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Integrated Water Resources Plan

Final Report

FEBRUARY 2017

FINAL REPORT

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List of Acronyms and Abbreviations

The following acronyms are used in this report.

ac-ft	acre-foot or acre-feet
ac-ft/yr	acre-foot per year or acre-feet per year
CWP	Colorado's Water Plan
DPR	direct potable reuse
EIS	Environmental Impact Statement
EL	Executive Limitation
ERMOU	Eagle River Memorandum of Understanding
Fry-Ark	Fryingpan-Arkansas Project
FVA	Fountain Valley Authority
GCM	Global Climate Model
IBCC	Interbasin Compact Committee
IPR	indirect potable reuse
IWRP	Integrated Water Resources Plan
MOEA	multi-objective evolutionary algorithm
MOU	Memorandum of Understanding
MGD	million gallons per day
O&M	operation and maintenance
OYM	Operations and Yield Model
RMD	reliably met demand
SDS	Southern Delivery System
SME	subject matter expert
SWSI	Statewide Water Supply Initiative
T&P	temperature and precipitation
TM	Technical Memorandum
Utilities	Colorado Springs Utilities
WEAP	Watershed Evaluation and Planning System Model
WPAG	Water Planning Advisory Group
WRP	Water Resource Plan
WTP	water treatment plant
WWTP	wastewater treatment plant
YOD	years of demand

Glossary

Adaptive Management – Approach to planning in which the recommendation is not static or fixed, but rather can be changed as future conditions change.

Alternative Transfer Methods (ATM) –Methods by which water owned by agricultural entities could be transferred (either temporarily or permanently) to municipal entities for their own beneficial use without adversely impacting the agricultural water users.

Buildout – Future condition when Utilities' existing service area is fully built out according to an assumed mixture of residential, commercial, and industrial development and density; assumed to occur around 2070.

Colorado River Compact – Agreement between the seven Colorado River Basin states and Mexico to allocate Colorado River water. Upper Basin states (CO, UT, NV, and WY) must deliver 7.5 million acre-ft/year at the outflow of Lake Powell on a 10-year rolling average. Major driver of regional, state, and local planning efforts.

Demand Management – Practices to reduce customer water demand and promote the responsible, wise, efficient, and sustainable use of water resources, also referred to as conservation. Demand management practices include landscape conversion, water efficient fixtures, education, and reducing system leaks, among other options.

Direct Potable Reuse (DPR) –Treating wastewater to levels that meet or exceed drinking water quality standards at a wastewater treatment plant (WWTP), then routing this water to the potable water treatment plant (WTP) for additional treatment and delivery to the potable water system.

Exchanges – Water right accounting procedure where volumes of legally and physically available water can be administratively transferred to a location at a higher point along the river. Allows Utilities to exchange water rights from return flows to locations that can then re-serve the Utilities service area.

Firm Yield – Volume of annual demand that can always be met under historical recorded hydrology for an assumed water supply system configuration.

Global Climate Model (GCM) – Computer model that projects future climate conditions (e.g., temperature and precipitation) based on an assumed set of environmental and emissions inputs.

Graywater Reuse – Use of wastewater collected from selected fixtures within residential, commercial, or industrial buildings (including bathroom or laundry sinks, bathtubs, showers, or laundry machines) by Utilities' customers as a source of nonpotable water for onsite water uses.

Indirect Potable Reuse (IPR) –Taking treated, recycled, or reclaimed water and then blending it with a natural water source (e.g., natural flow in a stream channel or reservoir water, which acts as an environmental buffer) prior to re-introduction into the water system for further treatment and distribution for potable water uses.

Identified Programs and Policies (IP&P) – Projects identified in the Colorado Water Plan as proposed by municipal, agricultural and industrial water users.

Level of Service Goals – Metrics used by Utilities to measure performance of the water supply system with respect to the governing policies set by the Executive Limitations.

Life-Cycle Cost – Estimated cost for a project or a collection of projects that includes both the capital cost and 50 years of operations and maintenance costs.

Metrics – Quantifiable measures used to assess the performance of an aspect of Utilities' water supply system.

Nonpotable Water – Water that has not been treated to drinking water standards but can be used for non-drinking applications such as irrigation and industrial processes.

Operations and Yield Model – Computer model of Utilities' water supply and collection system used to simulation operations under different future conditions and assist decision makers in the planning process.

Portfolio – Collection of individual projects.

Rainwater Harvesting – The process of capturing rainwater on an individual residential property for onsite use.

Regionalization – Concept that individual water providers share common goals, challenges, and opportunities and thus there are times when it is in the best interest of the region for these water providers to coordinate. For the IWRP, this refers to Utilities coordinating with small water providers in the Pikes Peak region.

Reliability – The percentage of time that some measure of the water supply system is in an acceptable state (e.g., percentage of years with total system storage above 1.0 Year of Demand, or percentage of years in which all demands are met).

Reliably Met Demand – Volume of annual demand that can be met while maintaining the Level of Service goals for an assumed future condition.

Reservoir System Storage – Total volume of water stored in all Utilities' reservoirs and in Utilities' accounts in reservoirs owned by others.

Resilience – The measure of the ability of the system to recover from an unacceptable state into an acceptable one.

Robustness – The ability of the system to maintain Level of Service goals for a variety of different futures with different system stressors (e.g. warmer climate, higher demands, pipeline outage, etc.)

Signpost – Conditions or factors that may have an effect on the system's performance and are monitored to see if action is needed.

Shortage Response Plan – Set of responses (e.g. outdoor watering restrictions) that Utilities enacts during periods of water supply shortage, either caused by drought or an unplanned emergency outage.

Storage Reserve – Volume of water that Utilities plans to always maintain in total system storage to mitigate against unknown events.

Temperature & Precipitation Offset – Future climate condition with a prescribed change in temperature (either warmer or cooler) and a prescribed change in precipitation (either drier or wetter) compared to current climate.

Transmountain Diversion – Process in which water derived from the Colorado River Basin is diverted across the Continental Divide to the Arkansas River Basin (or other East Slope basin).

Triple Bottom Line – Describes diverse performance criteria used to evaluate potential projects, including social, environmental, and economic criteria (sometimes referred to as People-Planet-Profit).

Vulnerability – The measure of how severe the system is in an unacceptable state.

Water Resource Options – Potential program, project, or policy Utilities could pursue to improve water supply system performance.

Water Resource Strategies – Collection of options that have similar characteristics, benefits and challenges that Utilities could pursue to improve water supply system performance (e.g., new reservoir storage, demand management, water reuse).

Water Reuse – The process of reusing water that Utilities has legal right to, either by exchange or a reclaimed water distribution system.

Years of Demand in Storage (YOD) – Method Utilities uses to characterize the total reservoir system storage in which the storage volume in acre-feet is translated into an equivalent number of years of annual demand (e.g., if total reservoir system storage is 160,000 ac-ft and annual demand is 80,000 ac-ft, reservoir storage is 2.0 YOD).

Acknowledgements

Colorado Springs Utilities would like to thank the following people for their collaborative contributions to the Integrated Water Resources Plan. Their technical expertise and professional insight were invaluable in developing and implementing the complex computational approaches used in the IWRP.

Dr. David Yates of the National Center for Atmospheric Research for his assistance in developing data sets, calibrating hydrologic models, preparing input files to the system model, assisting with the demand model, and climate change insight.

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Dr. Patrick Reed (now of Cornell University) for his part in allowing us to use of the Borg multi-objective evolutionary algorithm and for his thoughtful application insights.

Colorado Springs Utilities would also like to thank members of the IWRP citizen's Water Planning Advisory Group for their time and dedication to our community. The members spent a great deal of time over the course of two and a half years learning the details of our water system and the future challenges our community will experience. They engaged in thoughtful discussion and provided valuable insight and input into the planning process. In alphabetical order, the group members and the areas of the Colorado Springs community that they represented were:

- Alicia Archibald, Environmental Community
- Tom Binnings, Business Community
- Sean Chambers, Smaller Regional Water Providers
- Dirk Draper, Business Community
- Tim Emick, Landscaping Community
- Paul Fuschich, Industrial User Community
- Vince Guthrie, Military Community
- Ian Johnson, Education and Large Commercial User Community
- Donna Major, Real Estate Community
- Eric Moroski, Landscaping Community
- Marla Novak, Business Community
- Karen Palus, City of Colorado Springs
- Jane Ard Smith, Environmental Community

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Executive Summary

ES-1 Introduction

The Colorado Springs Utilities (Utilities) Integrated Water Resource Plan (IWRP) is a long-term strategic plan for providing a reliable and sustainable water supply to Utilities' customers in a cost-effective manner. It is a comprehensive approach to water resource planning that incorporates water supply and demand, water quality, infrastructure reliability, environmental protection, water reuse, financial planning, energy use, regulatory and legal concerns, and public participation. Key IWRP activities are shown in **Figure ES-1** and include strategic water resource planning, technical studies, and stakeholder involvement. The IWRP presents a strategic water supply plan that addresses a range of possible conditions in Utilities' existing service area at Buildout (50 or more years in the future) and sets policy level direction for Utilities to follow in meeting the future needs of the community.

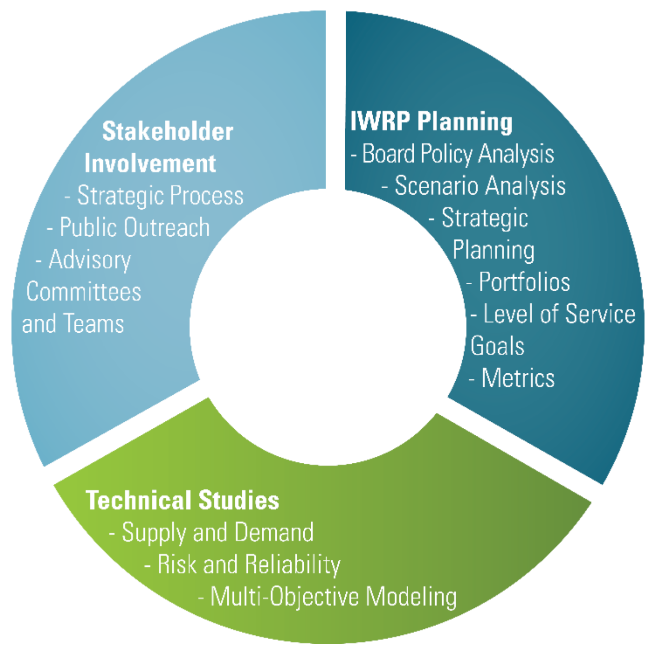


Figure ES-1. Key IWRP Activities

ES-2 Planning Approach and Assumptions

The IWRP focused on key policy questions which required input and direction from the Colorado Springs Utilities Board (Utilities Board). The policy questions addressed in the IWRP are:

1) What is an acceptable level of risk in addressing future water demands? (Risk Tolerance and Level of Service)
2) What is an appropriate approach for Colorado Springs Utilities to follow in meeting regional water demands within the Pikes Peak Region? (Proactive vs. Reactive Regionalization)

3) What role do different supply options contribute to achieving a balanced water supply portfolio? (Appropriate amounts of New Supply, Storage, Conveyance, Demand Management, and Reuse)
4) How do we ensure a proper level of investment in Colorado Springs Utilities' existing and future water system to maintain an acceptable level of risk? (Balancing Costs, Risks, and Project Phasing)

The IWRP adopted a risk-based planning approach that is "forward looking" in which risks and uncertainties affecting future raw water system performance were identified and analyzed in the context of multiple possible future scenarios. This new approach is a departure from previous planning processes in which water supply plans were "backward looking," and developed using a single set of assumed conditions and historical hydrology, where a static "firm yield" estimate was used to measure water system performance.

The key metrics now used to assess raw water system performance were total reservoir system storage and frequency of the need for shortage response actions. The Level of Service criteria used to quantify acceptable performance were:

1) Meet indoor water demand 100 percent of the time
2) Maintain a minimum of 1.0 year of demand in storage at all times; and
3) Maintain a minimum of 1.5 years of demand in storage 90 percent of the time.

ES-3 Technical Analyses

A water resources and water rights simulation model developed in the past by Utilities was combined with a decision support system, a weather generator, a hydrologic rainfall and runoff model, and an multi-objective optimization routine to evaluate the impact of potential risks and the benefits provided by future potential water supply projects. These analytical tools were used to estimate demands that can be reliably met by the water system for different level of service goals.

The current raw water system can reliably meet a demand of 95,000 acre-feet/year (ac-ft/yr) and still meet level of service goals. Buildout demand is estimated to be about 136,000 ac-ft/yr so if Utilities expects to maintain level of service goals at Buildout, it will need to add supply and infrastructure to address this significant water supply gap of approximately 41,000 ac-ft/yr.

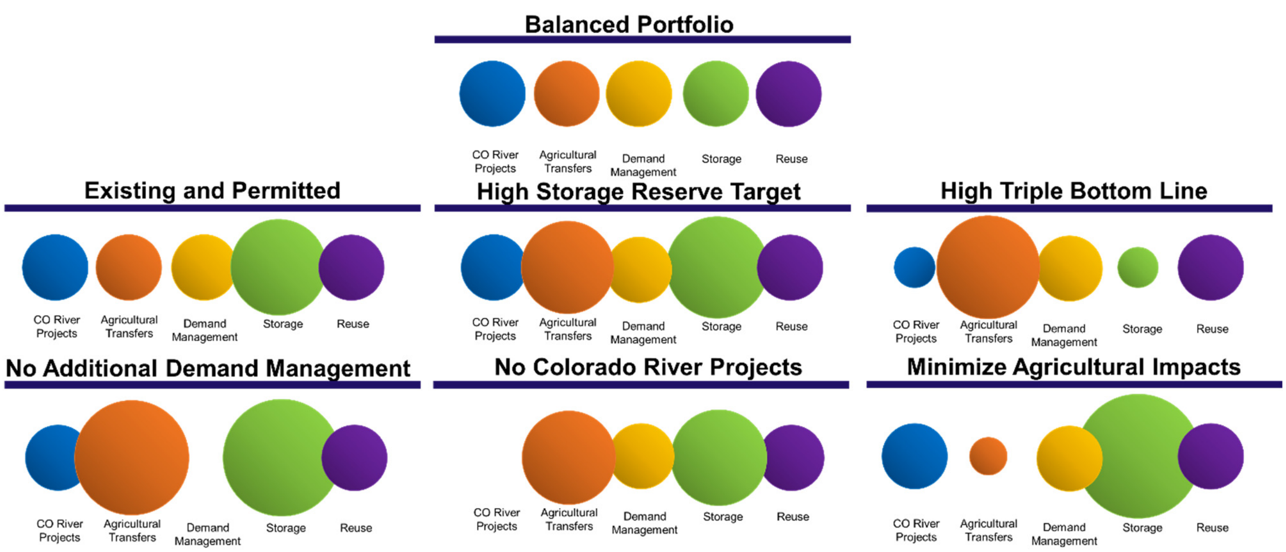
Internal subject matter experts identified over 60 risks and uncertainties in the six major categories shown in **Figure ES-2**. Key climate-related risks included drought and trends toward warmer temperatures as seen in the historical record. Key system (or non-hydrologic) related risks are associated with legal, administrative, or environmental factors which may impact Utilities' yields, Colorado River Compact administration, and emergency infrastructure outages.

Utilities has many strategies available for mitigating future water supply and demand uncertainties. Each has its own unique benefits and challenges that must be weighed when creating a future portfolio of projects, programs, and policies that addresses a broad range of future conditions. The six general water

Figure ES-2. Categories of Risk and Uncertainty

resources strategies considered in the creation of water supply portfolios were: Demand Management, Reuse and Non-Potable Water, Colorado River Basin Supplies, Agricultural Transfers, Increased Storage, and Conveyance. Within these strategies, over 50 individual projects, programs and policies were considered for improving Utilities' ability to meet level of service goals at Buildout conditions. Individual projects were evaluated and compared using triple bottom line criteria (i.e., environmental, social, economic), and life-cycle cost.

Several portfolio themes were developed to explore different ways to meet Buildout demands. These are shown in **Figure ES-3**, and demonstrate that there are many ways to meet Buildout demands with the available strategies and projects.



Note: Sizes of circles represent the relative magnitude of options to the Balanced Portfolio.

Figure ES-3. Portfolio Themes and Ranges of Total Project Sizes

The recommended water supply plan is to pursue a Balanced Portfolio, shown conceptually in **Figure ES-4**. This portfolio meets the level of service goals at an acceptable life-cycle cost and with a good triple bottom line score.

Figure ES-4. Components of Recommended Water Supply Balanced Portfolio

The IWRP analysis also demonstrates that it is possible for Utilities to pursue a proactive approach to Regionalization. By implementing the Balanced Portfolio and acquiring 5,000 to 10,000 ac-ft/yr of additional supply, Utilities would possess adequate supplies to meet the full Buildout demand of all regional entities (about 25,000 ac-ft/yr) while maintaining the desired level of service for all Utilities customers and regional customers. As a different approach to assisting regional entities in meeting their water needs, the water system has seasonal unused conveyance capacity now and at Buildout in off-peak months, which can accommodate deliveries to other water providers in the Pikes Peak region.

A phased project implementation schedule was prepared for the components of the Balanced Portfolio over a period of about 50 years.

ES-4 Findings and Recommendations

Utilities performed extensive technical analyses and collected public input from a broad range of sources to develop recommendations for the four policy questions posed above. The recommendations associated with each policy question are shown in **Figure ES-5**.

Implementation of the IWRP will require adaptive management in order to provide flexibility in the face of future uncertainty. Adaptive management will require careful tracking of key indicators of change or "signposts" such as annual water demand, per capita water demand, population, climate trends (i.e., magnitude and rate of change for mean annual temperature, precipitation, and stream flows), regulatory changes, and changes in water rights administration. These indicators will inform Utilities as to what projects, policies, and water supply strategies should be implemented at various points in time. Adaptive management concepts will also be used to determine a schedule for implementing or modifying the Balanced Portfolio in a manner that appropriately considers all relevant factors and conditions, including those listed above, plus acquisition and construction opportunities and financial capacity.

The IWRP recommends that Utilities make responsible, deliberate, and consistent investment in the water system to implement the Balanced Portfolio in a manner that balances costs and risks between now and Buildout. Projects will be actively developed in the short term, mid-term and long term according to an established phasing framework to accomplish this goal. There will necessarily be numerous follow-up studies and planning efforts to be able to accomplish the objectives set forth in this Plan.

	RECOMMENDATIONS
Policy Question 1: Level of Service What is an acceptable level of risk in addressing future water demands?	• Affirm current policy of triggering shortage analysis at 1.5 years of demand (YOD) • Accept planning criteria of 90 percent reliability for 1.5 YOD in storage • Formalize planning criteria of maintaining 1.0 YOD in storage at all times
Policy Question 2: Regionalization What is an appropriate approach for Colorado Springs Utilities to follow in meeting water demands within the Pikes Peak Region?	• Proactively pursue regionalization in a manner that assists in meeting regional water demands, while protecting ratepayer interests and water supply investments and providing a benefit to Colorado Springs Utilities ratepayers and citizen owners
Policy Question 3: Buildout Portfolio What role do different supply options contribute to achieving a balanced portfolio?	• Pursue a balanced portfolio that includes a diversity of Demand Management, Supply, Storage, Reuse, and Conveyance options
Policy Question 4: Portfolio Phasing How do we ensure a proper level of investment in Colorado Springs Utilities' existing and future water system to maintain an acceptable level of risk?	• Pursue a consistent and incremental investment so as to implement a balanced portfolio that balances costs and risks

Figure ES-5. Policy Question Recommendations

ES-5 IWRP Approval and Policy Direction

Colorado Springs' Utilities Board approved the Integrated Water Resource Plan, including the recommendations associated with the four policy questions, at its regular meeting on February 22, 2017. This Plan and these recommendations establish a policy direction and will be the tenets governing the provision of a reliable and sustainable long-term water supply to Utilities' customers in a cost-effective manner.

SECTION 1
Background

The Integrated Water Resources Plan (IWRP) for Colorado Springs Utilities (Utilities) is a long-term strategic plan for providing a reliable and sustainable water supply to Utilities' customers in a cost-effective manner. It is a comprehensive approach to water resource planning that incorporates water supply and demand, water quality, infrastructure reliability, environmental protection, water reuse, financial planning, energy use, regulatory and legal concerns, and public participation. Key IWRP activities are shown in **Figure 1-1** and include strategic water resource planning, technical studies, and stakeholder involvement. The IWRP presents a strategic water supply plan that addresses a range of possible conditions in Utilities' service area on an approximate 50 year time horizon and sets policy level direction for Utilities to follow in order to meet that goal.

The IWRP is a comprehensive long-term strategic plan for providing a reliable and sustainable water supply to Utilities' customers in a cost-effective manner.

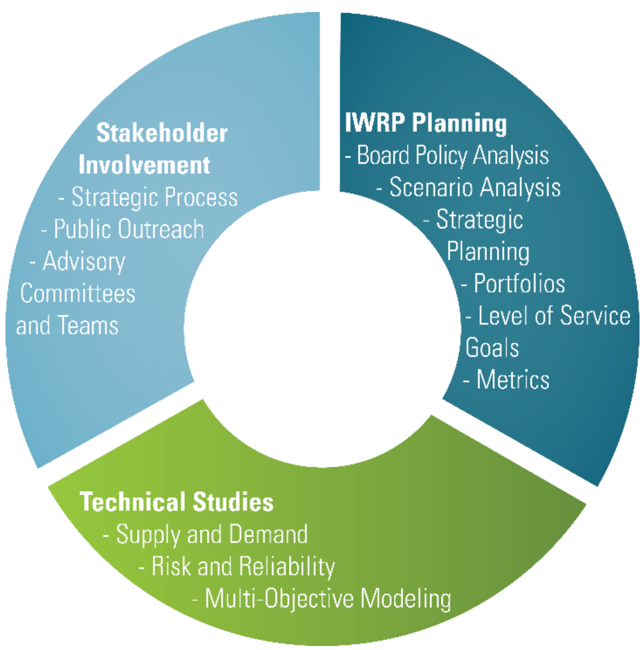


Figure 1-1. IWRP Activities

The IWRP was prepared by the Utilities Water Resource Management Section, with assistance from a number of subject-matter experts from across Utilities, as needed, and MWH, which served as the program management and modeling consultant for the IWRP. Additional technical and drafting assistance was provided by Black & Veatch.

1.1 Goals and Objectives

The goal of the IWRP is to develop a water resource planning and management strategy for Utilities that has the following attributes:

- **Robust** – Flexible and resilient to adapt to a variety of possible future conditions.
- **Sustainable** – Capable of being implemented over the long term using the resources expected to be available to Utilities and its customers
- **Reliable** – Able to deliver necessary water supplies from renewable sources of supply using dependable facilities.
- **Economical** – Able to deliver water supplies in a cost-effective manner at a price supportable by Utilities' customers.
- **Ecological** – Able to reasonably mitigate environmental consequences and maintain environmental quality.
- **Acceptable** – Supported by Utilities customers and other stakeholders
- **Explainable** – Well written, with objectives, strategies, and consequences that can be readily understood by Utilities customers and other stakeholders.

Strategic water supply planning for the IWRP was conducted in accordance with Utilities' mission and several of the Utilities Board's Executive Limitations (EL). EL-4 and EL-10 focus on protecting and developing Colorado Springs' water rights and water-related services. EL-11 requires Risk Management Plans designed to identify, monitor, manage, and report potential risks. EL-13 emphasizes the importance of maintaining existing infrastructure, while identifying and planning for future resource and infrastructure needs.

