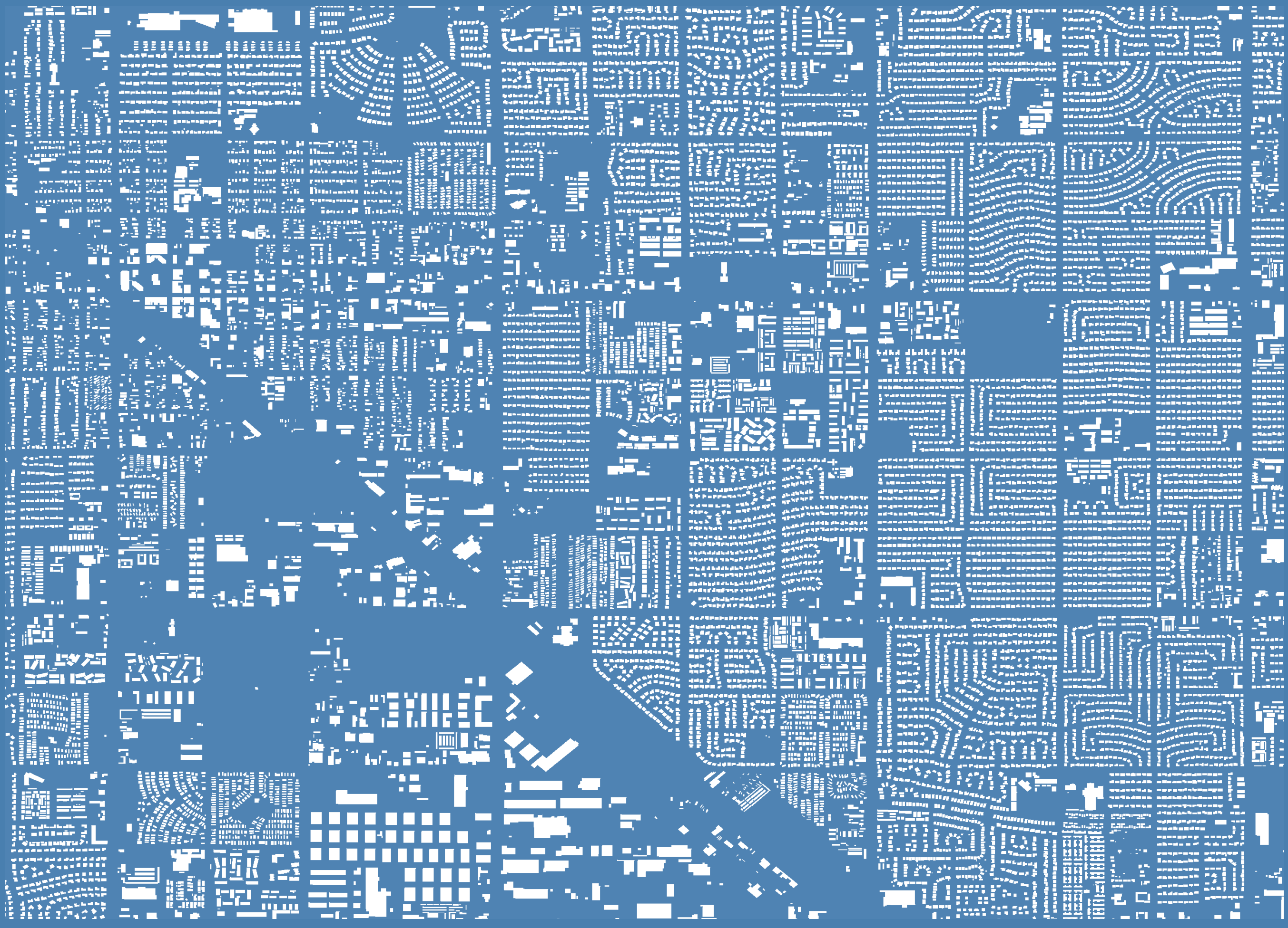
Urban Development and Water Consumption in the Salt River Project Service Area



Prepared for: Salt River Project

Report by: Dr. Philip Stoker, University of Arizona

Fall 2021

Table of Contents

Project Description

Overview

This research is the result of a multi-organization collaboration to better understand water consumption and urban development within the Salt River Project (SRP) Service Area. SRP and the University of Arizona were joined by several municipalities that supported this project. Collaborations such as these are essential to better understand and manage critical land and water resources. This report accompanies data that is being transferred to SRP and the project partners to assist long term planning efforts. The purpose of this data and report are to:

1. Support better understanding of water consumption within the SRP service area.

2. Document patterns of urban development that can affect water consumption.

3. Identify strategies for conservation and efficient planning.

4. Develop and transfer data that provides high resolution insight into water consumption and urban development within the SRP region.

The findings and recommendations in this report can be used by SRP and partners to evaluate how future land development and changes in urban form will affect water consumption in the coming years.

The report seeks to build upon previous research in the region, and therefore this report compares findings from new analyses to the 2019 Phoenix Metropolitan Area Multi-City Water Use Study: Single-Family Residential Sector (Drysdale et al. 2019). Though the data sources are different, there are important trends and differences that can be identified by comparing the results. Both reports highlight that there are similarities in water consumption between the different cities, however, the findings in this report suggest there is wider variety of water consumption within the region that must be accounted for when estimating future water consumption.

This report is organized into two sections. The first is an overview of the data that was used for analysis. The second is a presentation of the data and analyses that examine patterns of urban development and water consumption within the SRP service area.

Research Approach and Questions

Study Design

This research is a descriptive and cross-sectional analysis of water consumption and patterns of the built environment within the SRP service area. The data to measure patterns of urban development were obtained from publicly available data sources. Partnerships with municipalities allowed for water consumption to be shared and included in this report. When all data was gathered, a database was built that includes characteristics of urban development as well as water consumption records. The data sources used as well as the data processing in this report are described in the following Parts 2 and 3.

The findings from this study are compared to the 2019 study: "Phoenix Metropolitan Area Multi-City Water Use Study: Single-Family Residential Sector" (Drysdale et al. 2019). The 2019 study was conducted as a collaboration between the city of Phoenix, the city of Glendale, and the town of Gilbert water utilities and was published in 2019. The goal of this project was to analyze single family residential water use patterns in the region, and to identify if there were differences in water use patterns between the cities. Drawing on a sample of approximately 3,000 single family residential properties, the report provides insights into seasonal water consumption and indoor and outdoor water use. This present research is closely related to the 2019 study in terms of data analyzed, region, and context, and therefore will refer to the findings of the previous study. While the data sources are different, some comparisons are possible.

This previous study analyzes similar data in the same region during the approximately same period. However, the data samples vary in some important ways, so comparisons are made carefully. For example, data in the 2019 study is a sample of single-family residential properties at the parcel scale in three cities, while this present study is using tens of thousands of aggregated accounts from four cities. In the 2019 report, land cover was manually classified and this classification scheme is mimicked at times in this report for comparisons (Figure 1). Comparing this present study to the previous work is an effort to build upon understanding and awareness of water consumption in this region.

Figure 1. Landscape Coding Categories (from Drysdale et al. 2019)

Turf		at least 35% of the total parcel is turf; extensive irrigation system is required	High -Very High
Extensive		only dense tree canopy is visible; may have turf; turf/ground cover beneath is difficult to see; irrigation system is required	High -Very High
Moderate		partially desert; mixture of decompressed granite/rock/dirt and/or turf or other vegetation; irrigation system is required	Moderate
Sparse		mostly desert; mixture of desert landscape and plants, but no turf; may or may not have irrigation provided	Low
Arid		entirely desert; mixture of desert landscape and plants requiring no irrigation once established; no turf	None
Transition		overall parcel appears to have been turf at one time	Unknown

Statistical Analysis

Analysis

Several statistical analyses are used to present a clear picture of the data, as well as to identify trends, relationships, and differences. All statistics were calculated in SPSS v. 21, a statistical software package. The following approaches and statistical terms are used:

Descriptive statistics: Most analyses include a presentation of the mean (average) and standard deviation. The mean is a measure of central tendency and is always presented alongside a standard deviation to quantify the dispersion of the data. High standard deviations relative to the value of the mean indicate that the data is very spread out around the mean t.

T-tests and Analysis of Variance: These statistics measure differences in averages between groups. T-tests identify whether the mean values of two groups is statistically significantly different. Statistical significance is set at 95% confident interval and both a "t" statistic and "p" value are presented when this test was used. Analysis of Variance (ANOVA) compares the variance between three or more groups to see if variance is greater within groups or between groups. The "f" statistic is presented and large "f" values indicate high between-group differences; therefore differences exist between the groups.

Linear Regressions: Two types of linear regressions are used to measure relationships between variables in this analysis. The dependent variables used in this analysis do not follow a normal distribution, therefore the dependent variable is log- transformed so it exhibits a normal distribution, meeting the assumptions to accurately use linear regressions. When the independent variables are log-transformed, the results are presented as elasticities. For example, a 1% change in the dependent model results in an 8% change in a dependent variable. In all models, collinearity is avoided by measuring tolerance value and omitting any variable that exhibits high collinearity.

