Climate Vulnerability Analysis – Changes to Local and Regional Water Use

Prepared for

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Section 1.0 Introduction

This report discusses predicted changes to local and regional water use in Alachua County for future climate scenarios. These estimates were prepared as part of a climate vulnerability assessment for Alachua County developed by the Jones Edmunds Team. WSI was tasked with evaluating the local and regional water use changes based on future climate conditions and population estimates developed by other members of the project team. This report presents the data and methods used to develop these estimates and is intended to serve as a detailed appendix for the results presented in the main body of the climate vulnerability assessment.

Section 2.0 Changes to Local and Regional Water Use

Changes in climate and population are anticipated to impact water availability and water use in Alachua County in multiple ways. However, impacts associated with a changing climate are not anticipated in all water use categories. Models were developed to estimate water use for the primary user categories based on historic water use, projected population, and irrigated acreage. The following sections discuss the data used, methodology applied, and the estimated water use for the time periods evaluated: 2030, 2040, 2070, and 2100.

2.1 Data and Sources

This section presents the data used to estimate future water use. The sources of data are also presented and included information from publicly-available datasets as well as data developed specifically for this study.

2.1.1 Population Data

To estimate future water use this study relied on estimates of population developed by the University of Florida – Bureau of Economic and Business Research (BEBR) and the United States Census. BEBR develops a wide range of population products for the state including county-level estimates of population, generally with a 25-year forecast. For this project BEBR also developed an estimate of county population for 2070 and 2100 (attempting to factor in climate migration), both of which are outside their standard population modeling forecasts. The specific reports used for this study included:

- Florida Population: Census Summary 2010 (Bureau of Economic and Business Research, 2011).
- Florida Population: Census Summary 2020 (Bureau of Economic and Business Research, 2021).
- United States Census of Population – 1970 (United States Department of Commerce, 1973).
- Projections of Florida Population by County, 2020-2045, with Estimates for 2015 (Rayer & Wang, 2016).
- Projections of Florida Population by County, 2025-2050, with Estimates for 2021 (Rayer & Wang, 2021).
- Alachua County population estimates developed for 2070 and 2100 for this study by BEBR, including a separate estimate with climate migration (BEBR, 2023).

The Alachua County population is approaching 300,000 and is expected to exceed this level by 2030. Future projections for the county continue to show growth, but at a lower rate than the county population has historically grown. By 2100, BEBR (2023) estimated the county population would exceed 430,000 without climate migration and would exceed 450,000 with climate migration. Actual and estimated future populations, with and without climate migration, for Alachua County are shown in Figure 1.

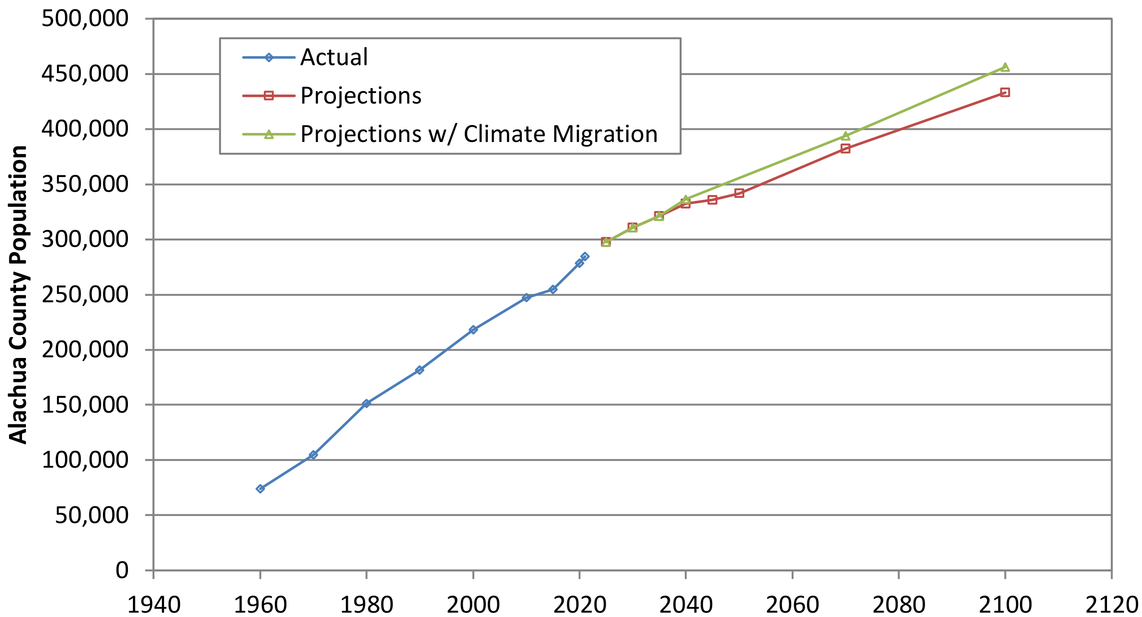

Figure 1. Historical and Future Population Projections for Alachua County

2.1.2 Non-Agricultural Water Use Data

Historical water use data were collected from the United States Geological Service (USGS) reports developed for Florida with county-level detail (Marella, 1985, 1992, 1999, 2004, 2009, 2014, 2020). These reports have generally been released every five years since 1999 with the first report from 1985 also including prior water use data back to 1965. These data include a categorization of uses including: public supply (permitted water treatment facilities); domestic self-supply (private wells); commercial, industrial, institutional, and mining self-supplied; and power generation. This data set does not include water use for irrigation wells when public supply water is also serving these parcels. These studies also present the sources of water, whether groundwater or surface water and the type of water (fresh or saline). In Alachua County nearly all water use is fresh and groundwater. As part of studies beginning in 1985 there was also a characterization of the type of public-supply water use: domestic, commercial, industrial, other, and public/losses.

