Colorado Water and Growth Dialogue
Final Report

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KEYSTONE POLICY CENTER

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Executive Summary

The Colorado Water and Growth Dialogue began as an effort of Colorado State University's Colorado Water Institute and Keystone Policy Center to explore the potential to utilize land use planning to reduce water demand from population growth. As an initial step a large group was convened in August 2014 to have a round table conversation about what data and information was needed, whether and how it could be effective and to solicit interest. At the initial convening the following themes emerged that needed to be illuminated with data.

"If we grow the next 5 million people like we grew the first, there won't be enough water"

"Before we spend the political capital required to reduce landscaping and increase density, we need to know whether these things will move the needle"

Through the development of a Steering Committee and Working Group, the Dialogue refined its goals to include the following:

- First, demonstrate how much water could be saved through the integration of water and land use planning for homes and neighborhoods that will be developed or redeveloped in the future;
- Second, develop a consensus-based set of recommended strategies for communities that can be incorporated into their planning that recognizes the uncertainties of how and where people in the future will want to live; and
- Finally, develop and disseminate these results to communities so that the information and data can feed into their planning processes.

Below and at the Dialogue's website, planners, policy makers, development interests and others interested can find the results.

Context:

By 2040, Colorado is projected to experience an approximately 40 percent increase in population and with these people will come an increase in municipal and industrial water demand. In the semi-arid climate of Colorado with limited water supplies, this increased water demand will result in a statewide water supply gap. Thus far, strategies to address the gap have generally taken three forms: develop new supply and water storage projects, implement reuse projects, and encourage water conservation. The Colorado Water and Growth Dialogue explored whether the integration of water and land use planning might reduce water demand from residential housing development and re-development associated with the projected population increase.

The Water and Growth Dialogue facilitates the exploration of data and information for land planners, water planners, policy makers, development interests, and others interested in the potential impact of integrating land and water planning. The topics of density and landscaping and their effects on water demand are important considerations for communities to examine as they plan for growth. Of course, land planners and policy makers need to think about many other factors in their planning. These include considerations such as quality of life, character, and livability of their communities; transportation; the urban heat island effect; storm water runoff, and myriad other considerations. One of the goals of the dialogue is to provide local planners and decision makers with accurate and useful information to consider water as a factor in new growth.

Results

The Dialogue's analysis proved that increasing residential density and reducing landscaping irrigation reduces water demand over conventional development. This is primarily because at higher densities there is less

landscaping per household. However, it is not as straight forward as past discussion would suggest. There are a number of factors that make such actions complicated, such as: the use of high water-use plants in landscaping, the efficiency of irrigating small spaces, the high variance in water efficiency that exists within existing residential properties and between various communities, and the wide range of possible strategies of increasing residential densities. These complications underline the need to conduct outreach and to help homeowners and renters understand the importance of community context in order to realize the potential water saving benefits from increasing densities and a reduction of landscaping-related water demand. It also reinforces the conclusion that land and water planners should be working hand-in-hand as they make long-term plans for growth as well as development decisions.

The results and products of the Dialogue can be found within this report or at https://keystone.org/waterandgrowthdialogue.com.

The results include:

- **Clarion report:** A report that identifies existing studies linking land use planning and water demand reduction, and to suggest policies that might further that goal.
- **Residential Density and Outdoor Efficiency Impact on Water Demand:** An analysis of how much water demand could be reduced by developing and redeveloping residential projects at higher densities.
- **Demand reductions from landscaping:** A case study analysis of water demand savings from the City of Aurora's landscaping policies
- **Residential Land Use and Water Demand Tool:** A tool that enables planners to develop their own scenarios of growth and compare the water use implications of the scenarios side-by-side.
- **Strategic levers:** A set of strategies to improve the integration of land and water policy in Colorado.

Clarion report: At the outset of the Dialogue, the group contracted with Clarion Associates to develop a report that identified existing studies linking land use planning and water demand reduction, and to suggest land use forms that might further that goal. The following 4 recommended land use pattern changes helped the dialogue focus on what to examine. Please see the Dialogue's website to access the full report.

Land use patterns that are recommended for further examination:

- Smaller single-family parcels
- Single-family to multifamily
- Increased density multifamily
- Landscape restrictions

Residential Density Impacts on Water Demand: An analysis of how much water demand could be reduced by developing and re-developing residential projects at higher densities. Given the assumptions and uncertainties inherent in an analysis such as this, it is the insights gained through the analysis that are the most important.

The study considered scenarios where significant economic and political measures were employed to generate higher residential densities, or changes in culture and values led to preferences for higher densities. These were termed "high resource cost" scenarios. The absence of those factors were considered "low resource cost."

The key strategic insights coming out of the analysis are as follows:

- Moving from Large Single Family and Typical Single Family building types, to Small Single Family homes or any other smaller building type, can result in 50% to 60% of the full potential from the more complex higher resource scenarios.
- Increasing residential density may decrease the total water demand of new growth in the range of 2 percent to 19 percent, with higher "resource costs" associated with the higher number.
- Lower "resource cost" scenarios that increase density may achieve 3 percent to 8 percent reduction for new development.
- Increasing the efficiency of outdoor water use, i.e. reducing demand per square foot of pervious area (DPSFP) may decrease total water demand of new growth in the range of 5 to 25 percent, and be as effective, if not more, at reducing future water demand as increasing residential density. These reductions can be achieved through a wide variety of measures, including more efficient irrigation, reduction of turf areas, choosing low water demand plants and using xeriscape techniques, as well as reducing landscaped area per se. This analysis did not attempt to parse out the relative potential water savings of the above outdoor landscaping techniques, but it does point to the significant savings that could be achieved if we change our outdoor landscaping practices to be more water efficient.
- Combining low "resource cost" residential density increases with low "resource cost" reductions of DPSFP may achieve reductions in total residential water demand of new growth by 5 to 15 percent.
- Moving household preferences from the Large Single Family and Typical Single Family housing types to other building types provides the largest reductions in total water demand of new housing.
- Scenarios of movement that do not include movement out of large and typical single-family building types have less benefit.
- The medium and high density multifamily building types have a very large variance in gallons per square foot of pervious area. If future development occurred in this higher density range without adequate outdoor landscaping controls, this could result in increased water demand.

Demand reductions from landscaping:
A case study analysis of water demand savings was conducted from the City of Aurora's landscaping policies. Key findings include:

- Reducing the amount of pervious landscaped area will lower overall outdoor water use, given all else stays the same.
- Landscaping codes should be complemented by an education program for residents to ensure the full potential of water conserving landscape design.
- When code is put in place, it would be in a city's best interest to develop an outreach and education program targeted toward the developer and the new occupants of the home, specifically focusing on both developers and builders as well as new home owners.

Strategic levers:
Members of the Colorado Water and Growth Dialogue's working group met during the summer of 2016 to participate in an exploratory scenario planning process. Through this process, participants discussed the future uncertainties that have the greatest ability to impact the region and the planning environment.

To orient and focus discussion, the group set out to answer the following focal question:

How can changes in urban form and landscaping practices for new growth and redevelopment assist in meeting future urban water demand along the Colorado Front Range?

The group decided that the future uncertainties that have the greatest impact on the planning environment regarding the focal question are future housing preferences, the economy, and innovations in transportation technology such as autonomous vehicles, which may either reinforce sprawling land use patterns or help in concentrating residential development along transit corridors. More detailed information on the process can be found on our website.

The strategies found on page 27 of this report are the result of the exploratory scenario planning process. The full report can be found on the Dialogue's website at https://keystone.org/waterandgrowthdialogue.com.

Residential Land Use and Water Demand Tool:
Local planners and decision makers have the best sense of their projected population growth and in what type of residential settings those people may live. In recognizing this, the Dialogue worked to develop the Residential Land Use and Water Demand Tool to allow planners to develop their own scenarios of growth and compare the water use implications of the scenarios side-by-side.

The Tool allows planners to input a population growth estimate and then develop scenarios of how they think those people will be distributed across the unique seven housing building types that underlie our analysis. They can use the Tool to get a sense of the magnitude of demand reductions that could be seen if people lived in denser settings with less landscaping for example. In this way, planners can get a sense of the trade-offs and factor water into the myriad other factors that they need to analyze to plan for impending growth. Utilizing the tool also creates an opportunity for local land and water planners to share data and develop scenarios together and discuss their assumptions and insights regarding how future growth may occur.

Conclusion
The information contained in this document and on the Dialogue's website (https://keystone.org/waterandgrowthdialogue.com) is meant as a resource for land and water planners, developers, policy makers and others interested in the topic. The report and the information contained was collaboratively developed to help local governments better understand the benefits of integrating land and water planning. However, there are no silver bullets found within the analyses that change the underlying assumptions that water planners traditionally hold true regarding the need for a diverse set of water supply and conservation measures to meet current and future water demands. Conversely, the assumptions that land planners hold regarding the supply and demand intrinsic to the housing market are also not being challenged.

The results of the Dialogue point to the need for better communication between land and water planners and increased access to, and development of, knowledge and data. It is the Dialogue participants' hope that better integration of land and water planning will become another commonly used tool for communities to reduce their water supply gap by lowering water demand as the region plans for significant population growth over the next 22 years and beyond.

Colorado Water and Growth Dialogue – Full Report

Context

By 2040, Colorado is projected to experience an approximately 40 percent increase in population and a corresponding increase in water demand by municipalities and industry. In the semi-arid climate of Colorado with limited water supplies, this increase in water demand will result in a statewide water supply gap. Thus far, strategies to address the gap have generally taken three forms: develop new supply and water storage projects, implement reuse projects, and encourage water conservation. The Colorado Water and Growth Dialogue explored whether the integration of water and land use planning, specifically the use of policies to increase residential housing densities and decrease the area devoted to high water use landscaping, might reduce water demand from new residential development and re-development associated with the projected population increase. If Colorado does experience a 40% increase in population as expected, the ensuing increase in demand for water, coupled with anticipated impacts of climate change, and an already limited water supply could result in a significant gap in Colorado's statewide water supply. Current strategies to address the growing gap – increased water conservation, implementation of reuse projects and development of new water storage must be augmented by new tools. The integration of water and land use planning could provide that augmentation through increased residential densities and reductions in high water use landscaping.

Integrating water and land use planning is increasingly recognized as a potentially important tool in meeting the future needs of Coloradans. The CWCB held a symposium on the topic in 2009 and subsequently released the *Water Management and Land Use Planning Integration* report. Western Resource Advocates and Pace University convened a series of Land Use Leadership Alliance (LULA) workshops demonstrating techniques that land use professionals, water planners, developers and municipalities can use to integrate land and water planning within their communities. The Sonoran Institute and Lincoln Institute of Land Policy convened the Growing Water Smart Workshop series. Colorado's Water Plan also has a section dedicated to integrating land and water planning with the specific goal of 75 percent of Coloradoans living in communities that have incorporated water-saving actions into land use planning by 2025. All this to say much great work is moving the State closer towards attaining the Colorado Water Plan goal. The Colorado Water and Growth Dialogue is building on this foundational goal to provide planners the data to determine whether integrate land and water planning is advantageous for their communities.

Introduction

The Colorado Water and Growth Dialogue facilitates the exploration of data and information for land planners, water planners, policy makers, development interests, and others interested in the potential impact of integrating land and water planning. The topics of density and landscaping and their effects on water demand are important considerations for communities to examine as they plan for growth. Of course, land planners and policy makers need to think about many other factors in their planning. These include considerations such as quality of life, character, and livability of their communities; transportation; urban heat island effect; storm water runoff, and myriad other considerations. One of the goals of the dialogue is to provide planners with the accurate and useful information they need to consider water as a factor in planning for development and redevelopment associated with new growth.

The Colorado Water and Growth Dialogue formed in order to gather data and information to help land planners make decisions about how their communities will grow and how to factor water demand into those decisions. Over three years this group has gathered information on the potential range of water savings that could be achieved by policies that encourage the efficient landscaping and to develop land use patterns that encourage higher residential densities. The Dialogue explored strategies and generated data to help communities with decisions related to new development and redevelopment prior to residents moving into homes.

