Hazen *Technical Memorandum*

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To: City of Santa Fe

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Development of Water Demand Projection for the City of Santa Fe

Introduction

The City of Santa Fe and Santa Fe County have initiated a science based, community informed, multi-year planning cycle to develop an integrated water resources plan looking out to the year 2100. The planning process is intended to be on-going and adaptive; such that new information can be incorporated as available, and plans modified as needed to reflect the latest scientific developments, current conditions, and public values. The current planning cycle is called Santa Fe Water 2100, or Water 2100, and the first element of Water 2100 which occurred in 2020 was to seek public input on the process. This memorandum documents the City of Santa Fe only demand projections out to 2100 that were developed as part of the second element in the planning cycle. Santa Fe County demand projections are being developed independently.

Projected potable demands presented in this memorandum were developed by analyzing trends in City water use and coupling this analysis with recent County population projections adjusted for the City population. Projected potable demands are broken down into indoor and outdoor use. Historical recycled water or “non-potable” use is also presented. Potable and non-potable demand combine to reflect total City of Santa Fe water demand.

Demand projections should not be regarded as a precise statement about future conditions, but rather as a basis for planning that can be used to examine potential vulnerabilities. Likewise, as the future unfolds, this demand baseline can be used to help understand changing conditions and adapt City actions as necessary. It is anticipated that as data are collected, and new information becomes available these demand projections will be refined.

Table of Contents

1. Potable Demand

1.1 Historical Per Capita Usage

For this analysis, per capita use is defined as gross potable water produced by the City of Santa Fe divided by historical estimates of resident population served.[1] Figure 1 plots historical monthly values of per capita use for the period December 1995 through December 2020.[2] The plot of historical per capita use demonstrates a pronounced seasonal pattern in water use, characterized by repeating wintertime troughs and summertime peaks, which are largely associated with normal weather patterns occurring over the course of the calendar year and associated water use for irrigation. Deviations from normal weather conditions, such as hotter/drier or cooler/wetter than normal conditions, can be expected to influence per capita use in any given year. For example, one should expect water use to be higher in the summer months, but actual weather conditions may lead to some differences in actual consumption from year to year.

The plot of Figure 1 also shows a general downward trend in consumption. Decreasing trends in per capita use have occurred in many regions of the US as national plumbing codes and new and more efficient water using technologies have gradually replaced older, inefficient, fixtures. These trends should be expected in Santa Fe, particularly for indoor residential uses of water, and are expedited by water conservation programs implemented by the City over time. Furthermore, the downward trend in Santa Fe's per capita use is particularly evident starting in the early 2000's, when, in response to severe drought conditions, watering restrictions went into effect and significantly higher prices for water were introduced, especially for customers using relatively large amounts of water for irrigation. In recent years, both the wintertime troughs (representative of indoor use) and relative summertime peaks (representative of irrigation use) in per capita use are lower than they were in the 1990s.

1.2 Modeled Per Capita Usage

An analysis of historical potable per capita water use observations was undertaken using regression analysis. Regression analysis is an accepted technique for estimating and fitting a statistical relationship between a variable of interest (or the dependent variable) – in this case, per capita water use – and one or more variables that are used to explain changes in the dependent variable. Based on the trend analysis and readily available information, the factors listed in

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[1]City water production is equal to total diversion from three of the City's supply sources (Canyon Road Water Treatment Plant and two groundwater well fields), plus "production" from the Buckman Direct Diversion. Production from the Buckman Direct Diversion is on average about 3.7% less than diversion due to transmission and treatment plant losses. Given BDD makes up almost 50% of the City's water supply, the City's total diversion is about 1.7% greater than "City production" for the period 2011 to 2020 (when BDD was online). Prior to 2011, the City's total diversion is equal to "City production." As defined, total per capita use includes nonrevenue water, including unbilled consumption and real losses and is consistent with the City's reporting of gpcd to the New Mexico Office of the State Engineer

[2]Note that 2 distinct outliers have been removed (December 2016 and December 2017).

Table 1 were used in the regression analysis.

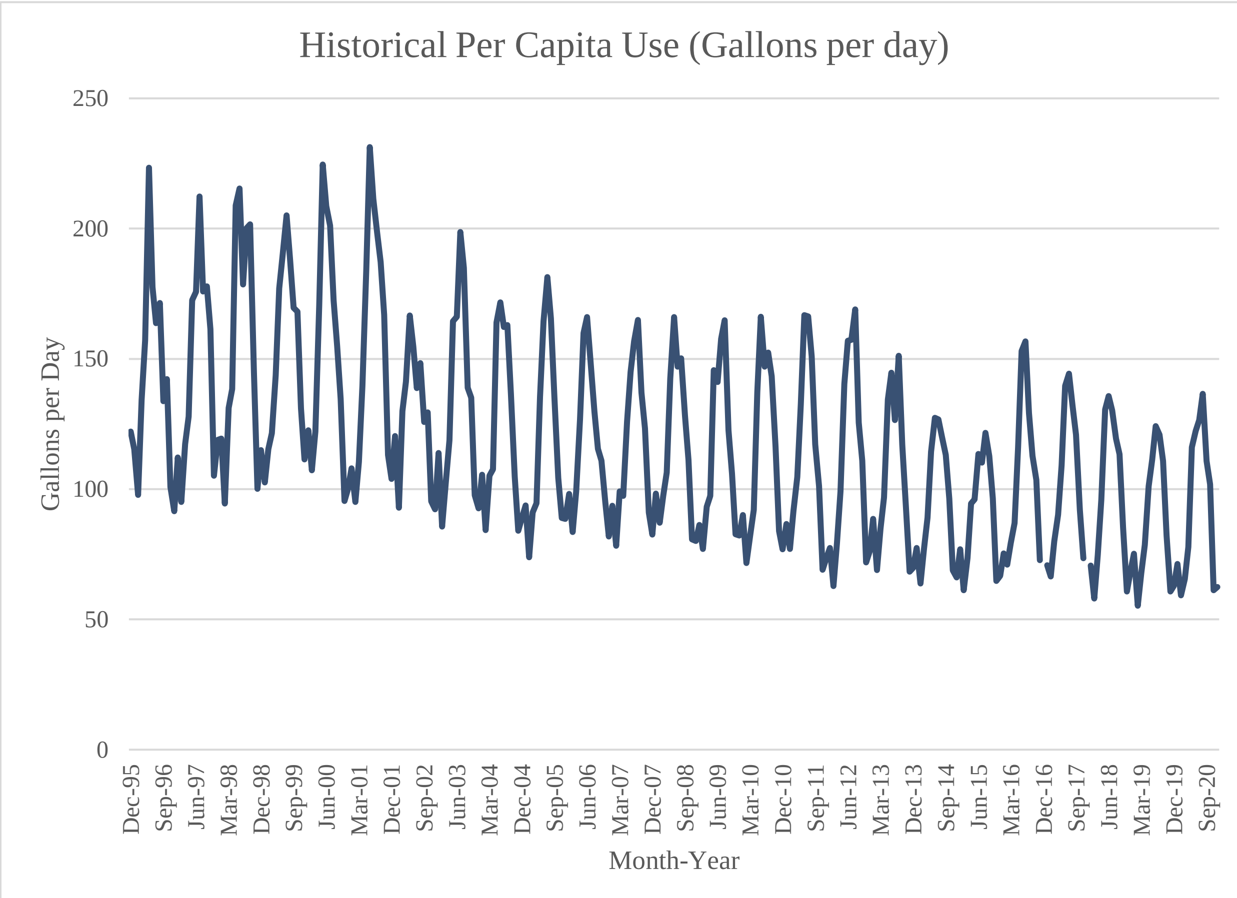

Figure 1 Historical Per Capita Use (Gallons per day)

Table 1: Variables Used to Model Per Capita Water Use

Independent Variable	Directional Impact on Per Capita Use	Notes
Monthly time index (trend)	-	Captures gradual downward trend, which is decreasing at a decreasing rate
Seasonal index	-/+	Captures normal repeating pattern in monthly use
Average Maximum Daily Temperatures	+	Higher temperatures lead to higher rates of water use
Monthly Precipitation	-	More precipitation leads to lower rates of water use
Price of Water and Sewer	-	Higher prices lead to lower rates of water use (calculated as the volumetric cost of the 12,001st gallon, adjusted for inflation)

Figure 2 shows a plot of monthly historical per capita use and monthly per capita use fitted using the regression model containing terms to capture normal seasonal oscillations, observed weather, prices for water and sewer, and remaining time trends.[3] Meanwhile, Figure 3 plots actual and fitted per capita use values on an annual basis.[4] The fitted lines are found to explain more than 95 percent of the historical variability in per capita use on both a monthly and annual basis. Appendix A provides the regression model output, including the variables and their respective estimated coefficients.