Figure 1-2 summarizes the four phases of the IWRP technical analysis: 1) identifying issues, risks, and uncertainties affecting Utilities' water system; 2) assessing vulnerabilities; 3) developing water supply strategies and options; and 4) developing a strategic plan. The previously published Planning Factors Report summarized the first phase, in which the Utilities' water system features were described and issues, risks, and uncertainties were identified and prioritized for future analysis. A separate and subsequent study, The Vulnerability Assessment Report, analyzed these issues, risks, and uncertainties (both climate change/hydrologic and non-hydrologic), and identified those to which the current water system was vulnerable.

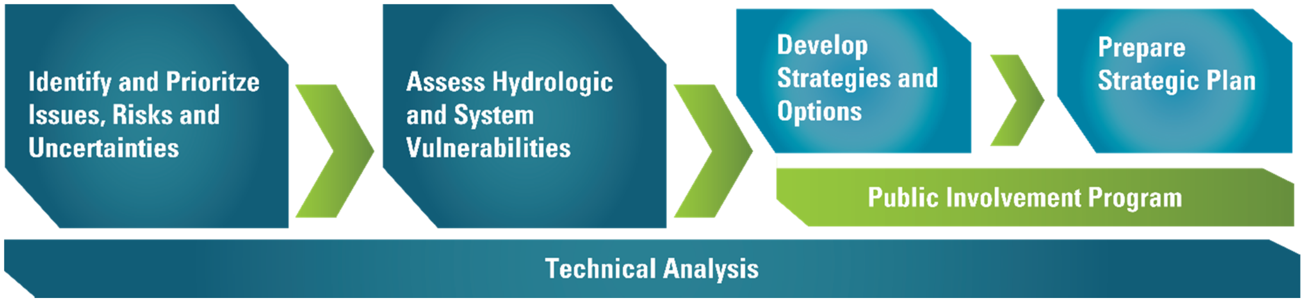


Figure 1-2. IWRP Phasing

1.2 Key Policy Questions

The IWRP focused on key policy questions which required input and direction from the Utilities Board. Several key policy questions were considered throughout the IWRP process in response to direction from Utilities management and the Utilities Board. This report and the associated IWRP recommendations are structured to answer the following questions:

1) What is an acceptable level of risk in addressing future water demands? (Risk Tolerance and Level of Service)
2) What is an appropriate approach for Colorado Springs Utilities to follow in meeting regional water demands within the Pikes Peak Region? (Proactive vs. Reactive Regionalization)
3) What role do different supply options contribute to achieving a balanced water supply portfolio? (Appropriate amounts of New Supply, Storage, Conveyance, Demand Management, and Reuse)
4) How do we ensure a proper level of investment in Colorado Springs Utilities' existing and future water system to maintain an acceptable level of risk? (Balancing Costs and Risks and Project Phasing)

The following subsections provide a brief background explanation for each of these policy questions.

1.2.1 POLICY QUESTION #1: WHAT IS AN ACCEPTABLE LEVEL OF RISK IN ADDRESSING FUTURE WATER DEMANDS? (RISK TOLERANCE AND LEVEL OF SERVICE)

This policy question addresses the level of risk that our community is willing to accept, with the answer driving the technical aspects of the IWRP analyses. The reliability of a water system is affected by supply availability and variability, as well as customer demand level and variability. Water storage serves as a buffer between supply and demand, and therefore reservoir storage levels can be used as an indicator of overall water system performance and ability to meet customer demands. Tracking storage levels then provides an appropriate measure of system performance and risk.

As described in Section 5-Risk Identification and Assessment, the Utilities water system will be subject to an increasing variety and severity of risks and uncertainties in the future. Maintaining a water storage reserve is a proven way to mitigate against unknown risks (**Figure 1-3**). It serves as an insurance policy. The desired storage reserve volume impacts how many supply and infrastructure projects will be required to maintain that desired level. Because of the variability in the annual amounts of both supply and demand, it can be very expensive to rely solely on new supplies and additional conveyance to maintain the desired storage reserves. Another powerful tool to mitigate this risk is to implement shortage response measures, which may include mandatory watering restrictions and other measures, during occasional times of shortage. Therefore, the desired level of reserve storage also affects how often Colorado Springs customers may need to be in watering restrictions. The scale in **Figure 1-4** shows conceptually the balance that must be struck between maintaining water in storage, increasing supply, and frequency. Through the IWRP process, factors associated with this balance were analyzed and weighed resulting in a recommendation for the acceptable tradeoff between risk and reservoir storage.

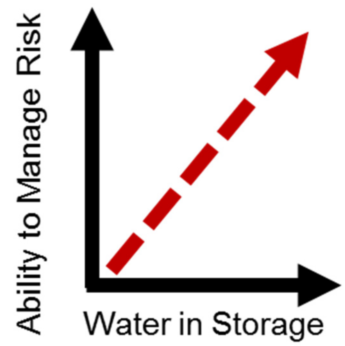


Figure 1-3. Relationship between Reservoir Storage and Risk Management

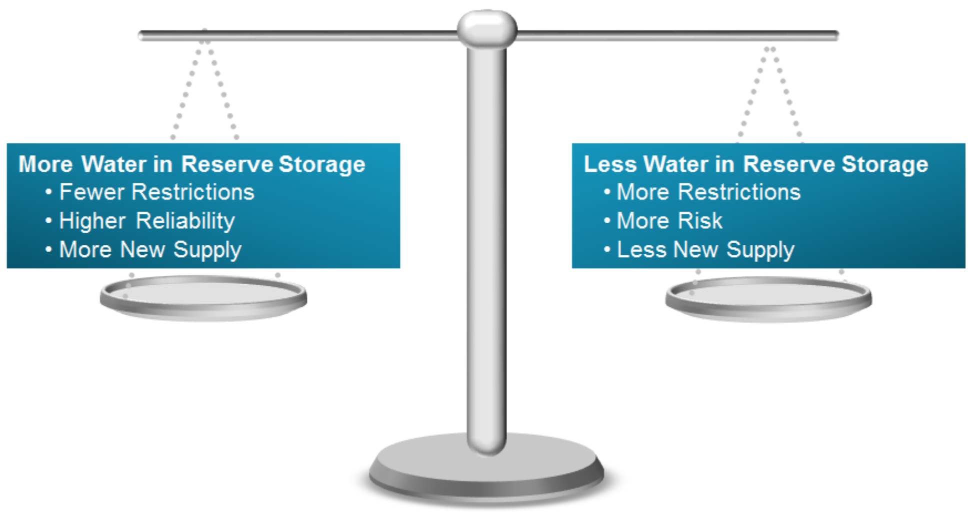


Figure 1-4. Tradeoffs in Setting Reserve Storage Level

1.2.2 POLICY QUESTION #2: WHAT IS AN APPROPRIATE APPROACH FOR UTILITIES TO FOLLOW IN MEETING REGIONAL WATER DEMANDS WITHIN THE PIKES PEAK REGION? (PROACTIVE VS. REACTIVE REGIONALIZATION)

Utilities anticipates increasing opportunities and demands relative to the provision of some form of water service to other communities in the greater Pikes Peak Region. These will most often arise in association with water availability and water quality challenges faced by those entities. This circumstance results in complex policy choices, as there are many ways in which Utilities could interact with other water supply entities in the region. One of the possible choices would be to forego any partnership or other contractual arrangements. This would have no direct water supply impact on Utilities' system, although there may be direct and indirect social and economic consequences. Providing regional water service would also have some level of direct system impact.

In order to assess the direct system impacts of providing regional water service, the following two analyses were performed to help inform the regionalization discussion. (Numerous variations of these concepts could be explored in the future.)

1) **Full Regionalization** – Assumes Utilities would meet, as a wholesale provider, full Buildout demands of all water providers within the region (25,000 ac-ft/yr total assumed demand) who could be physically served at a reasonable cost.
2) **If/When Regionalization** – Assumes Utilities would make unused conveyance capacity in the water system available to regional entities, which would be used to convey their own water supplies to their distribution areas and/or storage vessels.

The primary policy consideration is whether Utilities should be: (1) reactive to regional needs, i.e., providing water capacity and/or supply only in response to emergency demands, which is an approach which represents a potential risk to Utilities' water system if not approached carefully; or (b) proactively pursuing a regionalization strategy, which could represent an opportunity to Utilities and future regional participants by allowing thoughtful and careful consideration of how to provide benefits to both Utilities' customers and the regional participants.

1.2.3 POLICY QUESTION #3: WHAT ROLE DO DIFFERENT SUPPLY OPTIONS CONTRIBUTE TO ACHIEVING A BALANCED WATER SUPPLY PORTFOLIO? (APPROPRIATE AMOUNTS OF NEW SUPPLY, STORAGE, CONVEYANCE, DEMAND MANAGEMENT, AND REUSE)

This question addresses the major categories of water supply options Utilities could potentially employ in a portfolio (i.e., collection of water supply projects, programs and policies) to meet the future demands associated with Buildout. Buildout for planning purposes represents the maximum demands Utilities will need to meet when the current Utilities service area is fully built out based on current land use planning information. These main categories of potential future water supply options are:

- Water demand management
- Utilization of reuse, groundwater, and nonpotable water where economically and technically appropriate.
- Complete existing projects to provide additional water from the Colorado River Basin;
- An increased level of agricultural to urban water transfers, primarily from the Lower Arkansas Basin in the form of permanent (acquisition) and/or temporary (lease) transfers;
- An increase in water storage capacity; and
- Additional conveyance capacity.

As shown in **Figure 1-5**, Utilities investigated a variety of different water supply strategies that can be designed to address the risks to future water system reliability while maintaining a desired level of service. These are described in Sections 6 and 7. The primary policy question involves determining the relative amounts of the various water supply options that are appropriate for Utilities to pursue considering all the challenges and benefits associated with of each.

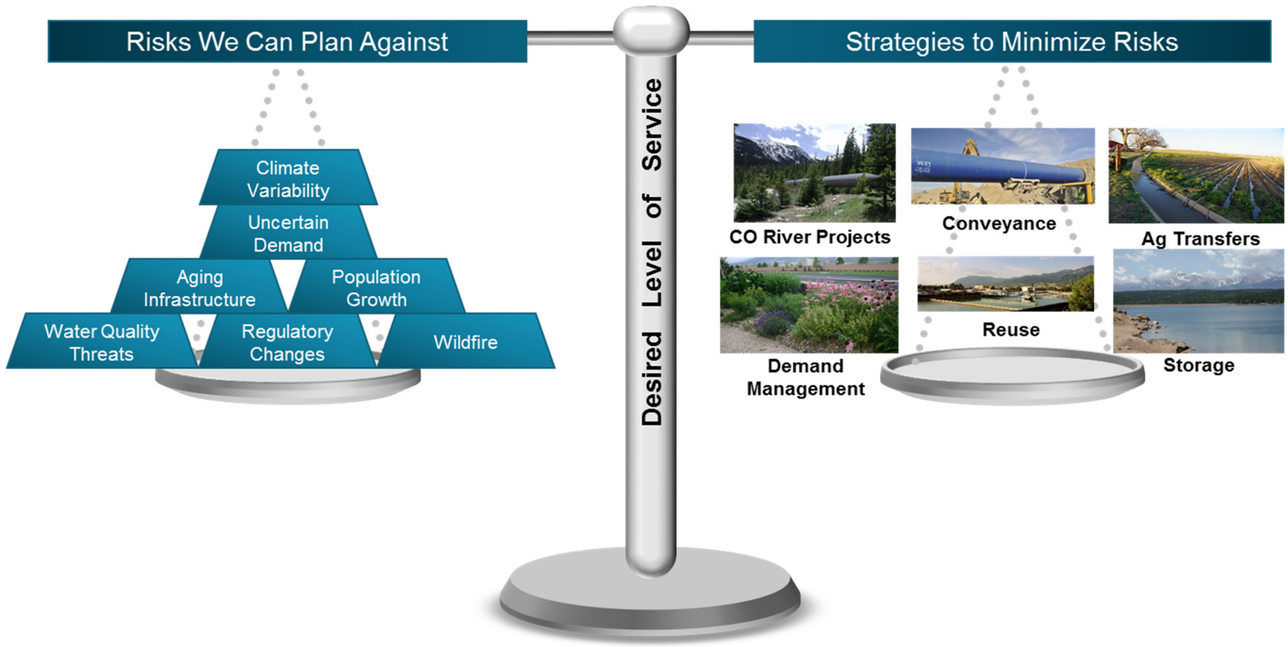


Figure 1-5. Factors Influencing Selection of a Balanced Portfolio

1.2.4 POLICY QUESTION #4: HOW DO WE ENSURE A PROPER LEVEL OF INVESTMENT IN UTILITIES' EXISTING AND FUTURE WATER SYSTEM TO MAINTAIN AN ACCEPTABLE LEVEL OF RISK? (BALANCING COSTS AND RISKS AND PROJECT PHASING)

This broad question encompasses many financial issues, including the appropriate level of investment for operation and maintenance (O&M) of the existing water system, appropriate pricing strategies, implementation of new water projects in the context of competing needs in other Utility service sectors, costs of other services, and other related financial issues. To help address certain aspects of this question, Utilities focused its IWRP analysis on the phasing and timing of projects in the Buildout portfolio. The financial analysis performed in the IWRP was used to make general comparisons between different portfolios and phasing scenarios. More detailed financial analyses for the existing and future water system (e.g., budget and rate impact studies) may be performed in separate post-IWRP evaluations.

General financial strategies that can be implemented to balance costs and risks include:

- Portfolio phasing and minimizing large or abrupt budget increases, and
- A dedicated water supply monetary fund, an opportunistic acquisition policy, and streamlined processes that would allow Utilities Management to respond quickly to unique opportunities when they arise.

Responding to this policy question resulted in an approach to project scheduling and investment that would balance strict system performance in meeting water needs with other relevant factors, such as competition for resources, windows of opportunity to implement certain projects, and Utilities-level financial planning. Utilities engages in the budget process every year to support and implement its planning goals. Thus, a high level strategy to guide this engagement is critically important. This is described in more detail in Section 11-Reccomended Plan.

1.3 Prior Plans

This IWRP is the latest water resource strategic planning effort for Utilities. The previous effort was Utilities' 1996 Water Resource Plan (WRP), which recommended a four-part strategy for enhancing water supplies to address future water needs using:

- Conservation,
- Water Reuse,
- Existing System Improvements, and
- Major New Delivery System.

Substantial progress has been made in each of those areas. In the area of conservation, Utilities has an award-winning conservation program, and Utilities customers have reduced their per capita water use substantially over the past 15 years. In 2001, the Nonpotable Master Plan was developed, and later in 2005, the Nonpotable Strategy outlined a long-term strategy for the nonpotable system. Several key improvements have been made to the existing system in the past last 20 years, including expansion of the Otero Pump Station and Lower Homestake Pipeline. The SDS, for which Phase 1 was completed in April 2016, is filling the requirement for a major new delivery system.

Since the adoption of the 1996 WRP, Utilities has completed numerous additional supply, infrastructure, water rights, conservation, and drought management plans and studies. Some of these include the 1998 Operations and Yield Model Study, the 1999 Local Water Use Study, the 1999 Otero Expansion Study, the 2001 Non-Potable Master Plan, the 2005 Raw Water Yield Study, and the 2007 Mesa Master Plan. In addition, water supply and demand studies were prepared for the SDS Environmental Impact Statement (EIS) between 2004 and 2008. The direction and recommendations proceeding from these plans and studies have led to numerous projects, acquisitions, and activities including new structures, purchases of water rights, and the adjudication of new water rights decrees. Utilities never stops planning for the future of its water supply system. However, this IWRP is the first comprehensive water resources assessment that has been completed since the 1996 WRP.

Finally, statewide planning efforts have been taken into consideration in the development of the IWRP. These efforts include the Statewide Water Supply Initiative (SWSI) studies of 2004 and 2010, the various Basin Implementation Plans developed by the Basin Roundtables for the Arkansas River and Colorado River Basins formed as part of the HB 1077 Interbasin Compact Committee (IBCC) process, and Colorado's Water Plan (CWP) of 2015. These statewide planning efforts identify conservation, reuse, alternative transfer methods for agricultural water, new Colorado River supply development, and storage as ways to meet the project water supply gap in Colorado. The IWRP is consistent with these statewide plans and processes.

SECTION 2

Planning Process

2.1 Overview

The IWRP planning process was governed by two basic tenets: policy-level direction and technical support. Policy level direction is set by the Colorado Springs Utilities Board, and technical support encompasses all of the technical data, tools, and analyses necessary to inform and assist the Utilities Board in setting that policy direction. Four components supported these two tenets: 1) specific Board policy questions directed from Utilities staff to the Board; 2) metrics and planning goals to serve as a foundation for the technical work; (3) technical analyses to assess risks, investigate water supply options, and develop feasible water supply portfolios; and 4) internal coordination and external stakeholder discussion supporting the technical and policy analyses. These four components were essential in the development of a successful plan for Utilities designed to meet future water demands in an increasingly complex world (see **Figure 1-1**).

Traditional planning processes are no longer adequate for long-term water supply planning due to the many uncertainties surrounding future conditions, including demand, hydrology, and many other factors. A risk-based planning process was adopted for the IWRP.

2.2 Planning Process Overview

Previous water supply planning approaches were "backward looking," and typically only considered a single future in which the conditions for hydrology, climate, and other risks were assumed to be the same as from the observed past. A firm yield (defined as the highest demand that could be met in all years based on observed hydrology) was determined based on this single future. Water supply projects were selected based on their ability to increase this firm yield to the level required to meet projected demands. However, as recent history has shown, the complexity of municipal water supply planning is increasing significantly, being influenced by such factors such as climate change, infrastructure vulnerability, demand uncertainty, dynamic legal and regulatory environments, and changing social values. All these factors are important when evaluating the need for water supply projects. Utilities recognized the need to move away from the traditional firm yield planning approach to a new planning framework. This new "forward looking" planning framework provides a more robust approach for planning and decision making, in which a variety of future situations and potential options are processed and evaluated simultaneously based on differing objectives, while taking into account the associated uncertainty.

2.3 Risk-Based Planning Process

A key to moving away from firm yield as the primary decision-making metric is utilizing risk-based planning. In this approach, the performance of the system is captured in key "metrics" (defined in Section 2.5-Level of Service Goals), with level of service goals defining success and failure of those metrics (defined in Section 2.4-System Evaluation Metrics). These metrics are used to evaluate the performance of the system under a variety of futures, ultimately allowing Utilities to determine how much effort it will expend to maintain level of service and how much risk it is willing to accept. This analysis was used to inform and support the policy question analysis and recommend a certain level of risk tolerance.

To accomplish this process, Utilities developed a type of Robust Decision Making framework that allowed it to consider tens of thousands of plausible futures, evaluate risk factor combinations and the resulting impacts to the water system. Climate change impacts were evaluated by applying changes in future temperature and precipitation (T&P) and "stress testing" Utilities' water system. This process searched for possible future changes in average T&P that would impact policy or infrastructure decisions; these are also known as signposts, which are discussed in Section 11.7.2-Signposts.

The Robust Decision Making framework was combined with a state-of-the-art multi-objective optimization model that was coupled with Utilities' existing water system simulation model to efficiently and effectively evaluate the many projects that could be employed to maintain level of service across a large subset of climate and other risk factors. This powerful combination of tools gave Utilities the necessary information required to help evaluate tradeoffs and compare the effects of a broad range of future uncertainties and management strategies.

The goal of this process was to identify the water supply strategies that perform best over the broadest range of future conditions rather than the one strategy that performs best under one single assumed most likely future condition. More water suppliers are transitioning to risk-based planning and moving away from traditional firm yield type analyses, and as an early adopter of this new planning paradigm, Utilities continues to be a leader in responsible water resource planning.

2.4 System Evaluation Metrics

As described above, the risk-based planning process requires development of key system measures (referred to as "metrics") that Utilities believes adequately capture the performance of the water system. Because the primary responsibility of Utilities is meeting customer demand, this is a basic performance metric. In addition, Utilities' water system is heavily reliant on water storage to manage the amount, variability, and timing of both supply and demand; therefore reservoir storage acts as a buffer and is an accurate metric for overall system performance.

Utilities chose to evaluate the performance of the water system based on the ability to (1) meet various levels of demand, while (2) keeping specified volumes of water in total reservoir system storage. Key metrics used were reliability (*how often* a certain level of demand is met or a volume of reservoir storage is maintained), resilience (*how long* a demand is not met or the volume of storage is not maintained), and vulnerability (*how much* demand was short or how far volume of storage goes below the desired level). These metrics capture frequency, duration, and severity of demands not being met or a certain desired level of storage not being maintained. **Figure 2-1** is a visual representation of these three metrics as applied to a generic time series plot of total reservoir system storage, with the volume of total storage expressed as years of demand (YOD).

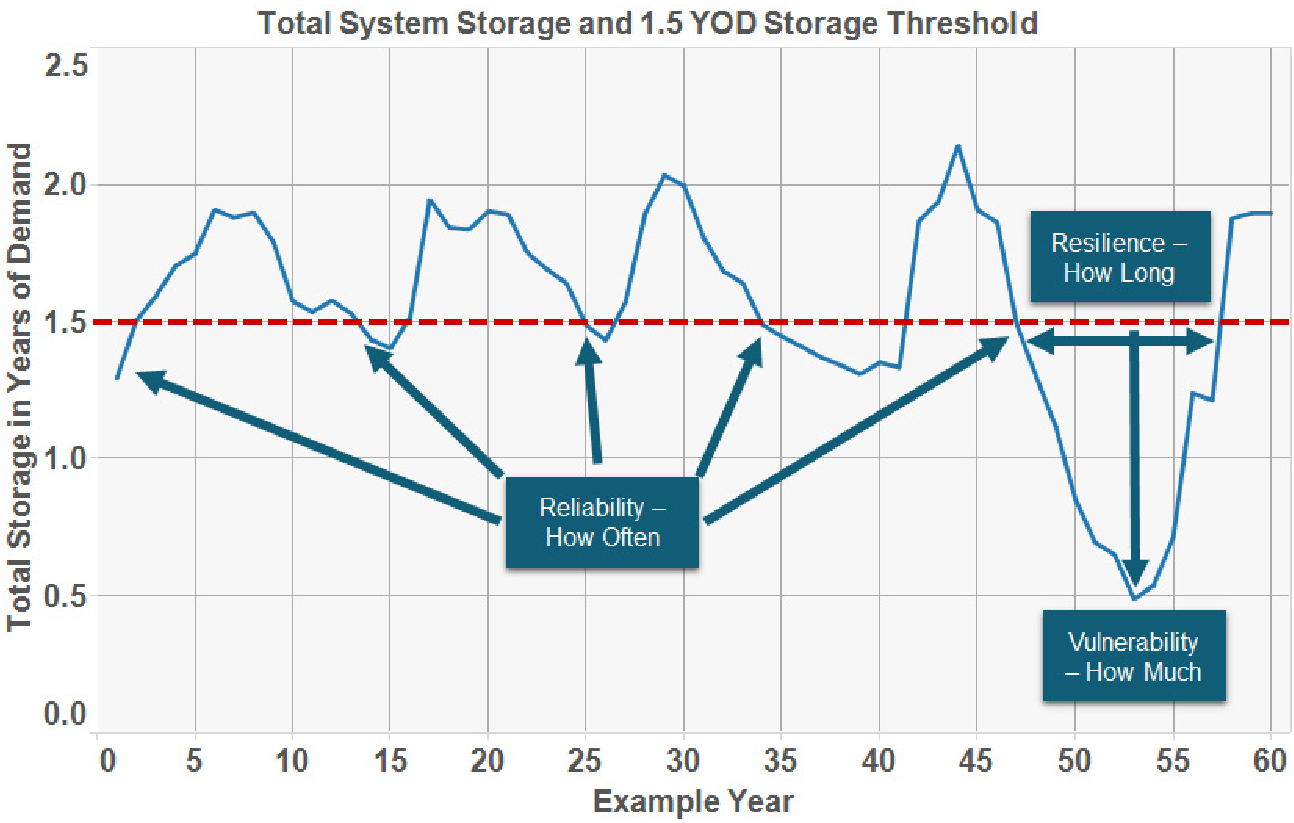


Figure 2-1. Conceptual Reservoir Storage Time Series Depicting Metric Definitions (YOD refers to Years of Demand in Storage)

2.5 Level of Service Goals

Two main questions were asked during the IWRP process in terms of level of service, each of which relates to answering Policy Question #1:

1) What is an acceptable frequency for implementing a shortage response (i.e. imposing water restrictions) on Utilities' customers?
2) What is the appropriate minimum amount of total reservoir system storage reserve that will adequately manage future risk?

