Water Usage & Drought in Austin

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Introduction

The City of Austin is no stranger to the impacts of drought on municipal water supply and demand. Within the past two decades, Austin has experienced a number of extended periods of drought lasting anywhere from several months to well over a year. The severity of these droughts has also varied from the lowest stage, Drought 0 (abnormally dry), to the highest, Drought Stage 4 (exceptional drought). Given the significant fluctuation associated with drought conditions in this region of Texas, the City faces a considerable challenge: how to balance its municipal water supply and demand not knowing when the next bout of drought will hit and how severe it will be. When these events do occur, the city's water system becomes stressed in two ways—drier conditions reduce the available water supply (as a result of the increased evaporation of Travis Lake) and also induce increased municipal water usage, further aggravating municipal supply.

In response to these issues, the City of Austin has employed various demand management strategies. In particular, this includes two-times-per-week outdoor water restrictions, which became a permanent, mandated component of the city's water conservation code in 2012 following the drought of 2011[1]. Although demand management represents a critical element of the city's strategy to managing its municipal demand, long-term conservation efforts will be of the upmost priority. When effectively promoted and implemented over an extended period of time, conservation serves more than to reduce demand—it can essentially become a new source of water supply for the future. The best approaches to achieving greater municipal water conservation, however, vary by municipality. In large part, it depends on the people consuming the water and their patterns of water use behavior. Understanding which municipal customers use the most water, when they use it, and how they use is necessary for designing and implementing effective conservation programs.

Given the importance that city-wide conservation represents for the City of Austin, the following report seeks to analyze the spatial and temporal trends associated with municipal water usage. This evaluation focuses specifically on residential consumption, which generates a large portion of Austin's municipal water demand. The primary objective of this study is to present a higher-level analysis of residential water use behaviors in order to highlight areas where it would be most ideal to directing conservation efforts. The City of Austin has made significant strides in increasing overall municipal conservation over the last couple of decades, but as the city's population continues to rapidly grow, conservation strategies much also continue to evolve. Doing so will help to ensure the city's future water security.

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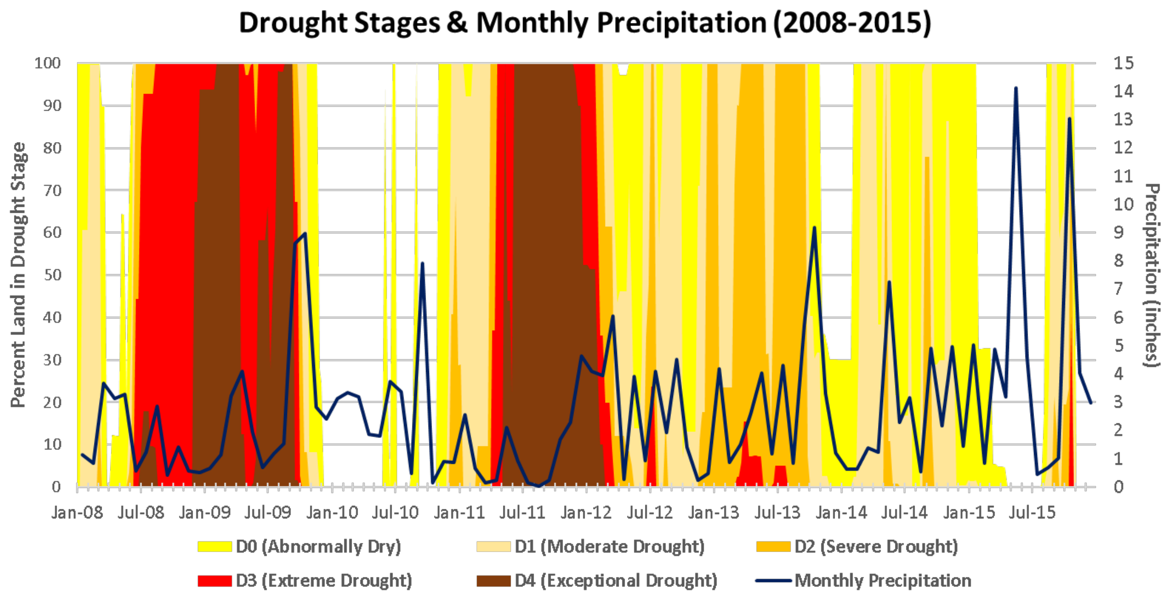
[1] City of Austin. (2013). *Water Conservation Plan.* https://www.austintexas.gov/sites/default/files/files/Water/Conservation/Planning_and_Policy/2014_Utility_Profile_and_Water_Conservation_Plan_final.pdf