Total water use in the county was estimated to be 45.6 MGD in 2015 with public supply making up more than 50% of total county use, 23.4 MGD. Water use data by sector, excluding agricultural use, is shown in Figure 2. Generally, all sectors of water use have decreased since 2000, despite an increasing population during this same period. This change in use corresponds with increased messaging about water use and water conservation. Other potential drivers of these changes include increasing water rates and increasing multi-family residential. A final driver of decreases is decreasing parcel areas which reduce total average irrigation (Knight et al., 2015).

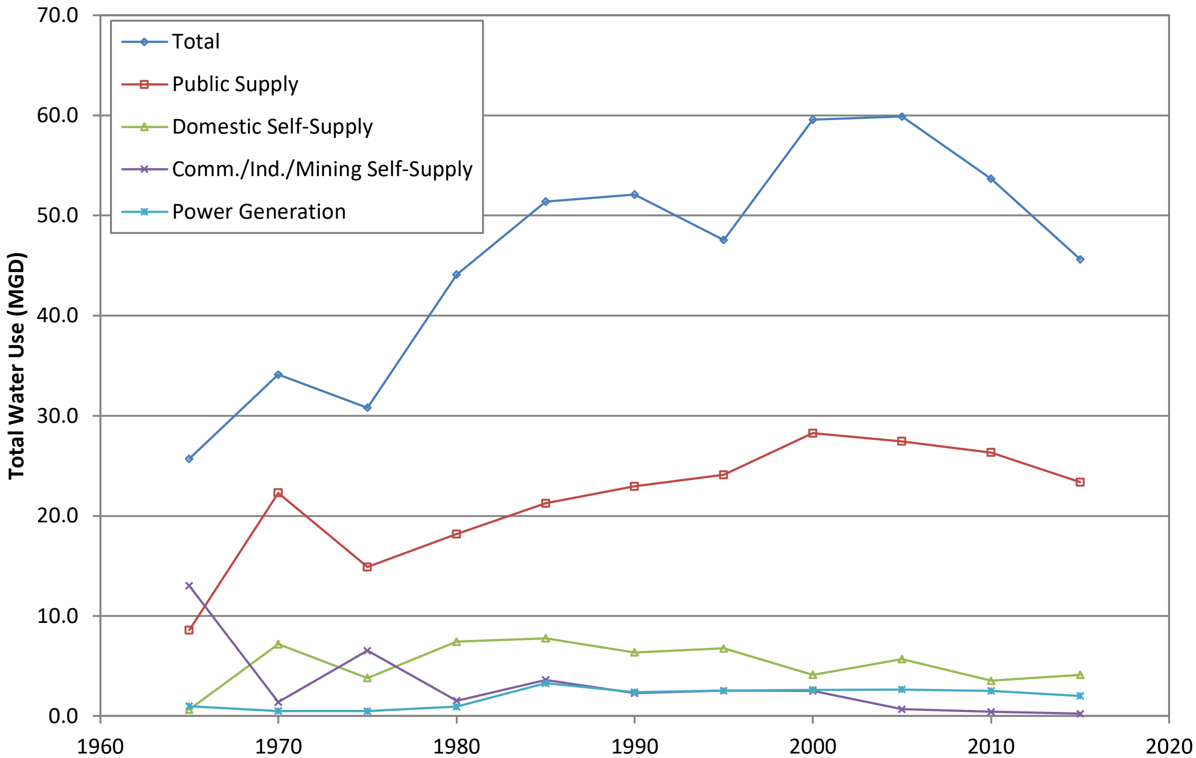

Figure 2. Alachua County Water Use

Also evaluated in the context of water use was the per capita water use (gallons per person per day [gpcd]). The per capita water use was calculated as total non-agricultural water use divided by the county population. This relationship was also evaluated for the reported sectors with calculated per capita water use for each sector and gross per capita water use shown in Figure 3.

This metric showed a decreasing trend in gross per capita water use over the period from 1985-2015. Over this period gross per capita water use has decreased from 225 to 118 gallons per capita per day (gpcd) with decreases in residential water use from 136 to 67 gpcd and in commercial water use from 58 to 31 gpcd. These changes in water use coincide with expansion of multi-family housing, increased education on water conservation, increased water conservation programs, more efficient water fixtures, and modified water rate structures.

