 x (10^6)	0.0005	2100	0.5	280	180	0.5	0.033
Fecal Coliform (cfu/100ml)	8 x (10^6)							0
Enterovirus (mpn/100 L)								
Cryptosporidium (oocysts/100 L)								
Giardia lamblia (cysts/100 L)								
Enterococci (cfu/100 mL)								
Clostridium perfringens (cfu/100 mL)								
Coliphages (pfu/100 mL)								
Enterovirus (PFU/100L)								
Coliphages Host E. coli (pFamp) (PFU/100 mL)								
Coliphages Host E. coli C (pfu/100 mL)								

Microbial Concentrations in Treated Wastewater (2)

Microbial Pathogens and Sewage Indicators	Secondary Effluent				
	Brevard County[5]				
	BCUD/ South Central Regional WWTF[6]	South Beaches WWTF[7]	BCUD/Port St. John WWTF	Barefoot Bay Advanced Wastewater Treatment Facility	BCUD/ Sykes Creek Regional WWTF
	daily sample results	daily sample results	daily sample results	daily sample results-R001 reuse irrigation	daily sample results-reuse
	(mon site EFA-1; avg of monthly)	(mon site EFA-1; avg of monthly)	(mon site EFA-1; avg of monthly)	(mon site EFA-1; avg)	(mon site EFA-2; avg)
Total Coliform (col/100ml)					
Fecal Coliform (cfu/100ml)	0.03	0.04	0.18	0	0
Enterovirus (mpn/100 L)					
Cryptosporidium (oocysts/100 L)					
Giardia lamblia (cysts/100 L)					
Enterococci (cfu/100 mL)					
Clostridium perfringens (cfu/100 mL)					
Coliphages (pfu/100 mL)					
Enterovirus (PFU/100L)					
Coliphages Host E. coli (pFamp) (PFU/100 mL)					
Coliphages Host E. coli C (pfu/100 mL)					

Microbial Concentrations in Treated Wastewater (3)

Microbial Pathogens and Sewage Indicators	Reclaimed Water			Advanced Wastewater Treatment			
	Pinellas County			Brevard County		Hillsborough County	
	Albert Whitted WRF, St. Petersburg[8]	St. Petersburg[9]		Cape Canaveral WWTP NPDES database		Howard Curren WWTP[12]	
	Sampling date 11/28/00	Average	Maximum	Annual average 1999[10]	Annual average 2001[11]	Sample date 5/5/00	Sample date 5/16/01
Total Coliform (col/100ml)							
Fecal Coliform (cfu/100ml)				0.125	1.15		
Enterovirus (mpn/100 L)							
Cryptosporidium (oocysts/100 L)	1.85	0.75	5.35			<0.7	2.33
Giardia lamblia (cysts/100 L)	0.26	0.49	3.3			<0.7	<0.29
Enterococci (cfu/100 mL)							
Clostridium perfringens (cfu/100 mL)							
Coliphages (pfu/100 mL)							
Enterovirus (PFU/100L)		0.01	0.133				
Coliphages Host E. coli (pFamp) (PFU/100 mL)							
Coliphages Host E. coli C (pfu/100 mL)							

Microbial Concentrations in Monitoring Wells (1)

Microbial Pathogens and Sewage Indicators	Deep Injection Monitoring Wells			
	Pinellas County			
	Well ID AWWRF 757[1]	Well ID AWWRF 758[1]	Well ID AWWRF 779[1]	St Petersburg[1]
	Average of the results from 20 sampling events between 4/98 and 12/00	Average of the results from 20 sampling events between 4/98 and 12/00	Average of the results from 20 sampling events between 4/98 and 12/00	Sampling date 10/13/00[2]
Total Coliform (col/100ml)				<0.058
Fecal Coliform (cfu/100ml)				<0.058
Enterovirus (mpn/100 L)	<1.0	<1.0	<1.0	<0.1
Cryptosporidium (oocysts/100 L)				<0.17
Giardia lamblia (cysts/100 L)				<0.17
Enterococci (cfu/100 mL)				<0.058
Clostridium perfringens (cfu/100 mL)				<0.058
Coliphages (pfu/100 mL)				
Enterovirus (PFU/100L)				
Coliphages Host E. coli (pFamp) (PFU/100 mL)				<5
Coliphages Host E. coli C (pfu/100 mL)				<5

Microbial Concentrations in Ground Water Monitoring Wells (2)

Microbial Pathogens and Sewage Indicators	Deep Injection Monitoring Wells				
	Various Counties				
	Native Water Monitoring Zones				
	Effluent Injection Zone	Lower Monitoring Zone	Upper Monitoring Zone	ASR Injection Zone	Biscayne Monitoring Zone
Total Coliform (col/100ml)	33.50	7.00	0.500	6.00	
Fecal Coliform (cfu/100ml)					
Enterovirus (mpn/100 L)					
Cryptosporidium (oocysts/100 L)					
Giardia lamblia (cysts/100 L)					
Enterococci (cfu/100 mL)					
Clostridium perfringens (cfu/100 mL)					
Coliphages (pfu/100 mL)					
Enterovirus (PFU/100L)					
Coliphages Host E. coli (pFamp) (PFU/100 mL)					
Coliphages Host E. coli C (pfu/100 mL)					

Microbial Concentrations in Ground Water Monitoring Wells (3)

Microbial Pathogens and Sewage Indicators	**Deep Injection Monitoring Wells**					
	Pinellas County					
	AWWRF well 779[2]	SWWRF well 765[2]	SWWRF well 768[2]	NWWRF well 798[2]	AWWRF well 758[2]	NEWRF well 784[2]
	Sample date 12/1/99	Sample date 12/1/99	Sample date 12/1/99	Sample date 12/1/99	Sample date 12/1/99	Sample date 12/1/99
Total Coliform (col/100ml)	<0.058	<0.058	<0.058	<0.058	<0.058	<0.058
Fecal Coliform (cfu/100ml)	<0.058	<0.058	<0.058	<0.058	<0.058	<0.058
Enterovirus (mpn/100 L)	<0.071	<0.060	<0.075	<0.05	0.074	<0.080
Cryptosporidium (oocysts/100 L)	1.18	<0.30	0.74	0.36	0.14	<0.11
Giardia lamblia (cysts/100 L)	<0.29	<0.30	<0.15	<0.30	<0.14	<0.11
Enterococci (cfu/100 mL)	<0.058	<0.058	<0.058	<0.058	<0.058	<0.058
Clostridium perfringens (cfu/100 mL)	<0.058	<0.058	<0.058	<0.058	<0.058	<0.058
Coliphages (pfu/100 mL)	<5	<5	<5	<5	<5	<5
Enterovirus (PFU/100L)						
Coliphages Host E. coli (pFamp) (PFU/100 mL)						
Coliphages Host E. coli C (pfu/100 mL)						

FOOTNOTES TO APPENDIX 1-3 (MICROBIAL PATHOGEN TABLE).

Footnotes for Table – Microbial Standards

1 Maximum Contaminant Level (MCL). National Primary Drinking Water Regulations, 40 CFR 141 et seq.

2 York, D.W., P. Menendez, and L. Walker-Coleman. 2002. Pathogens in Reclaimed Water: the Florida Experience. 2002 Water Sources Conference.
2a. Assumes all Enterovirus is highly infective Rotavirus.
2b. Assumes all Enterovirus is moderately infective Echovirus.

Footnotes for Table - Microbial Concentrations in Treated Effluent

1 Geldriech, E.E. 1978 in Wood, I.R. et al. 1993. Ocean Disposal of Wastewater. Advanced Series on Ocean Engineering. Volume 8. World Scientific Publishing Co. Pte. Ltd. Samples taken from several urban communities in the United States.

2 Englehardt al. 2001. Comparative Assessment of Human and Ecological Impacts from Municipal Wastewater Disposal Methods in Southeast Florida. Florida Water and Environment Utility Council.

3 Englehardt al. 2001. Comparative Assessment of Human and Ecological Impacts from Municipal Wastewater Disposal Methods in Southeast Florida. Florida Water and Environment Utility Council.

4 Broward County Office of Environmental Services, Environmental Operations Division, Compliance and Monitoring Section. Facsimile. Contact: Richard Walker.

5 Florida Department of Environmental Protection Discharge Monitoring Reports for Brevard County.

6 Florida Department of Environmental Protection Discharge Monitoring Reports for Brevard County. No detection limit was given; zero was used in calculations where non-detect (ND) was entered on data form. Values are averages from monthly reported values for March, April, and May 2001, except for "created wetlands" value, which is the average of March and April reported values (no discharge to wetlands in May 2001) and for "surface water" value.

7 Florida Department of Environmental Protection Discharge Monitoring Reports for Brevard County. Values are averages from monthly reported values for March, April, and May 2001, calculated by Horsley & Witten, Inc. No detection limit was given; zero was used in calculations where non-detect (ND) was entered on data form.

8 Sampling results provided by Mr. Alfredo Crafa, Environmental Compliance Division, Albert Whitted Wastewater Reclamation Facility, March 18, 2002, City of St. Petersburg, Florida.

9 York, D.W., P. Menendez, and L. Walker-Coleman. 2002. Pathogens in Reclaimed Water: the Florida Experience. 2002 Water Sources Conference.

10 Annual average calculated from monthly averages in 1999 supplied by Florida Department of Environmental Protection (Cape Canaveral National Pollution Discharge Elimination System constituent data). Data from May, June, November, and December are unavailable; therefore, coliforms per 100 mL annual averages for 1999 are calculated from 8 monthly averages. Seven of eight months reported 0 fecal coliforms; one month detected <1 fecal rk. Personal Communication (February 22, 2002). Results are for pathogens in reclaimed wastewater intended for reuse.

11 Annual average calculated from twelve monthly averages in 2001 supplied by Florida Department of Environmental Protection (Cape Canaveral NPDES constituent data). Eleven months reported <1 cfu/100 mL; one month (January) reported 2.8 cfu/100 mL.

12 David York, Ph.D., P.E., Reuse Coordinator, Florida Department of Environmental Protection, personal communication (February 22, 2002). Results are the pathogens in reuse effluent from the Howard Curran Wastewater Treatment Plant.

Footnotes for Table - Microbial Data from Monitoring Wells

1 The Albert Whitted Wastewater Reclamation Facility provided sampling data for microbes from effluent treated to Advanced treatment standards. Values are the average of 20 sampling events for microbial concentrations in three (3) monitoring wells between the period of March 1998 and December 2000.

2 Sampling results provided by Mr. Alfredo Crafa, Environmental Compliance Division, Albert Whitted Wastewater Reclamation Facility, March 18, 2002, City of St. Petersburg, Florida.

3 Rose, J.B., and W. Quintero-Betancourt, J. Jarrel, E. Lipp, S. Farrah, G. Lukasik, and T. Scott. 2001. Deep Injection Monitoring Well: Water Quality Monitoring Report. Report to the Florida Department of Environmental Protection.

Footnotes for Table - Microbial Data from Surface Waters

1 Florida Department of Environmental Protection, Risk Impact Statement, Phase II Revisions to Chapter 62-610, F.A.C., Docket No. 95-08R.

2 Average of samples taken on 3/13/01 at 10 surface water-sampling stations. Florida Department of Environmental Protection Discharge Monitoring Reports.

Footnotes for Table - Microbial Data from Ohio River in the Cincinnati, Ohio Area

1 York, D.W., P. Menendez, and L. Walker-Coleman. 2002. Pathogens in Reclaimed Water: the Florida Experience. 2002 Water Sources Conference. Values are the average of five separate sampling events.

2 York, D.W., P. Menendez, and L. Walker-Coleman. 2002. Pathogens in Reclaimed Water: the Florida Experience. 2002 Water Sources Conference. Values are the average of four separate sampling events.

3 York, D.W., P. Menendez, and L. Walker-Coleman. 2002. Pathogens in Reclaimed Water: the Florida Experience. 2002 Water Sources Conference. Values are the average of two separate sampling events.

Footnotes for Table - SDWTP Monitoring Well Data, Dade County

1 South District Wastewater Treatment Plant, Miami-Dade County, Florida. Monitoring Well Purging Report.

Appendix 1-3. Microbial Pathogens and Description of Data Sources

1.0 General

Appendix Table 1-3 provides data on microbial concentrations in treated effluent and monitoring samples, collected from various sources. These sources include information compiled from:

- The National Pollutant Discharge Elimination System (NPDES) effluent quality database for Cape Canaveral WWTP including years 1999-2001;
- David York *(personal communication), regarding microbial concentrations in* treated effluent at the Howard Curren WWTP in Hillsborough County;
- Several sets of microbial data from the Alfred Whitted AWT facility, including results for treated effluent and deep injection monitoring wells;
- A Florida Water Environment Association Utility Council (FWEAUC) report, including monitoring data from several groundwater monitoring zones and data from secondary-treated effluent from facilities in Broward and Dade counties;
- A report to the Florida Department of Environmental Protection authored by JB Rose, W. Quintero-Betancourt, J. Jarrel, E. Lipp, S. Farah, G. Lukasic, and T. Scott in 2001, which includes data for six deep injection monitoring well wells in St. Petersburg, Pinellas County;
- Florida Department of Environmental Protection Discharge Monitoring Reports for several wastewater treatment facilities in Brevard County, including:
    - BCUD/South Central Regional WWTF
    - Barefoot Bay WWTF
    - BCUD/Sykes Creek Regional WWTP
    - BCUD/Port St. John WWTF
    - South Beaches WWTF
- The Broward County Office of Environmental Services, which provided water quality data for reclaimed water (including total coliform and fecal coliform values) from the Broward County Regional Wastewater Treatment Plant for the month of September 2001;
- A report by D.W. York, P. Menendez, and L. Walker-Coleman entitled *Pathogens in Reclaimed Water: The Florida Experience* 2002, which includes a review of reclaimed water quality in St. Petersburg as reported by J.B. Rose and R. P. Carnahan; and
- A Risk Impact Statement prepared in 1998 by the Florida Department of Environmental Protection, which includes surface water monitoring data for microbes for Sarasota and Hillsborough Counties.

2.0 The National Pollutant Discharge Elimination System (NPDES)

National Pollutant Discharge Elimination System (NPDES) data for Cape Canaveral for the years 1999-2001were obtained in spreadsheet format from the Florida Department of Environmental Protection. The average annual concentrations of fecal coliform bacteria in treated effluent from this facility were calculated from monthly averages in 1999 and

2001. Data from May, June, November, and December 1999 were unavailable; therefore, the annual average number of fecal coliform colony forming units (cfu) per 100 mL was calculated from 8 monthly averages. Seven of eight months reported zero (0) fecal coliforms; one month detected fewer than 1 cfu per 100 mL of treated effluent. During 2001, eleven of twelve monthly results were less than 1 cfu/100 mL; one month (January) reported 2.8 cfu/100 mL.

3.0 Howard Curren WWTP

David York, Ph.D., Reuse Coordinator for the Florida Department of Environmental Protection, provided results from two sampling events at the Howard Current Wastewater Treatment Plant. These sampling events measured *Giardia* and *Cryptosporidium* in effluent treated to reuse standards. These sampling events occurred on May 5, 2000, and on May 16, 2001.

4.0 Albert Whitted Water Reclamation Facility

The Albert Whitted Wastewater Reclamation Facility provided sampling data for microbes from effluent treated to Advanced Treatment standards (sampling date November 28, 2000) as well as from three deep monitoring wells (sampling date October 13, 2000). The microbial results for the treated effluent sample were obtained from a single sample of 378.5 liters. The deep monitoring well results in the table reflect the data from each of the three wells as well as duplicate samples for each monitoring well; all microbial parameters were below detection limits (indicated by the "less than" (<) sign) in all the monitoring well samples.

5.0 Florida Water Environment Association Utility Council

The Florida Water Environment Association Utility Council (FWEAUC) report (Englehardt et al., 2001) provided analysis of sampling and monitoring results of effluent that had been treated to different standards (advanced wastewater treatment, secondary treatment, and advanced secondary treatment) as well as "native" ambient water in injection zones and monitoring zones in target aquifers. The data that presented in the "Native Water Monitoring Zones" columns in Table X.X represents "digested" data that have already been processed by the FWEAUC authors, who calculated the average concentrations of each parameter from several sampling locations and events. The "digested" data effectively assign a value of one-half the detection limit to non-detects, a standard approach not inconsistent with risk assessment methodologies (US EPA. 1998).

The authors of the FWEAUC report also include raw concentration data for each of the sampling stations in appendices B and C of their report. The concentration of total coliform bacteria for several wastewater treatment facilities in south Florida were obtained from these appendices and entered into Table X.X. Microbial data were only available for facilities treating to secondary treatment standards. Non-detects (for the City of Hollywood treated effluent and reuse filter) were assigned a value of one-half the detection limit of 1.0 cfu/100 mL (0.5 cfu/100 mL) in the table. Facilities for which total coliform bacteria concentrations were available include:

- City of Hollywood (Broward County);
- City of Sunrise Sawgrass Facility (IW3; Broward County);
- City of Ft. Lauderdale (Broward County);
- Miami-Dade Water and Sewer Department North District (IW3; Dade County);
- City of Hollywood Reuse Filter (Broward County); and
- City of Sunrise (IW1 + IW2; Broward County).

St. Petersburg, Pinellas County

A report to the Florida Department of Environmental Protection authored by JB Rose, W. Quintero-Betancourt, J. Jarrel, E. Lipp, S. Farah, G. Lukasic, and T. Scott in 2001 includes monitoring data for six deep monitoring wells associated with Class I municipal injection wells at four wastewater facilities in St. Petersburg: the Southwest Wastewater Reclamation Facility (SWWRF), the Northwest Wastewater Reclamation Facility (NWWRF), the Northeast Wastewater Reclamation Facility (NEWRF) and the Albert Whitted Wastewater Reclamation Facility (AWWRF). Values entered into Table X.X (monitoring wells) represent results from single sampling events at each monitoring well.

6.0 Florida Department of Environmental Protection Discharge Monitoring Reports

The Florida Department of Environmental Protection provided monthly Discharge Monitoring Reports covering March, April, and May 2001, for several wastewater treatment facilities in Brevard County. Those facilities include:

- BCUD/South Central Regional WWTF
- Barefoot Bay WWTF
- BCUD/Sykes Creek Regional WWTP
- BCUD/Port St. John WWTF
- South Beaches WWTF

For each of the facilities daily monitoring data were provided for Fecal Coliform levels. The values entered in Table XX (treated effluent) are the averages for March, April and May that are then averaged together.

7.0 Broward County Office of Environmental Services

Richard Walker provided monitoring data, via facsimile, from the Broward County Office of Envirnomental Services Analytical Laboratory, for the Broward County Regional WWTP. Daily monitoring data was supplied for the month of September 2001 for advanced secondary treated effluent. The sampling location was the Reuse Composite Sampler. Total and Fecal Coliform levels were reported in counts/100 mL.

The values in Table XX (treated effluent) are the average of the 30 values reported for September 2001.

8.0 Pathogens in Reclaimed Water: The Florida Experience

The paper authored by David York, Ph.D., and Lauren Walker-Coleman of the Florida Department of Environmental Protection and Pepe Menendez, P.E., of the Florida Department of Health outlines Florida's addition of required monitoring for the protozoan pathogens *Cryptosporidium* and *Giardia* in domestic wastewater, to the state's regulations regarding water reuse. The paper contains summarized monitoring data through September 2001 taken in Monterey County, California and St. Petersburg Florida. The data provided in Table XX (treated effluent) represents the average of all data collected through September 2001 and the maximum concentration of pathogens found reclaimed water. The paper also contains fecal and total coliform data from the Ohio River in the Cincinnati, Ohio area. These data were taken over a four month period from September 8, 1975 through December 1, 1975. Three separate sampling stations were monitored and the values in table XY (surface water) are the averages of the combined sampling events at each separate station.