<u>Historical Drought & Precipitation Trends in Austin</u>

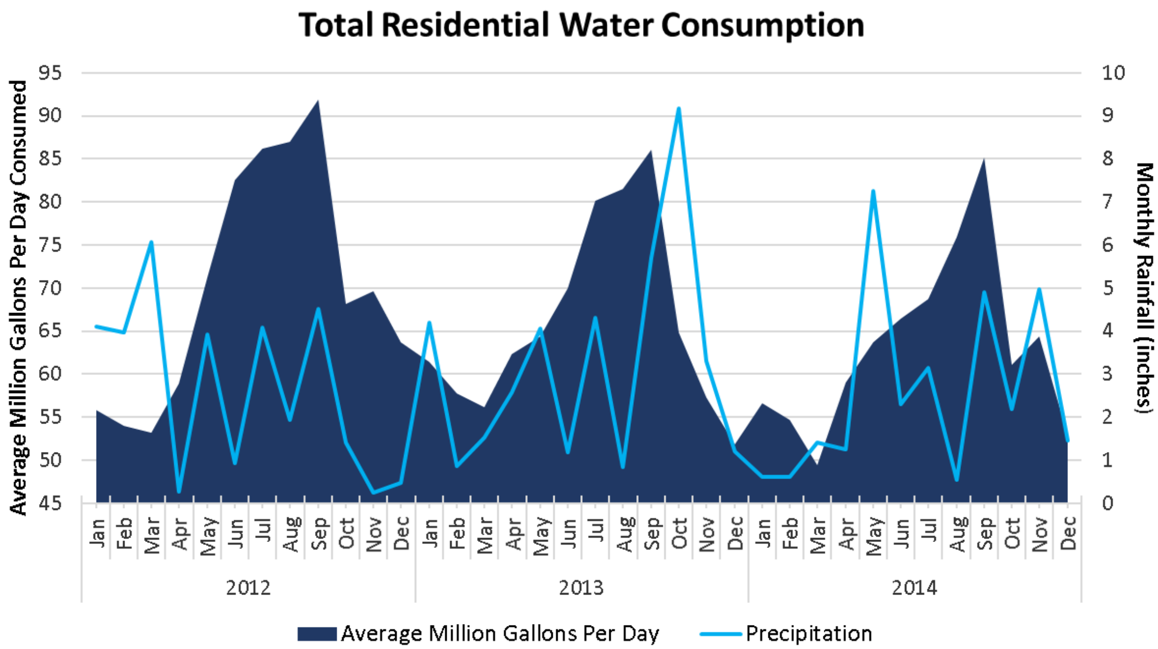
Looking at trends from 2008 to 2014, it was more common for the city of Austin to be in some degree of drought stage than it was to be completely 'drought-less'. In fact, the longest period of minimal drought intensity took place in early 2010. This period of reprieve, however, was short-lived, as the 2011 drought started to pick up by the end of the year. In the graph below, the city's exposure to drought in terms of percent of land in each drought stage is detailed. In addition, this information is compared to total monthly rainfall during the same time period.



During this most recent drought of 2011, the city observed 41 straight weeks of extreme to exceptional drought, and even after conditions began to let up in January of 2012, the city was still under lower drought stages through July 2013. It was not until January 2015 that these conditions ceased entirely. Although the previous drought of 2008 was not as severe as the 2011 drought, it persisted at elevated drought stages for a longer period of time. These prolonged periods of drought, of course, have direct impacts on municipal water demand.

<u>Impact of Drought on Municipal Water Usage</u>

As would be expected, drought conditions spur elevated rates of water consumption. While much of this increase in usage can be attributed to outdoor water irrigation in order combat reduced rainfall and increased temperatures/rates of evapotranspiration, it has a widespread impact on overall residential consumption in general. In the graph below, total residential water consumption from 2012 to 2014 is compared against precipitation patterns for that period.



