Colorado River Basin Stakeholders *Moving Forward* to Address Challenges Identified in the Colorado River Basin Water Supply and Demand Study

Phase 1 Report: Executive Summary

A Product of the *Moving Forward* Effort

May 2015

Executive Summary

In 2012, the Bureau of Reclamation (Reclamation), in partnership with the seven Colorado River Basin States[1] (Basin States) and in collaboration with a wide spectrum of Colorado River Basin (Basin) stakeholders, published the most comprehensive study of future Basin supply and demand ever undertaken. The Colorado River Basin Water Supply and Demand Study (Basin Study) confirmed that, in the absence of timely action, there are likely to be significant shortfalls between projected water supplies and demands in coming decades. The Basin Study also confirmed that a wide range of solutions are needed to mitigate and adapt to such shortfalls, which are likely to affect each sector (agricultural, municipal, energy, and environmental, for example) dependent on the Colorado River and its tributaries.

In response to the findings of the Basin Study, in May 2013, Reclamation and the Basin States, in collaboration with the Ten Tribes Partnership[2] and conservation organizations, initiated the *Moving Forward* effort to build on future considerations and next steps identified in the Basin Study.

The *Moving Forward* effort builds upon and enhances the broad, inclusive stakeholder process demonstrated in the Basin Study with an ultimate goal of identifying actionable steps to address projected water supply and demand imbalances that have broad-based support and provide a wide-range of benefits. The *Moving Forward* effort is being conducted in a phased approach. Phase 1, which was funded by Reclamation and the Basin States, began with the formation of a Coordination Team and three multi-stakeholder workgroups that focus on water conservation, reuse, and environmental and recreational flows. The Phase 1 Report documents the activities and outcomes of the workgroups during this phase.

Commenting on the information provided in the Phase 1 Report is encouraged. Written comments should be submitted within 90 days following the release of this report. The comments will be summarized and posted to the *Moving Forward* website and will be considered in future *Moving Forward* phases. Instructions for submitting comments are provided at: http://www.usbr.gov/lc/region/programs/crbstudy/MovingForward/index.html.

1.0 Need for Action in the Colorado River Basin

Today, between 35 and 40 million people[3] rely on the Colorado River and its tributaries for some, if not all, of their municipal water needs. These same water sources irrigate nearly 4.5 million acres of land[4] in the Basin and the adjacent areas that receive Colorado River water, generating many billions of dollars a year in agricultural and economic benefits. There are 22 federally recognized tribes in the Basin for whom the Colorado River and its tributaries are essential as a physical, economic, and cultural resource. The Colorado River and its tributaries provide habitat for a wide range of species and flows through seven national wildlife refuges and 11 National Park Service (NPS) units[5]; and provide a range of recreational opportunities which add significant benefits to regional economies. Hydropower facilities in the Basin can supply more than 4,200 megawatts of vitally important electrical capacity to assist in meeting the power needs of western states, reducing the use of fossil fuels. In addition, the Colorado River is vital to the United Mexican States (Mexico). The Colorado River Basin is depicted in Figure 1.

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[1] Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming

[2] Chemehuevi Indian Tribe, Cocopah Indian Tribe, Colorado River Indian Tribes, Fort Mojave Indian Tribe, Jicarilla Apache Nation, Navajo Nation, Quechan Indian Tribe, Southern Ute Indian Tribe, Ute Indian Tribe of the Uintah and Ouray Reservation, Ute Mountain Ute Indian Tribe

[3] The Basin Study estimated 40 million people by 2015 in the portion of the Basin and the adjacent areas that receive Colorado River water in the U.S. See Basin Study, *Technical Report C* for additional detail. Estimate of 35 million people is based on the 2010 U.S. Census Bureau population data from cities within planning areas (as defined in the Basin Study) that receive Colorado River water.

[4] The Basin Study estimated about 5.5 million irrigated acres by 2015 in the portion of the Basin and adjacent areas that receive Colorado River water in the U.S. See Basin Study, *Technical Report C* for additional detail. This number was updated to 4.5 million irrigated acres by the Agricultural Workgroup to better reflect acreage in adjacent areas potentially receiving Colorado River water.

[5] While there are more NPS units within the Basin, 11 are included in the NPS' Colorado River Program.

FIGURE 1
Colorado River Basin

Note:
Similar to the Basin Study, the scope of the *Moving Forward* effort is limited to the portion of the Basin and adjacent areas that receive Colorado River water within the U.S.

The challenges and complexities of ensuring a sustainable water supply and meeting future resource[6] needs in an over-allocated and highly variable system such as the Colorado River have long been recognized and documented by Reclamation, the Basin States, and many stakeholders. Consequently, for the last century, significant investments have been made in constructing infrastructure, developing other water resources, and implementing innovative conservation programs and policies to sustain current and future supplies.

These challenges will likely increase in the future due to continued population growth coupled with significant uncertainty regarding future water supply. The Basin States are some of the fastest growing in the U.S. and the communities and economies of major cities such as Albuquerque, Denver, Las Vegas, Los Angeles, Phoenix, Salt Lake City, and San Diego are in part dependent, or in the case of Las Vegas, almost entirely dependent on the Colorado River for water supply. As water demand for municipal and agricultural purposes increases to serve the needs of growing populations, ensuring the availability of water for non-consumptive uses such as the environment, recreation, and hydropower becomes increasingly challenging. Both consumptive and non-consumptive uses face increasing levels of risk. Water supply uncertainty is further compounded by the potential impacts from climate change. Evidence indicates increased future climate variability in the Southwest, which may include longer, more extreme dry (and wet) periods than previously observed.

It is impossible to know the precise trajectory of future water supply and demand or how those trajectories may impact the reliability of the Colorado River and its tributaries to meet Basin needs. The Basin Study confirmed that, absent future action, the Basin faces a wide range of plausible future long-term imbalances between supply and demand. This imbalance, computed as a 10-year running average, ranges from no imbalance to 6.8 million acre-feet (MAF) with a median of 3.2 MAF in 2060[7]. The assessment of impacts to Basin resources found that any long-term imbalance will impair the ability of the Colorado River system to meet the needs of Basin resources resulting in negative impacts (for example, reduced reliability of water deliveries for municipal and agricultural purposes, decreased hydropower generation, reduced recreational opportunities).

No one sector can provide the solution for ensuring long-term sustainability. To respond to these future challenges, diligent planning will be required to find adaptable solutions that build resiliency and apply a wide variety of ideas at local, state, regional, and Basin-wide levels. With this in mind, the Basin Study recommended several future actions to move closer towards implementing such solutions. These actions include, as a first step, resolving uncertainties related to water use efficiency, reuse, and environmental and recreational flows by shifting the focus from the Basin-wide approach taken in the Basin Study, to one that explores these opportunities in more detail.

2.0 The *Moving Forward* Effort

The *Moving Forward* effort was designed to pursue several next steps identified in the Basin Study. Central to the *Moving Forward* effort is the recognition that pursuing these areas must be done collaboratively and with a broad, inclusive stakeholder process as demonstrated in the Basin Study. Separate from the *Moving Forward* effort, Reclamation, the Basin States, and others (for example, the Ten Tribes Partnership) are simultaneously pursuing other actions identified in the Basin Study[8].

6 Resources include water allocations and deliveries for municipal, industrial, and agricultural use; hydroelectric power generation; recreation; fish, wildlife, and their habitats (including candidate, threatened, and endangered species); water quality including salinity; flow- and water-dependent ecological systems; and flood control.

7 Comparing the 90th percentile supply to the 10th percentile demand results in no imbalance. Comparing the 10th percentile supply to the 90th percentile demand results in a 6.8 MAF imbalance. Comparing the 50th percentile of both supply and demand results in a 3.2 MAF imbalance.

8 Other areas identified in the Basin Study currently being explored in other efforts include water banking, water supply augmentation, watershed management, the Colorado River Basin Ten Tribes Partnership Tribal Water Study, climate science research, and data and tool development.

The *Moving Forward* effort is being conducted in a phased approach, and Phase 1 began with the formation of a Coordination Team and three multi-stakeholder workgroups. The three workgroups are as follows:

- Municipal and Industrial (M&I) Water Conservation and Reuse Workgroup
- Agricultural Water Conservation, Productivity, and Transfers Workgroup
- Environmental and Recreational Flows Workgroup

The overall purpose of the workgroups during Phase 1 was to further investigate these areas by documenting past and projected future trends and exploring the opportunities and challenges of various water management actions. Each workgroup identified potential future actions to address critical challenges related to projected water imbalances that provide a wide-range of benefits and have broad-based support.

Each workgroup is led by three co-chairs and consists of members with subject-matter expertise from various stakeholder entities in an effort to bring important and different perspectives to the workgroups. Workgroup membership includes federal and state agencies, local municipalities, agricultural organizations and irrigation districts, federally recognized tribes, non-governmental organizations, consultants, and other interested stakeholders. The Coordination Team is led by representatives from Reclamation and the Basin States and was tasked with guiding and reviewing the workgroup activities.

The Coordination Team and workgroups used a collaborative problem-solving approach to complete their tasks and assist in the preparation of the Phase 1 Report. Chapters 3, 4, and 5 of the Phase 1 Report were contributed by each respective workgroup and reviewed by the Coordination Team. The Phase 1 Report is intended to identify opportunities and potential actions that convey the perspectives of the workgroups regarding the role of their respective sector in being a part of the solution set needed to address the challenges identified in the Basin Study.

3.0 Municipal and Industrial Water Conservation and Reuse

The Basin Study recognized the importance of M&I water conservation and reuse in the future planning and management of Colorado River water. The M&I Water Conservation and Reuse Workgroup was formed to provide a more thorough understanding of M&I water conservation and reuse throughout the Basin and those adjacent areas that use Colorado River water. The Workgroup documented historical trends in M&I water conservation and reuse in areas that receive Colorado River water, identified current and planned efforts to continue these efforts, and identified opportunities and challenges associated with expansion of water conservation and reuse programs in the future.

Chapter 3 of the Phase 1 Report documents the Workgroup's Phase 1 activities. This chapter represents the efforts of a Basin-wide collaboration of experts in the M&I water conservation and reuse fields. The expertise represented by its members allowed this Workgroup to offer new insights into current and possible future directions for M&I water conservation and reuse in areas that receive Colorado River water.

A short summary of the key findings and messages identified by the Workgroup follows.

- Many of the major metropolitan areas that currently receive Colorado River water, such as Albuquerque, Denver, Phoenix, Las Vegas, Salt Lake City, Los Angeles, and San Diego have experienced significant population growth in past decades and projections for future growth remain high. Although total M&I water use has generally increased in the areas over the past two decades due to increased population, available data demonstrate that water providers in the major metropolitan areas that receive Colorado River water have implemented a wide range of water conservation and reuse measures. These efforts have increased water use efficiency and substantially decreased per capita demand, partially attenuating the effect of population growth. Additionally, since 2000, M&I water use has either remained stable or decreased for many metropolitan areas receiving Colorado River water, despite increases in population.
- On average, per capita water use has decreased by 11 to 38 percent since 1990 and by 10 to 26 percent since 2000 in these major metropolitan areas. Water conservation has played an important role in these savings; however, other factors such as economic, social, and behavioral changes have also influenced water use over time. During the

last decade, the U.S. experienced a steep economic downturn, the Basin experienced its most severe drought in more than 100 years, and some water providers increased water conservation efforts to reduce water use in response to reduced water availability. These factors have each contributed to recent decreases in per capita use.

- Information on current and planned water conservation and reuse programs obtained for the Phase 1 effort suggests that more than 700,000 acre-feet per year (AFY) of additional water conservation and an additional 400,000 AFY of water reuse is planned by 2030.

- The types of water conservation measures, for example metering and billing, public outreach, residential indoor practices, and outdoor landscaping practices, and the extent to which they have been implemented vary extensively among municipal providers and among major metropolitan areas that receive Colorado River water based on water supply portfolios and reliability, climate, demographics, and available funding.
- M&I water providers in the major metropolitan areas that receive Colorado River water have also implemented water reuse to varying degrees depending on geographic, legal, regulatory, and other considerations.
- M&I water providers in the major metropolitan areas that receive Colorado River water will continue to increase water use efficiency and reuse. These efforts play an important role in meeting future demands, reducing or delaying needs for additional water supplies, and increasing the future reliability of water supplies.
- M&I water providers in the major metropolitan areas that receive Colorado River water manage their water supplies conjunctively and some must use surface supplies first to protect groundwater or prevent groundwater mining and its consequences. Additional M&I water conservation and reuse has the potential to reduce the amount of future development of Colorado River water. However, in many regions, conservation and reuse may not result in substantial reductions in diversions of Colorado River water because conservation and reuse are typically used to meet future growth or offset or delay the need for future water supplies. Municipal water providers are planning to use their full entitlements to Colorado River water.
- Opportunities and potential actions exist to increase water conservation and reuse by major metropolitan areas that receive Colorado River water and, in many cases, are currently being pursued. However, these opportunities will vary depending on many factors, including the extent to which these measures have already been implemented in an area, the cost of these conservation measures, cost of existing and new water supplies, public acceptance, laws and regulations, and other factors.

See Chapter 3 for additional details and information.

4.0 Agricultural Water Conservation, Productivity, and Water Transfers

Common to all of the strategies evaluated in the Basin Study to address future water imbalances was the concept of agricultural conservation at significantly higher levels than currently practiced. By 2060, the Basin Study assumed that an additional 1 million AFY of water savings could be achieved through conservation, water use efficiency improvement projects, and other measures including fallowing. Although agriculture is the largest Colorado River water use at approximately 70 percent, to achieve such savings would be a considerable task given the significant amount of conservation and other related activities already underway. For this reason, the Agricultural Water Conservation, Productivity, and Transfers Workgroup was formed to provide context to the Basin Study estimate of agricultural conservation opportunities. Chapter 4 of the Phase 1 Report documents the Workgroup's Phase 1 activities.

Agriculture is important in both historical and current use of Colorado River water, and reducing agricultural production impacts local economies as well as national food security. Ultimately, the extent to which additional agricultural conservation or other measures may play a role in helping to address water supply and demand imbalances will affect how the agricultural sector is impacted.

A short summary of the key findings and messages identified by the Workgroup follows.

- Data reporting and availability reflect the varying nature and evolution of agriculture across the Basin. Accordingly, consistent water use analyses may not be feasible.
- The types of water conservation measures, for example conveyance system improvements, on-farm efficiency improvements, and consumptive use reductions, and the extent of implementation vary extensively among producers and geographies depending on water supply portfolios, climate, crop mix, and available funding.
- Water use per acre has remained relatively constant historically while productivity has increased Basin-wide by about 25 percent since 1980.
- Increases in on-farm efficiency result in more uniform application of water and may improve productivity but may not result in consumptive use reduction if the water saved is used to increase productivity or by a downstream user. Thus, the potential for water savings varies by location (for example, in or out of the hydrologic basin).
- Many of the advances in agricultural conservation have been achieved as part of programs with a variety of federal, state, and local stakeholders working toward mutually beneficial solutions.
- Available data demonstrate that producers have implemented a wide range of conservation and efficiency measures and often increased productivity as a result.
- Agricultural producers will continue to increase the efficiency of water use depending on factors such as location, crops, economic, and other considerations. These efforts may play a role in improving reliability for agricultural producers and building flexibility for meeting additional demands.
- Opportunities exist for additional agricultural water conservation, transfers, and productivity enhancements, but may become more difficult and costly as they are implemented.

See Chapter 4 for additional details and information.

5.0 Environmental and Recreational Flows

The Basin Study analysis indicated that flow- and water-dependent ecological systems, recreation, and hydropower generation could be increasingly vulnerable in the future due to increasing water supply and demand imbalances. The Environmental and Recreational Flows Workgroup was formed to provide a more thorough understanding of these concerns. Chapter 5 of the Phase 1 Report documents the Workgroup's Phase 1 activities.

The Workgroup built upon the Basin Study's assessment of environmental and recreational flows to identify ideas for potential future voluntary, non-regulatory solutions that protect or improve ecological and recreational resources while supporting other management goals. These integrated solutions are intended to benefit multiple uses, both consumptive and non-consumptive, including hydropower. As issues pertaining to ecological and recreational resources are inherently site-specific (for example, necessary minimum flows to safely raft a river reach) but also broader in scale (for example, recovery of endangered species), the Workgroup took an approach that investigated both specific sites and the Basin more holistically.

To understand site-specific issues, the Workgroup selected four reaches in the Basin to focus upon and completed an assessment of each reach. The Workgroup also compiled examples of existing programs and mechanisms that contribute to the protection or improvement of ecological and recreational resources to help understand concepts that could be applied in focus reaches or other parts of the Basin. The review of existing programs helped generate ideas for future potential opportunities that would benefit ecological and recreational resources throughout the Basin.

A short summary of the key findings and messages identified by the Workgroup follows.

- Basin Study modeling indicates Basin resources, including environmental, recreational, and hydropower resources, are increasingly vulnerable through time.
- The Colorado River and its tributaries provide important habitat for many native species, including several threatened or endangered species; some of these species are found nowhere else in the world. The Upper Colorado River Endangered Fish Recovery Program, the San Juan River Basin Recovery Implementation Program, and the Lower Colorado River Multi-Species Conservation

Program are examples of existing critical and effective programs that focus on the recovery and protection of many species while allowing for continued water deliveries. This important work should continue.

- Abundant recreational opportunities are supported by the Colorado River and its tributaries. The nine NPS units[9] linked to the Colorado River accounted for nearly 20 million visits in 2012 and 2013, with total visitor spending exceeding $1.2 billion and $1.5 billion, respectively. These and other recreational opportunities contribute to local and regional economies.
- Hydropower facilities in the Basin provide power to over 200 contractors and millions of people throughout eight western states (Arizona, California, Colorado, Nebraska, Nevada, New Mexico, Utah, and Wyoming), while helping support important environmental programs in the Basin in addition to repaying the federal investment in the facilities.
- Potential interrelationships exist between environmental and recreational flows and hydropower resources. As options to protect or improve ecological and recreational resources are evaluated in any future efforts, the effects on all resources, including hydropower, should be considered.
- Though river reaches face unique challenges, some commonalities exist such as threatened and endangered species, threats from non-native fish species, and water quality concerns. Common scientific uncertainties relate to understanding the relationship between flow and ecological and recreational values, and the effect of invasive species removal and native vegetation restoration on flows.
- Many programs and processes that use a range of effective mechanisms currently operate within the Basin to address ecological and recreational resources.
- Cooperative, multi-interest/multi-party voluntary mechanisms have proven to be successful in protecting or improving ecological and recreational resources, and such mechanisms/programs normally benefit more from broader support among competing interests than mandatory, regulatory mechanisms do.
- Though meaningful and significant steps have been taken to protect or improve ecological and recreational resources, opportunities exist to expand or implement new environmental and recreational flow programs.
- Opportunities exist to protect and improve ecological and recreational resources through programs designed to benefit other Basin resources.
- The potential actions identified by the Workgroup include unique complexities and challenges that would necessitate further exploration and analysis to determine how each could be employed in the Basin.