9.0 Risk Impact Statement, Florida Department of Environmental Protection

Surface water monitoring data for microbes for Sarasota and Hillsborough Counties were taken from the Risk Impact Statement, Phase II Revisions prepared by the Florida Department of Environmental Protection. The data provided in Table XX represents the average concentrations and the range of oocysts/100L of water of Giardia and Cryptosporidium in reclaimed water in St. Petersburg and surface waters in Sarasota and Hillsborough Counties. The sampling dates for this study are unknown. The surface waters samples collected in Sarasota County include 24 samples taken in five streams, four samples taken from a high quality estuary within Sarasota Bay, and 16 samples taken from Phillippi Creek, an urban stream within Sarasota. The samples collected in Hillsborough County include seven samples taken from the Tampa Bypass Canal

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Barefoot Bay Advanced Wastewater Treatment Facility, Brevard County Water Resources Department, Brevard County. Discharge Monitoring Report May 9, 2001 – May 31, 2001.

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BCUD/South Central Regional Wastewater Treatment Facility, Brevard County Water Resources Department, Brevard County. Discharge Monitoring Reports April 01, 2001- April 30, 2001.

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BCUD/Sykes Creek Regional Wastewater Treatment Plant, Brevard County Water Resources Department, Brevard County. Discharge Monitoring Reports March 01, 2001- March 31, 2001.

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BCUD/Port St. John Wastewater Treatment Facility, Brevard County Water Resources Department, Brevard County. Discharge Monitoring Reports March 01, 2001- March 31, 2001.

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City of St. Petersburg, Environmental Compliance Division. Sampling data for October 13, 2000 at the Albert Whitted Wastewater Treatment Facility. Contact Alfredo J. Crafa, Manager.

David York, Ph.D., P.E., Reuse Coordinator, Florida Department of Environmental Protection, 2600 Blair Stone Rd.- MS 3540 Tallahassee, Florida 32399-2400, phone: (850) 922-2034, fax: (850) 921-6385, email: david.york@dep.state.fl.us

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South Beaches Wastewater Treatment Facility, Brevard County Water Resources Department, Brevard County. Discharge Monitoring Reports May 01, 2001 – May 31, 2001.

South District Wastewater Treatment Plant, Miami Dade Water and Sewer Department, Miami Dade County, Florida. Monitoring Well Purging Report (Report A.) December 26, 2002.

Appendix Table 1-4. Fecal Coliform Concentrations in Secondary Treated Wastewater Effluent, South Dade Wastewater Treatment Plant, Dade County.

Effluent[1]		
Number of times sampled and range of dates	**Fecal coliform colonies/100 mL**	**Date(s) detected**
44 5/7/91-5/4/93	0	5/7/91
	40,000	5/14/91
	>400	5/21/91
	9,200	5/28/91
	800	6/4/91
	72,000	6/18/91
	152,000	6/25/91
	180,000	8/6/91
	4,000	8/13/91
	80,000	8/20/91
	190,000	8/27/91
	150,000	9/17/91
	260,000	9/24/91
	490,000	10/1/91
	430,000	10/16/90
	300	10/22/91
	300,000	10/29/91
	160,000	11/5/91
	80,000	11/13/91
	50,000	11/19/91
	280,000	11/26/91
	170,000	12/3/91
	18,000	12/10/91
	24,000	12/17/91
	580,000	12/26/91
	17,000,000	1/2/92
	150,000	1/14/92
	0	1/21/91
	20,000	1/28/92
	80,000	2/4/92
	50,000	2/13/92
	30,000	2/18/92
	30,000	2/25/92
	510,000	3/3/92
	50,000	3/10/92
	50,000	3/17/92
	21	3/2/93
	10,000	3/9/93
	50,000	3/16/93
	160,000	3/30/93

Effluent[1]		
Number of times sampled and range of dates	Fecal coliform colonies/100 mL	Date(s) detected
44 5/7/91 - 5/4/93 (cont.)	10,000	4/6/93
	32,000	4/13/93
	160,000	4/20/93
	124	4/27/93
52 5/11/93-4/4/95	18,000	5/4/93
	29,000	5/11/93
	12,000	5/18/93
	7,000	5/25/93
	4,800	6/3/93
	55,000	6/8/93
	52,000	6/15/93
	16,000	6/21/93
	152,000	6/29/93
	19,400	7/8/93
	13,800	7/13/93
	58,000	7/20/93
	61,000	7/27/93
	39,000	8/5/93
	21,000	8/9/93
	31,000	8/18/93
	6,000	8/25/93
	6,600	9/1/93
	26,000	9/8/93
	22,000	9/14/93
	2,650	9/21/93
	17,400	9/28/93
	32,500	10/5/93
	5,000	10/13/93
	235	10/19/93
	12,000	10/28/93
	900	11/2/93
	40	11/9/93
	48,000	11/16/93
	140,000	11/30/93
	3,000	12/7/93
	210,000	12/21/93
	36,000	12/28/93
	310,000	1/6/94
	760,000	1/11/94
	74,000	1/18/94
	4	1/10/95
	2	1/31/95

Effluent[1]		
Number of times sampled and range of dates	Fecal coliform colonies/100 mL	Date(s) detected
52 5/11/93-4/4/95	4	2/6/95
	2	2/13/95
	19,800	2/21/95
	9,800	2/28/95
	156	3/8/95
	230,000	3/28/95
	120,000	4/4/95
49 4/18/95-2/4/97	62	4/18/95
	6	5/2/95
	12,000	5/16/95
	46,000	5/23/95
	100,000	5/31/95
	180,000	6/7/95
	8	6/13/95
	154,000	6/20/95
	70,000	6/27/95
	80,300	7/5/95
	120,000	7/18/95
	64,000	7/21/95
	24,000	8/3/95
	58,000	8/8/95
	13,000	8/15/95
	58,000	8/23/95
	14,000	8/29/95
	42,000	9/5/95
	18,500	9/12/95
	56,000	9/19/95
	70,000	9/28/95
	32,000	10/3/95
	29,000	10/11/95
	70,000	10/17/95
	29,000	10/31/95
	42,000	11/7/95
	67,000	10/8/96
	480,000	10/16/96
	140,000	10/22/96
	33,000	10/29/96
	45,500	11/5/96
	45,000	11/12/96
	99,000	11/19/96
	62,500	11/26/96
	93,000	12/3/96
	26,000	12/10/96

Effluent[1]		
Number of times sampled and range of dates	**Fecal coliform colonies/100 mL**	**Date(s) detected**
4/18/95-2/4/97 (cont.)	128,000	12/17/96
	680,000	12/24/96
	780,000	12/31/96
	130,000	1/7/97
	61,000	1/14/97
	780,000	1/21/97
	705,000	1/28/97
	50,000	2/4/97
40 2/11/97- 10/2/97	38,000	2/11/97
	22,500	2/18/97
	38,000	2/25/97
	38,000	3/4/97
	670,000	3/11/97
	92,300	3/18/97
	53,000	3/25/97
	25,500	4/2/97
	23,500	4/8/97
	21,500	4/15/97
	30,000	4/22/97
	150,000	4/29/97
	140,000	5/13/97
	90,000	5/20/97
	42,000	5/27/97
	142,000	6/3/97
	72,500	6/10/97
	25,600	6/17/97
	37,000	6/24/97
	42	7/1/97
	21,500	7/8/97
	176,000	7/15/97
	24,000	7/22/97
	36,000	8/5/97
	64,000	8/12/97
	16	8/19/97
	12,200	8/26/97
	415,000	7/28/98
	380,000	8/4/98
	715,000	8/11/98
	665,000	8/25/98
	2,300,000	9/1/98
	2,400,000	9/8/98
	9,000,000	9/15/98
	400,000	9/29/98

Effluent[1]		
Number of times sampled and range of dates	**Fecal coliform colonies/100 mL**	**Date(s) detected**
2/11/97- 10/2/97 (cont.)	2,400,000	9/8/98
	9,000,000	9/15/98
	400,000	9/29/98
	3,100,000	10/6/98
	7,050,000	10/14/98
	7,050,000	10/20/98
	1,090,000	10/28/98

[1] Reference: South District Wastewater Treatment Plant, Miami Dade Water and Sewer Department, Miami Dade County, Florida. Monitoring Well Purging Report (Report A) December 26, 2002.

Appendix Table 1-5. Fecal Coliform Concentrations From Monitoring Wells, South District Wastewater Treatment Plant, Dade County

Monitoring well[1]	Depth (feet)	Number of times sampled	Number of fecal coliforms detections (>0)	Fecal coliforms, colonies/100 mL	Date(s) detected
FA 1-U	980-1,090	230	7	2	3/1/87
				4	3/1/90
				14	1/1/91
				94	10/1/92
				400	12/8/92
				150	4/13/93
				6	1/10/95
FA 1-L	1,840-1,927	227	3	4	3/1/90
				4	10/1/92
				58	12/8/92
FA 2-U	980-1,020	208	6	2	12/1/90
				>2000	9/24/92
				520	10/1/92
				340	10/8/92
				110	10/14/92
				4	10/20/92
FA 2-L	1,645-1,672	213	1	10	10/1/92
FA 3-U	981-1,050	183	5	6	3/9/93
				2	3/16/93
				8	4/13/93
				200	11/28/94
				4	6/13/95
FA 3-L	1,771-1,892	184	2	2	5/21/91
				4	4/13/93
Zone 4	1,702-1,840	151	1	100	9/24/92
FA 5-U	1,490-1,588	95	1	2	1/10/95
FA 5-L	1,790-1,890	121	1	6	4/4/95
FA 6-U	1,490-1,584	99	1	4	1/10/95

Monitoring well[1]	Depth (feet)	Number of times sampled	Number of fecal coliforms detections (>0)	Fecal coliforms colonies/100 mL	Date(s) detected
FA 6-L	1,790-1,890	101	0	N/A	N/A
FA 7-U	1,488-1,580	105	1	18	4/4/95
FA 7-L	1,805-1,872	116	0	N/A	N/A
FA 8-U	1,490-1,575	103	1	2	6/13/95
FA 8-L	1,790-1,890	103	0	N/A	N/A
FA 9-U	1,490-1,587	94	1	14	6/13/95
FA 9-L	1,790-1,880	84	1	2	6/13/95
FA 10-U	1,490-1,592	67	0	N/A	N/A
FA 10-L	1,790-1,890	84	0	N/A	N/A
FA 11-U	1,490-1,588	42	0	N/A	N/A
FA 11-L	1,790-1,890	75	0	N/A	N/A
FA 12-U	1,495-1,597	87	0	N/A	N/A
FA 12-L	1,790-1,890	78	0	N/A	N/A
FA 13-U	1480-1,585	89	0	N/A	N/A
FA 13-L	1,740-1,845	81	0	N/A	N/A
FA 14-U	1,490-1,575	87	0	N/A	N/A
FA 15-U	1,490-1,575	83	0	N/A	N/A
FA 15-L	1,790-1,890	79	0	N/A	N/A
FA 16-U	1,490-1,590	89	0	N/A	N/A
FA 16-L	1,790-1,890	80	0	N/A	N/A
BZ 1	1,005-1,037	190	33	40	11/1/90
				16	12/1/90
				13	1/1/91
				50	3/31/92
				14	4/7/92
				116	4/21/92
				362	5/5/92
				62	5/12/92

Monitoring well[1]	Depth (feet)	Number of times sampled	Number of fecal coliforms detections (>0)	Fecal coliforms colonies/100 mL	Date(s) detected
				86	5/20/92
				22	5/26/92
				106	6/9/92
				14	6/16/92
				212	6/23/92
				2	6/30/92
BZ 1(cont.)	1,005-1,037	(cont)	33	2	7/7/92
				6	7/14/92
				4	7/21/92
				2	8/11/92
				2	8/18/92
				30	9/24/92
				400	10/1/92
				130	10/8/92
				500	10/14/92
				88	10/20/92
				208	10/27/92
				54	11/3/92
				530	11/10/92
				20	11/17/92
				200	1/8/93
				24	3/9/93
				400	3/16/93
				192	3/30/93
				496	4/6/93
BZ-2	1,577-1,664	97	0	N/A	N/A

[1] Reference: South District Wastewater Treatment Plant, Miami Dade Water and Sewer Department, Miami Dade County, Florida. Monitoring Well Purging Report (Report A) December 26, 2002.

Appendix 1-6. Class 1 Facilities in South Florida.

FACILITY AND WELL DATA

Facility	Injection Wells			
	Active	Inactive	Under Construction	Proposed
Albert Whitted	2	-	-	-
MDW&S South District Regional	13	4	4	-
Seacoast Utilities	1	-	-	-
McKay Creek	2	-	-	-
South Cross Bayou	3	-	-	-
St. Petersburg NE	3	-	-	-
St. Petersburg NW	2	-	-	-
St. Petersburg SW	3	-	-	-
Broward County - North District Regional	4	-	2	2
G.T. Lohmeyer	5	-	-	-
Margate	2	-	-	-
MDW&S North District Regional	-	2	2	-
Palm Beach County - Southern Regional	2	-	-	-
Plantation Regional (Broward County)	2	-	-	-
South Beaches	1	-	-	-
Sunrise	3	-	-	-
Sykes Creek (Merritt Island)	2	-	-	-
Belle Glade	1	-	-	-
Brentwood WWTP (Atlantic Utilities)	1	-	-	-
Coral Springs Improvement District	2	-	-	-
East Port (Charlotte)	2	-	-	-
East-Central Regional	6	-	-	1
Encon	1	-	-	-
Ft. Myers Beach	1	-	-	-
Ft. Pierce Utility Authority	1	-	-	-
Gasparilla Island	1	-	-	-
Immokalee	-	-	1	-
Manatee County SW - Subregional	1	-	-	-
Melbourne - Grant St.	1	-	-	-
Miramar WWTP	2	-	-	-
North Ft. Myers Utilities	1	-	-	-
North Port (Charlotte)	1	-	-	-
Pahokee	1	-	-	-
Palm Bay (GDU-Port Malabar)	1	-	-	-
Palm Beach County System #9	1	-	-	-
Pembroke Pines	2	-	-	-
Port St. Lucie Westport	-	-	-	1
Punta Gorda	-	-	2	-
Rockledge	1	-	-	-
Royal Palm Beach	1	-	-	-
South Collier County	1	-	-	-
South Port St. Lucie	1	-	-	-
Stuart	2	-	-	-
West Melbourne	1	-	-	-
West Port (Charlotte)	1	-	-	-

Appendix Table 1-6. Class I Facility Treatment and Flow Data

Facility	Permitted Treatment Capacity (MGD)	Permitted Injection Rate (Well Capacity) (MGD)		Total Well Capacity (MGD)	Injectate Characteristics/ Current Treatement in Place	Emergency Disposal Practice
Albert Whitted	12.40	24.00	Per 2 wells	48.00	Activated sludge process with chlorinated effluent to a reclaimed water spray irrigation system and back-up/wet weather disposal to wells.	Injection wells used for backup/wet-weather disposal.
MDW&S South District Regional		15.9 17.5 16.9 17.8 10.18 15.00 16.7 15.0 16.9 17.5 17.2 17.2 16.1 14.9 14.9 14.9 14.9 (208)	IW-1 IW-2 IW-3 IW-4 IW-5 IW-6 IW-7 IW-8 IW-9 IW-10 IW-11 IW-12 IW-13 IW-14 IW-15 IW-16 IW-17 (Total 1-13)	269.48	Secondary treated domestic wastewater effluent	
Seacoast Utilities		15.00	IW-1	15.00	Secondary treated domestic wastewater	
McKay Creek	6.00	6.35	Per 2 wells	12.70	Secondary treated municipal effluent from a Type 1 contact stabilization municipal sewage treatment plant with filtered chlorinated effluent.	
South Cross Bayou	24.50	10.20	Per 3 wells	20.40	Filtered and chlorinated effluent from a conventional activated sludge municipal treatment plant.	
St. Petersburg NE	16.00	27.00	Total 3 wells	27.00	Activated sludge process with chlorinated effluent to a reclaimed water spray irrigation system and back-up/wet weather disposal to wells.	
St. Petersburg NW	20.00	16.00	Per 2 wells	32.00	Activated sludge process with chlorinated effluent to a reclaimed water spray irrigation system and back-up/wet weather disposal to wells.	
St. Petersburg SW	20.00	9.00	Per 3 wells	27.00	Municipal effluent from a Type 1 activated sludge plant with chlorinated effluent to a reclaimed water spray irrigation system and backup disposal to wells.	
Broward County - North District Regional		15 16.7	Per 4 wells IW-5, 6	97.40	*Secondary treated domestic wastewater (effluent)*	
G.T. Lohmeyer		18.3 18.7 (67)	IW-1-4 IW-5 (Pump Cap.)	91.90	Secondary treatment	
Margate		8.15 15	IW- 1 IW- 2	23.15	Secondary treated domestic wastewater.	Excess wastewater from East WWTP discharged to Margate canal and excess from West WWTP discharged to One Mile canal.
MDW&S North District Regional		18.70	Per 2 wells	33.40	Secondary treated domestic wastewater (effluent)	
Palm Beach County - Southern Regional		15.00	Per 2 wells	30.00	Secondary treated domestic wastewater	3.5 MGD and 4.5 MGD diverted to Palm Beach County System #3 and #9, respectively. Remaining effluent will be disinfected and allowed to overflow to on-site stormwater detention ponds.
Plantation Regional (Broward County)		15 (24.00)	IW-1,2 (Pump cap.)	30.00	Secondary treated domestic wastewater.	
South Beaches		9.00		9.00	Secondary treated domestic wastewater (effluent)	Existing percolation ponds for overflow (15 million gallons storage). Ability to store water at Indian River and South Patrick treatment plants. A last option is discharging to the Indian River.
Sunrise		18.70	IW-1,2,3	56.10	Secondary treated domestic wastewater, may include membrane softening concentrate during planned	
Sykes Creek (Merritt Island)		8.2 8.1	Well 1 Well 2	16.30	Minimum to secondary treatment levels - no chlorination is necessary.	

