Technical Memorandum

December 1, 2008

MEMORANDUM

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THROUGH:	Mark Barcelo, P.E., Manager, Hydrologic Evaluation Section
FROM:	Ron Basso, P.G., Senior Professional Geologist, Hydrologic Evaluation Section
SUBJECT:	Predicted Groundwater Withdrawal Impacts to Chassahowitzka Springs based on Numerical Model Results

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1.0 Introduction

Chassahowitzka Springs is located in southwest Citrus County (Figure 1). The spring complex forms the headwaters of the Chassahowitzka River, which flows west to the Gulf of Mexico approximately six miles through low coastal hardwood hammock and marsh. There are as many as five springs that flow into the upper part of the river and many more springs are known to exist in the lower portion (Rosenau and others, 1977). The entire river is tidally influenced (FGS, 2001). Chassahowitzka Main Spring is 360 feet (ft) northeast of the boat ramp and is in the middle of the run. This spring is at the head of a large pool that measures 147 ft north to south and 135 ft east to west (FGS, 2001).

Prior to establishment of a Minimum Flow (MF), an evaluation of hydrologic changes in the vicinity of the spring is necessary to determine if the water body has been significantly impacted by existing groundwater withdrawals. The establishment of the MF for Chassahowitzka Springs is not part of this report. This memorandum describes the hydrogeologic setting near the spring and provides the results of a numerical model simulation of predicted spring flow change due to existing groundwater withdrawals.

2.0 Hydrogeologic Conditions

The hydrogeologic framework in the Chassahowitzka Springs area includes a surficial aquifer system, a discontinuous intermediate confining unit, and a thick carbonate Upper Floridan aquifer. At land surface and extending several tens of feet deep are generally fine-grained quartz sands that grade into clayey sand just above the contact with limestone. A thin, sometimes absent, sandy clay layer forms the intermediate confining unit (ICU) and overlies the limestone units of the Upper Floridan aquifer (UFA). In general, a regionally extensive surficial aquifer system is not present because the clay confining unit is thin, discontinuous, and breeched by numerous karst features. Because of this geology, the UFA is unconfined over most of the southwest Citrus County area.

The geologic units, in descending order, that form the freshwater portion of the UFA include the Oligocene age Suwannee Limestone, the upper Eocene age Ocala Limestone, and the middle Eocene age Avon Park Formation (Table 1). In northern Pasco and Hernando counties, the Suwannee Limestone is the uppermost unit. Further north in Citrus County, the Ocala Limestone forms the top of the Upper Floridan aquifer, except in extreme southern Levy County where the Avon Park Formation is exposed at land surface. The entire carbonate sequence of the UFA thickens and dips toward the south and southwest. Average thickness of the UFA ranges from 500 feet in southern Levy County to 1,000 feet in central Pasco County (Miller, 1986). The base of the UFA generally occurs at the first, persistent sequence of evaporitic minerals such as gypsum or anhydrite that occur as nodules or discontinuous thin layers in the carbonate matrix. This low

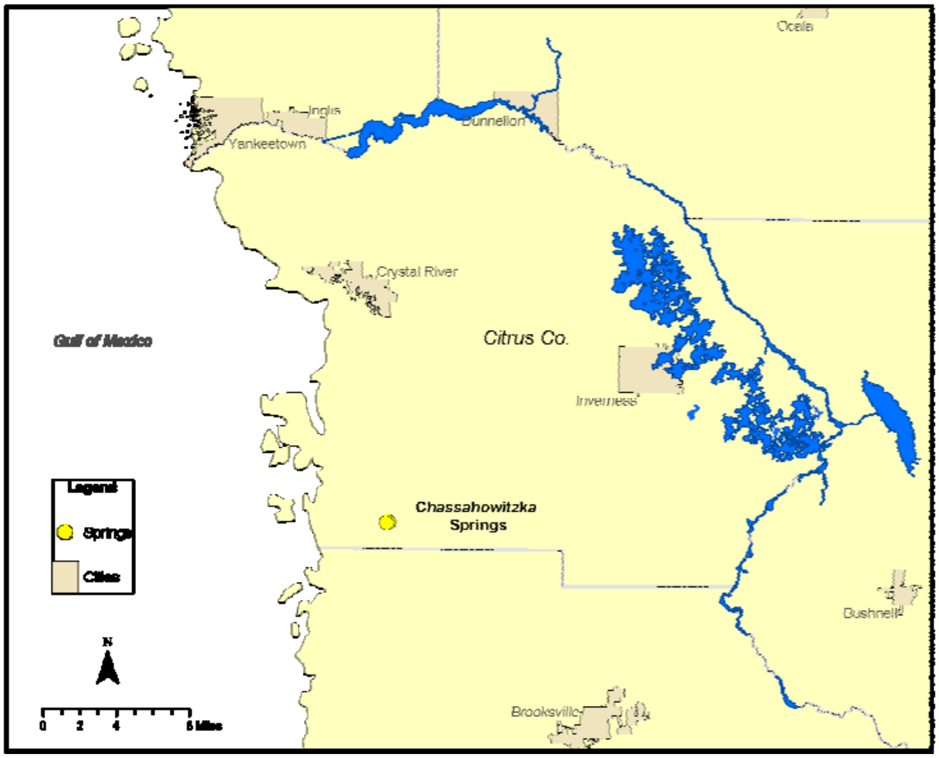

Figure 1. Location of Chassahowitzka Springs.

permeability unit is regionally extensive and is generally referred to as middle confining unit II (Miller, 1986).