The Colorado River and its tributaries provide habitat to a wide range of species, including several endangered species, provide recreational opportunities that provide significant benefits to regional economies, and generate hydropower that is a clean, renewable source of energy for millions of households. Balancing the benefits of these resources with other uses such as agriculture and M&I water supplies is a complex challenge. Each reach of the Colorado River and its tributaries is unique and an integrated management approach needs to be considered when implementing future actions to address future water imbalances, while protecting or improving ecological and recreational resources.

See Chapter 5 for additional details and information.

6.0 Summary of Opportunities and Next Steps

Based on insights from data collection, case studies, and exploring successes and challenges of existing programs, each workgroup identified future opportunities and potential actions to advance those opportunities within their particular areas of expertise. These opportunities look to increase or expand M&I water conservation and reuse, facilitate future agricultural water saving or productivity enhancements, and provide environmental and recreational benefits within the Basin. These opportunities are summarized in Table 1.

[9] While there are 11 units in the NPS' Colorado River Program, the Workgroup focused on the nine units that are considered to be directly linked to the Colorado River and its major tributaries.

The opportunities and potential future actions could help improve the long-term sustainability of the Basin resources and improve the resiliency of regions dependent on Colorado River water. The opportunities were developed to reflect the areas of greatest potential benefit and could be implemented during future *Moving Forward* phases or by stakeholders under separate efforts. Several commonalities emerged from the individual sets of opportunities and actions identified by each workgroup. The groupings below were developed in an attempt to highlight these commonalities.

- ***Funding and Incentives***: Each workgroup stressed the importance of developing sources of continuous, sustainable funding. Additionally, pursuing funding and technical assistance opportunities that leverage funds from multiple sources was encouraged. Such sources and opportunities could lead to more rapid, effective, and creative implementation of water use efficiency measures, reuse, and environmental and recreational flow projects. Further, sustainable funding and pursuing leveraged funding opportunities would help ensure that sufficient and stable revenue streams are available over the long-term to accomplish a program's goals and to implement desired projects.
- ***Resources, Data, and Tools***: Each workgroup recognized the importance of scientific research, reporting, data management, monitoring, and tool development in effectively and efficiently implementing water conservation programs as well as mechanisms to improving environmental and recreational resources. These items are critical to quantifying benefits and tradeoffs, evaluating cost-effectiveness, and facilitating information sharing.
- ***Outreach and Partnerships***: Whether implementing a water conservation program or a project to improve ecological and recreational resources, these efforts are more effectively implemented with improved stakeholder understanding of the project's goals and constraints, broader stakeholder involvement, and stakeholder commitment to the project. Outreach and partnerships facilitate this understanding and encourage broader involvement and can lead to enhanced stakeholder commitment and the design of more innovative programs that have broad support. Additionally, outreach and partnerships may increase the availability of funding sources.
- ***Coordination and Integration***: Water management in the Basin is complex. The complexities stem from challenges associated with balancing competing needs such as deliveries for M&I and agricultural purposes, hydropower generation, and environmental protection. Each workgroup recognized the importance of facilitating cross-program coordination and information exchange to improve program outcomes and focus of resources.
- ***Infrastructure Improvements***: Improved conveyance and distribution infrastructure and metering devices can reduce losses, reduce operation and maintenance costs, and facilitate other water-efficient investments. These activities provide significant opportunities to both the M&I and agricultural sectors. Both these workgroups identified potential actions to pursue funding measures to replace aging infrastructure, implement enhanced metering capabilities, and expand reuse. Infrastructure improvements can also yield ecological benefits by, for example, decreasing salinity levels.
- ***Flexible Water Management***: Opportunities related to creating additional flexibility in water management were identified by both the agricultural and environmental and recreational flows workgroups. Specifically, the expansion of existing or the addition of new programs such as water banking, exchanges, and transfers was identified as activities to enhance flexible water management. Flexible water management was identified as having the potential to be a useful tool in building water supply resiliency for agricultural users in the Basin in addition to facilitating multi-purpose solutions. The environmental and recreational flows workgroup found that the establishment of market-based mechanisms for such programs (for example, water banking) has the potential to further promote multi-purpose solutions, for example incentivizing water conservation activities in regions where flow improvements are needed to provide environmental and recreational benefits.

TABLE 1
Opportunities for Potential Future Actions Identified by Workgroups
The Workgroups did not prioritize their opportunities; therefore, the ordering of these lists does not imply a prioritization.

M&I Water Conservation and Reuse Workgroup	Agricultural Water Conservation, Productivity, and Transfers Workgroup	Environmental and Recreational Flows Workgroup
• Increase outdoor water use efficiency through technology improvements and behavior change, and increase the adoption of low-water-use landscapes. • Increase the end-user understanding of individual, community, and regional water use. • Increase the integration of water/energy-efficiency programs and resource planning. • Expand local and state goal-setting and tracking to assist providers in structuring programs. • Increase funding for water use efficiency and reuse. • Increase integration of water and land use planning. • Develop and expand resources to assist water providers in water conservation efforts. • Implement measures to reduce system water loss with specific metrics and benchmarking. • Increase commercial, institutional, and industrial water use efficiency and reuse through targeted outreach and partnerships. • Expand adoption of conservation-oriented rates and incentives. • Expand adoption of regulations and ordinances to increase water use efficiency and reuse.	• Increase and/or maintain productivity through more efficient on-farm activities. • Reduce losses and improve operational efficiency through improved conveyance infrastructure. • Pursue flexibility associated with strategic consumptive use reductions (for example, deficit irrigation, crop selection, or fallowing). • Enhance and use mechanisms to facilitate flexible water management (for example, banking, transfers, or exchanges). • Encourage efficient water management through conservation planning and reporting, data management, and tools development. • Foster efficient agricultural water use through sustainable funding and incentive programs. • Increase or maintain productivity and improve water management through soil health.	• Develop sources of sustainable funding for environmental and recreational flow projects. • Use structured and cooperative market-based mechanisms to provide benefits to multiple sectors, including ecological and recreational resources. • Develop projects that incorporate watershed management. • Develop partnerships that achieve the protection or improvement of ecological and recreational resources through payment for protection of environmental attributes. • Investigate opportunities to use voluntary water management optimization for the protection or restoration of environmental and recreational flows. • Facilitate enhanced coordination among existing programs. • Support additional capacity-building for existing and new stakeholder coalitions.

It was recognized that the applicability of such programs are dependent upon physical location and state and federal water law and will need to be vetted in consideration of local economies and related factors. However, such mechanisms are considered to have the potential to offer increased flexibility through partnership opportunities and could produce concurrent environmental and recreational benefits, while meeting water supply needs.

The *Moving Forward* effort builds upon and enhances the inclusive stakeholder process established during the Basin Study with an ultimate goal of identifying and implementing actionable steps to address projected water supply and demand imbalances that have broad-based support and provide a wide-range of benefits. The Phase 1 Report completes Phase 1 of the *Moving Forward* effort.

In Phase 2, which will commence in 2015, the Coordination Team, with input from the workgroups, will integrate and synthesize the Phase 1 opportunities and potential future actions identified by the workgroups and identify several proposed pilot projects. The goal of Phase 2 is the implementation of the proposed pilot projects. The structure of Phase 2 will be determined based on the nature of the pilot projects, however, the collaborative and inclusive approach demonstrated in the Basin Study and Phase 1 will be maintained. Additionally, it is the hope of the participants of the *Moving Forward* effort that the Phase 1 opportunities and potential future actions will be considered and undertaken by willing funding partners and interested stakeholders outside the *Moving Forward* effort.

  

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Acknowledgement

Funding provided by the Bureau of Reclamation and the seven Colorado River Basin States for Phase 1 of the *Moving Forward* effort and the generous contributions of time and expertise by stakeholders made the development of this Phase 1 Report possible.

Participating Members:

Federal Agencies
- Bureau of Reclamation
- National Park Service
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- U.S. Geological Survey
- Western Area Power Administration

State Agencies/Organizations
- Arizona Department of Water Resources
- Arizona Public Service
- California Department of Water Resources
- Colorado River Board of California
- Colorado River Commission of Nevada
- Colorado Water Conservation Board
- New Mexico Interstate Stream Commission
- New Mexico Office of the State Engineer
- Upper Colorado River Commission
- Utah Associated Municipal Power Systems
- Utah Department of Natural Resources
- Utah Division of Water Resources
- Wyoming State Engineer's Office

Municipal Agencies/Organizations
- City of Cheyenne Board of Public Utilities
- City of Flagstaff
- City of Santa Fe
- Colorado Springs Utilities
- Los Angeles Department of Water & Power

Water/Energy Providers
- Albuquerque-Bernalillo County Water Utility Authority
- Central Arizona Project
- Coachella Valley Water District
- Colorado River Water Conservation District
- Denver Water
- Eastern Municipal Water District
- Green River - Rock Springs - Sweetwater County Joint Powers Water Board
- Imperial Irrigation District
- Jordan Valley Water Conservancy District
- Maricopa-Stanfield Irrigation & Drainage District
- Northern Colorado Water Conservancy District
- Palo Verde Irrigation District
- Public Service Company of New Mexico
- Salt River Project
- San Diego County Water Authority
- San Juan Water Commission
- Southeastern Colorado Water Conservancy District
- Southern Nevada Water Authority
- The Metropolitan Water District of Southern California
- Wellton-Mohawk Irrigation & Drainage District

Federally-Recognized Tribes
- Colorado River Indian Tribes
- Ten Tribes Partnership

Non-governmental Organizations
- American Rivers
- American Whitewater
- Arizona Municipal Water Users Association
- Colorado River Energy Distributors Association
- Colorado Water Users
- Environmental Defense Fund
- Family Farm Alliance
- Front Range Water Council
- National Parks Conservation Association
- National Young Farmers Coalition
- Rio Grande Restoration
- The Nature Conservancy
- Theodore Roosevelt Conservation Partnership
- Trout Unlimited
- Yuma County Agricultural Water Coalition

Universities
- Colorado State University

Others
- CH2M HILL
- Squire, Sanders & Dempsey LLP
- Zebre Law Offices

Disclaimer

The *Moving Forward* effort was funded jointly by the Bureau of Reclamation and the seven Colorado River Basin States and is a collaborative product of the Coordination Team and Workgroup members listed at the start of Chapters 2, 3, 4, and 5 of this report. The purpose of the effort is to build on the critical investigations in the 2012 Colorado River Basin Water Supply and Demand Study related to the range of potential strategies to address projected future supply and demand imbalances. This report does not provide recommendations or represent a statement of policy or position of the Bureau of Reclamation, the Department of the Interior, the funding partners, or other participants. The report does not propose or address the feasibility of any specific project, program or plan. Nothing in the report is intended, nor shall the report be construed, to interpret, diminish, or modify the rights of any participant under applicable law. Nothing in the report represents a commitment for provision of federal funds.

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1 | Introduction

In 2012, the Bureau of Reclamation (Reclamation), in partnership with the seven Colorado River Basin States[1] (Basin States) and in collaboration with a wide spectrum of Colorado River Basin (Basin) stakeholders, published the most comprehensive study of future Basin supply and demand ever undertaken. The Colorado River Basin Water Supply and Demand Study (Basin Study) defined current and future imbalances in water supply and demand in the Basin over the next 50 years and developed and analyzed options and strategies to resolve those imbalances. The Basin Study confirmed that, in the absence of timely action, there are likely to be significant shortfalls between projected water supplies and demands in the Basin in coming decades that are likely to affect each sector (for example, agricultural, municipal, energy, and environmental) dependent on the Colorado River and its tributaries. The Basin Study also confirmed that a wide range of solutions are needed to mitigate and adapt to such shortfalls (Reclamation, 2012a).

In response to the findings of the Basin Study, in May 2013, Reclamation and the Basin States, in collaboration with the Ten Tribes Partnership[2] and conservation organizations, initiated the *Moving Forward* effort to build on future consideration and next steps identified in the Basin Study[3]. Other areas identified in the Basin Study, beyond the three considered in the *Moving Forward* effort, are being advanced through separate activities led by Reclamation, the Basin States, and others (for example, the Ten Tribes Partnership).

The *Moving Forward* effort continues to facilitate and build upon the broad, inclusive stakeholder process demonstrated in the Basin Study. As such, this effort is organized using three multi-stakeholder workgroups and a multi-stakeholder Coordination Team to guide and review the efforts of the workgroups. The three workgroups are as follows:

- Municipal and Industrial (M&I) Water Conservation and Reuse Workgroup
- Agricultural Water Conservation, Productivity, and Transfers Workgroup
- Environmental and Recreational Flows Workgroup

This report focuses on the outcomes of the three workgroups during Phase 1 of the *Moving Forward* effort, conducted between June 2013 and November 2014, and consists of the following chapters:

- Chapter 1 – Introduction
- Chapter 2 – The *Moving Forward* Effort
- Chapter 3 – Municipal and Industrial Water Conservation and Reuse
- Chapter 4 – Agricultural Water Conservation, Productivity and Transfers
- Chapter 5 – Environmental and Recreational Flows
- Chapter 6 – Summary and Next Steps

Commenting on the information provided in this Phase 1 Report is encouraged. Written comments should be submitted within 90 days following the release of this report. Comments will be summarized and posted to the *Moving Forward* website and will be considered in future *Moving Forward* phases.

Comments may be submitted in the following ways:

- Via the *Moving Forward* website at http://www.usbr.gov/lc/region/programs/crbstudy/MovingForward/index.html
- Email to ColoradoRiverBasinStudy@usbr.gov
- United States (U.S.) mail to Bureau of Reclamation, Attention: Ms. Pam Adams, LC-4017, P.O. Box 61470, Boulder City, NV 89006-1470
- Facsimile transmission to (702) 293-8340

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[1] Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming

[2] Chemehuevi Indian Tribe, Cocopah Indian Tribe, Colorado River Indian Tribes, Fort Mojave Indian Tribe, Jicarilla Apache Nation, Navajo Nation, Quechan Indian Tribe, Southern Ute Indian Tribe, Ute Indian Tribe of the Uintah and Ouray Reservation, Ute Mountain Ute Indian Tribe

[3] The Basin Study recommended future work in the following areas: water use efficiency and reuse, water banks, water transfers, water supply augmentation, watershed management, tribal water, environmental flows, data and tool development, climate science research, and partnerships.

1.1 Overview of the Colorado River Basin

Today, between 35 and 40 million people[4] in the seven Basin States rely on Colorado River and its tributaries for some, if not all, of their municipal water needs. These same water sources irrigate nearly 4.5 million acres of land[5] in the Basin and the adjacent areas that receive Colorado River water, generating many billions of dollars a year in agricultural and economic benefits. There are 22 federally recognized tribes in the Basin for whom the Colorado River and its tributaries are essential as a physical, economic, and cultural resource. In addition, the Colorado River is vital to the United Mexican States (Mexico). The river supports a thriving agricultural industry in the Mexicali Valley and provides municipal water supplies for communities in Mexico as far away as Tijuana. The Colorado River Basin is depicted in Figure 1.

The Colorado River and its tributaries provide habitat for a wide range of species, including several federally endangered species, and flows through seven national wildlife refuges and 11 National Park Service (NPS) units[6]. Throughout the Basin, the Colorado River and its tributaries provide a range of recreational opportunities such as boating, fishing, and hiking, all of which significantly benefit regional economies. Hydropower facilities in the Basin can supply more than 4,200 megawatts of vitally important electrical capacity to assist in meeting the power needs of western states, reducing the use of fossil fuels.

Total consumptive use[7] and losses in the Basin has averaged approximately 15.0 million acre-feet[8] (MAF) over the past decade. Agriculture is the dominant use of Colorado River water, with approximately 70 percent of total Colorado River water used to support agriculture. Of the total consumptive use, 40 percent is exported outside the Basin's hydrologic boundaries for use in adjacent areas. Colorado River water used in these areas is not returned to the Colorado River. As shown on Figure 1, several major metropolitan areas that receive Colorado River water, including Albuquerque, Denver, Los Angeles, Salt Lake City, and San Diego, are located outside the Basin's hydrologic boundaries.

The Colorado River system is operated in accordance with the Law of the River[9]. Apportioned water in the Basin exceeds the average long-term (1906-2012) historical natural flow[10] of approximately 16.2 MAF. Up to this point, the imbalance has been managed, and demands largely met as a result of the considerable amount of reservoir storage capacity in the system (approximately 60 MAF or nearly four years of average natural flow of the river), the fact that the Upper Basin States of Colorado, New Mexico, Utah, and Wyoming are still developing into their apportionments, and the continuing efforts that Basin States are making to reduce their demand for Colorado River water.

[4] The Basin Study estimated about 40 million people by 2015 in the portion of the Basin and the adjacent areas that receive Colorado River water in the U.S. See Basin Study, *Technical Report C* for additional detail (Reclamation 2012b). Estimate of 35 million people is based on the 2010 U.S. Census Bureau population data from cities within planning areas (as defined in the Basin Study) that receive Colorado River water.

[5] The Basin Study estimated about 5.5 million irrigated acres by 2015 in the portion of the Basin and adjacent areas that receive Colorado River water in the U.S. See Basin Study, *Technical Report C* for additional detail (Reclamation, 2012b). This number was updated to 4.5 million irrigated acres by the Agricultural Workgroup to better reflect acreage in adjacent areas potentially receiving Colorado River water.

[6] While there are more NPS units within the Basin, 11 are included in the NPS' Colorado River Program.

[7] Consumptive use is defined as water used, diminishing the available supply.

[8] Basin-wide consumptive use and losses estimated over the period 2003 to 2012, including the 1944 Treaty delivery to Mexico, reservoir evaporation, and other losses due to native vegetation and operational inefficiencies.

[9] The treaties, compacts, decrees, statutes, regulations, contracts, and other legal documents and agreements applicable to the allocation, appropriation, development, exportation, and management of the waters of the Colorado River Basin are often collectively referred to as the Law of the River. There is no single, universally agreed upon definition of Law of the River, but it is useful as a shorthand reference to describe this longstanding and complex body of legal agreements governing the Colorado River.

[10] Natural flow represents the flow that would have occurred at the location had depletions and reservoir regulation not been present upstream of that location.

FIGURE 1-1
Colorado River Basin

Note:
Similar to the Basin Study, the scope of the *Moving Forward* effort is limited to the portion of the Basin and adjacent areas that receive Colorado River water within the U.S.

