SECTION 4
STATEWIDE & BASIN RESULTS

Statewide and basin-specific results of Technical Update analyses are described in Section 4. Statewide results are described first followed by basin-specific results. Results are described for:

- Agricultural diversion demands
- M&I diversion demands
- Agricultural and M&I gaps
- Environment and recreation conditions
- Available water supply

4.1 KEY ASSUMPTIONS AND LIMITATIONS

The analyses used to estimate demands and gaps incorporated some key assumptions and limitations that are important to consider when reviewing and using the results of the Technical Update:

- As stated in Section 3, future water supply projects (or IPPs) were not included in the Technical Update (see section 3.2.1).
- While the models used for this analysis consider a wide range of detailed information on river diversions, water provider operations, etc., the analyses were conducted and reported at a regional scale for understanding basinwide and statewide demands, supplies, and gaps. Attempting to extrapolate model results for specific water providers is not useful given the regional scale of model input data, the regional focus of the modeling, and the relatively high level of uncertainty associated with individual water provider operations under various scenarios.

Agricultural considerations:

» Livestock water demands were not included in the analysis because they are difficult to quantify, are relatively small compared to irrigation demands and are not a component of the CDSS tools used for the agricultural diversion demand analysis and gap calculations.

» The analysis did not consider different types of crops that may be grown in the future under the different scenarios; however, it accounted for future changes in crop types in a general sense in the *Adaptive Innovation* scenario and assumed that future crops would have 10 percent lower IWR.

M&I considerations:

» Projected water demands for the planning scenarios do not contemplate how municipal water providers or industrial water users would respond to acute drought conditions (e.g., implementation of watering restrictions, etc.).

Operations with respect to transbasin imports/exports:

» Imports from transbasin diversion projects were set at historical levels and reflect historical operations. To accurately reflect how the change in water availability on the Western Slope would have impacted transbasin diversions, it would have been necessary to work with the major transbasin diverters to understand how their operations may change on both the Western and Eastern Slope in response to West Slope shortages and include those operations in the assessment. The level of investigation and modeling necessary to properly assess changed operations was beyond the scope of this current effort. Agricultural and M&I gaps do not directly reflect reductions in supply that would occur if transbasin imports are reduced.

» Data presented in Section 4.2.4 show how much of the historical transbasin imported supply is projected to be potentially reduced by 2050 in some of the planning scenarios.

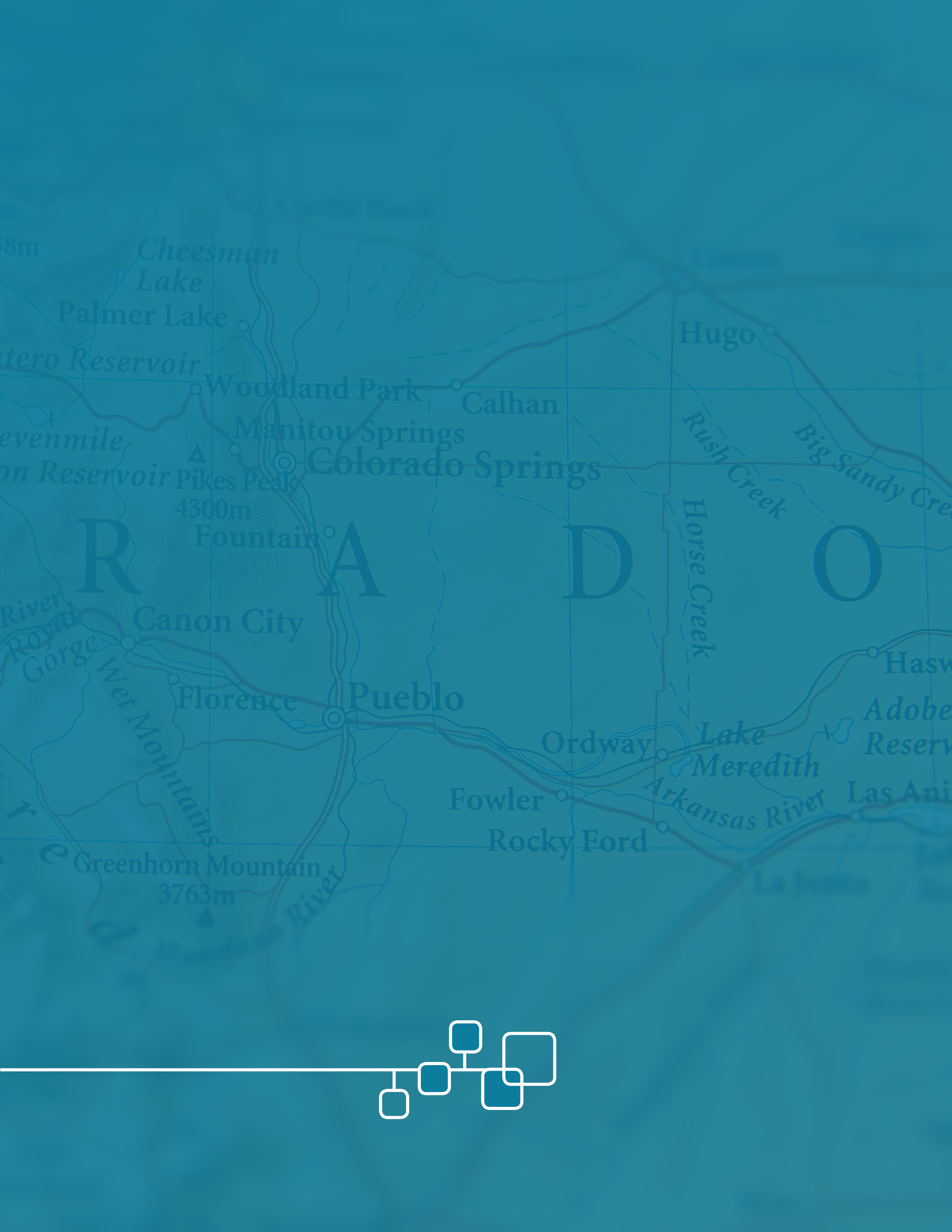
Statewide modeling results are shown in the following section followed by the results for each of the eight major river basins

CO
COLORADO STATEWIDE

A	C	G	RG	NP	SP METRO	SW	YWG
ARKANSAS BASIN	COLORADO BASIN	GUNNISON BASIN	RIO GRANDE BASIN	NORTH PLATTE BASIN	SOUTH PLATTE /METRO BASIN	SOUTHWEST BASIN	YAMPA-WHITE-GREEN BASIN

The results and findings of the Technical Update pertaining to statewide agricultural and M&I demands and gaps as well as findings related to environmental and recreational attributes and future conditions are summarized in the following section, which is followed by findings in each of the state's eight major river basins.

STATEWIDE


Cheesman Lake
Palmer Lake
Woodland Park
Calhan
Hugo
Manitou Springs
Colorado Springs
Pikes Peak
4300m
Rush Creek
Big Sandy Cre
Horse Creek
Fountain
R A D O
Canon City
Royal Gorge
Wet Mountains
Florence
Pueblo
Ordway
Lake Meredith
Fowler
Rocky Ford
Arkansas River
Las Ani
Adobe Reserv
Hasw
Greenhorn Mountain
3763m
River

4.2 STATEWIDE RESULTS

4.2.1 Summary of Technical Update Results

Key results and findings of the Technical Update pertaining to statewide agricultural and M&I demands and gaps, as well as findings related to environmental and recreational attributes and future conditions, are summarized below.

Agriculture

- On a statewide basis, current average annual agricultural diversion demands are approximately 13,000,000 AFY.
- Demand for groundwater is approximately 19 percent of the overall demand. Groundwater demands occur primarily in the Arkansas, Republican, Rio Grande, and South Platte basins.
- Future agricultural diversion demands will be affected by changes in irrigated acreage due to urbanization, aquifer sustainability, and agricultural to urban transfers of water.
  - Urbanization is projected to reduce irrigated lands statewide by 5 percent. Most of the reduction will occur in the South Platte Basin, with more than 12 percent of the basin's irrigated acreage projected to be urbanized.
  - 6 to 7 percent of irrigated acres supplied by groundwater is projected to be lost due to aquifer sustainability issues. The impacts of this will be focused in the Arkansas, Republican, and Rio Grande basins.
  - Stakeholders in the Arkansas and South Platte basins estimated that between 33,000 and 76,000 irrigated acres may be lost due to water rights purchases that have already taken place or are very likely to take place in the future. Specific estimates in the South Platte are likely understated because stakeholders did not have a projection of acreage that is likely to be lost in the reach of the South Platte between Denver and Greeley and in the tributaries in this region. The estimated loss of agricultural lands due to permanent water transfers conducted for the Technical Update is different than the amount estimated in SWSI 2010. The SWSI 2010 estimates included water transfers contemplated in portfolios of projects to fill future M&I gaps statewide, whereas the estimates in the Technical Update were focused in the South Platte and Arkansas basins and were conducted for the purposes of reducing agricultural diversion demands based on pending transfers that are very likely to occur in the foreseeable future. Basin roundtables may expand on this in their BIP updates and consider how alternative water transfers or future permanent transfers should be considered as future water supply projects and strategies to mitigate gaps.
- On average, approximately 80 percent of the overall agricultural diversion demand is currently met on a statewide basis, though this varies in each basin.
- Agricultural diversion demands statewide are projected to decrease in three of the five scenarios. In *Business as Usual* and *Weak Economy*, loss of irrigated land is projected to reduce diversion demands by around 9 percent. In *Adaptive Innovation*, demand reductions due to losses of irrigated lands will be offset in part by increases in crop consumptive use demand due to climate change. Adoption of emerging technologies that increase efficiency and decrease consumptive use, however, are projected to reduce overall diversion demand by 20 percent relative to current demand. In *Hot Growth*, irrigated lands are projected to be lost, but climate change is projected to more than offset the demand reductions associated with loss of irrigated lands and result in an overall increase in diversion demand of 5 percent compared to current conditions.
- In basins with significant potential acreage reductions like the South Platte and Republican, diversion demands in all planning scenarios are projected to be less than current.