In southwest Citrus County, the UFA is regionally unconfined and is located within a highly karst-dominated region. Dissolution of limestone is an active process via infiltration of rainwater because the limestone units of the UFA are close to land surface and poorly confined. Numerous sinkholes, internal drainage, and undulating topography that are typical of karst geology dominate the landscape. These active karst processes lead to enhanced permeabilities within the Floridan aquifer. The median transmissivity value of the UFA based on five aquifer performance tests in western Hernando and Citrus Counties is 210,000 ft^2/day (SWFWMD, 1999). There are three first-magnitude springs (flow greater than 100 cubic feet per second (cfs) discharge) found within this region: the Crystal River group, Homosassa, and Weeki Wachee. In addition, the highest recharge rates to the UFA occur in west-central Hernando and Citrus Counties with values ranging between 10 and 25 inches per year (Sepulveda, 2002).

The Chassahowitzka Springs basin is approximately 180 square miles in size and located in north-central Hernando and southwestern Citrus Counties (Figure 2). Knochenmus and Yobbi (2001) developed a water budget for the Chassahowitzka Springs basin for calendar years 1997 and 1998. According to their calculations:

Rainfall = 53 inches (in)/yr
Evapotranspiration = 34.5 in/yr
Springflow = 7 in/yr
Groundwater Withdrawals = 2.2 in/yr
Groundwater Outflow = 9 in/yr
Change in Storage = 0.3 in/yr

Table 1. Hydrogeology of the Chassahowitzka Springs Area (Modified from MIller,1986, Sacks and Tihansky, 1996).

<table>
<tr><th>Series</th><th>Stratigraphic Unit</th><th colspan="2">Hydrogeologic Unit</th><th>Lithology</th></tr>
<tr><td>Holocene to Pliocene</td><td>Undifferentiated Surficial Deposits</td><td colspan="2">Unsaturated Zone, Surficial Aquifer or locally perched Surficial Aquifer</td><td>Sand, silty sand, clayey sand, sandy clay, peat, and shell</td></tr>
<tr><td>Oligocene</td><td>Suwannee Limestone</td><td rowspan="2">Upper Permeable Zone</td><td rowspan="2">Upper Floridan Aquifer</td><td>Limestone,cream to tan, sandy, vuggy, fossiliferous</td></tr>
<tr><td rowspan="4">Eocene</td><td>Ocala Limestone</td><td>Limestone,white to tan, friable to micritic, fine-grained, soft, abundant foraminifera</td></tr>
<tr><td rowspan="2">Avon Park Formation</td><td colspan="2">Middle Confining Unit 2</td><td>Dolomite is brown, fractured, sucrosic, hard. Interstitial gypsum in MCU 2</td></tr>
<tr><td rowspan="2">Lower Permeable Zone</td><td rowspan="2">Lower Floridan Aquifer</td><td rowspan="2">Limestone and dolomite. Limestone is tan, recrystallized. Anhydrite and gypsum inclusions.</td></tr>
<tr><td>Oldsmar Formation</td></tr>
<tr><td>Paleocene</td><td>Cedar Keys Formation</td><td colspan="2">Basal Confining Unit</td><td>Massive anhydrites</td></tr>
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Based on the United States Geological Survey (USGS) water budget, net recharge to the UFA averaged 18.5 in/yr for the two-year period. As a percentage of recharge, groundwater withdrawals averaged about 12 percent of annual recharge.

2.1 Groundwater withdrawals in the vicinity of Chassahowitzka Springs

The Southwest Florida Water Management District (SWFWMD) maintains a metered and estimated water use data base from 1992 through 2005. Groundwater withdrawals in the vicinity of Chassahowitzka Springs for 2005 are shown in Figure 3. Groundwater withdrawn within a five-mile

