Analysis and Technical Update to the Colorado Water Plan

Technical Memorandum

Prepared for:

Colorado Water Conservation Board

Subject:

Potential Economic Impacts of Not Meeting Projected Gaps

Date: August 22, 2018

Prepared by: Doug Jeavons, BBC Research &Consulting
Reviewed by: Brown and Caldwell

Table of Contents

List of Figures

Section 1: Purpose and Overview

Using a scenario planning process, the Colorado Water Plan compares projected future water supply needs to projected future water supply availability. When projected needs exceed projected supplies, the difference is documented as supply versus demand gaps, or simply "gaps." Previous studies have evaluated different infrastructure, conservation, or policy projects that have potential to increase supplies or reduce demands in order to reduce the gaps. Each of those projects has varying financial costs as well as technical, environmental, and political challenges. The rough estimates of the financial costs of filling the gaps have received considerable attention. To date, however, limited information has been developed regarding the economic consequences of failing to meet the projected gaps between future water needs and future supplies.

This report provides order-of-magnitude estimates of the economic consequences of failing to meet the gaps within the state of Colorado and each of its basins. This economic impact case study is based on data developed for the medium scenario[1] for 2050 municipal and self-supplied industrial (M&SSI) gaps from the previous SWSI effort (SWSI 2010), which anticipated a statewide gap for these uses of approximately 390,000 acre-feet per year (AFY) by 2050,[2] and the projected 2050 gap in water supplies for irrigated agriculture from the previous SWSI study, which is estimated at more than 1.7 million AFY.[3]

When completed, the SWSI update will develop revised estimates of current water use, future water needs, and the remaining gaps between supplies and demands under the five specific planning scenarios identified in the 2015 Colorado Water Plan. The updated and revised gap analyses may indicate larger or smaller gaps than the example from the 2010 SWSI analysis analyzed in this case study and will likely result in different estimates of the future water supply-demand gaps under the planning scenarios. If desired, the methods, tools, and data sets developed for this economic case study could be applied to estimate the economic consequences of the revised estimates of future water supply gaps when those estimates become available.

The economic analysis conducted for this case study is based on a relatively simplified approach consistent with the goal of identifying the general magnitude of the economic consequences of failing to meet future gaps. In the simplified framework used for this analysis, water demands in Colorado meet one of two purposes: agricultural use or combined M&SSI use. Consequently, this analysis focuses on the economic implications of projected future gaps for these two use types. Further details regarding the analysis methodology are provided at the end of this technical memorandum.

There are also significant economic implications for the state of Colorado, and each of its river basins, in failing to meet non-consumptive needs for environmental and recreation purposes. Quantifying the economic implications of gaps in those needs is beyond the scope of this study.

The Colorado Water Conservation Board (CWCB) has supported, and continues to undertake, a number of other studies on related topics. The CWCB and the state's basin roundtables continue to examine Colorado's non-consumptive water needs, and have developed a non-consumptive toolbox.[4] The CWCB helped support a detailed examination of the short- and long-term impacts of the state's most recent

[1] Other scenarios examined in the SWSI 2010 analysis projected the 2050 gap in M&SSI supplies to potentially be as low as 190,000 acre-feet per year or as high as 630,000 acre-feet per year.

[2] See Table ES-6 from SWSI 2010 Executive Summary.

[3] See Table ES-4 from SWSI 2010 Executive Summary.

[4] .http://cwcb.state.co.us/environment/non-consumptive-needs/Pages/main.aspx

drought in 2012[5] and has developed a drought toolbox to assist in planning and preparing for future droughts.[6] The CWCB directed a study of climate change in Colorado to support water resources management and adaptation[7] and collaborates with other state agencies on the Colorado Climate Plan. Currently, the CWCB is working with the Colorado Department of Local Affairs on an evaluation—known as the Future Conditions Study—of potential future impacts from fires, floods, and droughts.

Components of the case study economic analysis. Three types of economic costs are included in this case study:

- **Agricultural costs which are already being incurred.** Colorado's agricultural sector has historically been limited by the water supplies available to irrigate crops, and the 2010 SWSI analysis projected that shortages would continue into the future. Consequently, the economic impacts of agricultural water gaps described in this case study do not necessarily represent new impacts that will occur between now and 2050. Instead, the economic impacts related to agriculture in this case study represent losses relative to potential production, and economic activity, if there were sufficient water supplies to meet the full irrigation water requirements of Colorado's irrigated acres.

  Figure 2-1 depicts the estimated agriculture-related job impacts that have already been incurred due to the lack of sufficient supplies to meet full irrigation water requirements in each basin.

- **Marginal costs of a portion of projected future M&SSI gaps.** Like many other commodities in our economy, the value of water consumed for M&SSI purposes is subject to diminishing marginal returns. In the context of this analysis, managing the first acre-foot of shortage in the M&SSI sector—which might logically involve mandatory reductions in the water supply available for outdoor use—would have a smaller economic impact than managing the last acre-foot of the projected M&SSI shortage.

  The exact threshold where M&SSI gaps begin to create larger impacts on the regional economy is unknown and likely varies among different locations and different providers. This case study provides a range of economic impacts from M&SSI gaps based on alternative assumptions regarding the point at which gaps in M&SSI supplies transition from marginal impacts to larger opportunity costs.

  Marginal impacts from M&SSI gaps of up to 10 or 15 percent of 2050 demand projections from the SWSI 2010 study were analyzed in terms of reduction in the welfare of the water users due to mandatory reduction or elimination of outdoor uses, as well as in terms of the corresponding impacts on the municipal "green industry," such as nursery production, landscaping services, and car washes. The bases for the 10 and 15 percent shortage thresholds in the M&SSI sector—which define the high range and low range of projected economic impacts from M&SSI gaps, respectively—are discussed further in the methodology section of this memorandum. It is worth noting that some measures to increase municipal water use efficiency, such as utility loss reduction efforts, may be largely transparent to water consumers and could reduce impacts to consumer welfare.

- **Opportunity costs of foregone future economic development.** In this case study, M&SSI gaps beyond 10 or 15 percent of projected 2050 demands were analyzed based on the average level of economic activity currently supported by each acre-foot of M&SSI water use. This effectively assumes that larger M&SSI shortages could result in tap moratoriums or other slowdowns in overall economic development due to limitations in available water supplies. While improvements in the efficiency of M&SSI use are likely to continue in the future, such efficiency gains will actually increase the economic

[5] Estimating the Short and Long-term Economic & Social Impacts of the 2012 Drought in Colorado. James Pritchett, Chris Goemans and Ron Nelson.

[6] http://cwcb.state.co.us/technical-resources/drought-planning-toolbox/Pages/main.aspx.

[7] http://cwcbweblink.state.co.us/WebLink/ElectronicFile.aspx?docid=191995&searchid=e3c463e8-569c-4359-8ddd-ed50e755d3b7&dbid=0

productivity of each acre-foot of water used in this sector. Consequently, this component of the case study analysis may understate the economic consequences of future M&SSI gaps.