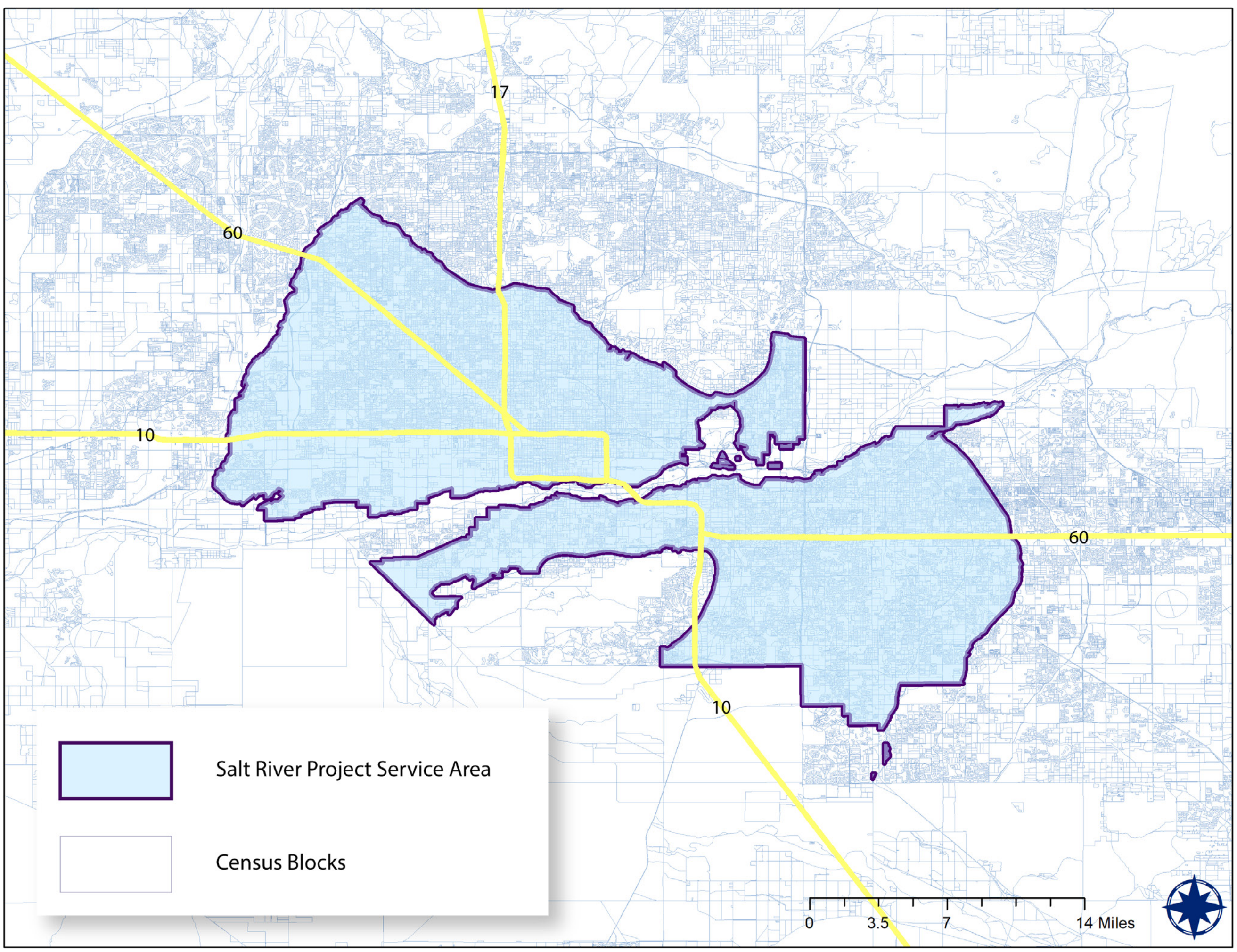
Data Sources

Data

U.S. CENSUS BLOCKS:

Census blocks are essentially city blocks, bounded by streets, roads, natural boundaries but are not delineated by population. They vary in size throughout suburban and rural areas (Figure 2). The U.S. census bock was chosen as the unit of analysis for this study for two reasons. First, the water consumption data needed to be aggregated to protect customer confidentiality. Second, this scale of analysis provides high resolution insights into water consumption patterns and urban development. There are some limitations to this scale, and population counts, demographics, and household characteristics are available for this year of analysis.

Figure 2. Census Blocks and the Salt River Project Service Area



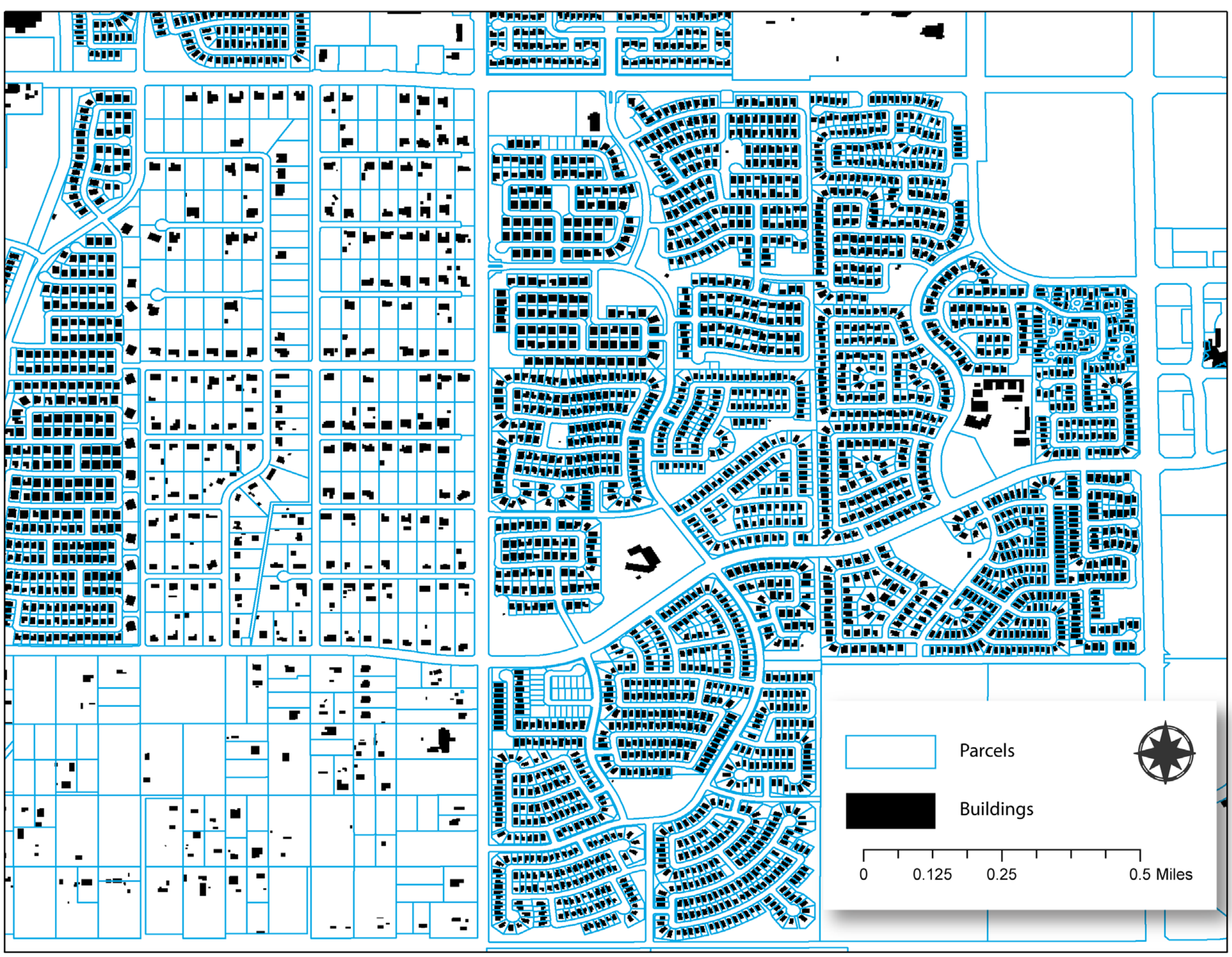
Data Sources

Parcel Data

2018 MARICOPA COUNTY TAX ASSESSORS:

This dataset is from the Maricopa County Tax Assessors office and includes detailed information on over 1.4 million properties in the county. Every property is assigned a unique identification number that contains details about land and property valuation, the size of the property, year built, and the specific land use of that property. The Property Use Code (PUC), is a four-digit code that provides detailed information on the type of property. For example, this information allows differentiation between single family residential properties and multi-family buildings, or commercial properties, golf courses, hospitals etc. The tax assessors' records were mapped in ArcGIS using the corresponding Maricopa County Tax Assessors shapefile (Figure 3). To aggregate this data, all parcels were assigned a census block Federal Information Processing Standard (FIPS) code that uniquely identifies the census block that contained the parcel. This was accomplished using a spatial join in ArcGIS and the FIPS code was assigned to every parcel in the county. After this join, all tax assessor's data was aggregated according to the census block FIPS code.

Figure 3. Parcel boundaries and buildings



Data Sources

Land Cover Data

2015 NATIONAL AGRICULTURAL INVENTORY PROGRAM (NAIP):
This is a multi-spectral imagery dataset where every pixel of data contains information about which wavelengths of light have reflected off the ground and returned to instruments in an airplane. The data is freely available and can be found at www.nationalmap.com. Over 200 files were downloaded and merged to form one single image for the entire region (Figure 4). This data was then classified in ArcGIS using a Maximum Likelihood Classification system which involved "training" the software to recognize patterns of wavelengths of light (Figure 5). The classified image was assessed to be 94% accurate based on a validation of 50 random points across the region. This accuracy is within the acceptable range for data at 1 meter resolution. This classified data was then summarized at both the parcel and census block scale to create three measures: 1) total vegetated area (acres), 2) average proportion of vegetated cover on a property, and 3) average amount of vegetation (acres).