To address these questions, level of service metrics were defined to broadly covers two concepts: the key reservoir system storage thresholds and the desired reliability of meeting the thresholds. Underlying those concepts is the basic level of service requirement to always meet indoor demands.

Three specific level of service goals were used for system stress testing designed to determine the future conditions under which the system can maintain acceptable performance. These are:

1) Maintain a minimum of 1.0 YOD in storage reserve at all times (100 percent reliability) – this represents an emergency storage reserve to mitigate against unforeseen or unprecedented events; and
2) Maintain a minimum of 1.5 YOD in storage reserve 90 percent of the time (90 percent reliability) – this represents a reasonable level at which to initiate shortage response analysis.
3) Meet indoor demands at all times (100 percent reliability)

These three criteria work together to define system performance and level of service. Adding different mixes of projects would improve both reliability and resiliency, while minimizing vulnerability of the system, as defined above. Increasing level of service goals and system performance requires increased investment in water supply projects, as shown conceptually in **Figure 2-2**

The primary goal of the IWRP portfolio analysis was to find portfolios that meet the adopted level of service goals while minimizing the amount of new projects, programs, and policies that must be implemented.

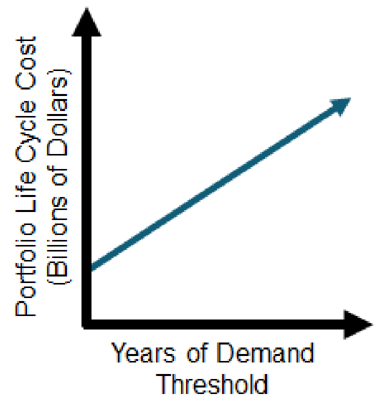


Figure 2-2. Conceptual Relationship between Level of Service and System Cost

2.6 Water Resources System Model and Decision Support System

Adequately assessing system performance requires a large amount of data and a detailed system model. The IWRP modeling approach utilized industry leading approaches and technology. The foundation of the technical analysis was Utilities' existing water system model, the Operations and Yield Model, which has been developed over the course of two decades. This model was combined with a new data management system and a state-of-the-art multi-objective optimization tool to allow Utilities to analyze the large and complex problems posed through the Risk Based Planning Process.

Modeling inputs included extremely large amounts of data such as hydrology, demands, etc., which were stored in a database format. Demand forecasts were prepared by Utilities staff for Buildout conditions and intermediate years. Inflow data were generated from a set of two models. A weather generator model was used to develop temperature and precipitation (T&P) sequences to simulate over 10,000 different potential future weather cycles. These weather cycles were subsequently used as inputs to the Watershed Evaluation and Planning (WEAP) hydrologic rainfall and runoff model to simulate available water supply and inflows. The demand and inflow data were used as inputs into the Operations and Yield Model. After simulations were performed, results were stored in the database and could then be accessed for visualization and analysis to assist Utilities in its understanding and summary of the results. The modeling approach and technical analysis performed, including a complete description of the models used, including a discussion of calibration and validation, are documented in detail in the *TM #11 – IWRP Modeling Systems*. These models were indispensable to the process because they provide the data and analysis used to inform decisions, however, it is Utilities staff and management that are the decision makers.

2.7 Internal and External Coordination

The IWRP was developed by an extensive cross-disciplinary team consisting of Utilities staff, consultants and external stakeholders. Internally, the IWRP planning structure consisted of a Technical Team, a Management Team, and a Public Process Implementation Team. The Technical Team was composed of subject matter experts (SMEs) from across Utilities, including Water Resource Management, Water System Operations, Water Planning & Design, Environmental Services, Water Conservation, Financial Planning, Risk Management, and the SDS Team. The teams participated in identification and prioritization of system risks, methods review, results analyses, and portfolio recommendations.

The Management Team members were from Planning, Engineering, and Resource Management, System Extensions, Water Conservation, Environmental Services, Government Affairs, Risk Management, Customer Care, and the SDS Team. Primary Management Team responsibilities were centered upon project guidance, which included work product reviews, policy consistency, and general Utilities consistency across the Water Division.

A comprehensive public/stakeholder outreach plan was a priority from the beginning of the IWRP. The Bleiker process was used to guide development of an outreach and communications plan for achieving informed consent upon completion of the IWRP. The Public Process Implementation Team included staff from Water Resource Management, Issues Management, Government and Corporate Affairs, Customer Research, and Water Conservation and Education. Its role was to develop and implement the public and stakeholder engagement program.

An extensive external public process was used to solicit feedback from a broad variety of stakeholders. A 12-member Water Planning Advisory Group (WPAG) represented a broad cross section of stakeholder interests (e.g., business community, landscapers, environmental groups, and military community), with which Utilities could vet different aspects of the planning process in greater detail. Other means of communication included a web page, open houses, customer surveys, focus groups, stakeholder group meetings, newsletters, and printed materials.

The Public Process is discussed in more detail in Section 10.

SECTION 3

Existing Service Area and Water Supplies

3.1 Service Area Description

Utilities plans to augment its current system and supplies to meet full Buildout demands in its water service area.

The IWRP provides a strategy for meeting future water needs at full Buildout of the Colorado Springs Utilities' Water Service Area based on current land use planning information. **Figure 3-1** is a map of the current Water Service Area. The 2015 population within the Colorado Springs City limits was 470,513. The forecasted Buildout population is about 723,000, based on State Demographer's projections. However, as with any forecast, estimated Buildout population and consequently water use could vary significantly depending on a number of assumptions, including population growth rate, density of future development, and other demographic factors.

3.2 Current Water Resources Facilities

Utilities currently obtains water from many local and regional sources. Water is utilized from three major river basins: the Arkansas River Basin, the Colorado River Basin, and a small amount from the South Platte River Basin. Water is obtained from the Twin Lakes, Fryingpan-Arkansas, Homestake, Blue River, Colorado Canal, and Local/Pikes Peak collection systems. This water comes primarily from surface water sources and is conveyed to Colorado Springs through four major pipelines and many other smaller raw water delivery pipelines. The major yield systems (i.e., water collection systems) and delivery systems (i.e., water conveyance systems) are shown in **Figure 3-2**.

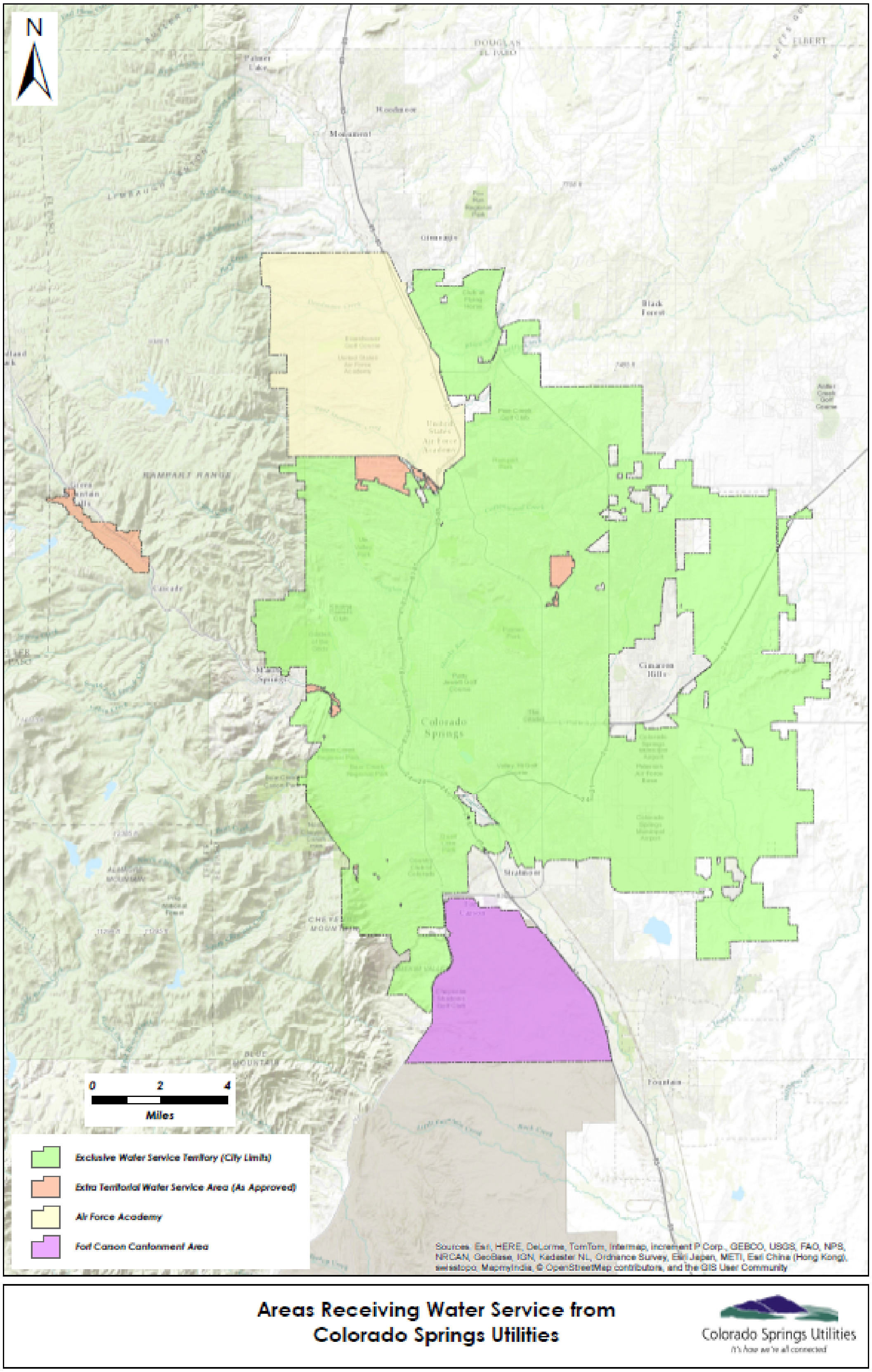


Figure 3-1. Colorado Springs Utilities Water Service Area

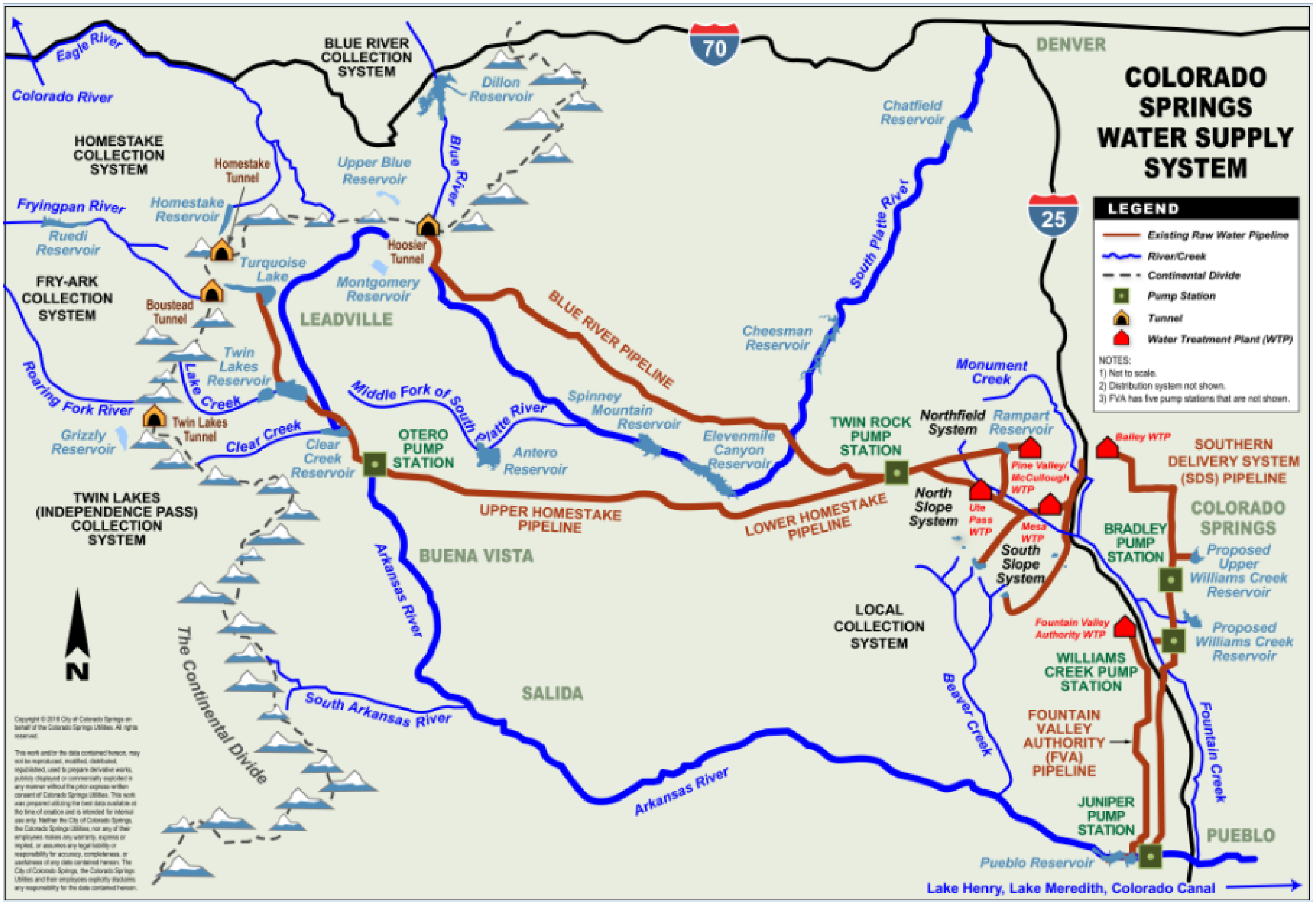


Figure 3-2. Colorado Springs Water System Map

3.3 Current Sources of Supply

When determining the amount of available water supply, Utilities quantifies what is called "legally and physically" available water. This quantification accounts for both the water produced by each watershed (physically) and Utilities' water right priorities with respect to other entities' senior water rights (legally). These inflow volumes represent new water available from existing rights to the water system on an annual basis. The average historical inflow volumes that were legally and physically available to the major collection systems during the 1950 – 2008 period and the critical drought year of 2002 are shown in **Table 3-1**. The study Period of 1950 – 2008 was chosen based on the availability of reliable streamflow and hydrology data at the start of the IWRP study, and encompasses a representative set of wet, average and dry years.

Table 3-1. Historical Legally and Physically Available Inflows

Collection System	Average Inflows (ac-ft/year)	2002 Inflows* (ac-ft/year)
Local System	58,000	29,786
Blue River	7,818	1,091
Homestake	15,429	1,039
Twin Lakes	25,726	10,617
Fry Ark Project (FVA)	14,952	2,585
Colorado Canal	29,634	8,654

* 2002 is the critical drought year during the Study Period.

An additional component of water available for use in the supply system that is not listed in the table is water reuse. Approximately three quarters of the water supply described in the table is legally reusable, meaning that Utilities can reuse that water until extinction (i.e., until it is all used up). How this works in practice is that when demands are met using reusable water, the return flows resulting from that water use (e.g. waste water effluent) can be captured and reused by Utilities. There are two primary ways Utilities reuses this type of water: it can be reused directly as nonpotable or potable supply, or through a series of water trades known as exchanges. The total amount of reusable return flow available is dependent on the amount of water used in the system, and grows over time as the city grows and demands increase.

The complex interactions between the inflows that are legally and physically available to Utilities, the configuration of the water system, and water use by customers are evaluated to determining the "reliably met demand" for the water system. A more detailed discussion of how to determine this reliably met demand is found in Section 6.2-Need for Strategies.

SECTION 4

Water Use

4.1 Historical and Current Water Use

Based on moderate assumptions for future growth and climate, total Buildout water use system wide is expected to be about 50% greater than recent total water use.

Water use is a measure of complex human behavior in response to many external influences, such as weather, economics, demographics, and others. **Figure 4-1** shows historical water use and population in Utilities' service territory from 1950 through 2015. The graph shows that the trend in water use generally followed the trend in population growth until the drought of 2002-2003. After this time there is not a clear correlation between population and water use, and per capita use declined.

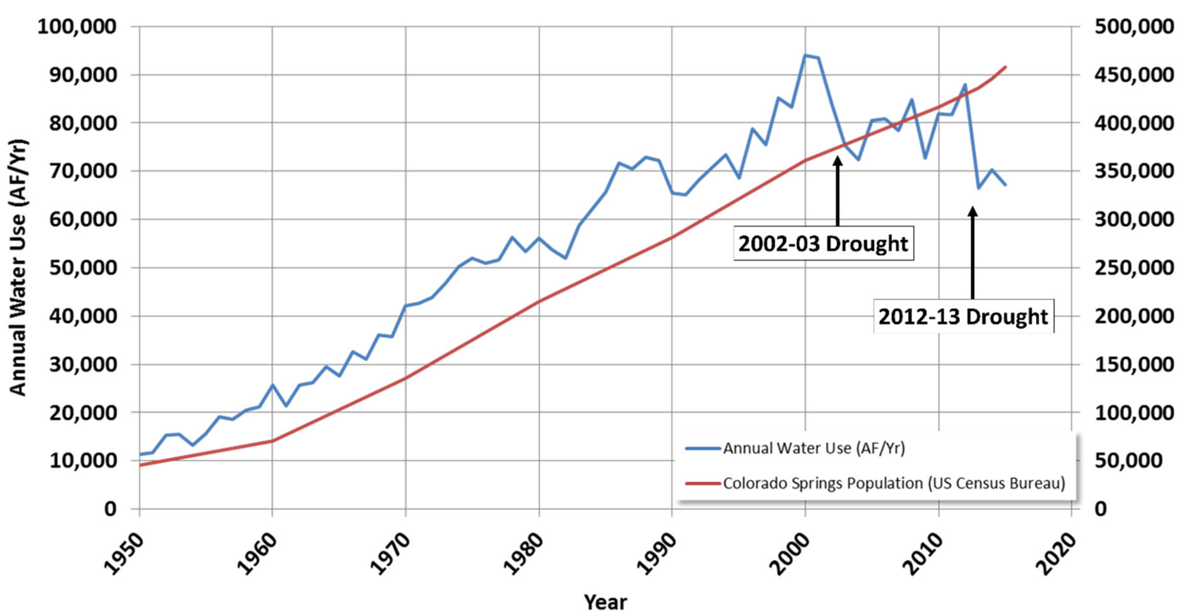


Figure 4-1. Historical Colorado Springs Population and Water Use, 1950-2015

The decline in per capita water use is attributable to a wide variety of social, political, and economic factors and conditions that have occurred over the past 15 years. A portion of the decrease in use is attributable to Demand Management. The introduction of more efficient indoor fixtures (showers, appliances, etc.), more efficient irrigation practices, and new landscapes have reduced the amount of water customers require.

Many other factors have also played a large role in the change in customer behavior and water use. The drought cycles of 2002-2005 and 2012-2013 changed customer water use patterns and habits. In addition, the economic recession of the late 2000's and other economic factors likely caused many customers to reduce or eliminate outdoor watering.

One of the most significant factors contributing to the drop in water use over the last few years has been the abandonment of landscapes. The social, political, and economic factors in combination with multiple years of drought have contributed to landscape abandonment by many customers who have not converted to more sustainable landscapes (e.g., native or drought tolerant vegetation). Utilities estimates that up to 30 percent of previously landscaped areas in Colorado Springs are not currently being maintained or irrigated. This trend, which is not a part of Utilities' demand management program or objectives, adds a level of uncertainty for Utilities, in that there is no reliable way of predicting when or if these landscapes will be restored, and if so, to what level of health and water use.

This persistent reduction in per capita water use since 2002 has become an important factor in forecasting future water demands, and has introduced significant uncertainty into the demand forecasting process. Because of this uncertainty, the responsible approach is to plan for supplying sufficient water to support what would be considered normal, reasonable, healthy residential and commercial landscapes and a healthy environment, as well as a robust business community. Therefore, Utilities has assumed for purposes of planning and forecasting future water use that a sustainable level of annual water demand in 2016 would be 88,000 ac-ft/yr, the approximate level of demands prior to the 2012-2013 drought. This is used as a Baseline demand in the analysis.

4.2 Estimated Future Water Use

Below is an analysis performed to estimate future water use in Utilities' water service area. Water use estimates are described in detail in *TM #15 – Demand Analysis*.

4.2.1 MUNICIPAL & INDUSTRIAL GROWTH ESTIMATE IN SERVICE AREA

Table 4-1 lists the estimated population growth inside Utilities' water service area through Buildout. This estimate is based on a moderate growth assumption provided by the State Demographer and shows a 59 percent increase between 2015 and Buildout. These estimates only include population inside Colorado Springs City limits and Utilities' current water service area and assumed no significant new areas would be annexed to the Utilities' water service area.

Table 4-1. Colorado Springs Historical and Forecasted Population

Year	City Population
2000	360,890
2010	420,716
2020	474,312
2030	533,261
2040	588,596
2050	631,133
2060	668,729
2070	706,324
Buildout	**723,037**

4.2.2 METHOD OF WATER USE FORECASTING

Future water use forecasts for Buildout conditions were prepared using a regional regression model developed by Utilities that estimates water use based on a number of demographic, economic, and climate variables. Separate water use estimates were prepared for indoor and outdoor use in the residential and non-residential sectors, which were then aggregated into an estimate of total water use in the Utilities' water service area.

Three demand scenarios were developed to estimate the possible range of water demand at Buildout. These are described in Table 4-2.

Table 4-2. Buildout Demand Scenarios

Demand Scenario	Assumptions
Moderate Demand Scenario	Normal economic conditions, known water-using appliance efficiency standards at the State and Federal level, planned population density, current commercial/industrial mix, and current climate
Low Demand Scenario	Some combination of poor economic conditions, increasing efficiency standards at the State or Federal level, increased population density, changes in the commercial/industrial mix, and other natural market forces, with current climate
High Demand Scenario	Some combination of excellent economic conditions, no new efficiency standards at the State or Federal level, decreased population density, changes in the commercial/industrial mix, and other natural market forces, with current climate

4.2.4 CURRENT DEMAND MANAGEMENT PROGRAM

Colorado Springs has a long history of wise and responsible water management, including water conservation and efficient water use. The concept of wise and efficient water use is known by many terms including conservation, water use efficiency, and demand management. In this document, the term demand management will be used as it best encompasses the concepts of efficiency, demand reduction when appropriate, and wise and sustainable water use. Demand management has been an integral part of water resource planning and management for over 60 years, and Colorado Springs is seen as a leader in demand management among Colorado municipal water utilities. With increased competition for state and regional water resources, demand management offers an element of flexibility given a semi-arid climate, changing conditions, and system uncertainties. Utilities educates and encourages customers to save water, and use it sustainably, because "it's the right thing to do," and because of resource, economic, lifestyle, and community benefits. Utilities also manages programs that address supply-side efficiency measures that optimize water resources through water reuse systems and distribution system efficiency.