Economic Terminology in this Case Study

Backward Linkages: Economic relationships between the primary activity being evaluated (e.g.agriculture) and its employees and suppliers (feed, equipment, etc.)

Consumer Welfare: A measure of effects on the well-being of consumers. Measured in terms of the difference between the value consumers would be willing to pay for a good (e.g. water) and the price they actually have to pay. Also referred to as "consumer surplus."

Employment: Full and part-time jobs, including self-employed business owners.

Forward Linkages: Economic relationships betweenthe primary activity being evaluated and industries that purchase and use its products (e.g. feed lots, processors, etc.)

Indirect Impacts: Impacts on suppliers of the directly affected industry (see backward linkages).

Induced Impacts: Impacts on suppliers to employees of the directly affected industry and employees of the indirectly impacted industries.

Labor Compensation: Includes wages, salaries, benefits, and employment taxes paid by businesses for social security and medicare.

Output: Generally equivalent to the total annual value of sales by businesses.

Value-added. The value of business sales net of the costs of supplies and materials purchased from other businesses. The sum of value-added across the economy is equivalent to "gross domestic product" or GDP (nationally), "**gross regional product**", or "**gross state product**."

Section 2: Summary Insights from the Economic Impact Case Study

The projected economic impacts of failing to meet the gaps identified in the specific 2010 SWSI demand conditions analyzed in this case study provide a number of general insights regarding the importance of Colorado's water planning efforts.

The lack of sufficient supply to meet the full consumptive use requirements for irrigated crops in Colorado is estimated to already result in an annual loss in potential production value of more than $3 billion and about 28,000 fewer jobs directly and indirectly supported by irrigated agriculture.[8] In many basins, economic impacts on livestock production due to reduced crop and forage output are larger than the economic impacts on the crop producers. Projected gaps in 2050 irrigation water supplies indicate that these reductions in potential agricultural economic activity will continue into the future.

Figure 2-1 depicts the estimated impact that is already occurring in agriculture-related employment in each basin due to the lack of a full irrigation supply across Colorado.

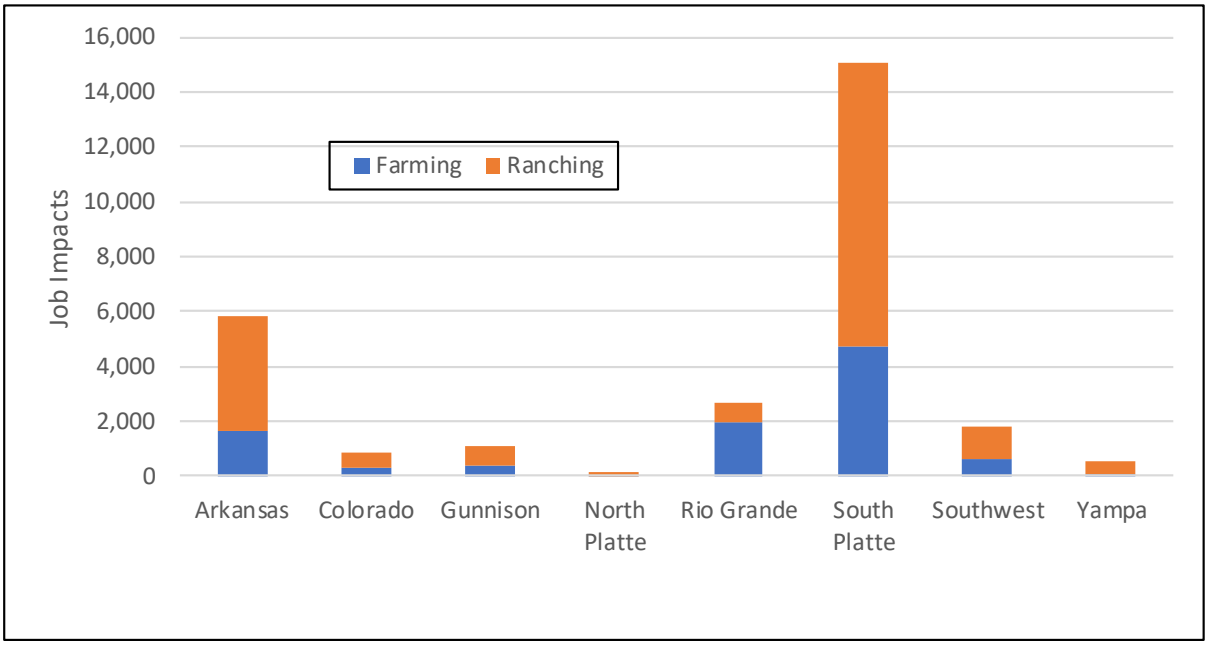

Figure 2-1. Farming and ranching job impacts already incurred due to limited irrigation supplies (Includes backward-linked support industries)

Figure 2-2 depicts the breakdown of the projected 2050 economic impacts in each basin under the low range scenario for future M&SSI economic impacts. Each bar in the figure summarizes the proportion of impacts that are already being incurred due to water supply gaps in the agricultural sector alongside incremental new impacts that are projected to occur in the future due to projected gaps in water supply

[8] Based on the estimated existing gap between available water supplies for irrigated agriculture and the full irrigation requirement for currently irrigated acres shown in Table ES-3 from SWSI 2010 Executive Summary.

for the M&SSI sector. Although the Arkansas Basin and the South Platte Basin have already incurred the largest impacts on agriculture and its supporting industries, in absolute terms, due to limited water supplies, the projected incremental new economic impacts in these basins are very large due to the scale and severity of their projected future gaps in M&SSI supplies.