1.2 Future Conditions and the Need for Future Action

The challenges and complexities of ensuring a sustainable water supply and meeting future resource[11] needs in an over-allocated and highly variable system such as the Colorado River have long been recognized and documented by Reclamation, the Basin States, and many stakeholders. Consequently, significant investments have been made in constructing infrastructure, developing other water resources, and implementing innovative conservation programs and policies to sustain current and future supplies. Many of these efforts have resulted in solutions to past water management challenges and will continue to provide benefits in meeting the challenges that lie ahead.

Future challenges arise from the likelihood of continued population growth coupled with significant uncertainty regarding an adequate future water supply. Nevada, Arizona, and Utah rank first, second and third, respectively, for the highest population growth rates in the U.S. from 2000 to 2010. During that same decade, California experienced the second highest numeric population increase in the U.S. (U.S. Census Bureau, 2011). The communities and economies of major cities such as Albuquerque, Denver, Las Vegas, Los Angeles, Phoenix, Salt Lake City, and San Diego are in part dependent, or in the case of Las Vegas, almost entirely dependent on the Colorado River for water supply. As water demand for municipal and agricultural purposes increases to serve the needs of growing populations, ensuring the availability of water for non-consumptive uses such as the environment, recreation, and hydropower becomes increasingly challenging. Both consumptive and non-consumptive uses face increasing levels of risk. Water supply uncertainty is further compounded by the potential impacts from climate change. Evidence indicates increased future climate variability in the Southwest, which may include longer, more extreme dry (and wet) periods than previously observed (Garfin et al., 2014).

It is impossible to know the precise trajectory of future water supply and demand or how those trajectories may impact the reliability of the Colorado River to meet the needs of Basin resources. To address this uncertainty, the Basin Study adopted a scenario planning process to capture a broad range of plausible water demand and supply futures and then assessed the impacts to Basin resources if such futures were to unfold. This approach confirmed that, absent future action, the Basin faces a wide range of plausible future long-term imbalances between supply and demand. This imbalance, computed as a 10-year running average, ranges from no imbalance to 6.8 MAF with a median of 3.2 MAF in 2060[12], as shown in Figure 1-2. The assessment of impacts to Basin resources found that any long-term imbalance will impair the ability of the Colorado River system to meet the needs of Basin resources resulting in negative impacts (for example, reduced reliability of water deliveries for municipal and agricultural purposes, decreased hydropower generation, reduced recreational opportunities).

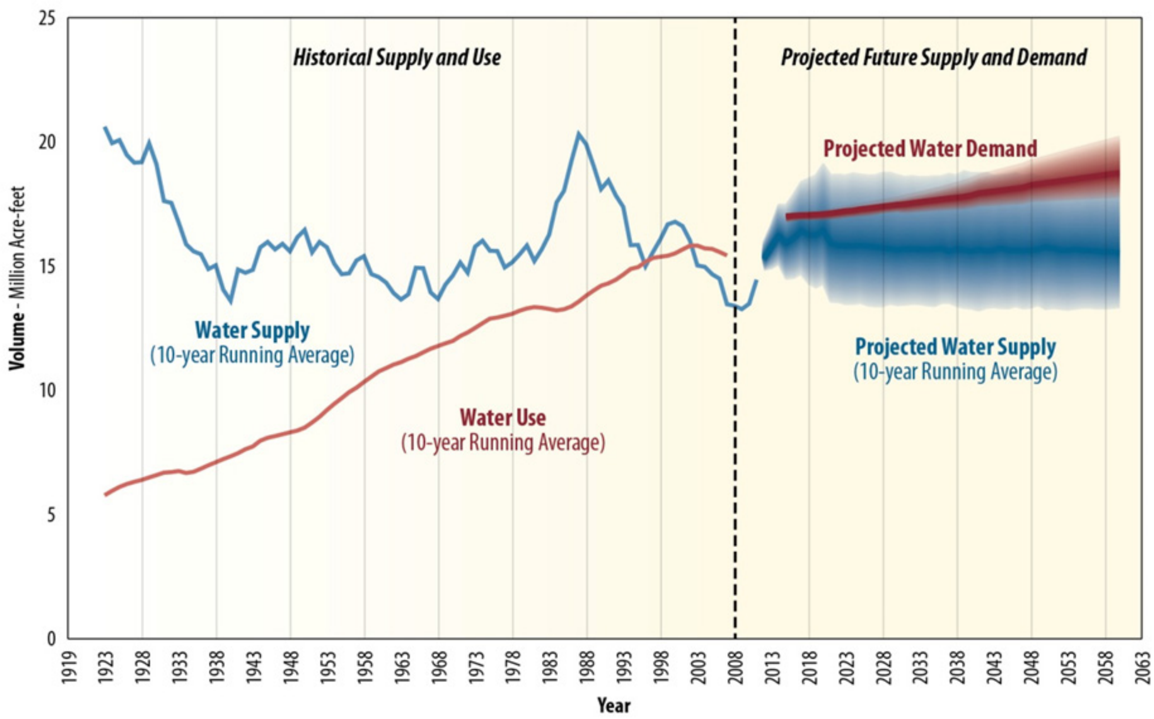
In addition to the long-term challenges identified in the Basin Study, current extended drought conditions in the Basin and in neighboring river basins have further heightened a sense of urgency for ensuring Colorado River sustainability. The period from 2000 to 2014 was the lowest 15-year period for natural flow in the last century. Paleo records indicate that this period was also one of the lowest 15-year periods for natural flow in the past 1,200 years (Meko et al., 2007). Fortunately, the Colorado River system reservoirs were nearly full at the start of this drought. As a result, all requested deliveries were made in the Lower Basin during this period.

Existing drought conditions in areas adjacent to the Basin that depend on the Colorado River for part of their water supply can result in greater strains on the Colorado River. California is facing one of its most severe droughts on record. In January 2014, Governor Brown declared a drought State of Emergency and directed state officials to take all necessary actions to prepare for water shortages. Recent flows of the Rio Grande have been some of the lowest in more than 130 years of record-keeping, prompting drought declarations for municipalities, much reduced agricultural allocations, shrinking reservoir storages, and stressing water available to protect endangered species.

[11] Resources include water allocations and deliveries for municipal, industrial, and agricultural use; hydroelectric power generation; recreation; fish, wildlife, and their habitats (including candidate, threatened, and endangered species); water quality including salinity; flow- and water-dependent ecological systems; and flood control.

[12] Comparing the 90th percentile supply to the 10th percentile demand results in no imbalance. Comparing the 10th percentile supply to the 90th percentile demand results in a 6.8 MAF imbalance. Comparing the 50th percentile of both supply and demand results in a 3.2 MAF imbalance.

FIGURE 1-2
Historical Supply and Use[1] and Projected Future Colorado River Basin Water Supply and Demand[1] (Reclamation, 2012a)



[1] Water use and demand include Mexico's allotment and losses such as those due to reservoir evaporation, native vegetation, and operational inefficiencies.

Had the Colorado River system reservoirs not been nearly full in 2000, the Basin could be experiencing similar drastic conditions. Nevertheless, every resource in the Basin is feeling the impact of this current drought, proving that no one sector solely bears the burden of these challenging conditions. Looking ahead, no one sector can provide the solution for ensuring long-term sustainability. To respond to these future challenges, diligent planning will be required to find adaptable solutions that build resiliency and apply a wide variety of ideas at local, state, regional, and Basin-wide levels. With this in mind, the Basin Study recommended several future actions to move closer toward implementing such solutions. These actions include, as a first step, resolving uncertainties related to water use efficiency, reuse, and environmental and recreational flows by shifting the focus from the Basin-wide approach taken in the Basin Study, to one that explores such areas in more detail. This Report provides information on the variety of water saving and management approaches currently being applied in various locations and regions throughout the Basin. This information is an important building block for exploring future innovative and cost-effective options that provide a wide-range of benefits to water users and enhance the health of the Basin's watersheds.

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Chapter 2
The *Moving Forward* Effort

May 2015

Coordination Team

Chairs:

- Carly Jerla, Bureau of Reclamation
- Kay Brothers, consultant to the Southern Nevada Water Authority

Members:

- Tom Buschatzke, Arizona Department of Water Resources
- Kathleen Ferris, Arizona Municipal Water Users Association (Workgroup Co-Chair[1])
- Alan Butler, Bureau of Reclamation (Workgroup Co-Chair[2])
- Kenneth Nowak, Bureau of Reclamation (Workgroup Co-Chair[3])
- Chuck Cullom, Central Arizona Project
- Tanya Trujillo, Colorado River Board of California
- Jayne Harkins, Colorado River Commission of Nevada
- Dave Kanzer, Colorado River Water Conservation District
- Reagan Waskom, Colorado State University (Workgroup Co-Chair[3])
- Ted Kowalski, Colorado Water Conservation Board (Workgroup Co-Chair[2])
- Erin Wilson, Colorado Water Users
- Marc Waage, Denver Water (Workgroup Co-Chair[1])
- Jennifer Pitt, Environmental Defense Fund
- Bennett Raley, Front Range Water Council
- Tina Shields, Imperial Irrigation District (Workgroup Co-Chair[3])
- Bill Hasencamp, The Metropolitan Water District of Southern California
- Jack Safely, The Metropolitan Water District of Southern California (Workgroup Co-Chair[1])
- Rob Billerbeck, National Park Service
- Kevin Flanigan, New Mexico Interstate Stream Commission
- Ed Smith, Palo Verde Irrigation District
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[1] Co-Chair of the Municipal and Industrial Water Conservation and Reuse Workgroup
[2] Co-Chair of the Environmental and Recreational Flows Workgroup
[3] Co-Chair of the Agricultural Water Conservation, Productivity, and Transfers Workgroup

2 | The *Moving Forward* Effort

The Colorado River Basin Water Supply and Demand Study (Basin Study) demonstrated that the implementation of a broad range of options can improve the Colorado River Basin's (Basin) resiliency to dry and variable hydrologic conditions and help lead to long-term sustainability (Bureau of Reclamation [Reclamation], 2012). Implementing such options requires diligent planning and collaboration that applies a wide variety of water management ideas throughout the Basin. With this in mind, the *Moving Forward* effort was designed to pursue several areas of the "next steps" identified in the Basin Study. Other areas are being advanced through separate Reclamation or State-led activities. Central to the *Moving Forward* effort is the recognition that pursuing these areas must be done collaboratively and with a broad, inclusive stakeholder process as demonstrated in the Basin Study.

Reclamation and the seven Colorado River Basin States[1] (Basin States), in collaboration with the Ten Tribes Partnership[2] and conservation organizations, initiated in May 2013 the *Moving Forward* effort, which includes participation by federal, State, tribal, and conservation organization representatives as well as other Basin stakeholders. The first phase of the *Moving Forward* effort, Phase 1, was funded by Reclamation and the Basin States and was completed in December 2014. This Report documents the outcomes of Phase 1 with contributed chapters from each of the multi-stakeholder workgroups formed as part of the effort. After the completion of Phase 1, Phase 2 will commence and build on the Phase 1 activities and outcomes. The structure of the effort will be reassessed and modified as needed to facilitate Phase 2 activities.

Figure 2-1 shows the areas of the "next steps" recommended in the Basin Study and whether they are being undertaken through the *Moving Forward* effort or by other State or Reclamation-led efforts. The Coordination Team, whose members are listed at the start of this chapter, guides and reviews the activities of the *Moving Forward* workgroups and receives periodic updates on the status of activities in these other areas in an ongoing effort to coordinate the activities of the workgroups.

2.1 Phase 1 Workgroups

A Coordination Team was formed in Phase 1 of the *Moving Forward* effort to guide and review the activities of the three workgroups, also formed as part of the effort. These workgroups are listed below:

- Municipal and Industrial (M&I) Water Conservation and Reuse Workgroup
- Agricultural Water Conservation, Productivity, and Transfers Workgroup
- Environmental and Recreational Flows Workgroup

The Basin Study found that, relative to the other options explored, water use efficiency in the M&I and agricultural sectors as well as water reuse were cost-effective solutions that could be implemented in the near-term. As such, it was recommended that workgroups in these areas be formed. The Basin Study was limited in its inclusion of options which specifically included objectives towards improving ecological and recreational resources, and a workgroup in this area was formed to further explore such options.

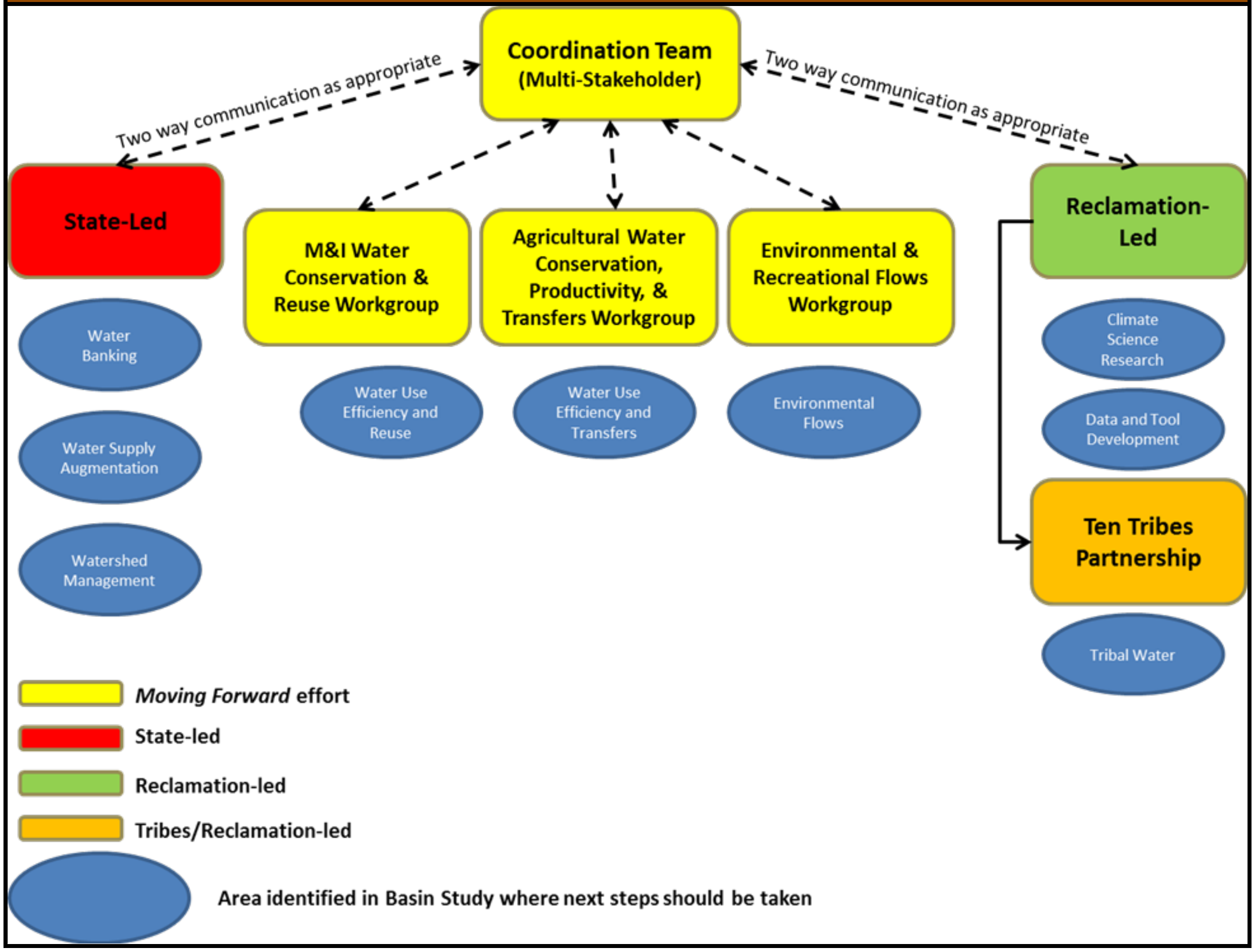
The overall purpose of these workgroups during Phase 1 was to further investigate these areas by documenting past and projected future trends and exploring the opportunities and challenges of various water management actions. Each workgroup identified potential future actions to address critical challenges related to projected water imbalances that provide a wide-range of benefits and have broad-based support.

Each workgroup is led by three co-chairs and consists of members with subject-matter expertise from various stakeholder entities in an effort to bring important and different perspectives to the workgroups.

[1] Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming

[2] Chemehuevi Indian Tribe, Cocopah Indian Tribe, Colorado River Indian Tribes, Fort Mojave Indian Tribe, Jicarilla Apache Nation, Navajo Nation, Quechan Indian Tribe, Southern Ute Indian Tribe, Ute Indian Tribe of the Unitah and Ouray Reservation, Ute Mountain Ute Indian Tribe

FIGURE 2-1
Organization of "Next Steps" Activities



Workgroup membership, listed at the beginning of each workgroup's chapter of this Report, includes federal and state agencies, local municipalities, agricultural organizations water districts, federally recognized tribes, non-governmental organizations, consultants, and other interested stakeholders. The Coordination Team is led by representatives from Reclamation and the Basin States. In September 2013, Reclamation entered into a contract with CH2M Hill to provide technical and administrative support for the *Moving Forward* effort.

The Coordination Team and workgroups used a collaborative problem-solving approach to complete their tasks and assist in the preparation of the Phase 1 Report. Chapters 3, 4, and 5 of this Report were contributed by each respective workgroup and reviewed by the Coordination Team. The workgroups met frequently, both in person and via webinar, during the approximately 18-month period needed to complete their Phase 1 activities, including preparing their chapters. The Coordination Team met, also in person and via webinar, to review the workgroup's completed tasks and the overall workgroup progress. The Coordination Team strove to coordinate the efforts of the workgroups with the recognition that some differences in their approaches remain.

The Phase 1 Report is intended to identify opportunities and potential actions that convey the perspectives of the workgroups regarding the role of their respective sector in being a part of the solution set needed to address the challenges identified in the Basin Study. This report is neither intended to make value judgments nor develop recommendations related to municipal and agricultural water conservation, reuse, transfers, or environmental and recreational flows.

2.2 Separate Efforts Led by the Basin States and the Bureau of Reclamation

Separate from the *Moving Forward* effort, Reclamation and the Basin States are simultaneously pursuing other areas of future considerations and next steps identified in the Basin Study. These efforts and the status of each are briefly described below.