[3] Note that modeled monthly per capita use observations start in July 1997, the date from which complete information on prices was available.
[4] Modeled annual per capita us begins in 1998, which is the first complete calendar year for which price information was available.

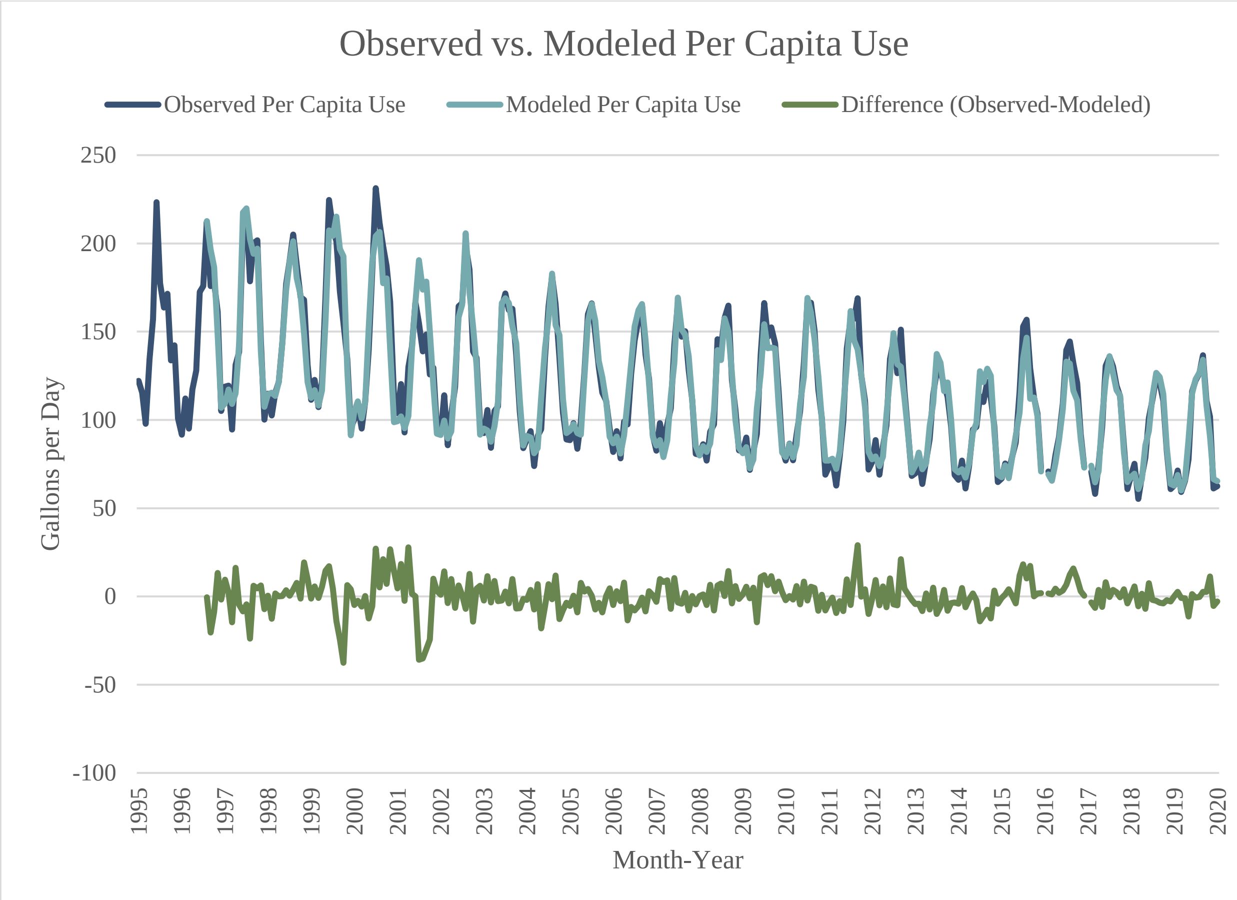

Figure 2 Observed versus Modeled Per Capita Use

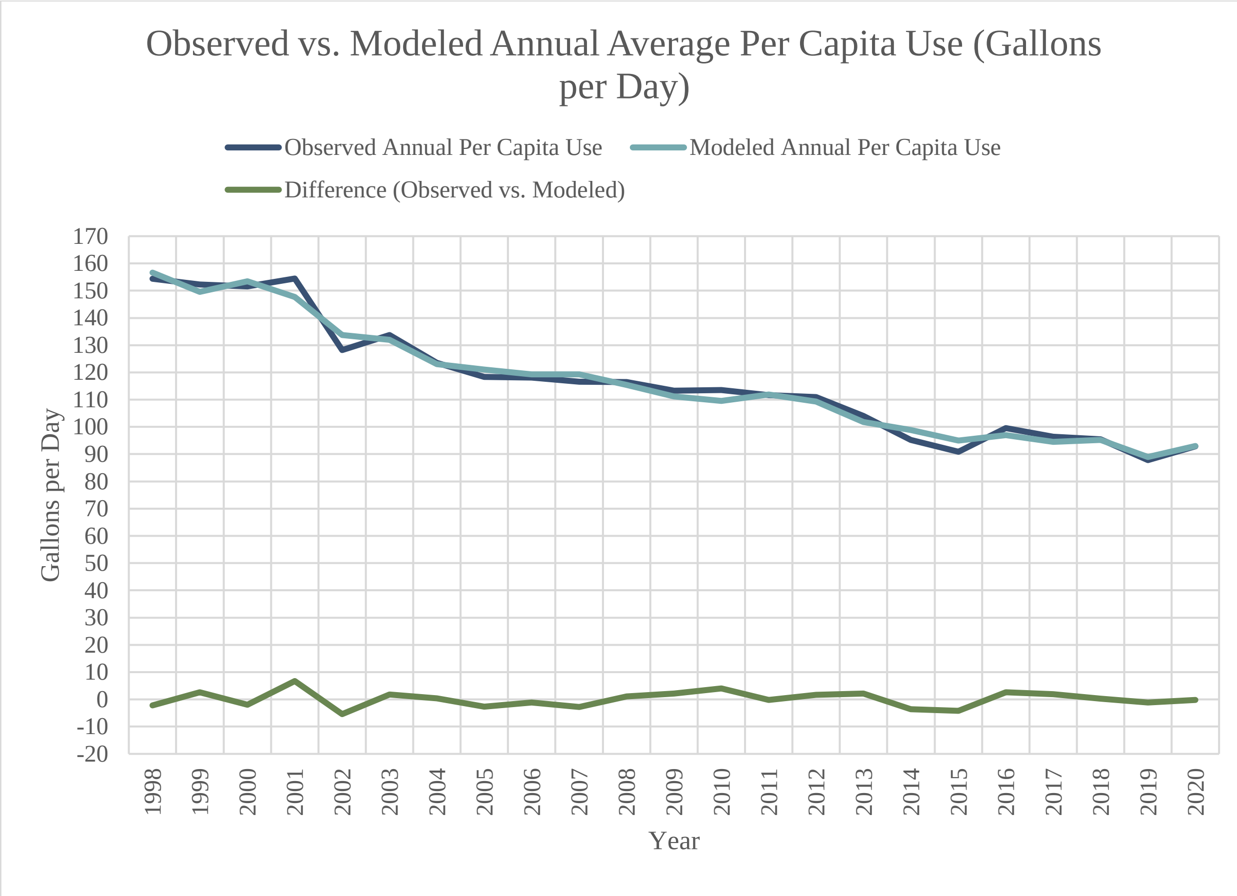

Figure 3 Observed versus Modeled Annual Average Per Capita Use

1.3 Projections of Per Capita Use

The regression model serves as an empirical basis for developing future projections of per capita use. Projections are derived by extending historical trends into the future, assuming real (inflation-adjusted) prices remain constant and weather conditions reflect historical averages.

Since the trend in modeled per capita water use is decreasing, there is a possibility that extending these trends into the future, especially for a long projection horizon, will result in projected per capita usage rates unsupported by existing or known water-using technologies. To mitigate this possibility, the projections employ alternative "floors" that per capita use estimates are not allowed to fall below. These floors, which effectively serve as lower bounds on the projected trend, represent assumptions about levels of residential indoor use that could be achieved under high levels of technological efficiency. The options examined are described in Appendix J of California State Water Control Board (2020), which conducted recent research for developing indoor water use standards in California.[5] Three alternative residential indoor per capita use estimates are used for alternative per capita usage projections for Santa Fe:

- 36 gallons per capita day (gpcd) as estimated by DeOreo et al. (2011)[6] for WaterSense New Homes.
- 34 gpcd as estimated by DeOreo et al. (2016)[7] for existing homes retrofitted with water efficient devices, plus leak detection.
- 24 gpcd as estimated by Feinstein (2018)[8] for leading edge flow rated appliances meeting essential indoor uses.