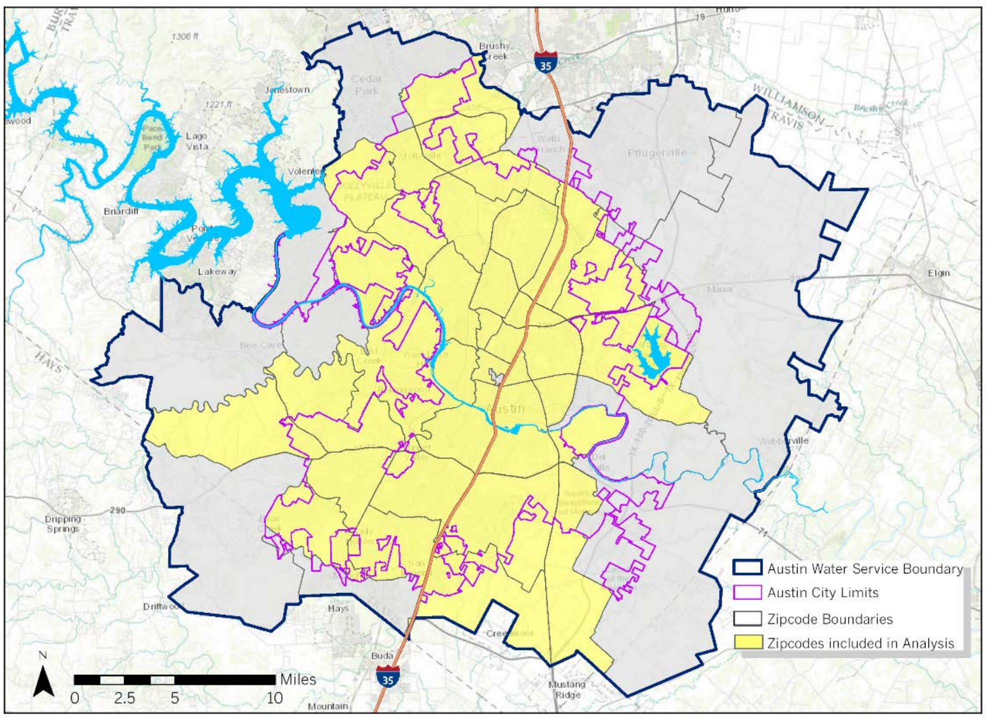
The above graph illustrates the connection between monthly water usage and rainfall. These patterns, in most instances, are inversely related—when precipitation increases, consumption decreases and vice versa. It should also be noted that the rate of increase or decrease in water consumption varies over time. The three prominent peaks seen in the graph above align with warmer months of the year. These peaks demonstrate unique patterns of drop-off. The first and second show a sharp drop-off followed by a slight up-take associated with lower precipitation. On the other hand, the middle peak shows a more exponential decay despite significant increase in rainfall. It is also relevant to call out the slight decrease in peak magnitude over time. This is likely due to the easing of drought-related conditions.

These fluctuations in water use behavior reflect precipitation and temperature trends quite strongly, but the timing of these events should also be taken into consideration when evaluating residential water usage. As the graph reveals in early 2014, water consumption increased minimally in response to a huge drop in precipitation. This likely occurred for two reasons: this period of low rainfall was preceded by a period of elevated rainfall and because this occurred during the months of January and February when outdoor irrigation requirements are low. With this understanding of how climatic conditions and temporal components impact residential water usage, the next step is to evaluate the spatial characteristics of these behaviors across the city of Austin.