Figure 4. Vegetation (highlighted in green) within the SRP service area

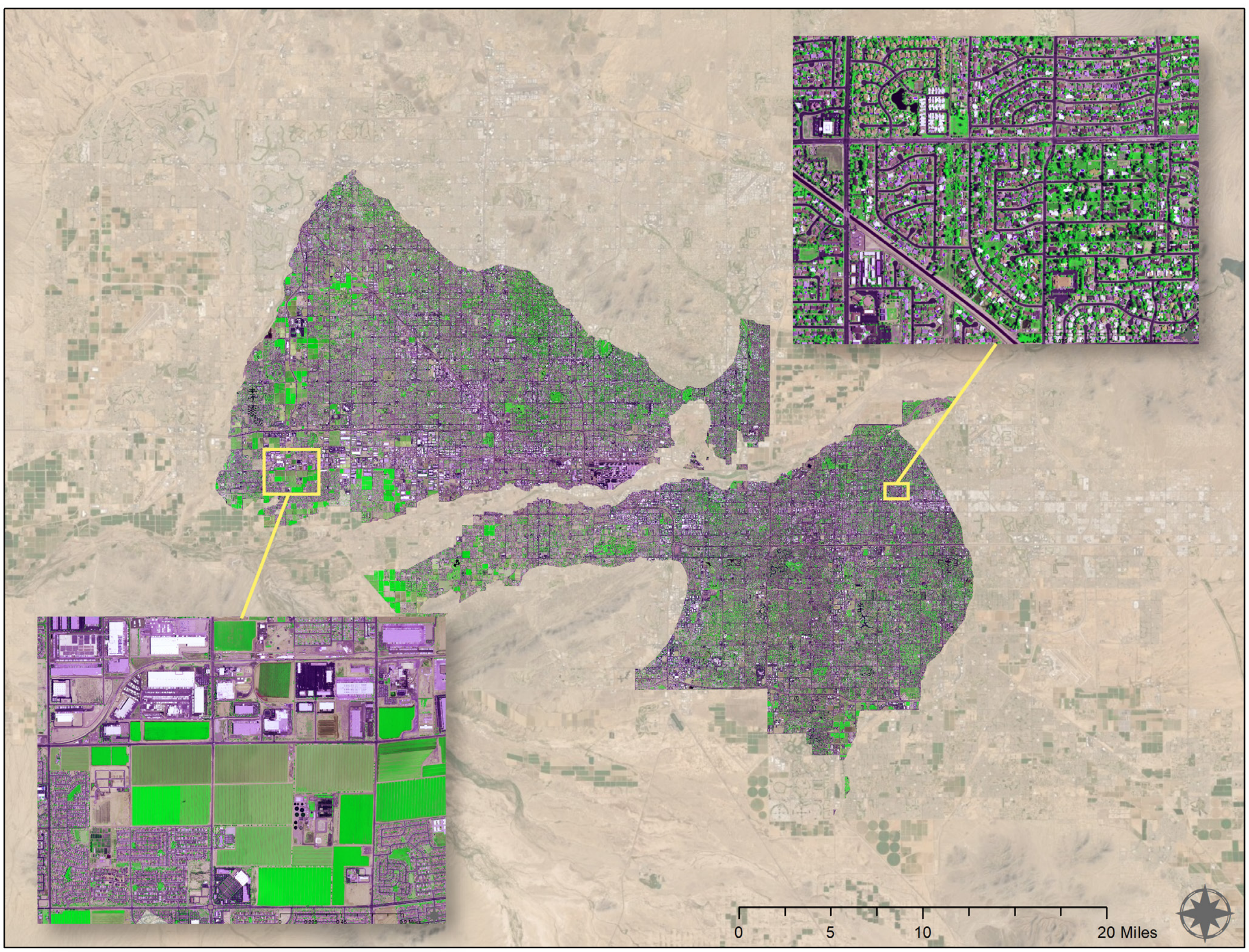
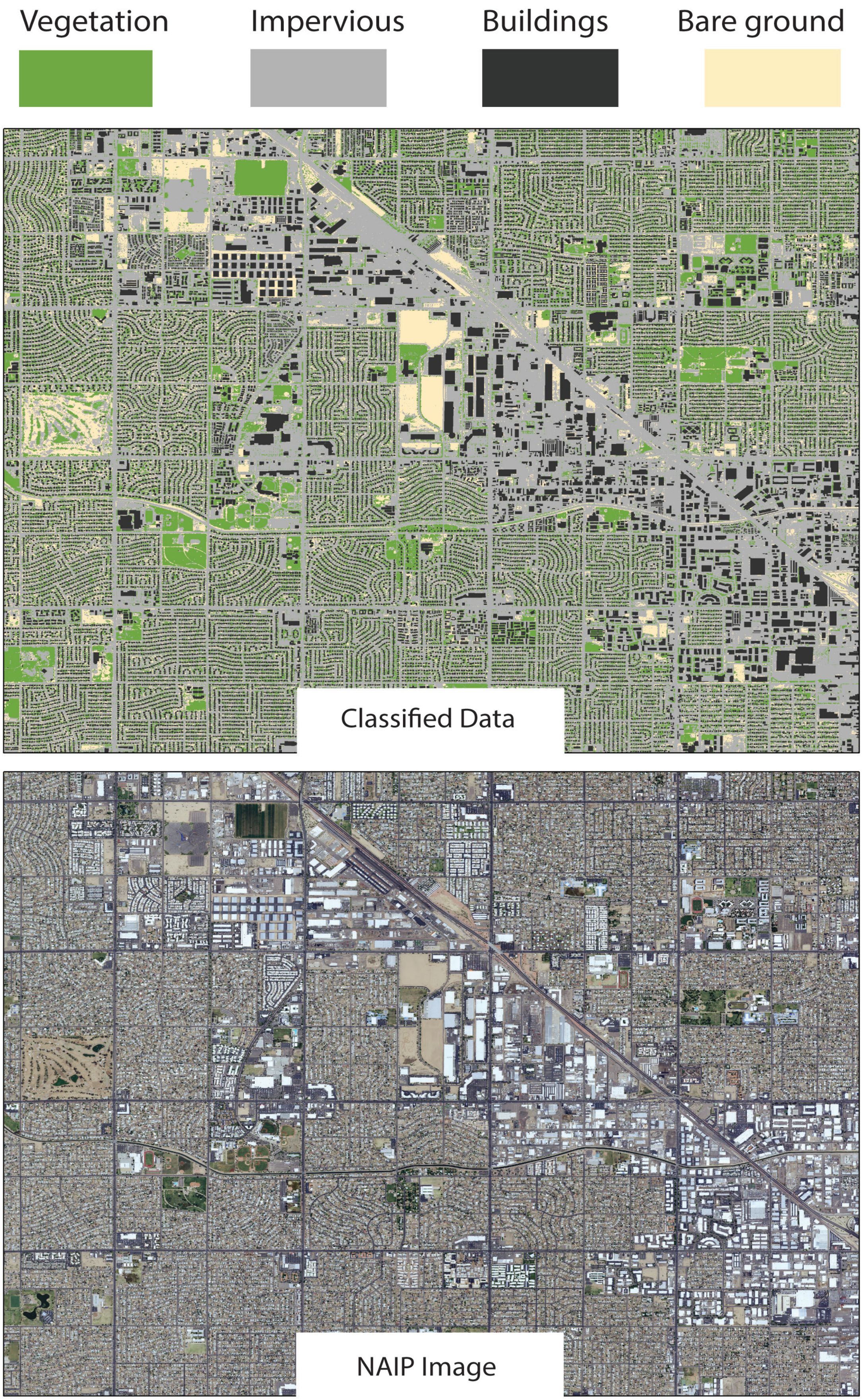


Figure 5. Comparing the classified image to the multi-spectral image (NAIP image)



Data Sources

Water Consumption Data

Central to the analysis in this report is the water consumption data shared by four municipalities. This data is treated confidentially by the municipalities and protecting the confidentiality of their customers was paramount. To share the data, each city took several precautions to protect customer confidentiality which are described for each city below. Data from each city was shared for every month in 2018. The unit of measurement varied between the cities and was converted to acre-feet and acre-feet per acre (AF/acre) throughout this report. The cities and the specific details for each are listed below.

GILBERT
The Town of Gilbert provided water consumption data for 2,262 census blocks. Domestic and potable water consumption was combined to calculate total consumption for these blocks. All census blocks with only one account of a certain type (i.e. commercial) were withheld for customer confidentiality.

PHOENIX
Phoenix shared water consumption for 6,767 census block and excluded any census block with fewer than 30 accounts to protect customer confidentiality.

PEORIA
Peoria shared 1,868 census blocks of water consumption and excluded census blocks with five accounts or fewer.