4.2.5 BUILDOUT WATER USE FORECAST

Baseline water use assumed for the IWRP and forecasts of Buildout water use for the low, moderate, and high demand scenarios are shown in **Figure 4-2**.

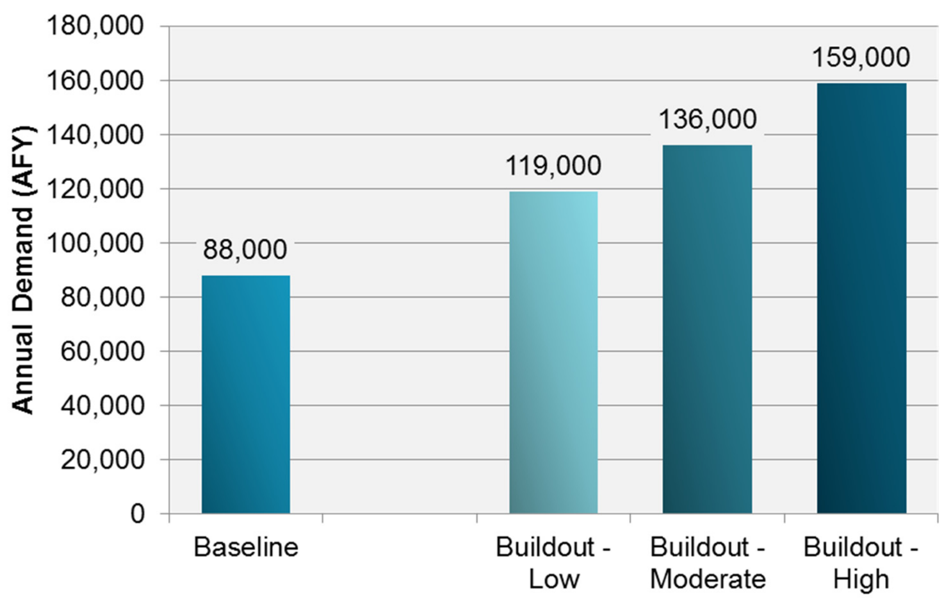


Figure 4-2. Water Use Forecasts Used for IWRP

4.2.6 POTENTIAL EXTRATERRITORIAL DEMANDS

The Pikes Peak Region outside of Colorado Springs City limits is served by many water providers (see **Figure 4-3**), some of whom Utilities could assist by providing water and/or access to infrastructure. In northern El Paso County, many of these water providers have grown largely dependent on non-renewable groundwater supplies from the Denver Basin aquifers. Other water providers in southern El Paso County rely on various alluvial groundwater and surface water sources that have experienced water quality and reliability issues. The cost of operating and maintaining groundwater wells is increasing, while production declines and water quality are becoming a greater issue. Additionally, it is difficult for these relatively small water providers to secure renewable surface supplies due to the permitting, environmental, and financial challenges. One option for Utilities is to continue having these water districts meet their own demands without outside assistance. However, these water districts serve as bedroom communities for Colorado Springs and contribute to the interdependent economic vitality of the Pikes Peak Region. Therefore, maintaining reliable water supply for the region is a desirable objective for Utilities.

The potential Buildout demands of many water providers in the Colorado Springs region that cannot be met with renewable supplies were estimated; this is their potential demand "gap." Utilities made these estimates for the IWRP to consider potential issues associated with Utilities providing regional water service. Estimates were derived from planning studies performed for El Paso County water users and other technical resources including studies by Pikes Peak Regional Water Authority. Not all water providers in the region can reasonably be served by Utilities water system because of location or legal constraints, however, many may be able to participate in a regional solution. Total Buildout demand for these water providers in the Colorado Springs vicinity is about 44,000 ac-ft/yr, and their maximum potential gap, i.e., water not currently available is around 25,000 ac-ft/yr.

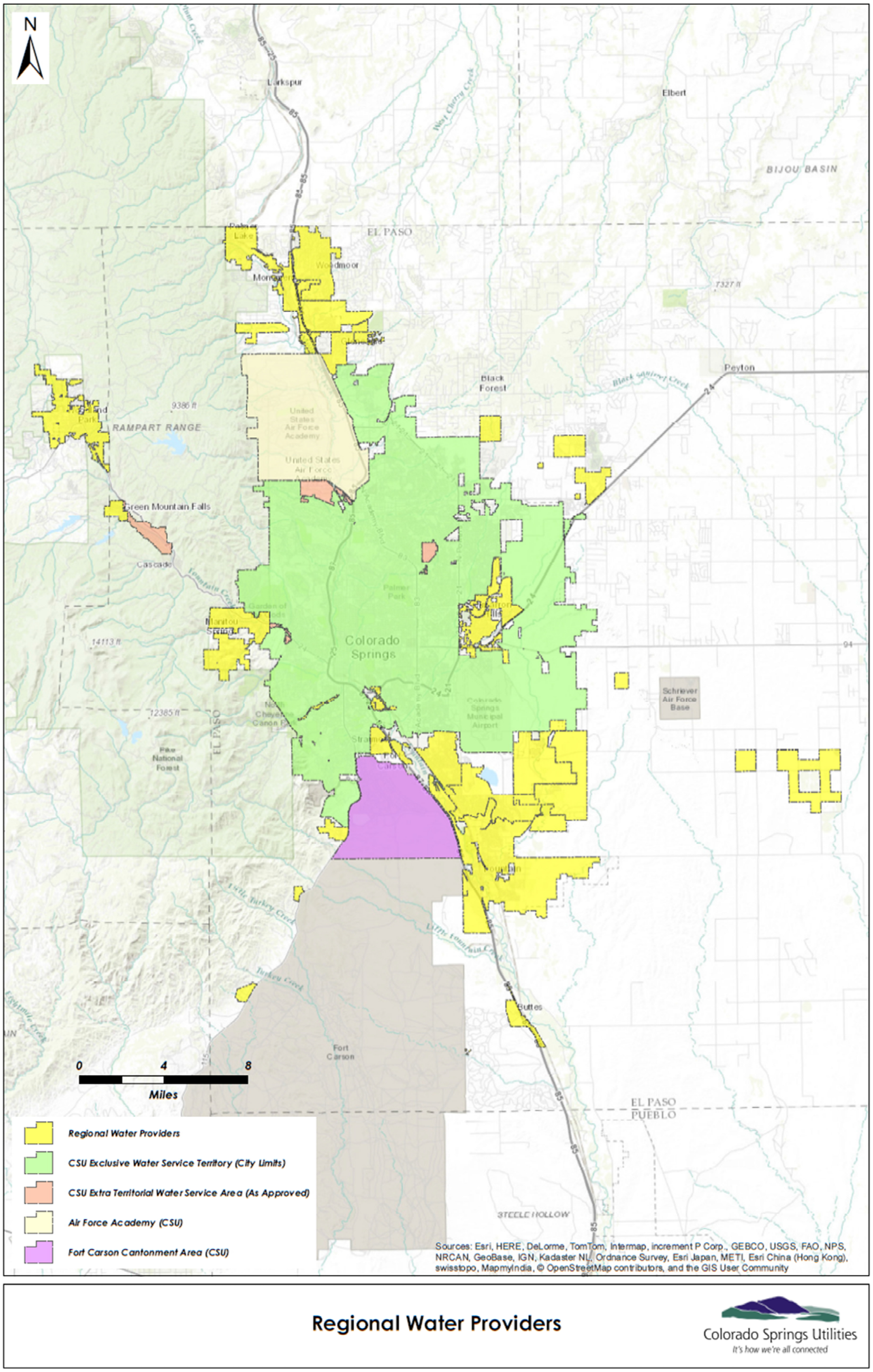


Figure 4-3. Water Providers in the Pikes Peak Region

SECTION 5

Risk Identification and Assessment

Risk and uncertainty were key drivers for the IWRP analysis, and inform future conditions under which Utilities water system must perform in order to meet customer water demands. This section describes the analysis used to determine the risks and uncertainties that have the potential to impact Utilities' future operations and therefore warrant inclusion in the analysis of future water supply strategies and options.

5.1 Risk Identification and Prioritization

Over 60 risks and uncertainties in six main categories were identified and prioritized. Risks and uncertainties associated with hydrology/climate and West Slope sources were found to have the most potential impact on the water system reliability.

5.1.1 PROCESS FOR IDENTIFYING RISKS

The foundation of the current IWRP process is the recognition that there are a large number of risks facing Utilities' water system. Therefore, the process has been approached as a risk management and mitigation problem and was performed in a systematic and robust way. Ten workgroups were formed to brainstorm and prioritize risks in the following categories: climate/hydrology, conservation, infrastructure, environmental, water reuse/nonpotable, regulatory/legal, political/social, water/energy, regionalization, and financial. During the peak of this phase of the analysis, about 40 SMEs were involved with workgroups. Findings from the 10 workgroups were consolidated into six thematic areas, as shown in Figure 5-1.

5.1.2 RISK PRIORITIZATION

Each workgroup scored risks in terms of likelihood of occurrence and impact, both with scores ranging from 1 to 5, with 5 being the most likely or most impactful. The product of likelihood and impact (25 maximum) became the risk score. Due to the disparate nature and

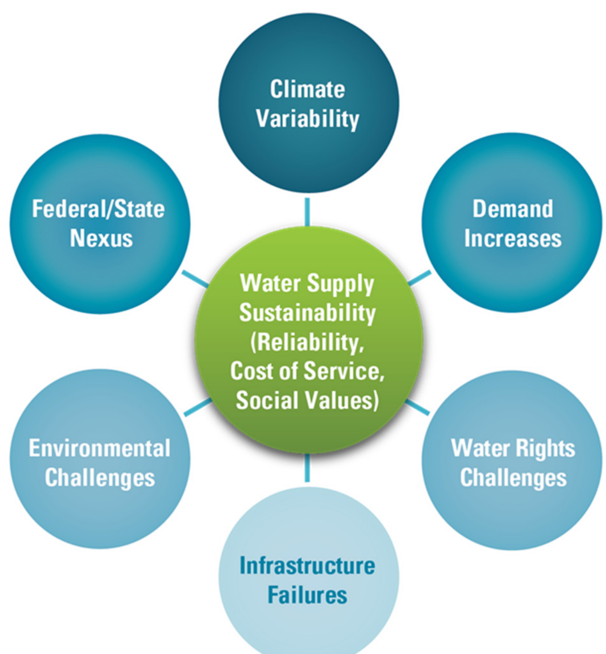


Figure 5-1. IWRP Risk Categories

relative impacts of events across the different areas, weighting or merging scores across workgroups was not desirable. For example, a high scoring climate change related risk of reduced hydrologic runoff would have a far greater impact than poorly funded O&M for the nonpotable system, which may have had a high score within the water reuse/nonpotable workgroup. To compare risks, Utilities ranked each risk as high, medium, or low in terms of overall system impacts. Utilities used these scores and professional judgment to identify the most impactful risks to carry forward for quantitative modeling.

The risk identification and prioritization process and results are described in detail in the IWRP Planning Factors Report.

5.2 Risk Assessment

Climate and hydrologic risks, along with certain infrastructure risks, were identified as the most impactful by the workgroups. They were then evaluated using the Utilities' water supply Operations and Yield model. Since these risks can occur individually or in combination and impact Utilities system in different and possibly unanticipated ways, multiple risk combinations were modeled that included both acute/short duration (12 months) and chronic/long duration (entire simulation) events. In total, over 1,000 risk scenarios were modeled. To evaluate these different types of risks, the metrics described in Section 2-Planning Process were used to quantify frequency, duration, and severity of the impacts.

5.2.1 CLIMATE AND HYDROLOGIC IMPACTS

To best capture climate and hydrologic impacts, several different methods of generating hydrologic flows beyond those captured in the historical 1950-2008 record were considered. These methods included resequencing historical flows based on historical drought patterns, two methods of resequencing historical flows based on drought patterns seen in the longer paleo reconstructed tree ring record, and generating new simulated flows using the weather generator model linked with the WEAP rainfall/runoff model for both the Upper Colorado and Upper Arkansas River Basins. After comparing all data sets, the simulated hydrology produced using the weather generator and rainfall/runoff models was determined to be representative of all data sets. It was also determined to be the most useful dataset for simulating and analyzing potential future flows, and was therefore selected as the basis for the hydrologic impact analysis.

The hydrology simulation procedure is summarized by the flow diagram in **Figure 5-2**. Step 1 was to generate 10,000 different temperature and precipitation (T&P) sequences (trials) for the Upper Colorado and Upper Arkansas River basins, keeping the mean temperature and precipitation across the entire trial within 2 percent of the respective historical means. Step 2 was to reduce the number of trial to a practical number for purposes analysis. This was done by sorting the resulting trials based on the length and severity of droughts and selecting 40 representative trials containing a rich variety of drought and wet conditions that would be used. These selected trials did not have any long-term climate change imposed and represented potential future weather under the current climate conditions. Step 3 was to run the 40 trials through the WEAP models, which simulated legally and physically available flows for each trial. This produced a range of future flows possible under the current climate that was carried forward for further analysis in Utilities Operations and Yield Model. Finally, Step 4 applied temperature and precipitation changes to the T&P time series to generate new legally and physically available flows reflecting the potential impacts of climate change for use in Utilities' water supply planning Operations and Yield Model. These time series represented the climate change hydrologic ensemble (i.e., a range of future flows possible under the climate change). Step 4 is described in more detail below.

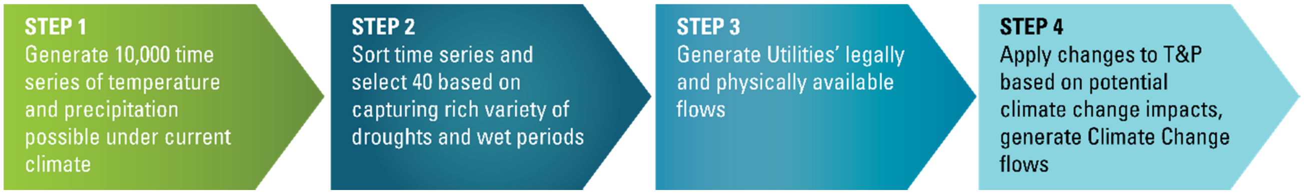


Figure 5-2. Weather Generator Procedure

To determine what changes to apply to the T&P time series required in Step 4, results from many Global Climate Models (GCMs) were evaluated. These GCMs are all separate models that reflect different methods and incorporate different assumptions about the future. Though no one GCM can be considered correct or better than another, considering all of these GCM results provides a range of possible future climates with the expectation that the range will bracket actual future conditions. GCM results suggests a broad range of potential future T&P changes in the Upper Arkansas River and Upper Colorado River Basins that supply water for Utilities. **Figure 5-3** shows the results of 112 GCMs in the form of changes to T&P around the year 2060 as compared to recently observed temperature and precipitation data. These climate model data have been widely used in the western United States by Federal, State, and municipal entities for water supply planning purposes.

The changes applied to the T&P time series were determined by bracketing the GCM results that best capture a reasonably plausible range of future climates of concern for water supply planning. This bracketed region is shown as a red box in **Figure 5-3**. The offsets from the historical mean in temperature ranged from -2°F to +7°F in increments of 1°F, and the offsets from the historical mean in precipitation ranged from -10% to +10% of the mean in 5% increments, giving a total of 50 T&P offset scenarios. Because significantly wetter conditions would not stress the Utilities' water system (despite the temperature increases and resulting changes in run-off timing) or increase the difficulty of meeting future demands, wetter future conditions were not analyzed for the IWRP.

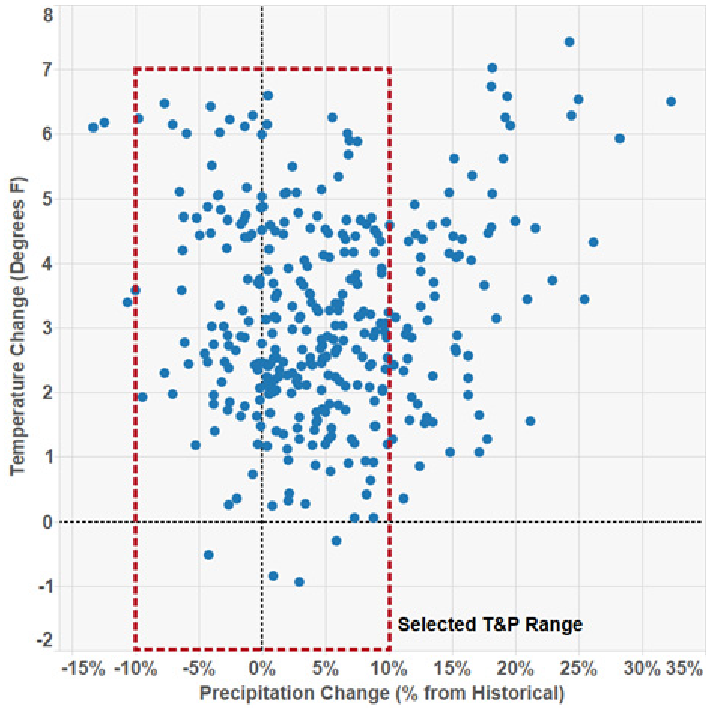


Figure 5-3. GCM and Climate Change Ranges used for IWRP

5.2.2 NON-CLIMATE SYSTEM RISK IMPACTS

The non-hydrologic risks to the Utilities' system, or system risks, were also evaluated as part of the IWRP. These system risks encompass a broad range of factors that could negatively impact Utilities' water system and represent the impact of some kind of event (e.g., a wild fire) on Utilities' water system (e.g., a reduction in yield from a watershed). These system risks were classified into acute, short duration impacts (e.g., emergency pipeline outage, reservoir maintenance, diversion tunnel collapse) and chronic, long term impacts (e.g., new minimum stream flow regulations, water quality impacts on supply, reduction in water yield from a basin, reduction in storage due to sedimentation). For this analysis, chronic risks were imposed for the entire study period. Acute risks were activated at one of three different outage times during the study period. These outage periods were chosen to correspond to different hydrologic events (entry into a drought, bottom of a drought, recovery from a drought).

In all, over 100 different risks were identified, and of these more than 60 were explicitly analyzed for their impacts on water system performance. A more detailed explanation of the system risks analysis methods and results can be found in the Vulnerability Assessment Report.

5.2.3 SUMMARY OF RISK ASSESSMENT

5.2.3.1 Hydrologic Risks

The baseline analysis evaluated system performance at 2016 and Buildout conditions under a range of hydrology that is possible under current climate conditions. At 2016 baseline conditions, system performance meets or exceeds all of Utilities' level of service goals. However, at Buildout baseline conditions system performance failed to meet the level of service goals.

System performance under the previously discussed climate change hydrology was simulated under Buildout conditions. The impact of climate change on system performance varies widely depending on the T&P scenario; however, performance of the system was below the level of service goals for all T&P scenarios. Because climate change is a gradual process, climate conditions can be monitored as part of a signpost approach, and the assessment can be repeated as new data becomes available.

5.2.3.2 Non-Hydrologic Risks

System risk analysis results demonstrated that the system had a wide variety of impacts resulting from the imposition of the various risks ranging from inconsequential to significant. However, Utilities' most critical non-hydrologic vulnerabilities are risks that impact West Slope yields or risks that compromise key delivery infrastructure. Though these risks were previously understood as vulnerabilities by Utilities staff, through the IWRP, the magnitude and severity of their potential impact the water system was better understood. Additionally, the nature and severity of other vulnerabilities, such as risks related to Colorado Canal storage, were identified and studied for the first time in the IWRP. These identified vulnerabilities were then used in the development of portfolios of projects that could still meet Buildout demands and level of service goals, while satisfying the key policy questions.

5.3 Risks and Uncertainties Selected for Analysis of Portfolios

Results from the assessment of hydrologic and non-hydrologic risks were incorporated into the Buildout portfolio selection process in two ways. One set of risks, listed in **Table 5-1**, were applied during the portfolio selection process and represent a combination of future hydrologic conditions and system conditions that are reasonably likely to occur and could significantly stress Utilities' water system. An additional set of risks, listed in **Table 5-2**, were applied to screened portfolios as part of the robustness analysis to evaluate their performance over a broader range of the possible future conditions. Application of these risks and uncertainties in the portfolio development process is described in Section 9-Development and Evaluation of Portfolios.

Table 5-1. Risks used for Initial Buildout Portfolio Development

Risks Selected for Portfolio Development	
Hydrology	Hydrologic traces with droughts greater severity and different timing than in the historical record
Climate	3°F warmer climate (consistent with recently observed temperature trends of 1°F warming per decade) No change in mean precipitation
System Risks	One year Otero Pump Station/Pipeline outage due to infrastructure failure, maintenance requirements, or natural disaster impacts (wildfire, landslide, etc.). Shortages in the Colorado River Basin result in: 20 percent reduction in all West Slope yields for a 10-year period 25 percent reduction in all exchange potential during same period (resulting from reduced flows in the Arkansas River due to reduced overall transmountain water imports by Utilities and others)

Table 5-2. Risks used for Buildout Portfolio Robustness

Additional Risks used for Portfolio Robustness	
Hydrology	Additional hydrologic traces
Additional Climates (18 total)	0°F, +1°F, +2°F, +3°F, +4°F, and +5°F temperature increases 0%, -5%, and -10% precipitation changes
Additional System Risks (each listed was applied individually)	Chronic 50% exchange potential reduction 1-year outage at each of the three major water treatment plants (applied individually) due to plant failure or inflow water quality impairment Chronic 25% reduction in Pueblo Reservoir or Local System storage capacity due to water quality problems or storage restriction due to structural issues No Colorado Canal system storage (every year) due to water quality impairment or other factors Colorado River Compact Curtailment with no West Slope supplies for 10 years due to unprecedented drought in the Colorado River Basin

SECTION 6

Future Water Resources Strategies

6.1 Introduction

Utilities has many strategies available for mitigating future water supply and demand uncertainties. Each has its own unique benefits and challenges that must be weighed when creating a future portfolio of projects, programs, and policies that addresses a broad range of future conditions. This section describes the seven general water resources strategies considered by Utilities in the creation of water supply portfolios: Demand Management, Reuse and Nonpotable Supplies, Colorado River Basin Supplies, Agricultural Acquisitions/Transfers, Increased Storage, Conveyance, and Groundwater. Specific options for projects or programs to implement each strategy are described in Section 7-Future Water Resources Options.

Utilities must pursue a variety of different water resources strategies in addition to new storage to achieve its level of service goals.

6.2 Need for Strategies

As discussed in Section 2.2-Planning Process Overview, Utilities has transitioned away from the concept of firm yield to a risk based planning methodology. As a result of this transition, the concepts of firm yield and risk based planning can be blended using what is called “reliably met demand” (RMD). The RMD represents the maximum demand level that can be met while maintaining the level of service goals described in Section 2.5-Level of Service Goals. Determining the RMD of the current system establishes whether there is a need to pursue strategies to develop future supplies. Therefore, the RMD of the current system was determined.

The RMD was determined using the alternative hydrologic sequences developed for possible future conditions as described in Section 5.2.1-Climate and Hydrologic Impacts, but assumed no additional climate or system risks. The RMD of the system as it exists at the time of this report is 95,000 ac-ft of annual demand. The RMD of the current system is much less than the estimated Buildout demand of 136,000 ac-ft/yr. Therefore, additional strategies will be required.