Analysis of Residential Water Usage Trends

For the purposes of this evaluation, monthly residential (both single family and multi-family) consumption data was obtained for the period of 2012 to 2014 from Austin Water. This data was described at the zip code level, thus allowing for the spatial component of this analysis. Based on the data provided by Austin Water, total consumption in gallons was normalized by population data from the U.S. Census bureau to achieve an average gallon per capita per day estimate for each zip code. After making these calculations, several discrepancies were noted in zip codes with exceptionally low GPCD estimations. When comparing these zip codes to the service area map for Austin Water, these zip codes were found to be on the periphery of the service area boundary. As a result, it was assumed that while Austin Water provided water to parts of these zip codes, it did not serve the entire population, which is why the GPCD calculations were so low. For that reason, these peripheral zip codes were excluded from the analysis. In the map below, the entire service area boundary along with each of the zip codes are identified. The zip codes in yellow represent the ones evaluated herein, and for context, the Austin city limits are also provided.

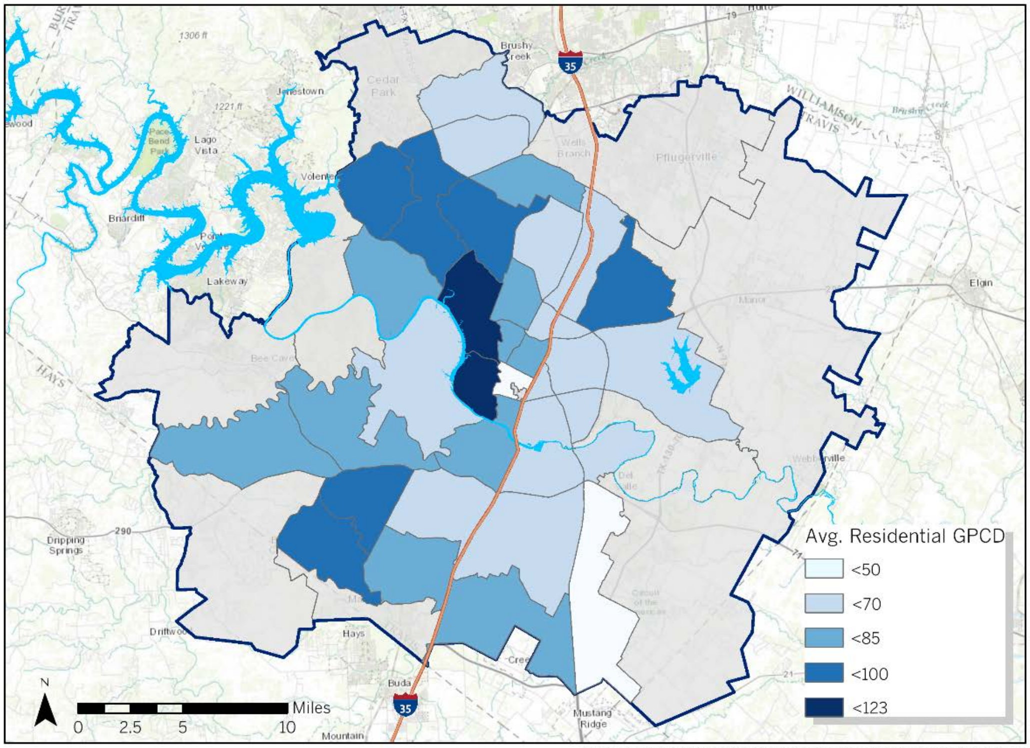
Austin Water Service Area



Projection: NAD 1983 2011 StatePlane Texas Central FIPS 4203 Ft US
Sources: City of Austin, ESRI Topography Basemap

Using this billing data, various aspects of residential water consumption were analyzed. To begin with, average GPCD was calculated across every month during the three-year time span and then mapped to visualize its spatial distribution. The results of this representation indicate that the zip codes west of I-35 tend to have higher rates of average daily consumption compared to those east of the highway. Furthermore, the two zip codes with the highest average GPCD are located immediately adjacent/north of Lake Austin. Assuming that higher value (which could equate to higher income, more outdoor landscaping, etc.) homes are located on the west side of Austin, it could be hypothesized that a correlation exists between consumption and home value. The figure below describes this information.