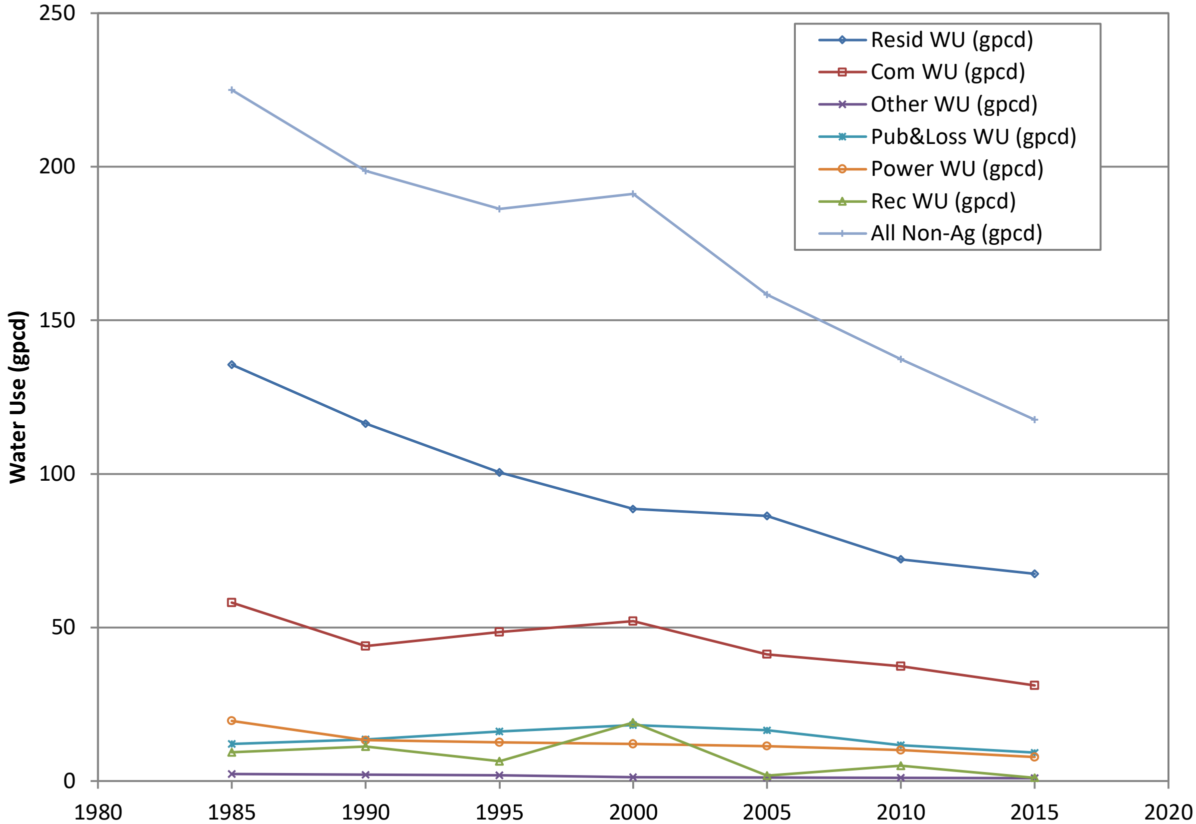

Figure 3. Gross Per Capita Water Use and Water Use by Sector

2.1.3 Agricultural Area Data

Data on agricultural acreages, irrigated acreage, and water use were collected from the United States Department of Agriculture (USDA), USGS, and the Florida Statewide Agricultural Irrigation Demand (FSAID) Studies prepared by the Balmoral Group. These organizations provided estimates of total agricultural acreage for Alachua County for various time periods. The USDA had estimates for the period from 1974 through 2017 (United States Department of Agriculture, 1977, 1984, 1994, 1999, 2004, 2014, 2019) and the FSAID had estimates for 2019 and 2022 with estimates through 2045 (The Balmoral Group, 2019, 2020, 2021, 2022). Total agricultural acreage and current and projected irrigated agricultural acreages are shown in Figure 4.

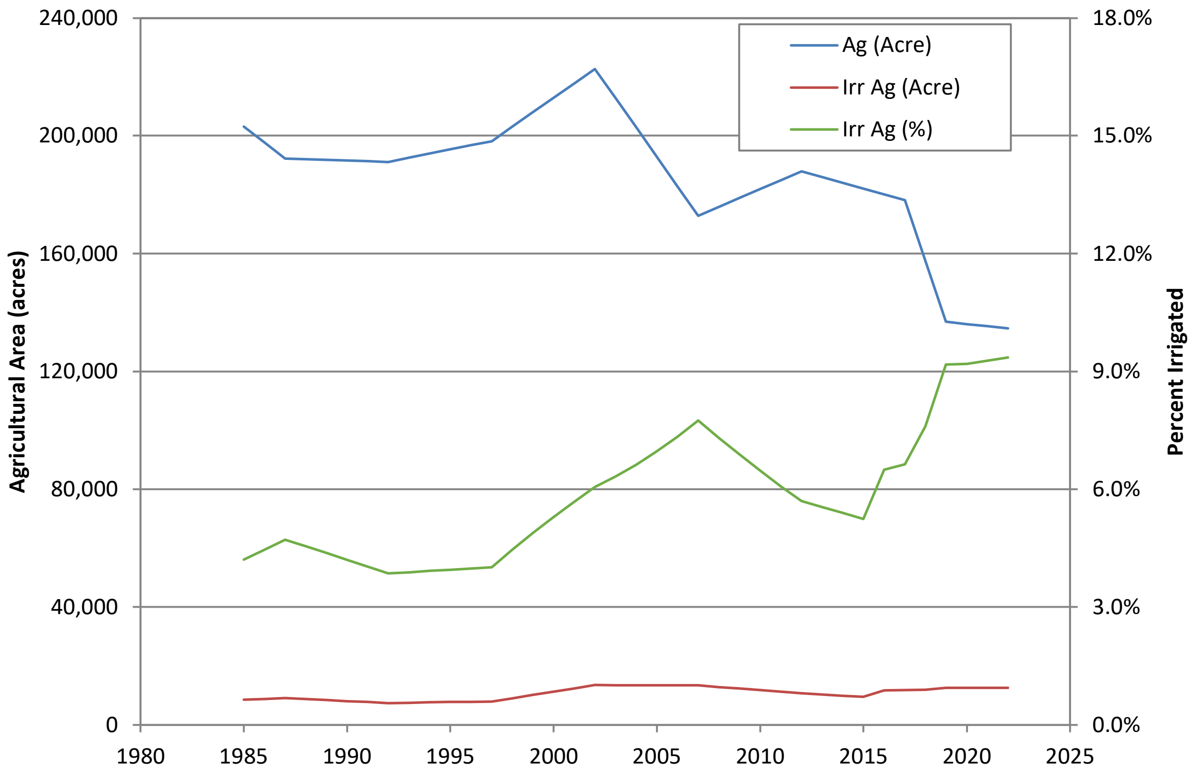

Figure 4. Agricultural Acreage and Irrigated Acreage

To extend the temporal period of agricultural acreages through 2100, estimates were made of the coverage of total agricultural acreage and irrigated agricultural acreage. These estimates were developed for three trends in acreage with three associated irrigated acreage estimates. The three estimates of total agricultural acreage for Alachua County were based on the following assumptions:

- Low Estimate: Acreage continues to decline in a linear fashion based on 1990 to 2022 data.
- Medium Estimate: Acreage decreases at a rate between the low and high estimates.
- High Estimate: Acreage remains constant at 2022 levels.

Based on these estimates of total agricultural acreage, irrigated agricultural acreage was projected based on three scenarios:

- Low Estimate: Irrigated area stays at the same percent of total agricultural lands for the period from 2004-2022 (7.1%) based on the medium estimate for total agricultural acreage.
- Medium Estimate: Irrigated area stays at the 2022 level over the planning period.
- High Estimate: Linear trend in irrigated area increase continues.

