Analyses of Water-Level Differentials and Variations in Recharge between the Surficial and Upper Floridan Aquifers in East-Central and Northeast Florida

By Louis C. Murray, Jr.

Prepared in cooperation with the

St. Johns River Water Management District

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Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
	Area	
square foot (ft^2)	0.0929	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow Rate	
cubic feet per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
	Hydraulic conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)
	Leakance	
foot per day per foot [(ft/d)/ft]	1.000	meter per day per meter (m/d/m)
	Transmissivity*	
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

Horizontal coordinate information (latitude-longitude) is referenced to the North American Datum of 1927 (NAD 27).

Altitude: in this report, altitude refers to distance above or below sea level as referenced to the National Geodetic Datum of 1929 (NGVD 29).

*Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness [(ft^3/d)/ft^2]xft. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Acronyms and abbreviations:

IAS	intermediate aquifer system
ICU	intermediate confining unit
LFA	Lower Floridan aquifer
MCU	middle confining unit
MSCU	middle semiconfining unit
NOAA	National Oceanic and Atmospheric Administration
R^2	coefficient of determination
SJRWMD	St. Johns River Water Management District
SAS	surficial aquifer system
USGS	U.S. Geological Survey
UFA	Upper Floridan aquifer

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Abstract

Continuous (daily) water-level data collected at 29 monitoring-well cluster sites were analyzed to document variations in recharge between the surficial (SAS) and Floridan (FAS) aquifer systems in east-central and northeast Florida. According to Darcy's law, changes in the water-level differentials (differentials) between these systems are proportional to changes in the vertical flux of water between them. Variations in FAS recharge rates are of interest to water-resource managers because changes in these rates affect sensitive water resources subject to minimum flow and water-level restrictions, such as the amount of water discharged from springs and changes in lake and wetland water levels.

Mean daily differentials between 2000-2004 ranged from less than 1 foot at a site in east-central Florida to more than 114 feet at a site in northeast Florida. Sites with greater mean differentials exhibited lower percentage-based ranges in fluctuations than did sites with lower mean differentials. When averaged for all sites, differentials (and thus Upper Floridan aquifer (UFA) recharge rates) decreased by about 18 percent per site between 2000-2004. This pattern can be associated with reductions in ground-water withdrawals from the UFA that occurred after 2000 as the peninsula emerged from a 3-year drought. Monthly differentials exhibited a well-defined seasonal pattern in which UFA recharge rates were greatest during the dry spring months (8 percent above the 5-year daily mean in May) and least during the wetter summer/early fall months (4 percent below the 5-year daily mean in October). In contrast, differentials exceeded the 5-year daily mean in all but 2 months of 2000, indicative of relatively high ground-water withdrawals throughout the year. On average, the UFA received about 6 percent more recharge at the project sites in 2000 than between 2000-2004.

No statistically significant correlations were detected between monthly differentials and precipitation at 27 of the 29 sites between 2000-2004. For longer periods of record, double-mass plots of differentials and precipitation indicate the UFA recharge rate increased by about 34 percent at a site in west Orange County between the periods of 1974-1983 and 1983-2004. Given the absence of a trend in rainfall, the increase can likely be attributed to ground-water development. At a site in south Lake County, double-mass plots indicate that dredging of the Palatlakaha River and other nearby drainage improvements may have reduced recharge rates to the UFA by about 30 percent from the period between 1960-1965 to 1965-1970.

Water-level differentials were positively correlated with land-surface altitude. The correlation was particularly strong for the 11 sites located in physiographically-defined ridge areas (coefficient of determination (R^2) = 0.89). Weaker yet statistically significant negative correlations were detected between differentials and the model-calibrated leakance and thickness of the intermediate confining unit (ICU).

Recharge to the UFA decreased by about 14 percent at the Charlotte Street monitoring-well site in Seminole County between 2000-2004. The decrease can be attributed to a reduction in nearby pumpage, from 57 to 49 million gallons per day over the 5-year period, with a subsequent recovery in UFA water levels that exceeded those in the SAS.

Differentials at Charlotte were influenced by system memory of both precipitation and pumpage. While not statistically correlated with monthly precipitation, monthly differentials were well correlated with the 9-month moving average of precipitation. Similarly, differentials were best correlated with the 2-month moving average of pumpage. The polynomial function that quantifies the correlation between differentials and the 2-month moving average of pumpage indicates that, in terms of UFA recharge rates, the system was closer to a steady-state condition in 2000 when pumpage rates were high, than from 2001-2004 when pumpage rates were lower. Although not statistically correlated on a monthly basis, the 9-month moving average of precipitation was well correlated with the 2-month moving average of pumpage. This memory-influenced relation was best quantified by a power function where changes in low levels of precipitation resulted in relatively large changes in pumpage, and vice versa.

An algorithm was developed that correlates monthly differentials with precipitation and pumpage and accounts for system memory and the distances between the Charlotte Street site and points of ground-water withdrawals. The correlation is well defined (R^2 = 0.84) and, assuming no addition of water-supply sites or closure of existing sites, offers potential as a predictive tool for estimating water-level differentials and

variations in UFA recharge rates based on changes in precipitation and pumpage.

A widely-applied analytical solution was used to estimate the time required for ICU storage effects to become negligible for an aquifer subject to an instantaneous change in head. Times varied by about three orders of magnitude across the 29 project sites, from about 1 day at sites in southwest Orange and south Lake Counties, to 1,595 days at the site in Baker County. Times were greater than 7 days at 18 sites but less than 1 month at 19 sites. Based solely on variations in regionally-mapped ICU thickness, timeframes ranged from less than 1 month in parts of Alachua, Brevard, Volusia, Lake, Marion, and Orange Counties, to more than 2 years in Nassau County and parts of Duval, Baker, and St. Lucie Counties. Uncertainty in parameter values and the constant-head boundary condition imposed in the unstressed aquifer limit the applicability of these results. Nonetheless, it does not appear that daily or weekly (or even monthly in some cases) stress periods would provide adequate timeframes in transient ground-water flow models to dissipate ICU storage effects across parts of east-central and northeast Florida. Accordingly, changes in differentials between the SAS and UFA should probably not be equated with proportionate changes in recharge for timescales of less than 1 month.

Introduction

Most of the water required to meet the municipal, agricultural, commercial, and industrial needs of east-central and northeast Florida is pumped from the Floridan aquifer system (FAS), a confined sequence of Eocene-age carbonate rocks. The FAS has been the focus of numerous ground-water flow modeling studies and is recharged primarily by leakage from the overlying surficial aquifer system (SAS), through the intermediate confining unit (ICU). Variations in FAS recharge rates are of interest to water-resource managers because changes in these rates affect sensitive resources subject to minimum flow and water-level restrictions, such as the amount of water discharged from springs and changes in lake and wetland water levels.

By Darcy's law, the rate of recharge, R (feet per day), from the SAS to the Upper Floridan aquifer (UFA) can be calculated as

$$R = K'*(h_s - h_{UF})/b' \qquad (1)$$

where

h_s and h_{UF} are water levels at the top and base of the ICU, respectively, in feet;

K' is the equivalent vertical hydraulic conductivity of the ICU, in feet per day; and

b' is the thickness of the ICU, in feet.

The water-level differential (h_s - h_{UF}), hereafter referred to as 'differential', is influenced by factors that include the hydrogeologic characteristics of the aquifers and confining unit, precipitation, proximity to and rates of ground-water withdrawals, and development-related activities such as canals, ditching, and other land-use alterations. Pumpage has the most immediate and pronounced affect on UFA levels but may also affect SAS levels, whereas precipitation has the greater affect on the water levels in the SAS. The effects of pumpage and precipitation on differentials are not additive but inversely related. For example, in wetter months, when SAS levels increase, reduced pumpage allows some recovery in UFA water levels that tends to offset, or even reverse, what would have otherwise been an increase in the differential. In drier months, when a lack of precipitation results in lowered SAS water levels, increased pumpage tends to lower UFA levels to an even greater degree to effectively increase the differential.

If water levels measured in clustered SAS/UFA monitoring wells are representative of those at the aquifer/confining unit boundaries, and if the hydraulic gradient though the confining unit is linear, then, by Darcy's law, changes in the differential between the SAS and UFA are proportional to changes in the flux between these aquifers. Although these simplifying assumptions are likely violated in most cases, they are nonetheless routinely applied to numerical ground-water modeling studies in which the SAS and UFA are both represented by single model layers (Sepúlveda, 2002). Thus, analyses of differentials can (a) provide insight into the temporal nature of FAS recharge conditions and (b) serve to help calibrate ground-water flow models and quality-assure simulated results. However, the results may have limited application in transient modeling studies that do not account for storage effects in the ICU, depending on the temporal resolution of selected time steps/stress periods. If time steps/stress periods are sufficiently long to dissipate storage effects, the results may be applied. Conversely, if selected time steps/stress periods are not sufficient to dissipate storage effects, then simulated changes in differentials cannot be assumed to be proportionate to changes in recharge. Additional analyses are needed to evaluate the timescales required to associate changes in differentials with proportionate changes in recharge.

The U.S. Geological Survey (USGS), in cooperation with the St. Johns River Water Management District (SJRWMD), completed a 2-½ year study to document temporal and spatial variations in recharge from the SAS to the UFA. In addition, the study addressed questions regarding the timescales required to apply these results in calibrating and quality-assuring the results from transient ground-water flow models that do not account for storage effects in the ICU.

Purpose and Scope

This report presents the results of a study designed to (a) provide water-resource managers a better understanding of the temporal and spatial variations in water-level differentials, and thus recharge, between the SAS and FAS; and (b) estimate the time required for water released from storage in the ICU to become negligible so that Darcy's equation can be used to estimate proportionate changes in recharge.

Continuous (daily) water-level data collected at 29 monitoring-well cluster sites operated by the SJRWMD and USGS were analyzed to quantify temporal and spatial variations in the differential between the SAS and UFA (table 1, fig. 1). The data used in these analyses have been quality-assured and published by the respective agencies. Temporal variations in differentials were evaluated with respect to changes in precipitation and proximity to nearby ground-water withdrawals. A 5-year period from 2000-2004 was selected for comparative analyses because this period is recent and, based on data collected at the nine National Oceanic and Atmospheric Administration (NOAA) stations (fig. 1), has an average annual rainfall close to the long-term average. The Lake Oliver and Mascotte sites also were analyzed for long-term (30+ years) trends and for correlation with precipitation. Spatial variations in differentials were evaluated with respect to the hydrogeologic setting (recharge and discharge areas), land-surface altitude, ICU thickness, and model-calibrated ICU leakance. The relations among differentials, precipitation, and pumpage were examined at the Charlotte Street site (no. 5). Algorithms were developed to account for system memory in relating changes in differentials to precipitation, ground-water withdrawals, and the distance of the site from points of ground-water withdrawals.

A widely-applied analytical solution was used to estimate the time required for a pressure transient resulting from a perturbed water level in one aquifer to move through the ICU and re-establish a new equilibrium between the SAS and UFA. Estimates were made at each of the project sites and regionally across the study area. Limitations of the estimates are discussed.

Description of Project Sites

The 29 sites selected for this study are dispersed geographically, cover areas of varying hydrogeologic conditions, and vary in proximity to areas of substantial ground-water withdrawals. Twenty-four sites are located in UFA recharge areas while five sites (nos. 2, 10, 15, 19, and 23) are located in discharge areas. Most sites had at least 90 percent of the daily record available for analyses. Each site has one monitoring well that penetrates the SAS and one that penetrates the UFA. Fifteen sites have monitoring wells that penetrate the ICU and water levels measured in these wells were used to verify the directional continuity of the hydraulic gradient between the SAS and UFA. Sites with known hydrologic divides were excluded from this study. USGS and SJRWMD data files and maps that depict the altitudes of the top and bottom of the ICU were examined to verify that the screened and open-hole intervals reported for each well on table 1 placed them within the indicated aquifer(s).

Methods of Analyses

Differentials were calculated by subtracting the altitude of the UFA water level from that of the SAS water level, yielding positive values at the recharge sites and negative values at the discharge sites. When comparing variations in differentials from one site to another, the results were normalized by calculating the percent changes in differentials at the individual sites, relative to respective 5-year daily means. When doing so, the sign convention was reversed for discharge sites so that increasing differentials at recharge sites would be synonymous with decreasing amounts of water being discharged from the UFA at the discharge sites.

Several statistical tools were used in the analyses. A Kolmogorov test (Conover, 1999) was applied to determine if daily values of differentials were normally distributed about the mean and thus identify appropriate tools for subsequent trend tests. Kendall's tau (Helsel and Hirsch, 1992) was used to determine if variations in the data were evidence of real trends rather than random occurrences. The Kendall test is a nonparametric procedure that measures the strength of a monotonic relation, whether linear or nonlinear, between x and y. As a ranked-based method, results are not affected by outliers in the data. The Kruskall-Wallis test (Helsel and Hirsch, 1992), another nonparametric ranked-based method, was used to assess if seasonal variations in differentials, and thus UFA recharge rates, were significant from one calendar month to the next. For all statistical tests, a probability level of 5 percent (p-value <0.05) was used as the criterion for significance. A p-value of <0.05 indicates that the probability of a correlation or difference occurring by chance is less than 5 percent.

Excel spreadsheet software was used to generate descriptive and frequency statistics and for regression analyses. Double-mass curves (Searcy and Hardison, 1960) were used to examine the relations between differentials and precipitation at sites with 30+ years of record. A double-mass analysis consists of plotting the cumulative data of an independent variable (in this case, precipitation) and the cumulative data of a dependent variable (water-level differentials). If the two quantities are proportional, and as long as other unplotted independent variables (such as pumping or land-use changes) remain unchanged, the plot is essentially a linear one. If, however, an unplotted independent variable (or variables) changes enough to affect the dependent variable, the timing of this change can be roughly identified by a change in the slope of the double-mass curve. The degree to which the curve departs from its original slope becomes a rough measure of the cumulative influence of the unplotted independent variable(s) on the dependent variable. This method and its limitations have been described by Searcy and Hardison (1960), Rutledge (1985), and Tibbals (1990).

Table 1. Construction specifications, hydrogeologic information, and periods of record for selected monitoring-well cluster sites.

[Aquifer: UFA, Upper Floridan aquifer; SAS, surficial aquifer system; ICU, intermediate confining unit; IAS, intermediate aquifer system. Site ID: 15-digit numbers are USGS site numbers; all other numbers are SJRWMD numbers. Latitude and longitude, in degrees, minutes, seconds; land-surface altitude, feet above NGVD 29; casing length, feet; depth, feet below land surface; top of ICU and top of UFA, feet above or below (-) NGVD 29; thickness of ICU, feet; leakance of ICU, per day. Thickness values from USGS and SJRWMD data files; leakance values from Sepúlveda, 2002]

Site ID	Cluster site name	Aquifer	Site no.	Latitude	Longitude	Land-surface altitude	Casing length	Total depth	Top of ICU	Top of UFA	Thickness of ICU	Leakance of ICU	Period of record
282202081384601	Lake Oliver	UFA	1	282202	813846	117.12	103	318	63	21	42	0.000800	1974-2004
282202081384602	Lake Oliver	SAS	1	282202	813846	117.06	13	30					1974-2004
BR1549	Cocoa	IAS	2	282256	804601	24.71	60	70					1996-2004
BR1550	Cocoa	SAS	2	282256	804601	24.61	20	30					1996-2004
BR1557	Cocoa	UFA	2	282256	804601	24	150	190	-6	-96	90	.000010	1996-2004
L-0709	Smokehouse Lake	UFA	3	282528	814247	119	81	101	82	45	37	.000340	2000-2004
L-0710	Smokehouse Lake	SAS	3	282528	814247	119	32	42					2000-2004
283204081544901	Mascotte	UFA	4	283204	815449	103.66	66	160	62	38	24	.000500	1960-2004
283204081544902	Mascotte	SAS	4	283204	815449	103.59	17	30					1960-2004
S-1014	Charlotte Street	UFA	5	284052	812126	77	142	300	31	-51	82	.000120	1995-2004
S-1015	Charlotte Street	SAS	5	284052	812126	80.33	40	50					1995-2004
S-1023	Geneva Replacement	SAS	6	284249	810707	49.96	30	30			38	.0000400	2000-2004
S-0001	Geneva Replacement	UFA	6	284249	810707	49.96	92	202	35	-3			2000-2004
L-0095	Groveland	UFA	7	284121	815345	134.9	148	368	73	17	56	.000240	2000-2004
L-0096	Groveland	SAS	7	284121	815345	134.94	111	130					2000-2004
S-1288	Geneva Fire Station	SAS	8	284411	810700	67.13	20	30					2000-2004
S-1328	Geneva Fire Station	UFA	8	284411	810700	67.29	340	380	52	-63	115	.000040	2000-2004
S-0086	Osceola	UFA	9	284715	810518	24.76	70	225			70	.000040	1990-2004
S-0202	Osceola	IAS	9	284715	810518	24.12	55	60					1990-2004
S-0266	Osceola	SAS	9	284715	810518	25.36	9	14					1990-2004
S-1385	Sanford Zoo	IAS	10	284935	811859	9	77	97					2000-2004
S-1386	Sanford Zoo	SAS	10	284935	811859	9	9	14					2000-2004
S-1397	Sanford Zoo	UFA	10	284935	811859	8	120	180	-41	-121	80	.000020	2000-2004
L-0289	Leesburg Fire Tower	SAS	11	285145	814748	85	40	50					2000-2004
L-0290	Leesburg Fire Tower	UFA	11	285145	814748	85	190	400	-57	-105	48	.000280	2000-2004
V-0810	Snook Road	UFA	12	285214	811313	31	290	312	29	-62	91	.000090	2000-2004
V-0814	Snook Road	SAS	12	285214	811313	31	32	42					2000-2004
V-0808	Lake Daughrty	UFA	13	290550	811625	50	90	140	22	-20	42	.000140	2000-2004
V-0812	Lake Daughrty	SAS	13	290550	811625	50	15	25					2000-2004
V-0813	Lake Daughrty	IAS	13	290550	811625	50	46	56					2000-2004
V-0742	Lee Airport	UFA	14	290616	811832	81.9	140	460			50	.000140	2000-2004
V-0743	Lee Airport	IAS	14	290616	811832	81.96	62	72					2000-2004
V-0744	Lee Airport	SAS	14	290616	811832	82.11	27	37					2000-2004
V-1028	De Leon Springs	SAS	15	290831	812155	21	40	50					1995-2004
V-1030	De Leon Springs	UFA	15	290831	812155	21	120	200			50	.000150	1995-2004
V-0501	State Road 40	IAS	16	291329	811913	44.72	60	70					2000-2004
V-0769	State Road 40	UFA	16	291329	811913	45.05	85	440			51	.000100	2000-2004
V-0770	State Road 40	SAS	16	291329	811913	45.04	25	35					2000-2004

Table 1. Construction specifications, hydrogeologic information, and periods of record for selected monitoring-well cluster sites—Continued.

[Aquifer: UFA, Upper Floridan aquifer; SAS, surficial aquifer system; ICU, intermediate confining unit; IAS, intermediate aquifer system. Site ID: 15-digit numbers are USGS site numbers; all other numbers are SJRWMD numbers. Latitude and longitude, in degrees, minutes, seconds; land-surface altitude, feet above NGVD 29; casing length, feet; depth, feet below land surface; top of ICU and top of UFA, feet above or below (-) NGVD 29; thickness of ICU, feet; leakance of ICU, per day. Thickness values from USGS and SJRWMD data files; leakance values from Sepúlveda, 2002]

Site ID	Cluster site name	Aquifer	Site no.	Latitude	Longitude	Land-surface altitude	Casing length	Total depth	Top of ICU	Top of UFA	Thickness of ICU	Leakance of ICU	Period of record
V-0528	Pierson Airport	SAS	17	291449	812748	62.34	13	23					2000-2004
V-0531	Pierson Airport	UFA	17	291449	812748	62.35	130	210				.000180	2000-2004
V-0557	Pierson Airport	IAS	17	291449	812748	62.18	88	98			50		2000-2004
V-0068	West Pierson	UFA	18	291459	812941	21.57	63	125	10	-45	55	.000110	1995-2004
V-0524	West Pierson	IAS	18	291459	812941	21.69	29	39					1995-2004
V-0525	West Pierson	SAS	18	291459	812941	21.27	4	14					1995-2004
P-0735	Middle Road	UFA	19	292120	813450	3.17	330	360	-13	-62	49	.000020	1995-2004
P-0737	Middle Road	SAS	19	292120	813450	3.51	50	60					1995-2004
P-0146	Silver Pond	IAS	20	292243	813133	44.46	45	55					1993-2004
P-0696	Silver Pond	UFA	20	292243	813133	43.24	80	400	33	-22	55	.000150	1993-2004
P-0724	Silver Pond	SAS	20	292243	813133	43.27	15	25					1993-2004
P-0143	Niles Road	IAS	21	292418	813308	35.52	56	66					1993-2004
P-0705	Niles Road	UFA	21	292418	813308	33.62	105	400	7	-58	65	.000150	1993-2004
P-0742	Niles Road	SAS	21	292418	813308	35.17	17	27					1993-2004
P-0776	Marvin Jones Road	UFA	22	292448	813705	31.78	155	160	-36	-89	53	.000140	1994-2004
P-0777	Marvin Jones Road	IAS	22	292448	813705	31.77	100	110					1994-2004
P-0778	Marvin Jones Road	SAS	22	292448	813705	31.81	40	50					1994-2004
F-0176	Bulow Ruins	UFA	23	292602	810815	8.09	91	120			48	.000160	2000-2004
F-0177	Bulow Ruins	SAS	23	292602	810815	7.89	24	43					2000-2004
F-0351	Westside Baptist	IAS	24	292759	812226	25	42	52					2000-2004
F-0352	Westside Baptist	SAS	24	292759	812226	25	15	25					2000-2004
F-0353	Westside Baptist	UFA	24	292759	812226	25	185	240	-94	-161	67	.000040	2000-2004
P-0408	Fruitland	UFA	25	292859	813757	95.77	127	148	57	-34	91	.000140	2000-2004
P-0409	Fruitland	SAS	25	292859	813757	95.63	40	55					2000-2004
A-0693	Alachua County	UFA	26	294104	821712	163.09	192	440	143	100	43	.000016	2000-2004
A-0702	Alachua County	SAS	26	294104	821712	162.97	12	22					2000-2004
C-0436	Lake Geneva #1	UFA	27	294611	820048	106.07	146	146	86	-94	180	.000100	1993-2004
C-0437	Lake Geneva #2	IAS	27	294611	820048	106.13	85	85					1994-2004
C-0438	Lake Geneva #3	SAS	27	294611	820048	106.2	20	20					1994-2004
D-0545	Southside Fire Tower	SAS	28	301710	813235	54.65	40	60					1992-2004
D-0545	Southside Fire Tower	IAS	28	301710	813235	55.1	100	120					1992-2004
D-0547	Southside Fire Tower	UFA	28	301710	813235	54.97	490	740			408	.000014	1992-2004
BA0057	Eddy Fire Tower	UFA	29	303235	822037	129.95	360	700	100	-222	322	.000004	1992-2004
BA0058	Eddy Fire Tower	IAS	29	303235	822037	129.92	40	50					1992-2004
BA0059	Eddy Fire Tower	SAS	29	303235	822037	129.86	20	40					1992-2004

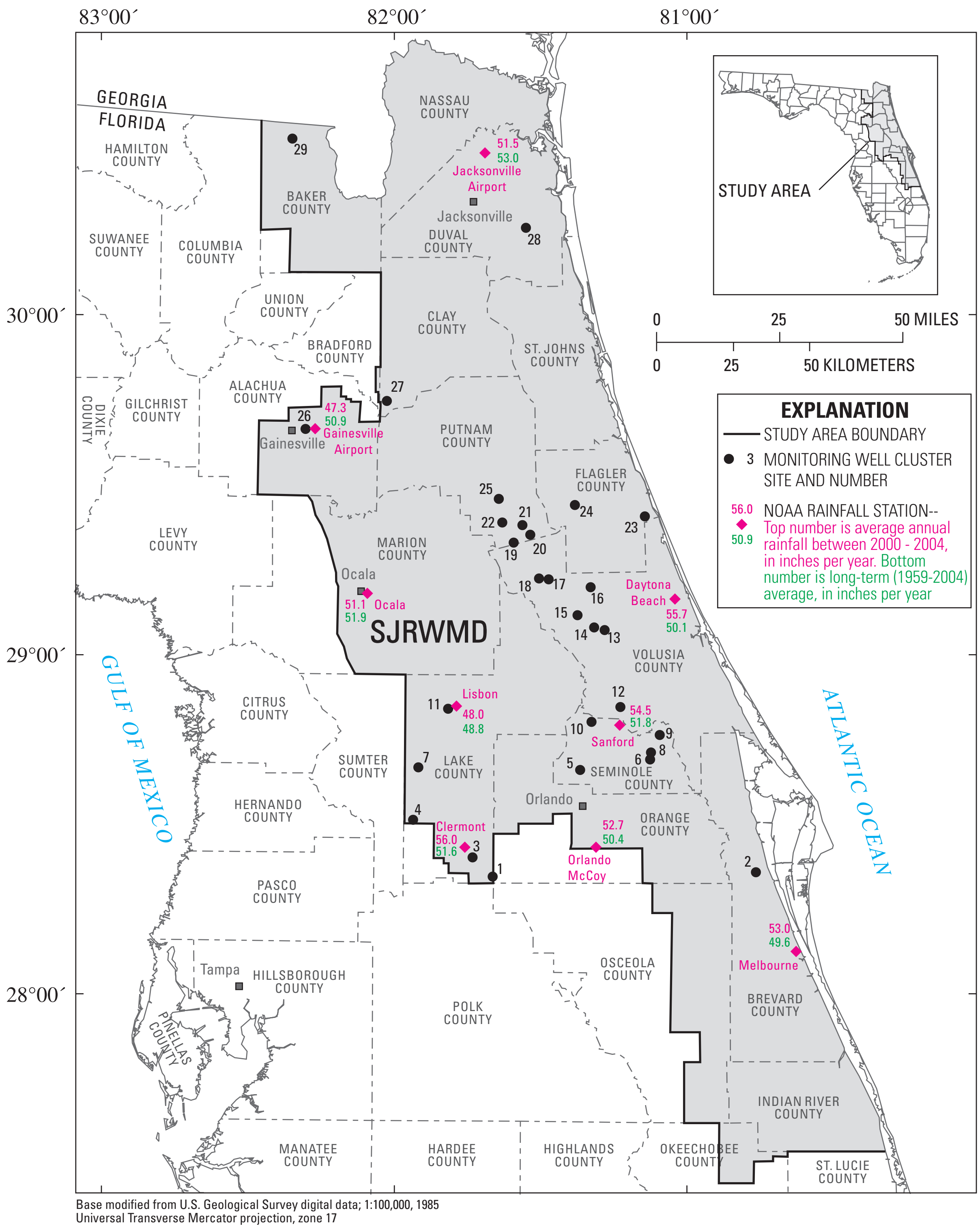


Figure 1. Location of study area, selected monitoring-well cluster sites, and average rainfall at selected National Oceanic and Atmospheric Administration rainfall stations between 2000-2004, east-central and northeast Florida.

Description of Study Area

The study area encompasses the St. Johns River Water Management District, an area of about 12,300 square miles that includes all or parts of 18 counties. Orlando and Jacksonville are the major population centers. The primary industries include tourism, agriculture, space research, and light manufacturing. Agricultural activities include citrus and vegetable farming, dairy farming, and cattle ranching.

Climate

The climate of the study area is classified as subtropical and is characterized by warm, relatively wet summers and mild, relatively dry winters. Temperatures commonly exceed 90°F from June through September, but may fall below freezing for a few days in the winter months. Long-term precipitation (1959-2004) averages 50.9 inches/year with about 55 percent of the total being derived from convective thunderstorms that occur frequently from June through September (Murray and Halford, 1996). Summer thunderstorms are usually localized and distribute rainfall unevenly across the area, while rainfall in winter months usually is associated with cold fronts and is more uniformly distributed.

Data collected at nine NOAA rainfall stations between 2000-2004 were used to quantify a 'regionally averaged' condition over this 5-year period (fig. 2). Precipitation averaged 52.2 inches/year, which compares favorably with the long-term average of 50.9 inches/year. Lowest precipitation (34.2 inches) occurred in 2000, the third and final year of an extended drought (1998-2000), while highest precipitation (62.3 inches) occurred in 2002. Monthly precipitation also reflects long-term conditions; that is, about 63 percent of the average annual precipitation between 2000-2004 occurred during the wet season as compared with the long-term average of 55 percent. Only two of the nine NOAA sites (Clermont and Ocala) exhibited statistically significant increases in monthly rainfall between 2000-2004 (table 2).

Hydrogeology and Physiography

East-central and northeast Florida are characterized by a wide range of hydrogeologic and physiographic conditions that have been described by previous investigators, either in regional ground-water modeling reports (Miller, 1986; Tibbals, 1990; Murray and Halford, 1996; Sepúlveda, 2002; and McGurk and Presley, 2002) or in county-wide assessments (Rutledge, 1982, 1985; Spechler and Halford, 2001; Knowles and others, 2002; and Adamski and German, 2004). This report presents a generalized description of conditions in the study area, and the reader is referred to these and other USGS and SJRWMD reports for greater detail.

The principal geologic and hydrogeologic units in east-central and northeast Florida are shown in figure 3. The SAS is the uppermost water-bearing unit and consists of an unconfined sequence of Holocene to early Pliocene-age quartz sands with varying proportions of silt and clay that generally increase in content near the base of the system. The SAS is recharged by rainfall and by upward leakage from the underlying UFA. Water is discharged from the SAS by downward leakage to the UFA, by seepage to lakes and streams and, in areas where the water table is near land surface, by evapotranspiration. Because the horizontal hydraulic conductivity of the SAS is small relative to that of the UFA, the SAS provides only a limited source of water to wells.

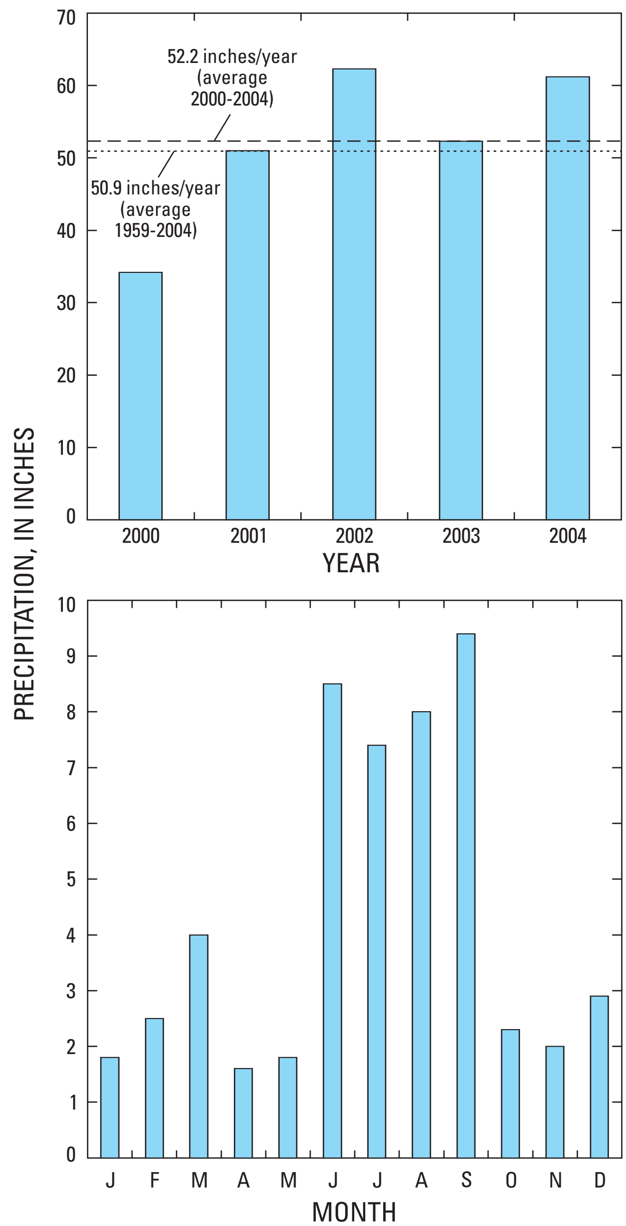


Figure 2. Regional average annual and monthly precipitation computed by averaging data from selected rainfall stations, 2000-2004 (locations of stations shown in figure 1).