2.2.1 Water Banking

Building on the Basin Study work related to Upper Basin water banking, the Upper Basin States of Colorado, New Mexico, Utah and Wyoming continue to explore the potential for water banking as a drought mitigation tool. The Upper Basin States have explored a wide variety of possible hydrology scenarios to understand possible durations and volumes of future water bank operations. To that end, the Upper Basin States have also analyzed reservoir capacities and operations and general feasibility questions regarding water conservation and banking. Moreover, in Colorado, the Colorado Water Conservation Board (CWCB) and a number of stakeholders are conducting a more detailed investigation of potential water bank participation, considering the differences based on type, size and management structures of ditch systems, irrigation methods, crop types and elevation. This Water Bank Working Group (consisting of the CWCB, the Colorado River Water Conservation District, the Southwestern Water Conservation District, The Nature Conservancy, and the Front Range Water Council) are conducting pilot studies and intensive field investigations to determine the benefits, impacts and possible water savings related to deficit irrigation of alfalfa and grass hay.

The Wyoming State Engineer's Office is also evaluating the feasibility of a "demand management" program within the Basin in Wyoming. The study is focusing on the development of voluntary water demand management strategies, including options and alternatives for a water bank program that can provide positive outcomes on a strategy for avoiding curtailment. This study will outline any information gaps, and the necessary technical, legal and policy questions and issues that will require future evaluation and actions by the State, whether through the State Engineers Office, Governor, or State Legislature working in concert with all of the stakeholders in the Basin.

2.2.2 Water Supply Augmentation

The possibility of future water supply and demand imbalances has been identified since the 1960's. Almost 40 years ago the study, "The Westside Study Report on Critical Water Problems Facing the Eleven Western States" (Reclamation, 1975), concluded that in spite of conservation, the Basin faces future water shortages unless its natural flows are augmented by more than 2.5 million acre-feet per year, or water-dependent Basin development is limited. In response to the promulgation of the Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead (Reclamation, 2007) in 2007 and the ongoing drought, the Basin States finalized the "Study of Long –Term Augmentation Options for the Water Supply of the Colorado River System" (Colorado River Water Consultants, 2008). Twelve potential long-term options for augmenting the Colorado River were evaluated against parameters related to water quality, technical implementation, environmental considerations, permitting, relative costs and projected water yield.

In March 2013 the Basin States Augmentation Workgroup began the development of a long-range augmentation plan. To aid in this effort the Central Arizona Water Conservation District (CAWCD) funded a study to evaluate new water supplies (above and beyond those already included in a supply portfolio) to augment the Colorado River that have a reasonable chance of being permitted/implemented, produce a reliable quantity of new water, and can be developed for a reasonable cost. This report will be used as one source of information for the Basins States Augmentation Workgroup to continue efforts to develop a long-range plan for augmentation of the Colorado River. The Arizona Department of Water Resources and the Upper Colorado River Commission co-chair this workgroup.

2.2.3 Watershed Management

Upper Basin Cloud Seeding

Orographic cloud seeding is a technology designed to enhance precipitation in winter storms with an inefficient precipitation process due to a lack of natural ice nuclei. The Wyoming Weather Modification Pilot Program (WWMPP) was conducted to assess the feasibility of increasing Wyoming water supplies through winter orographic cloud seeding. In the spring of 2015, the Wyoming Water Development Commission (WWDC) will publish the final report on their multi-year WWMPP. This program has been unique among other state and federally-sponsored programs in that it has included a substantial component to evaluate the feasibility and effectiveness of cloud-seeding in three mountain ranges in Wyoming. Results released to date from statistical, modeling, and physical studies suggest a positive orographic seeding effect, over a winter season, on the order of 5 to 15 percent for seedable cases (WWDC, 2014). Due to these positive results, Wyoming will likely seek to continue and expand their weather modification program in the Basin as well as across the state. Throughout the course of the pilot program, numerous Basin entities have contributed funds to support and enhance the programs operation. To date, Wyoming has spent over $14 million statewide on the WWMPP. A 2006 study commissioned by the Upper Colorado River Commission found that optimizing existing seeding operations and starting new operations where optimal conditions exist, has the potential to increase Colorado River runoff (North American Weather Consultants, 2006).

Since 2007 the CAWCD, the Six Agency Committee of California, and the Southern Nevada Water Authority have been contributing funds to the States of Colorado, Utah and Wyoming for cloud seeding projects. The goal is to increase snowfall from winter storms generating more runoff. The additional water generated is for the good of the system not any individual entity. Since 2007, over $1 million has been distributed to Colorado, and over $800,000 each has been distributed to Utah and Wyoming for these projects.

In 2015 the three agencies plan for an additional $192,500 to be distributed to Colorado, an additional $136,500 to be distributed to Utah, and an additional $369,000 to Wyoming. In addition to the contributions of the three agencies, various other State and Federal agencies are contributing $543,000 to Wyoming. The total Wyoming funds of $912,000 will support continuation of activities as well as a transition of the existing program in the Wind River Range from a research based program to an operational program.

Hydrologic Effects of Mountain Pine Beetle

Unhealthy forests can result in many threats to a watershed including increased erosion and higher sediment loadings, decreased water quality, decreased reservoir capacity, and negative impacts to environmental and recreational resources. Forest health depends on a variety of factors, such as drought, and unhealthy forests are more at risk to disturbances such as fire, insects and disease. Coniferous forests in much of the Upper Basin are experiencing a profound and intense invasion by the mountain pine beetle. Though beetles are part of natural forest succession, this ecological disturbance is altering the view and function of many mountains, hills and valleys by infesting and killing much of the forest. Many questions have emerged about the overall hydrologic impacts associated with runoff timing, peaks and volume; snow collection, retention and scouring; and the overall hydrology and magnitude of change caused by the mountain pine beetle. The present knowledge of hydrologic changes resulting from vast pine beetle disturbances is based primarily on experiments conducted either at stand level or on smaller watersheds. Only anecdotal information exists on the impacts of large watershed and forest-wide disturbances, and concern is often expressed in extrapolating the experimental findings of smaller to larger scales. Much remains unknown about the site-specific influences the mountain pine beetle will have on the water yield to watersheds.

Tamarisk and Russian Olive Efforts

In May 2008 the Basin States entered into a Memorandum of Understanding with the Tamarisk Coalition to prepare an assessment of Tamarisk and Russian Olive control options and evaluate potential water savings related to each control option. The final Colorado River Basin Tamarisk and Russian Olive Assessment was released by the Tamarisk Coalition in December 2009 and contained eleven specific findings, identified a set of research questions, and listed potential demonstration projects in the Upper and Lower Basins.

In addition, studies are ongoing that explore the value of reducing consumptive losses of Colorado River water through the management of tamarisk. Recently completed research at the Cibola National Wildlife Refuge, through collaborative funding from the Basin States, shows that groundwater levels near the main-stem of the Colorado River are affected by tamarisk water consumption and that estimates of evapotranspiration by energy balance methods correlate well to groundwater level fluctuations.

2.2.4 Climate Science Research

Reclamation's Research and Development Office recently released new hydrologic projections that will help local water managers answer questions about future climate, stream flow, and water resources. The hydrologic projections were derived from new downscaled climate projections using the Coupled Model Inter-comparison Project (CMIP) Phase 5 data from the World Climate Research Program (Reclamation, 2014). The World Climate Research Program develops global climate projections through its CMIP roughly every 5 to 7 years. Results from CMIP Phase 3 were released in 2007 and were used in the Basin Study. Reclamation is currently evaluating the new projections to better understand how they are projected to impact the Basin and how they compare with the projections used in the Basin Study.

2.2.5 Data and Tool Development

Reclamation continually works to enhance its suite of modeling tools, including the Colorado River Simulation System (CRSS), and data to support such tools. As a follow-up to the Basin Study, The Nature Conservancy completed a project, funded by the Southern Rockies Landscape Conservation Cooperative, which explored modeling improvements to more accurately consider environmental and recreational flow needs in CRSS (Alexander et al., 2013). As future, specific project needs arise, the recommendations from this project will be considered if model enhancements are necessary to meet a proposed project's needs.

During the Basin Study, Reclamation and the Basin States committed to work together to (1) develop natural flows for the Little Colorado, Virgin, and Bill Williams Rivers, (2) modify CRSS to use these flows, and (3) explore the feasibility and usefulness of computing natural flows for the Gila River Basin and the feasibility and usefulness of incorporating the Gila River Basin into CRSS. The development of natural flows for the Lower Basin tributaries requires several steps including the recalculation of the consumptive uses and losses from 1971 to the present and the extension of the consumptive uses and losses from 1970 to 1906. Reclamation, in coordination with the Basin States, is currently working to recalculate the consumptive uses and losses for the Little Colorado, Virgin, and Bill Williams Rivers. It is anticipated that the recalculation of consumptive uses and losses for 1971 to the present and the extension back through 1906 will be completed by the end of 2016.

Though not specifically a Reclamation-led effort or a next step identified in the Basin Study, several related efforts are underway to understand consumptive use calculation methods in the Basin. The Upper Basin States and Reclamation are working to understand different consumptive use calculation methods available, or currently being used, in the Upper Basin. Additionally, the U.S. Geological Survey (USGS) is working closely with Reclamation on a publication, anticipated for release in 2015, to (1) compare and contrast USGS and Reclamation terminology and methods as they relate to the calculation of water use and (2) identify opportunities for increased collaboration and efficiency in the future.

2.2.6 Colorado River Basin Ten Tribes Partnership Tribal Water Study

Begun in late 2013, this study is a partnership with the Ten Tribes Partnership, whose members hold a significant amount of quantified and unquantified federal reserved water rights to the Colorado River and its tributaries. The study builds on the technical foundation of the Basin Study by further assessing water supplies and demands for these tribes and identifies tribal opportunities and challenges associated with the development of tribal water. This study is anticipated to be completed in 2016.

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Chapter 3 | Municipal and Industrial Water Conservation and Reuse

This chapter is a product of the Municipal and Industrial Water Conservation and Reuse Workgroup

May 2015

Cover photo source: Central Arizona Project

3 Municipal and Industrial Water Conservation and Reuse

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Figures

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Appendices

Acronyms and Abbreviations

°F	degree(s) Fahrenheit
ABCWUA	Albuquerque Bernalillo County Water Utility Authority
ADWR	Arizona Department of Water Resources
AF	acre-foot (feet)
AFY	acre-foot (feet) per year
AMA	Active Management Area
AMI	Advanced Metering Infrastructure
AWWA	American Water Works Association
Basin	Colorado River Basin
Basin States	Colorado River Basin States
Basin Study	Colorado River Basin Water Supply and Demand Study
BOPU	City of Cheyenne Board of Public Utilities
CAP	Central Arizona Project
CII	commercial, industrial, and institutional
CUP	Central Utah Project
CUPCA	Central Utah Project Completion Act
CUWCD	Central Utah Water Conservancy District
CVWD	Coachella Valley Water District
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
GPCD	gallons per capita per day
GRUSP	Granite Reef Underground Storage Project
IID	Imperial Irrigation District
IRP	Integrated Water Resources Plan
JVWCD	Jordan Valley Water Conservancy District
KAF	thousand acre-feet
M&I	municipal and industrial
MAF	million acre-feet
MWD	The Metropolitan Water District of Southern California
MWDSLS	Metropolitan Water District of Salt Lake City and Sandy
NAUSP	New River-Agua Fria River Underground Storage Project
Reclamation	Bureau of Reclamation
SNWA	Southern Nevada Water Authority
SSI	self-supplied industrial
Workgroup	Municipal and Industrial Water Conservation and Reuse Workgroup

This chapter is a product of the Municipal and Industrial Water Conservation and Reuse Workgroup

Workgroup Co-Chairs:

- Kathleen Ferris, Arizona Municipal Water Users Association
- Jack Safely, The Metropolitan Water District of Southern California
- Marc Waage, Denver Water

Workgroup Members:

- John Stomp, Albuquerque-Bernalillo County Water Utility Authority
- Jenny Hoffner, American Rivers
- Carol Ward-Morris, Arizona Municipal Water Users Association (alternate Co-Chair)
- Robert Lotts, Arizona Public Service
- Scott Miller, Arizona Public Service
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- Armin Munévar, CH2M HILL (contractor team)
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- Angela Rashid, Colorado River Board of California
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- Scott Winter, Colorado Springs Utilities
- Kevin Reidy, Colorado Water Conservation Board
- Elizabeth Lovsted, Eastern Municipal Water District
- Rich Atwater, Environmental Defense Fund
- Ben Bracken, Green River-Rock Springs-Sweetwater County Joint Powers Water Board
- Michael Cohen, Independent Consultant Bart Forsyth, Jordan Valley Water Conservancy District
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- John Longworth, New Mexico Office of the State Engineer
- Mike Greene, Public Service Company of New Mexico
- Dan Denham, San Diego County Water Authority
- Thomas Maher, Southern Nevada Water Authority

3 Municipal and Industrial Water Conservation and Reuse

3.1 Introduction

Water conservation and reuse for municipal and industrial (M&I) purposes has long been recognized by Colorado River water managers and stakeholders as essential for adapting to and mitigating the impacts of current and future shortfalls between water supply and demand throughout the Colorado River Basin (Basin) and the adjacent areas that receive Colorado River water (Bureau of Reclamation [Reclamation], 2012a). Completed in 2012, the Colorado River Basin Water Supply and Demand Study (Basin Study) confirmed the importance of M&I conservation and reuse, but did so taking a broad-based Basin-wide approach. As a next step, the Basin Study recommended that a workgroup be established to identify current and potential future opportunities to improve water use efficiency and increase reuse in the M&I sector, but to do so by taking a more detailed and regional approach.

The M&I Water Conservation and Reuse Workgroup (Workgroup) was convened as part of the *Moving Forward* effort. This effort was initiated by Reclamation and the seven Colorado River Basin States[1] (Basin States) in collaboration with the Ten Tribes Partnership and conservation organizations.

The Workgroup is composed of leaders and experts in the M&I sector throughout the Basin and adjacent areas who represent a broad range of perspectives. The Workgroup strove to document trends in water conservation and reuse programs directed toward water use for M&I purposes, highlight innovative and successful programs and practices, identify opportunities to continue to build from such successes, and highlight and describe the important regional differences in M&I water conservation and reuse programs throughout the Basin and adjacent areas.

This chapter is a product of the Workgroup and documents their activities and findings during the approximately 18-month Phase 1 of the *Moving Forward* effort. The chapter provides information about the Workgroup's structure and specific Phase 1 objectives, background on M&I water use in the Basin and adjacent areas, past and planned future M&I water conservation and reuse programs and practices in metropolitan areas that receive Colorado River water, opportunities and challenges for expanding successful programs, and a suite of ideas that may be considered for potential future action.

[1] Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming

3.2 Background on Municipal and Industrial Water Conservation and Reuse Considered in the Basin Study

The Basin Study evaluated several strategies to address future vulnerabilities associated with the projected water supply and demand imbalances. Common to all strategies was considerable M&I water conservation and reuse beyond current levels. The Basin Study assessed the potential for and costs of conservation and reuse at a Basin-wide level and found that, combined, M&I water conservation and reuse are cost-effective and have the potential to result in significant Colorado River water savings.[2]

Although this broad-based assessment was appropriate for the Basin Study, it did not reflect important local differences in water conservation potential or legal issues associated with the various state water rights policies. For example, in estimating the potential of M&I conservation to reduce Colorado River demand by 2060, M&I water conservation measures were considered for the entire Basin despite state and regional differences in current and potential levels of conservation. Likewise for water reuse, important regional distinctions were simplified. Further details regarding the analysis and assumptions related to M&I conservation and reuse are in the Basin Study, *Technical Report F* (Reclamation, 2012b).

[2] The Basin Study estimated that beyond the M&I conservation and reuse included in the projections of future demand, these activities have the potential to result in approximately an additional 1.9 million acre-feet (MAF) of Colorado River water savings by 2060.

The Workgroup focused on highlighting local and regional efforts for M&I water conservation and reuse, describing past trends and future planned efforts, and identifying opportunities and challenges associated with expanding such efforts. While the Basin Study provided the impetus for the Workgroup formation, the objective of the Workgroup was not to confirm, verify, or revise the approach or assumptions used in the Basin Study.

3.3 Workgroup Objectives and Approach

The Workgroup's Phase 1 objectives were to document trends in M&I water conservation and reuse in areas that receive Colorado River water and to identify opportunities and challenges for expanding M&I water conservation and reuse programs to address projected future imbalances and to enhance the resiliency of the system.

The Workgroup identified six specific tasks for completing the Phase 1 objectives; these tasks are summarized in Table 3-1.

3.3.1 Workgroup Process and Approach

The Workgroup is composed of approximately 30 members representing a broad range of perspectives related to the M&I water sector. Workgroup members are representatives of water providers, conservation organizations, local municipalities, industries, state agencies, and federal agencies. Three Co-Chairs representing Denver Water, Arizona Municipal Water Users Association, and The Metropolitan Water District of Southern California (MWD) were selected to lead the Workgroup.

The Co-Chairs facilitated discussions and helped to define the Phase 1 tasks. The Workgroup was supported by resource personnel from Reclamation and the *Moving Forward* consulting team led by CH2M HILL. The Workgroup met periodically, either in person or by conference calls, between July 2013 and November 2014.

