

Water Supply Master Plan

Water Supply Master Plan

City of Steamboat Springs and Mount Werner Water & Sanitation District



August 16, 2019

AG File No. 18-116

Prepared for:



Mount
Werner
Water District

Prepared by:



*Water Resource Advisors for the West
In Association with:*



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EXECUTIVE SUMMARY

The Steamboat Springs City Council and the Mount Werner Water District have set a goal to “*identify and implement strategies to promote water supply resiliency by preparing for growth, planning for drought & wildfire, planning for a Colorado River Compact Call, planning for water conservation, and developing a redundant supply.*” This Water Supply Master Plan (WSMP) update was completed to help meet these goals.

The City and the District collectively serve a resident population of over 12,000 people with a visitor population that can exceed 20,000 people. The majority of the community’s treated water is served from the Fish Creek Filtration Plant with that supply being supplemented during the summer months with the Yampa Wells Treatment Plant for a total consumption of approximately 3,000 acre-feet per year. Although the City and the District function as separate districts, their collection and distribution systems are interconnected and they jointly own and/or operate two reservoirs (Fish Creek & Long Lake Reservoirs), two treatment plants and a wastewater plant. Therefore, the City and the District believe that a comprehensive Water Supply Master Plan that assesses the entire city’s needs is most beneficial to its customers.

This WSMP update was completed with a scenario-planning approach to address uncertainties that could impact Steamboat Springs’ water supply. This approach is similar to the approach described in the 2015 Colorado Water Plan. Vulnerabilities to the community’s water supply include, but are not limited to, population growth (infill and West Steamboat Area expansion), extended drought and climate change, wildland fire in the Fish Creek Basin, and the Colorado River Compact.

This WSMP update assessed the availability of current and future water supplies to meet future treated municipal water demands for the City of Steamboat Springs and Mount Werner Water Districts. Demands and supplies were analyzed separately for the City and District, which provides a conservative analysis of the ability of each of these entities to meet customers’ treated water demands. There may be a possibility of meeting greater total water demand if the City and District cooperatively manage their individual water supplies. The results of this study indicate that the City and District currently have adequate supplies to meet future demands without external stress being placed on their water supplies. However, stressors such as a wildfire in the watershed and a Colorado River Compact call could result in substantial shortages and should be addressed in order to minimize the risks of shortages. These shortages generally would occur at future demand levels, however, shortages at current demand would occur under the Fish Creek Basin wildfire scenario.

WATER DEMANDS

The City and District’s treated water demands have generally decreased since the early 2000s, even though the population increased during the same period. This decrease in water demand is attributable to increasing conservation and efficiency in water use. Current (2017) combined City and District demands range from a low of approximately 1.6 MGD average daily demand (2 MGD peak day demand) in the late fall months to a high of approximately 4.4 MGD average daily demand (5 MGD peak day demand) in the summer months. Current (2017) annual demand is approximately 1,270 acre-feet per year for the City and about 1,470 acre-feet per year for the District.

There are several commonly applied methods for assessing water demands. A traditional method of calculating water use in gallons per capita per day is based on dividing daily water use by the population of a city such as Steamboat Springs. A second method of assessing water demands is through the use of

Equivalent Residential Units (EQR), which are based on water use per a standardized unit of development. For example, an EQR is generally considered to have a water demand equivalent to a single-family home, which generally requires approximately 280 gallons of water per day. The use of EQRs in assessing water demands is commonly applied to communities with similar influence by visitors, and provides a means for assessing water demands not associated with permanent population. The traditional method of gallons per capita per day, and the alternative method of EQR water demands were both used in this study.

This historical demand analysis demonstrates that treated water demands have been decreasing for both the City and District. While it is not possible to accurately decipher how much conservation and efficient water use have contributed to this reduction, data indicates that passive indoor savings played a significant role in the long-term reduction of indoor demands. Increases in water rates and water conservation also play a role in reducing EQR unit demand, and water restrictions have historically been effective in lowering outdoor water demands during drought. Demand reductions per EQR may continue as indoor savings continue to be passively achieved and efforts are made to improve outdoor and supply-side distribution system efficiencies. Going forward, the rate of water savings achieved through passive indoor will likely be less than experienced from 2000 to 2017 since a considerable number of properties serviced by the City and District now have relatively efficient water fixtures and appliances. However, additional water savings may also be achieved by efficiency improvements to the City and District's water distribution systems and incorporating water conservation and efficiency considerations into land use planning.

Demand projections were based on current unit water demands and projected population. This methodology assumes the current mix of water use by visitors and residents will be similar in the future. This approach is common amongst other similar communities with a significant influence from visitors that are not permanent residents, such as the Colorado mountain towns of Aspen and Breckenridge. Population projections developed for this Water Supply Master Plan indicate that the current population of approximately 12,700 was projected to increase to between 28,700 and 34,500 residents at the end of the study period in 2070. This envelope of population projections was used to develop a range of treated water demands.

Future water demands were projected using three methods based on unit water demands¹. The first two methods are based on Equivalent Residential Units (EQRs), a common way of normalizing water use to account for a significant transient population.

Demand projections were completed based on the two EQR unit demand methods described above, and also using a more traditional gallons per capita per day (gpcd). The traditional gpcd approach is typically applied for communities with less influence from tourism, but is a valid comparison point, nonetheless. The resulting demand envelope indicated a range of future (2070) demand from a minimum of approximately 5,400 acre-feet per year, to a maximum of approximately 9,200 acre-feet (Figure 1).

¹ EQR A method based on population scaled EQRs. EQR B method assumes EQRs will continue to grow at historical rates. Gallons per capita per day (GPCD) method based on total use divided by permanent population, and multiplying that unit demand by projected population. Three population growth assumptions (low, medium, high) were applied to the EQR A and GPCD methods. Only one EQR B scenario was completed, because it is based on past growth rates and not on estimated range of future growth rates.

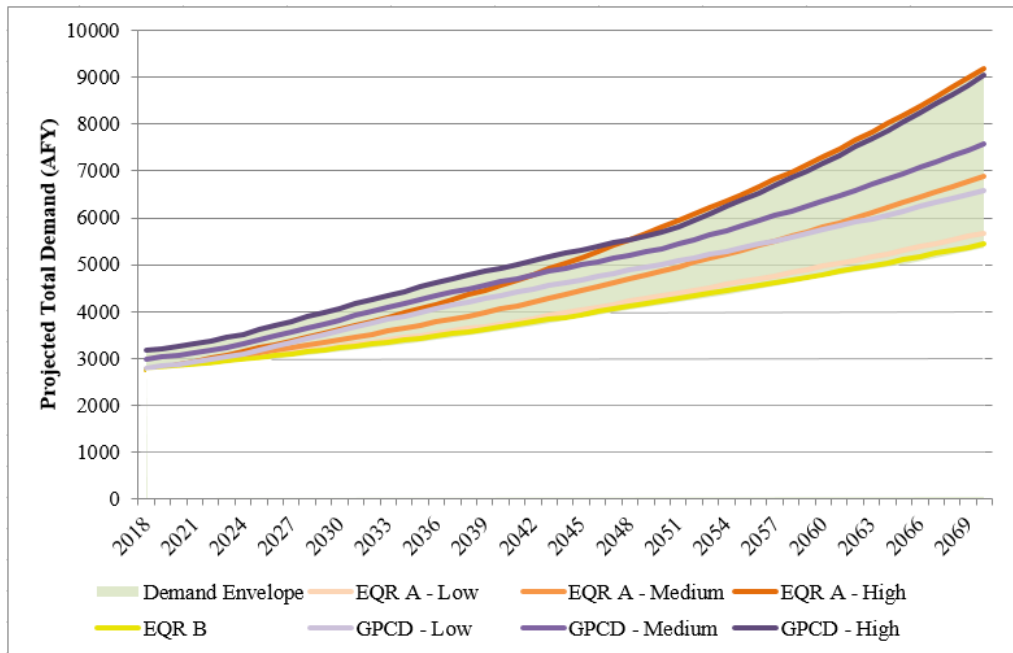


FIGURE 1. DEMAND PROJECTION ENVELOPE²

EXISTING WATER SUPPLIES

The primary water supplies for the City and District are yields from the Fish Creek Basin and from the Yampa Wellfields. A range of yields was estimated for these supplies using the Raw Water Supply Model developed for this study (Table 1).

TABLE 1. POTENTIAL YIELD FOR PRIMARY WATER SUPPLIES

Supply	Yield (ac-ft per year)	
	Minimum	Maximum
Fish Creek Basin	7,800	10,500
Yampa Wellfield	2,017	3,922

Note that Fish Creek Basin yield range is based on a range of hydrologic conditions at the maximum water right and WTP capacity. Yampa wellfield yield range is based on the range of current wellfield capacity (1.8 MGD) and future expanded wellfield capacity of 3.5 MGD.

The minimum annual yield from the two main sources of water supply total approximately 9,800 acre-feet per year, which is greater than the demand envelope maximum demand of approximately 9,200 acre-feet per year. This generally indicates that the City and District water supplies are adequate to meet future demands, absent any abnormal stress on the water supplies (Figure 2). The annual total demand is an

² EQR - A method based on population scaled EQRs. EQR B method assumes EQRs will continue to grow at historical rates. Gallons per capita per day (GPCD) method based on total use divided by permanent population, and multiplying that unit demand by projected population.

important metric for evaluating adequacy of supplies, and seasonal variations in demand are also discussed in this report.

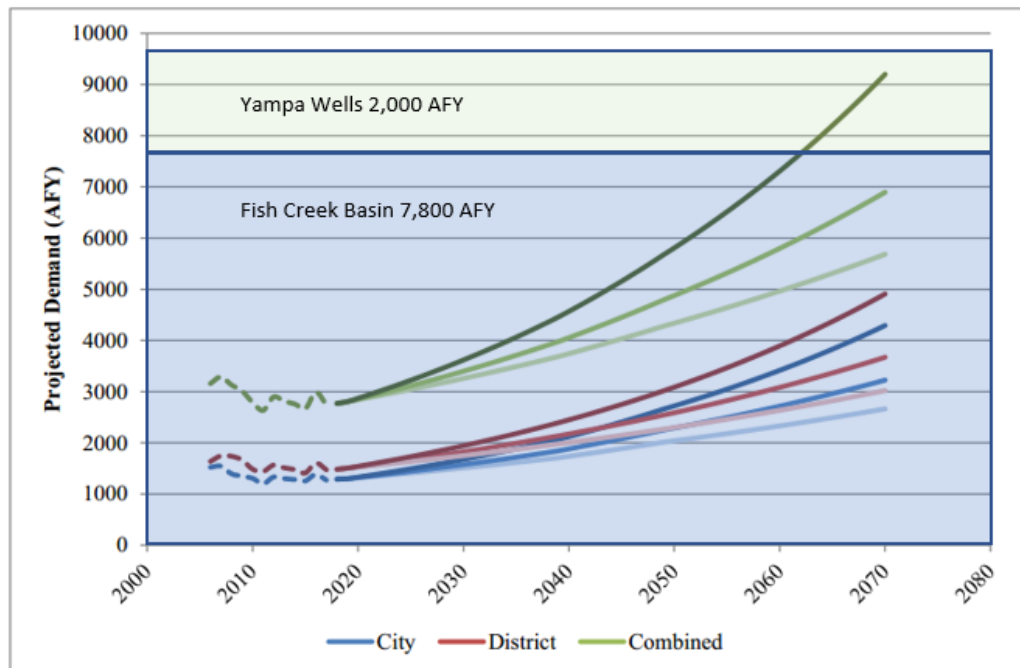


FIGURE 2. ANNUAL SUPPLY VS. DEMAND

Although City and District water supplies generally are adequate to meet future demands, there are shortages projected under the four system stressors modeled for this study: growth, climate change, wildfire, and Colorado River Compact call (Figure 3). A wildfire in the Fish Creek basin could result in shortages under all the demand scenarios, because of the inadequacy of a redundant raw water source to the Fish Creek water treatment plant. A Colorado River Compact call results in the second most significant shortages, with the vast majority occurring at 2070 future demands. As a result of this analysis, the City and District should focus future water supply alternative projects on those that provide water supply originating outside the Fish Creek Basin (i.e., Fish Creek redundancy) and Colorado River Compact scenarios.

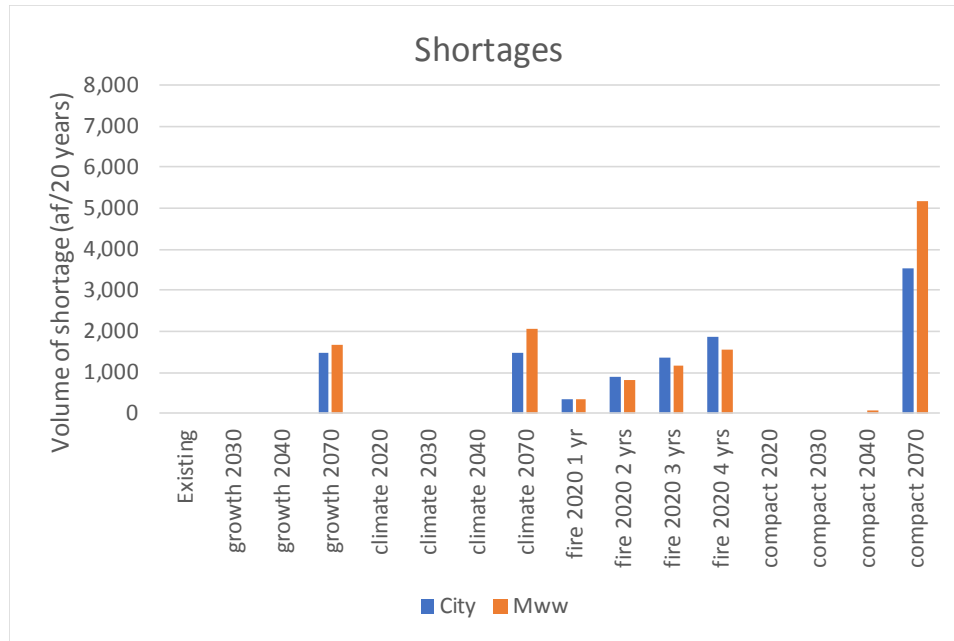


FIGURE 3. TOTAL SHORTAGE VOLUME BY SYSTEM STRESSOR

WATER QUALITY AND TREATMENT CAPACITY

The City and District have two existing water treatment plants: Fish Creek water treatment plant that has an existing sustained capacity of 7.5 MGD, and the Yampa River wellfield water treatment plant that has an existing sustained treatment capacity of 3.5 MGD and a pumping capacity of 1.8 MGD³. The Fish Creek water treatment plant can be enlarged to 12 MGD capacity, resulting in a total future treatment capacity of 15.5 MGD.

The City is considering the development of a new raw water source to provide redundancy, fire resiliency, and increased capacity for their treated water treatment system to meet future demands. Two raw water source locations are being considered, one on the Elk River and the other along the Yampa River. The Elk River location is constrained to an area which the City owns water rights. The other location, along the Yampa River, is more flexible and can be located between the City and the confluence with the Elk River in order to provide treated water to the west side of Steamboat Springs where the majority of future municipal development is anticipated to occur.

High level guidance is provided for the development of a new water treatment plant from the raw water diversion to the connection to the existing distribution system, with a focus on the following:

- Permitting, Easements, and Acquisitions:
 - 1041 Permit from Routt County
 - Floodplain Development Permit from Routt County
 - CWA Section 404 Permit from the Corps of Engineers
 - Special Use Permit if public rights of way are impacted
 - Easements for raw and finished water pipelines
- Water Quality and Treatment Process
 - Water quality at potential Yampa River and Elk River treatment plant locations are similar, but Elk River has a lower potential for upstream contamination.

³ Yampa River wellfield existing pumping capacity is 1.8 MGD, which limits the current ability to use the full 3.5 MGD Yampa River wellfield treatment capacity.

- Water quality monitoring should be completed before initiating design of a new treatment plant in order to determine the applicable treatment process.
- Available Water Volumes
 - Phasing of the treatment process is a key cost element, and should be considered when sizing the plant for current and future demands.
 - Preliminary data indicates that both locations have the potential to provide adequate water flow to feed a new 3 to 5 MGD water treatment plant. The Elk River plant location would likely require new storage upstream of the new treatment plant.
- Siting of the Intake and Water Treatment Plant
 - Site will likely need to be approximately 5 acres in size to accommodate the treatment plant.
 - A siting plan should be conducted several years before the design of the new plant, with focus on understanding how the plant could supply municipal development anticipated to occur on the west side of Steamboat Springs.

A conventional water treatment plant could be effective at either of the Elk River or Yampa River locations. A water quality monitoring program is recommended to provide several years of background data that would be needed to design a new treatment plant. A siting plan should be conducted once the water quality data are available to help determine the best treatment plant location. Land acquisition and easement acquisition would be initiated at the completion of the siting plan. Design and construction may take four years. A total of 7 to 10 years may be needed from the initiation of the water quality monitoring program to construction of the new treatment plant.

INCREMENTAL ACTION PLAN

City and District water supplies were found to be adequate to meet future projected treated water demands through the year 2070, with the exception of shortages that would occur in the event of a wildfire or Colorado River Compact call. Shortages would occur at current demands under a Fish Creek wildfire scenario. Shortages under a Compact call and drought scenario would only occur at future demands. Water supply projects were identified to address potential shortages to the City and District demands associated with the following stressors: growth, climate change, wildfire, and Colorado River Compact calls.

INTRODUCTION

This report is an updated Water Supply Master Plan for the City of Steamboat Springs (the City) and the Mount Werner Water and Sanitation District (the District).

City Council and the District have set a goal to “identify and implement strategies to promote water supply resiliency by preparing for growth, planning for drought & wildfire, planning for a Colorado River Compact Call, planning for water conservation, and developing a redundant supply.” This Water Supply Master Plan (WSMP) update was completed to help meet these goals.

The City and the District collectively serve a resident population of over 12,000 people with a visitor population that can exceed 20,000 people. The majority of the community’s treated water is served from the Fish Creek Filtration Plant with that supply being supplemented during the summer months with the Yampa Wells Treatment Plant for a total consumption of approximately 3,000 acre-feet per year. Although the City and the District function as separate districts, their collection and distribution systems are interconnected and they jointly own and/or operate two reservoirs (Fish Creek & Long Lake Reservoirs), two treatment plants, and a wastewater plant. Therefore, the City and the District believe that a comprehensive Water Supply Master Plan that assesses the entire city’s needs is most beneficial to its customers.

This WSMP update was completed with a scenario-planning approach to address uncertainties that could impact Steamboat Springs’ water supply. This approach is similar to the approach described in the 2015 Colorado Water Plan. Vulnerabilities to the community’s water supply include, but are not limited to population growth (infill and West Steamboat Area expansion), extended drought and climate change, wildland fire in the Fish Creek Basin, and the Colorado River Compact.

This WSMP update assessed the availability of current and future water supplies to meet future treated municipal water demands for the City of Steamboat Springs and Mount Werner Water Districts. Demands and supplies were analyzed separately for the City and District, which provides a conservative analysis of the ability of each of these entities to meet customers’ treated water demands. There may be a possibility of meeting greater total water demand if the City and District cooperatively manage their individual water supplies. The results of this study indicate that the City and District currently have adequate supplies to meet future demands without external stress being placed on their water supplies. However, stressors such as a wildfire in the watershed and a Colorado River Compact call could result in substantial shortages and should be addressed in order to minimize the risks of shortages. These shortages generally would occur at future demand levels, however, shortages at current demand would occur under the Fish Creek Basin wildfire scenario.

BACKGROUND

The City and the District cooperatively provide treated water supply to the residents of Steamboat Springs. The District generally provides water to the resort or mountain area of Steamboat Springs, which generally includes the area south of Fish Creek and Angler’s Drive east of the Yampa River. The attached Vicinity Map (Map 1) shows the location of the existing water supply system, and the service area boundaries for the City and District. The service area for the City and District may expand in the future, and the City/District would need to provide water supply to these growth areas. It should also be noted that the service area boundaries shown in Map 1 indicate where City/District treated water supply is delivered, and that there are locations outside of the service area where raw water is used by the City (e.g., Haymaker Golf Course).



The City generally provides treated water to the portion of Steamboat Springs north of Fish Creek, including the Old Town area, commercial and industrial areas, and the developing area on the north and west side of the City. The City and District have developed their own water rights and water supplies historically and have operated treatment facilities together since at least the 1980s. The City owns and operates the wastewater treatment facility that jointly treats wastewater from City and District customers.

The primary raw water supply for the City and the District originates in the Fish Creek watershed east of the City of Steamboat Springs. Raw water storage is provided by two reservoirs, Fish Creek and Long Lake Reservoirs, in the upper Fish Creek watershed, and water rights owned by the City and District are diverted at the Fish Creek water treatment facility throughout the year as a base supply. The City and District also both own wellfields on the Yampa River on the upstream side of town at the location shown in Map 1, which are generally used to supplement water supply during times of peak demand including the summer irrigation season. The City and District also lease storage rights upstream of Steamboat Springs, through renewable lease agreements with the Upper Yampa Water Conservancy District.

The City and District have a variety of decreed water rights described below that are used to meet their customers' water demands. These rights include a mix of pre- and post-Colorado River Compact water rights on Fish Creek, the Yampa River, Soda Creek, Spring Creek, Walton Creek, Burgess Creek, and Butcherknife Creek. The City also has a conditional right on the Elk River. The City and District have relatively junior water rights on the Yampa River for diversions at the Yampa River wellfields.

The Fish Creek water treatment facility has a current sustained capacity of 7.5 million gallons per day (MGD) that includes 10 filtration bays, with 6 of the bays being owned by the City and 4 of the bays being owned by the District. However, the 7.5 MGD capacity is equally shared by the City and District through a lease of one of the City's bays to the District. The Yampa River wellfields has a current pumping capacity of 1.8 MGD. The associated Yampa River wellfield treatment plant has a current capacity of 3.5 MGD, is operated by the District, and the capacity is shared by the City and District. The City's regional wastewater treatment facility is owned and operated by the City, but serves both the City and the District.

PROJECT SCOPE

The City, in cooperation with the District, initiated this project to assess the adequacy of their existing water supplies to meet projected treated municipal demands for its existing and future service areas. The City and District have additional raw water demands (i.e., demands not met with treated water). While the focus of this study is on treated water demands, raw water demands are addressed as well in order to estimate the potential impact on treated water demands (e.g., the potential for the City/District to need to supply treated water to meet raw water irrigation demands, such as athletic field irrigation, when the raw water supply is unavailable). Raw water irrigation demands were not included in the analysis of the historical treated water demand, but were assessed in the analysis of historical water efficiency and conservation efforts. Raw water irrigation use is clearly called out in this report when it is included, and should otherwise be assumed not to be included in the results.

This Water Supply Master Plan is an update to the 2008 Water Supply Master Plan.⁴ The scope of work includes the following:

⁴ Steamboat Water Supply Master Plan. Stantec. November 2008.



1. Assess the adequacy of current and future water supplies to meet future municipal demands, under a series of growth and climate scenarios, for both average and peak day demands.
2. Review of existing supplies and historical water demands to determine the baseline water portfolio for the City and District.
3. Develop projections for future water demands, based on projected growth for Steamboat Springs, including current and future service areas and a range of potential water use.
4. Develop a raw water supply planning model to assist the City and the District to simulate future demands, water conservation, system stressors (e.g., wildfire, growth, climate conditions, and administrative river calls), and to assess potential water supply shortages.
5. Assess existing water conservation and drought mitigation measures, and evaluate how future conservation and improved efficiency can reduce potential water supply shortages.

This study identifies and accounts for key uncertainties that could impact the City and District water supplies and ability to meet customers' demands. Vulnerabilities to the entities' systems are assessed to determine the range of potential effects on water supplies.

DEMANDS

INTRODUCTION TO HISTORICAL WATER DEMANDS

The City and the District provide treated water to the residents of Steamboat Springs, and also a portion of the water supply for the Steamboat II Metropolitan District. The District constructed the original Fish Creek Filtration Plant in 1972, and the City located its treatment facilities in the Fish Creek plant in 1983, with subsequent expansion in 2000 to the current capacity of 7.5 million gallons per day (MGD). The City and District share capacity of the water treatment plant equally. There is potential for expansion from 7.5 to 12 MGD through the addition of 6 filtration bays. The City and District also meet demands with Yampa River wellfields that have a current pumping capacity of 1.8 MGD. The Yampa River wellfield WTP has a sustained capacity of 3.5 MGD currently, but is limited by the current 1.8 MGD pumping capacity of the associated wellfields. The City and District deliver treated water to their customers through a shared distribution system that is hydraulically connected.

Water demands in the City and District are driven by resident population, and also are largely influenced by tourists visiting for winter activities and also for summer attractions. The influence of tourism on water demands is unique and presents challenges in predicting future demands. Per capita demands that are often used to assess historical and future demands will present a skewed water use perspective, and as a result, alternative demand methods are presented in this report.

EVALUATION OF HISTORICAL WATER DEMANDS

Daily production data (i.e., treated water leaving the Fish Creek Water Treatment Plant) was provided by the City and District, and used to analyze historical treated water demands. Meter data (measured deliveries at customers' taps) was also provided by the City and District, and was correlated to production data to check for anomalies in the production data. The production data from 2006 to 2017 were used to analyze historical demands. Data gaps and anomalies in the production data were adjusted by using production data from a period that had similar meter data that was also provided by the City and District, which was representative of deliveries at a customer's tap connection.



EVALUATION OF HISTORICAL WATER DEMANDS

The City and the District provide treated water for mainly residential and commercial uses. Water demands consist of treated and outdoor raw water demands. The WSMP update focuses on treated water demands (including indoor and outdoor uses), and the use of past trends in treated water demands to develop projected future treated water demands. Raw water demands are discussed separately in this evaluation of historical demands section, because together treated and raw water demands provide a snapshot on water conservation and efficiency of use.

RAW WATER IRRIGATION DEMANDS

Raw water demands are demands met by supplies other than treated water (e.g., park irrigation and snow making). While treated water is accurately measured as treated water leaving the water treatment plant, raw water demands are estimated based on limited meter data and consumptive use estimates. Figure 4 shows the City and District's raw water demands since 2013.⁵ Demands fluctuate on an annual basis with no obvious trends, yet are likely influenced by precipitation and temperature. The District's raw water demands is limited to irrigation on Rollingstone Golf Course. Figure 5 shows the City's raw water demands for snowmaking at Howelsen Hill Ski Area and by individual parks. Emerald Park, Howelsen Park, and Ski town Park have historically been irrigated with raw water, while Memorial Park and West Lincoln Park recently transitioned to being met with raw water supply in 2015 and 2017, respectively. Haymaker Golf Course comprises most of the City's raw water irrigation demands.

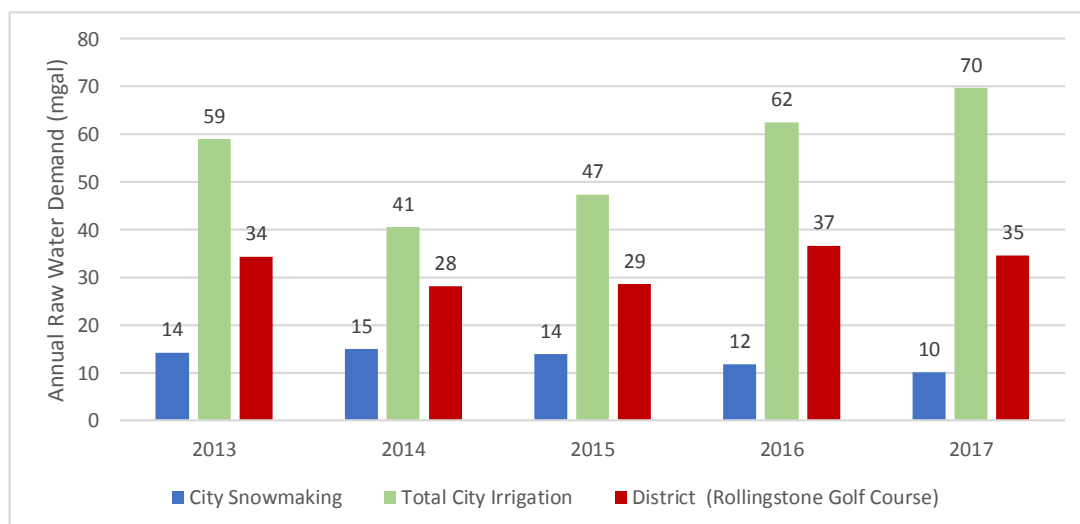


FIGURE 4. TOTAL CITY AND DISTRICT RAW WATER IRRIGATION DEMANDS

⁵ These raw water irrigation data are water accounting data from 2006 – 2017 for the District and from 2013 – 2017 for the City. For some of the individual raw water sources, estimates are made based on known pumping rates and approximate timing of pumping. The data is not to the same degree of precision as the treated water supply which is directly metered.



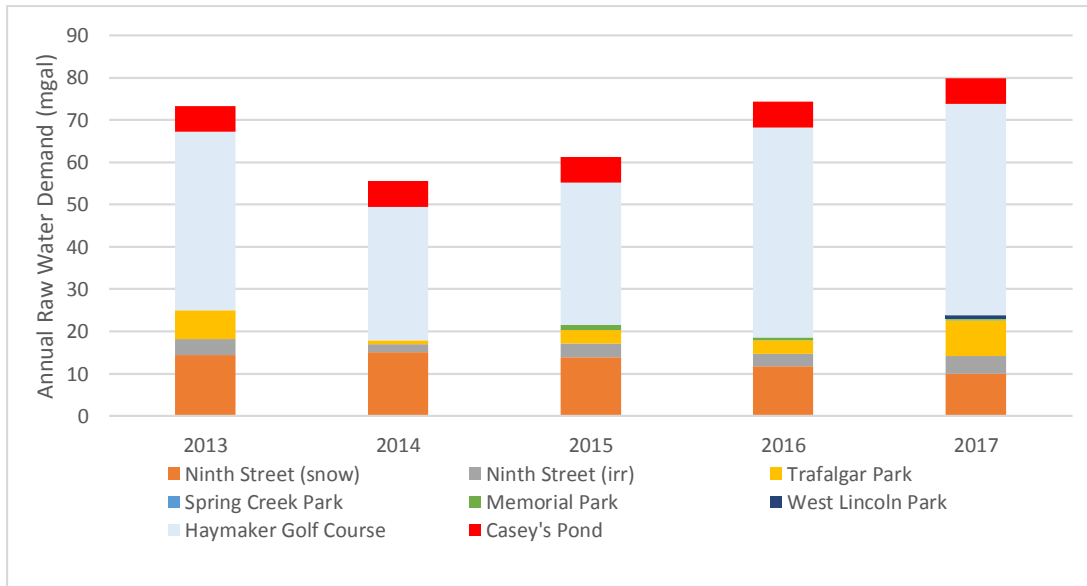


FIGURE 5. CITY RAW WATER IRRIGATION DEMANDS

Treated Water Demands

The proportion of treated indoor and outdoor demands is similar among both providers. As shown in Figure 6, annual outdoor treated use comprises about one third of total treated water use. The remaining two-thirds of treated demands are delivered for indoor use. It should be noted that the City and District have additional outdoor demand that is met by raw water supplies, which are not accounted for in Figure 6 but were described in the preceding section on Raw Water Irrigation Demands.

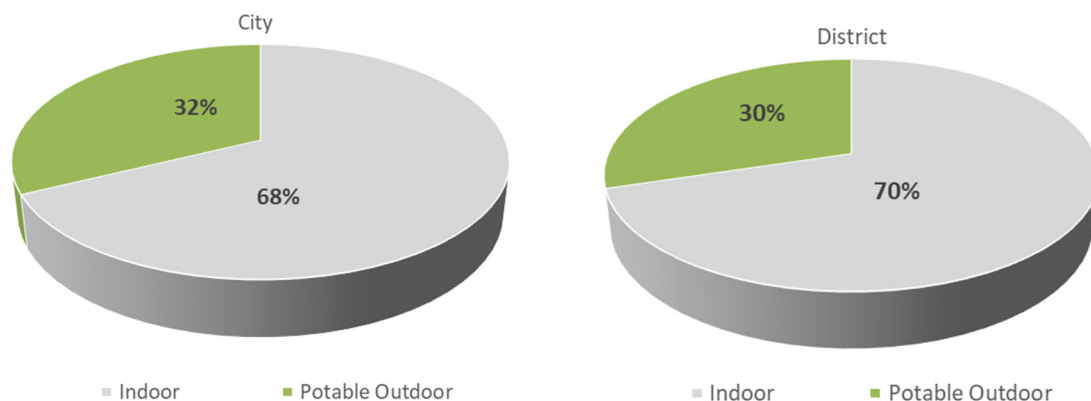


FIGURE 6. INDOOR AND OUTDOOR TREATED WATER DEMANDS⁶⁷

⁶ These charts are based on annual WTP production data from 2006 – 2017. They do not include deliveries made to Steamboat II.

⁷ The City and District's billing systems categorize customers as residential, commercial, and combined. Information on water by customer type will be included in the 2020 WCP update.



The City and District's historical treated water demands have been decreasing over the past 10 years while the population continues to increase. This is shown in Figure 7, where downward trends in demands have generally occurred since 2007. This trend is observed among providers throughout the State of Colorado and is partially attributed to passive savings accrued through more efficient indoor water fixtures and appliances.⁸ A variety of factors may influence the City and District's water demands. These are introduced in the bullets below and are described in further detail throughout this section.^{9,10,11}

- Population growth and seasonal tourist demands
- Water rates and water conservation
- Passive indoor water savings
- Increased raw water demand, e.g., raw water irrigation at City and District parks (shown for the 2014 to 2017 period in Figure 4 and Figure 5), which reduces the demand on treated water supply.
- Climate and drought response
- Efficiency of the water supply system

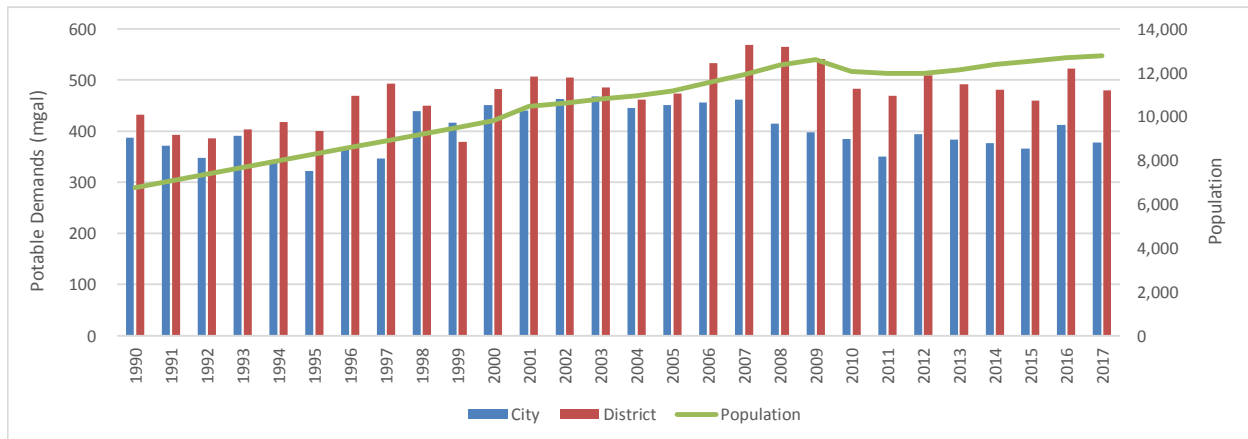


FIGURE 7. TREATED WATER DEMANDS AND POPULATION

Population and Seasonal Tourist Demands

The City and District serve a highly visited mountain resort community. Water demands are not only influenced by a growing community coupled with irrigation in the summer, but also by the winter and

⁸ Additional information on indoor passive savings is provided later in this section.

⁹ Treated water demand data prior to 2006 originate from the 2008 *Steamboat Water Supply Master Plan*. Treated water demand data for 2006 – 2017 are based on metered daily water treatment plant (WTP) production data.

¹⁰ In efforts to focus on the customer demands that the City services, the demand data presented in this section after 2005 does not include deliveries made to Steamboat II which services an area not part of the City customer base. To determine demands without Steamboat II, metered Steamboat II demands were subtracted from City metered WTP production data. This approach differs from the projected demands section which includes the Steamboat II deliveries to reflect the City's total supply needs that entails their obligation to deliver water to Steamboat II.

¹¹ Treated water deliveries to Steamboat II were available in 2009 and from 2014 to 2017. Annual deliveries from 2006 to 2008 and from 2010 to 2013 were assumed to be the annual average of available data (40.3 mgal/year). It is unknown when deliveries to Steamboat II started. Consequently, deliveries were assumed to start at a very low rate in 1990 and increase by 2.5 mgal/year until reaching the 40.3 mgal/year average in 2006. Monthly deliveries were estimated using prorating factors developed from the average of monthly deliveries from 2013 to 2017.



summer tourist seasons. This is reflected by the timeseries of monthly treated water demands shown in Figure 8. Treated water demands for both the District and City typically peak in July during the summer tourist and irrigation seasons and are lowest in November and April. During November and April customers are not irrigating, and tourism is at relatively low levels. The District's demands tend to respond more to irrigation and to the flux of tourists than the City. This is largely attributed to differences among the City and District's customer base. The City's customers consist of more long-term residents and year-round commercial businesses in the older portion of town, whereas the District serves the resort community on the mountainside consisting of many transient second homeowners and seasonal tourists and workers.

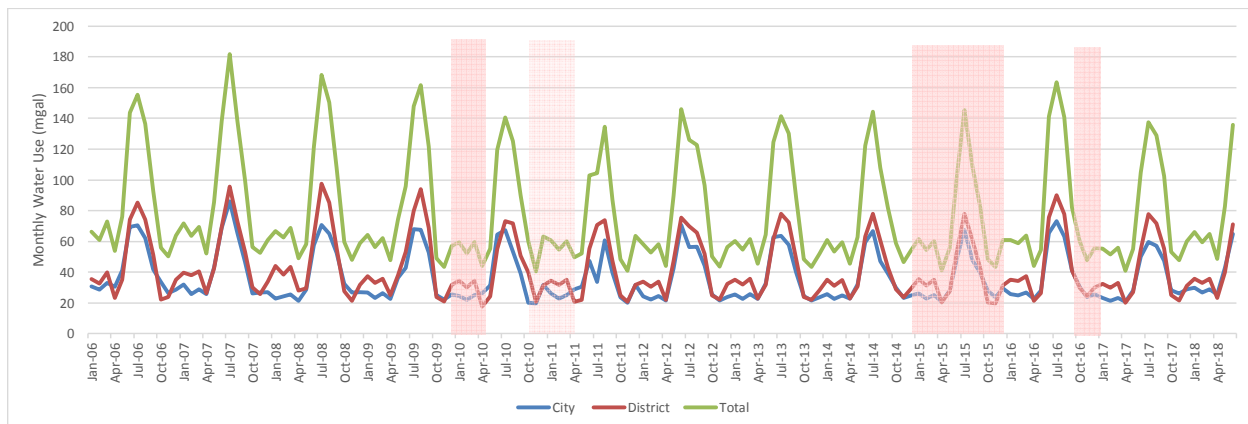


FIGURE 8. MONTHLY TREATED WATER DEMAND PATTERNS¹²

Figure 9 shows that the City and District's combined treated water per capita water demands (sum of City and District's demands divided by population) has been generally decreasing since 1990 while the community continues to grow. As previously mentioned, this trend is common among providers throughout Colorado. Figure 9 shows that there is not a significant change in the residential per capita demand based on the available four years of data, with residential use being approximately 110 gpcd.

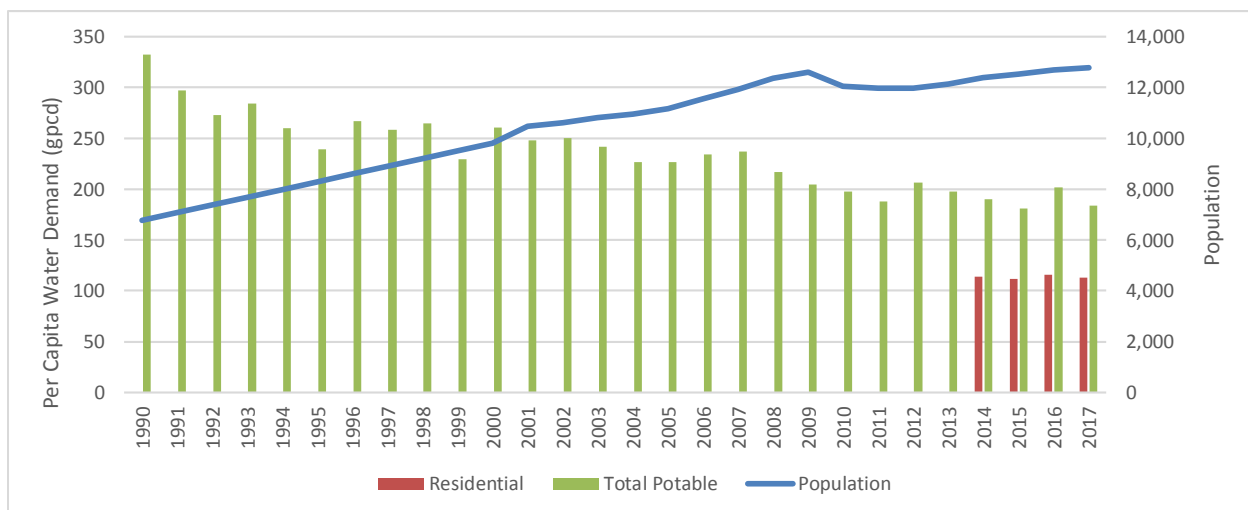


FIGURE 9. PER CAPITA TREATED WATER DEMANDS

¹² The rose shading shows where data gaps existed in the metered WTP production data, requiring replacement with representative data. This is described in further detail in the October 2018 *Historical and Projected Demands Memo attached*.



One method of analyzing water demands is by normalizing water demands through the use of equivalent residential units (EQRs). An EQR is generally considered to have a water demand equivalent to a single-family home, which generally requires approximately 280 gallons of water per day. The use of EQRs in assessing water demands is commonly applied to communities with similar influence by visitors, and provides a means for assessing water demands not associated with permanent population. Figure 10 provides treated water demands per EQR from 2000 to 2017 (gpd/EQR), also demonstrating a long-term decline in treated water demands. In comparison with per capita water demands (gpcd), the demand per EQR approach provides a more robust baseline to identify annual water demand trends for resort communities that experience a flux of seasonal tourism. The EQR approach uses development rather than population as the baseline denominator.

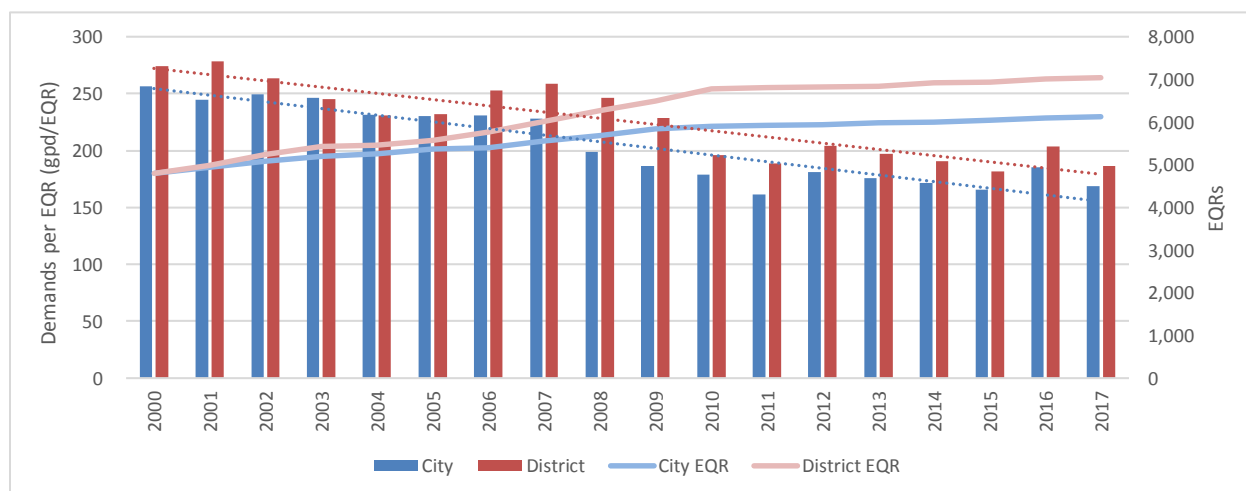


FIGURE 10. DEMANDS PER EQR

WATER RATES AND WATER CONSERVATION

Rates

The City and District have a tiered block rate structure for residential customers where customers that use more water are charged a higher rate per gallon than customers that use less. The City's commercial and combined accounts were recently adjusted from a fixed rate to a tiered block rate structure in 2017. This structure can provide a price incentive to use less water.

The City's water rates have increased incrementally over the past 15 years with the incremental increases occurring in 2011, 2012, 2013 and in 2017. The increases generally ranged from 5% to 6% for most commercial and combined accounts and 5% to 14% for residential accounts. A significant adjustment was made in 2010 where rates were increased by 51% for most customers. The District's water rates were increased in 2007, 2012 and 2017. Rate increases in 2012 were the highest for commercial customers with a 31% increase and residential rate increases ranged from 11% to 22%. In 2017, rates were increased by 7% for all residential accounts and by 19% for commercial accounts. The increase in water rates may have contributed to observed decreases in water demands per EQR for both the City and District.