Table 2. Results of regression analyses and trend testing of monthly precipitation, 2000-2004.

NOAA station	Regression analyses		Trend testing		
	Slope of line of best fit (inches per day)	Coefficient of determination (R^2)	Kendall's tau	P-value	Trend
Clermont	0.0018	0.042	0.17	0.050	yes
Daytona	.0013	.024	.10	.263	no
Gainesville	.0013	.037	.11	.215	no
Jacksonville	.0014	.033	.11	.226	no
Lisbon	.0014	.031	.15	.084	no
Melbourne	.0006	.006	.03	.734	no
Ocala	.0021	.081	.20	.025	yes
Orlando	.0015	.038	.17	.054	no
Sanford	.0017	.040	.13	.134	no
average all stations	.0015	.043	.13	.156	no

<table>
<tr><th colspan="2">SERIES</th><th>STRATIGRAPHIC UNIT</th><th>LITHOLOGY</th><th>HYDROGEOLOGIC UNIT</th><th>APPROXIMATE THICKNESS (feet)</th></tr>
<tr><td colspan="2">HOLOCENE</td><td rowspan="3">UNDIFFERENTIATED DEPOSITS</td><td>Alluvium, freshwater marl, peats, and muds in stream and lake bottoms. Also, some dunes and other windblown sand</td><td rowspan="2">SURFICIAL AQUIFER SYSTEM</td><td rowspan="2">0-150</td></tr>
<tr><td colspan="2">PLEISTOCENE</td><td>Mostly quartz sand. Locally may contain deposits of shell and thin beds of clay</td></tr>
<tr><td colspan="2">PLIOCENE</td><td>Interbedded deposits of sand, shell fragments, and sandy clay; base may contain phosphatic clay</td><td rowspan="2">INTERMEDIATE CONFINING UNIT</td><td rowspan="2">0-500</td></tr>
<tr><td colspan="2">MIOCENE</td><td>HAWTHORN GROUP</td><td>Interbedded quartz, sand, silt and clay, often phosphatic; phosphatic limestone often found at base of formation</td></tr>
<tr><td rowspan="3">EOCENE</td><td>UPPER</td><td>OCALA LIMESTONE</td><td>Cream to tan, soft to hard, granular, porous, foraminiferal limestone</td><td>UPPER FLORIDAN AQUIFER</td><td>100-400</td></tr>
<tr><td>MIDDLE</td><td>AVON PARK FORMATION</td><td>Light brown to brown, soft to hard, porous to dense, granular to chalky, fossiliferous limestone and brown, crystalline dolomite</td><td>MIDDLE CONFINING/ SEMICONFINING UNIT</td><td>100-1,000</td></tr>
<tr><td>LOWER</td><td>OLDSMAR FORMATION</td><td>Alternating beds of light brown to white, chalky, porous, fossiliferous limestone and porous crystalline dolomite</td><td rowspan="2">LOWER FLORIDAN AQUIFER</td><td rowspan="2">700-1,500</td></tr>
<tr><td colspan="2">PALEOCENE</td><td>CEDAR KEYS FORMATION</td><td>Dolomite, with considerable anhydrite and gypsum, some limestone</td></tr>
</table>

Figure 3. Geologic and hydrogeologic units in east-central and northeast Florida (modified from Spechler, 1994; Murray and Halford, 1996).

The SAS is underlain by the ICU, a sequence of Pliocene to Miocene-age sands, silts, and clays that retard the vertical exchange of water between the SAS and FAS. The Miocene-age Hawthorn Group within the ICU is comprised of distinctive green to gray phosphatic clays and, near its base, phosphatic limestone. Locally, where the ICU may contain permeable layers of sand, shell, or limestone that can yield appreciable quantities of water, the unit is referred to as the intermediate aquifer system (IAS). A number of the project sites have monitoring wells that penetrate the ICU/IAS and thus serve to document the directional continuity of the hydraulic gradient between the SAS and FAS.

The thickness of the ICU varies locally from 24 feet at site 4 in Lake County to 408 feet at site 28 in Duval County (table 1). The vertical leakance of the ICU, which is equal to the equivalent vertical hydraulic conductivity divided by the thickness, influences the head differential between the SAS and UFA and controls the rate of ground-water movement between them. Ground-water flow modeling studies have demonstrated that water levels and UFA recharge rates are particularly sensitive to the magnitude of this property. Values of ICU leakance referenced in a regional ground-water flow modeling study (Sepúlveda, 2002) range from $8x10^{-4}$ day^{-1} in the cell where site 1 is located, to about $4x10^{-6}$ day^{-1} in the cell where site 29 is located (table 1).

The ICU is underlain by the FAS, a sequence of highly-permeable Eocene-age limestone and dolomitic limestone. The FAS consists of two major permeable zones, the UFA and Lower Floridan aquifer (LFA), separated by a less permeable zone referred to as the middle semiconfining unit (MSCU) or, in the southwest part of the study area, by the middle confining unit (MCU). The UFA provides most of the water required to meet municipal, agricultural, and industrial/commercial demands in east-central and northeast Florida. The UFA is recharged by the SAS in areas where the water table is above the potentiometric surface of the UFA and discharges water to the SAS and to springs in areas where the potentiometric surface is above the water table.

Maps depicting the potentiometric surface of the UFA and generalized areas of recharge and discharge are shown on figures 4 and 5, respectively. Project sites located within recharge areas generally coincide with higher potentiometric surfaces whereas sites located in discharge areas (sites 2, 10, 15, 19, and 23) coincide with lower potentiometric surfaces.

White (1970) subdivided the east-central and northeast Florida areas into 27 physiographic regions, based on a combination of natural features, primarily geomorphology. When correlated with water levels, these regions can be further generalized and grouped into the six color-coded areas shown in figure 6. The directions and rates of ground-water movement between the SAS and UFA can vary substantially from one region to the next. Areas of effective recharge to the UFA are typically found in the ridge and upland regions, which are characterized by higher topography and, in the ridge areas, by karst. Eleven sites (5, 6, 8, 12, 13, 14, 17, 20, 21, 22, and 25) are located within ridge areas where SAS water levels are particularly susceptible to the affects of withdrawals from the UFA. These sites share similar hydrogeologic characteristics and, as discussed later in this report, have water-level differentials that behave similarly with respect to geomorphic features, such as land-surface altitude. Areas of UFA discharge are typically found in lower-lying regions such as the Eastern Valley, the Central Valley, the St. Johns River Offset, and the Wekiva Plain.

Water Use

Water use in the SJRWMD totaled about 1.36 billion gallons per day in 1995, most of which was pumped from the FAS (Water Supply Plan, 2005). The proximity of the project sites to ground-water withdrawals influences water-level differentials. The locations of municipal water treatment plants that treated a minimum of 1 million gallons per day (Mgal/d) of ground water in 2004 are depicted on figure 7. Plant locations are considered to coincide with contributing wellfields. Pumpage is concentrated around the Orlando and Jacksonville metropolitan areas in Orange and Duval Counties, respectively, and sites such as Charlotte Street (site 5) are more likely to be affected by ground-water withdrawals than sites further removed from withdrawals. The relation between water-level differentials and pumpage at the Charlotte Street site is examined later in this report.

Although not shown in figure 7, withdrawals for agricultural use can be substantial and affect water levels and water-level differentials on a more localized basis. In northern Volusia County, for example, pumpage to support the fernery-growing areas around the town of Pierson affects UFA water levels and water-level differentials at the Pierson airport and West Pierson sites (sites 17 and 18, respectively). During the winter months, pumpage in these areas for freeze protection may be particularly high for short periods of time.

Acknowledgments

The author would like to thank the St. Johns River Water Management District for providing water-level, water-use, geophysical, and other pertinent data and information used during this study. Specials thanks is also extended to Gregory Goodale (Water Production and Reclamation Superintendent, City of Casselberry) and Richard Kornbluh (Utilities Manager, City of Longwood) for their assistance in acquiring water-use information.

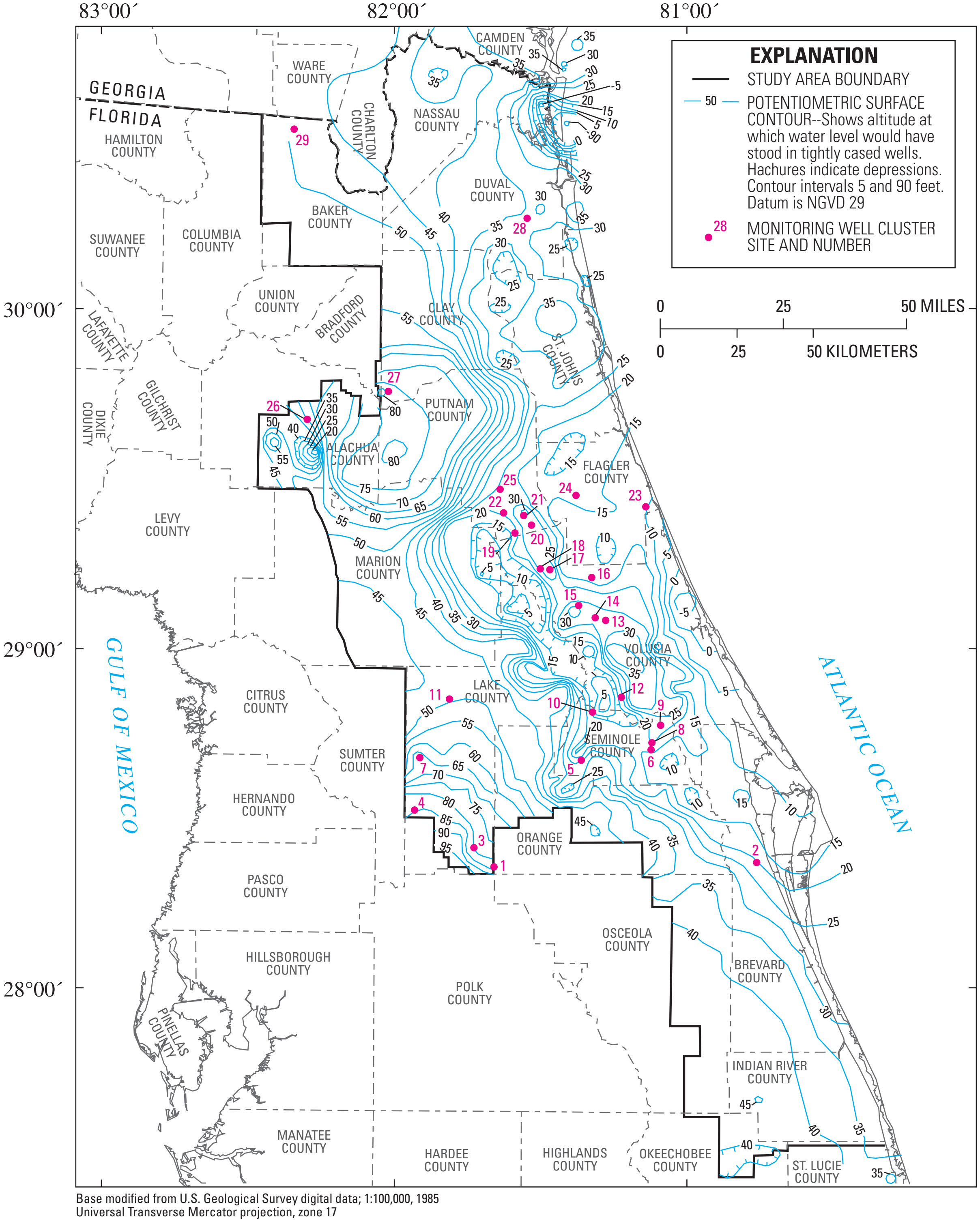
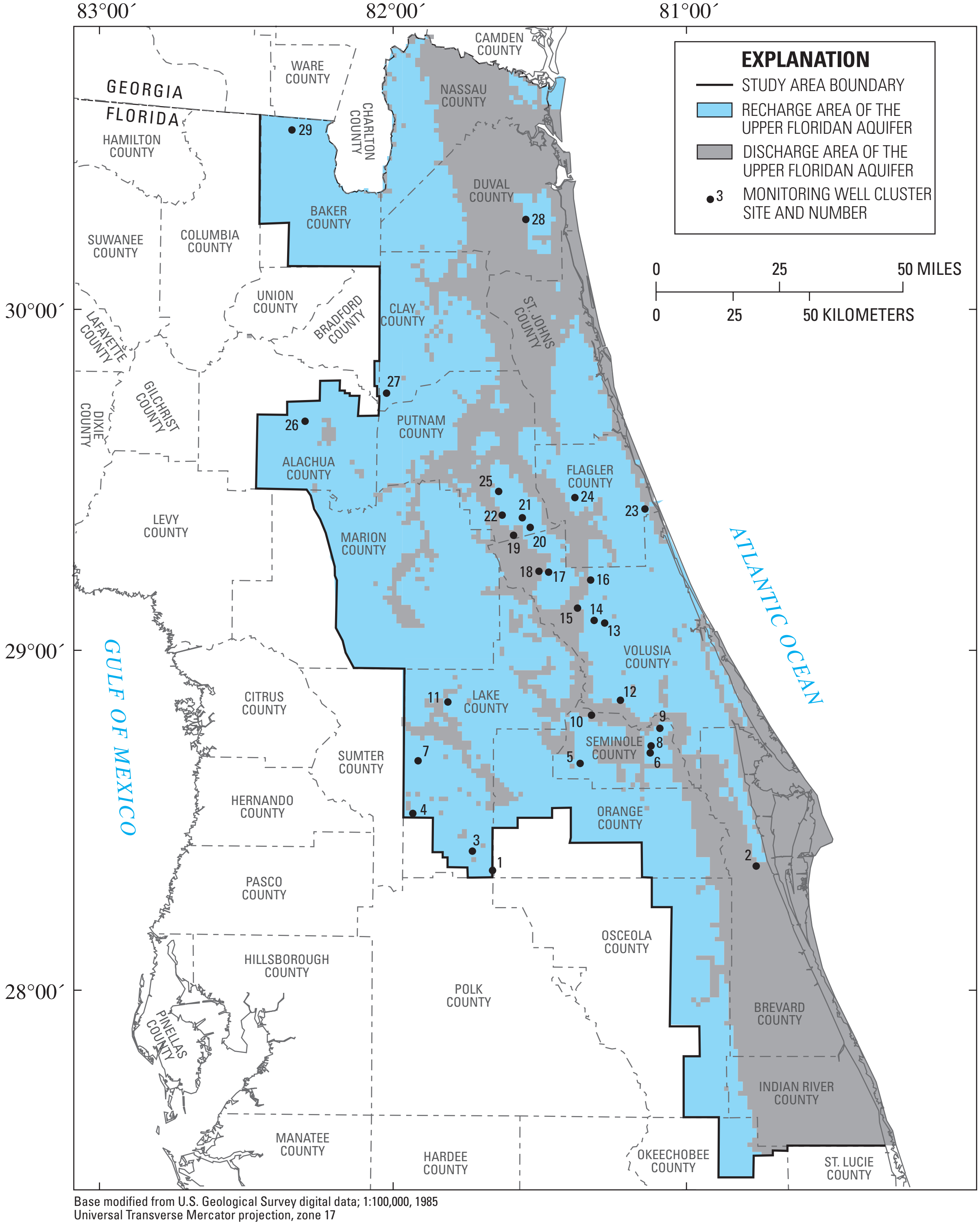


Figure 4. Potentiometric surface of the Upper Floridan aquifer, 1993-1994 (from Sepúlveda, 2002).



Base modified from U.S. Geological Survey digital data; 1:100,000, 1985
Universal Transverse Mercator projection, zone 17

Figure 5. Distribution of recharge and discharge areas of the Upper Floridan aquifer (from Sepúlveda, 2002).

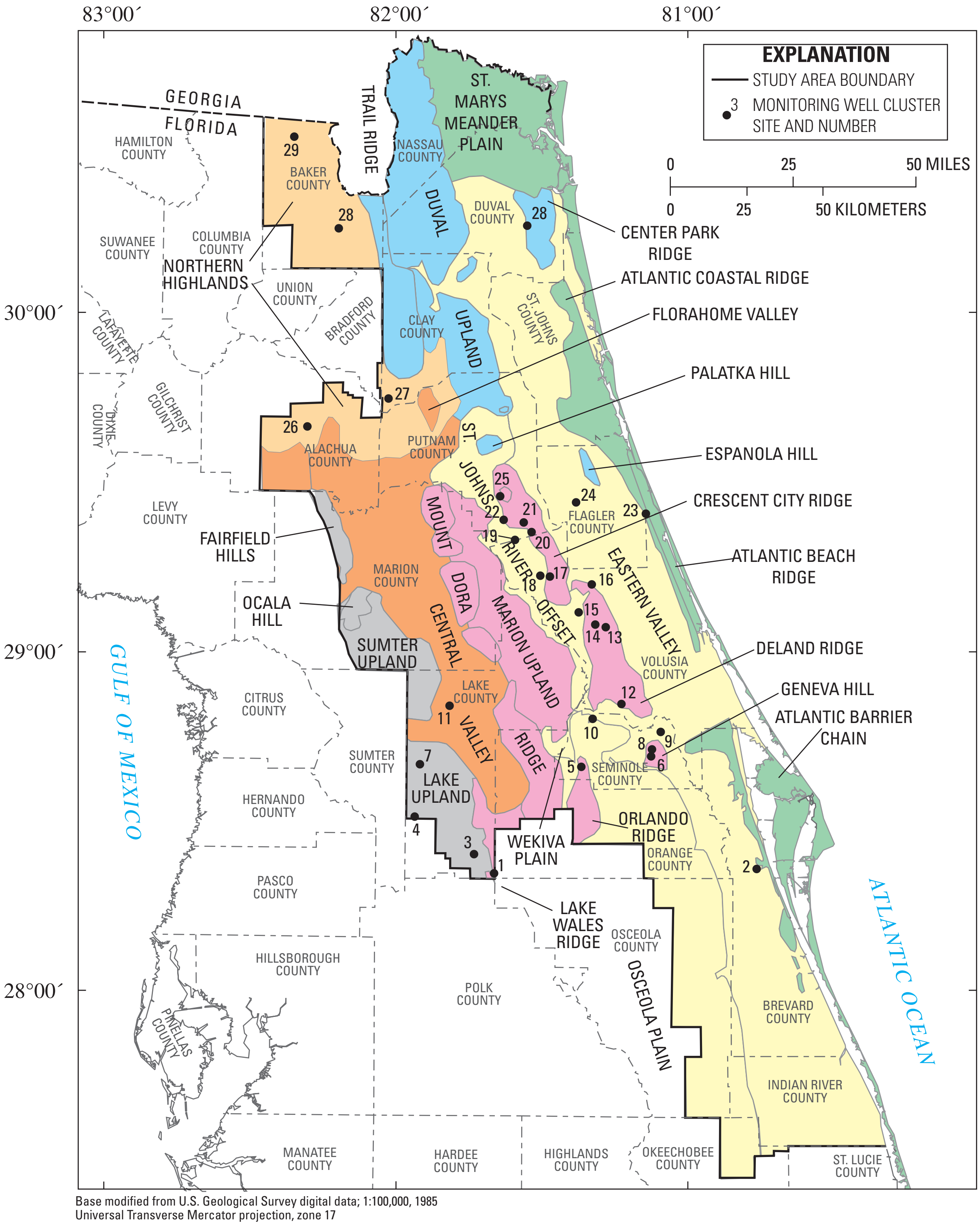
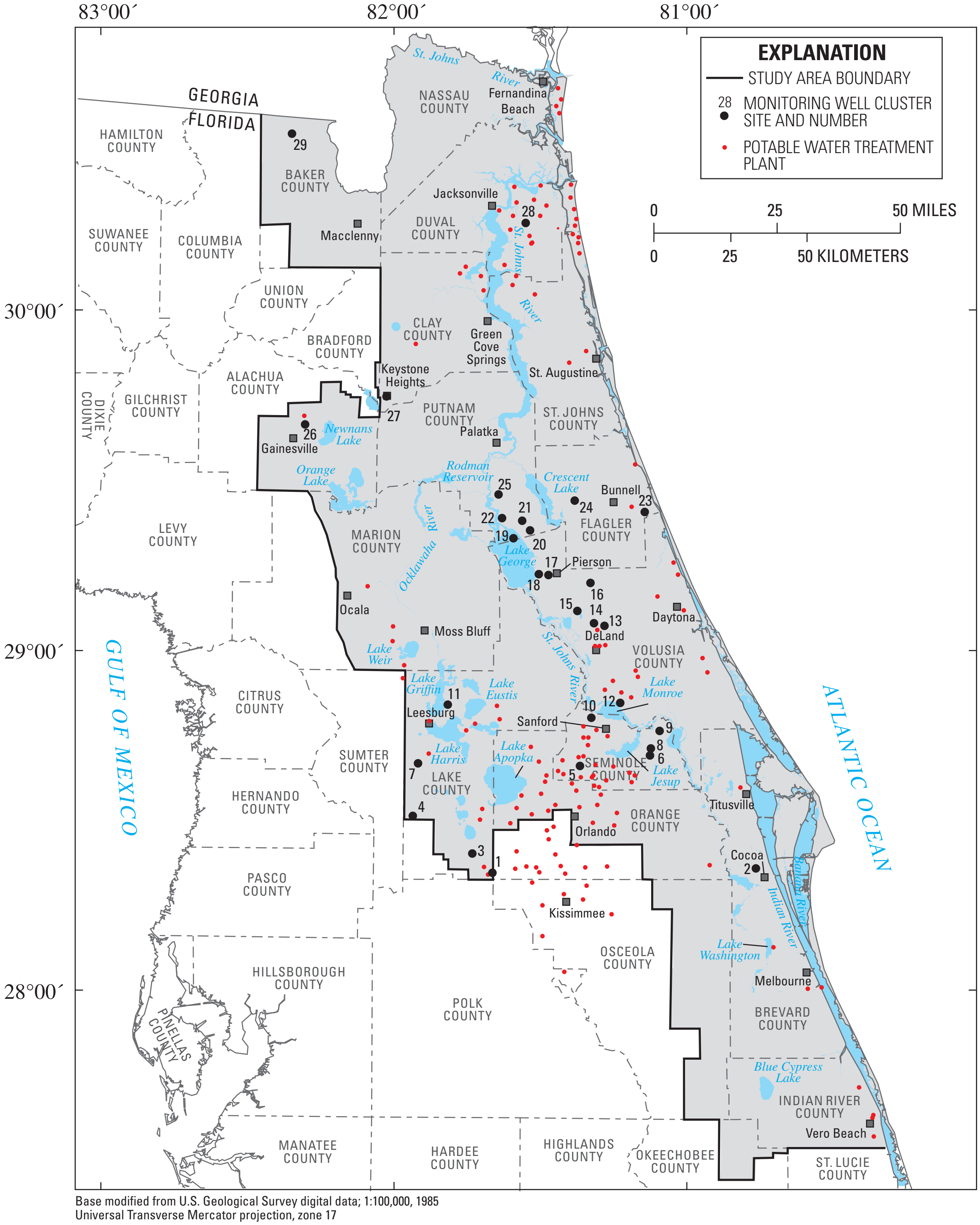


Figure 6. Groups of physiographic regions (modified from White, 1970, plate 1).



Base modified from U.S. Geological Survey digital data; 1:100,000, 1985
Universal Transverse Mercator projection, zone 17

Figure 7. Locations of public-supply water treatment plants that produced 1 million gallons per day or more in 2004.

Analyses of Water-Level Differentials

Temporal variations in recharge from the SAS to the UFA can be approximated by analyzing the differential between the paired water levels. The example shown for the Leesburg site (no. 11) in figure 8a demonstrates the limitation in examining only the paired water levels. The hydrographs appear to closely track one another and it is difficult to discern whether any appreciable changes in the differential, and thus recharge, occurred between these systems. By plotting the differential, however, it becomes apparent that substantive changes occur frequently at both intermediate (monthly) and smaller (daily) time scales (fig. 8b). Relative to its 5-year daily median of 2.37 feet, the differential at Leesburg varies from a low of about 0.90 feet (62 percent less than the median) to a high of about 4.30 feet (81 percent greater than the median). In terms of frequency statistics, the differential exceeded 1.67 feet 90 percent of the time and 3.21 feet 10 percent of the time. Thus, if the effects of storage in the ICU are assumed to be negligible, UFA recharge rates varied by about 65 percent about the 5-year median over 80 percent of the record.

The differentials documented in this report can be used to calculate UFA recharge rates, and changes in recharge rates, by multiplying the differentials by the leakance of the ICU. Model-calibrated leakance values published by Sepúlveda (2002) that coincide with the project site locations are given on table 1. At Leesburg, where ICU leakance is calibrated at 0.00028 day^{-1}, the average monthly recharge rate between 2000-2004 varied from about 1.6 inches per year (in/yr) in February 2004 to about 4.6 in/yr in April 2003 (fig. 8c). The 5-year daily average was 2.9 in/yr.

The discussions that follow summarize descriptive statistics for the project sites, the results of trend analyses, and the relations among differentials, precipitation, and ICU properties. A case study at the Charlotte Street site (no. 5) examines the interrelations among differentials, precipitation, and ground-water pumpage. Appendix A summarizes monthly differentials for all 29 project sites.

Descriptive Statistics

Statistics documenting the mean, median, standard deviation, coefficient of variation, and selected frequency-related percentile values for project site differentials are summarized in table 3. The analyses were conducted across a 5-year period of record (2000-2004) for all 29 project sites and, for those sites with longer-term daily record (minimum of 85 percent complete), for periods of 10 or more years.

Five-year daily mean differentials varied from -17.2 feet at Sanford Zoo (site 10) to 114 feet at Alachua County (site 26, fig. 9a). Sites located in the Lake Wales Ridge (site 1) and Lake Upland (sites 3, 4, and 7) physiographic regions have relatively small differentials that are characteristic of the leaky ICU known to exist in these areas. Differentials vary somewhat randomly with latitude but, in general, larger differentials occur in the northern part of the study area where the ICU is thickest.

Annually-averaged differentials vary from one year to the next and are affected by proximity to ground-water withdrawals (table 4). At the rurally-located Fruitland site (25), for example, the mean differential in 2001 (51 feet) was 2 percent higher than its 5-year daily mean, while the mean in 2004 (49.2 feet) was 1.6 percent lower than its 5-year daily mean. This 3.6-percent variation about the daily mean was the lowest for all sites as water levels at Fruitland are relatively unaffected by ground-water withdrawals. In contrast, the annual differential at West Pierson (site 18) ranged from 4.68 feet in 2000, or 71 percent above its 5-year daily mean, to 1.40 feet in 2004, about 49 percent lower than the 5-year mean. This variation of 120 percent is the largest of all the sites and can be attributed to the effects of nearby UFA ground-water withdrawals for freeze protection, which can be substantive and vary from one year to the next, depending on day-to-day changes in temperature. Annually-averaged water-level differentials were greatest in 2000, when precipitation averaged 34 inches at the nine NOAA sites, and decreased in the following years with increasing precipitation.

Variation about the 5-year daily mean decreases with increasing timescale (fig. 9b). Monthly and daily variations about the mean ranged from 8 to 11 percent at Fruitland, and from 322 to 794 percent at West Pierson. Monthly and daily variations are closer to one another (within a factor of two at 23 of the 29 sites) than are monthly and annual variations (within a factor of two at only 4 of the 29 sites). As discussed later in this report, however, daily variations shown on figure 9b cannot be associated with proportionate changes in recharge as this timescale is not sufficient to dissipate storage effects in the ICU. Results for the annual and monthly analyses, however, may provide cursory information that can be used to bracket a range of recharge rates simulated in transient ground-water flow models for selected stress periods or time steps.

As indicated by the coefficient of variation, sites with larger mean differentials exhibit smaller percentage-based variations about respective means than do sites with smaller means. The coefficient of variation is calculated by dividing the standard deviation of a sample or population by its mean and allows for comparisons of the variations of samples or populations that have significantly different mean values. Similarly, sites with larger median (d_{50}) differentials exhibit smaller percentage-based variations in differential than do sites with smaller median values (fig.10). The variation of differentials about median values was normalized for comparative purposes by dividing the difference between the 10^{th} and 90^{th} percentile values by the median value (fig. 10). When multiplied by 100, the resultant values quantify the percentage of the spread of the daily differentials relative to the median value. The plot shown on figure 10 exhibits a statistically significant trend and suggests that percentage variations in recharge can be roughly approximated as 100 divided by the square root of the median value.

Table 3. Descriptive statistics of daily water-level differentials between the surficial and Upper Floridan aquifers.