Additionally, the participants of the Dialogue participated in an exploratory scenario planning process to produce strategies that local governments can consider to better integrate land and water planning within their communities. These strategies recognize that the future is uncertain and therefore flexibility and preparing for the outcomes of many future scenarios is necessary for prudent planning.

The purpose of the Colorado Water and Growth Dialogue is three-fold: first, to demonstrate how much water could be saved through the integration of water and land use planning for homes and neighborhoods that will be developed or redeveloped in the future; second, to develop a consensus-based set of recommended strategies for communities that can be incorporated into their planning that recognizes the uncertainties of how and where people in the future will want to live; and third, to develop and disseminate these results to communities through existing outreach channels so that the information and data can feed into their planning processes.

Water resource planning is just one decision of many that land planners must evaluate as they develop their communities. A healthy urban environment depends on green spaces and providing a range of housing choices. The data, information and tools the Dialogue presented in this report are meant to inform the myriad of choices and tradeoffs planners make and are not intended to advocate for higher density development with minimal landscaping.

Results:

Clarion Report:

At the outset of the Dialogue, the group contracted with Clarion Associates to develop a report that identified existing studies linking land use planning and water demand reduction, and to suggest land use forms that might further that goal. The firm was requested to research what actions have been taken related to comprehensive planning, zoning, subdivision, and land development regulation that would have a significant impact on water consumption in that project, building, or facility after it is occupied and throughout its useful life. Items to be considered included planning, zoning, subdivision, site planning, and building code regulations and incentives to builders.

The following 4 recommended land use pattern changes helped the dialogue focus on what and where to examine.

Land use patterns that are recommended for further examination:

- Smaller single-family parcels
- Single-family to multifamily conversion
- Increased density multifamily
- Landscape restrictions

Please see the Dialogue’s website to access the full Clarion Report. (https://keystone.org/waterandgrowthdialogue.com)

Quantitative Results

A. The Impact of Increases in Residential Density on Water Demand: A Quantitative Scenario Analysis- Ray Quay, Senior Sustainability Scientist, Decision Center for a Desert City, Julie Ann Wrigley Global Institute of Sustainability

One of the key questions that is driving the Water and Growth Dialogue is whether promoting changes in land use planning practice to encourage higher residential development density, or changing the ways in which outdoor landscaping is treated, is a significant factor in future water demand. Would raising residential development density "move the needle" on future water demand? Likewise, how significant are changes in the ways in which outdoor landscaping is treated? If the practice of outdoor landscaping embraced water conserving landscape design, how significant an effect would this be for future water demand on the Front Range of Colorado?

The Dialogue set out to understand the impact that higher residential densities can have on reducing water demand with the understanding that this has the potential to be a highly charged topic as people consider the future of their communities. In any community, there will be a mix of development patterns that derive from the local housing market and choices about community character. A ubiquitous high-density environment is not necessarily realistic nor desirable from a quality of life standpoint.

This analysis is an exploration of "what-if" scenarios that assume future households move from less dense to more dense residential land use patterns. Such an analysis has never been attempted before using actual customer water use data from Aurora and Denver to determine what level of housing densification needs to occur before it amounts to significant water savings.

This analysis was funded through a National Science Foundation grant and completed by the Decision Center for a Desert City (DCDC) at Arizona State University. The analysis aimed to answer the following questions:

- What quantifiable impact does increasing residential density have on total water demand?
- What characteristics of increasing residential density correlate to change in total demand?
- What quantifiable impact might outdoor water use efficiency improvements have on total demand?
- What characteristics of outdoor water use efficiency improvements correlate to density and total demand?

Water managers, city planners and academics posit that total municipal water use can be reduced simply by increasing residential densities. Many studies, all limited in scope, find decreased per capita water use with increased density of single family detached homes. Although rarely definitive, decreased overall water use in these studies is attributed to reductions in outdoor water use (e.g., reduced tree, shrub, and turf irrigation and reduced presence/absence of swimming pools) as lot size decreases.

No studies that we are aware of have looked specifically at outdoor or total water use over the continuum of residential density from large lot, single family homes to high density, multi-story developments. Increased residential density can, obviously, be achieved through many pathways. For instance, a family could move from a large single-family lot to a smaller lot footprint with reduced interior and exterior square footage. Or, a household could move into a multi-family housing development from a small single-family home as a significant number of people do when they retire and/or become empty-nesters.

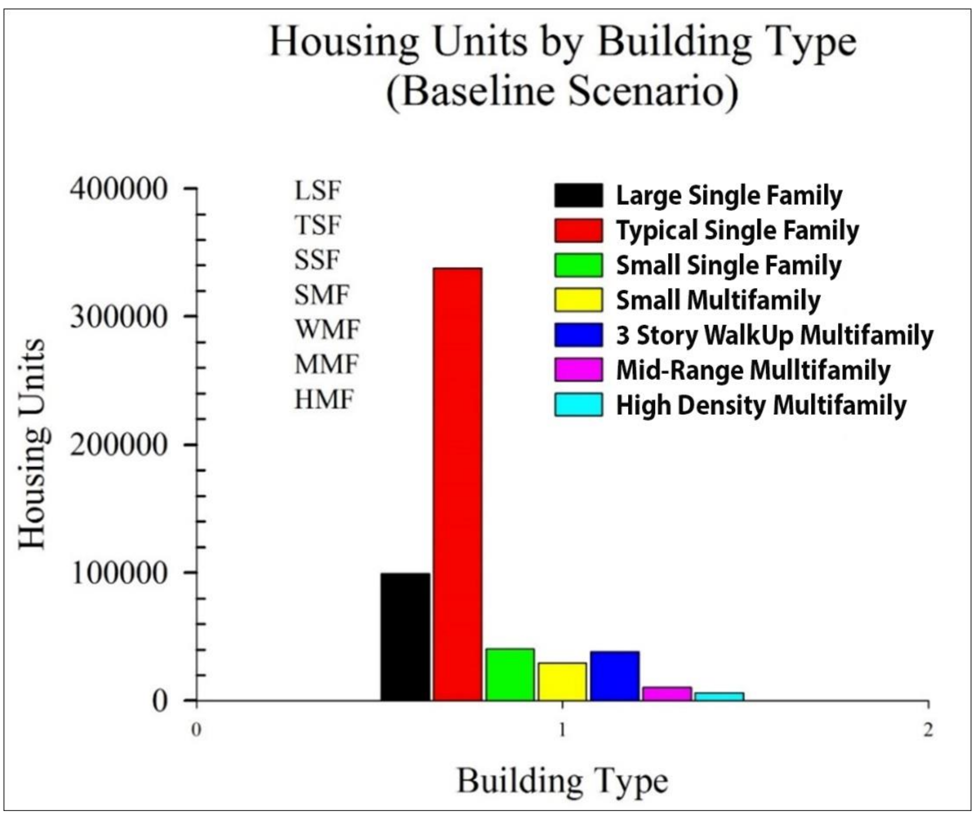
The analysis examined the potential change in total (and outdoor) water demand with increased dwelling units per unit area (DUUA) for seven common dwelling unit classifications (DUC) in the Denver Regional Council of Governments (DRCOG) service area. Using dwelling unit classifications, estimates of new population from the DRCOG, household size by type of dwelling unit, number of dwelling units, and pervious surface area per unit, the analysis developed a model to permit scenario analyses of water use data. The analysis examined hypothetical household "movement" from lower density to higher density units. The results suggest uneven, non-linear efficiency gains in water use with increased density, depending on the specific DUC movements. Outputs indicate that the largest gains in water savings can be achieved with short "movements" over the lowest density residential dwelling unit classes.

Analysis

The team at DCDC used a sample of Denver Water and Aurora Water customer data to estimate water demand by residential building type. These estimates were assumed applicable on a regional level. See Appendix A for a map of the area from which the data was derived. Denver Water performed an analysis of a sample of existing residential customers in both the Denver Water and Aurora Water service areas. They classified these customers by their building type and then estimated the characteristics of water use by building type. See Table 1 for these results. Using this information, DCDC then developed a water demand model to estimate the water demand per unit for each building type and the overall residential demand based on the number of households living in each building type.

The analysis used an exploratory scenario method to examine relationships between increasing residential density and outdoor water efficiency with total demand. The model considered only projected new residential units, with a projected increase between 2010 to 2040 of 562,069 new residential units. Estimates of how many units existed within the DRCOG region for each building type in 2010 were developed using DRCOG's parcel and building data. Figure 1 shows this allocation, which is dominated by Typical Single-Family units (TSF). (Please note that the housing categories and characteristics can be found on the next page in Table 1.) Estimates of the number of new households that would be added by 2040 were developed using DRCOG's population and employment forecasts. A baseline scenario was created by applying the percentage of 2010 households in each building type to the estimate of new households in 2040. That is to say, the baseline scenario assumes that the 562,069 new residential units projected in the DRCOG region by 2040 will be proportionally distributed among the seven building types in the same manner as the existing housing stock in 2010 (Figure 1 below).

Figure 1: Housing Units by Building Type – 2040 Baseline Scenario



New scenarios were then created based on various types of residential density changes resulting from the hypothetical redistribution of new households to higher density building types. This includes scenarios that ranged from some households just “moving up” one building type, such as from a Large Single Family (LSF) lot to a typical Single Family (TSF) lot, to scenarios where households would “move up” by skipping several building types up to a much higher density type, such as Large Single Family (LSF) lot to a 3-Story Walkup apartment (WMF). This created scenario sets of 5,040 different ways these household shifts could occur. Scenarios also reflected the absolute number of new households distributed into new building types, which include 5 brackets ranging from 10% to 50% shifts in the number of households moving from one building type to another. This resulted in a total of 25,200 discrete scenarios.

In these scenarios, when a household was reallocated from the baseline scenario building types to a higher density building type, the household persons (household size) and its indoor water use behavior (indoor GPCD) were assumed to remain the same. Building type characteristics, such as dwelling units per acre (DUA), Pervious Area (PA), and water use per pervious area (WPA), stayed with the building type unit and not the household. Thus, the focus of the analysis was on landscaped, or pervious, area and its corresponding water use as a primary contributor to total water use and did not vary indoor water use. Households moving from denser to less dense building types were not modeled. Table 1 presents the household and building type data used for the model. The figures in Table 1 were calculated from a combined sample dataset of Denver Water and Aurora Water customer billing records in 2014. Therefore, while these figures offer useful comparisons, they should not be assumed to be universally applicable to all climates or representative of a long-term average.

Table 1: Water Use and Household Characteristics of Denver/Aurora Building Types – *please see Appendix B for example images of housing product types*

Building Type	Code	Median Dwelling Units Per Acre	Persons Per Household (Assumed)	Indoor Gallons Per Capita Per Day	Pervious Sq.Ft. per Unit	Median Gallons Per Sq.Ft. Pervious Area
Large Single Family	LSF	2.8	2.5	63.5	8,837	11.9
Typical Single Family	TSF	5.1	2.5	50.9	4,492	8.2
Small Single Family	SSF	8.6	2.4	52.0	2,299	12.5
Small Multifamily	SMF	16.0	2.4	52.6	1,047	13.1
3-Story Walkup	WMF	24.3	2.3	59.8	641	27.2
Mid-Range Multifamily	MMF	71.8	2.1	69.3	160	31.9
High Density Multifamily	HMF	115.2	2.0	60.2	88	57.1

A few key concepts regarding household movement and increases to density:

- As new households choose to live in a denser building type, the average density of the community increases.
- The more households and the higher the density of building types, the higher the average housing unit density
- In most cases, increased density reduces per dwelling unit pervious area. In general, higher residential density leads to a reduction in landscape irrigation water demand per dwelling unit.
- Generally, increases in average community density result in declines in outdoor water demand.
    - But, decreasing per unit outdoor demand is not uniform across all building types.

Results

Results below come with the following cautions, caveats and limitations as to how this data should be used and interpreted, and more importantly, not used.

