Is Water Conservation an Effective Alternative Water Supply Solution? – North Florida Case Study

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Water supply deficits have been projected in many areas in Florida as a result of future population growth and increasing water demands. This has led water utilities to initiate water conservation measures over the past 15 years to protect Florida's water resources and minimize the need for an expanded water supply. Aggressive water conservation efforts, such as tiered rate structures and increases in reclaimed water use, combined with the recent economic downturn and return to more normal rainfall amounts, significantly reduced water use per connection throughout the state.

This new, unprecedented condition raises two critical questions: How much of the reduction in water use truly resulted from water conservation efforts, and more importantly, is this trend sustainable? To better understand the effectiveness of water conservation and evaluate its viability as an alternative water supply solution, quantifying water conservation savings is more important than ever. What has been accomplished and the potential for continued improvement in efficiency needs to be analyzed so that water utilities can make smart financial decisions and water management districts can equitably distribute the available water supply among legal users.

Water use data provided by the North Florida Utility Coordination Group (NFUCG) was used in the analysis. The NFUCG is composed of eight utilities: Jacksonville Electric Authority, Gainesville Regional Utilities (GRU), Clay County Utility, St. Johns County Utility, City of Atlantic Beach, City of Jacksonville Beach, City of Neptune Beach, and Town of Orange Park (Figure 1).

St. Johns River Water Management District (SJRWMD) has been working with local utilities and communities, including NFUCG and other stakeholders in north Florida, for effective, consistent, and equitable water resource and water supply planning and development. In partnership with the Suwannee River Water Management District and the Florida Department of Environmental Protection, the District initiated the North Florida Water Initiative (NFWI) in fall 2013, which includes the portion of the North Florida Regional Water Supply Partnership planning area that lies within the SJRWMD (Figure 1). As part of NFWI, the District has been working with stakeholders to develop a regional water supply plan, which includes development of alternative water supply options to meet existing and future water demands within the north Florida area, while protecting environmental resources. Understanding historical water use trends and the effect of water conservation efforts is very important as it directly impacts the magnitude of alternative water supply options needed to meet future demands and avoid unacceptable environmental impacts.

This article analyzes the long-term water use trends of several water utilities in NFUCG and discusses the challenges in quantifying the water conservation efforts. The analysis introduces a methodology based on climate variables (rainfall and temperature) to help quantify water use reduction caused by factors other than climate so that potential water savings due to water conservation efforts can be estimated using a top-down approach.