TABLE 3-1
Workgroup Task Summary

Task Number	Task
1	Quantify water conservation and reuse savings to date
2	Compile information on successful water conservation and reuse programs
3	Provide information on projected future water conservation and reuse program savings
4	Investigate the impact of historical and future water savings on Colorado River use and demand
5	Identify opportunities and challenges for expanding successful M&I water conservation and reuse programs
6	Prepare Phase 1 Workgroup chapter

A variety of methods to explore M&I water conservation and reuse was employed to maximize the Workgroup's input and obtain differing points of view. The following steps were included in the process:

1. Collect and analyze data
2. Select and develop case studies
3. Assess current and planned conservation and reuse programs
4. Identify opportunities and challenges

Geographic Representation and Detail

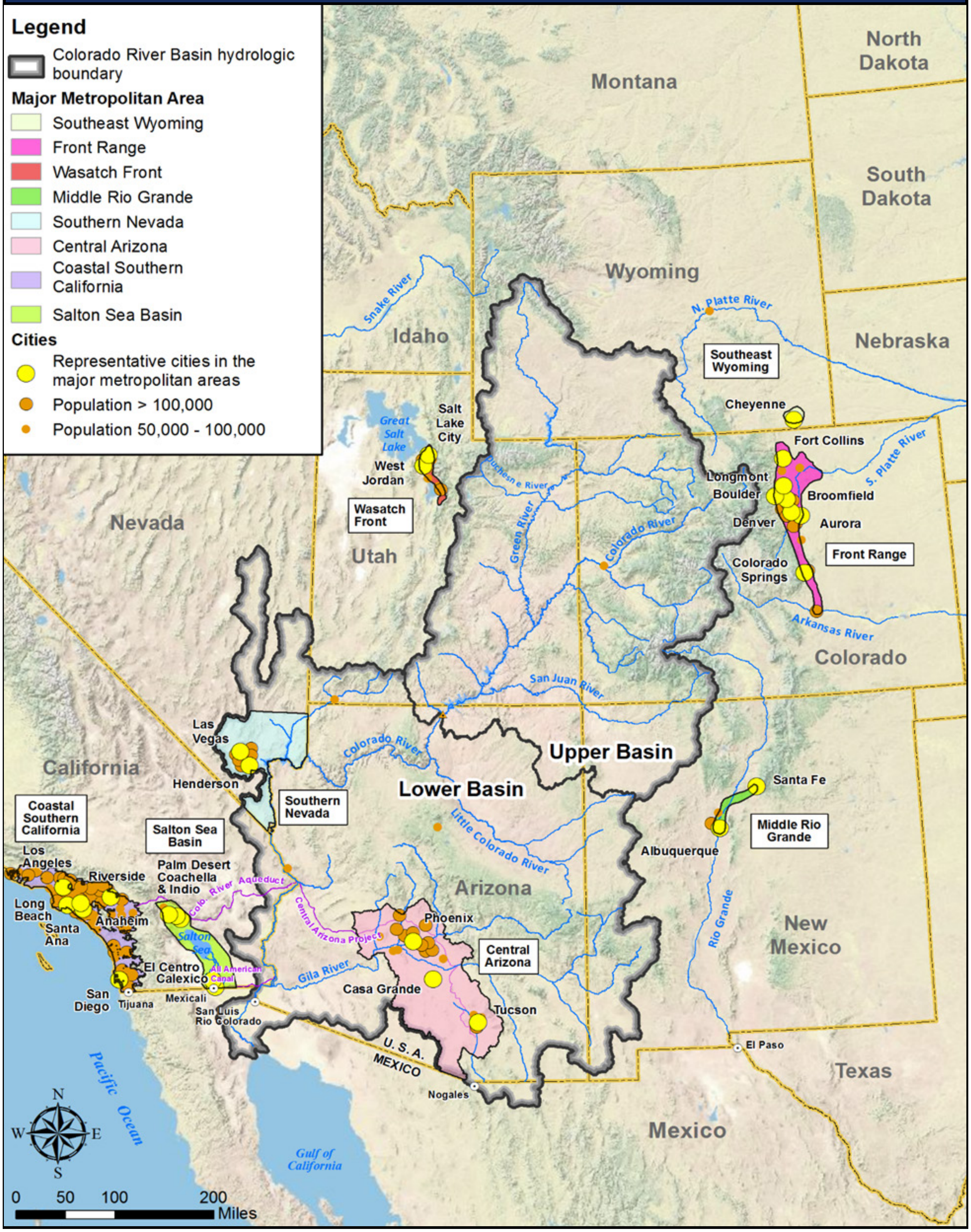
The Workgroup agreed to focus its efforts on major metropolitan areas in the U.S. with populations greater than 100,000 that receive Colorado River water. In addition, a metropolitan area was included for the state of Wyoming, even though the population was less than 100,000. The geographic areas included in this report refer to the major metropolitan areas within the hydrologic basin (such as Southern Nevada and Central Arizona) and also areas outside of the hydrologic basin where Colorado River water is used for M&I purposes (Front Range, Middle Rio Grande, Wasatch Front, Southeast Wyoming, Coastal Southern California, and Salton Sea Basin). The major metropolitan areas in the U.S. that receive Colorado River water and selected major cities within those areas are shown in Table 3-2; their locations are shown on Figure 3-1.

TABLE 3-2
Major Metropolitan Areas in the United States that Receive Colorado River Water

Basin State	Major Metropolitan Area	Water Provider or Planning Area	Representative Major Cities	Population Served (2010)
Wyoming	Southeast Wyoming	City of Cheyenne Board of Public Utilities (BOPU)	Cheyenne	72,000
Colorado	Front Range	Denver Water	Denver	1,310,000
		Colorado Springs Utilities	Colorado Springs	445,700
		Aurora Water	Aurora	325,100
		Fort Collins Utilities	Fort Collins	129,000
		City of Boulder Public Works	Boulder	109,600
		City of Longmont	Longmont	87,500
		City and County of Broomfield Water Utility	Broomfield	56,500
Utah	Wasatch Front	Jordan Valley Water Conservancy District (JVWCD)	West Jordan	585,400
		Metropolitan Water District of Salt Lake City and Sandy (MWDSLS)	Salt Lake City	385,300
New Mexico	Middle Rio Grande	Albuquerque Bernalillo County Water Utility Authority (ABCWUA)	Albuquerque	606,800
		City of Santa Fe Water Division	Santa Fe	79,200
Nevada	Southern Nevada	Southern Nevada Water Authority (SNWA)	Las Vegas, Henderson	1,956,900
Arizona	Central Arizona	Phoenix Active Management Area (AMA)	Phoenix, Mesa, Chandler, Scottsdale, Gilbert, Glendale, Tempe, Peoria, Surprise	3,701,600
		Tucson AMA	Tucson	835,000
		Pinal AMA	Casa Grande	100,600
California	Coastal Southern California	The Metropolitan Water District of Southern California	Los Angeles, San Diego, Long Beach, Santa Ana, Anaheim, Riverside	17,977,900
	Salton Sea Basin	Coachella Valley Water District (CVWD)	Indio, Palm Desert, Coachella	286,200
		Imperial Irrigation District (IID)	El Centro, Calexico	177,600
Total Population Served by Major Metropolitan Areas				29,228,600

Note:
Major metropolitan areas serve more than 85 percent of the population that receives Colorado River water.

FIGURE 3-1
Major Metropolitan Areas in the United States that Receive Colorado River Water



Note:
Similar to the Basin Study, the scope of the *Moving Forward* effort is limited to the portion of the Basin within the United States (U.S.).

Of the approximately 35 million[3] people in the U.S. that rely on Colorado River water for a portion of their water supply, more than 29 million, or more than 85 percent, are included in the major metropolitan areas represented in this report.

All of the major metropolitan areas are served by a mix of water sources that include Colorado River water, other surface water supplies, and groundwater supplies. Most major metropolitan areas (representing approximately 27 million people) that receive Colorado River water are located outside of the hydrologic basin or where water does not return directly to the mainstem Colorado River. Because multiple sources of supply are used to meet M&I demand in the major metropolitan areas, changes (growth or reductions) in this demand may not result in changes in the need for Colorado River water.

Data Collection and Analysis

Historical M&I water use, conservation, and reuse information was solicited from the large water providers within the major metropolitan areas. For this report, information was collected from 18 water agencies and planning areas. This information was summarized into eight major metropolitan areas. The data sources and periods of data availability are summarized in Appendix 3A.

M&I water use, conservation, and reuse information was requested for the period from 1980 through 2010. However, it was acknowledged that most water providers do not have complete or accessible records of M&I water use, conservation and reuse programs throughout this period, and that data gaps exist. Also, because water supply and water use information is managed by different entities, which range from multiple local water providers to state planning agencies, the presentation of water use and program information at the appropriate geographic scale can be challenging. Additionally, water use data measurement, tracking, and accounting varies significantly between water providers, further complicating analysis. There are no consistent accounting categories or definitions for water use categories; therefore, the information provided in this report is appropriate for presenting general trends in M&I water conservation and reuse practices and provides a baseline for consideration of future programs and for evaluating water demand reductions and conservation achievements over time. These data are not appropriate for comparisons between water providers and regions, and regional reports may present information in a different manner.

The historical M&I water use data were organized into five M&I water use categories: (1) residential; (2) commercial, industrial, and institutional (CII), (3) irrigation only; (4) losses and other non-categorized use; and (5) self-supplied industrial (SSI). Descriptions of these categories are presented in Table 3-3. Other important terminology used in this report is shown in the following text box. Residential and CII uses were generally categorized consistently among the water providers. However, information related to irrigation only, losses and other non-categorized use, and SSI water use categories was not provided by all water providers. Many municipal water providers do not account separately for water supplied for irrigation only. SSI water use is independent of municipal water supply systems and represents a small but potentially locally significant water use. Most of the SSI water use in the areas that receive Colorado River water is associated with cooling water supply for power plants, but also includes other uses for industries such as mining, dairy, and cattle feedlot operations.

The gross per capita water use was computed for each major metropolitan area to examine trends in use over time. The per capita use was calculated as the sum of all M&I water use in a metropolitan area, excluding SSI use, divided by the total service area population. Trends in per capita use are described by using 5-year averaging periods around 1990 (1988-1992), 2000 (1998-2002), and 2010 (2008-2012) to account for single-year variability in weather, economy, and behavior that influences short-term water use but may not be reflective of longer-term trends. Additional data were compiled on population, climate, and demographics (characteristics of the population) to assess the principal drivers of M&I water demand. This information was used to present an overview of M&I water use and trends in major metropolitan areas that receive Colorado River water.

[3] Estimate based on the 2010 Census population data from cities within planning areas, as defined in the Basin Study, that receive Colorado River water. See Basin Study, *Technical Report C* for more information on the planning areas (Reclamation, 2012c).

TABLE 3-3
Water Use Categories

Category	Description
Residential	Includes residential indoor and outdoor water uses by single-family, multi-family, and other dwelling units.
CII	Includes all CII uses such as industry, manufacturing, universities, hospitals, military facilities, fire protection, and other public institutions.
Irrigation Only	Includes designated uses for agriculture, parks, golf courses, or other landscaping irrigation. Residential and CII irrigation are captured in Residential and CII categories.
Losses and Other Non-Categorized Use	Includes water lost in the transmission and distribution portions of municipal water systems or due to inaccurate metering. Also includes water use that does not fit into the other categories, such as water used in exchanges.
SSI	Includes SSI water uses that are independent of the supply provided by municipal water systems. May include water use for cooling, mining, snow making, oil and gas extraction, or other industries.

M&I Water Conservation and Reuse Terminology

The terminology associated with M&I water use, water conservation, and water reuse varies considerably in the literature and throughout the M&I water providers that receive Colorado River water. In this report, the following definitions are used:

Water use: Uses for all M&I purposes including residential, commercial, institutional, industrial, municipal system irrigation, municipal system losses, and other non-categorized uses.

Per capita use: A measure of the per capita water use to evaluate trends over time. Calculated as the sum of all M&I water uses in the metropolitan area, except SSI uses, divided by the total area population. Reported as gallons per capita per day (GPCD).

Water conservation: Programs and practices that provide for sustained reductions in water use, loss, or waste.

Reclaimed water: Municipal wastewater that has been treated to meet specific water quality criteria with the intent of being used for beneficial purposes. The term “recycled water” is synonymous with reclaimed water.

Water reuse: The use of treated wastewater (reclaimed water) for a beneficial purpose. Synonymous with the term “wastewater reuse”.

Potable reuse: Augmentation of drinking water supply with reclaimed water through indirect or direct methods.

Non-potable reuse: Reuse of reclaimed water for non-potable uses such as industrial, irrigation, or agricultural uses.

The Workgroup members also provided information on current and future water reuse programs. Water reuse is the use of treated wastewater or reclaimed water for beneficial purposes such as for M&I water supply, agricultural water supply, or for environmental uses. Reuse programs were organized into two groups, depending on the intended end use: non-potable reuse or potable reuse. The amounts and types of reuse occurring in the major metropolitan areas were estimated based on this information.

Selection and Development of Innovative Water Saving Case Studies

Information on innovative or particularly successful M&I water conservation and reuse programs and practices was compiled based on responses to a Workgroup questionnaire. Based on the questionnaire responses, individual programs were selected as examples of innovative or successful water conservation and reuse programs and also to reflect the breadth of programs implemented across the major metropolitan areas that receive Colorado River water. The intent was not to collect information on all conservation and reuse activities, but rather to solicit information about efforts that providers deemed innovative or particularly effective for their service area. In addition to questionnaire responses, information was also solicited from Workgroup members related to water conservation and reuse programs through a data collection template. Combined with the cases studies, more than 400 programs were identified from the data collection process.

Assessment of Current and Planned Conservation and Reuse Programs

Water resources plans from the water providers that receive Colorado River water were reviewed to identify current and planned water conservation and reuse practices being considered as part of their water management strategies. Based on this review, the Workgroup estimated the potential future water savings from these practices.

Identification of Opportunities and Challenges

The Workgroup identified and documented opportunities and challenges associated with the expansion or implementation of new water conservation efforts throughout the major metropolitan areas that receive Colorado River water. For each opportunity, the Workgroup identified ideas for potential future action.

3.4 Municipal and Industrial Water Use in Areas that Receive Colorado River Water

3.4.1 Overview

Between 35 and 40 million people[4] in the U.S. currently rely on the Colorado River and its tributaries to provide some, if not all, of their M&I water needs. The cities and communities in the major metropolitan areas are some of the nation's most vibrant communities and robust economies. The combined gross state product (consistent with gross domestic product) of the Basin States represents approximately 20 percent of the total U.S. gross domestic product (U.S. Bureau of Economic Analysis, 2014)[5]. Much of the economic output and employment (more than 20 million employees) is spurred by the M&I sectors (U.S. Department of Labor, 2014).

Residential water use, which includes outdoor water use, accounts for the largest percentage of the overall M&I water use, ranging from 55 percent to almost 80 percent across the major metropolitan areas reviewed. Outdoor water use varies greatly depending upon geographic location. In dry climates such as the Southwest, average household outdoor water use can be as high as 60 percent (U.S. Environmental Protection Agency [EPA], 2014). In some areas with large institutional and industrial users, the CII sector can account for up to 30 to 40 percent of the total M&I water use. Educational complexes (such as schools and universities) and government complexes (such as research and data management centers) represent a significant portion of the CII use in the Basin. Cities such as Las Vegas and Phoenix feature a large number of resorts, golf courses, and transient populations, which influence M&I water use.

Many factors affect M&I water use, including population, climate, demographics, and the extent of the provider's water conservation programs. The sections below describe these key factors and their trends.

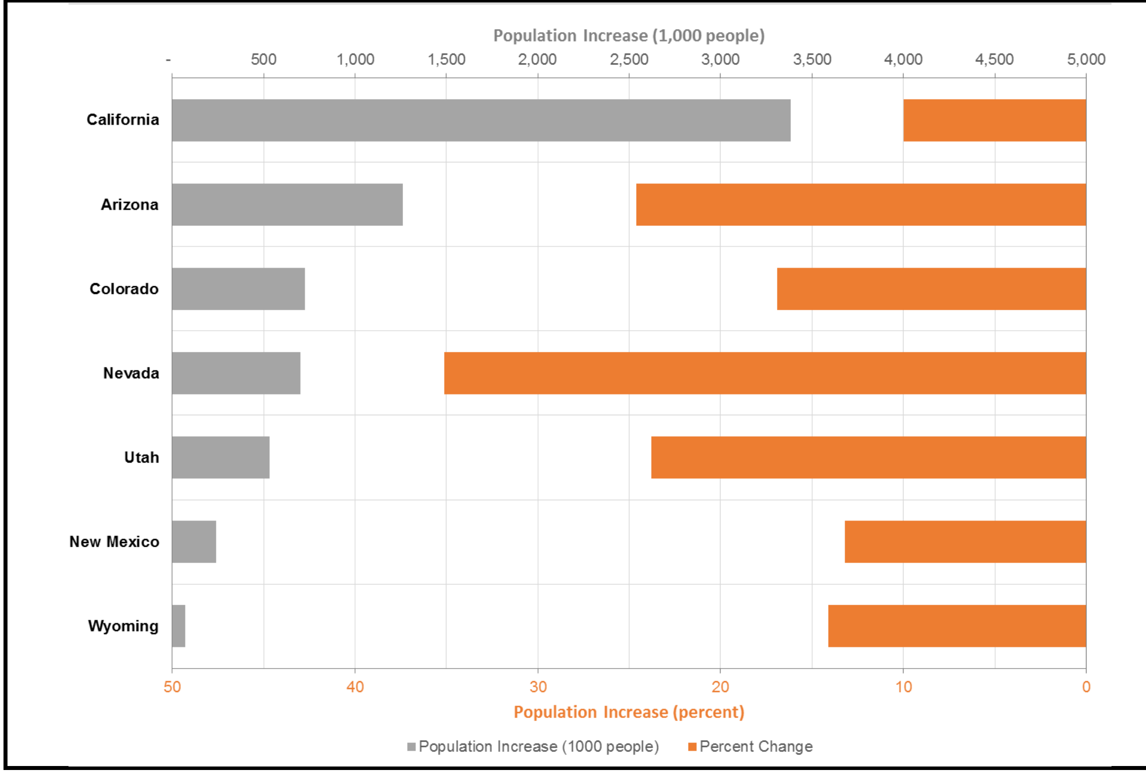
Population is one of the principal drivers influencing M&I water use. The Basin States include some of the nation's fastest-growing urban and industrial areas, and communities and economies of cities such as Albuquerque, Denver, Las Vegas, Los Angeles, Phoenix, Salt Lake City, and San Diego are in part dependent on Colorado River water. Changes in population for each of the Basin States from 2000 to 2010 (U.S. Census Bureau, 2011) are shown on Figure 3-2. California ranks second among all states in the country for populations increases, while Arizona, Nevada, Utah, and Colorado are among the top 10 states for population growth rates (U.S. Census Bureau, 2011).The Basin Study projected the total population in areas that receive Colorado River water could range from 49 to 77 million corresponding to a 23 and 91 percent increase by 2060 (Reclamation, 2012b).

Climate varies significantly across the major metropolitan areas and has a strong influence on water demand. A summary of climate in representative cities that receive Colorado River water is shown on Figure 3-3. The figure shows monthly temperature, precipitation, and potential evapotranspiration for selected climate stations near representative cities for each major metropolitan area.

[4] The Basin Study estimated 40 million people by 2015 in the portion of the Basin and the adjacent areas that receive Colorado River water in the U.S. See Basin Study, *Technical Report C* for additional detail (Reclamation, 2012c). Estimate of 35 million people is based on the 2010 population data from the U.S. Census Bureau for cities within planning areas, as defined in the Basin Study, that receive Colorado River water.