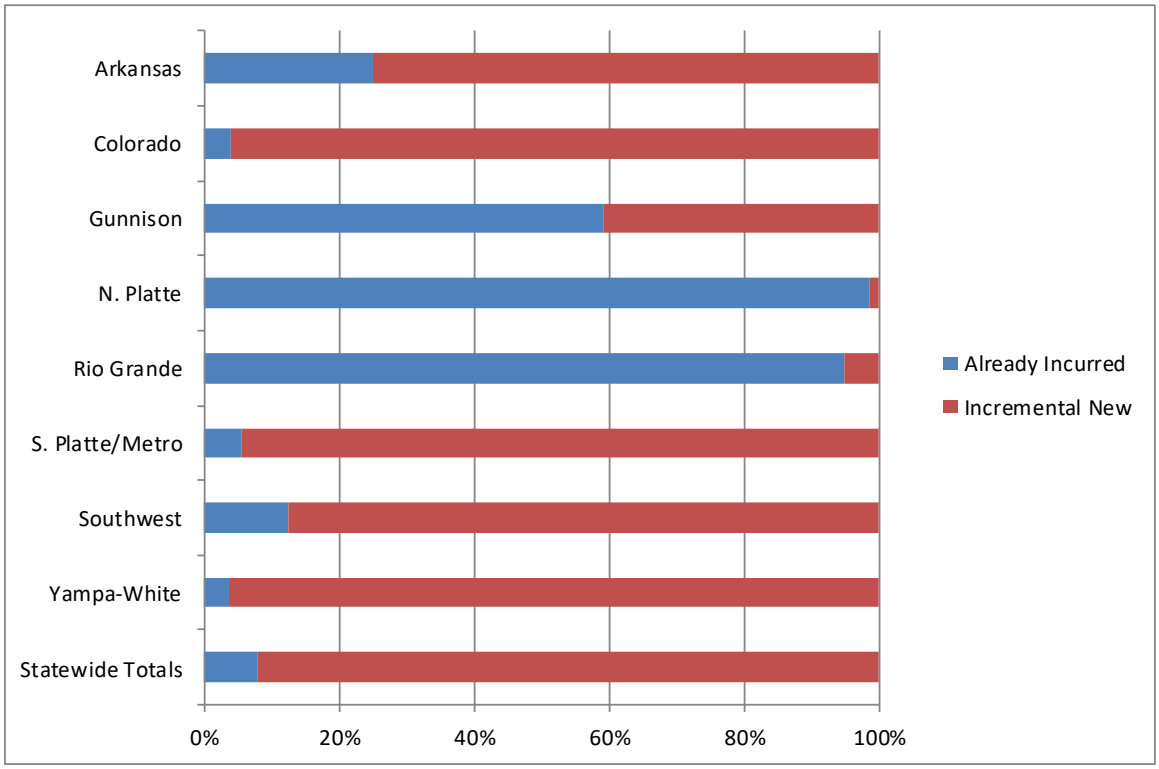

Figure 2-2. Proportions of projected 2050 economic impacts already incurred due to gaps in available agricultural water supply (Low range scenario for incremental new M&SSI impacts)

Figure 2-3 depicts the proportions of the projected 2050 economic impacts in each basin that have already been incurred under the high range scenario for incremental new M&SSI impacts.

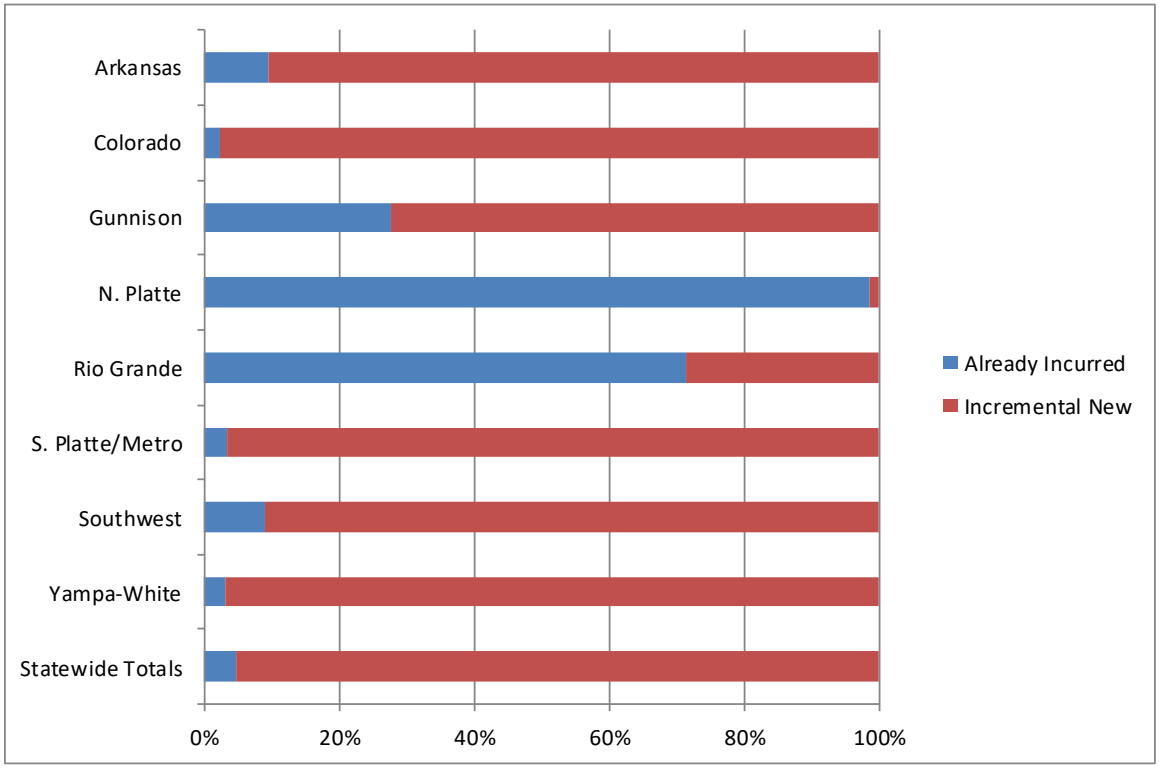

Figure 2-3. Proportions of projected 2050 economic impacts already incurred due to gaps in available agricultural water supply (High range scenario for incremental new M&SSI impacts)

Economic effects of projected M&SSI gaps depend on the severity of the projected gap in each basin. In areas with smaller M&SSI gaps relative to projected 2050 demands (less than 10 percent or 15 percent of projected demand), the primary effects would likely be a substantial reduction in consumer welfare due to greatly reduced water availability for outdoor use and severe effects on the municipal "green industry," involving sectors such as landscape services, nurseries, and car washes.

In areas with more severe M&SSI gaps (greater than 10 percent or 15 percent of projected future M&SSI demand), much larger economic impacts are projected due to the opportunity cost of foregone future residential, commercial, and industrial development.

Overall, the economic impacts and opportunity costs of the projected gaps in agricultural and M&SSI water supplies are substantial in every basin in Colorado. From a statewide perspective, failing to meet the gaps identified in the 2010 SWSI demand condition example analyzed in this case study could lead to between 355,000 and 587,000 fewer jobs in Colorado in 2050; $53 to $90 billion fewer dollars in annual economic output; a reduction in gross state product of between $30 and $51 billion per year; $20 to $33 billion in reduced labor income; and $3 to $6 billion fewer dollars in state and local tax revenues. To put these numbers in perspective, the projected economic impacts are equivalent to approximately nine to 16 percent of current statewide economic output, gross state product, statewide employment, and statewide labor income.

While the projected economic impacts of the gaps from the SWSI 2010 scenario analyzed in this case study are largest in the combined South Platte/Metro basin, that basin is also Colorado's largest in terms of its current population, overall economy, and agricultural economy. Relative to the scale of current

basin economies, the projected economic impacts of the SWSI 2010 scenario analyzed in this case study are the most severe in the Yampa-White Basin and the Southwest Basin.

The economic values associated with agricultural water use are substantial but are generally considerably lower than the economic values associated with M&SSI use. This reality, combined with the flexibility to move water among different uses and locations under Colorado law, implies that there will be continuing economic pressure to shift water from Colorado's farms to its cities and industrial users. Given the importance that the state's residents place on maintaining agriculture in Colorado,[9] these economic pressures highlight the need for strategies to mitigate potential future impacts resulting from water transfers that would negatively affect Colorado's agricultural economy. One important component of the current SWSI update is the study of alternative transfer methods to reduce impacts to agriculture and rural communities.