To identify when these alternative floors would be effective, initial trend-based per capita use projections were generated using the parameters of the regression model described above. The initial projections represent total per capita use, including all uses of water including nonresidential uses. To generate corresponding estimates of residential indoor per capita use, minimum monthly (low-use season) values for total per capita use are first assumed to represent total indoor per capita use.[9] Next, based on an assessment of class water use by the City of Santa Fe, these estimates are scaled downward, reflecting that, on average, residential use in Santa Fe is approximately 68 percent of total use.

Error! Reference source not found. illustrates the steps in identifying when along the projection period the t hree per capita use thresholds would be met according to the initial trend-based per capita use projection. Table 2 summarizes the estimated timing for each residential indoor per capita use floor.

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[5] California State Water Resources Control Board. 2020. Appendix J. Efficient Indoor Water Use and Practices. Prepared for California Department of Water Resources. https://www.waterboards.ca.gov/conservation/regs/docs/irwus-appendix-j.pdf

[6] DeOreo, William B. 2011. Analysis of Water Use in New Single Family Homes. By Aquacraft. For Salt Lake City Corporation and US EPA. https://aquacraft.com/wp-content/uploads/2015/10/Analysis-of-Water-Use-in-New-Single-Family-Homes.pdf

[7] DeOreo, W., Mayer, P., Dziegielewski, B., and J. Kiefer. 2016. *Residential End Uses of Water, Version 2.* Denver: Water Research Foundation.

[8]Feinstein, L. 2018. Measuring Progress Toward Universal Access to Water and Sanitation in California: Defining Goals, Indicators, and Performance Measures. Pacific Institute. https://pacinst.org/publication/measuring-progress/

[9] Recall that total per capita use includes unmeasured consumption and losses. Since non-revenue water isn’t separated into indoor and outdoor components no subsequent adjustments are made to the resulting floor values of gpcd.

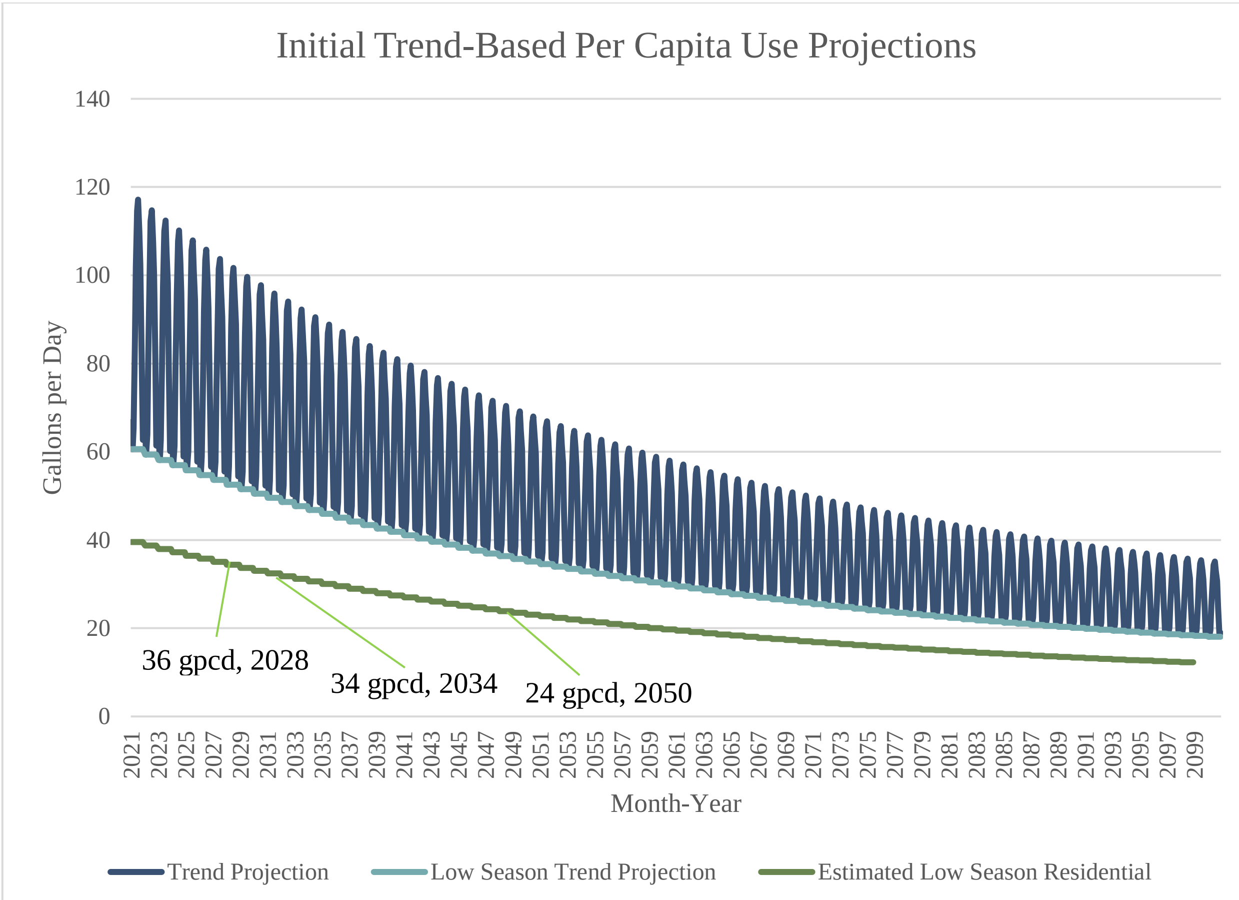

Figure 4 Initial Trend-Based Projection and Identification of Per Capita Use Thresholds

Table 2: Identified Projection Years when Residential Indoor Per Capita Use Thresholds Become Effective

Residential Indoor Per capita Use Floor	Effective Projection Year when Reached
36 gpcd	2028
34 gpcd	2031
24 gpcd	2050

1.3.1 Analysis of Non-seasonal and Seasonal Use

Prior to using the thresholds listed in Table 2 to generate alternative projections of per capita use, an evaluation was undertaken to judge if there were any significant trends in the split between indoor and outdoor use that may need to be considered. The proportion of total per capita use that is "non-seasonal" and taken as a proxy for indoor water use is calculated using the "minimum-month" method as:

$$\%\ \boldsymbol{Non\text{-}seasonal\ use} = \mathbf{100} * \left(\frac{\boldsymbol{Lowest\ monthly\ per\ capita\ use\ in\ calendar\ year}}{\boldsymbol{Average\ annual\ per\ capita\ use}}\right)$$

Equation 1

Therefore, for any given year, the proportion of seasonal use, which is assumed to represent outdoor water use, is calculated as the complement of Equation 1**:**

$$\%\ Seasonal\ use = 100 - (\%\ Non\text{-}seasonal\ use)$$

Equation 2

Figure 5 plots the annual estimates of the % Non-seasonal use metric over the historical period.[10] Two estimates are provided—one calculated using the raw data under observed weather conditions and another that modifies (or *normalizes*) the raw data to account for departures from historical normal weather conditions in the historical period. The ability to normalize for weather is provided by the weather parameters of the regression model described in the previous section. Historically, the average percentage indoor/outdoor split is approximately 65%/35%, but, as illustrated, this estimated split varies from year to year, as neither indoor nor outdoor use is constant. For the raw data, there is a slight downward trend in non-seasonal use over the historical period—suggesting a small increasing trend in the proportion of seasonal or outdoor use. The weather-normalized estimates, which imply the indoor/outdoor split under historical normal weather conditions, show virtually no trend. Therefore, for a normal-weather projection scenario it is not considered necessary to make any additional adjustments for projecting per capita use. However, for any future scenarios that involve changes in weather or climate from historical patterns, the weather component of the regression model should be used to modify the per capita use projections accordingly.

Figure 6 plots four alternative projection paths for total annual per capita use, including three representing the alternative residential minimum per capita use floors, along with a constant value set at the 2020 value of total per capita use (all assuming historical normal weather).

[10] Note that the diagram omits 2016 and 2017 due to outlier values for minimum month per capita use.