Water Conservation

The City and District consider water conservation to be an important component of future water-planning and decision-making pursuits. The City and District's Water Conservation Plan (WCP) was adopted in



2011 and an updated WCP is currently being developed and anticipated to be finalized in 2020. The 2011 WCP includes three quantitative water savings goals addressing annual system-wide savings, non-revenue water savings and peak-day demand savings. **Appendix A** to this WSMP provides an overview of these goals and how well these goals have been accomplished along with an overview of the conservation measures included in the 2011 WCP.¹³ While it is not possible to accurately quantify savings attributed to conservation measures using the historical demands presented in this section, conservation practices have contributed some to the declining demand trend.

PASSIVE INDOOR SAVINGS

Indoor water demands are decreasing in many parts of the country as technology is improving and indoor water fixtures and appliances are becoming more water efficient. Savings attributed to these technologies are referred to as passive savings as opposed to active savings. Active water savings occurs through effort of the City, District, and respective communities to reduce water use. The Energy Policy Act of 1992 requires all U.S. plumbing manufactures and importers to meet or beat specific water efficiency standards. In 2016, Colorado Revised Statute section 6-7.5-102 effectively banned the selling of new plumbing fixtures that have not been certified by the EPA WaterSense Program. Figure 11 shows the City and District's lowest monthly water demand (typically in November) on an annual basis, reflecting the decreasing national and statewide trends. This trend may continue as new development uses water efficient fixtures and appliances and older residential/commercial properties replace their old less efficient fixtures and appliances with water efficient devices. However, the rate of this decrease will decline when the majority of older properties are renovated. Notable declines in 2010 may be attributed to a decline in tourist visitation due to the economic recession.

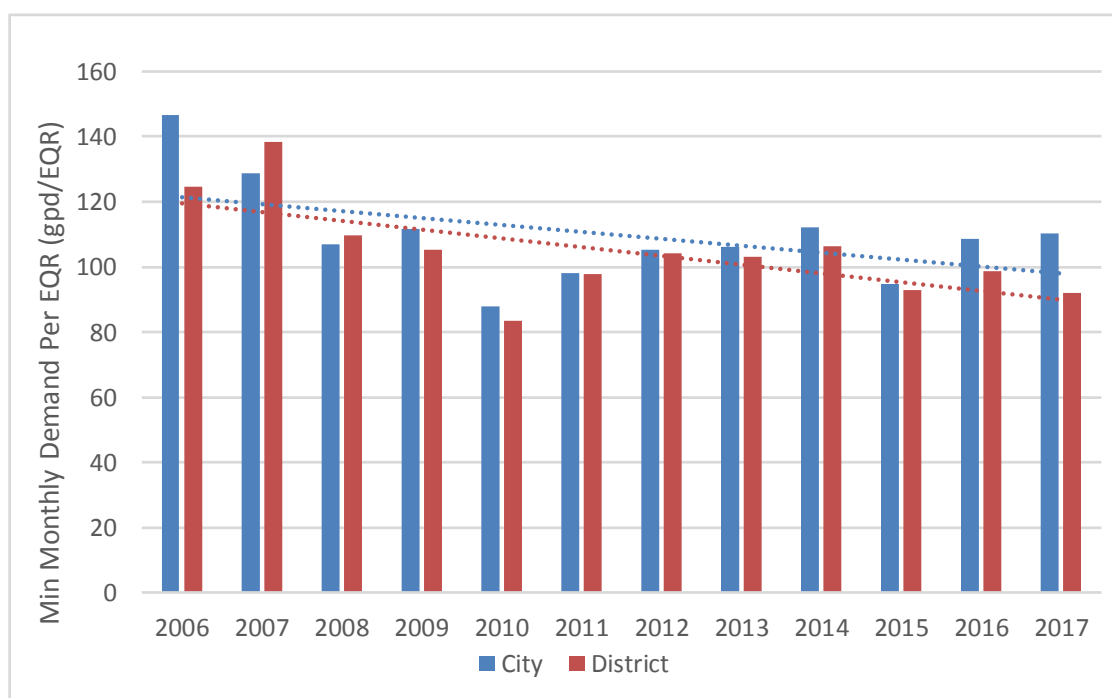


FIGURE 11. PASSIVE INDOOR SAVINGS (BASED ON LOWEST MONTHLY DEMAND)¹⁴

¹³ This information will also be provided in the 2020 WCP update.

¹⁴ The lowest monthly demand typically occurs in November.



CLIMATE AND DROUGHT RESPONSE

Precipitation and temperature, particularly during the irrigation season can significantly influence outdoor water demands. This section includes data on outdoor demands met with treated water as well as outdoor demands met with raw water. The distinction is made between treated and raw water outdoor use in the graphs and tables in order to provide clarity to the reader. In years when there is ample precipitation, landscapes do not require as much irrigation and consequently outdoor water demands on treated and raw water supplies can be lower. For example, the 2010/2011 winter snowpack was very high resulting in relatively low 2011 demands. Conversely during drought, higher temperatures and evapotranspiration coupled with less precipitation can increase outdoor irrigation demands. Figure 12 and Figure 13 show the City and District's outdoor water demands per EQR in relation to annual precipitation, respectively. Mandatory water restrictions were implemented in 2012, 2013, 2015 and 2017 as denoted by the purple and rose bars for the City and District, respectively.

Like indoor demands, there is a general downward trend in outdoor demands. This is particularly notable when comparing the dry years of 2008, 2013 and 2017 where precipitation received in the area during the irrigation season was between 7 to 8 inches. While precipitation was about the same, outdoor demands were less in 2013 and 2017 than in 2008. This could be attributed to improved irrigation efficiencies and drought response, particularly the mandatory drought restrictions.

TABLE 2. REDUCTIONS IN TREATED OUTDOOR DEMANDS PER EQR

	2008-2013	2008-2017	Average Reduction
City	10%	26%	18%
District	16%	20%	18%

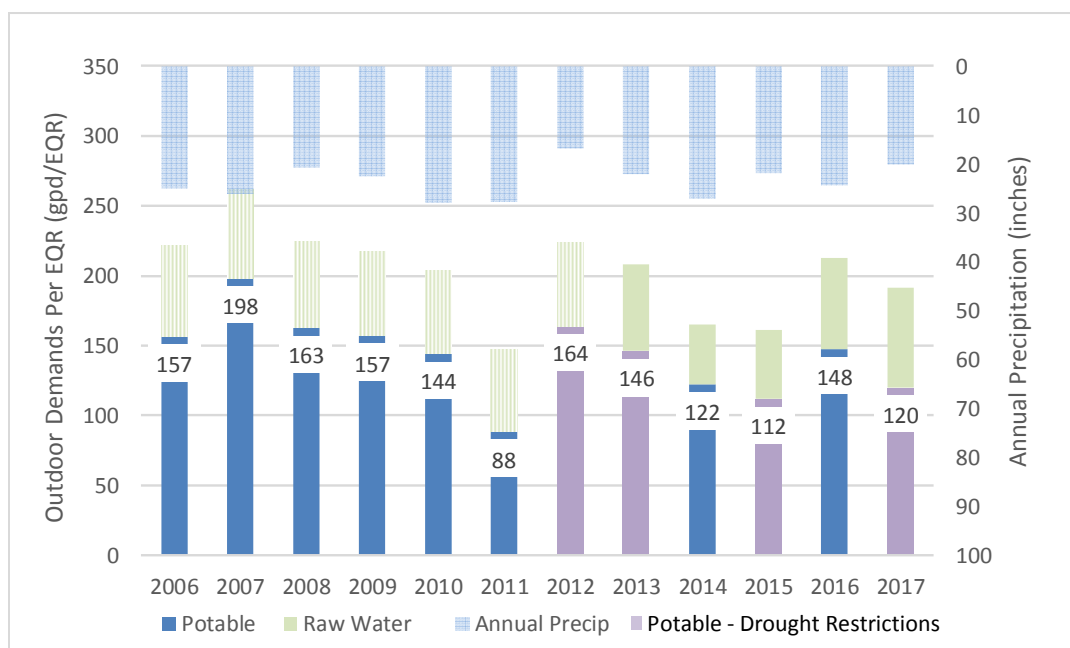


FIGURE 12. CITY OUTDOOR DEMANDS^{15,16}

¹⁵ Raw water irrigation accounting data was limited to 2013 – 2017. The lighter green stacked bars prior to 2013 are a representative average of raw water irrigation demand from 2013 to 2017.

¹⁶ As reflected in this figure and in others, the City 2011 demand per EQR decreases relatively significantly before increasing in 2012. This is likely attributed to multiple factors including the increase in City water rates in 2010, low tourist visitation and a really wet winter.



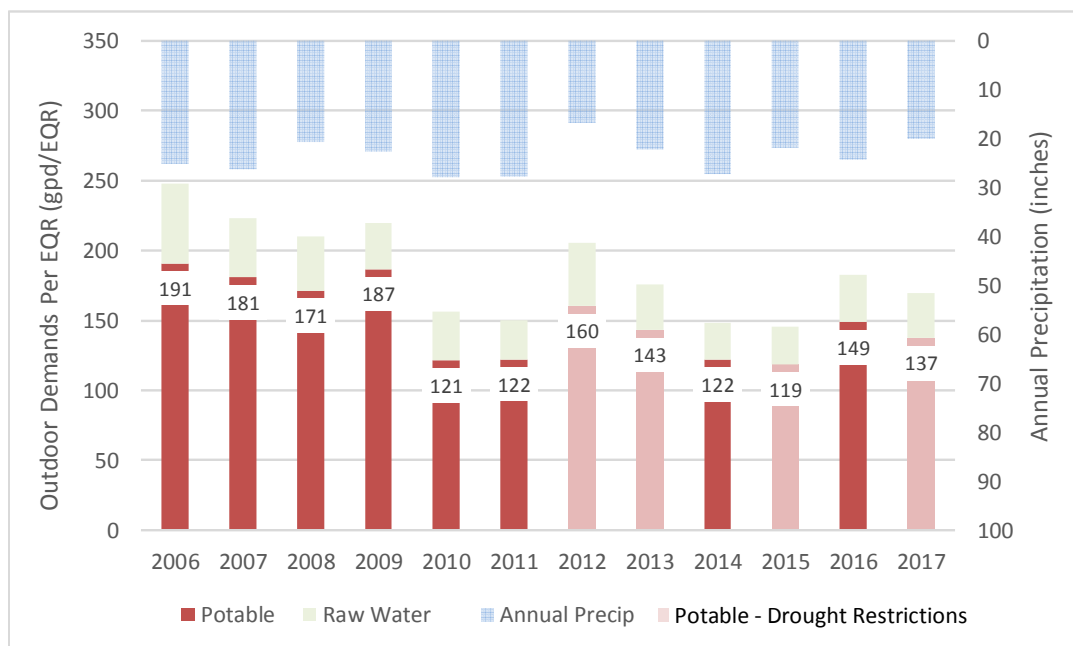


FIGURE 13. DISTRICT OUTDOOR DEMANDS

EFFICIENCY OF THE WATER SUPPLY SYSTEM

Minimizing conveyance losses and improving meter accuracy can provide both water and cost saving benefits and are often considered foundational components to water conservation. Table 3 shows the percentage of annual non-revenue losses for the City and District using annual water treatment plant (WTP) production (combined from Fish Creek and Yampa River wellfield WTPs) and billing data. Losses were calculated on an annual basis as shown in the equation below.¹⁷

$$\text{Non-revenue losses} = \frac{\text{WTP Production} - \text{Billed metered water}}{\text{WTP Production}}$$

TABLE 3. PERCENTAGE LOSSES OF NON-REVENUE WATER

Year	City	District
2010	No data available	15%
2011	No data available	14%
2012	No data available	12%
2013	No data available	13%
2014	14%	10%
2015	12%	10%
2016	12%	11%
2017	11%	5%
Average	12%	11%

Note: Daily gaps in WTP production data were replaced with representative data as follows: ½ in 2010, ¼ in 2011, all of 2015 and ¼ of 2016

¹⁷ To account for losses within the City's water supply system, Steamboat II deliveries were included in both the WTP production data and as a commercial account in the billed metered data to estimate losses. This contrasts with the remainder of the demand analysis where the Steamboat II deliveries were taken out in order to focus on the City's customer base.



The average annual losses are 12% and 11% for the City and District, respectively. Both data sets demonstrate an overall decrease in system losses, with the District's losses being lower than the City's losses. This is expected since the City's water system infrastructure is significantly older than the District's. Losses in 2017 for the District show a significant decline. This may be attributed to a variety of factors and may or may not coincide with future trends. For instance, in 2017 the District replaced the main water meters that measure flows from the FCTP-2 MG Tank to the City's and District main distribution lines. Water production was calculated using historical averages.

The City has an annual water main replacement program with a budget of one million dollars per year for the replacement of aging and deteriorated water mains within its distribution system. In 2015 and 2016, the City replaced 2,603 linear feet of old and undersized water main in the old town area. It is possible that leakage in this area could have been significant given water pressures. In 2018, the City also replaced water mains serving the Riverside subdivision; during construction several large cracks and corrosion holes were observed along the old water main which was far more deteriorated than anticipated. The 2018 water main replacement project may reduce losses in the future. The District has also made replacement and repairs to its water mains and since 2016, the District has required large water users (mostly condominium associations) to replace old meters that were suspected of not reading properly. Additional investigation and monitoring of future loss trends are needed to further understand losses within the City and District's systems.

Annual Treated Water Demands

Treated water demand, based on WTP production data, is summarized below in Figure 14. There is an overall trend of decreasing total annual treated water demand, despite a steady increase in population, which is indicative of increasing efficiency in water use.

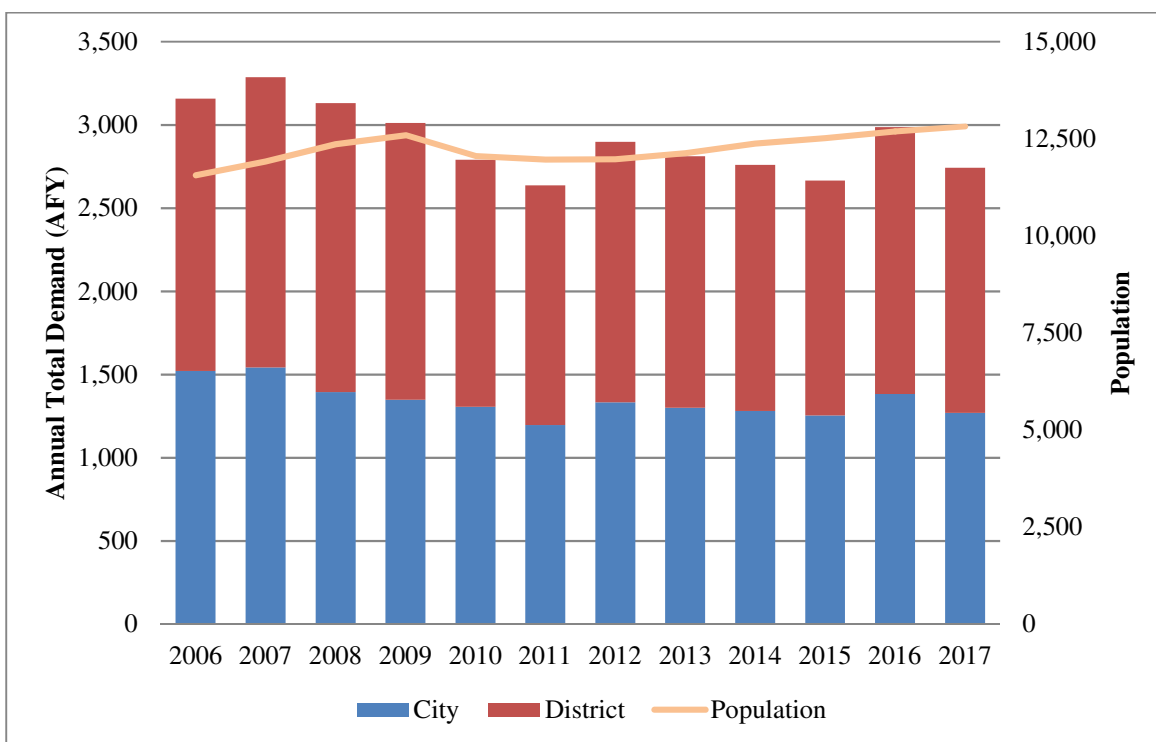


FIGURE 14 . ANNUAL TREATED WATER DEMAND



Average Daily Treated Water Demand

Average daily treated water demands show a slight decreasing trend over the data period, similar to the trend in annual demands (Table 4 and Figure 15).

TABLE 4. AVERAGE DAILY TREATED WATER DEMANDS

Year	City Average Day (MGD)	District Average Day (MGD)	Total System Average Day (MGD)
2006	1.356	1.457	2.813
2007	1.373	1.555	2.928
2008	1.240	1.543	2.783
2009	1.200	1.482	2.682
2010	1.164	1.322	2.486
2011	1.068	1.282	2.347
2012	1.185	1.392	2.577
2013	1.159	1.346	2.505
2014	1.142	1.316	2.458
2015	1.118	1.257	2.375
2016	1.229	1.426	2.655
2017	1.132	1.312	2.443

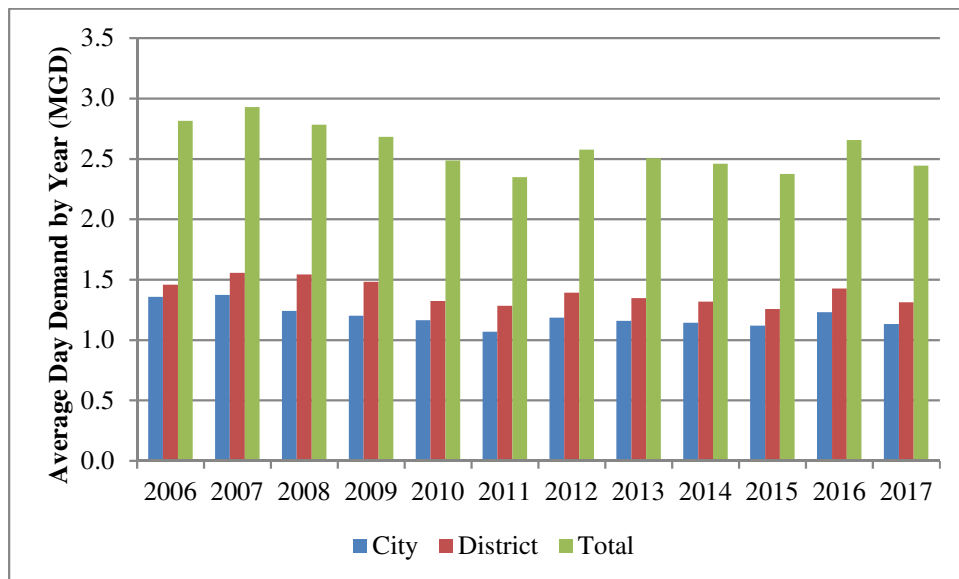


FIGURE 15. AVERAGE DAILY TREATED WATER DEMAND



Monthly Treated Water Demands

Average monthly treated water demands calculated for the 2006 to 2017 period of record demonstrate water use trends throughout the year (Table 5 and Figure 16). Treated water demand is highest in summer months when irrigation occurs, but there are isolated high demand months in the non-irrigation season (e.g., January and March) when water use spikes as a result of tourism.

TABLE 5. AVERAGE MONTHLY TREATED WATER DEMAND (2006-2017)

Month	Millions of Gallons			Acre-Feet		
	City	District	Combined	City	District	Combined
January	26	36	62	80	111	191
February	24	33	56	72	100	173
March	26	37	63	80	112	192
April	24	23	46	73	69	142
May	34	32	65	103	98	200
June	59	63	122	181	194	375
July	65	81	146	200	249	449
August	59	73	132	180	226	406
September	44	51	94	134	156	290
October	27	27	54	84	82	166
November	23	22	46	72	68	140
December	27	32	59	84	97	181
Totals	438	509	947	1344	1562	2906

A monthly time series of treated water use throughout the 12-year period of record (Figure 16), indicates the trends throughout the year are typically the same for both the City and the District, with a generally decreasing trend over the study period.



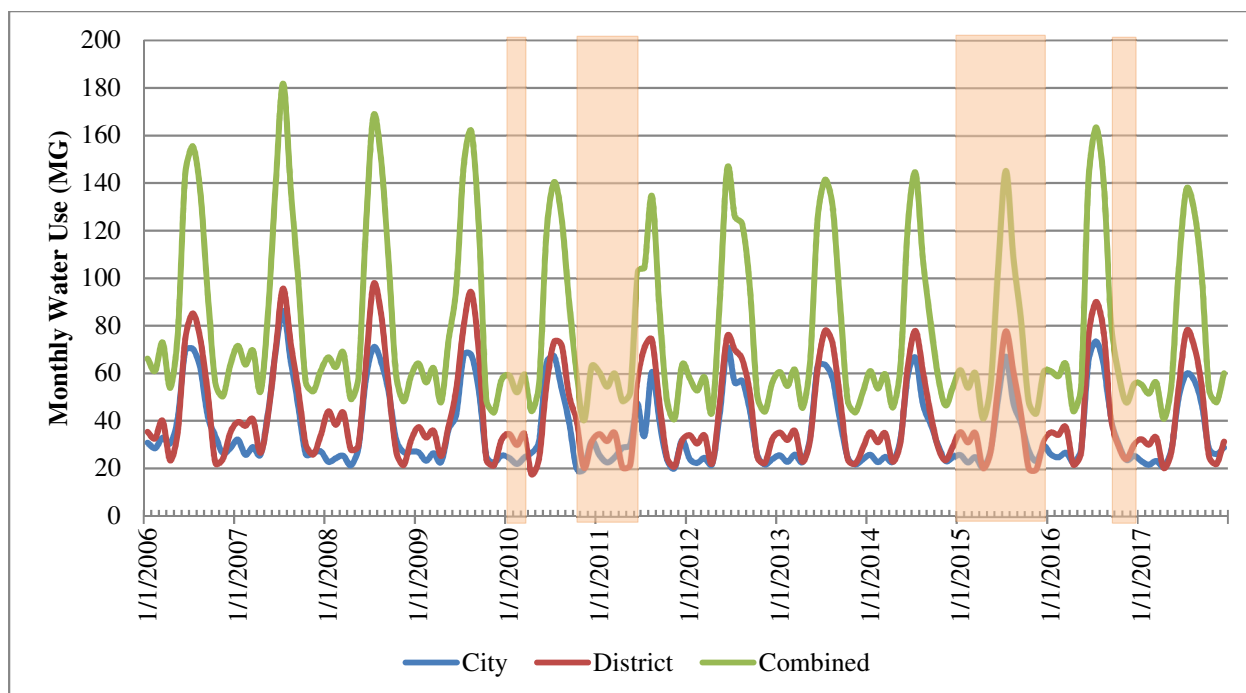


FIGURE 16. TREATED WATER DEMAND MONTHLY TIME SERIES

Note: Orange shading represents edits where production data was estimated based on quarters with similar customer delivery meter data.

Indoor vs. Outdoor Use

The monthly treated water demands were disaggregated into indoor and outdoor treated water demands, for both the City and District. Monthly average indoor use was determined based on winter (October through April) demands for each year during 2009-2017. Outdoor treated water demand was calculated as the total monthly demand, minus the average monthly indoor use. Figure 17 and Figure 18 show the resulting average indoor and outdoor demands for the City and District, respectively.



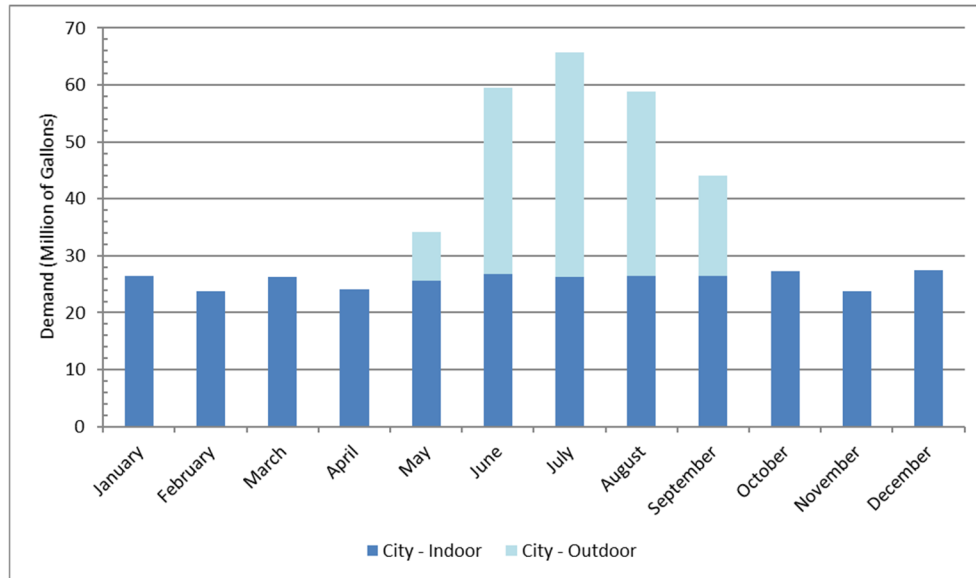


FIGURE 17. CITY INDOOR AND OUTDOOR TREATED WATER DEMANDS (2009-2017 AVERAGE).

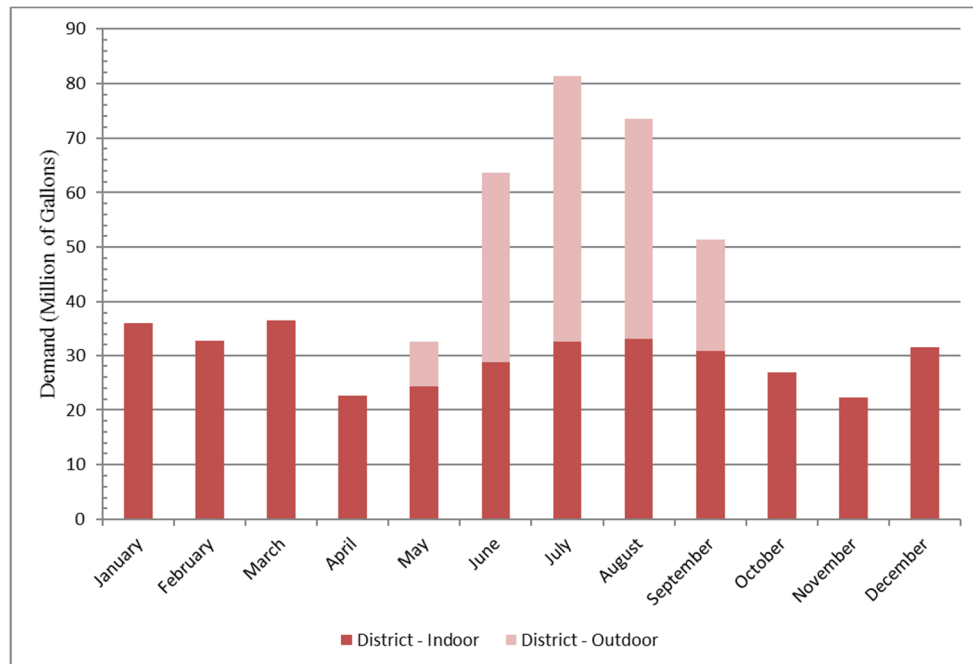


FIGURE 18. DISTRICT INDOOR AND OUTDOOR TREATED WATER DEMANDS (2009-2017 AVERAGE).

PROJECTED TREATED WATER DEMANDS

Projected demands are based on an analysis of current treated water demands, and projected into the future based on current demand and projected growth. Treated water demands were assessed based on a review of historical daily production data from 2006 to June 2018. These historical demands were used to calculate a unit rate of water use, including a per capita water use and water use per EQR. As previously mentioned, per capita water use may be skewed by the tourist population in Steamboat Springs, and water use per EQR is likely a more representative measure of water use. The unit water use was then multiplied by projected



population and EQR data to develop projected water demand for the 2019 to 2070 period. The methods used to develop per capita and EQR unit treated water demand are described in **Appendix B**.

Much of the projected growth is anticipated to occur in the West Steamboat Springs Area (WSSA), located adjacent to the City of Steamboat Springs on the northwesterly boundary of existing city limits but within the Urban Growth Boundary. The proposed West Steamboat Neighborhoods development within the WSSA is anticipated to consist of a mixture of 400 multiplex and single-family residential units, plus 50 apartment units (mix of one, two, and three-bedroom residences), constructed on approximately 160 acres of land located 2.5 miles northwest of downtown Steamboat Springs. There is an existing 12-inch diameter water trunk line that bisects the West Steamboat Neighborhood site, which provides water to the Steamboat II Metropolitan District. Anticipated treated water demands for the WSSA include domestic indoor and outdoor irrigation uses.

The results of the analysis of population projections, historical demands, and projected demands are described in detail below. Additional detail regarding population and demand projections is provided in the memorandum summarizing historical and future demands, which is provided in **Appendix B**.

BASELINE DEMANDS FOR TREATED WATER DEMAND PROJECTIONS

An evaluation of current treated water demands was necessary to develop a baseline demand for use in developing projected water demands. The year 2017 was determined to be a representative year for current demand, based on a review of total annual demands over the 2006 to 2017 period. Average day and peak day current treated water demands (Figure 19 and Table 6) are lowest in the transition months between summer and winter tourist seasons (November and April), and highest in the summer irrigation season. Note that the demand data in Figure 19 is for the year 2017 only. Historical peak day demands have at times been higher than the 2017 peak day demands shown.



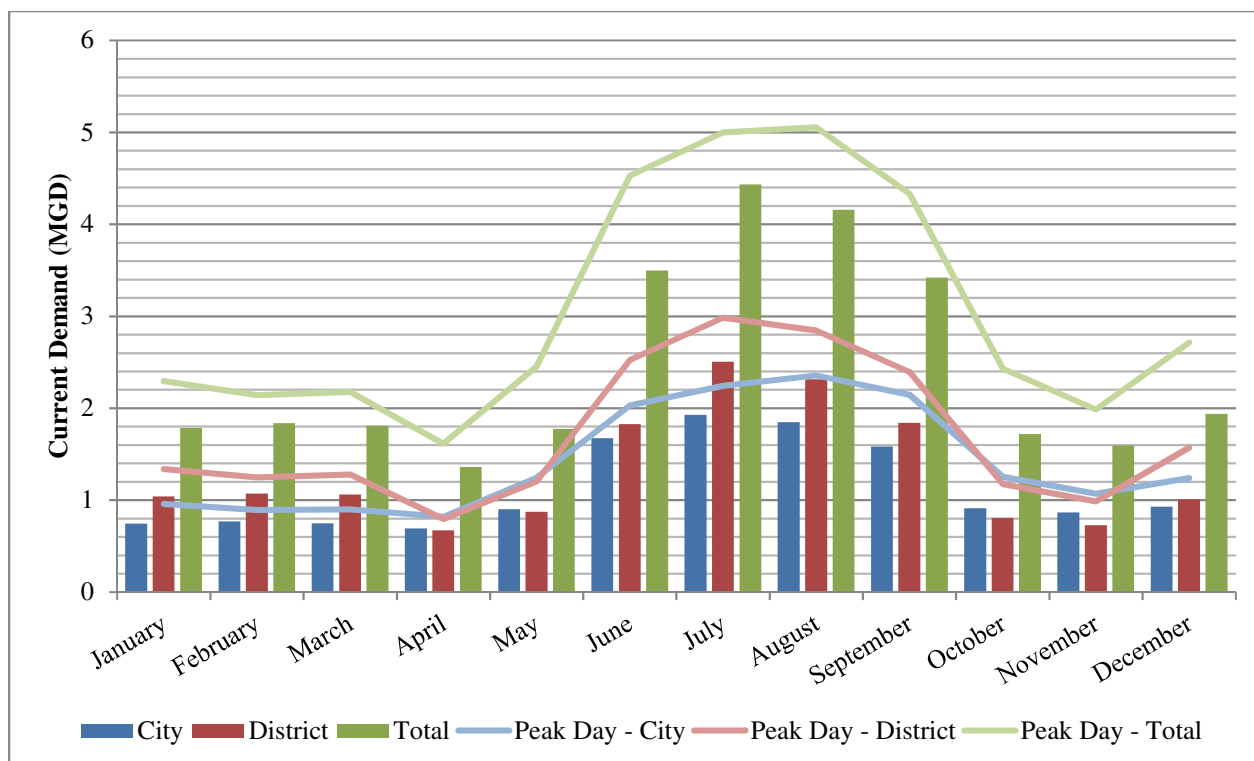


FIGURE 19. CURRENT (2017) AVERAGE DAY TREATED WATER DEMAND BY MONTH WITH PEAK DAY DEMAND.

TABLE 6. CURRENT (2017) TOTAL MONTHLY TREATED WATER DEMAND AND PERCENTAGE OF ANNUAL USE.

2017 Monthly Totals – Millions of Gallons						
	City	% of 2017 City Annual	District	% of 2017 District Annual	Total (City + District)	% of 2017 Total Annual
January	23.09	6%	32.25	7%	55.35	6%
February	21.48	5%	29.97	6%	51.45	6%
March	23.13	6%	32.91	7%	56.04	6%
April	20.71	5%	20.10	4%	40.81	5%
May	27.94	7%	27.05	6%	54.99	6%
June	50.13	12%	54.75	11%	104.88	12%
July	59.73	14%	77.67	16%	137.40	15%
August	57.24	14%	71.67	15%	128.91	14%
September	47.42	11%	55.21	12%	102.63	11%
October	28.27	7%	25.02	5%	53.28	6%
November	26.00	6%	21.80	5%	47.80	5%
December	28.76	7%	31.24	7%	60.00	7%
Total	413.90	100%	479.64	100%	893.53	100%



POPULATION PROJECTIONS

Population projections were developed as an indicator of potential growth in Steamboat Springs, and an indicator of how water demands would grow in the future. Population projections were developed based primarily on Routt County population projections from the Colorado State Demographer Office¹⁸ for the available period of record from 2017 to 2050, and extended to 2070 based on historical growth trends. The methodology used to develop population projections is discussed further in **Appendix B**. The resulting range of population projections for the City and District indicate a total population of between 28,700 and 34,500 at the end of the study period in 2070 (Figure 20).

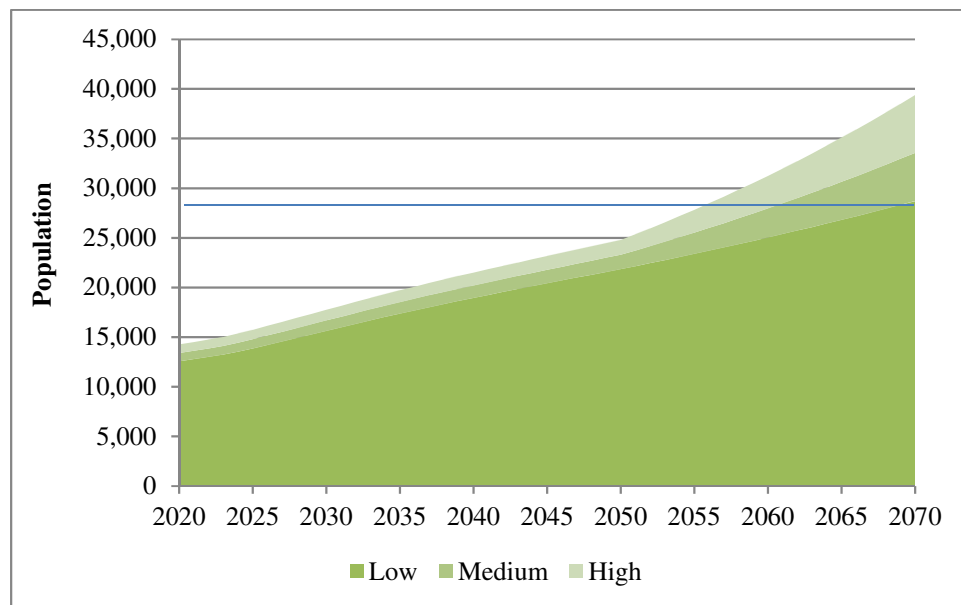


FIGURE 20. TOTAL STEAMBOAT SPRINGS POPULATION PROJECTIONS

EQUIVALENT RESIDENTIAL UNITS

Current EQRs were tabulated for use in calculating current unit water demand. Future EQR projections were also developed as a driver for projected demands.

Historical EQRs

The City EQR data for 2006 to current was calculated based on the Plant Investment Fee (PIF) data assuming 140 fixture units per EQR. The District provided their calculations for 2006-2017 EQRs. The calculated EQRs for the City and the District are displayed below in Table 7.

¹⁸ Colorado Department of Local Affairs, State Demography Office Dashboard. Accessed September 27, 2018. https://gis.dola.colorado.gov/apps/demographic_dashboard/



TABLE 7. HISTORICAL EQRs

Year	Historical EQRs		
	City	District	Total
2006	135.6	251.5	387.2
2007	150.7	218.3	369.0
2008	60.7	280.0	340.7
2009	26.7	37.0	63.7
2010	15.8	22.0	37.8
2011	37.4	17.0	54.4
2012	26.7	64.0	90.7
2013	38.1	19.0	57.1
2014	41.6	84.0	125.6
2015	40.0	36.0	76.0
2016	84.9	38.0	122.9
2017	48.8	110.0	158.8

The average annual changes in EQRs over the 2006 to 2017 period were as follows:

- City average annual increase of 59 EQRs, and
- District average annual increase of 98 EQRs.

Cumulative lagged EQRs were determined using PIF forms provided by the City, with an assumed 2-year lag between the PIF and the associated water demand. Cumulative 2-year lagged EQR projections were provided by the District. The cumulative lagged EQRs for 2006-2019 are shown in Figure 21.

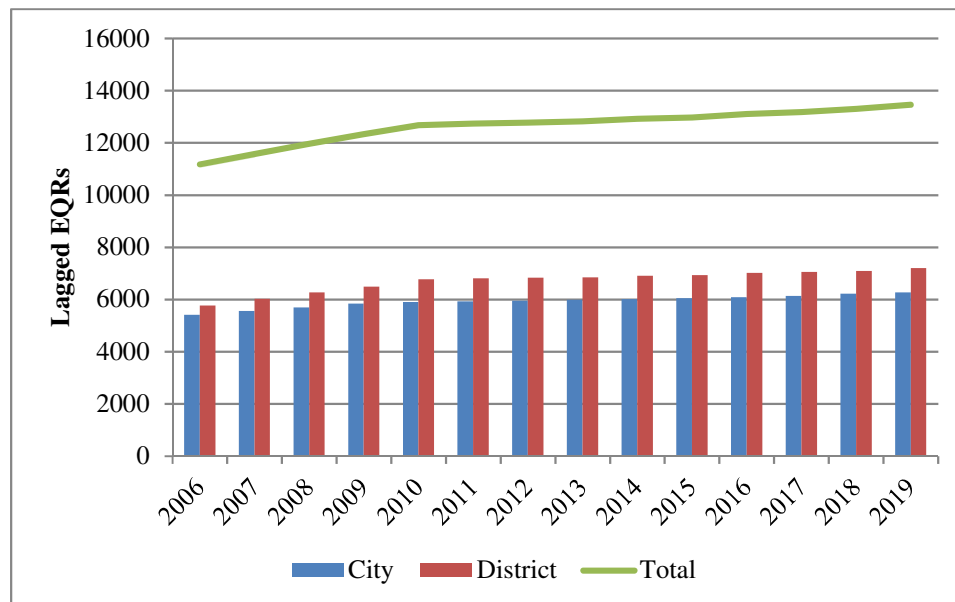


FIGURE 21. CUMULATIVE LAGGED EQRs.

Projected EQRs

Future EQRs were projected using two methods. The EQR A method is based on scaling the current (2017) EQRs by the projected annual increases in population. The EQR B method is based on scaling the current



EQRs by the average percent annual change in historical (2008 to 2019) EQRs. The average annual percent change for the City, District, and combined were 1.01%, 1.51% and 1.27%, respectively. The resulting EQR projections are summarized in Figure 22 through Figure 25.

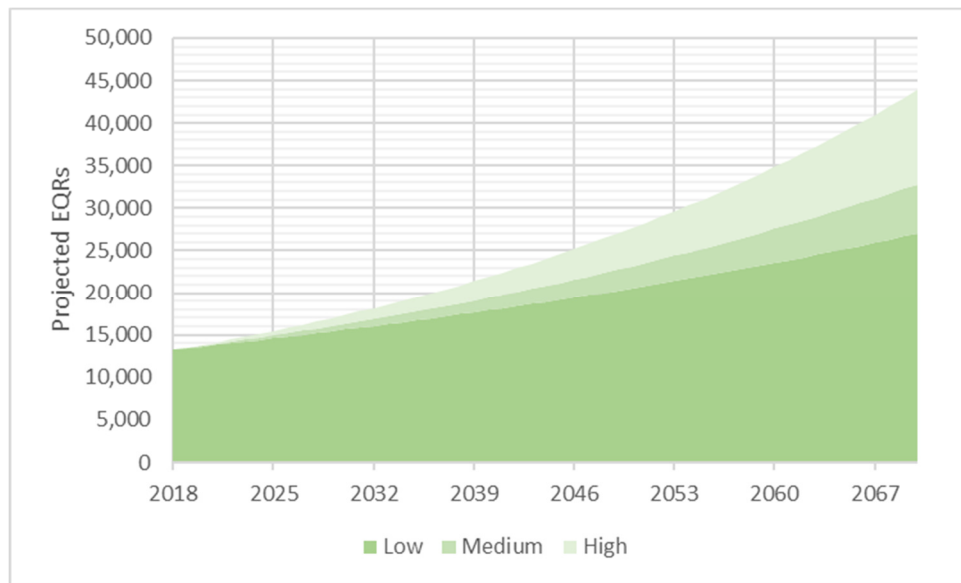


FIGURE 22. TOTAL PROJECTED EQRs (EQR A)

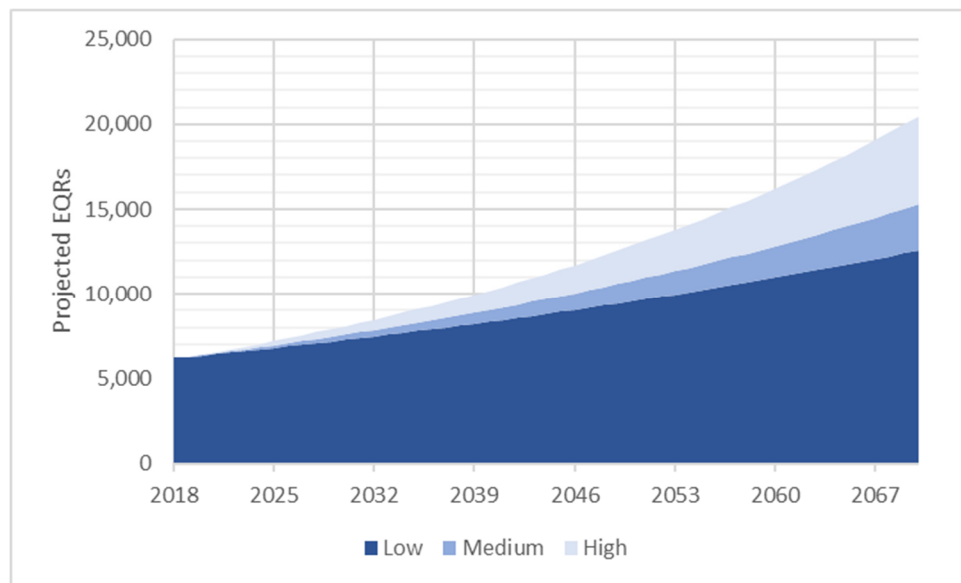


FIGURE 23. CITY PROJECTED EQRs (EQR A)

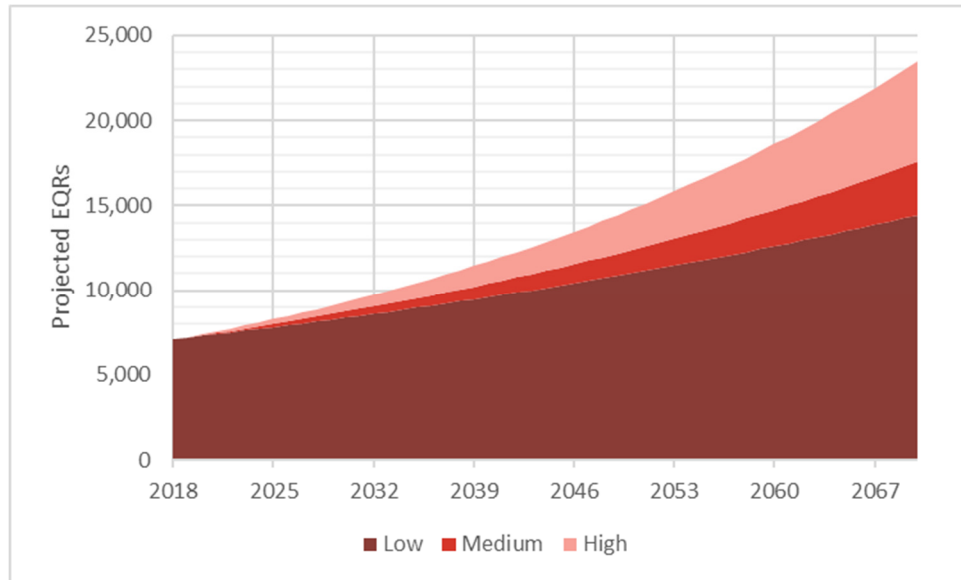


FIGURE 24. DISTRICT PROJECTED EQRs (EQR A)

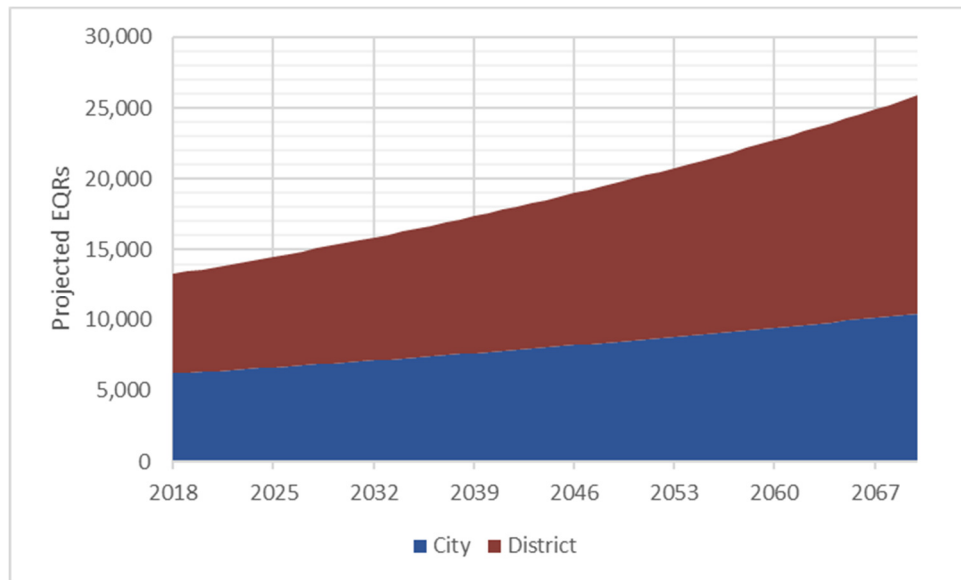


FIGURE 25. PROJECTED EQRs (EQR B)

Buildout EQR Analysis

Projected EQRs described above are based on population projections, and assume that EQRs can continue to increase without regard to current zoning and buildout limitations. This scenario may play out if zoning is changed to include more dense development, and also if the City service area is extended to accommodate the projected EQRs. However, previous buildout capacity studies suggest that growth will be limited under existing zoning and growth boundaries. The City of Steamboat Springs Vacant Land Buildout Capacity Analysis dated September 1, 2010 and the 2009 Steamboat Springs Water and Wastewater Master Plan Updates were used to determine an approximate buildout date for the existing service areas for the City and District. It should be noted that the buildout analysis described herein is based on buildout analysis data that is currently nine years old. One recommendation of this study is to update the City's buildout capacity analysis to provide a more current analysis of the anticipated extent of growth for Steamboat Springs. The buildout analysis described herein assumes the only land that will be annexed into the City is the Steamboat



II and WSSA, as shown in Map 1 attached to this report. Additional EQRs will be accommodated as land is annexed into the City's service area (e.g., annexation of the WSSA).