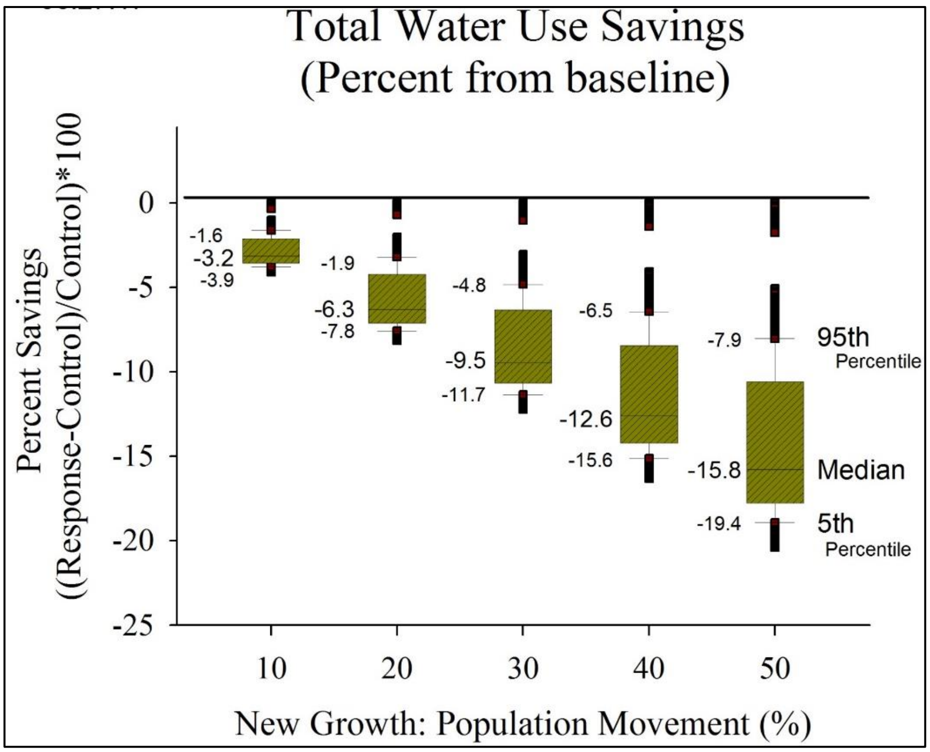
- This analysis was based on a sample of Denver Water and Aurora Water customer data and may not be directly applicable to other locales.
- This was not a predictive analysis; large amounts of variance and uncertainty exist. This information was developed to give a strategic sense of the water demand change that may be experienced with increased density. It is not meant as a guarantee to any amount or range of water savings.
- Systems of development and water use are very complex and many assumptions were made about how systems function to simplify the analysis. Different communities may require different assumptions.
- Other systems that affect changes in residential density, such as economics and community values were not considered.
- The analysis only examined new residential development, not existing housing stock.
- All estimated reductions in landscape water demand are relative to the estimated landscape water demand modeled for the baseline scenario. The baseline scenario assumes that the projected new residential units in the region are proportionally distributed among residential building types according to the 2010 distribution of existing residential units in the region (see Figure 1 for 2010 distribution of 2010 existing residential units).

Figure 2 shows the results for potential water demand reductions resulting from scenarios of different magnitudes of households moving to denser building types (ranging from 10% up to 50% of households within a given building type moving to another, denser, building type. The error bars represent the range of scenarios representing different ways these households could be distributed to higher density building types. A linear trend in the median percent water savings can be seen in the figure from a 3.2% reduction in water demand with a 10% household shift to a 15.8% reduction in water demand with a 50% household shift.

The range for each box plot in Figure 2 is the result of different scenarios in which lower density building types in the baseline scenario are allocated to higher density building types. There were some scenarios that regardless of the number of households that shifted to higher density had very little impact on water demand and some that had a significant impact on water demand. For example, scenarios that only shifted units from medium density to high density did not result in significant savings in water demand. Scenarios that shifted from the lower density household types to small single family had fairly large savings in water demand. This range between low and significant impact on water demand widens with an increase in the number of households shifting from low to high density building types. Scenarios with relatively low percentage of future housing (10% to 20%) shifting from low density to higher density building types had an impact on water demand in the range of a 1.6% to 7.9% water savings. Scenarios with higher percentage of future housing (30% to 50%) shifting to higher densities had an impact on water demand savings estimates in the range from a 4.8% to 19.4% savings.

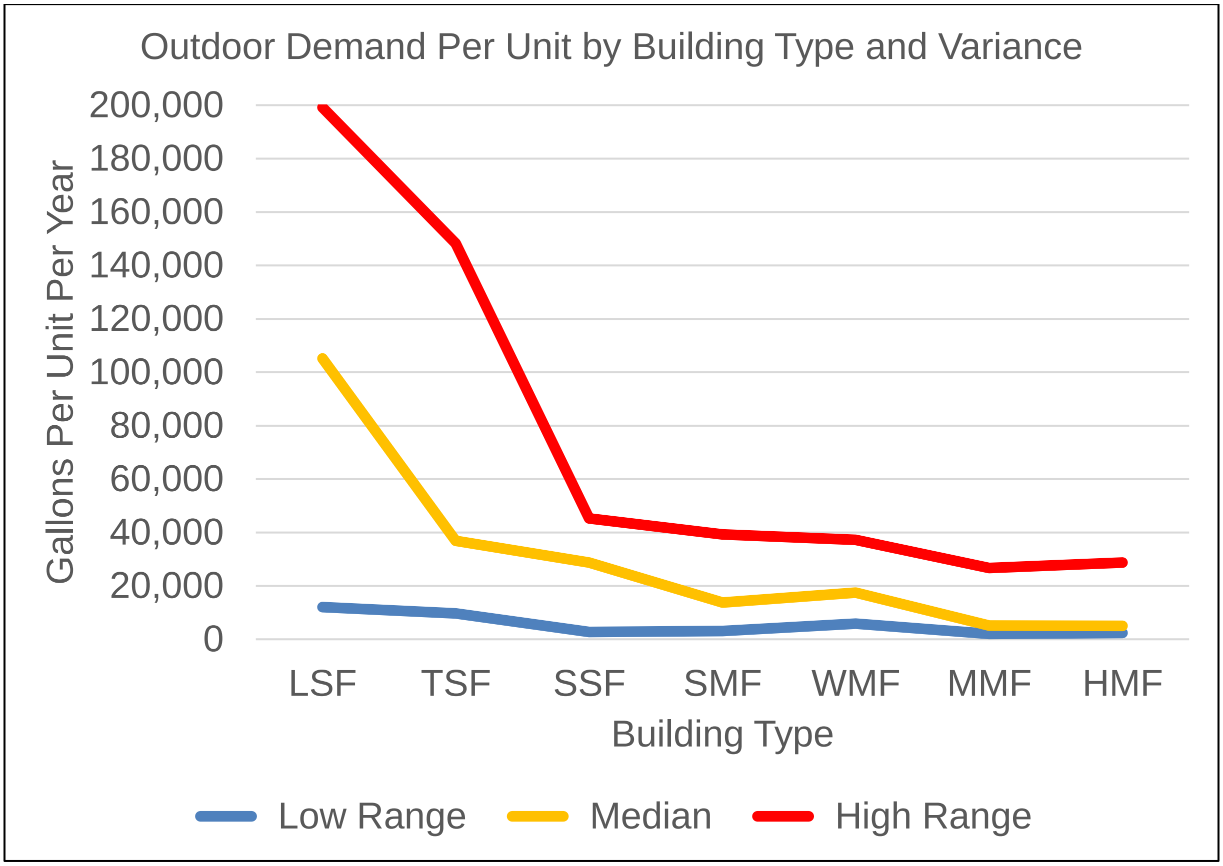
What magnitude of shift in density and how this shift will be distributed among higher density building types is unknown. A 10% household shift in density over a 25-year period would be well within the range of market shifts that have occurred historically. A 50% household shift would likely require some transformational change in housing economics and household preferences. How these shifts occur could vary widely. They could consist of shifts from large single-family lots to small single-family lots; shifts from walkup multifamily to high density multifamily; or complex shifts of households shifting to all higher building types.

Figure 2: Total Water Savings by Magnitude of Density Shifts.
Note: The solid line with in green/gray area is the median value of savings for the various different densities scenarios for each growth % density movement scenario. The green/gray area represents the range of 25% to 75% of these scenarios. The small lines above and below the green/gray area are the 95th and 5th percentile.



In general, the analysis showed a positive linear relationship between the percent of the population (i.e., the absolute number of households) that moves from a lower to a higher density housing type and the potential decrease in irrigation water demand. But this was not a clear linear relationship and did not hold for all building types. Figure 3 below shows the annual outdoor demand by building type across the range of units sampled. The low, medium and high ranges show the variance in outdoor water use for the given building type. The variance in Large Single Family Homes (LSF) and Traditional Single Family (TSF) homes are quite large while the difference between hgi8h water users and low water users narrows significantly as we move toward small lots. Both the high end and median of outdoor demand drops rapidly from Large Single Family to Small Single Family and then declines slowly as the density of building types increases.

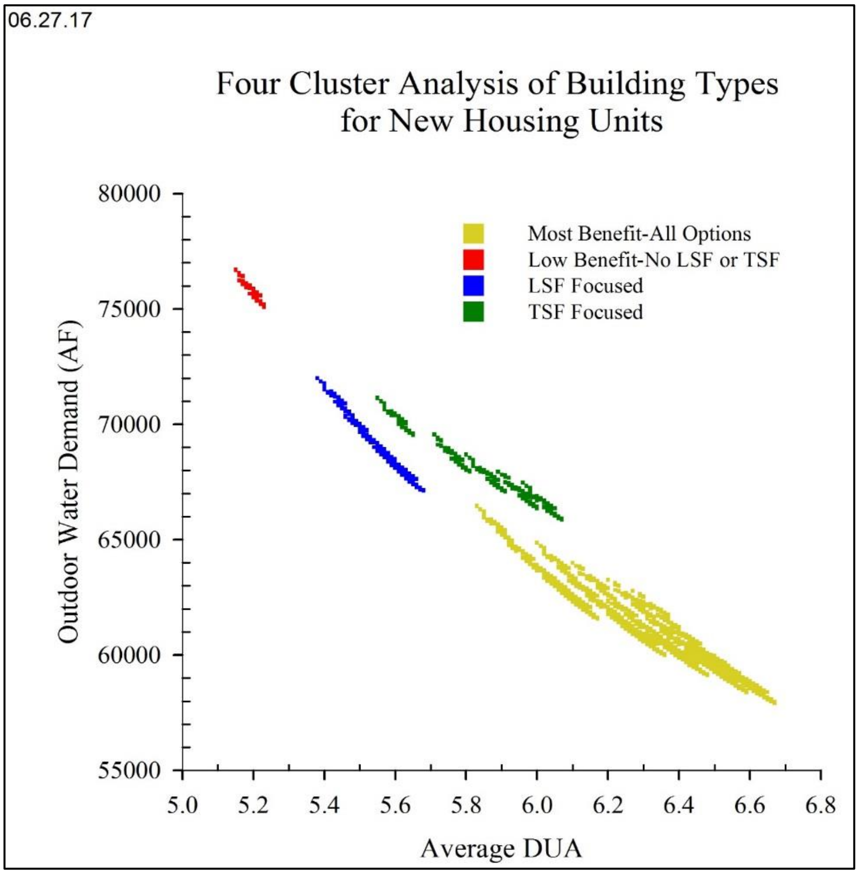
Figure 3: Outdoor Demand by Building Type



When the outdoor water demand for each scenario was examined, several distinct patterns were seen. Figure 4 shows the relationship between outdoor water demand and average dwelling units per acre by a classification of the type of density shifts for 30% of households shifting to higher density building types. As residential density increases, outdoor water demand declines, but this is not a clear linear relationship.

Further, when the type of density shift is classified, several patterns can be seen. There is a cluster of scenarios (shown in red in Figure 4) that show slight changes in average dwelling units per acre and decline in outdoor demand that do not involve any shifts out of the large single family and typical single-family building types. These scenarios had only minor reductions in water demand. But there is a cluster of scenarios (shown in blue in Figure 4) that show a moderate amount of outdoor water demand decline and a moderate increase in density, which are focused on shifts from mostly large lot single-family building types. A third cluster of scenarios (shown in green) shows a similar change in outdoor water demand but had greater increase in dwelling units per acre, which was focused on shifts out of typical single-family building types. Lastly there is a final group (shown in yellow) which shows the largest decline in outdoor water use and the largest increase in dwelling units per acre, which is focused on shifts of varying degrees from all building types to higher density building types. The lesson is that policy makers need an all-of-the above strategy to incentivizing or otherwise encouraging higher density developments.