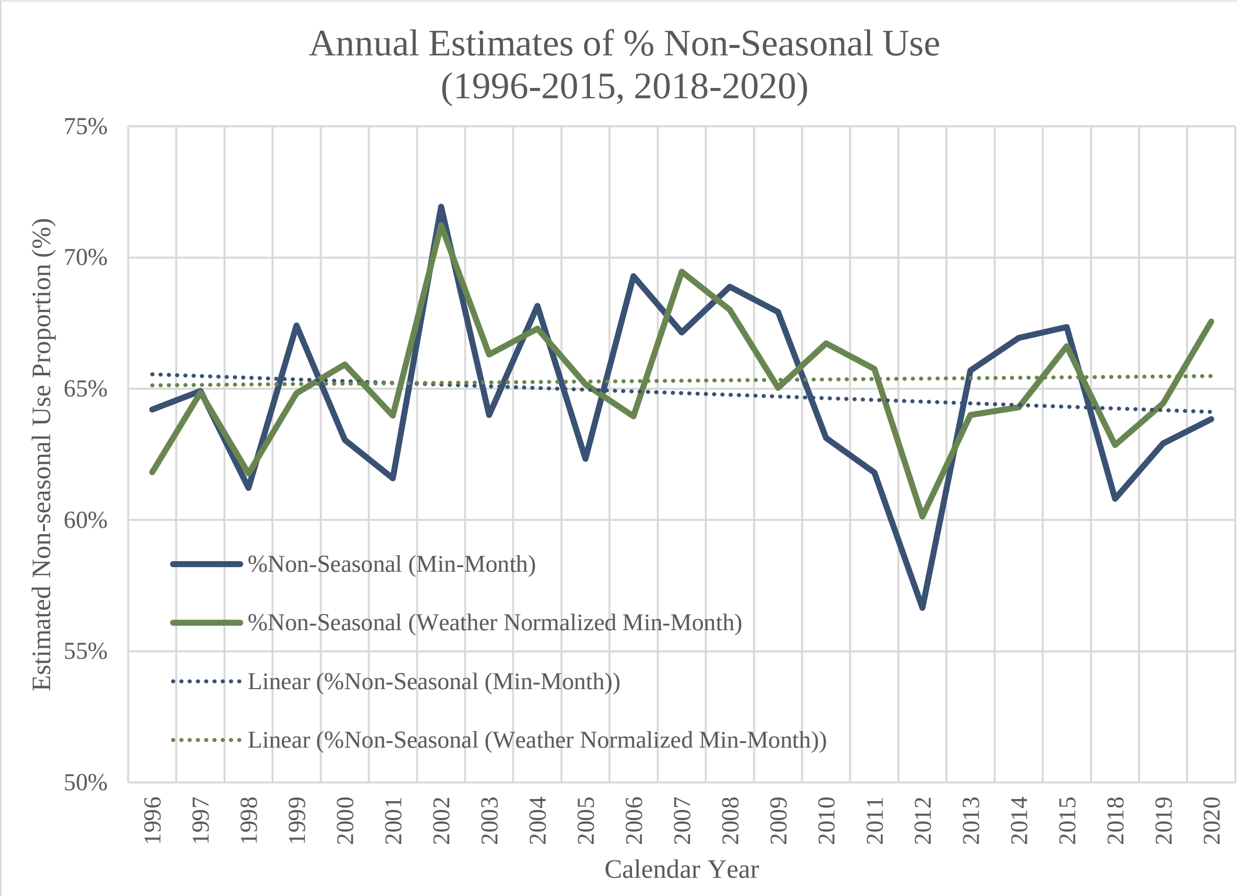

Figure 5 Annual Estimates of the Proportion of Total Use that is Non-seasonal with and without Normalizing for Weather

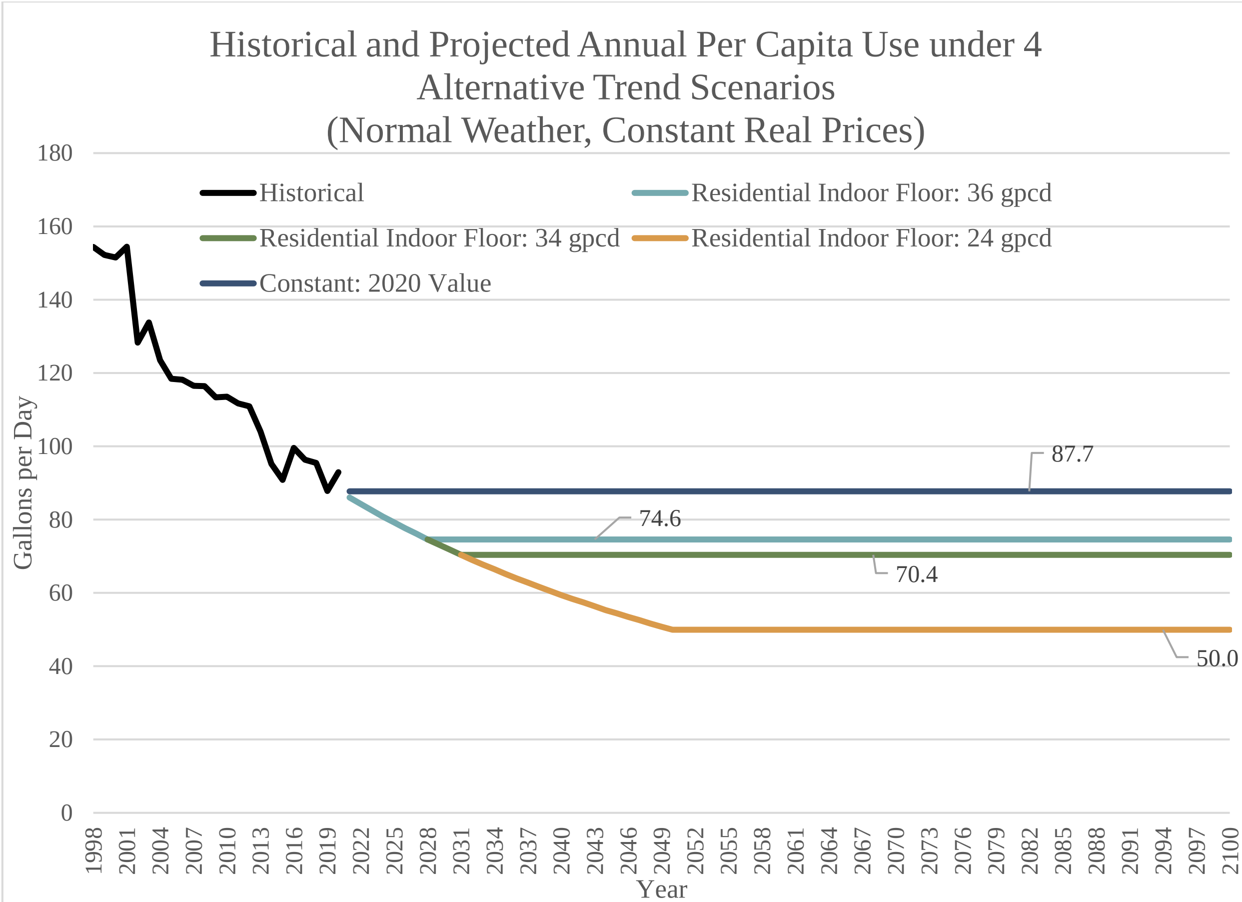

Figure 6 Projections of Annual Per Capita Use under 4 Trend Scenarios

2. Non-potable Demand

Total City of Santa Fe water demand includes both potable water demand as well as non-potable demand. Non-potable water is served to irrigation customers after treatment at the Paseo Real Water Reclamation Facility. Projections of future non-potable demand can be based off of the current system as it is not anticipated that this use will increase. **Error! Reference source not found.** shows historical non-potable d emand.