6.3 Demand Management

Benefits	Challenges
Consistency with growing customer expectation that lower water use landscaping will become the norm	At highest savings levels, may require some additional amount of regulation and oversight for new construction
Delays the need for new infrastructure projects or acquisition of additional water supplies	Demand hardening (achievable water savings during shortage response decreases as more customer demand becomes nondiscretionary)
Consistent with Colorado Water Plan and likely a prerequisite to permitting new water supply projects	Demand volatility (uncertainty of the permanence and level of savings)
Reduces costs to convey, treat and deliver water to support a given population	Negative short term and long term revenue impact may require rate redesign

Figure 6-1. Demand Management Benefits and Challenges

Demand management can be defined as the responsible, wise, efficient, and sustainable use of water resources. Demand management practices include landscape conversion, water efficient fixtures, education, and reducing system leaks, among other options. Demand management has been integrated into Utilities' business model and is reflected in Utilities' Water Use Efficiency Plan submitted to the CWCB, and was one of the key components of the 1996 Water Resources Plan. Results from the IWRP public process customer surveys and focus groups from the Colorado Springs community (discussed in Section 10-Public Process) identified demand management as an important future strategy. Demand management was also identified as a key strategy in the Colorado Water Plan and is in most cases considered a prerequisite for permitting new major projects. Benefits and challenges of implementing Demand Management are summarized in **Figure 6-1**.

6.4 Reuse and Nonpotable Supplies

This strategy includes enhanced use of local water sources, including the exchange program, nonpotable water, potable reuse, graywater reuse, and rainwater harvesting. While Utilities makes good use of many of these options, local geography, water rights law, and insufficient regulatory guidance make implementation of some of these options difficult for Utilities at this time.

The primary source for most of these options is reusable wastewater effluent. As discussed in Section 3.3, reusable water is very valuable to Colorado Springs because it represents the opportunity for multiple uses from a single initial diversion. Reusable water provides a larger water supply benefit compared to other water types, which are legally allowed only one use before we are obligated to return the water to the next user downstream. Therefore, it is important for Utilities to carefully manage these supplies to achieve the maximum overall water supply benefit. The strategies in this section that rely on reusable water compete with each other for reusable water supply, and therefore are properly considered alternate conveyance mechanisms as opposed to new sources of supply. The implications and impacts associated with this concept are discussed in more detail below.

6.4.1 EXCHANGE PROGRAM

The most efficient way to maximize the use of reusable water is the Exchange Program. This operation allows reusable effluent to be traded against flows on the river that are recaptured in existing upstream facilities to be returned to Colorado Springs for subsequent use. The exchange program is a major source of supply for the potable water system. Colorado Springs holds numerous exchange water rights, including rights to exchange to local Pikes Peak watersheds, and rights to exchange return flows to numerous locations on the Arkansas River extending from Rocky Ford to Leadville. In 2016, Colorado Springs was able to secure a decree to exchange leased water. The Case No. D2-05CW96 decree will be critical to the success of Utilities' Agricultural Transfer strategy described in Section 6.6. Maximizing our exchange program to increase water supply at minimal cost is a baseline strategy for all scenarios and futures, and therefore is not considered explicitly as a separate option in the IWRP analysis.

6.4.2 NONPOTABLE SYSTEM WATER USE

Utilities' nonpotable water system can deliver both untreated raw water and reclaimed wastewater return flows for nonpotable uses such as landscape irrigation and industrial process water. The existing system could be expanded, but its potential benefits have limits. Utilities already efficiently reuses its transmountain water rights through the water right exchange program, so redirecting that exchangeable water to nonpotable reuse provides little if any appreciable increased yield to the water system, but may provide financial, social, environmental, or other benefits. Therefore, the challenge is to find the appropriate balance of expanding the nonpotable system to achieve these benefits without significantly reducing water available through exchange. In addition, expansion of the nonpotable system would be dependent on identifying large customers with outdoor irrigation or industrial process water demands. The nonpotable reuse benefits and challenges are summarized in **Figure 6-2**.

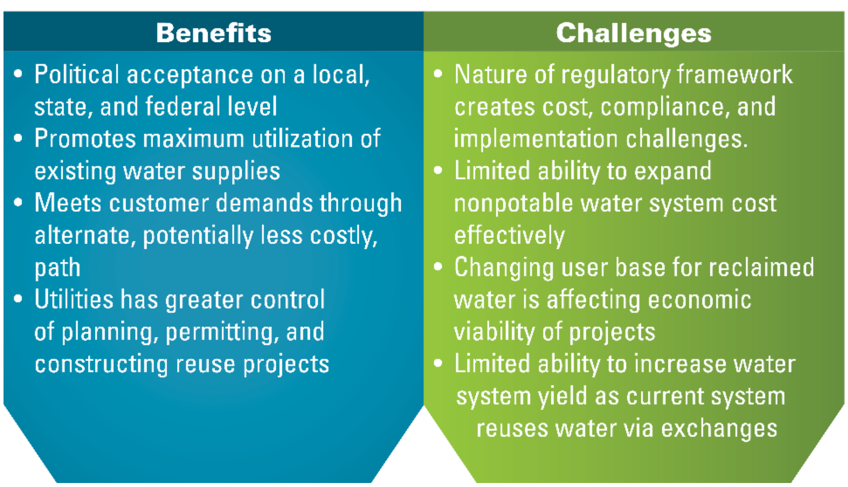


Figure 6-2. Nonpotable Reuse Benefits and Challenges

6.4.3 INDIRECT AND DIRECT POTABLE REUSE

Benefits	Challenges
• Promotes maximum water utilization and system flexibility through multiple options (exchange, IPR and/or DPR) • Helps mitigate exchange related risks • Reduces conveyance and evaporation losses	• Increased treatment and pumping costs • Customer perception and acceptance as a source of water supply • Concerns with known and emerging contaminants in DPR/IPR water sources

Figure 6-3. Potable Reuse (IPR and DPR) Benefits and Challenges

Indirect Potable Reuse (IPR) involves taking treated, recycled, or reclaimed water and then blending it with a natural water source (e.g., natural flow in a stream channel or reservoir water, which acts as an environmental buffer) prior to re-introduction into the water system for further treatment. For Utilities, IPR has the benefit of short-circuiting the process of exchanging reusable return flows, thereby reducing Utilities' risk to issues related to future limitations on exchange potential. IPR can also save water that would have been lost in the exchange program as the result of transit losses due to seepage and evaporation as water flows downstream.

Direct potable reuse (DPR), on the other hand, involves first treating wastewater to levels that meet or exceed drinking water quality standards at a wastewater treatment plant (WWTP), then routing this water to a connection between the wastewater treatment plant (WWTP) to and the potable water treatment plant (WTP) for additional treatment and delivery to the potable water system. It has the same benefits as IPR with respect to the exchange program. Neither IPR nor DPR are part of Utilities' current water supply portfolio. Both IPR and DPR would become more financially viable if nutrient discharge regulations or other regulations for wastewater discharge become more stringent. Those more stringent regulations would likely require more advanced treatment and would narrow the gap between wastewater discharge and potable water standards. Potable reuse benefits and challenges are summarized in **Figure 6-3**.

6.4.4 GRAYWATER AND RAINWATER

Graywater is wastewater collected from selected fixtures within residential, commercial, or industrial buildings (including bathroom or laundry sinks, bathtubs, showers, or laundry machines). It is typically used for landscape watering, but also can be used for toilet flushing and other limited applications. Rough estimates suggest that for every 1,000 graywater systems installed in single-family homes, overall customer potable water demand is reduced by about 50 ac-ft each year[1]. However, because Utilities already reuses most of its available water through the exchange program, customers reusing graywater at home will produce little if any net benefit in meeting Utilities' overall water needs. This is due to the fact that any reduction in demand resulting from graywater reuse is offset by an equal reduction in the supply of reusable water available as reusable return flows.

[1] One acre-foot of water meets the needs of 2-3 families in Colorado Springs for one year.

Rainwater harvesting involves capturing rainwater on an individual residential property for onsite use. Until recently, rainwater harvesting was not allowed under Colorado water law. During the course of the IWRP, rainwater harvesting was legalized in Colorado for single family residential use. However, because of the small amount of estimated water savings, the semi-arid climate in Colorado, and the limited number of customers expected to participate, the savings from rainwater harvesting are nominal. Even so, one main benefit of rainwater harvesting is customer education and awareness as to the value of water.

Due to the small benefits and the uncertainties regarding the extent of future customer adoption, graywater use and rainwater harvesting were not considered as significant future sources of supply, and were not explicitly included in the analysis.

6.5 Colorado River Basin Supplies

Existing Colorado River Basin (CRB) supplies are a critical component of Utilities' current water supply portfolio. As several of our existing systems were constructed in a phased manner, there are portions of some of these systems yet to be completed, and there is potential to develop more water from this basin with the completion of these projects. Colorado Springs already holds relatively senior water rights for these projects.

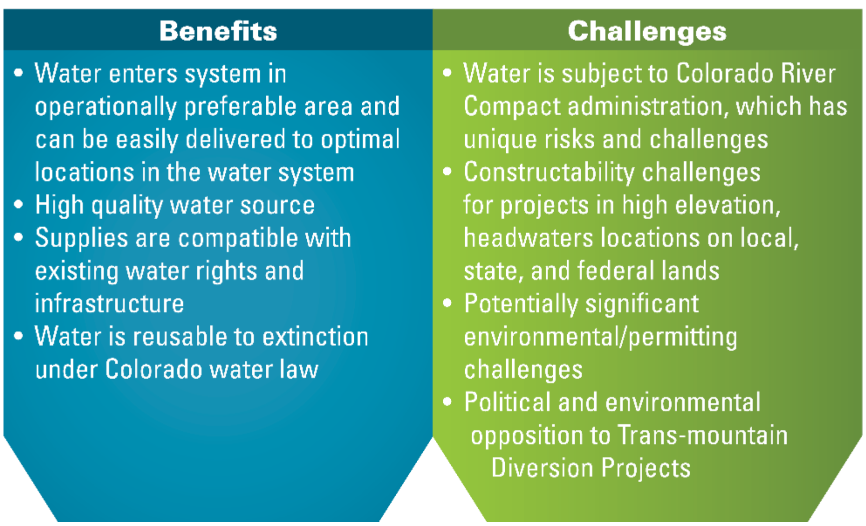


Figure 6-4. Colorado River Basin Supply Benefits and Challenges

Through first use, the CRB provides about 50 percent of Colorado Springs' water supply. When reuse and exchange are considered, the CRB typically accounts for around 70 percent of Colorado Springs' water supply. Utilities has been considering additional CRB projects for several years and owns CRB water rights that are currently undeveloped. Although Utilities has no plans to seek any new, large CRB projects, continued development and completion of existing CRB projects are already in the planning and permitting stages and will be pursued. These projects will have the benefits and challenges as shown in **Figure 6-4**.

Statewide planning efforts, including the Statewide Water Supply Initiative (SWSI) studies, Basin Implementation Plans (BIPs), and the Colorado Water Plan (CWP) recognize that responsible development of Colorado River supplies is an integral part of State water planning and an important option for meeting Colorado's water supply gap. Two of Colorado Springs proposed projects, the ERMOU Project and Montgomery Reservoir Enlargement Project, are included in these statewide planning documents as Identified Projects and Processes (IP&P's). This is an explicit recognition of these projects as being important to meeting the statewide water supply gap.

6.6 Agricultural Transfers

Agricultural to municipal water transfers to meet future water supply needs for Utilities would occur in the Arkansas River Basin and could take many forms, ranging from permanent acquisitions to a leasing program, with a continuum of hybrid options between these two bookends. Temporary water transfers, referred to as alternative transfer methods or "ATMs" in the Colorado Water Plan, involve any agricultural to municipal water transfer that does not result in a permanent transfer of water rights or assets from an agricultural owner to a municipal water provider. Leasing/fallowing is an agricultural transfer for which agricultural lands are fallowed on a temporary basis and the water that would otherwise be consumed by crops is transferred to another water user on an intermittent basis, typically through a lease. Other options include deficit irrigation, co-ownership of rights, and conservation easements.

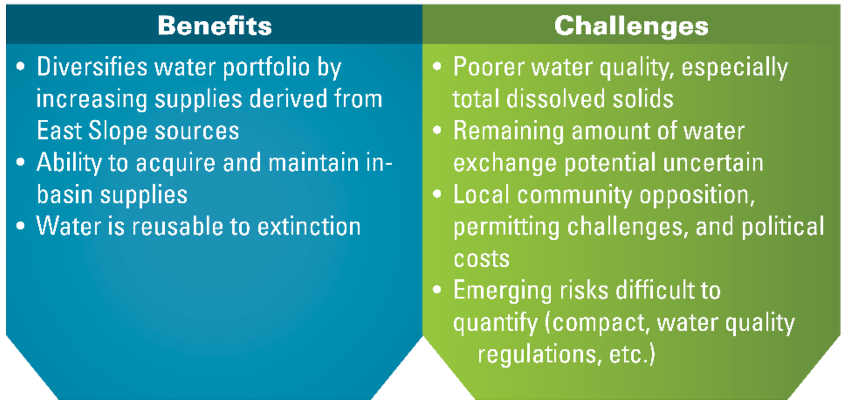


Figure 6-5. Agricultural Transfer Benefits and Challenges

Water from new agricultural transfers could be conveyed to the Utilities' service area by exchange to existing conveyance systems subject to existing and potentially modified permitting conditions (i.e., Otero Pipeline, or Fountain Valley Authority Pipeline, etc.). Benefits and challenges associated with agricultural transfers in the Arkansas River Basin are shown in **Figure 6-5**.

6.7 Increased Storage

Storage Options for Utilities system can be categorized as terminal, regulatory, and return flow storage. Terminal storage is located near the demand centers and water treatment plants, and serve to manage timing and fluctuation in peak demands, both daily and seasonally. Regulatory storage is located near the collection systems and is used to manage the timing of inflows and diversions to capture large amounts of water during runoff, and make it available at other times of the year. Regulatory storage is also useful for long term carry-over or reserve storage, to manage fluctuations in yield from year to year. Finally, return flow storage is useful to recapture and manage delivery of reusable return flows for direct use or exchange.

Utilities is heavily reliant on its existing reservoir storage facilities to mitigate water system risks and manage its water supplies through the full range of hydrologic conditions and other emergencies. Utilities' water reserves in storage are particularly critical for meeting customer demands and mitigating water system risks during droughts or system outages. Generally, increasing system storage capacity would have benefits towards meeting the level of service goals related to maintaining water in storage, as described in Section 2- Planning Process. Strategies to increase storage include enlarging existing reservoirs, new traditional on and off channel reservoirs, and excavated storage, (i.e. gravel lake storage).

Benefits	Challenges
• Facilitates maximum utilization of supplies • Serves as a water savings account to protect against uncertainty & and risk • Partnering opportunities to provide benefits to multiple parties • Recreation opportunities	• Political and environmental opposition • Potentially difficult environmental and permitting challenges • Limited availability of desirable storage sites • Constructability challenges

Figure 6-6. Increased East Slope Storage Benefits and Challenges

This strategy includes only reservoirs to capture East Slope water. Storage options that capture CRB water are included under the CRB strategy. Benefits and challenges to increased East Slope storage are shown in **Figure 6-6**.

6.8 Conveyance

Conveyance projects move water from one location to another, often from remote storage and diversion facilities to local terminal storage facilities that feed a water treatment plant. The water can be either first use water or exchangeable water and can either be conveyed by pumping or gravity depending on system topography. New conveyance projects would most likely consist of some configuration of pipelines, pump stations, and related facilities. Since Utilities is not located on or near a major source of water such as a river or lake, additional conveyance projects often provide the added benefit of system redundancy in the event of an outage on another portion of Utilities' vast and complex water system. Part of the recently completed pipeline component of Phase 1 of SDS is an example of a conveyance project that delivers water and provides for partial system redundancy. In addition, new conveyance may provide access to new sources of supply by adding the ability to deliver water from locations that were previously difficult or impossible to access.

6.9 Groundwater

Two local sources of groundwater are the Denver Basin aquifers (deep bedrock aquifers) and alluvial aquifers (hydraulically connected to a stream). Denver Basin groundwater is a non-renewable resource, and is the sole source of supply for many of the small regional water providers in the Pikes Peak Region. Utilities explored groundwater resources for augmenting supplies during periods of shortage following the 2002 drought. Several wells were put into service; however, challenges with low yields, water quality, and operations made the continued use of those wells undesirable. Aquifer storage and recovery (ASR) in the Denver Basin aquifers was also explored, but was unsuccessful due to the unfavorable characteristics of the aquifers in the Colorado Springs area. Per existing policy (Resolution 233-86), Utilities is only allowed to utilize Denver Basin groundwater for emergency supplemental supply and limited nonpotable water purposes. Based on these technical and policy limitations, development of additional Denver Basin groundwater supplies was not considered for the IWRP.

Utilities has historically used alluvial groundwater for limited potable and nonpotable water purposes. Development of additional alluvial groundwater supplies is problematic because alluvial groundwater wells would be located in areas which are not operationally advantageous to Utilities, the water rights are too junior in priority to yield water, and there are growing concerns about water quality in the alluvial aquifers from which water would be withdrawn. Based on these and other factors, alluvial groundwater was not considered as a source of future supply for the IWRP.

6.10 Currently Planned Local System Improvements

Utilities is always considering ways to improve the efficiency of its local supply system. The following local system improvements are included in the current capital improvement plan and are thus part of any future water supply plan:

- Rehabilitation of the 33rd Street Pump Station
- Mesa WTP Improvements
- Pikeview to Mesa Transfer Pipeline Upgrade
- Bear Creek Intake

6.11 Watershed Management

The health and quality of watersheds directly and indirectly affects and impacts the quantity and quality of water supplies available for use. Multiple factors affect water supply, including forest health conditions, wildfire, development, recreational use, security, source water contamination, invasive species, threatened and endangered species and changing regulations. A proactive approach to managing these factors is essential in meeting Utilities' overall mission. Utilities has a robust Watershed Management Program that is designed to proactively manage watershed lands and natural resources while honoring operational needs and community values. This Program is managed by a dedicated group of professionals in the Watershed Planning Team. The main activities of the Program are described below.

6.11.1 FOREST MANAGEMENT AND WILDFIRE MITIGATION

Sound forest management reduces the risk and severity of wildfire by mitigating the amount, types and structure of forest fuels. It also serves to stabilize and recover natural areas after a wildfire has occurred. Pre-fire mitigation activities help restore forest ecosystems to more natural conditions, making them more resilient to catastrophic wildfire, insect infestations and disease. Some management techniques include forest thinning, creating large openings up to 40 acres, cutting in fuel breaks and the responsible use of prescribed fire. Post-fire mitigation is performed to stabilize areas prone to erosion and to re-establish appropriate groundcover to protect watershed health, prevent damage to water infrastructure, and avert water quality degradation.

6.11.2 WATERSHED PARTNERSHIPS

The Watershed Planning Team depends on partners in a variety of local, regional and statewide capacities, as well as private landowners to address complex issues through holistic and collaborative management.

6.11.3 INVASIVE AQUATIC SPECIES MANAGEMENT

Invasive aquatic species, such as zebra and quagga mussels, are a growing threat to Colorado water resources and water system infrastructure. To reduce the risks and potential impacts associated with invasive aquatic species, a broad based coalition of stakeholders are working collaboratively to take actions which prevent or minimize their spread. As part of this effort, Utilities assisted in the development of the Colorado State Invasive Mussel Management Plan and works with partners to implement watercraft inspection and decontamination programs to protect water supplies and infrastructure.

6.11.4 SOURCE WATER PROTECTION & OUTREACH

The Colorado Source Water Assessment and Protection (SWAP) Program is part of a national program established under The Safe Drinking Water Act and administered by Colorado Department of Public Health and Environment and the United States Environmental Protection Agency. Utilities has assessed the susceptibility of source waters and are engaged in the watershed protection planning phase of the SWAP program. Source water protection is a focus area in Utilities' watershed management plans and protection strategies have been developed for the North Slope, South Slope of Pikes Peak and Local Systems. Current plans are in development for the Blue River watershed. Source water protection assessments will be conducted for other areas of Utilities' water system as additional watershed management plans are developed.

6.11.5 RECREATION AND PUBLIC ACCESS

More than 15,200 acres of municipal watershed lands and nine reservoirs are open to recreational use. Utilities jointly manages many of the lands and reservoirs with other agencies such as the U.S. Forest Service, Colorado Parks and Wildlife, El Paso County and Colorado Springs Parks, Recreation and Cultural Services. For the past several decades, Utilities has engaged in intensive public discussion to define and implement allowable recreational uses.

Utilities' reservoirs and watersheds are a natural attraction for anglers, families, hikers, bikers and other outdoor enthusiasts. Through this strategy of Watershed Management, Utilities strive to balance operational needs, environmental stewardship and recreational uses; providing clean, reliable drinking water is the first priority. As this strategy underlies all of Utilities' activities, it is assumed to be embedded in all future plans, activities, and operations to assure reliable supplies into the future.

SECTION 7
Future Water Resources Options

7.1 Approach to Option Identification and Definition

There are many options for implementing future water supply strategies. However, all the "easy" projects have been built.

This section describes the future water supply options evaluated in the IWRP. Water Supply Options (Options[2]) are projects, programs, and policies that can be implemented to address future water supply concerns. These options were identified based on previous assessments of potential water supply conducted by Utilities staff, previous technical studies, and input from the IWRP Technical Team.

Options are the specific methods by which the future water supply strategies, described in Section 6-Future Water Resources Strategies could be implemented. The options described in this section were evaluated and compared using the criteria described in Section 8-Evaluation of Options, and then combined into potential water supply portfolios as described in Section 9-Development and Evaluation of Portfolios. Specific options and a range of sizes assumed for each are described briefly below, and in more detail in *TM #18 – Lever Descriptions*. Some options were identified by the IWRP Technical Team, but were screened out prior to analyses because of technical/political infeasibility, the availability of another similar/better option, or because the anticipated benefit associated with it is small, i.e. below the level of precision of the planning model. **Figure 7-1** is a map of the main infrastructure options.

The various demand management, nonpotable and reuse, new supply, storage, and conveyance options identified below were all analyzed, in some level of detail, as part of the IWRP process. Given the long-term nature of the planning process, the types of risks and uncertainties identified, and the estimated Buildout demand, it is expected that not all of the options will be actively pursued or implemented, or remain in the form as described herein. This is true even though they may appear, today, to be technically and economically feasible. Option selection will be an iterative process occurring into the future, and will take into consideration all of those factors identified in this initial analysis. Option selection will include the political, environmental, social and financial acceptability of the alternatives at the time of consideration. Both internal and external outreach efforts will help inform this selection process.

[2] Options are alternately referred to as Levers in supporting technical memo's and reports.