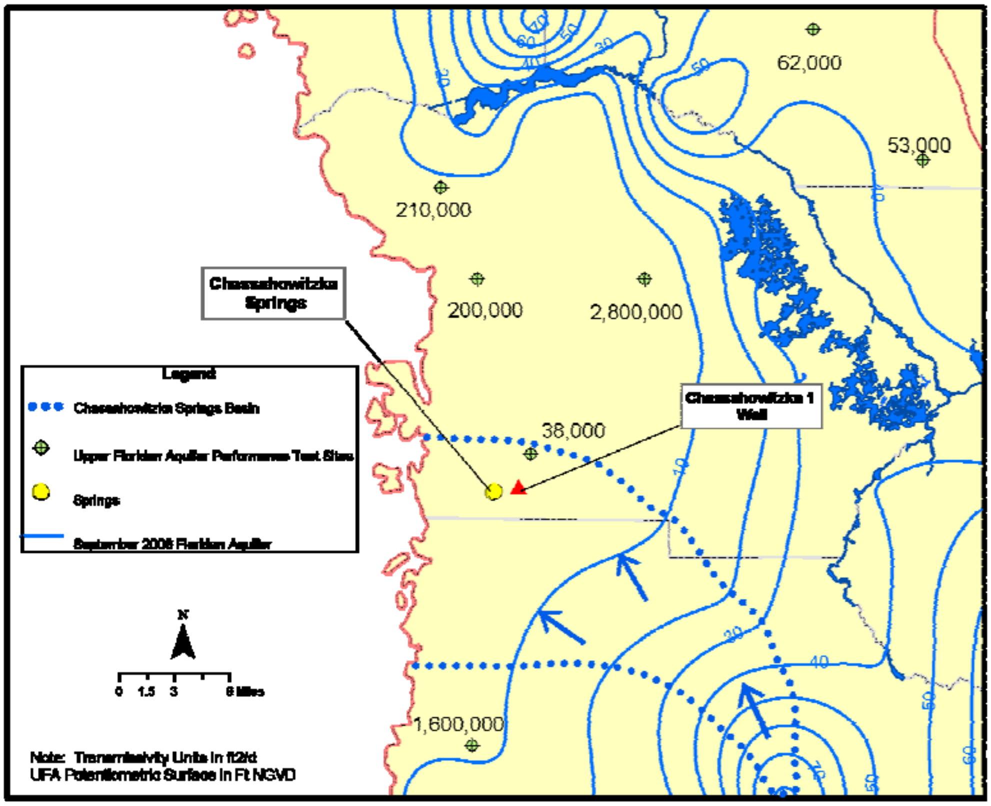

Figure 2. Location of Chassahowitzka Springs basin, transmissivity from aquifer performance tests, and September 2006 potentiometric surface of the Upper Floridan aquifer.

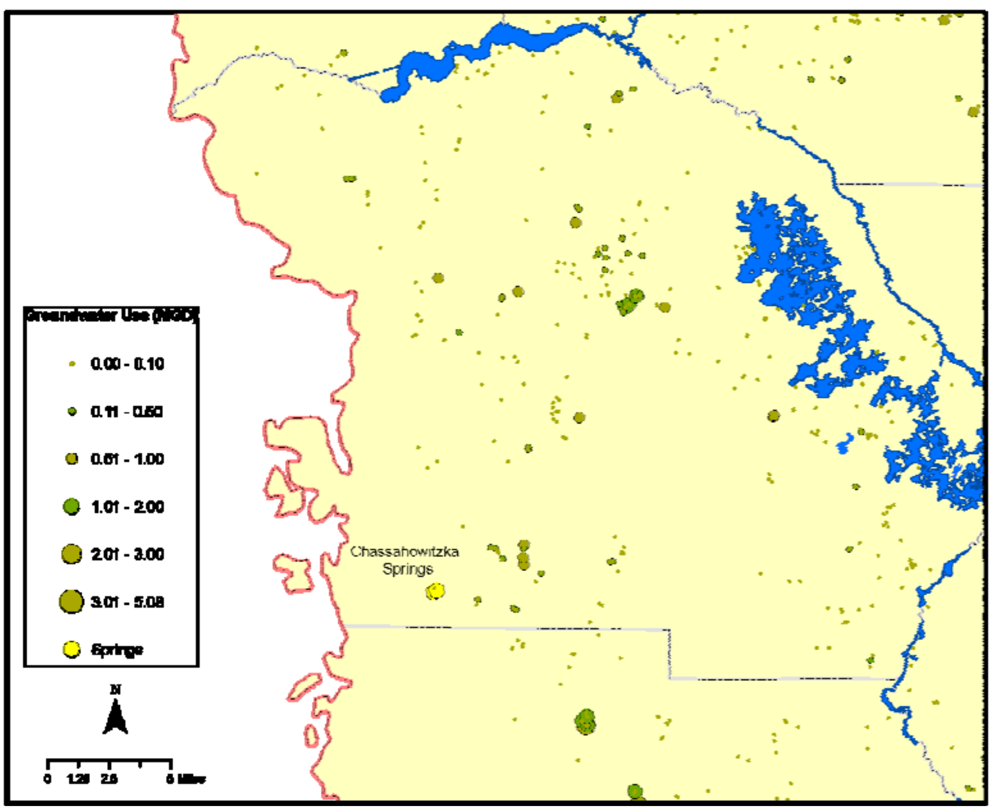

Figure 3. UFA groundwater withdrawals in the vicinity of Chassahowitzka Springs during 2005.

radius of the spring is relatively low and was 3.2 million gallons per day (mgd) in 2005. Ground water withdrawn within a 10-mile radius of the spring was 14.4 mgd in 2005. Approximately nine out of 14.4 mgd of ground water withdrawn within a 10-mile radius is related to limestone mining and associated industrial process in northern Hernando County. Over 90 percent of this water is not consumptively-used and returned to the UFA through infiltration from holding ponds (SWFWMD, 2006).