Table 8 summarizes buildout capacity data from the 2010 map and the 2009 report. The EQR Units column is based on the 2009 Water and Wastewater Master Plan¹⁹, with an additional assumption for Multi-Family and Mixed Use. The West Steamboat Springs area information was pulled from the 2009 report.

TABLE 8. BUILDOUT CAPACITY BASED ON 2010 DATA.

Type/Location	No. of units	Acres	EQR Units	EQRs		
				Existing*	New	Total
Source - 2010 Buildout Capacity Map						
Single-Family/Duplex (units)	1,404	-	1	-	1404	-
Multi-Family (units)	663	-	1.05	-	696	-
Mixed-Use (units)	2,545	-	0.9	-	2291	-
Commercial (SF)	1,064,573	24	4.44	-	109	-
Industrial (SF)	966,052	22	2.13	-	47	-
Total (City and District)				13,460	4,546	18,006
Source - 2009 West Area Steamboat - projected EQR						
WSSA	-	-	-	186	3,667	3,853
Steamboat II	-	-	-	406	47	453
Total				592	3714	4,306
Total (City/District plus West Steamboat & Steamboat II)				14,052	8,260	22,312

*Note the existing EQR breakdown by development type is unknown for the City and District.

Figure 26 displays the EQR envelope compared to the 22,312 EQR buildout capacity for the existing City service area, and assuming the City annexes the Steamboat II and WSSA. The envelope was created using EQR method A's high projection for the high end of the envelope and the EQR B method for the low end of the envelope. Depending on the EQR demand method used above, the resulting buildout date would be between 2041 (using EQR method A,) and 2059 (using EQR method B). This potential buildout should be considered when evaluating the feasibility of the demand projections described below. However, the projected buildout date may be pushed further into the future if the City annexes additional land into their service area.

¹⁹ Water and Wastewater Master Plan Updates for the City of Steamboat Springs. Prepared by McLaughlin Water Engineers. December 2009.



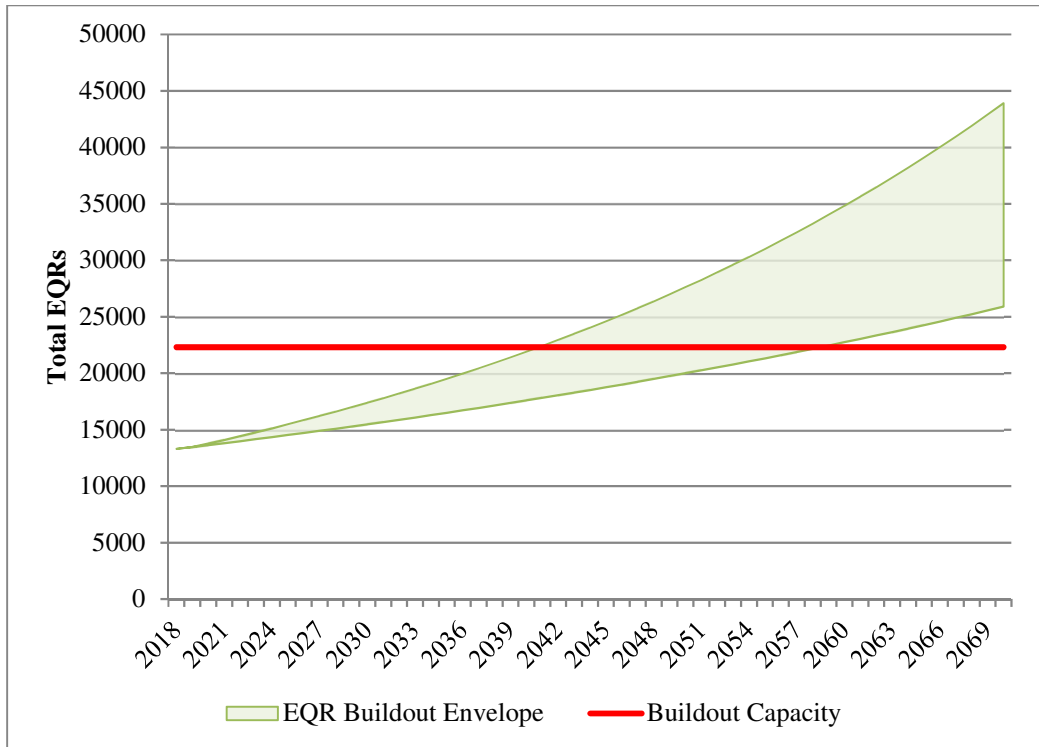


FIGURE 26. PROJECTED EQRs VS. STEAMBOAT BUILDOUT EQRs

PROJECTED TREATED WATER DEMAND RESULTS

Demands were projected using the two EQR methods described previously, and also using gallons per capita per day (gpcd) method that is a more traditional method for analyzing water use for entities not influenced by tourism.

EQR-Based Annual Demand

EQR-A

Demands projected using the EQR A method described previously (i.e., population scaled EQR projections) were completed by multiplying the projected EQRs by the current (2017) EQR unit demand. Current unit demand was 185 gpd per EQR for the City, 187 gpd per EQR for the District and 186 per EQR for combined. Steamboat II demands that have historically been provided by the City were incorporated into the entire study period, and additional Steamboat II demand was assumed for the possibility of the City meeting all of Steamboat II demands (i.e., City supply replace the current well pumping by Steamboat II). Steamboat II additional demands were added starting with 10% in the year 2040 and increasing by 10% each year for 10 years, until 2049. Based on conversations with the City, we assumed that the City would meet all Steamboat II demands starting in 2050. Resulting EQR-A demand projections are summarized in Figure 27.



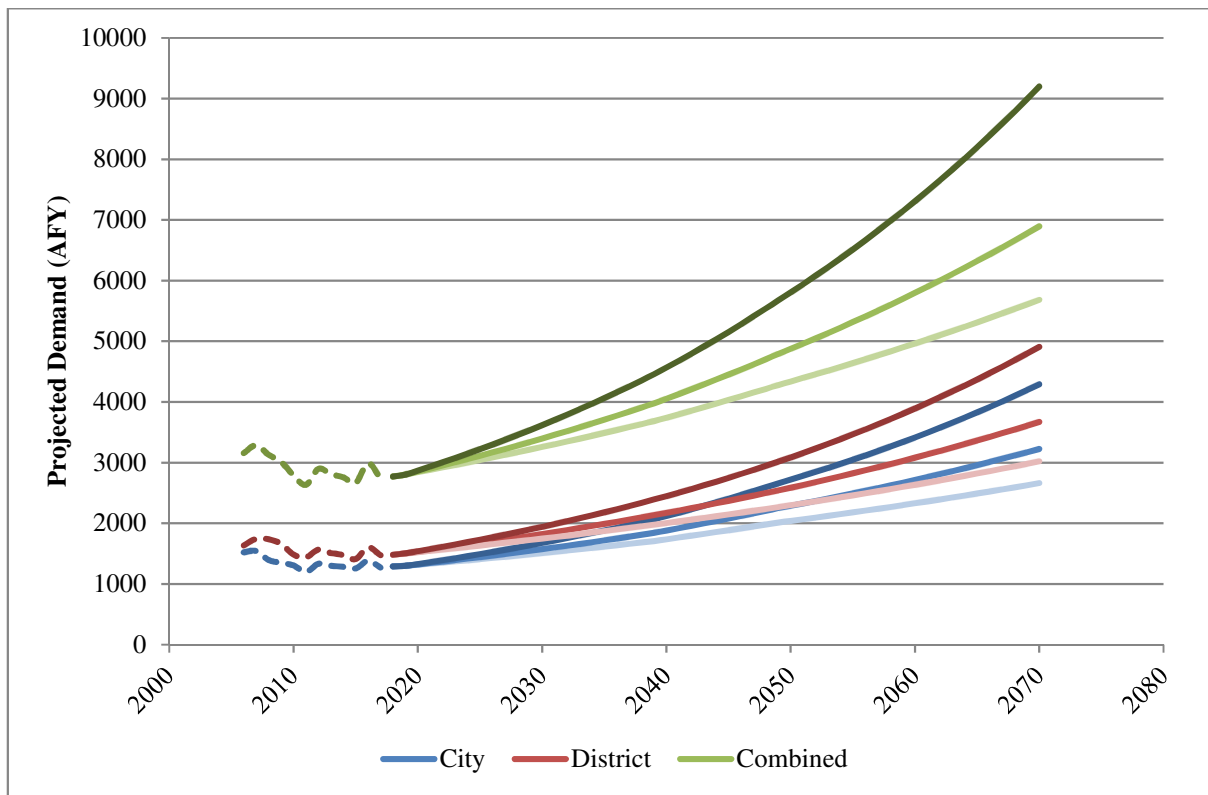


FIGURE 27. PROJECTED DEMAND WITH SCALED EQR BY ANNUAL POPULATION (EQR-A).²⁰

EQR-B

Demands projected using the EQR B method described previously (i.e., assume EQRs grow at a constant rate based on the 2006 to 2008 average annual increase) were developed by multiplying the projected EQRs by the current (2017) EQR unit demand. Current unit demand was 185 gpd per EQR for the City, 187 gpd per EQR for the District and 186 per EQR for combined. Steamboat II demands for the EQR-B method were added based on the same assumptions described above for the EQR-A method. Resulting EQR-A demand projections are summarized in Figure 28.

²⁰ Various shades of one particular color represent projected demands based on the low, medium, and high population projections. Further detail is provided in Appendix B.



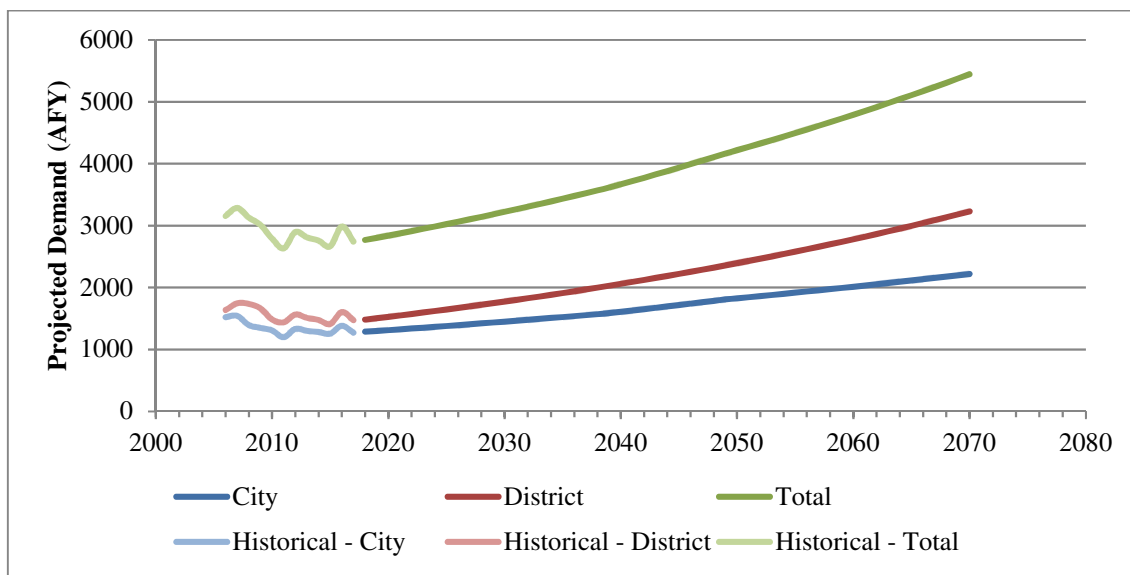


FIGURE 28. PROJECTED DEMANDS USING SCALED EQR BY AVERAGE POPULATION CHANGE (EQR-B).²¹

GPCD Based Annual Demand

Per capita demand was calculated for comparison purposes, although EQR based demand projections may be more accurate for a tourism-based community like Steamboat Springs. Total historical demand (for City and District) in gallons per day for the data period of 2006-2017 was calculated, and then divided by the historical population from the Census Bureau. The resulting annual per capita water use is shown in Figure 29. A base demand of 205 gpcd was determined, based on the average over the 2009 to 2017 period, and assumed to represent the current demand. The apparent fluctuation and decline in per capita water use in recent years are likely attributed to variations in annual precipitation and increased water efficiency and conservation efforts. This base demand of 205 gpcd was then applied to the projected population with the low, medium and high scenarios to create a range of demand projections (Figure 30).

²¹ Average population change is based on actual historical population change, and as a result there are not multiple projections for low, medium, and high population projections as in other charts of this report.



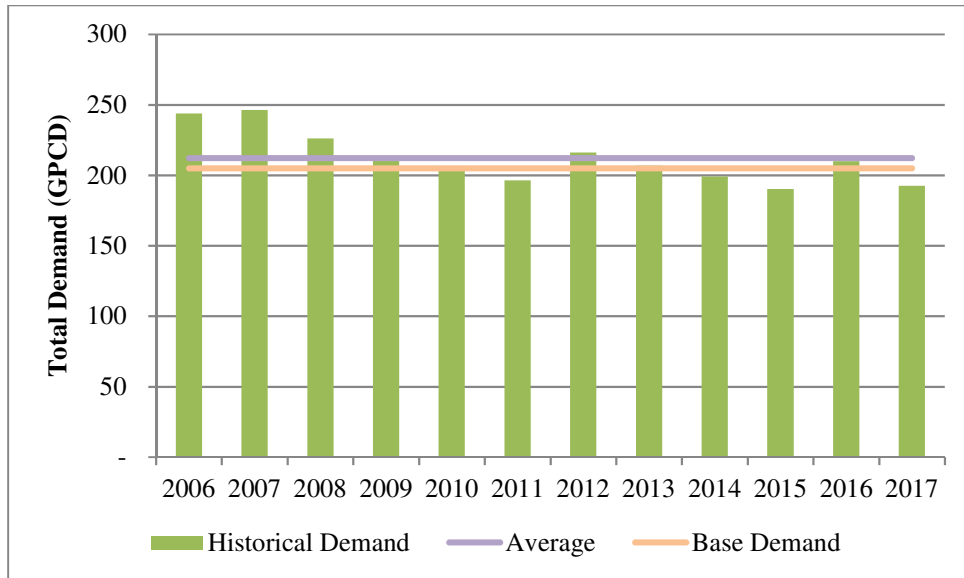


FIGURE 29. HISTORICAL DEMAND BASED ON POPULATION²²

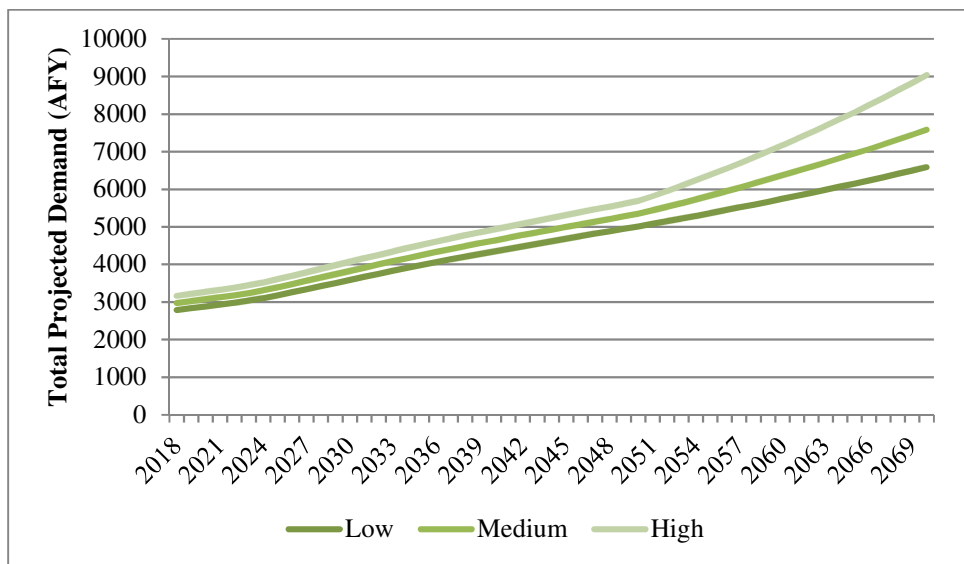


FIGURE 30. TOTAL PROJECTED GPCD-BASED DEMAND BASED ON GPCD APPROACH

Total projected demands were then disaggregated based on the average historical ratio of City/District production data to the total (Figure 31 and Figure 32). This assumes that the City and District water demands will grow at the same rate, and remain in the same relative ratios into the future. Based on historical production data, City demand is approximately 46 percent of the total, and the District is 54 percent of the total, which was fairly consistent over the 2006 to 2017 period. Using the gpcd method, City treated water demands are anticipated to grow from approximately 1,400 acre-feet per year to 3,500 acre-

²² Average demand is the average over the 2006 to 2017 period. Base Demand is the average over the 2009 to 2017 period, which was assumed to be more representative of current demands and as a result was used as the baseline for projecting future demands.



feet per year. District demands are anticipated to grow from approximately 1,500 acre-feet per year to 4,000 acre-feet per year.

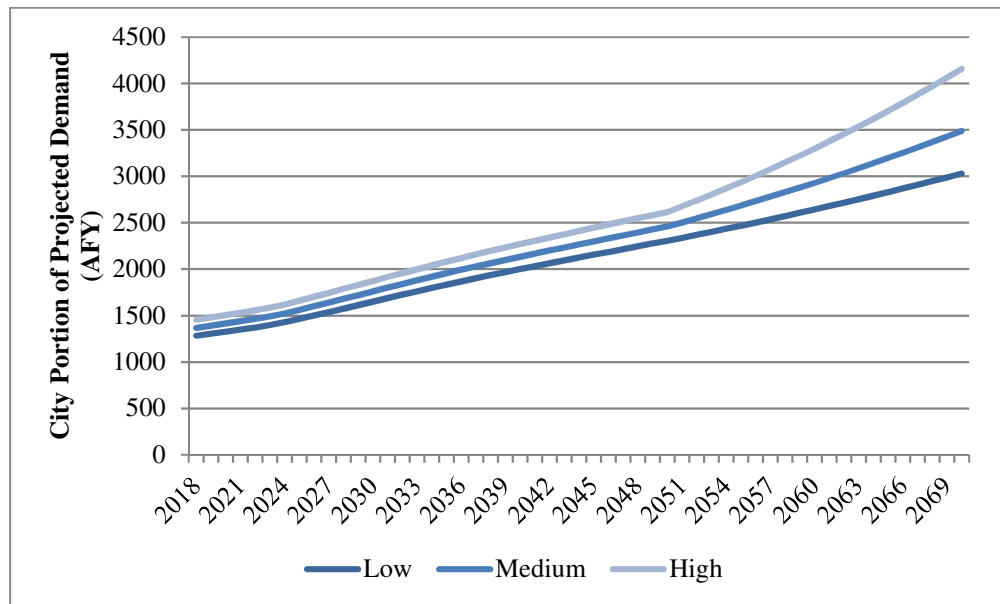


FIGURE 31. CITY PROJECTED TREATED WATER DEMAND BASED ON GPCD APPROACH.

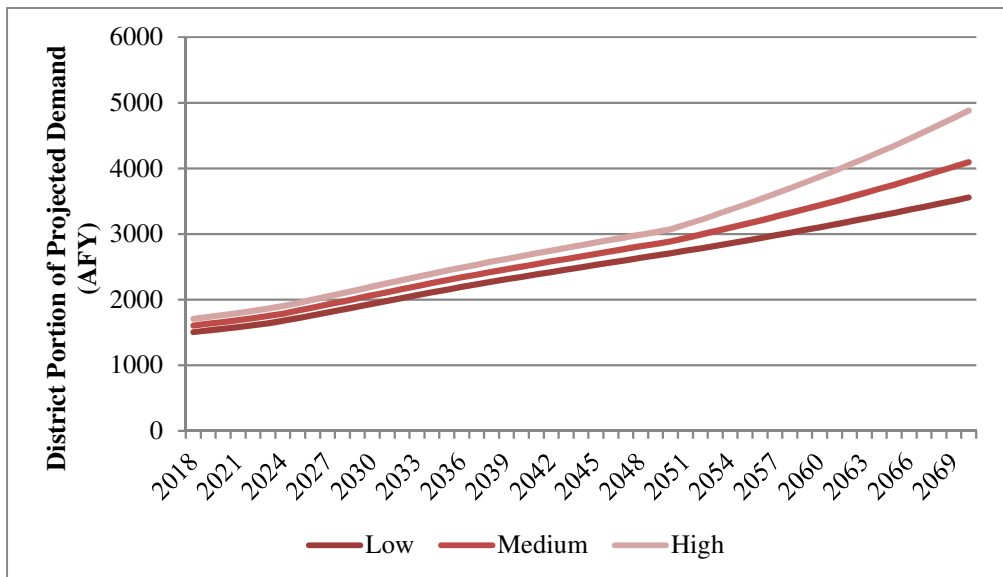


FIGURE 32. DISTRICT PROJECTED TREATED WATER DEMAND BASED ON GPCD APPROACH.



PROJECTED PEAK DAY TREATED WATER DEMAND RESULTS

Peak day demand was projected using the 2017 peak day demand as the baseline for scaling to project future peak day demand. The current sustained capacity of the Fish Creek and Yampa Wells water treatment plants is 9.3 MGD (i.e., 7.5 MGD from the Fish Creek water treatment plant and 1.8 MGD from the Yampa wellfield treatment plant as limited by current pumping capacity). This capacity would be exceeded by the projected peak day demand between 2040 and 2060, depending on which demand projection is utilized (Figure 33). The City and District have the ability to expand the total treatment plant capacity to 12 MGD at the Fish Creek plant plus 3.5 MGD at the Yampa Wellfield WTP²³ for a future total combined treatment capacity of 15.5 MGD. Peak day demand was projected to exceed the expanded 15.5 MGD combined treatment plant capacity after 2065 for all scenarios analyzed. This suggests that the City and District should plan to have additional water treatment capacity online as early as 2040, based on the highest projected peak day demand crossing the existing WTP capacity in approximately 2040. Additional consideration should be given to the distribution system constraints associated with supplying treated water to the WSSA. The current distribution system can supply treated water to the WSSA for up to approximately 800 EQRs²⁴. There are 592 existing EQRs in the WSSA including Steamboat II Metropolitan District, and a total of 4,306 EQRs anticipated in the WSSA including Steamboat II Metropolitan District (Table 8). Therefore, the City and District may need to consider additional treatment plant capacity and/or improvements to the existing treated water distribution system prior to 2040 depending on the rate of growth in the WSSA.

²³ Current Yampa River wellfield treatment capacity is 3.5 MGD, but the current Yampa River wellfield pumping capacity is limited to 1.8 MGD. As a result, it was assumed that the current Yampa River wellfield treatment capacity would be limited to the 1.8 MGD pumping capacity.

²⁴ Water and Wastewater Master Plan Updates for the City of Steamboat Springs. Prepared by McLaughlin Water Engineers. December 2009.



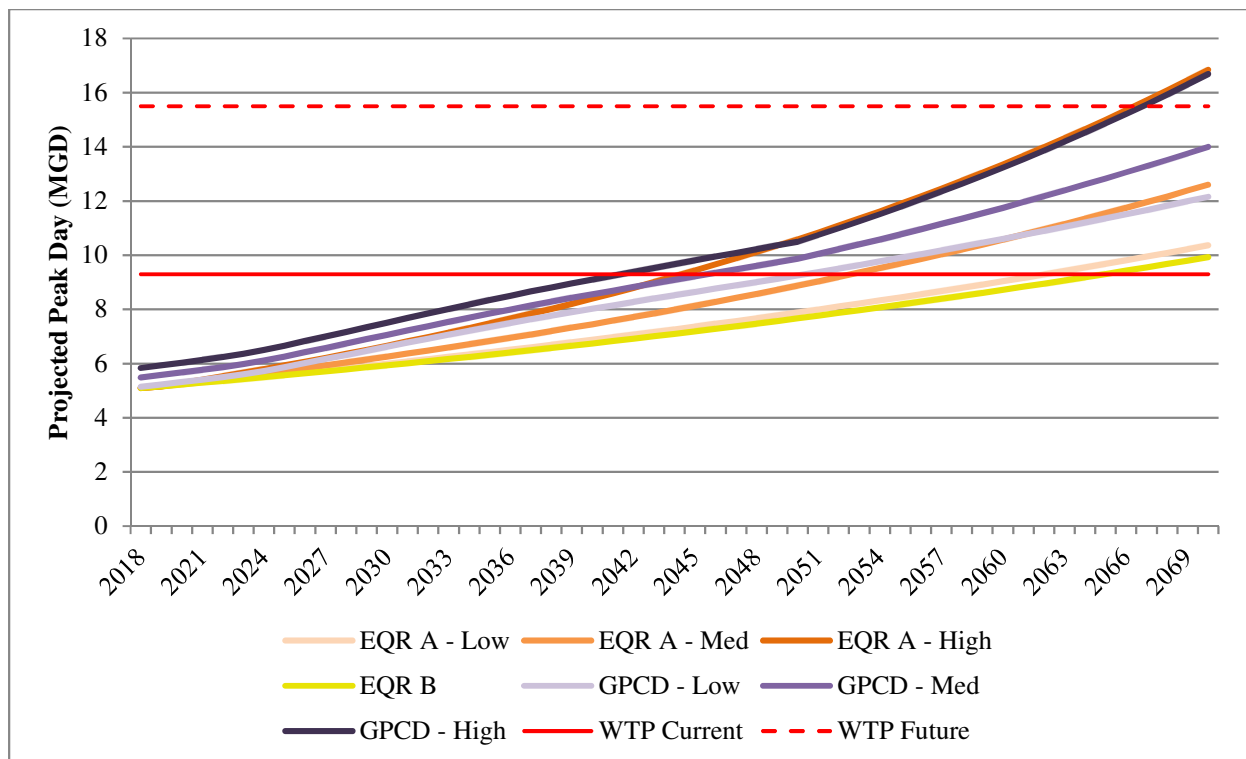


FIGURE 33. PROJECTED PEAK TREATED WATER DEMAND COMPARED TO WATER TREATMENT CAPACITY

EXISTING SUPPLIES

Treated water supply for the City and the District generally come from the 22 square mile Fish Creek watershed, and from Yampa River wellfields on the upstream side of town that have a drainage area of over 500 square miles. Fish Creek supplies are used to meet demands throughout the year, and the Yampa wellfields are primarily used to augment water supplies in the summer months. The Fish Creek basin provides approximately 90 percent of the total treated water demand for the City and District, with the other 10 percent coming from the Yampa River wellfields. The Fish Creek water supply originates from 58 inches of average annual precipitation on Buffalo Pass, with the majority of the supply coming from snowmelt that is used to fill Fish Creek and Long Lake Reservoirs.

The City and the District have storage capacity in the Fish Creek and Long Lake Reservoirs according to Table 9 below. The City can utilize all of its Long Lake Reservoir storage capacity, but can only utilize 61% of the storage capacity in Fish Creek Reservoir. The District has a contractual right to utilize the other 39% of the storage capacity in Fish Creek Reservoir. (Table 9). Portions of the enlargement capacity of Fish Creek Reservoir (2,280 AF) in Fish Creek Reservoir are subject to certain terms and conditions with the United States Forest Service (1,030 AF for use as an in-reservoir fishery pool) and the CWCB (200 AF to support the 2 cfs instream flow right decreed in Case No. 79CW104), but this water is available to the City and the District in the event of an emergency or drought.



TABLE 9. ALLOCATED STORAGE CAPACITY

Storage Facility	Storage Capacity (ac-ft) by Entity		
	Steamboat Springs	MWW District	Total
Fish Creek Reservoir	2,518.56	1,648.44	4,167
Long Lake	395.66	0	395.66
Total	2,914.22	1,648.44	4,562.66

In addition to their owned storage capacity in the Fish Creek basin, the City also leases water from Stagecoach Reservoir from the Upper Yampa Water Conservancy District (UYWCD). The District also leases water from Yamcolo and Stagecoach Reservoirs. (Table 10). These lease agreements for storage contracts in Yamcolo and Stagecoach Reservoirs expire in 2019, but have been extended until 2021 to allow the City, the District, and UYWCD to renegotiate them.

TABLE 10. LEASED STORAGE CAPACITY

Storage Facility	Leased Storage Water (ac-ft) by Entity			Release Period
	Steamboat Springs	MWW District	Total	
Yamcolo Reservoir ⁺	0	300	300	July 15 to March 1
Stagecoach Reservoir ⁺	552	200	752	July 15 to April 1
Total	552	500	1,052	

EXISTING WATER RIGHTS

Water rights owned by the City and the District generally include direct flow and storage rights in the Fish Creek basin, which are the primary source of treated water supply for the City and District. Storage rights in the Fish Creek basin (Fish Creek Reservoir and Long Lake) are critical for regulating snowmelt and meeting water demands throughout the year.

Water rights available to the City and District can be summarized as follows:

- **City of Steamboat Springs Water Rights**
 - Fish Creek basin direct flow rights that can be diverted at the Fish Creek WTP (Table 11).
 - Four Counties Ditch No. 1 water rights located above Fish Creek Reservoir. These water rights have an alternative point of diversion and storage at Fish Creek Reservoir, and can be used to fill and refill Fish Creek Reservoir.
 - Fish Creek basin storage rights: Fish Creek Reservoir storage rights with varying priority dates from the 1940s to 1990s, and Long Lake Reservoir with a 1946 adjudication date. Long Lake Reservoir is administered as being senior to the 1922 Colorado River Compact, because it was appropriated in 1914 and completed in 1918. In the Fish Creek basin, the City has a total storage capacity of 2,914.22 acre-feet (2,518.56 acre-feet in Fish Creek Reservoir, plus 395.66 acre-feet in Long Lake), of which 2,177.85 acre-feet is available under all conditions. (Table 13).
 - Water rights that are associated with the City's Municipal Well A near the Yampa River include a 6.67 cfs junior 1990 water right, a decreed alternate point of diversion for 0.0813 cfs, and 0.5 cfs of the senior Hoyle and Knight Ditch (1892) that can be used to augment out-of-priority depletions at the wellfield by exchange (Table 12).
 - Soda and Spring Creek direct flow rights include a series of early 1900s water rights senior to the Colorado River Compact, and also storage rights on Spring and Soda Creeks totaling 32.13 acre-feet of storage capacity.



- Conditional direct flow diversion for 8.0 cfs on Elk River with a 1999 priority date.
 - Other direct flow and storage water rights that are mostly used to meet some of the City's raw water demands. For example, many of these rights are used for raw water irrigation, snowmaking, and other uses.
- **Mount Werner Water and Sanitation District Water Rights**
 - Table 11 summarizes certain direct flow water rights exercised by the District through the Fish Creek Filtration Plant. This table is not intended to be an exhaustive description of the District's Fish Creek water rights or the terms and conditions under which the District may exercise those rights, but rather to present a summary of the water rights relied upon for purposes of this study.
 - Yampa Wellfield rights for 6.78 cfs with a 1990s priority date (Table 12).
 - Storage rights –The District has a contractual right to 1,648.44 acre-feet of storage capacity in Fish Creek Reservoir, of which 759.15 acre-feet is available under all conditions. (Table 13).

TABLE 11. FISH CREEK DIRECT FLOW WATER RIGHTS AVAILABLE FOR DIVERSION AT FISH CREEK TREATMENT PLANT

Priority	Water Right	Adjudication Year	Amount		Decreed Uses ¹
			City	District	
1	Hoyle & Knight (1892)	1892	2.0	4.8 ²⁵	2
2	Welch & Waters (1904)	1904	1.33	1.71	12356789Q
3	Hoyle & Knight (1911)	1911		0.56	2
4	Welch & Waters (1912)	1912		3.42	123568
5	Fish Crk Pipeline	1923	1.5		2789Q
7	Batton	1953	3.0		18
8	Batton	1953	3.7		18
12	Fish Creek Flowline (1972)	1972	3.5		128
13	Mt Werner Pipeline	1972		3.86	123568
	Total		15.03	14.35	

Notes:

¹ Decreed Uses: 1=Irrigation, 2=municipal, 3=commercial, 5=recreation, 6=fishery, 7=fire, 8=domestic, 9=stock, 9=power generation, Q=Other.

²⁵ District has 5.8 cfs decreed rate under the Hoyle & Knight 1892 right. Of this rate, 4.8 cfs can be diverted at the Fish Creek WTP. An additional 0.5 cfs is bypassed under W-959 but can be diverted for emergency municipal supply. The other 0.5 cfs remains decreed for irrigation use, but may be changed by the District for municipal use in the future.



TABLE 12. YAMPA WELLS WATER RIGHTS SUMMARY

Entity	Amount (cfs)	Decrees	Volumetric Limit (ac-ft/yr)	Capacity ⁵ (MGD)	
				Current	Future
City	6.67 ¹	90CW160	2,800 ³	0.8 MGD	1.8 MGD
	0.5 ²	CA 9/22/1892			
	0.0813	W-915-75			
District	2.29	90CW159	-- ⁴	1.0 MGD	1.7 MGD
	2.69	CA-3926			
	1.8	83CW225			

Notes:

¹ The City's decreed rate under Case No. 90CW0160 includes a 2.0 cfs absolute right and a 4.67 cfs conditional right.

² 0.5 cfs used to augment Municipal Well A per the decree in Case No. 09CW62.

³ The decree in Case No. 09CW62 allows up to 2,800 acre-feet per year.

⁴ There may be annual pumping limits in the District's well permit that could limit the annual volume of water pumped from the District's Yampa River wellfield. The District can also divert at these wells using other senior water rights.

⁵ Yampa River wellfield capacity is based on pumping capacity, which is the limiting factor. Current treatment capacity (3.5 MGD) is higher than current pumping capacity (1.8 MGD).

TABLE 13. FISH CREEK RESERVOIR CAPACITY ALLOCATION

FISH CREEK RESERVOIR CAPACITY ALLOCATION (acre-feet)				
		CITY	DISTRICT	TOTAL
Original Pool	--	1,842.06	--	1,842.06
Enlargement Pool	Amount Subject to City/Mt Werner Agreement (27.7%/72.3%)	631.56	1,648.44	2,280
	Amount Subject to Fisheries Pool	285.31	744.69	1,030
	Amount Subject to CWCB Agreement	55.4	144.6	200
	Amount Not Subject to City/Mt Werner Agreement	44.94	--	44.94
	Amount Not Subject to Fisheries Pool/CWCB	335.79	759.15	1,094.94
	Usable Amount if Drought/Emergency	676.50	1,648.44	2,324.94
Total		2,518.56	1,648.44	4,167



ESTIMATE OF PHYSICAL YIELD FOR EXISTING SUPPLIES

Estimates of the physical available yield of the Fish Creek basin and Yampa Wells (i.e., the two current sources of water supply for the City and District) were updated for this study using the Raw Water Supply Model developed for this study. The potential yield for the City's Elk River water right was also modeled with the constraints described below.

FISH CREEK BASIN YIELD

Physical yield from the Fish Creek water treatment facility (i.e., treated water delivered from the facility) was determined using the Raw Water Supply Model developed for this study. Previously in the 2008 Water Supply Master Plan²⁶, the Fish Creek basin firm yield was determined by scaling the monthly demand pattern to a peak day demand of 33 cfs (i.e., the total Fish Creek direct flow water rights for the City and District that can be taken at the Fish Creek treatment plant), which resulted in an annual demand of 14,221 acre-feet per year. For this study, the current (2017) demands in Table 6 were scaled up to match the 14,221 acre-feet per year annual total demand from the previous 2008 Water Supply Master Plan, resulting in the monthly demands in Table 14. This scaled up monthly demand pattern was input to the Raw Water Supply Model developed for this updated Water Supply Master Plan to determine Fish Creek basin yield over the 1999 to 2018 modeled period of record. Additional constraints applied were:

1. There were no diversions at the Yampa Wellfield, leaving all the City and District treated water demand to be met from the Fish Creek Water Treatment Plant.
2. Diversions at the Fish Creek water treatment facility were limited by:
 - a. 7.5 MGD (11.6 cfs) water treatment plant capacity (6.96 cfs City/4.64 cfs District)
 - b. 29 cfs²⁷ active water rights for the City and District (i.e., those rights decreed for diversion at the Fish Creek water treatment plant).
3. City and District demands were modeled separately.

TABLE 14. SCALED TREATED WATER DEMANDS USED TO DETERMINE FISH CREEK BASIN FIRM YIELD

	Monthly Demand (ac-ft)		
	City	District	Total
January	367	513	881
February	342	477	819
March	368	524	892
April	330	320	650
May	445	431	875
June	798	871	1,669
July	951	1,236	2,187
August	911	1,141	2,052
September	755	879	1,633
October	450	398	848
November	414	347	761
December	458	497	955
Total	6,587	7,634	14,221

²⁶ Steamboat Water Supply Master Plan. November 2008. Stantec.

²⁷ Includes the 15.03 cfs for the City in Table 11, the 14.35 cfs for the District in Table 11, and the 0.5 cfs additional bypass flow available to the District for emergency municipal supply.



Total annual yield ranged from approximately 7,800 to 10,450 acre-feet per year, resulting in an updated firm yield estimate of 7,800 acre-feet per year (Figure 34). Firm yield is a term used to represent the minimum anticipated yield from a water supply over a period of time. In this case, the firm yield was based on the yield for 2003, which was influenced by the 2002-2003 drought that was of historical significance as one of the worst droughts in Colorado over the last several decades.

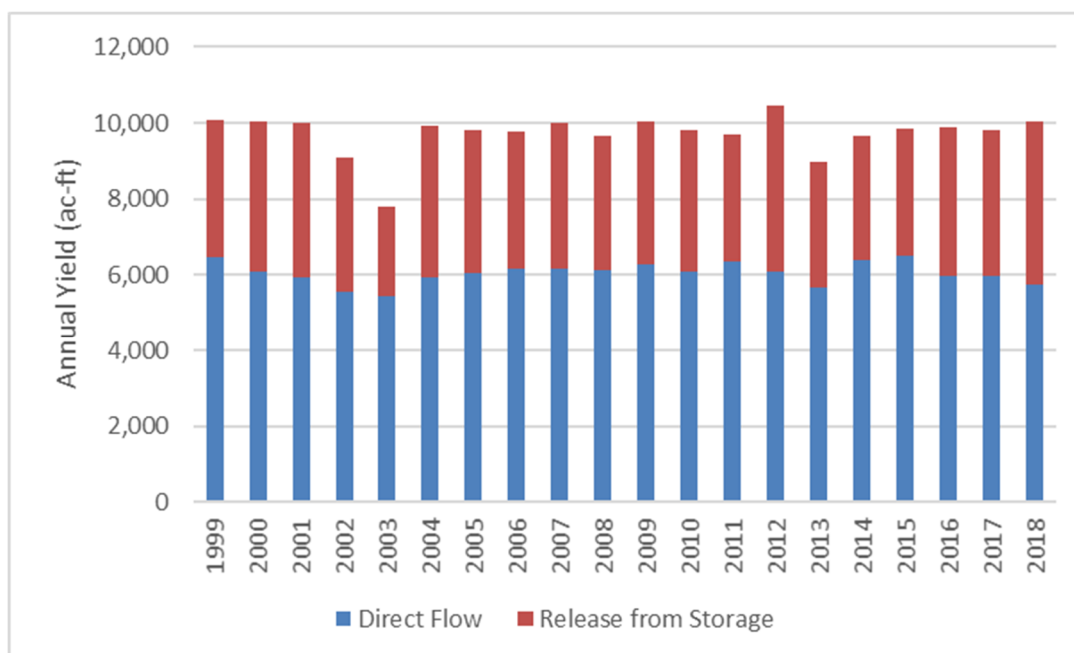


FIGURE 34. FISH CREEK BASIN ANNUAL YIELD SIMULATED WITH MAXIMUM DEMANDS FOR FIRM YIELD

YAMPA WELLS YIELD

Physical yield for the Yampa Wellfields is generally limited by the well capacities and water rights for the wells, but not by physical availability alluvial groundwater that is driven by Yampa River streamflows. Yampa River wellfield yield was estimated based on the current and future pumping capacity (Table 12) and the City's annual volumetric limit of 2,800 acre-feet per Case No. 09CW62. Pumping throughout the year was assumed to determine the potential yield, and it was assumed Yampa River physically available flows would not limit the potential yield. Total potential yield for the City and District Yampa River Wellfields could range from 2,017 acre-feet per year at the current 1.8 MGD capacity, up to 3,922 acre-feet per year at the expanded 3.5 MGD capacity²⁸ (Table 15).

TABLE 15. YAMPA WELLFIELD YIELD

Wellfield Capacity Scenario	Wellfield Yield ¹ (ac-ft)		
	City	District	Total
Current (1.8 MGD)	896	1,121	2,017
Future Expanded (3.5 MGD)	2,017	1,905	3,922

Notes:

¹ City and District yields were determined based on current and future wellfield pumping capacity, and assume Yampa River wellfield treatment capacity would be equivalent to wellfield pumping capacity.

²⁸ The current Yampa River wellfield treatment plant capacity is 3.5 MGD, but the associated wellfield pumping capacity is 1.8 MGD, with plans to expand to 3.5 MGD.



ELK RIVER YIELD

Potential yield for the City's 8 cfs conditional Elk River water right is modeled in the Raw Water Supply Model developed for this study. The City's treated water demands were scaled up to a max peak day of 8 cfs to match the conditional Elk River water right, resulting in the monthly demand distribution shown in Table 16²⁹. This scaled up demand was then applied in the Raw Water Supply Model, with all of the scaled City demand being applied at the proposed Elk River water treatment plant. It was assumed that an Elk River water treatment plant would have a capacity to treat the full 8 cfs (5.17 MGD) of the City's Elk River water right. Based on these assumptions, the Elk River demand was modeled over the 1999 to 2018 period and showed annual yield ranging from 1,826 acre-feet to 3,196 acre-feet (Figure 35).

TABLE 16 . CITY'S MONTHLY DEMAND FOR 8 CFS PEAK DAY DEMAND

	City Monthly Treated water Demand (ac-ft)		
	Indoor	Outdoor	Total
January	174	0	174
February	162	0	162
March	176	0	176
April	128	0	128
May	132	40	173
June	142	187	329
July	172	259	431
August	175	229	405
September	186	136	322
October	167	0	167
November	150	0	150
December	188	0	188
Total	1,953	852	2,805

²⁹ City's current max daily demand from 2017 demand was 3.77 cfs. All 2017 daily data were scaled by a factor of 2.1 (8.0 cfs divided by 3.77 cfs).