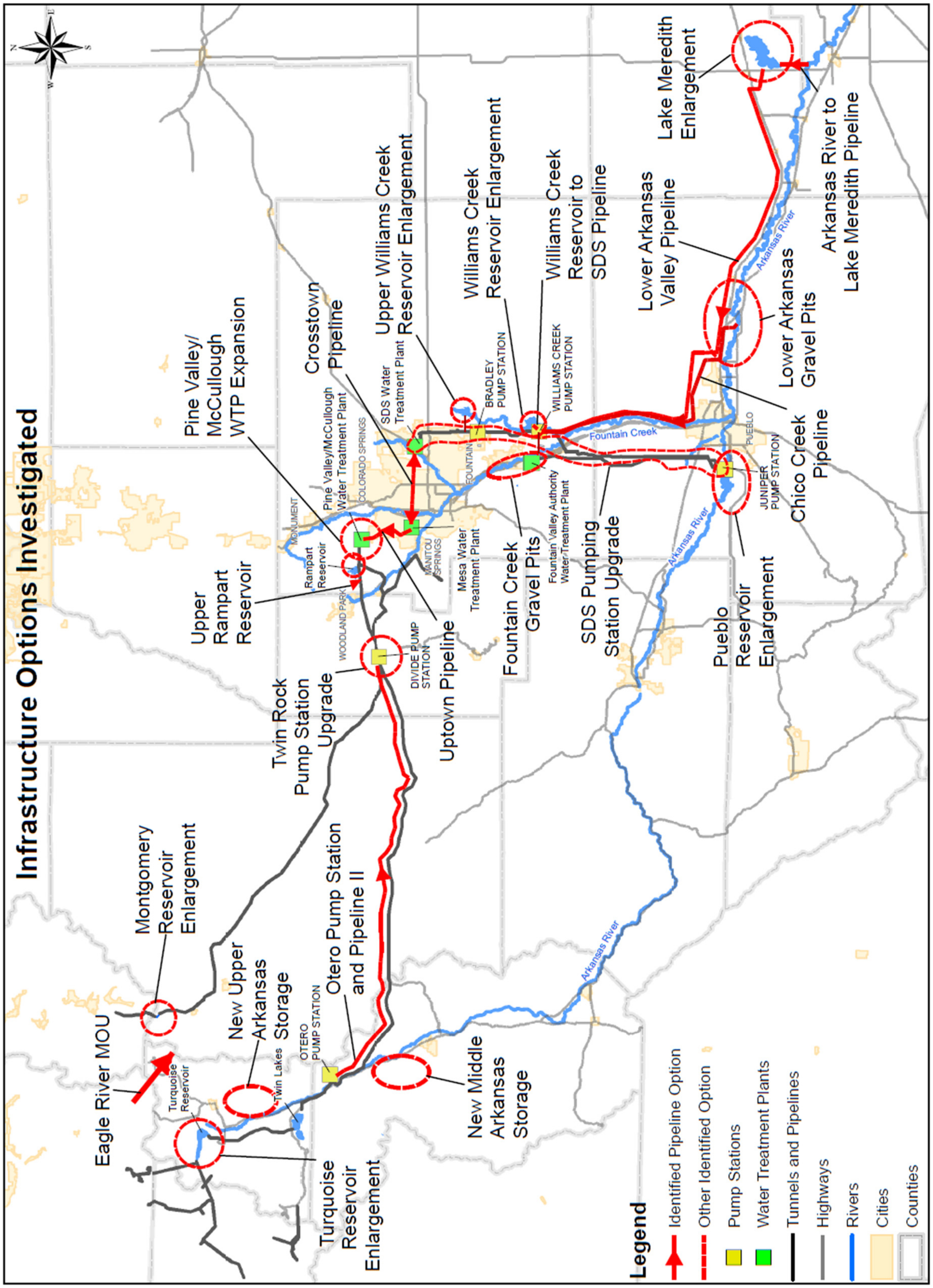


Figure 7-1. Map of Selected Infrastructure Options

7.2 Demand Management Options

Demand Management I: Demand management program that consists of additional measures similar to those currently being implemented, such as rebates, education, and tiered water pricing. This program reduces demand by approximately 2% at Buildout compared to only implementing the current Demand Management program.

Demand Management II: In addition to implementing the strategies in Demand Management I, this option implements more aggressive indoor and outdoor water efficiency incentives, as well significant investment in distribution system water loss reduction. This program reduced demand by approximately 7% at Buildout compared to only implementing the current Demand Management program.

Demand Management III: In addition to implementing the strategies in Demand Management I and II, this option implements more aggressive outdoor water efficiency incentives, as well as outdoor landscaping standards for new construction. This program is estimated to reduce demand by approximately 10% at Buildout compared to only implementing the current Demand Management program.

While individual demand management scenarios were developed for planning purposes, Utilities will ultimately seek some combination of measures that are financially sound, grounded and consistent with community values. For the purposes of the IWRP, ranges of percentage savings based on the above were used.

7.3 Reuse and Nonpotable Supply Options

Indirect Potable Reuse: New pipeline to transfer water from Fountain Creek return flow storage to the new SDS Bailey Water Treatment Plant (Bailey WTP) (assuming adequate blending water is available to meet treatment requirements at the Bailey WTP).

Indirect Potable Reuse with Additional Treatment: New pipeline to transfer water from Fountain Creek return flow storage to the Bailey WTP with additional treatment (assuming available blending water is not adequate to meet treatment requirements at the Bailey WTP).

Direct Potable Reuse: Advanced treatment of water at Las Vegas Street Wastewater Treatment Plant and J.D. Phillips Wastewater Treatment plant to drinking water standards, then pumping directly to either Mesa WTP or Bailey WTP for further treatment and delivery to the distribution system.

Optimized Nonpotable System – Expansion of the nonpotable system to the largest possible size without reducing the amount of return flows available for exchange. This represents a maximum increase of about 2,500 ac-ft/yr over the current nonpotable system capacity. Nonpotable water could be supplied from raw water sources (surface or ground water) or from treated wastewater.

Dual Nonpotable Distribution System – Strategic Deployment: Installation of a dual nonpotable system, but only in areas where feasible, both strategically and financially (e.g., to "anchor customers" like such as large parks or golf courses, and installed concurrent with development).

7.4 New Supply – Colorado River Options

Eagle River Memorandum of Understanding (MOU): Proposed system of new West Slope reservoir(s), diversions and pump stations to deliver decreed Colorado River Basin water from the Eagle River and its tributaries to the existing Homestake system. Currently, this project is envisioned as a joint-use project between Colorado Springs, Aurora, and West Slope partners and is seen as a replacement for the previously planned Homestake II Project. The assumed average annual yield of this project for Utilities is 10,000 ac-ft/yr. The ERMOU is an IP&P as discussed in section 6.5.

Transmountain Ditch Rights: Acquisition of West Slope ditch rights from East Slope or West Slope owners. It is assumed that Utilities would either acquire a portion all of an existing transmountain diversion system, or that transmountain water rights would be acquired in locations where they could be conveyed to existing Homestake, Fry-Ark, Twin Lakes, or Blue River collection and storage systems, such that new transmountain diversion facilities would not be needed. The average annual yield of these rights is assumed to be between 500 ac-ft/yr and 2,500 ac-ft/yr.

Montgomery Reservoir Enlargement: Enlargement of existing Montgomery Reservoir to provide Utilities with additional storage for water yielded under Utilities' Blue River and South Platte water rights. The enlargement size can be between 2,000 ac-ft and 7,000 ac-ft. The Montgomery Enlargement Project is an IP&P as discussed in section 6.5.

7.5 New Supply – Agricultural Transfer Options

Lower Arkansas Water Leases for Base Supply: Uses Lower Arkansas Basin agricultural water leases or interruptible supply agreements to provide an additional source of base supply in every year. It is assumed that such agreements may need to be executed with willing ditch companies instead of or in addition to individual farmers to gain access to sufficient water supplies and to comply with ditch company bylaws. The average annual yield of these collective leases is assumed to be between 5,000 ac-ft/yr and 30,000 ac-ft/yr.

Lower Arkansas Water Leases for Drought Response: Uses Lower Arkansas Basin agricultural water leases or interruptible supply agreements as an additional source of supply during droughts. The frequency of deliveries under the lease agreements is assumed to be three years out of ten, though the leasing arrangement would extend in-perpetuity. Agricultural water users would retain ownership of their water rights and would have access to their water in years when it is not called for by Utilities. The average annual yield of these leases is assumed to be between 500 ac-ft/yr and 3,000 ac-ft/yr.

Lower Arkansas Water Leases for Drought Recovery: Same as leasing for drought response, but in this option, leasing would occur in the years following droughts to refill reservoir storage accounts. The average annual yield of these leases is assumed to be between 5,000 ac-ft/yr and 20,000 ac-ft/yr.

Lower Arkansas Water Rights Purchases: Purchase of lower Arkansas Basin agricultural rights from willing sellers and converting them to annual municipal base supply. The average annual yield of these water rights is assumed to be between 5,000 ac-ft/yr and 30,000 ac-ft/yr.

Upper Arkansas Water Rights Purchases: Purchase of upper Arkansas Basin agricultural rights from willing sellers and converting them to annual municipal base supply. The average annual yield of these water rights is assumed to be between 500 ac-ft/yr and 2,500 ac-ft/yr.

7.6 Storage Options

7.6.1 NEW RESERVOIRS

Lower Williams Creek Reservoir – New reservoir planned in SDS Phase II of 25,000 ac-ft to store reusable return flows and additional Colorado Springs return flows diverted from Fountain Creek.

Lower Williams Creek Reservoir Enlargement: Enlargement of the proposed Lower Williams Creek Reservoir to greater than 25,000 ac-ft. The size of this expansion can be between 5,000 ac-ft and 25,000 ac-ft.

Upper Williams Creek Reservoir – Terminal storage reservoir planned in SDS Phase II that would store water for subsequent delivery to the SDS water treatment plant. The reservoir size is 28,000 ac-ft.

Upper Williams Creek Reservoir Enlargement: Expansion of the proposed Upper Williams Creek Reservoir to greater than 28,000 ac-ft. The size of this expansion can be between 5,000 ac-ft and 30,000 ac-ft.

Upper Rampart Reservoir: Construct a new reservoir immediately upstream of existing Rampart Reservoir, a key terminal storage reservoir in Utilities' system that receives transmountain and Upper Arkansas Basin water from the Otero Pump Station and Pipeline system. The size of this reservoir can be between 5,000 ac-ft and 15,000 ac-ft. Upper Rampart Reservoir would serve a function similar to that of existing Rampart Reservoir.

New Middle Arkansas Basin Storage: New off channel reservoir storage in the Arkansas River Basin upstream of Pueblo Reservoir and downstream of Twin Lakes Reservoir. The additional storage could be created by a new traditional dam(s) or gravel pit complex. The total size of this storage can be between 10,000 ac-ft and 75,000 ac-ft.

New Upper Arkansas Basin Storage: New off channel reservoir storage in the upper Arkansas River Basin, upstream of the Twin Lakes area. It is assumed that the additional storage would be created by a new dam(s) and reservoir(s). The total size of this storage can be between 10,000 ac-ft and 50,000 ac-ft.

7.6.2 ENLARGEMENTS OF EXISTING RESERVOIRS

Turquoise Reservoir Enlargement: Enlargement of Turquoise Reservoir would provide increased storage capacity for Utilities and improve the ability to store transmountain water, which could improve operational flexibility for the Fry-Ark Project and Homestake projects. The size of this enlargement can be between 12,000 ac-ft and 20,000 ac-ft.

Pueblo Reservoir Enlargement: Enlargement of Pueblo Reservoir would increase storage capacity for Utilities, improve operational flexibility for the SDS and FVA systems that draw water from the reservoir.

It would also improve the ability to operate lower Arkansas River and upper Arkansas River exchanges, and increase the potential for long-term excess capacity contract storage. The size of this enlargement can be between 25,000 ac-ft and 75,000 ac-ft, however Utilities' allocation of space would be less than the total size of enlargement.

Lake Meredith Enlargement for Return Flow Storage: Enlargement of existing Lake Meredith would provide additional storage of Utilities' return flows. This additional storage capacity would potentially improve Utilities' ability to exchange return flows to Pueblo Reservoir for diversion to the FVA or SDS pipelines, or to Twin Lakes. The size of this enlargement can be between 15,000 ac-ft and 75,000 ac-ft.

7.6.3 GRAVEL PIT STORAGE

Fountain Creek Gravel Pits: Storage for return flows in gravel pits located along Fountain Creek. Gravel pit storage would serve the same return flow storage function as Williams Creek Reservoir and enlargement. The cumulative size of these gravel pits can be between 5,000 ac-ft and 20,000 ac-ft.

Lower Arkansas Basin Gravel Pits: Storage along the lower Arkansas River downstream of the Fountain Creek/Arkansas River confluence. Used to facilitate the use of Lower Arkansas River leases or purchases. The cumulative size of these gravel pits can be between 5,000 ac-ft and 20,000 ac-ft.

7.7 Conveyance Options

7.7.1 DELIVERY PIPELINES

These Options would add new delivery capacity to the water supply system, and increase the total amount of water that could be delivered.

Pipeline from the Arkansas River below Fountain Creek to SDS System (Chico Creek Pipeline): This pipeline would convey Utilities' reusable return flows or other Lower Arkansas supplies to the Utilities' service area, with the assumed intake point on the Arkansas River near the Chico Creek confluence and outtake at SDS Williams Creek Pump Station. The size of this pipeline can be between 10 MGD and 78 MGD.

SDS Expansion to Current Permitted Capacity: Upgrade SDS conveyance capacity to 78 MGD.

SDS Pumping Capacity Upgrade: Upgrade pumping capacity of SDS pipeline from Pueblo Reservoir to 100 MGD.

Lower Arkansas Valley Pipeline: Pipeline from Lake Meredith to the SDS pipeline that would convey reusable return flows and other water (leased, purchased, etc.) stored in Lake Meredith directly to the SDS system for delivery to the Utilities service area. The size of this pipeline can be between 10 MGD and 78 MGD.

Otero Pump Station and Pipeline II: Expand Otero Pump Station capacity and construct a new pipeline parallel to the existing Otero Pipeline to convey flows from the Upper Arkansas River to Utilities terminal storage in Rampart Reservoir. The size of this pipeline can be between 10 MGD and 68 MGD.

Pikeview to Mesa WTP Transfer Upgrade: Increase the capacity of the pipeline that transfers water from Pikeview Reservoir to the Mesa WTP from 6 MGD.

Twin Rock Pump Station Upgrade: Upgrade the Twin Rock Pump Station to improve its ability to transfer water to either the North Slope Reservoirs for subsequent delivery to the Mesa WTP, or to Rampart Reservoir for subsequent delivery to the Pine Valley/McCullough WTP. The pump station takes water from the Homestake Pipeline and the Blue River Pipeline and directs it to either Rampart Reservoir or the Local System. The size of this upgrade is 10 MGD.

Pipeline from Williams Creek Reservoir/Fountain Creek Return Flow Storage to SDS: A new conveyance pipeline from return flow storage to the SDS raw water system for treatment and IPR. This assumes either Williams Creek Reservoir or Fountain Creek Return Flow Gravel Pits have been constructed and that stored return flows would be blended with water in the SDS system prior to treatment at the Bailey WTP. The size of this pipeline can be between 10 MGD and 78 MGD.

7.7.2 REDUNDANCY PIPELINES

These Options would provide redundant delivery capacity to existing conveyance to improve flexibility and efficiency of delivery, but would not increase the overall amount of conveyance capacity

Crosstown Pipeline (Mesa WTP to SDS WTP) – Full Redundancy: Two bi-directional pipelines between the Mesa WTP and the Bailey WTPs, one for treated water and the other for raw water. This would allow conveyance of water in either direction between the Bailey WTP and the Mesa WTPs. The size of these pipelines can be between 20 MGD and 100 MGD each.

Crosstown Pipeline (Mesa WTP to SDS WTP) – Partial Redundancy: One bi-directional pipeline between the Mesa WTP and the Bailey WTPs. It would be able to deliver raw water from the Mesa WTP to the Bailey WTP, and or finished water from the Bailey WTP to the Mesa WTP. This option would provide only partial redundancy and operational flexibility compared to the full redundancy option, but would be less expensive. The size of these pipelines can be between 20 MGD and 100 MGD each.

Uptown Pipeline (Mesa WTP to Pine Valley and McCullough WTP) – Full Redundancy: Pair of bi-directional pipelines between the Mesa WTP and the Pine Valley/McCullough WTP. This would allow conveyance of finished water in either direction between the Mesa WTP and the Pine Valley/McCullough WTP, and similarly concurrent conveyance of raw water in either direction. The size of these pipelines can be between 20 MGD and 100 MGD each.

Arkansas River to Lake Meredith Pipeline: A pipeline from the Arkansas River to Lake Meredith to convey Utilities' return flows to storage. Return flows are currently conveyed in the Colorado Canal from the headgate to Lake Meredith. This option is an alternative to lining the Colorado Canal to reduce significant conveyance losses. The size of this pipeline is 50 MGD.

Rampart Reservoir Bypass: A bypass conveyance system for Rampart Reservoir. This would convey water around the reservoir to the downstream delivery system in the event of an outage such as an outlet works failure. The size of this pipeline can be between 10 MGD and 78 MGD.

7.8 Other Options

Mesa Water Treatment Plant Upgrades: Modification of the Mesa WTP to be able to treat high fluoride source water, or other difficult to treat sources, to allow more full use of local supplies.

Pine Valley/McCullough Water Treatment Plant Upgrades: Expansion of the McCullough WTP portion of the Pine Valley/McCullough WTP complex, increasing the ability to meet demands on the north end of Utilities' service territory and feed more water into lower pressure zones without pumping. The size of this expansion is between 10 MGD and 75 MGD total.

Bear Creek Intake Relocation: Construction of a new Bear Creek Intake to improve the ability to capture water that is legally and physically available to be diverted by Utilities.

7.9 Options Screened Out

The following options were screened out prior to analysis for various reasons including:

- Significant technical, political, economic, or environmental feasibility issues exist
- A better alternative option exists
- Anticipated benefits to the water system small relative to the precision of the analysis
- There is high uncertainty about what the option configuration would be and/or how to appropriately analyze its impacts
- The option is already considered or included as part of the analysis in some other way

7.9.1 STORAGE

Jimmy Camp Creek Reservoir: Originally proposed in the SDS EIS, but was eliminated in favor of Upper Williams Creek Reservoir.

New Storage at 33rd Street Diversion: This storage option would allow management of volume, and timing issues, and sedimentation problems that have been experienced at the existing 33rd Street Diversion/Pump Station.

Gold Camp and South Suburban Reservoir Enlargement: Enlargement of existing Gold Camp and South Suburban Reservoirs would capture more local runoff water from North and South Cheyenne Creeks and the Rosemont system.

Pikeview Reservoir Enlargement: Enlargement of existing Pikeview Reservoir would capture more local water from Monument Creek.

7.9.2 CONVEYANCE

Otero River Intake Repair: Repair a currently non-functioning intake to the Otero Pump Station that would allow water to be exchanged directly to it. Work on this project began during the IWRP process; therefore it was removed as an option from the IWRP analysis, but included as part of the existing system.

7.9.3 COLORADO RIVER

Northern Supply Source: Additional West Slope water supply from an undetermined source from north of Colorado Springs. For purposes of the IWRP, this option was assumed to be a regional or state-wide project, such as the Flaming Gorge Pipeline Project.

Gunnison Basin Pumpback Project: New storage and delivery system from the Gunnison River Basin on the West Slope to deliver additional water to the East Slope.

Proactive Drought Response in Upper Colorado River Basin by East Slope Municipal Water Users: Proactive, temporary, and voluntary reduction of water imports from the Colorado River Basin to prevent a Colorado River Compact Curtailment. (A similar condition was assumed to be involuntarily imposed and applied as a risk in the Portfolio Development analysis described in section 9.1)

Colorado River Water Bank: Participation in a cooperative water banking operation on the West Slope to make senior agricultural water available to junior East Slope municipalities as mitigation for reduced Colorado River Basin yields.

New West Slope Reservoir: New reservoir storage project on the West Slope shared with other Front Range water providers in which Utilities would have a fixed share of the storage space that it could operate as necessary.

Ruedi Pumpback Project: State or Southeastern Colorado Water Conservancy District led project consisting of a new pipeline and associated facilities to capture Colorado River water in Ruedi Reservoir and then pump it to the Continental Divide.

7.9.4 OTHER OPTIONS

Denver Basin Groundwater Wells: Development of Denver Basin groundwater as a source of supply, which is currently not used by Utilities.

Denver Basin Groundwater Wells as Drought Supply: Development of Denver Basin groundwater as a source of supplemental supply during periods of droughts.

Rainwater Harvesting: Rainwater harvesting by Utilities' residential customers (recently approved under State law) as a nonpotable water source.

Graywater Use: Use of graywater by Utilities' customers as source of nonpotable water for onsite water uses.

Cloud Seeding: Program for cloud seeding to increase production of snowpack over Utilities' source watersheds. Currently an ongoing project where Utilities provides financial support in conjunction with other stakeholders in the Upper and Lower Colorado River basin.

Expanded Shortage Response Policy: Expanded or enhanced shortage response policy that would achieve greater waters savings during periods of watering restrictions, or would trigger shortage response measures at different times.

Dual Nonpotable Distribution System: Creation of a dual potable and nonpotable water distribution system in all areas of new development and an extension of the current nonpotable water system to all portions of currently developed service territory.

These options are described more fully in *TM #18 – Lever Descriptions*, which includes more detail on the configurations for all potential IWRP options.

SECTION 8

Evaluation of Options

8.1 Introduction

This section describes the process used to evaluate water supply options considered. Quantifiably evaluating options provides an objective basis for comparing their relative merits when creating water supply portfolios. The evaluation process consisted of preparing high level, life cycle cost estimates and conducting a multi-criteria assessment for each option, including criteria for technical, economic, environmental, and social factors.

All options were evaluated using technical, environmental, social, and economic criteria.

8.2 Cost Analysis

8.2.1 CAPITAL COST ESTIMATES

Capital cost estimates were developed for each of the options remaining after the results of the initial screening. The conceptual level cost estimates were prepared based on the best available information regarding the major project components (e.g., dam, pipeline, pump station). In some cases, conceptual designs existed and costs were available from those previous studies and were used. In other cases, a conceptual project definition and cost estimates had to be prepared using unit costs derived from other studies. In estimating costs, the accuracy of the cost estimates can vary depending on the level of detail of study, planning, and design associated with the project. For the sake of the IWRP, all costs should be considered as high level, preliminary costs, or Conceptual level cost estimates, and are subject to further refinement with additional study and design work. The Conceptual level cost estimates developed for use in the IWRP are considered Class V estimates based on the criteria promulgated by the Association for the Advancement of Cost Engineering International. Expected accuracy ranges are from –50% on the low side to +100% on the high side, depending on technological complexity of the project, appropriate reference information, and the level of contingency.

8.2.2 LIFE-CYCLE COST ESTIMATES

In addition to the capital costs of options developed, annual O&M costs were also estimated. O&M costs are those standard costs that are required for physically maintaining project facilities as well as the costs to operate the overall facility. O&M costs for the options were calculated as percentages of capital cost, plus where applicable, annual energy costs associated with supplying energy to pump stations and WTPs based on estimated flows.

Evaluation of total life-cycle costs for options required determination of the present worth of capital expenditures and the present worth of annual costs for O&M and energy. Present worth values of operation and maintenance (O&M) and energy costs were separately calculated and escalated for inflation over the project life span (assumed to be 50 years for all projects and programs) using an interest rate of 5 percent.

8.2.3 OPTION COST ESTIMATES

Estimates of capital and life-cycle costs for Options were prepared with lower/upper cost bounds corresponding to the lower/upper size bound of the option size (if applicable). These cost estimates were used to select Options that provide the best performance (see Section 9) at the most reasonable cost. Cost was also an important factor in the overall portfolio analysis. A cost filtering approach was applied to the relatively small number of portfolios that met the level of service and performance criteria and were determined to be technically feasible to implement. Details regarding how cost was considered during the portfolio selection process can be found in *TM # 21 – Portfolio Development and Evaluation.* Details of the cost analysis, methodologies, assumptions, unit costs, etc. used to develop conceptual level cost estimates are available in *TM # 20 – Lever Cost Estimates*.

8.3 Multi-Criteria Assessment

A key component was an evaluation of potential options using technical, environmental, social, and economic criteria. The purpose of the evaluation was to develop scores and ranks for the options that could be used when assessing water supply portfolios. Option evaluations were conducted by the IWRP Water Planning Advisory Group (WPAG) (the citizens' advisory group) and the Technical Team (Utilities' subject matter experts). The option evaluation approach employed a multi-criteria analysis, with weighted scores for each option derived from detailed input by each group. The two groups developed option scores independently based on their own knowledge, values, and understanding of issues.