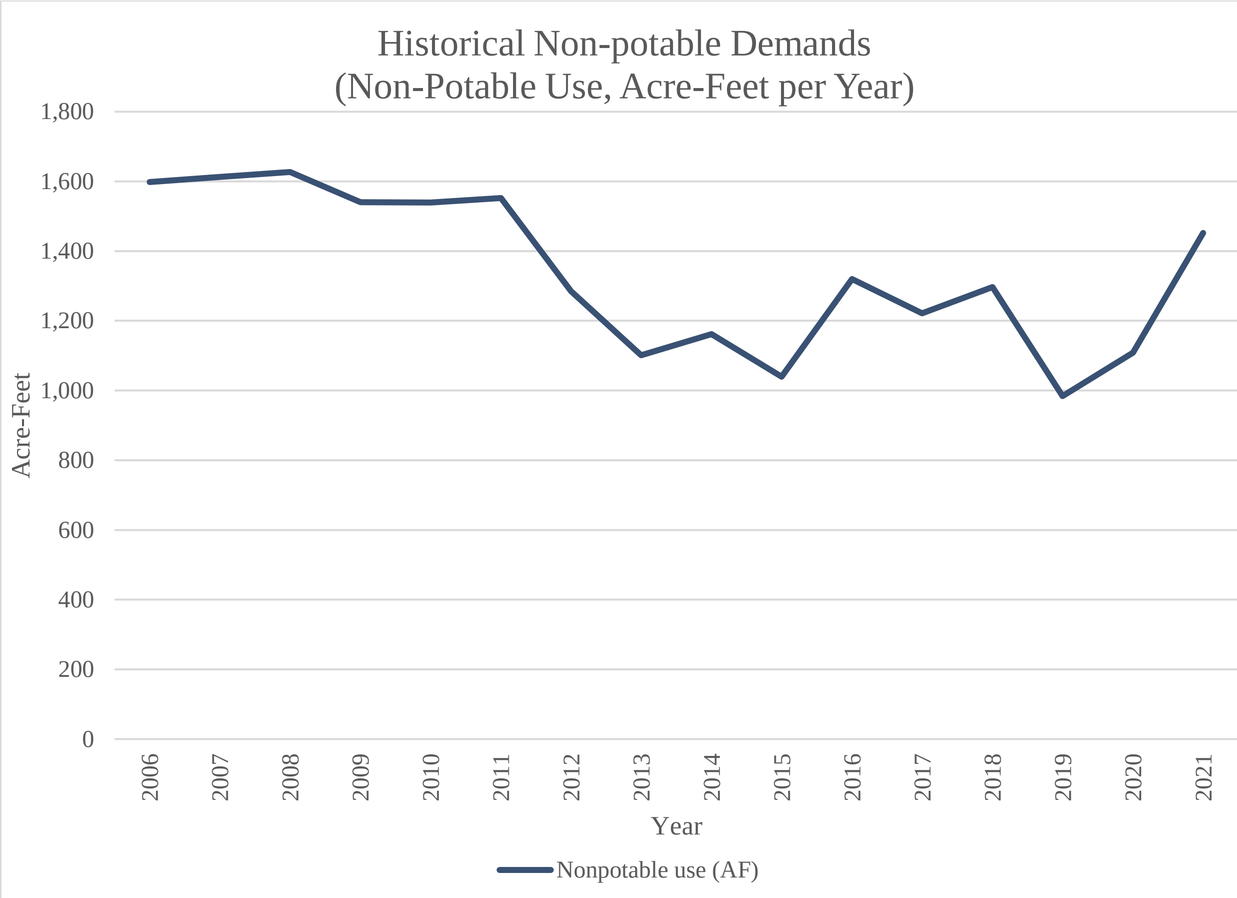

Figure 7 Historical Non-potable Demand

3. Population Projections

The City provided assistance in generating population projections, using historical estimates of population for the City in conjunction with historical estimates and projections of County Population derived from the University of New Mexico Bureau of Business and Economic Research (BBER) (UNM BBER, 2021). Some projections of future population were available for the County, but there were no population projections available for the City. The following steps were taken to generate City population projections to the end of the planning horizon (2100):

1. Adjust existing BBER County population projections to 2050. Projected 2020 population is about 5,500 people greater than actual 2020 population. Accordingly, all BBER projections were adjusted by subtracting a constant value of about 5,500 so historical and projected are aligned.

2. Estimate City population projections as a fixed fraction of the adjusted BEBR County projections to 2050; based on historical estimates City population has remained relatively stable relative to County population estimates, where City population is roughly 56 percent of the County's estimated population.

3. Extrapolate City population projections to 2100 using the calculated annual average rate of growth in City population estimates from 2035-2050 (approximately 0.5 percent per year)

Figure 8 presents the historical estimates and the projections of population used for this analysis. Based on the steps above, the City population is projected to grow to just over 130,000 in 2100. The City population projections shown in Figure 8 are used to generate the baseline water demand projection scenario.

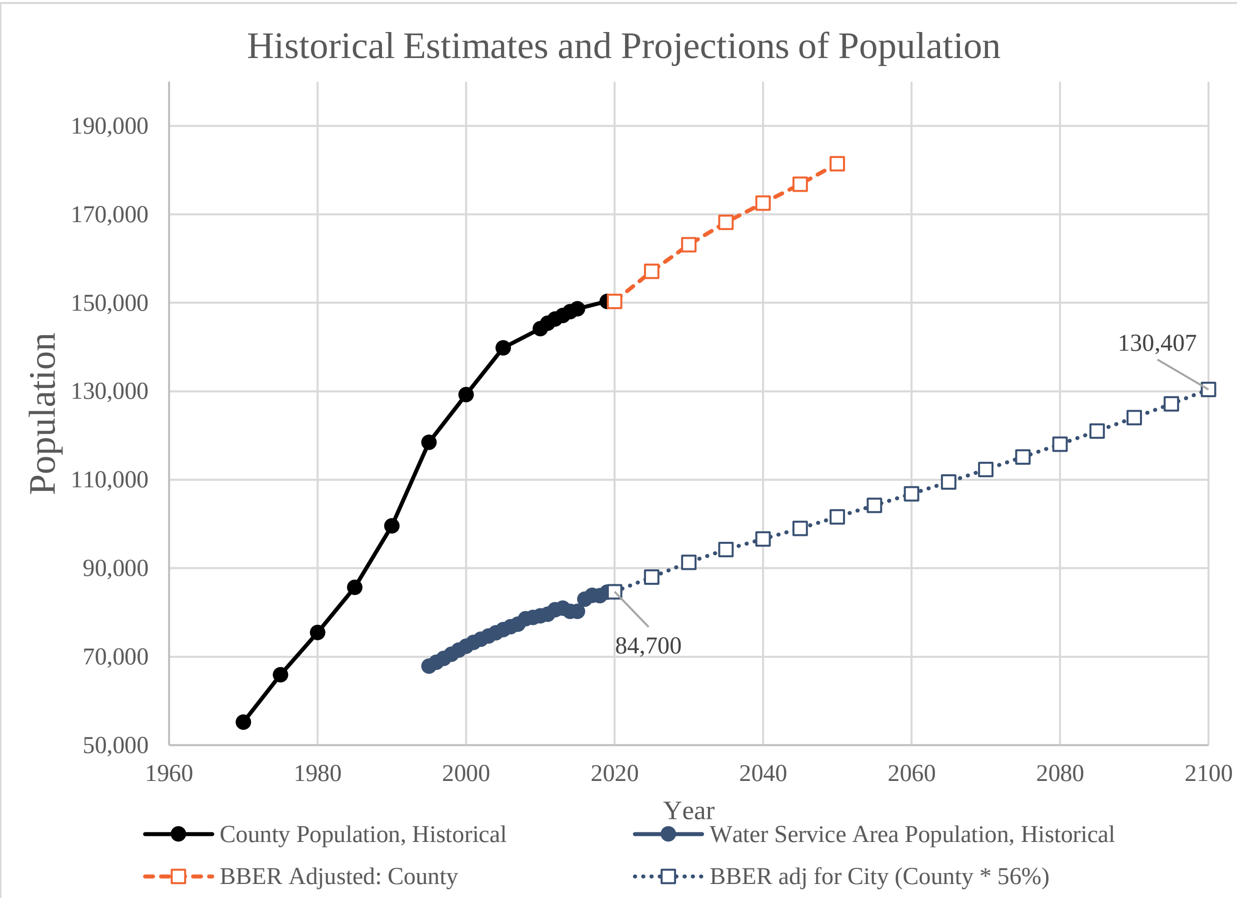

Figure 8 Historical Estimates and Derived Projections of Population

4. Demand Projections

4.1 Potable Water Production Demand Projections

To calculate a projection of total potable production demand, the projection methodology requires projections of population to match with corresponding projections of per capita use.[11] For any given time period, total use is calculated as:

$$Total\ Use\ (acre - feet) = \frac{days * gpcd * Population}{325{,}851} \quad \textbf{Equation 3}$$

where *gpcd* reflects a projection of gallons per capita per day (gpcd) using the model of per capita use described above, *days* represents the number of days in the time period (e.g., 30 days in a month, 365 days in a year), and the divisor of 325,851 represents the number of gallons in an acre-foot of water.