M&I Demands

- M&I demands currently comprise approximately 10 percent of overall statewide water demands.
- Current statewide population (as of 2015) is 5 percent less than the level projected in SWSI 2010.
- Current population is 5,448,100, and by 2050 is projected by the State Demography Office to increase by more than 3 million people to 8,461,300—a 55 percent increase. Low population projections estimate the population to increase by 41 percent (to 7,683,200 people) while high projections estimate the increase at 71 percent (to 9,312,400 people).
- The statewide baseline per capita systemwide demand has decreased from 172 gpcd in SWSI 2010 to approximately 164 gpcd, which is a nearly 5 percent reduction in demands between 2008 and 2015.
- Statewide per capita demands are projected to decrease compared to current conditions in each scenario except *Hot Growth*. *Adaptive Innovation* assumes the highest levels of conservation and has the lowest projected per capita demand at 143 gpcd, which is 13 percent lower than current per capita demand in spite of assumed hot and dry future climate conditions.
- While per capita usage is expected to decrease compared to current conditions in all but *Hot Growth*, overall statewide M&I water demand is projected to increase from current conditions to 35 percent in *Weak Economy* up to 77 percent in *Hot Growth*.

- Increase in overall M&I demand is very similar in *Adaptive Innovation* compared to *Business as Usual* despite the assumptions in *Adaptive Innovation* of high population growth and hot and dry future climate conditions. In addition, *Hot Growth* and *Adaptive Innovation* have similar assumptions related to population and climate, but *Adaptive Innovation* assumes much more aggressive conservation that result in M&I demands that are 15 percent lower than *Hot Growth*. These results demonstrate the potential benefit of aggressive conservation in managing future M&I demands.
- Self-supplied industrial demands are approximately 13 percent of overall M&I demands statewide, but are a greater proportion in certain basins.

Projected Gaps

- **Agriculture**
  - Agriculture currently experiences gaps, and gaps may increase in the future if climate conditions are hotter (which increases irrigation water demand) and supplies diminish (due to drier hydrology). Future gaps may increase by 440,000 AFY (in *Adaptive Innovation*) to 1,053,000 AFY (in *Hot Growth*) or 18 to 43 percent beyond what agriculture experiences, despite the loss of irrigated acreage.
  - Agricultural gaps under *Adaptive Innovation* are significantly less than *Hot Growth* despite similar assumptions related to future climate conditions, which demonstrates the potential benefits of higher system efficiencies and emerging technologies that could reduce consumptive use. While conservation and efficiency improvements can be a tool for addressing future agricultural gaps, particularly in return-flow-driven systems, it is important to consider projects on a case-by-case basis.
- **M&I**
  - Municipal and self-supplied industrial users do not currently experience a gap, but increasing population and potentially hotter and drier future climate conditions will create a need for additional supply despite efforts to conserve water. Statewide M&I gaps are projected to be from 250,000 AF (in *Weak Economy*) to 750,000 AF (in *Hot Growth*) in dry years. These gap estimates do not account for yields from water supply projects and strategies that water providers are pursuing.
  - Municipal conservation efforts, however, create significant future benefits in lowering the gap, as demonstrated by comparing *Adaptive Innovation* and *Hot Growth* (which have similar assumptions on population and climate). Projected future gaps under *Adaptive Innovation* are 325,000 AF less than projected gaps under *Hot Growth*.
  - Scenarios that include climate change project reduced available supplies for transbasin diversion projects. Reductions in transbasin imports will contribute to projected gaps, potentially to a greater degree than suggested in the analyses, because water providers reuse the return flows from transbasin imports.

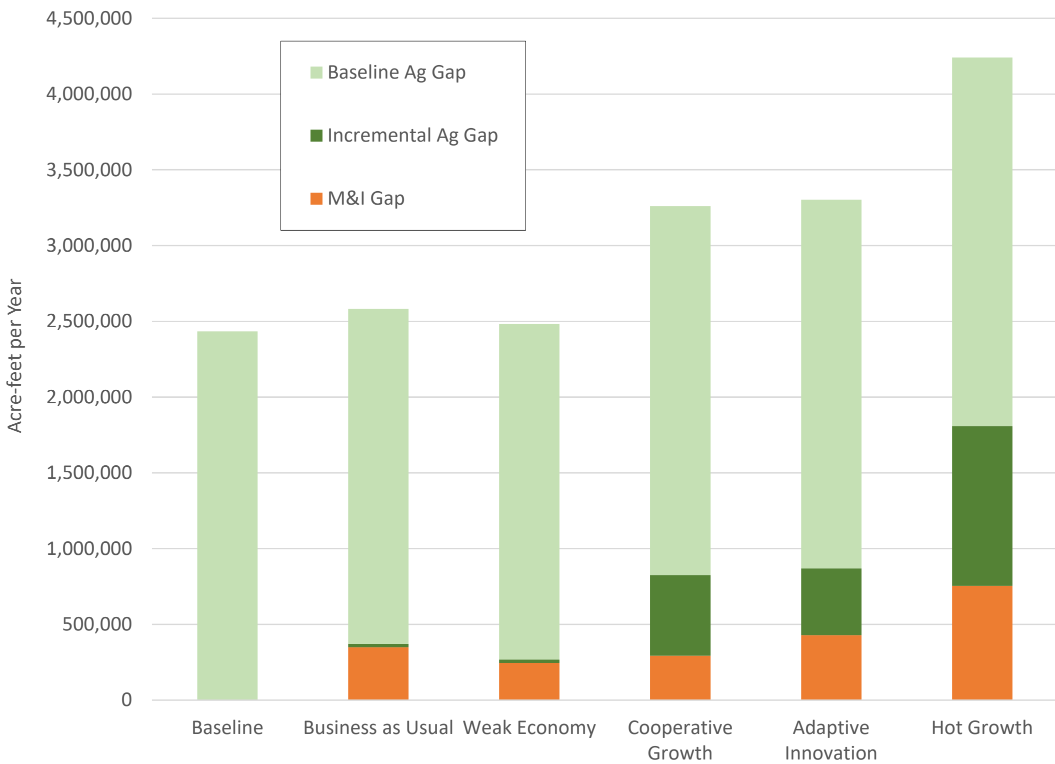
Environment and Recreation

- Climate change and its impact on streamflow will be a primary driver of risk to E&R attributes.
- Projected future streamflow hydrographs in most locations across the state show earlier peaks and potentially drier conditions in the late summer months under scenarios with climate change.
- Under climate change scenarios, runoff and peak flows may occur earlier, resulting in possible mis-matches between peak flow timing and species' needs.
- Climate change may lead to more frequent flooding events, especially in disturbed areas, including fire scars. Stream and watershed health may be impacted by these events and thresholds may be crossed, resulting in impaired ecosystem structure and function. While these are important considerations, they were beyond the scope of this analysis.
- Drier conditions in late summer months could increase risk to coldwater and warmwater fish due to higher water temperatures and reduced habitat. The degree of increased risk is related to the level of streamflow decline.
- In many mountainous regions without significant influence of infrastructure, peak flow and low flows are projected to be sufficient to sustain low to moderate risk for riparian plants and fish, but risks are projected to increase in scenarios with climate change.
- In mountainous regions with infrastructure, risks to E&R attributes may vary. Streams that are already depleted may see increased risks in scenarios with climate change; however, some streams may be sustained by reservoir releases, which will help moderate risks in scenarios with climate change.
- Instream flow water rights and recreational in-channel diversion water rights may be met less often in climate-impacted scenarios.

STATEWIDE RESULTS

Results describing current and potential future statewide M&I and agricultural gaps are summarized in Figure 4.2.1 and Table 4.2.1. Statewide gaps may vary substantially depending on future climate conditions and population increases, which underscores the need to take an adaptive approach to developing water management strategies, and projects and methods, to fill potential future gaps.

Figure 4.2.1 Summary of Statewide Gap Estimates by Planning Scenario



Results of calculations and analyses that support estimates of the statewide gap are presented in the subsections below.

INCREMENTAL GAP

The incremental agricultural gap quantifies the degree to which the gap could increase beyond what agriculture has historically experienced under water shortage conditions.