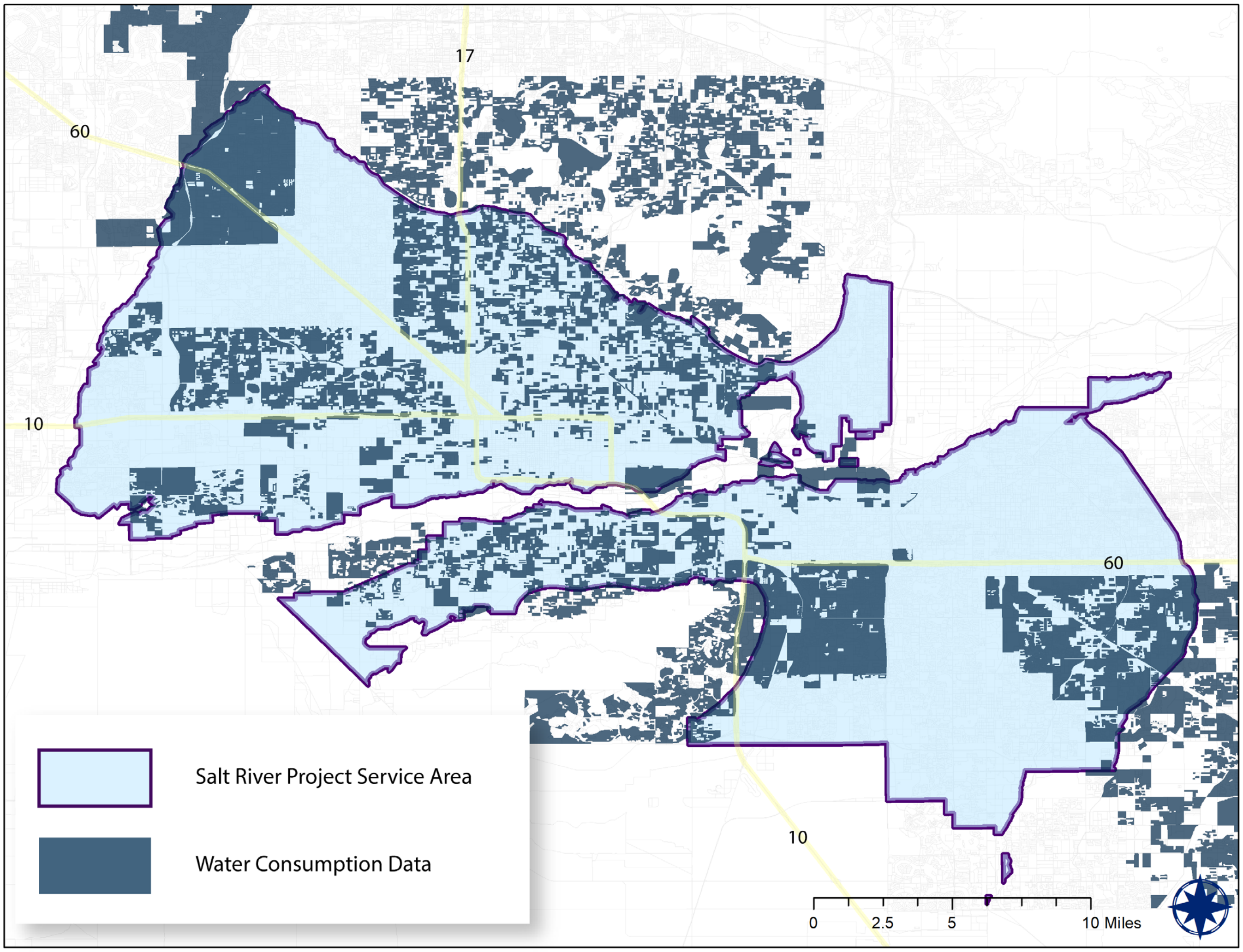
TEMPE
Tempe provided 49,664 water consumption accounts associated with meter locations. The location of the meters was indicated by a latitude and longitude and addresses for 22,681of the accounts was provided. 6,907 locations were not clearly associated with a parcel, and therefore were omitted by necessity from the analysis. A search area of 50ft was applied to identify the nearest parcel to join water consumption records to parcels. The land use classifications are assigned by the municipality not the county tax assessor. This data is first analyzed at the parcel scale and then aggregated to be included with the census block analysis.

SUMMARY OF WATER DATA
There are 25,357 total census blocks inside the SRP service area. Water consumption data for 10,365 census blocks was provided from municipalities and 5,969 were within the SRP region, representing 23.5% of the entire service area (Figure 6). Data from both the entire dataset (10,365 census blocks) and the sample within the SRP region will be used in the report and "on-project" data refers specifically to census blocks in the SRP service area.

Key Considerations:

- This analysis is based on a sample of water consumption in the region which represents less than a quarter of the SRP total service area.
- Census blocks with many smaller accounts are over-represented in this sample as there is no data for census blocks with single or very few accounts.
- There is variation in water consumption patterns between cities and not all cities within the SRP region are included in this analysis.

Figure 6. Locations of census blocks with water consumption data



Results

Parcel Analysis

This first part of the results section presents analysis of urban development and water consumption at the parcel scale. Almost all (90.2%) of the water consumption accounts were single family residential properties and these 14,224 accounts consumed the most amount of water cumulatively in 2018 (Table 1). There is high variation in annual consumption for landscaping accounts and multi-family residential properties as indicated by the very large standard deviations presented in Table 1 parenthetically. This is could be a result of the small sample sizes for these account types.

The distribution of water consumption for each account type indicates most of the accounts do not use very much water, but there are a few accounts that use large quantities of water. The outlying accounts (three standard deviations above the mean) were excluded and the average consumption rates for each account type were lower and exhibited less variation. Nonetheless, it is useful to see the scale of consumption of these outlying accounts, and the highest consumption per customer type is presented in Table 2. Cumulatively, single family residential properties consume the most water for this sample of accounts.

Table 1. Water consumption by account type

Customer Type	*Accounts (#)*	*Total consumption (AF)*	*Average annual use (AF)*	*Outlier Adjusted mean (AF)*	*Average annual use (AF/acre)*
Commercial	423	1,241	2.9 (6.1)	2.3 (3.3)	1.8 (3.4)
Industrial	11	1,227	111.6 (207.8)	111.6 (207.8)	7.0 (11.6)
Landscaping	277	1,440	5.2 (7.5)	5.1 (7.5)	10.5 (23.2)
Multi-family	839	751	0.9 (4.3)	0.4 (1.2)	5.3 (24.1)
Single Family	14,224	7,051	0.5 (0.4)	0.5 (0.3)	2.3 (1.4)

Table 2. Outlying accounts by account type

Outlying Account	*Commercial*	*Industrial*	*Landscaping*	*Multi-family*	*Single Family*
1	69.9	692.2	86.3	54.3	7.0
2	62.1	212.1	43.1	47.6	5.5
3	34.6	195.8	30.7	42.0	4.2
4	31.6	58.6	26.8	39.6	4.1
5	26.5	52.1	24.9	38.9	4.0

Results

Muti-family Accounts

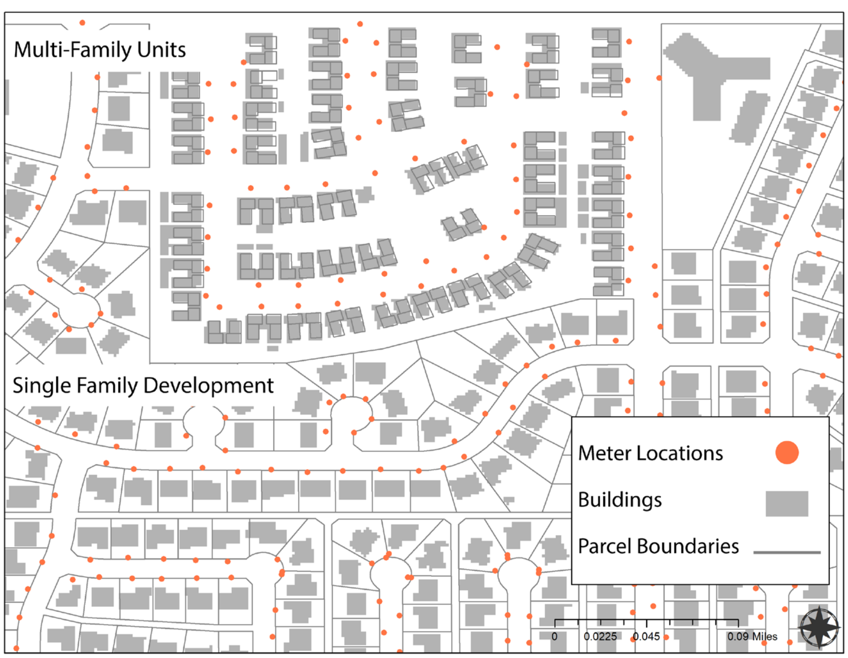
Multi-family residential accounts represented approximately five percent of the accounts in the sample. Most of these properties were constructed in the 1980's and represent very little recent development in the city. The properties range in assessed full cash value (FCV) from over a $110 million to $700,000. They exhibit high variation in consumption, but on average use 0.9 acre feet per year and 5.3 AF/acre (Table 3).

Table 3. Multi-family water consumption

	Maximum	*Mean*	*Std. Deviation*
Acre Foot	54.3	0.9	4.3
AF/Acre	394.68	5.3	24.1
Construction Year	2015	1980	7.8
Acres	29	0.4	1.9
Vegetated Proportion	93%	19%	15%
Total Full Cash Value	$ 112,100,000	$ 692,925	$5,832,351

Some data constraints make further insights into patterns of multi-family water consumption limited at this time. The tax assessor records indicate and detail specific types of multi-family development, i.e. duplex, triplex, large apartment buildings. However, the water consumption data is recorded differently and not associated with parcel identification numbers but instead with meter locations. By combining these datasets, it would be possible to obtain approximate measures of the number of residents in these developments and calculate per-capita water consumption rates for multi-family properties. Figure 7 illustrates the challenge of combining these datasets. While meters are clearly associated with single family properties, matching thousands of meters to specific multi-family parcels was not deemed possible with an automated process that could accurately join the datasets.