[9] Public Opinions, Attitudes and Awareness Regarding Water in Colorado. Colorado Water Conservation Board. July 2013.

Section 3: Basin Impact Summaries

The following pages provide estimated economic impacts from the case study scenario in each of Colorado's basins. Employment numbers described in these summaries include both wage and salary workers and self-employed proprietors (including farm owners). Labor compensation includes wages, benefits, and proprietor income.

3.1 ARKANSAS BASIN

Current Economic and Demographic Characteristics

- Population: 1,009,000
- Total Economic Output: $75.3 billion
- Gross Regional Product: $43.3 billion
- Employment: 586,000
- Total Labor Compensation: $29.1 billion

Agricultural Characteristics

- Irrigated Cropland: 428,000 acres
- Proportion of Cropland Irrigated: 20 percent
- Estimated Direct and Secondary Agricultural Economic Contribution:[10]
  - $1.6 billion in economic output
  - 14,300 jobs
  - $136 million in labor compensation

Projected 2050 Water Supply Conditions

- Agricultural gap: 386,000 AFY (45 percent)
- M&SSI gap: 64,000 AFY (17 percent)

Projected Annual Opportunity Costs of Failing to Meet Gaps (by 2050)

- Reduced Economic Output: $2.5 to $7.5 billion
- Reduced Gross Regional Product: $1.3 to $4.2 billion
- Reduced Employment: 22,500 to 60,400 jobs
- Reduced Labor Compensation: $0.9 to $2.9 billion
- Reduced State and Local Tax Revenues: $143 to $511 million
- Reduced Consumer Welfare: $258 to $442 million[11]

[10] Includes farming, ranching, and indirect and induced effects from agriculture on other industries.

[11] Estimated reduction in consumer surplus assuming first 10 percent of M&SSI gap leads to involuntary rationing measures such as prohibitions on outdoor water use and/or substantially increased water rates designed to drive down consumption.

3.2 COLORADO BASIN

Current Economic and Demographic Characteristics

- Population: 309,000
- Total Economic Output: $29.4 billion
- Gross Regional Product: $17.0 billion
- Employment: 233,000
- Total Labor Compensation: $9.9 billion

Agricultural Characteristics

- Irrigated Cropland: 268,000 acres
- Proportion of Cropland Irrigated: 80 percent
- Estimated Direct and Secondary Agricultural Economic Contribution:[12]
  - $334 million in economic output
  - 5,100 jobs
  - $65 million in labor compensation

Projected 2050 Water Supply Conditions

- Agricultural gap: 77,000 AFY (17 percent)
- M&SSI gap: 33,000 AFY (22 percent)

Projected Annual Opportunity Costs of Failing to Meet Gaps (by 2050)

- Reduced Economic Output: $3.0 to $4.9 billion
- Reduced Gross Regional Product: $1.7 to $2.9 billion
- Reduced Employment: 25,000 to 39,000 jobs
- Reduced Labor Compensation: $1.2 to $1.9 billion
- Reduced State and Local Tax Revenues: $212 to $354 million
- Reduced Consumer Welfare: $99 to $170 million[13]

[12] Includes farming, ranching, and indirect and induced effects from agriculture on other industries.

[13] Estimated reduction in consumer surplus assuming first 10 percent of M&SSI gap leads to involuntary rationing measures such as prohibitions on outdoor water use and/or substantially increased water rates designed to drive down consumption.

3.3 GUNNISON BASIN

Current Economic and Demographic Characteristics

- Population: 103,000
- Total Economic Output: $6.3 billion
- Gross Regional Product: $3.0 billion
- Employment: 54,000
- Total Labor Compensation: $1.8 billion

Agricultural Characteristics

- Irrigated Cropland: 272,000 acres
- Proportion of Cropland Irrigated: 91 percent
- Estimated Direct and Secondary Agricultural Economic Contribution:[14]
    - $332 million in economic output
    - 4,800 jobs
    - $85 million in labor compensation

Projected 2050 Water Supply Conditions

- Agricultural gap: 116,000 AFY (20 percent)
- M&SSI gap: 5,100 AFY (13 percent)

Projected Annual Opportunity Costs of Failing to Meet Gaps (by 2050)

- Reduced Economic Output: $122 to $395 million
- Reduced Gross Regional Product: $52 to $184 million
- Reduced Employment: 1,800 to 4,000 jobs
- Reduced Labor Compensation: $41 to $118 million
- Reduced State and Local Tax Revenues: $4 to $31 million
- Reduced Consumer Welfare: $26 to $45 million[15]

[14]Includes farming, ranching, and indirect and induced effects from agriculture on other industries.

[15] Estimated reduction in consumer surplus assuming first 10 percent of M&SSI gap leads to involuntary rationing measures such as prohibitions on outdoor water use and/or substantially increased water rates designed to drive down consumption.

3.4 NORTH PLATTE BASIN

Current Economic and Demographic Characteristics

- Population: 1,400
- Total Economic Output: $115 million
- Gross Regional Product: $47 million
- Employment: 900
- Total Labor Compensation: $34 million

Agricultural Characteristics

- Irrigated Cropland: 117,000 acres
- Proportion of Cropland Irrigated: 86 percent
- Estimated Direct and Secondary Agricultural Economic Contribution:[16]
    - $27 million in economic output
    - 180 jobs
    - $8 million in labor compensation

Projected 2050 Water Supply Conditions

- Agricultural gap: 110,000 AFY (44 percent)
- M&SSI gap: 20 AFY (3 percent)

Projected Annual Opportunity Costs of Failing to Meet Gaps (by 2050)

- Reduced Economic Output: $32 million
- Reduced Gross Regional Product: $9 million
- Reduced Employment: 170 jobs
- Reduced Labor Compensation: $9 million
- Reduced State and Local Tax Revenues: $0.8 million
- Reduced Consumer Welfare: $0.5 million[17]

[16] Includes farming, ranching, and indirect and induced effects from agriculture on other industries.

[17] Estimated reduction in consumer surplus assuming first 10 percent of M&SSI gap leads to involuntary rationing measures such as prohibitions on outdoor water use and/or substantially increased water rates designed to drive down consumption.

3.5 RIO GRANDE BASIN

Current Economic and Demographic Characteristics

- Population: 46,000
- Total Economic Output: $2.9 billion
- Gross Regional Product: $1.5 billion
- Employment: 27,000
- Total Labor Compensation: $947 million

Agricultural Characteristics

- Irrigated Cropland: 622,000 acres
- Proportion of Cropland Irrigated: 93 percent
- Estimated Direct and Secondary Agricultural Economic Contribution:[18]
    - $668 million in economic output
    - 5,500 jobs
    - $202 million in labor compensation

Projected 2050 Water Supply Conditions

- Agricultural gap: 369,000 AFY (33 percent)
- M&SSI gap: 3,600 AFY (13 percent)

Projected Annual Opportunity Costs of Failing to Meet Gaps (by 2050)

- Reduced Economic Output: $298 to $396 million
- Reduced Gross Regional Product: $135 to $185 million
- Reduced Employment: 2,400 to 3,400 jobs
- Reduced Labor Compensation: $95 to $127 million
- Reduced State and Local Tax Revenues: $9 to $21 million
- Reduced Consumer Welfare: $18 to $31 million[19]

[18] Includes farming, ranching, and indirect and induced effects from agriculture on other industries.