Figure 4: New Outdoor Water Demand by Average Dwelling Units Per Acre of New Growth

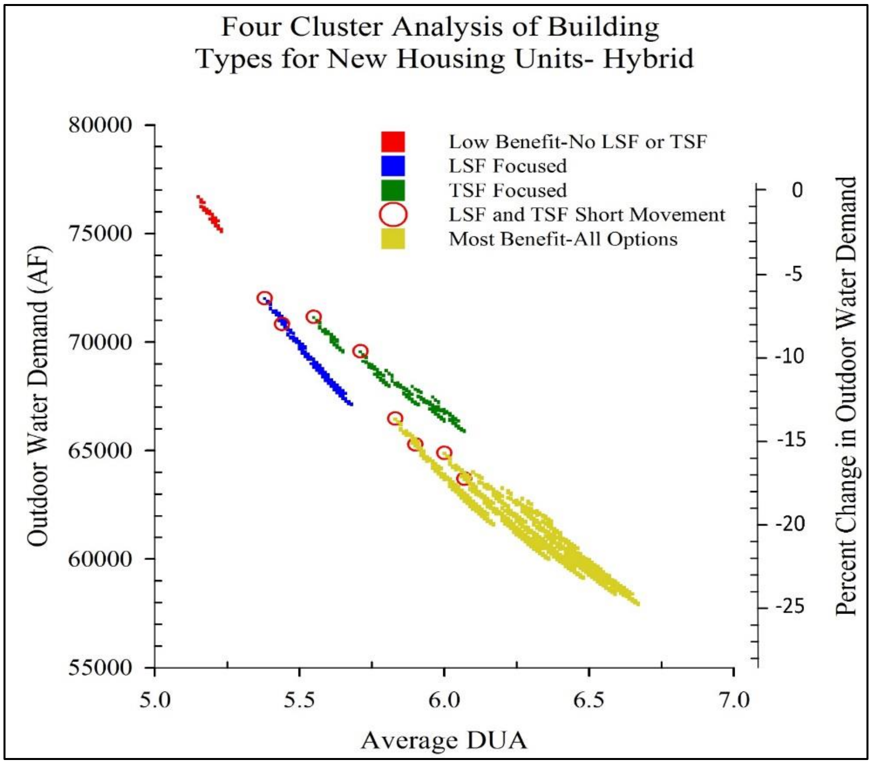


Another factor considered was the "resource cost" of efforts to influence the household choice of residential building types. These resource costs may be political, such as the effort to change zoning and building codes; economic, such as the such as the cost of new infrastructure or costs of educational programs to encourage smaller lots in order to reduce community water needs subsidy of the higher costs of denser housing; or social, such as changes in culture, values or quality of life. Markets and consumer choice change over time in response to changes in a wide variety of socio-economic and behavioral factors. Influencing these trends is not an easy task, as evidenced by the amount and cost of product marketing that is done to influence consumer purchasing. In many communities, changing zoning to higher residential density can be a highly charged political process. Trying to address the economics of a housing market can involve highly expensive efforts to subsidize infrastructure, land and regulatory costs. Thus, efforts to push or accelerate market choices to higher density could require significant "resource" costs.

If we assume that the greater the desired shift in existing market demand the greater the resource cost will be required, then a basic assessment of cost and benefit is possible. In this analysis it was assumed that resource costs increase with the bigger movements toward higher residential density. Figure 5 shows clusters of outdoor water demand resulting from different types of scenarios. The red "low benefit" clusters are scenarios that do not move units out of the large single family or typical single family. The "LSF Focus" and "TSF Focus" clusters show scenarios that only move units out of large single family to other building types or out of typical single family to other building types. The yellow "Most Benefit" clusters have units moving from all building types to all higher density building types. Figure four also identifies low costs transfers where smaller jumps in residential density, requiring lower resource costs, "capture" significant reductions in future water demand (red circles).

Specifically, these are scenarios that only shift households from Large Single Family to Typical Single Family and from Typical Single Family to Small Single Family. This shows that "short moves" from both Large Single Family and Typical Single Family building types can result in 50% to 60% of the full potential from the more complex higher resource scenarios.

Figure 5: New Outdoor Water Demand by Average Dwelling Units Per Acre of New Growth



What happens to overall potential water savings if increases in the efficiency of water use for outdoor landscaping is included? Up to this point in the analysis, a median factor of outdoor water use efficiency (gallons per square foot of pervious surface area) was used. Figure 6 shows the relationship between changing this median efficiency and outdoor water use. This is a linear relationship that results in a 5% reduction in landscape water demand with each 10% increase in gallon per pervious square foot efficiency. The analysis of building types shows that there was a range in this efficiency by building type. Figure 7 shows the impact on outdoor water demand across this range of efficiency. For instance, when using the median impervious surface value for each building type and the lowest efficiency (higher end of the gallons per pervious square foot range) rather than the median efficiency, estimated outdoor water demand is approximately 300% of the median outdoor water use. Conversely, when the highest efficiency (lower end of gallons per pervious square foot range) rather than the median efficiency is applied, estimated outdoor water demand is approximately 15% of the median outdoor water use.

Figure 8 shows scenarios of change in both density and outdoor water efficiency together. This shows that percent changes in outdoor efficiency have a similar impact on demand as percent changes in density. It also shows that the effect of each these factors can be additive though at a diminished level. For example, a 20% increase in density **or** a 20% reduction in Gallons per Square Feet could result in a 10% reduction in total water demand, while a 20% change **in both** could result in a 15% reduction in water demand.

Figure 6: Outdoor Water Demand Based on Gallons Per Square Foot of Pervious Area

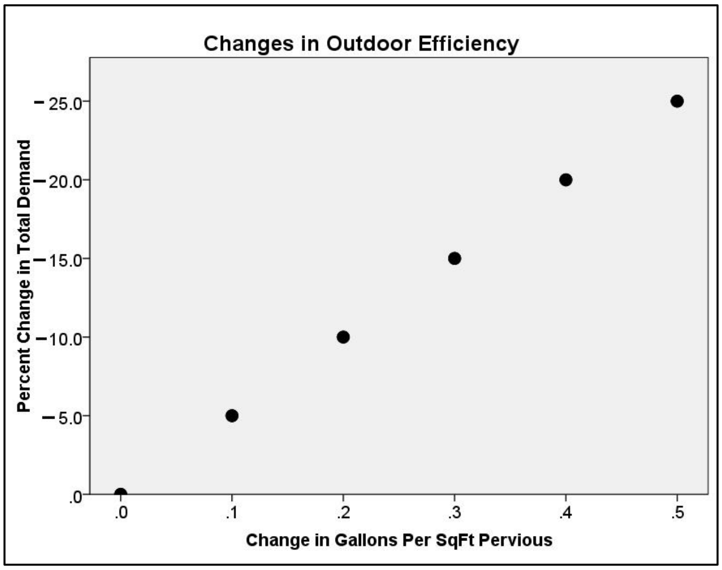


Figure 7: Outdoor Water Demand Based on Gallons Per Square Foot of Pervious Area

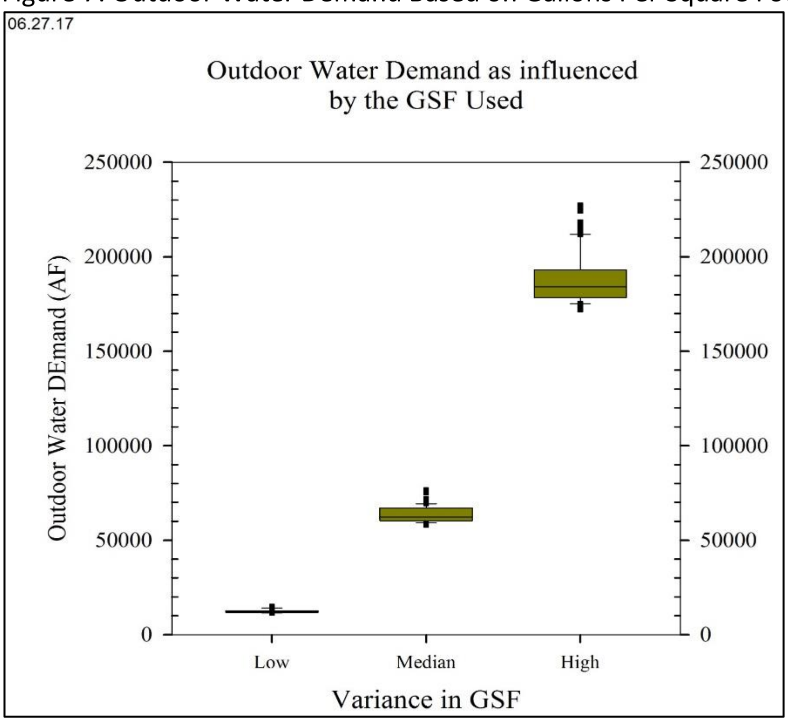
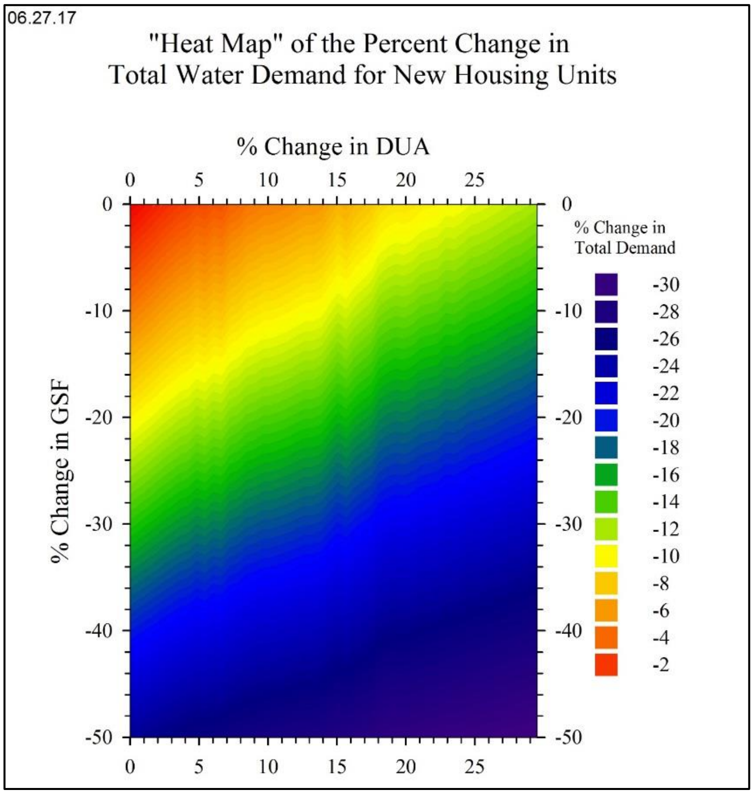


Figure 8: Change in Total Water Demand by Changes in Average Dwelling Units Per Acre (DUA) and Changes in Outdoor Water Use Efficiency (GSF)



Key Strategic Insights

Given the assumptions and uncertainties inherent in an analysis such as this, it is the insights gained through the analysis that are the most important. The key strategic insights coming out of the analysis are as follows:

- "Short moves" from both Large Single Family and Typical Single Family building types, that is moves from these building types to just the next higher density type, can result in 50% to 60% of the full potential from the more complex higher resource scenarios.
- Increasing residential density may decrease the total water demand of new growth in the range of 2 percent to 19 percent, with higher "resource costs" associated with the higher number.
- Lower "resource cost" scenarios that increase density may achieve 3 percent to 8 percent reduction for new development.
- Increasing the efficiency of outdoor water use, (i.e. reducing demand per square foot of pervious area (DPSFP)) may decrease total water demand of new growth in the range of 5 to 25 percent, and be as effective, if not more effective, at reducing future water demand as increasing residential density. These reductions can be achieved through a wide variety of measures, including more efficient irrigation, reduction of turf areas, choosing low water demand plants and using xeriscape techniques, as well as reducing landscaped area per se. This analysis did not attempt to parse out the relative potential water savings of the above outdoor landscaping techniques, but it does point to the significant savings that could be achieved if we change our outdoor landscaping practices to be more water efficient.
- Combining low "resource cost" residential density increases with low "resource cost" reductions of DPSFP may achieve reductions in total residential water demand of new growth by 5 to 15 percent.