The WPAG and Technical Team selected four categories for option evaluation criteria: the three triple bottom line categories of economic, environment, and social criteria, plus a technical category based on the analyses performed for option performance (i.e., from the modeling analysis). Twenty specific criteria were selected in these categories, as shown in **Figure 8-1**. The WPAG and Technical Team then independently scored each option for each criterion. The Technical Team performed an evaluation and sensitivity exercise for the previously described categories. Due to the wide diversity of issues and options considered, and relative insensitivity to weighing, each of the four categories were assigned equal weight. Finally, the total score was calculated by each group as the sum of the scores for all the criteria.

Technical Criteria
- Improved Water Supply
- Robustness
- Phasable and Timeliness
- Potential Risk
- Dependence on Other Projects
- Water Quality

Economic Criteria
- Life-Cycle Cost
- Cost Uncertainty
- Revenue Impact

Environmental Criteria
- Federal Permitting
- State/Local Permitting
- Geographic Footprint
- Watershed Impacts
- Wildlife Impacts

Social Criteria
- Regional Benefits
- Impacts on Agriculture
- Impacts on Other Water Users
- Political Complexity
- Socioeconomic Impact
- Recreation

Figure 8-1. Criteria Used to Evaluate Options

The scores were reviewed and adjusted to reconcile any significant differences based on further discussion and professional judgment. The scores were then carried forward for use in the portfolio assembly process. In general, higher scoring options were the demand management programs, already permitted projects, enlargements to existing reservoirs, and improvements to existing facilities. Lower scoring options were new West Slope projects (supply and storage), large new reservoirs, and large new conveyance systems.

Option scores, as well as the details of the entire option evaluation process, are available in *TM #19 – Lever Evaluations*.

SECTION 9

Development and Evaluation of Portfolios

9.1 Analysis and Modeling Assumptions

A flexible, balanced portfolio will meet Utilities' level of service goals across a broad range of possible conditions at Buildout.

The final step of the IWRP technical analysis was to develop portfolios of projects to meet the level of service goals at Buildout. To define the future conditions at Buildout for purposes of portfolio development, Utilities reviewed its recent history. In 2002, Utilities experienced a combination of system stresses: a severe drought, an unfavorable Blue River decree administrative action, an Otero Pump Station outage, and reduced reservoir storage at Pueblo Reservoir due to safety of dam maintenance work. Utilities staff and management realized that multiple significant system impacts can occur at once and therefore wanted to select portfolios accounting for similar potential situations at Buildout. Using results from the climate, hydrology, and system risk as well as past experience, Utilities developed the future for Buildout portfolio selection described in Table 9-1.

Table 9-1. Buildout Assumptions for Portfolio Development

Buildout Future Summary	
Hydrology	180 years of simulation with a variety of droughts, including those more severe than the historical record
Climate	3°F warmer climate (consistent with recently observed temperature trends of 1°F warming per decade) No change in mean precipitation
System Risks	One year Otero Pump Station/Pipeline outage due to infrastructure failure, maintenance requirements, or natural disaster impacts (wildfire, landslide, etc.). Shortages in the Colorado River Basin result in: 20 percent reduction in all West Slope yields for a 10-year period 25 percent reduction in all exchange potential during same period (resulting from reduced flows on the Arkansas River due to reduced overall transmountain water imports by Utilities and others)

9.2 Development of Buildout Portfolios

9.2.1 MODELING ANALYSIS

A challenge for the modeling component of this analysis was the large number of potential portfolios to evaluate. As detailed in Section 7-Future Water Resources Options, Utilities had identified over 40 potential options, many with variable sizes and configurations. A state-of-the-art Multi-Objective Evolutionary Algorithm (MOEA) was used to help evaluate the tradeoffs between competing objectives such as maximizing system performance metrics and minimizing the amount of projects that Utilities would have to build in the future. The MOEA is a computer tool that automatically assembles a portfolio of options, runs the water supply planning model with those options across the Buildout future described above, and processes the resulting metrics to determine how well the portfolio performed as compared to others. This process was repeated thousands of times, generating a set of portfolios that represented the better options available to Utilities.

Several of these multi-objective optimization runs were completed, and in total tens of thousands of possible project combinations were evaluated. Utilities went through a portfolio identification process to showcase how several different strategies could meet the same desired level of level of service. Utilities then investigated model results and filtered portfolio results using professional judgment to reflect non-technical attributes, such as triple bottom line criteria and operational difficulties. Utilities did not take results as the final answer, but considered many additional factors and rigorously questioned and investigated model output.

9.2.2 LEVEL OF SERVICE GOAL DEVELOPMENT

Part of the Buildout Portfolio analysis involved developing recommended level of service performance goals. To accomplish this, Utilities looked at setting different level of service goals when selecting Buildout portfolios and then further evaluating the resulting portfolios. As a starting point for level of service goals, Utilities utilized prior planning criteria, such as the existing Water Shortage Ordinance (WSO) that requires analysis/recommendations if storage is projected to fall below 1.5 YOD and a past unofficial policy planning goal to always keep storage above 1.0 YOD. The 1.0 YOD storage level is used as a reserve to help protect against unforeseen or worse than anticipated circumstances or events. Historically, Colorado Springs has imposed the shortage response measure of mandatory watering restrictions 9 out of the last 60 years, which corresponds to 85% reliability.

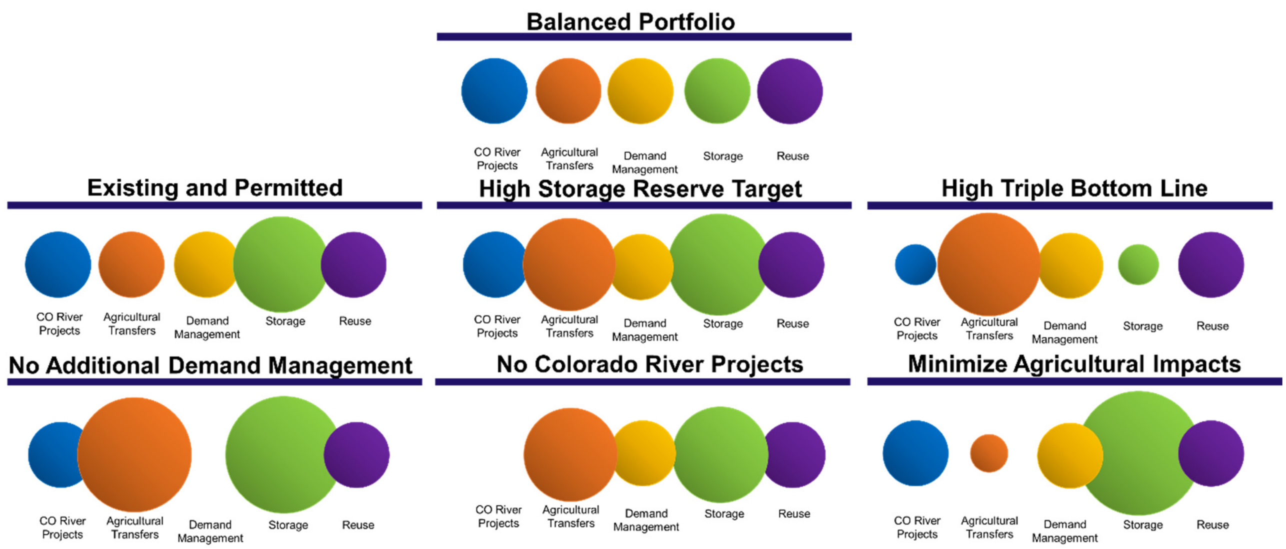
The target reliability that portfolios would have around these two storage levels was then varied in the analysis. Ultimately, Utilities found the two level of service goals of 1) meeting the 1.5 YOD threshold at a 90 percent reliability level while 2) maintaining the 1.0 YOD threshold at 100 percent reliability, as appropriately balancing risk with project development, and ultimately cost. All portfolios that were carried forward in the Buildout Portfolio analysis met these level of service goals. The portfolios that did not meet these level of service criteria were removed from further consideration in the Buildout Portfolio analysis.

9.2.3 TECHNICAL AND STAKEHOLDER INPUT

Through a combination of rigorous technical analysis by Utilities, WPAG, and other stakeholder input, several portfolios themes were developed, as shown in **Figure 9-1**. In this figure, each colored circle represents a different major water resources strategy as described in Section 6-Future Water Resources Strategies (with the exception of the Groundwater strategy, which was screened out). For the sake of presentation, the Balanced Portfolio was selected as a baseline for comparison, and the size of each of the colored circles in the other portfolios corresponds to the relative contribution of that strategy to the amount contained in the Balanced Portfolio. Portfolio themes were essentially bookends that were developed for testing policy questions and exploring options under different planning goals (e.g., no additional Colorado River Basin supplies, or maximize the triple bottom line score of the water supply options comprising the portfolio).

In addition to these themed portfolios, a portfolio that best represents a sound balance between the five major water resource strategies was selected and is described in greater detail in Section 9-Development and Evaluation of Portfolios. These portfolios demonstrate there are many ways to meet level of service goals at Buildout, and show that doing less of one type of project means doing more of another. All portfolios contain difficult projects, are expensive, and pose many political, environmental, and social challenges.

One unanticipated result of this analysis was that traditional conveyance projects were not included in any of the selected water supply portfolios. Conveyance projects that would increase deliveries from source water areas such as the lower Arkansas River Basin (e.g., Chico Creek Pipeline) were found to be inferior to other options based on cost and triple bottom line score. Conveyance projects that would improve the ability to move water between different parts of Utilities' treatment and distribution system (e.g., Crosstown Pipeline) would provide redundancy benefits but would not significantly improve system performance for the Buildout conditions selected for portfolio development. Thus the analysis shows that from a water supply point of view, the water system is not significantly conveyance limited. This is not surprising given the recent completion of a major conveyance project, the SDS pipeline. As a result, no traditional conveyance options were carried forward to the portfolio development phase. However, further study and assessment of benefits and drawbacks of redundancy conveyance should be analyzed in post-IWRP planning studies.



Note: Sizes of circles represent the contribution of the water resources strategy in the portfolio relative to the Balanced Portfolio.

Figure 9-1. Portfolio Strategies Based on Themes

9.3 Robustness Analysis for Buildout Portfolios

The Buildout portfolios in the previous section were selected based on their performance against a representative set of system stresses. However, because the future at Buildout is uncertain, it was important to evaluate the performance of the various Buildout portfolios across a variety of many possible futures conditions in addition to the one outlined in Section 9.1-Analysis and Modeling Assumptions. These alternate futures were used to (i) evaluate how robust the Buildout portfolios were by determining if they continued to meet level of service goals across a variety of these futures and (ii) identify if one portfolio consistently performed better than the others. This robustness analysis was the last major piece of the Robust Decision Making process used for the IWRP.

Table 9-2 lists the future conditions evaluated in the robustness analysis:

Table 9-2. Additional Future Conditions for Robustness Analysis

Additional Risks used for Portfolio Robustness	
Hydrology	Additional hydrologic traces
Additional Climates (18 total)	0°F, +1°F, +2°F, +3°F, +4°F, and +5°F temperature increases 0%, -5%, and -10% precipitation changes
Additional System Risks (each listed was applied individually)	• Chronic 50% exchange potential reduction • 1-year outage at each of the three major water treatment plants (applied individually) due to plant failure or inflow water quality impairment • Chronic 25% reduction in Pueblo Reservoir or Local System storage capacity due to water quality problems or storage restriction due to structural issues • No Colorado Canal system storage (every year) due to water quality impairment or other factors • Colorado River Compact Curtailment with no West Slope supplies for 10 years due to unprecedented drought in the Colorado River Basin

Results from this robustness analysis showed that if the future climate is slightly warmer or slightly drier than what was assumed, or if additional system risk occurs, the Buildout portfolios are nevertheless adequately robust to meet future demands. However, the portfolios are unable to maintain the level of service performance goals for futures that are both warmer and significantly drier, or futures with an extended Colorado River curtailment. In addition, they do not protect against acute water treatment plant outages. This result was consistent across all Buildout portfolios. Finally, the Balanced Portfolio performs similar to or slightly better than the other portfolio alternatives.

9.4 Buildout Regionalization Analysis

A technical analysis of regionalization concepts at Buildout was also performed on the portfolios described above. These analyses were completed to evaluate the high-level technical feasibility of regionalization at Buildout. This analysis only considered the ability of the water system to serve regional needs on a water supply and infrastructure basis. A more detailed regionalization analysis, including consideration of broader issues such as costs, development policy, economic impacts, etc. is proposed as a post-IWRP effort. To determine the feasibility, it was assumed that a regional supply gap of around 25,000 ac-ft/yr as described in Section 4.2.5-Potential Extraterritorial Demands would be met by Utilities under two different service scenarios.

In the first part of the regionalization analysis, the available unused conveyance capacity in the system was evaluated to determine whether Utilities could facilitate the delivery of water owned by regional entities utilizing existing Utilities infrastructure. For the technical analysis, the capacity and utilization of the SDS pipeline was used as a surrogate for any existing conveyance facilities that could assist in meeting regional needs. At Buildout, there is sufficient unused capacity in the system, at least the off peak months, to deliver enough water to meet the full annual need of these regional entities, assuming storage was available to these entities in shared facilities or their own facilities to manage the timing of deliveries.

The second part of the regionalization analysis assumed Utilities would act as a wholesale water provider to regional entities in the greater Pikes Peak Region. This analysis assumes Utilities would deliver treated water to the entities at a master meter connection of its potable water distribution system. The regional demands described in Section 4.2.6-Potential Extraterritorial Demands were added to the water supply planning model, and the additional amount of supply required to meet these regional demands was determined. The result of this analysis, displayed in **Figure 9-2**, showed that Utilities could meet these regional demands by adding between 5,000 ac-ft/yr and 10,000 ac-ft/yr of water supply to the system, while still meeting level of service goals. It is assumed that the additional water introduced would be reusable water, and therefore the reuse and subsequent uses of that water would provide the additional supplies necessary to make up the full amount of additional demand.

These two analysis approaches demonstrate that the water system is generally not a limitation to pursuing regionalization if such a proactive approach to regionalization is approved by the Utilities Board.

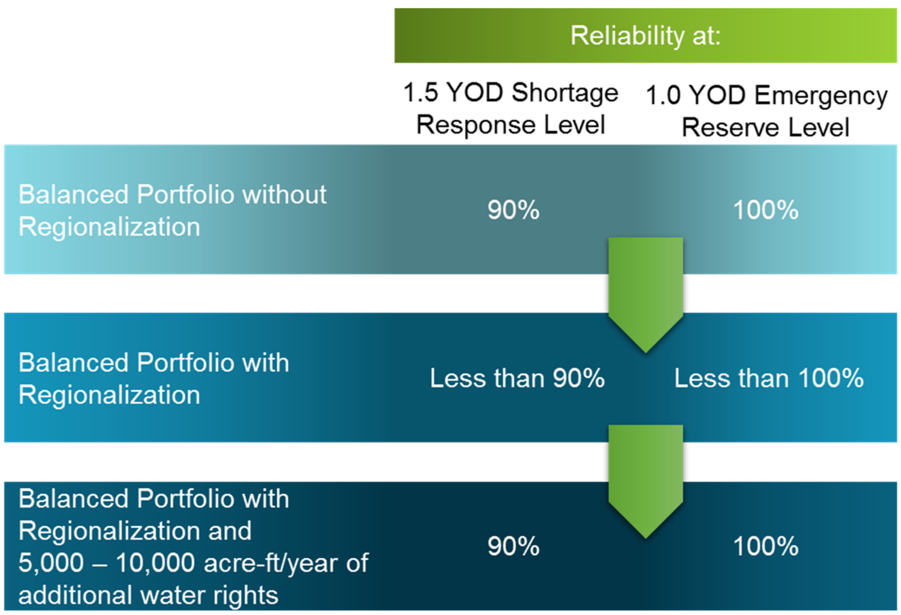


Figure 9-2. Regionalization Results

SECTION 10
Public Process

The IWRP utilized both technical and public processes to develop the long term water plan. The public process employed a comprehensive approach to capture feedback and opinions from a diverse group of stakeholders in the community. This comprehensive approach utilized a variety of communication and feedback methods designed to reach different audiences and gather different kinds of feedback. These are summarized in **Figure 10-1** and described in more detail below. Further information on the IWRP public process can be found in *TM #22 – Public Process*.

A wide variety of methods were used to gather and incorporate input from key stakeholders and the Colorado Springs community.

Figure 10-1. IWRP Public Engagement Methods

10.1 Methods

10.1.1 WATER PLANNING ADVISORY GROUP

Utilities convened a citizens' Water Planning Advisory Group (WPAG) consisting of 12 people to assist with the IWRP. WPAG members were selected based on active involvement in the community; had good working relationships across Colorado Springs and the surrounding communities; were informed on local issues; had specific technical water expertise; and were seen as an active water user. The WPAG participants represented the following customer segments: nonprofits, environmental organizations, water districts, landscape professionals, large water users, local businesses, military, higher education, city government, real estate, and the development community.

The group met 10 times with Utilities staff over the course of about two years. Specifically, the WPAG provided feedback to Utilities by reviewing baseline data and assumptions, reviewing results from the risk identification and assessment analysis, scoring water supply options based on triple bottom line criteria, and providing input on key recommendations.

10.1.2 OPEN HOUSES

Utilities held five open house format meetings between October 2014 and January 2017 which drew more than 90 members of the public. These open houses were scheduled at key transitions points during the IWRP, with the each open house having a different emphasis. In each case the overall goal was public education and outreach. The goals of the first two open houses were to educate attendees on Utilities' water system and the water supply planning process, and solicit general feedback on the IWRP objectives and approach. The goal of the third open house was to educate attendees on the broad strategies Utilities could pursue in the future to address water supply challenges. The goal of the last two open houses was to introduce the key Board policy questions and the proposed approach for a reliable water system at Buildout.

10.1.3 FOCUS GROUPS

In 2014, Utilities conducted two focus groups to gather input from customers on their main concerns related to water supply reliability and their preferences for addressing future water shortages. A total of 25 customers participated in the two groups. Utilities staff led participants through a structured process of gathering input on water issues of concern (e.g., shortages, water quality, cost) and preferences for meeting growing water demands in the future (e.g., more conservation, more storage, more agricultural water acquisitions).

10.1.4 SURVEYS

Utilities conducted customer surveys to gather input on their understanding of current water issues, values around water, and preferences for addressing future water needs. Some IWRP surveys were coordinated with other Utilities customer surveys for efficiency. In 2014, surveys were sent randomly to over 600 community members to gather feedback on water values and understanding. In 2016, surveys were sent to the Utilities customer panel that consists of customers who have agreed to receive occasional on-line surveys and other information. Of the 2,000 people from the on-line panel, 687 completed the survey and provided input on their concerns related to existing and future water issues and their preferences for different types of water supply strategies.

10.1.5 STAKEHOLDER MEETINGS

Nearly 50 meetings were held with a wide variety of community stakeholder groups over a period of about four years, with over 1,300 total attendees. Presentations were made to many different community groups and ranged, from professional associations of realtors and landscapers to a Military Forum. These stakeholder meetings were held to not only reach organizations and corporations, but to reach out to the community through the Council of Neighbors and Organizations (CONO) and Organization of Westside Neighbors (OWN). These two groups alone represented more than 100 homeowner associations. Stakeholder meetings were used to provide the public with information on the IWRP goals and study approach, the risks and uncertainties affecting future water supply planning, and the strategies available to address those risks and uncertainties.

10.1.6 OTHER METHODS

Additional methods were used in order to provide education and solicit feedback from a wider range of stakeholders.

1) **Water Outreach Centers** – partnered with various libraries, colleges, and community centers in delivering and distributing IWRP planning documents and other water resources materials.
2) **Web Page** – web page on Colorado Springs Utilities website included IWRP goals, public process opportunities, process flow chart, issue summaries, generally relevant water resource information, and contact information for providing feedback or asking questions.
3) **Employee (Internal) Communication** – used Insight eNewsletter, ambassador meetings, and talk at the Officer Meetings.
4) **Public (External) Communication** – used Utilities Connection regular newsletter, regular stakeholder newsletters, and the local Colorado Springs newspaper (The Gazette) to promote the open houses and planning efforts.
5) **Leadership Engagement** – held ongoing meetings with the Management Team, Strategic Planning Committee of the Utilities Board, and the Utilities Board proper.

10.2 Key Messages

Through all of these methods of engagement, Utilities collected and documented a number of recurring themes and key messages that are important to customers and stakeholders. These are:

- Water quality is important, and is generally more of a concern to the public than water supply reliability.
- Maintain high standards for safety and aesthetics.
- Emphasize conservation and reuse and consider how they fit with other options.
- Make sure Colorado Springs has the water it needs to serve current customers and a growing community.

- Help meet regional water needs if possible.
- Repair and maintain aging infrastructure.
- Look at other methods to preserve/reuse water.
- Help customers understand how to use water efficiently.
- Try to minimize impacts to agriculture and the environment.
- Make sure costs are realistic for customers.
- It is prudent to take advantage of timely opportunities for supply acquisitions and projects.

The feedback Utilities received and the key messages gleaned from this feedback guided the technical and policy level analysis, and recommendations found in the IWRP. Utilities values active participation of the public in their planning processes as it ensures the planning process and recommendations are complementary to the needs and expectations of both the customers and neighboring communities.

SECTION 11

Recommended Plan

11.1 Introduction

This section presents a summary of the findings and recommendations of the IWRP. The discussion is organized around responses to the key policy questions that formed the basis of the planning effort, and recommendations for introducing adaptive implementation strategies into the plan.

Adopting recommended policies and implementing the recommended plan in an adaptive manner will keep Utilities on the path to a sustainable future.

11.2 Summary of Key Policy Recommendations

Recommendations related to the four key policy questions are summarized in **Figure 11-1**. Recommendations are based on the results of the technical analyses described previously, input from technical and management teams, input from customers and stakeholders, and input and direction for the Utilities Board. Policy recommendations are discussed in the following subsections.