[19] Estimated reduction in consumer surplus assuming first 10 percent of M&SSI gap leads to involuntary rationing measures such as prohibitions on outdoor water use and/or substantially increased water rates designed to drive down consumption.

3.6 SOUTH PLATTE/METRO BASIN

Current Economic and Demographic Characteristics

- Population: 3.8 million
- Total Economic Output: $434 billion
- Gross Regional Product: $250 billion
- Employment: 2.6 million
- Total Labor Compensation: $162 billion

Agricultural Characteristics

- Irrigated Cropland: 1,381,000 acres
- Proportion of Cropland Irrigated: 33 percent
- Estimated Direct and Secondary Agricultural Economic Contribution:[20]
    - $8.5 billion in economic output
    - 50,000 jobs
    - $2.1 billion in labor compensation

Projected 2050 Water Supply Conditions

- Agricultural gap: 434,000 AFY (25 percent)
- M&SSI gap: 240,000 AFY (21 percent)

Projected Annual Opportunity Costs of Failing to Meet Gaps (by 2050)

- Reduced Economic Output: $43 to $72 billion
- Reduced Gross Regional Product: $25 to $41 billion
- Reduced Employment: 273,000 to 442,000 jobs
- Reduced Labor Compensation: $16 to $27 billion
- Reduced State and Local Tax Revenues: $2.7 to $4.7 billion
- Reduced Consumer Welfare: $0.7 to $1.3 billion[21]

[20] Includes farming, ranching, and indirect and induced effects from agriculture on other industries.

[21] Estimated reduction in consumer surplus assuming first 10 percent of M&SSI gap leads to involuntary rationing measures such as prohibitions on outdoor water use and/or substantially increased water rates designed to drive down consumption.

3.7 SOUTHWEST BASIN

Current Economic and Demographic Characteristics

- Population: 108,000
- Total Economic Output: $9.2 billion
- Gross Regional Product: $4.8 billion
- Employment: 74,000
- Total Labor Compensation: $3.0 billion

Agricultural Characteristics

- Irrigated Cropland: 259,000 acres
- Proportion of Cropland Irrigated: 71 percent
- Estimated Direct and Secondary Agricultural Economic Contribution:[22]
    - $192 million in economic output
    - 4,000 jobs
    - $29 million in labor compensation

Projected 2050 Water Supply Conditions

- Agricultural gap: 191,000 AFY (34 percent)
- M&SSI gap: 12,000 AFY (25 percent)

Projected Annual Opportunity Costs of Failing to Meet Gaps (by 2050)

- Reduced Economic Output: $1.7 to $2.4 billion
- Reduced Gross Regional Product: $0.9 to $1.2 billion
- Reduced Employment: 14,000 to 20,000 jobs
- Reduced Labor Compensation: $548 to $787 million
- Reduced State and Local Tax Revenues: $133 to $196 million
- Reduced Consumer Welfare: $32 to $55 million[23]

[22] Includes farming, ranching, and indirect and induced effects from agriculture on other industries.

[23] Estimated reduction in consumer surplus assuming first 10 percent of M&SSI gap leads to involuntary rationing measures such as prohibitions on outdoor water use and/or substantially increased water rates designed to drive down consumption.

3.8 YAMPA-WHITE BASIN

Current Economic and Demographic Characteristics

- Population: 43,000
- Total Economic Output: $5 billion
- Gross Regional Product: $2.7 billion
- Employment: 33,000
- Total Labor Compensation: $1.4 billion

Agricultural Characteristics

- Irrigated Cropland: 119,000 acres
- Proportion of Cropland Irrigated: 49 percent
- Estimated Direct and Secondary Agricultural Economic Contribution:[24]
    - $197 million in economic output
    - 2,900 jobs
    - $36 million in labor compensation

Projected 2050 Water Supply Conditions

- Agricultural gap: 39,000 AFY (19 percent)
- M&SSI gap: 37,000 AFY (42 percent)

Projected Annual Opportunity Costs of Failing to Meet Gaps (by 2050)

- Reduced Economic Output: $2.4 to $2.8 billion
- Reduced Gross Regional Product: $1.3 to $1.5 billion
- Reduced Employment: 15,000 to 18,000 jobs
- Reduced Labor Compensation: $682 to $799 million
- Reduced State and Local Tax Revenues: $162 to $191 million
- Reduced Consumer Welfare: $59 to $100 million[25]

[24] Includes farming, ranching, and indirect and induced effects from agriculture on other industries.

[25] Estimated reduction in consumer surplus assuming first 10 percent of M&SSI gap leads to involuntary rationing measures such as prohibitions on outdoor water use and/or substantially increased water rates designed to drive down consumption.

3.9 STATEWIDE SUMMARY

Current Economic and Demographic Characteristics

- Population: 5.5 million
- Total Economic Output: $563 billion
- Gross State Product: $323 billion
- Employment: 3.6 million
- Total Labor Compensation: $208 billion

Agricultural Characteristics

- Irrigated Cropland: 3.5 million acres
- Proportion of Cropland Irrigated: 40 percent
- Estimated Direct and Secondary Agricultural Economic Contribution:[26]
  - $11.8 billion in economic output
  - 87,000 jobs
  - $2.7 billion in labor compensation

Projected 2050 Water Supply Conditions

- Agricultural gap: 1.7 million AFY (30 percent)
- M&SSI gap: 390,000 AFY (21 percent)

Projected Annual Opportunity Costs of Failing to Meet Gaps (by 2050)

- Reduced Economic Output: $53 to $90 billion
- Reduced Gross State Product: $30 to $51 billion
- Reduced Employment: 355,000 to 587,000 jobs
- Reduced Labor Compensation: $20 to $33 billion
- Reduced State and Local Tax Revenues: $3.4 to $6.0 billion
- Reduced Consumer Welfare: $1.2 to $2.1 billion[27]

[26] Includes farming, ranching, and indirect and induced effects from agriculture on other industries.

[27] Estimated reduction in consumer surplus assuming first 10 percent of M&SSI gap leads to involuntary rationing measures such as prohibitions on outdoor water use and/or substantially increased water rates designed to drive down consumption.

Section 4: Case Study Methodology

Models and data sources. The economic analysis presented in this case study was conducted using the IMPLAN regional economic modeling system. IMPLAN was originally developed by the U.S. Forest Service and is now the most commonly used regional economic modeling tool in the U.S. The case study analysis incorporated data from the following sources:

- Current and projected water use and projected future gaps for irrigated agriculture and M&SSI uses in each basin from SWSI 2010 (Section 4);
- Irrigated and non-irrigated harvested acreage by crop and county from the 2007 and 2012 Censuses of Agriculture;
- 2016 IMPLAN data files for each county in Colorado and corresponding regional economic models for each basin;
- Average statewide municipal cost of water per 10,000 gallons from the 2016 Colorado Municipal Water and Wastewater Rate Survey; and
- Approximate municipal water price elasticity of demand based on prior study team analyses for the cities of Aurora, Denver, and Greeley

Agricultural sector impacts. Figure 4-1 shows the current water supply available for irrigated crops in each basin from the SWSI 2010 report. The table also shows the projected available irrigation supply in 2050, the projected full irrigation water requirement, and the corresponding gap in irrigation supplies from the 2010 SWSI analyses.