- Combining low “high cost” residential density increases with low “high cost” reductions of DPSFP may achieve reductions in total residential water demand of new growth by 15 to 25 percent.
- Household movement from the Large Single Family and Typical Single Family to other building types provides the largest reductions in total water demand of new housing.
- Scenarios of movement that do not include movement out of Large and Typical single-family building types have less water use reductions
- The Medium and High Density multifamily building types have a very large variance in gallons per square foot of pervious area. If future development occurred in this higher density range without adequate outdoor landscaping controls, this could result in increased water demand.

Qualification: DCDC resources to conduct this analysis were limited and these insights were based on a preliminary assessment. Data used for the analysis was based on Denver Water analysis of Denver Water and Aurora Water customers in late 2016. Since then, Denver Water is continuing to refine the information about building types and customer water use. Further refinement of the model, data, and assessment may reveal other insights or change these insights.

This material is based upon work supported by the National Science Foundation under Grant No. SES-1462086, DMUU: DCDC III: Transformational Solutions for Urban Water Sustainability Transitions in the Colorado River Basin.

B. Demand reductions from landscaping/pervious area: Aurora Water Analysis and Case Study – Lyle Whitney, Senior Water Resources Specialist, City of Aurora

The Colorado Water and Growth Dialogue set out to determine how local laws that discourage high water use landscaping can affect water demands by analyzing the implementation of landscape regulation in the City of Aurora. The team at Aurora Water reviewed both landscape limitations and irrigation regulations within city code since 1980. The goal of these laws was to reduce the overall water demand per square foot of landscaped area.

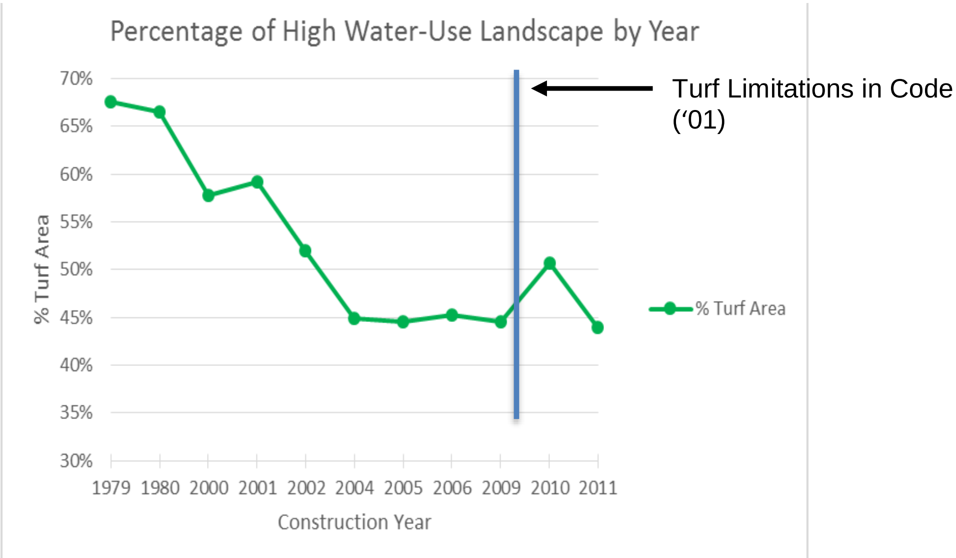
Municipal Code changes occurred in Aurora in the years 1980 through 2007. Archival records are not available to recreate specific timelines, but according to institutional knowledge, a requirement to use outdoor irrigation systems was implemented in the mid-1990s. This change was put in place primarily to promote healthier looking landscapes. In the 2002 landscape code moved away from requiring a certain percentage of turf to capping the amount of turf allowed in residential landscapes. Finally, in 2004, code was changed again to address drought concerns and further promote water-wise landscaping practices. Additional adjustments have been made over time. Customer cohorts were selected to represent homes built at times corresponding with changes in the landscape code between 1980 and 2007. The team evaluated customer cohorts in the following years:

- 1979-1980
- 2001-2002
- 2004-2006
- 2009-2011

Statistically significant samples (150 – 175 per year) of single family detached lots were mapped to identify pervious areas within each property and distinguish between high water use landscape (turf grass, 17.5 gallons/sf) and low water-use landscape (remainder - shrubs, perennials, xeriscape, etc., 9 gallons/sf). Additionally, each cohort’s mean water use per square foot of landscaped area for 2013, 2014, 2015 and 2016 were then compared.

As the graph below shows (Figure 9), there is a clear correlation between age of home and the percent of landscape that is turf area. This reduction in cool season turf is largely attributable to turf limitation code enacted in 2001.

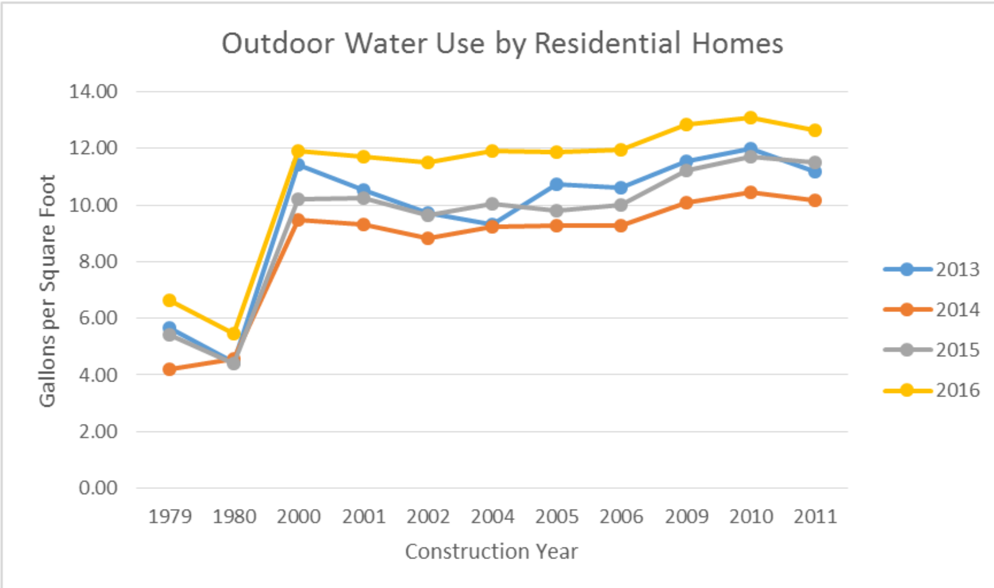
Figure 9: Average Percentage of High Water-Use Turf Grass in Single-Family Lots Over Time.



While Figure 9 shows that the landscape code was effective at reducing the average proportion of lot size that is turf, the purpose of this analysis was to explore the concurrent impact to irrigation water demand. The graph below (Figure 10) shows that while the amount of high water use turf grass decreased with newer single-family homes, the mean water use per square foot actually jumped up significantly between the 1979-1980 and 2000-2002 cohorts. The water use per square foot did remain relatively constant from the 2000-2002 cohort through the 2009-2011 cohort. Cohorts were compared in each year rather than across years negating the need to normalize for weather. Since the data was not normalized for weather, this accounts for the differences between water years 2013 through 2016.

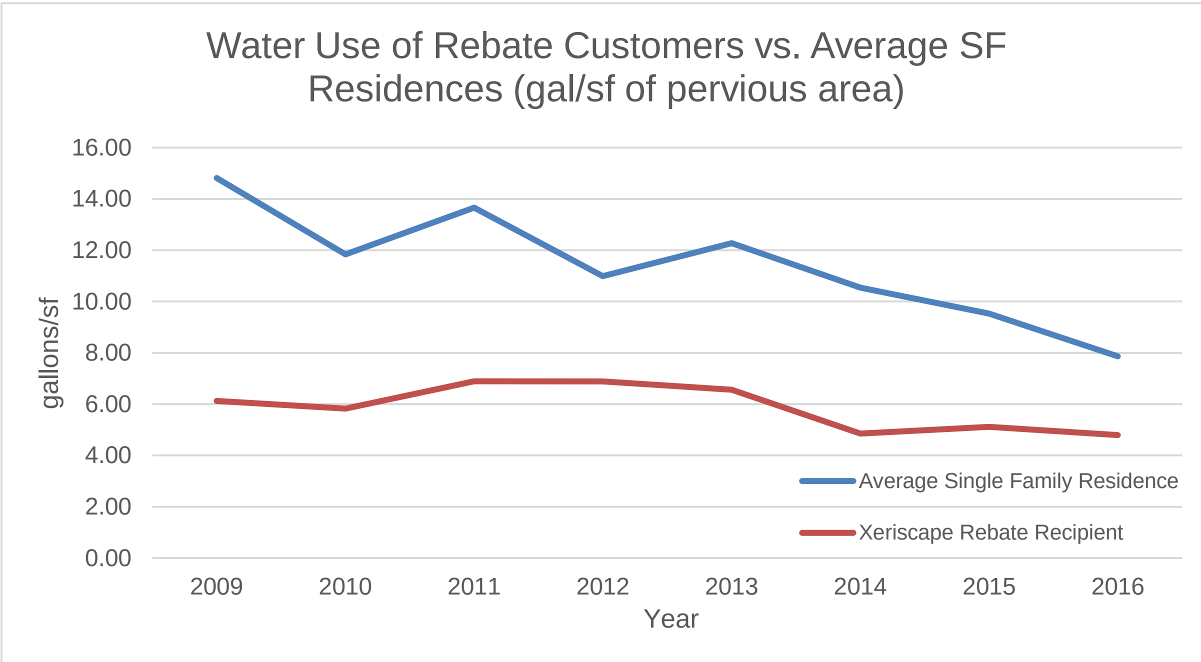
The significant difference between the 1979-1980 cohort and the others led the team to look at possible other factors that may be influencing water consumption. Two significant possible theories came to the surface almost immediately. Upon further research, it was discovered that between 1980 and 2000 (more than likely in the mid-90’s) the city instituted an automatic irrigation system requirement for all new builds. Research has shown that homes without irrigation systems tend to use less water. Homeowners often don’t have the time or the patience to water as much as those with systems in place. These “hose draggers” only have so much time in the day and while a system can efficiently put water down over an hour or more, those who water by hand do it for much shorter time periods. The fact that the remaining cohorts show consistent water use also lends support to the idea that irrigation systems play a significant role in water consumption as well.

Figure 10: Outdoor Water Use by Residential Homes.



A second theory materialized as well. This theory addresses the idea that education also plays a significant role in water use. For example, homeowners often move into a home with a pre-programmed automatic irrigation system and often don't understand the proper use of the system nor the correct amount of water to put down on irrigated areas. This often results in the system remaining at establishment programming, often leading to overwatering. To test this, the team evaluated Aurora's xeriscape rebate program. The xeriscape program is a rebate program that pays customers to convert their high water-use turf grass areas to water-wise plant materials that use much less water per square foot. The rebate is designed to incentivize customers to create mini-demonstration gardens in their yards, which would help educate the public and promote the use of water-wise landscapes. Throughout the program, customers must attend classes to learn how to maintain their new landscapes as well as understand the appropriate use of water within these landscapes. This program was evaluated by looking at all 568 participants (2007 – 2015) and their water use per square foot of pervious area over time (2009 – 2016). Water use was evaluated 2 years after initial program participation to reflect changed landscapes and behaviors, and the data was normalized for weather so that wet years didn't look artificially low and dry years artificially high. If the theory is wrong, then the rebate program should show little water use savings. However, as the graph below (Figure 11) shows, the rebate has seen great success over time.