Yellow highlighted denotes facilities reviewed for risk assessment

Source: Florida status reports -January 2002; Florida Discharge Monitoring Reports-February 2002

Appendix 1-6 - Class I Facility Treatment and Flow Data

Facility	Permitted Treatment Capacity (MGD)	Permitted Injection Rate (Well Capacity) (MGD)	Total Well Capacity (MGD)	Injectate Characteristics/ Current Treatement in Place	Emergency Disposal Practice
Belle Glade		10.20	10.20	Secondary treated domestic wastewater	
Brentwood WWTP (Atlantic Utilities)		3.41	3.41	Secondary treated domestic wastewater	
Coral Springs Improvement District		IW-1 4.87 15 IW-2	19.87	Secondary treated domestic wastewater	IW-1 serves as the backup well when IW-2 is out of service.
East Port (Charlotte)		2.04 IW-1 7.56 IW-2	9.60	Domestic wastewater	To existing onsite spray irrigation system, onsite storage pond and discharge to surface waters.
East-Central Regional		IW-1 15.3 15 IW-2 17.3 IW-3 20.7 IW-4 18.7 IW-5 18.7 IW-6 (98.00) (Pump Cap.)	105.70	Secondary treated domestic wastewater	Treated, chlorinated effluent to remaining injection wells and an equalization basin with capacity of 8 million gallons, and then to the Atlantic Ocean via drainage system.
Encon		18.00	18.00	Secondary treated domestic wastewater	Chlorinated effluent to stabilization pond, overflow to recharge lake to a tributary of the Loxahatchee River.
Ft. Myers Beach		7.92	7.92	Domestic wastewater	Sent to reclaimed water system, then percolation ponds with injection used for excess effluent disposal.
Ft. Pierce Utility Authority	10.00	14.92	14.92	Conventional activated sludge secondary domestic wastewater plant with influent screening, grit removal, aeration, secondary clarification, chlorination, and dechlorination.	Surface water discharge to Indian River Lagoon
Gasparilla Island		0.81	0.81	Back up disposal of secondary treated domestic wastewater following filtration and disinfection	Well is a backup discharge mechanism to golf course irrigation. There is 2.13 million gallon onsite holding pond.
Immokalee		2.50	2.50	Backup disp of secondary treated domestic effluent	If well is out of service, flow directed to existing effluent holding ponds.
Manatee County SW - Subregional		15.00	15.00	Treated municipal effluent receiving min. of secondary treatment	
Melbourne - Grant St.		14.92	14.92	Pretreated domestic wastewaters	Suface water discharge directed to Crane Creek and on to the Indian River.
Miramar WWTP		18.50 per 2 wells	37.00	Secondary treated municipal effluent	Directed to plant's stormwater collection system, which flows into a drainage canal.
North Ft. Myers Utilities		4.00	4.00	Secondary treated domestic wastewater; following filtration and disinfection	Well is back up for plant. Additional disposal is to onsite storage pond.
North Port (Charlotte)		4.75	4.75	Secondary treated domestic wastewater	
Pahokee		4.00	4.00	Secondary treated domestic wastewater	Directed to onsite polishing ponds.
Palm Bay (GDU-Port Malabar)		10.00	10.00	Secondary treated domestic wastewater	Directed to South Harris Ditch to Turkey Creek and on to the Indian River.
Palm Beach County System #9		12.70	12.70	Concentrate rejected waters from low-pressure membrane softening process generated from the water treatment facility	
Pembroke Pines		7.69 IW-1 15.27 IW-2 (7.69) (Pump Cap.)	22.96		IW-1 is used for emergency disposal. If flows exceed permitted amount, part of flow will be diverted to existing percolation pond.
Port St. Lucie Westport					
Punta Gorda		12.00 For 1 well	12.00	Secondary treated domestic effluent	Directed to existing effluent disposal ponds.
Rockledge		4.50	4.50	Secondary treated effluent	Directed to Indian River via 2934 feet of effluent pipeline.
Royal Palm Beach		6.34	6.34	Secondary treated domestic wastewater	onsite percolation ponds.
South Collier County		18.00	18.00	Secondary treated domestic effluent	
South Port St. Lucie		3.41	3.41	Secondary treated domestic wastewater	
Stuart		3.5 IW-1 10.00 IW-2	13.50	Secondary treated domestic wastewater; IW-1 (emergency back-up well) will inject potable water once a month	Additional emergency flow is diverted to outfall system into the St. Lucie River.
West Melbourne	2.50	4.80	4.80	Secondary treated effluent	Emergency ponds store 3.2 million gallons, additional flow diverted to Crane Creek drainage canal.
West Port (Charlotte)		4.75	4.75	Secondary treated domestic wastewater	Flow directed to 3 existing percolation ponds (capacity 6.3 MGD) and to onsite spray irrigation system.

Source: Florida status reports -January 2002; Florida Discharge Monitoring Reports-February 2002

Appendix 1-6. Injectate Characteristics for Class I Injection Wells.

Facility	Injectate Characteristics/ Current Treatement in Place	Emergency Disposal Practice
Albert Whitted	Activated sludge process with chlorinated effluent to a reclaimed water spray irrigation system and back-up/wet weather disposal to wells.	Injection wells used for backup/wet-weather disposal.
MDW&S South District Regional	Secondary treated domestic wastewater effluent	
Seacoast Utilities	Secondarily treated domestic wastewater	
McKay Creek	Secondary treated municipal effluent from a Type 1 contact stabilization municipal sewage treatment plant with filtered chlorinated effluent.	
South Cross Bayou	Filtered and chlorinated effluent from a conventional activated sludge municipal treatment plant.	
St. Petersburg NE	Activated sludge process with chlorinated effluent to a reclaimed water spray irrigation system and back-up/wet weather disposal to wells.	
St. Petersburg NW	Activated sludge process with chlorinated effluent to a reclaimed water spray irrigation system and back-up/wet weather disposal to wells.	
St. Petersburg SW	Municipal effluent from a Type 1 activated sludge plant with chlorinated effluent to a reclaimed water spray irrigation system and backup disposal to wells.	
Broward County - North District Regional	Secondarily treated domestic wastewater	
G.T. Lohmeyer	Secondary treatment	
Margate	Secondary treated domestic wastewater.	Excess wastewater from East WWTP discharged to Margate canal and excess from West WWTP discharged to One Mile canal.
MDW&S North District Regional	Secondary treated domestic wastewater (effluent)	
Palm Beach County - Southern Regional	Secondarily treated domestic wastewater	3.5 MGD and 4.5 MGD diverted to Palm Beach County System #3 and #9, respectively. Remaining effluent will be disinfected and allowed to overflow to on-site stormwater detention ponds.
Plantation Regional (Broward County)	Secondary treated domestic wastewater.	
South Beaches	Secondarily treated domestic wastewater (effluent)	Existing percolation ponds for overflow (15 million gallons storage). Ability to store water at Indian River and South Patrick treatment plants. A last option is discharging to the Indian River.
Sunrise	Secondary treated domestic wastewater, may include membrane softening concentrate during planned outages of Injection Well CW-1.	
Sykes Creek (Merritt Island)	Minimum to secondary treatment levels - no chlorination is necessary.	
Belle Glade	Secondary treated domestic wastewater	
Brentwood WWTP (Atlantic Utilities)	Secondary treated domestic wastewater	
Coral Springs Improvement District	Secondary treated domestic wastewater	IW-1 serves as the backup well when IW-2 is out of service.
East Port (Charlotte)	Domestic wastewater	To existing onsite spray irrigation system, onsite storage pond and discharge to surface waters.

Appendix 1-6. Injectate Characteristics for Class I Injection Wells.

Facility	Injectate Characteristics/ Current Treatement in Place	Emergency Disposal Practice
East-Central Regional	Secondary treated domestic wastewater	Treated, chlorinated effluent to remaining injection wells and an equalization basin with capacity of 8 million gallons, and then to the Atlantic Ocean via drainage system.
Encon	Secondary treated domestic wastewater	Chlorinated effluent to stabilization pond, overflow to recharge lake to a tributary of the Loxahatchee River.
Ft. Myers Beach	Domestic wastewater	Sent to reclaimed water system, then percolation ponds with injection used for excess effluent disposal.
Ft. Pierce Utility Authority	Conventional activated sludge secondary domestic wastewater plant with influent screening, grit removal, aeration, secondary clarification, chlorination, and dechlorination.	Surface water discharge to Indian River Lagoon
Gasparilla Island	Back up disposal of secondarily treated domestic wastewater following filtration and disinfection	Well is a backup discharge mechanism to golf course irrigation. There is 2.13 million gallon onsite holding pond.
Immokalee	Backup disp of secondarily treated domestic effluent	If well is out of service, flow directed to existing effluent holding ponds.
Manatee County SW - Subregional	Treated municipal effluent receiving min. of secondary treatment	
Melbourne - Grant St.	Pretreated domestic wastewaters	Suface water discharge directed to Crane Creek and on to the Indian River.
Miramar WWTP	Secondary treated municipal effluent	Directed to plant's stormwater collection system, which flows into a drainage canal.
North Ft. Myers Utilities	Secondary treated domestic wastewater; following filtration and disinfection	Well is back up for plant. Additional disposal is to onsite storage pond.
North Port (Charlotte)	Secondary treated domestic wastewater	
Pahokee	Secondary treated domestic wastewater	Directed to onsite polishing ponds.
Palm Bay (GDU-Port Malabar)	Secondary treated domestic wastewater	Directed to South Harris Ditch to Turkey Creek and on to the Indian River.
Palm Beach County System #9	Concentrate rejected waters from low-pressure membrane softening process generated from the water treatment facility	
Pembroke Pines		IW-1 is used for emergency disposal. If flows exceed permitted amount, part of flow will be diverted to existing percolation pond.
Port St. Lucie Westport		
Punta Gorda	Secondary treated domestic effluent	Directed to existing effluent disposal ponds.
Rockledge	Secondary treated effluent	Directed to Indian River via 2934 feet of effluent pipeline.
Royal Palm Beach	Secondarily treated domestic wastewater	Surficial aquifer recharge through rapid rate infiltration in onsite percolation ponds.
South Collier County	Secondarily treated domestic effluent	
South Port St. Lucie	Secondary treated domestic wastewater	
Stuart	Secondary treated domestic wastewater; IW-1 (emergency back-up well) will inject potable water once a month	Additional emergency flow is diverted to outfall system into the St. Lucie River.
West Melbourne	Secondary treated effluent	Emergency ponds store 3.2 million gallons, additional flow diverted to Crane Creek drainage canal.
West Port (Charlotte)	Secondary treated domestic wastewater	Flow directed to 3 existing percolation ponds (capacity 6.3 MGD) and to onsite spray irrigation system.

Appendix Table 2-1 Dade County

	Authors	Title	Date	Source	Hydrogeologic Unit	Depth Below Land Surface (ft)	Thickness (ft)	Hydraulic Conductivity K (ft/day)	Transmissivity T (ft^2/day)	Effective Porosity	Notes
1	Reese, R.S.	Hydrogeology and the Distribution and the Origin of Salinity in the Floridan Aquifer System, Southeastern Florida	1994	USGS WRI 94-4010	**Surficial Aquifer**						**Salinity (mg/L)**
					Surficial Aquifer (Biscayne)	0 - 270	175 - 270				
					Intermediate Confining Unit	270 - 990	600 - 1050				
					Floridan Aquifer System	990 - ???	2500 - 3000				1840
					Upper Floridan Aquifer	990 - 1530	500 - 600		10000 - 60000 2700, 10000, 31000		
					Suwannee		120 - 300				
					Ocala		150 - 200			0.2 - 0.45	
					Avon Park	1100 - 1199	100 - 270			0.5, 0.3 - 0.4	3800
					Middle Confining Unit	*1530 - 2450*		0.003 - 3 (V) 1.3×10^{-4} - 0.24 (n=8)		0.336 - 0.464, Avg 0.402 (n=6)	*11800 - 35600*
					Lower Floridan Aquifer	2450 - ???	1000 - 1200 lower 300 - 600 (Boulder Zone)		3.2×10^{6} - 24.6×10^{6} (boulder zone)		
2	Reese, R.S. and Cunningham, K.J.	Hydrogeology of the Gray Limestone Aquifer in Southern Florida	1-Jan-00	USGS WRI 99-4213	**Surficial Aquifer**	0 - 270					
					Biscayne Aquifer		0 - 120				
					Upper Semiconfining to Confining Unit		0 - 130				
					Gray Limestone Aquifer		0 - 130	148 - 2900	5800 - 160000		
					Lower Semiconfining Unit		0 - 20				
					Sand Aquifers		0 - 100				
3	Maliva, R.G. and Walker, C.W.	Hydrogeology of Deep-Well Disposal of Liquid Wastes in Southwestern Florida, USA	Aug-98	Hydrogeology Journal	**Surficial Aquifer**	0 - 50	50				
					Intermediate Confining Unit	50 - 200	150				
					Floridan Aquifer System						
					Upper Floridan Aquifer	200 - 450	250				
					Middle Confining Unit	450 - 700	250				
					Lower Floridan Aquifer	700 - 1000	300				Temp (°F) 74, 61.3, 60.5, 60.6
					Bolder Zone, 750 - 950 bls						
4	Meyer, F.W.	Hydrogeology, Ground-Water Movement, and Subsurface Storage in the Floridan Aquifer System in Southern Florida	1989	USGS Prof. Paper 1403-G	**Surficial Aquifer**	0 - 275	275				Temp (°F) 98-73
					Intermediate Confining Unit	275 - 850	575				73 - 67
					Floridan Aquifer System						
					Upper Floridan Aquifer	850 - 1550	700		10000 - 60000	0.30	67 - 63
					Middle Confining Unit	1550 - 1990	440				63 - 58
					Lower Floridan Aquifer	1990 - 3900	1910				58 - 60
					Bolder Zone	2900 - 3500	600		3.2×10^{6} - 24×10^{6}	0.30	53, 74, 61.3, 60.5, 60.6
5	Reese, R.S. and Memburg, S.J.	Hydrogeology and the Distribution of Salinity in the Floridan Aquifer System, Palm Beach County, Florida	1999	USGS WRI 99-4061	**Surficial Aquifer**		150 - 830				
					Intermediate Confining Unit		600 - 700				
					Floridan Aquifer System						
					Upper Floridan Aquifer		500 - 700		10000 - 100000 32000 - 132000, 24000, 64800, 49100		
					Middle Confining Unit		0 - 900	V: 2×10^{-2} - 2×10^{-5} (n=9), 1.3×10^{-4} (n=8)			
					Lower Floridan Aquifer		1800				
					Bolder Zone	2500 - 3100	300 - 650		3.2×10^{6} - 24×10^{6}		
6	Duerr, A.D.	Types of Secondary Porosity of Carbonate Rocks in Injection and Test Wells in Southern Peninsular Florida	1995	USGS WRI 94-4013	**Surficial Aquifer**	0 - 105	105, 180				
					Intermediate Confining Unit	105 - 910	805, 590				
					Floridan Aquifer System	910 - 3190	2280				
					Upper Floridan Aquifer						
					Middle Confining Unit						
					Lower Floridan Aquifer						
					Bolder Zone						
					USDW	1750, 1415, 2170, 1640					
7	Englehardt, J.D., et al.	Comparative Assessment of Human and Ecological Impacts from Municipal Wastewater Disposal Methods in Southeast Florida	23-Apr-01	University of Miami	**Intermediate Confining Unit**						
					Hawthorn Formation (Upper Confining Unit)		300	V: 0.089 - 8.8e-5			Geraghty & Miller 1975
					Floridan Aquifer System						
					Upper Floridan Aquifer			V: 0.80, H: 0.73	10000 - 60000	0.32	Meyer 1989
					Middle Confining Unit						
					Lower Floridan Aquifer						

21 - 26°C

Appendix Table 2-2 Pinellas County

	Authors	Title	Date	Source	Hydrogeologic Unit	Depth Below Land Surface (ft)	Thickness (ft)	Hydraulic Conductivity K (ft/day)	Transmissivity T (ft^2/day)	Effective Porosity	Notes
1	Hutchinson, C.B. and Trommer J.T.	Model Analysis of Hydraulic Properties of a Leaky Aquifer System, Sarasota County, Florida	December, 1992	USGS WSP 2340	**Surficial Aquifer**						
					Surficial Aquifer	0-50	50	10			
					Intermediate Confining Unit						
					Semiconfining Unit	50-60	10	0.005			
					Tamiami-upper Hawthorn Aquifer	60-100	40	125	5100		
					Semiconfining Unit	100-240	140	0.1			
					Lower Hawthorn-upper Tampa Aquifer	240-410	170	59	9600		
					Lower Tampa Semiconfining Unit	410-500	90	10			
					Floridan Aquifer System						
					Upper Floridan Aquifer						
					Suwannee Permeable Zone	500-750	250	70	13000		
					Lower Suwannee-Ocala Semiconfining Unit	750-1100	350	0.1			
					Avon Park Upper Permeable Zone	1100-1400	300	25			
					Avon Park Highly Permeable Dolomite	1400-2075	675	100			
					Middle Confining Unit	2075-2400					Unused
2	Knochenmus, L.A. and Robinson, J.L.	Description of Anisotropy and Heterogeneity and Their Effect on Ground Water Flow and Areas of Contribution to Public Supply Wells in a Karst Carbonate Aquifer System	January, 1996	USGS WSP 2475	**Intermediate Confining Unit**						
					Tampa		99			0.41	
							137			0.21	
							203			0.30	
					Upper Floridan Aquifer		1125		29400 - 130000 mean 57000		
					Suwannee		232			0.3	
							273			0.42	
							397			0.39	
					Ocala		418			0.38	
							436			0.40	as cited in CH2M Hill (1990a)
							452			0.27	as cited in CH2M Hill (1990a)
							490			0.34	as cited in CH2M Hill (1990a)
							500			0.49	
							540			0.25	
							616			0.48	as cited in Hickey (1977)
					Avon Park		892			0.20	as cited in Hickey (1977)
							957			0.07	as cited in Hickey (1977)
							1028			0.02	as cited in Hickey (1977)
							1155			0.11	as cited in CH2M Hill (1990a)
							1174			0.24	as cited in CH2M Hill (1990a)

Appendix Table 2-2 Pinellas County

	Authors	Title	Date	Source	Hydrogeologic Unit	Depth Below Land Surface (ft)	Thickness (ft)	Hydraulic Conductivity K (ft/day)	Transmissivity T (ft^2/day)	Effective Porosity	Notes		
3	Hickey, J.J.	Hydrogeology and Results of Injection Tests at Waste Injection Test Sites in Pinellas County, Florida	1982	USGS WSP 2183							Salinity (mg/L)	Density	
					Surficial Aquifer	0 - 85	20 - 85	V: 0.36 - 13, Avg 2.6 H: 13 - 33		0.292, 0.322	25, 32, 259, 404, 3040, 210, 120,		
					Intermediate Confining Unit								
					Hawthorn Formation (Upper Confining Unit)	85 - 200	115	0.00011 - 0.021 (n=12), Avg 0.0083 (Clay)6.6×10^{-5} - 2.8×10^{-3} (n=16), Avg 7.6×10^{-4}			52		
					Floridan Aquifer								
					Upper Floridan Aquifer								
					Tampa (Zone A)	200 - 350	112 - 245, Avg 180		21000 - 43200, 29000, 29000, 25000 - 30000		450, 6540, 508, 969, 32900, 1530, 5530	1.003, 1.0, 1.0, 1.018, 0.998, 1.002	
					Suwannee (Semiconfining Zone)		90	0.0013		0.26, 0.31 0.22 - 0.36, Avg 0.3	19000		
					Suwannee (Zone B)	350 - 500					19000 - 20000, 35500, 38400, 30400, 26700	1.025, 1.024, 1.024, 1.020, 1.018	
					Ocala (Semiconfining Zone)	500 - 750	50 - 75, Avg 60 250	0.1 - 1		0.19, 0.24, 0.30 0.22 - 0.36, Avg 0.3			
					Avon Park (Zone C)		300 - 386, Avg 330		900000 - 1200000 Avg 1000000	0.15, 0.14, 0.21	20001 - 21000, 39200, 38200, 38100, 41800, 37900, 37800	1.025, 1.025, 1.025, 1.026	Injection Zone
					Avon Park (Semiconfining Zone)	750 - 1250	100			0.26, 0.33	21000 - 25000		
					Avon Park (Zone D)		22 - 121, Avg 70			0.22, 0.39	39800, 43500, 38600, 42500	1.026, 1.026, 1.026, 1.026	
					Middle Confining Unit						25000 - 31000		
					Lake City	1250 - 2000	750	6.6×10^{-7}, 4.0×10^{-5}, 3.0×10^{-3}, 3.3×10^{-3}, 5.2×10^{-2}, 1.1, 2.0					
					Lower Floridan Aquifer Oldsmar	2000 - 3260	1260		2000 - 3000				
4	Knochenmus, L.A. and Bowman, G	Transmissivity and Water Quality of Water-Producing Zones in the Intermediate Aquifer System, Sarasota County, Florida	1-Jan-98	USGS WRI 98-4091	**Intermediate Confining Unit**		400						
					Confining Unit Producing Zone 1 Confining Unit		80		1100 - 8000, 8000		Barr, 1996, Duerr and others, 1988		
					Tamiami-upper Hawthorn Aquifer (Producing Zone 2)		200		100 - 26,000 (n=18), 200 - 5000, 740 - 2400, 500 - 3500		Barr, 1996, Duerr and others, 1988, Wolansky, 1983		
					Confining Unit								
					Lower Hawthorn-upper Tampa Aquifer (Producing Zone3)		150		1300 - 6200 (n=4), 5600 - 15400, 500 - 10000		Barr, 1996, Wolansky, 1983		
					Lower Tampa Semiconfining Unit (Confining Unit)								