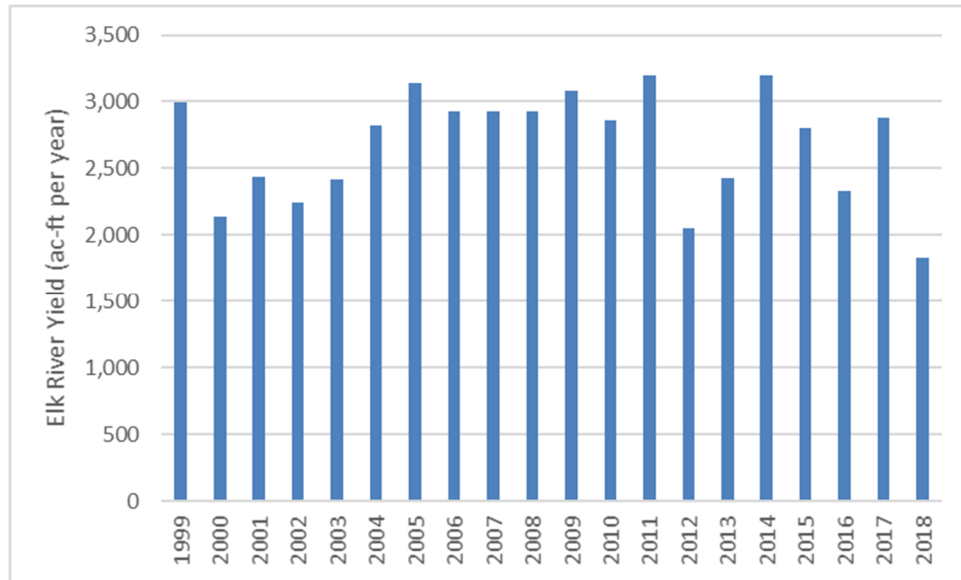


FIGURE 35. ELK RIVER YIELD FOR CITY DEMANDS

ABILITY TO MEET FUTURE TREATED WATER DEMANDS

A WSMP Treated Water Model was developed to assess the City and District existing water rights and the associated ability to meet projected treated water demands. System stressors (e.g., wildfire, climate change, Colorado Compact call, growth) were incorporated into the model to assess the range of impacts on the ability to meet customers' treated water demands. Potential shortages are summarized for several possible system stressors. An incremental action plan for the City and District was then developed to summarize alternatives for meeting future demands with the highest resiliency to address system stressors.

OVERVIEW OF THE RAW WATER SUPPLY MODEL

An overview of the Raw Water Supply Model is provided in this section, with a more detailed documentation of the model included in **Appendix C** to this report.

The model simulates the City and District's treated water demands through a drought period. The model uses two study periods that incorporate wet, normal, and drought years to show how the water system may behave under various hydrologic conditions. The model operates on a daily basis over a 20-year period. There are two sets of hydrology, one for water years 1999-2018, and another from 1143-1162, the period with the worst drought in the paleo-hydrology developed from tree-rings.³⁰ The model only tracks treated water use, and includes the ability to add park raw water irrigation demands to the treated water demand modeled. The model includes physical and legal flows, as well as storage in various reservoirs.

To provide a familiar user interface, the model was built in MS Excel. To make the model logic as easy as possible to follow, all calculations are made using formulas rather than macros. The model has several sheets containing input data, including physical inflows, demands, water rights, and fixed data such as

³⁰ <https://www.treeflow.info/content/tree-rings-and-streamflow>



reservoir area-capacity curves. While some preparatory calculations are completed on these input data sheets, the mass-balance calculations are all done on the Calculations sheet.

The model starts with the daily flows physically available at each diversion point. These flows are allocated to the City and District based on water rights. These physically and legally available flows are then diverted to meet demand, stored, or bypassed to the stream. Diversions are limited first to daily demand and second to the physical diversion capacity. Diversions to storage are limited to the available reservoir space. The model assumes that the City and District's water supply systems operate in an independent manner where for instance, yields from the City's water rights would never be used by the District and vice versa. This is a conservative approach because there could be opportunities in the future to cooperatively operate their supplies to meet demands (e.g., water leasing arrangements). As a result, physical supplies, water rights, and storage space that is unused by one entity is not available for use by the other entity.

The user interface on the Calculations and Conservation sheets has dropdown boxes which allow the user to select from a range of model variables. This allows the user to see what the normal range is for each user input, and also eliminates the possibility of entering a variable in an incorrect input format (e.g., text rather than a number) or unit (e.g., MGD rather than cfs). The values for the dropdown boxes are located to the right of the user input section, and can be modified by the user if different or additional options are required.

To help users follow the logic of the calculations, comments are included in the column headers to explain how or why the calculations were made. The formulas use named ranges rather than just cell references to make it easier to follow the calculations. This is particularly helpful for formulas that reference cells that are not adjacent the cell with the formula, particularly cells and ranges on other sheets. It also helps with QA/QC because it allows subsequent users to understand the intended calculation and give more information besides just the cell references.

MODEL INPUTS

Dry Hydrology and Climate Change

The model operates on a daily basis for water years 1999-2018 using historical data, and for years 1143-1162 that were constructed from tree-ring data.³¹ Both data sets include drought periods, which are preceded and followed by two average years to show how the system enters and recovers from the drought period.

Based on annual flows from tree-rings, the drought of the early 2000s has a recurrence interval of 150 years, and the drought of the 1150s has a recurrence interval of 1000 years. Because of the uncertainty of the impact of warmer temperatures on hydrology in the high mountains, the drought of the 1150s is used as a surrogate for future conditions considering climate change.

Multiple Demand Levels

As explained in the Projected Demands section, daily demands are based on 2017 historical data and scaled up for future demand projections based on a range of potential growth in Steamboat Springs. Using population projections from the Colorado Department of Local Affairs, demands were calculated for the future years through 2070. The model scenario controls include the ability to model demand levels at five-

³¹ <https://www.treeflow.info/>



year increments between 2020 and 2040, and ten-year increments from 2040 through 2070. Model scenario controls also provide the ability to select from the low, medium, and high growth rates (described above in the Demands section). The demand scenarios included in the model were based on the population-scaled EQR projection approach (i.e., EQR-A) described in the Projected Demands section³².

There are two adjustments the user can make for conservation scenarios: the percent reduction in overall demand compared to current (2017) demands, and the year this percentage reduction is targeted to be achieved. On the Conservation Controls sheet the user can also set the conservation percentages for different types of savings (non-revenue water, additional passive savings beyond what is being experienced in 2017, active conservation savings) in the “Goal Breakdown” settings. However, these values are currently set by formulas and not dropdowns where the values are limited to certain values, the user must be careful when changing the values to make sure that the sum of the savings in different areas (e.g., indoor active, indoor passive, and outdoor) equals the total target selected. Graphics on the Conservation Controls sheet show the reductions in demands and achieved per capita demand over time. On the Scenario Controls sheet there is also a dropdown that allows for additional reductions in treated demand associated with outdoor irrigation in response to drought. For simplicity, these savings are not applied to just the below-average years, but to the entire modeled period.

Water Rights Curtailments

The model has settings for both a Colorado River compact call and a local District 58 call.

When the compact call is on, all rights with administration dates more recent than November 24, 1922, become unavailable for diversion, though water already stored under post-compact rights is released to meet demand. The Division 6 Engineer uses appropriate dates to assess water rights seniority to the Colorado River Compact. There is an option in the model to simulate this practice by the Division Engineer practice, where the user can simulate water rights based on their appropriation dates rather than the adjudication dates. The compact call can be turned on starting when the drought begins or for the entire period of record. By default, the compact call is assumed to be in place for five years, though the period is adjustable by the user on the right-hand side of the Scenarios Control sheet. The City owns seven rights that were appropriated before 1922 but adjudicated after that date. Of those, the Fish Creek Pipeline and the Long Lake storage right provide water for direct treated water use. While these water rights should be administered as senior to the Compact because they were appropriated before November 24, 1922, the model includes a control that lets the user choose whether rights like these are considered pre-compact or post-compact. This control allows the user to simulate a conservative scenario to determine what the potential effects would be if the seniority was administered by adjudication date rather than the current practice of administration by appropriation date.

The model also allows the user to place a District 58 call on the river. This control allows the user to select the day, month, and year when a call begins and ends, and curtails diversions of water by rights junior to the selected date during that period for the entire modeled period. Setting the priority date for the District 58 call as November 24, 1922, and turning it on for the entire year has the same effect as setting the compact call control on for the entire modeled period.

³² The EQR-A method was determined to be the most applicable projection method based on review of other entities like Steamboat Springs that are influenced by visitor population.



ADDITIONAL SYSTEM STRESSORS

Besides growth and water rights curtailments, the City and District may experience other stressors on their water supply system. This includes wildfire in the Fish Creek watershed, various instream flow requirements, and an increase in demand from switching parks currently irrigated with raw water supplies to demand on the treated water system.

The model simulates a wildfire in the watershed by curtailing diversions during the summer months following a fire. It includes four different levels of progressively larger curtailment. These include:

- Mild – three months curtailment for a single year;
- Moderate – four months of curtailment for Year 1, and a five-month curtailment for Year 2;
- Severe – five months of curtailment for Year 1, six and a half months for Year 2, and four months of curtailment for Year 3; and
- Extreme – six months of curtailment for Year 1, seven- and one-half month curtailment for Year 2, a six-month curtailment for Year 3, and three-month curtailment for Year 4.

These forgone diversions are shown graphically in Figure 36.

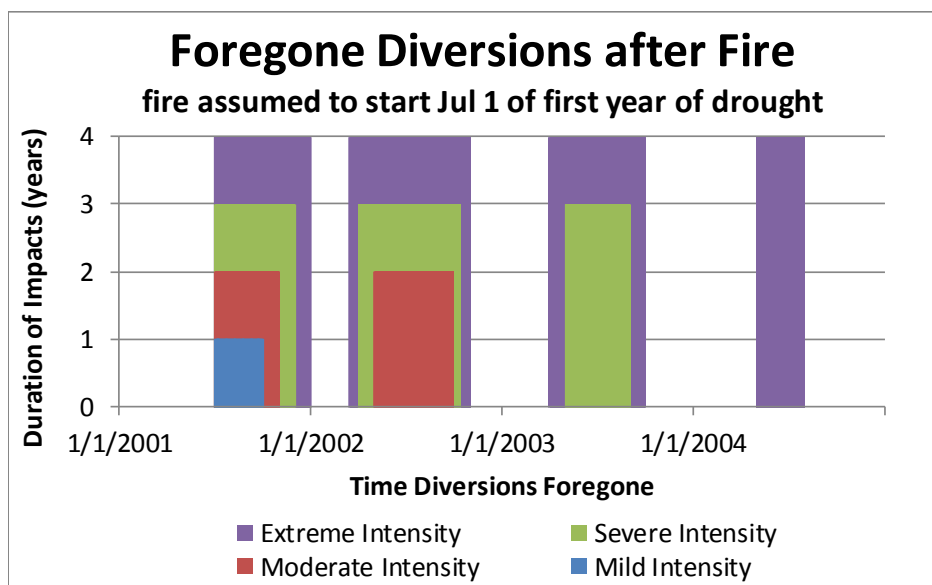


FIGURE 36. FROM FIRE EFFECTS SHEET IN MODEL.

The CWCB holds a decreed instream flow right for 2 cfs on Fish Creek between the Fish Creek Water Treatment Plant and the confluence with the Yampa River. The District dedicated some additional water rights to the CWCB in Case No. W-959, but there is disagreement on whether the CWCB has legally changed those dedicated rights to instream flow water rights. To allow the user to determine the sensitivity of the system's yield to various levels of instream flows on Fish Creek, the model can be set to one of three different levels of instream flow: no instream flow, 2.0 cfs, or 9.1 cfs instream flow. There is also a 0.5 cfs bypass right decreed in W-959, which the District can divert for emergency municipal supply. This 0.5 cfs bypass right is included in the model's toggle for "Fish Creek Instream-Flow", although it should be noted that the 0.5 cfs is not a decreed instream flow right that can only be decreed to the Colorado Water Conservation Board.

The City currently irrigates some of its parks with raw water diverted from local streams. It has considered converting these parks to be irrigated with treated water to reduce operational problems caused by high



sediment levels and insufficient supply in the late summer. The model has a switch that increases the City's demand by the amount of water currently supplied from its raw water systems. This existing raw water supply is kept constant throughout the model period, and assumed not to grow over time based on input from the City and District.

SYSTEM MODIFICATIONS

In addition to various settings to stress the system, the model also has options for increasing the water available to the City and District at the Yampa Wells, the Fish Creek WTP, and an intake on the Elk River. This is done by allowing the user to input increased capacity at these diversion points up to rates that are currently envisioned by the City and District.

The Yampa wells currently have a pumping capacity of 1.8 MGD and operate during the summer months to provide supplemental water to the City and District's treated water systems. The model has controls to set the diversion rate of the wells (off, 1.8 MGD current, and 3.5 MGD future expanded capacity), the time period when the wells pump, and the priority for pumping the wells (as a baseload plant before taking water from storage, as a supplemental plant after storage has been depleted 50%, and strictly as a supplemental source after storage has been exhausted).

The Fish Creek WTP has a current diversion capacity of 7.5 MGD, with the Raw Water Supply Model assuming 4 MGD going to the City and 3.5 MGD going to the District. This 60/40 City/District capacity split is based on the ownership of treatment capacity at the Fish Creek WTP, but it is our understanding that the City leases some of their ownership that results in a 50/50 split of the use of current treatment plant capacity. There are two other options: a capacity of 7.5 MGD with 3.75 MGD going to each entity, and an expanded capacity of 12 MGD with 6 MGD going to each entity.

The City has a conditional water right for 8 cfs on the Elk River, and the model has a control that allows this potential diversion to be turned on. Water from the Elk River diversion is only used to meet the City's demand. While reducing the City's demand for water at the Fish Creek WTP could increase the District's supply, as described above this model strictly enforces the allocation of water and facilities, and does not allocate the unused water or capacity of one entity to the other.

MODEL OUTPUTS

There are two aspects to the model's output: one associated with how conservation affects the need for future treatment capacity, and the other that shows reservoir contents and system shortages under various system configurations.

Adjusting the conservation targets on the Conservation Controls sheet modifies the graphs below the controls on the left side of the sheet, and allows the user to compare future demands four ways:

1. Growth in annual demand with and without passive and active conservation.
2. Growth in the peak day demand compared to the current treatment plant capacity.
3. Treated water demands per EQR over time.
4. Treated water demand per EQR vs the historical demands for the most recent 12 years.



The last two graphs in particular provide a reality check about how demand goals would compare to recent historical demands. It should be noted that the controls on the Conservation Controls sheet are duplicated on the Scenario Controls sheet, and that changing a control on one sheet changes it on the other.

Once the demand levels and conservation targets have been selected, the model can quantify the timing, duration, and volume of shortages, as well as how storage fluctuates in the various reservoirs during the modeled periods. The City and District reservoir contents, demands, deliveries, and shortages are shown graphically to the right of the controls on the Scenario Controls sheet, and there are tables of City and District shortages by month - in both acre-feet and millions of gallons - below the graphs. The graphs provide a quick summary of system performance, while the tables are valuable for determining which months shortages occur. For example, consider Table 17, which shows the shortages for both the City and District for the existing system but with 2070 demands. The consistently repeated shortages for the City imply a limitation in the diversion or treatment capacity, whereas the varied shortages for the District at the same time of year implies a limitation in the physical or legal supply. Some of the output figures available in the model are:

- Simulated reservoir storage contents plots are available output in the model. For example, Figure 37 shows how the City and District storage in Fish Creek Reservoir fluctuates over the 21-year model simulation period. As shown, Fish Creek Reservoir contents fluctuate each year as the City and District pull from their respective storage accounts in summer months to meet outdoor demands, and that the storage accounts typically refill each year during runoff with the exception of the drought of 2002 to 2003 when the storage accounts did not refill. Similar simulated storage contents plots are available for Long Lake (City only), Stagecoach Reservoir (City and District), and Yamcolo Reservoir (District only).
- Daily shortages plots by City and District (Figure 38) is provided to summarize the range of demands that cannot be met under user-selected demand and conservation levels. This plot can be used to approximate additional treatment plant capacity that is required at future demand levels. Figure 38 summarizes shortages for a constant (2070) demand level, over a range of hydrologic conditions (1998 to 2018).
- Peak day demand over a range of growing demands (Figure 39) is provided to give a tool that can estimate the timing for when additional treatment plant capacity will be needed. This plot includes a range of hydrologic conditions over the 21-year simulation period, and also includes growth of treated water demands over time. It is shown that the existing water treatment plant capacity of 9.3 MGD (7.5 MGD at the Fish Creek Water Treatment Plant, plus 1.8 MGD pumping capacity at the Yampa Wellfield) will be exceeded in approximately 2053 given user-selected assumptions for conservation and growth rate.



TABLE 17. SHORTAGE FOR EXISTING SYSTEM WITH 2070 DEMANDS

Shortages - City of Steamboat Springs (af/m)													
Water yr	10	11	12	1	2	3	4	5	6	7	8	9	Total
1998	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	1	14	8	0	23
2000	0	0	0	0	0	0	0	0	1	14	8	0	23
2001	0	0	0	0	0	0	0	0	1	14	8	0	23
2002	0	0	0	0	0	0	0	0	1	14	8	0	23
2003	0	0	0	0	0	0	0	0	1	14	8	0	23
2004	0	0	0	0	0	0	0	0	1	14	8	0	23
2005	0	0	0	0	0	0	0	0	1	14	8	0	23
2006	0	0	0	0	0	0	0	0	1	14	8	0	23
2007	0	0	0	0	0	0	0	0	1	14	8	0	23
2008	0	0	0	0	0	0	0	0	1	14	8	0	23
2009	0	0	0	0	0	0	0	0	1	14	8	0	23
2010	0	0	0	0	0	0	0	0	1	14	8	0	23
2011	0	0	0	0	0	0	0	0	1	14	8	0	23
2012	0	0	0	0	0	0	0	0	1	14	8	0	23
2013	0	0	0	0	0	0	0	0	1	14	8	0	23
2014	0	0	0	0	0	0	0	0	1	14	8	0	23
2015	0	0	0	0	0	0	0	0	1	14	8	0	23
2016	0	0	0	0	0	0	0	0	1	14	8	0	23
2017	0	0	0	0	0	0	0	0	1	14	8	0	23
2018	0	0	0	0	0	0	0	0	1	14	8	0	23
Avg >0	0	0	0	0	0	0	0	0	1	14	8	0	23
total	0	0	0	0	0	0	0	0	12	282	153	8	455
Shortages - Mt. Werner Water District (af/m)													
Water yr	10	11	12	1	2	3	4	5	6	7	8	9	Total
1998	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	68	162	3	0	234
2000	0	0	0	0	0	0	0	0	9	73	0	0	82
2001	0	0	0	0	0	0	0	0	7	65	0	0	72
2002	0	0	0	0	0	0	0	0	0	1	0	0	1
2003	0	0	0	0	0	0	0	0	21	33	0	0	53
2004	0	0	0	0	0	0	0	0	45	55	0	0	101
2005	0	0	0	0	0	0	0	0	80	47	1	0	128
2006	0	0	0	0	0	0	0	0	22	131	1	0	154
2007	0	0	0	0	0	0	0	0	23	35	0	0	59
2008	0	0	0	0	0	0	0	0	76	106	0	0	182
2009	0	0	0	0	0	0	0	0	79	126	1	0	206
2010	0	0	0	0	0	0	0	0	27	152	4	0	182
2011	0	0	0	0	0	0	0	0	91	141	17	0	249
2012	0	0	0	0	0	0	0	0	0	28	0	0	28
2013	0	0	0	0	0	0	0	0	21	87	0	0	108
2014	0	0	0	0	0	0	0	0	60	128	8	8	205
2015	0	0	0	0	0	0	0	0	27	140	1	0	168
2016	0	0	0	0	0	0	0	0	38	99	0	0	137
2017	0	0	0	0	0	0	0	0	29	60	0	0	90
2018	0	0	0	0	0	0	0	0	3	13	0	0	16
Avg >0	0	0	0	0	0	0	0	0	38	84	3	4	117
total	0	0	0	0	0	0	0	0	729	1,683	35	8	2,455



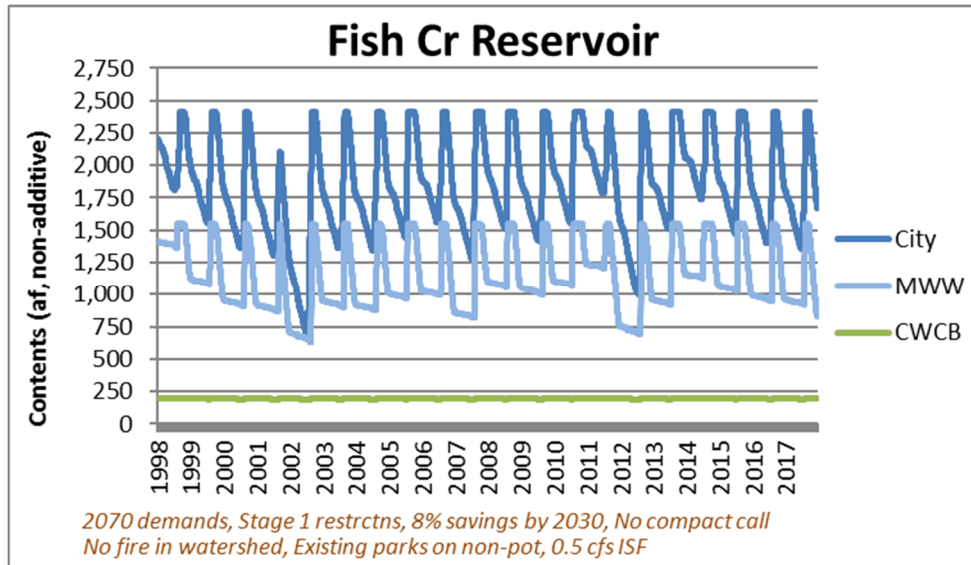


FIGURE 37. EXAMPLE PLOT FOR FISH CREEK RESERVOIR STORAGE CONTENTS³³

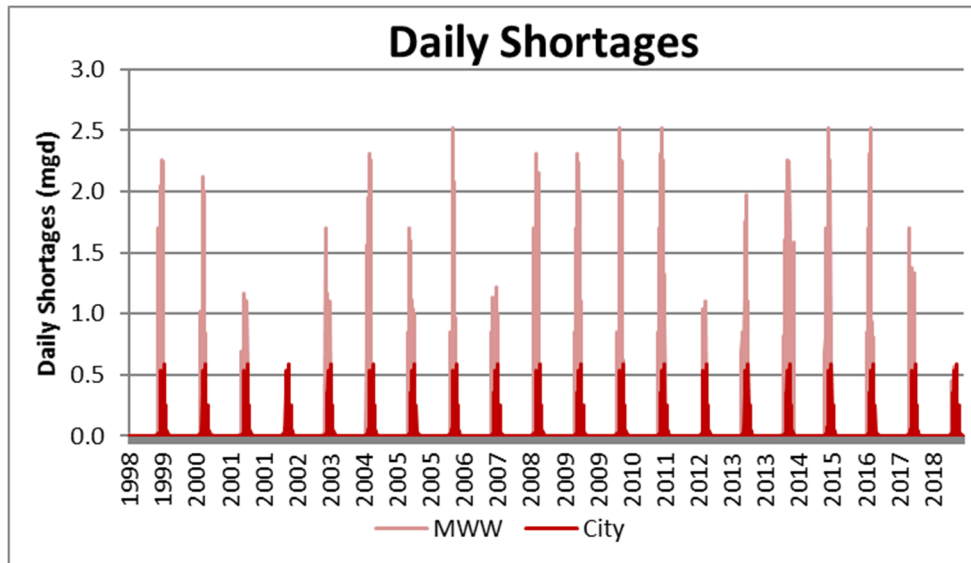


FIGURE 38. EXAMPLE PLOT FOR DAILY SHORTAGES AT 2070 DEMANDS³⁴

³³ The 0.5 cfs is a bypass flow for the District’s water rights available at the Fish Creek WTP, and is not truly an instream flow water right that can only be decreed to the Colorado Water Conservation Board. However, for the sake of simplicity it is labeled as an ISF in the plot.

³⁴ Daily shortages based on 2070 demands under the existing system (e.g., Yampa River wellfield pumping capacity of 1.8 MGD).



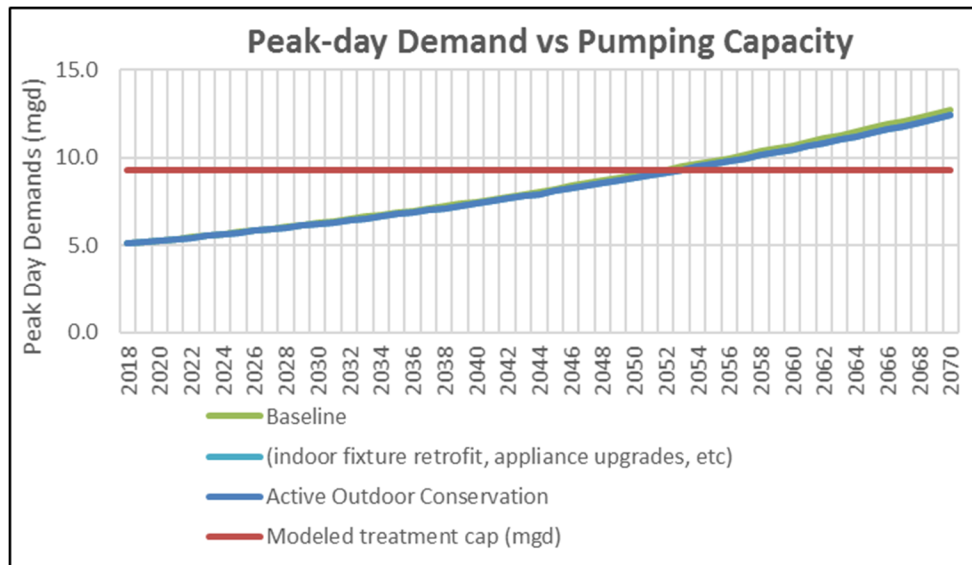


FIGURE 39. EXAMPLE PLOT FOR GROWTH OF PEAK DAY DEMAND

SUPPLY VS. DEMAND

ADEQUACY OF SUPPLY TO MEET ANNUAL DEMANDS

The projected maximum (2070) demands range from about 5,400 acre-feet to 9,200 acre-feet depending on the whether the low, medium, or high growth rate is assumed (Figure 40). This combined demand represents between 73 and 119 percent of the 7,800 acre-feet dry-year firm yield for the Fish Creek basin water supply described above. With the additional minimum 2,000 acre-feet per year yield of the Yampa Wellfields added to the Fish Creek basin dry-year firm yield, the combined demand ranges from 58 to 94 percent of the total combined supply of 9,800 acre-feet per year. This indicates that the City and District existing water supply is generally adequate to meet annual demands. However, it should be noted that system stressors such as wildfire and Colorado River Compact calls could impact the existing water supply to a point where the projected demands exceed the existing supply. These shortages from system stressors are more fully described below in the Shortages section.



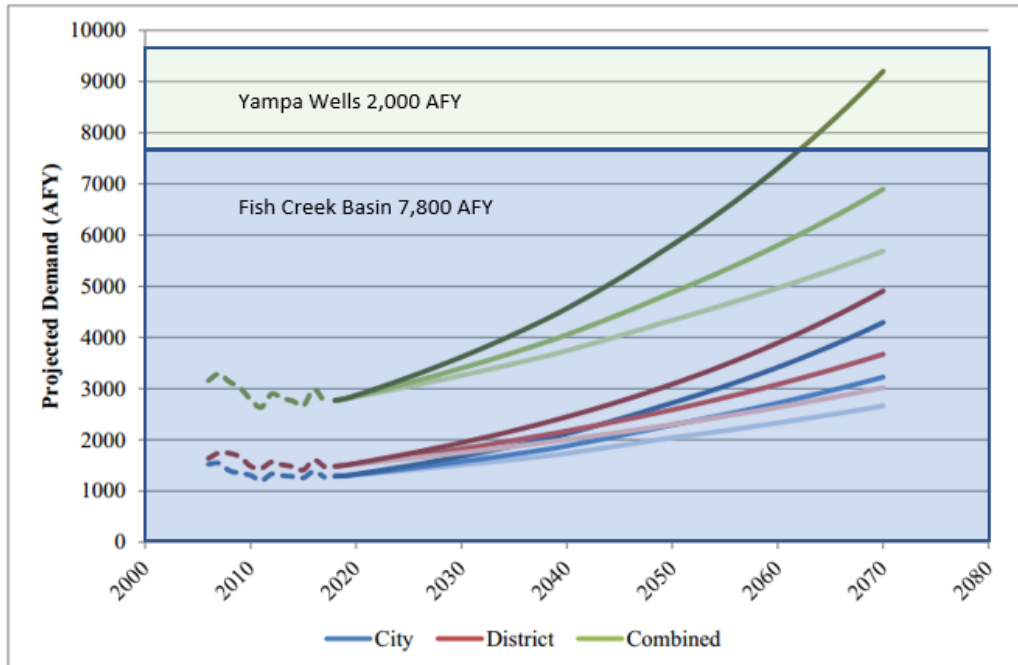


FIGURE 40. PROJECTED ANNUAL DEMANDS VS. FIRM YIELD³⁵

Note: the three shades of each color on the figure represent the low, medium, and high projected demands as calculated using the EQR A method described previously.

ADEQUACY OF SUPPLY TO MEET PEAK DAILY DEMANDS

Projected peak day demand was compared to the existing total City and District water treatment capacity to determine when additional capacity may be needed. The combined projected peak day demand was projected to exceed the existing 9.3 MGD water treatment capacity (7.5 MGD for the Fish Creek water treatment plant, plus 1.8 MGD for the Yampa Wellfields as limited by wellfield pumping capacity) between 2045 and 2063, using the population scaled EQR method (EQR-A) to scale current (2017) peak day demand (Figure 41). The combined projected peak day demand will likely not exceed the future 15.5 MGD water treatment plant capacity (12 MGD for the Fish Creek water treatment plant, plus 3.5 MGD for the Yampa Wellfields), with the possible exception near 2070 under the highest growth scenario.

³⁵ The Fish Creek Basin yield shown is limited by water rights, but not by current treatment plant capacity. Although annual demands indicate that yield from the Fish Creek Basin could meet current demands, the City and District operate the Yampa Wellfields to help meet peak summer demand.



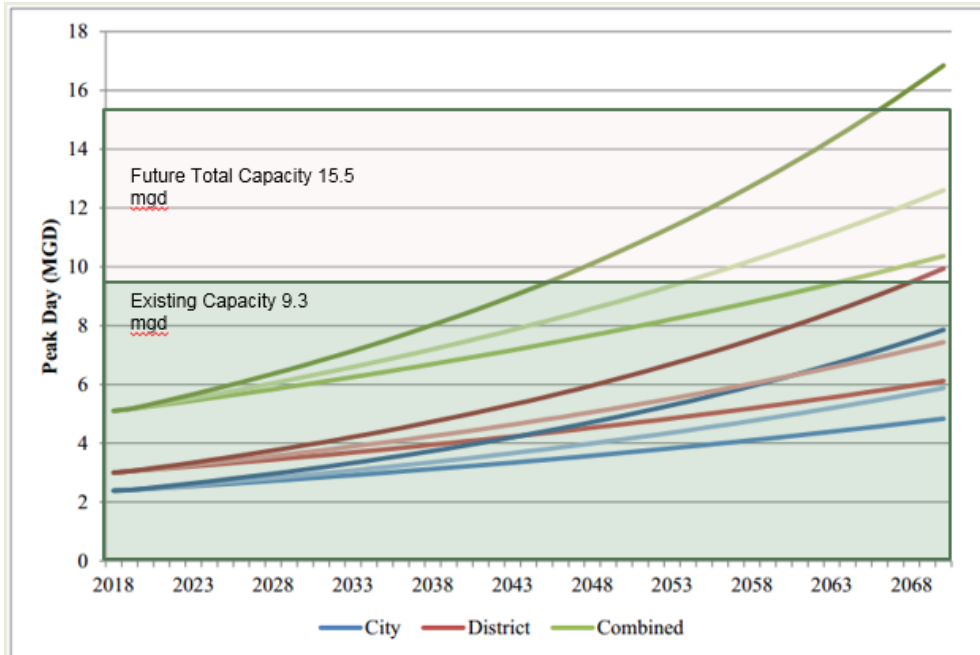


FIGURE 41. PROJECTED PEAK DAY DEMAND VS. TREATMENT PLANT CAPACITY

Note: the three shades of each color on the figure represent the low, medium, and high projected peak day demands as calculated using the EQR A method described in **Appendix B**.

SHORTAGES UNDER VARIOUS SYSTEM STRESSORS

With the various options available for each dropdown control, the model is capable of simulating countless system combinations. This report looks at four of the controls to evaluate the following individually:

1. Hydrology: the historical drought vs potential climate change represented by the paleo drought from 1143-1162 (the period with the worst drought in the paleo-hydrology developed from tree-rings³⁶),
2. Growth: future demands from 2020 through 2070,
3. A Colorado River Compact call, and
4. A fire in the Fish Creek watershed.

To determine the sensitivity of the City and District's systems to these stressors, the model was run 16 times, varying one stressor each time. Figure 42 shows the months of shortage and the total volume of shortage over the 21-year modeling period in Figure 43. These graphs show that both systems have growth, climate, and Compact call shortages under the 2070 demand levels, as well as under all the fire scenarios. The graphs also indicate that shortages would be greatest under a Colorado River Compact scenario. The output tables (Table 18 and Table 19) show that shortages under the fire scenarios occurs in July, August and September.

³⁶ <https://www.treeflow.info/content/tree-rings-and-streamflow>



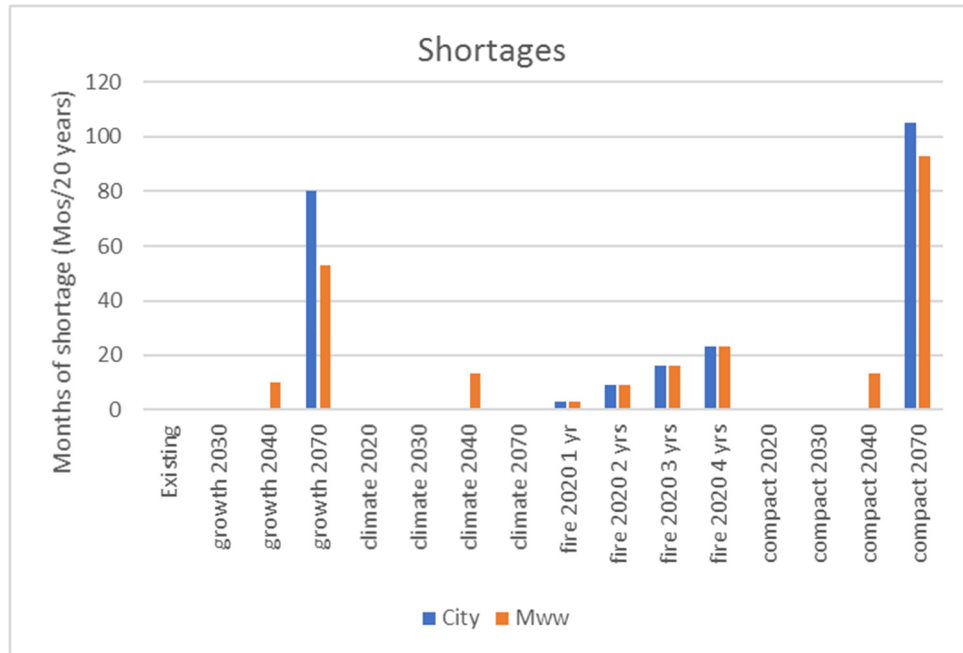


FIGURE 42. TOTAL MONTHS OF SHORTAGE BY SCENARIO

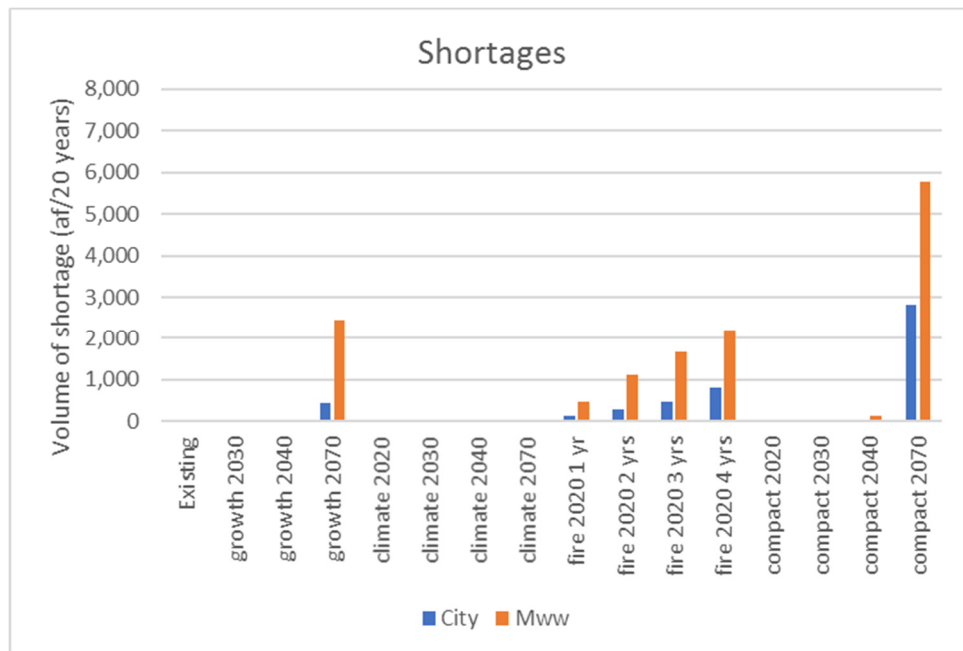


FIGURE 43. TOTAL SHORTAGE VOLUME BY SCENARIO



TABLE 18. CITY SHORTAGES UNDER A 1-YEAR 2020 FIRE SCENARIO

Shortages - City of Steamboat Springs (af/m)													
Water yr	10	11	12	1	2	3	4	5	6	7	8	9	Total
1998	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	217	197	139	554
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg >0	0	0	0	0	0	0	0	0	0	217	197	139	554
total	0	0	0	0	0	0	0	0	0	217	197	139	554

TABLE 19. DISTRICT SHORTAGES UNDER A 1-YEAR 2020 FIRE SCENARIO

Shortages - Mt. Werner Water District (af/m)													
Water yr	10	11	12	1	2	3	4	5	6	7	8	9	Total
1998	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	235	212	145	592
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg >0	0	0	0	0	0	0	0	0	0	235	212	145	592
total	0	0	0	0	0	0	0	0	0	235	212	145	592

The daily model calculations show that these shortages occur because the Fish Creek Intake is shut down, and there is not sufficient capacity in the Yampa Wells to supply the demands during the summer irrigation season. Adjusting the model parameters shows that this shortage can be eliminated by increasing the pumping capacity of the Yampa Wells to 3.5 MGD in combination with curtailing outdoor irrigation.



This analysis shows that the City and District’s most immediate threat to maintaining water supplies is a fire in the watershed that degrades the water quality enough that the Fish Creek WTP is unable to treat water to potable standards. The analysis also indicates that a Colorado River Compact call would have the most significant long-term impact on shortages for the City and District, but would not have any impact on short-term demands over the next approximately 30 years.

WATER SUPPLY ALTERNATIVES

Alternatives were identified for addressing the four system stressors (wildfire, growth, Colorado Compact call, and drought/climate change). These alternatives are summarized in Table 20. The potential stressors that would be addressed by each of the alternatives were identified, and a tier was assigned to inform the incremental action plan for the City and District. The potential timing for each of the alternatives was identified, and a relative cost was described for comparison purposes.

There are several alternatives that are already planned and labeled as “P” tier in the alternatives table. These alternatives include low cost conservation savings such as passive conservations and water restrictions, moderate cost of expanding the two water treatment facilities to add 1.7 MGD at the Yampa River wellfield and 4.5 MGD at the Fish Creek facility, and low cost of using the City’s existing pre-Compact water rights for raw water irrigation.

Tier 1 alternatives are those alternatives that are currently being considered, may require Water Court applications, or storage contracts in the near term, and/or construction of new facilities. These alternatives can generally be grouped as follows:

- Use of existing pre-Compact water rights by adding operational flexibility through an application with Water Court. This could include a junior exchange right to exchange pre-Compact rights into storage and possibly to water treatment facilities. This exchange generally requires a physical diversion at the “exchange to” point (e.g., to storage in Stagecoach Reservoir), but there are some cases where exchanges have been approved to well depletion points (e.g., Yampa Wellfield). It is also possible that a plan for augmentation could be approved that would utilize the pre-Compact water rights for replacement of Yampa Wellfield depletions.
- Additional storage contracts that would provide the City and District needed supply in the event of a fire (i.e., provide redundancy to the Fish Creek basin) or a Colorado River Compact call. This could be achieved through expansion of the City and District storage contracts in Stagecoach Reservoir, or new storage contracts for water out of Elkhead Reservoir or Steamboat Lake.
- Additional flexibility in the operations of existing facilities, such as increasing the Yampa Wellfield treatment capacity to provide a year-round supply that could address demands associated with future growth. The Yampa Wellfield is generally not limited by water availability, but rather only limited by its physical capacity and historical operational period. Increasing the operational period would increase yield from this existing infrastructure. The operational period for the Yampa Wellfield has historically included the irrigation season to supplement supply to meet outdoor demands, and the operational period can be extended to meet additional demands without legal constraints.

Tier 2 alternatives are those projects that may not result in as much yield or ability to address multiple needs (e.g., those projects that may only address growth or a Colorado River Compact call), and those that would have a higher cost with more administrative constraints. These would generally be grouped as follows:

- Storage of pre-Compact water rights in existing storage facilities. This would require negotiated agreements with owners of those storage facilities (if not already owned by the City).



- Changes of water rights for existing pre-Compact water rights that have not previously been quantified for their historical consumptive use. This could allow these pre-Compact water rights to be taken at the location of an existing or proposed water treatment plant. Opening these pre-Compact water rights up for the Water Court process is not without risk and could diminish the amount of the water rights available for use.
- Construction of a new downstream water treatment facility would provide redundancy to the existing Fish Creek facility. The preferred location would be the Elk River upstream of the confluence with the Yampa River, because of better water quality than the Yampa River, and also because of redundancy in the case of an upstream wildfire.

Tier 3 alternatives are those projects that may be unacceptable to the City and District because of existing policies, and those projects that are cost prohibitive. The Tier 3 alternatives can generally be grouped as follows:

- Acquisition of an existing pre-Compact water right. This type of acquisition is common around the State of Colorado, but permanent “buy and dry” of existing water rights is contrary to existing City policies and may not be palatable to Steamboat Springs residents and the desire to protect the agricultural community within the Yampa River basin.
- Expansion of the existing Fish Creek water treatment plant capacity beyond the currently planned 12 MGD capacity expansion to meet all future needs. This alternative may be cost prohibitive and would not provide redundancy in the event of a wildfire in the Fish Creek basin.
- Alternative transfer methods (ATMs) are common around the State of Colorado, and typically provide a means for a municipality to occasionally utilize senior agricultural water rights without permanent buy and dry. ATMs could help to firm Steamboat Springs’ pre-compact water rights on the Yampa River, but would not provide a reliable yield in all years.



TABLE 20. WATER SUPPLY ALTERNATIVES³⁷

No.	Water Supply Description	Tier ¹	Performance Metric				Primary Objective	Implementation Timing	Cost		Notes
			Fire Redundancy	Compact	Climate	Growth			Capital	O&M	
1	Water Savings from Water Conservation	P	X	X	X	X	Climate		Low	Low	
2	Drought Response (e.g., Water Restrictions)	P	X	X	X	X	Climate		Low	Low	
3	Increase Capacity of Yampa River Wells to 3.5 MGD (1.8 MGD City & 1.7 MGD MWW)	P	X		X	X	Redundancy	Construction 2021-2022	Moderate	Moderate	
4	Steamboat Lake Storage Contract (City)	P	X		X	X	Redundancy / Growth	Finalize contract 2019	Low	Low	Negotiations in-progress for 1,200 ac-ft to help supply the City's future Elk River Treatment Plant.
5	Expand Stagecoach Reservoir Contract to Augment Yampa Wells Expansion	P	X		X	X	Redundancy	Finalize contract 2020	Low	Low	Negotiations in-progress to expand current City contract from 552 AF to 1,200 AF to augment Yampa Wells, Casey's Pond, park irrigation, and for water quality purposes near the WWTP.
6	Increase Fish Creek WTP Capacity to 12 MGD	P		X		X	Growth	Needed between 2045 and 2063 depending on demand projection used.	Moderate	Moderate	
7	Existing Pre-Compact Water Rights										
7a	Existing City Pre-Compact Rights (Spring/Soda/Butcherknife) for Raw Water Irrigation, and Restoring Streamflow for Water Quality Purposes near the WWTP	P		X	X	X	Compact	Existing/Ongoing uses. Feasible new projects 2019-2021	Low	Low	Existing raw water irrigation at Memorial Park, West Lincoln Park, etc. Potential future raw water irrigation at Little Toots, Staley Park, Bear River. WWTP effluent irrigates City and Stanko property and augments streamflow. Implement Yampa River Health Assessment & Streamflow Management Plan to restore flows and improve water quality near the
7b	Pre-Compact Rights at Yampa Wells (APOD)	1	X	X	X	X	Compact	Feasibility 2019, Water Court Application 2020	Moderate	Low	Potential limits on exchanges to wells due to legal uncertainty following the Division 1 Tri-State case. Feasibility depends on reliability of exchange potential to Yampa Wells. While water may not be physically available at the original point of diversion during dry years, recovering from a compact call will likely include a string of wetter-than-average years, and during the recovery years there could be a physical supply for these rights.
7c	Exchange Pre-Compact HCUs into Storage or Wells	1	X	X	X	X	Compact	Feasibility 2019, Water Court Application 2020	Low	Low	Potential limits on exchanges to wells due to legal uncertainty following the Division 1 Tri-State case
7d	Utilize Existing Pre-Compact HCUs for Augmentation	1		X	X	X	Compact	Feasibility 2019, Water Court Application 2020	Low	Low	Island Ditch HCUs (105 acre-feet) are decreed for augmentation and could cover depletions; evaluate other water rights with quantified HCUs.
7e	Change Existing Pre-Compact Rights (not yet quantified) for Augmentation Use	2		X	X	X	Compact	Feasibility 2019, Water Court Application 2021	Moderate	Low	Requires HCU analysis, and reopening historical decree
7f	Existing City Pre-Compact Rights Change APOD (e.g., at Downstream new Water Treatment Facility)	2	X	X	X	X	Compact	Feasibility 2019 – City Water & Sewer Master Plan Update. Implementation unknown.	Moderate	Low	APOD to measure at original point of diversion and convey via stream channel to WTP. Elk River Plant is preferred option due to water quality and redundancy benefits. Assess in City Water & Sewer Master Plan Update. Implementation unknown.
7g	Store Pre-Compact Water Rights in Existing Storage Facilities	2	X	X	X	X	Compact	Feasibility 2019, Water Court Application 2020	Low	Low	Island Ditch HCUs – negotiate agreements and/or file new case to store in Fish Creek, Stagecoach, Elkhead, or Steamboat Lake. Analyze feasibility of exchanging pre-compact rights on

³⁷ Alternatives are organized by highest priority first, and lowest priority last, with the exception that all “Existing Pre-Compact Water Rights” alternatives were grouped together.

