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PROJECTED AQUIFER DRAWDOWNS
CITY OF OCALA WELLFIELD
MARION COUNTY, FLORIDA

by

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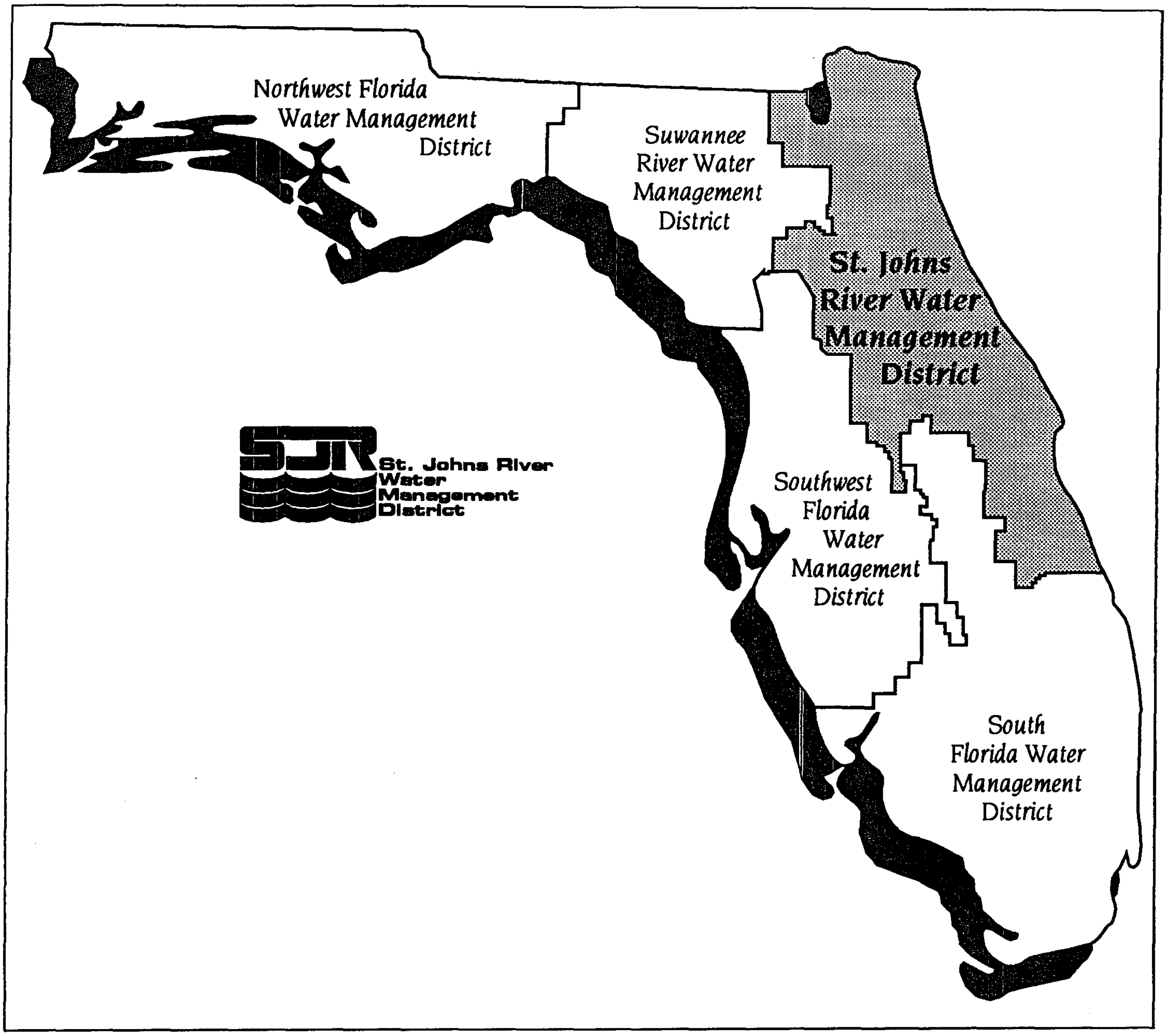

The **St. Johns River Water Management District** (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 19 counties in northeast Florida. The mission of SJRWMD is to manage water resources to ensure their continued availability while maximizing environmental and economic benefits. It accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; operation and maintenance of water control works; and land acquisition and management.

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ABSTRACT. This paper is part of an assessment of water supply needs and sources, in which the St. Johns River Water Management District has been required to identify areas expected to have inadequate water resources to meet the water supply demand in 2010. A linear analytical ground water model, DRAWDOWN, was used to simulate changes in the potentiometric surface of the Upper Floridan aquifer (UFA) based on 2010 projected pumpages at the City of Ocala wellfield. Water use is expected to increase by approximately 8 million gallons per day between 1988 and 2010. The model calculates the drawdown in a two-layered, coupled, leaky-artesian aquifer system. The method assumes homogeneous, isotropic, and steady-state conditions. In the wellfield area, UFA is unconfined. A conceptual surficial aquifer (CSA) was assumed by using a very high leakance coefficient to represent a direct hydraulic connection between the unconsolidated surficial sediments and UFA. Simulated 1988 drawdowns ranged from 0.7 to 1.2 feet (ft) for UFA and from 0.7 to 0.9 ft for CSA. Simulated 2010 drawdowns ranged from 1.5 to 2.4 ft for UFA and from 1.4 to 1.8 ft for CSA. The drawdowns at the pumping wells for CSA and UFA are almost identical. These simulated drawdowns are small because of the very high transmissivities in UFA.

Section 17-40.50(1), *Florida Administrative Code,* requires the St. Johns River Water Management District (SJRWMD) to identify "specific geographical areas that have water resource problems which have become critical or are anticipated to become critical within the next 20 years." As part of this identification, SJRWMD is assessing water supply needs and sources to determine those areas expected to have inadequate water resources to meet the projected 2010 water supply demand. Regional numerical ground water models and local analytical ground water models were used as part of this overall assessment.