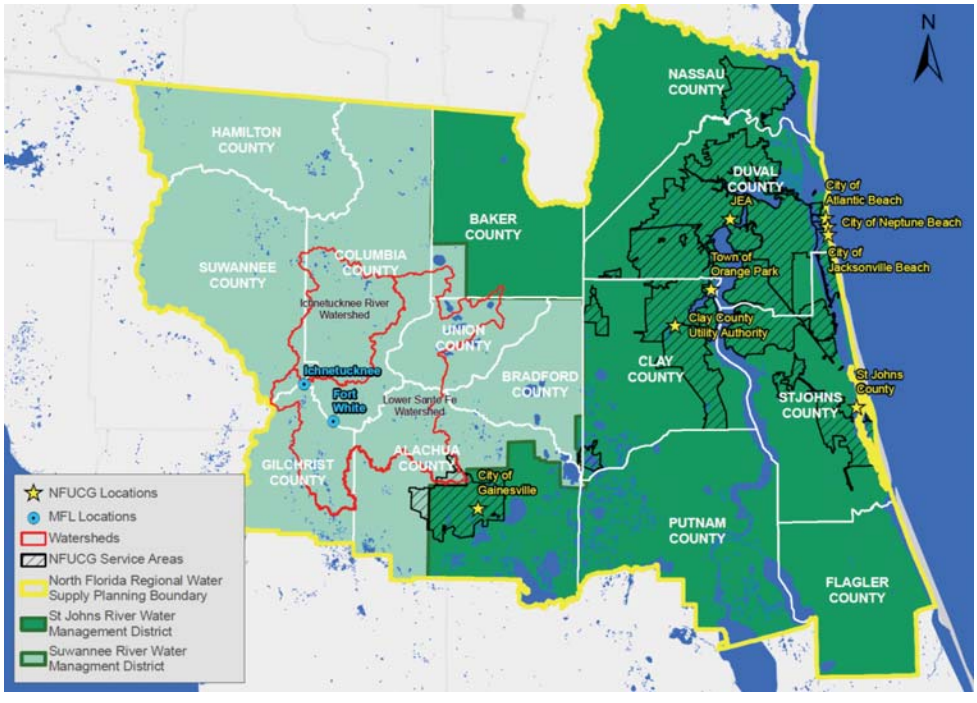

Figure 1. North Florida Regional Water Supply Partnership

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Methodology

A method was needed to better quantify how much water use reduction is attributable to climate and nonclimate factors. Previous studies (Rockaway, T.D., et al., 2011 and Dziegielewski and Kiefer, 2010) indicated that water use was highly correlated with temperature and rainfall. A multilinear regression model was developed by building a relationship between single-family water use and climate for calibration periods before implementation of any major conservation measures, including a tiered rate structure. These calibration periods were determined by analyzing historical water use trends and the changes in rate structure over time for each utility. The model utilizes the following variables:

- Monthly single-family residential water use per connection
- Monthly average rainfall
- Monthly average maximum temperature

The regression equation was developed as follows:

Wi = Per connection water use in Month i (gpd)

Wa = Average daily water use per connection for Month i over calibration period (gpd)

Ri = Rainfall in Month i (inches)

Ra = Long-term average rainfall for Month i (inches)

MaxTi = Maximum daily temperature in Month i (Fahrenheit)

Max Ta = Long-term average maximum daily temperature for Month i (Fahrenheit)

α = Regression coefficient

β = Regression coefficient

Once the best correlation was achieved, the water use was predicted using the regression model for the subsequent years. Then, the predicted water use was compared with the actual water use for the analysis.

Gainesville Regional Utilities Example

Water demands from GRU customers have decreased significantly over the past 10 years. During this time, GRU invested heavily in water conservation, but climate (specifically rainfall and temperature) also influenced water use. To better quantify how much water use reduction is attributable to climate and nonclimate factors, the climate data and GRU's water use trends from 1993 to 2012 were analyzed. The analysis was intended to help GRU better understand its customers' water use behavior changes based on climate, water conservation efforts, reclaimed water use, etc. Figure 2 shows the GRU water service area.

Monthly single-family residential water use data and the number of residential connections from 1993 to 2012 were provided by GRU, and the rainfall and maximum temperature data (Figure 3) were obtained for the

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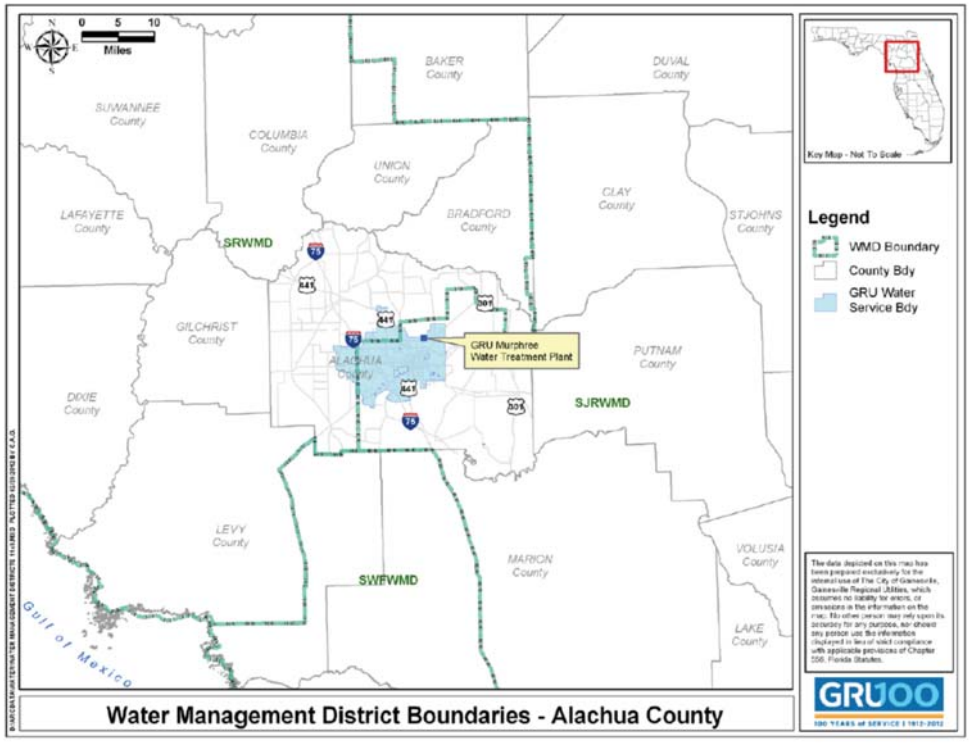