Appendix Table 2-2 Pinellas County

	Authors	Title	Date	Source	Hydrogeologic Unit	Depth Below Land Surface (ft)	Thickness (ft)	Hydraulic Conductivity K (ft/day)	Transmissivity T (ft^2/day)	Effective Porosity	Notes	
5	Hutchinson, C.B.	Assessment of Hydrogeologic Conditions with Emphasis on Water Quality and Wastewater Injection, Southwest Sarasota and West Charlotte Counties, Florida	1991	USGS OFR 90-709							Salinity (mg/L)	
					Surficial Aquifer	0-50	50		1340 - 1850, 1100		<500	
					Intermediate Confining Unit							
					Semiconfining Unit	50-60	10		7800, 5500, 1260, 3320, 3800, 1525, 1608, 2970			
					Tamiami-upper Hawthorn Aquifer	60-100	40		200, 650, 300, 400, 650, 550, 800, 5000		660, 1200, 1300, 390, 1900, 660, 1240, 228, 326, 3000, 21000, 500, 546, 458, 650, 756, 791, 590, 484, 423, 406, 1630, 3240, 980, 330, 4700, 2040, 5500	
					Semiconfining Unit	100-240	140					
					Lower Hawthorn-upper Tampa Aquifer	240-410	170		8200, 5600, 10000		2170, 1700, 420, 1400, 2200, 2300, 1900, 2750, 2930, 2058, 890, 3000, 21000, 2900, 2750, 2930, 2058, 1600, 1200, 250, 1700, 2170, 2800, 2200, 1910, 1700, 4000, 1200	
					Lower Tampa Semiconfining Unit	410-500	90		17900, 15400			
					Floridan Aquifer System							
					Upper Floridan Aquifer							
					Suwannee Permeable Zone	500-750	250		13000, 8900, 72000, 13000		3210, 2900, 2500, 1600, 2300, 3780, 3520, 21000, 3000, 1500, 10900, 4490, 1500, 15000, 14000	
					Lower Suwannee-Ocala Semiconfining Unit	750-1100	350	H: 65 V: 0.01, 0.01, 0.09, 0.57, 2.27, 0.28, 0.09, 0.06, 0.06, 0.03, 0.02, 0.01, 0.1, 0.01, 0.005 H: 0.023, 0.03, 0.11, 0.25, 0.57, 0.14, 0.09, 0.06, 0.06, 0.02, 0.01, 0.19, 0.52, 0.23, 0.1, 0.08, 0.007.		0.37, 0.4, 0.45, 0.37, 0.37, 0.37, 0.31, 0.24, 0.22, 0.22, 0.22, 0.27, 0.09,0.43, 0.03, 0.28, 0.24, 0.28, 0.22, 0.25	CH2M Hill, Inc., 1986, Geraghty and Miller, Inc. 1985, Hutchinson and Trommer (in press), Law Environmental, Inc. 1989, Post, Buckley, Schuh and Jernigan, Inc. 1982	
					Avon Park Upper Permeable Zone	1100-1400	300	H: 100	64000, 48000, 80000, 67000, 24000, 150000, 140000, 300000,		35000, 1800, 37500, 32100, 34090, 2100, 3000, 25200, 32800, 35000, 33300, 35200,	Injection Zone
					Avon Park Highly Permeable Dolomite	1400-2075	675					
					Middle Confining Unit	2075-2400						
					Lower Floridan Aquifer	2400-?			370000			
6	Broska, J.C. and Barnette, H.L.	Hydrogeology and Analysis of Aquifer Characteristics in West-Central Pinellas County, Florida	January 1, 1999	USGS OFR 99-185	**Surficial Aquifer**		50	V: 0.36 - 13 H: 13 - 32			Salinity (mg/L)	
					Intermediate Confining Unit		50 - 140 Avg 90	V: $1.3x10^{-4}$ - $6.9x10^{-3}$				
					Floridan Aquifer System							
					Upper Floridan Aquifer						1000 - 10000 @ 100 - 400 ft bls	
					Tampa (Zone A)		115 - 250 Avg 180	H: 18	10000 - 40000			
					Suwannee (Semiconfining Zone B)	350 - 547	125 - 170 Avg 150	V: $1.3x10^{-3}$ - 2 H: 0.1				
					Suwannee (Zone B)		50 - 75 Avg 62		5000			

Appendix Table 2-2 Pinellas County

	Authors	Title	Date	Source	Hydrogeologic Unit	Depth Below Land Surface (ft)	Thickness (ft)	Hydraulic Conductivity K (ft/day)	Transmissivity T (ft^2/day)	Effective Porosity	Notes		
7	Barr, G.L.	Hydrogeology of the Surficial and Intermediate *Aquifer Systems in Sarasota and Adjacent* Counties, Florida	1-Jan-96	USGS WRI 96-4063	**Surficial Aquifer**		3 - 60	H: $2x10^{-3}$ - 159 (n=15)	150 - 1800		300 *mg/L*, 23.6 - 32.4°C		
					Intermediate Confining Unit		221 - 745						
					Confining Unit		5 - 150	V: $2.4x10^{-3}$					
					Permeable Zone 1		80	H: 17 - 56	1100 - 8000				
					Confining Unit		0 - 29	V:$2.4x10^{-3}$					
					Permeable Zone 2		20 - 190		200 - 5000		316 - 10300 mg/L, 24.4 - 27.5°C		
					Confining Unit		15 - 240	V: 0.1 - 10					
					Permeable Zone3		0 - 300		5600 - 15400		1120 - 7700 mg/L, 25.6 - 28.4°C		
					Confining Unit		10 - 240	V: 0.1 - 10					
8	Knochenmus, L.A. and Thompson, T.H.	Hydrogeology and Simulated Development of the Brackish Ground-Water Resources in Pinellas County, Florida	Jan 1 1991	USGS WRI 91-4026	**Surficial Aquifer**		0 - 132	H: 13 - 33 V: 0.36 - 13		0.292, 0.322	25		
					Intermediate Confining Unit		0 - 115				52		
					Floridan Aquifer								
					Upper Floridan Aquifer								
					Tampa (Zone A)		100 - 250		$2.2x10^4$ - $3.5x10^4$	0.26, 0.32, 0.41	450		
					Suwannee (Semiconfining Zone)			H: 0.4 *V: $1.3x10^{-3}$ - 2, 0.4,* 0.1 - 1					
					Suwannee (Zone B)		50 - 75				19000		
					Ocala (Semiconfining Zone)								
					Avon Park (Zone C)						20000		
					Avon Park (Semiconfining Zone)								
					Avon Park (Zone D)						21000		
					Middle Confining Unit						25000		
					Lower Floridan Aquifer						31000		
9	Duerr, A.D. and Enos, G.M.	Hydrogeology of the Intermediate Aquifer System and Upper Floridan Aquifer, Hardee and De Soto Counties, Florida	1991	USGS WRI 90-4104	**Surficial Aquifer**		25 - 100		1100				
					Intermediate Confining Unit		200 - 500		400 - 7000		24.5, 26 deg C		
					Floridan Aquifer System	200 - 600							
					Upper Floridan Aquifer				100000 - 850000		28, 31 deg C		
					Middle Confining Unit								
					Lower Floridan Aquifer								
10	Hickey, J.J.	Hydrogeology, Estimated Impact, and Regional Well Monitoring of Effects of Subsurface *Wastewater Injection, Tampa Bay Area, Florida*	1981	USGS WRI 80-118	**Surficial Aquifer**		85	V: 0.36 - 13 Avg 2.6					
					Intermediate Confining Unit			V: 0.01 - 0.0001, Avg 0.008					
					Floridan Aquifer System								
					Upper Floridan Aquifer			V: 0.0013 - 2.5, Avg 0.6, 1	$7.5x10^4$, $5.1x10^4$, $3.0x10^4$, $2.9x10^4$				
					Middle Confining Unit			V: 6e-7, 3.3e-3, 1.1, 4e-5, 3e-3, 5.2e-2, 2					
					Lower Floridan Aquifer				$1x10^1$, $1.2x10^6$, $0.9x10^6$				
11	Duerr, A.D.	Types of Secondary Porosity of Carbonate Rocks in Injection and Test Wells in Southern Peninsular Florida	1995	USGS WRI 94-4013	**Surficial Aquifer**		15						
					Intermediate Confining Unit		50						
					Floridan Aquifer System								
					Upper Floridan Aquifer		555						
					Middle Confining Unit								
					Lower Floridan Aquifer		705				80 - 84 deg F		
					Bolder Zone								
					USDW	100 - 140, 1013 - 1053, 1300, 540 - 590							

Appendix Table 2-3 Brevard County

	Authors	Title	Date	Source	Hydrogeologic Unit	Depth Below Land Surface (ft)	Thickness (ft)	Hydraulic Conductivity K (ft/day)	Transmissivity T (ft^2/day)	Effective Porosity	Notes
1	Duerr, A.D.	Types of Secondary Porosity of Carbonate Rocks in Injection and Test Wells in Southern Peninsular Florida	1995	USGS WRI 94-4013	**Surficial Aquifer**	0 - 95, 0 - 120	95, 120				
					Intermediate Confining Unit	95 - 360, 120 - 250	360, 130				
					Floridan Aquifer System	360 - 2977, 250 - 2906	2617, 2656				
					Upper Floridan Aquifer						
					Middle Confining Unit						
					Lower Floridan Aquifer						
					Bolder Zone	2070 - 2770	700				
					USDW	1190, 1634, 1670, 1700, 1190					
2	Schiner, G.R.	Geohydrology of Osceola County, Florida	1993	USGS WRI 92-4076	**Surficial Aquifer**		30 - 270	H: 20 - 100 V: $1.5x10^{-2}$ - $7.8x10^{-7}$, $5x10^{-3}$	400, 2000, 1000		
					Intermediate Confining Unit		40 - 300				
					Floridan Aquifer System		2400 - 2900				
					Upper Floridan Aquifer		300 - 350		65000 - 250000, 100000 - 200000, 10000 - 35000, 10000 - 50000		
					Middle Confining Unit		450 - 700		5600, 8900, 43000		
					Lower Floridan Aquifer		1400 - 2100		6500 - 60000, 60000		
					Bolder Zone	2500 - 3000	500 - 800		$1x10^7$		
					USDW						
3	Duncan, J.G., Evans, W.L., Taylor, K.L.	Geologic Framework of the Lower Floridan Aquifer System, Brevard County, Florida	1994	Florida Geological Survey Bulletin No. 64	**Surficial Aquifer**		90 - 150				
					Intermediate Confining Unit						
					Floridan Aquifer System		2300 - 2900				
					Upper Floridan Aquifer				50e3 - 100e3, 100e3 - 250e3		
					Middle Confining Unit		110 - 250	H: 0.78 V: 0.07, 0.06,		0.20	
					Lower Floridan Aquifer		1500 - 2000	V: <0.28 H: 0.28, 0.00283		0.10 - 0.30	
					Boulder Zone		85 - 190				
4	Tibbals, C.H.	Hydrogeology of the Floridan Aquifer System in East-Central Florida	1990	USGS Prof. Paper 1403-E	**Floridan Aquifer System**		2300 - 2900				
					Upper Floridan Aquifer				120000, 10000 - 400000, 74000, 210000, 510000,		
					Middle Confining Unit		500 - 900				
					Lower Floridan Aquifer				30000 - 130000		
5	Adams, Karin	A Three Dimensional Finite Difference Flow Model of the Surficial Aquifer In Martin County, Florida	March-92	SFWMD Technical Publication 92-02	**Surficial Aquifer**			45, 53, 33, 58, 50, 100, 78, 78, 32, 40, 42, 52, 49, 50, 71, 33, 59, 62, 97, 33, 33, 49, 35, 36, 121, 53, 53, 48, 37, 38, 56, 33, 44, 91, 58, 57, 126, 76	3610, 3743, 1337, 3476, 6016, 12032, 4679, 2674, 4011, 4011, 6016, 7353, 2005, 11364, 4011, 5348, 4011, 8021, 3342, 3342, 8021, 2674, 2005, 26738, 1872, 2406, 3342, 3342, 2005, 3342, 3342, 4412, 10027, 5214, 5749, 22727, 10695		
6	Lukasiewiez, J. and Adams, K.S.	Hydrogeologic Data and Information Collected from the Surficial and Floridan Aquifer Systems, Upper East Coast Planning Area	March-96	SWFMD Technical Publication 96-02 (WRE #337)	**Surficial Aquifer**				394		
					Intermediate Confining Unit						
					Floridan Aquifer System		2700 - 3400				
					Upper Floridan Aquifer		500		34		
					Middle Confining Unit		300				
					Lower Floridan Aquifer						

Appendix 3

Weighted Mean Values

A primary literature review was conducted and all published values of hydrogeologic parameters characterizing the hydrologic units in each county studied were tabulated in this appendix and summarized in the following tables. The weighted means ($\overline{Z}$) of the data were calculated to determine representative values to be used in the risk assessment. The weighted mean method essentially reduces the effect of extreme data outliers (very high or very low values). The following equation was used to develop the weighted means for all hydrogeologic data (Mendenhall and Beaver, 1994).

$$\overline{Z} = \left[\frac{0.5Z_1 + 0.75Z_2 + \sum_{i=3}^{m-2} Z_i + 0.75Z_{m-1} + 0.5Z_m}{m - 1.5} \right] \qquad \text{(Eqn. 1)}$$

Where: Z = Hydrogeologic datum
m = Total number of values
i = Chronological interger

The above equation is not valid for data sets containing less than five values, therefore, the following equation was used.

$$\overline{Z} = \left[\frac{0.5Z_1 + \sum_{i=2}^{m-1} Z_i + 0.5Z_m}{m - 1.0} \right] \qquad \text{(Eqn. 2)}$$

For data sets with two values, an average was calculated.

In the Intermediate, Upper Floridan and Lower Floridan aquifers, hydrogeological data for the discretized geologic units within the aquifer are presented in the following tables. Representative hydrogeologic data for the entire aquifer were then determined by weighting the data in proportion to the thickness of the individual geologic units within each hydrogeologic unit.

Weighted means for the data sets are color coded in blue, while representative values used in the analysis are color coded in red.

Where there were insufficient data available, the following assumptions were made:

- Anisotropy ratios and porosity values were assumed to be consistent for equivalent aquifer units in each county, in the absence of site-specific data.

- Parameters for the horizontal and vertical hydraulic conductivities and porosities for each geologic layer in Brevard County were assumed to be consistent with data provided for the same equivalent depositional unit in Dade County.

- A horizontal hydraulic gradient of 0.001 were assumed for the injection zone and the overlying units in Dade and Brevard Counties.

- In Pinellas County, a horizontal hydraulic gradient of 0.05 in the injection zone was assumed. This accounted for the effects of pressure head due to injection. In the overlying units, a horizontal hydraulic gradient of 0.001 was used.

- A porosity of 0.5 was assumed for the Boulder Zone for horizontal ground water flow. Conduit flows occur in the Boulder Zone due to cavernous pores or large fractures in the rock (Meyer, 1984, Maliva and Walker, 1998); therefore a larger porosity is required to address this issue.

Appendix Table 3-1 Dade County

County: Dade																
Hydrogeologic Units	Surficial	Intermediate					Upper Floridan							Middle Confining Unit	Lower Floridan	
		Semiconfining Unit	Tamiami-upper Hawthorn Aquifer	Semiconfining Unit	Lower Hawthorn-upper Tampa Aquifer	Lower Tampa Semiconfining Unit	Tampa (Zone A)	Suwannee (Semiconfining Zone)	Suwannee (Zone B)	Ocala (Semiconfining Zone)	Avon Park (Zone C)	Avon Park (Semiconfining Zone)	Avon Park (Zone D)			Bolder Zone
Horizontal Conductivities	148									0.45				8.37E-07		2,307
	2900									9				0.003		2,461
	1924									55				0.03		18,923
										121.8				3		6538
										42				4.3		
														6		
														28		
														4.7		
Vertical Conductivities				8.8E-05										2.00E-05		
				0.1										1.30E-04		
														1.30E-04		
														2.00E-02		
														0.24		
														0.04		
Transmissivity	5800			10000						2,700						3.20E+06
	160000			100000						10,000						3.20E+06
	82900			55000						10,000						1.30E+07
										10,000						2.46E+07
										10,000						2.46E+07
										24,000						1.36E+07
										31,000						
										32,000						
										49,100						
										60,000						
										60,000						
										64,800						
										100,000						
										132,000						
										40,060						
Thickness	50			150			250	120		150		100		250	100	300
	105			450			500	300		200		270		440	200	300
	150			575			700	210		175		185		450	300	600
	175			590			700							900	200	600
	180			600			1100							488		650
	200			600			650									500
	270			700						1220					700	
	270			805											1300	
	275			1050											1800	
	830			614											1910	
	232														1468	
Porosity							0.3			0.2		0.3		0.336		0.3
										0.45		0.4		0.464		
										0.33		0.5		0.45		
												0.4		0.43		
										0.32						
Temperature	73.04			66.92			66.92							62.96	57.92	53
	98.06			73.04			62.96							57.92	60.08	60.5
	85.55			69.98			64.94							60.44	59.00	60.6
																61.3
																74
																61.56
Salinity								1840				3800		11800		
														35600		
USDW (below land surface)	1415															
	1640															
	1750															
	2170															
	1728															

Appendix Table 3-2 Pinellas County

County: Pinellas																
Hydrogeologic Units	Surficial	Intermediate					Upper Floridan							Middle Confining Unit	Lower Floridan	
		Semiconfining Unit	Tamiami-upper Hawthorn Aquifer	Semiconfining Unit	Lower Hawthorn-upper Tampa Aquifer	Lower Tampa Semiconfining Unit	Tampa (Zone A)	Suwannee (Semiconfining Zone)	Suwannee (Zone B)	Ocala (Semiconfining Zone)	Avon Park (Zone C)	Avon Park (Semiconfining Zone)	Avon Park (Zone D)			
Horizontal Conductivities	2.00E-03 10 13 13 13 32 33 33 159 29	0.005	17 56 125 64	0.1 23 1.00E-04 1.1E-04 0.021 3.91	18 59 38.5	10		0.0013 0.1 0.4 0.20	70 65 1 67.5	0.007 0.01 0.02 0.023 0.03 0.06 0.06 0.08 0.09 0.1 0.1 0.1 0.11 0.14 0.19 0.23 0.25 0.52 0.57 1 0.16 19.78 0.003 0.3 0.45 121.8 22	25	100	100			
Vertical Conductivities	0.36 0.36 0.36 13 13 13 6.68	2.40E-03 2.40E-03 2.40E-03		1.00E-04 1.10E-04 1.30E-04 6.90E-03 1.00E-02 0.021 0.1 0.1 10 10 1.50 1.16				1.30E-03 1.30E-03 0.1 0.4 1 2 2 0.73		0.005 0.01 0.01 0.01 0.01 0.02 0.03 0.06 0.09 0.09 0.1 0.28 0.57 1 2.27 2.5 0.29				6.60E-07 4.00E-05 3.00E-03 3.30E-03 5.20E-02 1.1 2 0.34		
Transmissivity	150 1100 1100 1340 1800 1850 1248	1260 1525 1606 2970 3320 3800 5500 7800 3307	100 200 300 400 500 550 650 650 800 1100 1100 5100 8000 8000 1708	7259 400 7000 5415	200 200 500 740 1300 2400 3500 5000 5000 5600 8200 8200 9600 10000 4071	15400 17900 16650	500 5600 5600 10000 10000 15400 15400 21000 22000 25000 29000 29000 30000 35000 40000 43200 20,928		5,000 8,900 13,000 13,000 13,000 72,000 17,983		900,000 1,200,000 1,050,000			1.00E+01 9.00E+05 1.20E+06 750003	2,000 3,000 370,000 84,500	3.20E+06 1.30E+07 2.46E+07 1.35.E+07
Transmissivity										539,999 29,000 30,000 51,000 75,000 100,000 850,000 198,727						