[Mean water level in feet above NGVD 29; SAS, surficial aquifer system; UFA, Upper Floridan aquifer]

Site no.	Site name	Period of record	Percent of record available	Mean SAS water level	Mean UFA water level	Mean water-level differential, in feet	10th percentile (dH_{10})	Median (dH_{50})	90th percentile (dH_{90})	(dH_{10}-dH_{90})/dH_{50}	Standard deviation	Coefficient of variation
1	Lake Oliver	1/74-12/04	90.1	110.92	108.46	2.46	3.01	2.48	1.82	0.48	0.45	0.18
		1/00-12/04	97.4	110.74	107.98	2.76	3.28	2.77	2.15	.41	.45	.16
2	Cocoa	1/00-12/04	92.3	21.30	23.71	-2.41	-3.96	-2.61	-.67	1.26	1.30	.54
3	Smokehouse Lake	1/00-12/04	95.1	107.77	106.26	1.52	2.33	1.41	.78	1.10	.61	.4
4	Mascotte	1/60-12/04	87.1	100.39	99.74	.65	1.00	.73	.16	1.15	.37	.57
		1/00-12/04	73.5	98.72	97.93	.79	.99	.81	.54	.56	.18	.23
5	Charlotte Street	1/95-12/04	91.6	77.09	43.49	33.6	36.0	33.7	31.1	.15	1.85	.055
		1/00-12/04	96.3	76.91	43.01	33.9	36.3	34.0	31.5	.14	1.92	.057
6	Geneva Replacement	1/00-12/04	92.2	41.43	19.55	21.9	20.9	21.9	22.6	.078	.7	.032
7	Groveland	1/00-12/04	90.0	82.01	80.60	1.41	1.62	1.39	1.20	.30	.17	.12
8	Geneva Fire Station	1/00-12/04	91.0	52.87	17.63	35.2	36.1	35.2	34.2	.054	.79	.022
9	Osceola	1/00-12/04	92.9	16.57	12.15	4.41	5.36	4.43	3.50	.42	.73	.17
10	Sanford Zoo	1/00-12/04	96.6	5.06	22.26	-17.2	-18.5	-17.2	-15.8	.16	1.10	.06
11	Leesburg Fire Tower	1/00-12/04	98.5	63.86	61.46	2.40	3.21	2.37	1.67	.65	.59	.25
12	Snook Road	1/00-12/04	97.9	17.16	14.31	2.86	3.31	2.87	2.37	.33	.37	.13
13	Lake Daughrty	1/00-12/04	90.0	42.88	40.05	2.83	3.25	2.84	2.29	.34	.48	.17
14	Lee Airport	1/00-12/04	98.3	76.31	33.11	43.2	46.0	42.7	40.9	.12	2.11	.049
15	De Leon Springs	1/95-12/04	93.1	15.39	18.77	-3.37	-5.06	-3.4	-1.67	1.00	1.46	.43
		1/00-12/04	96.3	15.37	18.80	-3.42	-5.29	-3.62	-1.25	1.12	1.71	.5
16	State Road 40	1/00-12/04	97.9	37.07	26.19	10.9	12.4	10.8	9.49	.27	1.17	.11
17	Pierson Airport	1/00-12/04	94.6	59.37	23.32	36.1	39.7	35.1	32.7	.20	3.84	.11
18	West Pierson	1/95-12/04	92.2	19.70	17.33	2.37	4.40	1.89	.62	2.00	1.99	.84
		1/00-12/04	96.4	19.67	16.94	2.73	4.80	2.37	.73	1.72	2.13	.78
19	Middle Road	1/95-12/04	93.5	8.27	11.61	-3.34	-3.54	-3.36	-3.08	.14	.17	.051
		1/00-12/04	97.6	8.15	11.44	-3.29	-3.53	-3.29	-3.04	.15	.19	.058
20	Silver Pond	1/93-12/04	93.8	35.96	26.87	9.10	10.45	8.92	7.89	.29	1.62	.18
		1/00-12/04	96.4	35.90	26.54	9.36	10.92	9.18	8.05	.31	1.31	.14
21	Niles Road	1/93-12/04	95.2	32.82	28.51	4.31	5.75	4.13	3.16	.63	.99	.23
		1/00-12/04	99.8	32.72	28.30	4.42	6.09	4.22	2.97	.74	1.16	.26
22	Marvin Jones Road	1/94-12/04	93.5	25.82	23.66	2.16	2.53	2.11	1.74	.37	.42	.19
		1/00-12/04	97.3	25.70	23.46	2.24	2.64	2.19	1.83	.37	.42	.19
23	Bulow Ruins	1/00-12/04	95.2	3.02	7.93	-4.91	-6.22	-4.88	-3.63	.53	.94	.19
24	Westside Baptist	1/00-12/04	95.8	21.57	9.78	11.8	15.3	11.2	9.01	.56	2.56	.22
25	Fruitland	1/00-12/04	92.3	68.77	18.72	50.0	51.5	50.0	48.8	.054	.99	.02
26	Alachua County	1/00-12/04	94.5	156.8	42.6	114.2	117.1	114.3	110.9	.054	2.44	.021
27	Lake Geneva	1/93-12/04	92.8	96.40	79.37	17.0	19.9	17.3	13.9	.35	2.37	.14
		1/00-12/04	90.8	95.81	76.74	19.1	20.6	19.2	17.4	.17	1.19	.062
28	Southside Fire Tower	1/92-12/04	88.9	42.88	22.55	15.9	22.2	15.3	10.3	.78	4.6	.29
		1/00-12/04	84.9	42.89	22.59	20.3	24.5	20.2	16.0	.42	3.1	.15
29	Eddy Fire Tower	1/92-12/04	90.9	116.9	48.4	68.5	72.0	68.0	65.8	.091	2.51	.037
		1/00-12/04	96.8	117.2	46.8	70.4	73.1	70.8	67.3	.082	2.14	.03

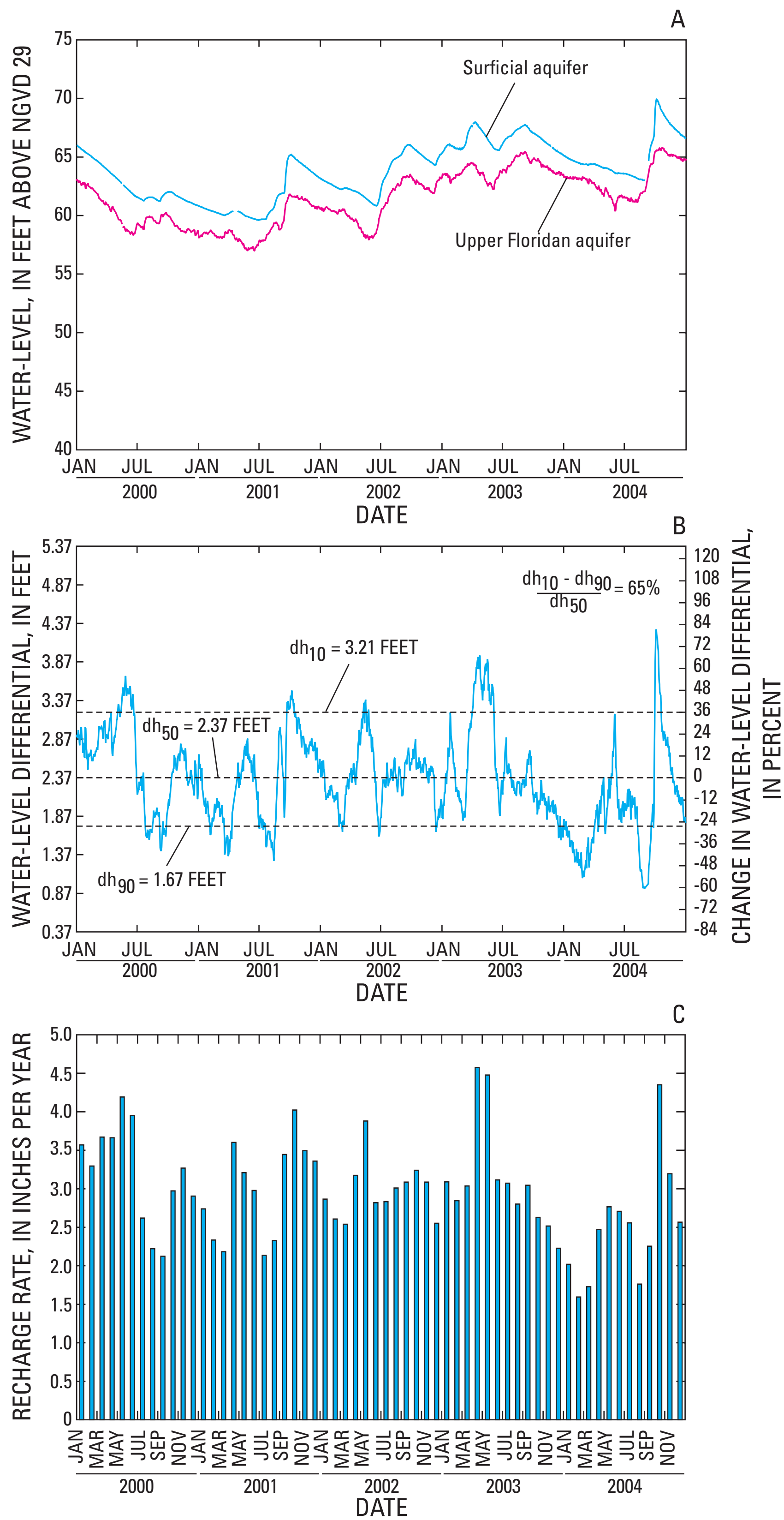


Figure 8. (A) Water levels, (B) water-level differentials in and between the surficial and Upper Floridan aquifers, and (C) Upper Floridan aquifer recharge rates at the Leesburg fire tower monitoring-well cluster site, 2000-2004.

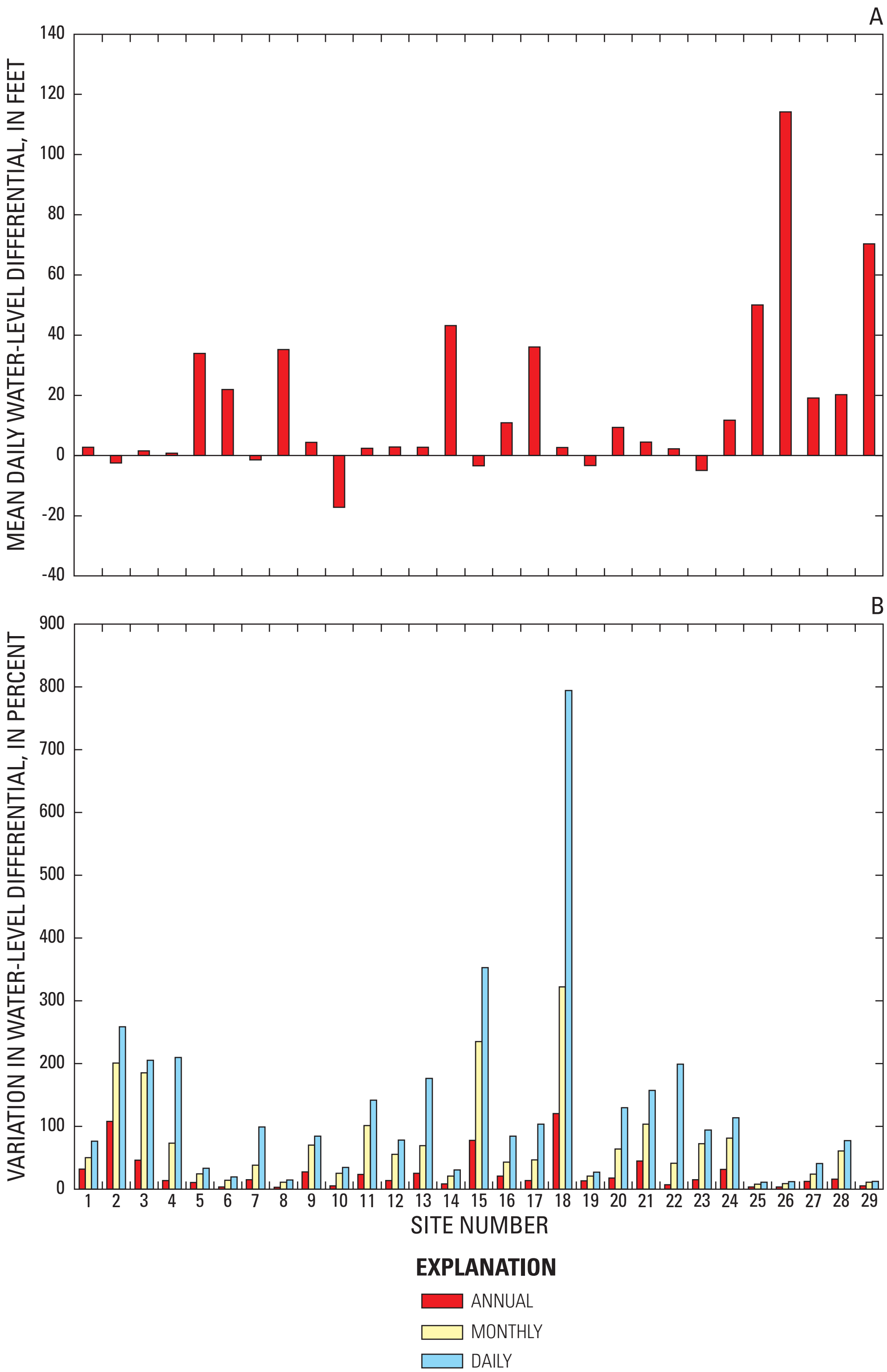


Figure 9. (A) Mean daily water-level differentials by project site and (B) variations about the mean on daily, monthly, and annual time scales, 2000-2004.

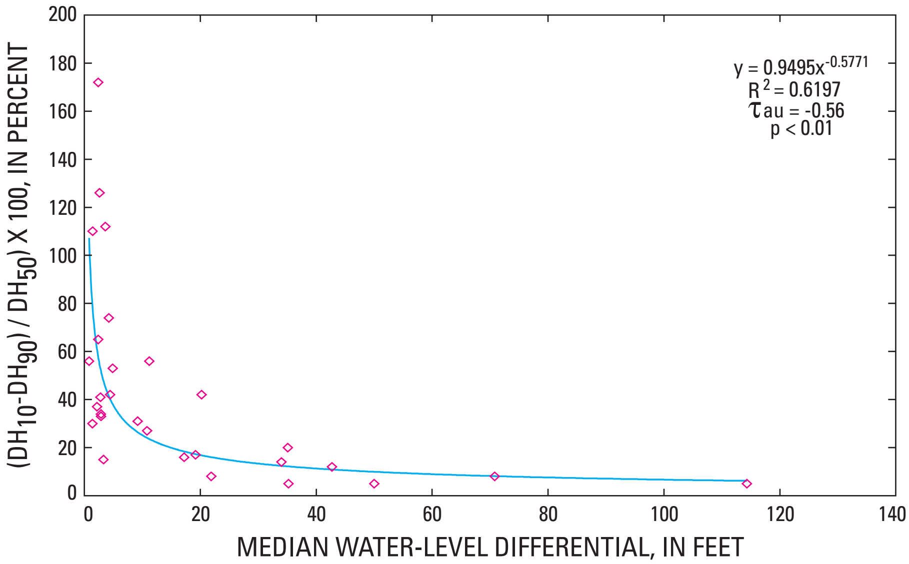


Figure 10. Variability in project site water-level differentials as a function of the median value, 2000-2004.

Table 4. Average annual water-level differentials between the surficial and Upper Floridan aquifers and changes with respect to the 5-year mean, 2000-2004.

Site no.	Site name	5-year mean	2000	Percent differential	2001	Percent differential	2002	Percent differential	2003	Percent differential	2004	Percent differential
1	Lake Oliver	2.76	2.57	-6.9	2.33	-15.6	2.52	-8.7	3.21	16.3	3.15	14.1
2	Cocoa	-2.41	-1.27	47.4	-1.56	35.4	-2.46	-1.91	-3.87	-60.8	-3.07	-27.4
3	Smokehouse Lake	1.52	1.18	-22.4	1.22	-19.7	1.74	14.5	1.88	23.7	1.49	-2.0
4	Mascotte	.79	.84	6.3	.80	1.3	.77	-2.5	.73	-7.6	.74	-6.3
5	Charlotte Street	33.9	35.9	5.9	34.9	2.9	34.2	.9	32.3	-4.7	32.4	-4.4
6	Geneva Replacement	21.9	22.3	1.8	21.5	-1.8	21.8	-.5	22.0	.5	21.8	-.5
7	Groveland	1.41	1.48	5.0	1.52	7.8	1.45	2.8	1.32	-6.4	1.31	-7.1
8	Geneva Fire Station	35.2	35.9	2.0	34.8	-1.1	34.9	-.9	35.6	1.1	35.0	-.6
9	Osceola	4.41	5.07	15.0	4.36	-1.1	4.65	5.4	3.85	-12.7	4.17	-5.4
10	Sanford Zoo	-17.2	-16.8	2.3	-17.2	0	-16.9	1.7	-17.7	-2.9	-17.4	-1.2
11	Leesburg Fire Tower	2.40	2.61	8.8	2.37	-1.3	2.43	1.3	2.55	6.3	2.05	-14.6
12	Snook Road	2.86	3.11	8.7	2.80	-2.1	2.93	2.5	2.72	-4.9	2.73	-4.6
13	Lake Daughrty	2.83	2.76	-2.5	2.41	-14.8	2.87	1.4	3.12	10.3	2.94	3.9
14	Lee Airport	43.2	45.3	4.9	45.1	4.4	42.5	-1.6	41.6	-3.7	41.6	-3.7
15	De Leon Springs	-3.42	-2.01	41.5	-2.06	39.8	-3.76	-9.9	-4.59	-34.2	-4.67	-36.6
16	State Road 40	10.9	9.84	-9.7	10.4	-4.6	11.28	3.5	12.1	11.0	10.7	-1.8
17	Pierson Airport	36.1	38.9	7.8	37.7	4.4	35.5	-1.7	34.2	-5.3	33.9	-6.1
18	West Pierson	2.73	4.68	71.4	3.38	23.8	2.59	-5.1	1.89	-30.8	1.40	-48.7
19	Middle Road	-3.29	-3.09	6.0	-3.12	5.2	-3.58	-8.1	-3.45	-4.9	-3.49	-6.1
20	Silver Pond	9.36	8.84	-5.6	10.4	11.1	9.45	1.0	9.33	-.3	8.73	-6.7
21	Niles Road	4.42	4.49	1.6	5.56	25.8	4.79	8.4	3.70	-16.3	3.58	-19.0
22	Marvin Jones Road	2.24	2.15	-4.0	2.31	3.1	2.28	1.8	2.24	0	2.20	-1.8
23	Bulow Ruins	-4.91	-5.32	-8.4	-4.86	1.0	-4.59	6.6	-5.17	-5.2	-4.69	4.5
24	Westside Baptist	11.8	13.5	14.4	12.9	9.3	11.7	-.9	9.77	-17.2	11.2	-5.1
25	Fruitland	50.0	50.8	1.6	51	2.0	50.1	.2	49.4	-1.2	49.2	-1.6
26	Alachua County	114.2	112.3	-1.7	115.1	.8	116.3	1.8	114.1	-.1	112.6	-1.4
27	Lake Geneva	19.1	17.5	-8.4	19.0	-.5	19.9	4.2	19.6	2.6	18.8	-1.6
28	Southside Fire Tower	20.3	20.1	-1.0	21.3	4.9	21.5	5.9	18.3	-9.9	19.8	-2.5
29	Eddy Fire Tower	70.4	71.7	1.8	71.5	1.6	72.0	2.3	68.5	-2.7	68.2	-3.1

A Kolmogorov normality test (Conover, 1999) indicated that, at a significance level of 0.05, the daily values were not normally distributed about respective means at the project sites. Accordingly, non-parametric statistical tools were applied for trend analyses.

Trends

Temporal trends in annually-averaged water-level differentials were evaluated with Kendall's tau (Helsel and Hirsch, 1992) for the 13 sites having 10 or more years or record (table 5). Four of the sites (1, 4, 7, and 28) exhibited statistically significant increases in differentials. The pattern of change in differentials at these sites is typical of that seen at Lake Oliver (site 1), where a long-term increasing trend is punctuated by shorter-term seasonal fluctuations (fig. 11). The shorter-term fluctuations are probably induced by changes in both pumpage and precipitation while, given the absence of a 5-year trend in rainfall (table 5), the longer-term trend is likely induced by ground-water development. Based on the slope of the regressed equation, the average UFA recharge rate at Lake Oliver increased by about 44 percent from 1974 to 2004.

In contrast to the increasing trend seen for sites with more than 10 years of record, a statistically significant decreasing trend in differentials is seen 'regionally' between 2000-2004 (fig. 12). The term 'regionally' is used because the points plotted on figure 12 were averaged for all 29 sites; that is, plotted values were determined by calculating, for each site, the percent change represented by each of the 60 monthly differential values relative to respective 5-year means. Then, for each month between 2000-2004, the percent changes were averaged for all 29 sites to produce 60 'regionally' averaged monthly values. The plot of these data shows a definitive downward trend punctuated by shorter-term monthly variations. The overall decrease in differentials can be attributed to a greater rate of recovery in UFA water levels than in SAS water levels that resulted from reduced UFA pumpage across the SJRWMD, from about 1.18 billion gallons per day in 2000 (Florence, 2004) to about 0.938 billion gallons per day in 2002 (Parks, 2005). Based on the slope of the regressed equation, UFA recharge rates decreased by an average of about 18 percent per site between 2000-2004.

Table 5. Results of trend testing of annually averaged water-level differentials and precipitation at sites with 10 or more years of record.

Site no.	Site name	Period of record analyzed	Water-level differential			NOAA station	Precipitation		
			Kendall's tau	P-value	Significant trend? ($\alpha = 0.05$)		Kendall's tau	P-value	Significant trend?
1	Lake Oliver	1974-2004	0.44	0.0006	increasing	Clermont	0.05	0.97	no
4	Mascotte	1960-2004	.29	.005	increasing	Clermont	.02	.85	no
5	Charlotte Street	1995-2004	.24	.38	no	Sanford	.07	.86	no
7	Groveland	1990-2004	.49	.013	increasing	Lisbon	.07	.73	no
15	De Leon Springs	1995-2004	.20	.50	no	Daytona	.24	.42	no
18	West Pierson	1995-2004	.022	.50	no	Ocala	-.02	.93	no
19	Middle Road	1995-2004	-.022	.50	no	Daytona/Ocala	.16	.59	no
20	Silver Pond	1993-2004	.21	.37	no	Daytona/Ocala	.12	.63	no
21	Niles Road	1993-2004	-.18	.45	no	Daytona/Ocala	.12	.63	no
22	Marvin Jones Road	1994-2004	.33	.22	no	Daytona/Ocala	-.02	.94	no
27	Lake Geneva	1993-2004	.27	.25	no	Gainesville	.05	.85	no
28	Southside Fire Tower	1992-2004	.82	<.0001	increasing	Jacksonville	-.26	.25	no
29	Eddy Fire Tower	1992-2004	.31	.16	no	Jacksonville	-.26	.25	no

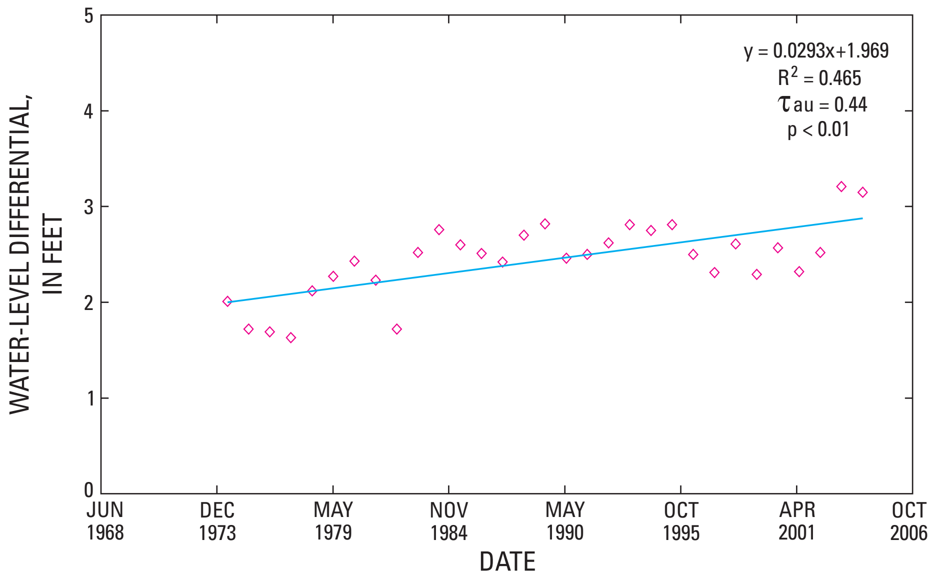


Figure 11. Average annual water-level differentials between the surficial and Upper Floridan aquifers at the Lake Oliver monitoring-well cluster site, 1974-2004.

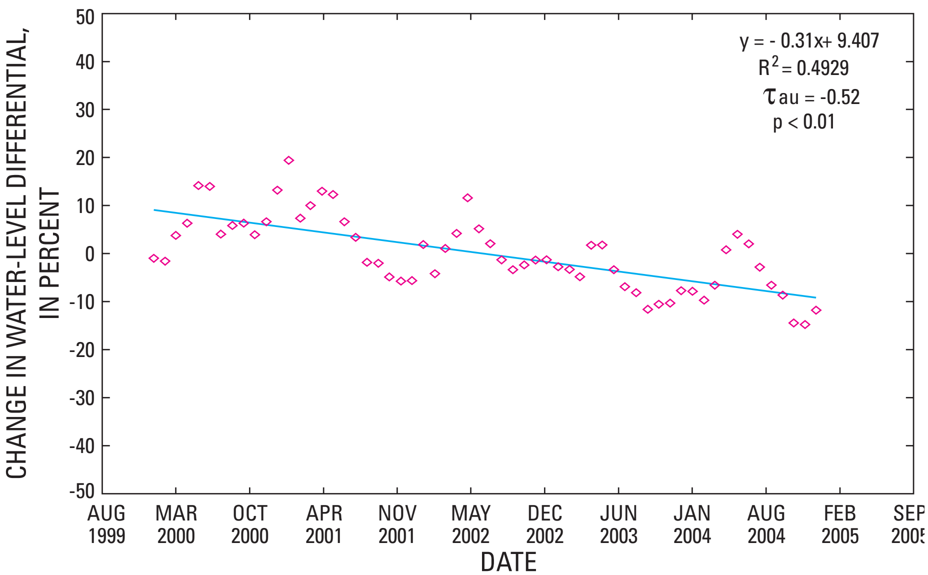


Figure 12. Monthly change in water-level differentials between 2000-2004 relative to the 5-year daily mean (averaged for all sites).

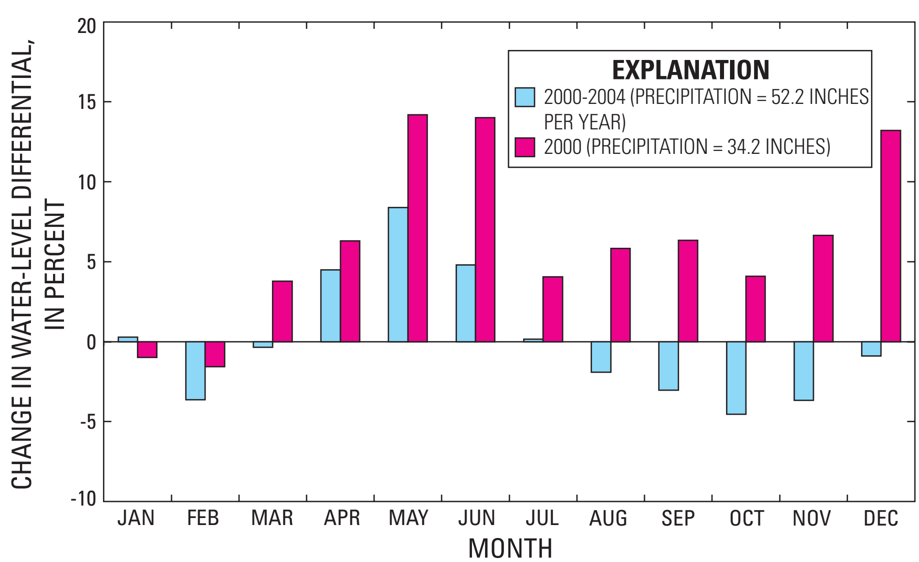


Figure 13. Change in water-level differential, by calendar month of the year, for 2000-2004 and 2000, relative to the 5-year daily mean (averaged for all sites).

Differentials varied by calendar month of the year and were affected by drought (fig. 13). The results shown on figure 13 were adjusted to remove the influence of the long-term trend depicted in figure 12 and thus isolate the monthly variations (residuals) for analyses. Differentials between 2000-2004 can be associated with near-average long-term rainfall conditions and depict a well-defined seasonal pattern in which UFA recharge rates increase during the dry season (February through May) and decrease during the wet season (June through October). A Kruskal-Wallis test (Helsel and Hirsch, 1992) indicated that at least one of the monthly means was statistically different from the others. On average, recharge rates were greatest in May (about 8 percent above the 5-year mean) and least in October (4 percent below the 5-year mean). This pattern is somewhat counterintuitive because recharge rates would normally be expected to peak during the wetter summer months, when the SAS is most effectively recharged, and to decline with SAS water levels during the drier months. However, because pumpage is usually greatest during the peak of the Florida growing season in late spring and least during the wetter summer months, seasonal differences in the pumpage-induced component of UFA drawdowns are most likely responsible for this pattern.

Monthly variations in 2000 were affected by drought and differ markedly from those averaged for 2000-2004. Precipitation in 2002 totalled only 34.2 inches and, except for the months of January and February, differentials exceeded the 5-year daily mean by as much as 13 to 14 percent in May, June, and December. Results coincide with unusually high ground-water withdrawals that reduced UFA water levels and resulted in additional recharge from the SAS. The UFA received an average of about 6 percent more recharge per site in 2000 as compared to the 2000-2004 average.

Influence of Selected Parameters

Water-level differentials were analyzed for correlation with land-surface altitude, thickness of the ICU, model-calibrated leakance of the ICU, and precipitation. Land-surface altitudes and ICU thickness values were acquired from USGS or SJRWMD data files (table 1). Leakance values were obtained from a regional ground-water flow model (Sepúlveda, 2002). Precipitation data were acquired from the NOAA rainfall stations.

Land-Surface Altitude

Differentials are positively correlated with land-surface altitude (fig. 14). The relation is best quantified for all 29 sites by a polynomial function that yields a coefficient of determination of 0.40. When excluding the four sites located with in the Lake Upland physiographic region, however, the correlation improves markedly ($R^2 = 0.83$). The Lake Upland region has a unique water table configuration that is relatively flat and does not represent a subdued reflection of topography, a condition indicative of a leaky confining unit (Knochenmus and Hughes, 1976). When grouping sites by physiographic region, an even stronger linear relation exists between the differentials and land-surface altitude for the 11 physiographically-defined ridge sites ($R^2 = 0.89$). While results indicate a potential for using land-surface altitude to estimate the mean differential between the SAS and UFA, additional sites should be evaluated to better quantify the relation and to establish confidence intervals.

Given that sites with greater mean differentials exhibit smaller percentage-based variations in recharge (fig. 10) and that differentials are generally greater in areas of higher topography (fig. 14), it may be reasonable to infer that UFA recharge rates vary less (percentage-wise) in higher topographic areas than in lower topographic areas. From a water-budgeting perspective, this inference is reasonable because the maximum possible recharge rate in higher topographic areas is more constrained in its percentage-based increase because the recharge rate cannot theoretically exceed the difference between precipitation and a minimum evapotranspiration value (estimated at 27 in/yr; Sumner, 1996).

Intermediate Confining Unit Properties

Differentials are statistically correlated with model-calibrated leakance of the ICU (fig. 15). Because leakance accounts for both the thickness and the equivalent hydraulic conductivity of the comprising sediments, it is a measure of the relative ‘ease’ in which water moves vertically from one aquifer to the next. Accordingly, smaller differentials are generally associated with areas of relatively high leakance and vice versa (Knochenmus and Hughes, 1976; Tibbals and Grubb, 1982). The power function that best quantifies the relation shown in figure 15 indicates differentials increase markedly with changes in relatively low values of leakance and increase only marginally with changes in relatively high values of leakance. The leakance values plotted on figure 15 were obtained from a regionally-calibrated ground-water flow model (Sepúlveda, 2002) and are subject to considerable error when applied to specific locations. Nonetheless, the presence of a statistically significant correlation, even though characterized by well-dispersed data ($R^2 = 0.24$), suggests leakance is probably highly correlated with differentials and a much improved correlation would be evident if the model-derived values accurately quantified specific site conditions.

Differentials are also statistically correlated with ICU thickness, though the data are even more widely dispersed about the mean ($R^2 = 0.21$, results not plotted). Although ICU thicknesses were site-specifically determined (table 1), the parameter does not account for the considerable variability—up to three orders of magnitude—in the equivalent vertical hydraulic conductivity of sediments.