											Spring/Soda/Butcherknife Creeks or other pre-Compact rights in City portfolio.
8	Stagecoach Reservoir Additional Storage	1	X		X	X	Redundancy	Feasibility 2019	Low	Low	
9	Change Operational Period of Yampa River Wells	1	X		X	X	Growth	Growth	Low	Low	Operate Yampa Plant year-round to supply growth of indoor use.
10	Build New Elk River WTP at 3-5 MGD	2	X		X	X	Redundancy, Growth	TBD – Growth dependent, but minimum of 7 years planning	High	Moderate	Approx. 2.5 MGD needed for WSSA full buildout. Up to 5 MGD could provide redundancy for fire. Consider phasing plant.
11	Water Banking	2		X	X	X	Compact	Engage Colo River District 2019, Implementation depends on external policies and legislation	Low	Low	Colorado River District is leading the concept of water banking, and legislation may be needed for feasibility. Ideally Store Pre-Compact Rights in Elkhead Reservoir.
12	Acquire Additional Pre-Compact Water Rights	3	X	X	X	X	Compact	Feasible 2019	Moderate	Low	City policy against permanent buy and dry of agricultural water rights.
13	Increase Fish Creek WTP Capacity > 12 MGD	3		X		X		TBD – Growth dependent.	High	Moderate	
14	Alternative Transfer Methods and Temp Leases for Short-Term Redundancy	3	X	X	X		Compact	Feasibility 2019-2020	Moderate	Low	Firm City’s pre-Compact rights on Yampa River, and future Elk River supplies.

Notes

¹ P = Planned, Tier 1 through 3 indicates projects with a high priority (Tier 1), moderate priority (Tier 2), and low priority (Tier 3).

RECOMMENDATIONS REGARDING WATER TREATMENT FACILITIES

The City is considering the development of a new raw water source to provide redundancy, fire resiliency, and increased capacity for their drinking water treatment system to meet future demands. The scope for this Water Supply Master Plan included the following water quality and treatment related tasks:

1. Guidance on siting a new water treatment facility, including a decision matrix with factors to consider. This guidance includes a general list of considerations, and more specifically cost and technical issues to consider.
2. Factors to consider when determining whether a surface or groundwater diversion would be the most appropriate for a new water treatment plant.
3. Identification of high-level fatal flaws that would influence locating a new water treatment plant.

Key considerations for the City regarding water treatment are when new treatment capacity is needed, and what additional capacity would be needed based on projected demands. Current treatment capacity is 9.3 MGD (7.5 MGD from the Fish Creek WTP, plus 1.8 MGD from the Yampa wellfield). There is potential for expansion of the Fish Creek WTP capacity from 7.5 to 12 MGD through the addition of 6 filtration bays. The City and District also meet demands with Yampa River wellfields that have a pumping capacity of 1.8 MGD, and can be expanded to 3.5 MGD. Based on this information, the existing total treatment capacity of 9.3 MGD can be expanded to a total of 15.5 MGD through expansion of the existing Fish Creek WTP and Yampa wellfield WTP. The 2017 City and District combined peak day demand was approximately 5.1 MGD, and projected peak day demand could be in the range of 12 to 14 MGD at the end of the study period in 2070 (Figure 33). The following guidance should be considered when planning for timing for the need for additional treated water capacity.

- The current 9.3 MGD sustained capacity of the Fish Creek and Yampa Wells water treatment plants would be exceeded by the projected peak day demand between 2040 and 2060, depending on which demand projection is utilized (Figure 33).
- The expanded 15.5 MGD sustained capacity of the Fish Creek and Yampa Wells would be exceeded by projected peak day demand after 2060 (Figure 33).
- Water treatment plant redundancy for protection against impacts from wildfire in the Fish Creek basin may warrant bringing on new water treatment capacity as soon as is financially feasible for the City.

The size (i.e., treatment capacity) of a new WTP is another key factor that needs to be determined. Some possible approaches to sizing the new WTP are as follows, and result in the range of capacity for a new WTP between 1.4 MGD and 8.5 MGD:

- Size a new WTP based on providing full redundancy for the Fish Creek WTP. This approach would require that a new WTP would need to be located with a diversion location that would not be impacted by a wildfire in the Fish Creek basin, such as a location on the Elk River at the City's conditional water right. This approach would result in additional treatment capacity of 8.5 MGD at a new WTP location (i.e., 12 MGD projected peak day demand in 2070, minus the 3.5 MGD expanded capacity at the Yampa River wellfields). This option may not be financially feasible for the City, and also may be overly conservative assuming no water supply available from the Fish Creek basin.
- Size a new WTP according to demand associated with development in the West Steamboat Spring Area. A new plant sized to meet the entire 4,306 EQR projected for the WSSA (Table 8) would need to provide 1.7 MGD treatment capacity. Steamboat Springs staff have indicated that approximately 800 EQRs can be supplied to the WSSA based on the City's current treated water



distribution system. If 3,500 of the anticipated 4,306 EQRs in the WSSA need to be supplied by a new WTP, the treatment capacity of the WTP would need to be 1.4 MGD.

- Size a new WTP based on the City's 8 cfs Elk River conditional water right. This would result in a new WTP capacity of up to 5 MGD.

The first steps in proceeding with the project to construct a new water treatment plant should be taken at least 7 years prior to the need for the new plant, which is typical for a new facility of this size. The process of obtaining new easements, completing siting studies, capacity determinations, water quality monitoring plans, submitting planning permits, and other elements will take time. Based on recent experience, design, and construction is likely to take four years from start to finish. Prior to design, a siting study needs to be conducted and easements and land acquisition negotiations need to be initiated.

WATER QUALITY AND TREATMENT PROCESS

The new WTP will provide a third source of water to the City's water system, reducing the risk from wildfire impacts, while optimizing the use of the City's water rights. Two raw water source locations are being considered, one on the Elk River and the other along the Yampa River. Each potential source would provide high quality water that is somewhat protected from fire impacts, but neither are completely immune to some impacts of a serious fire.

Water Quality: The water quality at both potential source locations were similar, and is not different enough to eliminate one of the sites from being eligible new WTP site locations. However, the risk of potential contamination on the Elk River is lower than that of the Yampa River. Currently available data was established for the study of aquatic species, so a water quality monitoring plan is recommended prior to the design of a new WTP in order to provide the latest data, and to meet CDPHE design criteria standards for building a new WTP.

Treatment processes that will be required for a new WTP were considered based on initial water quality data available from the USGS³⁸, and include the following process steps:

1. Pretreatment: chemical mixing, coagulation, flocculation, and advanced sedimentation. Fine screening and other considerations should be considered during design particularly if membrane filtration is required. Removal of iron and manganese may be required through peroxidation (or other similar process), depending on results of pre-design water quality sampling.
2. Filtration: multi-media sand filters or ultra-filtration membranes could be used to meet State drinking water standards.
3. Disinfection: disinfectant chemicals can be added, or ultra -violet light (UV) can be used. Chemical disinfection is typically the most economical disinfection option.

Residuals handling is vital to the water treatment process as well. Based on excellent source water quality, residuals handling can be minimized by recycling residuals. Drying beds and mechanical dewatering can be used to address waste residuals. Mechanical dewatering would most likely include a gravity thickener followed by a belt filter press or centrifuge.

Cost: The cost of constructing, operating and maintaining a WTP long-term should be taken into consideration during the treatment process selection and design. The higher capital cost to build a conventional plant similar to the Fish Creek and Yampa WTPs may outweigh a packaged membrane plant when the net present value of operating cost is factored in.

³⁸ https://co.water.usgs.gov/infodata/yampa_summaries/html/Sites.html



NEXT STEPS FOR DETERMINING FEASIBILITY OF CONSTRUCTING A NEW WATER TREATMENT FACILITY

Planning for the development of future treatment capacity requires obtaining adequate water quality data which demonstrates the new raw water source will provide consistent and sufficient quality water for drinking water treatment. Careful consideration of the selected treatment process should be exercised due to the higher concentrations of iron and manganese in both potential sources. The Yampa Wells WTP currently treats for elevated levels of iron and manganese successfully.

In order to quantify the difference between the two potential water sources (Elk River or Yampa River), a water quality monitoring program should be conducted over a 12-month period prior to the preliminary design stage of any treatment processes. The purpose of the water quality testing program includes the following:

- Provide information necessary for treatment process selection and design criteria,
- Receiving CDPHE design and construction approval,
- Provide data that would be necessary for future equipment specification and procurement,
- Provide data needed to develop projections of residual quantities, and associated handling and disposal, and
- Establish base-line water quality data so that changes in water quality can be identified and tracked.

The water quality data which should be collected includes:

- Monthly: Basic Parameters
Temperature, dissolved oxygen, turbidity, TSS, TDS, pH, alkalinity, hardness, TOC, conductivity, color
- Quarterly: Extended Metals and Miscellaneous
Major cations (calcium, magnesium, sodium, potassium) and major anions (chloride, sulfate)
Metals (aluminum, arsenic, barium, beryllium cadmium, chromium, copper, iron, lead, manganese, magnesium, molybdenum, nickel, selenium, silver, zinc)
Misc. parameters (total phosphorus, fluoride, nitrate, nitrite, silica, ammonia, bromide, mercury, UV254)
- Bi-Annually: Radionuclides and Cryptosporidium
Gross Alpha, Beta, uranium, radium 226+228 (Winter / Summer)
Cryptosporidium (Spring / Fall)
- Seasonal (Summer): Algae + Taste and Odor
Algae numeration and speciation, geosmin and MIB

The cost of this type of sampling program would be around \$50,000 (2019 dollars), and the sampling will provide the necessary data to verify the treatment requirements for each raw water source. This program will also provide flexibility in the treatment selection, as it will provide a seasonal representation of the source water allowing for a more refined treatment selection.



Permitting, easements, and property acquisitions are also short-term next steps. Major permits that will be required for plant development may include a 404 Permit from the Corps of Engineers, a Special Use Permit if public rights of way are impacted, possibly a 1041 permit from Routt County, and possibly a floodplain development permit from Routt County. Easements for the raw and finished water pipelines should be factored into the project schedule, because easements can get delayed when considering negotiations with private landowners.

CONCLUSIONS

The City and District water supplies must meet the demands of their permanent residents year-round and visitors during the tourist season. Treated water demands have decreased over time, indicating increasing efficiencies. Current demand is approximately 2,800 acre-feet per year, and demand projections indicate that future demands could increase to between 5,400 and 9,200 acre-feet per year by 2070. The existing Fish Creek basin supply (7,800 acre-feet per year) and Yampa River wellfield yield (2,000 acre-feet per year) are generally adequate to meet City and District treated water demands through the end of the study period used in this analysis (2070). However, system stressors such as wildfire, Colorado River Compact calls, climate change, and growth could result in shortages in treated water supply.

Water demands for the City and District should be projected based on Equivalent Residential Units (EQRs), in order to account for the significant influence of tourism on treated water demands. EQRs were projected to grow from approximately 14,000 at current conditions to almost 44,000 EQRs at the end of the study period (2070). However, a previous buildout capacity study completed in 2010 indicated maximum EQRs of 22,310 at buildout. The buildout analysis described herein is based on buildout analysis data that is currently nine years old. This buildout capacity information should be revisited in an updated study to reflect current planning and zoning information, and could be used to check the treated water demand projections developed for this study.

The current capacity of the two water treatment facilities (9.3 MGD³⁹) is projected to be exceeded between 2040 and 2060, depending on which demand projection is utilized. Dependent on the results of a potential future buildout study, the max day demand projected for this study may be delayed or not reached. However, it is important for the City and District to plan for the conservative assumption that growth will continue as projected. This growth may occur if zoning does not remain static, for example if Steamboat Springs becomes more densely developed in the future relative to current zoning.

The future WTP capacity should be at a location that can provide treated water redundancy in the event of a wildfire in the Fish Creek basin, can be delivered to areas of anticipated future growth (e.g., West Steamboat Springs Area), and where water quality and quantity are adequate to meet future demands. The locations that meet these criteria are the Elk River upstream of the confluence with the Yampa River, or the Yampa River between the western City limits and the confluence with the Elk River. There may be additional yield available in the Fish Creek basin, but additional treatment capacity in the Fish Creek basin may not be as beneficial as new treatment capacity on the west side of City limits because of the risk of impacts from wildfire and because of constraints in the existing treated water distribution system to deliver

³⁹ Current water treatment facility capacity is 11.0 MGD assuming 3.5 MGD capacity at the Yampa River wellfield. However, the Yampa River wellfield treatment plant is limited by the current 1.8 MGD pumping capacity.



water from the Fish Creek WTP to the WSSA. Additional legally available water supply may be available at the existing Yampa River wellfield, but additional WTP capacity at the Yampa River wellfield may not benefit the location where future development is anticipated in the WSSA, unless the existing distribution is modified to accommodate additional deliveries from the Yampa River wellfield to the WSSA.

A Raw Water Supply Model developed for this Water Supply Master Plan update was used to simulate the ability of the City and District to separately meet their constituents' treated water demands. As noted above, the existing City and District water supplies generally meet future anticipated treated water demand. There were shortages projected for long-term (i.e., 2070) growth both with and without Colorado River Compact calls, and also for short-term shortages associated with wildfire impacts. A series of potential water supply projects were developed to identify actions that the City and District should consider protecting themselves against these potential stressors. It is noted that the City and District are currently completing a Fish Creek Critical Community Watershed Wildfire Protection Plan, and that recommendations from that study should be followed to minimize the risks of impacts of wildfire to the City and District water supplies.

The following summary of recommendations for water supply alternatives apply to both the City and District:

1. Immediate action alternatives:
 - a. The City and District should focus on implementing conservation to achieve water savings as well as other community and environmental benefits.
 - b. The City and District should revisit and update the Drought and Emergency Response Preparedness Plan after the Water Conservation Plan is updated to ensure compatibility between long-term water conservation measures and short-term drought response.
 - c. The City should obtain 1,200 ac-ft of storage in Steamboat Lake to help supply the City's future Elk River Treatment Plant (City).
 - d. The City and District should expand treated water capacity by 2040 to meet projected peak daily demands. The short-term expansion should include expansion of the Fish Creek WTP capacity to 12 MGD. The feasibility of additional storage capacity at a new Elk River WTP should also be assessed.
 - e. The City and District should expand the existing Yampa Wellfields to add 1.7 MGD of pumping capacity, resulting in a total of 3.5 MGD capacity. This would include expansion of the City's current pumping capacity of 0.8 MGD to an expanded pumping capacity of 1.8 MGD, and an expansion of the District's current pumping capacity of 1.0 MGD to an expanded pumping capacity of 1.7 MGD. The Yampa River wellfields are generally capacity limited, and additional capacity would provide additional yield without limitations from physical availability of water supply. Additionally, expansion of the Yampa Wellfields would provide additional redundancy to the Fish Creek treatment plant to minimize shortages associated with wildfire in the Fish Creek basin.
 - f. The City should use existing pre-Compact water rights for raw water irrigation. The focus should be on water rights that are decreed for irrigation, as this will prevent the need for changes of water rights. This would address potential shortages from wildfire by reducing treated water demand (and allowing the Yampa Wellfields to better meet treated water demand), and also shortages from a future Compact call.
 - g. The City and District should monitor Statewide efforts to address impacts of a potential Colorado River Compact call. These efforts currently include drafting of a Statewide Drought Contingency Plan and pilot efforts to mitigate for impacts from a potential Compact call. The City and District should seek opportunities to participate in these



mitigation efforts, particularly if mitigation could reduce impacts to the Yampa/White River Basins.

2. Alternatives for current planning and implementation in the next five years:
 - a. The City and District should use existing pre-Compact water rights for municipal use. This most likely will require an application with Water Court to change the use or point of diversion of the water rights, but the pre-Compact priority date would be maintained. This would address all four system stressors. Pre-Compact water rights changed for municipal use could be stored or exchanged to the Yampa Wellfields, depending on results of the Water Court process.
 - b. The City and District should negotiate additional storage in Stagecoach Reservoir with the UYWCD. This could be implemented as soon as an agreement is reached with the UYWCD.
 - c. The City and District should store existing pre-Compact water rights in existing storage facilities for municipal use (e.g., Fish Creek Reservoir, Stagecoach Reservoir, Elkhead Reservoir, Yamcolo Reservoir, and Steamboat Lake).
 - d. The City and District should increase the operational period of the Yampa River Wellfields to address anticipated growth. This is a low-cost alternative that addresses future growth and immediate needs for redundancy. There is no legal constraint to extending the operational period of the Yampa River Wellfield.
 - e. The City should construct a new Elk River water treatment plant to provide redundancy to the Fish Creek WTP and to help meet municipal treated water demand associated with growth that is anticipated on the west side of Steamboat Springs.
 - f. The City and District should follow the water banking concept as it is developed, and potentially implement water banking depending on Colorado legislation that may be forthcoming.
 - g. The City and District should formulate a plan for full utilization of the its existing water rights.
3. Alternatives that may warrant additional consideration in the long-term (i.e., starting in 2025):
 - a. The City and District should consider the feasibility and effectiveness of meeting projected treated water demands through increasing the existing Fish Creek WTP capacity beyond the 12 MGD currently being considered. This may not be cost effective, and would not provide the necessary redundancy to the Fish Creek basin water supply.
 - b. The City and District should consider alternative transfer methods and temporary water leases. These methods may provide short-term redundancy to the Fish Creek supply, and could increase the yield of the City's pre-Compact water rights on the Yampa River.
 - c. The District should consider options to move or obtain alternative points of diversion for pre-Compact rights not currently being used for treated water purposes.



APPENDIX A

CONSERVATION AND DROUGHT MEMO





Memorandum

Date: January 16, 2019

To: City of Steamboat Springs and Mount Werner
Water District

From: Headwaters Corporation

RE: Historical Demand and Water Conservation Analyses

The City and District consider water conservation to be an important component of future water-planning and decision-making pursuits. This memorandum summarizes the historical demand and water conservation analysis conducted for the City of Steamboat Springs (City) and the Mount Werner Water District (District) in updating their Water Supply Master Plan (WSMP) and Water Conservation Plan (WCP). The intent of this memorandum is to provide the City and District an initial review of the analysis, and an opportunity to comment on the approach and results. Headwaters Corporation (Headwaters) will address the comments and include any necessary edits when incorporating this information in the final WSMP and WCP. This memorandum is organized into the following sections:

- Introduction to historical demands
- Historical demand trends
- Evaluation of 2011 water conservation goals
- Recommendations

In efforts to focus on the customer demands that the City services, the demand data presented in this memo (unless noted) do not include snowmaking by the Steamboat Ski Resort nor deliveries made to Steamboat II which services an area not part of the City customer base.¹ This differs from the October 2018 *Historical and Current Demands Memo* which includes the Steamboat II deliveries to reflect the City's total supply needs that entails their obligation to deliver water to Steamboat II.² Demand data prior to 2006 originate from the 2008 *Steamboat Water Supply Master Plan*. Demand data for 2006 – 2017 are based on metered daily water treatment plant (WTP) production data.³ Population and EQR data originate from the October 2018 *Historical and Current Demands Memo*.

¹ To determine demands without Steamboat II, metered Steamboat II demands were subtracted from City metered WTP production data.

² Data on monthly Steamboat II delivery data were available in 2009 and from 2014 to 2017. Annual deliveries from 2006 to 2008 and from 2010 to 2013 were assumed to be the annual average of available data (40.3 mgal/year). It is unknown when deliveries to Steamboat II started. Deliveries were assumed to start at a very low rate in 1990 and increase by 2.5 mgal/year until reaching the 40.3 mgal/year average in 2006. Monthly deliveries were estimated using prorating factors developed from the average of monthly deliveries from 2013 to 2017.

³ As described in the October 2018 *Historical and Current Demands Memo*, there were data gaps in these WTP production data and consequently, the data gaps and other questionable data were replaced with representative production data from other months, based on a comparison of meter data available from 2010 to 2017. Additional details are provided in the October 2018 *Historical and Current Demands Memo*.

INTRODUCTION TO HISTORICAL WATER DEMANDS

The City and the District's water demands consist of both treated water and outdoor raw water demands.

TREATED WATER DEMANDS

The proportion of treated water indoor and outdoor demands is similar among both providers. As shown in Figure 1, annual outdoor treated water use comprises about one third of total treated water use. The remaining two-thirds of treated water demands are delivered for indoor use.

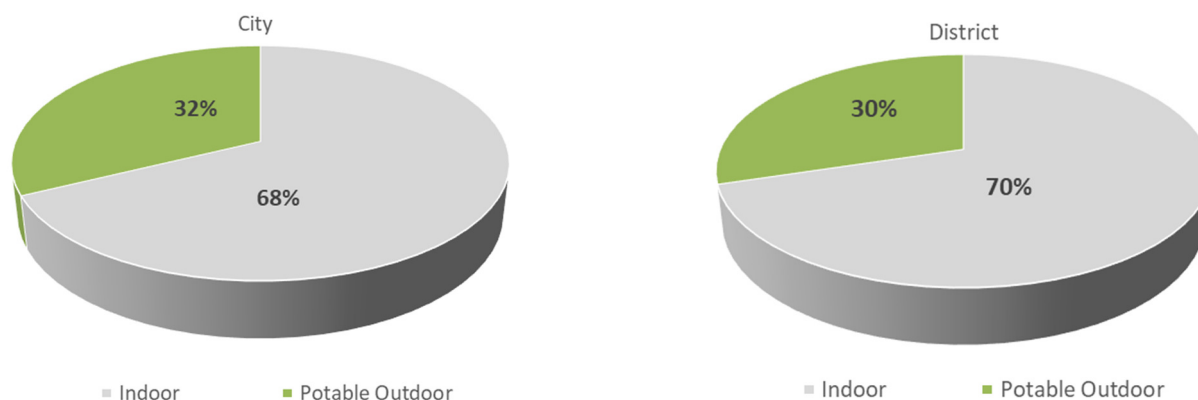


FIGURE 1. INDOOR AND OUTDOOR TREATED WATER DEMANDS⁴

Historical treated water demands have been decreasing over the past 10 years while the population continues to increase. This is shown in Figure 2, where downward trends in demands have generally occurred since 2007. This trend is observed among providers throughout the State of Colorado and is partially attributed to passive savings accrued through more efficient indoor water fixtures and appliances. Additional information on indoor passive savings is provided later in this section.

⁴ These charts are based on annual WTP production data from 2006 – 2017.

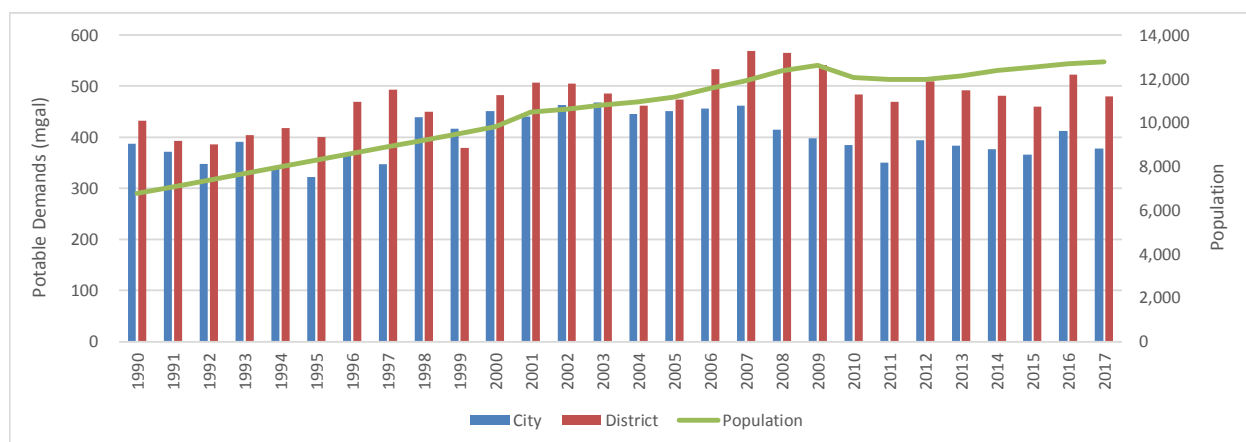
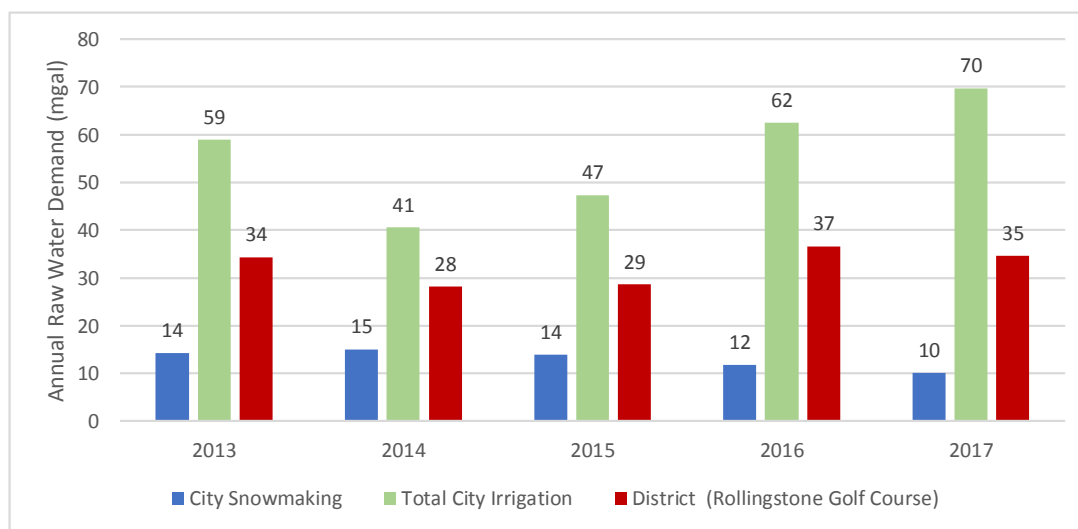


FIGURE 2. TREATED WATER DEMANDS AND POPULATION

RAW WATER DEMANDS

Outdoor demand consists of both treated water supplies and raw water for irrigation and for snowmaking by the City. Figure 3 shows the City and District's raw water demands since 2013.⁵ Demands fluctuate on an annual basis with no obvious trends yet are likely influenced by precipitation and temperature. The District's raw water demands comprise of irrigation on Rollingsstone Golf Course. Figure 4 shows the City's raw water demands for snowmaking and by individual park. Memorial Park and West Lincoln Park recently came online in 2015 and 2017, respectively. Haymaker Golf Course comprises most of the City's raw water demands.



⁵ These raw water data are water accounting data from 2006 – 2017 for the District and from 2013 – 2017 for the City. For some of the individual raw water sources, estimates are made based on known pumping rates and approximate timing of pumping. The data is not to the same degree of precision as the treated water supply which is directly metered.

FIGURE 3. TOTAL CITY AND DISTRICT RAW WATER DEMANDS

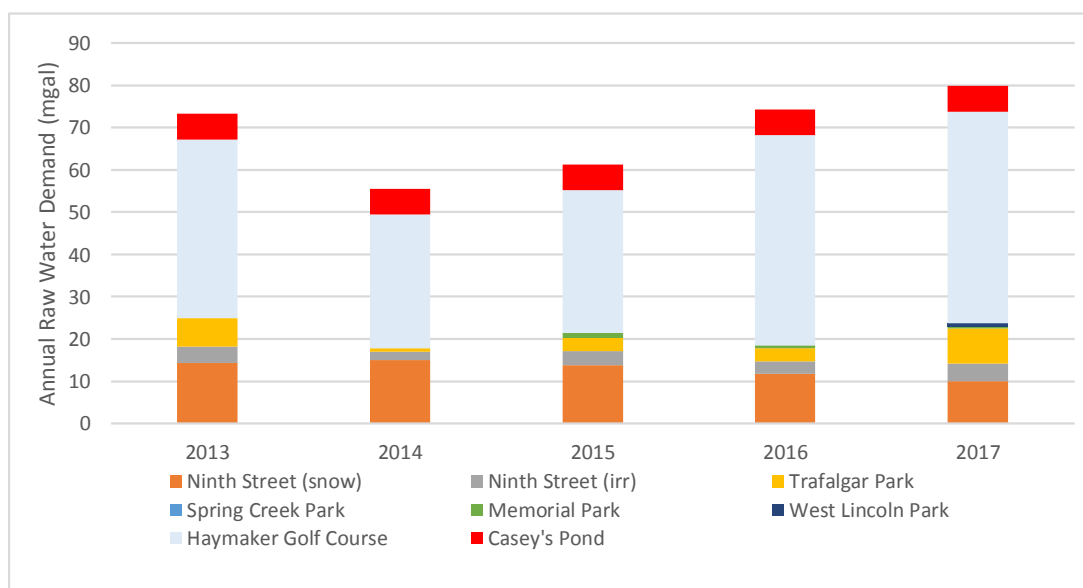
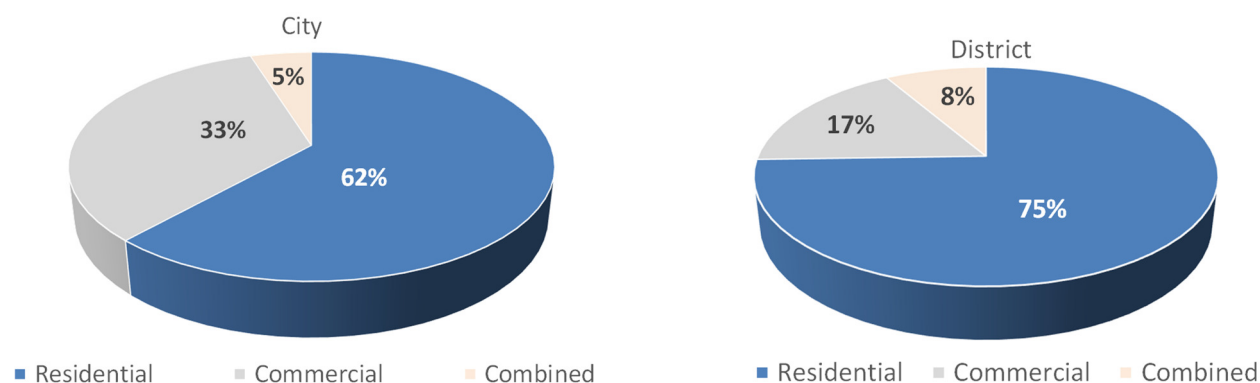


FIGURE 4. CITY RAW WATER DEMANDS

TREATED WATER DEMANDS AND TYPES OF CUSTOMERS

The City and District's billing systems categorize customers as residential, commercial and combined. There are minor differences in how these categories are described, as reflected in Table 1. Figure 5 shows that the demands from residential customers comprise over half the demand for both the City and District. The District has a higher percentage of residential demand while the City serves a larger percentage of commercial. As a reference point, City treated water use was 377 mgal/year in 2017, and District treated water use was 480 mgal/year in 2017.

FIGURE 5. CITY AND DISTRICT TREATED WATER DEMANDS BY CUSTOMER TYPE⁶

⁶ These percentages are annual averages from 2010-2017 City billing data and 2014 -2017 District billing data.

TABLE 1. CITY AND DISTRICT DESCRIPTIONS OF CUSTOMER TYPES

Type	City	District
Residential	All types of residential development including multi-family housing	Single or multi-family housing
Combined	Residential and commercial customers housed in a single structure served by a single service line	Properties that have both residential and commercial customers within the same structure served by a single water connection
Commercial	All other types of customers that are not residential or combined	Businesses, including hotels and motels

Figure 6 shows the City's billing data for 2014 through 2017 where the City bills customers on a monthly basis. Residential customer demands result in a higher peak water demand during the irrigation season than commercial customers. Very minimal peak is observed with the combined customer accounts.

Figure 7 shows the District's billing data where the District bills customers on a quarterly basis. The District's billing data appears to be about three times as high as the City's billing data, but in reality, this difference is caused by the quarterly nature of the District's data when compared to the monthly data for the City's data. The City's treated water use is generally less than the District's treated water use, but the difference is not as significant as Figures 6 and 7 might suggest. Residential demands are significantly higher than commercial demands throughout the year. While there is a peak in commercial demands during the irrigation season, most of the demand is still attributed to residential irrigation. Very little increase is observed with the combined accounts during the irrigation season.

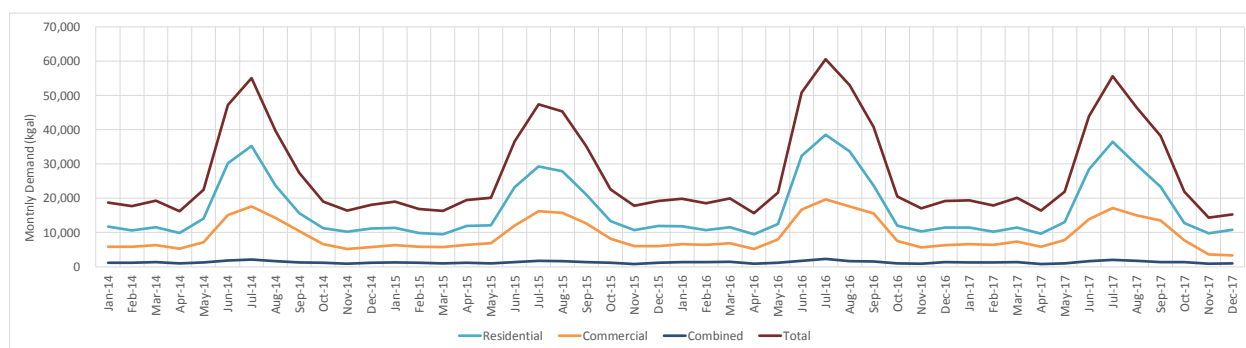


FIGURE 6. CITY MONTHLY BILLING DATA FOR TREATED WATER USE (2014 THROUGH 2017)

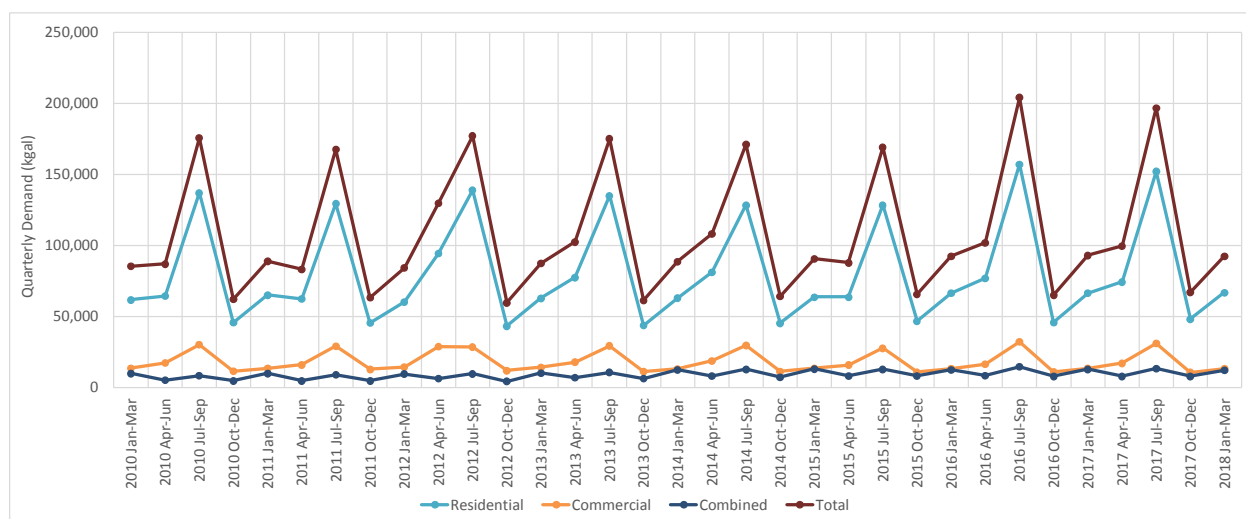


FIGURE 7. DISTRICT QUARTERLY BILLING DATA FOR TREATED WATER USE (2010 THROUGH 2018)

HISTORICAL DEMAND TRENDS

INTRODUCTION TO FACTORS THAT IMPACT WATER DEMANDS

A variety of factors may influence the City and District's water demands. These are introduced in the bullets below and are described in further detail throughout this section.

- Population growth and seasonal tourist demands
- Water rates and water conservation
- Passive indoor water savings
- Climate and drought response
- Efficiency of the water supply system

HISTORICAL DEMAND ANALYSIS

POPULATION AND SEASONAL TOURIST DEMANDS

The City and District serve a highly visited mountain resort community. Water demands are not only influenced by a growing community coupled with irrigation in the summer, but also by the winter and summer tourist seasons. This is reflected by the timeseries of monthly treated water demands shown in Figure 8. Demands for both the District and City typically peak in July during the summer tourist and irrigation seasons and are lowest in November and April. During November and April customers are not irrigating, and tourism is at relatively low levels. The District's demands tend to respond more to irrigation and to the flux of tourists than the City. This is largely attributed to differences among the City and District's customer base. The City's customers consist of more long-term residents and year-round commercial

businesses in the older portion of town, whereas the District serves the resort community on the mountainside consisting of many transient second homeowners and seasonal tourists and workers.

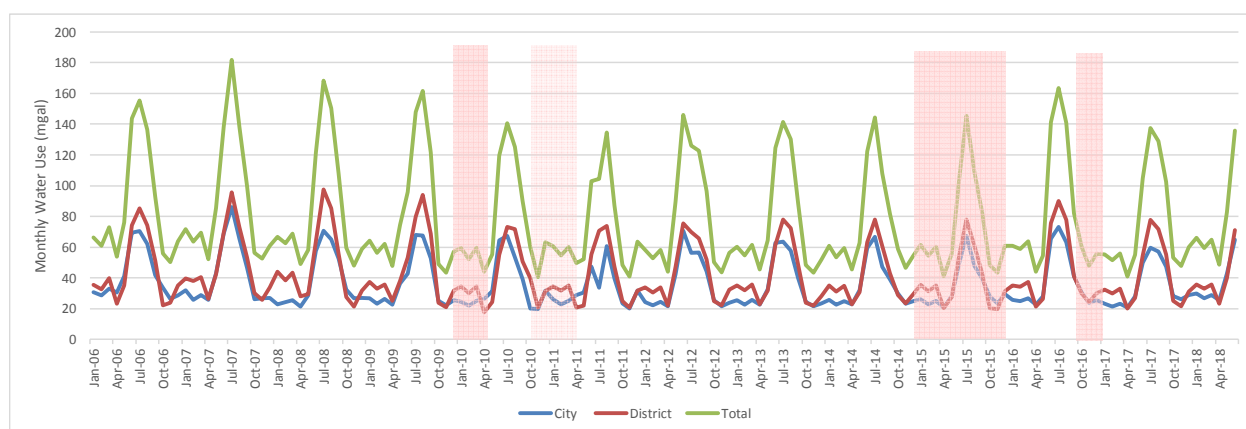


FIGURE 8. MONTHLY TREATED WATER DEMAND PATTERNS⁷

Figure 9 shows that the combined City and District's treated water per capita water demands (sum of City and District's demands divided by population) has been generally decreasing since 1990 while the community continues to grow. As previously mentioned, this trend is common among providers throughout Colorado. The Colorado Water Plan calls for a municipal per capita demand goal of 146 gpcd by 2050 for the South Platte Basin, assuming a 2010 baseline of 188 gpcd. While the City and District have a different climate and customer base than providers in the South Platte Basin, the City and District's total 2010 per capita demand of 197 gpcd is within the general range of the 2010 baseline for the northern Front Range.⁸ Figure 9 shows that there is not a significant change in the residential per capita demand based on the available four years of data, with residential use being approximately 110 gpcd.

⁷ The rose shading shows where data gaps existed in the metered WTP production data, requiring replacement with representative data. This is described in further detail in the October 2018 *Historical and Projected Demands Memo*.

⁸ Additional information on per capita water use (gpcd) for resort communities in Colorado will be provided during the Water Efficiency Plan update.

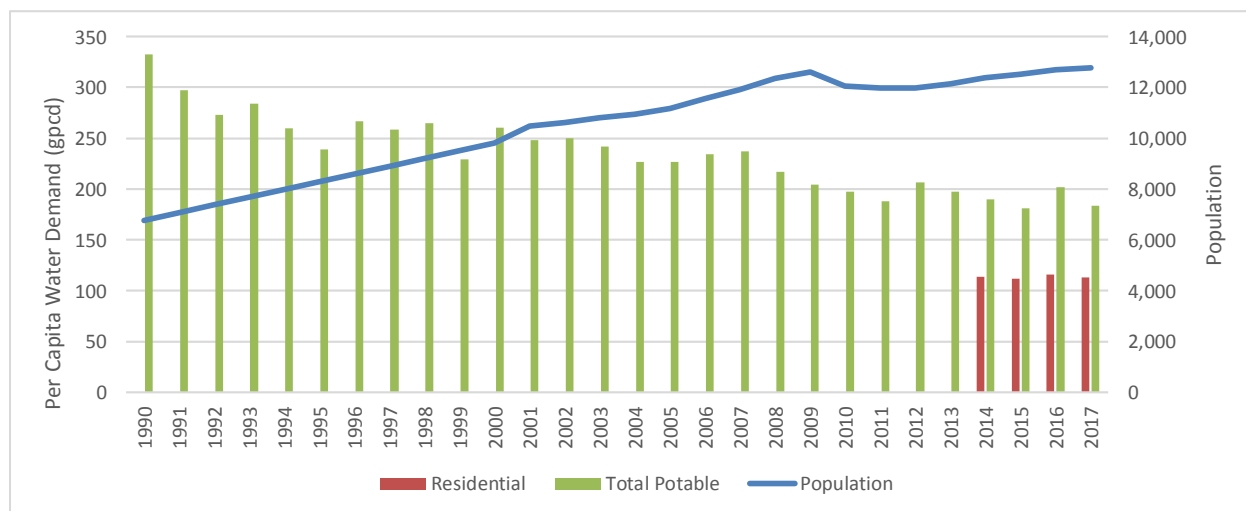


FIGURE 9. PER CAPITA TREATED WATER DEMANDS

Figure 10 provides water demands per EQR from 2000 to 2017 (gpd/EQR), also demonstrating a long-term decline in water demands. In comparison with per capita water demands (gpcd), the demand per EQR approach provides a more robust baseline to identify annual water demand trends for resort communities that experience a flux of seasonal tourism. The EQR approach uses development rather than population as the baseline denominator.

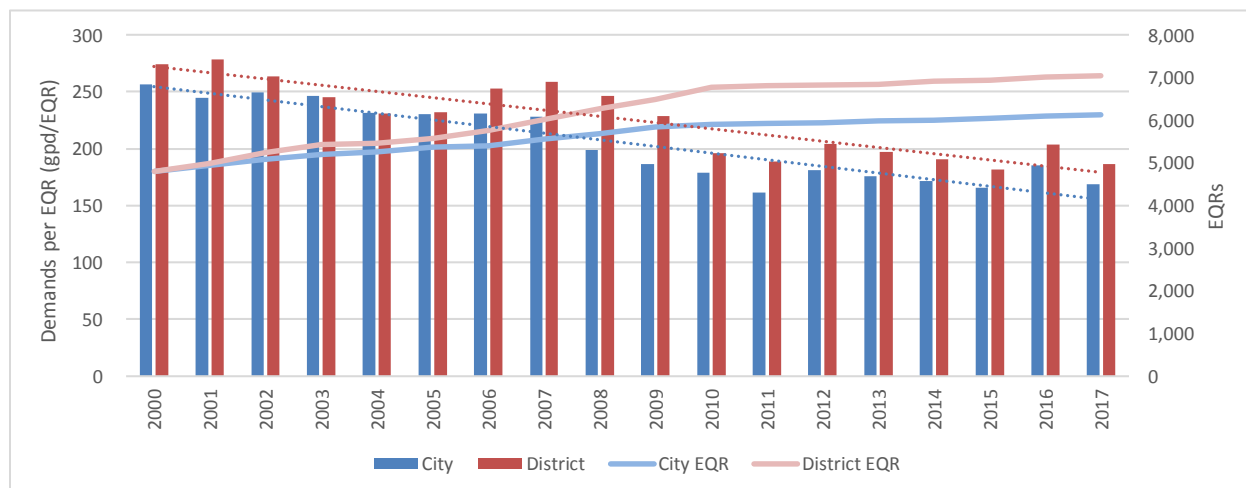


FIGURE 10. DEMANDS PER EQR

WATER RATES AND WATER CONSERVATION

Rates

Headwaters Corporation
405 Urban St.
Lakewood, CO
720.524.6115

INTERA Incorporated
6707 Winchester Circle, Suite 200
Boulder, Colorado 80301 USA
720.749.1900

The City and District have a tiered block rate structure for residential customers where customers that use more water are charged a higher rate per gallon than customers that use less. The City's commercial and combined accounts were recently adjusted from a fixed rate to a tiered block rate structure in 2017. This structure can provide a price incentive to use less water.