2.2 Spring discharge, UFA water levels, and Rainfall

Chassahowitzka Main Spring discharge has been recorded by the USGS since 1997 at the Chassahowitzka River gage above Crab Creek (Figure 4). From February 1997 to May 2007, median spring discharge was 60.1 cfs. This site includes flow from the main vent, Bubba Spring, and an unnamed tributary. Prior to this date, there were only infrequent measurements of discharge from the spring.

The Chassahowitzka 1 well is located about 1.5 miles east of the main spring vent (see Figure 2). UFA water levels were first recorded in 1965 and are shown in Figure 5. Aquifer water levels have generally fluctuated between five and nine ft NGVD over the last 42 years. Simple linear regression of the monthly water levels since 1965 shows a statistically significant downward trend of about 0.65 ft. for the period 1965-2007. Much of this decline is related to lower than average rainfall during the period.

Analysis of Brooksville rainfall from 1965 through 2007 shows a declining trend, especially pronounced after 1989. Cumulative departure from mean annual rainfall for the 42-year period is -86 inches with about 80 percent of this departure occurring after 1989 (Figure 6). Annual departure in mean rainfall shows that 14 out of 19 years since 1989 have recorded below average rainfall at the Brooksville station (Figure 7).

As another method to measure potential impact to UFA water levels near the spring, a cumulative sum graph was created of annual rainfall versus mean annual water level from the Chassahowitzka 1 well. (Figure 8). In the cumulative sum analysis, any major deviation in slope that occurs for more than five years would indicate an influence other than rainfall affecting water levels in the well. The plot indicates no significant deviation in slope suggesting climatic influences dominate the historic fluctuation of water levels at this well.

3.0 Numerical Model Results

A number of regional groundwater flow models have included the Chassahowitzka Springs area. Ryder (1982) simulated the entire extent of the SWFWMD. In 2002, the USGS simulated the entire Florida peninsula in their Mega Model of regional groundwater flow (Sepulveda, 2002).

3.1 Northern District Model

The SWFWMD Northern District groundwater flow model (NDM) was completed in May 2008 by the consulting firm HGL, Inc (Hydrogeologic, 2008). The domain of the NDM includes portions of the SWFWMD, the St. Johns River Water Management District (SJRWMD), and the Suwannee River Water Management District (SRWMD). The flow model encompasses the entire extent of the Central West-Central Florida Groundwater Basin (CWCFGWB) and the Northern West-Central Florida Groundwater Basin (NWCFGWB). The eastern boundary of the regional groundwater flow model extends just east of the Lake County/Orange County line. The western boundary of the model domain extends approximately five miles offshore of the Gulf of Mexico.

The regional model finite-difference grid consists of 182 columns and 275 rows of 2,500 ft uniform grid spacing (Figure 9). The NDM is fully 3-Dimensional with top and bottom elevations specified for each model layer. Topographic elevations were assigned to the top of model layer 1 from a

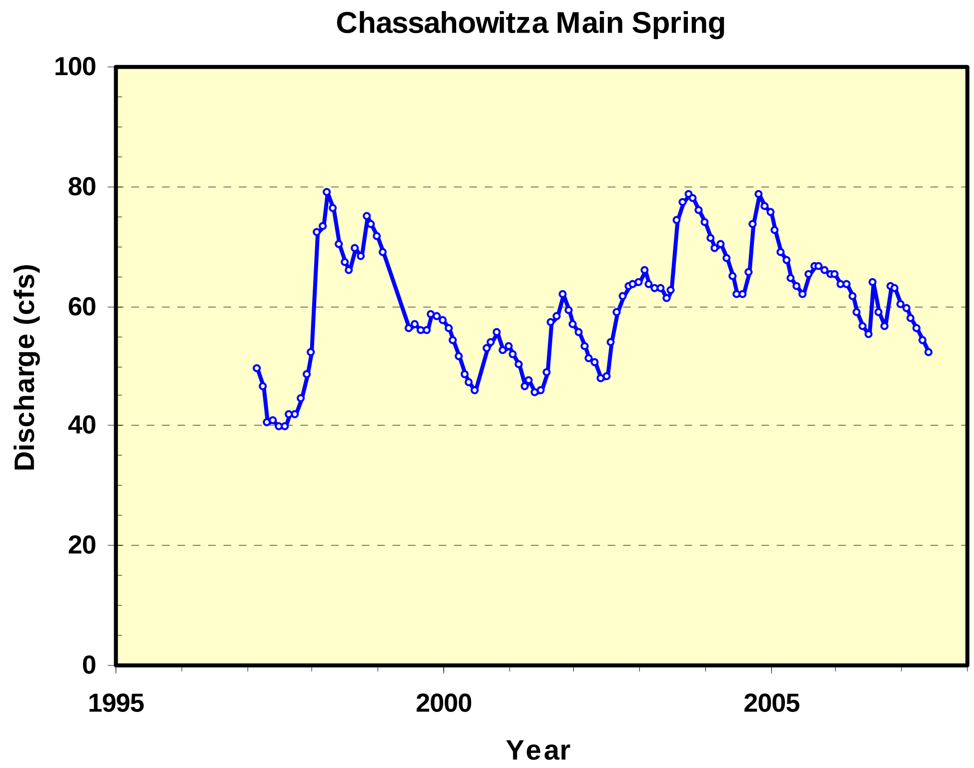

Figure 4. Discharge history of Chassahowitzka main spring.