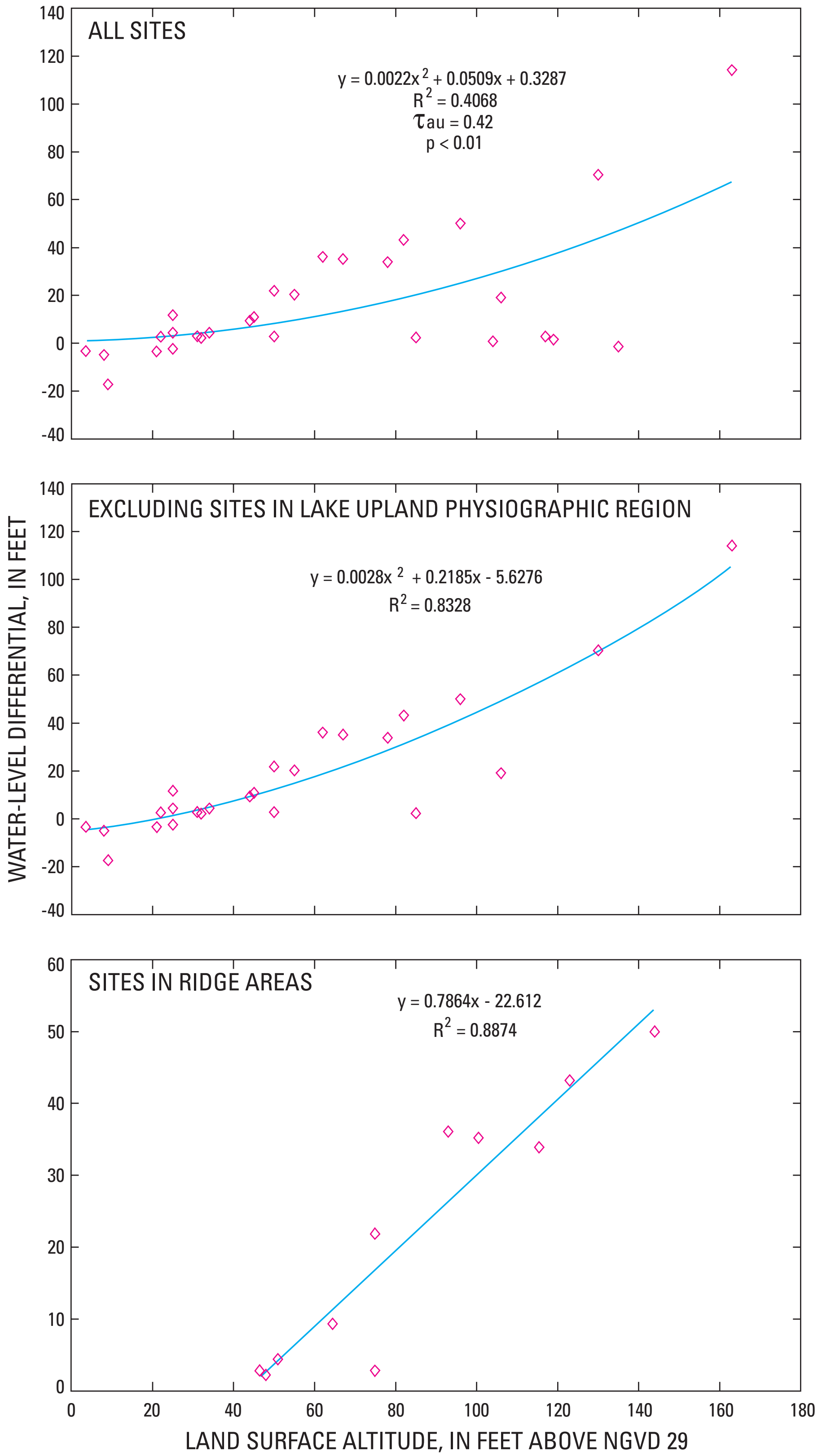


Figure 14. Mean water-level differential and land-surface altitude, 2000-2004.

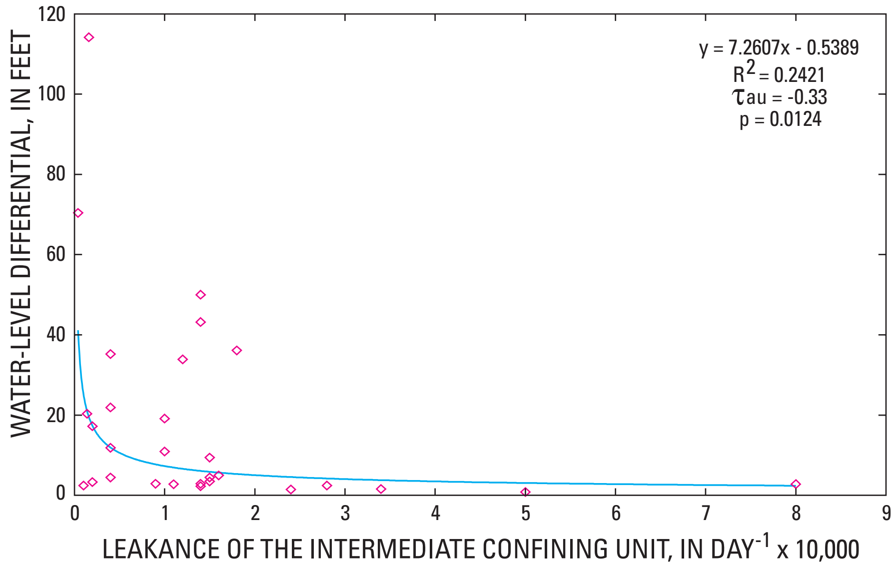


Figure 15. Water-level differential and model-calibrated leakance of the intermediate confining unit, 2000-2004.

Precipitation

With the exceptions of the Snook Road (site 12) and Fruitland (site 25) sites, monthly differentials were not significantly correlated with precipitation at nearby NOAA stations (table 6). Annually-based trends, however, are evident at 22 of the 29 sites having a coefficient of determination greater than 0.10 (sites with coefficients of less than 0.10 had no visually apparent trend). Differentials decreased with precipitation at 16 of the 22 sites indicating that, for the majority of the sites, the UFA received less recharge during wetter years in 2000-2004 than during the drier years. A plausible explanation for the negative trends is that reduced pumpage in the wetter periods contributed to recovered UFA levels, while increased pumpage in the drier periods contributed to increased drawdown. Although it is beyond the scope of this study to analyze the proximities of the individual sites to sources and amounts of pumpage, it would be interesting to determine if the six sites with positive trends are further removed from significant sources of ground-water withdrawals than the 16 sites with negative trends. At least one of the sites with a negative trend, the Charlotte Street site (site. 5), is located in a metropolitan area of concentrated pumpage. The Kendall tau test was not applied to the annual plots because of the paucity of data points.

Annually-derived coefficients of determination were substantially greater than monthly-derived values for all but seven sites (table 6). Differences in these results are due, in part, to the influence of outliers in the monthly data. More importantly, however, may be the role of system memory; that is, a current month's differential may be influenced not only by the current month's precipitation, but also by precipitation of preceding months. Annually-based correlations would better account for such system memory.

Double-mass plots of differentials and precipitation were constructed for the Lake Oliver and Mascotte sites to determine if UFA recharge conditions may be affected by factors other than precipitation over relatively long (30+ years) periods of record (fig. 16). The plot at Mascotte is characterized by a positive slope between 1961-1964, a flattening of the slope between 1965-1970, and re-establishment of a positive slope after 1970. The flattening of the slope between 1965-1970 can be attributed to a decline in the altitude of the water table with relatively little response in the potentiometric surface of the UFA. It is likely that drainage improvements made in the area during the 1960s, which included dredging of the nearby Palatlakaha River channel (Knowles and others, 2002), decreased SAS levels at this site. Based on a comparison of regressed slopes, the UFA at Mascotte received about 30 percent less recharge from the SAS between 1965-1970 as compared to the period between 1961-1965. After 1970, it is likely that increased ground-water withdrawals in the area lowered UFA water levels to re-establish the positive slope.

At Lake Oliver, the slope of the double-mass curve increased after 1983 as the rate of decline in UFA levels exceeded those in the SAS. This pattern is likely due to the effects of increased ground-water withdrawals. Based on a comparison of slopes, the UFA at Lake Oliver received about 34 percent more recharge per year between 1983-2004 as compared to the period between 1974-1983.

Table 6. Results of regression analyses and trend testing of monthly and annually-averaged water-level differentials and precipitation, 2000-2004.

[na, not analyzed; <, less than; >, greater than. The p-value is the probability that a pattern of increasing or decreasing differential could result from a trendless set of data due to chance. A probability of 0.05 or less is taken as evidence of a significant trend and is in bold type]

Site no.	Site name	Nearest NOAA station	Monthly coefficient of determination (R^2)	Monthly p-value	Annual coefficient of determination (R^2)	Slope of line of best fit through annual data
1	Lake Oliver	Clermont	<0.10	>0.05	< 0.10	na
2	Cocoa	Melbourne	<.10	>.05	<.10	na
3	Smokehouse Lake	Clermont	<.10	>.05	.77	positive
4	Mascotte	Clermont	<.10	>.05	.44	negative
5	Charlotte Street	Sanford	<.10	>.05	.47	negative
6	Geneva Replacement	Sanford	<.10	>.05	<.10	na
7	Groveland	Lisbon	<.10	>.05	.20	positive
8	Geneva Fire Station	Sanford	<.10	>.05	.59	negative
9	Osceola	Sanford	<.10	>.05	.32	negative
10	Sanford Zoo	Sanford	<.10	>.05	.14	negative
11	Leesburg Fire Tower	Lisbon	<.10	>.05	.37	negative
12	Snook Road	Sanford	.45	**<.0001**	.46	negative
13	Lake Daughrty	Sanford/Daytona	<.10	>.05	<.10	na
14	Lee Airport	Sanford/Daytona	<.10	>.05	.54	negative
15	De Leon Springs	Sanford/Daytona	<.10	>.05	.49	negative
16	State Road 40	Daytona	<.10	>.05	.31	positive
17	Pierson Airport	Ocala	<.10	>.05	.79	negative
18	West Pierson	Ocala	<.10	>.05	.88	negative
19	Middle Road	Ocala	<.10	>.05	.67	negative
20	Silver Pond	Ocala	<.10	>.05	<.10	na
21	Niles Road	Ocala	<.10	>.05	.19	negative
22	Marvin Jones Road	Daytona	<.10	>.05	.41	positive
23	Bulow Ruins	Daytona	<.10	>.05	.66	positive
24	Westside Baptist	Daytona	<.10	>.05	.37	negative
25	Fruitland	Gainesville	<.10	>.05	.55	negative
26	Alachua County	Gainesville	<.10	>.05	<.10	na
27	Lake Geneva	Gainesville	.18	**.0034**	.43	positive
28	Southside Fire Tower	Jacksonville	<.10	>.05	<.10	na
29	Eddy Fire Tower	Jacksonville	<.10	>.05	.21	negative

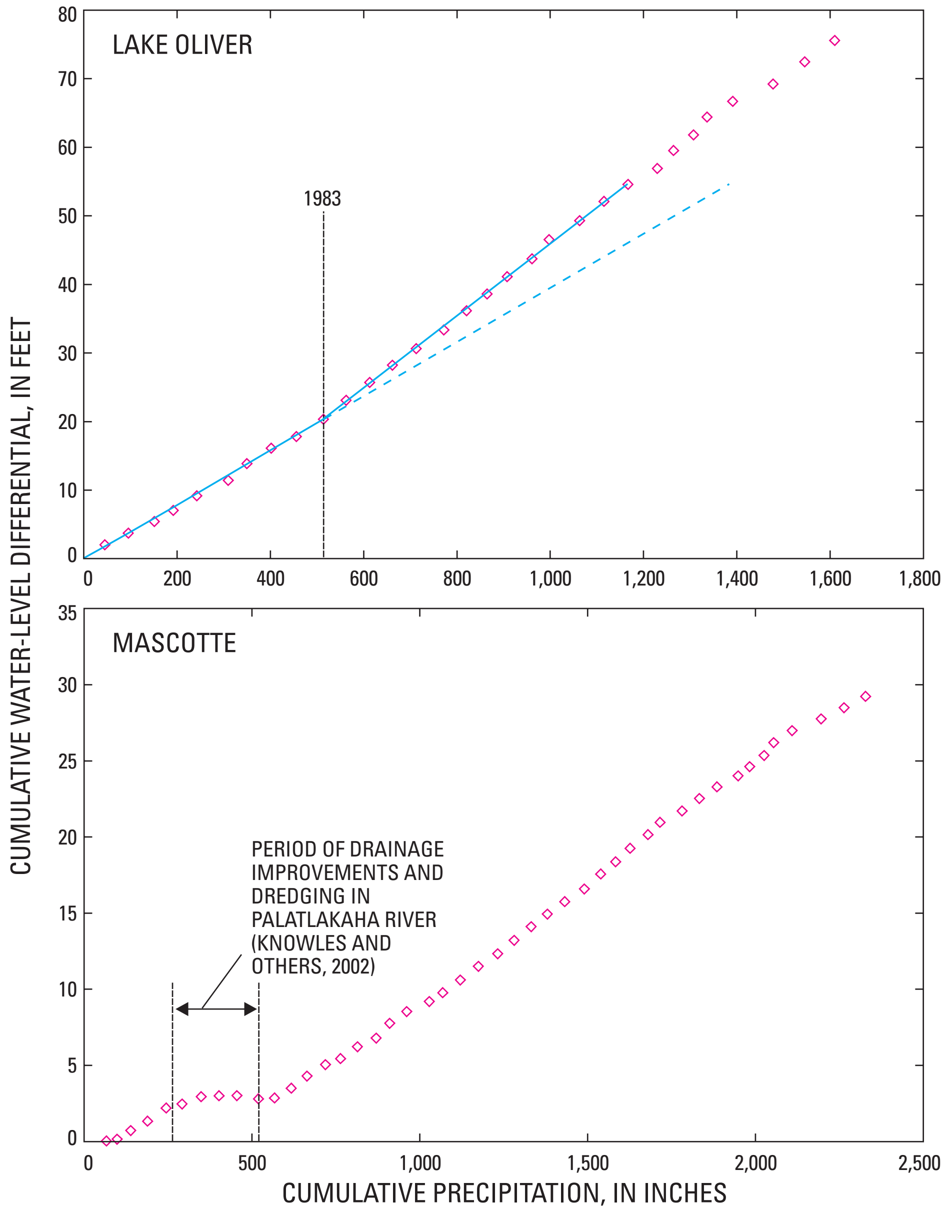


Figure 16. Double-mass plots of annually-averaged water-level differentials at the Lake Oliver (1974-2004) and Mascotte (1960-2004) sites and precipitation at Clermont.

Interrelations among Differentials, Precipitation, and Pumpage

The interrelations among differentials, precipitation, and pumpage were examined at the Charlotte Street monitoring-well cluster site in Seminole County (site 5). The site is located within the greater Orlando metropolitan area and provides an appropriate test case for evaluating these interrelations. Regression analyses were used to develop algorithms in relating differentials, and changes in differentials, to precipitation, ground-water withdrawals, and the distance of the site from points of withdrawals.

Water-use data were acquired from the Florida Department of Environmental Protection and selected utilities. All water-treatment plants located within an 8-mile radius of the site and which treated more than 100,000 gallons per day of water pumped from the UFA between 2000-2004 were inventoried for this study (table 7). The locations of the water-treatment plants are considered to coincide with contributing wellfields. On average, about 52.4 Mgal/d of water was pumped from the aquifer between 2000-2004. Highest withdrawals (59.3 Mgal/d) occurred in 2000, at the peak of a 3-year drought (1998-2000), and decreased over the following 2 years with increasing rainfall (51.0 and 49.6 Mgal/d, respectively, for 2001 and 2002). Pumpage data are summarized in appendix B.

Trends

Plots of precipitation at the Sanford NOAA station and pumpage near the Charlotte Street site were examined for trends (fig. 17). While there was a slight increasing trend in monthly precipitation between 2000-2004, it was not statistically significant at the 0.05 level. Pumpage, on the other hand, did exhibit a significant decrease across the 5-year period as the area emerged from a prolonged drought. Pumpage near Charlotte was typically greatest in May, near the end of the dry season, and least in September, near the end of the wet season.

Based on changes in differentials, recharge to the UFA decreased by about 14 percent between 2000-2004 as water levels in the UFA recovered at a greater rate over this period than did those in the SAS (fig.18). The water-level changes depicted individually for the two aquifers on figure 18 provide insight into the effects of precipitation and pumpage on variations in UFA recharge rates. If the water levels were affected solely by precipitation, one would have expected to see more of a muted response in UFA water levels; that is, the increase in UFA levels should have been less than (and not exceeded) that seen in the SAS. At most, the increase in the UFA water level may have equaled that in the SAS. Thus, if it can be assumed that the maximum potential effect of precipitation would result in equal changes in water levels, then some other factor—most likely reduced pumpage—would be responsible for at least that fraction of the UFA water-level increase that is greater than that seen in the SAS.

Differentials at the Charlotte Street site were not statistically correlated with monthly rainfall at Sanford but were correlated with nearby pumpage (figs. 19 and 20, respectively). Differentials increased by an average of 0.17 feet per Mgal/d of increased pumpage, which is equivalent to a 0.5 percent increase in the UFA recharge rate per million gallons per day of pumpage when compared to the 5-year daily mean of 33.9 feet. Increased differentials can be attributed to greater reductions in UFA water levels than in SAS water levels.

Influence of System Memory

The absence of a significant relation between monthly precipitation and differentials does not necessarily indicate that the differentials are insensitive to changes in precipitation, but that system memory may exert more influence in defining this relation than with pumpage. The influence of system memory on the relation between Charlotte Street differentials and Sanford precipitation was examined by plotting the monthly differentials and the moving averages of precipitation for 1-, 2-, 3-, and 12-month time periods. Twelve plots were constructed. The coefficient of determination (R^2) obtained from each plot was plotted against the number of months used in the moving average calculation to identify which timeframe provided the best correlation between precipitation and differentials. As shown on figure 21, the best correlation occurred with a 9-month moving average of precipitation (R^2 of 0.63). Moving averages above and below the 9-month mark produced poorer fits of the data.

The true duration of system memory may be considerably less than 9 months, and the results depicted on figure 21 do not necessarily represent a unique, or optimal, solution. The moving averages were equally weighted, whereas the current month or most recent 2 or 3 months may exert more influence on the differentials than do later months, and should be weighted accordingly. A more rigorous multivariant regression or transfer function analyses would quantify the relative monthly weights to provide a more accurate estimate of system memory. These results do, however, indicate that the differentials, and thus current monthly UFA recharge rates, are affected by system memory of precipitation.

When plotted against the 9-month moving average of precipitation, the correlation with differentials improve markedly, from an R^2 of 0.037 (fig. 19) to 0.63 (fig. 22). Differentials decrease linearly with precipitation by about 1.2 feet per inch of change in the 9-month moving average of precipitation. This represents about a 3.5 percent change in the UFA recharge rate per inch of change in precipitation relative to its 5-year daily mean of 33.9 feet.

Table 7. Listing of municipal water-supply treatment plants near the Charlotte Street monitoring-well cluster site.

[Mgal/d, million gallons per day; see appendix B for monthly values, January 2000-December 2004]

Public water supply ID	Utility	Water treatment plant name	Plant ID no.	Plant latitude (degrees, minutes, seconds)	Plant longitude (degrees, minutes, seconds)	Distance from Charlotte site, miles	Average flow, Mgal/d, 2000-04
3594107	Seminole County	Heathrow	1	284550	812141	5.74	2.465
3594107	Seminole County	Hanover Woods	2	284603	812300	6.19	.454
3594107	Seminole County	Markham Woods	4	284746	812143	7.97	1.149
3591451	Weathersfield	Weathersfield	1	283936	812424	3.34	.322
3591394	Winter Springs	Tuskawilla	1	284042	811543	5.77	2.557
3591121	Sanlando Utilities	Despinar	1	284221	812242	2.14	3.240
3591121	Sanlando Utilities	Overstreet	2	284146	812241	1.64	.106
3591121	Sanlando Utilities	Wekiva Hunt Club	3	284149	812556	4.69	5.282
3590879	Winter Springs	W. Shenendoah Blvd.	1	284243	811859	3.27	.601
3590879	Winter Spring	W. Bahama Blvd.	2	284100	811820	3.13	.839
3590823	Meredith Manor	Meredith Manor	1	284119	812447	3.43	.259
3590785	Seminole County	Lynwood	1	283952	812647	5.53	1.343
3590571	Seminole County	Consumer	1	283815	811707	5.30	4.514
3590571	Seminole County	Consumer/Indian Hills	2	283850	811959	2.74	2.019
3590473	Seminole County	Greenwood Lakes	1	284426	812051	4.16	1.615
3590473	Seminole County	Greenwood/CC Estates	2	284402	811940	4.06	.636
3590202	Longwood	Plant no. 1	1	284200	812041	1.52	1.017
3590202	Longwood	Plant no. 2	2	284229	812141	1.88	1.292
3590201	Lake Mary	Lake Mary	1	284547	812045	5.72	3.716
3590159	Casselberry	Howell Park	1	283907	811942	2.66	1.699
3590159	Casselberry	North Plant	2	284059	811916	2.19	.801
3590159	Casselberry	South Plant	3	283703	811837	5.21	.979
3590111	Bretton Woods	Druid Hills	1	283836	812257	3.03	.106
3590039	Apple Valley-Sanlando	Apple Valley	1	284035	812333	2.16	.487
3590026	Altamonte Springs	Spring Lake	2	283849	812213	2.48	2.599
3590026	Altamonte Springs	San Sebastian	4	283957	812445	3.53	.648
3590026	Altamonte Springs	Pearl Lake	5	283919	812544	4.69	2.731
3590205	Sanford	Sanford	1	284709	811905	7.62	5.176
3590205	Sanford (auxillary plant)	Sanford	2	284604	811656	7.52	1.211
3480203	Maitland	Thistle Lane	3	283810	812040	3.20	.760
3480203	Maitland	Wymore Road	4	283724	812302	4.30	.067
3480327	Eatonville Water Dept.	Eatonville	1	283655	812249	4.75	.400
3480200	Apopka	Grossenbacher	1	284133	813038	9.33	1.273
						Total Mgal/d	52.363

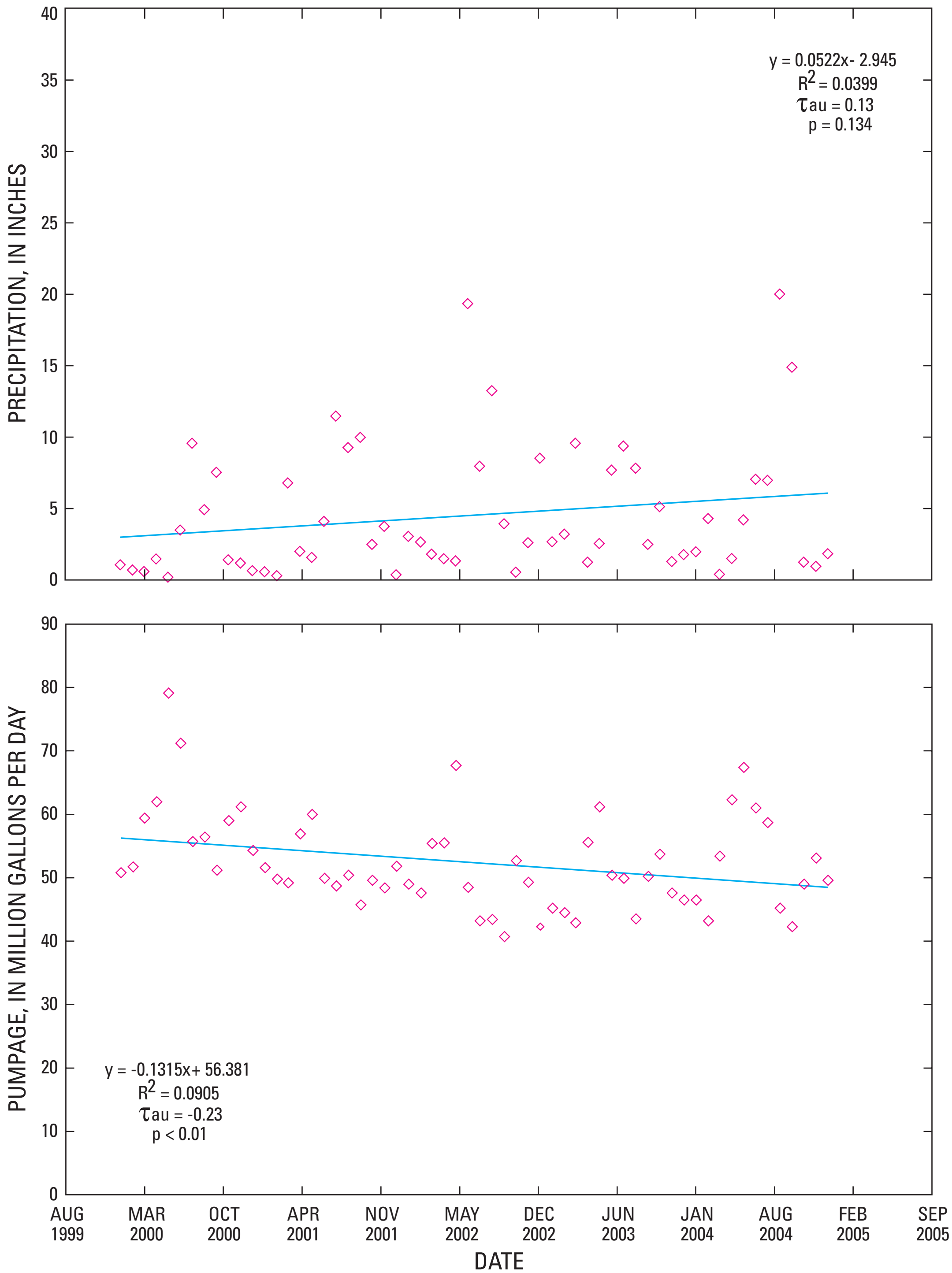


Figure 17. Monthly precipitation at Sanford and pumpage near the Charlotte Street monitoring-well cluster site between 2000-2004.

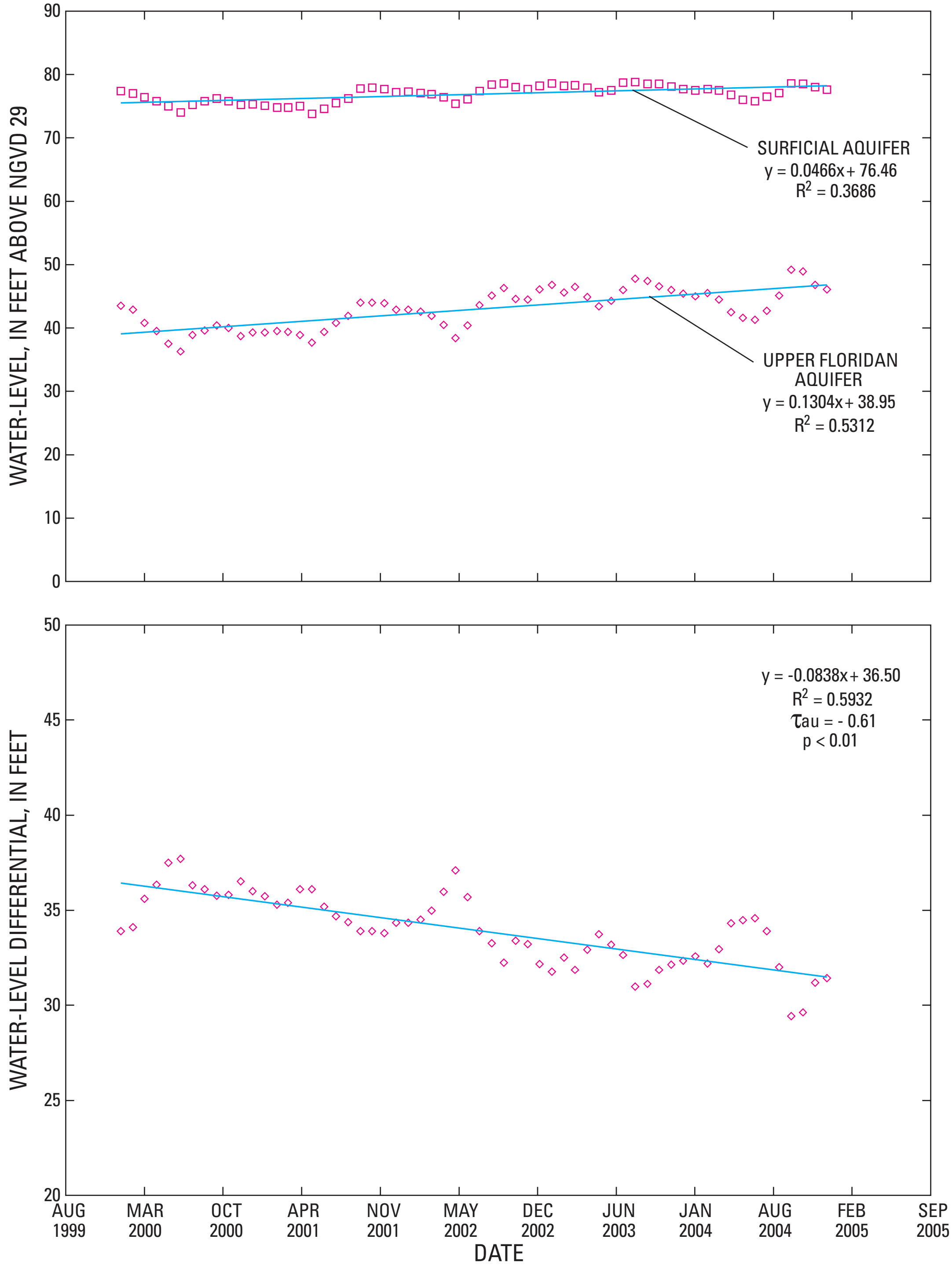


Figure 18. Monthly water levels and water-level differentials in and between the surficial and Upper Floridan aquifers at the Charlotte Street monitoring-well cluster site, 2000-2004.

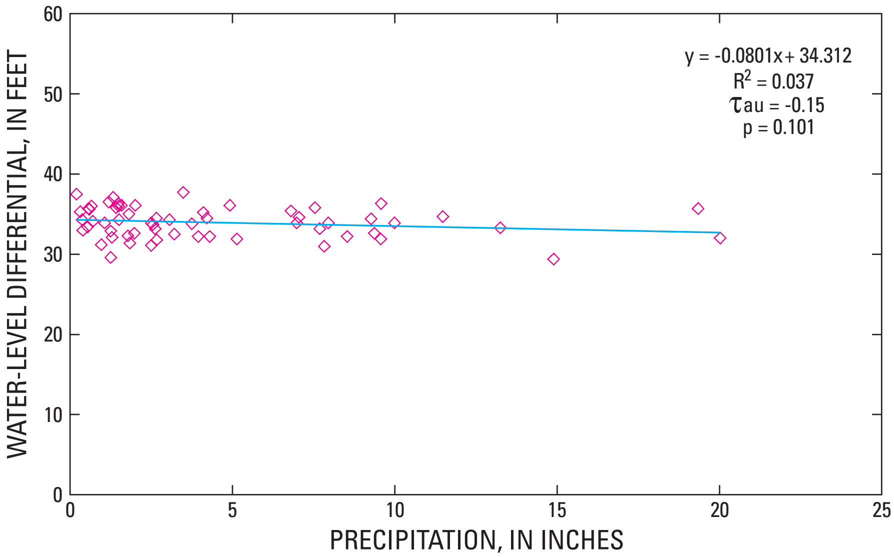


Figure 19. Average monthly water-level differentials at the Charlotte Street monitoring-well cluster site and precipitation at Sanford, 2000-2004.

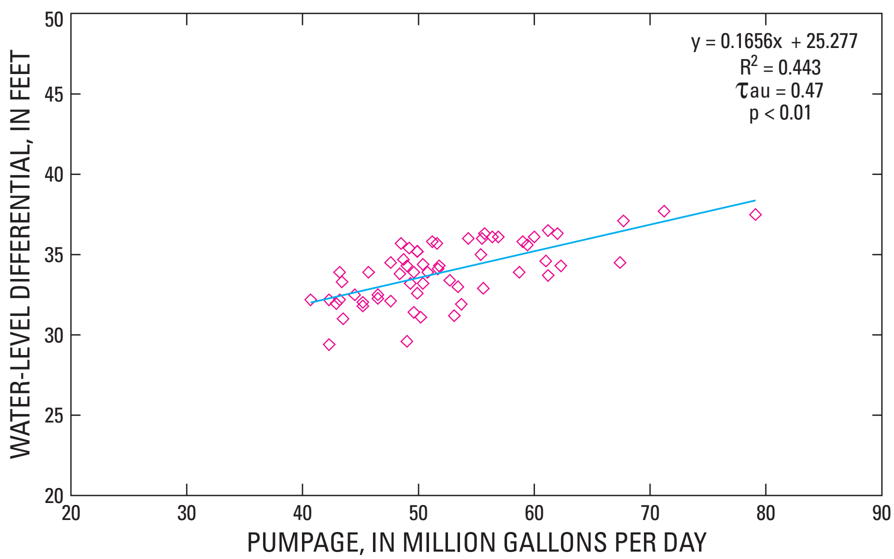


Figure 20. Average monthly water-level differentials at the Charlotte Street monitoring-well cluster site and nearby pumpage, 2000-2004.