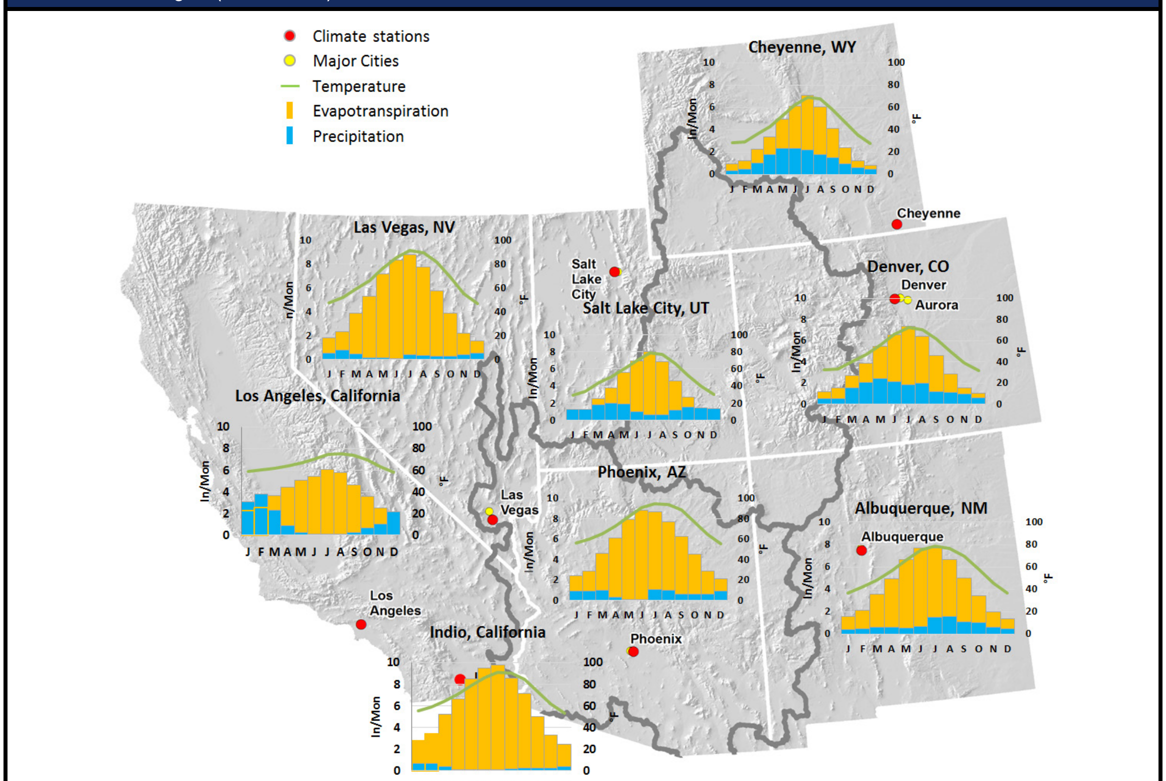
[5] Estimates of gross state product are for entire state and not separately evaluated for the specific areas within each state that receive Colorado River water.

FIGURE 3-2
Population Change in the Basin States between 2000 and 2010



Source: U.S. Census Bureau, 2011

FIGURE 3-3
Climate Averages (1981-2010) for Selected Cities in Areas that Receive Colorado River Water



The mean annual climate for stations in selected representative cities is shown in Table 3-4. Mean annual precipitation ranges from approximately 17 inches in Denver to approximately 4 inches in Las Vegas. Summer temperatures can regularly exceed 100 degrees Fahrenheit (°F) in Phoenix, Las Vegas, and Indio. Potential evapotranspiration, the main driver influencing outdoor water demand, ranges from less than 45 inches in Cheyenne and Salt Lake City to over 70 inches in Phoenix and Las Vegas. As a result of climate conditions, landscape watering needs can be relatively high in many municipal areas, but particularly so in the desert areas. Even landscaping designed for arid and semiarid climates may require supplemental irrigation. The Basin Study reported that outdoor irrigation demands were projected to increase by approximately 3 to 4 percent per degree Celsius of climate warming (Reclamation, 2012b).

TABLE 3-4
1981-2010 Average Annual Precipitation, Temperature, and Potential Evapotranspiration for Selected Stations in the Proximity of Selected Cities

Basin State	Representative City	Average Annual Precipitation (inches)	Average Annual Temperature and Range (Jan., July) (°F)	Average Annual Potential Evapotranspiration (inches)	Potential Evapotranspiration Minus Precipitation (inches)
WY	Cheyenne	16	46 (29, 69)	40	25
CO	Denver	17	50 (33, 73)	45	28
UT	Salt Lake City/West Jordan	16	53 (30, 79)	45	29
NM	Albuquerque	9	57 (37, 79)	53	43
NV	Las Vegas	4	68 (48, 92)	90	86
AZ	Phoenix	8	75 (57, 95)	77	69
CA	Los Angeles	15	67 (59, 74)	48	34
CA	Indio	3	72 (55, 91)	68	65

Source: Annual values estimated from monthly observations of precipitation, mean average temperature, and reference evapotranspiration downloaded from Utah Climate Center at the Utah State University (2014). These data are from the National Weather Service cooperative network of weather observation stations and Global Historical Climatology Network. The selected stations are Wyoming (USW00024018), Colorado (USC00054762), Utah (USW00024127), New Mexico (USW00023050), Nevada (USW00023169), Arizona (USC00024829), and California (USW00093134). Reference evapotranspiration is from the Utah Climate Center except for Las Vegas, which is from International Water Management Institute World Water and Climate Atlas database, and Arizona, which is from the Arizona Meteorological Network.

Demographic characteristics that influence M&I demand are socioeconomic factors such as housing densities, types and age of housing, and economic characteristics (such as income, employment, and main industries). In the major metropolitan areas, these factors vary considerably, and even within individual communities important differences can be found. The following are some important socioeconomic factors and differences that can be identified from U.S. Census Bureau information[6].

- Housing units in the Basin States represent approximately 17 percent of the total in the entire U.S (U.S. Census Bureau, 2013a).
- High population and housing unit densities exist in the Coastal Southern California, Front Range, and Southern Nevada metropolitan areas, with the lowest densities in Wyoming (U.S. Census Bureau, 2013a).
- Single-family homes are the dominant housing stock in the metropolitan areas and exceed 70 percent of the total housing units in Utah, Wyoming, and Colorado (U.S. Census Bureau, 2014).
- The percentage of multi-family units is higher than the national average in California and Nevada (more than 30 percent of the total housing stock) and relatively low in New Mexico (only 15 percent of the total housing stock and lower than the percent of mobile homes) (U.S. Census Bureau, 2014).

[6] Information is for an entire state and not separately evaluated for the specific areas within each state that receive Colorado River water unless otherwise specified.

- The percentage of renter-occupied housing units varies throughout the metropolitan areas. In California and Nevada, more than 40 percent of the occupied houses are being rented, while in other metropolitan areas the number of renter-occupied units is about 30 percent, below the national average of 35 percent (U.S. Census Bureau, 2014).
- Household economic characteristics also vary across the Basin States; median household income ranges from $44,900 in New Mexico to $61,400 in California. In addition, within each state are significant income distribution variations (U.S. Census Bureau, 2014). For example, in New Mexico an estimated 16 percent of households had annual incomes below $15,000 and 6 percent had annual income above $150,000 (U.S. Census Bureau, 2014).
- The average single-family home size in Denver is approximately 2,100 square feet (U.S. Census Bureau, 2013b), while the average single-family home size in San Diego is approximately 1,700 square feet, just below the national average (U.S. Census Bureau, 2013c).

Research shows that these types of factors influence M&I water use, primarily in the residential sector. For example, higher housing densities and multi-family housing units tend to correspond with lower per capita residential water demands due to the relatively small amount of outdoor landscaping as compared to single-family units. Conversely, older homes and renter-occupied houses tend to have a higher per capita water demand than newer, homeowner-occupied homes. Larger residential properties with horses or other livestock also have a higher per capita use. Higher-income homes tend to have more updated indoor water-efficient fixtures than lower-income homes, but also tend to have higher outdoor water uses due to greater application of automated irrigation controllers and larger landscaped areas.

3.4.2 Municipal and Industrial Water Use and Trends for Major Metropolitan Areas

The M&I water use for each major metropolitan area is described in the following sections to provide an understanding of the unique regional characteristics related to water management, water use, and historical water use trends. The general characteristics of each major metropolitan area are described, and summaries of the water management and water infrastructure in the region are provided. Factors such as climate and demographics that influence water demand in these areas are also described. The categories of water use in the major metropolitan area and their relative contribution to total water use are identified, and historical and ongoing efforts related to water conservation and reuse are summarized. Finally, historical trends in population and per capita water use are presented to examine gross trends over time.

3.4.2.1 Southeast Wyoming

The Southeast Wyoming major metropolitan area is represented by the service area of the City of Cheyenne Board of Public Utilities (BOPU). The BOPU supplies water to approximately 72,000 customers and is located in Laramie County, which includes the City of Cheyenne and extends to the Colorado border.

The principal water source for the City of Cheyenne has historically been surface water from multiple watersheds, which has provided on average 70 percent of total demand. The surface water comes from mountain streams in the Medicine Bow and Laramie Mountain Ranges through a trans-basin trade system, known as Stage I/II, which moves water from one side of a mountain to another, trades water across a valley, and then pipes water across two mountain ranges to Cheyenne. The City of Cheyenne diverts, on average, 10,664 acre-feet (AF) of water annually from the Little Snake River Basin to replace out-of-priority diversions of North Platte River Basin water used within Cheyenne. Groundwater has been used as a supplemental source for water quality blending and as an important way to meet peak summer demands. As the water demands increase, groundwater will become an even more important source of supply.

Hog Park Reservoir Outlet, web camera image from October 29, 2014
Source: City of Cheyenne Board of Public Utilities

The climate in this metropolitan area is relatively cool because of Wyoming's northerly latitude and the state's high average elevation. Winters are cold and moderately long, with January average temperature below 30°F. Summers are generally warm, with a July average temperature of 69°F and a high diurnal temperature range. Average annual precipitation in Cheyenne is about 16 inches.

BOPU has the authority for implementation and enforcement of specific water conservation programs based on the BOPU Resolution No. 2004-03, City of Cheyenne Resolution No. 4564, water supply status and conservation level declaration, and annual fine and fee ordinances approved by the Board and City Council (BOPU, 2011). Wasting water is prohibited and can result in a warning or fine. Conservation programs include restrictions on watering, water budgets for watering large community areas, increasing tiered rate structures, rebate programs and incentives, and commercial and industrial best management practices among others. An annual conservation goal is identified based on a forecast impact on reservoir levels during May. During normal years, the conservation goal ranges from 5 to 10 percent and during severe and extreme conditions can range from 30 to 60 percent.

In 2007, the BOPU began producing Class "A" reuse water or "recycled water" as it is called in Cheyenne. The reuse water replaces drinking water resources to irrigate parks, athletic fields and green spaces in Cheyenne. The system produces approximately 550 acre-feet per year (AFY), saving an equivalent amount of drinking water resources (BOPU, 2013).

Water use data availability for Southeast Wyoming for this report was limited. However, based on information included in Cheyenne BOPU's 2013 Master Plan (BOPU, 2013), annual potable water use for the 2010 period (2008-2012 average) was approximately 14,200 AF and served nearly 72,000 customers within the service area. The estimated per capita water use for this period is approximately 207 GPCD.

3.4.2.2 Front Range

The Front Range metropolitan area includes the following Colorado cities: Denver, Colorado Springs, Aurora, Fort Collins, and Boulder, and the smaller cities of Longmont and Broomfield. Several other cities in the Front Range metropolitan area use Colorado River water, but they did not provide water use information so were not included in the analyses for this report. The population served by participating cities in this area is approximately 2.4 million. The two largest water service providers are Denver Water and Colorado Springs Utilities. Denver Water serves more than 1.3 million people in Denver and its surrounding suburbs. The majority of Denver's water comes from rivers and streams fed by mountain snowmelt. The South Platte River, Blue River, Williams Fork River, and Fraser River watersheds are Denver Water's primary water sources, but Denver Water also uses water from the South Boulder Creek, Ralston Creek, and Bear Creek watersheds. The Blue, Williams Fork, and Fraser Rivers are tributaries to the Colorado River. Approximately half of Denver's supply comes from the Basin imports. Colorado Springs Utilities serves nearly 450,000 people with water from local and non-local surface water systems. The local system includes the south and north slopes of Pikes Peak, the Northfield System, the South Suburban System, and the Monument Creek diversions. The non-local systems are complex projects that include mountain water collection systems, pump stations, and terminal storage infrastructure. These systems include projects such as the Homestake Project, Twin Lakes, The Continental-Hoosier system, and the Fry-Ark project, all of which bring water from the other side of the Continental Divide, and the Colorado Canal, Lake Henry, and Lake Meredith Systems which provide native Arkansas River water.

The Front Range climate has four distinct seasons. The weather is subject to sudden changes due to its location along the Front Range of the Colorado Rockies. Average annual precipitation is about 17 inches in Denver, but can range from about 14 inches in Longmont to about 21 inches in Boulder. Precipitation occurs throughout the year, but is higher from March through June. Summers range from mild to hot with occasional afternoon thunderstorms and high temperatures regularly exceeding 90°F in July in Denver. Winters range from mild to occasionally bitter cold, with periods of snow and low temperatures alternating with periods of mild weather, the result of Chinook winds.

There are a variety of water uses in the Front Range metropolitan area. In the Denver Water service area, residential water use accounts for nearly 80 percent of the total use, while CII water use accounts for less than 15 percent. Conversely, in the Colorado Springs Utilities service area, CII water use accounts for almost

40 percent of total deliveries due to the classification of multi-family customers as CII, the presence of five military bases with more than 40,000 military personnel and their families, and the delivery of water to high-tech manufacturing.

In the Front Range area, emphasis on water conservation education programs has contributed to reductions in residential per capita use. A culture of conservation in Denver dates back to 1936 when Denver Water advertised on street trolleys asking customers to help save water. Each summer, Denver Water hires temporary workers known as Water Savers to educate thousands of customers about water waste and enforce summer watering rules. From 2007 to 2010, Denver Water invested $5.13 million in conservation outreach (Denver Water, 2011). During this same period, Denver Water reported issuing nearly 58,000 washing machine and toilet rebates for residential customers, which represented an investment of $7.8 million (Denver Water, 2011). From 2005 to 2007, Colorado Springs Utilities went through the rigorous process of identifying and selecting water conservation programs for implementation as part of its 2008-2012 Water Conservation Plan. Final programs were selected based on water savings, cost-effectiveness, social acceptance, likelihood of success, and business and system impacts. The five higher ranked programs were associated with residential block rates, commercial seasonal rates, commercial landscape codes and policy, conservation education, and water waste ordinances (Colorado Springs Utilities, 2008). The City of Fort Collins Utilities includes as part of its conservation program reduction of indoor demand through improved technology, leak reduction, and behavior change and reduction of outdoor demand through improved irrigation efficiency and landscape transformation (City of Fort Collins Utilities, 2009).

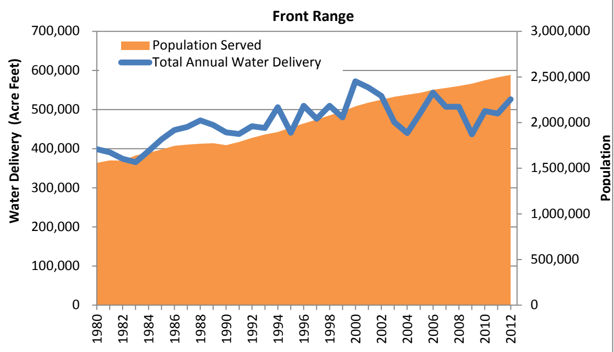
Dillon Reservoir
Source: Denver Water

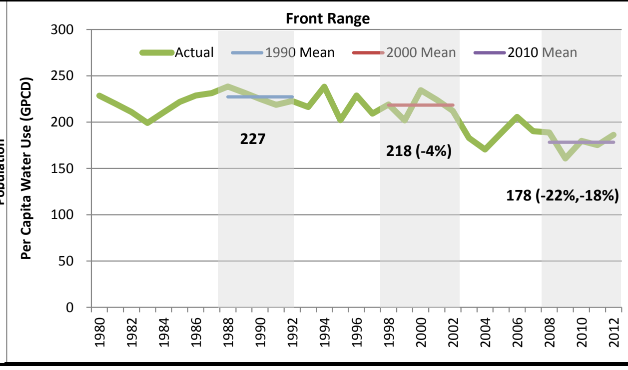
Water reuse has been practiced for decades in the Front Range metropolitan area. In 1961, Colorado Springs built a reuse system and began delivering treated wastewater to parks, cemeteries, golf courses, and commercial properties for turf grass irrigation (Colorado Springs Utilities, 2008). Front Range providers also reuse their reusable effluent indirectly through exchanges or re-diversion, utilizing projects such as Colorado Springs Southern Delivery System project and Aurora's Prairie Waters Project. Denver Water also implements wastewater reuse through exchanges with downstream agricultural users for surface water rights.

The Front Range uses a complex network of water systems to help maximize the use and reuse of available supplies. Depending on the situation, municipalities reuse water through river exchanges and through non-potable and potable recycling systems. Except during periods of high river flows, most of the municipal wastewater from Front Range cities is used as water supplies for the large farming areas located downstream on the eastern plains of Colorado. Water rights decrees and various operating requirements determine whether a city can reuse its wastewater or whether the wastewater belongs to downstream users. For instance, water rights decrees prevent Denver Water from reusing most of its local South Platte supplies, and a water rights settlement agreement limits the reuse of a portion of Denver's Colorado River supplies. The cities that receive Colorado River water from the Colorado-Big Thompson project, including Fort Collins and Boulder, cannot reuse water from the project, thereby making it available for downstream agricultural users. Reuse of lawn irrigation return flows is also controlled by water rights decrees.

The historical population, total M&I water use, and gross per capita water use for the Front Range metropolitan area are shown on Figure 3-4. This metropolitan area has added nearly 1 million people to the municipal water service population since 1980, an increase of approximately 60 percent. Over the same period, total annual water use increased by about 26 percent. Per capita water use rates have decreased by approximately 22 percent since 1990 (1988-1992 average) and by approximately 18 percent since 2000 (2008-2012 average). The most recent annual average (2008-2012 average) per capita use was estimated at 178 GPCD.

FIGURE 3-4
Water Delivery, Population, and Per Capita Water Use Trends in the Front Range Metropolitan Area
Includes aggregated service areas of Colorado Spring Utilities, Aurora Water, City and County of Broomfield Water Utility, City of Boulder Public Works, City of Longmont, Denver Water, and Fort Collins Utilities





3.4.2.3 Wasatch Front

The Wasatch Front metropolitan area includes the service areas of the Jordan Valley Water Conservancy District (JVWCD) and the Metropolitan Water District of Salt Lake City and Sandy (MWDSLS) near the Great Salt Lake, Utah.

The JVWCD, created in 1951 under the Water Conservancy Act, is a political subdivision of the State of Utah and one of the largest water districts in the state. It is primarily a wholesaler of water to cities and improvement districts within Salt Lake County. JVWCD has a retail service area primarily in unincorporated areas of the county, making up about 10 percent of its deliveries; approximately 90 percent of its municipal water is delivered on a wholesale basis to cities and water improvement districts in the Wasatch Front area such as the city of West Jordan and Granger-Hunter Improvement District in West Valley City.