Average Residential GPCD for Austin (2012-2014)

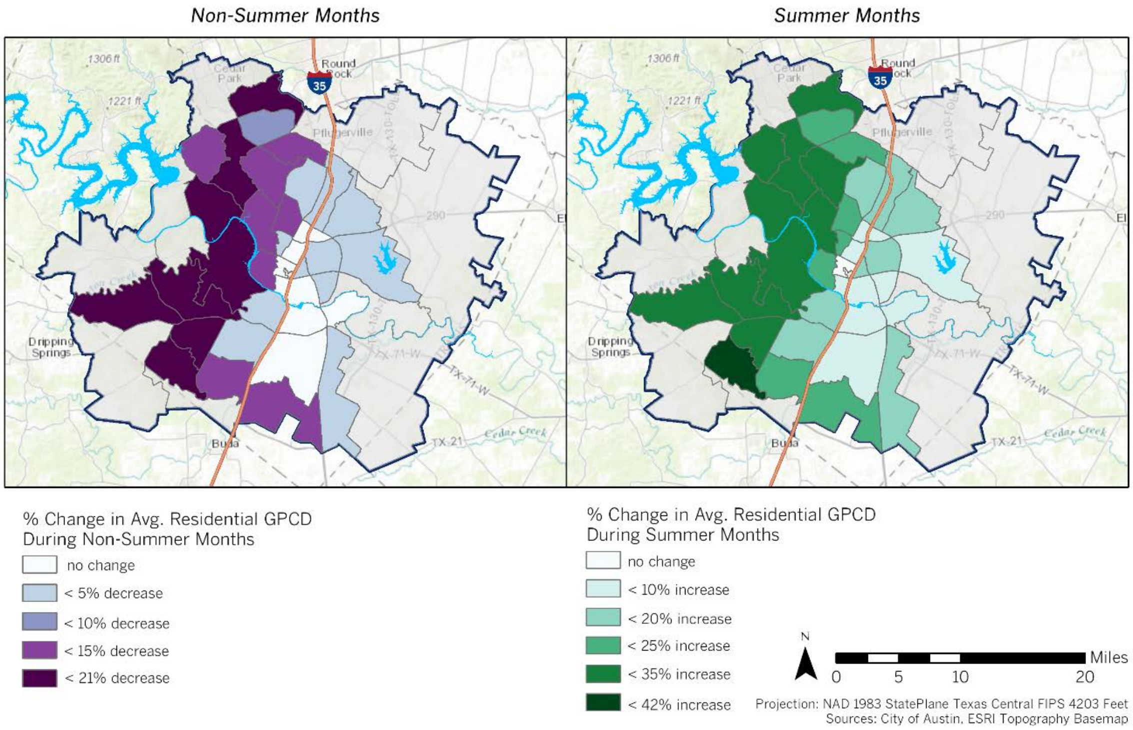


Projection: NAD 1983 2011 StatePlane Texas Central FIPS 4203 Ft US
Sources: City of Austin, ESRI Topography Basemap

As this map demonstrates, there is considerable variation in water usage across the city of Austin. For the most part, however, higher consumption is concentrated on the western half of the city, with the exception of two zip codes on the eastern half (one adjacent to US-290 and another south of town where new development is likely occurring). The next step in the analysis was to illustrate these spatial differences across time.