The evaluation discussed here is based on the results of an analytical model, which was used to simulate the impacts associated with ground water withdrawals at the City of Ocala wellfield (Figures 1 and 2). The evaluation was used ultimately as part of the overall assessment of water supply needs and sources to arrive at the projected 2010 districtwide elevation of the potentiometric surface of the Floridan aquifer system and the elevation of the water level in the surficial aquifer system.

Within the area covered by the City of Ocala wellfield, the Upper Floridan aquifer is the primary source of water supply. The Upper Floridan aquifer in this area is composed of the Ocala Limestone from the Eocene Epoch. In most parts of northern Florida, the Hawthorn Group from the Miocene Epoch is located above the Ocala Limestone. In these areas, the Hawthorn Group serves to confine the Upper Floridan aquifer. In the area around the City of Ocala wellfield, however, the Hawthorn Group is absent and the Upper Floridan aquifer is unconfined.

The City of Ocala has five wells at its current municipal wellfield. Plans exist to develop another wellfield in the future. The exact location of the new wellfield is unknown at this time; however, the new wellfield will not be placed near the current wellfield and may not be located within SJRWMD. Approximately 78 percent of the water withdrawn at the wellfield is used for residential household use (SJRWMD 1991), 14 percent is used for commercial and industrial purposes, and 6 percent is used for water utility purposes.

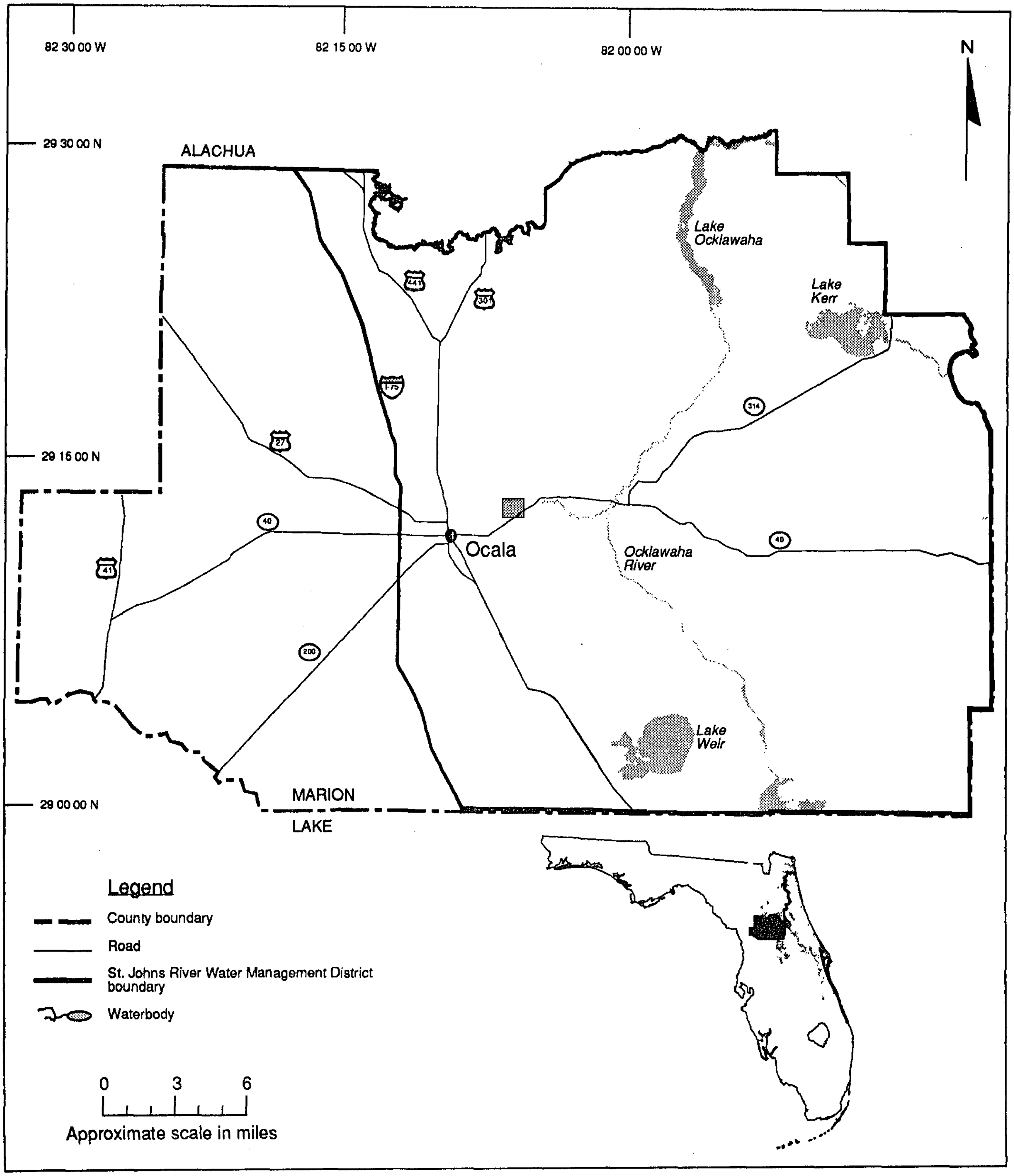

Figure 1. DRAWDOWN model domain for the City of Ocala wellfield. *Model domain is within the shaded box northeast of the City of Ocala.*