In addition, JVWCD treats and delivers water to the MWDSLS on a contractual basis for delivery to Salt Lake City and Sandy City, even though neither city is within JVWCD's service boundaries. JVWCD also delivers untreated water to irrigators in Salt Lake and Utah Counties to meet commitments under irrigation exchanges.

Water sources for JVWCD are mainly derived from the Provo River through the Central Utah Project (CUP), Provo River Project, and irrigation exchanges. Other surface water sources are direct flow supply from mountain streams. Approximately 20 percent of JVWCD's supply is groundwater from wells scattered throughout the Salt Lake Valley. Low-quality groundwater, which is approximately 7 percent of the total supply, is treated with reverse osmosis as part of a groundwater cleanup project. In addition to potable water deliveries by JVWCD, many of the member agencies have their own water sources, which represent about 44 percent of the total water deliveries in the district service area, including secondary (untreated) water.

The CUP currently provides more than one half of JVWCD's annual water supply. While this water is physically diverted from the Provo River System, it is the CUP and its facilities that make this diversion possible. Under the CUP, water is captured and stored by CUP facilities on the eastern slopes of the Uinta Mountains, within the Colorado River Basin. The water is then stored and conveyed through a series of reservoirs, tunnels, and pipelines to the Wasatch Front. This is water that would have naturally reached the Colorado River, but through the CUP, provides a significant source of supply through exchanges on the Provo River System. JVWCD's current CUP supply is 50,000 AFY, but will grow to more than 70,000 AFY in the future.

Jordanelle Reservoir
Source: Jordan Valley Water Conservancy District

The Salt Lake Valley receives approximately 16 inches of precipitation annually, mostly during late fall/early winter and in spring, while early summer is the driest season. During winter, temperature inversions are a common problem. The inversion traps pollutants, moisture, and cold temperatures in the valley while the surrounding mountains experience warm temperatures and sunshine. Average summer temperatures in West Jordan range from 67°F to 90°F (average low and high during July), and average winter temperatures range from 22°F to 37°F (average low and high during January).

The average household size is high in this area, while population and housing unit densities are low. Also in this area, the number of homes built after 2000 is significant, and represents almost 30 percent of the total housing stock.

Based on water use data in 2010, residential water use accounted for 71 percent of the total water delivered by JVWCD. The combined total of CII (12 percent) and Irrigation Only (12 percent) use categories account for 24 percent of the total annual water use.

Several of JVWCD's member agencies own and operate their own secondary irrigation water systems. Water used in secondary systems is derived through agricultural conversions and is of low quality and high hardness and total dissolved solids concentrations. These systems are used to deliver non-treated secondary water for residential and CII irrigation use. Currently, most secondary water delivered in JVWCD's service area is unmetered, which significantly increases per capita water use.

Since 1999, JVWCD has aggressively implemented water conservation programs and has updated its Water Conservation Plan every 5 years. Since 2001, the JVWCD has spent nearly $19 million in conservation programs including conservation personnel and demonstration garden maintenance (JVWCD, 2014).

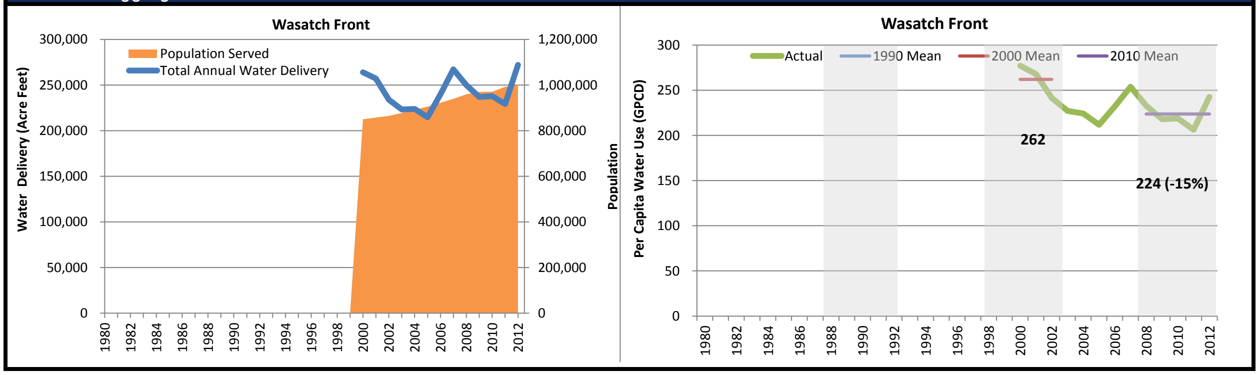
A Member Agency Assistance Program allows JVWCD's member agencies to apply for funding in the form of grants for conservation-related projects.

Examples of JVWCD conservation programs include a public education and media campaign named Slow the Flow, Save H2O, a 7.5-acre conservation garden and education center, free water audit program, and a high-flush toilet replacement program. JVWCD is currently investing in advanced metering infrastructure for its retail service area. In addition to specific programs, JVWCD has implemented a wholesale water conservation rate structure and developed model water efficiency landscape ordinances to encourage and promote proper design, installation, and maintenance of water-wise landscapes.

Under CUP repayment and water sales contracts, the Central Utah Water Conservancy District (CUWCD) has significant future water reuse requirements. As such, plans are now underway to begin building projects involving reuse of the CUP supply in JVWCD's service area. In addition, plans are underway to begin metering secondary irrigation deliveries over the next 5 years.

The historical population, total M&I water use, and the gross per capita water use for the Wasatch Front are shown on Figure 3-5. The metropolitan area has increased population significantly since 1999, adding more than 150,000 to the municipal water service area population. Drought in 2003 and above normal precipitation in 2010 clearly had an effect on water use patterns, showing a drop in water delivered during those years. The unusually hot, dry summers of 2007 and 2012 also contributed to increased per capita water use. On average, per capita water use rates have decreased by approximately 15 percent since 2000 (1999-2002 average), and the current annual average (2008-2012 average) per capita use was estimated at 224 GPCD.

FIGURE 3-5
Water Delivery, Population, and Per Capita Water Use Trends in the Wasatch Front Metropolitan Area
Includes aggregated service areas of JVWCD and MWDSLS



Note:
The 2000 mean represents the average period from 2000 to 2002.

3.4.2.4 Middle Rio Grande

The Middle Rio Grande metropolitan area includes the service areas of two major utilities that receive Colorado River water: the Albuquerque Bernalillo County Water Utility Authority (ABCWUA) and the City of Santa Fe Water Division. Both receive Colorado River water through the San Juan-Chama Project, which conveys water diverted in Colorado from tributaries of the San Juan River to the Chama River, a tributary of the Rio Grande. The ABCWUA, the largest water utility in New Mexico, provides water to the greater Albuquerque metropolitan area, while the City of Santa Fe Water Division serves the greater Santa Fe area. The total population served by these utilities is about 700,000.

The ABCWUA currently (2012) supplies about 106,000 AFY from surface water (the San Juan-Chama project), local groundwater, and reuse. In the mid-1990s, the ABCWUA embarked on development and implementation of a comprehensive water resource management strategy. This strategy resulted in an extensive conservation program and a gradual transition from groundwater as their sole source of supply to today's more diverse portfolio. The ABCWUA began diverting non-potable surface water for irrigation and industrial supply in the early 2000s and began direct diversion and treatment of San Juan-Chama water in 2008. Non-potable reuse was recently added, and an aquifer storage and recovery program is being piloted.

The City of Santa Fe Water Division produces about 10,000 AFY from the Santa Fe River, the City wellfield, the Buckman wellfield, and the Rio Grande (San Juan-Chama project). The City of Santa Fe Water Division also uses reclaimed wastewater and water conservation to reduce the total demand for potable water (City of Santa Fe, 2013). The percentage of water from any one source changes from month to month and year to year depending on a number of factors including availability, status of infrastructure, water rights, turbidity in the Rio Grande, customer use, and engineering improvements.

The Middle Rio Grande metropolitanrea has a semiarid climate; average annual temperature is 57°F, ranging from an average of 36°F in January to 79°F in July. Peak water use on a hot summer day is about twice the use of an average winter day. Annual precipitation in Albuquerque is approximately 9 inches per year and tends to fall mostly in the late summer and early fall during the monsoon season. Precipitation events vary widely across the service area, with the foothills generally receiving twice as much as areas on the west side of the river. Santa Fe receives an average of 14 inches of rainfall annually. Droughts lasting several years are not unusual.

The major water use in the Middle Rio Grande metropolitan area is for residential customers. The recent 5-year annual average (2008-2012) period indicates that the residential water use accounts for about 70 percent of the total water delivered by the Rio Grande area's water suppliers. About two thirds of the population live in single-family residences and one third live in multi-family homes (ABCWUA, 2013). The CII water use category represents 22 percent of the total water use, while use for irrigation only represents about 9 percent. Approximately 1,300 irrigation-only accounts are in the service area for golf courses, parks, and athletic fields. The federal government (such as national laboratories) and tourism are important industries that contribute to local water use rates. With ongoing conservation efforts, there has generally been a steady downward trend in total water use while sustaining a significant population increase. The success of outdoor conservation efforts has led to an increase in the proportion of indoor use to outdoor use, from about a 50-50 mix to approximately 60 percent indoor use.

The ABCWUA and its predecessor, the City of Albuquerque, have made significant progress in the first 17 years of the water conservation program, moving from among the highest municipal water users in the Southwest to among the lowest. The ABCWUA provides a number of services (including free water audits and a rebate program) to help customers conserve water. Since the water conservation program was initiated in 1995 and enhanced due to the 2002 drought, the area has experienced a significant transition to xeriscaping in both residential and commercial landscapes. More than 3 million square feet of turf has been converted to xeriscape since 1995. As customers transition to xeriscape for private use, public use space that provides turf has become increasingly important.

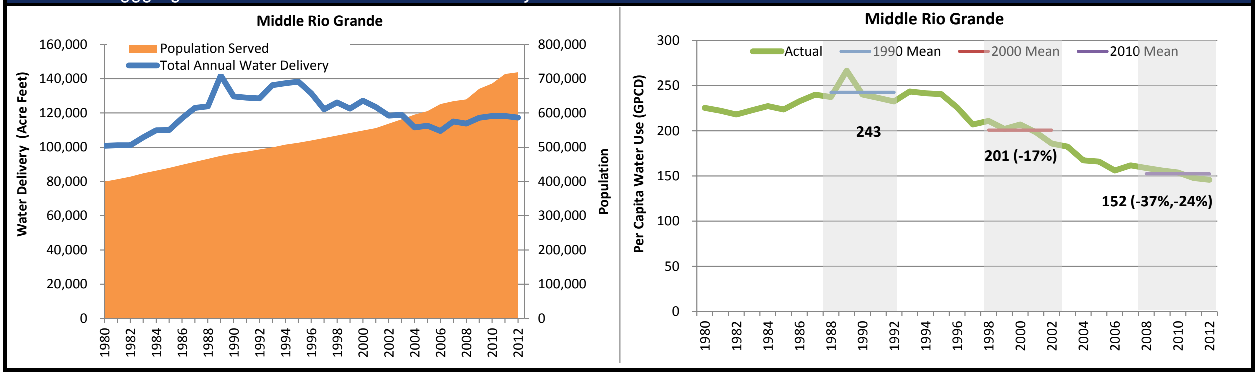
Rio Grande River
Source: Bureau of Reclamation

The City of Santa Fe has built a comprehensive and effective water conservation program from incremental steps that began in 1997. Currently, the Water Conservation Office provides educational activities for all ages, administers rebate and incentive programs, enforces the water conservation requirements of various city ordinances, provides public outreach through the media and participation in community events, and leads by example with low-water-use demonstration gardens. Tiered water rates have also played a key role in reducing consumption. This rate structure adjusts seasonally to allow for additional water usage during the months when irrigation systems are typically in use. Also, the City of Santa Fe has addressed some aspects of the tourism industry through ordinances limiting hotel linen changes, mandating requests for water at restaurants, and implementing requirements for public signage. Other examples of conservation efforts are the rebates in conjunction with the City's Water Bank, and the Qualified Water Efficient Landscaper training (EPA certification).

Reclaimed wastewater is a vital and valuable water resource that helps the City of Santa Fe meet its current water supply needs; it can also play a critical role in meeting future potable water supply demand. In 2013 the City of Santa Fe created the Reclaimed Wastewater Reuse Plan, which replaces the 1998 Treated Effluent Management Plan. The Reclaimed Wastewater Reuse Plan allocates the reclaimed wastewater among the current needs and reserves 2,200 AF to meet future potable water demand.

The historical population, total M&I water use, and the gross per capita water use for the Middle Rio Grande metropolitan rea are shown on Figure 3-6. The etropolitan area population has increased significantly since 1980, adding more than 320,000 users to the municipal water service area. However, total water deliveries have declined by about 12 percent since 1990, while per capita water use rates have decreased by approximately 38 percent since 1990 (1988-1992 average) and by 24 percent since 2000 (1998-2002). The most recent annual average (2008-2012 average) per capita use was estimated at 153 GPCD.

FIGURE 3-6
Water Delivery, Population, and Per Capita Water Use Trends in the Middle Rio Grande Metropolitan Area
Includes agggregated service areas of ABCWUA and City of Santa Fe Water Division



3.4.2.5 Southern Nevada

The Southern Nevada metropolitan area includes the service areas of the member agencies of the Southern Nevada Water Authority (SNWA): Big Bend Water District, City of Boulder City, City of Henderson, City of Las Vegas, City of North Las Vegas, Clark County Water Reclamation District, and Las Vegas Valley Water District. SNWA was formed by coorperative agreement in 1991 and charged with managing the region's water resources and providing the Las Vegas Valley with present and future water supplies. Together, the seven member agencies provide water and wastewater service to more than 2 million residents in Boulder City, Henderson, Las Vegas, Laughlin, and North Las Vegas, and areas of unincorporated Clark County. The majority of the SNWA service areas lies within the Las Vegas area, with a population density that is among the highest in the interior west. The SNWA service area represents approximately 70 percent of the population of Nevada, the driest state in the nation.

About 90 percent of the water delivered by SNWA to its member agencies is from Nevada's basic Colorado River consumptive use apportionment of 300,000 AFY, while the remaining 10 percent comes from SNWA member agency Las Vegas Valley Water District groundwater rights. SNWA supplements these resources with extensive water reuse. Nearly all of the wastewater flows in Southern Nevada are reused through direct non-potable reuse and indirect potable reuse (through Colorado River return flow credits). SNWA's plan for meeting future water demands relies on the use of a portfolio of water resources that includes current and future permanent and interim Colorado River and in-state water resources, water conservation, direct non-potable reuse, and indirect potable reuse. SNWA maintains a water resource plan to assess the role of water resources and conservation in meeting long-term regional water demands.

Southern Nevada has a hot and dry climate, typical of the Mojave Desert in which it lies. The summer months of June through September are very hot and mostly dry, with a July average daily maximum temperature of 104°F, while average daily minimum temperatures remain above 80°F. Winters are short and the season is generally mild. December, the coolest month, consists of average daily maximum temperatures of 57°F and average daily minimum of 39°F. Annual precipitation is about 4 inches in Las Vegas Valley. Most of the precipitation falls in the winter, but even the wettest month (February) averages only 0.76 inch of precipitation with only 4 days of precipitation. The water use patterns in Southern Nevada show that approximately 40 percent of overall use is returned to wastewater treatment plants, while the remaining 60 percent is consumed with a majority being used for outdoor irrigation.

The recent 5-year annual average (2008-2012) period indicates that the residential water use accounts for about 56 percent of the total water delivered by SNWA. Within residential water use, the use by single-family housing represented about 45 percent in 2012. The CII water use category represents about 26 percent of the total water use, of which 7 percent corresponds to water use by the resort industry. Gaming and tourism are the major Las Vegas sources of employment and the historical drivers for the economy with annual visitor volume in Las Vegas of nearly 40 million. The use for irrigation represents 12 percent of total water delivered for use by common areas and golf courses. Golf course use represents 6 percent of water deliveries.

The average age of infrastructure in the water distribution system in Southern Nevada is less than 25 years, and 60 percent of the regional transmission system is less than 20 years; as a result, the systems operate efficiently.

Since its creation in 1991, SNWA has implemented an array of conservation programs focused on reducing water use throughout the community. SNWA service area residences include nearly 70 percent with plumbing fixtures meeting or exceeding the national plumbing standards adopted in early 1990s, and significant natural replacement in the housing stock with plumbing fixtures predating these standards.

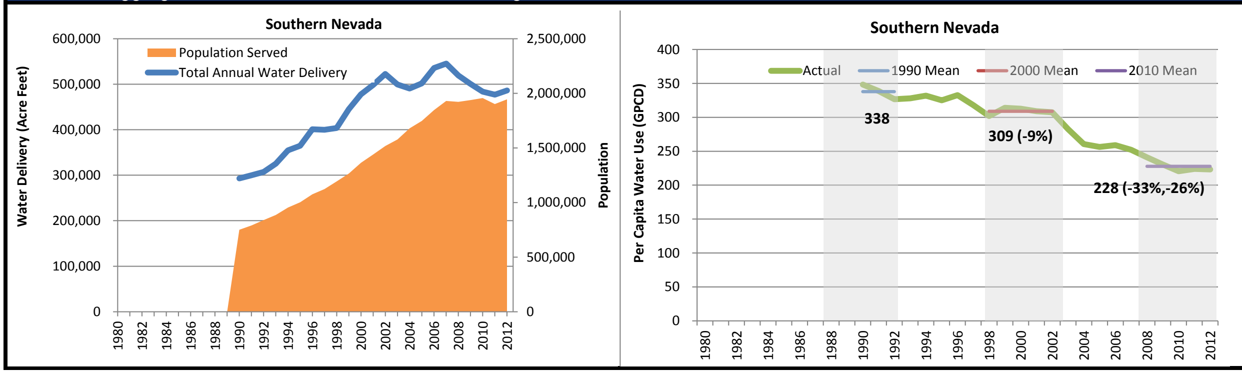
While SNWA actively promotes indoor conservation, in Southern Nevada the greatest opportunity for water conservation lies in curbing outdoor water use (SNWA, 2009). SNWA has embarked on an aggressive long-term water conservation program that has contributed to extraordinary conservation gains. In recent years, participation in SNWA's rebate programs realized peak participation levels in almost every area. SNWA and its member agencies use a variety of tools to promote conservation and reduce overall water use. These tools include a combination of regulation, water pricing, incentives, and education to elicit the necessary community response to reduce demands (SNWA, 2009).