Appendix Table 3-2 Pinellas County

County: Pinellas															
Hydrogeologic Units	Surficial	Intermediate					Upper Floridan							Middle Confining Unit	Lower Floridan
		Semiconfining Unit	Tamiami-upper Hawthorn Aquifer	Semiconfining Unit	Lower Hawthorn-upper Tampa Aquifer	Lower Tampa Semiconfining Unit	Tampa (Zone A)	Suwannee (Semiconfining Zone)	Suwannee (Zone B)	Ocala (Semiconfining Zone)	Avon Park (Zone C)	Avon Park (Semiconfining Zone)	Avon Park (Zone D)		
Thickness	3 20 25 50 50 60 60 85 100 132 56	5 10 10 150 32.5	40 40 80 80 60	29 115 140 140 113 465 115 99 115 137 150 200 203 500 219	20 170 170 190 200 157	15 90 90 240 103	100 112 115 150 245 250 250 300 1100 256	10 90 125 170 240 127 208 232 273 397 269	50 50 50 75 75 75 250 81	250 350 419 436 452 490 500 540 616 453 1943	300 386 343	100 515 892 957 1028 1155 1174 970	22 121 72	750	1260
Porosity	0.292 0.292 0.322 0.322 0.31			0.21 0.3 0.41 0.31			0.26 0.26 0.31 0.31 0.41 0.31	0.22 0.36 0.29 0.29 0.3 0.42 0.39 0.35	0.19 0.24 0.3 0.49 0.29	0.22 0.03 0.09 0.22 0.22 0.22 0.22 0.24 0.24 0.24 0.25 0.25 0.27 0.27 0.28 0.28 0.31 0.34 0.36 0.37 0.37 0.37 0.37 0.38 0.4 0.40 0.43 0.45 0.48 0.49 0.43 0.26	0.15 0.14 0.21 0.16	0.26 0.33 0.30 0.21 0.02 0.07 0.11 0.20 0.24 0.14	0.22 0.39 0.31	0.034 0.45 0.317	
Temperature	74.48 90.32			75.92 81.5 76.1 78.8						78.08 83.12 82.4 87.8					
Salinity	25 25 32 120 210 259 300 404 500 3040 383		228 326 330 390 406 423 458 484 500 546 590 650 660 660 756 791 980 1200 1240 1300 1630 1900 2040 693	52	250 316 420 890 1200 1200 1400 1600 1700 1700 1700 1900 1910 2058 2058 2170 2,170 2170 2200 2200 2300 2600 2750 1583		450 508 969 1120 1530 5530 6540 7700 32900 5136		450 1500 1500 1600 2300 2500 2900 3000 3210 3520 3780 4490 10900 15000 19,000 21000 26700 30400 35500 38400 10755	19000	19000 20000 37800 37900 38100 38200 39200 41800 34892	35480 1800 18000 20000 20000 21000 21000 25200 30000 32100 32800 32800 33300 34090 23481	21000 38600 43500 38600 42500 38300	21000 25000 23000	27000 31000 29000

Appendix Table 3-2 Pinellas County

County: Pinellas															
Hydrogeologic Units	Surficial	Intermediate					Upper Floridan							Middle Confining Unit	Lower Floridan
		Semiconfining Unit	Tamiami-upper Hawthorn Aquifer	Semiconfining Unit	Lower Hawthorn-upper Tampa Aquifer	Lower Tampa Semiconfining Unit	Tampa (Zone A)	Suwannee (Semiconfining Zone)	Suwannee (Zone B)	Ocala (Semiconfining Zone)	Avon Park (Zone C)	Avon Park (Semiconfining Zone)	Avon Park (Zone D)		
Salinity			3000 3240 4700 5500 21000 1681		2750 2930 2930 2930 3000 4000 10300 21000 2609							35,000 35000 35200 37500 29741			
Density	0.997 0.998 0.998 0.997 0.998 0.998						0.998 1 1 1.002 1.003 1.018 1.003		1.025 1.024 1.024 1.02 1.018 1.022		1.025 1.025 1.025 1.025 1.028 1.025		1.026 1.026 1.026 1.029 1.027		
USDW below land surface									100 140 540 590 1013 1053 1300 680						

Appendix Table 3-3 Brevard County

County: Brevard																
Hydrogeologic Units	Surficial	Intermediate					Upper Floridan							Middle Confining Unit	Lower Floridan	
		Semiconfining Unit	Tamiami-upper Hawthorn Aquifer	Semiconfining Unit	Lower Hawthorn-upper Tampa Aquifer	Lower Tampa Semiconfining Unit	Tampa (Zone A)	Suwannee (Semiconfining Zone)	Suwannee (Zone B)	Ocala (Semiconfining Zone)	Avon Park (Zone C)	Avon Park (Semiconfining Zone)	Avon Park (Zone D)			Bolder Zone
Horizontal Conductivities	20													0.8	1.00E-03	500
	32														0.0026	800
	33														0.028	650
	33														8.65E-03	
	33															
	33															
	33															
	35															
	36															
	37															
	38															
	40															
	42															
	44															
	45															
	48															
	49															
	49															
	50															
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	52															
	53															
	53															
	53															
	56															
	57															
	58															
	58															
	59															
	62															
	71															
	76															
	78															
	91															
	97															
	100															
	100															
	121															
	126															
	58															
Vertical Conductivities				7.80E-07										5.10E-05	2.80E-01	
				5.00E-03											0.005	
				1.50E-02											0.06	
				6.25E-03											0.07	
															0.12	
															0.1	
Transmissivity	400									3,289				5,600	6,500	1.00E+07
	394									3,637				8,900	30,000	
	488									4,932				43,000	60,000	
	562									5,416				16,600	130,000	
	564									6,551					52,750	
	575									6,685						
	630									6,912						
	669									7,346						
	715									7,436						
	781									7,594						
	853									8,172						
	868									8,201						
	869									9,084						
	925									9,422						
	980									9,615						
	1000									9,827						

Appendix Table 3-3 Brevard County

County: Brevard																
Hydrogeologic Units	Surficial	Intermediate					Upper Floridan							Middle Confining Unit	Lower Floridan	
		Semiconfining Unit	Tamiami-upper Hawthorn Aquifer	Semiconfining Unit	Lower Hawthorn-upper Tampa Aquifer	Lower Tampa Semiconfining Unit	Tampa (Zone A)	Suwannee (Semiconfining Zone)	Suwannee (Zone B)	Ocala (Semiconfining Zone)	Avon Park (Zone C)	Avon Park (Semiconfining Zone)	Avon Park (Zone D)			Bolder Zone
Transmissivity	1042									9,953						
	1123									10,000						
	1150									10,000						
	1255									10,000						
	1315									10,050						
	1337									10,243						
	1372									10,896						
	1455									10,919						
	1482									11,064						
	1497									11,115						
	1532									11,584						
	1645									11,691						
	1724									12,271						
	1736									12,560						
	1765															
	1799									12,566						
	1859									12,609						
	1859									12,693						
	1872									13,284						
	1908									13,381						
	2000									13,815						
	2005									13,945						
	2005									13,988						
	2005									14,025						
	2006									14,266						
	2006									14,307						
	2006									14,316						
	2026									14,588						
	2313									14,707						
	2366									14,887						
	2406									14,890						
	2407									15,001						
	2644									15,988						
	2674									16,567						
	2674									16,857						
	2808									18,692						
	2947									19,926						
	2991									20,140						
	3022									20,510						
	3075									20,816						
	3209									22,023						
	3342									22,073						
	3342									22,462						
	3342									23,616						
	3342									24,485						
	3342									27,876						
	3476									28,077						
	3476									29,072						
	3476									29,204						
	3610									30,626						
	3743									31,754						
	3944									31,866						
	4011									34,537						
	4011									34,774						
	4011									35,000						
	4011									37,279						
	4319									37,365						
	4412									38,045						
	4679									41,313						
	4800									43,285						
	5214									45,672						
	5348									46,079						
	5348									49,023						
	5589									49,832						
	5749									50,000						

Appendix Table 3-3 Brevard County

County: Brevard																
Hydrogeologic Units	Surficial	Intermediate					Upper Floridan							Middle Confining Unit	Lower Floridan	
		Semiconfining Unit	Tamiami-upper Hawthorn Aquifer	Semiconfining Unit	Lower Hawthorn-upper Tampa Aquifer	Lower Tampa Semiconfining Unit	Tampa (Zone A)	Suwannee (Semiconfining Zone)	Suwannee (Zone B)	Ocala (Semiconfining Zone)	Avon Park (Zone C)	Avon Park (Semiconfining Zone)	Avon Park (Zone D)			Bolder Zone
Transmissivity	5829 6016 6016 6017 6217 6642 6819 7086 7313 7353 8021 8021 9292 9546 10027 10424 10589 10695 11364 12032 12777 13330 13343 22727 26738 4100									50,000 61,729 62,037 65,000 67,905 71,065 72,090 74,000 74,337 84,124 98,225 100,000 100,000 100,000 120,000 200,000 210,000 250,000 250,000 400,000 510,000 42,025						
Thickness	90 95 120 150 112			40 130 300 360 210						300 350 325		2410 2300 2400 2617 2656 2900 2900 2194		110 250 450 500 700 900 335	1400 1500 2000 2100 1750	85 190 700 291
Porosity																0.2
Temperature																
Salinity																
USDW below land surface									1190 1190 1634 1670 1700 1499							

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Appendix 4

4.1. Total Vertical Time of Travel

Total vertical time of travel is defined as the time required for secondary treated wastewater to migrate upward from the point of injection to the USDW and hypothetical receptor wells. Given the velocity and distance of travel, the time it takes to travel the distance can be determined by dividing the distance by the velocity. To estimate the vertical travel time (t) through each hydrologic unit, the thickness of the unit (b) is divided by the seepage velocity (v_s) (Eqn. 3). Seepage velocity is defined as the velocity representing the average rate at which ground water moves (Fetter, 1994) and is estimated by dividing the Darcy flow (q) by the porosity (n) of the hydrologic unit (Eqn. 4). Porosity represents the ratio between the volume of voids over the total volume of the media (Freeze and Cherry, 1979). In this analysis, published porosity values were used. Darcy flow is defined as fluid flow through porous media (e.g. sand) (Freeze and Cherry; 1979), taking into consideration that ground water flows through porous media, Darcian assumptions must be applied. Darcy flow takes into account vertical hydraulic conductivity (K) and the hydraulic gradient (I) (Eqn. 5). Hydraulic conductivity represents the ability of the media to transmit water (Fetter, 1994). Hydraulic gradient is estimated by dividing the total pressure head (H_T) by the thickness of the hydrologic unit (Eqn. 6).

$$t = \frac{b}{v_s} \qquad \text{(Eqn. 3)}$$

$$v_s = \frac{q}{n} \qquad \text{(Eqn. 4)}$$

$$q = K \times I \qquad \text{(Eqn. 5)}$$

$$I = \frac{H_T}{b} \qquad \text{(Eqn. 6)}$$

4.2. Total Pressure Head

Pressure head can be simply viewed as a driving force for vertical migration of treated wastewater. In this analysis, two driving components of pressure head were considered. Pressure head due to injection (H_I) and pressure head due to buoyancy (H_B). These components are described separately below. The total pressure head acting on the overlying hydrogeologic unit may be expressed as the sum of the buoyancy and the injection components (Eqn. 7):

$$H_T = H_I + H_B \qquad \text{(Eqn. 7)}$$

4.2.1. Pressure Head Due to Injection

Injection-derived pressure is a controlling force that drives the wastewater plume throughout the regional ground water system. As millions of gallons of water are injected into the aquifer, that volume displaces an equivalent volume of native water in the formation. This causes a pressure build-up in the aquifer, which must be dissipated throughout the aquifer unit.

The vertical migration component due to injection-derived over-pressuring was calculated using the following leaky aquifer steady-state pressure drawdown/increase equation (Gupta, 1995).

$$H_I = \frac{Q}{2\pi T} K_O\left(\frac{r}{B}\right) \qquad \text{(Eqn. 8)}$$

$$H_I = \frac{Q}{2\pi T} \ln\left(1.123\frac{B}{r}\right) \text{ for } \frac{r}{B} < 0.05 \qquad \text{(Eqn. 9)}$$

where:

Q	= Injection rate	
K	= Vertical hydraulic conductivity	
b	= Thickness of aquifer	
T	= Transmissivity of the receiving unit = $K \times b$	(Eqn.10)
r	= Distance from injection well	
$K_O\left(\frac{r}{B}\right)$	= Zero-order modified Bessel function of the second kind (Tabulated values)	
B	= Leakage factor = $\sqrt{\frac{T}{K'/b'}}$	(Eqn. 11)
K'	= Vertical hydraulic conductivity of the overlying layer	
b'	= Thickness of the overlying layer	

A distance of one hundred feet from the injection well (r) was chosen in Pinellas County, where pressure due to injection occurs. A distance of one hundred feet was chosen because at this distance away from the injection point, it is assumed that steady upward flow would be occurring. This value will also result in a conservative travel time estimation. The closer one is to the injection point, the greater the effects of pressure due to injection, resulting in a faster travel time. Representative injection rates of 112.5 million gallons per day (mgd) in Dade County, 7 mgd in Pinellas County, and 5 mgd in Brevard County were used (Starr et al., 2001, Florida Department of Environmental Protection, 2001 and Florida Department of Regulation, 1989). In Dade and Brevard Counties the pressure head due to injection is negligible due to injection into the Boulder Zone. The Boulder Zone is highly karstified with cavernous pores and wide fractures, which does not constrain the flow of injected effluent; therefore negligible pressure build up will occur (Singh et al., 1983; Haberfeld, 1991).

4.4.2. Pressure Head Due to Buoyancy

The buoyancy pressure head component, related to variations in fluid temperature and fluid density, also influences upward migration of the injectate. The wastewater injected into the aquifer is relatively fresh in comparison to the native ground water found in the injection zone (Florida Department of Environmental Protection, 1999a). As a result, the less dense injected wastewater rises above the denser, native ground water. In hydraulic terms, the fresh water is more buoyant than the salt water.

Density is also dependent on temperature: warm water is less dense than cold water. The temperature difference between the warm injected wastewater and the comparatively cold, native formation water is yet another driving force for the upward migration of the plume.

Upward pressure heads due to the buoyancy (from salinity and temperature differences) were calculated using the following derived equation (Hwang and Hita, 1987):

$$H_B = \frac{[\rho_n h - \rho_i h]}{\rho_{water}} \qquad \text{(Eqn. 12)}$$

where: H_B = Pressure head due to buoyancy (salinity and temperature gradient)

ρ = Density of native (n) and injected (i) fluid

h = Height of injected fluid (through each hydrologic unit)

Steady state conditions were assumed in this analysis. Under steady state conditions, no mixing or dispersion occurs and the injectate has a continuous path to the hypothetical water supply well or USDW. Travel times were estimated through each hydrologic unit. *Therefore a simplifying assumption, valid for steady state conditions, was that the height* of the injected fluid is the thickness of the hydrologic unit.

There is a natural salinity and temperature gradient in the native fluid. The native fluid in the injection zone has salinity comparable to sea water and becomes comparable to fresh water at the surficial aquifer. The injected wastewater has salinity comparable to fresh water therefore the pressure head due to buoyancy (salinity gradient) will decrease as the injectate moves closer to the hypothetical water supply well. The same result will occur with respect to temperature gradient. The temperature of the native fluid in the injection zone is approximately 60 degrees Fahrenheit and can reach up to 80 degrees in the surficial aquifer. The injected wastewater has a temperature of 80 degrees. As the injected wastewater moves closer to the hypothetical water supply well, the pressure head due to buoyancy (temperature gradient) will decrease. The buoyancy calculations were based on the discretization of the density gradient due to temperature and salinity difference.

In this analysis, two scenarios were considered: 1) porous media flow and 2) bulk flow through preferential flow paths. To assess the two scenarios, primary porosities and hydraulic conductivities and secondary porosities and hydraulic conductivities were used in the above equations, respectively. The results are presented in the following tables for Dade, Pinellas and Brevard Counties.

Appendix Table 4-1 Vertical Travel Time to Receptor Well

(Scenario 1: Porous Media Flow)

Dade

Hydrogeologic Units	Injection Fluid Travel (bls)		Vertical Hydraulic Conductivity (K_V)	Porosity (n)	Aquifer Thickness (effective) (b)	Transmissivity (T)	H_B	H_I	H_T	Hydraulic Gradient (I)	Darcy Velocity (q)	Seepage Velocity (v_s)	Travel Time (t)	
	From (feet)	To (feet)	(ft/day)		(feet)	(ft^2/day)	(feet)	(feet)	(feet)		(ft/day)	(ft/day)		
Biscayne Aquifer	230	100	15	0.31	130	2550	1	0	0.66	0.004	0.058	0.188	1.9	Years
Intermediate Confining Unit	840	230	0.10	0.31	610	61	5	0	4.69	0.008	0.001	0.002	674	Years
Upper Floridan Aquifer	2060	840	0.42	0.32	1220	512	19	0	18.5	0.015	0.006	0.020	168	Years
Middle Confining Unit	2550	2060	0.04	0.43	490	20	23	0	22.5	0.046	0.002	0.004	314	Years
Lower Floridan	2750	2550	0.10	0.40	200	20	15	0	14.6	0.073	0.007	0.018	30	Years
Boulder Zone	3000	2750	65	0.20	250	16250	12	0	12.0	0.048	3.13	15.7	16	Days
												Travel Time	**1,188**	**Years**

Pinellas

Hydrogeologic Units	Injection Fluid Travel (bls)		Vertical Hydraulic Conductivity (K_V)	Porosity (n)	Aquifer Thickness (effective) (b)	Transmissivity (T)	H_B	H_I	H_T	Hydraulic Gradient (I)	Darcy Velocity (q)	Seepage Velocity (v_s)	Travel Time (t)	
	From (feet)	To (feet)	(ft/day)		(feet)	(ft^2/day)	(feet)	(feet)	(feet)		(ft/day)	(ft/day)		
Surficial Aquifer	56	30	7	0.31	26	182	0.1	0	0.10	0.004	0.027	0.087	297	Days
Intermediate Confining Unit	275	56	1.2	0.31	219	263	1.8	0	1.82	0.008	0.010	0.032	18.6	Years
Upper Floridan Aquifer	1250	275	0.3	0.226	975	293	15.6	533	548	0.563	0.169	0.747	3.58	Years
												Travel Time	**23**	**Years**

Brevard

Hydrogeologic Units	Injection Fluid Travel (bls)		Vertical Hydraulic Conductivity (K_V)	Porosity (n)	Aquifer Thickness (effective) (b)	Transmissivity (T)	H_B	H_I	H_T	Hydraulic Gradient (I)	Darcy Velocity (q)	Seepage Velocity (v_s)	Travel Time (t)	
	From (feet)	To (feet)	(ft/day)		(feet)	(ft^2/day)	(feet)	(feet)	(feet)		(ft/day)	(ft/day)		
Surficial Aquifer	130	100	13	0.31	30	390	0	0	0.125	0.004	0.054	0.175	172	Days
Intermediate Confining Unit	340	130	0.10	0.31	210	21	2	0	1.56	0.007	0.001	0.002	240	Years
Upper Floridan Aquifer	665	340	0.20	0.26	325	65	6	0	6.13	0.019	0.004	0.015	61	Years
Middle Confining Unit	1000	665	0.04	0.43	335	13	11	0	11.0	0.033	0.001	0.003	301	Years
Lower Floridan	2460	1000	0.10	0.40	1460	146	45	0	45.4	0.031	0.003	0.008	515	Years
Boulder Zone	2754	2460	65	0.20	294	19110	47	0	46.9	0.160	10.4	51.9	5.67	Days
												Travel Time	**1118**	**Years**

Appendix Table 4-2 Vertical Travel Time to USDW

(Scenario 1: Porous Media Flow)