These projections yielded three trends in total agricultural acreage and irrigated agricultural acreage. Total agricultural acreage was estimated to stay the same (high estimate) or decrease (low and medium estimates) over the planning horizon. Irrigated agricultural acreage was estimated to decrease, stay the same, or increase based on the individual scenarios. The irrigated area estimates were more variable over the planning horizon because of uncertainty about whether a larger share of the total agricultural acreage would be transitioned to irrigation, or if the overall decreasing trend in total agricultural area would lead to irrigated area similarly decreasing. The estimates for total agricultural acreage, irrigated agricultural acreage, and the FSAID estimates of irrigated agriculture are shown in Figure 5.

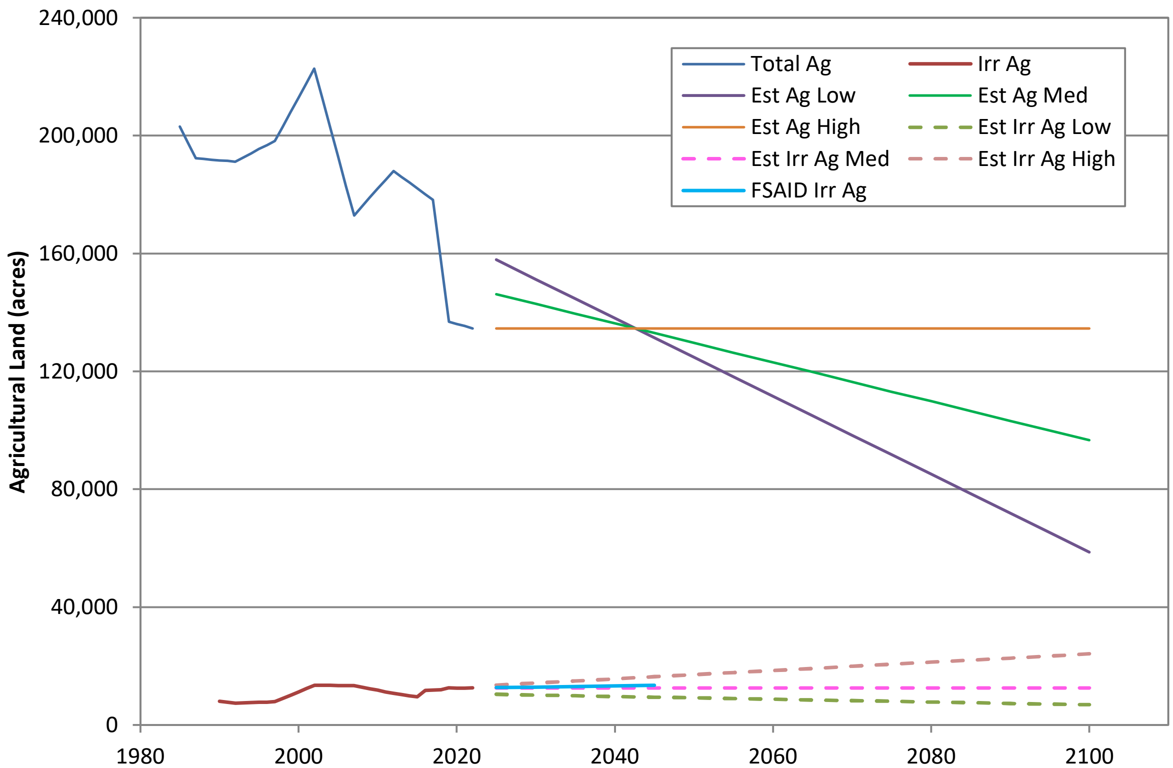

Figure 5. Estimated Total and Irrigated Agricultural Acreage in Alachua County

In addition to evaluating the anticipated changes in agricultural and irrigated areas it was necessary to understand the amount of water used for agriculture. This estimate was derived by using the estimates of agricultural water use from the USGS in conjunction with the estimates of irrigated agricultural lands from the USDA, USGS, and FSAID. The total agricultural irrigation and amount of water applied per acre per day is shown in Figure 6. This chart shows that while total water applied to agriculture has increased, the amount applied per acre has remained generally consistent over this time period. The average application rate for the period from 1985 to 2015 was 1,658 gallons per acre per day (22.3 inches per year). This is slightly lower than the application rate recommended by crop modeling for bahiagrass (26 inches per year).