The City's water rates have increased incrementally over the past 15 years with the incremental increases in 2011, 2012, 2013 and in 2017. The increases generally ranged from 5% to 6% for most commercial and combined accounts and 5% to 14% for residential accounts. A significant adjustment was made in 2010 where rates were increased by 51% for most customers. The District's water rates were increased in 2007, 2012 and 2017. Rate increases in 2012 were the highest for commercial customers with a 31% increase and residential rate increases ranged from 11% to 22%. In 2017, rates were increased by 7% for all residential accounts and by 19% for commercial accounts. The increase in water rates may have contributed to observed decreases in water demands per EQR for both the City and District.

Water Conservation

The City and District's WCP was adopted in 2011. Table 2 lists the three measures that were implemented prior to the 2011 WCP and then incorporated into the WCP, new measures that were adopted in the 2011 WCP and a list of measures to gradually be added to the water conservation program on an annual basis. Most of these measures have been implemented by the City and District. More information will be provided on conservation measures in the updated WCP.

TABLE 2. CONSERVATION MEASURES IN THE 2011 WCP

Previous measures	New measures	One per a year
Distribution system, infrastructural repair/replacement	Website enhancements	Irrigation education
Tiered rate structure (City & District)	Bill stuffers	Irrigation training
Meter enhancements/software (City & District)	Park irrigation monitoring (City)	Indoor and Outdoor residential audits
	Raw water conversion for irrigation (City)	Commercial education (partnering with Steamboat Sustainable Biz Program)
	HOA and Lodging Property Program (District)	Leak Detection
	Appliance and/or irrigation component rebate programs with residential & commercial audits as necessitated	
	Hydrant flushing quantification	
	Meter testing	

The City and District have implemented a rebate program since 2012. As shown in Table 3, the City and District have provided 241 and 342 fixture and appliance rebates, respectively. The City has given \$2,317 in irrigation rebates and the District has provided \$1,055.

TABLE 3. CITY AND DISTRICT REBATES

	Toilet Residential		Toilet Commercial		Dishwasher		Clothes washer		Irrigation		HOA Irrigation	
	City	District	City	District	City	District	City	District	City	District	City	District
2012	54	71	0	0	15	19	11	14	\$550	\$0	\$544	\$0
2013	54	27	0	0	9	5	8	4	\$375	\$550	\$643	\$0
2014	43	46	0	3	9	8	13	12	\$205	\$505	\$0	\$0
2015	5	17	5	0	4	79	0	4	\$0	\$0	\$0	\$0
2016	1	12	2	0	1	3	0	2	\$0	\$0	\$0	\$0
2017	5	12	1	0	1	1	0	3	\$0	\$0	\$0	\$0
Total	162	185	8	3	39	115	32	39	\$1,130	\$1,055	\$1,187	\$0

While it is not possible to quantify savings attributed to these rebates using the historical demands presented in this memo, the replacement of fixtures and appliances has contributed to indoor water savings. The replacement of indoor fixtures and appliances is naturally occurring over time as customers renovate their properties and new development is more water efficient. Rebates can accelerate the pace of this replacement, yielding savings at an earlier time. The irrigation rebates have also likely contributed to outdoor water savings.

PASSIVE INDOOR SAVINGS

Indoor water demands are decreasing in many parts of the country as technology is improving and indoor water fixtures and appliances are becoming more water efficient. The Energy Policy Act of 1992 requires all U.S. plumbing manufactures and importers to meet or beat specific water efficiency standards. In 2016, Colo Rev State 6-7.5-102 banned the selling of new plumbing fixtures that have not been certified by the EPA WaterSense Program. Figure 11 shows the City and District's lowest monthly water demand (typically in November) on an annual basis, reflecting the decreasing national and statewide trends. This trend may continue as new development uses water efficient fixtures and appliances and older residential/commercial properties replace their old less efficient fixtures and appliances with water efficient devices. However, the rate of this decrease will decline when the majority of older properties are renovated. Notable declines in 2010 may be attributed to a decline in tourist visitation due to the economic recession.

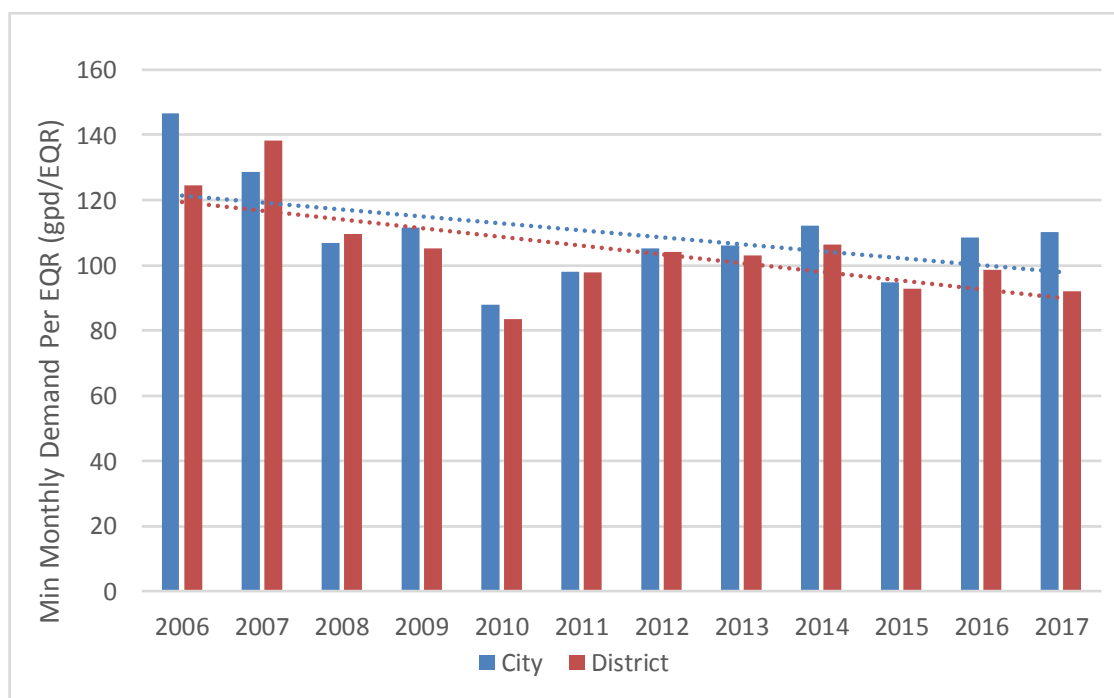


FIGURE 11. PASSIVE INDOOR SAVINGS (BASED ON LOWEST MONTHLY DEMAND)⁹

CLIMATE AND DROUGHT RESPONSE

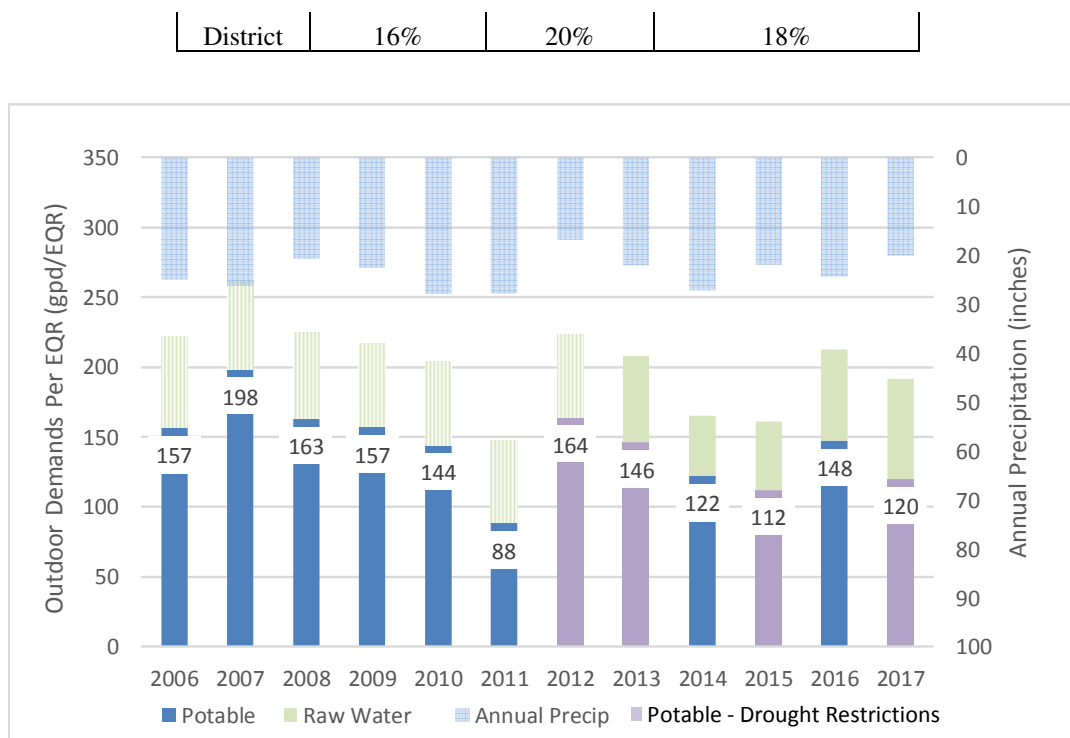
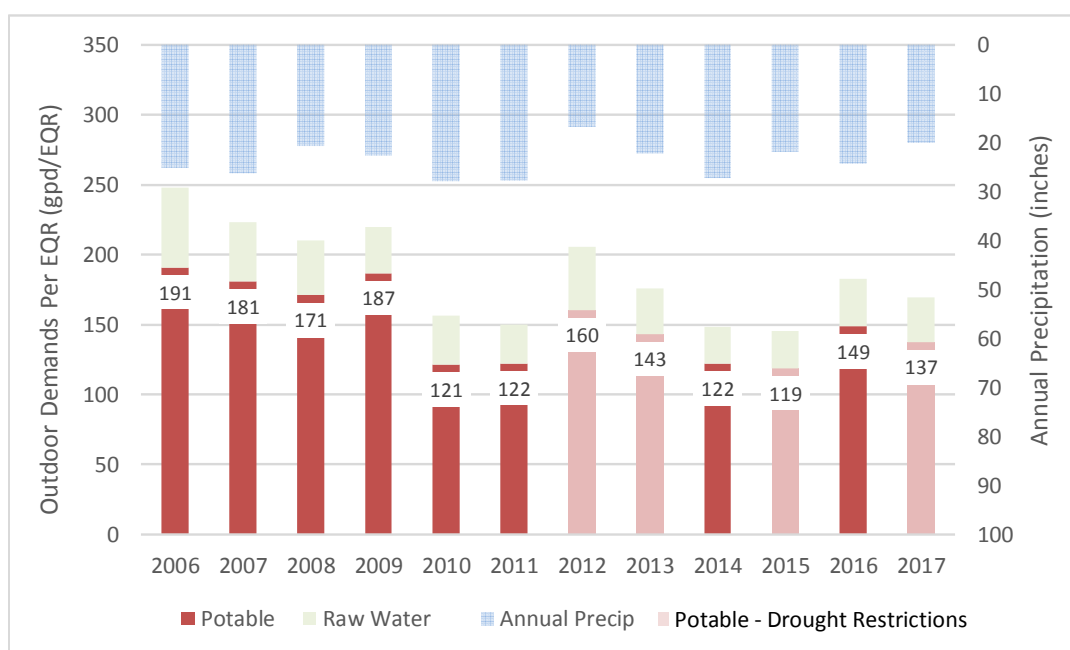
Precipitation and temperature, particularly during the irrigation season can significantly influence outdoor water demands. In years when there is ample precipitation, landscapes do not require as much irrigation and consequently outdoor water demands can be lower. For example, the 2010/2011 winter snowpack was very high resulting in relatively low 2011 demands. Conversely during drought, higher temperatures and evapotranspiration coupled with less precipitation can increase outdoor irrigation demands. Figures 12 and 13 show the City and District's outdoor water demands per EQR in relation to annual precipitation, respectively. Mandatory water restrictions were implemented in 2012, 2013, 2015 and 2017 as denoted by the purple and rose bars for the City and District, respectively.

Like indoor demands, there is a general downward trend in outdoor demands. This is particularly notable when comparing the dry years of 2008, 2013 and 2017 where precipitation during the irrigation season was within a narrow range of 7 to 8 inches. While precipitation was about the same, outdoor demands were less in 2013 and 2017. This could be attributed to improved irrigation efficiencies and drought response, particularly the mandatory drought restrictions. Conclusions drawn from Table 4 may differ if the City or District enacted drought restrictions prior to 2012. This should be discussed prior to finalizing the WSMP.

TABLE 4. REDUCTIONS IN OUTDOOR DEMANDS PER EQR

	2008-2013	2008-2017	Average Reduction
City	10%	26%	18%

⁹ The lowest monthly demand typically occurs in November.

FIGURE 12. CITY OUTDOOR DEMANDS¹⁰

¹⁰ Raw water accounting data was limited to 2013 – 2017. The lighter green stacked bars prior to 2013 are a representative average of raw water demand from 2013 to 2017.

FIGURE 13. DISTRICT OUTDOOR DEMANDS

EFFICIENCY OF THE WATER SUPPLY SYSTEM

Minimizing conveyance losses and meter accuracy can provide cost saving benefits and save waters. The CWCB Municipal Water Efficiency Guidance Document considers this to be a foundational component to water conservation. This will be discussed in more detail in the following section.

SUMMARY

This historical demand analysis demonstrates that indoor and outdoor water demands have been decreasing for both the City and District. Figure 14 highlights this showing the demands per EQR in relation to drought restrictions and annual precipitation. While it is not possible to accurately decipher how much each of the factors previously discussed are contributing to this reduction, it is concluded that passive indoor savings play a significant role in the long-term reduction of indoor demands. Increase in water rates and water conservation also play a role and drought restrictions appear to be effective in lowering outdoor water demands during drought.¹¹ Demand reductions per EQR may continue as indoor savings continue to be passively achieved and efforts are made to improve outdoor and supply-side system distribution system efficiencies.

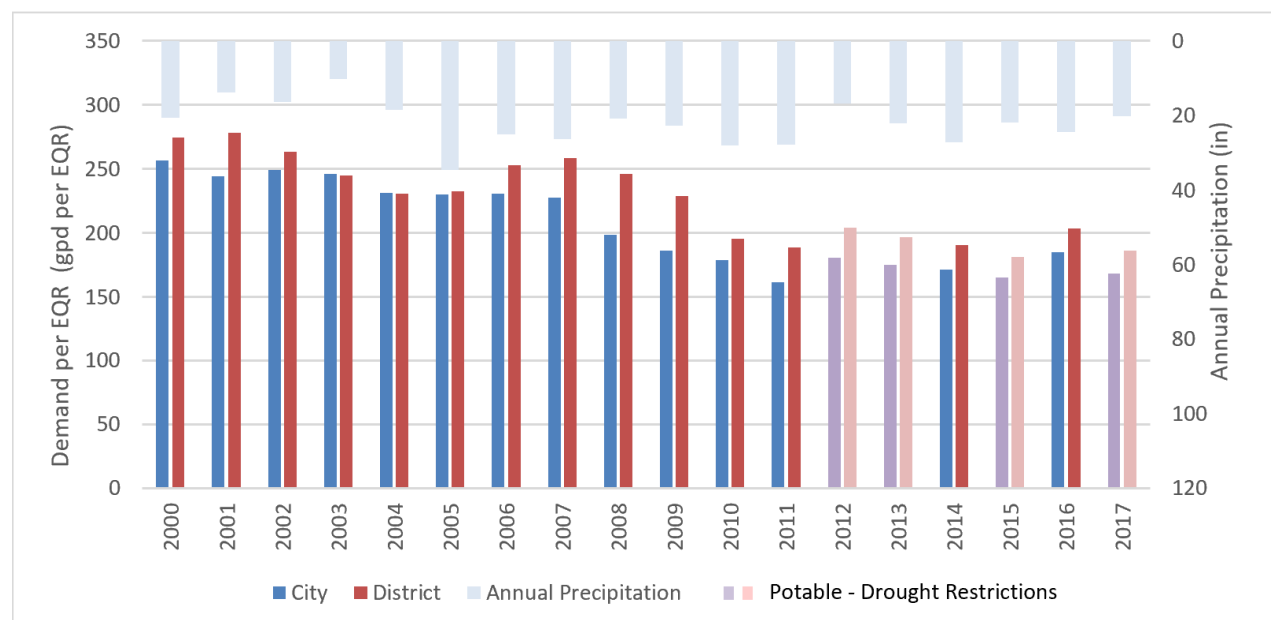


FIGURE 14. CITY AND DISTRICT DEMAND PER EQR TRENDS

EVALUATION OF 2011 WATER CONSERVATION GOALS

¹¹ The City 2011 demand per EQR decreases relatively significantly before increasing in 2012. This is likely attributed to multiple factors including the increase in City water rates in 2010, low tourist visitation and a really wet winter.

The overarching goals of the WCP adopted in 2011 are listed below. These goals will be revisited during the WCP update and where appropriate, changed/refined.

- To raise awareness of the need for and benefits of water conservation and help create a “conservation culture” in Steamboat Springs that protects our limited and essential water supply.
- To foster the understanding that making wise water use choices directly correlates to future investment of public funds – saving water means saving money on mandatory water supply and wastewater plant expansions.
- To convey how every user and each water supplier can benefit from implementing a conservation ethic.
- To prepare the community for responding effectively to a drought or other water emergency and prescribe a response plan.

In addition to these overarching goals, the 2011 WCP includes three quantitative water savings goals addressing system-wide savings, non-revenue water savings and peak-day demand savings. This section focuses on how well these goals are being accomplished.

GOAL 1: SYSTEM-WIDE SAVINGS

The 2011 WCP calls for a 15% reduction in produced water by 2035. However, the WCP does not specify the baseline to use when calculating annual savings in relation to this goal. Table 5 shows how the 15% target was intended to be distributed among conservation practices in the 2011 WCP. The City and District have implemented many of the measures specified in the first column of this table, however the level of effort necessary to develop accurate water saving estimates of how the 15% goal is being achieved among these categories is not feasible.

TABLE 5. ALLOCATION OF TARGETED 15% SAVINGS

Water Conservation Program General Category		Approximate water savings (mgal) using projected 2035 water production of 1.8 billion gallons
Indoor residential and commercial water savings through water efficient appliances/equipment & behavioral best practices	15% of the goal will be achieved through this category	40.5
Irrigation and Landscaping Efficiencies	15% of the goal will be achieved through this category	40.5
Utility enhancements (such as distribution system repair/replacement, leak detection, tiered rate structure, meter enhancements and monitoring, hydrant testing/monitoring, bill stuffers & newsletters, decorative water feature standards, park irrigation monitoring, and raw water conversion for irrigation). For details see sections 8 and 9 of the Water Conservation Plan	70% of the goal will be achieved through this category	189

Evaluation

The evaluation of this conservation goal focuses on where the City and District are at in accomplishing the 15% target by 2035 in 2017. Percentage annual savings is calculated assuming the baseline is the average of annual demands observed in 2008, 2009 and 2010 which is 399 and 531 mgal per year for the City and District, respectively. This average occurs prior to the City's notable temporary reduction in annual demands in 2011 (likely attributed to a short-term response in the 50% increase in water rates, a wet winter and reduction in tourist visits due to the economic recession) and is also representative of the demands observed just prior to the adoption of the 2011 WCP. A three-year running average was applied to "smooth" some of the variability observed with demand data in response to annual weather conditions and other factors.¹²

Figure 15 shows the percentage savings to date in relation to the 15% target in 2035. The green line represents the target, assuming that savings are achieved in a linear fashion from 2011 to 2035. The City and District's demands are lower than what was observed during the baseline years of 2008, 2009 and 2010, yielding the savings shown in Figure 15. Savings for the District average 8.1% while the average percentage savings for the City is 4.7%. Both averages exceed the 2017 target of 3.8% (shown by the green line), although the City's annual savings are just under the target in 2017. While a three-year average was applied to the demand data in attempt to "smooth" some of the natural fluctuation in annual demands, the percentage annual savings shown in Figure 15 still tend to fluctuate in response to factors such as climate and annual tourist visitation. It may be concluded that the City and District are sufficiently maintaining demands below levels observed prior to 2011. However, there is not a trend within the past six years demonstrating an incremental increase in savings over time.

¹² For example, 2015 savings was calculated as: 2015 water savings = Average of 2013, 2014 2015 demands minus baseline demands divided baseline demands. Baseline demands is the average of 2008, 2009, 2010 demands.

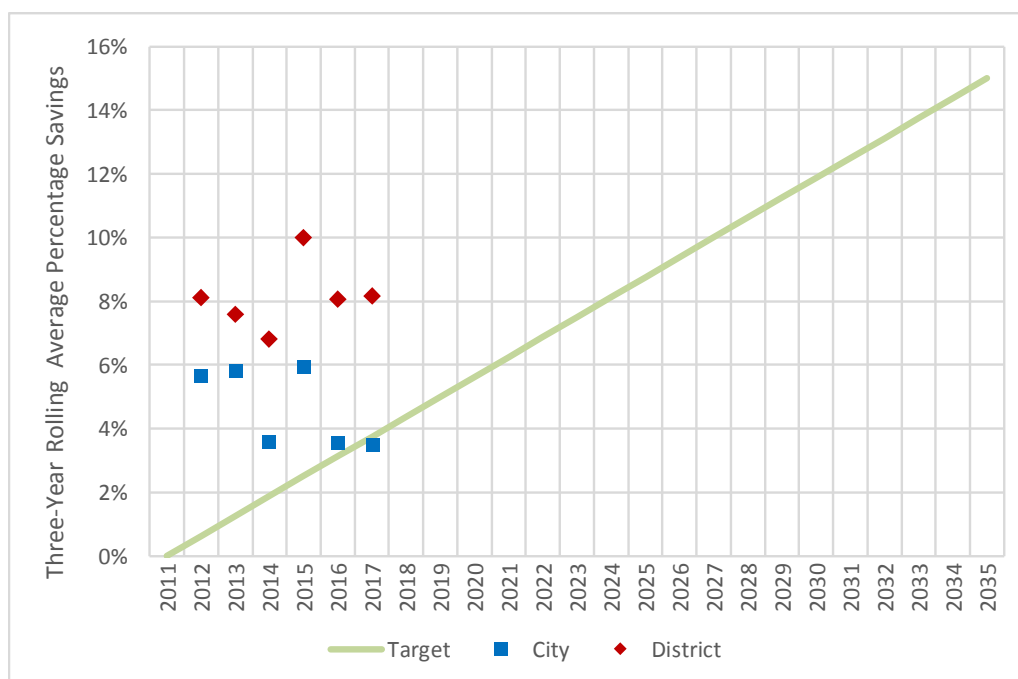


FIGURE 15. CITY AND DISTRICT WATER SAVINGS AND THE 2035 15% SAVINGS TARGET¹³

GOAL 2: WATER SYSTEM EFFICIENCY – ANNUAL NON-REVENUE WATER

Non-revenue water consists of distribution system leakage, metering inaccuracies, un-metered demand and non-metered park irrigation. During the development of the 2011 WCP, water losses were estimated at 19.9% for the City and 12% for the District. This estimation included infrastructure leakage (approximately 50%), water main breaks (approximately 20%), hydrant-flushing-related loss (approximately 10%), street cleaning (10%), malfunctioning meters (5%), and non-metered park irrigation (5%). While this information is useful, the WCP does not give the specific methodology used to estimate these losses or a timeframe for when the losses should be achieved. The 2011 WCP specifies the saving targets for non-revenue water provided in the bullets below.

- City – 19.9% to 12%
- District – 12% to 8%

Evaluation

Table 6 shows the percentage annual non-revenue losses for the City and District using annual WTP production and billing data. Losses were calculated on an annual basis as shown in the equation below.¹⁴

¹³ Three-year averages were calculated using the two proceeding years. For example, the three-year average for 2012 represents the average of annual demands from 2010, 2011 and 2012.

¹⁴ To account for losses within the City's water supply system, Steamboat II deliveries were included in both the WTP production data and as a commercial account in the billed metered data to estimate losses. This contrasts with the remainder of the demand analysis where the Steamboat II deliveries were taken out in order to focus on the City's customer base.

$$\text{Non-revenue losses} = \frac{\text{WTP Production} - \text{Billed metered water}}{\text{WTP Production}}$$

TABLE 6. PERCENTAGE LOSSES OF NON-REVENUE WATER

Year	City	District
2010	No data available	15%
2011	No data available	14%
2012	No data available	12%
2013	No data available	13%
2014	14%	10%
2015	12%	10%
2016	12%	11%
2017	11%	5%
Average	12%	11%

Note: Daily gaps in WTP production data were replaced with representative data as follows: ½ in 2010, ¼ in 2011, all of 2015 and ¼ of 2016.

The average annual losses are 12% and 11% for the City and District, respectively. Both data sets demonstrate an overall decrease in system losses, with the District's losses being lower than the City's losses. This is expected since the City's water system infrastructure is significantly older than the District's. Losses in 2017 for the District show a significant decline below the District's goal outlined above. This may be attributed to a variety of factors and may or may not coincide with future trends. For instance, in 2017 the District replaced the main water meters that measure flows from the FCTP-2 MG Tank to the City's and District main distribution lines. Water production was calculated using historical averages.

In addition, in 2015 and 2016 the City replaced 2,603 linear feet of old and undersized water main in the old town area. It is possible that leakage in this area could have been significant given water pressures. In 2018, the City also replaced the main for the Riverview subdivision and replaced pipes where there was observed corrosion/cracks. These 2018 changes may improve losses in the future. The District has also made replacement and repairs to its water mains and since 2016, the District has required large water users (mostly condo associations) to replace old meters that were suspected of not reading properly. Additional investigation and monitoring of future loss trends is needed to further understand losses within the City and District's systems.

GOAL 3: PEAK DAY DEMAND

The 2011 WCP adopted a peak day water demand goal to address the need to maintain capacity at the filtration plan. The 2011 WCP highlights the importance of maintaining peak day demands stating:

Water usage can triple from winter high season to summer high season. Every summer, irrigation for landscaping strains the ability to provide treated water for all users. Demand on peak days can exceed average daily demand by more than 40%. The City and the MWW must maintain filtration capacity at the filtration plant that is sufficient to meet the 7 to 10 peak-demand days each summer...Neither the City nor MWW experience frequent shortages or supply emergencies... however, the continued growth in tourism and second home ownership in the resort area,

residential development west of the old town, and residential infill in the old town may combine to increase demand significantly.

The 2011 WCP calls for percentage reductions in peak day water demand of 5% in 2015, 10% in 2025 and 15% in 2035. The WCP also refers to a baseline metric of 550 gpcd which is the average of 2004 to 2007 total peak day demands for both the City and District presented in Table 2-15 of the 2008 *Steamboat Water Supply Master Plan*.

Evaluation

There are a variety of methods to evaluate peak day demand. The following three figures show peak day demand at volumetric demand per day, per capita demand, and demand per EQR.¹⁵ Figure 16 demonstrates that there is a downward trend in peak day demands (mgd/day) for both the City and District, although peak day demands fluctuate on an annual basis.

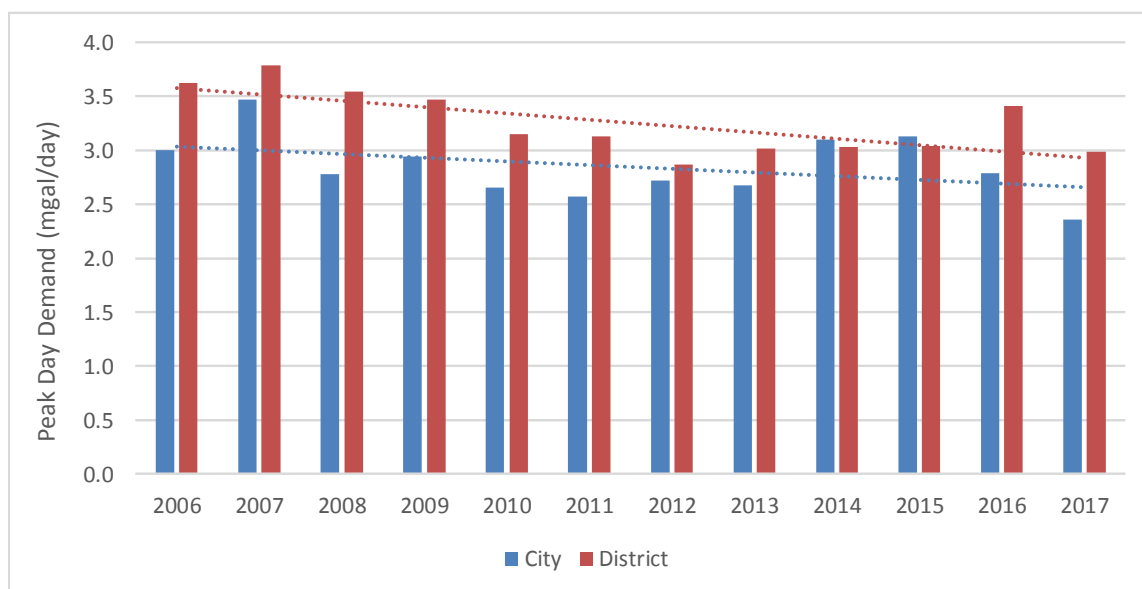


FIGURE 16. PEAK DAY DEMANDS

Figure 17 shows the reduction in total peak per capita water demand for the City and District using a three-year rolling average to smooth out some of the variability shown in Figure 16. A reduction of 12% was observed in 2015 based on the 550 gpcd metric specified in the 2011 WCP.¹⁶ This far exceeds the 2011 WCP savings goal of 5% by 2015.

¹⁵ In contrast to the monthly and annual data presented in this memo, daily Steamboat II deliveries are not subtracted from the City's peak day demands. Steamboat II deliveries are treated by the City and therefore are factored into peak day demands when assessing water treatment capacity.

¹⁶ As discussed above, the 550 gpcd metric specified in the 2011 WCP is the average of 2004 to 2007 total peak day demands for both the City and District presented in Table 2-15 of the 2008 *Steamboat Water Supply Master Plan*.

Figure 18 shows the three-year rolling average of peak day demand per EQR for the City and District. Peak day demand per EQR has declined by 19% and 26% for the City and District, respectively using a 2008 peak day demand three-year rolling average as the baseline.¹⁷

Each of these methods demonstrate the reduction in peak day demands, while Figure 17 shows that the City and District are exceeding the goal specified in the 2011 WCP. If the WCP update includes a peak day demand goal, it is recommended that demands per EQR be used as opposed to the per capita demand approach (gpcd). The EQR method is more compatible with resort communities and is also the preferred method for projecting future water demands.

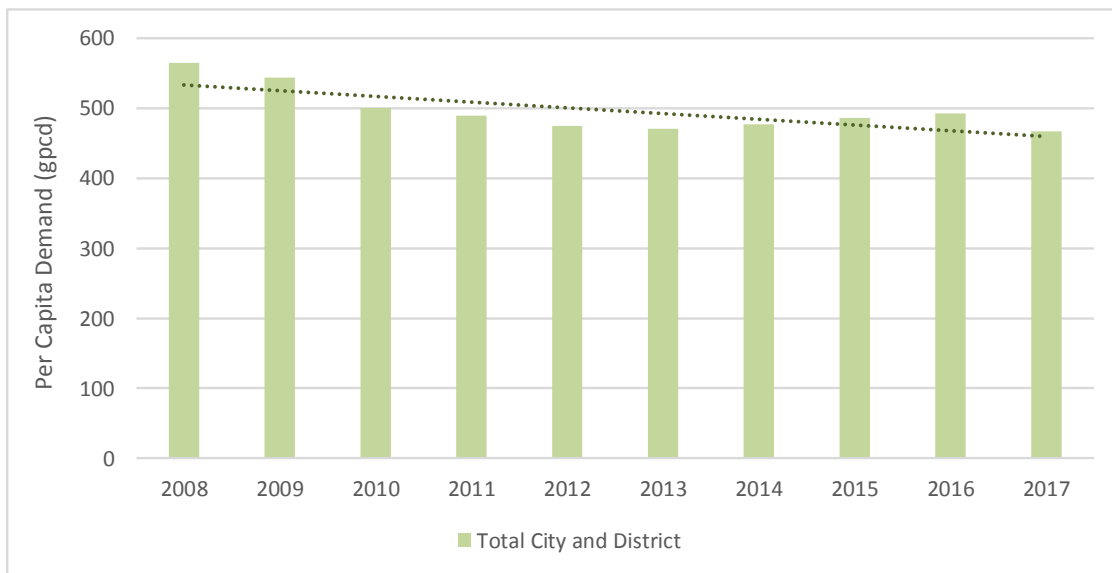


FIGURE 17. THREE-YEAR ROLLING AVERAGE OF PER CAPITA PEAK DAY DEMANDS¹⁸

¹⁷ A 2008 baseline was selected based on available data. The 2008 baseline is the average of peak day demands in 2006, 2007 and 2008.

¹⁸ The rolling average was estimated as the average of the current plus two preceding years. For example, the average 2015 peak day production was estimated as the average of 2013, 2014 and 2015 per capita peak day demands.

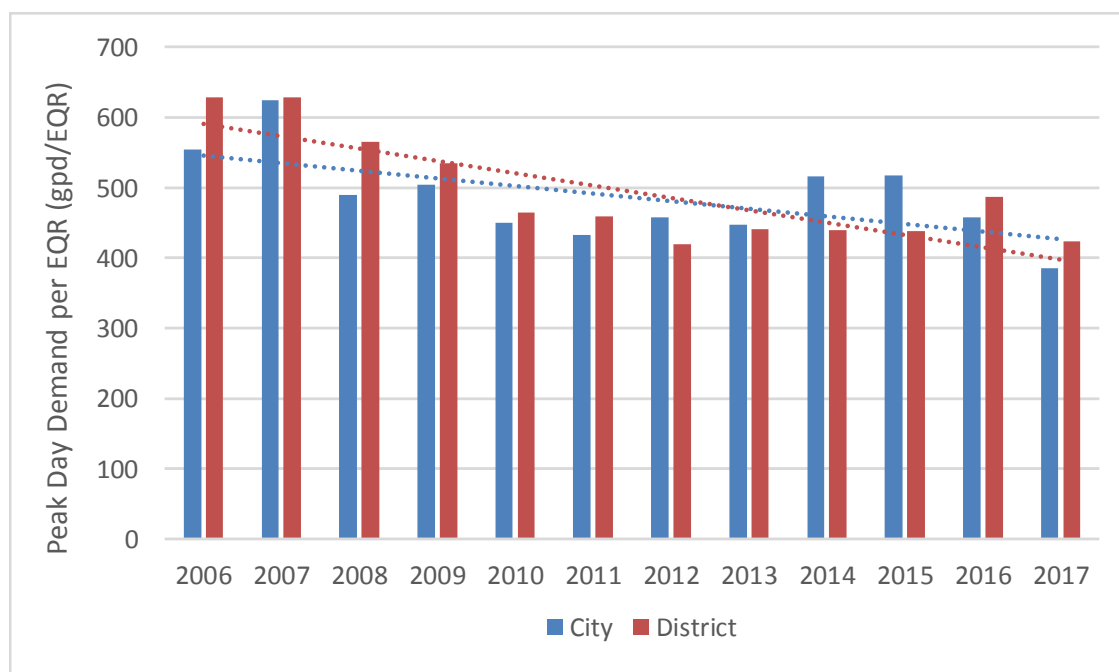


FIGURE 18. THREE-YEAR ROLLING AVERAGE OF PEAK DAY DEMAND PER EQR¹⁹

RECOMMENDATIONS

The following bullets address recommendations to consider as the WSMP and WCP are being developed.

- For purposes of the WSMP and associated modeling effort, it is recommended that a system-wide water savings goal be developed (e.g. 10% savings by 2035). The model being developed by High Country Hydrology will enable the user to test various water conservation savings targets and years in which the goal is to be achieved. Following development of this system-wide goal, the District and the City can partition the savings into finer resolution. For instance, if a 10% system-wide goal is desired, during the WCP update, it may be broken into an 8% target for residential customers and a 2% target for commercial customers.
- The CWCMB Municipal Water Efficiency Guidance Document uses the terminology of water efficiency rather than water conservation. Water efficiency speaks more to the fundamental objective of a water conservation plan, which is to improve water efficiency both on the supply-side and on the demand/end user side. Demand management is also terminology commonly used. We suggest discussing what terminology you would like to have incorporated into the WCP and WSMP.
- It is our understanding that the Drought Stage 1 recommended guidelines are always in affect. The Stage 1 guidelines, outlined in the Drought and Water Emergency Preparedness Plan, are good water-wise practices that are often included in water conservation plans. However, including these practices in your drought response plan causes some ambiguity between conservation (measures that are always

¹⁹ The rolling average was estimated as the average of the current plus two proceeding years. For example, the average 2015 peak day production was estimated as the average of the peak 2013, 2014 and 2015 water demand per EQR per day.

implemented regardless of weather conditions) versus drought response (actions that are taken during drought). From a public outreach perspective, it can be advantageous to have conservation practices and drought response clearly differentiated so that when a utility enters a drought, the message is “we are in a drought and need to save more water than what we typically would do through everyday water conservation practices.”

- If it is of interest to provide a more concise version of this historical analysis in the WCP and WSMP, we recommend removing trends using per capita demands and just focusing on demands per EQR in the WSMP and WCP. If desired, we can discuss additional ways in which the write-up of this analysis can be consolidated.

APPENDIX B

DEMANDS MEMO





Water Resource Advisors for the West

Memorandum

Date: January 21, 2019

AG Job No.: 18-116

To: Steamboat Springs and Mount Werner Water District

From: Applegate Group

RE: Steamboat Historical and Future Demands Overview

This memorandum summarizes the historical and future demands analysis completed for the Steamboat Springs Water Supply Master Plan (WSMP). The work was completed for the City of Steamboat Springs (City) and the Mount Werner Water District (District). The City and District reviewed the initial draft of this memorandum, and this final version includes revisions made to address comments received from the City and District.

HISTORICAL AND CURRENT DEMANDS

WATER PRODUCTION DATA BACKGROUND

The City and District provided daily production data from 2006 to June 2018. Production data included the following daily data that was used to determine historical and current demands:

- Influent to Fish Creek Treatment Plant
- Fish Creek filtration plant production data by City, District, and total
- Yampa wells production data
- The original interconnect (Rollingstone), with data extending back to 2006
- The additional interconnect, with data starting in mid-2017 (Kum & Go)
- Skyline Tank, which was provided in quarterly totals and assumed to be constant over the quarter to develop daily production from the Skyline Tank

City, District, and combined totals were then calculated based on the above disaggregated data provided by the District and City.

MODIFICATIONS TO PRODUCTION DATA

Production data from 2006 through 2017 were used to develop historical demands. The current year, 2018, was excluded because the data was incomplete. There were some gaps in the data due to meters not being online, broken, or giving incorrect readings that lead to issues such as negative City totals or no values at all. Questionable production data was replaced with production data from other months in the study period, based on a comparison of meter data available from 2010 to 2017. Quarterly customer meter data was compared to identify quarterly periods with similar meter usage, e.g., fourth quarter example meter data in Figure 1.

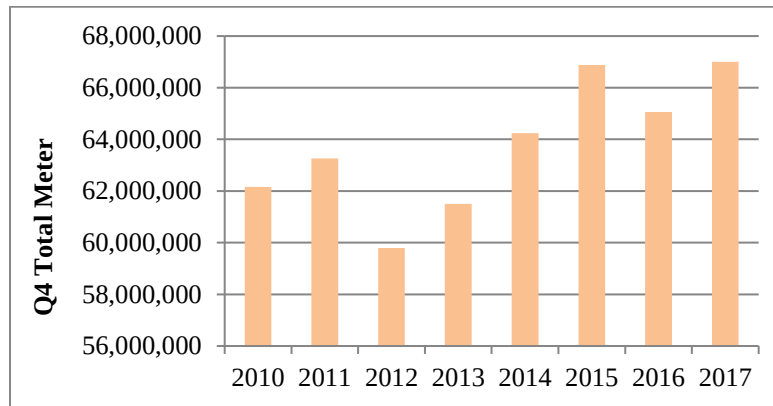


FIGURE 1. EXAMPLE METER DATA FOR FOURTH QUARTER.

Overall, the following significant (i.e., more than one month of data) changes to the data were made to address erroneous production data. There were other changes made to shorter time periods, but those are not noted here and were generally replaced from average adjacent days rather than wholesale replacement based on other quarters with similar meter data. Production data for the following periods were modified as indicated (also shown in orange on Figure 4):

- 2010
 - Q1 replaced with Q1 2012
 - Q4 replaced with Q4 2017
- 2011
 - Q1 replaced with Q1 2014
 - Q2 replaced with Q2 2010
- 2015
 - Q1 replaced with Q1 2014
 - Q2 replaced with Q2 2017
 - Q3 replaced with Q3 2014
 - Q4 replaced with Q4 2017
- 2016
 - Q4 replaced with Q4 2014

HISTORICAL DEMANDS

Historical demands were calculated based on production data provided by the City and District, and are discussed in this section based on various time periods (e.g., annual, daily) and normalization approaches (e.g., gallons per capita and gallons per equivalent residential units).

ANNUAL DEMANDS

Production data is summarized below in Table 1 and Figure 2. There is an overall trend of decreasing total annual production demand, despite a steady increase in population, which is indicative of increasing efficiency in water use.

TABLE 1. ANNUAL TOTALS FOR CITY, DISTRICT AND COMBINED.

Year	Annual Totals (MG)			Total (AF)
	City	District	Total	
2006	496	533	1,029	3,157
2007	503	568	1,071	3,287
2008	454	566	1,020	3,130
2009	439	542	981	3,012
2010	425	484	909	2,791
2011	390	469	858	2,633
2012	434	510	944	2,897
2013	424	492	916	2,810
2014	418	481	899	2,758
2015	409	460	869	2,666
2016	451	523	973	2,987
2017	414	480	894	2,742

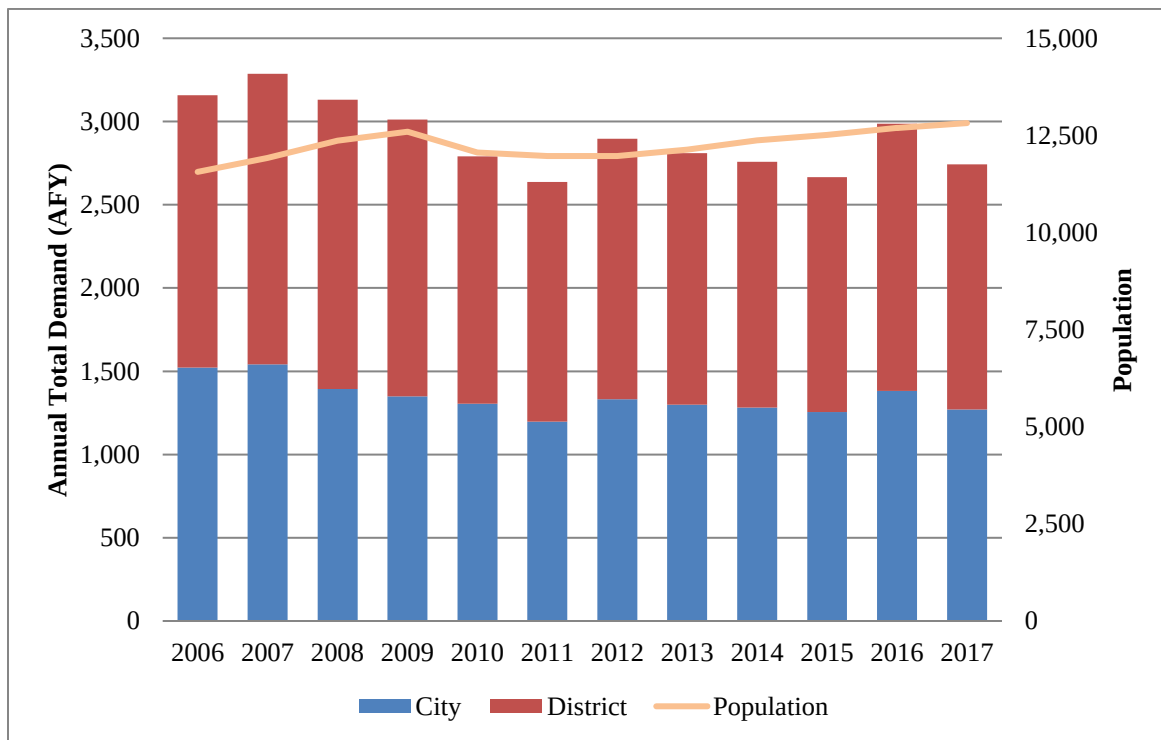


FIGURE 2. ANNUAL WATER DEMAND FOR CITY, DISTRICT AND COMBINED.

Note: Historical population data for 2017 was unavailable and was projected using a 1% annual increase based on the years prior.

AVERAGE DAILY DEMAND

Average daily demands are represented in the following Table 2 and Figure 3. As the total annual demands show above, the daily averages also show a slight decreasing trend over the data period.

TABLE 2. AVERAGE DAILY DEMANDS FOR CITY, DISTRICT AND TOTAL.