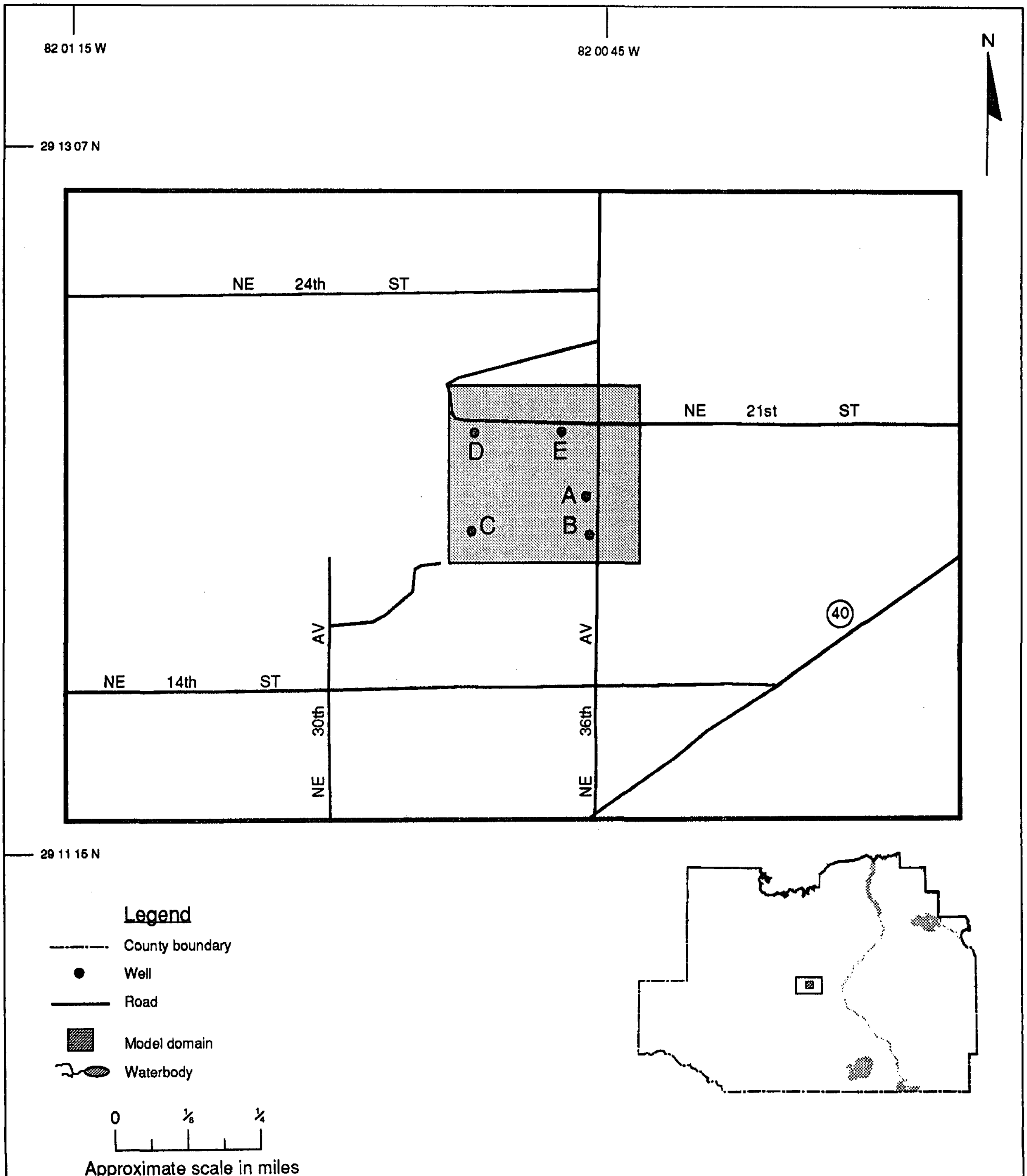

Figure 2. Model domain and well locations of the City of Ocala wellfield

METHODS

The City of Ocala wellfield was evaluated using the DRAWDOWN model (SJRWMD unpublished). The model uses a linear analytical solution to calculate the amount of drawdown in a coupled, two-layered, leaky-artesian aquifer (Motz 1981). The method assumes that homogeneous and isotropic conditions are present in the aquifer system. The model simulated steady-state conditions.

The model domain was chosen to be large enough to include the most significant drawdown in the area around the wellfield. Drawdowns actually occur beyond the extent of the model domain. The model domain, which is 2,000 feet (ft) long and 2,000 ft wide, was selected so that the wells would be approximately in the center.

The Upper Floridan aquifer is the primary source of water for the City of Ocala, and at the location of the City of Ocala wellfield, this aquifer is unconfined. In order to use the two-layer DRAWDOWN model, a conceptual surficial aquifer was assumed by using a very high leakance value to represent a direct hydraulic connection between the unconsolidated surficial sediments and the Upper Floridan aquifer. By setting up the model in this way, unconfined conditions were approximated.

Aquifer characteristics used in the model include transmissivity of the Upper Floridan and conceptual surficial aquifers, leakance, and evapotranspiration reduction (Table 1). The evapotranspiration reduction coefficient, measured in feet per day per foot, was determined using a graph from Tibbals (1990, p. E10). The evapotranspiration reduction coefficient describes the rate at which evapotranspiration is reduced per unit of water table drawdown. It is based upon a depth to the water table of 9 ft below land surface. The transmissivity of the Upper

Table 1. Aquifer characteristics used in the DRAWDOWN model, City of Ocala wellfield

Aquifer Characteristics	Value
Evapotranspiration reduction coefficient	0.0002 (ft/day)/ft
Leakance	1.25 (gpd/ft^2)/ft
Transmissivity—conceptual surficial aquifer	2,000 gpd/ft
Transmissivity—Upper Floridan aquifer	8,580,000 gpd/ft

Note: gpd = gallons per day
ft = feet

Floridan aquifer (measured in gallons per day per foot [gpd/ft]) is an average value calculated from pump tests at the City of Ocala municipal supply wells (Black, Crow and Eidsness 1969). The transmissivity of the conceptual surficial aquifer was determined using Equation 1.

$$Transmissivity = aquifer\ thickness \cdot hydraulic\ conductivity \qquad (1)$$

CH2M HILL (1991) indicated that the thickness of the surficial sediments is approximately 40 ft at the wellfield. Geologic information indicates that the surficial sediments are composed of clayey-sandy material (CH2M HILL 1991, p. 5). Based on the composition of the surficial sediments and the surficial layer thickness, a hydraulic conductivity of 50 gallons per day per square foot was used to calculate the transmissivity of the conceptual surficial aquifer (Freeze and Cherry 1979, p. 29).