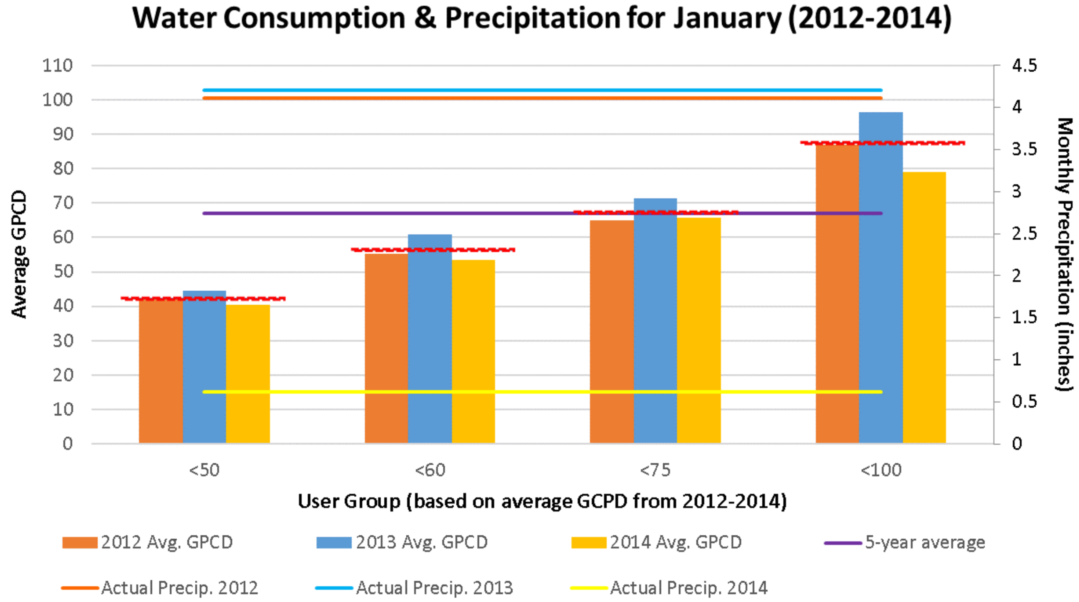
In order to discern temporal variances in residential water use relative to each zip code, average consumption during summer months (June, July, August, and September) was compared against average consumption for the remaining non-summer months. This analysis was largely driven by the fact that, as alluded to earlier, residential water use observes a considerable spike during warmer months of the year. These four months were selected based on their average temperature across the time span, which was approximately 80 degrees and above. To show the extent to which average consumption increased or decreased relative to the overall average in each zip code for each of these seasonal periods, percentage change was calculated and mapped. According to these results, the zip codes west of I-35 exhibited percent decreases during the non-summer months while the eastern zip codes remained relatively stable. A similar trend was also noted during the summer months—this time, the western zip codes displayed higher percent increases in residential water use compared to their average. Moreover, the highest percent increase is approximately 42%, which is double the largest percent decrease observed during the non-summer months. The two maps below illustrate these findings.

Percentage Change in Average Residential GPCD
During Non-Summer and Summer Months