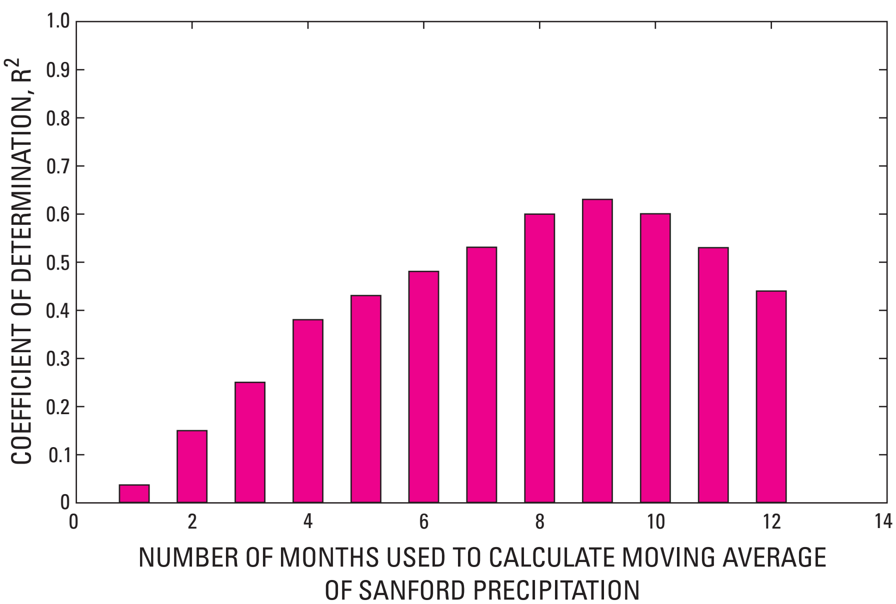


Figure 21. Coefficient of determination, R^2, and the moving average of precipitation at Sanford, 2000-2004.

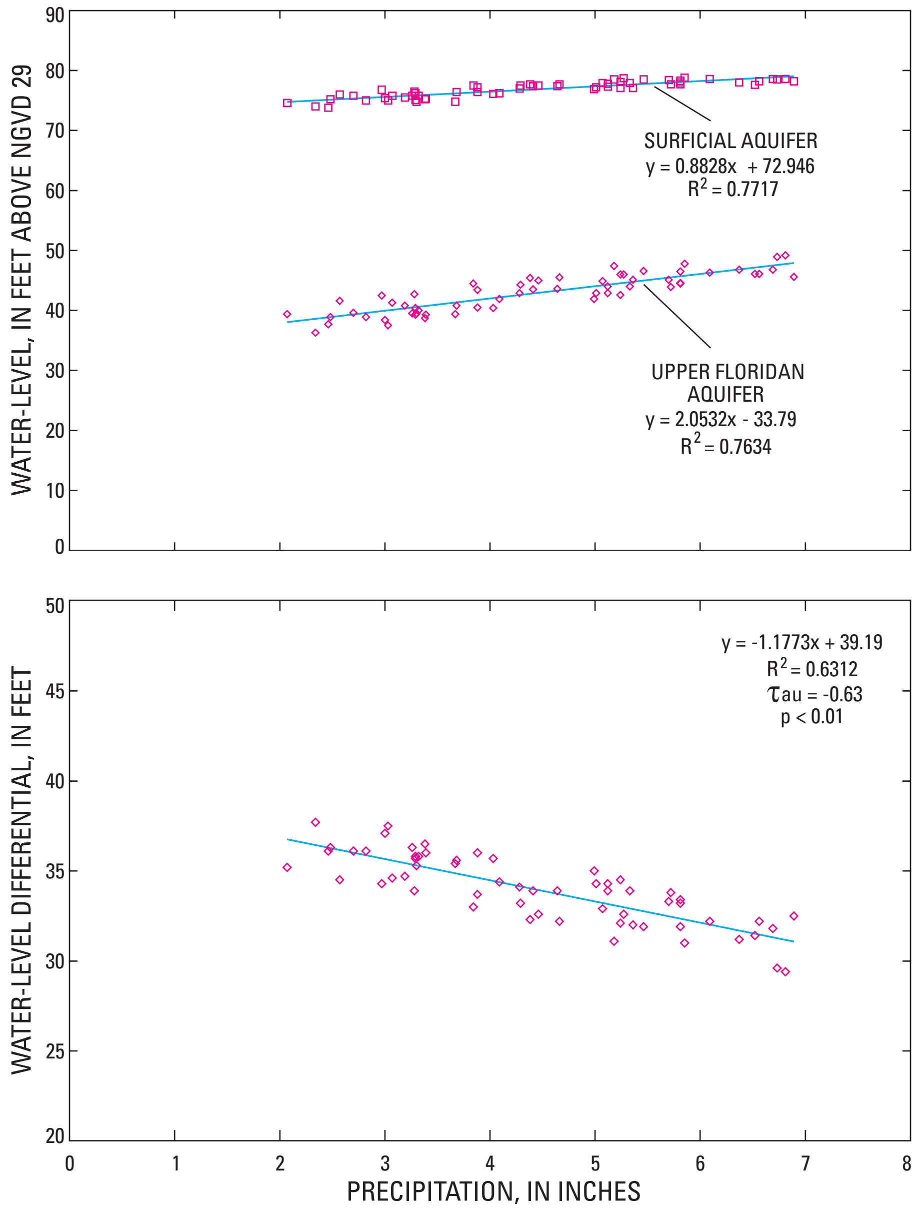


Figure 22. Average monthly water-levels and water-level differentials in and between the surficial and Upper Floridan aquifers at the Charlotte Street monitoring-well cluster site and the 9-month moving average of precipitation at Sanford, 2000-2004.

Monthly differentials at Charlotte also exhibited system memory to nearby ground-water withdrawals, although to a lesser extent. Differentials were best correlated to the 2-month moving average of pumpage (R^2 of 0.54, fig. 23), as compared with an R^2 of 0.44 for the month-to-month plot (fig. 20). The improved correlation is best quantified by a polynomial function in which the increase in the differential per million gallons per day of pumpage is greater along the lower end of the pumpage scale and smaller along the higher end of the pumpage scale. Thus, in terms of UFA recharge rates, the system appeared to be closer to a steady-state condition in 2000 when pumping rates were greatest and more similar to rates in the preceding drought years of 1998 and 1999 than in subsequent years of higher precipitation.

Ground-water withdrawal rates near Charlotte are statistically correlated with precipitation at Sanford (fig. 24a, b). The inverse nature of this relation is apparent but loosely defined on a month-by-month plot of the data. When accounting for system memory, however, in which the 2-month moving average of pumpage is plotted against the 9-month moving average of precipitation, the relation improves markedly (from $R^2 = 0.19$ to 0.60) and is best quantified by a power function where increases in low levels of precipitation (i.e., 2 to 3 inches) resulted in relatively large decreases in pumpage. Conversely, increases in precipitation along the higher end of the scale resulted in relatively small decreases in pumpage. The nonlinearity of this relation can possibly be explained by variations in precipitation-affected irrigation demands. At low levels of precipitation, greater amounts of water are required to meet irrigation-related deficits. At higher levels of precipitation, irrigation-related deficits are reduced or eliminated. By comparison, the amount of water required for non-irrigation purposes is relatively constant from one month to the next and thus unaffected by variations in precipitation. Accordingly, it may be possible to estimate the amount of water required for non-irrigation purposes by extending the line-of-best fit shown in figure 24b to quantify the constant (horizontal) component of the plot.

Descriptive Algorithms

The analyses discussed thus far have examined the memory-influenced relations between differentials individually with precipitation and pumpage (R^2 values of 0.63 and 0.54 in figs. 22 and 23, respectively). Treating these factors as a lumped parameter (equal to the quotient of precipitation divided by pumpage), however, further improves the correlation ($R^2 = 0.70$, fig. 25). As a quotient, the lumped parameter honors the relations seen individually between differentials with precipitation (negatively correlated and thus placed in the denominator) and pumpage (positively correlated and thus placed in the numerator).

The correlation between differentials with precipitation and pumpage can be even further improved by accounting for the distances between the Charlotte Street site and the sources of ground-water withdrawals given on table 7 ($R^2 = 0.84$, fig. 26). In this analyses, the pumpage term in the lumped parameter is multiplied by the log term in the Cooper-Jacob (1946) nonequilibrium equation ($\log(2.25Tt/r^2{*}S)$) that relates drawdown in a confined pumped aquifer to the radial distance from the source of pumpage (i) as

$$Q^* = \sum_{i=1}^{33} [Q_i \log(2.25Tt/r^2S)] \qquad (2)$$

where

Q* is the cumulative monthly distance-weighted discharge rate in million gallons per day.

Inclusion of the log term in the Cooper-Jacob equation in Eq (2) seems reasonable given that the differentials at Charlotte are particularly sensitive to pumpage-induced changes in confined UFA water levels. Values typical of UFA aquifer storage coefficients (1×10^{-4}) and transmissivity (100,000 feet squared per day) were used as constants in Eq (2), along with a time of 30 days. The plotted values of P/Q* shown on figure 26 are well correlated with the water-level differentials at Charlotte and, assuming no addition of newly-located water-supply sites or closure of existing sites, offer potential as a predictive tool for estimating water-level differentials and variations in UFA recharge rates based on changes in precipitation and pumpage.

Estimating the Time Dependency of Confining Unit Storage

Water-level differentials can be equated with proportionate changes in UFA recharge rates only if the water levels measured at the project sites are in a quasi steady-state condition; that is, the gradient through the ICU is linear and water released from or taken into storage in the unit is negligible. If, however, a water-level change induced in one of the aquifers has not had sufficient time to traverse the ICU to re-establish steady flow, storage effects from the ICU may not be negligible. Consequently, water levels measured at the cluster sites could not be used in Darcy's law to infer proportionate changes in recharge.

Given some simplifying assumptions, the time required for a pressure transient to move through a confining unit and re-establish steady flow conditions can be estimated from an analytical solution that has been applied in numerous studies (Bredehoeft and Pinder, 1970; Leake and others, 1994). This equation is described below and used to evaluate the applicability of daily, weekly, monthly, and annual time scales for relating changes in water-level differentials with proportionate changes in recharge.

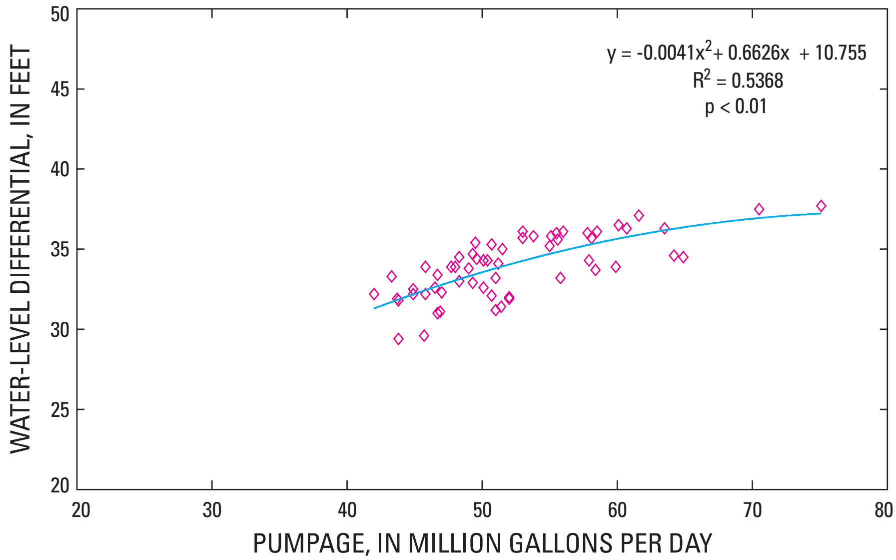


Figure 23. Monthly water-level differentials and the 2-month moving average of pumpage near the Charlotte Street monitoring-well cluster site, 2000-2004.

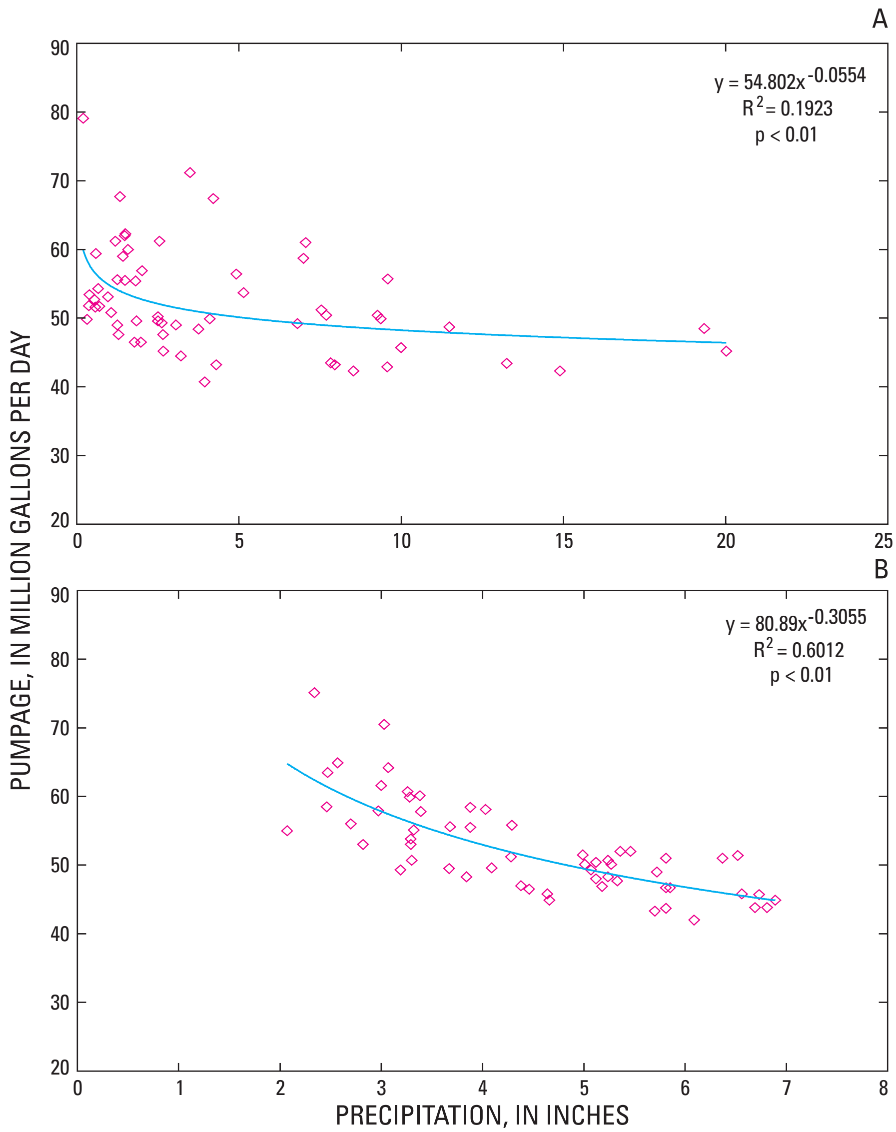


Figure 24. (A) Monthly pumpage near the Charlotte Street monitoring-well cluster site and precipitation at Sanford, and (B) 2-month moving average of pumpage and 9-month moving average of precipitation, 2000-2004.

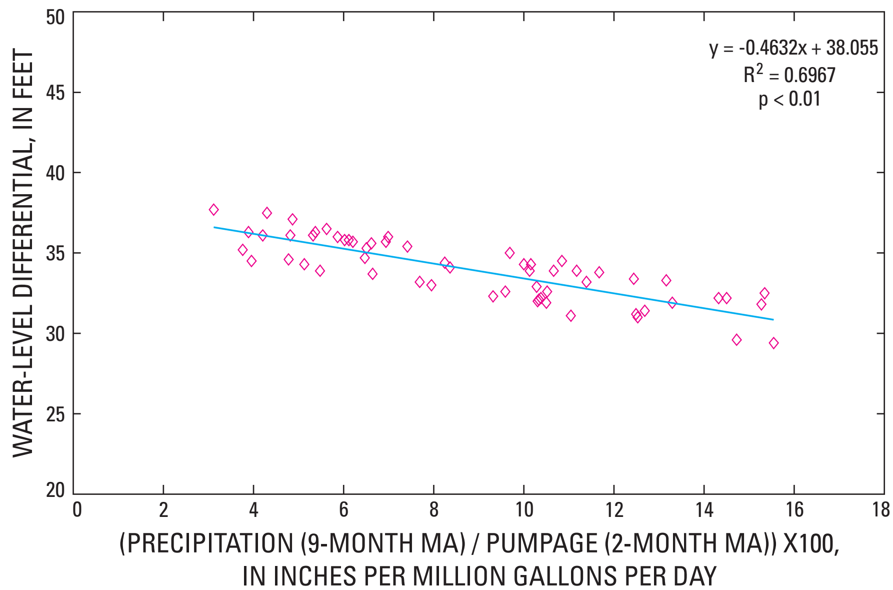


Figure 25. Monthly water-level differentials at the Charlotte Street monitoring-well cluster site and precipitation at Sanford (9-month moving average (MA) divided by pumpage (2-month MA)), 2000-2004.

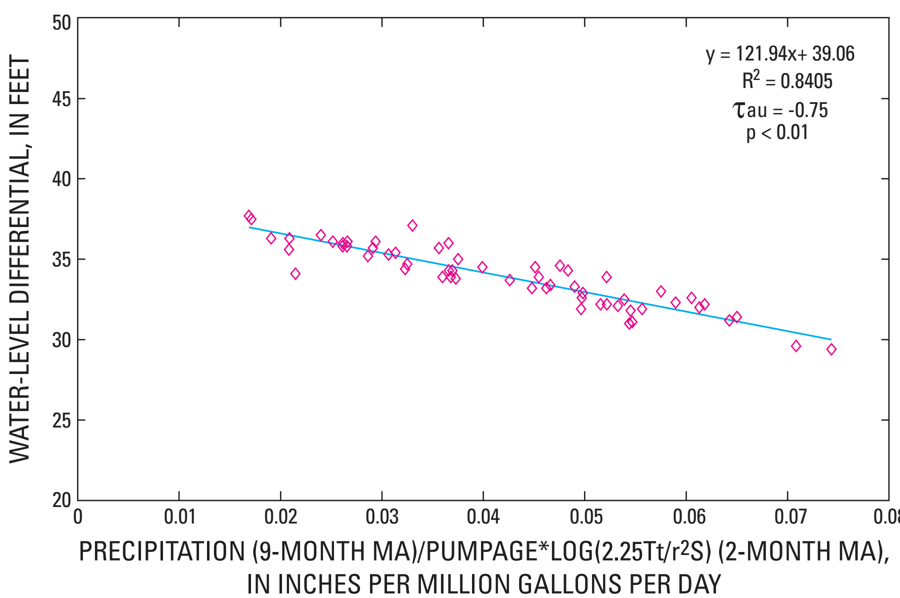


Figure 26. Monthly water-level differentials at the Charlotte Street monitoring-well cluster site and precipitation at Sanford (9-month moving average (MA) divided by the product of pumpage and log(2.25 Tt/r^2S)(2-month MA)), 2000-2004.

Application of an Analytical Solution

Nonsteady one-dimensional flow in a two-aquifer flow system subjected to a stepwise change in head at the aquifer/confining layer interface can be described by the following partial differential equation:

$$\delta^2 h'/\delta z^2 = S_s'\delta h'/K'\delta t \qquad (3)$$

where

- h' is the change in head imposed on a two-aquifer system in equilibrium (feet);
- S_s' is the specific storage of the confining unit (1/feet);
- z is the distance below (or above) the confining unit/aquifer interface where the step change in head is applied (feet); and
- t is time.

The following boundary and initial conditions apply:

$$h'(z,0) = 0 \text{ at } t = 0$$

$$h'(0,t) = 0 \text{ at } t > 0 \qquad (4)$$

$$h'(b',t) = H_0 \text{ at } t > 0$$

where

- H_0 is the stepwise change in head applied at the aquifer/confining unit interface (feet).

The analytical solution to this equation was developed by Carslaw and Jaeger (1959) as

$$h'(z,t) = H_0 \sum_{n=0}^{\infty} \{\mathrm{erf}((2n+1) + z/b')/(4K't/S_s'b'^2)^{1/2}) - \mathrm{erf}((2n+1) - z/b')/(4K't/S_s'b'^2)^{1/2})\}. \qquad (5)$$

Equation (5) was developed for isotropic and homogeneous conditions and assumes vertical and horizontal flow regimes, respectively, in the confining unit and perturbed aquifer.

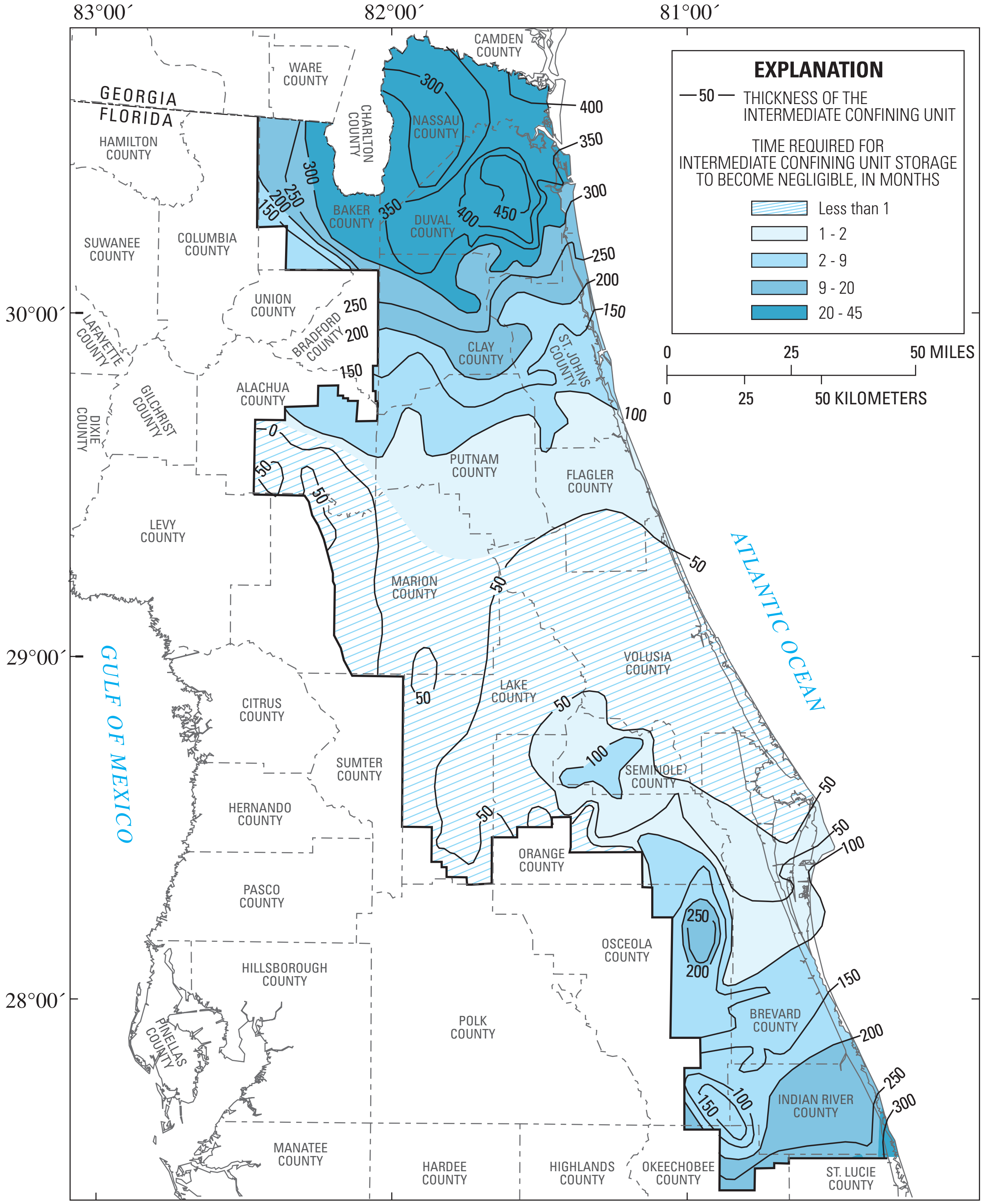
Bredehoeft and Pinder (1970) presented a graphical analysis of Eq (5) relating dimensionless time ($K't/S_s'b'^2$) to movement of the head change (h'/H_0) through the unit. At dimensionless times of greater than 0.2, storage in the confining unit may be considered negligible and steady flow is re-established through the unit (Bredehoeft and Pinder, 1970, p. 888). In terms of real time, this criterion can be expressed as

$$t = 0.2\, S_s'b'^2/K'. \qquad (6)$$

Equation (6) was applied to provide a gross estimate of the time required for a head change in either aquifer to transit the ICU at each of the project sites (table 8). Confining unit thickness values used in these calculations were acquired from USGS and SJRWMD data files. The equivalent vertical hydraulic conductivity of the ICU was estimated at each site by multiplying the model-calibrated leakance by unit thickness (table 1). References of specific storage for clastic fine-grained sediments, such as those that comprise the ICU, are sparse. However, Neuman and Witherspoon (1969b) reference a comprehensive study of core samples, varying in texture from silty sands to clay and collected from several different confining units in central California, that yielded specific storage values ranging from 3×10^{-6} to 5×10^{-4} ft^{-1}. In east-central Florida, Tibbals and Grubb (1982) performed an aquifer test in Polk County that yielded an average specific storage of 1×10^{-4} ft^{-1}. Given that this value was locally determined and lies within the range of those referenced by Neuman and Witherspoon (1969b) for similarly-textured sediments, 1×10^{-4} ft^{-1} was used to calculate the times in Eq (6) for all the project sites. It should be noted, however, that because specific storage varies with effective grain size, actual values of this parameter would likely be greater in areas of east-central and northeast Florida where the ICU is comprised of a relatively high percentage of clay as compared with those areas where the unit is comprised of coarser-grained sediments or limestone.

The times documented on table 8 vary by about three orders of magnitude, from 1 to 1,595 days. Calculated times are greater than 7 days at 18 of the 29 sites but less than 1 month at 19 sites. Lowest times were calculated for sites in Lake County within the Lake Wales Ridge and Lake Upland physiographic regions (sites 1, 3, and 4) where the ICU is relatively thin and breached by numerous karst features. Hydraulic conductivity values calculated for these sites range from 0.012 to 0.034 ft/d as compared to a median value of 0.0027 ft/d for all 29 sites. In contrast, largest times were calculated for sites in northeast Florida (sites 28 and 29) where the ICU is thickest, followed by two sites (2 and 10) located in areas of UFA discharge where the simulated vertical hydraulic conductivity of the ICU is relatively low.

The time required for storage effects in the ICU to become negligible is most sensitive to unit thickness. Regionally, and based solely on variations in regionally-mapped ICU thickness, calculated timeframes range from less than 1 month in parts of Alachua, Brevard, Volusia, Lake, Marion, and Orange Counties, where ICU thickness is less than 50 feet, to greater than 2 years in Nassua County and parts of Duval, Baker, and St. Lucie Counties where ICU thickness is greater than 300 feet (fig. 27). Values of specific storage and vertical hydraulic conductivity used in these calculations were assumed constant at 1×10^{-4} ft^{-1} (Tibbals and Grubb, 1982) and 3×10^{-3} feet per day (median value for the project sites), respectively.



Base modified from U.S. Geological Survey digital data; 1:100,000, 1985
Universal Transverse Mercator projection, zone 17

Figure 27. Thickness of the intermediate confining unit and the time required for water released from storage to become negligible (thickness contours from Sepúlveda, 2002).

Table 8. Time required for storage effects in the intermediate confining unit to become negligible for selected hydraulic and storage parameter values.

[b', estimated thickness of ICU; K', vertical hydraulic conductivity of ICU calculated by multiplying model-calibrated leakance by the unit thickness (table1); S_s', specific storage of sediments comprising the ICU (Tibbals and Grubb, 1976); ft, feet; ft/d, feet per day; ft-1, per foot; t (days), time in days]

Site no.	Site name	b′ (ft)	K′ (ft/d)	S_s′ (ft^{-1})	t (days)
1	Lake Oliver	42	0.034	1×10^{-4}	1
2	Cocoa	90	.0009	1×10^{-4}	180
3	Smokehouse Lake	37	.013	1×10^{-4}	2
4	Mascotte	24	.012	1×10^{-4}	1
5	Charlotte Street	82	.010	1×10^{-4}	13
6	Geneva Replacement	38	.0015	1×10^{-4}	19
7	Groveland	56	.013	1×10^{-4}	5
8	Geneva Fire Station	115	.0046	1×10^{-4}	58
9	Osceola	70	.0028	1×10^{-4}	35
10	Sanford Zoo	80	.0016	1×10^{-4}	80
11	Leesburg Fire Tower	48	.013	1×10^{-4}	4
12	Snook Road	91	.0082	1×10^{-4}	20
13	Lake Daughrty	42	.0059	1×10^{-4}	6
14	Lee Airport	50	.0070	1×10^{-4}	7
15	De Leon Springs	50	.0075	1×10^{-4}	7
16	State Road 40	51	.0051	1×10^{-4}	10
17	Pierson Airport	50	.009	1×10^{-4}	6
18	West Pierson	55	.0061	1×10^{-4}	10
19	Middle Road	49	.0010	1×10^{-4}	48
20	Silver Pond	55	.0083	1×10^{-4}	7
21	Niles Road	65	.0098	1×10^{-4}	9
22	Marvin Jones Road	53	.0074	1×10^{-4}	8
23	Bulow Ruins	48	.0077	1×10^{-4}	6
24	Westside Baptist	67	.0027	1×10^{-4}	33
25	Fruitland	91	.013	1×10^{-4}	13
26	Alachua County	43	.00070	1×10^{-4}	53
27	Lake Geneva	180	.018	1×10^{-4}	36
28	Southside Fire Tower	408	.0057	1×10^{-4}	584
29	Eddy Fire Tower	322	.0013	1×10^{-4}	1,595

Limitations of Results and Suggestions for Future Studies

Uncertainty in the parameter values, particularly those assigned for K' and S_s', limit the applicability of the calculated times shown on table 8 to accurately assess when ICU storage effects may become negligible at the project sites. Because this uncertainty has implications for transient flow modeling studies that do not account for ICU storage effects, the practitioner should recognize that some areas of a regional model domain will be more adversely affected by parameter value uncertainties than others. For example, simulated results would be subject to greater error in areas where the ICU is thick and comprised of a relatively high percentage of clay than in areas where the unit is thin and comprised of coarser-grained materials. This limitation notwithstanding, the results illustrate the considerable variability in the time required to reach steady flow conditions that can exist from one site to the next.

Assumptions inherent in the analytical solution present other limitations. Because Eq (5) was developed for a constant-head boundary at the unstressed aquifer/confining unit interface, results shown on table 8 and figure 27 do not account for the effects of a subsequent head change that may occur in the unstressed aquifer. Changes in SAS heads induced by pumpage from the UFA, for example, would affect the drawdown distribution in the ICU at times greater than those calculated in Eq (6), essentially delaying, perhaps significantly, the time required to re-establish steady flow conditions (Neuman and Witherspoon, 1969b). This limitation would be of more concern in areas of high ICU leakance, where drawdown in the UFA is more likely to affect SAS water levels, than in areas of low leakance where a greater degree of hydraulic separation exists between the two aquifers.