Table 4.2.1 Summary of Statewide Gap Results

Basin	Gap	Baseline	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Arkansas	Ag- Average annual gap (AFY)	617,300	586,400	585,200	701,700	734,800	819,500
	Ag- Average annual incremental gap (AFY)	0	0	0	84,400	117,500	202,200
	M&I- Max annual gap (AF)	0	68,500	53,100	58,500	62,900	108,700
Colorado	Ag- Average annual gap (AFY)	45,300	44,000	44,000	76,200	61,500	103,800
	Ag- Average annual incremental gap (AFY)	0	0	0	30,900	16,200	58,500
	M&I- Max annual gap (AF)	0*	4,200	3,300	5,300	6,600	15,800
Gunnison	Ag- Average annual gap (AFY)	87,300	77,200	77,300	157,600	112,600	222,000
	Ag- Average annual incremental gap (AFY)	0	0	0	70,300	25,300	134,700
	M&I- Max annual gap (AF)	0*	2,300	700	3,500	4,300	11,500
North Platte	Ag- Average annual gap (AFY)	85,700	108,000	107,900	177,900	168,100	231,100
	Ag- Average annual incremental gap (AFY)	0	22,200	22,200	92,100	82,400	145,400
	M&I- Max annual gap (AF)	0	0	0	0	0	0
Rio Grande	Ag- Average annual gap (AFY)	683,900	655,800	661,500	737,400	741,900	826,400
	Ag- Average annual incremental gap (AFY)	0	0	0	53,500	58,000	142,500
	M&I- Max annual gap (AF)	0	3,400	0	2,400	4,000	8,100
Southwest	Ag- Average annual gap (AFY)	126,600	120,300	119,800	276,700	219,000	355,100
	Ag- Average annual incremental gap (AFY)	0	0	0	150,100	92,400	228,400
	M&I- Max annual gap (AF)	0*	7,500	1,800	7,700	13,800	24,800
South Platte /Metro *(and Republican)*	Ag- Average annual gap (AFY)	773,500	606,300	604,000	610,900	577,600	665,400
	Ag- Average annual incremental gap (AFY)	0	0	0	0	0	0
	M&I- Max annual gap (AF)	0*	257,000	184,500	213,300	333,700	543,500
Yampa-White-Green	Ag- Average annual gap (AFY)	14,500	14,800	14,800	66,200	62,300	155,800
	Ag- Average annual incremental gap (AFY)	0	400	300	51,700	47,800	141,400
	M&I- Max annual gap (AF)	0*	5,600	1,600	2,600	3,800	41,700
Statewide Total	**Ag- Average annual gap (AFY)**	**2,434,200**	**2,212,800**	**2,214,500**	**2,804,500**	**2,677,800**	**3,379,100**
	Ag- Average annual incremental gap (AFY)	**0**	**22,600**	**22,500**	**533,000**	**439,600**	**1,053,000**
	M&I- Max annual gap (AF)	**0**	**348,500**	**245,100**	**293,300**	**429,200**	**754,200**

* *CDSS water allocation models in these basins calculate small baseline M&I gaps, but they are either due to calibration issues or they are reflective of infrequent, dry-year shortages that are typically managed with temporary demand reductions such as watering restrictions.*

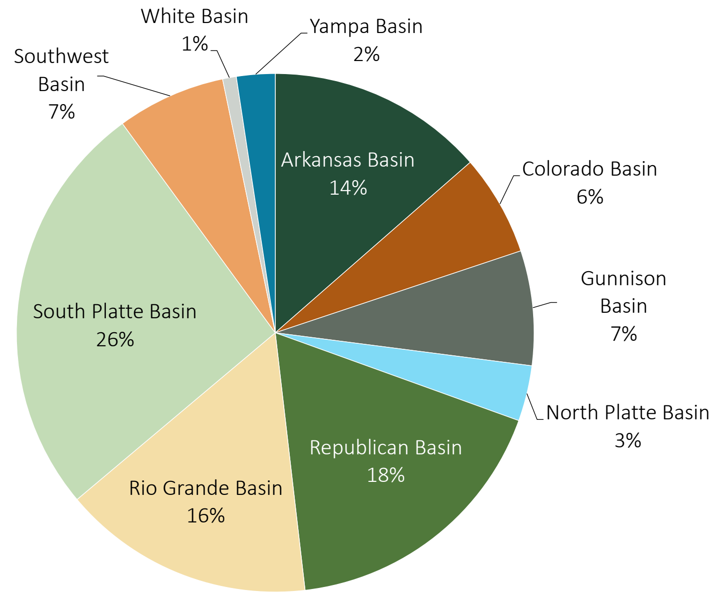
4.2.2 Statewide Agricultural Diversion Demands

Current Diversion Demands

Currently, 3.28 million acres of agricultural land are irrigated statewide. Irrigated agriculture supports a wide network of agribusiness in Colorado from producers of agricultural goods to those that process and deliver those goods to consumers. Agricultural production in Colorado is a large part of the state's economy, with agribusiness contributing $41 billion annually and employing nearly 173,000 people.[10] Working agricultural operations also remain the economic backbone of many of Colorado's rural communities and provide important ecosystem services such as open space and wildlife habitat.

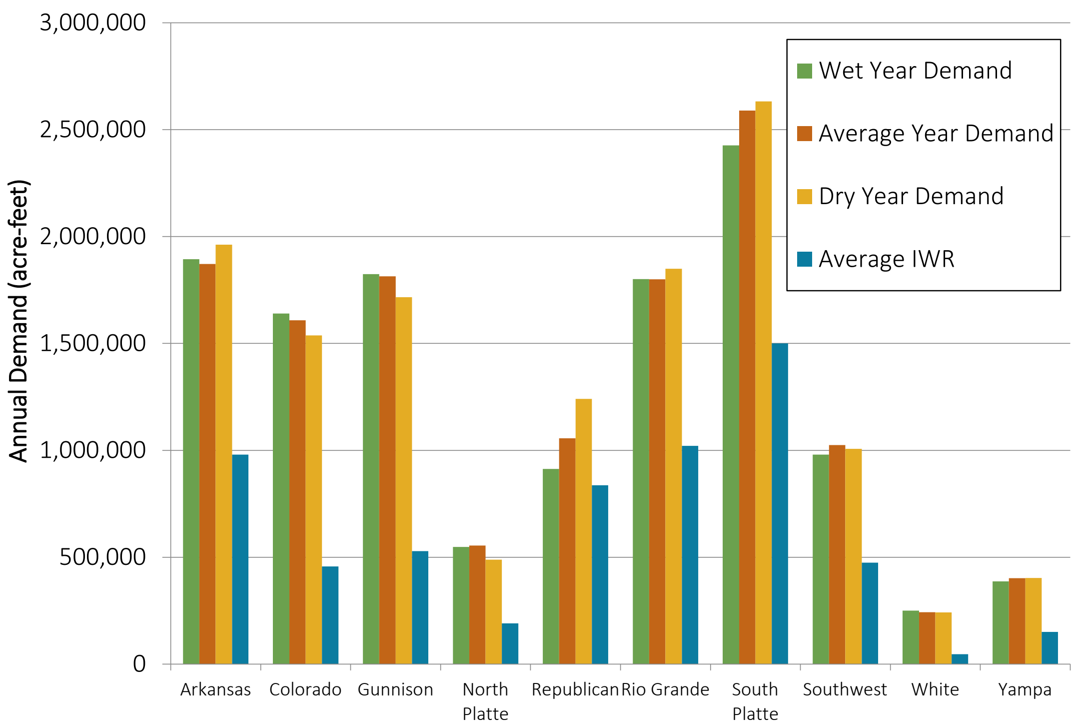
Figure 4.2.2 shows the proportion of statewide irrigated acreage in each basin. Over a quarter of the irrigated acreage in Colorado is located in the South Platte Basin. The Arkansas, Rio Grande, and Republican Basins also have significant acreage, each with approximately 15 percent of the statewide total. Grass pasture is the predominant crop grown in the state, particularly in the West Slope basins; however, irrigators also grow alfalfa, wheat, cereals/grains, fruits, and vegetables. Much of the irrigated acreage supports ranching operations, either through grass hay production for livestock operations or grazing of irrigated pastures. Refer to the basin-specific results summaries for more information on crops grown in each basin.

Figure 4.2.2 Proportion of Statewide Irrigated Acreage in Each Basin



Tables 4.2.2 and 4.2.3 and Figure 4.2.3 show the agricultural diversion demand for surface and groundwater supplies summarized by basin for wet, dry, and average hydrological year types compared to average IWR. Results are displayed over a range of hydrological year types to illustrate both how demands and system efficiencies change under different climatic/hydrological conditions and when different types of supplies are used.

Figure 4.2.3 Current Agricultural Diversion Demand by Basin



As discussed in Section 2, the agricultural diversion demand is calculated by dividing the IWR by system efficiency. In dry years for example, IWR is generally higher due to increased temperatures, lower precipitation, and decreased available surface water supplies for irrigation. In these types of years, many irrigators implement additional operational measures to be more efficient with the limited surface water irrigation supplies, resulting in a lower overall dry-year diversion demand. For irrigators with groundwater supplies, the groundwater demand generally increases in response to higher IWR in dry years. System efficiencies range across basins and year types due to availability of irrigation supplies; irrigation practices (i.e., sprinkler or flood applications); and on-farm conditions such as ditch/lateral alignments, soil types, and field topography. Refer to the basin-specific results for more information on conditions that impact the system efficiency and the agricultural diversion demand.