	Current Water Demand (SWSI 2010)			Projected Demand 2050		
Basin	Supply Limited	Full Requirement	Gap	Supply Limited	Full Requirement	Gap
Arkansas	542,000	995,000	453,000	476,000	862,000	386,000
Colorado	485,000	584,000	99,000	366,000	443,000	77,000
Gunnison	505,000	633,000	128,000	457,000	573,000	116,000
North Platte	113,000	202,000	89,000	140,000	250,000	110,000
Republican	602,000	802,000	200,000	480,000	640,000	160,000
Rio Grande	855,000	1,283,000	428,000	739,000	1,108,000	369,000
South Platte	1,117,000	1,496,000	379,000	820,000	1,094,000	274,000
Southwest	382,000	580,000	198,000	367,000	558,000	191,000
Yampa-White	181,000	235,000	54,000	170,000	209,000	39,000
Total	4,782,000	6,810,000	2,028,000	4,015,000	5,737,000	1,722,000

Figure 4-1. Projected current irrigation water use and future needs, supplies, and gaps from SWSI 2010

Source: SWSI 2010 Section 4, Consumptive Needs Assessments.

To quantify the economic value of agricultural water supplies in each basin, the study team conducted the following analysis:

1. Based on 2007 and 2012 Census of Agriculture data and general estimates of the relative yields of irrigated versus non-irrigated lands by crop, we estimated the portion of the economic activity (e.g., output or sales value) in each of the six agricultural sectors in IMPLAN that are most relevant to Colorado crop production.
2. We then summed the direct economic activity from crop production attributable to irrigation across the six sectors and divided the sum by the total water use for irrigation in the basin (water

supply limited consumptive use in the SWSI 2010 analysis) to determine the direct economic value per acre-foot.

3. We used the IMPLAN model to calculate the indirect and induced economic contribution in each basin corresponding to the direct contribution from irrigated cropping. Note that IMPLAN captures only backward linkages from effects on farm suppliers and farm labor; it does not capture forward linkages on sectors that further process the production from irrigated farms.
4. The most important forward linkage related to irrigated crop production is livestock production. To calculate the effects on livestock production related to irrigated farming, we estimated the portion of the output in the two IMPLAN cropping sectors that account for most of the livestock feed that is produced from irrigated lands (Sector 2—Grain Farming and Sector 10—Hay Production) based on the same data used in step 1. We then used the portion of the feed sectors that is contributed by irrigated lands to apportion the direct economic contribution from the livestock-raising sectors.
5. We then calculated the indirect and induced economic contributions associated with the portion of livestock-raising activity attributable to irrigated farms and netted out the indirect effects on the crop production sectors (to avoid double counting). The combined direct, indirect, and induced effects from irrigation-based crop production and irrigation-related livestock production were then summed and divided by irrigated agricultural water use to estimate the total economic contribution per acre-foot of irrigation consumptive use.

The statewide relationship between projected irrigation water shortages and agriculture-related employment (including direct crop production, livestock raising based on feed from irrigated acres, supporting industries, and local governments) is illustrated in Figure 4-2. The shortage–employment relationship differs in each basin and is based on current agricultural economic activity per acre-foot of irrigation supply from the SWSI 2010 analyses, so the relationship illustrated in Figure 4-2 may not be applicable to other scenarios or locations or the revised analyses that are being developed in the SWSI update.

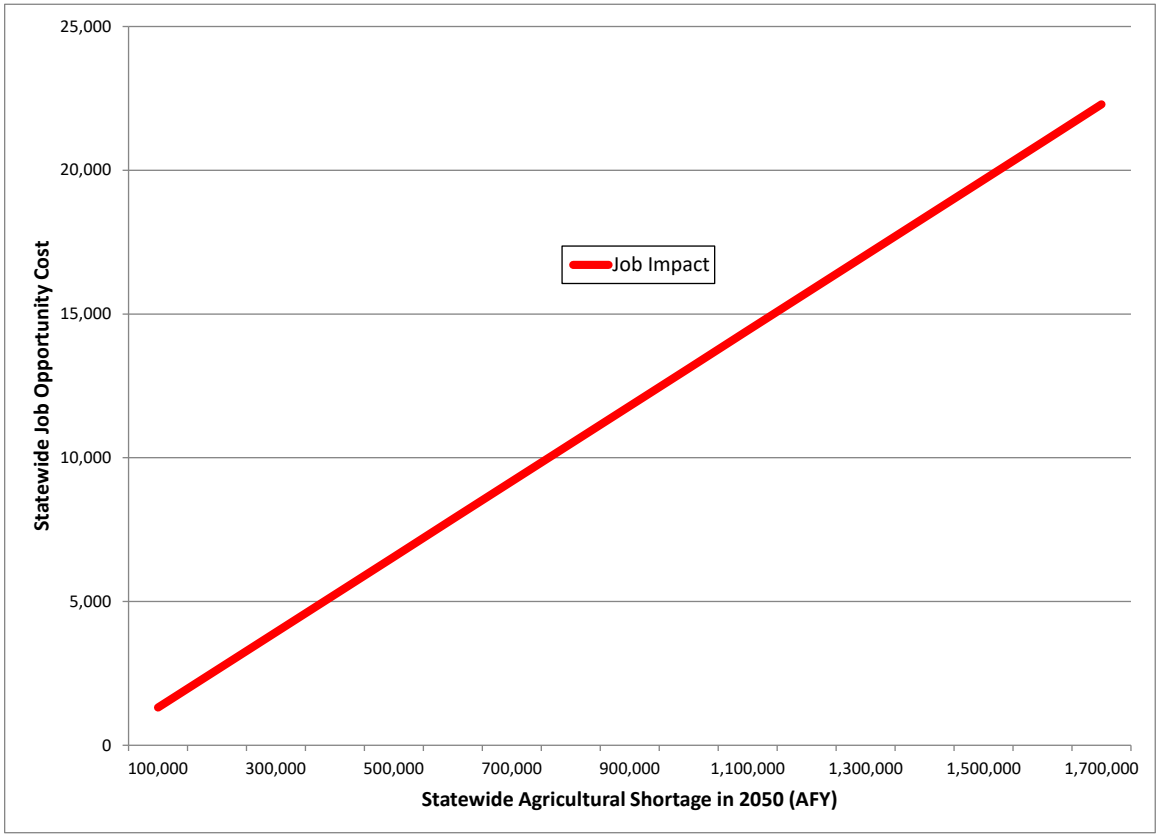

Figure 4-2. Estimated statewide relationship between irrigation water shortages and agriculture-related employment in this case study

M&SSI impacts. Considering the information available from the previous SWSI analysis and Colorado Water Plan, and the resources and time constraints for this analysis, the economic implication of municipal and self-supplied industrial gaps were evaluated on a combined basis. The M&SSI economic analysis was designed to reflect a combination of the marginal economic value of water supplies in these uses for a portion of the projected gap as well as the average economic value of those supplies for larger gaps.