In summary, because of the uncertainty in parameter values and the constant-head boundary condition imposed in the unstressed aquifer, the times calculated on table 8 and shown in figure 27 should be referenced with caution. Nonetheless, it does not appear that daily or weekly (or monthly, in some cases) stress periods provide adequate timeframes for negating the effects of storage in the ICU across parts of east-central and northeast Florida. Similarly, inferences made to equate changes in differentials between the SAS and UFA with proportionate changes in recharge probably should not be applied to timescales of less than 1 month.

A more rigorous analysis of these limiting assumptions is required to provide more definitive guidance in selecting transient timeframes for ground-water flow modeling applications. Site-specific multi-layered cross-sectional flow models with an active SAS could be constructed for all cluster sites to evaluate the effects of the constant-head assumption in the analytical solution. Such models could also address parameter uncertainty by using the continuous head differential records described in this study to produce calibrated estimates of S_s' and K' at each site. Given these estimates, the models could be applied to evaluate the times required for ICU storage effects to become negligible on a site-by-site basis.

Summary and Conclusions

The study area encompasses about 12,300 square miles in east-central and northeast Florida and is characterized by a wide range of hydrogeologic and physiographic conditions. The principal hydrogeologic units include the surficial aquifer system (SAS), the uppermost water-bearing unit comprised of varying proportions of sand, silt, and clay; the intermediate confining unit (ICU), a sequence of silts, clays, and sand that confines the underlying Floridan aquifer system; and the Floridan aquifer system, a sequence of highly transmissive carbonate rocks, that provides virtually all of the water used to meet the area's needs. The Floridan aquifer system is subdivided on the basis of permeability into the Upper Floridan aquifer (UFA), the middle semiconfining unit, and the Lower Floridan aquifer.

The UFA is recharged primarily by downward leakage from the SAS and is discharged by pumpage, springflow, and upward leakage to the SAS. Variations in UFA recharge rates are of interest to water-resource managers because changes in these rates affect sensitive resources subject to minimum flow and water-level restrictions such as the amount of water discharged from springs and changes in lake and wetland water levels. According to Darcy's law, changes in recharge rates from the SAS to the UFA are proportional to changes in the differentials between the aquifers. Continuous water-level data collected at 29 clustered SAS/UFA monitoring-well sites were analyzed, therefore, to evaluate temporal and spatial variations in UFA recharge rates. Twenty-four sites are located in areas of recharge to the UFA, and five sites are located in areas of discharge. Results can be applied to help calibrate ground-water flow models and to quality-assure simulated results. However, when applied to transient models that do not account for ICU storage, selected time steps/stress periods should be long enough to dissipate the effects of water released from or taken into storage by the ICU.

Descriptive statistics were developed for the 29 project sites from 2000-2004. Mean differentials ranged from -17 feet at the Sanford Zoo site to 114 feet at the Alachua County site. Largest differentials occurred at sites in northeast Florida where the ICU is thickest, whereas smallest differentials occurred at sites in east-central Florida where the ICU is thin and/or breached by collapse features. Daily values of differentials were not normally distributed about 5-year means at any of the 29 sites.

The coefficient of variation, defined as the standard deviation divided by the 5-year daily mean, was greater at sites with smaller mean differentials and smaller at sites with greater mean differentials. Similarly, sites with larger median differentials exhibited smaller percentage-based variations, expressed as the difference between the 10^{th} and 90^{th} percentile values divided by the median value, about the median than did sites with smaller median differentials. Percentage-based variations in differentials, and thus recharge, could be roughly approximated as 100 divided by the square root of the median value.

The degree to which differentials fluctuate about the 5-year daily mean is also affected by a site's proximity to pumpage. At the rurally-located Fruitland site, monthly differentials fluctuated 8 percent about the mean. At the West Pierson site, where ground-water withdrawals for freeze protection affected UFA water levels, monthly differentials fluctuated 322 percent about the mean.

Water-level differentials were analyzed for trends and for correlation with precipitation, land-surface altitude, and ICU properties. Four of the project sites having more than 10 years of record, including one site in southwest Orange County and two sites in south Lake County, exhibited significant increases in mean annual differentials. Increased differentials can be attributed to a greater decrease in UFA levels than in SAS levels which, in the absence of any corresponding trend in annual rainfall at nearby National Oceanic and Atmospheric Administration (NOAA) stations, can likely be attributed to ground-water development. Differentials at the Lake Oliver site, and thus UFA recharge, increased about 44 percent between 1974-2004.

Recharge to the UFA decreased by an average of about 18 percent at the 29 sites between 2000-2004. Given the absence of a trend in rainfall, the decline is probably due to recovery in UFA water levels resulting from reduced pumpage as the area emerged from a 3-year drought in 2001. When subtracting the effects of the 5-year trend, the differentials exhibited a well-defined and statistically significant seasonal pattern of change by calendar month of the year. Greatest differentials occurred during the drier spring months, peaking at about 8 percent above the 5-year daily mean in May, and decreasing during the wetter summer months to a low of about 4 percent below the 5-year daily mean in October. This pattern can be attributed to seasonal variations in pumpage with subsequent drawdown or recovery in UFA water levels. In contrast, differentials exceeded the 5-year daily mean in all but 2 months of 2000, the third and final year of an extended drought. The UFA received an average of about 6 percent more recharge at the project sites in 2000 as compared with the average between 2000-2004.

Project-site differentials were positively correlated with land-surface altitude. The correlation was particularly well defined for the 11 sites located within physiographic ridge areas (coefficient of determination (R^2) = 0.89). Weaker, yet statistically significant, negative correlations exist between differentials and model-calibrated leakance and thickness of the ICU.

Double-mass plots of differentials and precipitation were constructed for the Lake Oliver (1974-2004) and Mascotte (1960-2004) sites to evaluate if changes in stressors other than precipitation affected differentials over long periods of record. At Lake Oliver, increased pumpage after 1983 may have increased differentials, and thus recharge to the UFA, by about 34 percent relative to the period between 1974-1983. At the Mascotte site, dredging of the Palatlakaha River and other nearby drainage improvements in the 1960s coincided with a lowering of the water table at the site and a subsequent decrease in differentials. Based on a comparison of slopes, the UFA at the Mascotte site received an average of about 30 percent less recharge from the SAS between 1965-1970 as compared to 1961-1965.

The interrelations among differentials, precipitation, and pumpage were evaluated at the Charlotte Street site between 2000-2004. The site is located in the metropolitan Orlando area where water levels and differentials are appreciably affected by pumpage. While there was a slight increase in monthly precipitation at the nearby NOAA Sanford rainfall station, it was not significant at the 0.05 level. Pumpage near the site, however, decreased significantly from about 57 to 49 million gallons per day as the area emerged from a prolonged drought. Pumping rates were greatest in late spring and least in late summer, a pattern consistent with the seasonal trend in differentials averaged for the project sites. Differentials at Charlotte decreased by about 14 percent between 2000-2004 due to a greater increase in UFA water levels than in SAS water levels. Assuming that an increase in UFA levels would not exceed that in the SAS for a site affected solely by precipitation, the amount of increase in UFA levels that exceeds that in the SAS has to be attributed to something other than precipitation, most likely a recovery in UFA levels due to decreased pumpage.

Differentials at Charlotte are influenced by system memory of both precipitation and pumpage. While not statistically correlated with monthly precipitation at Sanford, differentials were well correlated with the 9-month moving average of precipitation. Differentials were statistically correlated with monthly pumpage, but even more so with the 2-month moving average of pumpage. The relation between differentials and the 2-month moving average of pumpage is best quantified by a polynomial function in which the increase in the differential per million gallons per day of pumpage is greater along the lower end of the pumpage scale and smaller along the higher end of the pumpage scale. In terms of UFA recharge rates, the system appeared to be closer to a steady-state condition in 2000 with higher sustained rates of pumpage than in the subsequent 4 years (2001-2004) when pumping rates were lower.

Ground-water withdrawal rates near the Charlotte Street site are affected by precipitation at Sanford. Though not correlated on a monthly basis, the two parameters were well correlated when plotting the 2-month moving average of pumpage and the 9-month moving average of precipitation. The relation was best quantified by a power function where changes in low levels of precipitation resulted in relatively large changes in pumpage, and vice versa.

An algorithm was developed that correlates monthly differentials with precipitation and pumpage while accounting for system memory. The algorithm incorporates the log term of the Cooper-Jacob nonequilibrium equation to account for the distances of the individual ground-water withdrawal points to the site. The linear relation quantified by the regressed equation is well defined ($R^2 = 0.84$) and, assuming no addition of water-supply sites or closure of existing sites, offers potential as a predictive tool for estimating water-level differentials and variations in UFA recharge rates based on changes in precipitation and pumpage.

A widely-applied analytical solution was used to estimate the time required for a pressure transient, induced by an instantaneous head change in one aquifer, to move through the ICU and re-establish steady flow conditions between the SAS and UFA. Values used in the equation for ICU thickness, equivalent vertical hydraulic conductivity, and specific storage were acquired from U.S. Geological Survey (USGS) and St. Johns River Water Management District files, published USGS ground-water flow model results, and published literature. Calculated times varied by about three orders of magnitude across the 29 project sites, from 1 day at sites in southwest Orange and south Lake Counties where the ICU is relatively thin and breached by numerous karst features, to 1,595 days in Baker County where the unit is relatively thick. Calculated times were greater than 7 days at 18 sites but less than 1 month at 19 sites. Based solely on variations in regionally-mapped ICU thickness, timeframes ranged from less than 1 month in parts of Alachua, Brevard, Volusia, Lake, Marion, and Orange Counties, to greater than 2 years in Nassau County and parts of Duval, Baker, and St. Lucie Counties.

Uncertainty in parameter values used in the analytical solution and the constant-head boundary condition imposed in the unstressed aquifer limit the application of these results. Nonetheless, it does not appear that daily or weekly (or even monthly in some cases) stress periods would provide adequate timeframes in transient flow models for negating the effects of storage in the ICU across parts of east-central and northeast Florida. Accordingly, changes in differentials between the SAS and UFA should not be equated with proportionate changes in recharge for timescales of less than 1 month.

Additional analyses are needed to better quantify the lengths of stress periods/time steps required for transient flow models that do not account for ICU storage effects. Site-specific multi-layered cross-sectional flow models with an active SAS could be constructed for all of the cluster sites to evaluate the effects of the constant-head boundary in the analytical solution. These models could also address parameter uncertainty by using the water-level differential data described in this study to produce calibrated estimates of both S_s' and K' at each site. Given these estimates, the models could be applied to evaluate the times required for ICU storage effects to become negligible on a site-by-site basis.

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Appendix A. Mean, residual, and percent change in water-level differentials at the project sites, 2000-2004.

[mean = average of daily readings for the month, in feet; residual = monthly mean - 5-year mean (2000-2004), in feet; % change = ((monthly mean – 5-year daily mean)/(5-year daily mean))x100; ID, insufficient data available for analyses (less than 50 percent of daily values). Five-year daily means are shown on table 4]

Month, year	Lake Oliver, site 1			Cocoa, site 2			Smokehouse Lake, site 3			Mascotte, site 4			Charlotte Street, site 5		
	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change
Jan-00	2.37	-0.39	-14.2	-2.67	-0.26	-10.8	1.48	-0.04	-2.6	0.62	-0.17	-22.0	33.9	0.00	0.0
Feb-00	2.43	-.33	-11.9	-2.48	-.07	-2.8	1.31	-.21	-13.8	.65	-.14	-18.0	34.1	.21	.6
Mar-00	2.66	-.10	-3.6	-1.48	.93	38.5	1.11	-.41	-27.0	.77	-.02	-3.0	35.6	1.70	5.0
Apr-00	2.78	.02	.7	-1.08	1.33	55.2	1.23	-.29	-19.1	.83	.04	5.5	36.3	2.44	7.2
May-00	2.91	.15	5.6	-.26	2.15	89.3	1.43	-.09	-5.9	.92	.13	17.0	37.5	3.59	10.6
Jun-00	ID	ID	ID	.48	2.89	120.0	1.47	-.05	-3.3	.98	.19	24.0	37.7	3.80	11.2
Jul-00	2.45	-.31	-11.4	-.52	1.89	78.3	.90	-.62	-40.8	ID	ID	ID	36.3	2.41	7.1
Aug-00	2.54	-.22	-7.9	-1.44	.97	40.4	.66	-.86	-56.6	.99	.20	25.0	36.1	2.20	6.5
Sep-00	2.37	-.39	-14.0	-1.49	.92	38.2	.82	-.70	-46.1	.92	.13	17.0	35.8	1.86	5.5
Oct-00	2.58	-.18	-6.4	-1.81	.60	24.8	1.05	-.47	-30.9	.86	.07	9.0	35.8	1.90	5.6
Nov-00	2.67	-.09	-3.1	-1.49	.92	38.1	1.34	-.18	-11.8	.84	.05	5.9	36.5	2.61	7.7
Dec-00	2.60	-.16	-5.9	-1.08	1.33	55.3	1.42	-.10	-6.6	.86	.07	9.4	36.0	2.10	6.2
Jan-01	2.62	-.14	-5.2	-.67	1.74	72.2	1.50	-.02	-1.3	.77	-.02	-2.4	35.7	1.83	5.4
Feb-01	2.59	-.17	-6.2	-.87	1.54	63.9	1.35	-.17	-11.2	.81	.02	2.6	35.3	1.39	4.1
Mar-01	2.56	-.20	-7.2	-.72	1.69	70.1	ID	ID	ID	.83	.04	4.9	35.4	1.49	4.4
Apr-01	2.56	-.20	-7.3	-.65	1.76	73.1	.97	-.55	-36.2	.94	.15	19.0	36.1	2.20	6.5
May-01	2.61	-.15	-5.5	-.69	1.72	71.4	1.28	-.24	-15.8	.99	.20	25.0	36.1	2.20	6.5
Jun-01	2.29	-.47	-16.9	-.50	1.91	79.1	1.10	-.42	-27.6	.92	.13	16.9	35.2	1.29	3.8
Jul-01	2.07	-.69	-25.1	-.93	1.48	61.4	.60	-.92	-60.5	.80	.01	1.7	34.7	.78	2.3
Aug-01	1.99	-.77	-27.9	-2.16	.25	10.3	.24	-1.28	-84.2	.78	-.01	-1.1	34.4	.47	1.4
Sep-01	2.03	-.73	-26.6	-2.18	.23	9.7	.55	-.97	-63.8	.76	-.03	-4.2	33.9	.00	.0
Oct-01	2.12	-.64	-23.3	-3.07	-.66	-27.4	1.84	.32	21.1	.54	-.25	-31.4	33.9	.00	.0
Nov-01	2.18	-.58	-21.1	-3.33	-.92	-38.3	2.09	.57	37.5	.64	-.15	-19.4	33.8	-.10	-.3
Dec-01	2.28	-.48	-17.4	-3.27	-.86	-35.6	1.89	.37	24.3	.78	-.01	-1.6	34.3	.44	1.3
Jan-02	2.20	-.56	-20.4	-2.89	-.48	-20.1	1.58	.06	4.0	.91	.12	15.2	34.3	.44	1.3
Feb-02	2.26	-.50	-18.0	-2.92	-.51	-21.0	1.39	-.13	-8.6	.89	.10	12.6	34.5	.61	1.8
Mar-02	2.27	-.49	-17.6	-2.59	-.18	-7.5	1.22	-.30	-19.7	.92	.13	16.4	35.0	1.08	3.2
Apr-02	2.29	-.47	-16.9	-1.70	.71	29.4	1.40	-.12	-7.9	.93	.14	17.7	36.0	2.07	6.1
May-02	2.45	-.31	-11.2	-.82	1.59	65.8	1.62	.10	6.6	.99	.20	25.4	37.1	3.19	9.4
Jun-02	2.33	-.43	-15.5	-.79	1.62	67.2	1.10	-.42	-27.6	.92	.13	16.9	35.7	1.80	5.3

Appendix A. Mean, residual, and percent change in water-level differentials at the project sites, 2000-2004—Continued.

[mean = average of daily readings for the month, in feet; residual = monthly mean - 5-year mean (2000-2004), in feet; % change = ((monthly mean – 5-year daily mean)/(5-year daily mean))x100; ID, insufficient data available for analyses (less than 50 percent of daily values). Five-year daily means are shown on table 4]

Month, year	Lake Oliver, site 1			Cocoa, site 2			Smokehouse Lake, site 3			Mascotte, site 4			Charlotte Street, site 5		
	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change
Jul-02	2.03	-0.73	-26.6	-1.91	0.50	20.8	0.49	-1.03	-67.8	0.73	-0.06	-8.1	33.9	0.00	0.0
Aug-02	2.14	-.62	-22.3	-2.76	-.35	-14.5	1.57	.05	3.3	.57	-.22	-27.7	33.3	-.64	-1.9
Sep-02	2.64	-.12	-4.2	-3.34	-.93	-38.5	2.63	1.11	73.0	.41	-.38	-47.7	32.2	-1.66	-4.9
Oct-02	3.05	.29	10.5	-3.11	-.70	-29.2	3.06	1.54	101.0	.52	-.27	-33.9	33.4	-.51	-1.5
Nov-02	3.24	.48	17.5	-3.14	-.73	-30.2	2.81	1.29	84.9	.60	-.19	-23.5	33.2	-.68	-2.0
Dec-02	3.31	.55	20.0	-3.45	-1.04	-43.3	2.05	.53	34.9	.80	.01	1.3	32.2	-1.73	-5.1
Jan-03	3.11	.35	12.8	-3.95	-1.54	-63.7	2.18	.66	43.4	.59	-.20	-25.9	31.8	-2.14	-6.3
Feb-03	3.14	.38	13.7	-3.76	-1.35	-55.9	2.54	1.02	67.1	.60	-.19	-24.5	32.5	-1.39	-4.1
Mar-03	3.20	.44	15.9	-3.89	-1.48	-61.4	2.28	.76	50.0	.70	-.09	-11.4	31.9	-2.03	-6.0
Apr-03	3.36	.60	21.7	ID	ID	ID	2.17	.65	42.8	.78	-.01	-1.7	32.9	-.98	-2.9
May-03	3.38	.62	22.6	ID	ID	ID	1.90	.38	25.0	.85	.06	7.2	33.7	-.17	-.5
Jun-03	3.25	.49	17.6	-3.09	-.68	-28.1	1.57	.05	3.3	.98	.19	23.8	33.2	-.71	-2.1
Jul-03	3.25	.49	17.9	-4.26	-1.85	-76.9	1.17	-.35	-23.0	ID	ID	ID	32.6	-1.25	-3.7
Aug-03	3.23	.47	16.9	-3.67	-1.26	-52.4	1.08	-.44	-29.0	.70	-.09	-11.0	31.0	-2.92	-8.6
Sep-03	3.00	.24	8.8	-4.17	-1.76	-72.9	1.74	.22	14.5	.73	-.06	-7.6	31.1	-2.78	-8.2
Oct-03	3.14	.38	13.8	-3.92	-1.51	-62.6	2.15	.63	41.5	ID	ID	ID	31.9	-2.03	-6.0
Nov-03	3.21	.45	16.3	-3.91	-1.50	-62.1	2.09	.57	37.5	ID	ID	ID	32.1	-1.76	-5.2
Dec-03	3.20	.44	15.9	-3.71	-1.30	-54.1	1.84	.32	21.1	ID	ID	ID	32.3	-1.56	-4.6
Jan-04	3.16	.40	14.4	-3.64	-1.23	-51.1	1.58	.06	4.0	ID	ID	ID	32.6	-1.32	-3.9
Feb-04	3.16	.40	14.4	-3.68	-1.27	-52.9	1.29	-.23	-15.1	ID	ID	ID	32.2	-1.70	-5.0
Mar-04	3.21	.45	16.2	-3.66	-1.25	-52.0	1.15	-.37	-24.3	ID	ID	ID	33.0	-.95	-2.8
Apr-04	3.22	.46	16.6	-2.61	-.20	-8.2	1.35	-.17	-11.2	ID	ID	ID	34.3	.41	1.2
May-04	3.30	.54	19.5	-1.80	.61	25.2	1.42	-.10	-6.6	ID	ID	ID	34.5	.58	1.7
Jun-04	3.32	.56	20.4	-1.17	1.24	51.3	1.29	-.23	-15.1	ID	ID	ID	34.6	.68	2.0
Jul-04	3.00	.24	8.8	-1.94	.47	19.7	1.20	-.32	-21.1	ID	ID	ID	33.9	.00	.0
Aug-04	2.99	.23	8.5	-2.48	-.07	-3.1	.83	-.69	-45.4	ID	ID	ID	32.0	-1.90	-5.6
Sep-04	3.14	.38	13.6	-3.36	-.95	-39.4	1.03	-.49	-32.2	ID	ID	ID	29.4	-4.47	-13.2
Oct-04	3.01	.25	9.2	-4.36	-1.95	-80.9	1.91	.39	25.7	ID	ID	ID	29.6	-4.27	-12.6
Nov-04	3.18	.42	15.3	-4.22	-1.81	-75.3	2.43	.91	59.9	ID	ID	ID	31.2	-2.71	-8.0
Dec-04	3.19	.43	15.4	-3.81	-1.40	-58.1	2.22	.70	46.1	.74	-.05	-5.7	31.4	-2.47	-7.3

Appendix A. Mean, residual, and percent change in water-level differentials at the project sites, 2000-2004—Continued.

[mean = average of daily readings for the month, in feet; residual = monthly mean - 5-year mean (2000-2004), in feet; % change = ((monthly mean – 5-year daily mean)/(5-year daily mean))x100; ID, insufficient data available for analyses (less than 50 percent of daily values). Five-year daily means are shown on table 4]

Month, year	Geneva Replacement, site 6			Groveland, site 7			Geneva Fire Station, site 8			Osceola, site 9			Sanford Zoo, site 10		
	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change
Jan-00	21.2	-0.68	-3.1	-1.35	0.06	4.6	35.7	0.46	1.3	4.74	0.33	7.3	-16.8	0.45	2.6
Feb-00	21.2	-.72	-3.3	-1.33	.08	6.0	35.7	.49	1.4	4.78	.37	8.1	-16.8	.41	2.4
Mar-00	21.9	-.02	-.1	-1.41	.00	.1	36.4	1.20	3.4	5.38	.97	21.4	-16.5	.71	4.1
Apr-00	22.5	.61	2.8	-1.46	-.05	-3.6	36.7	1.51	4.3	5.46	1.05	23.1	-17.4	-.21	-1.2
May-00	23.5	1.64	7.5	-1.48	-.07	-5.3	37.5	2.25	6.4	5.95	1.54	33.9	-17.1	.14	.8
Jun-00	23.0	1.14	5.2	-1.49	-.08	-5.4	37.7	2.50	7.1	6.19	1.78	39.3	-16.9	.29	1.7
Jul-00	22.7	.77	3.5	-1.60	-.19	-13.6	36.3	1.06	3.0	4.99	.58	12.7	-17.1	.14	.8
Aug-00	22.5	.57	2.6	-1.52	-.11	-8.0	35.9	.67	1.9	4.58	.17	3.7	-15.5	1.69	9.8
Sep-00	21.9	.04	.2	-1.59	-.18	-12.6	35.1	-.09	-.3	4.83	.42	9.3	-15.9	1.27	7.4
Oct-00	21.9	.02	.1	ID	ID	ID	34.8	-.35	-1.0	4.74	.33	7.2	-16.1	1.10	6.4
Nov-00	22.1	.22	1.0	-1.54	-.13	-9.3	35.3	.07	.2	4.68	.27	5.9	-17.2	.00	.0
Dec-00	22.0	.07	.3	-1.52	-.11	-7.5	35.3	.14	.4	4.82	.41	9.1	-17.6	-.40	-2.3
Jan-01	22.0	.09	.4	-1.50	-.09	-6.6	35.3	.14	.4	4.63	.22	4.9	-18.0	-.79	-4.6
Feb-01	21.5	-.35	-1.6	-1.50	-.09	-6.6	34.9	-.30	-.9	4.64	.23	5.1	-18.4	-1.17	-6.8
Mar-01	21.5	-.39	-1.8	-1.58	-.17	-11.8	34.9	-.30	-.8	4.41	.00	.0	-18.1	-.91	-5.3
Apr-01	21.8	-.07	-.3	-1.70	-.29	-20.4	35.2	-.04	-.1	4.41	.00	.0	-16.8	.43	2.5
May-01	22.1	.20	.9	-1.65	-.24	-17.3	35.4	.20	.6	4.98	.57	12.6	-17.3	-.14	-.8
Jun-01	21.8	-.11	-.5	-1.59	-.18	-13.1	35.1	-.14	-.4	4.41	.00	.0	-19.1	-1.86	-10.8
Jul-01	21.1	-.77	-3.5	ID	ID	ID	ID	ID	ID	4.66	.25	5.4	-18.7	-1.48	-8.6
Aug-01	21.6	-.28	-1.3	-1.47	-.06	-4.1	ID	ID	ID	4.24	-.17	-3.8	-14.9	2.25	13.1
Sep-01	22.0	.11	.5	-1.51	-.10	-7.3	35.0	-.24	-.7	4.33	-.08	-1.8	-15.1	2.15	12.5
Oct-01	21.5	-.44	-2.0	-1.27	.14	9.7	34.6	-.56	-1.6	3.87	-.54	-11.9	-16.7	.50	2.9
Nov-01	20.7	-1.16	-5.3	-1.28	.13	9.3	33.9	-1.34	-3.8	3.98	-.43	-9.4	-16.8	.45	2.6
Dec-01	20.7	-1.16	-5.3	-1.37	.04	2.9	33.8	-1.37	-3.9	3.94	-.47	-10.4	-17.0	.19	1.1
Jan-02	20.7	-1.25	-5.7	-1.43	-.02	-1.4	33.9	-1.27	-3.6	4.35	-.06	-1.3	-17.0	.15	.9
Feb-02	20.4	-1.47	-6.7	-1.48	-.07	-5.2	33.7	-1.48	-4.2	4.46	.05	1.1	-16.8	.36	2.1
Mar-02	20.9	-.96	-4.4	-1.57	-.16	-11.3	34.0	-1.23	-3.5	4.80	.39	8.6	-16.0	1.22	7.1
Apr-02	21.5	-.42	-1.9	-1.47	-.06	-4.6	34.8	-.39	-1.1	5.23	.82	18.1	-16.1	1.12	6.5
May-02	22.6	.70	3.2	-1.45	-.04	-3.1	35.8	.60	1.7	5.75	1.34	29.6	-17.3	-.09	-.5
Jun-02	22.0	.13	.6	-1.59	-.18	-12.9	34.9	-.28	-.8	5.40	.99	21.8	-18.1	-.86	-5.0

Appendix A. Mean, residual, and percent change in water-level differentials at the project sites, 2000-2004—Continued.

[mean = average of daily readings for the month, in feet; residual = monthly mean - 5-year mean (2000-2004), in feet; % change = ((monthly mean – 5-year daily mean)/(5-year daily mean))x100; ID, insufficient data available for analyses (less than 50 percent of daily values). Five-year daily means are shown on table 4]

Month, year	Geneva Replacement, site 6			Groveland, site 7			Geneva Fire Station, site 8			Osceola, site 9			Sanford Zoo, site 10		
	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change
Jul-02	22.3	0.44	2.0	-1.63	-0.22	-15.8	34.6	-0.63	-1.8	5.27	0.86	19.0	-14.9	2.34	13.6
Aug-02	22.5	.59	2.7	-1.44	-.03	-1.8	35.0	-.19	-.5	4.46	.05	1.2	-15.6	1.62	9.4
Sep-02	22.5	.64	2.9	-1.32	.09	6.4	34.9	-.27	-.8	4.07	-.34	-7.4	-16.2	1.01	5.9
Oct-02	22.7	.79	3.6	-1.33	.08	5.9	35.6	.42	1.2	3.72	-.69	-15.1	-17.2	-.02	-.1
Nov-02	22.1	.24	1.1	-1.24	.17	11.8	35.4	.19	.5	3.97	-.44	-9.8	-19.2	-1.98	-11.5
Dec-02	21.8	-.13	-.6	-1.45	-.04	-3.1	35.1	-.10	-.3	4.36	-.05	-1.1	-18.6	-1.38	-8.0
Jan-03	22.5	.61	2.8	-1.37	.04	2.5	35.6	.42	1.2	3.88	-.53	-11.6	-17.7	-.48	-2.8
Feb-03	22.1	.24	1.1	-1.35	.06	4.6	35.6	.39	1.1	3.77	-.64	-14.0	-17.4	-.22	-1.3
Mar-03	21.8	-.13	-.6	-1.39	.02	1.2	35.2	.04	.1	4.03	-.38	-8.3	-16.3	.86	5.0
Apr-03	22.0	.11	.5	-1.34	.07	4.8	35.9	.70	2.0	3.85	-.56	-12.3	-17.2	-.02	-.1
May-03	22.6	.68	3.1	-1.31	.10	7.3	36.5	1.27	3.6	4.24	-.17	-3.8	-18.0	-.83	-4.8
Jun-03	22.2	.26	1.2	-1.38	.03	2.3	36.0	.77	2.2	3.67	-.74	-16.2	-18.4	-1.17	-6.8
Jul-03	22.3	.42	1.9	-1.35	.06	4.0	36.0	.81	2.3	4.11	-.30	-6.5	-17.8	-.58	-3.4
Aug-03	22.1	.24	1.1	-1.29	.12	8.4	35.9	.70	2.0	4.71	.30	6.5	-17.3	-.07	-.4
Sep-03	21.7	-.18	-.8	-1.26	.15	10.9	35.4	.21	.6	3.48	-.93	-20.5	-18.0	-.84	-4.9
Oct-03	21.7	-.18	-.8	-1.22	.19	13.7	35.2	.00	.0	3.23	-1.18	-26.1	-18.1	-.86	-5.0
Nov-03	21.5	-.42	-1.9	-1.28	.13	8.9	35.1	-.11	-.3	3.33	-1.08	-23.8	-18.1	-.93	-5.4
Dec-03	21.3	-.57	-2.6	-1.30	.11	7.8	34.9	-.32	-.9	3.68	-.73	-16.1	-18.5	-1.26	-7.3
Jan-04	21.1	-.81	-3.7	-1.30	.11	8.0	34.8	-.42	-1.2	3.71	-.70	-15.5	-18.7	-1.48	-8.6
Feb-04	20.7	-1.25	-5.7	-1.39	.02	1.7	34.2	-.95	-2.7	3.85	-.56	-12.3	-17.6	-.41	-2.4
Mar-04	21.0	-.90	-4.1	-1.35	.06	4.1	34.5	-.74	-2.1	4.09	-.32	-7.0	-16.9	.28	1.6
Apr-04	21.7	-.18	-.8	-1.30	.11	7.8	35.3	.06	0.2	4.58	.17	3.8	-17.0	.17	1.0
May-04	22.3	.44	2.0	-1.38	.03	2.2	35.7	.46	1.3	4.88	.47	10.4	-16.6	.57	3.3
Jun-04	22.2	.33	1.5	-1.37	.04	2.6	35.6	.35	1.0	4.91	.50	11.0	-17.7	-.52	-3.0
Jul-04	22.0	.07	.3	-1.36	.05	3.9	35.5	.27	.8	4.85	.44	9.6	-16.8	.36	2.1
Aug-04	21.5	-.35	-1.6	-1.37	.04	2.8	34.5	-.67	-1.9	4.69	.28	6.1	-15.4	1.84	10.7
Sep-04	22.6	.74	3.4	-1.37	.04	2.5	34.8	-.42	-1.2	4.71	.30	6.5	-16.9	.33	1.9
Oct-04	22.5	.64	2.9	-1.19	.22	15.4	35.1	-.11	-.3	3.21	-1.20	-26.5	-17.9	-.71	-4.1
Nov-04	22.3	.39	1.8	-1.16	.25	17.6	35.2	-.05	-.1	3.01	-1.40	-30.9	-18.2	-1.05	-6.1
Dec-04	22.1	.20	.9	-1.16	.25	17.8	35.2	-.04	-.1	3.28	-1.13	-24.9	-18.5	-1.31	-7.6

Appendix A. Mean, residual, and percent change in water-level differentials at the project sites, 2000-2004—Continued.