Dade

Hydrogeologic Units	Injection Fluid Travel (bls)		Vertical Hydraulic Conductivity (K_V)	Porosity (n)	Aquifer Thickness (effective) (b)	Transmissivity (T)	H_B	H_I	H_T	Hydraulic Gradient (I)	Darcy Velocity (q)	Seepage Velocity (v_s)	Travel Time (t)	
	From (feet)	To (feet)	(ft/day)		(feet)	(ft^2/day)	(feet)	(feet)	(feet)		(ft/day)	(ft/day)		
Upper Floridan Aquifer	2060	1500	0.42	0.32	560	512.4	18.5	0	18.5	0.015	0.006	0.020	77	Years
Middle Confining Unit	2550	2060	0.04	0.43	490	19.6	22.5	0	22.5	0.046	0.002	0.004	314	Years
Lower Floridan	2750	2550	0.1	0.4	200	20	14.6	0	14.6	0.073	0.007	0.018	30	Years
Boulder Zone	3000	2750	65	0.2	250	16250	12.0	0	12.0	0.048	3.13	15.7	16	Days
												Travel Time	**421**	**Years**

Pinellas

Hydrogeologic Units	Injection Fluid Travel (bls)		Vertical Hydraulic Conductivity (K_V)	Porosity (n)	Aquifer Thickness (effective) (b)	Transmissivity (T)	H_B	H_I	H_T	Hydraulic Gradient (I)	Darcy Velocity (q)	Seepage Velocity (v_s)	Travel Time (t)	
	From (feet)	To (feet)	(ft/day)		(feet)	(ft^2/day)	(feet)	(feet)	(feet)		(ft/day)	(ft/day)		
Upper Floridan Aquifer	1250	680	0.30	0.226	570	293	16	533	548	0.56	0.17	0.75	2	Years
												Travel Time	**2**	**Years**

Brevard

Hydrogeologic Units	Injection Fluid Travel (bls)		Vertical Hydraulic Conductivity (K_V)	Porosity (n)	Aquifer Thickness (effective) (b)	Transmissivity (T)	H_B	H_I	H_T	Hydraulic Gradient (I)	Darcy Velocity (q)	Seepage Velocity (v_s)	Travel Time (t)	
	From (feet)	To (feet)	(ft/day)		(feet)	(ft^2/day)	(feet)	(feet)	(feet)		(ft/day)	(ft/day)		
Lower Floridan	2470	1500	0.1	0.4	970	146	45	0	45	0.03	0.00	0.01	342	Years
Boulder Zone	2754	2470	65.00	0.20	284	19110	47	0	47	0.160	10.378	51.892	5	Days
												Travel Time	**342**	**Years**

Appendix Table 4-3 Vertical Travel Time to Receptor Well

(Scenario 2: Preferential Flow Paths)

Dade

Hydrogeologic Units	Injection Fluid Travel (bls)		Vertical Hydraulic Conductivity (K_V)	Porosity (n)	Aquifer Thickness (effective) (b)	Transmissivity (T)	H_B	H_I	H_T	Hydraulic Gradient (I)	Darcy Velocity (q)	Seepage Velocity (v_s)	Travel Time (t)	
	From (feet)	To (feet)	(ft/day)		(feet)	(ft^2/day)	(feet)	(feet)	(feet)		(ft/day)	(ft/day)		
Biscayne Aquifer	230	100	15	0.31	130	2550	1	0	0.7	0.004	0.058	0.19	1.9	Years
Intermediate Confining Unit	840	230	2.38	0.10	610	61	5	0	4.7	0.008	0.018	0.18	9.1	Years
Upper Floridan Aquifer	2060	840	2.38	0.10	1220	512	19	0	18.5	0.015	0.036	0.36	9.3	Years
Middle Confining Unit	2550	2060	1.5	0.10	490	20	23	0	22.5	0.046	0.069	0.69	1.9	Years
Lower Floridan	2750	2550	0.1	0.10	200	20	15	0	14.6	0.073	0.007	0.07	7.5	Years
Boulder Zone	3000	2750	65	0.2	250	16250	12	0	12.0	0.048	3.131	15.66	16	Days
												Travel Time	**30**	**Years**

Pinellas

Hydrogeologic Units	Injection Fluid Travel (bls)		Vertical Hydraulic Conductivity (K_V)	Porosity (n)	Aquifer Thickness (effective) (b)	Transmissivity (T)	H_B	H_I	H_T	Hydraulic Gradient (I)	Darcy Velocity (q)	Seepage Velocity (v_s)	Travel Time (t)	
	From (feet)	To (feet)	(ft/day)		(feet)	(ft^2/day)	(feet)	(feet)	(feet)		(ft/day)	(ft/day)		
Surficial Aquifer	56	30	7	0.31	26	182	0.1	0.0	0.1	0.003873	0.027	0.09	297	Days
Intermediate Confining Unit	275	56	1.50	0.10	219	329	1.8	0.0	1.8	0.008313	0.012	0.12	5	Years
Upper Floridan Aquifer	1250	275	2.38	0.10	975	2321	16	122	138	0.141048	0.336	3.36	290	Days
												Travel Time	**6.4**	**Years**

Brevard

Hydrogeologic Units	Injection Fluid Travel (bls)		Vertical Hydraulic Conductivity (K_V)	Porosity (n)	Aquifer Thickness (effective) (b)	Transmissivity (T)	H_B	H_I	H_T	Hydraulic Gradient (I)	Darcy Velocity (q)	Seepage Velocity (v_s)	Travel Time (t)	
	From (feet)	To (feet)	(ft/day)		(feet)	(ft^2/day)	(feet)	(feet)	(feet)		(ft/day)	(ft/day)		
Surficial Aquifer	130	100	13	0.31	30	390	1	0	1	0.03	0.39	1.26	24	Days
Intermediate Confining Unit	340	130	2.38	0.10	210	499.8	6	0	6	0.03	0.071	0.714	294	Days
Upper Floridan Aquifer	665	340	2.38	0.10	325	773.5	11	0	11	0.03	0.080	0.799	1	Years
Middle Confining Unit	1000	665	1.50	0.10	335	502.5	16	0	16	0.05	0.069	0.695	1	Years
Lower Floridan	2460	1000	0.10	0.10	1460	146	45	0	45	0.03	0.003	0.031	129	Years
Boulder Zone	2754	2460	65	0.20	294	19110	47	0	47	0.16	10.38	51.89	6	Days
												Travel Time	**136**	**Years**

Appendix Table 4-4 Vertical Travel Time to USDW

(Scenario 2: Preferential Flow Paths)

Dade

Hydrogeologic Units	Injection Fluid Travel (bls)		Vertical Hydraulic Conductivity (K_V)	Porosity (n)	Aquifer Thickness (effective) (b)	Transmissivity (T)	H_B	H_I	H_T	Hydraulic Gradient (I)	Darcy Velocity (q)	Seepage Velocity (v_s)	Travel Time (t)	
	From (feet)	To (feet)	(ft/day)		(feet)	(ft^2/day)	(feet)	(feet)	(feet)		(ft/day)	(ft/day)		
Upper Floridan Aquifer	2060	1500	2.38	0.10	560	512.4	19	0	19	0.015	0.036	0.36	4	Years
Middle Confining Unit	2550	2060	1.50	0.10	490	19.6	23	0	23	0.046	0.069	0.69	2	Years
Lower Floridan	2750	2550	0.1	0.1	200	20	15	0	15	0.073	0.007	0.07	8	Years
Boulder Zone	3000	2750	65	0.2	250	16250	12	0	12	0.048	3.1	15.7	16	Days
												Travel Time	**14**	**Years**

Pinellas

Hydrogeologic Units	Injection Fluid Travel (bls)		Vertical Hydraulic Conductivity (K_V)	Porosity (n)	Aquifer Thickness (effective) (b)	Transmissivity (T)	H_B	H_I	H_T	Hydraulic Gradient (I)	Darcy Velocity (q)	Seepage Velocity (v_s)	Travel Time (t)	
	From (feet)	To (feet)	(ft/day)		(feet)	(ft^2/day)	(feet)	(feet)	(feet)		(ft/day)	(ft/day)		
Upper Floridan Aquifer	1250	680	2.38	0.1	570	2321	16	122	138	0.14	0.34	3.36	170	Days
												Travel Time	**170**	**Days**

Brevard

Hydrogeologic Units	Injection Fluid Travel (bls)		Vertical Hydraulic Conductivity (K_V)	Porosity (n)	Aquifer Thickness (effective) (b)	Transmissivity (T)	H_B	H_I	H_T	Hydraulic Gradient (I)	Darcy Velocity (q)	Seepage Velocity (v_s)	Travel Time (t)	
	From (feet)	To (feet)	(ft/day)		(feet)	(ft^2/day)	(feet)	(feet)	(feet)		(ft/day)	(ft/day)		
Lower Floridan	2470	1500	0.1	0.1	970	146	45	0	45	0.031	0.003	0.031	86	Years
Boulder Zone	2754	2470	65.00	0.20	284	19110	47	0	47	0.160	10.4	51.9	5	Days
												Travel Time	**86**	**Years**

Appendix 5

Horizontal Travel Distance

The horizontal travel distance (X) is defined in this analysis as the distance of horizontal migration corresponding to the vertical travel time. The horizontal travel distance of the injected wastewater can be estimated by multiplying the seepage velocity (v_s) in the horizontal direction by the vertical travel time (t) estimated earlier (Eqn. 13). Seepage velocity is defined as the velocity representing the average rate at which ground water moves (Fetter, 1994) and is estimated by dividing the Darcy flow (q) by the porosity (n) of the hydrologic unit (Eqn. 14). Porosity represents the ratio between the volumes of voids over the total volume of the media (Freeze and Cherry, 1979). In this analysis, published porosity values were used. Darcy flow is defined as fluid flow through porous media (e.g. sand) (Freeze and Cherry; 1979), taking into consideration that ground water flows through porous media, Darcian assumptions must be applied. Darcy flow takes into account horizontal hydraulic conductivity (K_h) and the horizontal hydraulic gradient (i) (Eqn. 15). Hydraulic conductivity represents the ability of the media to transmit water (Fetter, 1994). Simple substitution of the seepage velocity and Darcy flow equations into Equation 13, will result in Equation 16.

$$X = v_s \times t \qquad \text{(Eqn. 13)}$$

$$v_s = \frac{q}{n} \qquad \text{(Eqn. 14)}^1$$

$$q = K_h \times i \qquad \text{(Eqn. 15)}$$

$$X = \frac{K_h i}{n} t \qquad \text{(Eqn. 16)}$$

As in the analysis of vertical travel time, two scenarios were considered: 1) porous media flow and 2) bulk flow through preferential flow paths. To assess the two scenarios, vertical travel times respective to the two scenarios were used in estimating the horizontal travel distances.

In Dade and Brevard Counties, a horizontal hydraulic gradient of 0.001 was assumed for all the hydrologic units. In Pinellas County, a horizontal hydraulic gradient of 0.05 was assumed in the injection zone and 0.001 in the overlying units. A greater horizontal hydraulic gradient in the injection zone accounts for the effects of injection pressure due to the injection of millions of gallons of wastewater a day.

Primary porosities were used in this analysis (Eqn. 16) however, in the Boulder Zone a porosity of 0.5 was assumed in Dade and Brevard Counties. A larger porosity in the Boulder Zone takes into account cavernous pores or large fractures found in the Boulder Zone (Meyer, 1984, Maliva and Walker, 1998).

The results of this analysis and a summary of the assumptions made are presented in the following tables for Dade, Pinellas and Brevard Counties (Table 5-1, 5-2 and 5-3).

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[1] Same equation used in Appendix 4 (Eqn. 4)

Appendix Table 5-1 Horizontal Migration
(Scenario 1: Porous Media Flow)

Dade

Hydrogeologic Units	Horizontal Hydraulic Conductivity (K_H) (ft/day)	Hydraulic Gradient (i)	Porosity (n)	Time (t) Days	Horizontal Distance (X) ft
Biscayne Aquifer	1,524	0.001	0.31	2	9
Intermediate Confining Unit	90.0	0.001	0.31	246082	71443
Upper Floridan Aquifer	42	0.001	0.32	61270	8042
Middle Confining Unit	5	0.001	0.43	114671	1253
Lower Floridan Aquifer	0.10	0.001	0.40	10984	3
Boulder Zone	6,538	0.001	0.50	16	209
				Total Horizontal Distance	**80,959**

Pinellas

Hydrogeologic Units	Horizontal Hydraulic Conductivity (K_H) (ft/day)	Hydraulic Gradient (i)	Porosity (n)	Time (t) Days	Horizontal Distance (X) ft
Surficial Aquifer	29	0.001	0.31	297	28
Intermediate Confining Unit	4	0.001	0.31	6806	88
Upper Floridan Aquifer	22	0.05	0.226	1306	6355
				Total Horizontal Distance	**6,471**

Brevard

Hydrogeologic Units	Horizontal Hydraulic Conductivity (K_H) (ft/day)	Hydraulic Gradient (i)	Porosity (n)	Time (t) Days	Horizontal Distance (X) ft
Surficial Aquifer	56	0.001	0.31	172	31
Intermediate Confining Unit	20.00	0.001	0.31	87494	5645
Upper Floridan Aquifer	20	0.001	0.26	22406	1724
Middle Confining Unit	1	0.001	0.43	109982	205
Lower Floridan Aquifer	0.1	0.001	0.40	187918	47
Boulder Zone	650	0.001	0.50	6	7
				Total Horizontal Distance	**7,658**

Appendix Table 5-2 Horizontal Migration
(Scenario 2: Preferential Flow Paths)

Dade

Hydrogeologic Units	Horizontal Hydraulic Conductivity (K_H) (ft/day)	Hydraulic Gradient (i)	Porosity (n)	Time (t) Days	Horizontal Distance (X) ft
Biscayne Aquifer	1,524	0.001	0.31	2	9
Intermediate Confining Unit	90.0	0.001	0.10	3,335	3,002
Upper Floridan Aquifer	42	0.001	0.10	3,379	1,419
Middle Confining Unit	5	0.001	0.10	711	33
Lower Floridan Aquifer	0.10	0.001	0.10	2,746	3
Boulder Zone	6,538	0.001	0.20	16	522
				Total Horizontal Distance	**4,988**

Pinellas

Hydrogeologic Units	*Horizontal* Hydraulic Conductivity (K_H) (ft/day)	Hydraulic Gradient (i)	Porosity (n)	Time (t) Days	Horizontal Distance (X) ft
Surficial Aquifer	29	0.001	0.31	297	28
Intermediate Confining Unit	4	0.001	0.1	1,756	70
Upper Floridan Aquifer	22	0.05	0.1	290	3,195
				Total Horizontal Distance	**3,293**

Brevard

Hydrogeologic Units	Horizontal Hydraulic Conductivity (K_H) (ft/day)	Hydraulic Gradient (i)	Porosity (n)	Time (t) Days	Horizontal Distance (X) ft
Surficial Aquifer	56	0.001	0.31	172	31
Intermediate Confining Unit	20.00	0.001	0.10	3	1
Upper Floridan Aquifer	20	0.001	0.10	724	145
Middle Confining Unit	1	0.001	0.10	682	5
Lower Floridan Aquifer	0.1	0.001	0.10	46980	47
Boulder Zone	650	0.001	0.20	6	18
				Total Horizontal Distance	**247**

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Appendix 6

Uncertainty Analysis

Upper and lower boundary travel times to use for the risk assessment were computed based on the results of the uncertainty analyses. For purposes of this risk assessment, times of travel were computed by altering one parameter in each scenario. Vertical hydraulic conductivity of the confining unit was the tested parameter for the porous media scenario (Scenario 1). Porosity was the tested parameter for the preferential flow path scenario (Scenario 2).

Vertical hydraulic conductivity was evaluated by computing travel times based on variation of the mean vertical hydraulic conductivity by up to one order of magnitude above and below the mean value calculated from review of the scientific literature. Porosity was varied from 0.01 to 0.20, a range within typical porosity values found for limestones and dolomites (Freeze and Cherry, 1979). for the travel times computed in the preferential flow path scenario. Graphical representation of the uncertainty analysis time of travel computations can be found in Appendix Figures 6-1, 6-2 and 6-3 for Dade, Brevard and Pinellas Counties.

Upper and lower bounds of times of travel were computed from the results of the uncertainty tests. The first step in developing these bounds is to determine the statistical average time of travel ($t_{average}$) (Eqn. 17).

$$t_{average} = \frac{t_{90} + t_{10}}{2} \qquad \text{(Eqn. 17)}$$

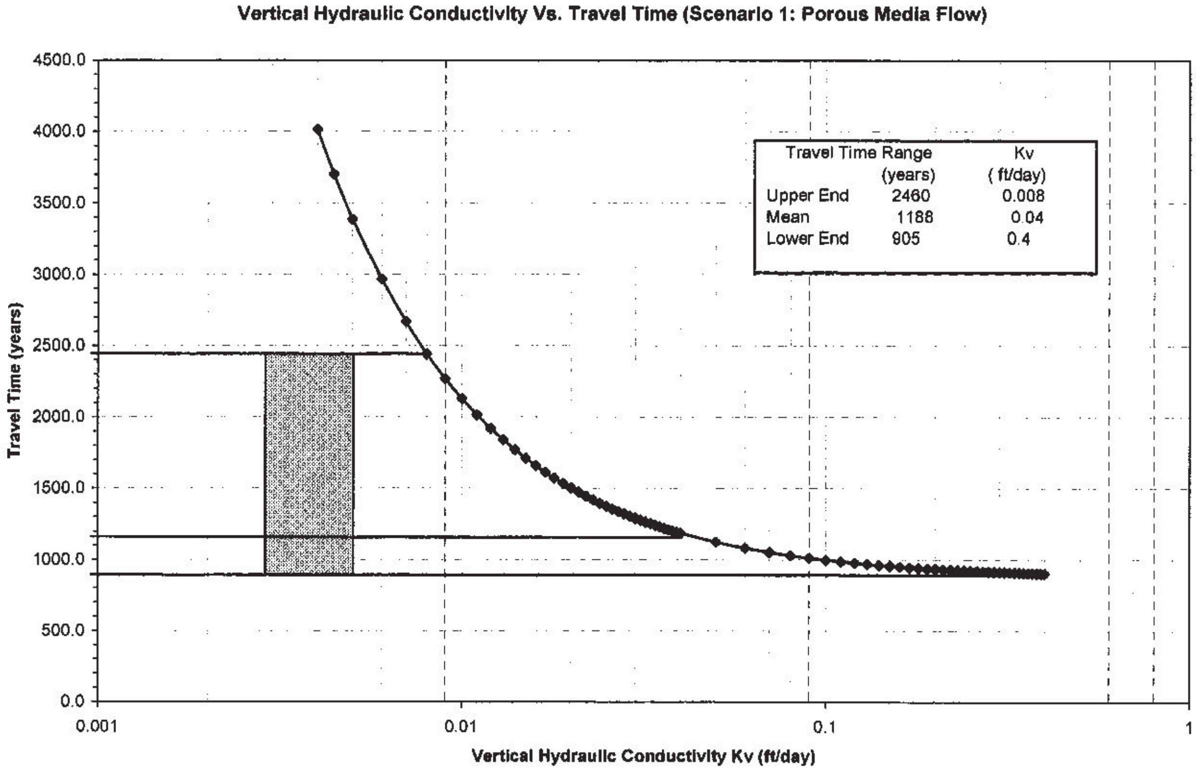
The t_{90} and t_{10} values are the vertical travel times associated with the ninetieth and the tenth percentile, respectively, within the range of the time of travel calculations for each scenario. The resulting $t_{average}$ value thus represents a statistical calculation that incorporates the weight of the travel time variations across two orders of magnitude for the lowest hydraulic conductivity unit, and across the reasonably expected range of porosity typically associated with preferential (i.e.- secondary) flow.