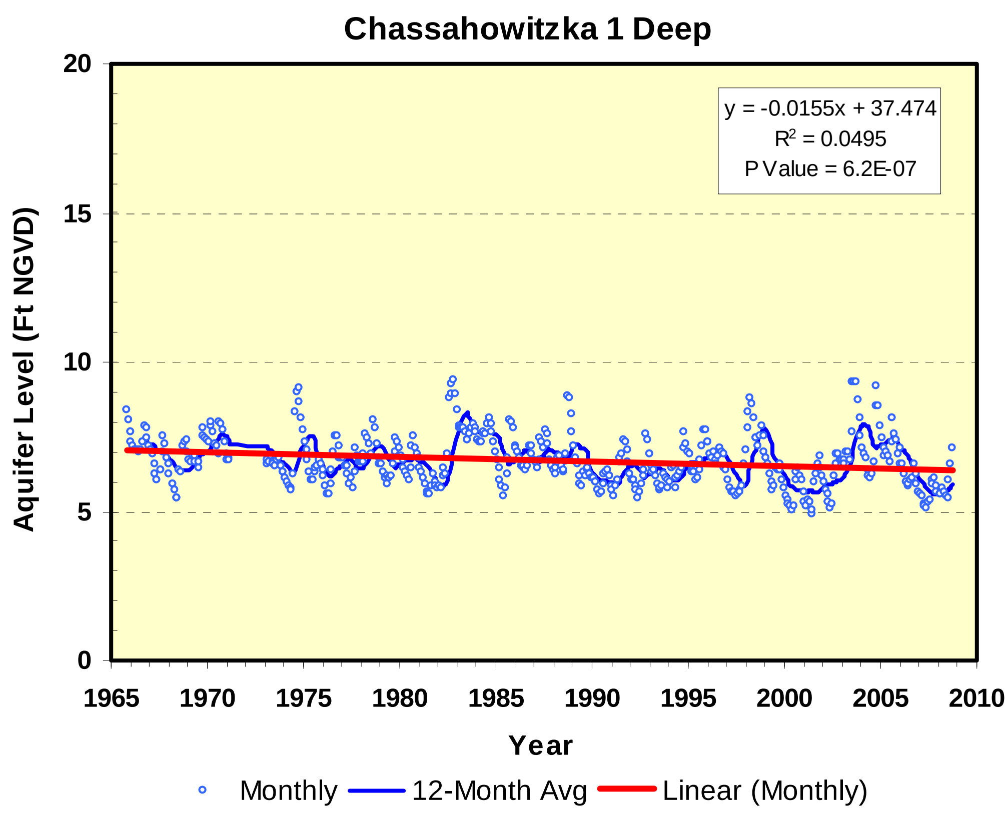

Figure 5. Simple linear regression of Chassahowitzka 1 well water levels.