DIVERSION DEMAND

The diversion demand represents the amount of water that would need to be diverted or pumped to meet the full crop IWR and does not reflect historical irrigation supplies. Irrigators often operate under water-short conditions and do not have enough supply to fully irrigate their crop.

Table 4.2.2 Current Irrigated Acreage, Average Annual IWR, and Diversion Demand

Basin	Acreage	Average IWR (AF)	Unit IWR (feet)	Total Diversion Demand (AF)		
				Wet Year	Average Year	Dry Year
Arkansas	445,000	980,000	2.20	1,894,000	1,872,000	1,962,000
Colorado	206,700	456,500	2.21	1,640,000	1,608,000	1,538,000
Gunnison	234,400	528,200	2.25	1,824,000	1,814,000	1,716,000
North Platte	113,600	191,100	1.68	548,000	555,000	489,000
Rio Grande	515,300	1,021,000	1.98	1,801,000	1,800,000	1,849,000
South Platte/Metro (and Republican)	1,433,100	2,337,000	1.63	3,340,000	3,645,000	3,873,000
Southwest	222,500	474,900	2.13	980,000	1,025,000	1,007,000
Yampa-White-Green	107,000	197,000	1.84	637,000	645,000	645,000
Total	**3,280,000**	**6,190,000**	**1.89**	**12,664,000**	**12,964,000**	**13,079,000**

Table 4.2.3 Current Agricultural Diversion Demand for Surface and Groundwater Supplies

Basin	Surface Water Demand (AF)			Groundwater Demand (AF)		
	Wet Year	Average Year	Dry Year	Wet Year	Average Year	Dry Year
Arkansas	1,567,000	1,497,000	1,501,000	327,000	375,000	461,000
Colorado	1,640,000	1,608,000	1,538,000	-	-	-
Gunnison	1,824,000	1,814,000	1,716,000	-	-	-
North Platte	548,000	555,000	489,000	-	-	-
Rio Grande	1,237,000	1,172,000	1,195,000	564,000	628,000	654,000
South Platte/Metro (and Republican)	2,078,000	2,186,000	2,108,000	1,262,000	1,459,000	1,765,000
Southwest	980,000	1,025,000	1,007,000	-	-	-
Yampa-White-Green	637,000	645,000	645,000	-	-	-
Total	**10,511,000**	**10,502,000**	**10,199,000**	**2,153,000**	**2,462,000**	**2,880,000**

As reflected in the Tables 4.2.2 and 4.2.3 (on previous page), the current statewide total agricultural diversion demand is approximately 13 million acre-feet, with more than 80 percent of that demand attributable to surface water supplies.

Future Diversion Demands

The following graphics and tables summarize the acreage, IWR, and the agricultural diversion demand attributable to surface and groundwater supplies in each basin calculated for the five planning scenarios based on the adjustment factors and approach discussed in Section 2. Future agricultural diversion demands were adjusted to reflect:

- Urbanization
- Planned Agricultural Projects
- Groundwater Acreage Sustainability
- Climate
- Emerging Technologies

The two factors anticipated to have substantial statewide impact are urbanization and climate. Table 4.2.4 reflects basin-specific and statewide historical urbanization, projected urbanized acreage and current levels of irrigated acreage for context. Between the late 1980s and early 1990s to present, more than 58,000 irrigated acres were urbanized (based on historical irrigated acreage assessments and current municipal boundaries). By 2050, approximately 152,500 additional irrigated acres are projected to be taken out of production due to urbanization (based on irrigated lands within or intersecting current municipal boundaries). This is approximately 5 percent of the total irrigated land statewide. The largest amount of urbanization is expected in the South Platte Basin, with more than 12 percent of the irrigated acreage in basin projected to be urbanized.

Table 4.2.4 Projected Loss of Irrigated Acreage Due to Urbanization

Basin	Historically Urbanized Irrigated Acreage	Projected Urbanized Irrigated Acreage	Current Irrigated Acreage
Arkansas	N/A*	7,240	445,000
Colorado	6,060	13,590	206,700
Gunnison	2,380	14,600	234,400
North Platte	2	40	113,600
Rio Grande	N/A*	4,010	515,300
South Platte/Metro (and Republican)	49,400	107,310	1,433,100
Southwest	100	3,800	222,500
Yampa-White-Green	135	1,860	107,000
Total	**58,060**	**152,450**	**3,277,600**

* *Neither a 1987 nor a 1993 basin-wide acreage assessment has been developed.*

Future agricultural diversion demands will be affected by climate conditions. Section 2 described two climate projections with warmer and drier futures (“Hot and Dry” and “In Between” projections) that are incorporated into three of the five planning scenarios. Figure 4.2.4 shows annual factors used to adjust IWR and reflect future conditions in “Hot and Dry” and “In Between”. The factors in Figure 4.2.4 were averaged across the West Slope and East Slope basins. “Hot and Dry” and “In Between” generally predict warmer summer conditions in basins at higher elevations. Consequently, the West Slope factors are generally higher than those developed for the East Slope basins. Additionally, projections tend to show warmer conditions during years that were historically cooler and/or had higher precipitation, resulting in higher IWR adjustment factors. The opposite occurs during drought periods, when some warming may occur, but during periods that are expected to already be hot and dry. As a result, IWR adjustment factors during drought years tend to be lower (for example, 2002 or 2012).

Statewide Results

Future statewide agricultural diversion demand estimates range from 10 million AFY in *Adaptive Innovation* to 13.5 million AFY in *Hot Growth*. For basins with limited acreage adjustments, such as the Colorado, Gunnison, and Southwest basins, the agricultural diversion demands in *Business as Usual* and *Weak Economy* are projected to be similar to current demand. In these basins, climate change projections and efficiency adjustments had a significant impact on results, showing more variable demands in *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth*. For basins with significant irrigated acreage reductions, such as the South Platte and Republican basins, demands in all planning scenarios are projected to be lower than current demand. The largest variation in most basins occurred in the *Adaptive Innovation*. scenario due to the 10 percent reduction in IWR and 10 percent increase to system efficiency. In some basins, such as the Southwest basin, the combined impact of the *Adaptive Innovation* scenario adjustments resulted in lower projected agricultural diversion demands than current.

Figure 4.2.4 Average IWR Change Factors

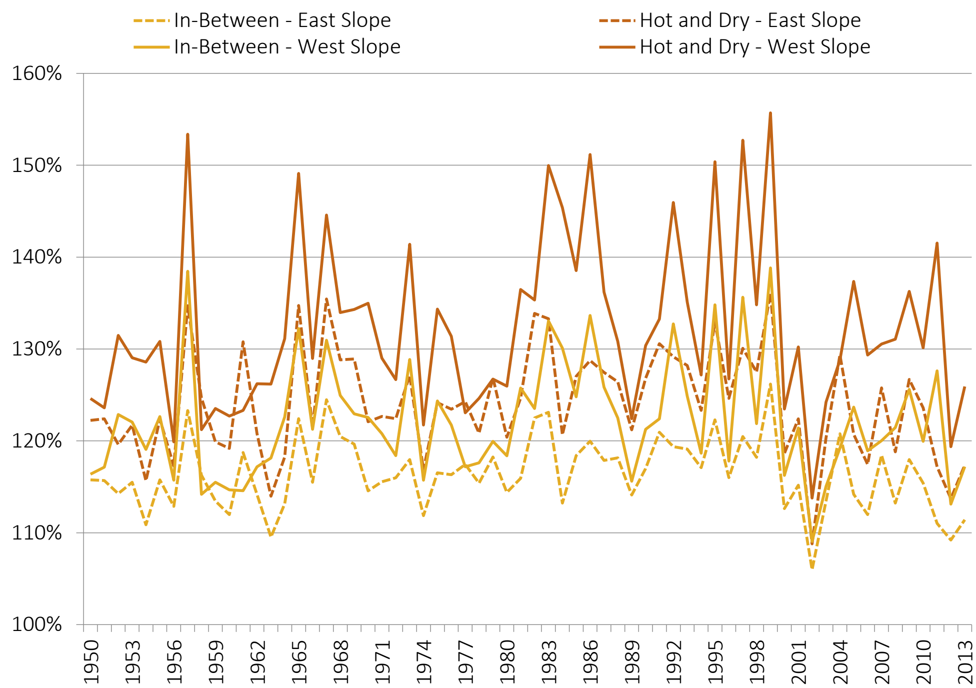
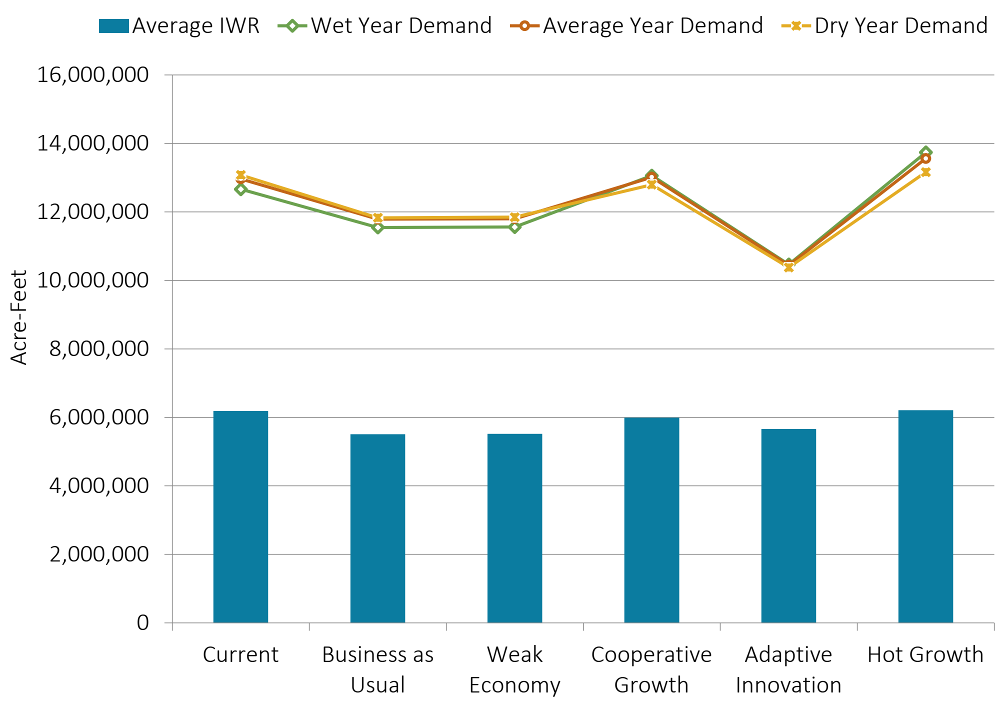