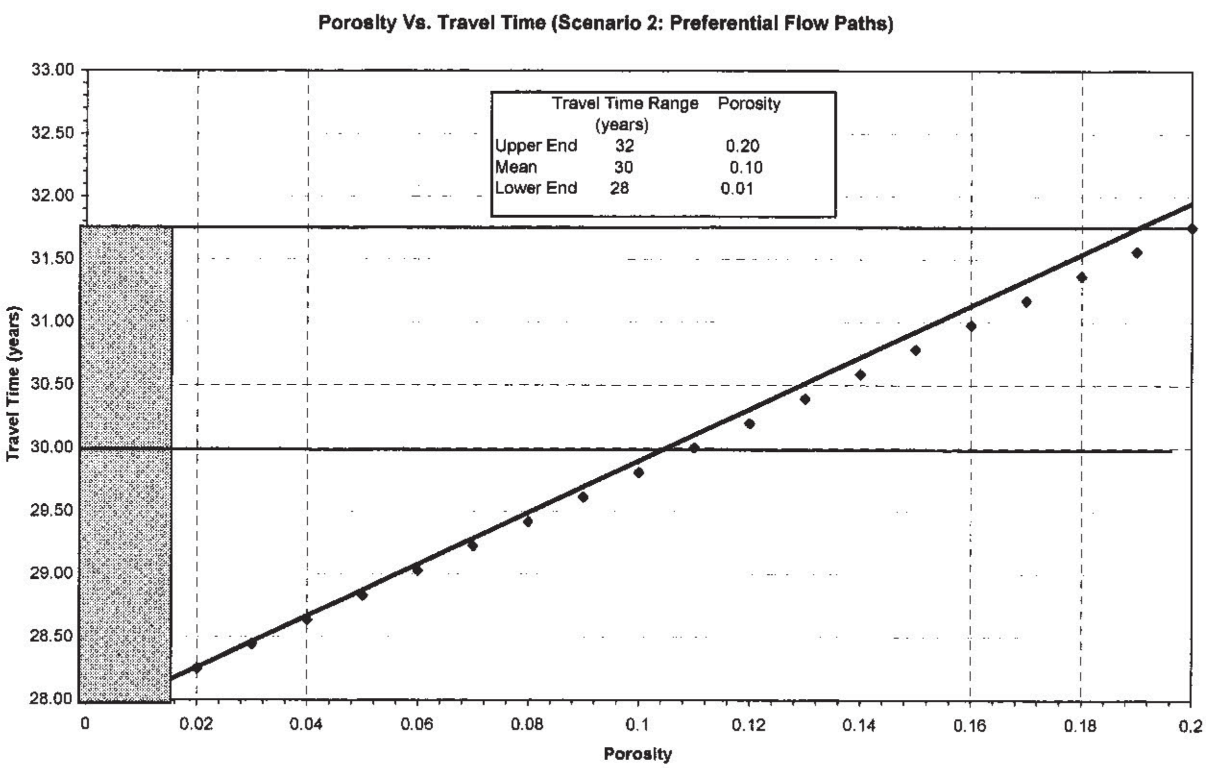
The upper and lower bounds for time of travel are then computed based on the relationship between $t_{average}$, computed in the uncertainty tests, and the vertical travel time (t) estimated earlier. Equations 18 and 19 depict the computations used to generate the upper and lower time of travel bounds, respectively:

$$t_{upper} = t + \left(t_{average} - t\right) \qquad \text{(Eqn. 18)}$$

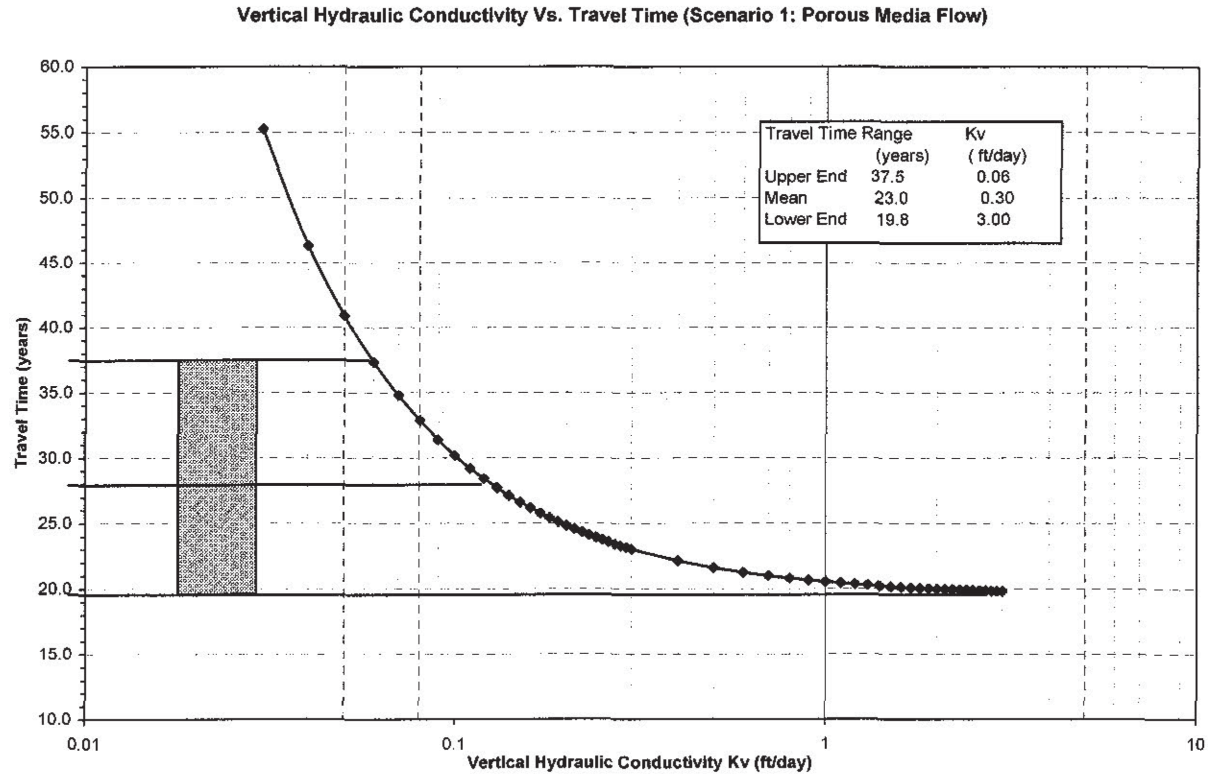
$$t_{lower} = t - \left(t_{average} - t\right) \qquad \text{(Eqn. 19)}$$

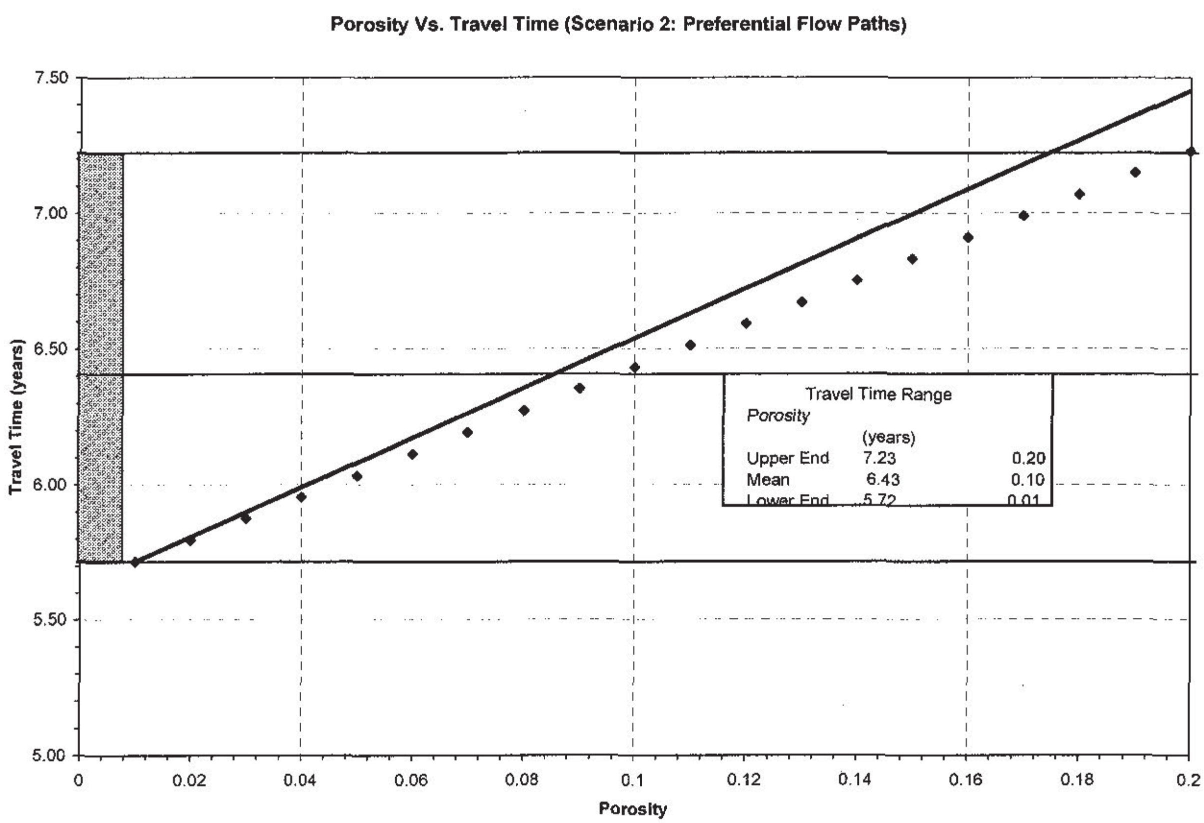
Appendix Figure 6-1
Uncertainty Analysis Results for Dade County



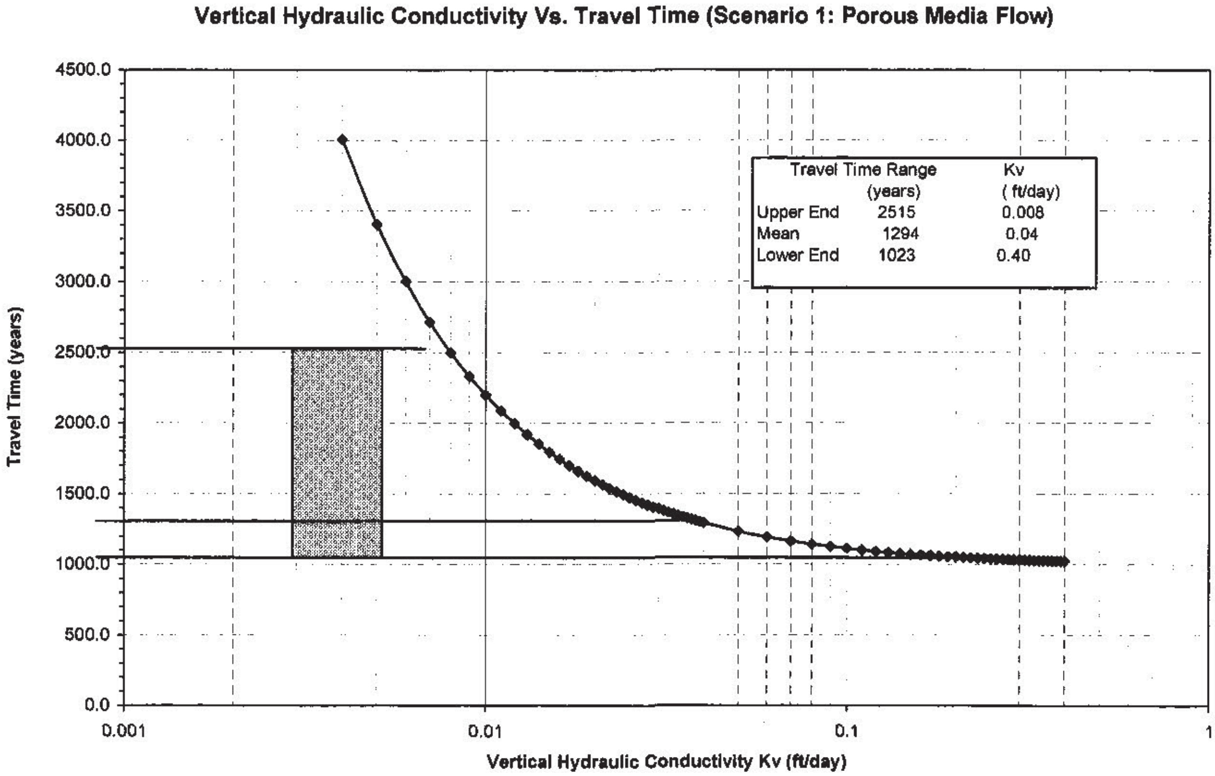


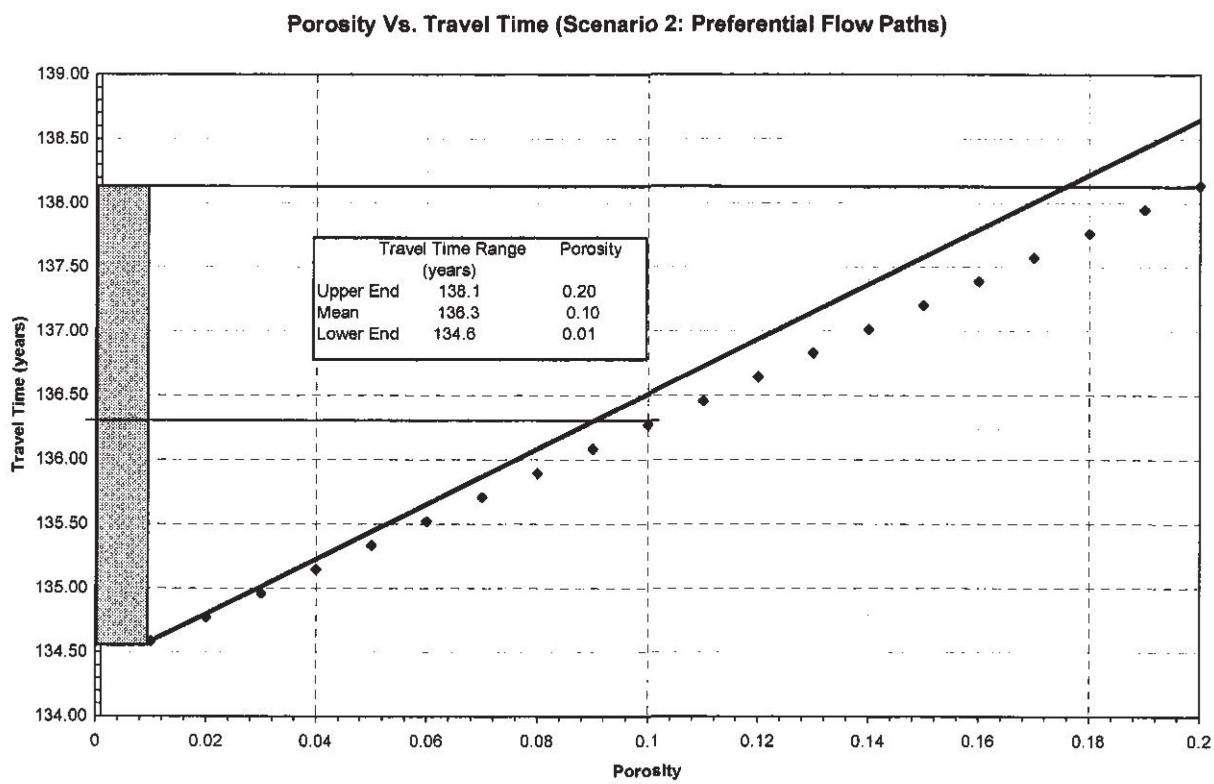
Appendix Figure 6-2
Uncertainty Analysis Results for Pinellas County





Appendix Figure 6-3
Uncertainty Analysis Results for Brevard County





Appendix 7

Fate and Transport

The fate and transport of representative stressors can be estimated by a first order decay model (Eqn. 20), which estimates the final concentration (C) of the representative stressors in correlation to vertical travel times estimated earlier. This first order decay model is appropriate for analysis of the organic constituents, because it takes into account natural attenuation processes such as biodegradation, hydrolysis and sorption (Suthersan, 2002).

$$C = C_O e^{-kt_C} \qquad \text{(Eqn. 20)}$$

where:

C	= Final concentration of stressors	
C_O	= Initial concentration of stressors	
k	= Decay coefficient of stressors	
t_C	= Travel time of stressors	

Half-life ($t_{1/2}$) is defined as the time it takes for stressors to reach half of the initial concentration. The decay coefficient (k) can be determined by rearranging Equation 20, substituting the half-life in place of the travel time of stressors (t_C) and equating the ratio of the final versus initial concentrations to 0.5 (Eqn. 21). The decay coefficient (Eqn. 22) is simplified by rearranging Equation 21. Published values for half-life are available and were identified for the selected representative stressors (Howard et al., 1991).

$$\frac{C}{C_O} = 0.5 = e^{-kt_{1/2}} \qquad \text{(Eqn. 21)}$$

$$k = \frac{0.693}{t_{1/2}} \qquad \text{(Eqn. 22)}$$

The travel time of representative stressors (t_C) are determined by multiplying the retardation coefficient (R) by the effluent travel time (t_E) (Eqn. 23). In this analysis, the effluent travel time is equivalent to the vertical travel time estimated earlier.

$$t_C = R \times t_E \qquad \text{(Eqn. 23)}$$

The retardation coefficient takes into account sorption, a natural attenuation process which increases the travel time of stressors. The greater the travel time of stressors, the more time there is for other natural attenuation process to occur, such as biodegradation and hydrolysis to a lesser extent. Biodegradation results in the degradation of organic material and may also mediate transformations in the state of inorganic material resulting in decreasing concentrations over time. Hydrolysis is the process whereby organic and inorganic solutes react with water resulting in degradation and transformation (Suthersan, 2002). Calculation for the retardation coefficient, for dissolved organic constituents, is shown below in Equation 24 (Suthersan, 2002).

$$R = 1 + \frac{\rho_b K_d}{n} \qquad \text{(Eqn. 24)}$$

where:

ρ_b	= Bulk density $= \rho_s(1-n)$	(Eqn. 25)
ρ_s	= soil density	
n	= porosity	
K_d	= Distribution coefficient $= K_{oc} f_{oc}$	(Eqn. 26)
K_{oc}	= Sorption coefficient	
f_{oc}	= fraction of total organic carbon	

$$R = 1 + \frac{\rho_s(1-n) K_{oc} f_{oc}}{n} \qquad \text{(Eqn. 27)}$$

Sorption coefficients (K_{oc}) were obtained from published values for each representative stressor (Montgomery, 2000). For purposes of risk assessment, conservative values (indicating the least sorption) were selected to calculate the distribution coefficient and therefore the retardation coefficient. Ultimately, this produces conservative estimates of stressor concentrations at the receptors, since the data used relate to the lowest reasonably expected retardation and the shortest travel time. The calculations incorporated a typical value for sediment density of 2.63 g/cm^3 (Freeze and Cherry, 1979). Weighted mean porosity values (Appendix 3), based on unit thickness, were used in the calculations.