Figure 4-3 shows the estimated combined demand for M&SSI water use from SWSI 2010 and projected demands and gaps for the specific scenario analyzed in this case study. For consistency with the 2016 IMPLAN economic data used in this case study analysis, we estimated 2016 M&SSI water use (demand) by interpolating between the 2008 water use estimates and 2035 water use projections from SWSI 2010.

	Estimated Demand 2016*			Projected Demand 2050			Projected Gap	
Basin	M&I	SSI	Combined	M&I	SSI	Combined	Combined	Percentage
Arkansas	219,000	60,000	279,000	320,000	67,800	387,800	64,000	17%
Colorado	76,000	5,000	81,000	140,000	9,440	149,440	33,000	22%
Gunnison	24,000	0	24,000	39,000	650	39,650	5,100	13%
Metro	473,000	64,000	537,000	642,000	67,400	709,400	130,000	18%
North Platte	1,000	0	1,000	700	0	700	20	3%
Rio Grande	19,000	0	19,000	26,000	1,500	27,500	3,600	13%
South Platte	237,000	32,000	269,000	367,000	51,320	418,320	110,000	26%
Southwest	26,000	3,000	29,000	43,000	5,310	48,310	12,000	25%
Yampa-White	14,000	36,000	50,000	30,000	58,070	88,070	37,000	42%
Total	1,088,000	202,000	1,290,000	1,607,700	261,490	1,869,190	394,720	21%

Figure 4-3. Estimated current M&SSI demands by basin
and projected demands and gaps in 2050 from SWSI 2010 scenario

*Note: *2016 demands estimated based on interpolation between reported 2008 demands and 2035 forecasts in SWSI 2010 report.*

Source: SWSI 2010 Section 4, Consumptive Needs Assessments.

Threshold where M&SSI gaps move from marginal economic effects to greater economic opportunity costs. If less water is available in the M&SSI sector than customers would like to use, the economic effects could be relatively modest or quite severe, depending on the severity of the shortfall. The approach employed in this economic impact case study is intended to recognize the difference in economic impacts between relatively modest shortfalls in the M&SSI sectors (similar to Colorado's experience during the 2002 drought) and more severe and sustained shortages of water available for M&SSI purposes.

Sizeable municipal providers in Colorado generally have established drought response plans. These plans are essentially intended to mitigate the economic impacts of relatively modest, short-term water shortages. Typically, drought response plans involve sequential stages targeting a reduction in outdoor water use, ranging from voluntary watering restrictions to complete bans on outdoor irrigation (and often bans on other water intensive activities such as car washing).

Denver Water provides an example of the potential reductions in water use from municipal drought response plans. Denver Water's Drought Response Plan indicates that their water use reduction goal under Stage 2 drought restrictions would be a 35 percent cut in overall systemwide water use. This goal is evaluated by comparing water use during the months when the restrictions are in place to average water use without the restrictions. In essence, Denver Water expects to reduce overall water use during the irrigation season by 35 percent while effects on indoor use during the rest of the year are expected to be minimal with some reduction occurring due to behavioral drought awareness response (personal communication with Mitch Horrie, July 27, 2018). About 70 percent of Denver Water's total annual use occurs during the irrigation season, from April through October. If Denver Water reduced that use by 35 percent, overall annual use would be reduced by approximately 25 percent (70 percent*35 percent = 24.5 percent).

Although the Denver Water Drought Response Plan provides a useful example of how a large urban provider intends to manage a short-term water shortage, the threshold where projected future gaps in M&SSI supplies begin to have much larger economic impacts would likely be at a lower level than a 20 or 25 percent gap. This case study evaluates the effects of projected water supply gaps more than 30 years in the future. The proportion of water used for outdoor irrigation in the Front Range is generally declining for several reasons; firstly, decreasing this type of use is a growing focus of municipal water conservation plans. Outdoor water use is also generally more responsive to price increases (more price elastic) than indoor use, and Denver Water and other Front Range providers report that an increasing number of their customers are ceasing to irrigate their lawns for what are believed to be economic reasons. Further,

changes in development patterns towards more multifamily housing and smaller lots for detached single family homes will also tend to reduce outdoor use as a proportion of total demand.

Perhaps more importantly, the SWSI analysis estimated overall gaps in water supply at the basin, and statewide, levels. The aggregated M&SSI gaps mask the fact that shortages would not likely be equally distributed across all of the municipal providers in a particular basin. For example, in the scenario analyzed in this case study, the South Platte/Metro Basin is projected to have a 21 percent gap in M&SSI supply. However, that basin-wide estimate does not mean that the major established water providers—like Denver, Aurora, Fort Collins, and Greeley—would be 21 percent short of water supplies in 2050. Instead, much of this growth-related gap would likely fall on smaller and newer providers, perhaps including providers that do not even exist today, which would experience much larger shortages (in percentage terms) than the overall basin-wide average.

With these considerations in mind, this case study examines a range of potential economic impacts from the projected M&SSI gaps. The low range estimate assumes that gaps of up to 15 percent of projected 2050 demands in this sector would primarily affect 1) consumer welfare, as measured in terms of lost consumer surplus due to mandatory reductions or prohibition of outdoor uses; and 2) the "green industry" in each region, including landscaping services, nurseries, and car washes. The high range estimate assumes that more severe economic effects would begin to occur when the projected gaps in M&SSI supplies reach 10 percent of projected 2050 demands.

In economic analysis focusing on consumer welfare, the contribution of a particular good to consumer wellbeing is typically measured in terms of consumer surplus. To estimate the reduction in consumer surplus from a mandatory 10 or 15 percent decrease in municipal water use, the study team estimated a generic demand curve for municipal water supplies based on the average cost per 1,000 gallons from the 2016 Colorado Municipal Water and Wastewater Rate Survey and an estimated typical municipal water price elasticity of -0.3 based on our previous studies. Figure 4-4 illustrates the generic demand curve and the reduction in consumer surplus that would result from a mandatory 10 percent decrease in consumption due to involuntary restrictions or prohibitions on outdoor water uses or substantial penalty pricing. Based on the generic demand curve, the study team estimated the annual impact on consumer welfare of an involuntary 10 percent reduction in M&SSI water use at approximately $700 per acre-foot.