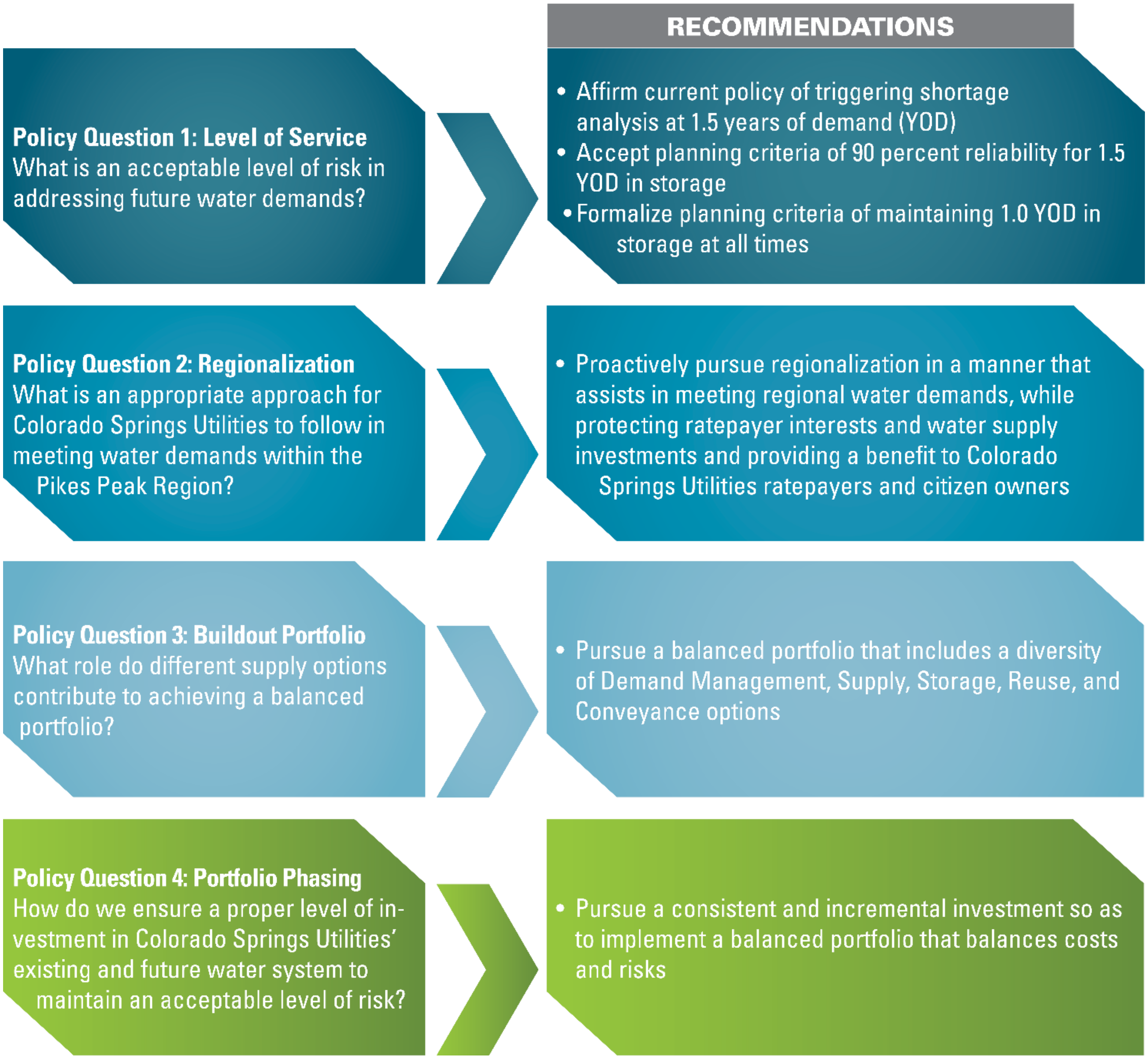


Figure 11-1. Summary of Policy Questions and Recommendations

11.3 Level of Service

Current drought risk mitigation policies and practices, and proposed changes based on the IWRP analyses, are summarized in **Table 11-1**. Setting a minimum threshold of 1.0 YOD for total reservoir storage provides sufficient protection against future unknown risks and against failing to meet indoor demands at all times. Triggering shortage response analyses when total reservoir storage falls to 1.5 YOD provides sufficient time to implement shortage response measures that would prevent storage from falling below the minimum threshold of 1.0 YOD.

Current policy contained in EL-10 states, that "the CEO shall not fail to protect existing and future consumers from compulsory restrictions on the use of water, specifically when considering and managing special contracts, except as provided for in the City Code". This policy has been interpreted to mean that shortage response should never be triggered and that the system reliability goal should be 100% in all cases. The IWRP recommendation is to modify the reliability goal of allowing implementation of shortage response measures no more than 10 percent of the time. This change is consistent with historical experience over the past 60 years, the results of the IWRP technical analysis, and with customer preferences. This represents a significant change in Utilities' water resource management strategy which acknowledges the need to provide a reasonable balance between the cost of new water supply infrastructure, water system risks, and customer impacts and establishes metrics which are both realistic and achievable given our current understanding and approach to risk-based planning.

Table 11-1. Risk Mitigation Policy Summary

Current Risk Mitigation Policies	Proposed Risk Mitigation Policies
Trigger shortage response analysis at 1.5 YOD in storage Reliability Goal: 100 Percent Never go into shortage response conditions	Trigger shortage response analysis at 1.5 YOD Reliability Goal: 90 Percent Shortage response 1 in 10 years on average
Planning Preference to maintain 1.0 YOD in storage at all times	Formalize policy planning criterion of maintaining 1.0 YOD in storage at all times as emergency reserve.

11.4 Regionalization

Findings of the regionalization technical analysis, public process, and Board communication support the recommendation that Utilities pursue a proactive approach to meeting regional water demands and generating financial benefits for its ratepayers as summarized in Table 11-2. Potential impacts to water supply reliability for Utilities' customers are small and can be overcome with a modest amount of additional supply, while there is also the potential to realize significant benefits associated with the receipt of supplemental revenue for Utilities and enhanced regional water supply security.

A goal of the IWRP analysis was to determine the feasibility, from a water supply and water system performance standpoint, of pursuing regionalization in a proactive manner. Additional regionalization studies will be conducted following the IWRP to more fully evaluate the technical, legal, political, and economic considerations associated with potential regionalization strategies.

Table 11-2. Summary of Findings of Regionalization Technical Analysis

Regionalization Option for Utilities	Possible Regionalization Strategies	Technical Findings
If/When Provider of Conveyance Capacity	Utilities would allow regional entities to use Utilities infrastructure to deliver their own water if/when capacity is available.	At Buildout, Utilities will have sufficient unused capacity in its system in the off peak months to be able to deliver water to regional suppliers, but additional storage may be needed by regional participants.
Wholesale Treated Water Provider	Utilities could provide regional entities with a firm supply of water as if they were service area customers.	At Buildout, Utilities could deliver full service treated water on a wholesale basis to regional entities with the addition of 5,000 to 10,000 ac-ft/yr of new supply.

11.5 Balanced Portfolio

The IWRP recommendation for implementing an appropriate mix of water supply options is to pursue a balanced portfolio that contains a diversity of supply, storage, demand management, reuse, and conveyance options. This section describes in more detail the contents of this the Balanced Portfolio, which is the Buildout portfolio that is recommended to be pursued by Utilities.

A summary of the five major water resources strategies that encompass the Buildout portfolio are shown in **Figure 11-2.** The specific projects, programs, and policies that comprise the Balanced Portfolio are listed in **Table 11-3**.

Figure 11-2. Water Resources Strategies in the Balanced Portfolio

Table 11-3. Components of the Balanced Portfolio

Water Resources Strategy Category	Water Resources Projects and Options
Colorado River Projects	New supply of 10,000 to 15,000 ac-ft/yr • Montgomery Reservoir Enlargement • Eagle River MOU
Agricultural Transfers	New supply of 15,000 to 25,000 ac-ft/yr • Drought response leases • Base supply leases • Water rights acquisitions
Demand Management	Annual demand savings of 11,000 to 13,000 ac-ft/yr • Conservation measures • Distribution system efficiency savings • Landscaping standards
Arkansas Basin Storage	New or enlarged storage of 90,000 to 120,000 ac-ft • Upper Williams Creek Reservoir • Phased gravel pit reservoirs along Fountain Creek • Phased gravel pit reservoirs along the Arkansas River below Pueblo Reservoir • Additional storage in the Upper Arkansas River Basin • Additional storage in the Middle Arkansas River Basin • Upper Rampart Reservoir
Reuse	Additional nonpotable demands of 1,200 to 2,500 ac-ft/yr Indirect potable reuse of 50 MGD to 75 MGD

The benefits of pursing the recommended Balanced Portfolio include:

- Flexibility in terms of the number of options available for meeting the future water supply "gap" (i.e., all eggs are not in one basket)
- Performs well against a wide range of potential risks and future conditions
- Distributes impacts of potential risks across a broad range of the water resources system
- Maximizes utilization of existing infrastructure (e.g., SDS) and water rights
- Is consistent with Colorado Water Plan recommendations
- Provides for use of adaptive management strategies to address changing and uncertain future conditions

Due to the flexibility in implementing the Balanced Portfolio, the Buildout RMD is estimated to be equal to or greater than the estimated Buildout Demand of 136,000 ac-ft/yr.

Overall, there are many potential configurations of portfolios to meet the level of service goals at Buildout and the recommendations in this plan represent a sound balance between the major project categories. For the specific Balanced Portfolio presented above, the total capital cost is about $1.7 billion and the total life-cycle cost for 50 years of operation is about $1.9 billion. All portfolio configurations require significant investments in projects and will face political, environmental, and/or social challenges. Therefore, implementing the Balanced Portfolio will require support across the Colorado Springs community.

This policy direction gives Utilities a roadmap of projects and options to pursue, and Utilities will implement this plan, and subsequent updates of this plan, as appropriate, over the next 50 years to meet customer demands. Utilities also recognizes that as conditions change, there is the ability to adjust the amounts, timing, and types of projects in order to assure that the water system meets level of service goals and assures that customer demands are met.

11.6 Implementation Timing

The projects listed in **Table 11-3,** or their equivalents, are all required to meet Buildout conditions and thus will all eventually be required at some level. As part of this plan, an overall approach for phased implementation of the projects in the Balanced Portfolio was developed and is discussed below. Timing estimates are based on a moderate population growth and water demand forecast and other relevant factors. Actual future conditions will vary, affecting the time periods in which projects must be brought on-line, but the timing outlined below is based on the best information available in February 2017.

Several approaches for determining the recommended timing for implementation of the projects in the Balanced Portfolio were evaluated to determine and demonstrate the consequences of each approach. These approaches were evaluated using a Revenue Impact Model, which translates a proposed phasing of projects over time into an estimate of revenue required in order to finance those projects. Utilities used this tool in conjunction with expert judgment to develop a reasonable, representative timing strategy based on opportunistic availability (i.e., projects that have a limited window of availability) and the goal of balancing project need with avoiding multiple large step increases in revenue requirements. The project implementation timeframe is divided into near-term projects (present-2030), mid-term projects (2031-2050), and long-term projects (2051-Buildout) and is detailed below.

The following sections list the IWRP projects scheduled for implementation in the three timeframes.

11.6.1 NEAR-TERM PORTFOLIO PROJECTS

The near-term portfolio projects are those scheduled for 2017-2030 because they are already budgeted for, have significant work already completed, or have a window of opportunity in the near term. Specific near-term projects and their justification for inclusion are listed in **Table 11-4**.

Table 11-4. Near-Term Projects in Balanced Portfolio

Short Term Projects	Justification
Mesa Treatment Plant Upgrades	Already included in capital improvement plan.
Bear Creek Intake – 3 MGD	Already included in capital improvement plan.
Pikeview to Mesa Transfer Expansion up to 8 MGD	Already included in capital improvement plan.
Shortage response Leasing at 5,000 ac-ft/yr	Significant existing progress.
Upper Williams Creek Reservoir – 28,000 ac-ft	Significant existing progress.
Montgomery Reservoir Enlargement – up to 7500 ac-ft	Significant existing progress.
Gravel pit reservoir off Fountain Creek at 5,000 ac-ft	Complementary to other projects and can be phased.
Gravel pit reservoir off Arkansas River at 5,000 ac-ft	Complementary to other projects and can be phased.

Implementation of the above projects is not limited to actual construction or contract execution. Each project requires a significant amount of associated activities and preliminary work prior to implementation. These associated activities include planning studies, design, negotiations and agreements, permitting, land acquisition and easements, option agreements, etc. Many of these associated activities entail a significant level of effort and a long lead time, therefore Utilities needs to commence these activities upon approval of the IWRP.

In addition to those projects listed above for implementation in the near term, Utilities must be prepared to act upon "Opportunistic Projects." Such opportunities including water rights acquisitions, project partnerships, land acquisition and easements, option agreements, and acquisition of storage facilities could arise anytime during the planning horizon. The timing is based on a combination of need, financial capacity, and when the opportunity presents itself. In addition, facilities, sites, and/or rights can be acquired opportunistically, but full development after acquisition can be phased based on need as demands and other conditions warrant. A recommended method to facilitate this is described in Section 11.7.1, Water Acquisition Fund.

11.6.2 MID-TERM PORTFOLIO PROJECTS

Projects that are to be completed in the mid-term future, between approximately 2031 and 2050 are listed in Table 11-5.

Table 11-5. Mid-Term Projects in Balanced Portfolio

Mid-Term Projects
Middle Arkansas New Reservoir – up to 15,000 ac-ft
Arkansas Basin Leasing as Base Supply at 10,000 ac-ft/yr
Eagle River MOU Project – 10,000 ac-ft/yr
Expanded Nonpotable System – up to 1500 ac-ft/yr
Upper Arkansas New Reservoir up to 13,000 ac-ft
Gravel pit reservoir off Fountain Creek at 5,000 ac-ft
Gravel pit reservoir off Arkansas River at 5,000 ac-ft.

Preliminary associated activities for these projects should be started in the next few years if these projects are to be developed in a timely manner.

11.6.3 LONG-TERM PORTFOLIO PROJECTS

Projects that are to be completed in the long-term future, between 2051 and Buildout are listed in Table 11-6.

Table 11-6. Long-Term Projects in Balanced Portfolio

Long-Term Projects
Upper Arkansas Water Rights at 1,500 ac-ft/yr
SDS Treatment/Pumping Expansion – up to 100 MGD/78 MGD Total
Upper Rampart Reservoir – up to 15,000 ac-ft
Gravel pit reservoir off Fountain Creek at 5,000 ac-ft
Gravel pit reservoir off Arkansas River at 5,000 ac-ft.
Indirect Potable Reuse at 50 – 75 MGD

Associated activities for these projects will need to be started approximately 10 – 15 years prior to the need date, depending on the project scope and complexity.

The implementation timing outlined above represents a responsible, consistent and incremental approach to investment in and development of the water supply system in order to meet customer demands and level of service goals at Buildout.

11.7 Adaptive Management Strategies

The plan set out in the IWRP is not a single set path, but rather a preferred path forward based on the information currently available; it therefore must be adaptable if the future proves to be different than what was assumed. This section details strategies designed to ensure the recommendations of this plan can be adapted to accommodate changing future conditions.

11.7.1 WATER ACQUISITION FUND

It is recommended that Utilities establish a Water Acquisition Fund, a proactive acquisition policy, and streamlined processes that would provide Utilities' management with a dedicated budget, direction and timely means with which it could pursue small projects or portions of large projects recommended in the IWRP on an opportunistic basis. For example, the Balanced Portfolio set forth in this plan contains 15,000 ac-ft to 25,000 ac-ft of agricultural water right transfers. The water rights that will eventually make up this element of the portfolio typically become available without much advanced warning, are on the market for only a brief period of time, and are subject to being quickly acquired by others. This makes traditional budgeting for acquiring these water rights difficult and could significantly weaken Utilities' future if they cannot be acquired. Therefore, Utilities will be best positioned if it sets up a Water Acquisition Fund, a proactive acquisition policy, and an effective process that can be relied upon to purchase these water rights as they become available.

11.7.2 SIGNPOSTS

An integral part of the IWRP is adaptive management. There are numerous possible futures, numerous paths to follow, and many opportunities and decision points along these paths. As time passes, conditions change, and new information is discovered or developed. Therefore, Utilities will be in a better position to discern which of the possible futures is materializing. These changing conditions and new information will serve as "signposts" that can inform Utilities as to which parts of the plan to implement at which points in time. Signposts are conditions or factors that may have an effect on the system's performance and are monitored to see if action is needed. Signposts inform responses and responses suggest actions that could include reassessment, corrective action, defensive action, or capitalizing actions. A response action could be specified after a critical value of a signpost variable has been reached. For example, reservoir levels or demand levels may give Utilities a composite look at the way many factors materialize and could be the trigger for implementing certain options or exploring additional options.

The recommendations of this IWRP are built upon foundational assumptions about what the future will look like in terms of climate, water use, demographics, regulations, and regionalization. However, there is substantial uncertainty around all these factors. Therefore, by monitoring indicators of future conditions (signposts), the recommendations of this plan can be adapted to the updated trends. Major signposts for this plan, the assumptions for the IWRP, trends to monitor, and potential impacts on the recommendations of this plan are summarized in Table 11-7.

Table 11-7. IWRP Signposts

Signpost	IWRP Assumption	Trends to Monitor	Impacts to Plan Recommendations
Climate	Future climate changes will be consistent with the recent past, with 1°F warming per decade and no change to average annual precipitation.	Means in temperature and precipitation, and rate of change compared to historical, both in Colorado Springs and in major source water areas.	More rapid temperature increases and/or precipitation decreases will require projects be completed earlier. Conversely, slower temperature increases and/or precipitation decreases can push projects farther into the future.
Annual Demands	Annual demands will recover to pre-2012 levels, then increase over time.	Annual demands compared to forecast.	If demand growth slows, then planned projects may not be required as soon. If demand grows more quickly, projects may need to be moved up in time.
Water Use	Per capita water use, outdoor water use, and water restriction savings will be consistent with high conservation assumptions	Per-capita water use compared to forecast.	Savings from demand management strategies may be more or less than what was assumed, affecting timing of future projects or implementation of demand management programs.
Demographics	Steady population growth in accordance with state demographer's projections.	Population growth; and if actual population growth is different than what was assumed.	Faster population growth may require projects to be online sooner, slower growth could delay projects.
Regionalization	Baseline analysis performed for Utilities Customers only.	Utilities decisions on regional partnerships, and levels of participation by regional entities.	Utilities taking on regional participants may increase overall demand, which may require projects to be completed sooner.

11.7.3 RESPONSES

There are outside factors or events that cannot be accounted for in the technical analysis. However, these factors or events can be accounted for by anticipating what they could be and identifying appropriate responses if they occur. Possible actions that can be taken in response to reaching signposts that represent a significant change in conditions could be:

- Modify planning criteria (e.g., YOD in storage thresholds, acceptable frequency of drought response)
- Modify policy (e.g,. impose land use regulations, more aggressive acquisition policy)
- Modify financial practices (e.g., rates, rate and/or structures, financial metrics)

- Modify portfolios or projects (e.g., timing, size)

The question of how to balance the trade-offs of building projects according to the IWRP implementation schedule versus waiting until a later time will be based on the same adaptive management strategies. The overall implementation schedule will be used to develop short term and long term budgets. At regular intervals, or as significant events emerge, Utilities will assess and evaluate all relevant factors and conditions, including water supply needs, opportunities, and financial conditions to determine if the construction of a project is warranted. Utilities will monitor the signposts and use planned responses in combination with professional judgment and collaborative decision making to determine the best path forward.

11.8 Ongoing Water Resource Activities

In addition to the proceeding primary recommendations related to the four policy questions, it is recommended that the following ongoing activities be continued to assure a reliable and sustainable water supply into the future:

- Continue to actively exercise and maximize the exchange program. This includes operating conditional exchange rights to make such conditional rights absolute.
- Continue to actively pursue watershed management for the protection of the natural environment, Colorado Springs' water supply, water infrastructure, and water quality.
- Actively engage at a state and national level to influence water policy and planning activities.

11.9 Recommendation Summary

Utilities is well positioned to meet current water demands with the existing system, but will need to implement additional projects, programs, and policies in the future to maintain level of service goals and prevent a water supply gap from developing. With the system as it exists today, Utilities can reliably meet up to 95,000 ac-ft/yr of demand. At Buildout the RMD increases to at least 136,000 ac-ft/year, depending on the final composition of the Balanced Portfolio. These RMD levels for the existing and future systems are summarized in **Table 11-8**

Table 11-8. Reliably Met Demand of the Water Supply System

System Configuration	Reliably Met Demand
Existing System (2016)	95,000 ac-ft/year
Existing System + Full Balanced Portfolio	136,000 ac-ft/year

It is recommended that Utilities adopt and use planning criteria that will result in a level of service that maintains 1.5 YOD in storage with a 90% reliability, triggering a shortage response analysis no more than 1 year out of 10 on average, and maintains 1.0 YOD in storage as emergency reserve with 100% reliability. It is also recommended that Utilities pursue a proactive approach to serving regional entities that protects and enhances our customer's interests. In addition, it is recommended that Utilities pursue a balanced portfolio that includes a diversity of Demand Management, Supply, Storage, Reuse, and Conveyance options, and make responsible, deliberate, and consistent investment in the water system to implement the Balanced Portfolio in a manner that balances costs and risks between now and Buildout.

11.10 IWRP Updates and Follow-up Studies

Updates to the IWRP are recommended to occur every 5 to 10 years or as significant new information becomes available such as improved climate science or changes associated with regional relationships. However, planning studies of various kinds will occur continuously between formal IWRP updates. Investment in the analytical framework created during the course of this study will greatly facilitate future water supply studies and formal plan updates.

This IWRP did not include a detailed analyses of all areas of interest or concern related to water supply planning due to budget constraints. It is recommended that the following post-IWRP studies be conducted as time and resources allow.

- Perform a more detailed analysis of impacts of various regionalization futures.
- Re-evaluate IPR/DPR; as representations for the IWRP were necessarily simplified.
- Perform a detailed analysis for Montgomery Reservoir Enlargement sizing.
- Continue to work collaboratively with parties to the 1998 Eagle River MOU to refine and finalize project configurations that can be successfully permitted, and constructed, and which meet the yield objectives of project participants.
- Perform a comprehensive storage site assessment to identify and prioritize opportunities for new and enlarged terminal, regulatory, and return flow storage sites. Develop a plan for meeting IWRP goals that contains an appropriate mix of New Upper Arkansas, Middle Arkansas, Lower Arkansas/Fountain Creek, and other storage facilities.
- Conduct a comprehensive assessment of the City's existing water rights portfolio with the purpose of adjusting and optimizing our portfolio to best position Utilities for future success. File new water appropriations, as necessary, to meet IWRP goals and consider taking other legal and administrative actions, as necessary to aggressively protect and develop Utilities' water rights portfolio consistent with Executive Limitation 10.
- Develop Operations and Yield Model hydrology for East Slope yields that better captures impacts of temperature and precipitation changes.
- Further evaluate various possible strategies for Utilities to manage through a Colorado River Compact curtailment or proactive reduction in West Slope supply.
- Evaluate impacts of wide-scale rainwater/graywater harvesting and if this is a strategy Utilities should promote.
- Update assumptions from the Finished Water Master Plan as demand projections have changed since those assumptions were last considered.
- Perform a more detailed distribution system and water treatment redundancy analysis to better identify and characterize risks and recommend appropriate mitigation.
- Develop an updated Nonpotable System Master Plan.

- Continue to identify, study and pursue potential gravel lake opportunities in the Fountain Creek and Arkansas River corridors.
- Conduct studies of potential agricultural water right leasing opportunities to refine the estimates of supplies that may be available from those sources.
- Perform detailed evaluation of risks associated with developing water supplies from the Arkansas River Basin to more fully understand how factors such as exchange potential, compact compliance (State of Kansas), and water quality may impact the ability to meet water supply goals.

11.11 IWRP Approval and Policy Direction

Colorado Springs' Utilities Board approved the Integrated Water Resource Plan, including the recommendations to the four policy questions, at its regular meeting on February 22, 2017. This Plan and these recommendations are now official policy direction set by the Utilities Board.

SECTION 12
Supporting Documentation

The IWRP technical analysis was documented in two separately bound technical reports and a number of technical memoranda that are compiled in a technical appendix. Available technical reports and technical memoranda are listed below.

Separately Bound Technical Reports

- Issues, Risks and Vulnerabilities Affecting Colorado Springs Water Resources System (Planning Factors Report), including technical appendices
- Vulnerability Assessment Report, including technical appendices

Separately Bound Technical Appendix

- Technical Memorandum #10 – Baseline Modeling Analysis
- Technical Memorandum #11 – IWRP Modeling Systems
- Technical Memorandum #12 – Method for Developing Risk and Lever Scenarios
- Technical Memorandum #13 – Baseline Analysis
- Technical Memorandum #15 – Demand Analysis
- Technical Memorandum #18 – Lever[3] Description
- Technical Memorandum #19 – Lever Evaluation
- Technical Memorandum #20 – Cost Analysis
- Technical Memorandum #21 – Portfolio Development and Evaluation
- Technical Memorandum #22 – Public Process
- Technical Memorandum #23 – Regionalization Analysis
- Technical Memorandum #24 – Reliably Met Demand Definition

[3]Projects, programs and policies collectively referred to as “options” in this report were often referred to as “levers” during the technical analysis based on the XLRM framework developed by RAND Corporation.