Figure 7. Meter locations for multi-family and single family development



Results

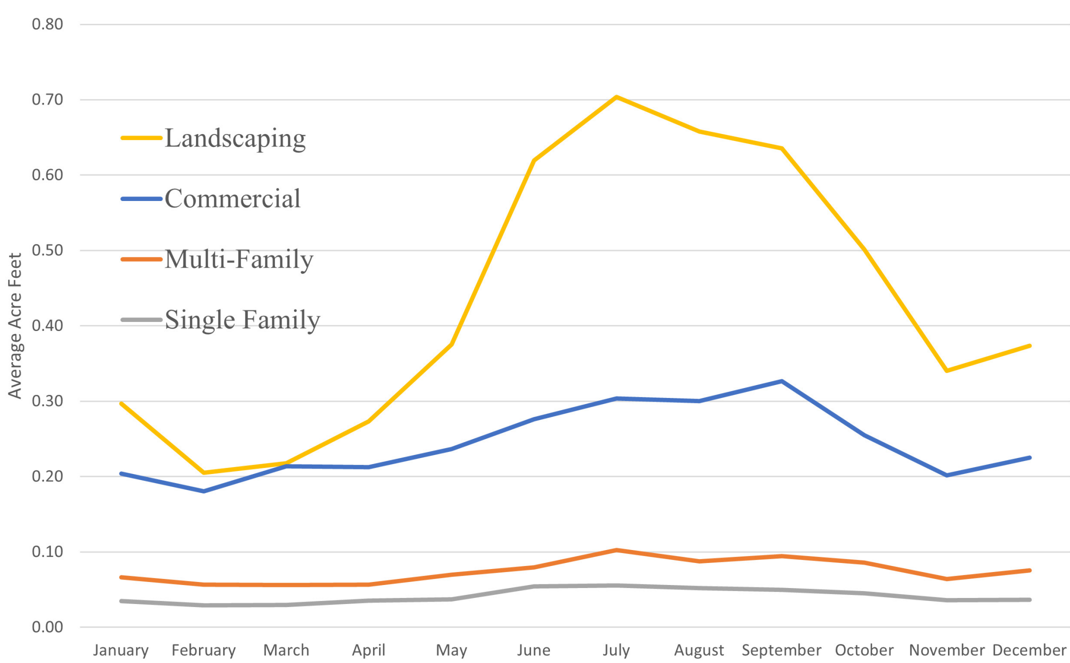
Landscaping Accounts

Among the utility classified account types, "landscaping" accounts consumed more water year-round with higher seasonal variation compared to all other account types (Figure 8). Following landscaping accounts, commercial and multi-family residential accounts used more than single family residential properties on average. Industrial accounts were not included in this analysis because there were too few accounts available.

There are statistically significant differences in the total amount of vegetated land cover (f=339.7, p< 0.00) and the proportion of the property that is vegetated (f= 201.3, p< 0.00) between the account types. Landscaping accounts on average had the highest vegetated proportion and a single account had over 30 acres of vegetation (Table 4).

This seasonal fluctuation clearly shows that more water is being used for outdoor irrigation. While there is an intrinsic connection between vegetated land cover and water consumption, there is only a moderate statistical association between both the proportion of vegetation and total acres to annual water consumption (R^2=0.2), where larger properties with more vegetation are associated with an increased water consumption.

Figure 8. Average annual water consumption by account type



Results

Landscaping Accounts

Using the categories developed in the 2019 study, the parcel dataset indicates that single-family residential properties with more vegetation are associated higher average water use (Table 5). However, multi-family residential water consumption is not associated with vegetation. As Table 5 indicates, the AF/acre is much higher for "arid" landscaping practices. This is likely a result of many apartments or rooms occupying a larger multifamily property. Unfortunately, with this dataset, it is not possible to normalize water consumption per capita, as no measure of population is available at this scale.

While these AF/acre values are much higher than any of the other accounts, the proportion of multi- family units in this sample is very low (5.6%). If this development pattern increases with growing populations, it will be important to focus on indoor water conservation efforts in large multi-family properties.

Table 4. Vegetated land cover by account type

		Mean	*Standard deviation*	*maximum*
Vegetated Proportion	Commercial	16%	12%	87%
	Industrial	13%	6%	24%
	Multi-Family	19%	15%	93%
	Single Family	29%	14%	99%
	Landscaping	41%	28%	100%
Vegetated Acres	Commercial	0.57	1.45	17.20
	Industrial	1.32	1.63	5.07
	Multi-Family	0.10	0.52	6.65
	Single Family	0.08	0.10	2.15
	Landscaping	0.85	2.44	30.05

Table 5. Water consumption by landscape type

Landscape Coding	*Single Family*		*Multi-Family*		*2019 Study*
	AF/Acre	Acre feet	AF/Acre	Acre feet	GPD
Arid	1.71	0.46	22.91	0.54	206
Sparse	1.65	0.27	18.53	0.45	224
Moderate	2.11	0.40	3.56	0.42	392
Turf/Extensive	2.61	0.70	8.59	3.78	490

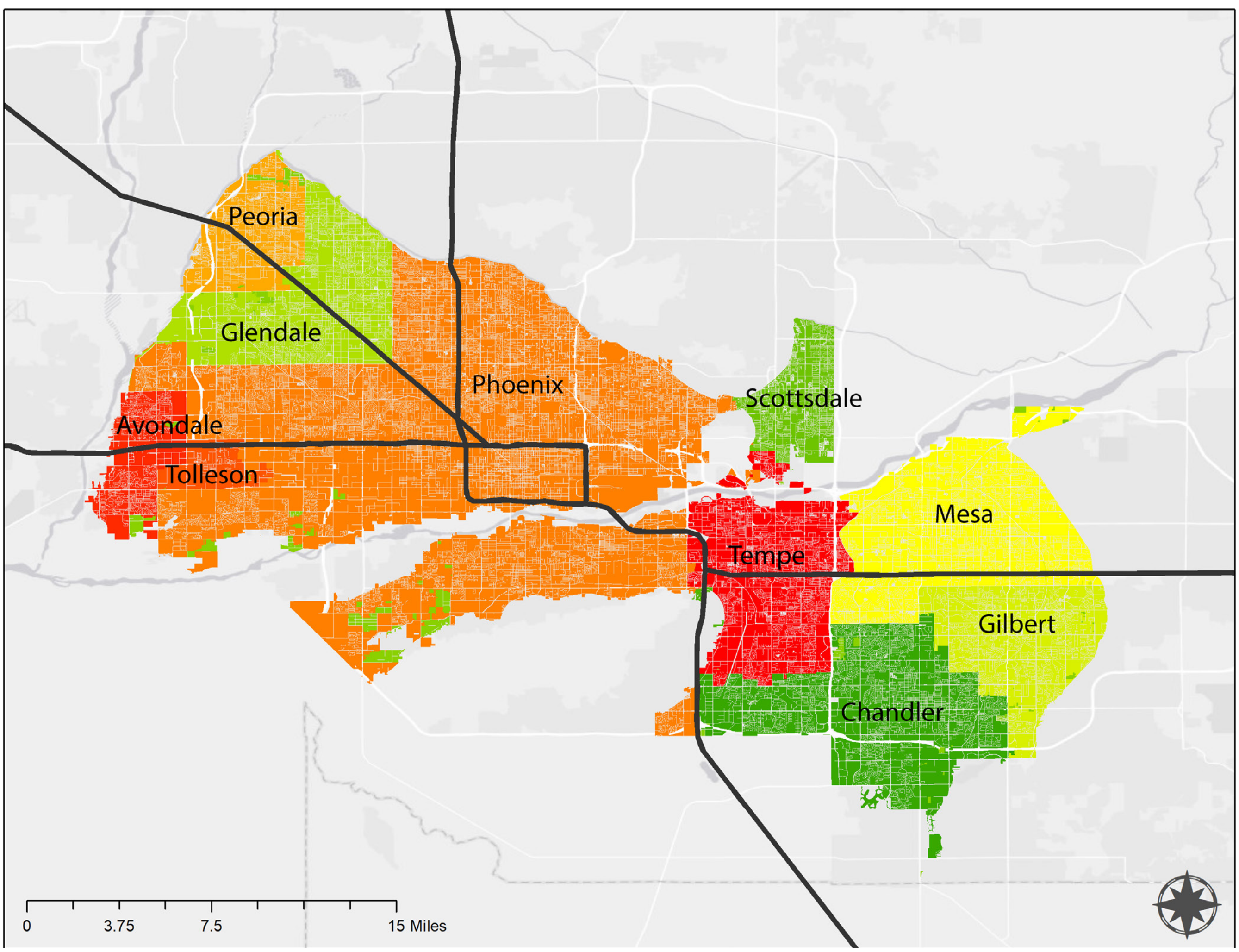
Results

Urban Development

Though water consumption data was not available for all 10 municipalities within the SRP service area, it was possible to develop a database urban development for each city within the SRP region (Figure 9). This parcel data can serve as a baseline assessment of development patterns within the SRP region in 2018.

A selection of characteristics obtained from the NAIP multi-spectral imagery and the Maricopa County Tax Assessor's database for the SRP service area is presented in Table 5. The cities vary in terms of land values, average property sizes, pool sizes, vegetated and impervious acres, the proportion of rental units and the average year that properties were built.

Figure 9. Parcels and municipalities within the SRP service area



Results

Parcel Characteristics

Most of the parcels within the SRP service area are in Phoenix, Mesa, and Chandler. The parcel characteristics vary substantially as presented in Table 5. For example, properties in Gilbert have more vegetation per property than the other cities. The parcels in Scottsdale have the highest full cash value and the highest proportion of rental properties.

The oldest parcels are located in Phoenix, and on average the properties were built in 1971, compared to the more recent developments in Laveen and Avondale which on average were built in 1999 and 2002 respectively. Average pool size varies between the cities, from 58 square feet in Phoenix to 174 square feet in Gilbert. This dataset can be used by the utilities in the service area to associate water consumption records to parcel characteristics.