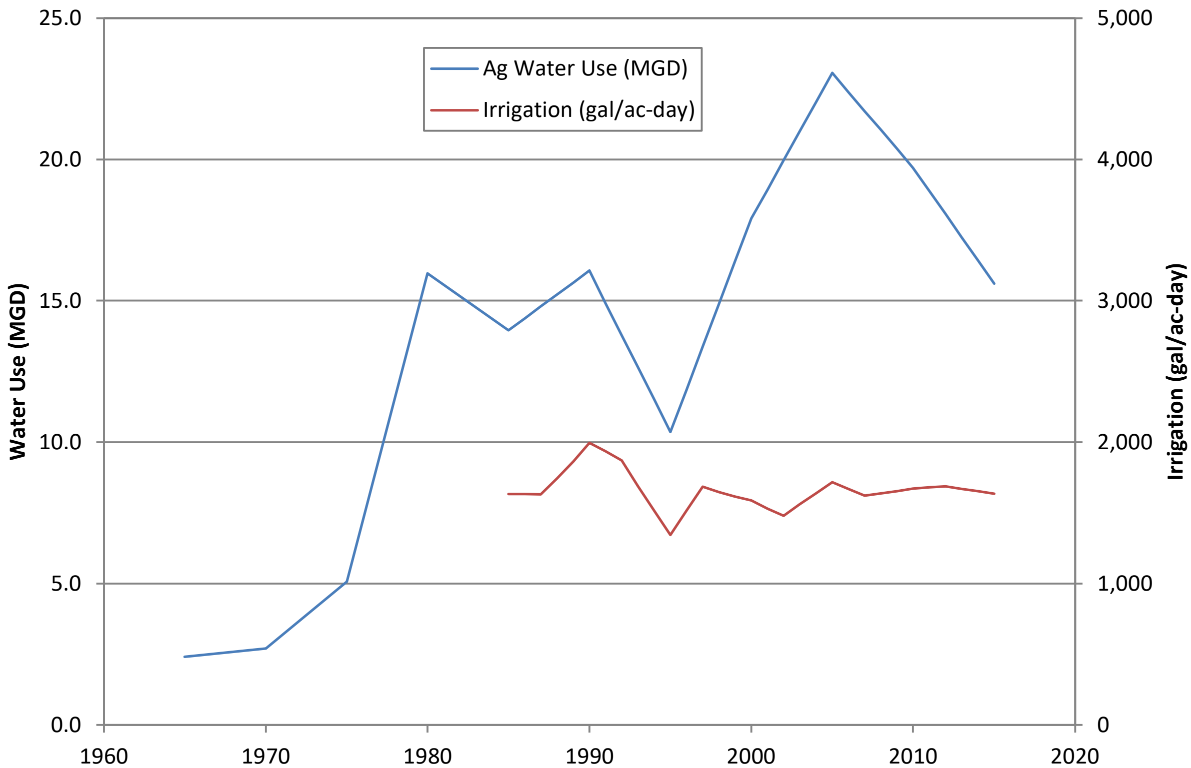

Figure 6. Agricultural Irrigation in Alachua County

2.1.4 Weather Changes

Water use projections are complicated not only by changes in population, changes in acreages of land uses, and changes in the portion of irrigated agriculture; but also by changes in climate. Climate changes are expected to have impacts in some sectors of water use but are not expected to have the same degree of impacts for all water use types. For example, increasing evapotranspiration (ET) and increasing but more sporadic rainfall are likely to have impacts on outdoor water use both in urban and rural areas. However, these same impacts are likely to cause minimal changes in indoor water uses. Although increasing temperatures are likely to lead to increased power usage for air conditioning which may have impacts on water used for power generation.

For this project the largest impacts of changing climate are expected to be on irrigation of landscapes and crops. To estimate the change in irrigation, the net rainfall was used as the metric of interest. The change in net rainfall was calculated as the difference between annual rainfall and annual reference ET (RET). Over the projection period from present to 2100, the net rainfall decreased, with RET exceeding rainfall by a larger amount on average during the later portions of the study period as shown in Figure 7. This approach does not account for timing of rainfall at a finer time scale, which could lead to further increases in irrigation demand if inter-rainfall event durations increase.

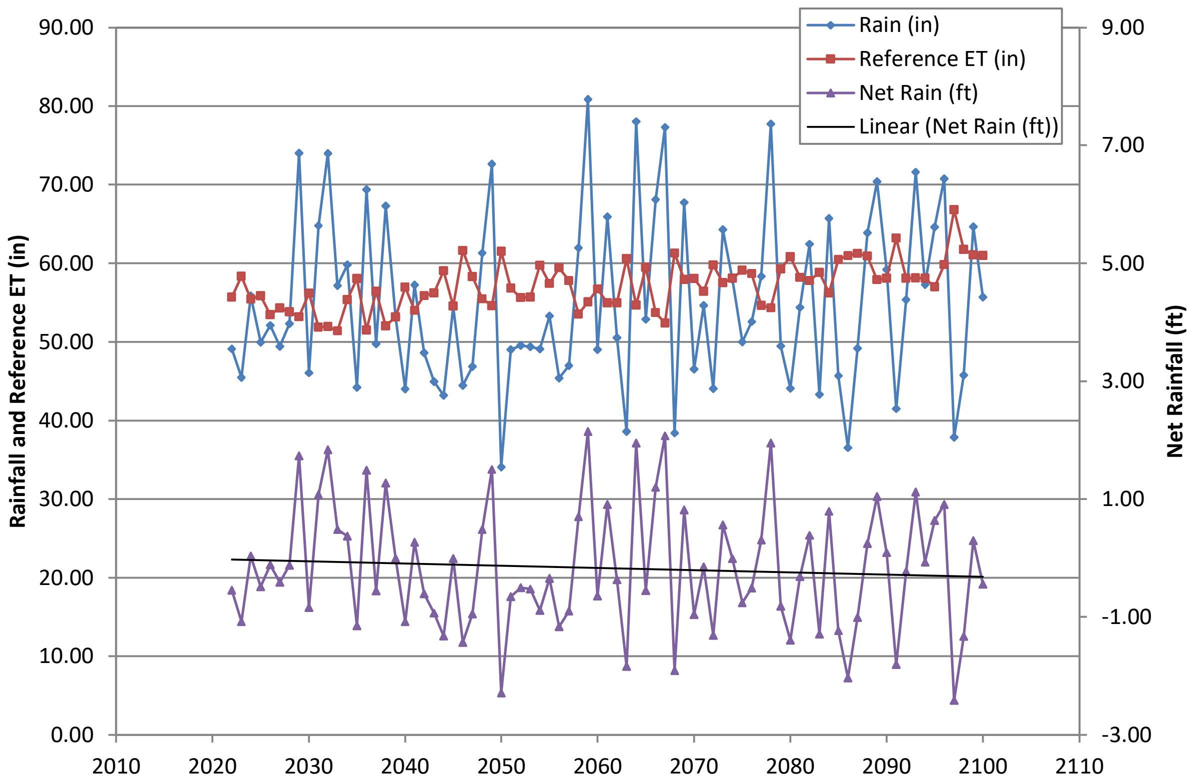

Figure 7. Projected Rainfall, Reference Evapotranspiration, and Net Rainfall (2022-2100)

The decrease in net rainfall was shown through crop modeling to increase the need for supplemental irrigation during future periods (Agsilico, 2023). The increase in irrigation was calculated based on the trend in net rainfall over the study period assuming that only the additional deficit was satisfied. As previously described, this does not account for timing of rainfall versus RET which could further increase the need to satisfy short-term water deficits during dry portions of the year. However, uncertainty about projected irrigated areas, crop types, irrigation application, future growing seasons, and crop rotation does not allow for evaluation at a finer than annual timescale.