4.1.1 Derivation of Baseline Production Demand Projection Scenario

As described in Section 1.3 and shown in Figure 6, three alternative projections of gpcd were generated using three different assumptions about minimum thresholds (or floors) for indoor residential use. A single baseline projection of total use was calculated as the average of individual projections calculated using the City population projections and the 36 gpcd and 34 gpcd residential indoor usage floors, respectively. This approach accounts for the small difference between the individual per capita use scenarios and does not incorporate the gpcd scenario that is relatively more speculative with respect to residential water using technologies.

plots the total potable production demand projections along with historical production demands for reference. These projections represent estimates of total potable use for the City and are collectively considered a “baseline scenario,” which in addition to incorporating an effective floor on gpcd, assumes normal weather and constant real prices.

[11] Note that the term *production* demand is used, since the per capita use model is based on City water production inclusive of nonrevenue water.

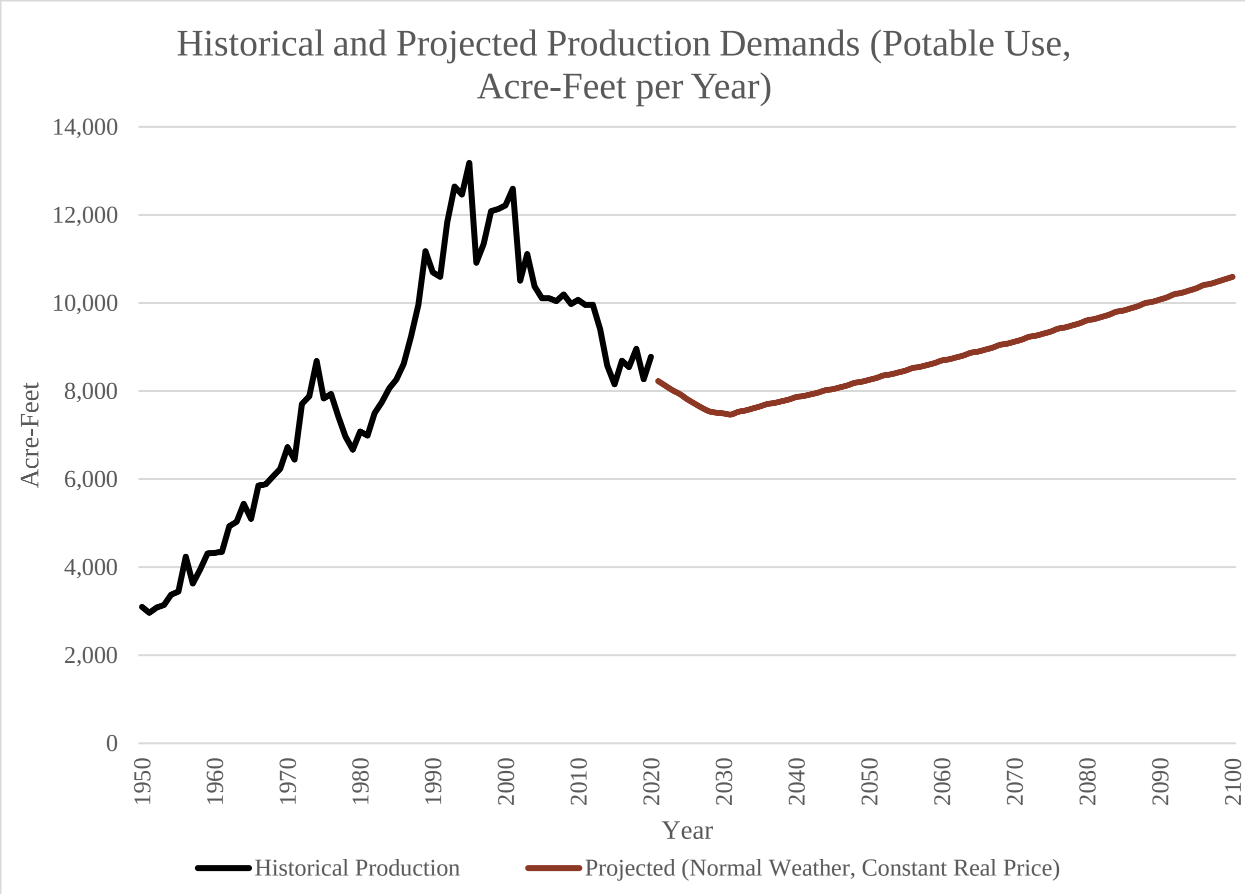

Figure 9 Historical and Projected Baseline Demands

Meanwhile, Figure 10 presents a breakdown of the baseline projections into estimated non-seasonal (proxy for indoor) and non-seasonal (proxy for outdoor) components. Under the normal weather assumption of the baseline scenario, these projections follow the estimated historical average split (roughly 65% non-seasonal/35% seasonal).

4.2 Non-potable Water Production Demand Projections

As noted in Section 2, non-potable water demand has historically varied year over year based on climatic conditions. The City currently has no plans to expand the user base or demand on the non-potable system. As such, non-potable production demand is projected as average use for all users from 2018-2021 and 2021 usage for Las Campanas who resumed non-potable use in that year. This results in a projected non-potable production water demand of 1,374 afy.

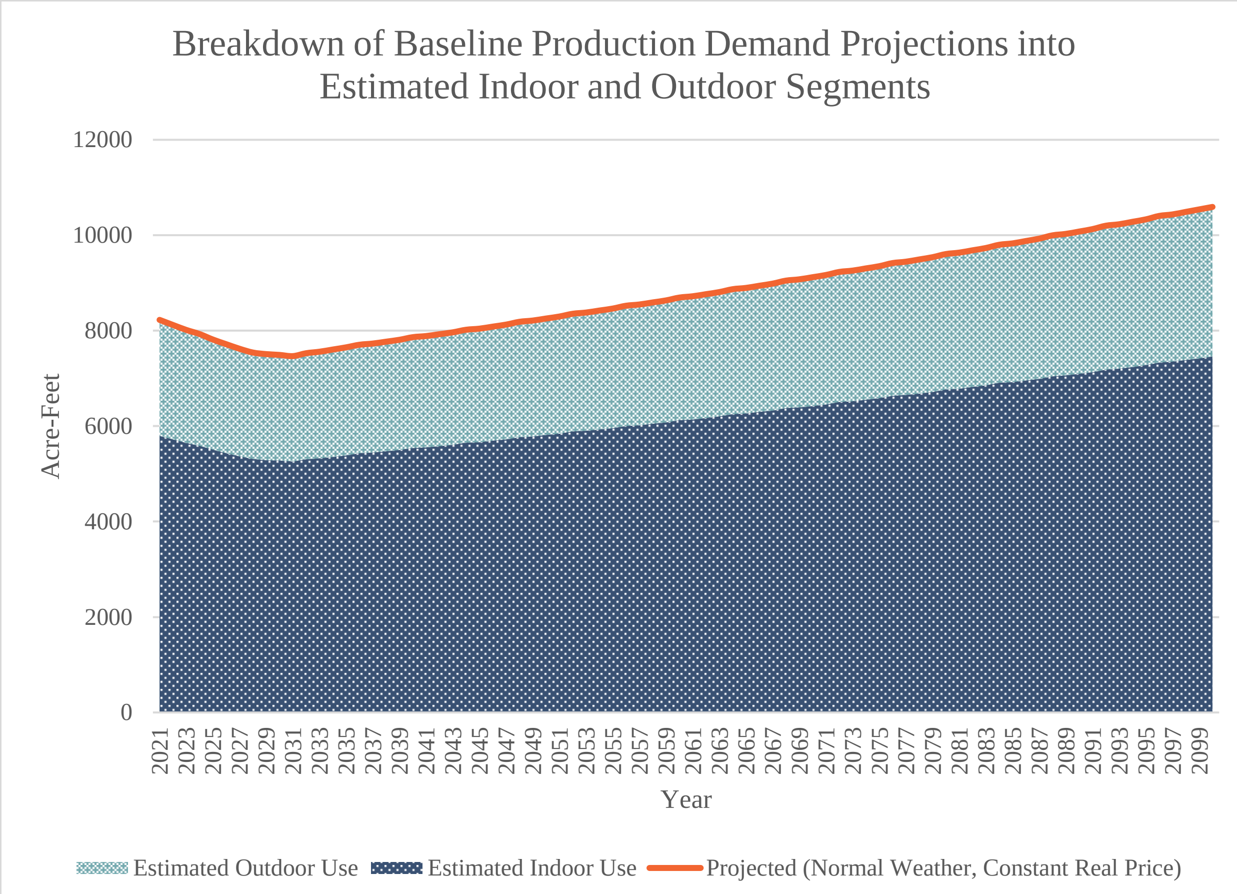

Figure 10 Estimated Non-seasonal (Indoor) and Seasonal (Outdoor) Segments of Baseline Production Demand Projections

4.3 Total Production Demand Projections

Total projected water production demand includes both potable production demand and non-potable water production demand. **Error! Not a valid bookmark self-reference.** provides a tabular summary of the baseline projections for five-year increments over the projection period. The baseline projection scenario is a planning-level reference point for other possible projection scenarios that could be generated under different model assumptions to address uncertainty about future demands and adaptation strategies (such as changes in population growth, different from historical weather, and changes in prices).