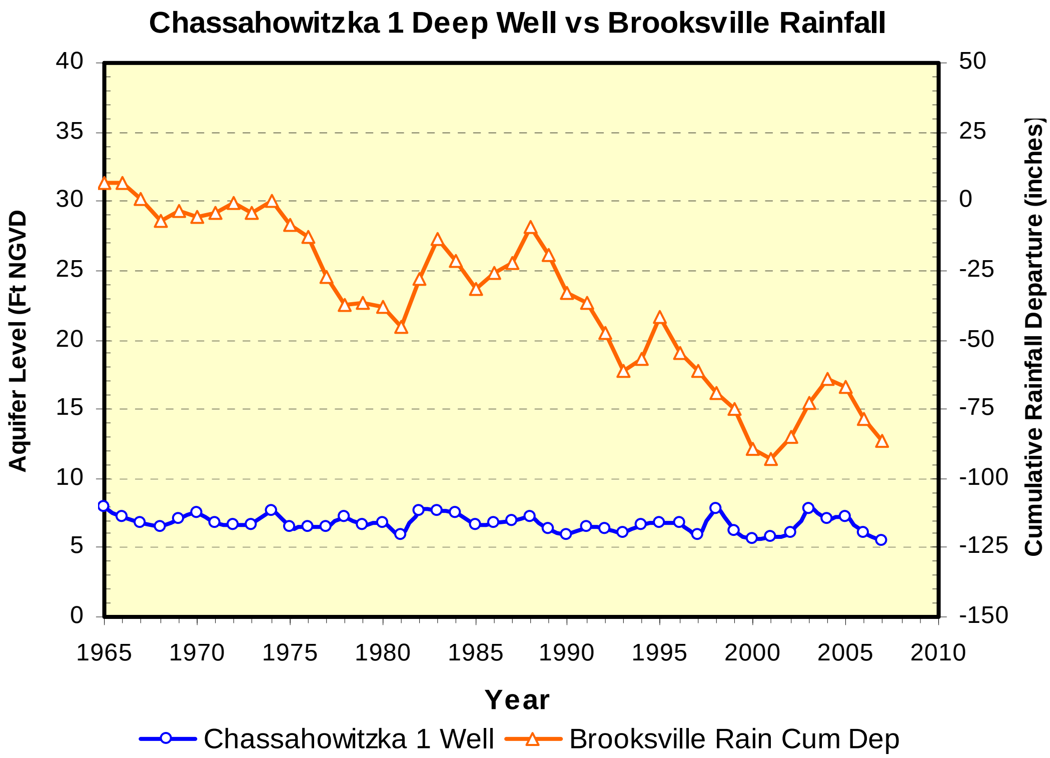

Figure 6. Mean annual water levels at Chassahowitzka 1 well compared to cumulative rainfall departure at the Brooksville station.

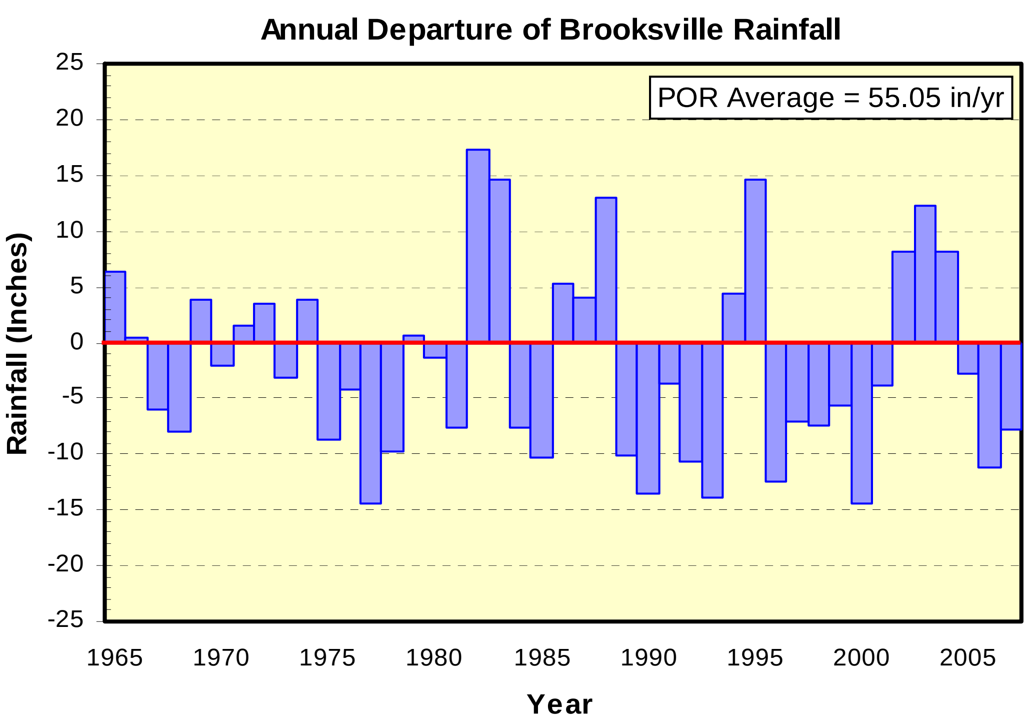

Figure 7. Annual rainfall departure at the Brooksville station from 1965-2007.