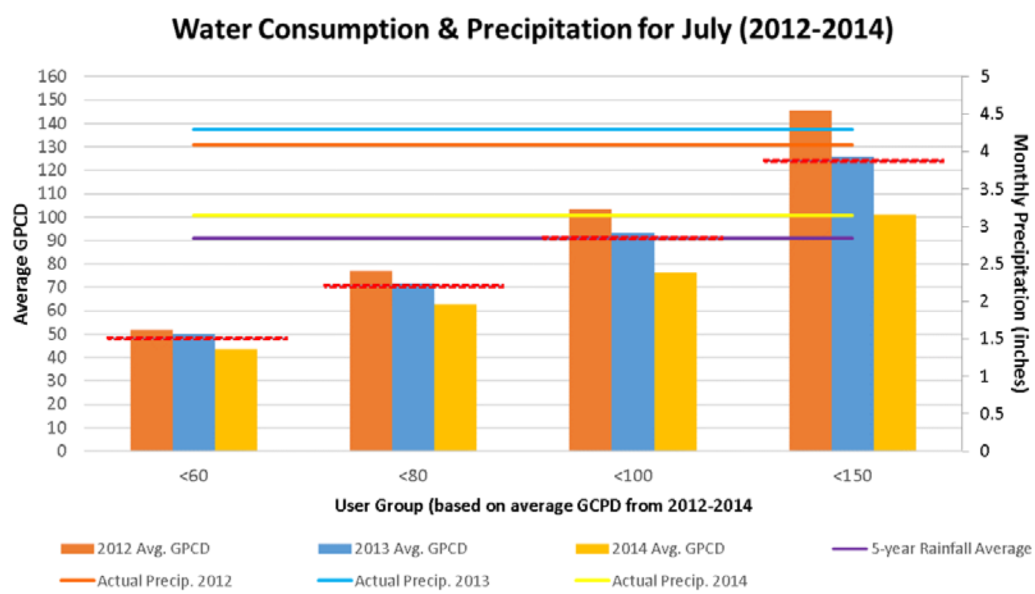


These results draw attention to the potential reasons for which these particular zip codes are observing greater percent decreases and increases compared to their three-year average. Although an increase is expected during the summer months, it is interesting that much of this uptake in residential water usage occurs predominantly in the zip codes to the west. Again, this could be due to household factors, such as larger lot size (i.e., greater need for outdoor irrigation), since these zip codes are located on the peripheral of the city core. Alternatively, many of the zip codes to the east, especially adjacent to I-35, contain neighborhoods with older homes and thus smaller lot sizes. Lastly, it can also be deduced that a possible explanation for why average consumption of the zip codes straddling I-35 and on the east side tends to remain reasonably stable is because these households do not use as much water for irrigation purposes. Assuming the zip codes on the west consume significantly more water during the summer months for outdoor watering, this would cause their three-year average to be skewed. As a result, these zip codes experience a greater percent decrease during the non-summer months when they do not need to irrigate as much.

Now that general trends in water use behavior have been identified across the spatial extent of Austin, these patterns can now be evaluated in relation to weather conditions. This was done by looking specifically at two months across the three-year span: January and July. These two months were selected because they reflect the two extremes of residential water usage. This data is first illustrated by aggregating consumption by zip code and identifying four different water user groups based on their average consumption in January and July in each of the three years. From there, the average GPCD for all of the zip codes assigned to each group was calculated. This was compared against monthly rainfall and the five-year average. The two graphs reflecting all of this information are found below.



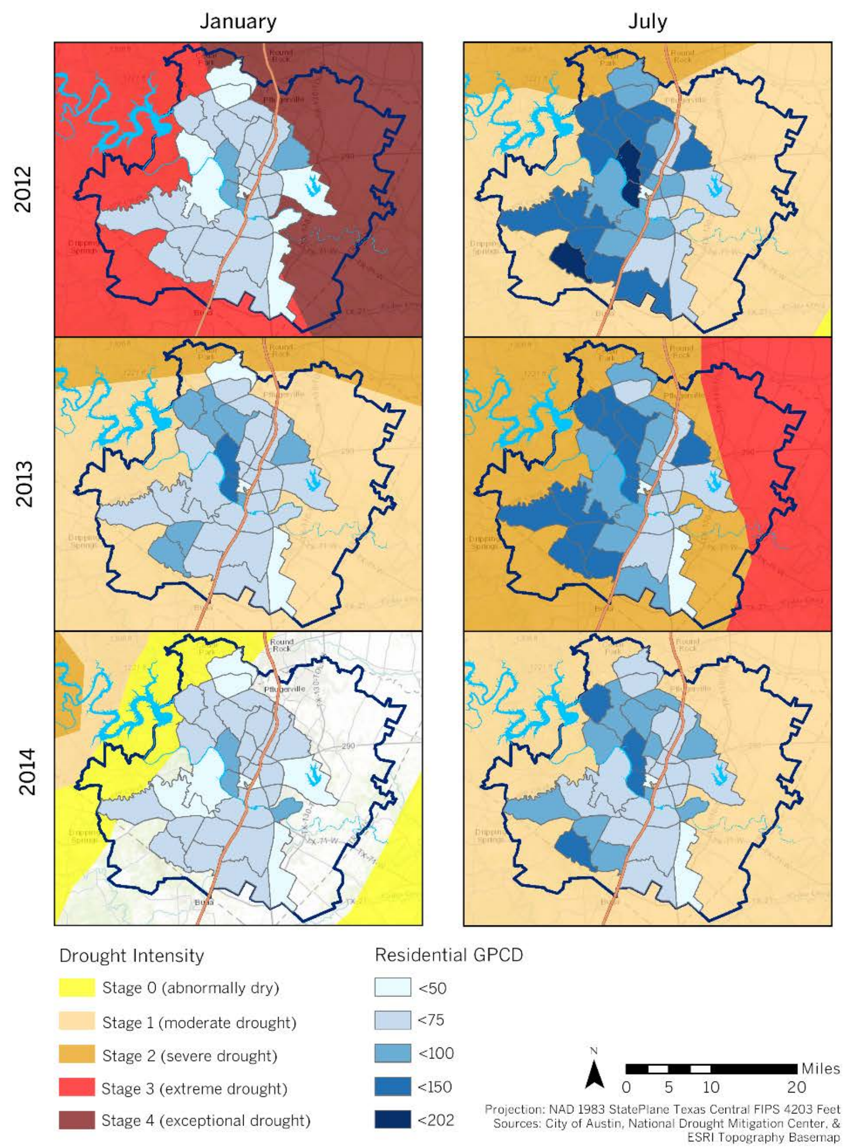
According to this graph, average water consumption was the highest for each group in January 2013. Surprisingly, this is observed despite a jump in rainfall. Alternatively, January 2014 saw the lowest water usage for all but one of the groups in spite of below average rainfall. Lastly, January 2012 was on par for average use for three of the four groups. Even though the city was still in the midst of a drought in January 2012, this month saw a decent amount of rainfall. Since the month of January requires less outdoor irrigation, it can be reasoned that these patterns of use reflect predominantly indoor usage, and for that reason, they would not follow weather trends as closely. In this instance, it seems as though other factors may be influencing these behaviors. In the next graph, July is evaluated.