[mean = average of daily readings for the month, in feet; residual = monthly mean - 5-year mean (2000-2004), in feet; % change = ((monthly mean – 5-year daily mean)/(5-year daily mean))x100; ID, insufficient data available for analyses (less than 50 percent of daily values). Five-year daily means are shown on table 4]

Month, year	Leesburg Fire Tower, site 11			Snook Road, site 12			Lake Daughrty, site 13			Lee Airport, site 14			De Leon Springs, site 15		
	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change
Jan-00	2.91	0.51	21.3	3.01	0.15	5.1	2.56	-0.27	-9.4	44.8	1.64	3.8	-1.9	1.55	45.3
Feb-00	2.69	.29	12.0	3.11	.25	8.8	ID	ID	ID	44.5	1.25	2.9	-1.8	1.58	46.3
Mar-00	3.00	.60	24.8	3.34	.48	16.7	2.70	-.13	-4.6	44.4	1.17	2.7	-2.2	1.24	36.4
Apr-00	2.99	.59	24.5	3.31	.45	15.7	2.32	-.51	-18.0	44.4	1.17	2.7	-2.0	1.44	42.2
May-00	3.42	1.02	42.5	3.66	.80	28.1	3.20	.37	12.9	45.1	1.86	4.3	-2.6	.84	24.7
Jun-00	3.22	.82	34.3	3.23	.37	13.1	3.34	.51	17.9	44.6	1.43	3.3	-3.2	.24	6.9
Jul-00	2.14	-.26	-11.0	2.81	-.05	-1.6	3.10	.27	9.6	44.9	1.73	4.0	-2.3	1.15	33.5
Aug-00	1.81	-.59	-24.5	2.96	.10	3.5	ID	ID	ID	46.2	3.02	7.0	-1.7	1.73	50.7
Sep-00	1.73	-.67	-27.8	2.80	-.06	-2.1	ID	ID	ID	46.1	2.94	6.8	-1.0	2.44	71.2
Oct-00	2.42	.02	1.0	2.97	.11	3.7	2.25	-.58	-20.6	45.8	2.64	6.1	-2.0	1.42	41.5
Nov-00	2.67	.27	11.1	3.12	.26	9.1	2.53	-.30	-10.6	46.2	3.02	7.0	-2.0	1.43	41.9
Dec-00	2.37	-.03	-1.3	3.00	.14	5.0	ID	ID	ID	46.7	3.46	8.0	-1.6	1.82	53.3
Jan-01	2.23	-.17	-6.9	3.07	.21	7.5	ID	ID	ID	48.6	5.44	12.6	.5	3.89	113.7
Feb-01	1.90	-.50	-20.7	3.05	.19	6.6	2.80	-.03	-1.2	45.9	2.72	6.3	-.8	2.67	78.0
Mar-01	1.78	-.62	-25.8	3.04	.18	6.4	2.57	-.26	-9.3	46.1	2.94	6.8	-.4	2.98	87.2
Apr-01	2.94	.54	22.4	3.05	.19	6.8	2.30	-.53	-18.6	46.1	2.89	6.7	-1.1	2.36	69.0
May-01	2.62	.22	9.1	3.20	.34	11.8	2.62	-.21	-7.5	45.9	2.72	6.3	-1.9	1.55	45.3
Jun-01	2.43	.03	1.2	2.85	-.01	-.3	2.45	-.38	-13.4	45.4	2.25	5.2	-2.3	1.08	31.5
Jul-01	1.74	-.66	-27.4	2.55	-.31	-11.0	2.13	-.70	-24.8	45.6	2.42	5.6	-1.0	2.46	71.8
Aug-01	1.90	-.50	-20.9	2.34	-.52	-18.2	2.05	-.78	-27.7	45.0	1.77	4.1	-1.6	1.78	52.1
Sep-01	2.81	.41	17.1	2.27	-.59	-20.7	2.10	-.73	-25.7	44.8	1.56	3.6	-2.9	.50	14.6
Oct-01	3.28	.88	36.7	2.54	-.32	-11.3	2.34	-.49	-17.3	43.0	-.22	-.5	-4.4	-.97	-28.5
Nov-01	2.85	.45	18.8	2.69	-.17	-5.9	2.32	-.51	-18.1	42.4	-.82	-1.9	-4.2	-.78	-22.8
Dec-01	2.74	.34	14.2	3.01	.15	5.1	2.55	-.28	-10.0	42.3	-.86	-2.0	-4.7	-1.29	-37.7
Jan-02	2.34	-.06	-2.6	3.02	.16	5.6	2.93	.10	3.4	43.1	-.09	-0.2	-3.1	.33	9.7
Feb-02	2.13	-.27	-11.4	3.01	.15	5.3	2.48	-.35	-12.3	42.2	-1.04	-2.4	-3.7	-.24	-6.9
Mar-02	2.07	-.33	-13.7	3.15	.29	10.2	2.62	-.21	-7.4	42.8	-.39	-.9	-3.2	.24	7.0
Apr-02	2.59	.19	7.9	3.30	.44	15.3	2.63	-.20	-7.0	42.6	-.60	-1.4	-3.9	-.48	-14.0
May-02	3.17	.77	31.9	3.47	.61	21.4	3.11	.28	9.8	43.4	.22	.5	-4.0	-.60	-17.4
Jun-02	2.30	-.10	-4.2	2.69	-.17	-5.8	2.82	-.01	-.3	43.7	.48	1.1	-3.6	-.13	-3.9

Appendix A. Mean, residual, and percent change in water-level differentials at the project sites, 2000-2004—Continued.

[mean = average of daily readings for the month, in feet; residual = monthly mean - 5-year mean (2000-2004), in feet; % change = ((monthly mean – 5-year daily mean)/(5-year daily mean))x100; ID, insufficient data available for analyses (less than 50 percent of daily values). Five-year daily means are shown on table 4]

Month, year	Leesburg Fire Tower, site 11			Snook Road, site 12			Lake Daughrty, site 13			Lee Airport, site 14			De Leon Springs, site 15		
	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change
Jul-02	2.31	-0.09	-3.7	2.51	-0.35	-12.1	2.83	0.00	-0.1	43.1	-0.13	-0.3	-3.1	0.33	9.6
Aug-02	2.46	.06	2.3	2.59	-.27	-9.3	2.79	-.04	-1.3	42.0	-1.21	-2.8	-4.0	-.57	-16.8
Sep-02	2.52	.12	4.9	2.67	-.19	-6.5	2.78	-.05	-1.6	41.5	-1.73	-4.0	-4.2	-.82	-23.9
Oct-02	2.64	.24	10.1	3.09	.23	7.9	2.96	.13	4.7	41.5	-1.68	-3.9	-4.7	-1.32	-38.5
Nov-02	2.52	.12	4.9	2.99	.13	4.5	3.14	.31	10.9	41.8	-1.38	-3.2	-4.4	-.94	-27.6
Dec-02	2.08	-.32	-13.3	2.72	-.14	-4.9	3.28	.45	15.8	42.9	-.35	-.8	-3.3	.14	4.2
Jan-03	2.52	.12	5.0	2.84	-.02	-.7	4.00	1.17	41.3	44.1	.91	2.1	-2.3	1.15	33.7
Feb-03	2.32	-.08	-3.3	2.92	.06	2.0	3.00	.17	6.1	42.0	-1.17	-2.7	-3.5	-.10	-3.0
Mar-03	2.48	.08	3.2	2.64	-.22	-7.7	2.94	.11	3.9	42.0	-1.21	-2.8	-4.2	-.75	-21.9
Apr-03	3.73	1.33	55.5	3.17	.31	10.7	3.04	.21	7.4	41.6	-1.56	-3.6	-5.0	-1.54	-45.1
May-03	3.65	1.25	52.2	3.13	.27	9.6	3.25	.42	14.8	41.7	-1.51	-3.5	-5.3	-1.86	-54.5
Jun-03	2.54	.14	5.9	2.62	-.24	-8.4	3.17	.34	12.0	41.4	-1.81	-4.2	-4.9	-1.46	-42.8
Jul-03	2.51	.11	4.4	2.44	-.42	-14.6	3.14	.31	10.9	41.5	-1.73	-4.0	-4.6	-1.16	-33.9
Aug-03	2.28	-.12	-4.8	2.37	-.49	-17.1	3.03	.20	7.1	41.2	-2.03	-4.7	-4.6	-1.20	-35.2
Sep-03	2.48	.08	3.5	2.79	-.07	-2.6	2.89	.06	2.1	41.0	-2.25	-5.2	-5.4	-1.95	-57.1
Oct-03	2.14	-.26	-10.7	2.72	-.14	-5.0	2.93	.10	3.4	40.7	-2.55	-5.9	-5.5	-2.06	-60.1
Nov-03	2.05	-.35	-14.5	2.53	-.33	-11.4	2.93	.10	3.7	40.6	-2.59	-6.0	-5.0	-1.59	-46.6
Dec-03	1.82	-.58	-24.3	2.63	-.23	-8.0	3.10	.27	9.4	41.4	-1.77	-4.1	-4.6	-1.17	-34.3
Jan-04	1.65	-.75	-31.4	2.72	-.14	-4.9	3.12	.29	10.4	41.5	-1.68	-3.9	-4.3	-.91	-26.7
Feb-04	1.30	-1.10	-45.8	2.63	-.23	-7.9	2.96	.13	4.6	41.4	-1.77	-4.1	-3.7	-.30	-8.9
Mar-04	1.41	-.99	-41.3	2.96	.10	3.4	2.97	.14	4.9	41.5	-1.73	-4.0	-3.9	-.47	-13.6
Apr-04	2.02	-.38	-16.0	3.24	.38	13.2	3.08	.25	8.9	41.7	-1.47	-3.4	-4.0	-.57	-16.6
May-04	2.26	-.14	-6.0	3.25	.39	13.8	3.25	.42	14.7	42.1	-1.08	-2.5	-3.7	-.28	-8.1
Jun-04	2.21	-.19	-8.0	2.89	.03	1.2	3.16	.33	11.7	42.8	-.39	-.9	-3.7	-.24	-6.9
Jul-04	2.09	-.31	-13.1	2.65	-.21	-7.5	2.90	.07	2.5	43.5	.35	.8	-3.0	.41	12.0
Aug-04	1.44	-.96	-40.1	2.14	-.72	-25.1	2.87	.04	1.4	43.5	.26	.6	-3.8	-.36	-10.5
Sep-04	1.84	-.56	-23.4	2.08	-.78	-27.3	2.81	-.02	-.7	41.5	-1.68	-3.9	ID	ID	ID
Oct-04	3.55	1.15	47.9	2.58	-.28	-9.8	2.68	-.15	-5.3	40.0	-3.20	-7.4	-7.6	-4.15	-121.4
Nov-04	2.61	.21	8.6	2.84	-.02	-.6	2.65	-.18	-6.4	39.7	-3.50	-8.1	-7.5	-4.13	-120.7
Dec-04	2.09	-.31	-12.8	2.75	-.11	-4.0	2.80	-.03	-1.0	39.9	-3.28	-7.6	-6.6	-3.16	-92.4

Appendix A. Mean, residual, and percent change in water-level differentials at the project sites, 2000-2004—Continued.

[mean = average of daily readings for the month, in feet; residual = monthly mean - 5-year mean (2000-2004), in feet; % change = ((monthly mean – 5-year daily mean)/(5-year daily mean))x100; ID, insufficient data available for analyses (less than 50 percent of daily values). Five-year daily means are shown on table 4]

Month, year	State Road 40, site 16			Pierson Airport, site 17			West Pierson, site 18			Middle Road, site 19			Silver Pond, site 20		
	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change
Jan-00	8.71	-2.19	-20.1	39.8	3.68	10.2	4.90	2.17	79.4	-3.2	0.09	2.8	7.20	-2.16	-23.1
Feb-00	8.70	-2.20	-20.2	38.6	2.45	6.8	4.21	1.48	54.2	-3.2	.13	3.8	7.96	-1.40	-15.0
Mar-00	8.93	-1.97	-18.1	38.5	2.42	6.7	3.67	.94	34.3	-3.1	.19	5.7	8.10	-1.26	-13.5
Apr-00	9.93	-.97	-8.9	37.4	1.34	3.7	3.77	1.04	38.2	-3.1	.18	5.6	8.16	-1.20	-12.8
May-00	10.55	-.35	-3.2	40.1	4.01	11.1	4.73	2.00	73.3	-3.1	.18	5.5	8.53	-.83	-8.9
Jun-00	10.88	-.02	-.2	40.6	4.55	12.6	4.64	1.91	70.0	-3.1	.21	6.4	8.46	-.90	-9.6
Jul-00	10.01	-.89	-8.2	38.7	2.64	7.3	3.79	1.06	38.8	-3.1	.21	6.5	8.18	-1.18	-12.6
Aug-00	9.74	-1.16	-10.6	37.9	1.81	5.0	4.91	2.18	80.0	-3.0	.27	8.3	9.73	.37	3.9
Sep-00	10.09	-.81	-7.4	36.4	.32	.9	4.02	1.29	47.2	-3.0	.27	8.3	11.02	1.66	17.7
Oct-00	9.85	-1.05	-9.6	36.5	.36	1.0	3.37	.64	23.6	-3.1	.19	5.8	10.08	.72	7.7
Nov-00	9.98	-.92	-8.4	39.4	3.29	9.1	4.21	1.48	54.3	-3.1	.20	6.0	9.85	.49	5.2
Dec-00	10.74	-.16	-1.5	43.2	7.08	19.6	6.28	3.55	130.0	-3.0	.25	7.5	12.28	2.92	31.2
Jan-01	11.86	.96	8.8	48.5	12.38	34.3	7.23	4.50	165.0	-2.9	.35	10.5	13.18	3.82	40.8
Feb-01	9.40	-1.50	-13.8	39.1	3.00	8.3	3.69	.96	35.0	-3.0	.26	7.9	10.89	1.53	16.3
Mar-01	9.61	-1.29	-11.8	ID	ID	ID	4.22	1.49	54.7	-3.0	.29	8.7	11.01	1.65	17.6
Apr-01	10.31	-.59	-5.4	38.6	2.45	6.8	4.56	1.83	67.0	-3.0	.24	7.4	11.21	1.85	19.8
May-01	10.36	-.55	-5.0	39.6	3.50	9.7	4.41	1.68	61.5	-3.0	.26	8.0	10.68	1.32	14.1
Jun-01	9.97	-.93	-8.5	38.6	2.49	6.9	4.07	1.34	49.2	-3.1	.24	7.2	10.23	.87	9.3
Jul-01	9.58	-1.32	-12.1	37.2	1.08	3.0	3.78	1.05	38.6	-3.1	.24	7.2	10.34	.98	10.5
Aug-01	9.40	-1.50	-13.8	36.6	.54	1.5	3.50	.77	28.2	-3.1	.16	4.9	9.89	.53	5.7
Sep-01	10.73	-.17	-1.6	35.3	-.83	-2.3	2.73	.00	-.1	-3.1	.18	5.6	10.31	.95	10.2
Oct-01	11.80	.90	8.3	33.4	-2.67	-7.4	1.37	-1.37	-50.0	-3.3	.01	.2	9.75	.39	4.2
Nov-01	11.18	.28	2.6	33.7	-2.42	-6.7	1.23	-1.50	-54.8	-3.3	-.05	-1.6	8.85	-.51	-5.5
Dec-01	10.97	.07	.6	34.5	-1.62	-4.5	1.61	-1.12	-40.9	-3.4	-.10	-3.1	8.85	-.51	-5.5
Jan-02	11.10	.20	1.8	38.3	2.20	6.1	4.28	1.55	56.6	-3.4	-.06	-1.9	10.04	.68	7.3
Feb-02	10.16	-.74	-6.8	34.5	-1.55	-4.3	2.14	-.59	-21.7	-3.4	-.07	-2.1	9.69	.33	3.5
Mar-02	10.80	-.10	-.9	36.1	.04	.1	3.48	.75	27.4	-3.3	-.01	-.3	9.82	.46	4.9
Apr-02	10.65	-.25	-2.3	36.1	.00	.0	2.15	-.58	-21.2	-3.2	.05	1.4	9.64	.28	3.0
May-02	11.17	.27	2.5	37.8	1.73	4.8	3.07	.34	12.4	-3.2	.06	1.8	9.82	.46	4.9
Jun-02	11.28	.38	3.5	36.4	.25	.7	2.78	.05	2.0	-3.2	.10	3.0	9.90	.54	5.8

Appendix A. Mean, residual, and percent change in water-level differentials at the project sites, 2000-2004—Continued.

[mean = average of daily readings for the month, in feet; residual = monthly mean - 5-year mean (2000-2004), in feet; % change = ((monthly mean – 5-year daily mean)/(5-year daily mean))x100; ID, insufficient data available for analyses (less than 50 percent of daily values). Five-year daily means are shown on table 4]

Month, year	State Road 40, site 16			Pierson Airport, site 17			West Pierson, site 18			Middle Road, site 19			Silver Pond, site 20		
	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change
Jul-02	12.71	1.81	16.6	34.5	-1.55	-4.3	2.92	0.19	6.9	-3.3	0.04	1.1	10.16	0.80	8.5
Aug-02	11.95	1.05	9.6	34.0	-2.13	-5.9	2.24	-.49	-17.8	-3.3	.04	1.2	9.50	.14	1.5
Sep-02	11.88	.98	9.0	33.7	-2.42	-6.7	1.77	-.96	-35.2	-3.3	-.03	-.9	8.77	-.59	-6.3
Oct-02	11.29	.39	3.6	34.3	-1.84	-5.1	1.62	-1.11	-40.8	-3.4	-.07	-2.1	8.41	-.95	-10.1
Nov-02	11.09	.19	1.7	35.3	-.79	-2.2	2.05	-.68	-24.8	-3.2	.07	2.0	8.60	-.76	-8.1
Dec-02	11.43	.53	4.9	37.0	.90	2.5	ID	ID	ID	-3.2	.07	2.0	9.54	.18	1.9
Jan-03	13.42	2.52	23.1	40.7	4.58	12.7	-1.56	-4.29	-157.0	-3.2	.07	2.0	11.58	2.22	23.7
Feb-03	11.07	.17	1.6	34.9	-1.19	-3.3	2.46	-.27	-9.8	-3.3	-.03	-.8	8.81	-.55	-5.9
Mar-03	12.01	1.11	10.2	33.2	-2.92	-8.1	1.41	-1.32	-48.4	-3.3	-.06	-1.8	9.30	-.06	-.6
Apr-03	12.52	1.62	14.9	33.9	-2.17	-6.0	1.35	-1.38	-50.6	-3.4	-.10	-3.0	9.75	.39	4.2
May-03	12.55	1.65	15.1	34.9	-1.19	-3.3	1.23	-1.50	-55.0	-3.4	-.14	-4.2	9.04	-.32	-3.4
Jun-03	12.37	1.47	13.5	34.2	-1.88	-5.2	1.43	-1.30	-47.5	-3.5	-.20	-6.1	9.15	-.21	-2.2
Jul-03	12.37	1.47	13.5	33.4	-2.67	-7.4	1.58	-1.15	-42.1	-3.5	-.21	-6.4	9.99	.63	6.7
Aug-03	13.00	2.10	19.3	ID	ID	ID	1.20	-1.53	-56.0	-3.5	-.23	-7.1	9.82	.46	4.9
Sep-03	11.95	1.05	9.6	32.5	-3.61	-10.0	.95	-1.78	-65.2	-3.5	-.26	-7.8	8.76	-.60	-6.4
Oct-03	11.72	.82	7.5	33.0	-3.10	-8.6	.89	-1.84	-67.5	-3.5	-.23	-7.0	8.62	-.74	-7.9
Nov-03	11.42	.52	4.8	33.0	-3.10	-8.6	.86	-1.87	-68.5	-3.5	-.26	-7.8	8.32	-1.04	-11.1
Dec-03	11.53	.63	5.8	35.3	-.76	-2.1	2.05	-.68	-24.9	-3.5	-.23	-7.0	8.69	-.67	-7.2
Jan-04	11.11	.21	1.9	36.1	.00	.0	2.45	-.28	-10.2	-3.5	-.21	-6.3	8.76	-.60	-6.4
Feb-04	10.68	-.22	-2.0	34.2	-1.95	-5.4	2.06	-.67	-24.5	-3.5	-.20	-6.1	8.57	-.79	-8.4
Mar-04	10.94	.04	.4	33.9	-2.20	-6.1	2.01	-.72	-26.2	-3.5	-.23	-7.1	9.09	-.27	-2.9
Apr-04	10.95	.05	.5	34.7	-1.41	-3.9	1.56	-1.17	-42.9	-3.5	-.21	-6.3	9.46	.10	1.1
May-04	10.95	.05	.5	35.2	-.90	-2.5	2.47	-.26	-9.5	-3.5	-.21	-6.4	8.89	-.47	-5.0
Jun-04	11.26	.36	3.3	35.1	-1.05	-2.9	1.95	-.78	-28.5	-3.4	-.13	-3.8	8.77	-.59	-6.3
Jul-04	10.73	-.17	-1.6	34.6	-1.48	-4.1	.96	-1.77	-65.0	-3.4	-.10	-2.9	8.62	-.74	-7.9
Aug-04	10.12	-.78	-7.2	33.6	-2.45	-6.8	1.54	-1.19	-43.6	-3.4	-.11	-3.2	8.85	-.51	-5.4
Sep-04	11.07	.17	1.6	31.9	-4.19	-11.6	.63	-2.10	-76.8	-3.4	-.14	-4.4	9.38	.02	.2
Oct-04	10.69	-.21	-1.9	31.7	-4.44	-12.3	.05	-2.68	-98.1	-3.5	-.26	-7.9	8.42	-.94	-10.0
Nov-04	10.34	-.56	-5.1	32.3	-3.83	-10.6	-.22	-2.95	-108.0	-3.6	-.31	-9.3	7.71	-1.65	-17.6
Dec-04	10.28	-.62	-5.7	33.7	-2.42	-6.7	1.32	-1.41	-51.7	-3.6	-.34	-10.3	7.91	-1.45	-15.5

Appendix A. Mean, residual, and percent change in water-level differentials at the project sites, 2000-2004—Continued.

[mean = average of daily readings for the month, in feet; residual = monthly mean - 5-year mean (2000-2004), in feet; % change = ((monthly mean – 5-year daily mean)/(5-year daily mean))x100; ID, insufficient data available for analyses (less than 50 percent of daily values). Five-year daily means are shown on table 4]

Month, year	Niles Road, site 21			Marvin Jones Road, site 22			Bulow Ruins, site 23			Westside Baptist, site 24			Fruitland, site 25		
	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change
Jan-00	3.23	-1.19	-27.0	2.15	-0.09	-4.1	-6.7	-1.82	-37.0	11.9	0.14	1.2	50.2	0.15	0.3
Feb-00	3.10	-1.32	-29.8	1.83	-.41	-18.5	-6.6	-1.70	-34.7	12.5	.67	5.7	50.4	.35	.7
Mar-00	3.27	-1.15	-26.1	1.96	-.28	-12.3	-5.6	-.73	-14.9	16.7	4.92	41.7	50.1	.10	.2
Apr-00	4.12	-.30	-6.9	2.14	-.10	-4.6	-4.9	.02	.4	14.3	2.45	20.8	ID	ID	ID
May-00	4.06	-.36	-8.2	2.35	.11	4.8	-4.3	.56	11.5	14.6	2.82	23.9	ID	ID	ID
Jun-00	4.01	-.41	-9.3	1.94	-.30	-13.4	ID	ID	ID	14.4	2.60	22.0	ID	ID	ID
Jul-00	4.30	-.12	-2.8	1.80	-.44	-19.5	-5.1	-.16	-3.2	14.3	2.53	21.4	49.5	-.50	-1.0
Aug-00	4.94	.52	11.8	2.14	-.10	-4.5	-5.4	-.51	-10.4	13.1	1.30	11.0	49.9	-.10	-.2
Sep-00	6.04	1.62	36.7	2.41	.17	7.5	-5.2	-.31	-6.3	12.9	1.14	9.7	50.6	.60	1.2
Oct-00	5.28	.86	19.4	2.41	.17	7.5	-5.0	-.06	-1.2	11.6	-.22	-1.9	51.8	1.75	3.5
Nov-00	5.49	1.07	24.3	2.23	-.01	-.3	-4.7	.19	3.9	12.4	.65	5.5	51.9	1.90	3.8
Dec-00	6.05	1.63	36.8	2.60	.36	16.1	-4.7	.17	3.5	13.3	1.50	12.7	51.8	1.75	3.5
Jan-01	6.94	2.52	57.1	2.73	.49	22.0	-4.6	.35	7.1	14.2	2.44	20.7	52.0	1.95	3.9
Feb-01	6.14	1.72	39.0	2.33	.09	3.8	-4.9	.04	.8	13.9	2.11	17.9	51.2	1.20	2.4
Mar-01	6.27	1.85	41.9	2.36	.12	5.2	-4.5	.46	9.3	14.7	2.87	24.3	50.8	.80	1.6
Apr-01	6.21	1.79	40.4	2.70	.46	20.7	-3.6	1.33	27.0	17.1	5.31	45.0	50.7	.70	1.4
May-01	5.85	1.43	32.4	2.54	.30	13.2	-3.9	1.00	20.4	15.4	3.62	30.7	50.9	.90	1.8
Jun-01	6.37	1.95	44.1	1.92	-.32	-14.2	-4.9	.00	.0	14.1	2.29	19.4	50.6	.55	1.1
Jul-01	6.27	1.85	41.9	2.29	.05	2.4	-6.0	-1.12	-22.9	13.2	1.39	11.8	49.9	-.10	-.2
Aug-01	5.61	1.19	27.0	2.48	.24	10.5	-6.4	-1.44	-29.4	11.9	.09	.8	50.2	.15	.3
Sep-01	5.42	1.00	22.6	2.27	.03	1.3	-5.6	-.64	-13.1	11.1	-.71	-6.0	51.3	1.25	2.5
Oct-01	4.03	-.39	-8.9	2.16	-.08	-3.7	-4.9	.04	.9	9.7	-2.07	-17.5	52.0	2.00	4.0
Nov-01	3.84	-.58	-13.2	1.97	-.27	-11.9	-4.5	.40	8.1	10.3	-1.48	-12.5	51.4	1.35	2.7
Dec-01	3.82	-.60	-13.5	2.04	-.20	-9.1	-4.5	.44	8.9	9.5	-2.30	-19.5	51.0	.95	1.9
Jan-02	4.80	.38	8.5	2.21	-.03	-1.5	-4.5	.38	7.7	11.1	-.72	-6.1	50.8	.80	1.6
Feb-02	4.48	.06	1.3	2.18	-.06	-2.8	-4.8	.08	1.6	10.9	-.90	-7.6	50.3	.30	.6
Mar-02	4.90	.48	10.8	2.33	.09	3.9	-4.2	.73	14.8	12.3	.54	4.6	50.1	.10	.2
Apr-02	5.01	.59	13.4	2.42	.18	7.9	-3.6	1.35	27.5	15.3	3.54	30.0	50.1	.10	.2
May-02	5.39	.97	21.9	2.43	.19	8.7	-3.2	1.74	35.5	15.4	3.56	30.2	50.4	40	.8
Jun-02	5.99	1.57	35.5	1.98	-.26	-11.4	-3.7	1.24	25.3	13.6	1.78	15.1	49.9	-.10	-.2

Appendix A. Mean, residual, and percent change in water-level differentials at the project sites, 2000-2004—Continued.

[mean = average of daily readings for the month, in feet; residual = monthly mean - 5-year mean (2000-2004), in feet; % change = ((monthly mean – 5-year daily mean)/(5-year daily mean))x100; ID, insufficient data available for analyses (less than 50 percent of daily values). Five-year daily means are shown on table 4]

Month, year	Niles Road, site 21			Marvin Jones Road, site 22			Bulow Ruins, site 23			Westside Baptist, site 24			Fruitland, site 25		
	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change
Jul-02	5.51	1.09	24.7	2.46	0.22	9.9	-3.4	1.47	30.0	ID	ID	ID	49.6	-0.45	-0.9
Aug-02	4.91	.49	11.1	2.35	.11	5.1	-4.3	.61	12.4	11.2	-.61	-5.2	49.4	-.65	-1.3
Sep-02	4.12	-.30	-6.9	2.25	.01	.3	-5.5	-.58	-11.8	10.0	-1.76	-14.9	49.8	-.20	-.4
Oct-02	3.54	-.88	-19.8	2.18	-.06	-2.6	-5.6	-.71	-14.5	9.7	-2.10	-17.8	50.2	.20	.4
Nov-02	4.14	-.28	-6.4	2.32	.08	3.4	-6.1	-1.15	-23.5	9.9	-1.90	-16.1	50.1	.10	.2
Dec-02	4.63	.21	4.7	2.29	.05	2.1	-6.2	-1.33	-27.1	10.0	-1.83	-15.5	49.6	-.45	-.9
Jan-03	4.95	.53	12.1	2.72	.48	21.5	-6.0	-1.06	-21.6	9.4	-2.37	-20.1	50.1	.10	.2
Feb-03	4.23	-.19	-4.3	2.17	-.07	-3.3	-6.0	-1.14	-23.2	9.5	-2.29	-19.4	50.1	.05	.1
Mar-03	3.93	-.49	-11.0	2.15	-.09	-4.0	-4.7	.21	4.3	9.4	-2.42	-20.5	49.2	-.80	-1.6
Apr-03	3.75	-.67	-15.2	2.36	.12	5.5	-3.9	.96	19.6	13.6	1.78	15.1	50.1	.05	.1
May-03	3.89	-.53	-11.9	2.30	.06	2.9	-3.5	1.41	28.8	11.9	.13	1.1	49.9	-.10	-.2
Jun-03	4.11	-.31	-7.1	2.25	.01	.4	-4.3	.59	12.0	10.5	-1.31	-11.1	49.2	-.85	-1.7
Jul-03	4.03	-.39	-8.9	2.24	.00	-.1	-5.3	-.40	-8.1	10.4	-1.36	-11.5	48.8	-1.25	-2.5
Aug-03	3.66	-.76	-17.2	2.20	-.04	-1.7	-5.5	-.56	-11.5	9.0	-2.84	-24.1	49.2	-.80	-1.6
Sep-03	2.78	-1.64	-37.2	2.09	-.15	-6.9	-6.3	-1.39	-28.3	7.5	-4.27	-36.2	49.3	-.70	-1.4
Oct-03	2.89	-1.53	-34.6	2.08	-.16	-7.3	-5.8	-.88	-18.0	8.5	-3.34	-28.3	49.1	-.95	-1.9
Nov-03	2.86	-1.56	-35.2	2.15	-.09	-3.9	-4.9	-.03	-.6	8.7	-3.12	-26.4	48.7	-1.30	-2.6
Dec-03	3.31	-1.11	-25.2	2.17	-.07	-3.0	-4.9	-.04	-.8	9.0	-2.84	-24.1	48.7	-1.35	-2.7
Jan-04	3.39	-1.03	-23.4	2.26	.02	1.1	-5.4	-.53	-10.8	9.6	-2.16	-18.3	48.6	-1.45	-2.9
Feb-04	3.78	-.64	-14.4	2.06	-.18	-8.1	-5.2	-.26	-5.2	9.5	-2.29	-19.4	48.0	-2.00	-4.0
Mar-04	3.77	-.65	-14.7	2.33	.09	4.2	-4.7	.22	4.4	12.2	.35	3.0	48.4	-1.65	-3.3
Apr-04	4.16	-.26	-5.8	2.50	.26	11.4	-3.8	1.09	22.1	16.7	4.89	41.4	49.8	-.25	-.5
May-04	4.21	-.21	-4.8	2.32	.08	3.5	-3.6	1.30	26.5	13.6	1.76	14.9	49.6	-.45	-.9
Jun-04	4.58	.16	3.7	2.18	-.06	-2.5	-3.7	1.21	24.6	11.5	-.28	-2.4	49.3	-.70	-1.4
Jul-04	4.01	-.41	-9.3	2.30	.06	2.8	-5.1	-.17	-3.5	11.2	-.58	-4.9	49.3	-.75	-1.5
Aug-04	3.97	-.45	-10.2	2.33	.09	3.9	-4.9	.02	.4	11.2	-.57	-4.8	48.9	-1.15	-2.3
Sep-04	3.50	-.92	-20.9	2.11	-.13	-5.8	-4.1	.77	15.7	9.7	-2.10	-17.8	49.2	-.80	-1.6
Oct-04	2.36	-2.06	-46.5	2.02	-.22	-9.8	-5.0	-.07	-1.4	9.5	-2.28	-19.3	50.0	-.05	-.1
Nov-04	2.39	-2.03	-45.9	1.95	-.29	-13.0	-5.2	-.31	-6.4	10.0	-1.77	-15.0	49.7	-.30	-.6
Dec-04	2.74	-1.68	-38.1	2.01	-.23	-10.2	-5.5	-.60	-12.3	9.3	-2.47	-20.9	49.4	-.60	-1.2

Appendix A. Mean, residual, and percent change in water-level differentials at the project sites, 2000-2004—Continued.