Figure 2. Gainesville Regional Utilities Water Service Area

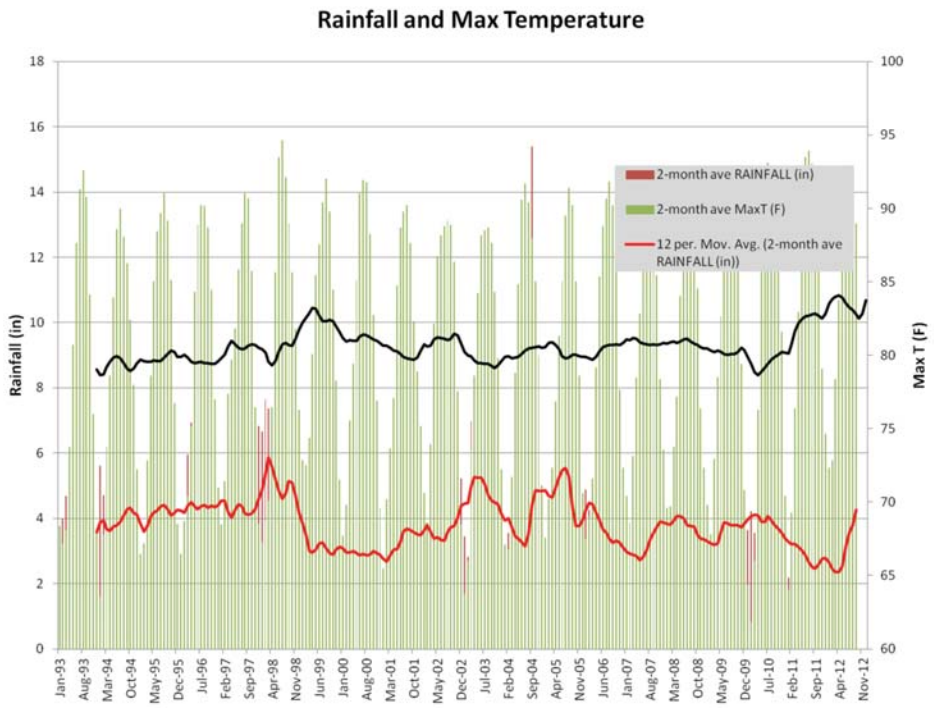

Figure 3. Rainfall and Maximum Temperature Data at Gainesville Regional Airport

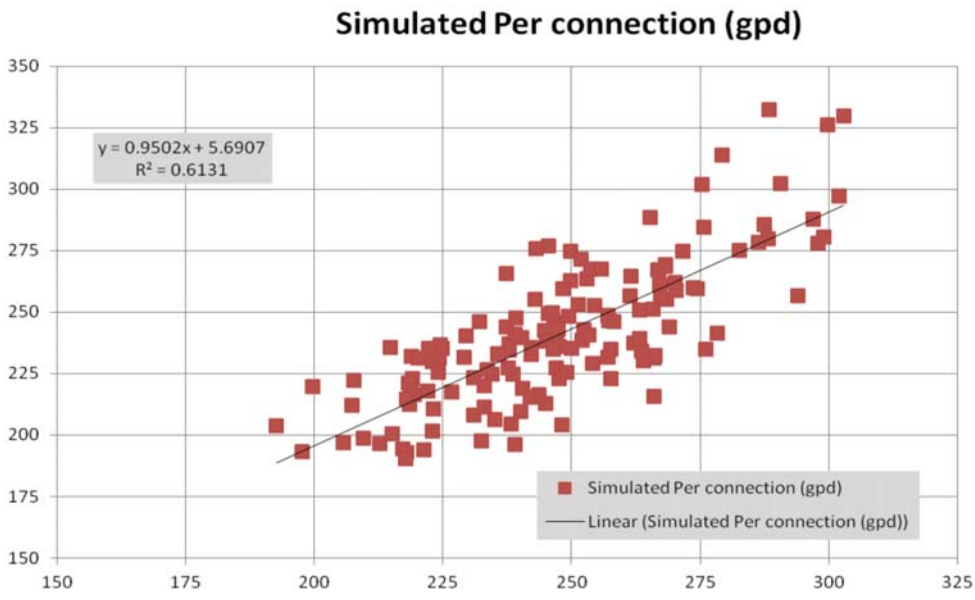

Figure 4. Correlation Between Climate Variables and Two-Month Monthly Average Water Use Per Connection During 1993-1998 Calibration Period