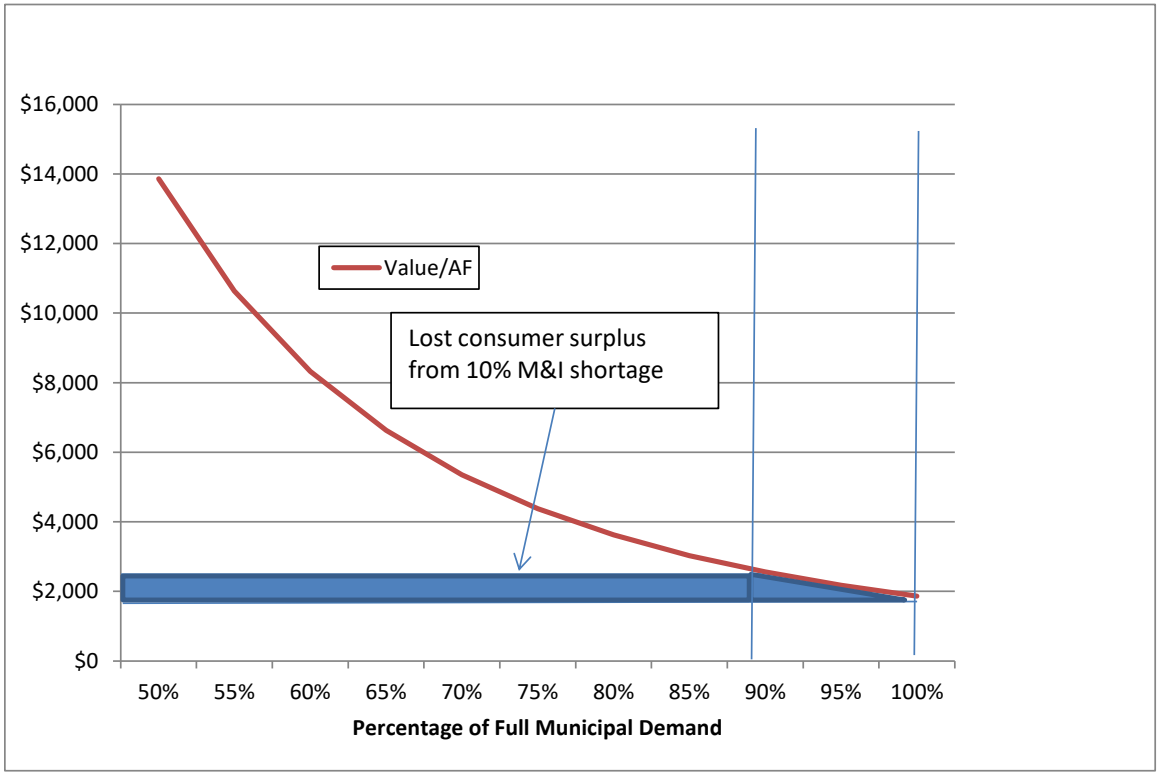

Figure 4-4. Generic municipal water supply demand curve and projected reduction in annual consumer surplus from involuntary 10 percent reduction in use

Source: 2016 Colorado Municipal Water and Wastewater Rate Survey and prior study team water demand studies for Aurora, Denver, and Greeley.

Gaps beyond 10 or 15 percent of projected M&SSI demands in 2050 were assumed to result in foregone opportunities for future residential, commercial, and industrial development. Since the combined M&SSI category in SWSI includes municipal, self-supplied industrial, and self-supplied domestic water uses, the economic effects of these larger gaps in M&SSI water supply were estimated based on total regional economic activity—net of the activity directly and indirectly supported by the agricultural sector—per acre-foot of M&SSI water use.

Based on the methodology used in this case study, the economic impacts of projected M&SSI gaps in each basin reflect a varying blend of marginal and average economic values for M&SSI water use, depending on the projected percentage gap in M&SSI supply. Figure 4-5 illustrates the estimated statewide relationship between projected M&SSI water shortages and future decreases in employment from this case study. The shortage–employment relationship differs in each basin and is based on current economic activity per acre-foot of M&SSI supply from the SWSI 2010 analyses, so the relationship illustrated in Figure 8 may not be applicable to other scenarios or locations or the revised analyses that are being developed in the SWSI update.

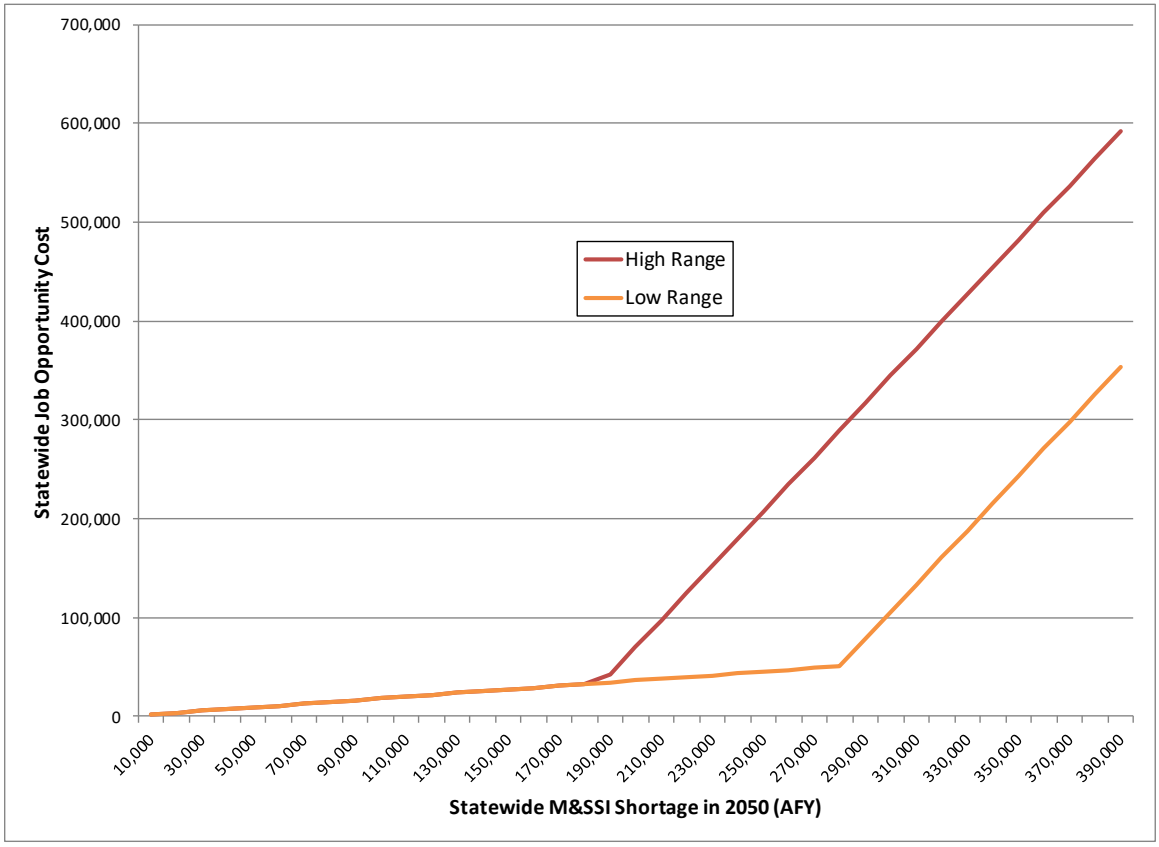

Figure 4-5. Estimated statewide relationship between M&SSI water shortages and employment in this case study