Table 5. Parcels characteristics by city

	Parcels		Land FCV	Total FCV	Sq Ft.	Property Sq Ft	Year	Pool Size	Vegetated	Impervious	Rental	Acre
Avondale	13,504	Mean	$45,236	$210,697	2,268	12,035	1999	84	18%	69%	21%	0.28
		SD	$215,734	$998,388	8,362	73,217	11	166	13%	19%	41%	1.69
Chandler	63,278	Mean	$74,309	$328,169	2,919	14,693	1990	125	24%	71%	15%	0.34
		SD	$336,767	$1,845,226	16,590	85,115	12	198	16%	17%	36%	1.95
Gilbert	34,569	Mean	$68,217	$311,246	2,883	14,344	1993	174	26%	69%	12%	0.33
		SD	$193,790	$872,908	8,534	58,160	9	226	16%	16%	33%	1.35
Glendale	42,749	Mean	$45,080	$231,185	2,719	14,144	1981	107	22%	66%	19%	0.32
		SD	$166,413	$3,257,656	15,422	73,771	16	193	16%	18%	39%	1.63
Guadalupe	175	Mean	$42,644	$141,846	1,726	5,830	1983	-	3%	98%	0%	0.13
		SD	$147,220	$633,817	8,450	23,375	6	-	9%	4%	0%	0.54
Laveen	6,340	Mean	$40,102	$176,065	1,907	31,497	2002	67	25%	52%	10%	0.72
		SD	$151,979	$823,661	6,020	243,234	13	161	27%	28%	30%	5.58
Mesa	68,591	Mean	$57,035	$248,372	2,695	13,510	1977	96	23%	73%	18%	0.31
		SD	$234,255	$1,477,170	13,667	62,840	14	186	18%	18%	38%	1.43
Peoria	22,212	Mean	$48,461	$229,777	2,473	13,184	1989	100	20%	67%	14%	0.30
		SD	$170,152	$966,729	9,524	53,880	11	182	15%	17%	35%	1.23
Phoenix	224,566	Mean	$64,698	$302,605	3,340	14,579	1971	58	22%	68%	18%	0.33
		SD	$348,555	$2,804,793	26,244	91,381	21	154	19%	21%	39%	2.09
Scottsdale	46,860	Mean	$101,059	$433,568	4,013	15,561	1978	135	24%	71%	22%	0.35
		SD	$495,143	$2,637,813	26,112	84,540	14	218	18%	18%	42%	1.91
Total		Mean	$65,245	$297,998	3,101	14,566	1979	92	23%	69%	18%	0.33
		SD	$320,535	$2,386,568	21,103	85,287	19	184	18%	19%	38%	1.94

Results

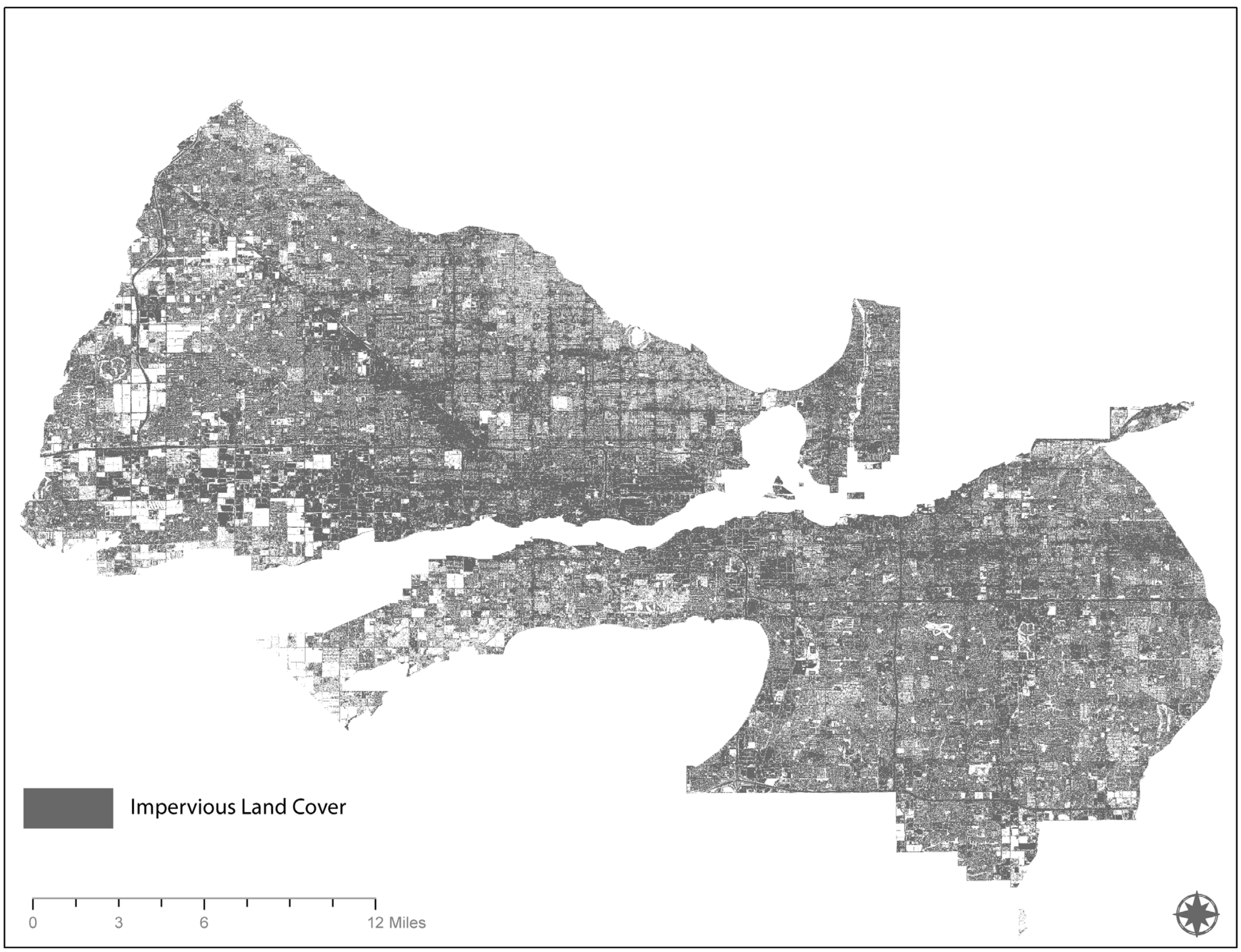
Impervious Surfaces

The extensive urban development within the SRP service area is apparent when examining impervious land cover. Most of the SRP service area is impervious surface (Figure 10). These impervious surfaces include all roads, buildings, sidewalks, and parking lots. The data were created from the NAIP imagery from 2015, and can be used as a baseline assessment for tracking current and future development.

Of the 256,718 acres in the SRP service area:

- 65.2% of the area is covered in impervious surfaces (119,450 acres).
- 24.9% of the land on project is vegetated (63,845 acres).
- 9.7% is bare ground (24,798 acres) and 0.2% is water and pools.

Figure 10. Impervious land cover in the SRP service area



Results

Census Block Scale Analysis

The parcel scale data described in Part 1 of the results section was aggregated to the census block and Part 2 presents the analysis of this dataset (n=10,365) . Water use peaks in the summer months and exhibits the greatest variability in the summer months as measured by high standard deviations (Table 6). To test whether these values can be used to estimate future consumption patterns, these averages were extrapolated to all census blocks within the SRP service area (n=25,357). This process produced an estimated total water consumption of 549,626 acre feet in 2018. This estimate is within the range of actual annual water consumption in the SRP services area from 2015-2019. However, this estimate is 11% higher than the actual water consumption in 2018. This suggests that the sample of water consumption uses more water on average than the census blocks that are not included in the analysis.

Monthly AF/acre is statistically significantly different between On-Project census blocks (5,969) and Off-Project census blocks (4,396) for every month (Table 7). In all months, on project water consumption also exhibits higher variability than off-project blocks. This discrepancy indicates that patterns of water consumption vary across the larger metropolitan area, as well as within the SRP service area.

Table 6. Census block average water consumption

	Maximum	*Mean*	*Std. Deviation*	*Sum*
January	10.7	0.13	0.268	1,347.52
February	9.73	0.119	0.248	1,238.14
March	9.55	0.118	0.242	1,232.80
April	11.08	0.142	0.288	1,475.53
May	10.9	0.165	0.315	1,717.96
June	10.82	0.201	0.375	2,085.20
July	16.08	0.209	0.428	2,170.63
August	12.16	0.202	0.384	2,096.34
September	11.33	0.186	0.372	1,936.46
October	10.65	0.155	0.308	1,615.06
November	10.2	0.146	0.292	1,513.37
December	8.78	0.130	0.259	1,348.01
Annual	129.89	1.908	3.724	19,777.03

Table 7. Consumption on and off project

		MEAN	STD. DEVIATION
JANUARY	On Project	0.14	0.32
	Off Project	0.12	0.18
FEBRUARY	On Project	0.13	0.28
	Off Project	0.11	0.19
MARCH	On Project	0.13	0.28
	Off Project	0.11	0.19
APRIL	On Project	0.15	0.33
	Off Project	0.13	0.22
MAY	On Project	0.18	0.37
	Off Project	0.15	0.22
JUNE	On Project	0.21	0.44
	Off Project	0.18	0.27
JULY	On Project	0.22	0.50
	Off Project	0.19	0.30
AUGUST	On Project	0.22	0.45
	Off Project	0.18	0.27
SEPTEMBER	On Project	0.20	0.43
	Off Project	0.17	0.28
OCTOBER	On Project	0.17	0.36
	Off Project	0.14	0.23
NOVEMBER	On Project	0.15	0.33
	Off Project	0.14	0.22
DECEMBER	On Project	0.14	0.30
	Off Project	0.12	0.19

Results

Land Use On and Off Project

Like the parcel scale analysis, most of the development within the census blocks are primarily single family residential homes. There is a high variability of commercial properties in the blocks, indicating that some census blocks have a high proportion of commercial accounts which reflects the development patterns in the cities (Table 6). There is a statistically significant difference between the water duty (AF/Acre) as the proportion of single family residential properties increases ($F=4.23$, $p< 0.01$). The data suggests that in general the higher proportion of single family residential development the higher the water consumption (Table 9).