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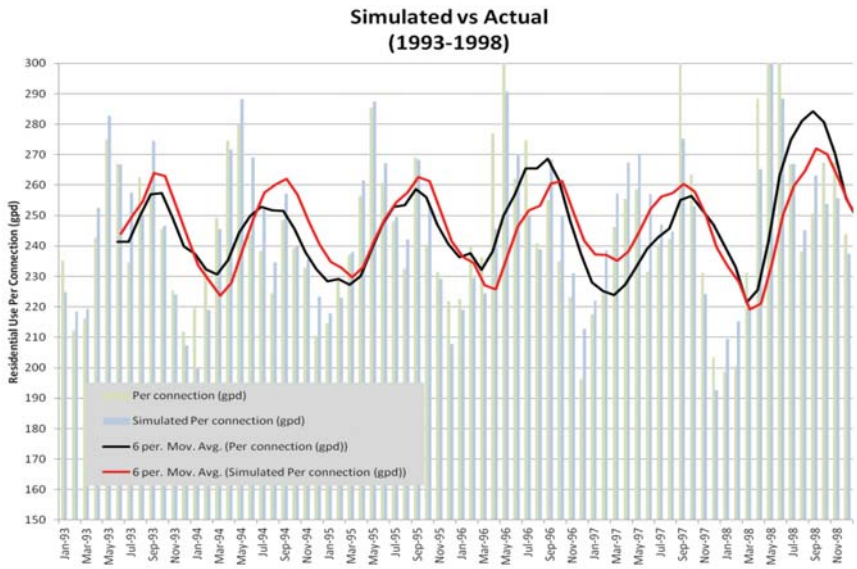
Gainesville Regional Airport weather station from the National Oceanic Atmosphere Administration's website. The data was analyzed using the multilinear regression described previously.

After testing periods of varying durations, the best correlation between water use and climate variables was achieved using a two-month average water use per connection. The period from 1993 to 1998 was selected as the correlation period because of the review of historical water use trend and changes in GRU's rate structure. It indicated that climate was the main driver for water use changes during this period. Figure 4 shows the correlation between climate variables and the two-month monthly average water use per connection and Figure 5 shows the simulated and actual water use per connection for the correlation period.

Once a good correlation was achieved between the water use per connection and climate variables, the model was run to predict water use per connection from 1999 to 2012 (Figures 6 and 7). The simulated water use per connection shows what the water use per con-

Figure 5. Simulated Versus Actual Water Use per Connection for Correlation Period



nection for GRU would be from 1999 to 2012 if nonclimatic factors (i.e., rate changes and water conservation efforts) were implemented. The simulated water use per connection follows GRU's actual water use per connection until 2001, when it starts to deviate. In 2001, GRU began implementing an aggressive tiered water rate structure. Figure 8 shows GRU's tiered residential water rates over time.

Using the average of the 2011 and 2012 simulated and actual residential water use per connection, it was determined that GRU's single-family residential customers' water use was reduced by 28 percent due to factors other than climate change. In addition, there were three distinct water use behavior periods:

- Pre-2001
- 2001-2007
- 2008-2012

The decline in water use between 2001 and 2007 was most likely due to water conservation measures, including changes in rate structure, given that the simulated water use during this time period would have been significantly higher (Figure 7) if climate conditions were the only factor affecting water use.

As shown in Figure 8, from 2008 through 2012 GRU dramatically increased its third-tier water rate, which is likely the primary cause of the further reduction in water use during this period. In addition, there had been an increasing awareness among the public on the need for conservation as a result of conservation messaging by utilities, local government, and the water management districts, and the increasing public awareness regarding minimum flows and levels. The economic downturn likely contributed to some extent to this further reduction; however, due to the fact that much of Gainesville's economy is based on the University of Florida and area hospitals, Gainesville was less hard hit than many other areas of the state.