To estimate the effects of projected changes in net rainfall on agricultural water use it was assumed that baseline use was the average of the applied rate for the period from 1985 to 2015 and increases in use were equal to the volume of water necessary to satisfy the decrease in the linear trend of net rainfall. This additional irrigation was assumed to be supplied with no additional water loss. The estimated rates for agricultural water use are shown in Table 1 for the years of interest. No data were available on the rates of water use for lawn irrigation to allow for calculation of residential irrigation separately. This use was estimated as part of the aggregate estimates for non-agricultural uses. These increases (15% through 2100) are similar in magnitude to the estimated increased irrigation needs projected by crop modeling; 20% for maize, 8% for snap beans, and 4% for bahiagrass.

Table 1. Agricultural Water Use Estimates for Selected Years

Year	Agricultural Water Use (gal/ac-d)
2022	1,658
2030	1,684
2040	1,716
2070	1,812
2100	1,907

2.2 Water Use Projections

To develop an overall estimate of future water use for Alachua County separate projections were made for non-agricultural water use and agricultural water use. These estimates were separated because of the different drivers and trends that exist for these types of use. Development of estimates for each type of use are described below.

2.2.1 Agricultural Water Use

The extent of agricultural acreage in Alachua County has gradually decreased as land use has shifted to more urban land uses. This loss of agricultural acreage is reflected in the data, with a decrease of 21,000 acres of agricultural lands between 1985 and 2015 in Alachua County. During the period from 1985 to 2022 irrigated acreage increased by about 4,000 acres, or 47%. These conversions to irrigation are consistent with an increase in land values and increasing crop prices which encourage generation of higher yields, increased predictability, and higher value crops. Furthermore, crop modeling for future projected periods shows that irrigation will be required to sustain yields under higher temperatures.

Agricultural water use was estimated for each of the three projected irrigated agricultural acreage scenarios that were previously described. For each of the acreage estimates (low, medium, and high) the average irrigation was estimated by multiplying the irrigated acres and the climate-adjusted irrigation application rate to yield total agricultural water use. The projected water demands for irrigated agriculture are provided in Figure 8.

These estimates show a range of projected agricultural water use that could result in more than a doubling in irrigation overall if lands continue to be converted to irrigated agriculture at about the same rate, or a slight decrease in agricultural water use if decreases in agricultural acreage continue with irrigated agriculture retaining the same share of total acreage.

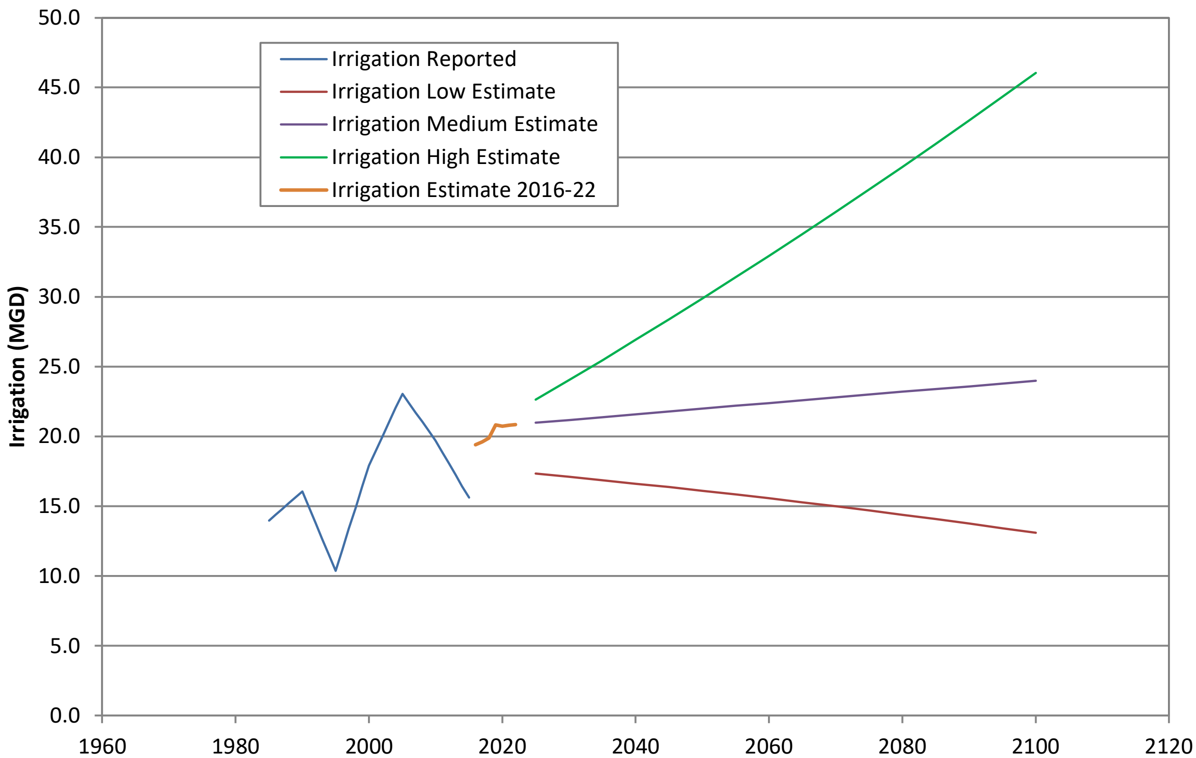

Figure 8. Projected Agricultural Water Use

2.2.2 Non-Agricultural Water Use

Water use for all sectors other than agriculture were estimated in aggregate based on trends in historical water use and projected changes in population. Water use for individual use sectors were evaluated, but estimating future use by sector did not appear to offer any benefits over estimation of aggregate water use for this study. To estimate non-agricultural water use, gross per capita water use was estimated for three future scenarios to show the potential range of likely scenarios. The three scenarios considered were:

- Low Estimate: Per capita water use continues to decrease based on a power fit of the decrease observed between 2000 and 2015.
- Medium Estimate: Per capita water use stays the same at 2015 levels.
- High Estimate: Per capita water use increases linearly from 2015 levels (118 gpcd) to 2010 levels (137 gpcd) by 2100 as increasing RET leads to more irrigation to maintain landscapes (12.5% increase in demand estimated for St. Augustine grass), more lawns are constructed with automatic irrigation systems, and higher temperatures lead to increased demands for power generation.