Figure 4.2.5 Statewide Agricultural Diversion Demand Estimates for Scenarios



RETURN FLOWS

Irrigation return flows (irrigation water not consumed by crops) return to streams and are part of the supply that downstream irrigators divert. In effect, diverted irrigation water can be used and reused several times in a basin. The agricultural diversion demand is the amount of water that would need to be diverted or pumped to meet the full crop irrigation demand, it but does not consider the re-diversion of return flows. As a result, it is not appropriate to assume the total diversion demand reflects the amount of native streamflow that would need to be diverted to fully irrigate crops.

Table 4.2.5 Statewide Summary of Projected Agricultural Diversion Demands

Planning Scenario	Acreage	Average IWR (AF)	Total Diversion Demand (AF)		
			Wet Year	Average Year	Dry Year
Current	3,280,000	6,190,000	12,664,000	12,964,000	13,079,000
Business as Usual	2,890,000	5,510,000	11,544,000	11,786,000	11,829,000
Weak Economy	2,890,000	5,520,000	11,559,000	11,802,000	11,846,000
Cooperative Growth	2,840,000	5,990,000	13,059,000	13,012,000	12,796,000
Adaptive Innovation	2,820,000	5,660,000	10,465,000	10,442,000	10,377,000
Hot Growth	2,780,000	6,210,000	13,736,000	13,561,000	13,163,000

Table 4.2.6 Statewide Summary of Projected Surface Water and Groundwater Diversion Demands

Basin	Surface Water Demand (AF)			Groundwater Demand (AF)		
	Wet Year	Average Year	Dry Year	Wet Year	Average Year	Dry Year
Current	10,511,000	10,502,000	10,199,000	2,153,000	2,462,000	2,880,000
Business as Usual	9,755,000	9,714,000	9,393,000	1,789,000	2,072,000	2,436,000
Weak Economy	9,775,000	9,735,000	9,415,000	1,784,000	2,067,000	2,431,000
Cooperative Growth	11,226,000	10,899,000	10,369,000	1,833,000	2,113,000	2,427,000
Adaptive Innovation	8,771,000	8,492,000	8,164,000	1,694,000	1,950,000	2,213,000
Hot Growth	11,848,000	11,399,000	10,723,000	1,888,000	2,162,000	2,440,000

4.2.3 Statewide M&I Diversion Demands

The updated M&I diversion demands include baseline demands (estimated for the year 2015) and projected future demands for the year 2050 for the five planning scenarios. Results of population projections, water usage rates, total municipal demands and total SSI demands are described below.

Population Projections

Approximately 88 percent of the state's population lives along the Front Range in either the Arkansas or South Platte Basins (which includes the "Metro" sub-basin). The statewide baseline population, which is based on 2015, is less than the amount that SWSI 2010 projected for the year 2015. While most basins have increased in population, the Gunnison, North Platte, Rio Grande, and Yampa-White basins have decreased. A basin-level summary is provided in Table 4.2.7.

As described in Section 2, population projections for the five planning scenarios were derived from 2017 SDO population projections and statistically-derived high and low growth projections for each basin. Population projections based on these methodologies are shown in Table 4.2.7.

DROUGHT RESPONSE

M&I demand projections do not represent drought conditions when more aggressive conservation may occur or associated responses to drought when measures such as watering restrictions may be imposed.

POPULATION GROWTH PROJECTIONS

Business as Usual:	Medium
Weak Economy:	Low
Cooperative Growth:	Medium, Adjusted
Adaptive Innovation:	High, Adjusted
Hot Growth:	High

Table 4.2.7 Current and Projected Future Population (in number of people unless otherwise indicated)

Basin	SWSI 2010 Projection for 2015*	SWSI Update Baseline (2015)		Planning Scenarios				
		Population	% of state total	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Arkansas	1,067,000	1,008,400	19%	1,509,500	1,462,800	1,544,400	1,626,000	1,568,000
Colorado	366,000	307,600	6%	515,500	456,300	549,200	572,900	577,800
Gunnison	125,000	103,100	2%	162,600	123,100	158,600	196,000	204,900
North Platte	1,600	1,400	0%	1,300	1,100	1,200	1,400	1,500
Rio Grande	54,000	46,000	1%	55,100	42,300	52,100	63,000	67,300
South Platte/Metro ** (and Republi-can)	3,964,000	3,829,800	70%	5,954,300	5,433,200	5,884,400	6,492,400	6,507,700
Southwest	123,000	108,000	2%	195,800	125,800	201,000	264,200	282,100
Yampa-White-Green	53,000	43,700	1%	67,300	38,600	70,500	96,600	103,200
Statewide	**5,754,600**	**5,448,100**	**100%**	**8,461,300**	**7,683,200**	**8,461,300**	**9,312,400**	**9,312,400**

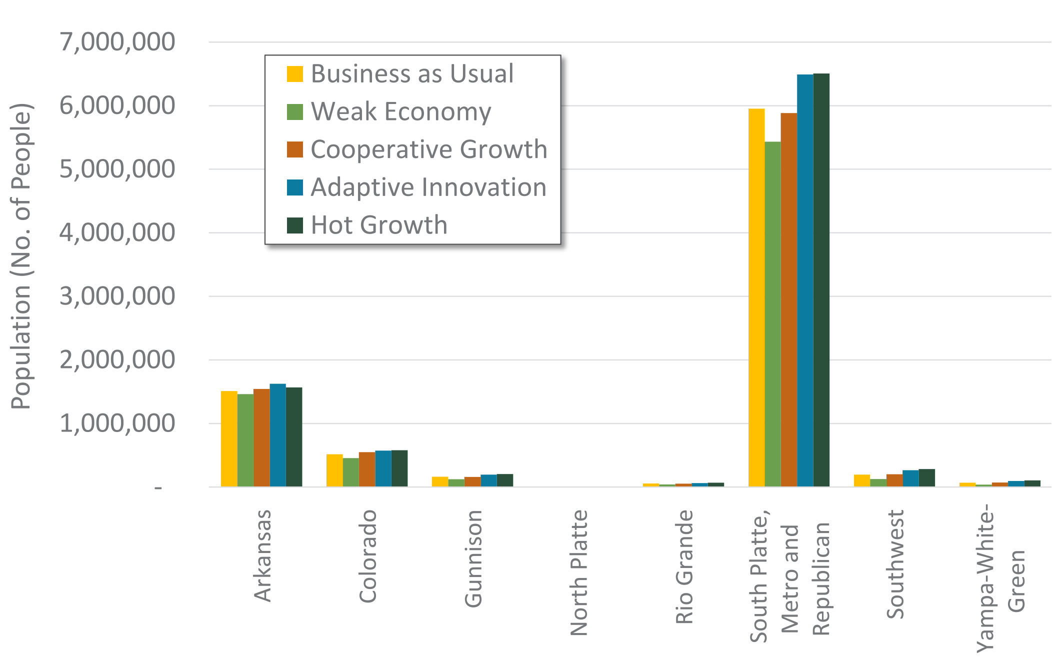
* *SWSI 2010 Appendix H, Exhibit 36 (CWCB, 2010a)*
** *Metro region was reported separately in SWSI 2010*
Note: Due to rounding, the statewide total may not precisely match the sum of basin results shown in the table above

Figure 4.2.6 shows population projections for 2050, summarized by river basin. Between the years 2015 and 2050, the population is projected to grow from approximately 5.5 million to between 7.7 million to 9.3 million in the low and high scenarios, respectively, which is an increase of about 41 to 71 percent.

Municipal Demands

Municipal demands were calculated for each county and then summarized by river basin. Water demands for counties located in multiple basins were distributed between basins by using the portion of the county population located within each basin to prorate the water demands.