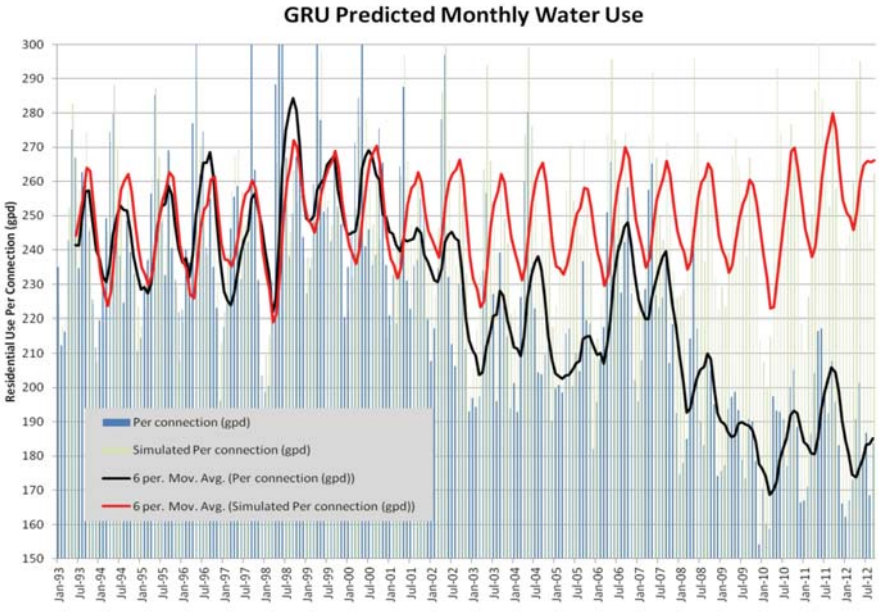


Figure 6. Gainesville Regional Utilities Predicted Monthly Single-Family Residential Water Use

North Florida Utility Coordination Group Water Conservation Estimate

Similar to the GRU example, a best correlation was obtained for each utility analyzed in this study. As was the case with GRU, other utilities in the NFUCG implemented increasingly aggressive tiered rate structures, particularly over the 2007 through 2012 period. The results of the analysis indicated that the NFUCG has achieved water use reduction of more than 20 percent, or over 40 mil gal per day (mgd) over the past 10 years (Figure 9).

Conclusion

This analysis introduces a methodology based on climate variables (rainfall and temperature) to help quantify water use reduction caused by factors other than climate so that potential water savings due to water conservation efforts can be estimated using a top-down approach.

The multilinear regression model indicates a significant reduction in water use among customers served by NFUCG. Water use reduction could be due to water conservation and the economic downturn; however, the analysis of GRU's water use trend between

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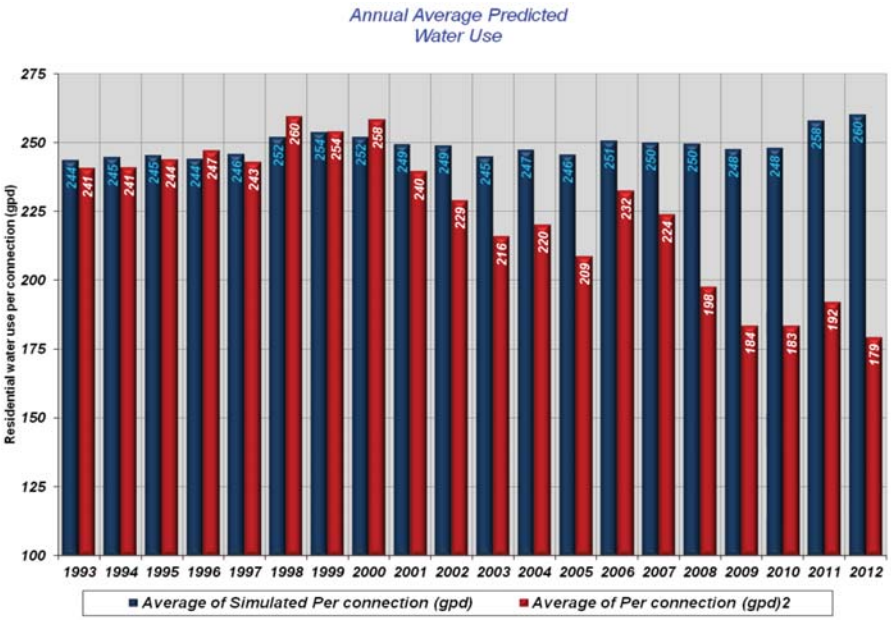