The per capita water use estimates for each of the scenarios are shown in Figure 9.

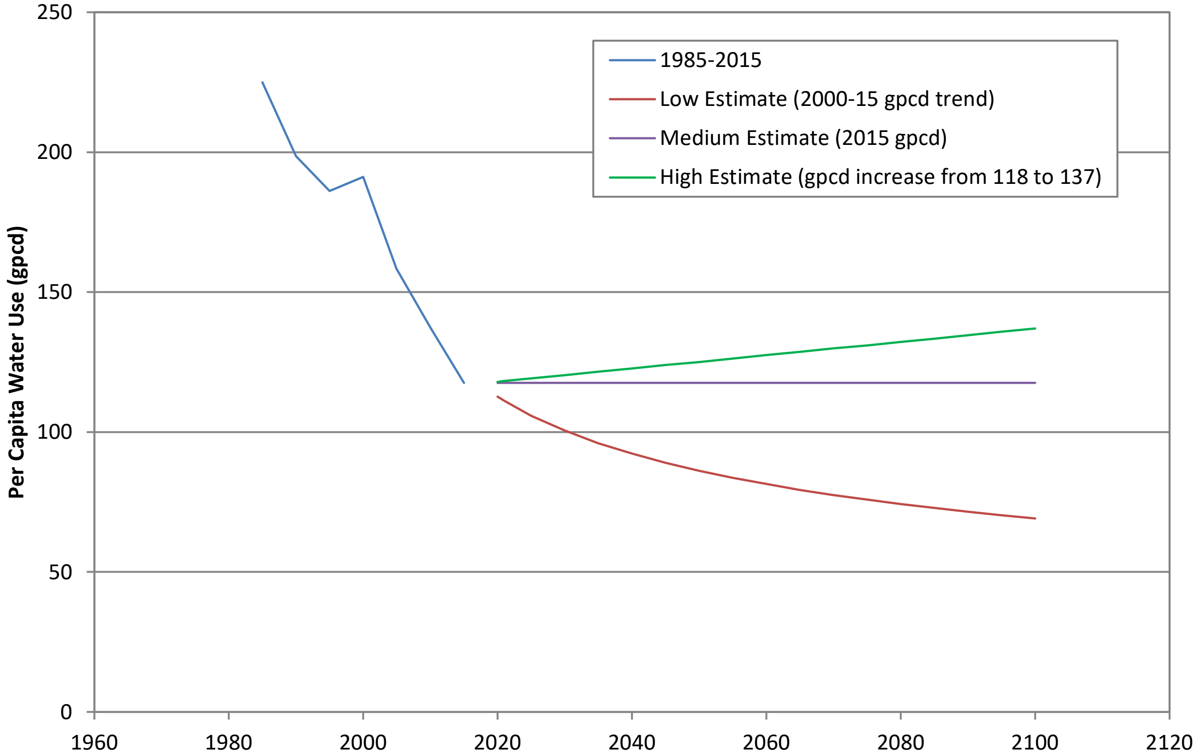

Figure 9. Projected Per Capita Water Use

The developed per capita water use values were multiplied by the estimates of population, including climate migration to project future water use for each of the scenarios. Total non-agricultural water use is shown in Figure 10 for Alachua County.

The estimates of non-agricultural water use show water use continuing at about the same level in the low estimate to more than doubling from 2015 levels in the high estimate. The lack of continued decreases in water use are largely driven by the county population which is predicted to increase significantly over the planning period.