Figure 4.2.6 2050 Projected Population by Scenario by Basin



The statewide baseline water demands were largely based on water provider-reported data, with approximately 70 percent of the baseline population demands represented by 1051 data as shown in Figure 4.2.7. The figure also shows the sources of other demand data.

The statewide baseline per capita systemwide demand has decreased from 172 gpcd in SWSI 2010 to approximately 164 gpcd, which is nearly a 5 percent reduction in demands between 2008 and 2015. The reduction is associated with improved data availability, conservation efforts, and ongoing behavioral changes. There are more significant differences from SWSI 2010 at a basin level and these are described in Volume 2 titled *Current and Projected Planning Scenario Municipal and Self-Supplied Industrial Water Demands*.

Figure 4.2.7 Statewide Baseline Municipal Demand Data Sources

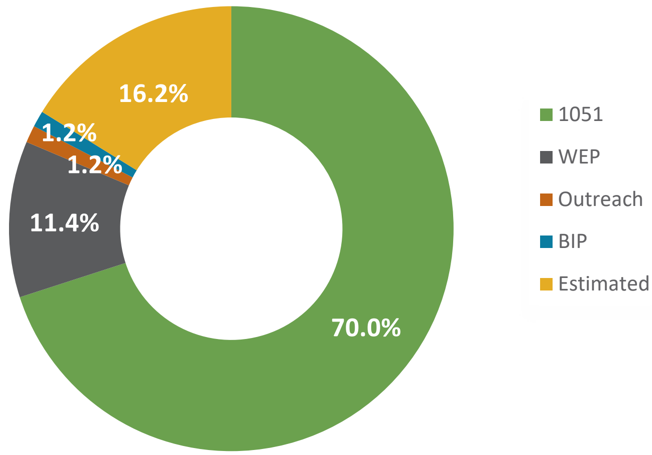


Table 4.2.8 shows baseline and projected per capita demands for basins throughout the state for the five planning scenarios. *Adaptive Innovation* has the lowest per capita demands, and *Hot Growth* has the highest per capita demands, both statewide and within each basin. Note that the statewide per capita demand projections do not match the Water Plan scenario ranking and they were not intended to do so. For example, *Adaptive Innovation* results in the lowest per capita demand, but coupling this with the highest population projection results in the second highest overall demand volume across the scenarios, as further described below.

Table 4.2.8 Per Capita Demand Projections by Planning Scenario for Each Basin (gpcd)

Basin	SWSI 2010 Projection for 2015 *	2015 Baseline	Planning Scenarios				
			Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Arkansas	185	194	179	179	170	164	192
Colorado	182	179	153	156	145	136	165
Gunnison	174	158	146	149	140	133	160
Metro	155	141	138	135	130	126	148
North Platte	310	264	245	254	242	232	270
Rio Grande	314	207	194	198	188	177	209
Republican	see note**	245	236	236	221	214	251
South Platte	188	181	176	174	164	158	190
Southwest	183	198	181	186	173	166	199
White	see note***	252	240	254	240	231	269
Yampa	230	224	172	197	161	150	180
Statewide	**172**	**164**	**157**	**155**	**148**	**143**	**169**

** SWSI 2010 per capita values from SWSI 2010 Appendix L, Tables 8, 14, 15, and 16 (CWCB, 2011b)*
*** The Republican Basin demands were included in the South Platte Basin demand reporting for SWSI 2010*
**** The White Basin demands were included with the Yampa Basin demand reporting for SWSI 2010.*

Statewide baseline municipal water demands are comprised of the water use classes shown in Figure 4.2.8. Residential indoor is the largest category of municipal demand statewide followed by residential outdoor and non-residential indoor.

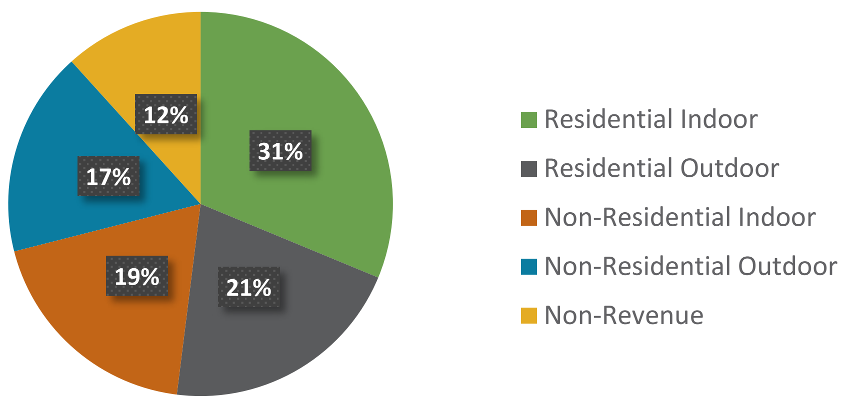
For each planning scenario, residential indoor demands represent the largest category of water demand, starting at nearly 52 gpcd for the 2015 Baseline. The projected residential indoor demands vary greatly across planning scenarios, from 46 gpcd in *Weak Economy* to 36.5 gpcd in *Adaptive Innovation*. Other demand categories show less variability across the scenarios, as shown in Figure 4.2.9.

Adjustments related to climate change that increase demand tended to offset reductions in outdoor use that decreased demand, especially in *Cooperative Growth* and *Adaptive Innovation*. In spite of climate change impacts, however, *Adaptive Innovation* projects the lowest total per capita demand.

CONSERVATION POTENTIAL

The indoor and outdoor demand driver adjustments, coupled with the adoption rate methodology, generally result in higher per-capita demand projections than the active conservation savings projected in SWSI 2010. Unlike SWSI 2010, the Technical Update demand projections are not intended to capture the full range of future active conservation potential. Additional future conservation may still be achieved under each planning scenario through identified projects and processes.

Figure 4.2.8 Statewide Baseline Municipal Demand Category Distribution



CONSERVATION & GROWTH

The planning scenarios often paired high water-savings drivers with high population growth or low demand reductions with low growth, resulting in a narrowing of the range in demand projections.

Figure 4.2.9 Statewide per Capita Demand for Five Planning Scenarios by Demand Category

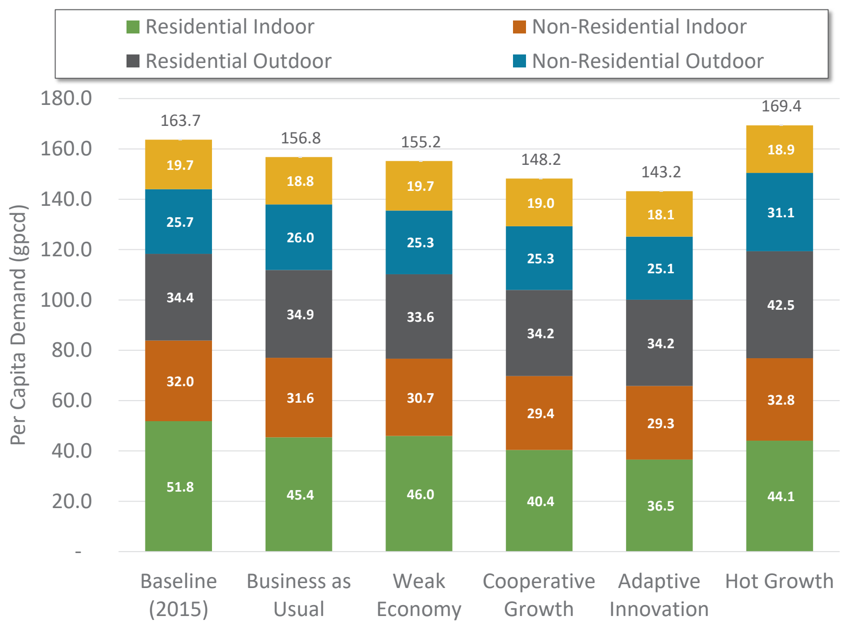


Table 4.2.9 presents baseline and projected demands for basins throughout the state, showing the combined effect of population and per capita demands. The municipal demands are projected to grow from approximately 1.0 million AFY in 2015 to between 1.34 and 1.77 million AFY in 2050.