Leakance, measured in gallons per day per square foot divided by feet, was calculated using Equation 2.

$$Leakance = hydraulic\ conductivity \div thickness \qquad (2)$$

The leakance value was selected to simulate a direct hydraulic connection between the unconsolidated surficial sediments and the Upper Floridan aquifer.

Well pumpage rates for 1988 and 2010, measured in million gallons per day (mgd), were used in the model (Table 2). Pumpage for each well was calculated using data from the City of Ocala Comprehensive Plan (Ocala Planning Department 1991) and Florence (1990). The average daily water use in 1988 for the City of Ocala wellfield was 8.021 mgd (Florence 1990, p. 91). Daily pump capacities were determined for

Table 2. Pumpage values used in the DRAWDOWN model, City of Ocala wellfield

Well	Latitude*	Longitude*	Calculated 1988 Pumpage (mgd)	Projected 2010 Pumpage (mgd)
A	291227	820527	2.366513	4.700160
B	291217	820527	0.414140	0.822528
C	291217	820514	0.591628	1.175040
D	291221	820514	3.986095	7.916832
E	291227	820517	0.662624	1.316045

Note: mgd = million gallons per day
*Source: SJRWMD 1991

each well (Ocala Planning Department 1991, p. IV-D-12), and the pump capacities were multiplied by the percentage of time each well was in service (City of Ocala 1992). If there was a difference between the calculated pumpage and the pumpage recorded by Florence (1990), the pumpage was multiplied by a correction factor to arrive at a total pumpage that matched the pumpage recorded by Florence (1990). The correction factor was calculated by dividing the recorded pumpage by the calculated pumpage. The final pumpages calculated for each well were used in the model (see Table 2).

The 2010 projected pumpage for this wellfield is estimated to be 16 mgd (Doug Harris, City of Ocala, pers. com. 1992). The same methodology that was previously discussed was used to calculate projected pumpages. Pump capacities taken from the City of Ocala Comprehensive Plan (1991, p. IV-D-12) were multiplied by the percentage of time each well would be in service and then by a correction factor to arrive at a total pumpage that matched the Harris projection.

RESULTS

The model calculated the drawdowns. These drawdowns are based on the assumption that all wells were pumping. In reality, however, the wells in this wellfield are never pumped 100 percent of the time. The purpose of using the model was to examine the long-term regional impacts of the wellfield. Consequently, site-specific results, which would be sensitive to the number of wells pumping and the amount of time each well was pumped, were not necessary.

The change in simulated drawdowns from 1988 to 2010 at the wells ranged from 0.8 to 1.2 ft for the Upper Floridan aquifer and from 0.6 to 0.9 ft for the conceptual surficial aquifer (Table 3). Simulated 1988 drawdowns ranged from 0.7 to 1.2 ft for the Upper Floridan aquifer and from 0.7 to 0.9 ft for the conceptual surficial aquifer. Simulated 2010 drawdowns ranged from 1.5 to 2.4 ft for the Upper Floridan aquifer and from 1.4 to 1.8 ft for the conceptual surficial aquifer.

Simulated drawdowns at the City of Ocala wellfield were contoured for 1988 and 2010 for the Upper Floridan and conceptual surficial aquifers (Figures 3-6). Differences between the drawdown in 1988 and in 2010 were contoured for the Upper Floridan and conceptual surficial aquifers (Figures 7 and 8). Figures 3-6 show the localized effect that the pumping of these wells has on the aquifer. In reality, the effect of pumping extends beyond the model domain.

Table 3. Simulated drawdowns at the City of Ocala wellfield for 1988 and 2010

Well	Simulated 1988 Drawdown (feet)		Simulated 2010 Drawdown (feet)		Drawdown Difference (feet)	
	Upper Floridan Aquifer	Conceptual Surficial Aquifer	Upper Floridan Aquifer	Conceptual Surficial Aquifer	Upper Floridan Aquifer	Conceptual Surficial Aquifer
A	1.0	0.8	2.0	1.7	1.0	0.9
B	0.7	0.7	1.5	1.4	0.8	0.7
C	0.8	0.7	1.5	1.4	0.7	0.7
D	1.2	0.9	2.4	1.8	1.2	0.7
E	0.9	0.8	1.7	1.6	0.8	0.6

DISCUSSION

The primary reason for the small simulated drawdowns is the very high transmissivities in the Upper Floridan aquifer in this area. Faulkner (1973, p. 95) stated that the Upper Floridan aquifer transmissivities in the Ocala area are on the order of 15,600,000 gpd/ft. A transmissivity of 8,580,000 gpd/ft was used in this model. The City of Ocala wellfield is located approximately 3 miles from Silver Springs, which is one of the largest springs in Florida. Because of the dominance of conduit flow in the Upper Floridan aquifer in Marion County, particularly in the vicinity of a spring as large as Silver Springs, the transmissivity values at the location of the wellfield are expected to be high.

The drawdowns at the pumping wells for the conceptual surficial and the Upper Floridan aquifers were almost identical. This indicates that leakance between the conceptual surficial and the Upper Floridan aquifers was insignificant in the model.

The simulated drawdowns for the Upper Floridan aquifer were compared to measured drawdowns from the wells during pump tests. The simulated and measured drawdowns provide a good match for most of the wells.

CONCLUSION

Based on the results of the model, pumping from the City of Ocala wellfield has little impact on the potentiometric surface of the Upper Floridan aquifer. The simulated change in the elevation of the potentiometric surface of the Upper Floridan aquifer ranged from 0.8 to 1.2 ft. The simulated change in the elevation of the water level in the conceptual surficial aquifer system ranged from 0.6 to 0.9 ft.