According to this graph, July 2012 saw the highest average water consumption across the three-year span despite receiving moderate rainfall. Average usage, however, continued to decrease year-over-year as precipitation patterns stayed above average. Overall, these trends follow expectations related to higher summer consumption and the relationship between outdoor water usage and ambient conditions. Accordingly, it is helpful to compare these results back to the drought stage graph to confirm that drought conditions improved over the three-year timeframe.

The last component of this temporal and spatial analysis involves a side-by-side comparison of the water consumption patterns by zip code for the months of January and July, which is found in the figure below. In addition to presenting water usage by zip code, the drought intensity in each month-year is also included.

Water Usage & Drought Conditions in Austin
(January & July, 2012-2014)



By placing these maps side-by-side, the magnitude of variation by year and by month (which also serves to demonstrate seasonal variation), can be better grasped. Regardless of summer and non-summer seasons, droughts can persist at any point in the year. While the impact of drought conditions on water usage is minimal for the month of January in comparison to July, this further illustrates the need to prioritize conservation strategies geared towards the drivers of higher summer consumption rates, namely outdoor irrigation. Not only will these efforts achieve greater water savings, but they will also supplement demand management objectives by helping reduce peak demands during the summertime. A prime example of this is smart irrigation controllers, which utilize weather forecasts and evapotranspiration-sensing technology to determine appropriate water requirements for landscaping.

Although outdoor water use certainly merits lots of attention, there are still a number of other strategies that can lead to water savings during the non-summer months. For instance, conservation programs can encourage municipal customers to install rain barrels for capturing rainfall and then reusing it for landscaping purposes. Although this is an initiative the City of Austin has already sought, it has not been incredibly successful to date. However, this campaign can be re-strategized in a way to attract more participants, whether that involves greater outreach/education, identifying specific customer types to target, etc. The greatest challenge in designing and implementing effective conservation programs is attaining high response rates. This, of course, has very much to do with how customers are targeted for participation. Knowing how customers use their water and when they use their water is essential for scoping these conservation efforts. In order to target specific customer groups, though, it is equally important to know the distribution of water user types (e.g., low, medium, high users) across the service area. As this analysis demonstrates, while there is considerable variation in water usage across the city of Austin, a pattern of higher water users is observed west of I-35, especially during the summer months. Using analyses such as these as a starting point, a finer approach incorporating neighborhood and household characteristics can be utilized to pinpoint specific customer groups to target.

Conclusion

Balancing water supply with the water demands of a rapidly growing population is a challenge in itself—to compound this, however, is the added uncertainty of when the next drought will take place, how long it will persist, and how severe it will be. In order to sustain its water supply well into the future, the city of Austin will have to underpin its water security through proactive, multi-pronged approaches to both the supply and demand sides of distribution. The city is currently working on expanding its purple pipe system, implementing advanced-metering infrastructure, and laying out its first water resources plan for the next 100 years. Complementing these efforts will, of course, be comprehensive efforts aimed municipal conservation. As this analysis seeks to demonstrate, effective scoping and execution of the city's conservation objectives requires careful consideration of its customer's water use behaviors across time and space. Through informed strategizing, municipal conservation can play an even larger role in Austin's water future.