Year	City Average Day (MGD)	District Average Day (MGD)	Total System Average Day (MGD)
2006	1.356	1.457	2.813
2007	1.373	1.555	2.928
2008	1.240	1.543	2.783
2009	1.200	1.482	2.682
2010	1.164	1.322	2.486
2011	1.068	1.282	2.347
2012	1.185	1.392	2.577
2013	1.159	1.346	2.505
2014	1.142	1.316	2.458
2015	1.118	1.257	2.375
2016	1.229	1.426	2.655
2017	1.132	1.312	2.443

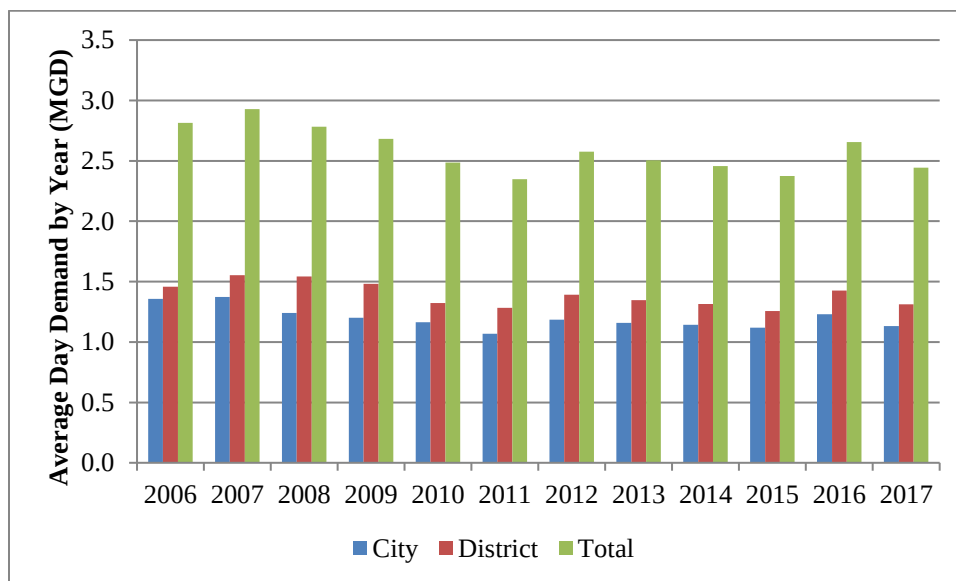


FIGURE 3. AVERAGE DAY DEMAND BY YEAR FOR CITY, DISTRICT AND TOTAL.

A monthly time series of water use throughout the 12-year period of record, Figure 4, indicates the trends throughout the year are typically the same for both the City and the District, with a generally decreasing trend over the study period.

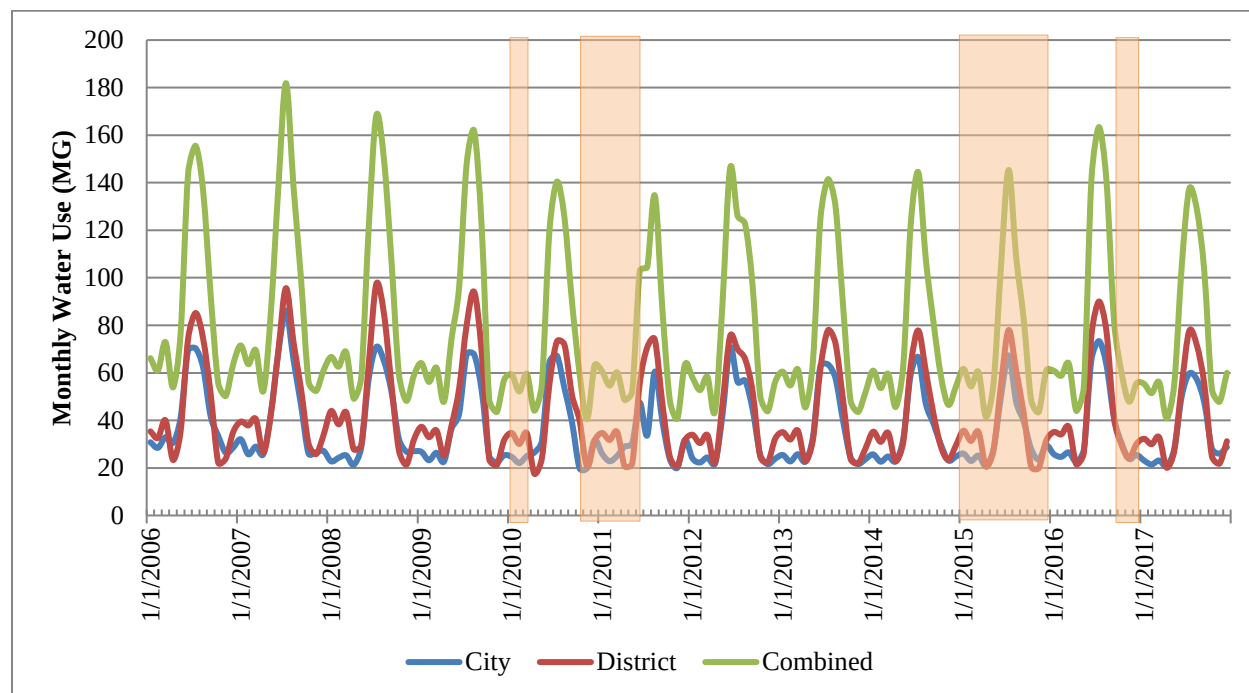


FIGURE 4. TOTAL PRODUCTION DATA MONTHLY TIME SERIES.

Note: Orange shading represents edits where production data was estimated based on quarters with similar meter data.

MONTHLY DEMANDS

Monthly demands identify water use trends throughout the year. Table 3 and Figure 5 display the totals for each month, averaged over the 2006-2017 study period.

TABLE 3. MONTHLY TOTALS AVERAGED BY MONTH OVER 2006-2017 TIME PERIOD.

Total Monthly Average 2006-2017						
Month	Millions of Gallons			Acre-Feet		
	City	District	Combined	City	District	Combined
January	26.10	36.06	62.16	80.10	110.67	190.77
February	23.61	32.70	56.31	72.46	100.36	172.82
March	26.13	36.59	62.72	80.19	112.28	192.47
April	23.93	22.57	46.40	73.43	69.26	142.40
May	33.51	31.82	65.32	102.83	97.64	200.47
June	59.10	63.11	122.21	181.36	193.69	375.04
July	65.25	81.12	146.37	200.24	248.95	449.19
August	58.72	73.48	132.20	180.20	225.50	405.70
September	43.64	50.84	94.48	133.92	156.02	289.94
October	27.29	26.80	54.09	83.75	82.24	165.98
November	23.48	22.23	45.71	72.05	68.24	140.29
December	27.30	31.56	58.86	83.80	96.85	180.65
Totals	438.05	508.88	946.83	1344.33	1561.69	2905.71

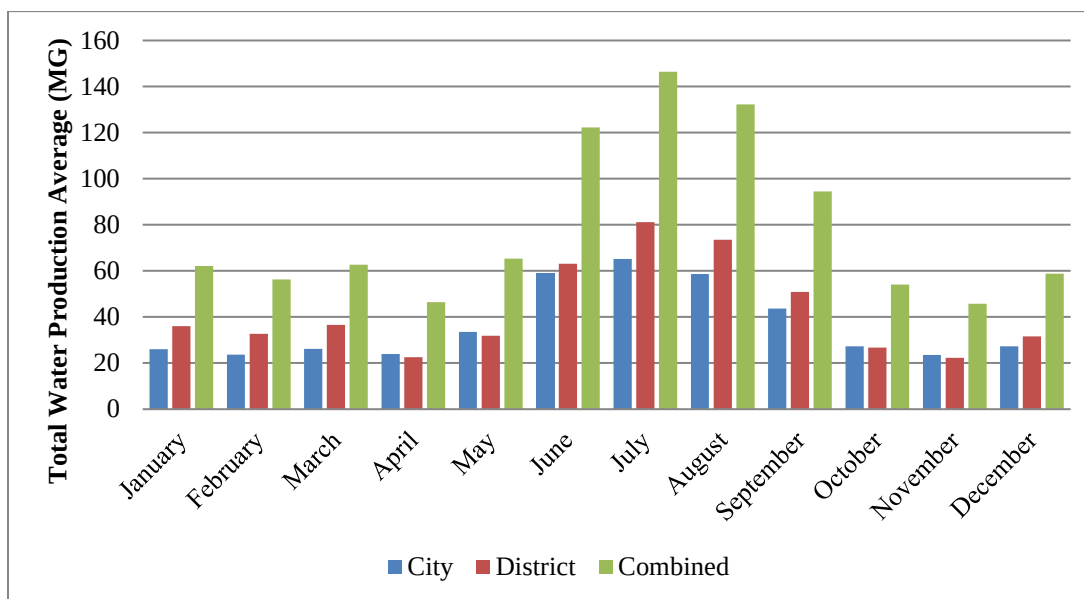


FIGURE 5. AVERAGE MONTHLY TOTAL OVER 2006-2017 TIME PERIOD.

INDOOR AND OUTDOOR TREATED WATER DEMANDS

The monthly treated water demands were further disaggregated into indoor and outdoor demands, for both the City and District. It was assumed that there are no outdoor demands from October through April. Demand was split between indoor and outdoor for the May through September period. Monthly average indoor use was determined based on winter demands for each year during 2009-2017. Average monthly indoor use was subtracted from each total demand for the summer months for all years between 2009-2017 to calculate the outdoor demand by month. Table 4 displays the resulting indoor and outdoor percentages of the total demand averaged over 2009-2017 for the City and District Separately. Using these percentages, Figure 6 and Figure 7 show the resulting average indoor and outdoor demands for the City and District, respectively.

TABLE 4. INDOOR AND OUTDOOR TREATED WATER DEMANDS AS % OF TOTAL DEMANDS.

Month	City		District	
	Indoor	Outdoor	Indoor	Outdoor
January	100.0%	0.0%	100.0%	0.0%
February	100.0%	0.0%	100.0%	0.0%
March	100.0%	0.0%	100.0%	0.0%
April	100.0%	0.0%	100.0%	0.0%
May	76.5%	23.5%	94.8%	5.2%
June	43.2%	56.8%	47.3%	52.7%
July	39.9%	60.1%	37.4%	62.6%
August	43.3%	56.7%	40.1%	59.9%
September	57.8%	42.2%	57.8%	42.2%
October	100.0%	0.0%	100.0%	0.0%
November	100.0%	0.0%	100.0%	0.0%
December	100.0%	0.0%	100.0%	0.0%

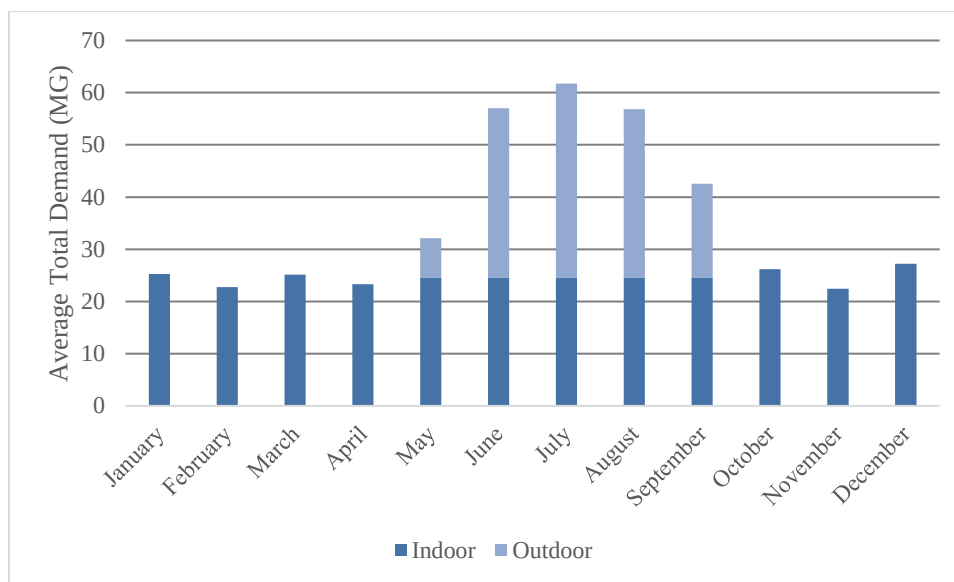


FIGURE 6. CITY INDOOR AND OUTDOOR TREATED WATER DEMANDS 2009-2017 AVERAGE.

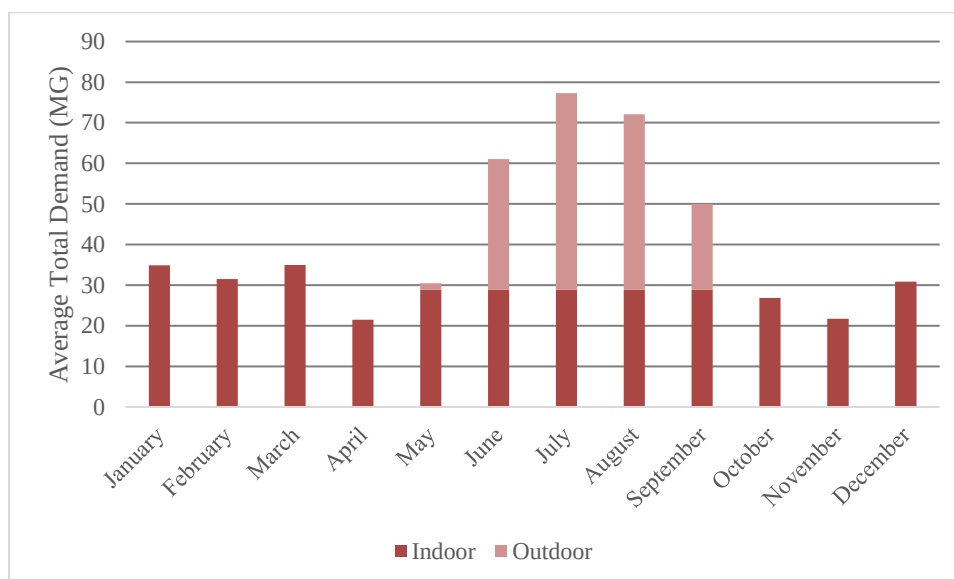


FIGURE 7. DISTRICT INDOOR AND OUTDOOR TREATED WATER DEMANDS 2009-2017 AVERAGE.

CURRENT DEMANDS

A determination of current demands was necessary to develop a base demand that will be used in developing projected water demands. The year 2017 was determined to be a representative year for current demand, based on a review of total annual demands over the 2006 to 2017 period. The year 2017 captures the overall trend of total water use, particularly since the dry year of 2012 (Figure 3).

Figure 8 and Table 5 summarize current water demands, which are based on 2017 production data and the assumption that 2017 is representative of current conditions. Peak and average day demands are at a maximum in the summer months, which is expected due to outdoor water use. Current (2017) demands are about six percent lower than the average annual demand over the 2006 to 2017 period of record. This is because of the trend for increased water efficiency over the period of record.

Peaking factors (peak day demand, divided by average day demand) for total demand range from 1.1 to 1.4 for the current demand. The main peak in demand occurs in the summer months of June, July, and August due to the added outdoor demand. There is also a small, yet noticeable increase in the winter months (December through March) due to the number of visitors for winter recreation, which generally peaks in February and March. Demands are lowest in the off-season months of April and November, which are months between the summer/fall and winter/spring tourist seasons.

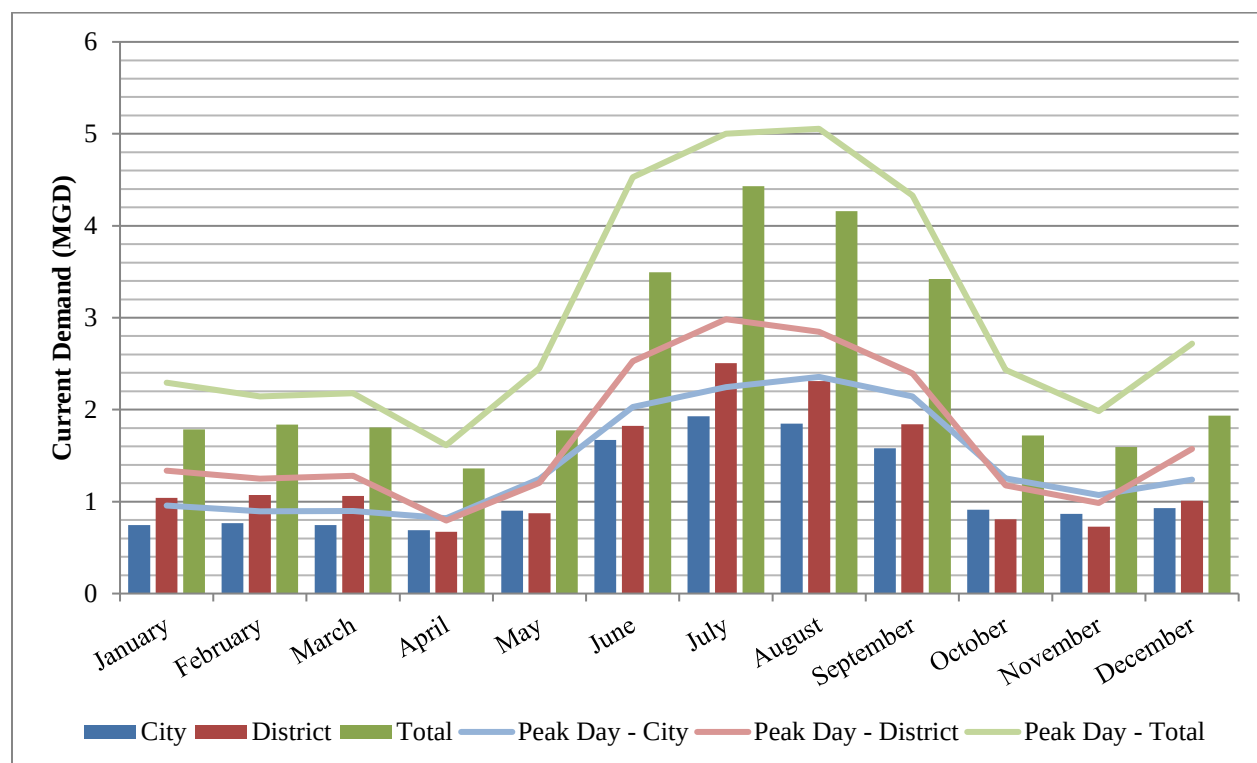


FIGURE 8. CURRENT (2017) AVERAGE DAY DEMAND BY MONTH WITH PEAK DAY DEMAND.

Note that the demand data in Figure 8 is for the year 2017 only. Historical peak day demands have at times been higher than the 2017 peak day demands shown.

TABLE 5. CURRENT (2017) TOTAL MONTHLY DEMAND AND PERCENTAGE OF ANNUAL USE.

2017 Monthly Totals – Millions of Gallons						
	City	% of 2017 City Annual	District	% of 2017 District Annual	Total (City + District)	% of 2017 Total Annual
January	23.09	6%	32.25	7%	55.35	6%
February	21.48	5%	29.97	6%	51.45	6%
March	23.13	6%	32.91	7%	56.04	6%
April	20.71	5%	20.10	4%	40.81	5%
May	27.94	7%	27.05	6%	54.99	6%
June	50.13	12%	54.75	11%	104.88	12%
July	59.73	14%	77.67	16%	137.40	15%
August	57.24	14%	71.67	15%	128.91	14%
September	47.42	11%	55.21	12%	102.63	11%
October	28.27	7%	25.02	5%	53.28	6%
November	26.00	6%	21.80	5%	47.80	5%
December	28.76	7%	31.24	7%	60.00	7%
Total	413.90	100%	479.64	100%	893.53	100%

CURRENT EQUIVALENT RESIDENTIAL UNITS

In order to account for visitor population present in Steamboat Springs, an equivalent residential unit (EQR) is used as the unit for water demand. This method is important for resort type communities, since a per capita demand does not accurately reflect the water use per permanent resident.

The City's annual EQR growth from 2006 to current was calculated based on the Plant Investment Fee (PIF) calculation form that are required for determining tap fees. Total points for both water and wastewater are calculated in the PIF, and new EQRs were calculated assuming 140 fixture units per EQR. The District provided their calculations for new EQRs over the 2006 to 2017 period. Annual growth in EQRs for the City and the District are displayed below in Table 6.

TABLE 6. ANNUAL EQR INCREASES

Year	Annual Increases in Historical EQRs		
	City	District	Total
2006	135.6	251.5	387.2
2007	150.7	218.3	369.0
2008	60.7	280.0	340.7
2009	26.7	37.0	63.7
2010	15.8	22.0	37.8
2011	37.4	17.0	54.4
2012	26.7	64.0	90.7
2013	38.1	19.0	57.1
2014	41.6	84.0	125.6
2015	40.0	36.0	76.0
2016	84.9	38.0	122.9
2017	48.8	110.0	158.8

The average annual changes in EQRs over the 2006 to 2017 period were as follows:

- City average annual increase of 59 EQRs
- District average annual increase of 98 EQRs

The base cumulative number of EQRs for the City and District (i.e., year 2007) was taken from the 2008 Water Supply Master Plan and assumed as the starting point for determining cumulative future EQR estimates. The assumed baseline (2007) EQRs were 5,555 EQRs for the City, and 6,021 EQRs for the District. New EQRs for the City were added to the 2007 baseline EQRs, based on Plant Investment Fee (PIF) forms provided by the City. Future EQR projections for the District were provided by the District. The calculated new EQR was added to the previous years' total EQR. New EQRs were then lagged two years, as it is assumed that EQRs would come online two years after completing the PIF and determining the associated tap fee. From this data, a combined EQR was established using the City and District data. The cumulative lagged EQRs for 2006-2019 are shown in Figure 9.

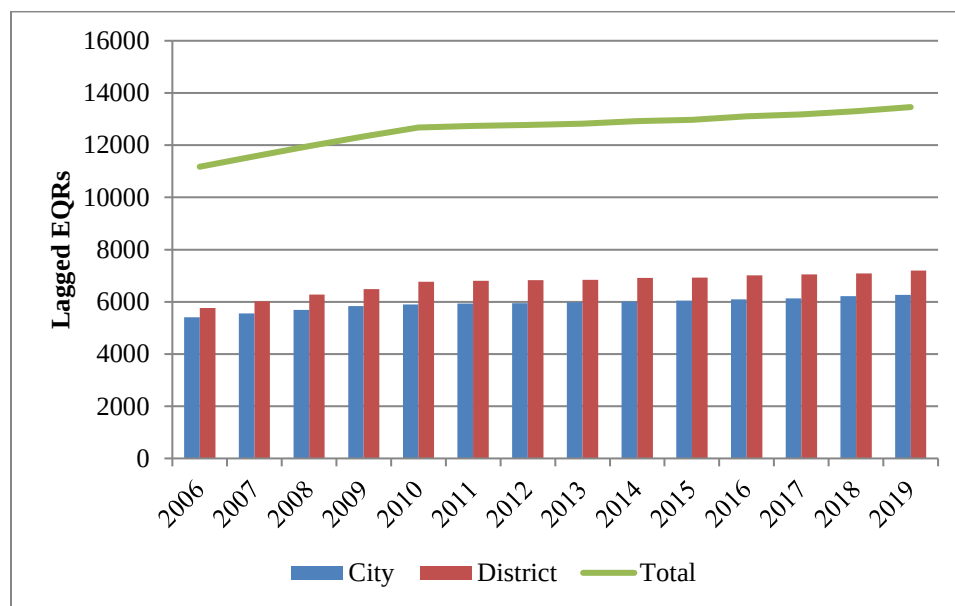


FIGURE 9. CUMULATIVE LAGGED EQRs.

FUTURE DEMANDS

Future demands were estimated on an annual basis from 2019 through 2070. Future demands were dependent on current unit demands and population projections.

POPULATION PROJECTIONS

Historical Steamboat Springs population data were available through 2016. Population projections were needed to estimate future water demands, and were developed for Steamboat Springs for the period from 2017 to 2070. Data used to develop population projections were:

- Annual population projections were obtained for Routt County from the Colorado State Demographer Office¹ for the available period of record from 2017 to 2050.
- Historical population estimates for the 1990 to 2016 period of record were obtained from the U.S. Census Bureau² for the City of Steamboat Springs and for Routt County (Figure 10). The Steamboat Springs population estimates from the 1990 to 2000 period include a sharp increase in population between 1999 and 2000. This sharp increase from approximately 7,000 to 10,000 people was assumed to be a correction during the 2000 Census. In order to correct this, it was assumed that the population grew linearly from 1990 to 2000. This creates more conservative results since it projects a higher population project and thus a higher demand projection.

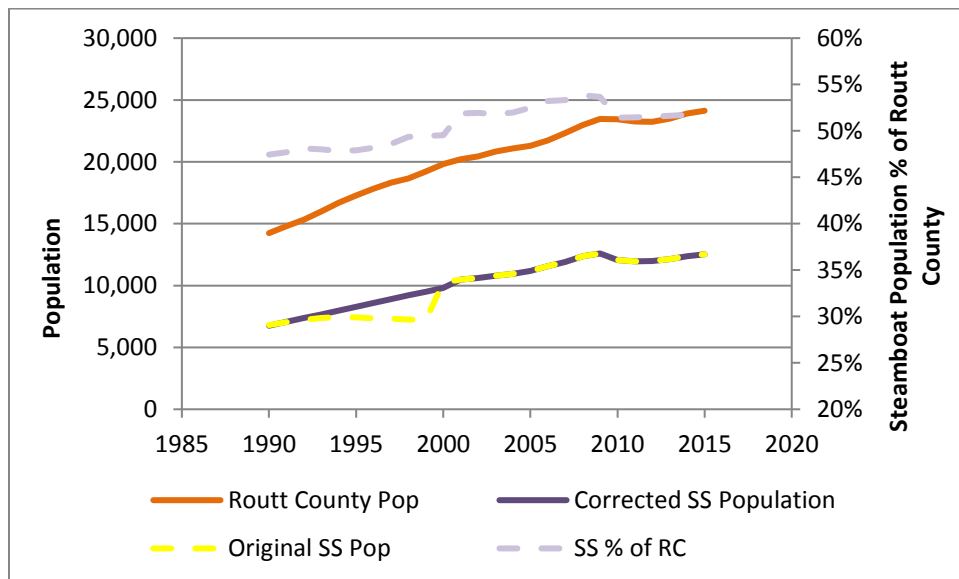


FIGURE 10. HISTORICAL POPULATION DATA.

The following steps were taken to develop population projections based on the base data described above:

1. Extend Routt County population projections from 2050 to 2070. This was done using a 10-year rolling average of annual growth for the 2017 to 2050 projections obtained from the State Demographer's Office. This method resulted in a range of annual population increases of a minimum of 1.4%, average of 1.8%, and maximum 2.3% over the 2017 to 2050 period of available Routt County population projections.

¹ Colorado Department of Local Affairs, State Demography Office Dashboard. Accessed September 27, 2018. https://gis.dola.colorado.gov/apps/demographic_dashboard/

² United States Census Bureau, Population and Housing Unit Estimates. Accessed September 27, 2018. <https://www.census.gov/programs-surveys/popest.html>

2. Calculate the percentage of historical Routt County population made up by historical Steamboat Springs population over the 1990 to 2015 period of record. This resulted in a minimum of 47% (1990), average of 51%, and maximum of 54% (2008 and 2009).
3. Develop low/medium/high Steamboat Springs population projections for the 2017 to 2050 period. Routt County population projections were multiplied by the minimum/average/maximum %s described in #2 above to estimate low/medium/high Steamboat Springs population projections for the 2017 to 2050 period.
4. Develop low/medium/high Steamboat Springs population projections for the 2051 through 2070 period. The low/medium/high Steamboat Springs population projection for 2050 (described in #3 above) were increased by the factors described in #1 above (i.e., 1.4% annual increase for the low projection, 1.8% annual increase for the medium projection, and 2.3% annual increase for the high projection).

The resulting range of population projections for City of Steamboat and Mount Warner Water District indicate a total population of between 21,500 and 33,000 at the end of the study period in 2070 (Figure 11). Total City of Steamboat population projections were then disaggregated into population within the City limits and the Mount Werner Water District boundary, according to the pro-rata volume of treated water over the 2006 to 2017 period of record. This analysis indicated that about 46 percent of water use was within the City boundary, and that 54 percent of water use was within the District boundary. The resulting population projections for the City and District are presented in Figure 12 and Figure 13.

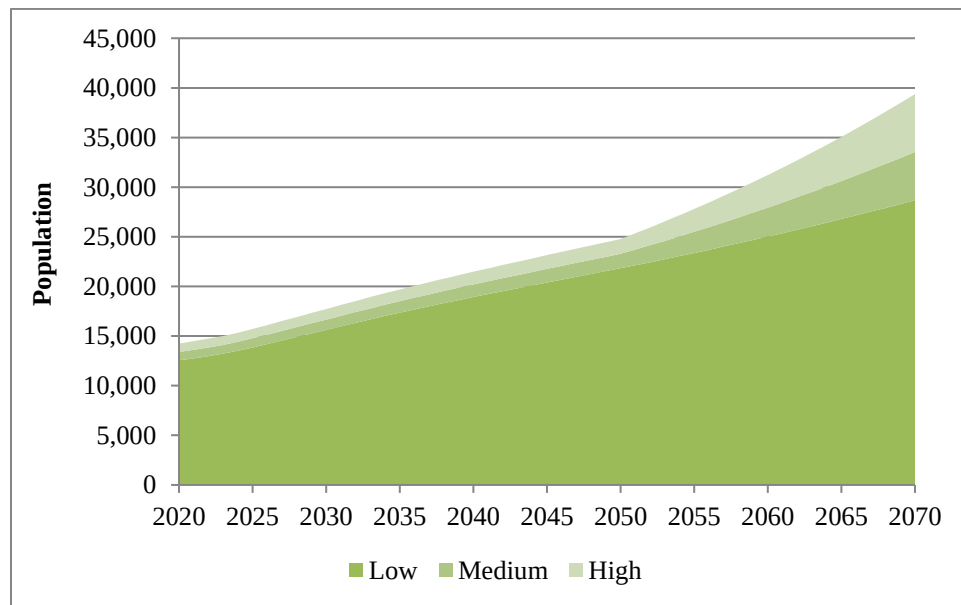


FIGURE 11. TOTAL STEAMBOAT SPRINGS POPULATION PROJECTIONS

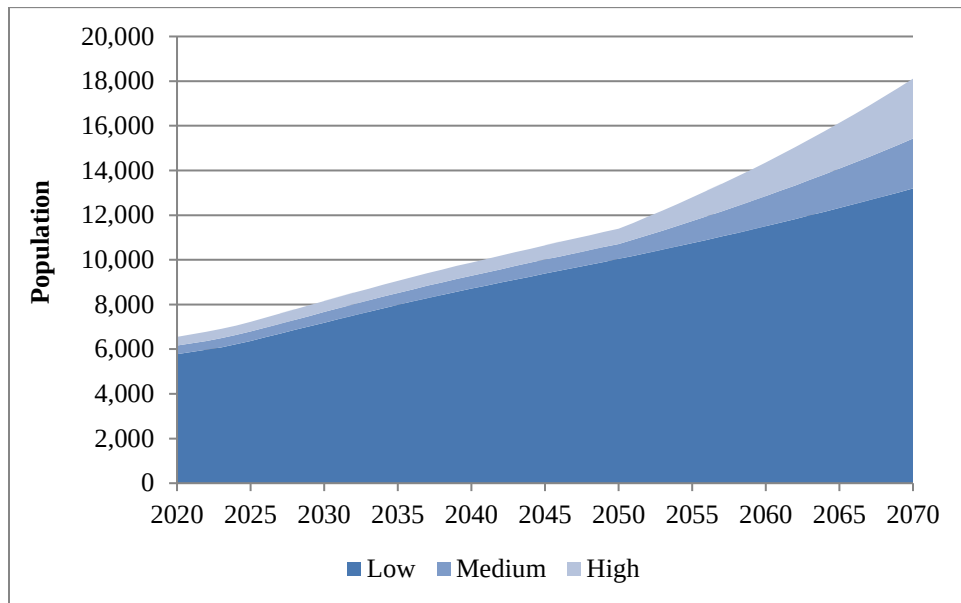


FIGURE 12. POPULATION PROJECTIONS WITHIN CITY BOUNDARY.

Note: Population projections within City boundary were based on assumption of 46 percent of total Steamboat Springs population, following the distribution of produced water within Steamboat Springs.

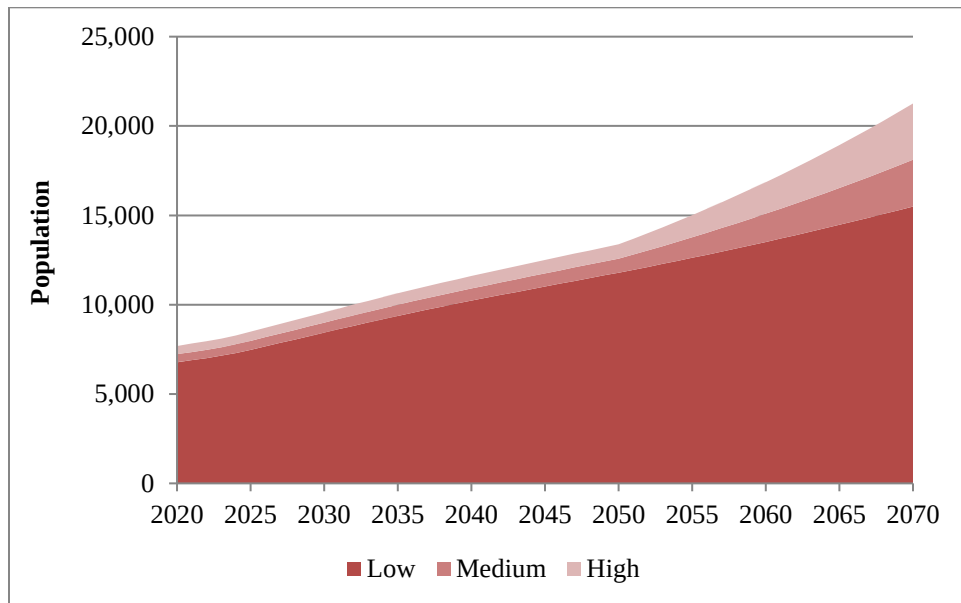


FIGURE 13. POPULATION PROJECTIONS WITHIN DISTRICT BOUNDARY.

Note: Population projections for the District based on assumption of 54 percent of total Steamboat Springs population, following the distribution of produced water within Steamboat Springs.

FUTURE DEMAND PROJECTIONS

Future demand projections were based on three different approaches, which resulted in an envelope of possible future demands. The three different approaches for estimating future demands are generally identified below, with more detail provided in this section.

1. Equivalent Residential Units (EQR) scaled by the projected annual increase in Steamboat Springs population. Projected EQRs were then multiplied by current EQR unit water demand.
2. EQR scaled by average percent of historical increase in EQRs over the 2008 to 2019 period (lagged dates). Projected EQRs were then multiplied by current EQR unit water demand.
3. Population based future demands were estimated by multiplying projected population by current unit water demands in gallons per capita per day (GPCD).

Note that Steamboat II data was included in methods 1 (EQR A) and 2 (EQR B) listed above. See relevant sections below for additional information.

APPROACHES TAKEN BY OTHER COMMUNITIES

Similar communities to Steamboat Springs were researched regarding means and methods of projecting future water demands. The following areas and water districts were considered:

- The City of Aspen
- The Town of Crested Butte
- The Town of Breckenridge
- Eagle River Water and Sanitation District
- Park City, Utah
- Yampa/White/Green Basin Implementation Plan

There is no one standard approach, and there are a variety of methods in determining future water demands. For example, some municipalities use population projections but show a separation between permanent and seasonal population. Detailed population and visitor data are needed for this method. Others simply use population projections and gallons per capita per day, with the acknowledgement that the estimates for per capita water use are skewed due to the visitor population. Lastly, there are some that use an equivalent residential unit (or equivalent) to calculate the demand projections by creating an annual EQR growth rate projection. In communities with a significant influence from non-permanent residents, the EQR approach may be the most accurate, since it is not reliant on accurately determining the population for water users. However, the EQR approach is reliant on accurate predictions for future development including projected types and rates of new development, redevelopment, and buildout.

EQR BASED DEMAND

Steamboat Springs is a resort community, and using EQR unit demand is one way to normalize overall water use by development, which can account for both permanent residents and tourists. In order to project the future demand based on the current EQRs, the following methods were used:

1. EQR A: Scale current EQRs by annual population projection percent change by year.

The EQR A method first estimated future EQRs by scaling current EQRs by the projected annual percent increases in population. Low, medium and high population projections were used, creating low, medium and high EQR projections. Scaled EQRs were then multiplied by the current (2017) EQR unit demand, 185 gpd per EQR for the City, 187 gpd per EQR for the District and 186 per EQR for combined, to estimate future demands. The projected EQR data are summarized in acre-feet per year (Figure 14) and peak day

demand (Figure 15). The peak day demand was calculated using the 2017 peak day demand as the baseline for scaling to project future peak day demand. This method applies the projected change in population directly to the EQRs, which assumes that the current mix of water use by permanent residents and tourists will continue into the future.

There is a small increase in demand starting in 2040 that is associated with Steamboat II demands. The amount added into the demands to account for Steamboat II was calculated using the diversion records which date back to 1977. A 20-year average (1997-2017) was calculated and added into the projected demands. The 20-year average, approximately 50,000 gallons/day is slightly lower, but assumed to be more representative, than the entire average due to much higher diversions during the early 1990s. This demand was added in starting with 10% in the year 2014 and increasing by 10% each year for 10 years, until 2049. After 2050 and beyond, the additional demand was added in as a constant through 2070. It was assumed Steamboat will start to meet Steamboat II demands entirely once a new water treatment plant comes online. The timing of the new water treatment plant is based on when the peak day demand in Figure 15 begins to encroach on the 9.3 MGD capacity, which is made up of 7.5 MGD from the Fish Creek water treatment plant and 1.8MGD from the Yampa wells. This is the capacity of the existing water treatment plants. However, there is the potential to expand to 15.5 MGD (i.e., 12 MGD for the Fish Creek plant and 3.5 for the Yampa Wells). Note that for both EQR A and EQR B methods, Steamboat II was not included into the peak day demand calculations because the demand being added for Steamboat II is less than 1% of the total demand.

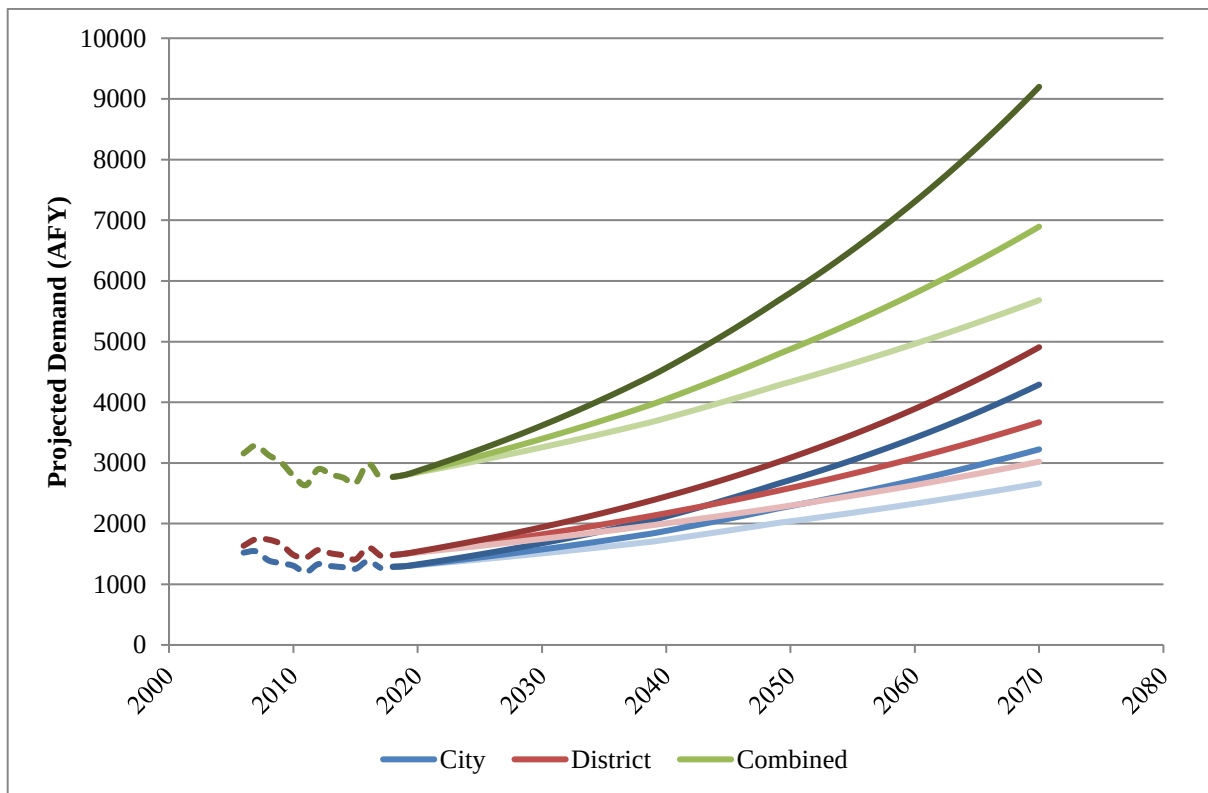


FIGURE 14. PROJECTED DEMAND WITH SCALED EQR BY ANNUAL POPULATION (EQR-A).

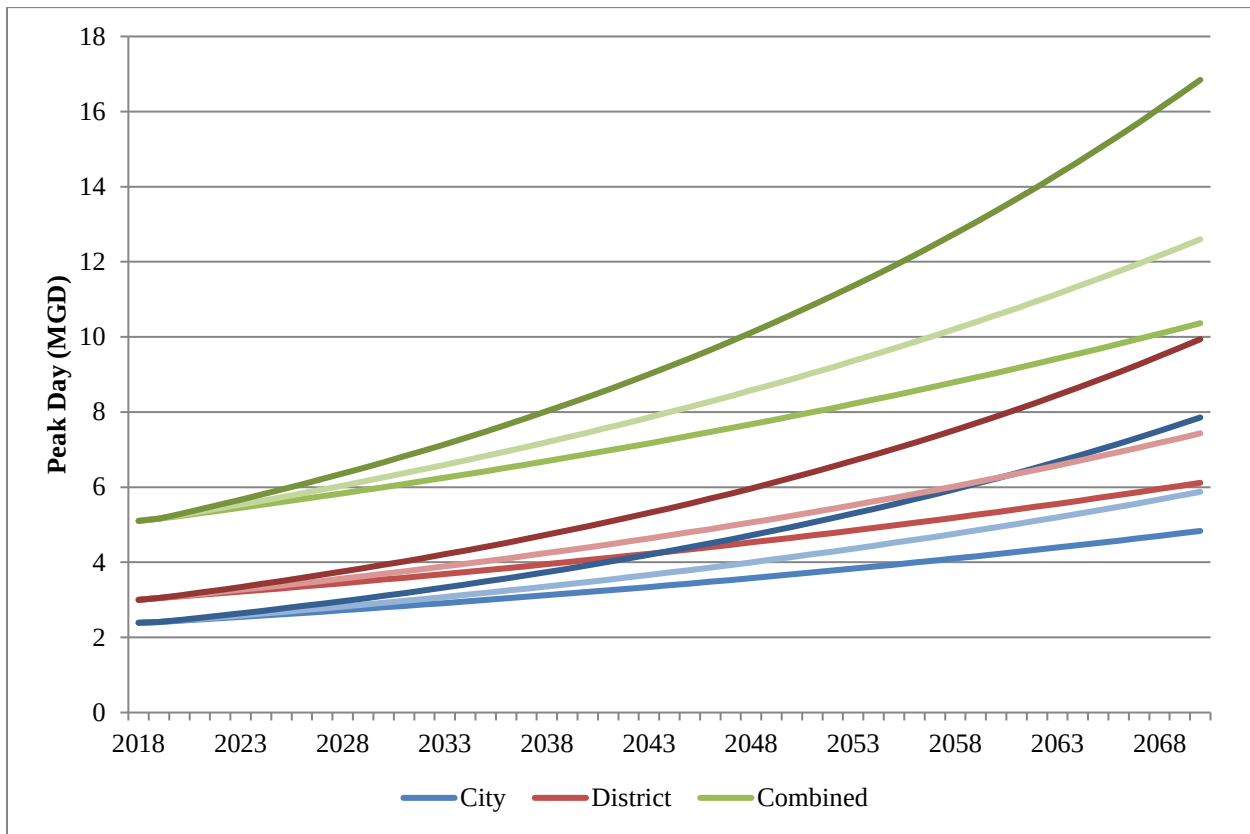


FIGURE 15. PROJECTED PEAK DAY DEMAND USING EQR-A METHOD.

Note: peak day demand does not include Steamboat II.

2. EQR B – Scale current EQRs by the average percent of annual historical change for EQRs.

Future EQRs were projected using one average annual change in the historical lagged EQR data from 2008-2019. The average annual increase in EQRs includes the years 2006 through 2008, which were years with high growth, particularly for the District. This time period was used for the City and District in the EQR B method, which may overestimate growth for the District, but provides a conservative projection.

The average annual percent change for the City, District and combined are 1.01%, 1.51% and 1.27%, respectively. The projected EQR data was then multiplied by current EQR unit demands to project future demands. The projected volumetric demand is shown in Figure 16, and the peak day demand is shown in Figure 17.

To remain consistent to the EQR A method, Steamboat II was added into the system as an increased percentage over the 2040 to 2049 time period and continued as a constant until the end of the projection period in 2070.