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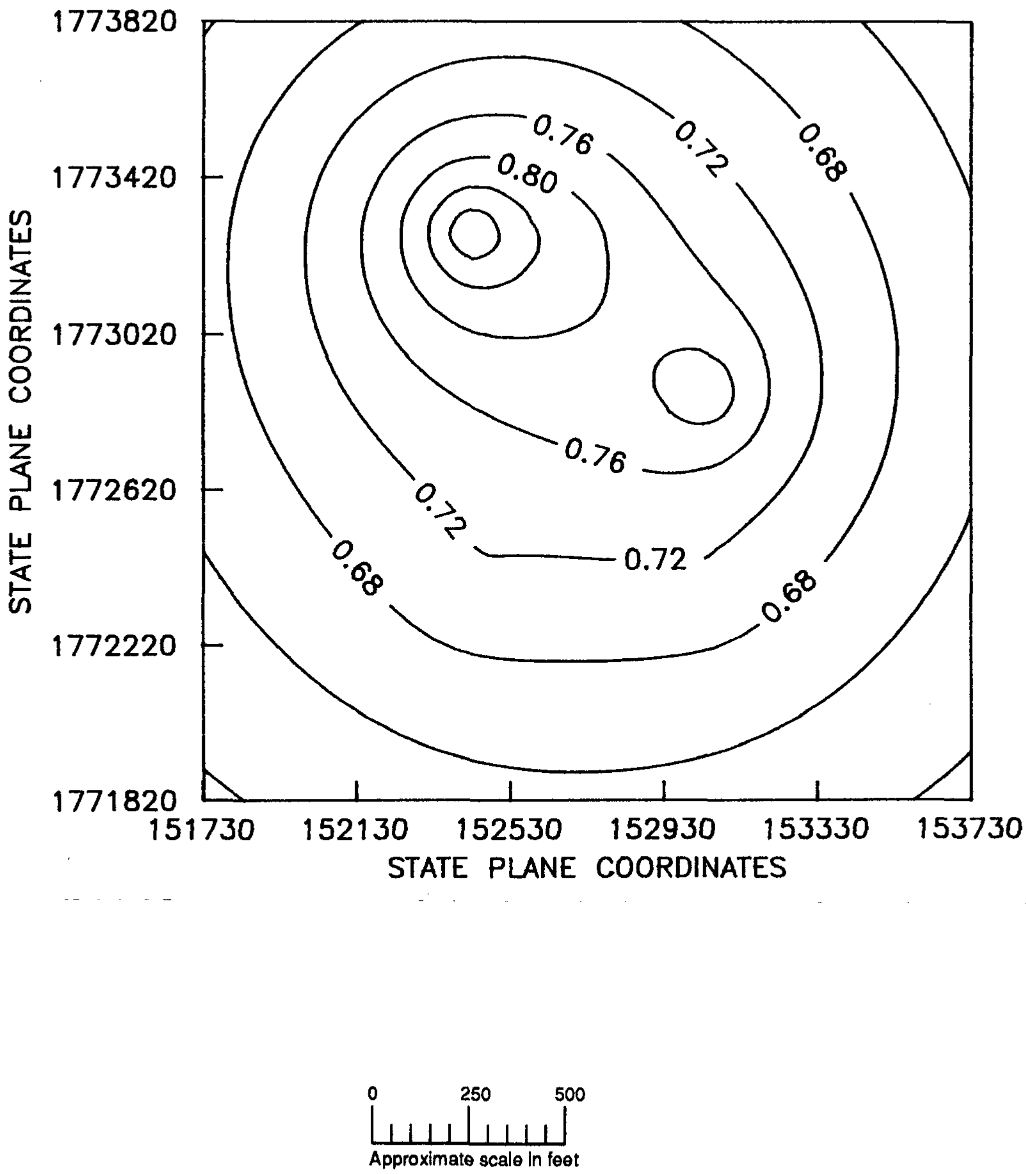


Figure 3. **Simulated 1988 drawdown for the conceptual surficial aquifer at the City of Ocala wellfield (measured in feet)**