Table 4.2.9 Statewide Municipal Baseline and Project Demands by Basin (AFY)

Basin	Baseline (2015)	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Arkansas	219,200	303,400	293,800	294,500	298,100	337,200
Colorado	61,800	88,600	79,900	89,000	87,500	106,600
Gunnison	18,300	26,700	20,500	24,900	29,100	36,800
North Platte	400	400	300	300	400	400
Rio Grande	10,600	11,900	9,400	11,000	12,500	15,700
South Platte/Metro (and Republican)	653,300	1,001,600	896,600	932,800	999,900	1,185,200
Southwest	24,000	39,800	26,200	38,900	49,200	62,900
Yampa-White-Green	11,200	13,500	8,800	13,300	17,200	21,900
Statewide	**998,700**	**1,485,800**	**1,335,500**	**1,404,700**	**1,493,900**	**1,766,700**

Note: Due to rounding, the statewide total may not precisely match the sum of basin results shown in the table above

Figure 4.2.10 Statewide Baseline and Projected Population and Municipal Demands

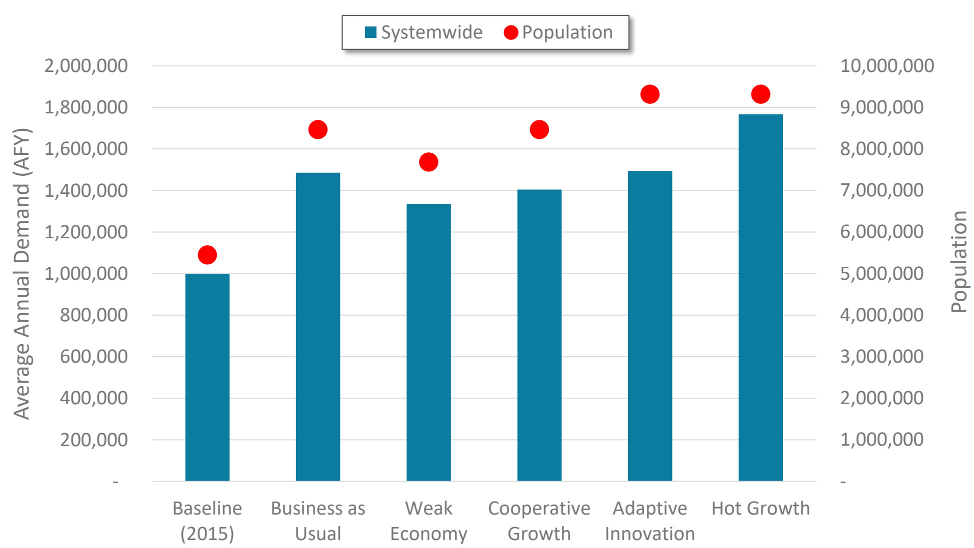


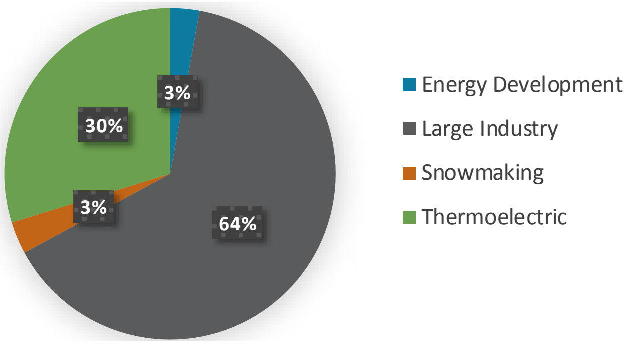
Figure 4.2.10 compares municipal water demands with population projections for each of the planning scenarios. *Business as Usual* and *Cooperative Growth* both use the medium population projection on a statewide basis, with different distributions between counties. Similarly, *Adaptive Innovation* and *Hot Growth* both use the high population projection on a statewide basis, with different distributions between counties. The influence of the population is so significant that the demand projections for all scenarios are relatively similar aside from *Hot Growth*, which has high population coupled with climate change. *Adaptive Innovation* stands out among the others in that it has the greatest reductions in per capita demand but is paired with both the highest population and "Hot and Dry" climate projection. Even with the high population projection and high outdoor demands due to hot and dry future climate conditions, the water-saving measures included in *Adaptive Innovation* are projected to reduce demands to just above *Business as Usual*, demonstrating the benefits of increased conservation.

Self-Supplied Industrial Diversion Demands

As with municipal diversion demands, the updated SSI demands include both baseline demands (estimated as 2015 demands) and demands in the year 2050 for the five planning scenarios. The demand projections do not reflect drought conditions or associated responses. SSI demands were calculated at the county level and then summarized by river basin. No county-level SSI demands had to be distributed between multiple basins.

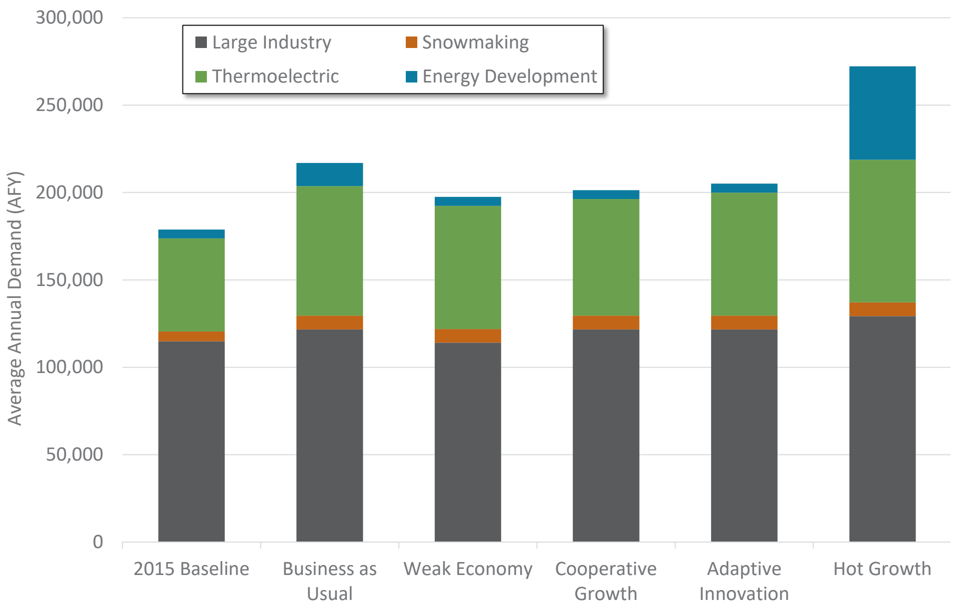
Statewide baseline SSI water demands are comprised of four major industrial uses, as shown on Figure 4.2.11.

Figure 4.2.11 Statewide Baseline SSI Sub-Sector Distribution



The projected demands for all planning scenarios were calculated based on the methodology described in Section 2. The results of the calculations are illustrated in Figure 4.2.12 and shown in Table 4.2.10. With the exception of *Hot Growth*, the updated projections for all planning scenarios were below SWSI 2010 estimates, primarily due to changes in assumptions for thermoelectric demands related to regulations that require an increase in power generation from renewable sources (the assumption was based on input from M&I TAG participants). Thermoelectric demand accounts for a large component of total SSI demand, and the methodology changes had a relatively large effect on the results. Large industry, snowmaking, and energy development projections are generally comparable to the ranges projected in SWSI 2010. There is little variation in the projections aside from *Hot Growth*.

Figure 4.2.12 Statewide Baseline and Projected SSI Demands



Total M&I

Table 4.2.10 and Figure 4.2.13 show statewide municipal and industrial baseline 2015 and projected 2050 water demands for the five planning scenarios. Total statewide M&I demands projected for 2050 range from approximately 1.5 million AFY (*Weak Economy*) to 2.0 million AFY (*Hot Growth*).

For all basins except for the Yampa, municipal demands exceed the self-supplied industrial demands for every planning scenario. Statewide, self-supplied industrial demands are around 15 percent to 18 percent of the municipal demands.

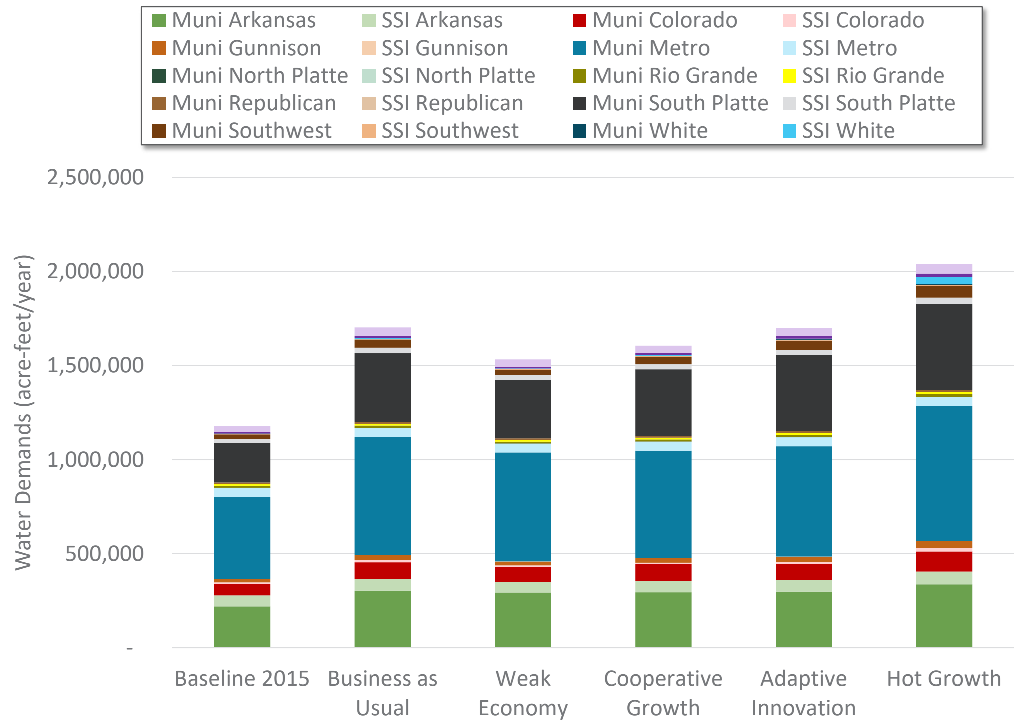
As discussed previously, the Water Plan rankings were the guiding objective in preparing average annual statewide volumetric demands. Statewide municipal projections followed the Water Plan rankings; however, industrial and combined M&I demands deviated to a limited degree, with *Business as Usual* demands exceeding *Adaptive Innovation* demands. These results show that *Business as Usual* and *Adaptive Innovation* futures may be similar, which indicates innovative conservation program measures have the potential to significantly offset the higher population and much warmer climate in *Adaptive Innovation* scenario.