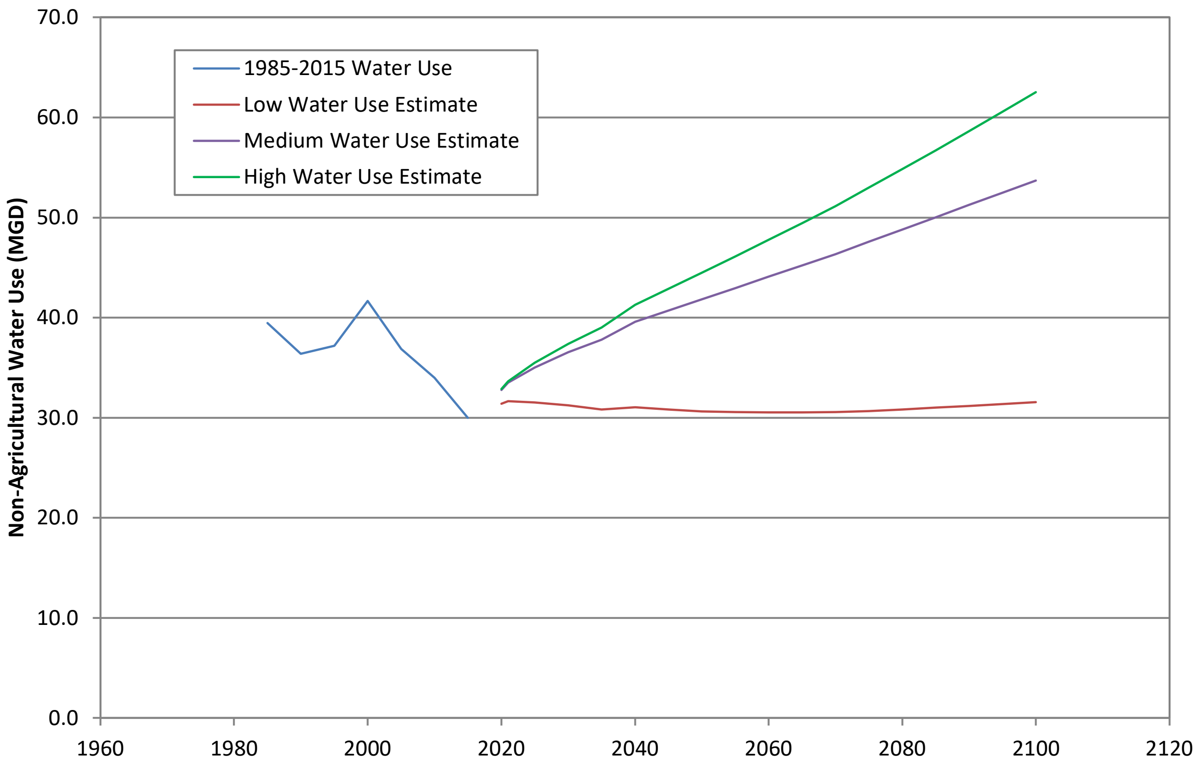

Figure 10. Non-Agricultural Water Use Estimates

2.3 Total Alachua County Water Use

By combining the agricultural and non-agricultural uses a projection of total Alachua County water use was calculated. Given the methods and multiple estimates developed for each of the water use types, there are a wide range of possible outcomes depending on the specific combination of scenarios. Additionally, there is uncertainty in these estimates due to an array of other potential drivers of water use that include, but are not limited to:

- Regulatory restrictions on future water withdrawals.
- Increased adoption of residential irrigation wells, assuming regulatory requirements are not adopted.
- Challenges in developing additional surface or groundwater resources for water supply due to Minimum Flows and Minimum Levels (MFLs).
- Implementation of stronger conservation rate structures that increase the cost of water and reduce consumption.
- Increased water conservation due to education, incentives, and improved fixtures.
- Development of new, more drought resistant crops and landscapes with reduced irrigation demands.
- Increased agricultural demand and prices that leads to increased irrigated acreage.
- Crops with higher water demands.

- Technological advancements that improve irrigation efficiency.
- Smaller lot sizes that reduce the irrigated footprint of the lot and applied irrigation.
- Greater population increases due to climate migration.
- Increased water use for power generation to meet cooling demands.

By combining the agricultural and non-agricultural water use a total water use was estimated for Alachua County through 2100 (Figure 11). For the sake of presentation, low scenarios were paired, medium scenarios were paired, and high scenarios were paired; although it is possible that a different combination of scenarios could occur, i.e., low agricultural use with medium non-agricultural use. However, by combining the uses in this way the potential range of future scenarios are evident.

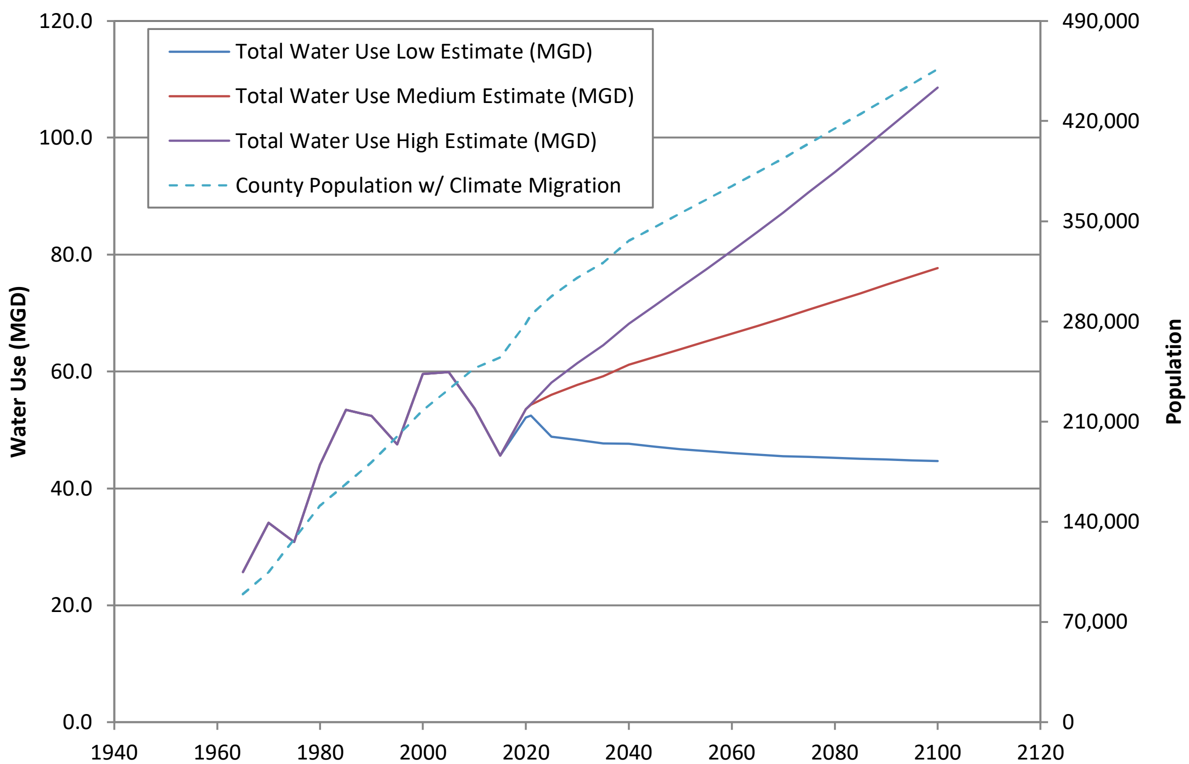

Figure 11. Projected Total Water Use for Alachua County

Based on these projections total water use is estimated to range from levels similar to 2015 in the low scenario to more than doubling from 2015 levels by 2100 in the high scenario. A final note with regard to these projections, the future is characterized by substantial uncertainty and there is undoubtedly an opportunity to influence future levels of water use through education, policy, and planning.

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