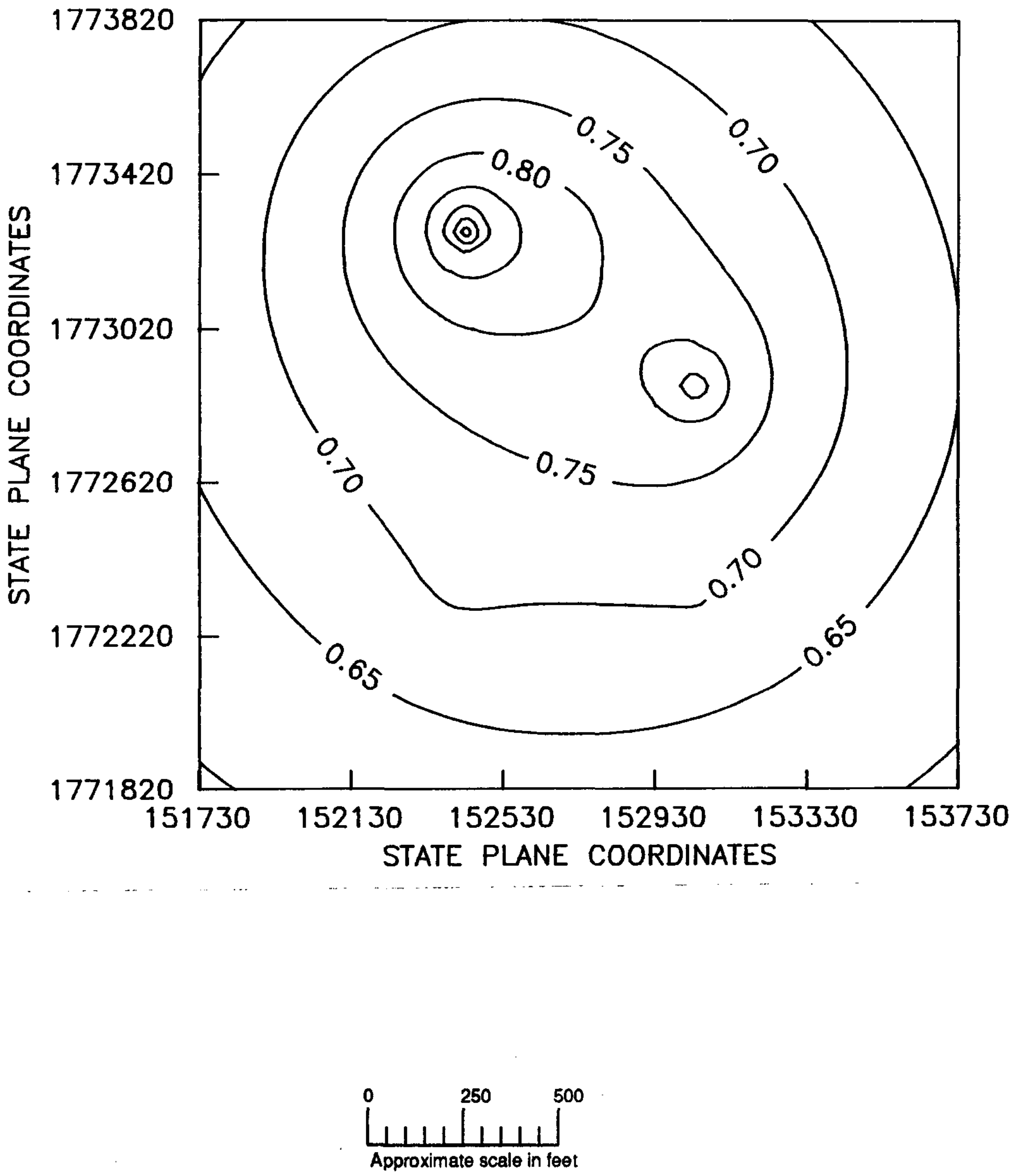


Figure 4. **Simulated 1988 drawdown for the Upper Floridan aquifer at the Ciyt