There are some also some differences between development patterns in the sample of census blocks that are on-project compared to off-project:

- Vegetated proportion was higher on-project ($t= 5.96$, $p< 0.01$)
- The construction year on average is older on-project ($t= -39.56$, $p< 0.01$)
- Proportion of single-family residential properties is slightly lower on-project ($t=-2.65$, $p< 0.01$)
- Proportion of multi-family residential properties is higher on-project ($t=7.743$, $p< 0.01$)
- Proportion of commercial properties is higher on-project ($t=4.69$, $p< 0.01$)
- Proportion of industrial properties is higher on project ($t=7.33$, $p< 0.01$)

Table 8. Land use on and off project

	All census blocks		*On-project*	
	Mean	Std. Deviation	Mean	Std. Deviation
Single Family Residential	88.2%	26.1%	87.5%	27.3%
Multi-family Residential	0.5%	4.0%	0.7%	4.9%
Apartment	0.2%	2.1%	0.2%	1.8%
Commercial	2.5%	11.8%	2.9%	12.3%
Industrial	0.9%	7.9%	1.4%	9.8%

Table 9. Annual consumption (AF/acre feet) and single family residential development

Proportion of Single Family	**Mean**	**Standard Deviation**
0-25%	1.60	0.15
26-50%	1.18	1.64
51-75%	1.92	5.18
76-100%	1.95	3.68

Results

City Comparisons

The sample of census blocks from four different cities indicates some similarities between the cities, though it is clear there are variations in water consumption between the cities (Figure 11). There is a statistically significant difference in average annual water consumption between the four cities ($f= 59.56$, $p< 0.01$; $f=15.81$, $P<0.01$), where one city exhibits higher water consumption than the other three samples (Figure 12). Each line in Figure 12 represents a different city in the sample of water consumption records. All cities exhibit similar seasonal patterns where water consumption is highest in the summer months.

Figure 11. Average annual water consumption by city

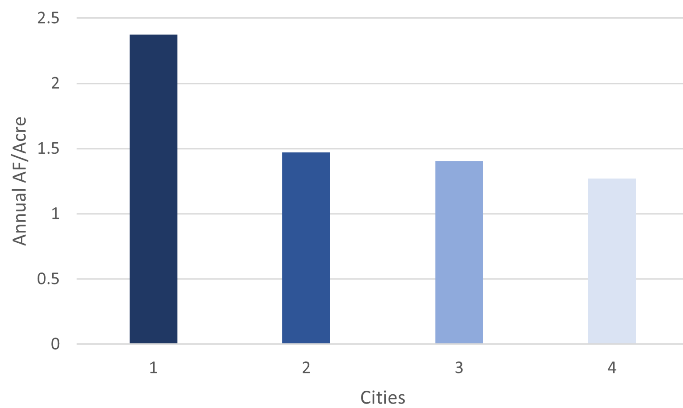
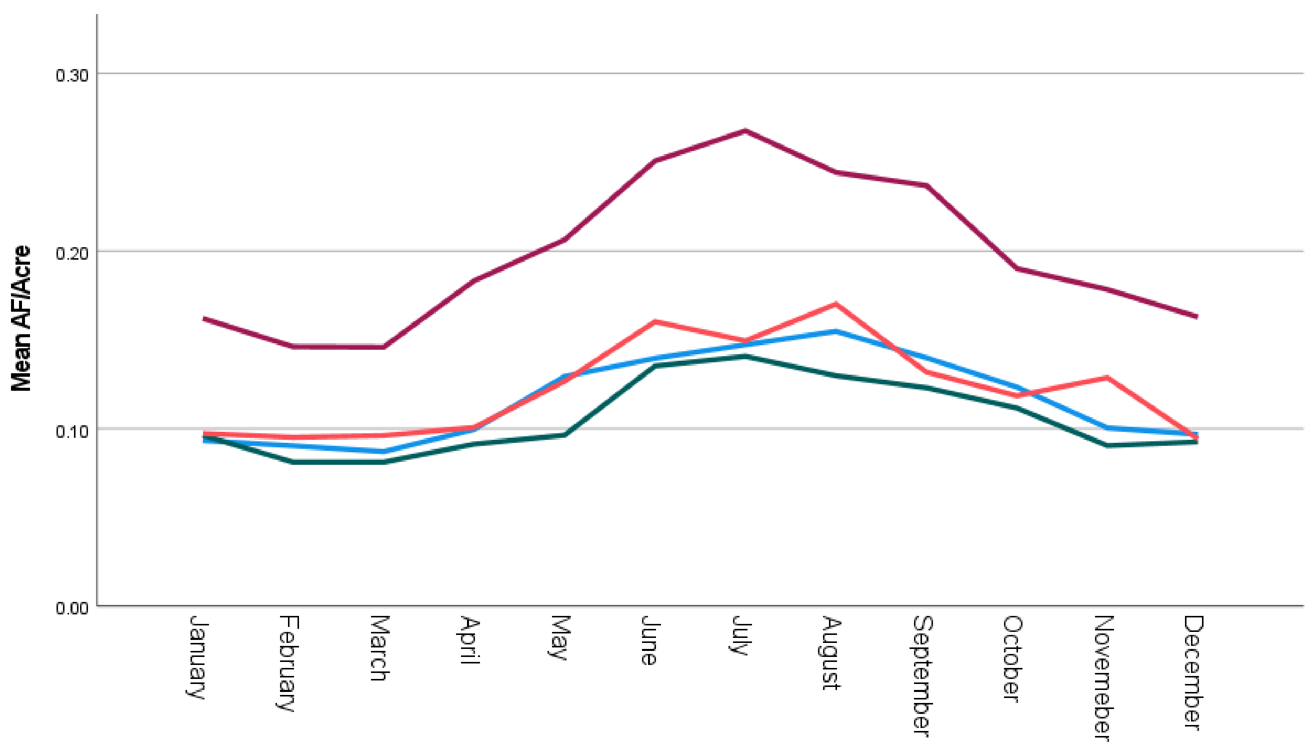


Figure 12. Average monthly water consumption (AF/acre) by city



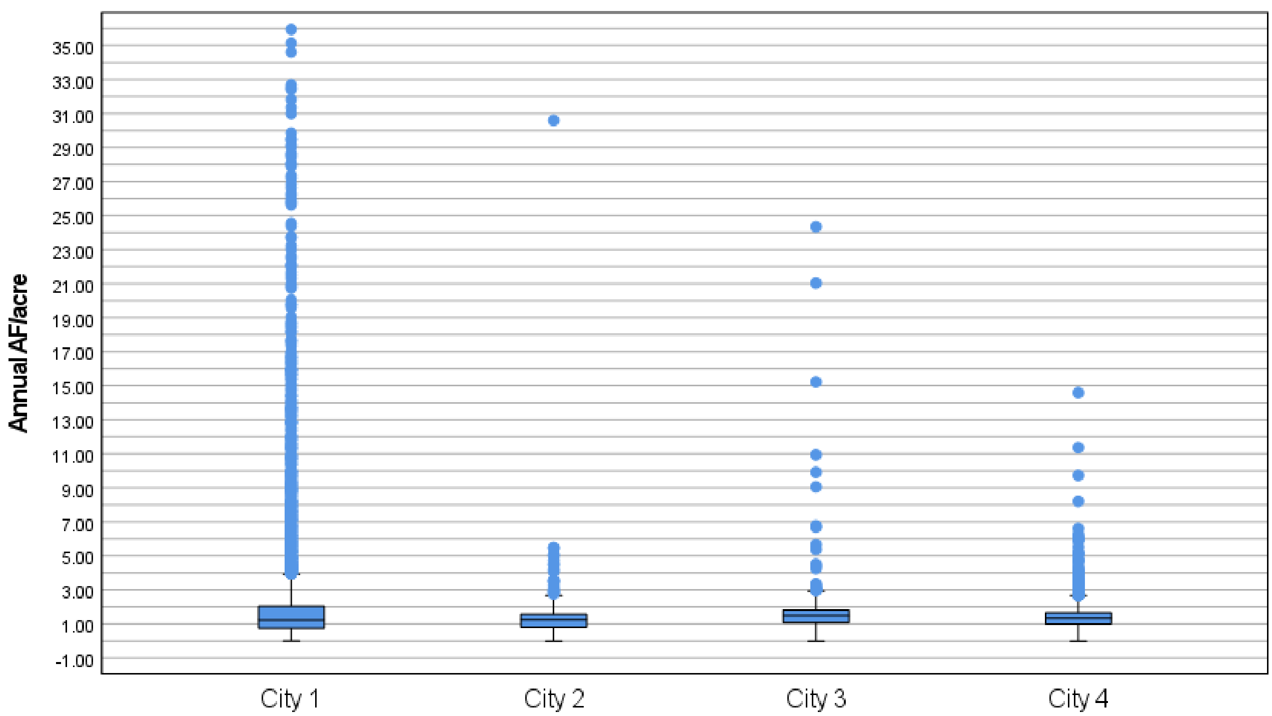
Results

Outliers

There are a several census blocks in the sample that use substantially more water than the majority of other blocks. Though most census blocks use on average relatively low amounts of water (and constitute the greatest cumulative water use), Figure 13 illustrates that each city contains census blocks where water consumption is substantially greater than average water consumption per census block. Each blue point represents a census block.