[mean = average of daily readings for the month, in feet; residual = monthly mean - 5-year mean (2000-2004), in feet; % change = ((monthly mean – 5-year daily mean)/(5-year daily mean))x100; ID, insufficient data available for analyses (less than 50 percent of daily values). Five-year daily means are shown on table 4]

Month, year	Alachua County, site 26			Lake Geneva, site 27			Southside Fire Tower, site 28			Eddy Fire Tower, site 29		
	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change
Jan-00	110.0	-4.23	-3.7	16.3	-2.81	-14.7	15.9	-4.43	-21.8	70.1	-0.28	-0.4
Feb-00	110.7	-3.54	-3.1	16.9	-2.20	-11.5	16.1	-4.22	-20.8	70.3	-.14	-.2
Mar-00	111.8	-2.40	-2.1	ID	ID	ID	18.2	-2.09	-10.3	70.1	-.28	-.4
Apr-00	112.1	-2.06	-1.8	ID	ID	ID	19.3	-.97	-4.8	70.1	-.28	-.4
May-00	114.0	-.23	-.2	ID	ID	ID	ID	ID	ID	70.6	.21	.3
Jun-00	110.8	-3.43	-3.0	17.7	-1.38	-7.2	24.0	3.69	18.2	71.9	1.55	2.2
Jul-00	111.7	-2.51	-2.2	18.1	-.99	-5.2	23.6	3.33	16.4	72.7	2.32	3.3
Aug-00	112.1	-2.06	-1.8	18.2	-.88	-4.6	23.6	3.35	16.5	73.7	3.31	4.7
Sep-00	114.1	-.11	-.1	18.7	-.36	-1.9	21.6	1.32	6.5	73.8	3.38	4.8
Oct-00	115.3	1.14	1.0	ID	ID	ID	20.9	.63	3.1	73.0	2.60	3.7
Nov-00	114.2	.00	.0	17.4	-1.74	-9.1	20.7	.41	2.0	72.6	2.18	3.1
Dec-00	112.9	-1.26	-1.1	17.4	-1.68	-8.8	19.0	-1.32	-6.5	72.3	1.90	2.7
Jan-01	112.6	-1.60	-1.4	17.6	-1.51	-7.9	18.0	-2.33	-11.5	72.1	1.69	2.4
Feb-01	112.5	-1.71	-1.5	17.8	-1.26	-6.6	18.3	-1.97	-9.7	71.8	1.41	2.0
Mar-01	112.7	-1.48	-1.3	18.5	-.63	-3.3	19.1	-1.22	-6.0	71.5	1.06	1.5
Apr-01	115.3	1.14	1.0	18.8	-.31	-1.6	22.4	2.07	10.2	71.2	.84	1.2
May-01	115.1	.91	.8	18.8	-.34	-1.8	25.6	5.30	26.1	71.7	1.27	1.8
Jun-01	114.1	-.11	-.1	19.0	-.08	-.4	23.2	2.94	14.5	72.2	1.83	2.6
Jul-01	116.5	2.28	2.0	20.1	.97	5.1	23.2	2.90	14.3	71.9	1.48	2.1
Aug-01	117.2	2.97	2.6	20.5	1.39	7.3	22.3	1.99	9.8	71.7	1.34	1.9
Sep-01	116.3	2.06	1.8	20.5	1.36	7.1	21.2	.91	4.5	71.6	1.20	1.7
Oct-01	117.7	3.54	3.1	19.3	.15	.8	22.0	1.75	8.6	71.2	.84	1.2
Nov-01	116.7	2.51	2.2	18.8	-.31	-1.6	20.9	.57	2.8	71.0	.56	.8
Dec-01	114.9	.69	.6	18.9	-.19	-1.0	19.5	-.79	-3.9	70.6	.21	.3
Jan-02	114.3	.11	.1	19.1	-.02	-.1	18.1	-2.17	-10.7	70.7	.28	.4
Feb-02	115.1	.91	.8	19.1	.02	.1	18.1	-2.23	-11.0	70.8	.42	.6
Mar-02	115.2	1.03	.9	19.3	.19	1.0	19.7	-.63	-3.1	70.6	.21	.3
Apr-02	116.0	1.83	1.6	19.3	.25	1.3	22.8	2.46	12.1	70.8	.42	.6
May-02	116.4	2.17	1.9	19.5	.36	1.9	27.2	6.94	34.2	71.8	1.41	2.0
Jun-02	114.4	.23	.2	19.5	.40	2.1	26.0	5.70	28.1	72.6	2.18	3.1

Appendix A. Mean, residual, and percent change in water-level differentials at the project sites, 2000-2004—Continued.

[mean = average of daily readings for the month, in feet; residual = monthly mean - 5-year mean (2000-2004), in feet; % change = ((monthly mean – 5-year daily mean)/(5-year daily mean))x100; ID, insufficient data available for analyses (less than 50 percent of daily values). Five-year daily means are shown on table 4]

Month, year	Alachua County, site 26			Lake Geneva, site 27			Southside Fire Tower, site 28			Eddy Fire Tower, site 29		
	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change	Mean	Residual	% change
Jul-02	115.9	1.71	1.5	20.5	1.43	7.5	25.0	4.69	23.1	73.2	2.82	4.0
Aug-02	117.5	3.31	2.9	20.9	1.80	9.4	23.2	2.90	14.3	73.4	2.96	4.2
Sep-02	118.9	4.68	4.1	20.6	1.49	7.8	21.6	1.30	6.4	73.3	2.89	4.1
Oct-02	118.9	4.68	4.1	19.5	.38	2.0	21.8	1.52	7.5	73.1	2.75	3.9
Nov-02	116.6	2.40	2.1	20.5	1.39	7.3	19.0	-1.26	-6.2	72.7	2.25	3.2
Dec-02	116.6	2.40	2.1	20.9	1.78	9.3	16.3	-4.00	-19.7	72.0	1.62	2.3
Jan-03	116.4	2.17	1.9	20.7	1.60	8.4	15.8	-4.53	-22.3	71.5	1.13	1.6
Feb-03	116.4	2.17	1.9	20.4	1.34	7.0	15.3	-5.01	-24.7	71.2	.77	1.1
Mar-03	116.3	2.06	1.8	20.8	1.74	9.1	14.9	-5.42	-26.7	68.7	-1.69	-2.4
Apr-03	115.7	1.48	1.3	19.6	.50	2.6	17.2	-3.07	-15.1	67.0	-3.38	-4.8
May-03	115.0	.80	.7	18.9	-.19	-1.0	21.5	1.20	5.9	68.0	-2.39	-3.4
Jun-03	114.5	.34	.3	19.3	.21	1.1	20.0	-.28	-1.4	68.8	-1.62	-2.3
Jul-03	114.0	-.23	-.2	19.7	.57	3.0	20.0	-.30	-1.5	68.7	-1.69	-2.4
Aug-03	113.3	-.91	-.8	19.8	.73	3.8	17.8	-2.52	-12.4	68.4	-1.97	-2.8
Sep-03	113.1	-1.14	-1.0	19.0	-.13	-.7	19.8	-.49	-2.4	67.7	-2.75	-3.9
Oct-03	112.1	-2.06	-1.8	18.9	-.19	-1.0	19.2	-1.12	-5.5	67.7	-2.68	-3.8
Nov-03	111.7	-2.51	-2.2	18.7	-.36	-1.9	18.2	-2.09	-10.3	67.7	-2.68	-3.8
Dec-03	111.3	-2.86	-2.5	18.6	-.46	-2.4	17.3	-2.96	-14.6	67.7	-2.75	-3.9
Jan-04	110.7	-3.54	-3.1	18.7	-.44	-2.3	15.9	-4.36	-21.5	67.5	-2.89	-4.1
Feb-04	111.6	-2.63	-2.3	19.3	.25	1.3	14.9	-5.44	-26.8	67.5	-2.89	-4.1
Mar-04	113.1	-1.14	-1.0	19.4	.31	1.6	18.0	-2.29	-11.3	67.0	-3.38	-4.8
Apr-04	114.1	-.11	-.1	19.2	.13	.7	22.6	2.31	11.4	67.7	-2.68	-3.8
May-04	115.0	.80	.7	19.3	.23	1.2	25.6	5.28	26.0	68.6	-1.76	-2.5
Jun-04	113.4	-.80	-.7	19.6	.52	2.7	ID	ID	ID	70.2	-.21	-.3
Jul-04	112.7	-1.48	-1.3	19.8	.67	3.5	ID	ID	ID	70.8	.42	.6
Aug-04	113.5	-.69	-.6	19.8	.73	3.8	ID	ID	ID	71.0	.63	.9
Sep-04	114.9	.69	.6	20.3	1.17	6.1	19.5	-.79	-3.9	69.3	-1.06	-1.5
Oct-04	114.2	.00	.0	17.5	-1.62	-8.5	20.1	-.20	-1.0	65.8	-4.58	-6.5
Nov-04	109.9	-4.34	-3.8	16.4	-2.71	-14.2	19.3	-1.02	-5.0	66.0	-4.44	-6.3
Dec-04	108.8	-5.37	-4.7	16.5	-2.64	-13.8	19.4	-.85	-4.2	66.7	-3.73	-5.3

Appendix B. Amounts of water treated at municipal water treatment plants near the Charlotte Street monitoring-well cluster site, 2000-2004.

[Reported unit is gallons per day]

Water treatment plant name	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00
Heathrow	2724000	3124000	3153200	3405000	5000000	3267000	2429000	2849000	2299000	3625000	2598000	2843000
Hanover Woods	398000	454000	530300	626000	1089000	1186000	856000	845000	694000	942000	790000	649000
Markham Woods	0	0	0	0	0	0	0	0	0	0	0	0
Weathersfield	315000	338000	404000	387000	416000	363000	340000	334000	326000	396000	354000	317000
Tuskawilla	2478000	2604000	3000300	2942000	4205000	3693000	2687000	2671000	2496000	2729000	2924000	2392000
Despinar	3441000	3523000	4402000	4443000	5670000	5399000	3932000	3809000	3075000	4038000	4228000	3586000
Overstreet	122000	156000	233000	238000	394000	239000	149000	157000	139000	171000	286000	168000
Wekiva Hunt Club	5261000	5591000	6831000	6880000	8637000	7983000	6448000	6067000	5509000	6464000	6403000	5450000
W. Shenendoah Blvd.	1091000	663000	772600	722000	614000	516000	505000	568000	457000	691000	845000	649000
W. Bahama Blvd.	1200000	1039000	1135200	1114000	1451000	1319000	930000	866000	709000	1093000	1116000	1069000
Meredith Manor	307774	307138	333100	355133	417516	382133	305906	292448	278867	314774	303903	306290
Lynwood	1172000	1319000	1315800	1481000	1859000	1744000	1487000	1392000	1243000	1573000	1745000	1507000
Consumer	3585000	3912000	4441000	4970000	6788000	5195000	3744000	4645000	4442000	5126000	5406000	4545000
Consumer/Indian Hills	2534000	2643000	2582800	2787000	3092000	3149000	2884000	2837000	2618000	2572000	2449000	2162000
Greenwood Lakes	1456000	1531000	1713500	1854000	2643000	2296000	1714000	1602000	1448000	1742000	1911000	1670000
Greenwood/Country Club Estates	563000	588000	688600	708000	1307000	1323000	730000	672000	506000	665000	708000	545000
Plant no. 1	883322	899207	1166800	1268182	927871	2100000	756500	892387	977033	870000	793367	417129
Plant no. 2	728870	879758	1194900	1067133	2251355	857700	1392000	1215000	604533	1293290	1555000	1794935
Lake Mary	3409000	3138000	3991000	4196000	5016000	5378000	3898000	3855000	3840000	3892000	6094000	4585000
Howell Park	2120000	2105000	2282900	2293000	3154000	2778000	1828000	1969000	1704000	1938000	1701000	1868000
North plant	0	0	844800	0	0	0	0	0	0	0	0	0
South plant	0	0	1242400	0	0	0	0	0	0	0	0	0
Druid Hills	108258	114828	160600	137570	180097	140000	100419	111545	88400	121906	106470	11510
Apple Valley	470000	472728	614600	579963	818519	676067	508774	526129	454870	566803	593807	472123
Spring Lake, Oakland Road	2472710	2316935	2912400	2786645	3404000	3004935	2562161	2434419	2197452	3450742	3518161	3022516
San Sebastian	705387	622065	643100	1046935	1257742	1274323	1177613	882452	679323	190387	0	175355
Pearl Lake, McNeal Road	2802161	2627226	3127500	3271161	4479290	3469258	2738903	2998935	3161806	2973194	3007000	3093710
Sanford	4974000	5323000	5722700	5360000	6178000	6022000	5225000	7124000	6349000	6178000	5933000	5645000
Sanford	997000	733000	1024700	1659000	1828000	2007000	1688000	0	430000	600000	868000	758000
Thistle Lane	775000	810000	987800	1011000	1064000	901000	630000	749000	730000	827000	873000	739000
Wymore Road	0	0	26600	0	0	0	0	0	0	0	0	0
Eatonville	400000	456000	530000	590000	625000	542000	544000	509000	499000	481000	512000	530000
Grossenbacher	0	0	1341600	0	0	0	0	0	0	0	0	0
Total Mgal/d	50.77	51.66	59.35	61.95	79.14	71.15	55.69	56.41	51.17	59.02	61.17	54.30

Appendix B. Amounts of water treated at municipal water treatment plants near the Charlotte Street monitoring-well cluster site, 2000-2004—Continued.

[Reported unit is gallons per day]

Water treatment plant name	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01
Heathrow	2436000	2427000	2094000	2184000	2219000	1632000	1491000	2656000	3529000	3523000	3882000	3035000
Hanover Woods	656000	999000	1104000	1142000	1154000	850000	675000	225000	74000	358000	191000	651000
Markham Woods	0	0	0	0	0	0	0	0	0	0	0	0
Weathersfield	311000	309000	304000	346000	380000	312000	315000	334000	307000	308000	312000	311000
Tuskawilla	2316000	2286000	2571000	2958000	2984000	2344000	2292000	2379000	2141000	2497000	2504000	2769000
Despinar	3418000	3490000	3185000	3982000	4281000	3036000	3017000	2994000	2541000	3110000	3016000	3310000
Overstreet	89000	60000	90000	133000	146000	43000	26000	15000	12000	59000	59000	91000
Wekiva Hunt Club	4907000	4855000	4686000	5765000	6335000	4732000	4389000	4464000	4069000	4701000	4559000	4872000
W. Shenendoah Blvd.	630000	651000	240000	495000	458000	212000	374000	424000	327000	674000	606000	472000
W. Bahama Blvd.	1123000	1262000	1264000	1185000	1204000	1003000	949000	860000	754000	561000	587000	754000
Meredith Manor	304226	291286	287516	324233	340903	295500	283419	293065	283400	227939	288033	298758
Lynwood	1352000	1338000	1158000	1394000	1572000	1151000	1230000	1193000	1132000	1287000	1315000	1435000
Consumer	4198000	4141000	4084000	5433000	5549000	4523000	4505000	4854000	4130000	4630000	4350000	4631000
Consumer/Indian Hills	2303000	2160000	2297000	2368000	2399000	2255000	2068000	2155000	1933000	2020000	1916000	2004000
Greenwood Lakes	1549000	1486000	1389000	1256000	1894000	1450000	1479000	1495000	1448000	1687000	1708000	1530000
Greenwood/Country Club Estates	481000	731000	837000	951000	1033000	845000	759000	593000	719000	465000	448000	457000
Plant no. 1	577849	422750	475968	801500	966612	691500	471097	615633	701900	559225	693633	530935
Plant no. 2	1630645	1489214	1513645	1511283	1484193	1343665	1732322	1651548	1290300	632787	1034000	1371452
Lake Mary	4120000	3084000	3119000	4350000	5056000	4705000	4742000	4233000	2803000	3702000	3368000	4962000
Howell Park	1708000	1470000	1401000	2308000	2158000	1529000	1461000	1467000	1293000	1329000	1301000	1334000
North plant	0	0	0	0	0	0	0	0	0	0	0	0
South plant	0	0	0	0	0	0	0	0	0	0	0	0
Druid Hills	99677	97286	101777	127697	136935	90870	95287	112613	88967	89839	100373	118100
Apple Valley	475642	484964	468387	608800	613777	424950	434671	468503	390167	461426	446727	512677
Spring Lake, Oakland Road	2693871	1870714	2332161	2734800	2478419	2355867	2444871	3050645	2576155	2593419	1331871	1972129
San Sebastian	615226	733500	813032	884100	891032	785867	973935	680516	597774	704613	842355	1156000
Pearl Lake, McNeal Road	2873710	3261429	2668806	2493700	2743355	2558667	2247161	2259355	2203874	2470968	3139323	2696774
Sanford	5221000	4807000	4845000	4918000	5288000	5244000	5824000	5274000	5000000	5295000	5439000	4971000
Sanford	1011000	1232000	1266000	1580000	1407000	1111000	455000	1144000	1059000	893000	650000	1077000
Thistle Lane	713000	757000	780000	857000	864000	733000	677000	876000	736000	834000	776000	816000
Wymore Road	0	0	0	0	0	0	0	0	0	0	0	0
Eatonville	480000	374000	416000	457000	446000	390000	381000	373000	375000	406000	423000	395000
Grossenbacher	0	0	0	0	0	0	0	0	0	0	0	0
Total Mgal/d	51.60	49.83	49.19	56.90	60.00	49.88	48.68	50.43	45.72	49.60	48.36	51.81

Appendix B. Amounts of water treated at municipal water treatment plants near the Charlotte Street monitoring-well cluster site, 2000-2004—Continued.

[Reported unit is gallons per day]

Water treatment plant name	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02
Heathrow	2941000	3096000	3560000	3089000	3985000	3092000	2338000	2905000	2732000	4063000	4204000	3084000
Hanover Woods	610000	579000	640000	295000	800000	374000	185000	251000	294000	456000	344000	227000
Markham Woods	0	0	0	0	0	0	0	0	0	0	0	0
Weathersfield	294000	288000	350000	358000	427000	323000	308000	304000	304000	345000	308000	288000
Tuskawilla	2646000	2678000	2962000	2670000	3319000	2032000	1821000	1762000	1695000	2305000	2021000	1758000
Despinar	2811000	2847000	3627000	3493000	4458000	2727000	2289000	2125000	2180000	3294000	2946000	2214000
Overstreet	71000	52000	99000	145000	290000	90000	43000	23000	26000	114000	104000	42000
Wekiva Hunt Club	4469000	4625000	5446000	5753000	6852000	4565000	3887000	3875000	3995000	5408000	5033000	3982000
W. Shenendoah Blvd.	569000	507000	584000	553000	735000	405000	443000	604000	539000	750000	717000	505000
W. Bahama Blvd.	469000	497000	783000	1032000	1206000	1106000	828000	730000	713000	864000	1023000	1164000
Meredith Manor	272129	206857	238323	254700	304194	231533	194774	185355	191633	231194	223400	210581
Lynwood	1351000	1316000	1537000	1674000	1922000	1087000	1118000	1089000	1122000	1356000	1329000	1061000
Consumer	4190000	3892000	4832000	5046000	5963000	5376000	4736000	3547000	3300000	4697000	4166000	3449000
Consumer/Indian Hills	1907000	1844000	2158000	2175000	2656000	1983000	1720000	1613000	1698000	1814000	1709000	1743000
Greenwood Lakes	1092000	1052000	1689000	1899000	798000	1607000	1640000	2540000	1979000	2205000	1782000	1040000
Greenwood/Country Club Estates	384000	560000	528000	520000	2386000	452000	446000	513000	471000	499000	601000	641000
Plant no. 1	711871	1302464	1257903	1318733	1421745	1301684	1207097	1277193	1381233	1370548	1386533	1327677
Plant no. 2	1933548	993357	1324064	1305433	2149329	1205944	1119258	976483	865033	1484322	668151	509400
Lake Mary	4600000	4408000	4600000	4959000	5930000	3389000	2387000	2387000	1716000	3201000	2888000	2622000
Howell Park	1292000	1281000	1485000	1457000	1916000	1106000	1029000	1151000	1020000	1693000	2118000	1,816,800
North plant	0	0	0	0	0	0	0	0	0	0	0	0
South plant	0	0	0	0	0	0	0	0	0	0	0	0
Druid Hills	101713	97450	126773	126133	158252	111834	91423	91465	90420	128000	101824	87794
Apple Valley	457148	437193	526258	534333	690774	408133	380777	351829	399673	512529	431967	363400
Spring Lake, Oakland Road	1998194	1910129	2306097	1987129	2752526	1794548	2217613	2355871	2870300	2882645	2375633	1866968
San Sebastian	653774	723419	1027194	957000	962968	991516	443290	713806	302400	780839	522867	893613
Pearl Lake, McNeal Road	2958226	2424839	2741290	2872581	3254516	2509839	2821290	2379677	2287567	2288548	2751533	2833226
Sanford	5151000	4667000	5819000	5263000	5095000	4845000	5073000	4553000	4400000	5545000	4583000	4444000
Sanford	816000	1188000	422000	843000	1660000	1182000	742000	1351000	799000	669000	1339000	1267000
Thistle Lane	720000	772000	884000	818000	937000	680000	641000	671000	663000	806000	773000	599000
Wymore Road	0	0	0	0	0	0	0	0	0	0	0	0
Eatonville	395000	359000	354000	352000	420000	394000	370000	350000	340000	350000	323000	318000
Grossenbacher	0	0	0	0	0	0	0	0	0	0	0	0
Total Mgal/d	49.00	47.61	55.35	55.45	67.68	48.48	43.16	43.41	40.74	52.68	49.34	42.33

Appendix B. Amounts of water treated at municipal water treatment plants near the Charlotte Street monitoring-well cluster site, 2000-2004—Continued.

[Reported unit is gallons per day]

Water treatment plant name	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03	Nov-03	Dec-03
Heathrow	3628000	3579000	3016000	2048000	1648000	684000	2654000	848000	1000000	1378600	1335483	1141290
Hanover Woods	223000	252000	239000	292000	217000	169000	151000	116000	239066	231774	204677	163612
Markham Woods	0	0	0	3686000	4741000	3589000	1943000	2927000	3562633	3481709	2968161	2952677
Weathersfield	284000	284000	280000	342000	349000	312000	320000	294000	309000	296000	298000	286000
Tuskawilla	1949000	2016000	1779000	2690000	3123000	2494000	2284000	1786000	2241000	2296000	2663000	2552000
Despinar	2504000	2542000	2208000	3499000	3517000	3806000	4083000	2576000	2804000	2457000	2346000	2200000
Overstreet	54000	66000	27000	40000	240000	104000	91000	13000	74000	37000	28000	26000
Wekiva Hunt Club	4326000	4294000	4033000	5519000	5721000	4565000	3887000	3875000	4892000	5246000	5034000	4914000
W. Shenendoah Blvd.	837000	1026000	835000	910000	995000	802000	791000	690000	704000	681000	570000	508000
W. Bahama Blvd.	733000	498000	579000	748000	777000	521000	659000	818000	761000	726000	367000	381000
Meredith Manor	224484	220968	220968	247933	265742	228967	223935	199452	233067	227613	222633	193774
Lynwood	1213000	1172000	1233000	1433000	1558000	1181000	1052000	1010000	1261300	1173000	1223200	1086387
Consumer	3806000	3947000	3555000	4968000	5663000	4286000	3901000	3286000	4159200	4464096	4338000	4218741
Consumer/Indian Hills	1747000	1755000	1726000	1893000	1994000	1772000	1708000	1213000	1322533	1373064	1369100	1341838
Greenwood Lakes	1043000	1177000	1000000	1638000	1896000	1292000	1802000	1744000	1772766	1906967	1722322	1482419
Greenwood/Country Club Estates	590000	602000	567000	569000	352000	417000	427000	458000	462033	540483	461870	706838
Plant no. 1	1300871	1129428	1352900	1410200	1241315	520267	137000	525527	1485000	4545000	48333	1290322
Plant no. 2	658700	728700	499000	1357700	1751452	2037000	2465000	1874000	1501900	1332900	1259700	530000
Lake Mary	2923000	2770000	2626000	3543000	4348000	3323000	3190000	2567000	3309000	3173000	2993000	2970000
Howell Park	2047000	2600000	2619000	2062000	2174000	1376000	1317000	1205000	1459666	1367419	1333333	1240645
North plant	0	0	0	0	0	0	0	0	0	0	0	0
South plant	0	0	0	0	0	0	0	0	0	0	0	0
Druid Hills	99658	81326	81326	114863	129974	95197	102419	75571	92377	105255	95357	96603
Apple Valley	399294	363894	350000	553373	578694	430137	439126	400000	421450	437477	432153	429281
Spring Lake, Oakland Road	2674677	2266645	2311903	2675065	2991742	2569129	2194419	2517548	2618966	2697677	2724933	2558323
San Sebastian	683065	452387	530355	589226	688323	529774	576710	443065	470466	365774	241067	426710
Pearl Lake, McNeal Road	2242968	2191452	2624355	2579355	2632903	2548710	2953226	2623226	2616600	2600968	2691333	2619032
Sanford	4998000	4384000	4447000	4891000	5018000	5129000	4995000	4569000	4781000	4545000	4663000	4655000
Sanford	875000	1368000	1208000	1316000	1849000	1302000	1353000	1418000	1616000	1578000	1485000	1315000
Thistle Lane	621000	613000	595000	869000	935000	814000	848000	627806	829066	750000	685366	661903
Wymore Road	0	0	0	0	0	0	0	0	0	0	0	0
Eatonville	347000	327000	313000	367000	390000	320000	350000	356000	352000	350000	350000	350000
Grossenbacher	0	0	0	0	0	0	0	0	0	0	0	0
Total Mgal/d	45.23	44.47	42.85	55.60	61.24	50.37	49.90	43.47	50.22	53.72	47.57	46.45

Appendix B. Amounts of water treated at municipal water treatment plants near the Charlotte Street monitoring-well cluster site, 2000-2004—Continued.

[Reported unit is gallons per day]

Water treatment plant name	Jan-04	Feb-04	Mar-04	Apr-04	May-04	Jun-04	Jul-04	Aug-04	Sep-04	Oct-04	Nov-04	Dec-04
Heathrow	1236193	1138806	2875129	2030000	1745322	1504000	1489000	1422000	783000	938000	1160000	1105000
Hanover Woods	199161	616967	330225	363766	406483	339000	234000	59000	0	0	0	0
Markham Woods	2895645	2052612	1855483	3715700	4416838	3819000	3844000	2350000	2540000	3510000	4321000	3760000
Weathersfield	281000	269000	298000	332000	348000	309000	319000	296000	292000	295000	280000	311000
Tuskawilla	2793000	2698200	2654000	3412733	3479000	2855000	2732000	2220290	2127367	2419064	2675000	2950000
Despinar	2479000	2396000	3090000	3546000	3980000	3524000	3319000	2455000	2044000	2780000	3127000	3181000
Overstreet	40000	60000	105000	226000	378000	134000	81000	19000	21000	31000	55000	36000
Wekiva Hunt Club	4460000	4486000	5842000	6694000	7076000	7000000	7000000	4300000	3907000	5555000	5700000	4846000
W. Shenendoah Blvd.	294000	280000	553484	786800	825323	534900	458161	534613	340300	461613	544533	529677
W. Bahama Blvd.	566000	500000	833355	609300	624000	692000	615548	460710	612467	739419	1014333	542677
Meredith Manor	202065	190448	226452	264933	278258	258400	241613	202581	215933	191903	200000	189968
Lynwood	1159612	951193	1395161	1560900	1722483	1518000	1543000	1473000	1473000	1384000	1290000	1157000
Consumer	4174451	3912870	5180967	6624800	7354032	5787800	5648000	3889000	2437000	2801000	3798000	3619000
Consumer/Indian Hills	1326064	1225903	1568000	1891700	2007967	1831000	2022000	1793000	1649000	1760000	1831000	1812000
Greenwood Lakes	1342096	1178096	1655451	1871200	2151161	1768000	1288000	1368000	1334000	1671000	1801000	1721000
Greenwood/Country Club Estates	663806	236096	538129	836258	940870	773000	1037000	448000	355000	378000	390000	87000
Plant no. 1	1160000	1020000	660000	1258166	1250000	860000	1310000	500000	880600	650000	870000	890000
Plant no. 2	1230000	820000	2080000	1502143	1930000	1990000	1730000	98000	860000	1200000	1070000	960000
Lake Mary	2894000	2531000	3364000	4158000	4668000	4592000	3852000	3002000	2691000	3625000	3757000	3468000
Howell Park	1323548	1307100	1420968	1805300	2046419	2457333	2350323	1246129	1227667	1494194	1401333	1193871
North plant	0	0	0	0	0	0	0	0	0	0	0	0
South plant	0	0	0	0	0	0	0	0	0	0	0	0
Druid Hills	91774	83759	109539	142737	149445	103700	115845	84226	67500	97129	98233	92065
Apple Valley	448552	380466	483794	617640	687665	541383	548674	548674	326633	445000	475867	441710
Spring Lake, Oakland Road	2642097	2800517	2835548	2592067	3424935	2722567	2842387	2691968	2970800	3259452	3512400	3008581
San Sebastian	417774	320814	329710	423033	421290	443633	508000	409548	259267	442806	751467	850452
Pearl Lake, McNeal Road	2541935	2402759	2595806	3102167	2649258	3031900	2705484	2922129	2721667	2470581	2026667	2275161
Sanford	4890000	4753000	4975000	5409000	5586000	5510000	5150000	5722000	4763000	4994000	5214666	4920645
Sanford	1124000	1162000	1489000	1868000	1931000	1757000	1681000	857000	1690000	1610000	1560000	1492290
Thistle Lane	634354	602724	749483	946366	964612	888133	634000	501100	466033	583000	636066	665193
Wymore Road	0	0	0	0	0	0	0	0	0	0	0	0
Eatonville	348000	313000	326000	370000	500000	413000	389000	388000	422000	340000	264000	296000
Grossenbacher	0	0	0	0	0	0	0	0	0	0	0	0
Total Mgal/d	46.54	43.20	53.39	62.33	67.38	60.99	58.65	45.18	42.26	48.96	53.13	49.64