Table 3 Projected Values for Baseline Projection Scenario

Projection year	Gallons per capita day (gpcd)	Population	Total Potable Production Demand (acre-feet)	Estimated Non-seasonal Demand (acre- feet)	Estimated Seasonal Demand (acre- feet)	Non-potable Production Demand (acre- feet)	Total Demand (acre- feet)
2025	79.3	88,011	7,814	5,503	2,312	1,374	9,188
2030	73.2	91,361	7,492	5,275	2,217	1,374	8,866
2035	72.5	94,189	7,651	5,386	2,265	1,374	9,025
2040	72.5	96,626	7,864	5,541	2,323	1,374	9,238
2045	72.5	99,009	8,042	5,662	2,380	1,374	9,416
2050	72.5	101,624	8,255	5,812	2,443	1,374	9,629
2055	72.5	104,190	8,463	5,958	2,505	1,374	9,837
2060	72.5	106,821	8,694	6,126	2,568	1,374	10,068
2065	72.5	109,519	8,896	6,263	2,633	1,374	10,270
2070	72.5	112,284	9,121	6,421	2,700	1,374	10,495
2075	72.5	115,120	9,351	6,583	2,768	1,374	10,725
2080	72.5	118,026	9,606	6,768	2,838	1,374	10,980
2085	72.5	121,007	9,829	6,920	2,909	1,374	11,203
2090	72.5	124,062	10,078	7,095	2,983	1,374	11,452
2095	72.5	127,195	10,332	7,274	3,058	1,374	11,706
2100	72.5	130,407	10,593	7,458	3,135	1,374	11,967

4.4 Estimated Wastewater Return (Influent) Flows

Although non-seasonal production demands are taken as a useful proxy for indoor demands, estimates of non-seasonal production can differ from the amount of water returning to the wastewater stream for several reasons including:

- Nonrevenue water losses
- City water users employing septic systems
- Miscellaneous other factors, including, for example:
  - Sewer contributions of non-City water customers
  - Leaks at water use premises
  - Evaporative indoor water loss
  - Private recycling of indoor use
  - Miscellaneous outdoor uses occurring in the low demand season
  - Sewer collection system losses
  - Demand model inaccuracies

Recent measurements of influent into the City's wastewater treatment facilities were assessed relative to the non-seasonal water production demands to estimate differences and generate projections of future wastewater influent. Influent projections were derived using the following steps, which are illustrated in Table 4.

1. *Estimate and deduct non-revenue water from non-seasonal demand.* Based on data provided by the City for the period 2018-2020, non-revenue water (i.e., the difference between the amount of water produced and the amount sold to end users) is approximately 7.9 percent of water produced.

2. *Identify and estimate non-seasonal use of city customers on septic systems.* Based on data provided by the City from its Beacon system, the average annual non-seasonal use of City customers on septic systems for the period 2017-2023 is 159 acre-feet.

3. *Deduct average non-seasonal use of City customers on septic systems from City non-seasonal demand.* For the first calculated projection period of 2021, this results in a projection of sanitary flows of 5,178 acre-feet.

4. *Compare resulting estimate to recent measure of influent.* For 2021, influent is estimated at 5,390 acre-feet, which is 212 acre-feet greater than the projection of sanitary flows from step 3.

5. *Derive and apply influent calibration factor to all projection years.* The projection of sanitary flows for 2021 is less than the observed influent for 2021. Relative to the sanitary flow projection, this corresponds to a difference of about 4.1 percent. This proportion of "other influent" is added to the sanitary flow projection for 2021 and all subsequent projection periods to generate projections of influent. Based on independent estimates of volume influent from non-City water customers (domestic well users and county utility customers that use the City sewer system), "other influent" is assumed to consist primarily of sewer contributions from non-City water customers.

Table 4 Comparison of City Water Production and City Influent for 2021 (acre-feet unless noted)

Projected Non-Seasonal Production Demands	(1) Deduct Non-revenue water @7.9% of Water Produced	(2) Estimated Non-seasonal Demands of City Water Users on Septic Systems	(3) Deduct Non-seasonal Demands of Septic Users	(4) Observed Influent	Difference (Observed - Estimated)	(5) Percent Difference Relative to Estimated
5,794	5,337	159	5,178	5,390	212	4.1%

The influent projections are summarized in

Table 5 using calculated non-revenue water and other influent proportions and corresponding to the methodology demonstrated in Table 4. Note that the influent projections assume no additional City water customers on septic systems and that the non-seasonal demands of City water customers on septic will track non-seasonal per capita use estimates associated with the baseline demand projections.

Table 5 Derived Projections of Wastewater Influent

Projection year	Estimated Non-seasonal Water Demand	Non-Seasonal Water Sold	Non-Seasonal Water Sold to Customers on Septic	Sanitary Flows	Other Influent	Influent
2025	5,503	5,068	146	4,922	202	5,124
2030	5,275	4,858	135	4,723	194	4,917
2035	5,386	4,961	134	4,827	198	5,025
2040	5,541	5,103	134	4,969	204	5,173
2045	5,662	5,215	134	5,081	208	5,290
2050	5,812	5,353	134	5,219	214	5,433
2055	5,958	5,488	134	5,354	220	5,574
2060	6,126	5,642	134	5,508	226	5,734
2065	6,263	5,769	134	5,635	231	5,866
2070	6,421	5,914	134	5,780	237	6,017
2075	6,583	6,064	134	5,930	243	6,173
2080	6,768	6,234	134	6,099	250	6,350
2085	6,920	6,374	134	6,240	256	6,496
2090	7,095	6,535	134	6,401	263	6,663
2095	7,274	6,700	134	6,566	269	6,835
2100	7,458	6,869	134	6,735	276	7,011

4.5 Production Demand Climate Change Scenarios

The baseline water production demand scenario represents projections under the assumption that historical climate patterns persist over the planning horizon. As discussed previously, the regression model contains climatic variables that can be used to generate projections for assumed values of temperature and precipitation. Using the weather parameters of the model, alternative projections assuming climate change were prepared to evaluate climate change scenarios derived from an available CMIP3 database, which contains climate projections and historical simulations for 112 different climate model runs. The data for the 112 model runs were condensed into 3 scenarios of temperature change over the planning horizon. The data for the three scenarios were then substituted into the demand model to generate water production demand projections adjusted for potential climate change. The following steps were implemented to implement the climate change adjustments:

1. Collect CMIP3 simulated temperature data for the period 1950-2099 for 112 individual model runs.
2. Calculate minimum, median, and maximum temperature values across the 112 model runs creating 3 time series of temperature estimates from the 112 model runs
3. Calculate mean monthly values of temperature and ln(temperature) for the minimum, median, and maximum temperature series for the period 1950-2000

4. Calculate ratios of projected temperatures to the mean monthly values in Step 3 for each of the minimum, median, and maximum temperature series for 2021-2099
5. Apply ratios from Step 4 to scale observed normal average maximum temperatures used in modeling to generate departures from normal temperatures consistent with the historical temperature data used in modeling and the temperature variable of the regression model.
6. Substitute the derived departures from Step 5 into the per capita projection model for each year and month over forecast horizon for minimum, median, and maximum temperature climate scenarios
7. Calculate percentage differences from the normal weather demand projections by calendar year for minimum, median, and maximum scenarios
8. Apply the percentage change to the baseline historical normal weather production water demand projection scenario to derive climate change adjusted (low, median, and high) projection scenarios (graduating values from 2021 to 2029 then applying estimated ratio values onward)

Figure 11 plots the three climate change scenarios for potable demands alongside the baseline projections scenario. The implications of warming climate are evident in that all three climate adjustments result in projections that are higher than the baseline scenario which assumes historical normal climate. Since the low and high scenarios can stem from different model runs from the CMIP3 data, this results in considerable year-to-year variability in the plotted lines for those scenarios. By design, the median scenario is less prone to this variability and demonstrates a smoother upward trend in projected demands associated with the temperature projections.

Table 6 summarizes and compares the median climate change scenarios with the baseline projections reported in Table 3 above, and assumes non-potable demands deviate from the baseline scenario by the same proportion as the potable projections. The median climate change adjustment suggests that projections of total demands would be about 16 percent higher than the historical normal climate projection by the end of the planning horizon.