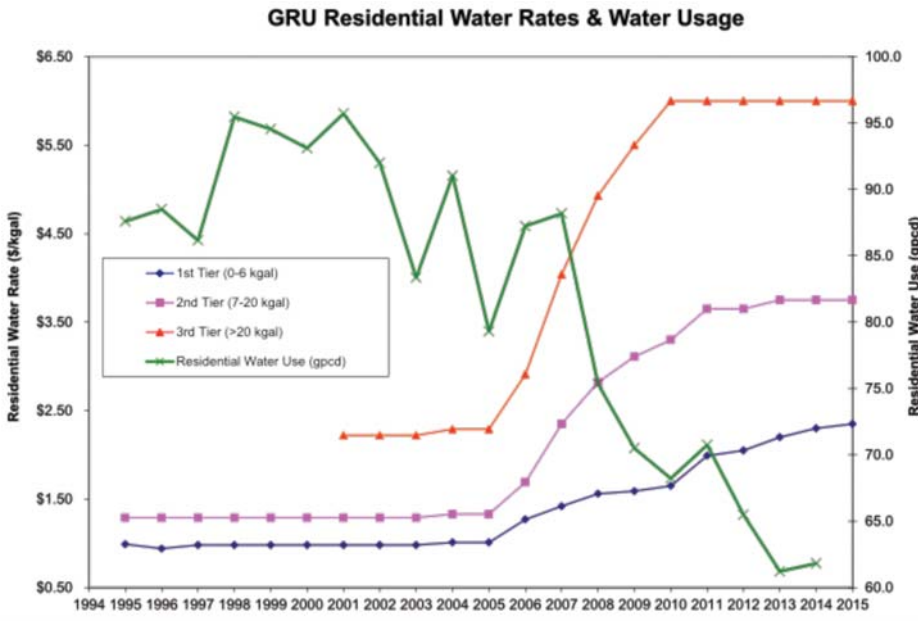

Figure 7. Gainesville Regional Utilities Predicted Annual Single-Family Residential Water Use

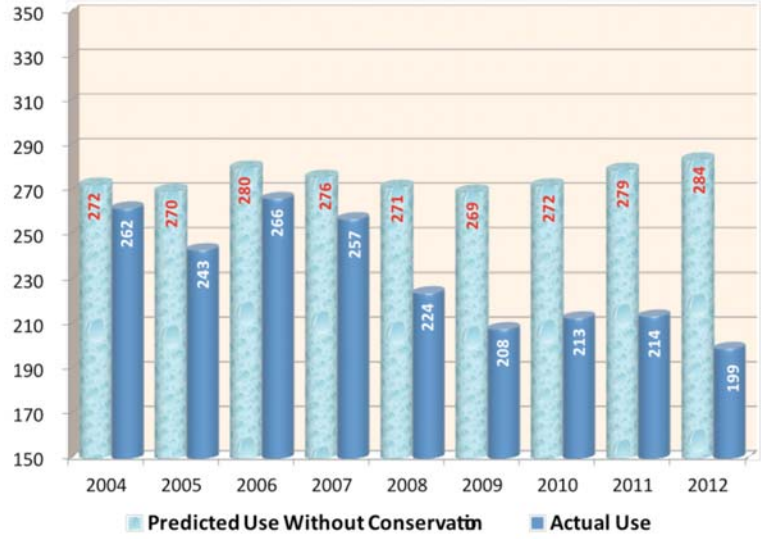

Figure 8. Gainesville Regional Utilities Tiered Residential Water Rates

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2001 and 2007 (before the economic downturn) indicated that a significant portion of the water use decline is due to water conservation measures, including changes in rate structure.

Recent data also indicated that the current low level of water use could be sustainable even after the economy fully recovers because although the regression model predicted that water use should have increased in 2011 and 2012 because of low-rainfall and high-temperature conditions (Figure 9), water use declined during the same period. Additional analysis of water use trends as the economy recovers should be performed in order to verify them.

The review of long-term trends of several north Florida utilities indicated that water conservation measures, especially changes in rate structures, have been very effective and provided the following benefits:

- Utilities will be able to serve an increasing population with less allocation than would have been required in the absence of conservation.
- The water conservation efforts helped GRU reduce the need for future water use and successfully renew its consumptive use permit without increasing the existing permitted allocation with a 20-year duration.
- Conservation will reduce and defer the need for costly recovery and prevention projects.

References

- Dziegielewski, B. and Kiefer, J.C. Appropriate Design and Evaluation of Water Use and Conservation Metrics and Benchmarks. *Journal AWWA*, 2010.
- Rockaway, et al. Residential Water Use Trends in North America. *Journal AWWA*, 2011.
- http://www.northfloridawater.com/

Figure 9. North Florida Utility Coordination Group Water Use Analysis