One city has far more census blocks with substantially higher water outliers than the other cities. As a result, this city has higher average water consumption, despite the majority of census blocks using comparable amounts of water between the four cities.

Figure 13. Outlying census blocks in each city

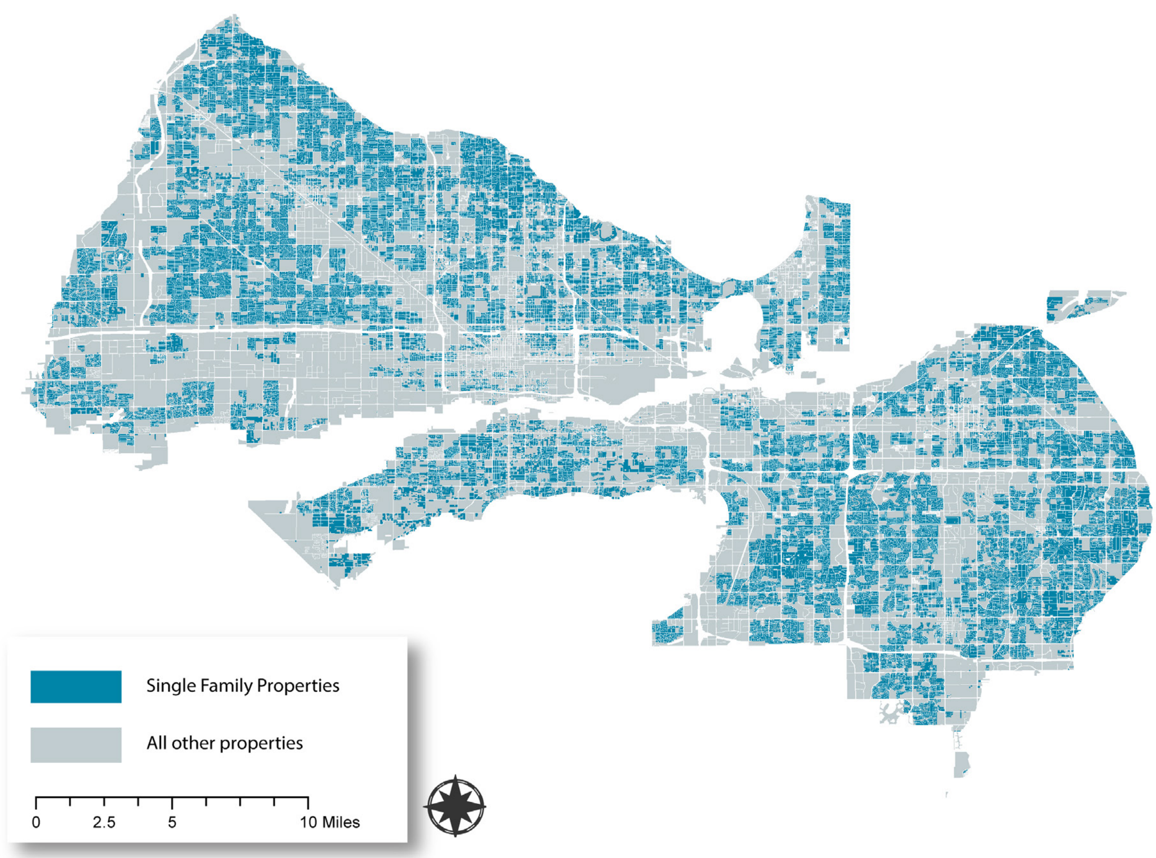


Key Findings

Part 1: Parcel Analysis

- Almost all accounts in the sample and the majority of water consumption are single family residential properties (Table 1).
- Of the 586,342 properties in the SRP service area, 68% of the properties are single family residential properties (Figure 14).
- Individual accounts may use very high amounts of water but are relatively small contributions to total water consumption. (Table 2).
- Increases in vegetation are generally associated with higher water consumption when demand is highest, however there are other factors that are influencing water consumption (Figure 6).
- Multi-family water consumption is not strongly related to landscaping and vegetation, and the multi-family accounts with the least amount of vegetation used the most amount of water (Table 3).
- Single family residential properties exhibit the typical association between vegetated cover and water consumption.
- The majority of the SRP service area is impervious land cover.
- Phoenix, Mesa, and Chandler constitute the greatest proportion of parcels in the SRP service area.
- The urban forms of the cities vary in terms of average size of property, average amount of vegetation, as well as the year that the property was built.

Figure 14. Location of single family residential properties in the SRP service area



Key Findings

Census Block and City Scale Findings

• Most water customers are single family residential development, and on average census blocks with the highest proportion of single family properties use more water per acre (Table 8).

• The data indicates that three of the four cities exhibit similar water consumption per acre throughout the year, while one city uses on average more (Figure 8). This is likely a result of several census blocks with substantially higher water consumption rather than city-wide policies.

• There is also more variation in consumption patterns that is being isn't captured by these samples (Figure 6).

• All cities contained outliers that represent census blocks with very high water consumption. These outliers constitute a very low percentage of total water consumption (Figure 9)

• Conservation efforts can target peak usage in the summer focusing on the highest users, while long-term policies can influence consumption in single family residential properties. This data supports the that changes in water consumption at the single-family household level has the potential for greatest cumulative savings across the service area.

Future Research and Applications

Conclusions

Based on analysis of this data there are several key conclusions. First, most of the SRP service area is single-family residential development (Table 1, Table 8, and Figure 14). Most single-family residential accounts use relatively low amounts of water every month of the year. However, the cumulative total of single-family residential water consumption is greater than all other land uses. These single-family residential properties exhibit the intuitive trend that the more vegetation is on the property, the more water is consumed (Table 5). Though the NAIP multi-spectral data used in this analysis cannot differentiate between native vegetation and turf grass, it was a useful data source identify the location and quantity of vegetation across the 256,718 acres of the SRP service area. Furthermore, these findings reinforce the conclusions from the 2019 Phoenix Metropolitan Area Multi-City Water Use Study: Single-Family Residential Sector report. Based on this sample of water consumption, the majority of water supplies in the SRP region support single-family residential properties, and a substantial portion of the water is used to irrigate residential landscapes.

Therefore, changes to landscaping practices and development for single family residential properties would influence total water consumption within the region. Municipal ordinances that regulate landscaping in new developments before landscapes are installed would likely be very effective. The effects of a policy change like this may be slow, but should be considered for long-term planning efforts.

While most accounts within the SRP region are single family residential, it is important to note that there is substantial variation in the amount of water between different account types (Table 1, Figure 8). Put simply, there are some accounts and census blocks that use far more water than any of the others. These high user accounts constitute a very small proportion of accounts in each city as well as a relatively small amount of total water consumed in the city. However, should conservation efforts be needed quickly these accounts could be targeted for efficiency improvements.

There is variation in water consumption patterns between the cities (Figure 11, Figure 12). A full accounting of the extent of water consumption across the region is limited due to a lack of data: both a comprehensive measurement of water consumption in each of the contributing cities and information for the other cities within the SRP region. While the sample of water consumption data is substantial (n=10,365), there are gaps in the data (Figure 6). Based on this sample of water consumption and inventory of urban development for all cities within the service area, it is possible that this current analysis is missing meaningful variations in water consumption patterns related to urban development.

For example, census blocks with very few accounts are omitted from this analysis. This omission causes an oversampling of certain types of census blocks, i.e. single family residential blocks with many accounts, while under sampling census blocks with fewer accounts but larger buildings. This gap includes large multi-family developments as well as commercial and industrial accounts. These sampling biases must be accounted for when interpreting these results

Future Research and Applications

Conclusions

When analyzing the NAIP data, it was interesting to find that over 60% of the land area in the SRP service area is impervious land cover (Figure 10). This has important implications for many aspects of water resource management. First, stormwater flooding is known to be directly associated with the amount of impervious surface in a region. The water quality of this stormwater is also negatively impacted by impervious surfaces. Finally, the urban heat island effect is much higher in regions with high proportions of impervious surfaces which may cause increases in water consumption and energy consumption. The municipalities within the SRP region can consider design and permitting strategies which could reduce the amount of impervious surfaces being developed.

The analysis in this report shows that increasing vegetation in single family residential properties is associated with higher water consumption (Table 5), but this is not the case for other account types. For example, multi-family residential water consumption did not appear to be related to the proportion of vegetated cover on a property, but rather is a function of the number of units and occupants (Table 3). Therefore, the potential increase in water consumption resulting from vegetation on these properties is likely to be less than the amount of indoor water consumption. The benefits of more vegetation on multi-family, commercial, and industrial accounts may outweigh the relative water consumption costs.

Measuring additional insights into multi-family consumption patterns across the SRP service area will likely be challenging because of the various data collection used by different agencies and organizations. Figure 7 illustrates how differences in data collection between the tax assessors dataset and the municipal water consumption records exist. While combining the datasets for individual accounts would be possible, an individual approach for coding thousands of multi-family parcels was not feasible. Combining these datasets could allow refined analysis into understanding patterns of water consumption for multi-family development and produce per-capital measures of water consumption for multi-family development. Future research and improved data integration/collection could provide a better estimates of multi-family residential developments in the SRP service area.

This report and accompanying data transfers to project partners can support regional efforts to better plan and manage our critical water resources. This project could not have been completed without the support of several municipalities, SRP, and Arizona Municipal Water Users Association. Regional collaborations such as this project can lead to the creation of shared datasets, information dissemination, and support connections between the organizations that manage critical water resources for the residents of southern Arizona.