Figure 11: Comparison of outdoor water use (gal/sf of pervious area) between xeriscape rebate



While Figure 11 suggests that code changes helped average customer water use to drop over time, the graph shows that rebate recipients achieved much lower consumption than residents simply adhering to code. The most significant difference between the code changes and the xeriscape program is the amount of education that comes with each. In the code changes, our primary points of contact tend to be the builders and developers and little to no education or outreach is done or passed onto homeowners. When customers participate in the xeriscape rebate program, they are required to attend classes and do homework to better understand the full benefits and proper maintenance of low water use landscapes. This, more than anything, can result in water savings. It should be noted that those customers who participate in the program are motivated to save water compared to the average new homeowner.

The results of the xeriscape rebate program suggest that with greater education provided by the water utility to new homeowners, other water conservation efforts will produce greater savings. While increasing rates may also incentivize customers to save water and participate in programs like the xeriscape rebate program, Figure 10 shows that rates may not always reduce water consumption in irrigated areas.

Key Strategic Insights

- Reducing the amount of pervious landscaped area will lower overall outdoor water use, with all else held constant.
- Landscaping codes should be complemented by an education program for residents to ensure the full potential of water-conserving landscape design.
- When code is put in place, it would be in a city's best interest to develop an outreach and education program specifically focusing on new home owners as well as both developers and builders.

C. Residential Land Use and Water Demand Tool – Mitch Horrie, Senior Planner, Denver Water

As the Colorado Water and Growth Dialogue participants began to explore the implications of how the Front Range may grow, it became clear that local communities have the best sense of their projected growth as well as the preferred housing options for communities. In recognizing this, the Dialogue worked to develop the Residential Land Use and Water Demand Tool to allow planners to develop their own scenarios of growth and compare the water use implications of the scenarios side-by-side. The Tool underwent beta testing with a group of land and water planners and efforts were made to incorporate the feedback of those professionals.

The tool offers two options for comparing residential water demands. First, users can input a population growth estimate and then develop scenarios of how that population will be distributed across the seven different housing building types that underlie the analysis (see part A of the Quantitative Results section of this report for additional information on the seven building types). Variables, such as people per household, households per acre, and outdoor and indoor water consumption levels, can be manipulated to understand and bookend what water demand may look like depending on the population distribution by housing building type. Second, users can input a land area (i.e., acres) for residential development or re-development. The user can then create scenarios of the number of dwelling units on that area, persons per household, and outdoor and indoor water consumption levels to compare estimated annual water use. The tool allows for comparison of the water demands confined to the parcels of residential development. It does not attempt to estimate the demands of any other commercial, industrial, institutional or recreational activity.

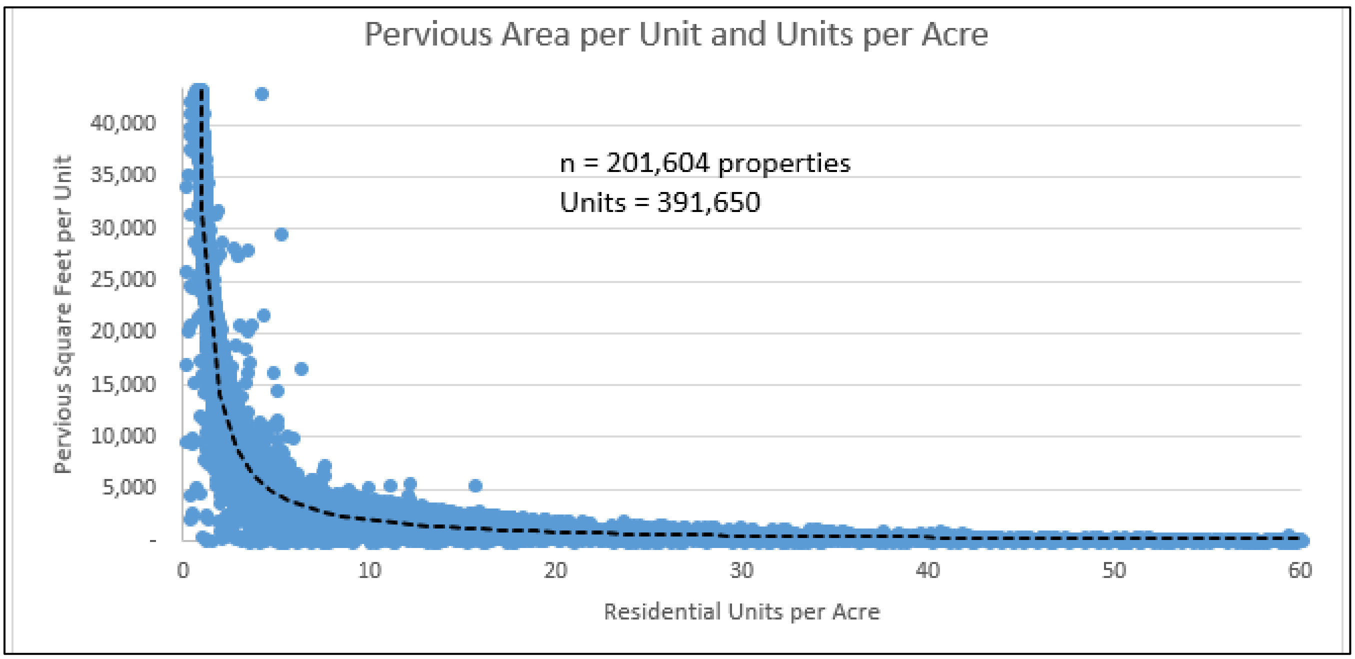
Not all land use planners are water experts and not all water resources planners are land use experts. The tool allows the user to explore a range of alternative scenarios with the ability to enter continuous values for their assumptions. The tool offers guidance in setting assumptions but it is not prescriptive. The user can customize scenarios to the characteristics of their area of interest. Consequently, users of the tool are encouraged to communicate with colleagues in the water and land use fields to refine assumptions and develop scenarios that provide useful comparisons of water demand in their communities.

As mentioned above, the tool provides planners with guidance to formulate assumptions for indoor and outdoor water consumption rates based on anticipated indoor fixture efficiencies and predominant landscape material. Guidance for indoor water consumption assumptions are based on evaluation of state and federal indoor plumbing code requirements for indoor fixtures, empirical evidence of current residential indoor use rates and research on currently available indoor fixture technology. Guidance for outdoor water consumption rates are based on plant requirements for common landscape material in Colorado as well as different landscape configurations. It should be noted that rates of outdoor water use are influenced by many variables including weather, landscape type and landscape configuration. Moreover, the price of water and consumer tastes, preferences and behavior also play a significant role in outdoor water consumption.

A primary behind-the-scenes feature of the tool is the empirically-derived and non-linear relationship between residential density (i.e., units per acre) and pervious area per residential unit. The relationship among these two variables provides insight into the amount of pervious or irrigable area that may be present at different situations of residential density. The relationship was derived from a dataset of more than 200,000 residential properties (nearly 400,000 residential units) in the Denver metro area. The analysis relied upon data obtained from the Denver Regional Council of Governments, as well as modified county assessor residential parcel boundaries and independently verified counts of residential units generated by Denver Water staff. The analysis showed that about 90 percent of the variability in a residential parcel's pervious area is explained by the density of the parcel. Figure 12 shows a scatterplot whereby individual parcel unit per acre is on the x-axis and the pervious area per residential units is on the y-axis. As the chart shows, there is a steep decline in pervious area per unit as residential density increases. As residential densities approach around 30 or 40 units per acre there is very little change in the amount of pervious area per unit.

It should be noted that modeling of the relationship between residential density and pervious area per unit is different for this tool compared to the analysis presented in Part A of this section. The analysis in Part A uses a discrete approach to modeling product types whereby it is assumed that all units within the product type category have identical pervious area per unit. That is to say, each unit possesses the average pervious area per unit derived from a sample of residential units in the Denver Water and Aurora Water service areas. Therefore, as movement of households from one product type to another is modeled, it assumes that a household that looks like the average of one product type shifts to look like the average of the destination product type with respect to the pervious area per unit. This approach is useful in evaluating relative changes in water use with changes in building form. The tool discussed in this section, on the other hand, allows for users to evaluate a continuous range of density that is driven by both user-defined parameters and the empirically-derived non-linear relationship between residential density and pervious area per residential unit.

Figure 12: A Steep Decline in Pervious Area per Unit as Residential Density Increases.



The tool can be accessed at: https://keystone.org/waterandgrowthdialogue

Qualitative results

A. Recommended Strategic Levers

Members of the Colorado Water and Growth Dialogue's working group met during the summer of 2016 to participate in an Exploratory Scenario Planning process. Through this process, participants discussed the future uncertainties that have the greatest ability to impact the region and the planning environment. In progressive stages, the group designed a series of future scenarios or narratives of how the future could unfold, discussed the implications of these, and prioritized a set of near-term strategies that would apply equally well given the alternate outcomes of future uncertainties.

To orient and focus discussion, the group set out to answer the following focal question:

How can changes in urban form and landscaping practices for new growth and redevelopment assist in meeting future urban water demand along the Colorado Front Range?

The group decided that the future uncertainties that have the greatest impact on the planning environment regarding the focal question are future housing preferences, the economy, and innovations in transportation technology such as autonomous vehicles, which may either reinforce sprawling land use patterns or help in concentrating residential development along transit corridors. More detailed information on the process can be found on our website.

The following strategies are the result of the Exploratory Scenario Planning process.

1. **Encourage the consideration of higher residential densities as a means to reduce water demand**
    - More compact, higher density development has been shown to lead to greater water efficiency, (see quantitative results of density analysis beginning on page 9) but the water efficiency benefits of increased residential development density appears to diminish between 30-40 units per acre.
    - Water efficiency is just one more reason, in addition to housing affordability, transportation efficiency (and its associated reduction in greenhouse gas emissions), and lowering infrastructure costs, for communities to consider this form of development as they plan for the future.
    - It's important to note that certain forms of density also can have negative consequences on livability. Removing all plant materials can negatively impact air and water quality, exacerbate heat island effect, and affect aesthetics and general livability. Replacing pervious surfaces with impervious surfaces can complicate storm water drainage and retention leading to increased flooding during major storm events.
    - The optimal development density for stewarding water resources is regionally and climate specific and will depend on the different planning circumstances and character of each community. This can only be determined by local planners, policy makers, community leaders and the citizens that elect them. Each community should review the data and analyses found in this report and factor those findings into the planning process and decisions being made with regard to growth and locally specific water needs. Communities can use the Residential Land Use and Water Demand Tool that the Dialogue has developed. After entering an assumption of population growth, distributing it through seven common housing building types, and setting a value for landscaping efficiency, the tool estimates how much water the growing population could use.
    - Further studies into building and systems design are needed and would provide additional data for communities to consider when optimizing water efficiency through land use and landscaping

practices. The positive benefits of vegetation and pervious surfaces should also be considered by planners and low-water using plants chosen where possible.

- Further study is needed regarding the benefits of better integrating landscaping into developments with the potential for green infrastructure that enhances water quality and uses surface drainage to enhance environmental quality.

2. Adopt landscaping policies to lower future water demand from population growth

- Limiting the amount of pervious landscaped area for any given parcel will lower total water use given all else remaining the same.
- Setting limitations in local landscaping laws to create greater water savings should be combined with community outreach and education to achieve desired results.
- Increasing the efficiency of outdoor water use, (i.e. reducing demand per square foot of pervious area (DPSFP) may decrease total water demand of new growth in the range of 5 to 25 percent, and be as effective, if not more effective, at reducing future water demand as increasing residential density. These reductions can be achieved through a wide variety of measures, including more efficient irrigation, reduction of turf areas, choosing low water demand plants and using xeriscape techniques, as well as reducing landscaped area per se. This analysis did not attempt to parse out the relative potential water savings of the above outdoor landscaping techniques, but it does point to the significant savings that could be achieved if we change our outdoor landscaping practices to be more water efficient.