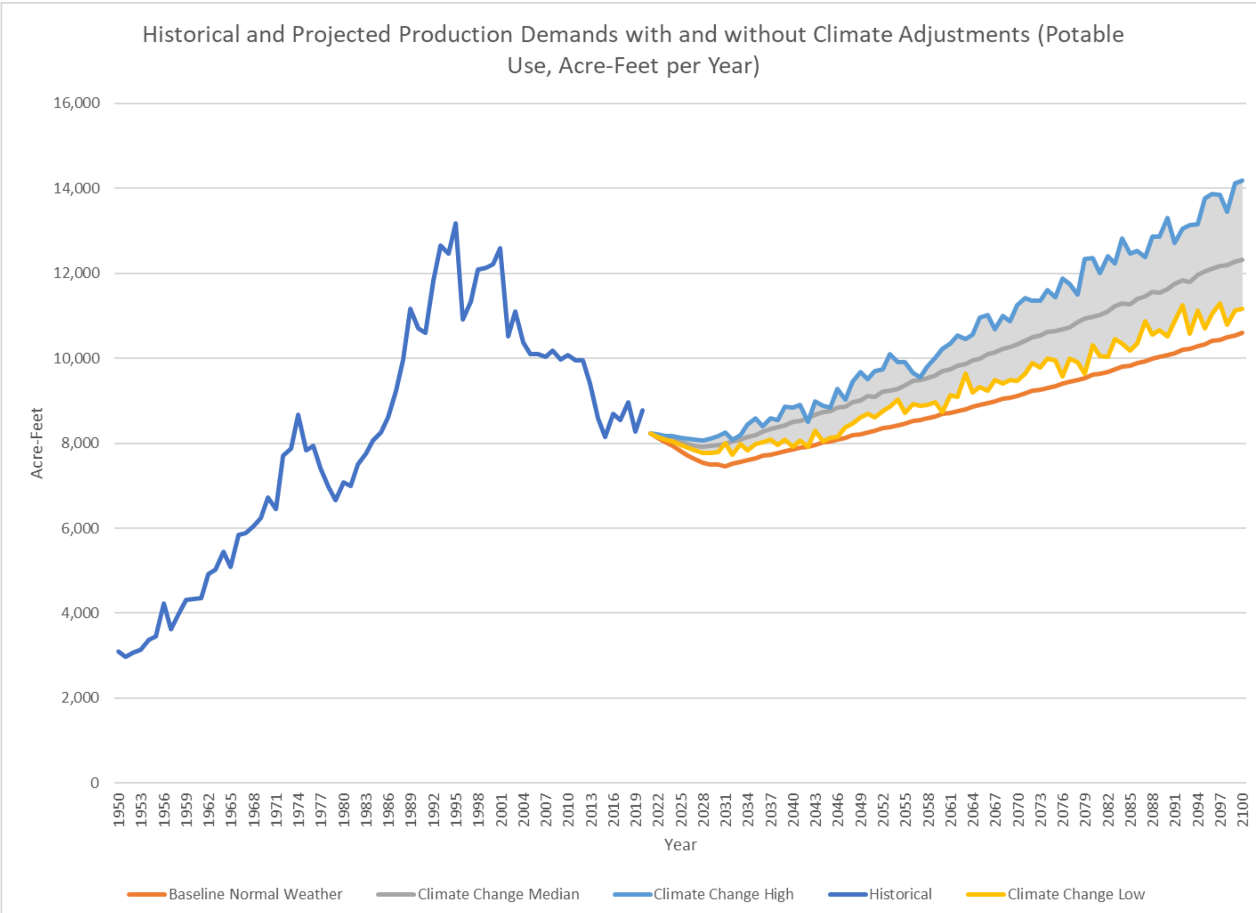

Figure 11 Historical and Projected Demands with and without Climate Change Adjustments

Table 6 Projected Values for Baseline and Median Climate Change Projection Scenarios

Year	Historical Normal Baseline Scenario (acre-feet) Potable Water Production Demand	Non-Potable Water Production Demand	Total Water Production Demand	Median Climate Change Scenario (acre-feet) Potable Water Production Demand	Non-Potable Water Production Demand	Total Water Production Demand	Percent Difference with Climate Adjustment
2025	7,814	1,374	9,188	8,033	1,412	9,445	2.8%
2030	7,492	1,374	8,866	7,964	1,461	9,424	6.3%
2035	7,651	1,374	9,025	8,181	1,469	9,651	6.9%
2040	7,864	1,374	9,238	8,510	1,487	9,997	8.2%
2045	8,042	1,374	9,416	8,762	1,497	10,259	8.9%
2050	8,255	1,374	9,629	9,107	1,516	10,623	10.3%
2055	8,463	1,374	9,837	9,372	1,522	10,894	10.7%
2060	8,694	1,374	10,068	9,696	1,532	11,229	11.5%
2065	8,896	1,374	10,270	10,001	1,545	11,546	12.4%
2070	9,121	1,374	10,495	10,331	1,556	11,887	13.3%
2075	9,351	1,374	10,725	10,634	1,562	12,196	13.7%
2080	9,606	1,374	10,980	10,985	1,571	12,556	14.4%
2085	9,829	1,374	11,203	11,273	1,576	12,849	14.7%
2090	10,078	1,374	11,452	11,623	1,585	13,208	15.3%
2095	10,332	1,374	11,706	12,038	1,601	13,638	16.5%
2100	10,593	1,374	11,967	12,329	1,599	13,929	16.4%

Appendix A Regression Model Estimates

Table A-1
Key for Regression Model Variables

Variable Name	Description
PERCAP	Total potable water produced per person per day (GPCD)
C	Model intercept
S1-S4	Sine harmonics 1 through 4
C1-C2	Cosine harmonics 1 through 2
@TRENDC(1997M07)	Time index starting July 1997
@TRENDC(1997M07)^2	Square of time index
LNMAXT_RESID	Departure of LN(Avg Daily High Temperature) from its long-term conditional mean
LNPPT01_RESID	Departure of LN(Precipitation+0.01") from its long-term conditional mean
RMP_RESID	Real uniform volumetric price instrument
RMP_UNIFORM	Real uniform volumetric price
TMIN<20 (0/1)	Binary (0/1) indicator for average daily minimum temperatures below 20 degrees
WATER_REAL+SEWER_REAL	Volumetric cost of the 12,001st gallon of water plus volumetric cost of sewer, adjusted for inflation

NOTE: asterisks (*) in regression variable field denotes multiplication (i.e., interactions) of listed terms

Table A-2
Regression Model Estimates

Dependent Variable: LN(PERCAP)					
Method: Least Squares					
Sample (adjusted): 1997M07 2016M11 2017M01 2017M11 2018M01 2020M12					
Included observations: 280 after adjustments					
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 6.0000					
Component	**Variable**	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Intercept	C	5.1808	0.0522	99.16	0.0000
Trend	@TRENDC(1997M07)	-0.0020	0.0005	-4.47	0.0000
	@TRENDC(1997M07)^2	4.84E-07	0.0000	0.41	0.6833
Seasonality	S1	-0.0975	0.0525	-1.86	0.0643
	C1	-0.4144	0.0440	-9.42	0.0000
	S2	0.0145	0.0065	2.24	0.0262
	C2	0.0136	0.0062	2.18	0.0299
	S3	0.0553	0.0040	13.82	0.0000
	S4	0.0316	0.0057	5.57	0.0000
Weather	LNMAXT_RESID	0.9804	0.1055	9.29	0.0000
	LNMAXT_RESID*S1	-0.4498	0.1242	-3.62	0.0004
	LNMAXT_RESID*C1	-0.8231	0.1347	-6.11	0.0000
	LNPPT01_RESID	-0.0431	0.0044	-9.83	0.0000
	LNPPT01_RESID*S1	0.0156	0.0072	2.16	0.0315
	LNPPT01_RESID*C1	0.0282	0.0041	6.87	0.0000
	L1LNPPT01_RESID	-0.0070	0.0040	-1.73	0.0847
	TMIN<20 (0/1)	0.0456	0.0174	2.62	0.0093
Price	LN(WATER_REAL+SEWER_REAL)	-0.0694	0.0270	-2.57	0.0108
	LN(WATER_REAL+SEWER_REAL)*S1	-0.0238	0.0168	-1.41	0.1594
	LN(WATER_REAL+SEWER_REAL)*C1	0.0318	0.0150	2.12	0.0348

Regression Diagnostics			
R-squared	0.9503	S.D. dependent var	0.3234
Adjusted R-squared	0.9466	Durbin-Watson stat	1.8491
S.E. of regression	0.0747	F-statistic	261.4234
Mean dependent variable	4.7163	Prob(F-statistic)	0.0000

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