of Ocala wellfield (measured in feet)**

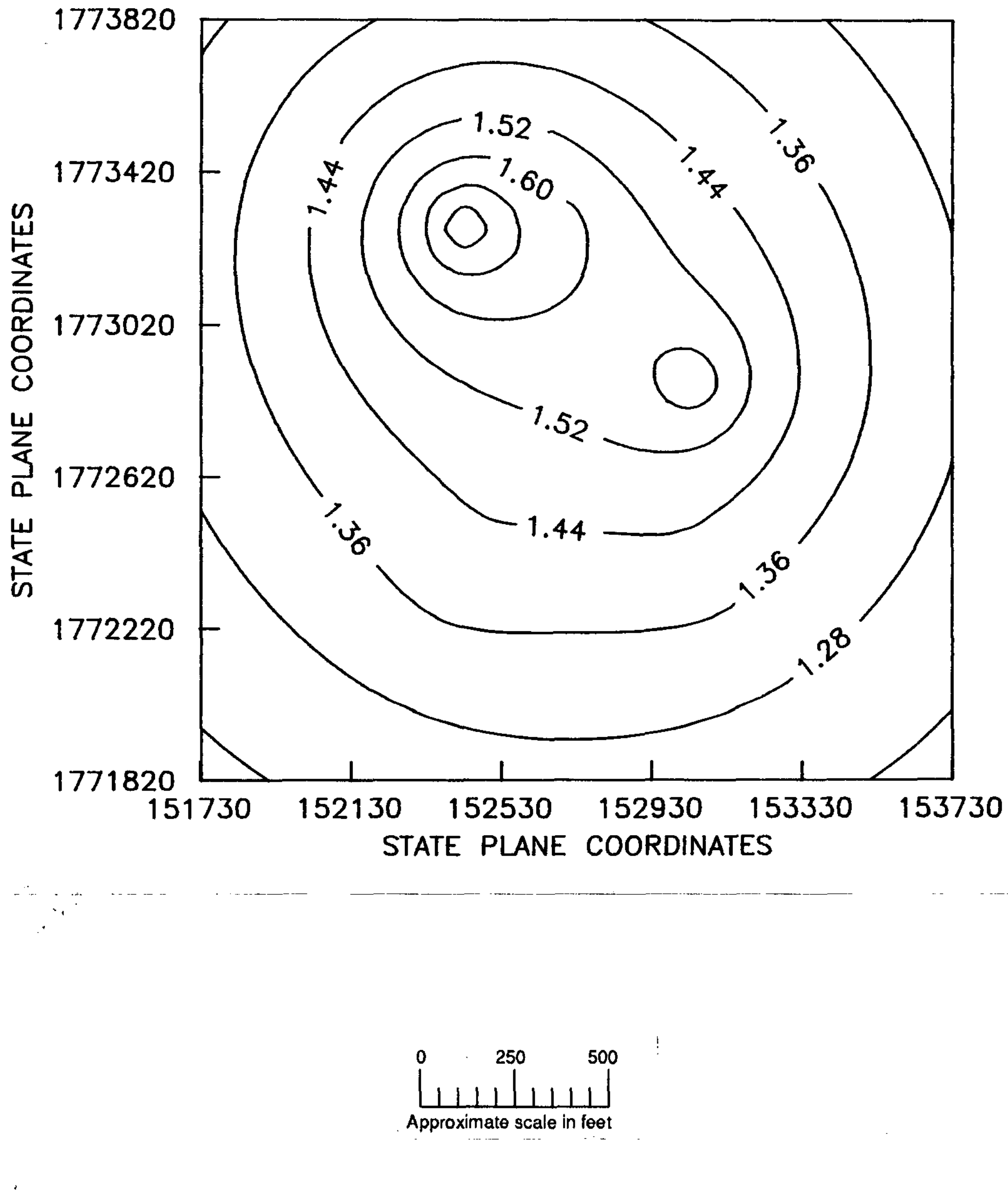
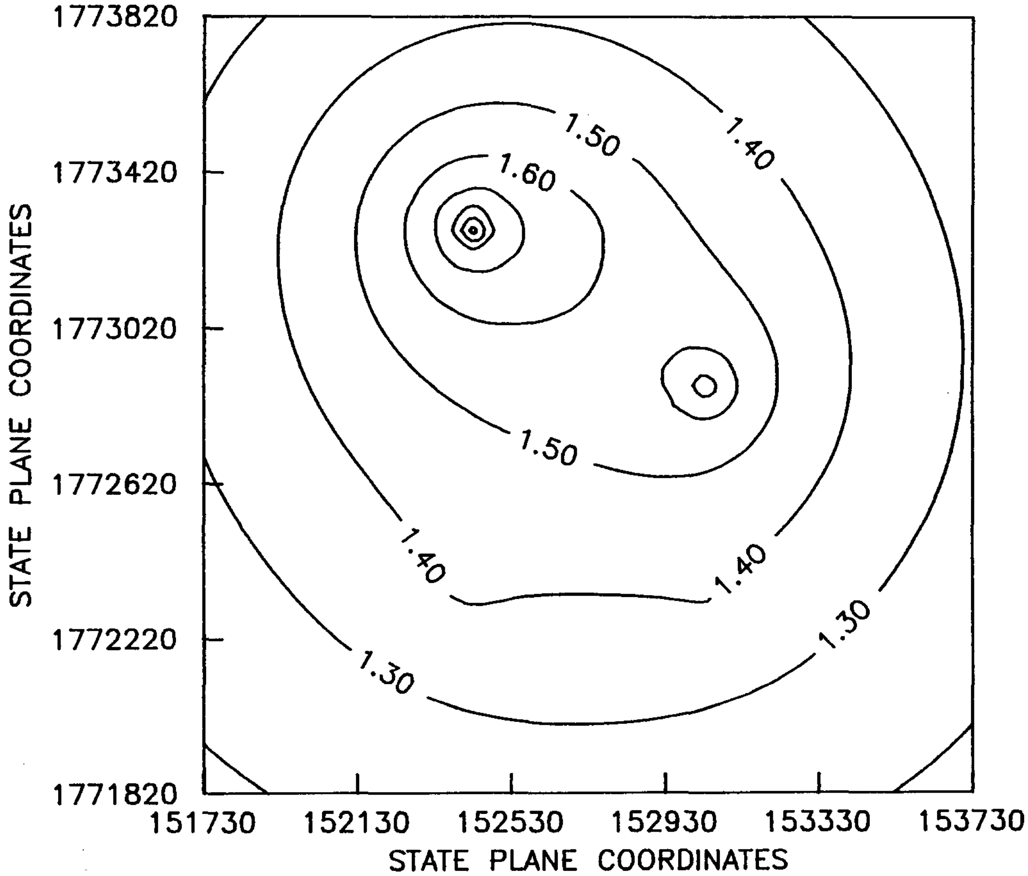