3. Incorporate aspects of water planning into long range planning

- Traditionally, land use planners and water resource managers have operated in separate worlds. While land use planners help determine zoning and growth patterns around how much growth of each type kind will take place in their communities, water resource managers ensure there is an adequate water supply available to support that growth. Little to no discussion focuses on integrating land use plans with water resources, especially with an eye toward increasing water efficiency through land use planning or landscaping practices. Increasing population growth and water supply uncertainty puts pressure on our arid region’s ability to do business as usual, necessitating that land and water planners should communicate at key junctures of their respective planning processes to ensure understanding and to integrate aspects of the plans where appropriate.
- One opportunity to better integrate land use planning and water resource management is through comprehensive planning efforts. A comprehensive plan considers projected land use and its implications for a wide variety of functions, like transportation, parks and open space, housing, economic development, infrastructure needs, and the character of development. This is a particularly useful point for integrating land use planning and water resource management. A wide variety of issues should be addressed in this process. For instance: what are the water supply implications of projected land use patterns? What policies should inform the development of the community as to its water use characteristics? What is the master plan for supplying water for development that is likely to occur over the planning period?
- Land use planners often define a community’s long-range vision for future land use and development character. Some of these visioning exercises take the form of clarifying community values and choosing from among a series of desirable future land use plans. Water demand characteristics and community attitudes toward water conservation should be evaluated and made part of the visioning process.

- Exploratory Scenario Planning or other approaches can also be employed to develop strategies to deal with future uncertainties. This approach also identifies important future inflection or trigger points where trends may be more clearly discerned, allowing some strategies to be emphasized over others.
- As land planning and development models are developed, they should be able to integrate water use data, and vice versa; as water demand models are developed, they should be able to integrate land planning and development data, incorporating land use considerations into water plans.
- Overall, the two disciplines need better coordination and communication.

4. Share success stories and case studies

- People learn in a variety of ways. Compelling, honest, accurate and engaging stories can be a significant source of new knowledge. Compelling individuals to action requires both awareness and convenient access to resources to expedite adoption of best practices.
- Colorado communities collectively hold a wide range of experiences regarding land and water use, water efficiency, cost savings and environmental implications. These stories need to be developed and shared with elected officials, water managers, land use planners, business owners, developers, residents, students and visitors in engaging ways that drive thought and empower action.
- Collecting, monitoring, sharing and broadcasting data provides an opportunity to increase the awareness of practices that reduce water demand and foster other communities to adopt practices and strategies to integrate land and water planning. Organizations that are running land and water planning trainings should utilize case studies to show planners and decision-makers how to effectively integrate the disciplines and the potential demand reductions that could be achieved. Data such as those found in this report should be utilized to encourage increased planning integration.

5. Develop, track, and refine new metrics that link water use to land use

- Only what is measured can be managed. Land use sensitive water metrics need to be developed that would aid land use planners in understanding and achieving greater water efficiency.
- For instance, a metric of water use for different land uses and business types beyond residential, (commercial, mixed use, recreational, etc.) would enable communities to understand how their development and growth decisions fit within the constraints of their water system. As was done in this project, using real customer data, and the development types typical of a particular jurisdiction, can give us the tools we need to understand the water implications of different land use choices.
- Another possible metric to share between land and water planners might include the costs of new increments of supply and the avoided costs if new development uses water more efficiently.

6. Encourage water smart development through a suite of new local development standards and incentives

- An alternative to regulating all aspects of water smart development is to provide incentives for more compact development or more efficient landscaping. Water and land use planners should work together to develop and provide incentives, and/or create a mix of regulations and incentives, that would afford communities more flexibility in choosing options to increase water efficiency.
- Incentives for building cluster developments, increasing density, increasing lot coverage, reducing building setbacks and adopting and enforcing demand-based tap fees can entice developers to build water smart projects. Examples include density bonuses, reduced tap fees and an expedited permit process.
- Adopting zoning and overlay districts to encourage in-fill, increased density, and reductions in irrigated landscaping will provide opportunities for developers and residents to benefit from

reduced demand for increasingly expensive water supplies. Maintaining a balance of personal landscaping, community parks and open space is essential in these densifying neighborhoods to ensure sustainability as well as desirability.
- Communities will also benefit from adopting landscaping and enforcement standards and provide education to developers and homeowners. See landscaping analyses on page 19.
- Communities should regularly check to ensure their codes and standards reflect evolving best practices and water conservation technology.

7. **Develop water smart design guidelines and standards for government owned buildings, public spaces and rights of way**
    - An important way for communities to encourage water efficiency is to lead by example. Water smart buildings, landscaping of parks and other public spaces, and efficient watering of public spaces can demonstrate best practices for residents.
    - Given the significant water invested in total outdoor use, laws or policies requiring water conserving landscaping in new development can be an effective tool at lessening water use.
    - While many local jurisdictions have already developed water conserving landscaping standards for new development, many others do not have the resources to enforce new laws. The state of Colorado can help by setting model policies and defining best practices and communities can adopt and enforce these policies.
    - A state driven effort to establish and disseminate model landscaping ordinances in Colorado would encourage the development and adoption of local community-driven landscaping codes that best manage water use in the landscaped areas and ensures residents enjoy the quality to of life that they expect.

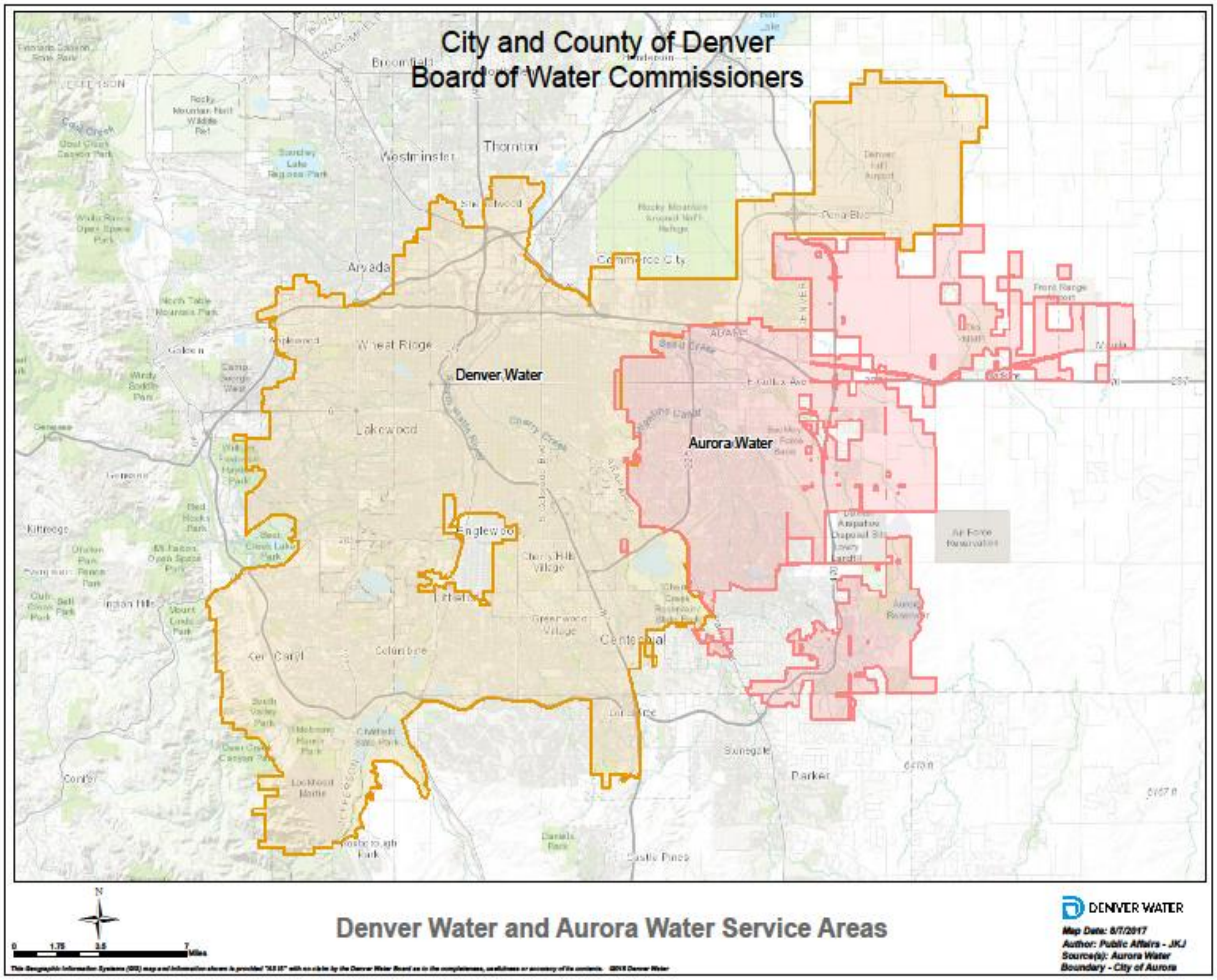
8. **Incorporate a One Water approach into planning**
    - While not a central focus of the project, the strategies that come from looking at water as a single resource, without the barriers that we created within the water world, may generate new opportunities that allow for the more efficient use of water. The typical boundaries between water supply, water quality, storm water, and flood water may miss some ways to improve efficiency and improve environmental quality, such as water reuse strategies and enhancing water quality through the use of landscaping.
    - The Water Environment and Reuse Foundation (WE&RF) uses the following definition for One Water: [an] approach that considers the urban water cycle as a single integrated system, in which all urban water flows are recognized as potential resources, and the interconnectedness of water supply, groundwater, stormwater and wastewater is optimized, and their combined impact on flooding, water quality, wetlands, watercourses, estuaries and coastal waters is recognized." (Howe and Mukheibir 2015, 3). Traditionally, even water sources within the water management community have been siloed.
    - Integrating the One Water concept within land use planning provides a much more integrated approach and allows for the inherent interconnectedness of all water sources to be managed together across varied land use patterns.
    - While it may appear straightforward on paper, a One Water approach will require a great deal of intra-utility and inter-utility coordination as well as institutional and leadership support. While incorporating municipal water supply, groundwater, stormwater and wastewater into an integrated approach can be difficult, this One Water integration will only be feasible if integrated early on during the land use planning process.

Conclusion

The information contained in this document and on the Dialogue's website, is meant as a resource for land and water planners, developers, policy makers and others interested in the topic. The report and the information contained was collaboratively developed to help local governments better understand the benefits of integrating land and water planning. However, there are no silver bullets found within the analyses that change the underlying assumptions that water planners traditionally hold true regarding the need for a diverse set of water supply and conservation measures to meet current and future water demands. Conversely, the assumptions that land planners hold regarding the supply and demand intrinsic to the housing market are also not being challenged.

The results of the Dialogue point to the need for better communication between land and water planners and increased access to, and development of, knowledge and data. It is the Dialogue participants' hope that better integration of land and water planning will become another commonly used tool for communities to reduce their water supply gap by lowering water demand as the region plans for significant population growth over the next 22 years and beyond.