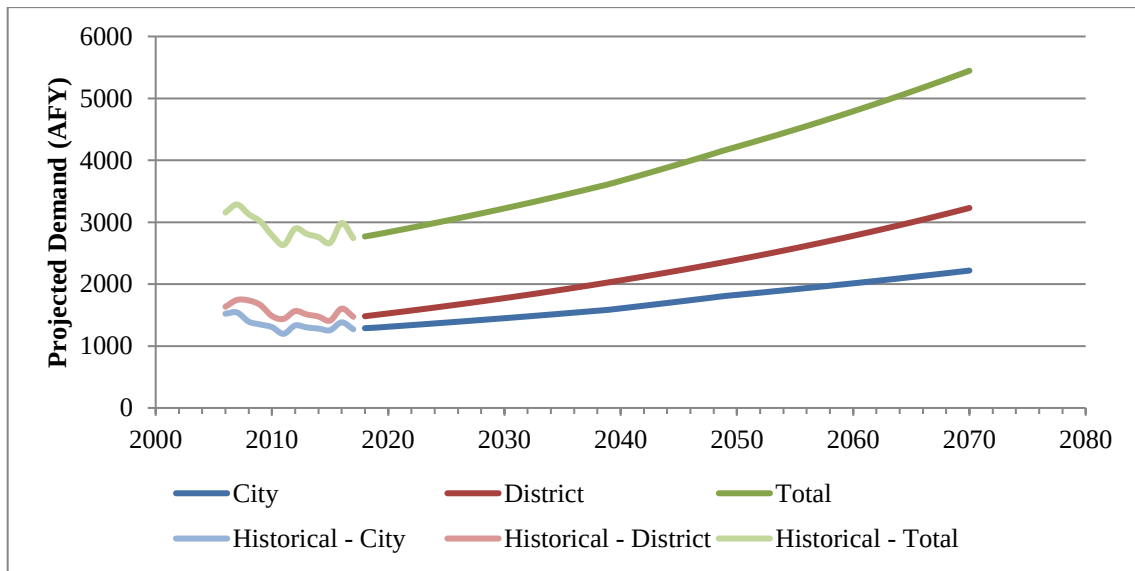


FIGURE 16. PROJECTED DEMANDS USING SCALED EQR BY AVERAGE POPULATION CHANGE (EQR-B).

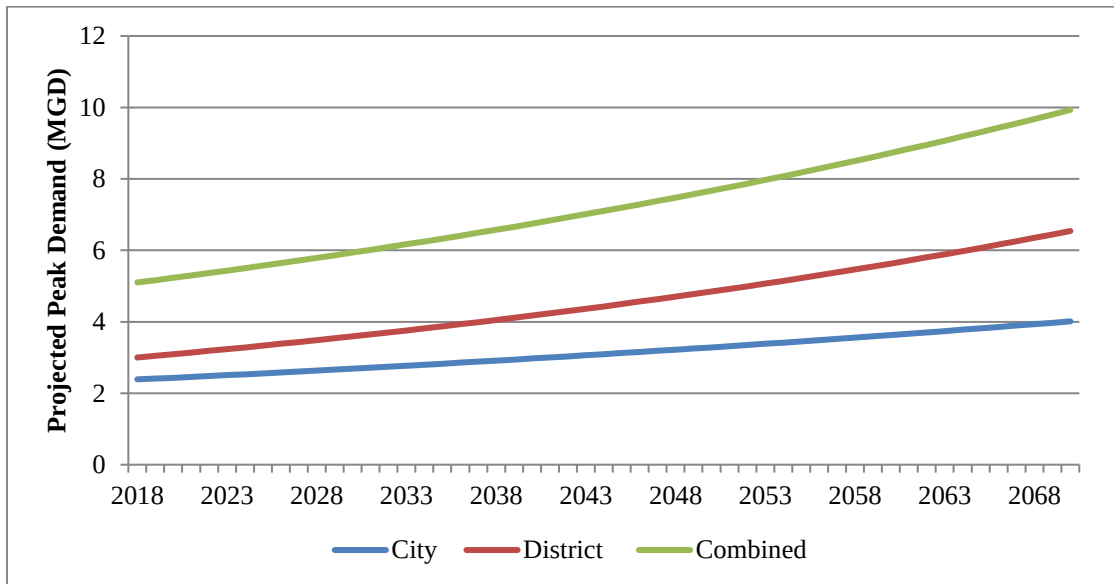


FIGURE 17. PROJECTED PEAK DAY DEMANDS USING SCALED EQR USING EQR-B METHOD.

GPCD BASED

Per capita demand was calculated for comparison purposes, although EQR based demand projections may be more accurate for a tourism-based community like Steamboat Springs. Per capita future projections were based on historical unit demands, and projected population for Steamboat Springs.

Total historical demand (for City and District) in gallons per day for the data period of 2006-2017 was calculated, and then divided by the historical population from the Census Bureau. The resulting annual per capita water use is shown in Figure 18. A base demand of 205 GPCD was determined, based on the average

over the 2009 to 2017 period, and assumed to represent the current demand. Use of the more recent period accounts for increased water efficiency, and also captures fluctuations in use dependent on conditions such as variations in annual precipitation. This base demand of 205 GPCD was then applied to the projected population with the low, medium and high scenarios to create a range of demand projections (Figure 19).

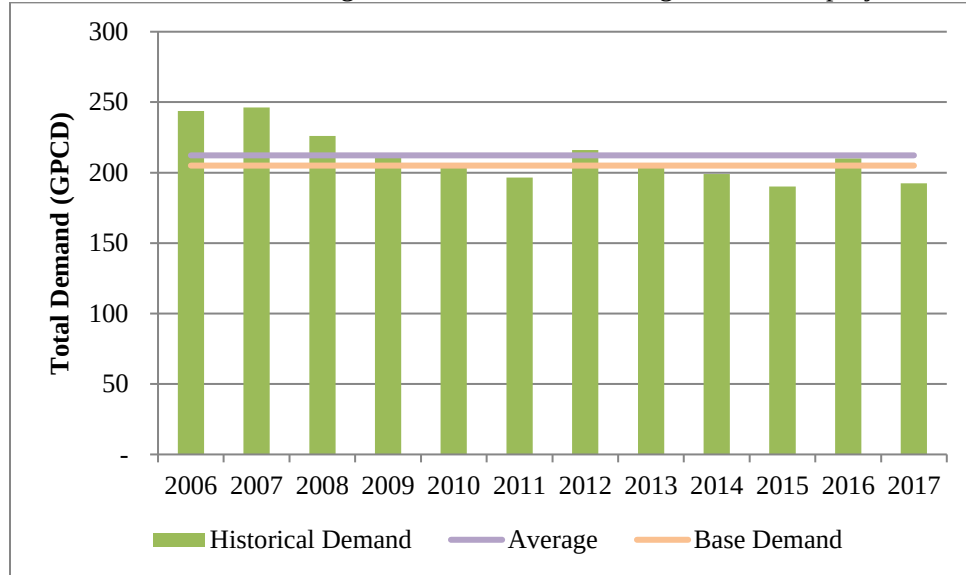


FIGURE 18. HISTORICAL DEMAND BASED ON POPULATION.

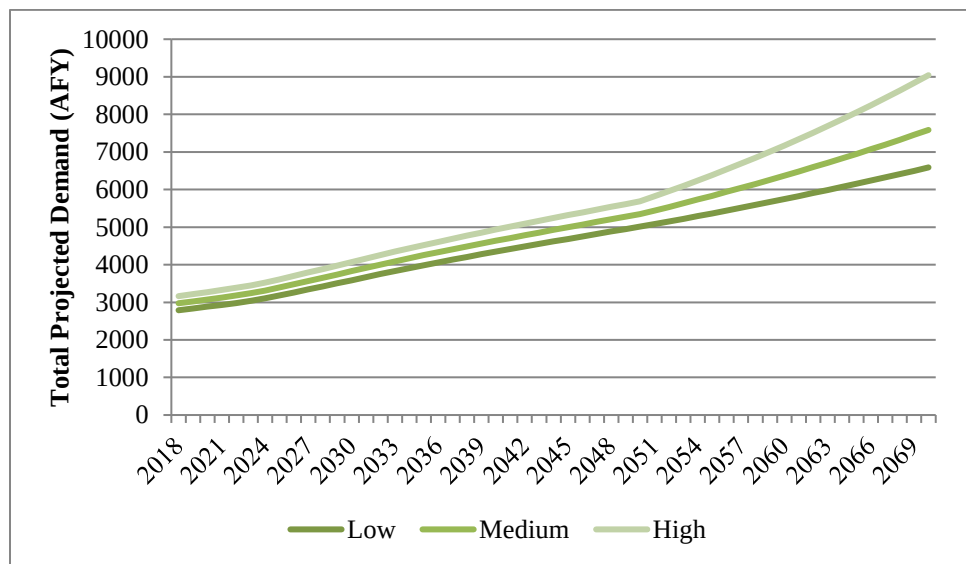


FIGURE 19. TOTAL PROJECTED GPCD-BASED DEMAND BASED ON GPCD APPROACH.

Total projected demands were then disaggregated based on the average historical ratio of City/District production data to the total (Figure 20 and Figure 21). This assumes that the City and District water demands will grow at the same rate, and remain in the same relative ratios into the future. Based on historical production data, City production is approximately 46 percent of the total, and the District is 54 percent of the total, which was fairly consistent over the 2006 to 2017 period.

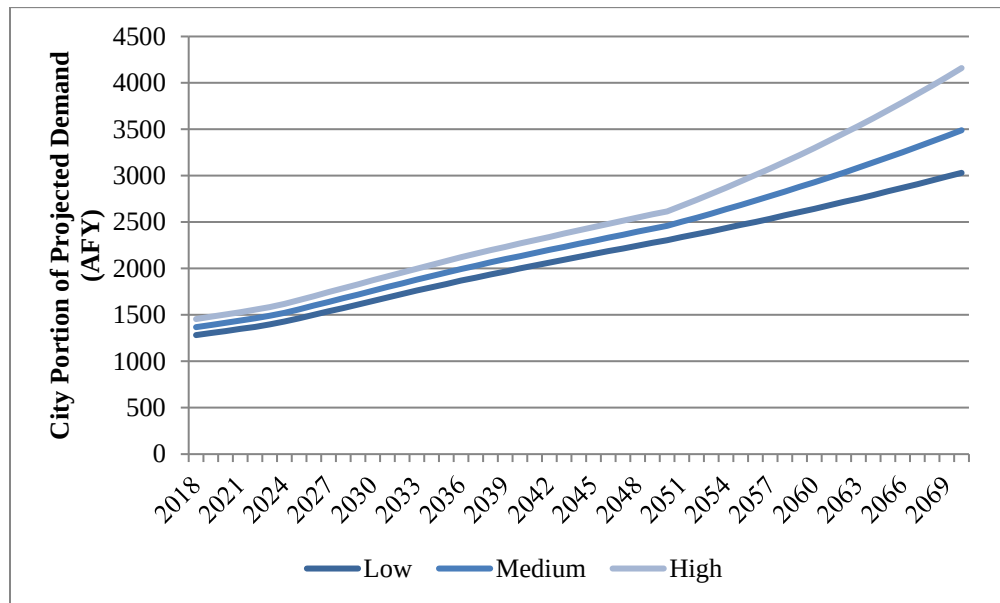


FIGURE 20. CITY PROJECTED DEMAND BASED ON GPCD APPROACH.

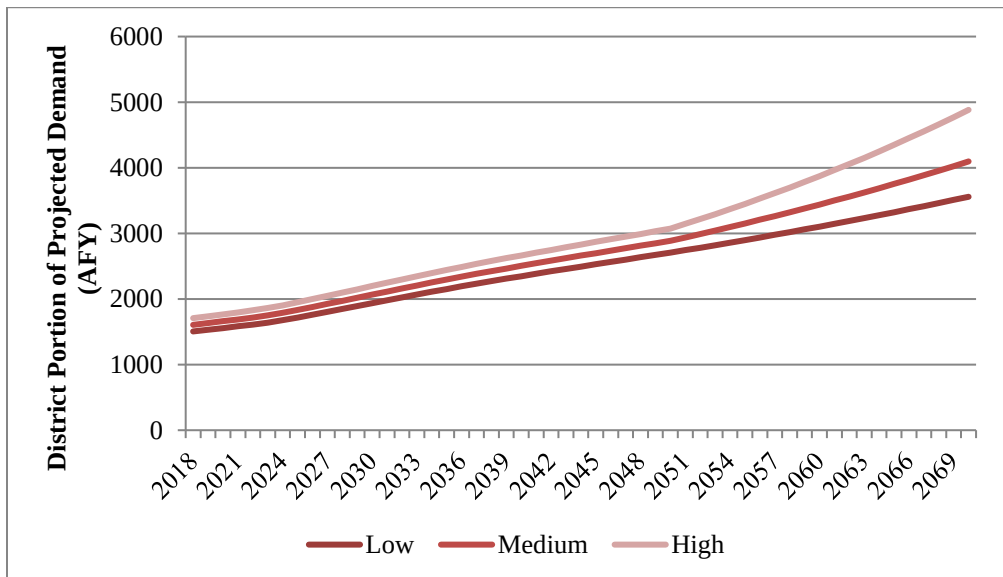


FIGURE 21. DISTRICT PROJECTED DEMAND BASED ON GPCD APPROACH.

Projected peak day demand was also estimated based on the gallons per capita per day approach (Figure 22).

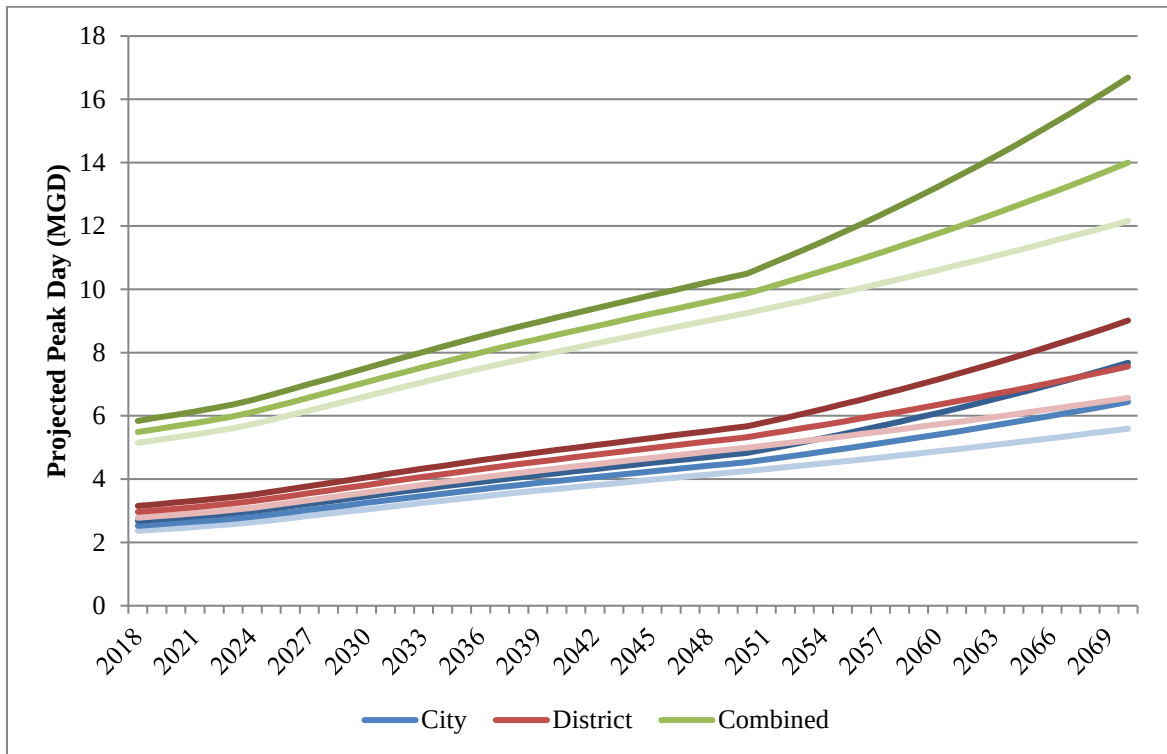


FIGURE 22. PEAK DAY DEMAND PROJECTIONS USING GPCD APPROACH

FUTURE DEMAND PROJECTIONS SUMMARY

The three methods used to estimate demand projections are compared in Figure 23. The GPCD method creates a wide envelope, which could be used to “book end” the possible range of future demands. EQR Method A may be the most accurate approach to estimating future demands, based on its representation of water use in a tourist-influenced area, and its use of annual population projections.

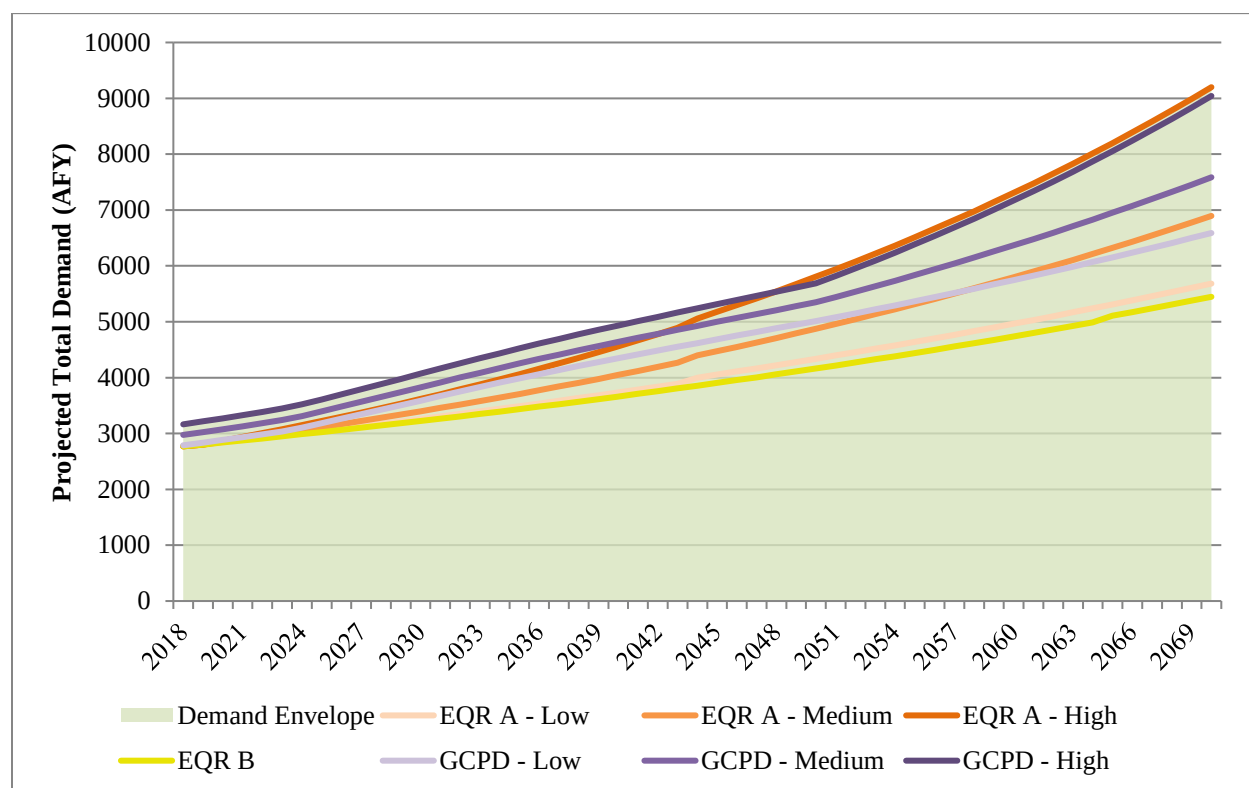


FIGURE 23. DEMAND CALCULATION METHOD COMPARISON.

BUILDOUT DATE

Analyzing demand projections in the context of previous buildout capacity analyses can provide a check on demand projections. We compared projected EQRs to previous Steamboat Springs' buildout capacity studies to determine when the current City limits would be fully developed under the existing zoning and water use patterns. The City of Steamboat Springs Vacant Land Buildout Capacity Analysis dated September 1, 2010 and the 2009 Steamboat Springs Water and Wastewater Master Plan Updates were used to determine an approximate buildout date for the City and District. Note that both analyses are more than about eight years old, and we are not aware of updated buildout information. Table 7 summarizes both the 2010 map and the 2009 report. The EQR per Units column is based on the 2009 Water and Wastewater Master Plan³, with an additional assumption for Multi-Family and Mixed Use. The West Steamboat area was not included in the 2010 Buildout Capacity and is accounted for with information from the 2009 report.

³ Water and Wastewater Master Plan Updates for the City of Steamboat Springs. Prepared by McLaughlin Water Engineers. December 2009.

TABLE 7. BUILDOUT CAPACITY BASED ON 2010 DATA.

Type/Location	No. of units	Acres	EQR Units	EQRs		
				Existing EQRs*	New EQRs	Total
Source - 2010 Buildout Capacity Map						
Single-Family/Duplex (units)	1,404	-	1	-	1404	-
Multi-Family (units)	663	-	1.05	-	696	-
Mixed-Use (units)	2,545	-	0.9	-	2291	-
Commercial (SF)	1,064,573	24	4.44	-	109	-
Industrial (SF)	966,052	22	2.13	-	47	-
Total (City and District)				13,460	4,546	18,006
Source - 2009 West Area Steamboat - projected EQR						
WSSA (less Steamboat II)	-	-	-	186	3,667	3,853
Steamboat II	-	-	-	406	47	453
Total				592	3714	4,306
Combined Total (City/District plus W Steamboat)				14,052	8,260	22,312

*Note the existing EQR breakdown by development type is unknown for the City and District.

The combined existing EQR in 2019 is 14,052. With the additional EQR units of 8,260, total buildout EQR would be 22,312 EQRs for the City and District combined and the complete development of the West Steamboat area. Depending on which type of EQR demand method used above, the resulting buildout date would be between 2041 (using EQR method A,) and 2059 (using EQR method B). Figure 24, below, displays the EQR envelope compared to the buildout capacity. The envelope was created using EQR method A's high projection for the high end of the envelope and the EQR B method for the low end of the envelope.

EQR projection at buildout assumes static zoning, but in reality, future zoning could change if the population increases dramatically in Steamboat Springs. If the City becomes re-zoned to fit a higher population, the 2010 buildout capacity would be an underestimate of the potential future EQRs.

We also analyzed when the current water treatment plants would not provide adequate capacity to meet projected peak day demand. This analysis compared projected peak day demand to the existing capacity of the Fish Creek water treatment plant and the Yampa wellfield. The timing of the new water treatment plant is based on when the projected peak day demand surpasses 9.3 MGD (i.e., 7.5 MGD from the Fish Creek water treatment plant and 1.8 MGD from the Yampa wellfield), as mentioned above. Peak day demand was projected to exceed the existing capacity of 9.3 MGD between 2040 and 2060, depending on which demand projection is utilized (Figure 25). Peak day demand was projected to exceed the expanded 15.5 MGD capacity after 2065 for all scenarios analyzed. This suggests that the City and District should plan to have additional water treatment capacity online as early as 2040.

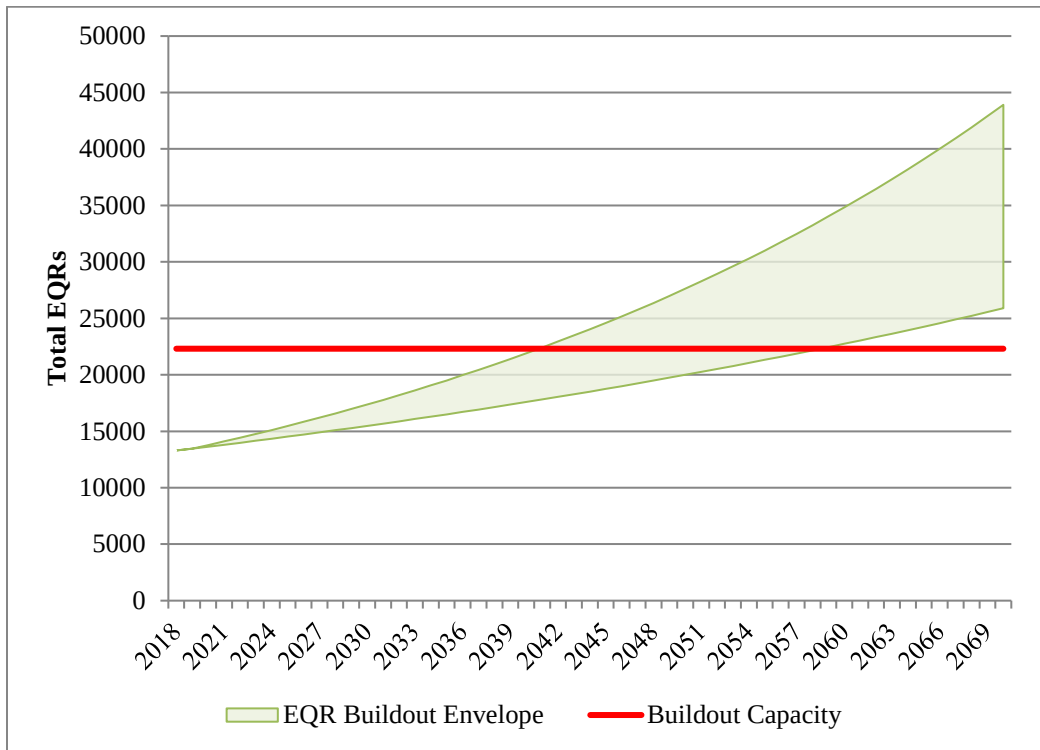


FIGURE 24. PROJECTED EQRs VS. STEAMBOAT BUILDOUT EQRs

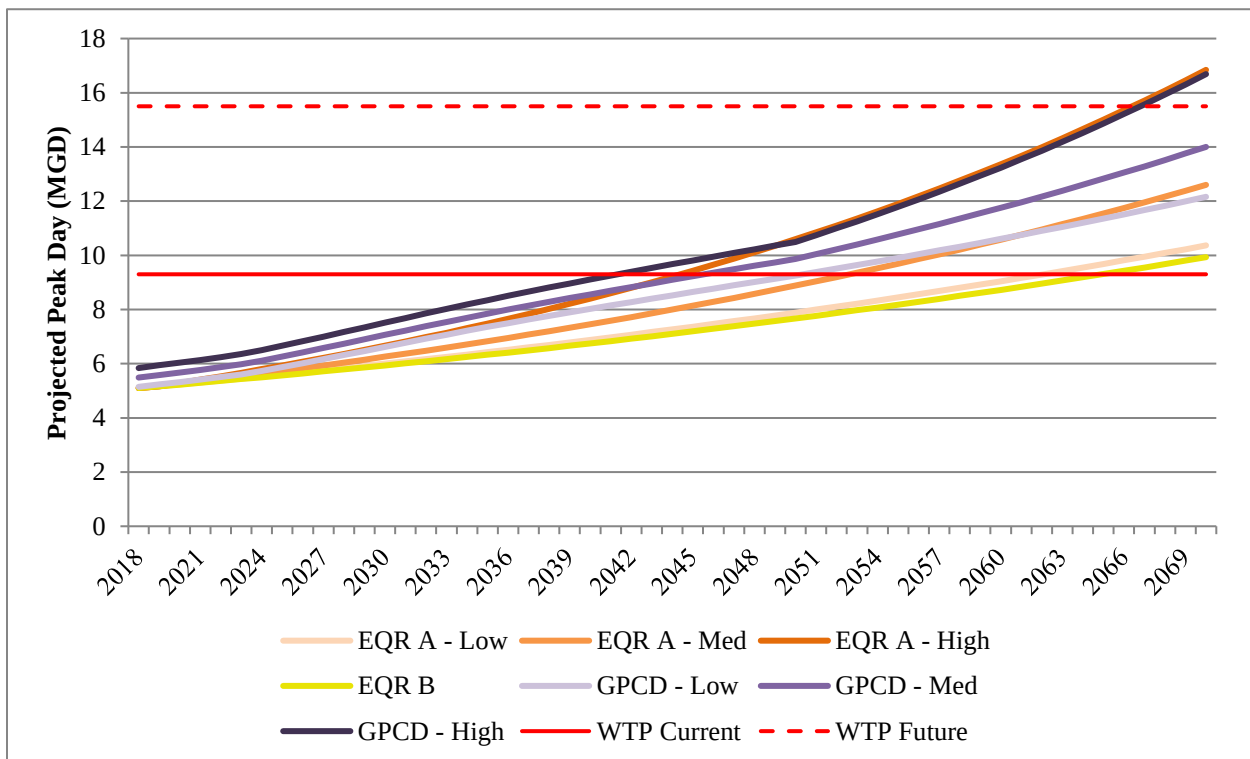


FIGURE 25. PROJECTED PEAK DEMAND COMPARED TO WATER TREATMENT CAPACITY

APPENDIX C

RAW WATER MODEL DOCUMENTATION MEMO



Date: February 8, 2019

To: Frank Alfone Kelly Romero-Heaney
Mt. Werner Water & San District City of Steamboat Springs

From: John Winchester, P.E., High Country Hydrology, Inc.

CC: Steve Smith, P.E., Applegate Group
Courtney Black, P.E., Headwaters Corp.

Re: Memo Regarding Raw Water Model

Kelly and Frank,

This memo summarizes the modeling work we have done on behalf of the City of Steamboat Springs (City) and the Mt. Werner Water and Sanitation District (MWW).

1. MODEL PURPOSE

The purpose of the model is to allow the City and MWW to identify and implement strategies to promote water supply resiliency by preparing for growth, planning for drought & wildfire, planning for a Colorado River compact call, planning for water conservation, and developing a redundant supply. The model allows users to determine the ability of the two systems to meet demand under different combinations for supply, demand, infrastructure, and operating assumptions.

2. MODEL CONSTRUCTION

After reviewing the modeling software available, the City and MWW decided to have the model created in Microsoft Excel, both because it would be easier for others to use, and for others to trace the model's logic.

a. SOFTWARE

The model was built using MS Excel 2010, though it should be both backwards and forwards compatible. To make the logic more easily traceable, the model operations are coded into the spreadsheet formulas rather than macros. The model does contain a macro used to control a slider used for user-input, but no model logic.

b. LEVEL OF DETAIL

The model operates on a daily basis over a 20 year period. There are two sets of hydrology, one for water years 1999-2018, and another from 1143-1162, the period with the worst drought in the

paleo-hydrology developed from tree-rings.¹ The model includes all the physical features that supply raw water for municipal use by the City/MWW, and the major water rights owned by the City/MWW.

i. WHAT'S INCLUDED IN THE MODEL

Specifically, the model includes the existing infrastructure of Fish Creek and Long Lake reservoirs, the Fish Creek Water Treatment Plant, the Yampa wellfield, and storage accounts in Stagecoach and Yamcolo reservoirs. These facilities are all divided by the current water rights or percentage of ownership.

Future infrastructure includes an intake on Elk Creek, as described in the 2015 Elk River Diversion and Steamboat Lake Yield Study by Wheeler. Unlike the Wheeler report, the model only includes the Elk River intake, not yield from the Four Counties water rights or storage in Steamboat Lake. The Elk River intake can only supply water to the City's distribution area. The potential yields used in the 2019 model are based on flows in the Elk River. Following the Wheeler report, the Elk River water rights are assumed to be in priority whenever flows at Milner are greater than 65 cfs, the CWCB's instream flow right below the Milner gauge. If diversions were made off the Yampa River, the potential yield would presumably be larger because restrictions due to the call would occur less often.

Water rights for the modeled infrastructure include the City/MWW rights in the Fish Creek basin, the Yampa wellfield rights, the Elk Creek water rights, and the storage contracts in Stagecoach and Yamcolo reservoirs. Water rights and associated yields are modeled separately for the City and MWW. City/MWW raw water use included in the model includes irrigation at parks and golf courses, but excludes other uses such as lakes in parks or snowmaking. All other water rights that are currently used for raw water irrigation or are not currently diverted for municipal use are not included in the model. For example, these include rights on Soda Creek, Spring Creek, Butcherknife, Burgess Creek, and local springs (City); and Burgess Creek (MWW).

The model has controls that allow the user to adjust operating parameters (e.g., the instream flow requirement on Fish Creek below the WTP intake, the diversion rate of the Yampa wellfield, and the capacity of the Fish Creek WTP), and add stressors to the system (Colorado River Compact call, fire in the Fish Creek watershed).

The model has a year of daily demands, based on the 2017 calendar year. The daily demands for future years are based on population projections by the State of Colorado to simulate demands in the years 2030, 2040, and 2070. Future demands are included in the model based on Equivalent Residential Units (EQRs), and current (2017) unit water use of 186 gpd per EQR.

At the direction of the City, current (2017) non-potable demands are included in the model, and are assumed to remain constant in future years (i.e., non-potable demands are not anticipated to increase in the future).

¹ <https://www.treeflow.info/content/tree-rings-and-streamflow>

Future demands will also include the 764 acre-feet of buildout demands anticipated for West Steamboat, as explained in the Demands Memo. In addition to pre-defined growth scenarios, the model also includes a control that allows the user to add additional demands as EQRs to either the City or MWW. These additional demands let the user determine how reliably the City/MWW could supply a particular proposed project.

Because the model operates on a daily basis, the model can be used to analyze peak day demands. The model includes reductions for long-term conservation, as well as reductions during drought years.

In response to the City/MWW comment that they are moving towards irrigating parks with potable water, the model also has a control that lets the user switch all parks currently irrigated with non-potable water to being irrigated with treated water. The control is for all parks in the system, not individual parks.

The model includes two periods, one from 1999-2018, and one from 1143-1162. The recent period includes the most recent drought, and the second from the worst drought in the tree-ring record, which is used as a surrogate for climate change.

ii. WHAT'S NOT INCLUDED IN THE MODEL

Due to budgetary limits the model does not contain water rights used for irrigation or rights not currently used for potable supply. These rights could be added to the model to determine how much additional supply they would yield.

Based on input from the City and MWW, potential additions to the model could include:

- Ability to switch individual parks to irrigation by non-potable water.
- Varying degrees of drought scenarios (e.g., different return periods reflective of more levels of severity).
- Constraint on Yampa wellfield to limit total pumping to annual volumetric limit.

3. MODEL DATA

The data in the model can generally be categorized into three different types; yield data, demand data, and facilities data.

a. POTENTIAL YIELD DATA

There are two sets of yield data, one from the most recent 20-year period (1999-2018), and one from the longest and deepest drought in the paleohydrologic record (1143-1162).

The recent record was created using gauge records from Fish Creek and its tributaries, and the Yampa River. Inflows were calculated for Fish Creek Reservoir, Long Lake Reservoir, the Fish Creek WTP diversion structure, the Yampa wellfield, Stagecoach and Yamcolo reservoirs, as well as Elk Creek.²

The paleohydrologic period was determined by using annual records from the TreeFlow site to calculate the length and total shortage of each drought. As shown in the following table, the 1146-1159 period of record was equivalent to a 1 in 1000 year drought.³

Yampa River Basin Drought Record

	Gauge Record (Yampa nr Maybell)				Record Reconstructed from Tree-rings				Composite Record for statistics											
	1917-2017 (101 years of record)				1000-1916 (918 years of record)				1000-2017 (1018 years of record)											
Length of drought (yrs)	No. of droughts	deficit below avg (MAF)			No. of droughts	deficit below avg (MAF)			No. of deficit below avg (MAF)				rounded							
		min	max	median		droughts	min	max	median	droughts	min	max	median	rank	exceed %	recurr int	recur int (yr)	years	deficit (maf)	
1	12	0.0	0.6	0.2	68	0.0	1.0	0.2	80	0.0	1.0	0.2	12	1.18%	85					
2	7	0.1	1.2	0.6	36	0.1	1.6	0.5	43	0.1	1.6	0.5	11.0	1.08%	93					
3	3	0.4	1.1	0.7	23	0.2	2.0	0.7	26	0.2	2.0	0.7	10.0	0.98%	102	100	1939-1941		0.7	
4	2	0.8	1.5	1.2	11	0.3	2.8	1.3	13	0.3	2.8	1.3	9.0	0.88%	113					
5	1	1.5	1.5	1.5	6	0.8	1.7	1.5	7	0.8	1.7	1.5	8.0	0.79%	127					
6	2	2.0	2.5	2.2	9	0.9	2.6	1.5	11	0.9	2.6	1.7	7.0	0.69%	146	150	1999-2004		2.0	
7					6	1.3	2.4	1.8	6	1.3	2.4	1.8	6.0	0.59%	170					
8					2	1.5	2.3	1.9	2	1.5	2.3	1.9	5.0	0.49%	204					
9					2	2.1	2.1	2.1	2	2.1	2.1	2.1	4.0	0.39%	255	250	1886-1894		2.1	
10					1	4.9	4.9	4.9	1	4.9	4.9	4.9	3.0	0.29%	340			1452-1461	4.9	
11																				
12					1	3.4	3.4	3.4	1	3.4	3.4	3.4	2.0	0.20%	510	500	1706-1717		3.4	
13																				
14					1	5.5	5.5	5.5	1	5.5	5.5	5.5	1.0	0.10%	1019	1000	1146-1159		5.5	
recurrence interval based on drought length																				

recurrence interval based on drought length

b. DEMAND DATA

The model has demand data for 2020, 2030, 2040, and 2070. Demands for the City and the District are modeled separately. Demand data was developed by Applegate Group. The 2020 demand is based on historical demands from 2017 as a baseline data (i.e., unit demand per EQR), and scaled up using population projections. Demand data incorporated into the model was for the “EQR A medium” method described in the demand projections memorandum. The user interface also includes options for the population-scaled EQR based (EQR-A) High and Low scenarios.

c. FACILITIES DATA

Facilities data, including diversion and treatment plant capacities, water rights, storage volumes, etc, was provided by the City and MWW.

4. MODEL SCENARIOS

Modeling allows the user to test how Steamboat’s raw water system is able to meet demands under two basic scenarios, increased demands and/or reduced supply, either from a physical lack of water, the inability to legally divert, or the physical inability to divert. The model has been built so it can analyze combinations of five specific scenarios.

² Contemporary inflow data can be found in “2. Model inflows.xlsx”

³ Paleohydrologic inflows can be found in “1. Reconstructed tree-ring flows.xlsx”

a. COMPROMISED INFRASTRUCTURE

One aspect of system reliability is what effect is there when a particular piece of infrastructure goes out of service. The model includes controls for three specific facilities; the fish creek intake is taken offline due to a fire in the watershed, the Yampa wellfield is not functional, or Fish Creek and/or Long Lake is unable to deliver water to the water treatment plant.

i. FIRE IN FISH CREEK BASIN

Because of its natural condition with limited access the Fish Creek watershed is susceptible to wildfire, either from human or natural causes.

The model contains a control that curtails diversions at the Fish Creek WTP assuming one of five fire scenarios, each with a different severity. The fire is assumed to start affecting flows on July 1 of the first year of the drought, and continue for one, two, three or four years. Flows during the base flow months, outside the runoff and summer thunderstorm season, are assumed to be clean enough to treat. The water in the reservoirs is assumed to be unaffected, either because the fire is on the mainstem of Fish Creek and not above the reservoirs, or because the reservoirs provide enough residence time for the material to sufficiently settle out while they are off-line.

1. No fire severe enough to forego diversions
2. Mild - no diversions July1-Oct1 Yr1 only
3. Moderate - no diversions Jul1-Nov1 Yr1, Apr1-Nov1 Yr2
4. Severe - no diversions Jul1-Dec1 Yr1, Apr1-Sep1 Yr2, May1-Jul1 Yr3
5. Extreme - no diversions July1-Jan1 Yr1, Mar1-Oct1 Yr2, Apr1-Sep1 Yr3, May1-Jul1 Yr4

These curtailments assume that ash and other runoff will make water quality at the Fish Creek intake more polluted than the treatment plant can purify. Because ash will contaminate the mainstem, the logic assumes that both direct diversions and reservoir releases will be curtailed at this time. Because the reservoirs are on-channel and cannot be turned out, the model assumes that they will continue to fill in priority during the curtailment period.

ii. YAMPA WELLFIELD

The Yampa wellfield supplies both the City and MWW. The dropdown for the Yampa wells allows the user to set the capacity of the wellfield to its current capacity of 1.8 mgd, an expanded capacity of 3.5 mgd, or off at 0 mgd. There are also radio buttons that divert water from the well field before taking water from storage, when storage is less than 50% full, or only when demand cannot be met from storage. There are also controls that allow the user to set the dates the wellfield can be pumped.

b. ABILITY TO MEET FUTURE DEMANDS

Daily demands are based off the historical records for 2017, and are modeled separately for the City and MWW. The user can scale up the demands to 2030, 2040, and 2070, as well as reduce demand for long-term conservation and/or short-term drought reductions.

To assess the ability of the City/MWW system to provide for growth, the user interface includes demands for select future years (2030, 2040, 2070), variable reductions for both conservation and short-term demand reduction, as well as the ability to add future development (e.g., West Steamboat). Shortages are modeled separately for the City's and MWW's systems, which will provide each of the individual entities to complete their own independent planning using the model.

Because the model operates on a daily timestep the model can be used to analyze the ability to meet peak day demand. This ability comes with the caveat that within the City/MWW systems, there are no hydraulic limitations in the model downstream of the water treatment plant. That is to say, the model assumes demands in any part of the distribution system can be supplied from the Fish Creek water treatment plant or the Yampa wellfield, or in the City's case, the proposed Yampa River/Elk River water treatment plan.

In addition to adjust the capacity of the Yampa wellfield, the model also includes the ability to adjust the capacity of the Fish Creek WTP. The capacity can be set to the current capacity of 7.5mgd (4.5 mgd City, 3 mgd MWW), 7.5 mgd (3.75 ea), or an expanded capacity of 12 mgd (6 mgd ea).

c. COLORADO RIVER COMPACT CALL

The model simulates a Colorado River Compact call by preventing diversions of water rights junior to 1922. The user-control has three settings; no call, a call that starts the first year of the drought (the year is adjustable, but not on the immediate user-interface), or a compact call that starts at the beginning of the model run.

d. DISTRICT 58 CALL

Prompted by the call placed on the Yampa in 2018, user controls were added to the model to allow a call on Division 58 water rights. This allows the user to specify the seniority date of a water rights call. For simplicity the call is assumed to be on for the same period each year, though assuming the call is on for only part of the year the user can set the dates when the call is put on and taken off.

e. CRITICAL DROUGHT

The model has two 20-year inflow data sets, one for 1999-2018, and one for 1143-1162. The contemporary period contains the 2002 drought period, while the 1143-1162 period contains the deepest and longest drought in the paleo record. As explained above, based on the tree-ring record, this includes a 1 in a 1,000-year drought.

f. CLIMATE CHANGE

The model does not have specific controls for climate change. Changes in precipitation due to climate change for the Rocky Mountains in Colorado is very uncertain because the orographic lifting caused by the mountains is much more significant than changes in precipitation due to a warmer atmosphere. In theory a warmer atmosphere will contain more moisture, and the current models are divided whether this will result in more or less precipitation in the future.

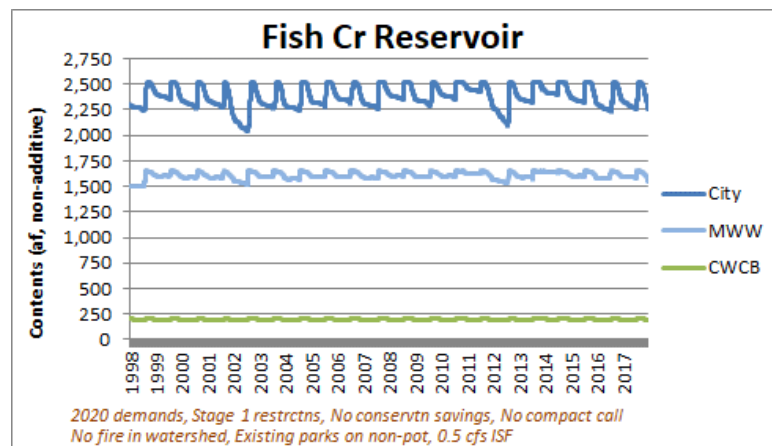
Besides the annual amount of precipitation, climate change could also affect the timing and type of precipitation. Again, uncertainty rules. If the timing and amounts stayed the same, but early fall and late spring precipitation came as rain rather than snow, there might not be a noticeable change in the hydrograph. If the soil moisture is low in the fall, then late fall rains, if they are of low intensity, may be absorbed by the ground rather than run off. If rainfall rates are greater than the infiltration rate of the soil, then some of the rain will run off where it might have otherwise remained in place as snow. However at least some of the early snows often melt off, so again, the amount of change is very uncertain.

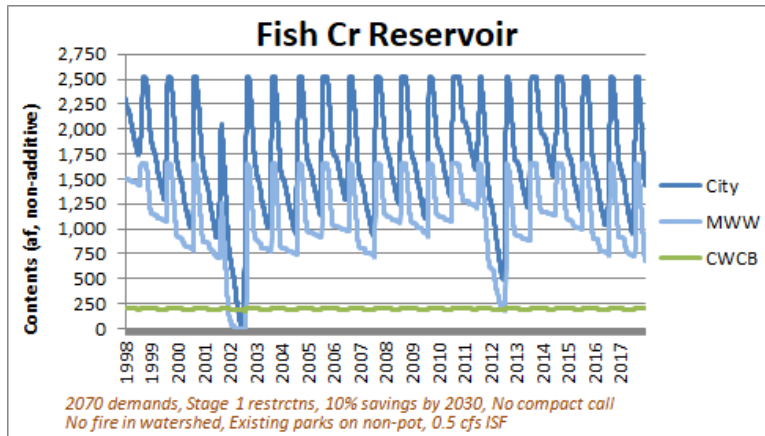
Controls could be added to the model to simulate later fall and earlier spring runoff, or changes in the amount of precipitation, but at this point they would be total guesses, and the only value would be to determine the sensitivity of the model to changes with an unknown probability of occurring.

5. MODEL RESULTS

The model has summary graphs that show the City/MWW storage in each of the reservoirs (Fish Creek, Long Lake, Stagecoach, Yamcolo), annual deliveries and shortages, and daily potable demands broken down by indoor and outdoor use. In addition to graphs, the control sheet has tables by month and year of shortages, so the user can identify exactly when shortages occur.

For example, graphs showing the difference in contents in Fish Creek Reservoir under 2020 and 2070 demands are show below.





More detailed model results and analysis can be found in the 2019 Water Supply Master Plan.