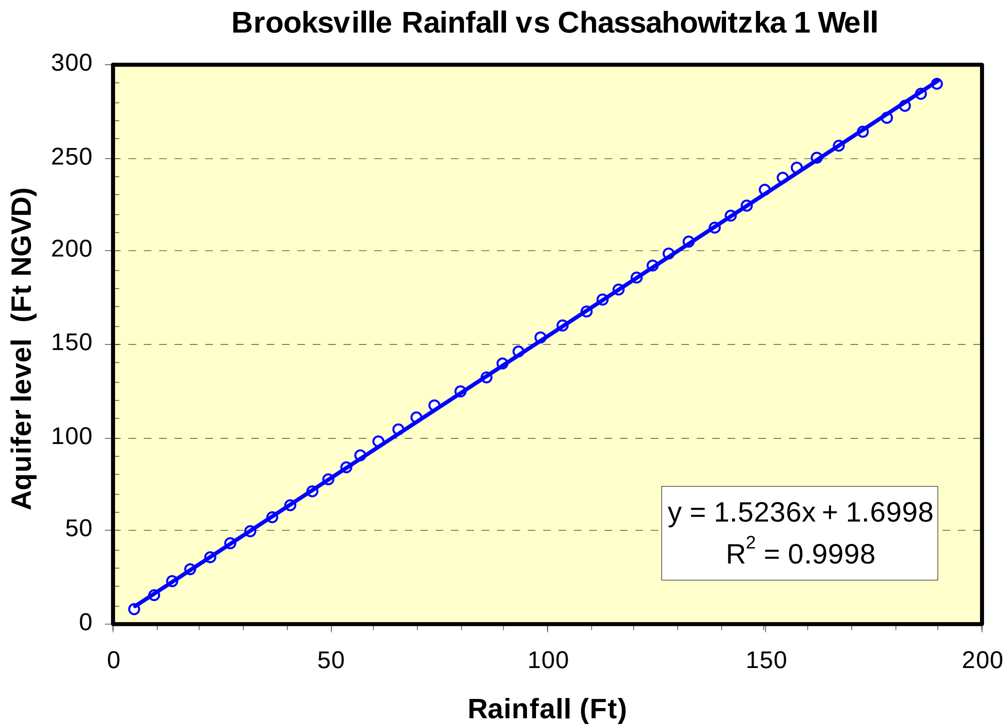

Figure 8. Cumulative sum of Chassahowitzka 1 well water level versus Brooksville rainfall (1965-2007).

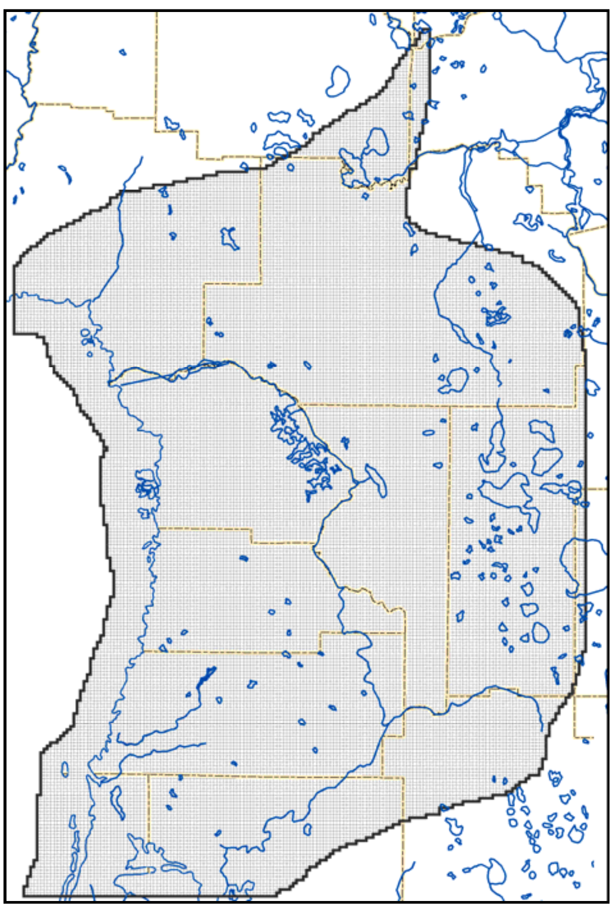

Figure 9. Groundwater grid in the Northern District model.

digital elevation model provided by SWFWMD, based on the USGS 30m National Elevation Dataset (NED). The Florida Geological Survey supplied elevation data for all other layers in the model.

The NDM consists of seven layers that represent the primary geologic and hydrogeologic units including: 1. Surficial Sands; 2. Intermediate Confining Unit (ICU); 3. Suwannee Limestone; 4. Ocala Limestone; 5. upper Avon Park Formation; 6. Middle Confining Unit (MCU) I and MCU II; and 7. lower Avon Park Formation or Oldsmar Formation. The UFA is composed of the Suwannee Limestone, Ocala Limestone, and Upper Avon Park; the Lower Floridan aquifer (LFA) is composed of the permeable parts of both the lower Avon Park and the Oldsmar Formation. Due to the permeability contrasts between the units, each unit is simulated as a discrete model layer rather than using one model layer to represent a thick sequence of permeable units (e.g., UFA).

In regions where the UFA is unconfined, the second model layer represents the uppermost geologic unit in the UFA. The Suwannee Limestone is absent over a large part of the model domain. Where the Suwannee Formation is absent, model layers 3 and 4 represent the Ocala Limestone. The Ocala Limestone is absent in some local areas in the northernmost region of the model domain. In those areas, model layers 3 through 5 represent the Avon Park Formation. With the exception of the eastern part of the domain, the Oldsmar Formation is assumed to have a relatively low permeability being similar to the permeability of the overlying MCU II, which includes the lower Avon Park. Consequently, with the exception of the eastern part of the model domain, the finite-difference cells representing the LFA (model layer 7) are inactive and groundwater flow is not simulated.

The NDM was calibrated to steady-state 1995 calendar year conditions and transient conditions from 1996 through 2002 using monthly stress periods. This model is unique for west-central Florida in that it is the first regional flow model that represents the groundwater system as fully three-dimensional. Prior modeling efforts, notably Ryder (1985), Sepulveda (2002), and Knowles et al (2002), represented the groundwater system as quasi-three-dimensional.

The groundwater flow and solute transport modeling computer code MODFLOW-SURFACT was used for the groundwater flow modeling (HGL, 2005). MODFLOW-SURFACT is an enhanced version of the USGS modular three-dimensional groundwater flow code (McDonald and Harbaugh, 1988).