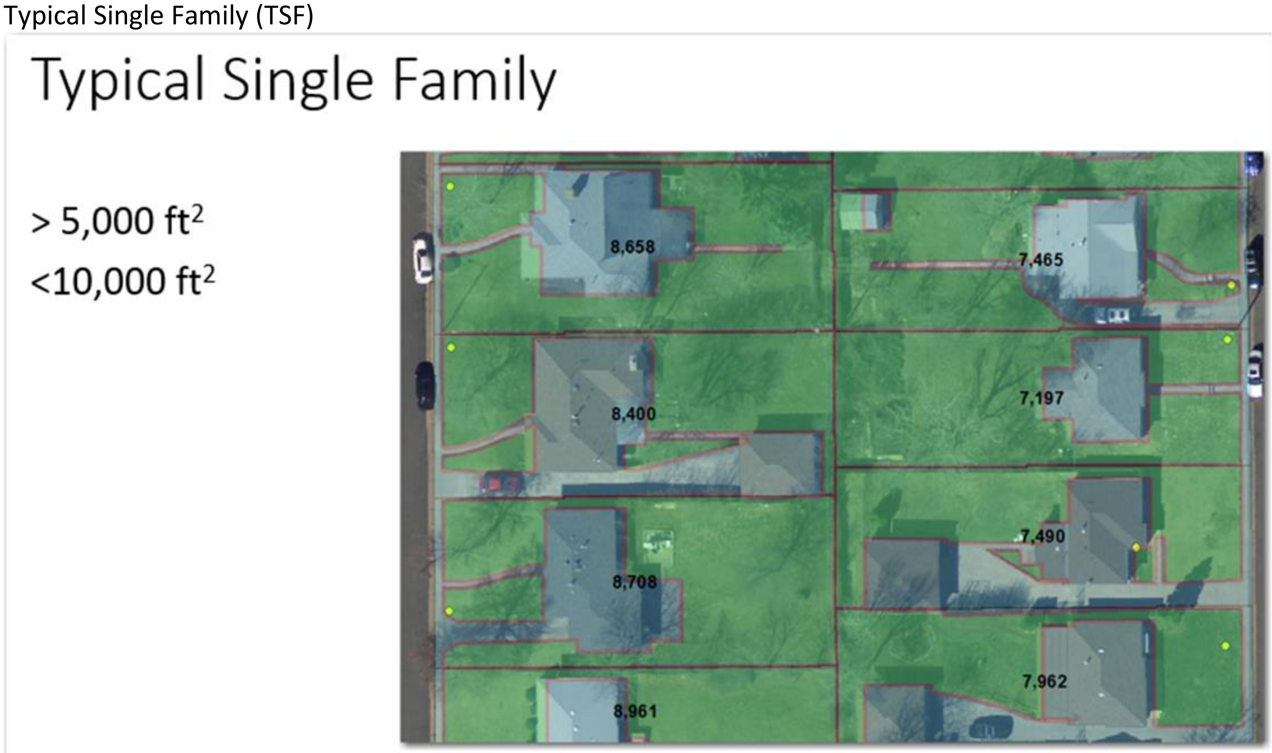
Appendix A: Map of Denver Water and Aurora Water Service Areas; from which water use and housing data were gathered



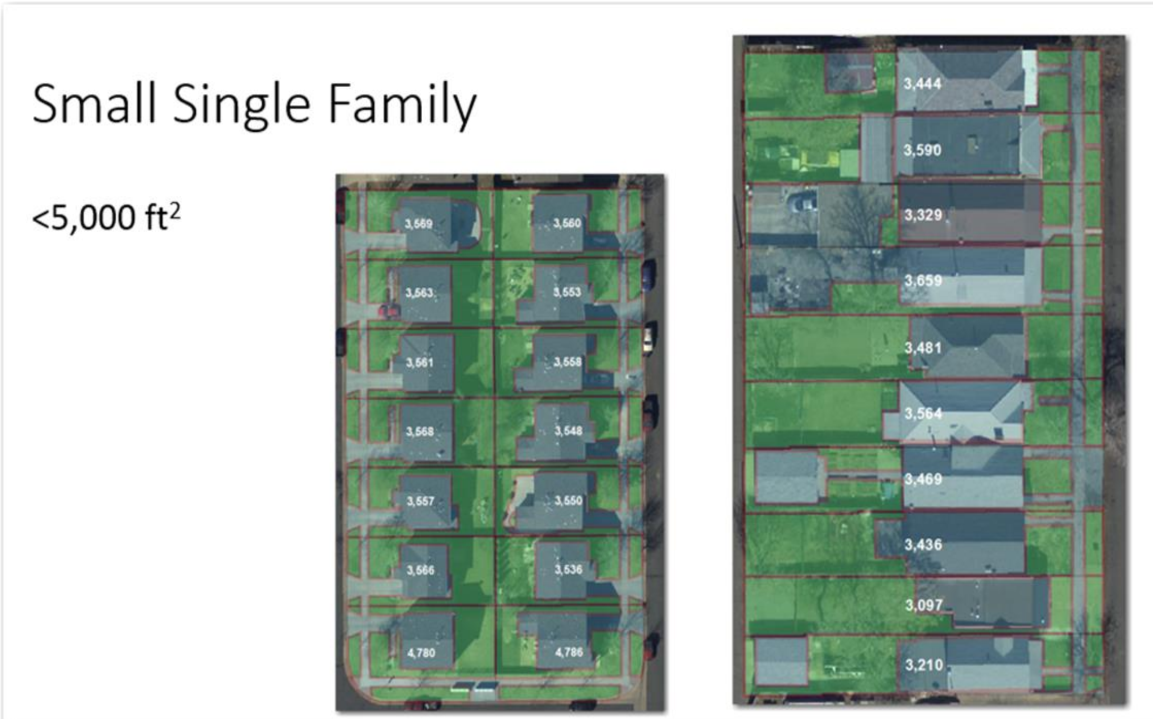
Appendix B – Images of housing building type examples

Large Single Family (LSF)

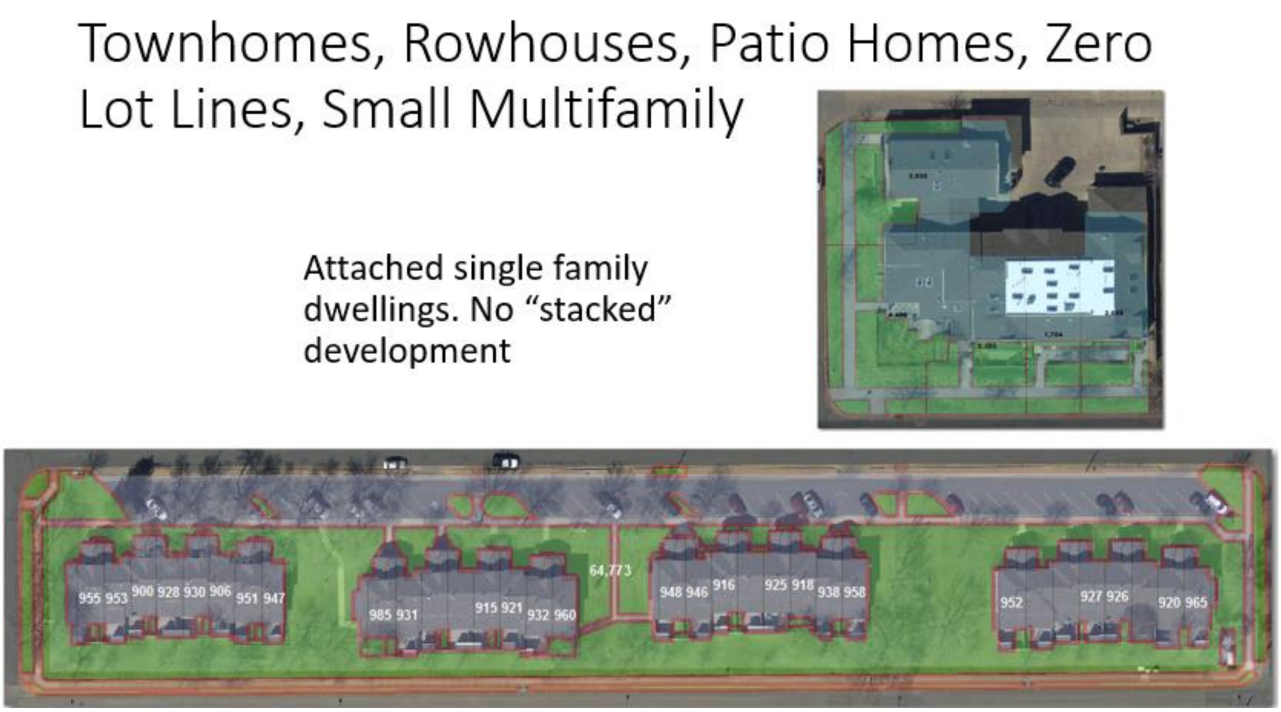
Typical Single Family (TSF)



Small Single Family (SSF)



Small Multi Family (SMF)



Walk-up Multi Family (WMF)

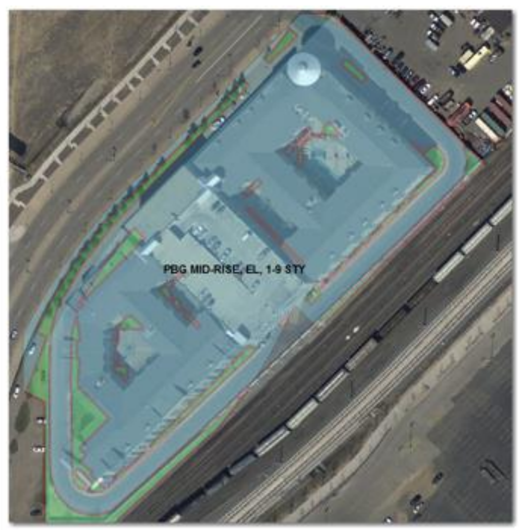
Walkup Apartment

Mid-Range Multi Family (MMF)

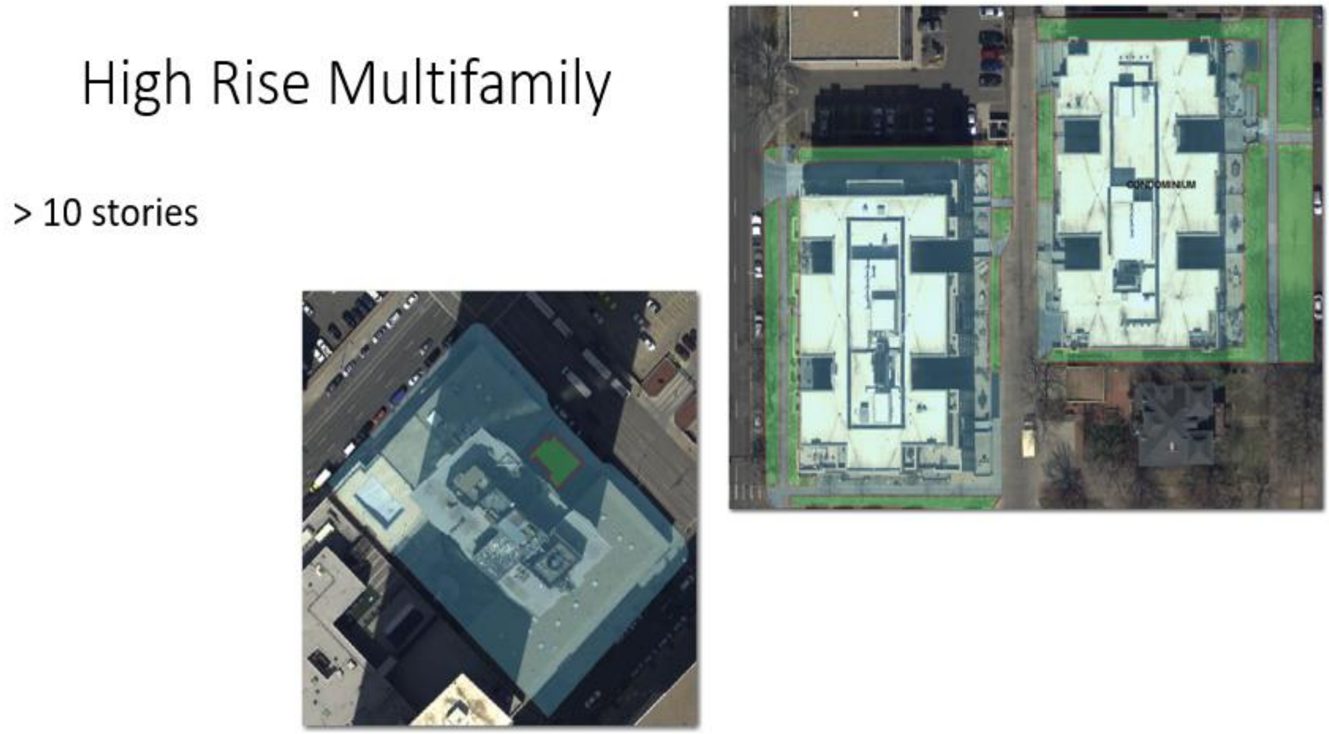
Mid-Rise Multifamily

<10 stories

Not walkup-apartments



High-Rise Multi Family (HMF)



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