Appendix Table 7-1 Representative Stressors Concentrations at Receptor Wells
(Scenario 1: Porous Media Flow)

Dade County															
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Effluent Travel Time to Receptor Wells (days)	Contaminant Travel Time (t_r) (days)	Decay Coefficient (k) (day $^{-1}$)	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.33	1.76	1.08	1188	1279	433620	466962	0.0004	61.58	0.00
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.33	1.76	1.12	1188	1331	433620	485716	0.0010	**4.66**	0.00
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.33	1.76	1.25	1188	1487	433620	542907	0.0003	0.010	0.000
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.33	1.76	1.15	1188	1361	433620	496830	N/A	0.010	0.010
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.33	1.76	1.24	1188	1472	433620	537350	0.0018	5.00	0.00
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.33	1.76	1.03	1188	1219.1	433620	444965	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1188	N/A	433620	N/A	N/A	3.82	3.82

Pinellas County															
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Effluent Travel Time to Receptor Wells (days)	Contaminant Travel Time (t_r) (days)	Decay Coefficient (k) (day $^{-1}$)	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.24	2.00	1.12	23.00	25.8	8395	9402	0.0004	6.70	0.18
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.24	2.00	1.19	23.00	27.3	8395	9968	0.0010	0.63	0.00
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.24	2.00	1.39	23.00	32.0	8395	11695	0.0003	0.64	0.03
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.24	2.00	1.23	23.00	28.23	8395	10304	N/A	0.003	0.003
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.24	2.00	1.37	23.00	31.6	8395	11527	0.0018	1.25	0.00
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.24	2.00	1.04	23.00	23.9	8395	8738	N/A	18.00	18.00
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	23.00	N/A	8395	N/A	N/A	0.28	0.28

Brevard County															
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Effluent Travel Time to Receptor Wells (days)	Contaminant Travel Time (t_r) (days)	Decay Coefficient (k) (day $^{-1}$)	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.36	1.68	1.07	1118	1193	408070	435545	0.0004	**230**	0.00
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.36	1.68	1.11	1118	1236	408070	450999	0.0010	1.00	0.00
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.36	1.68	1.22	1118	1365	408070	498125	0.0003	0.010	0.000
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.36	1.68	1.13	1118	1261	408070	460157	N/A	0.005	0.005
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.36	1.68	1.21	1118	1352	408070	493546	0.0018	5.00	0.00
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.36	1.68	1.02	1118	1144	408070	417419	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1118	N/A	408070	N/A	N/A	9.60	9.60

N/A = not applicable

Appendix Table 7-2 Representative Stressors Concentrations at USDW

(Scenario 1: Porous Media Flow)

Dade County													
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to USDW (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day $^{-1}$)	Concentration at Injection Pt. (C_O)	Concentration at USDW (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.33	1.76	1.08	421	453	0.0004	61.58	0.00
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.33	1.76	1.12	421	472	0.0010	**4.66**	0.00
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.33	1.76	1.25	421	527	0.0003	0.010	0.00
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.33	1.76	1.15	421	482	N/A	0.010	0.010
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.33	1.76	1.24	421	522	0.0018	5.00	0.00
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.33	1.76	1.03	421	432.0	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	421	N/A	N/A	3.82	3.82

Pinellas County													
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to USDW (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day $^{-1}$)	Concentration at Injection Pt. (C_O)	Concentration at USDW (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.24	2.00	1.12	2.00	2.2	0.0004	6.70	4.89
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.24	2.00	1.19	2.00	2.4	0.0010	0.63	0.27
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.24	2.00	1.39	2.00	2.8	0.0003	0.64	0.50
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.24	2.00	1.23	2.00	2.45	N/A	0.003	0.003
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.24	2.00	1.37	2.00	2.7	0.0018	1.25	0.21
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.24	2.00	1.04	2.00	2.1	N/A	18.00	18.00
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.00	N/A	N/A	0.28	0.28

Brevard County													
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to USDW (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day $^{-1}$)	Concentration at Injection Pt. (C_O)	Concentration at USDW (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.36	1.68	1.07	342	365	0.0004	**230**	0.0
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.36	1.68	1.11	342	378	0.0010	1.00	0.0
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.36	1.68	1.22	342	417	0.0003	0.010	0.0
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.36	1.68	1.13	342	386	N/A	0.005	0.005
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.36	1.68	1.21	342	414	0.0018	5.00	0.0
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.36	1.68	1.02	342	350	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	342	N/A	N/A	9.60	9.60

N/A = not applicable

Appendix Table 7-5 Representative Stressors Concentrations at Receptor Wells
(Scenario 2: Preferential Flow Paths)

Dade County												
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day^{-1})	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.3	1.84	1.09	30	33	0.0004	61.58	0.63
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.3	1.84	1.14	30	34	0.0010	**4.66**	0.00
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.3	1.84	1.29	30	39	0.0003	0.010	0.000
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.3	1.84	1.17	30	35	N/A	0.010	0.010
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.3	1.84	1.27	30	38	0.0018	5.00	0.00
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.3	1.84	1.03	30	30.9	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	30	N/A	N/A	3.82	3.82

Pinellas County												
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day^{-1})	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.25	1.97	1.11	6.40	7.1	0.0004	6.70	2.46
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.25	1.97	1.18	6.40	7.5	0.0010	0.63	0.04
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.25	1.97	1.37	6.40	8.8	0.0003	0.64	0.29
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.25	1.97	1.22	6.40	7.78	N/A	0.003	0.003
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.25	1.97	1.35	6.40	8.7	0.0018	1.25	0.00
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.25	1.97	1.04	6.40	6.6	N/A	18.00	18.00
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.40	N/A	N/A	0.28	0.28

Brevard County												
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day^{-1})	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.36	1.68	1.07	136	145	0.0004	**230**	0.00
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.36	1.68	1.11	136	150	0.0010	1.00	0.00
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.36	1.68	1.22	136	166	0.0003	0.010	0.000
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.36	1.68	1.13	136	153	N/A	0.005	0.005
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.36	1.68	1.21	136	164	0.0018	5.00	0.00
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.36	1.68	1.02	136	139	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	136	N/A	N/A	9.60	9.60

N/A = not applicable

Appendix Table 7-4 Representative Stressors Concentrations at USDW
(Scenario 2: Preferential Flow Paths)

Dade County

Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to USDW (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day^{-1})	Concentration at Injection Pt. (C_O)	Concentration at USDW (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.3	1.84	1.09	14	15	0.0004	61.58	7.24
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.3	1.84	1.14	14	16	0.0010	**4.66**	0.02
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.3	1.84	1.29	14	18	0.0003	0.010	0.00
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.3	1.84	1.17	14	16	N/A	0.010	0.010
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.3	1.84	1.27	14	18	0.0018	5.00	0.00
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.3	1.84	1.03	14	14.4	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14	N/A	N/A	3.82	3.82

Pinellas County

Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to USDW (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day^{-1})	Concentration at Injection Pt. (C_O)	Concentration at USDW (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.25	1.97	1.11	0.47	0.5	0.0004	6.70	6.23
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.25	1.97	1.18	0.47	0.5	0.0010	0.63	0.52
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.25	1.97	1.37	0.47	0.6	0.0003	0.64	0.60
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.25	1.97	1.22	0.47	0.57	N/A	0.003	0.003
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.25	1.97	1.35	0.47	0.6	0.0018	1.25	0.83
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.25	1.97	1.04	0.47	0.5	N/A	18.00	18.00
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47	N/A	N/A	0.28	0.28

Brevard County

Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to USDW (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day^{-1})	Concentration at Injection Pt. (C_O)	Concentration at USDW (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.36	1.68	1.07	86	92	0.0004	**230**	0.0
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.36	1.68	1.11	86	95	0.0010	1.00	0.0
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.36	1.68	1.22	86	105	0.0003	0.010	0.0
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.36	1.68	1.13	86	97	N/A	0.005	0.005
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.36	1.68	1.21	86	104	0.0018	5.00	0.0
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.36	1.68	1.02	86	88	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	86	N/A	N/A	9.60	9.60

N/A = not applicable

Appendix 8. Aquifer Recharge Calculations

To determine risk associated with aquifer recharge of treated effluent, the fate and transport of representative stressors were conducted for a range of required setbacks of 200, 500 and 2,640 feet (0.5 mile). Utilizing hydrologic data for the Surficial Aquifer, the fate and transport of the selected representative stressors can be estimated.

The time of travel to the horizontal setback distances (X) can be estimated by dividing the setback distances by the seepage velocity (v_s) (Eqn. 28). Seepage velocity is defined as the velocity representing the average rate at which ground water moves (Fetter, 1994) and is estimated by dividing the Darcy flow (q) by the porosity (n) of the hydrologic unit (Eqn. 29). Porosity represents the ratio between the volumes of voids over the total volume of the media (Freeze and Cherry, 1979). In this analysis, published porosity values were used. Darcy flow is defined as fluid flow through porous media (e.g. sand) (Freeze and Cherry; 1979), taking into consideration that ground water flows through porous media, Darcian assumptions must be applied. Darcy flow takes into account horizontal hydraulic conductivity (K_h) and the horizontal hydraulic gradient (i) (Eqn. 30). Hydraulic conductivity represents the ability of the media to transmit water (Fetter, 1994). Simple substitution of the seepage velocity and Darcy flow equations into Equation 28 will result in Equation 31.

$$t = \frac{X}{v_s} \qquad \text{(Eqn. 28)}$$

$$v_s = \frac{q}{n} \qquad \text{(Eqn. 29)}^1$$

$$q = K_h \times i \qquad \text{(Eqn. 30)}^2$$

$$t = \frac{Xn}{K_h i} \qquad \text{(Eqn. 31)}$$

Once the time of travel to the predetermined setback distances (Appendix Table 8-1) has been estimated, a fate and transport analysis can be used to determine the final concentrations of representative stressors. The fate and transport of representative stressors can be estimated by a first order decay model (Eqn. 32), which estimates the final concentration (C) of the representative stressors in correlation to vertical travel times estimated earlier. This first order decay model is appropriate for analysis of the organic constituents, because it takes into account natural attenuation processes such as biodegradation, hydrolysis and sorption (Suthersan, 2002).

$$C = C_O e^{-kt_c} \qquad \text{(Eqn. 32)}^3$$

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[1] Same equation used in Appendix 4 and 5 (Eqn. 4 and Eqn. 14)
[2] Same equation used in Appendix 5 (Eqn. 15)
[3] Same equation used in Appendix 7 (Eqn. 20)

where: C = Final concentration of stressors
C_O = Initial concentration of stressors
k = Decay coefficient of stressors
t_C = Travel time of stressors

Half-life ($t_{1/2}$) is defined as the time it takes for stressors to reach half of the initial concentration. The decay coefficient (k) can be determined by rearranging Equation 32, substituting the half-life in place of the travel time of stressors (t_C) and equating the ratio of the final versus initial concentrations to 0.5 (Eqn. 33). The decay coefficient (Eqn. 34) is simplified by rearranging Equation 33. Published values for half-life are available and were identified for the selected representative stressors (Howard et al., 1991).

$$\frac{C}{C_O} = 0.5 = e^{-kt_{1/2}} \qquad \text{(Eqn. 33)}^3$$

$$k = \frac{0.693}{t_{1/2}} \qquad \text{(Eqn. 34)}^3$$

The travel time of representative stressors (t_C) are determined by multiplying the retardation coefficient (R) by the effluent travel time (t_E) (Eqn. 35). In this analysis, the effluent travel time is equivalent to the vertical travel time estimated earlier.

$$t_C = R \times t_E \qquad \text{(Eqn. 35)}^3$$

The retardation coefficient takes into account sorption, a natural attenuation process which increases the travel time of stressors. The greater the travel time of stressors, the more time there is for other natural attenuation process to occur, such as biodegradation and hydrolysis. Biodegradation results in the degradation of organic material and may also mediate transformations in the state of inorganic material, resulting in decreasing concentrations over time. Hydrolysis is the process whereby organic and inorganic solutes react with water resulting in degradation and transformation (Suthersan, 2002). Calculation for the retardation coefficient, for dissolved organic constituents, is shown below in Equation 36 (Suthersan, 2002).

$$R = 1 + \frac{\rho_b K_d}{n} \qquad \text{(Eqn. 36)}^3$$

where: ρ_b = Bulk density = $\rho_s(1-n)$ (Eqn. 37)[3]
ρ_s = soil density
n = porosity
K_d = Distribution coefficient = $K_{oc} f_{oc}$ (Eqn. 38)[3]
K_{oc} = Sorption coefficient

[3] Same equation used in Appendix 7 (Eqn. 21 to Eqn. 26)

f_{oc} = fraction of total organic carbon

$$R = 1 + \frac{\rho_s (1-n) K_{oc} f_{oc}}{n} \qquad \text{(Eqn. 39)}^3$$

Sorption coefficients (K_{oc}) were obtained from published values for each representative stressor (Montgomery, 2000). For purposes of risk assessment, conservative values (indicating the least sorption) were selected to calculate the distribution coefficient and therefore the retardation coefficient. Ultimately, this produces conservative estimates of stressor concentrations at the receptors, since the data used relate to the lowest reasonably expected retardation and the shortest travel time. The calculations incorporated a typical value for sediment density of 2.63 g/cm^3 (Freeze and Cherry, 1979). Weighted mean porosity values (Appendix 3), based on unit thickness, were used in the calculations.

Appendix Table 8-2 to 8-4 summarizes the fate and transport of the representative stressors within 200, 500 and 2640 feet (0.5 mile) from the facility in Dade, Pinellas and Brevard Counties.

[3] Same equation used in Appendix 7 (Eqn. 27)

Appendix Table 8-1. Fate Transport (200')

Dade County													
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day^{-1})	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
	Max	Max		Max				Max		Max	Max		Min
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.33	1.76	1.08	0.11	0	0.0004	7.18	7.06
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.33	1.76	1.12	0.11	0	0.0010	**4.66**	**4.46**
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.33	1.76	1.25	0.11	0	0.0003	0.010	0.01
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.33	1.76	1.15	0.11	0	N/A	0.010	0.010
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.33	1.76	1.24	0.11	0	0.0018	5.00	4.57
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.33	1.76	1.03	0.11	0.1	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.11	N/A	N/A	0.64	0.64

Pinellas County													
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day^{-1})	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.25	1.97	1.11	5.86	6.5	0.0004	6.70	2.68
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.25	1.97	1.18	5.86	6.9	0.0010	2.50	0.22
Hexachlorobenzene (µg/L)	4178	2.56	0.01	0.026	2.63	0.25	1.97	1.20	5.86	7.0	0.0002	**1.74**	**1.14**
Pentachlorophenol (µg/L)	1520	2.76	0.01	0.028	2.63	0.25	1.97	1.22	5.86	7.1	0.0005	**1.28**	0.39
Benzo(a)pyrene (µg/L)	1060	5.95	0.01	0.060	2.63	0.25	1.97	1.47	5.86	8.6	0.0007	**1.82**	**0.23**
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.25	1.97	1.37	5.86	8.0	0.0003	0.640	0.31
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.25	1.97	1.22	5.86	7.12	N/A	0.003	0.003
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.25	1.97	1.35	5.86	7.9	0.0018	1.25	0.01
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.25	1.97	1.04	5.86	6.1	N/A	18.00	18.00
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.86	N/A	N/A	0.28	0.28

Brevard County													
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day^{-1})	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.36	1.68	1.07	3.03	3	0.0004	**230**	**146**
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.36	1.68	1.11	3.03	3	0.0010	1.00	0.3
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.36	1.68	1.22	3.03	4	0.0003	0.010	0.0
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.36	1.68	1.13	3.03	3	N/A	0.005	0.005
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.36	1.68	1.21	3.03	4	0.0018	5.00	0.5
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.36	1.68	1.02	3.03	3	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.03	N/A	N/A	9.60	9.60

N/A = not applicable

Dade County

Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day $^{-1}$)	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.33	1.76	1.08	0.28	0	0.0004	7.18	6.88
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.33	1.76	1.12	0.28	0	0.0010	**4.66**	**4.17**
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.33	1.76	1.25	0.28	0	0.0003	0.010	0.01
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.33	1.76	1.15	0.28	0	N/A	0.010	0.010
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.33	1.76	1.24	0.28	0	0.0018	5.00	3.99
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.33	1.76	1.03	0.28	0.3	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.28	N/A	N/A	0.64	0.64

(Appendix 8 continued)

Pinellas County

Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day $^{-1}$)	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.25	1.97	1.11	14.64	16.3	0.0004	6.70	0.68
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.25	1.97	1.18	14.64	17.2	0.0010	2.50	0.01
Hexachlorobenzene (µg/L)	4178	2.56	0.01	0.026	2.63	0.25	1.97	1.20	14.64	17.6	0.0002	**1.74**	0.60
Pentachlorophenol (µg/L)	1520	2.76	0.01	0.028	2.63	0.25	1.97	1.22	14.64	17.8	0.0005	**1.28**	0.07
Benzo(a)pyrene (µg/L)	1060	5.95	0.01	0.060	2.63	0.25	1.97	1.47	14.64	21.5	0.0007	**1.82**	0.01
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.25	1.97	1.37	14.64	20.1	0.0003	0.640	0.10
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.25	1.97	1.22	14.64	17.80	N/A	0.003	0.003
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.25	1.97	1.35	14.64	19.8	0.0018	1.25	0.00
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.25	1.97	1.04	14.64	15.2	N/A	18.00	18.00
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14.64	N/A	N/A	0.28	0.28

Brevard County

Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day $^{-1}$)	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.36	1.68	1.07	7.58	8	0.0004	**230**	73.7
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.36	1.68	1.11	7.58	8	0.0010	1.00	0.1
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.36	1.68	1.22	7.58	9	0.0003	0.010	0.0
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.36	1.68	1.13	7.58	9	N/A	0.005	0.005
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.36	1.68	1.21	7.58	9	0.0018	5.00	0.0
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.36	1.68	1.02	7.58	8	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.58	N/A	N/A	9.60	9.60

N/A = not applicable

Appendix Table 8-3. Fate Transport (0.5 mile)

Dade County													
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day^{-1})	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.33	1.76	1.08	1.47	2	0.0004	7.18	5.75
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.33	1.76	1.12	1.47	2	0.0010	**4.66**	2.61
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.33	1.76	1.25	1.47	2	0.0003	0.010	0.01
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.33	1.76	1.15	1.47	2	N/A	0.010	0.010
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.33	1.76	1.24	1.47	2	0.0018	5.00	1.53
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.33	1.76	1.03	1.47	1.5	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47	N/A	N/A	0.64	0.64

Pinellas County													
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day^{-1})	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.25	1.97	1.11	77.32	86.1	0.0004	6.70	0.00
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.25	1.97	1.18	77.32	91.0	0.0010	2.50	0.00
Hexachlorobenzene (µg/L)	4178	2.56	0.01	0.026	2.63	0.25	1.97	1.20	77.32	92.9	0.0002	**1.74**	0.01
Pentachlorophenol (µg/L)	1520	2.76	0.01	0.028	2.63	0.25	1.97	1.22	77.32	94.2	0.0005	**1.28**	0.00
Benzo(a)pyrene (µg/L)	1060	5.95	0.01	0.060	2.63	0.25	1.97	1.47	77.32	113.6	0.0007	**1.82**	0.00
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.25	1.97	1.37	77.32	106.1	0.0003	0.640	0.00
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.25	1.97	1.22	77.32	93.97	N/A	0.003	0.003
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.25	1.97	1.35	77.32	104.6	0.0018	1.25	0.00
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.25	1.97	1.04	77.32	80.3	N/A	18.00	18.00
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	77.32	N/A	N/A	0.28	0.28

Brevard County													
Surrogate	Published Half-Life in Groundwater ($t_{1/2}$) (days)	Published Sorption Coefficient (K_{OC})	Fraction of Total Organic Carbon (f_{oc})	Distribution Coefficient (K_d)	Soil Density (ρ_s)	Porosity (n)	Bulk Density (ρ_b)	Retardation Coefficient (R)	Effluent Travel Time to Receptor Wells (t_E) (years)	Contaminant Travel Time (t_C) (years)	Decay Coefficient (k) (day^{-1})	Concentration at Injection Pt. (C_O)	Concentration at Supply Well (C)
Chloroform (µg/L)	1800	1.44	0.01	0.014	2.63	0.36	1.68	1.07	40.04	43	0.0004	**230**	0.6
Tetrachloroethylene (PCE) (µg/L)	720	2.25	0.01	0.023	2.63	0.36	1.68	1.11	40.04	44	0.0010	1.00	0.0
Chlordane (µg/L)	2772	4.72	0.01	0.047	2.63	0.36	1.68	1.22	40.04	49	0.0003	0.010	0.0
Arsenic (mg/L)	N/A	2.73	0.01	0.027	2.63	0.36	1.68	1.13	40.04	45	N/A	0.005	0.005
Di(2-ethylhexyl) Phthalate (DEHP) (µg/L)	389	4.48	0.01	0.045	2.63	0.36	1.68	1.21	40.04	48	0.0018	5.00	0.0
Ammonia (mg/L) (conservative behavior)	N/A	0.49	0.01	0.005	2.63	0.36	1.68	1.02	40.04	41	N/A	8.75	8.75
Nitrates (mg/L)(conservative behavior)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	40.04	N/A	N/A	9.60	9.60

N/A = not applicable