3.2 2005 Scenario

To determine drawdown in the UFA and potential impacts to Chassahowitzka Springs flow, 2005 groundwater withdrawals were simulated in the NDM under long term transient conditions (five years) and compared to pre-pumping conditions (zero withdrawals). UFA heads generated at the end of the 2005 simulation were subtracted from UFA heads at the end of the pre-pumping simulation to determine aquifer drawdown. The model predicts UFA drawdown of approximately 0.1 feet from pre-pumping to 2005 conditions at Chassahowitzka Springs (Figure 10). Based on the impacts of groundwater withdrawals of 458 mgd over the NDM domain in 2005, predicted reduction in Chassahowitzka Springs discharge was 0.7 cfs or one percent of mean annual discharge (60.1 cfs).

4.0 Summary

The Chassahowitzka Springs complex forms the headwaters of the Chassahowitzka River, which flows west to the Gulf of Mexico approximately six miles through low coastal hardwood hammock and marsh. There are as many as five springs that flow into the upper part of the river and many more springs are known to exist in the lower portion (Rosenau and others, 1977). The springs are located in a karst-dominated region where the Upper Floridan aquifer is largely unconfined. Due to this unique geology, recharge to and permeability within the UFA is very high. Review of long term

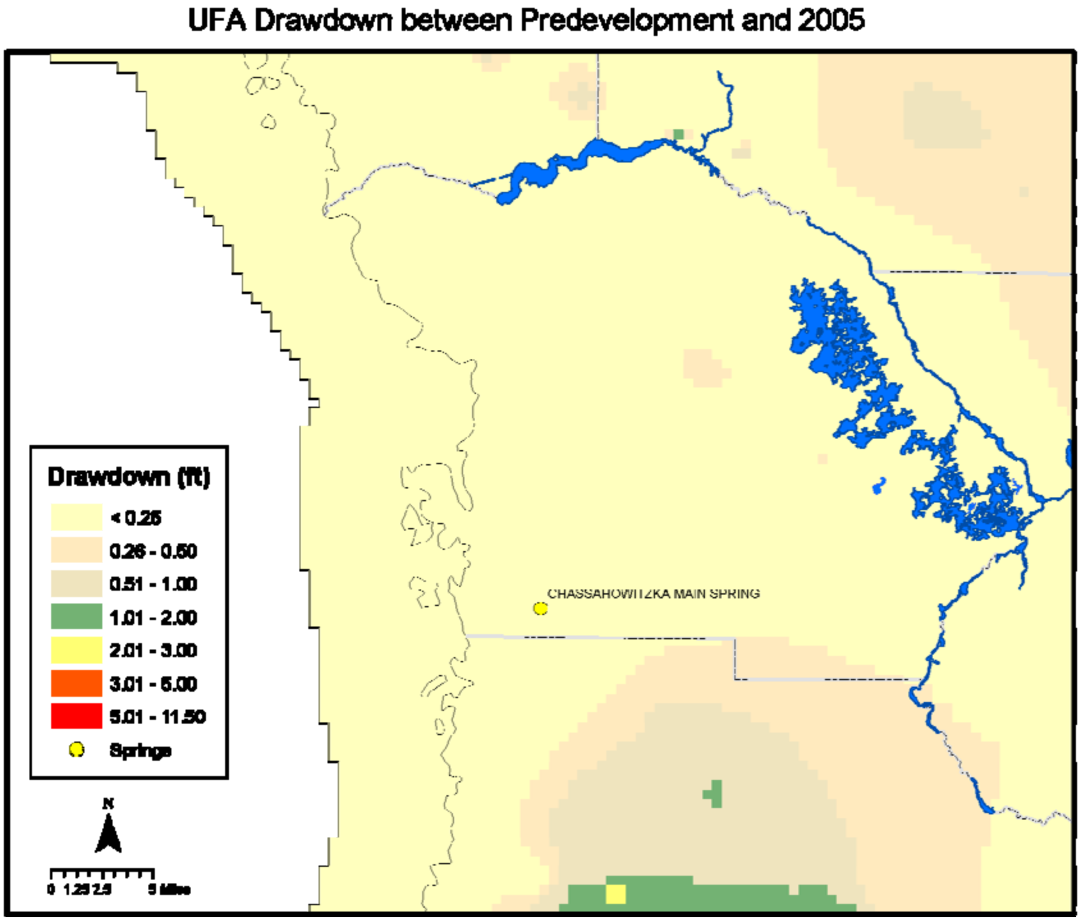

Figure 10. Predicted drawdown in the UFA due to 2005 groundwater withdrawals.

UFA water levels indicates a declining trend since 1965. This is mostly due to lower than average rainfall over the last 40 years which became more pronounced after 1989.

Statistical analysis indicates that UFA water levels fluctuate closely with rainfall and mirror the long term trend of below average rainfall. The simulation results of the Northern District model indicate a projected reduction to Chassahowitzka Springs discharge due to current groundwater withdrawals of 0.7 cfs or about one percent of mean annual spring flow.

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