Figure 5. Simulated 2010 drawdown for the conceptual surficial aquifer at the City of Ocala wellfield (measured in feet)



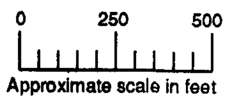


Figure 6. **Simulated 2010 drawdown for the Upper Floridan aquifer at the City of Ocala wellfield (measured in feet)**

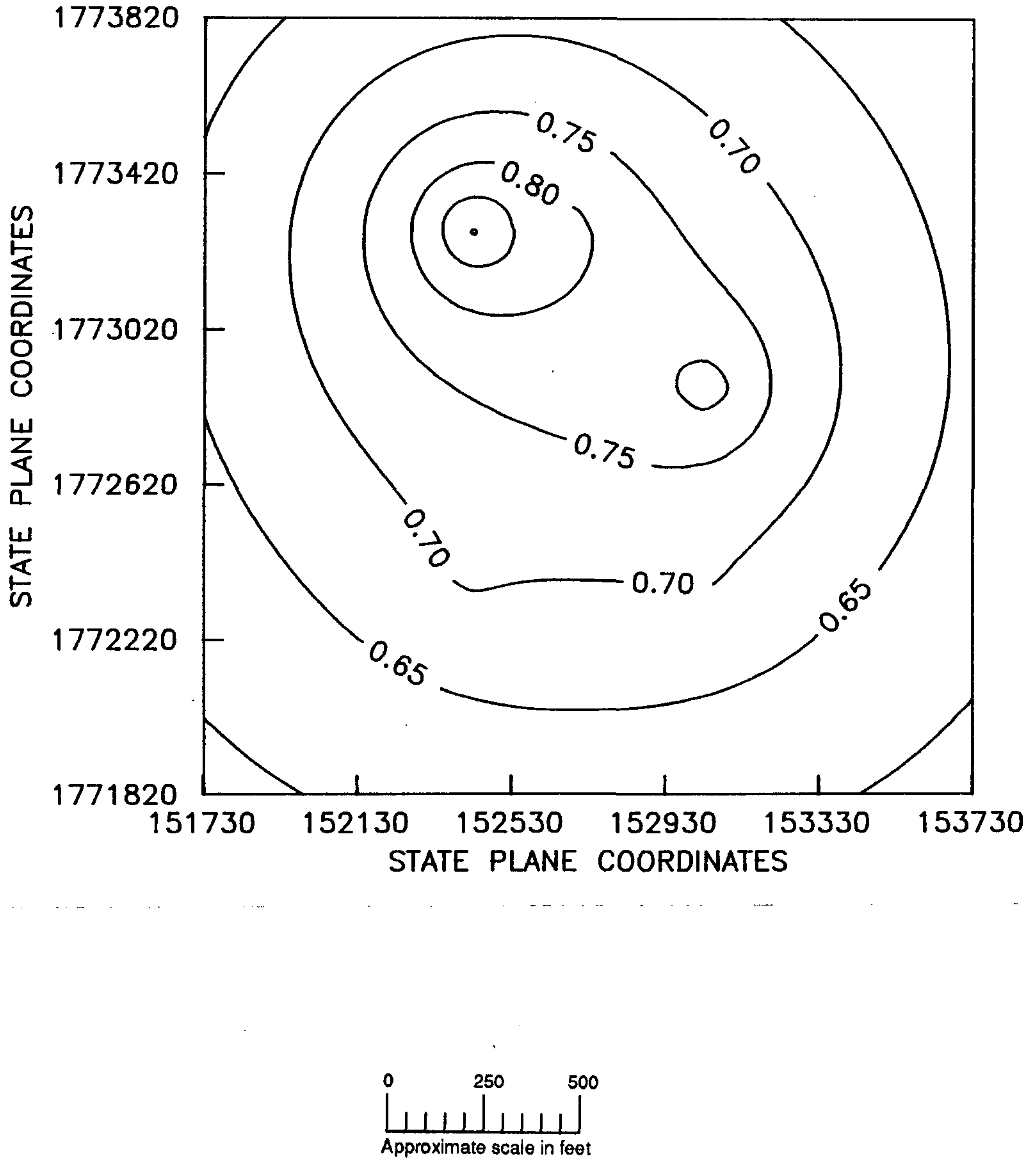


Figure 7. **Difference in simulated drawdowns between 1988 and 2010 for the conceptual surficial aquifer at the Ocala wellfield (measured in feet)**

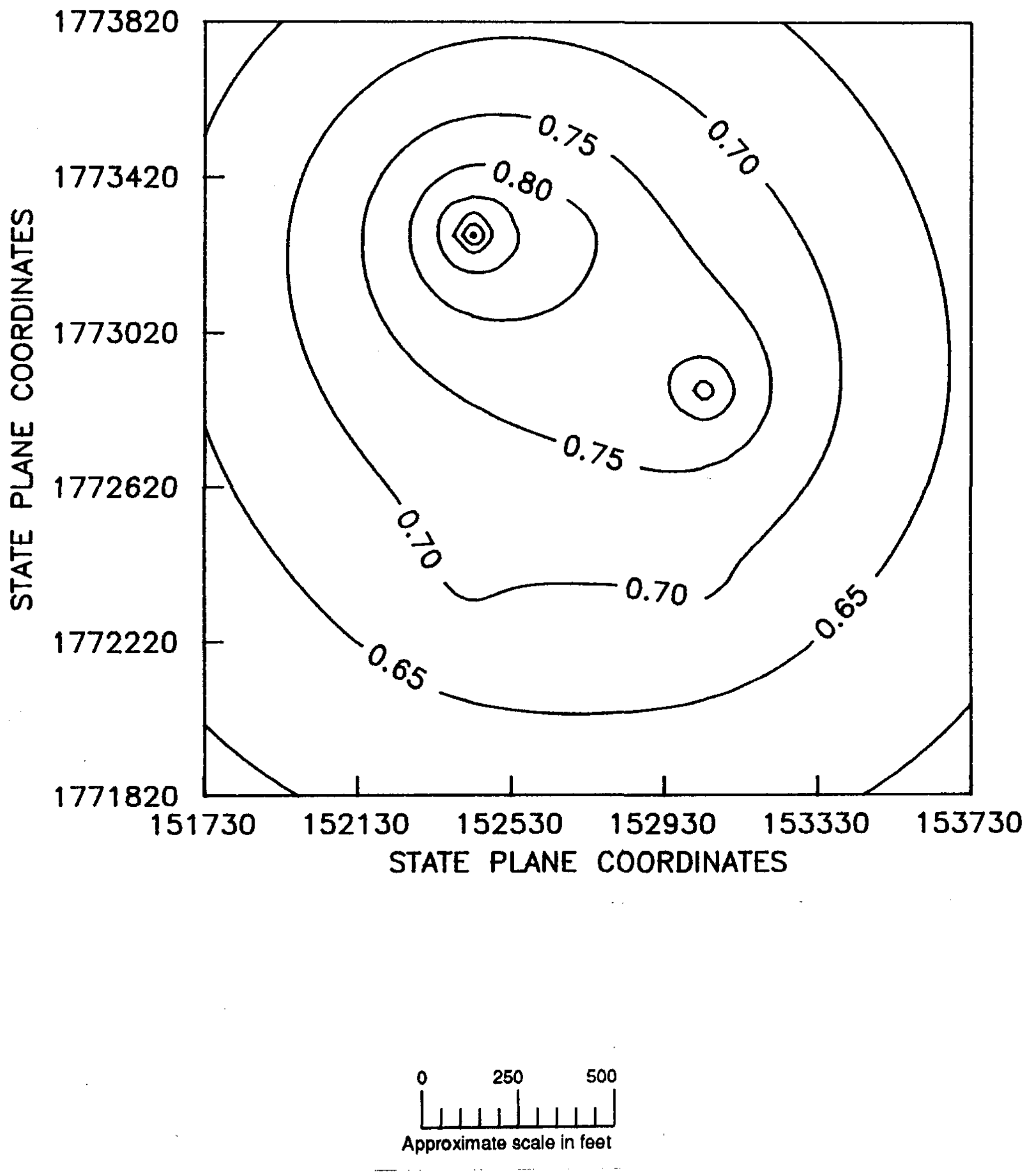


Figure 8. **Difference in simulated drawdowns between 1988 and 2010 for the Upper Floridian aquifer at the City of Ocala wellfield (measured in feet)**

CONVERSION TABLE

Multiply	By	To Obtain
foot (ft)	0.3048	meter (m)
million gallons per day (mgd)	3.785×10^3	cubic meters per day (m^3/d)
gallons per day per foot (gpd/ft)	1.242×10^{-2}	square meters per day (m^2/d)
gallons per day per square foot (gpd/ft^2)	4.075×10^{-2}	meters per day (m/d)
gallons per day per square foot per foot ([gpd/ft^2]/ft)	0.1337	meters per day per meter ([m/d]/m)
feet per day per foot ([ft/d]/ft)	1.0	meters per day per meter ([m/d]/m)