Table 4.2.10 Summary of M&I Demands for Each Basin and Statewide (AFY)

Basin	Demand Type	Baseline 2015	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Arkansas	Municipal	219,200	303,400	293,800	294,500	298,100	337,200
	SSI	58,700	61,700	56,200	60,500	61,100	67,900
	Total	277,900	365,100	350,000	355,000	359,200	405,100
Colorado	Municipal	61,800	88,600	79,900	89,000	87,500	106,600
	SSI	7,800	12,300	7,600	7,800	7,800	18,500
	Total	69,600	100,900	87,500	96,800	95,300	125,000
Gunnison	Municipal	18,300	26,700	20,500	24,900	29,100	36,800
	SSI	300	700	700	700	700	700
	Total	18,500	27,300	21,200	25,500	29,800	37,400
North Platte	Municipal	400	400	300	300	400	400
	SSI	-	-	-	-	-	-
	Total	400	400	300	300	400	400
Rio Grande	Municipal	10,600	11,900	9,400	11,000	12,500	15,700
	SSI	7,900	9,900	9,000	9,900	9,900	10,800
	Total	18,500	21,800	18,300	20,900	22,400	26,500
South Platte /Metro (and Republi-can)	Municipal	653,300	1,001,600	896,600	932,800	999,900	1,185,200
	SSI	72,200	78,200	76,300	75,700	76,900	81,500
	Total	725,500	1,079,800	972,900	1,008,500	1,076,900	1,266,700
Southwest	Municipal	24,000	39,800	26,200	38,900	49,200	62,900
	SSI	2,300	4,300	4,100	3,900	4,100	4,700
	Total	26,300	44,100	30,400	42,800	53,300	67,600
Yampa-White-Green	Municipal	11,200	13,500	8,800	13,300	17,200	21,900
	SSI	29,600	49,800	43,700	43,000	44,600	88,300
	Total	40,800	63,300	52,400	56,300	61,800	110,200
Statewide	**Municipal**	**998,700**	**1,485,800**	**1,335,500**	**1,404,700**	**1,493,900**	**1,766,700**
	SSI	**178,800**	**216,900**	**197,500**	**201,400**	**205,100**	**272,200**
	Total	**1,177,500**	**1,702,700**	**1,533,000**	**1,606,100**	**1,699,000**	**2,039,000**

Note: Due to rounding, the statewide total may not precisely match the sum of basin results shown in the table above

Figure 4.2.13 Baseline and Projected M&I Demands by Basin



4.2.4 East Slope Transbasin Imports

Water from the West Slope of Colorado is a significant source of supply to East Slope municipal and agricultural water users in the South Platte and Arkansas basins. In the future, historical levels of West Slope supply may not be available, and a portion of the demand could go unmet depending on future climate conditions. Table 4.2.11 below provides combined demands for West Slope supplies for both the South Platte and Arkansas basins and combined unmet demands in these basins for the planning scenarios. The amount of unmet demand for West Slope supplies would increase the gap in these basins, likely in an amount that is more than the unmet demand, because municipalities reuse their return flows from water imported from the West Slope.

The focus of this section and Table 4.2.11 is on East Slope transbasin imports, but transbasin imports occur in other basins aside from the South Platte and Arkansas; however, the amount of water associated with these other basin transfers are significantly less. While data describing other transbasin imports and potential changes in the planning scenarios is not presented in the Technical Update report, the modeling data will be available to basin roundtables that choose to evaluate potential future changes to transbasin imports.

Table 4.2.11 Transbasin Demands in the South Platte and Arkansas Basins

	Scenario					
	Baseline	Business as Usual	Weak Economy	Cooperative Growth	Adaptive Innovation	Hot Growth
Average Annual Import Demand (ac-ft)	515,000	515,000	515,000	515,000	515,000	515,000
Average Annual Unmet Demand (ac-ft)	0*	0*	0*	26,000	50,000	55,000
Import in Max East Slope Gap Year (ac-ft)	495,000	495,000	495,000	560,000	467,000	467,000
Unmet Demand in Max East Slope Gap Yr (ac-ft)	0*	0*	0*	57,000	122,000	158,000
Percent Unmet Demand in Max East Slope Gap Year	0%	0%	0%	10%	26%	34%

**CDSS water allocation models calculate unmet demands in the baseline and Business as Usual and Weak Economy scenarios. Because historical values were used for import demand, the unmet demands in these scenarios indicate a calibration issue in the source basin.*

4.2.5 Water Availability

The projected availability of future water supplies varies across the state and is influenced by basin-specific hydrology and water uses, geographic location within basins, and compact constraints. As a result, it is difficult to generalize future water availability on a statewide basis and can be complicated to describe within basins. The following general observations can be made:

- No water is currently available or will be available in the future to meet additional needs in the Republican, Arkansas, and Rio Grande basins.
- Water availability is projected to decrease in *Cooperative Growth*, *Adaptive Innovation*, and *Hot Growth* due to the impacts of warmer and drier climate conditions. Peak flows are projected to occur earlier in the runoff season, and streamflows may be diminished later in the summer.
- In locations where available flows occur only periodically under current conditions (mainly during wet years), it may be available less frequently and in lower volumes. If the climate becomes warmer and drier, droughts and periods of low to no flow availability in these basins may be longer in duration.
- In basins where water is generally available every year, volumes of annual available flow may decrease overall and timing may change (peak flows may occur earlier in the runoff season).

4.2.6 Yield of Future Projects

As described in Section 3, the Technical Update analyses did not include future water supply projects and strategies that will help mitigate M&I and agricultural gaps; however, water providers are contemplating a wide variety of projects and strategies to meet their future needs. SWSI 2010 provided information on future projects and strategies that were then being pursued by water providers to meet future demands. The types of projects and strategies included agricultural water transfers (traditional and alternative), reuse, growth into existing supplies, regional in-basin projects, new transbasin projects, firming in-basin water rights, and firming transbasin rights. Ranges of potential yields for these projects and strategies by type and by basin were presented assuming 100 percent and also lower rates of success in achieving the contemplated yield of the projects. Table 4.2.12 shows the amount of yield in each basin for various rates of success that were included in the gap calculations in SWSI 2010.

The data in Table 4.2.12 were not updated in the Technical Update, and yields of future projects in SWSI 2010 were not developed considering future potential impacts of the planning scenarios. Nevertheless, the data in the table show that water providers are currently pursuing significant water supply projects and strategies that will help fill future gaps. Basin roundtables will be encouraged to update and improve the quality of their data describing future projects and strategies during upcoming BIP updates (see Section 5 for more details).

Table 4.2.12 Yields of Identified Projects and Processes from SWSI 2010

	SWSI 2010 Estimated Yield of Identified Projects and Processes (AFY)		
	100% IPP Success Rate (low)	Alternative IPP Success Rate (medium)	Status Quo IPP Success Rate (high)
Arkansas	88,000	85,000	76,000
Colorado	42,000	49,000	63,000
Gunnison	14,000	14,000	16,000
Metro	140,000	97,000	100,000
North Platte	100	200	300
Rio Grande	5,900	6,400	7,700
South Platte	120,000	78,000	58,000
Southwest	14,000	13,000	15,000
Yampa-White-Green	10,000	11,000	13,000
Statewide	**430,000**	**350,000**	**350,000**

This table reflects data from Table 5-12 in the SWSI 2010 report.

4.2.7 Environment and Recreation Conditions

Future conditions and risks for E&R attributes vary across the state depending on location and planning scenario. Future E&R conditions will be influenced by basin-specific hydrology, water uses, and geographic location within basins. As a result, it is difficult to precisely characterize future E&R conditions and risks on a statewide basis (regional specific observations are included in basin summaries). The following general observations can be made:

- Climate change and its impact on streamflow will be a primary driver of risk to E&R attributes.
- Projected future streamflow hydrographs in most locations across the state show earlier peaks and potentially drier conditions in the late summer months under scenarios with climate change.
- Under climate change scenarios, runoff and peak flows may occur earlier, resulting in possible mismatches between peak flow timing and species' needs.
- Drier conditions in late summer months could increase risk to coldwater and warmwater fish due to higher water temperatures and reduced habitat. The degree of increased risk is related to the level of streamflow decline.
- In many mountainous regions without significant influence of infrastructure, peak flow, and low flows are projected to be sufficient to sustain low to moderate risk for riparian plants and fish, but risks are projected to increase in scenarios with climate change.
- In mountainous regions with infrastructure, risks to E&R attributes may vary. Streams that are already depleted may see increased risks in scenarios with climate change. However, some streams may be sustained by reservoir releases, which will help moderate risks in scenarios with climate change.
- Instream flow water rights and recreational in-channel diversion water rights may be met less often in climate-impacted scenarios.

Modeling results for each of the eight major river basins are listed alphabetically in the following sections.