To date, SNWA has invested roughly $200 million in various water conservation efforts. Between 2002 and 2013, Southern Nevada's consumption of Colorado River water decreased by approximately 100 thousand acre-feet (KAF), despite the addition of 480,000 residents during that decade. While some of the reductions in water use can be attributed to the economic downturn in recent years, there is no question that the community's conservation efforts played a critical role (SNWA, 2014). Over the past six years, the community has lowered its GPCD well ahead of the projected GPCD expected in order to meet the 2035 goal of 199 GPCD. SNWA's Water Smart Landscape Rebate Program has helped the community to upgrade more than 168 million square feet of lawn to water-efficient landscaping, saving the community thousands of acre-feet of water each year. More than 33,000 coupons have been distributed to participants in the Pool Cover Instant Rebate Coupon Program, contributing to a total of more than 1,200 AF of water saved annually. The Irrigation Clock Rebate Program, which provided financial assistance for customers to upgrade landscape irrigation controllers to models that can increase water efficiency, facilitated replacement of nearly 2,000 controllers for residential and commercial properties, saving the community more than 400 AF annually.

Lake Mead and intakes
Source: CH2M HILL

The historical population, total M&I water use, and the gross per capita water use for the Southern Nevada metropolitan area are shown on Figure 3-7. The population of the SNWA service area has increased by approximately 2.6 times between 1990 and 2013. During the same period, SNWA's annual water use increased by approximately 1.7 times. The recent Great Recession resulted in measured unemployment peaking above 14 percent, and nearly no change in population between 2007 and 2011 for Southern Nevada. Annual water use has declined in the SNWA service area over the past decade as a result of many factors including SNWA's aggressive water conservation efforts and the recent economic downturn. On average, per capita water use rates have decreased by approximately 33 percent since 1990 (1988-1992 average) and 26 percent since 2000 (1998-2002). The most recent (2008-2012 average) annual average per capita use was estimated at 228 GPCD. The SNWA service area is continuing to recover economically and this recovery may place upward pressure on water demand.

FIGURE 3-7
Water Delivery, Population, and Per Capita Water Use Trends in the Southern Nevada Metropolitan Area
Includes aggregated service areas of SNWA member agencies



Note:
1990 mean represents the average period from 1990 to 1992.

3.4.2.6 Central Arizona

Located approximately 200 miles from the Colorado River, the Central Arizona metropolitan area consists of the vast majority of Maricopa, Pinal, and Pima Counties and covers more than 13,000 square miles. Major cities within Central Arizona include Phoenix, Mesa, Chandler, Scottsdale, Gilbert, Glendale, Tempe, Peoria, Surprise, Tucson, and Casa Grande. The population of the Central Arizona area in 2012 was approximately 4.7 million. Forty-one municipal water providers in this area have allocations to use Colorado River water delivered through the Central Arizona Project (CAP), totaling 548,762 AF. Nine of the largest municipal water providers in Maricopa County serving approximately 83 percent of the county's population, receive about 50 percent of their total supplies from the Salt River Project, which operates reservoirs on the Salt and Verde Rivers. These municipal providers also use reclaimed water and a small percentage of groundwater. Municipal water providers in Pinal and Pima Counties rely on CAP water, reclaimed water, and groundwater.

Situated in the Sonoran Desert, Central Arizona has one of the nation's most arid climates. Rainfall is highly variable, averaging between 7 and 11 inches annually, with more precipitation at higher elevations. Average daily maximum summer temperatures are between 100°F and 110°F, and average annual evapotranspiration across the metropolitan area is between 77 and 79 inches.

The Central Arizona metropolitan areas has the highest percentage of CII use of any of the metropolitan areas analyzed. The recent 5-year annual average (2008-2012) period indicates that the residential water use accounts for about 60 percent of the total water delivered in this area, while the CII water use represents about 30 percent of the total water use. The residential and CII water uses have actually decreased by more than 2 percent compared to 1990 (5-year annual average, 1988-1992), while the CII sector has decreased by more than 5 percent (as a percentage of overall use) over the same period.

In the early 1900s, modern municipal water conservation measures began to emerge in Tucson and Phoenix, including fines for wasting water, irrigation restrictions, elimination of flat rate water fees, and requirements for metering of all connections.

For nearly 35 years, the 1980 Groundwater Management Act has shaped Arizona's approach to water management. Enacted in response to decades of depletion of the state's limited groundwater supplies, the Act aims to halt groundwater mining in the state's most heavily populated areas, known as AMAs. The Act encourages the use of renewable supplies (surface water and wastewater) before groundwater is pumped. All of the Central Arizona metropolitan area is included within the AMAs.

The Act established the Arizona Department of Water Resources (ADWR) and gave it extensive authority to regulate water uses and consumption. Within AMAs, the Act prohibits new residential growth without a proven 100-year assured water supply. Significantly, ADWR has broad inspection and enforcement authority.

To achieve the Act's goal of safe-yield in the Phoenix and Tucson AMAs by 2025 (a balance between the amount of groundwater withdrawn and the amount replenished), ADWR is required to adopt five management plans for each of five management periods between 1980 and 2025. The plans must include mandatory conservation requirements for all water uses. For municipal uses, the conservation requirements are based on reductions in per capita use and other appropriate measures. Large municipal providers are required to meter all connections and limit system losses to no more than 10 percent, and many municipal providers in the Phoenix area have reduced their losses to 4 to 7 percent. Landscaping in public medians and rights-of-way is restricted to low-water-use plants identified in Regulatory Plant Lists. Many jurisdictions within the AMAs have officially adopted the local regulatory list and incorporated it into ordinances and design guidelines for development. More than 90 percent of the population in this metropolitan areas is served by municipal providers implementing a wide range of best management practices in the categories of public awareness, education and training, outreach service, system evaluation and improvement, ordinances and conditions of service and tariffs, rebates and incentives, and research and innovation. Most large providers have conservation rate structures.

Central Arizona Project aqueduct delivers Colorado River water to Pima, Pina, and Maricopa Counties
Source: Central Arizona Project

A primary focus of Central Arizona municipal conservation programs has been exterior water use, driving the acceptance and adoption of desert-adapted landscaping and water-efficient practices. Preliminary results of research into residential landscaping in Phoenix indicate that only 10 percent of single-family residences continue to maintain large areas of turf.

Efforts to encourage low-impact design and passive and active residential and commercial water harvesting have gained ground. Tucson recently adopted the nation's first commercial rainwater harvesting ordinance.

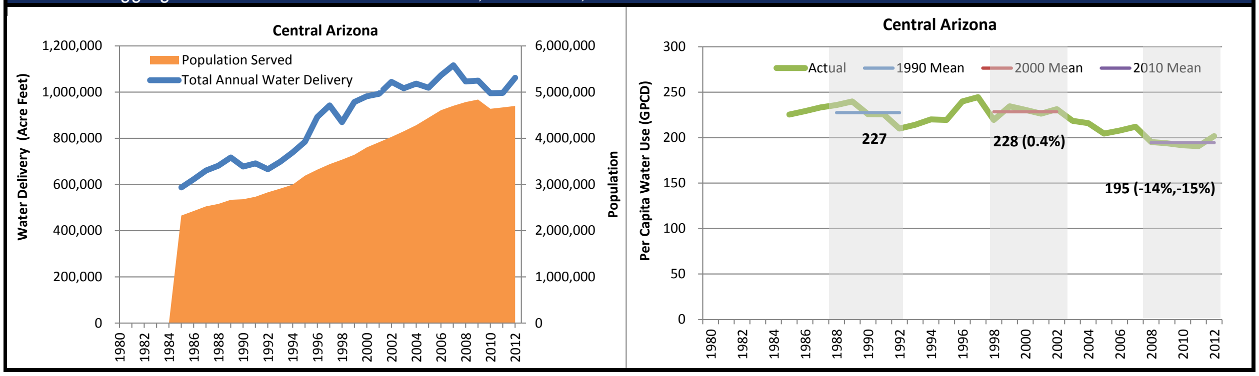
Conservation requirements have also been established for persons or entities receiving water from a municipal provider for a non-agricultural uses. These uses include turf-related facilities, large-scale cooling facilities, and publicly owned rights-of-way.

Arizona established itself as a leader in reuse in 1926 with the construction of the first operational water reclamation plant in the U.S., providing reclaimed water for non-potable needs at the Grand Canyon Village. As early as 1932, the City of Phoenix supplied treated wastewater for agricultural purposes. Today, 95 percent of the wastewater generated in the Phoenix, Pinal, and Tucson AMAs is reclaimed to serve beneficial uses, including agriculture, underground storage, power generation, industrial uses, turf irrigation, and aquatic and riparian habitat (Thomure et al., 2013). Arizona law allows cities to contract for the disposition of their treated wastewater, and most uses of reclaimed water are allowed and practiced in the state. The one purpose that is not permitted is reuse for human consumption. A steering committee, formed by WateReuse Arizona in 2012 as a result of the Governor's Blue Ribbon Panel on Water Sustainability, is working to identify opportunities to enhance the State's regulatory framework for potable reuse and develop a roadmap for communities to use in developing future water reuse projects.

The population, total M&I water use, and the gross per capita water use for the Central Arizona metropolitan area between 1985 and 2012, based on annual report data collected by ADWR, are shown on Figure 3-8. As noted, the Central Arizona metropolitan area had the highest percentage of CII use of any of the major metropolitan areas that receive Colorado River water. CII uses may have a disproportionate impact on per capita water use, but industry provides an important economic value to the metropolitan area. Several large municipal providers in the Central Arizona metropolitan area have seen significantly greater GPCD declines than the average shown on Figure 3-8. For example, between 1991 and 2013, Phoenix, the sixth largest city in the country, increased in population by 47 percent, yet the city's per capita use rate decreased by 29 percent while water deliveries rose by only 4.5

percent. On average, per capita water use rates in the Central Arizona metropolitan area have decreased by approximately 14 percent since 1990 (1988-2002 average) and by 15 percent since 2000 (1998-2002 average). The most recent current annual average (2008-2012 average) per capita use was estimated at 195 GPCD.

FIGURE 3-8
Water Delivery, Population, and Per Capita Water Use Trends in the Central Arizona Metropolitan Area
Includes aggregated service areas of Phoenix AMA, Pinal AMA, and Tucson AMA



3.4.2.7 Coastal Southern California

The MWD, established in 1928 under an act of the State Legislature, is a public agency and a regional water wholesaler that provides supplemental water supplies to 26 member agencies and serves about 18 million people across six counties (Los Angeles, Orange, San Diego, Riverside, San Bernardino, and Ventura) in coastal Southern California. For this report, the Coastal Southern California metropolitan area is the same as MWD's service area.

MWD draws supplies from the Colorado River through the Colorado River Aqueduct, which it owns and operates; from Northern California via the State Water Project and from local programs and transfer arrangements. In fiscal year 1990, Colorado River water represented 26 percent of the total water supply, Northern California supply 33 percent, 34 percent from local supply, which included groundwater recovery, and 7 percent from conservation, and water recycling. In fiscal year 2014, the Colorado River water supply represented 23 percent of the total water supply, Northern California supply 17 percent, 33 percent from local supply, which included groundwater, surface water, Los Angeles Aqueduct, and groundwater recovery, and 28 percent from conservation and water recycling.

The Coastal Southern California metropolitan area has a Mediterranean climate with average summer temperatures ranging from 64°F to 85°F during August, the warmest month, and average winter temperatures ranging from 46°F to 70°F during December, the coolest month. In the more inland areas, the climate is semiarid, with colder winters and markedly hotter summers. Precipitation in the metropolitan area occurs primarily during the winter months and ranges from 10 to 17 inches per year.

The average household size and population and housing unit densities are high in this area. Higher housing unit density often translates into smaller lot sizes and potential lower irrigated acreage per housing unit. In Los Angeles, which represents more than 20 percent of the total MWD-served population, the population density is 12.6 persons per acre, housing unit density is approximately 4.7 units per acre, and the median home size is 1,600 square feet, all below the national average. The median household income and median home value are relatively high compared to other areas served with Colorado River water. In 2011, the median home value was $400,000 in Los Angeles (U.S. Census Bureau, 2013d), and the median household income for 2010 ranged from $35,600 in the Central Basin to $95,300 in San Marino (MWD, 2010).

The recent 5-year annual average (2008-2012) period indicates that residential water use accounts for about 70 percent of the total water delivered by MWD. Within the residential water use, the use by single-family housing represented about 60 percent in 2010. The use by multi-family housing has been increasing as growth of urban in-fill development has increased. The CII water use category represents 26 percent of the total water use, while use for irrigation only represents about 4 percent. The residential and CII water uses have increased by almost 7 percent compared to the 1990 period (5-year annual average, 1988-1992),while the irrigation only use has dropped by more than 60 percent (from 10 percent to 4 percent) over the same period.

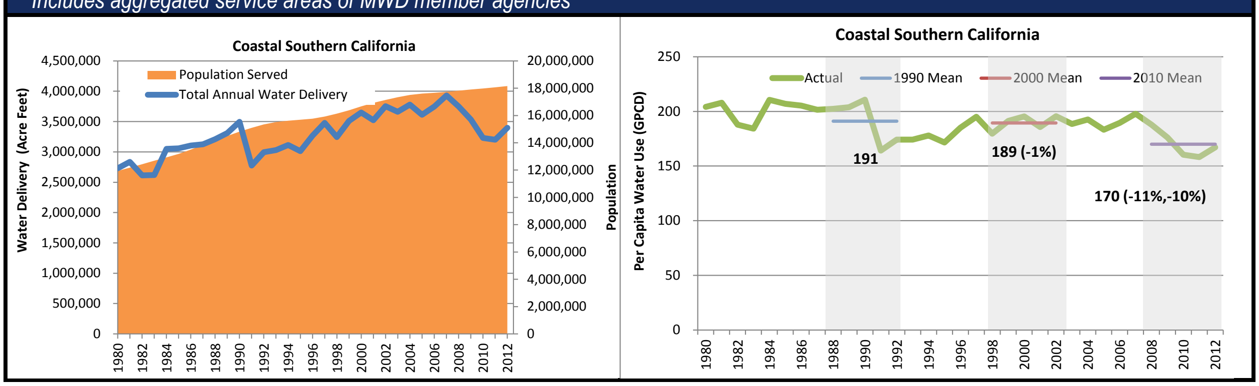
Colorado River Aqueduct
Courtesy Metropolitan Water District of Southern California

A growing element of MWD's water supply reliability is water conservation and reuse. Water conservation and reuse represented 7 percent of the 1990 water supply mix and is planned to grow to 33 percent by 2015. Over the past two decades, MWD has invested more than $352 million for incentive programs to reduce residential and commercial water use, resulting in about 2.05 million AF of cumulative savings.

Currently, MWD's region-wide residential conservation program is operated under the umbrella of SoCal Water$mart. This program provided 51,000 rebates for water-efficient products, and the estimated water savings is about 3,350 AF for fiscal year 2013-14. The regional commercial program is also administered through SoCal Water$mart and saved an additional 4,020 AF in fiscal year 2013-14. Popular rebates in the two programs are for turf removal, high-efficiency clothes washers and toilets, multi-stream rotating nozzles for sprinklers, and weather-based irrigation controllers. For the commercial sector, incentives are also available through a customized program called the Water Savings Incentive Program and through member agency administered-programs. Combined with "code-based" conservation achieved through building and plumbing codes, and water use restriction ordinances, and from reduced consumption resulting from changes in water pricing, the area saved about 923,000 AF in fiscal year 2013-14.

The historical population, total produced water (treated water delivered through M&I water systems), and the gross per capita water use for the Coastal Southern California metropolitan area are shown on Figure 3-9. The metropolitan area population has increased by about 50 percent since 1980, adding more than 6 million to the municipal water service area population, while total annual water use increased by approximately 20 percent. On average, per capita water use rates have decreased by approximately 12 percent since 1990 (1988-1992 average) and by 10 percent since 2000 (1998-2002 average). The most recent annual average (2008-2012 average) per capita use was estimated at 170 GPCD.

FIGURE 3-9
Water Delivery, Population, and Per Capita Water Use Trends in the Coastal Southern California Metropolitan Area
Includes aggregated service areas of MWD member agencies



3.4.2.8 Salton Sea Basin

The Salton Sea Basin metropolitan area is represented in this report as the M&I service areas in the Imperial and Coachella Valleys of California. This area includes cities such as Indio, Palm Desert, El Centro, and Calexico. Water is served to these cities by the Coachella Valley Water District (CVWD) and Desert

Water Agency in Coachella Valley and the Imperial Irrigation District (IID) in the Imperial Valley.

The CVWD began operation in 1918 providing service to approximately 1,000 square miles from the San Gorgonio Pass to the Salton Sea, mostly within the Coachella Valley in Riverside County, California. The boundaries also extend into small portions of Imperial and San Diego counties and provides water-related service to over 303,000 people living in the nine cities of CVWD's service area. The CVWD relies on three sources of water (groundwater, recycled water, and imported water) to provide service to its customers, either through the State Water Project (via exchange) or from the Colorado River via the Coachella Canal, a branch of the All-American Canal.

All-American Canal
Source: Bureau of Reclamation

IID, the largest irrigation district in the nation, was formed in 1911 to import and distribute raw Colorado River water mainly to agricultural irrigation customers. However, IID also supplies water to approximately 178,000 people across seven municipalities. The largest cities included in the IID M&I service area are El Centro and Calexico. The IID diverts water at Imperial Dam on the Colorado River through the 80-mile-long All-American Canal.

The Salton Sea Basin is located in the northernmost part of the Sonoran Desert and characterized by hot, dry summers and mild winters. Summer temperatures typically exceed 100°F and the winter low temperatures rarely drop below 32°F. Annual rainfall in the Imperial Valley averages less than 3 inches, with most rainfall associated with brief but intense summer monsoon storms.

The IID delivers an average of 2.8 million AF of water each year and 97 percent is used for the irrigation of over 400,000 acres. The remaining 3 percent of water delivered is distributed among M&I customers in seven municipalities, one private water company, and two community water systems as well as a variety of industrial uses and rural homes or businesses. The majority of the M&I use is associated with residential water users with about 85 percent of the customers represented as single-family residential (City of El Centro, 2011).

In the CVWD service area, approximately 300,000 AFY of water delivered from the Coachella Canal was initially used exclusively by agriculture. As residential growth moved into the eastern valley, other water users, primarily golf courses and homeowner associations, began using Colorado River water for large landscape irrigation. Based on the 2010 Urban Water Management Plan (CVWD, 2011), single-family residential water use represents about 57 percent of the total M&I use and landscape irrigation represents about 28 percent of the total M&I use. During the 2008-2012 period, more than 40 percent of the total CVWD deliveries was distributed to M&I water users.

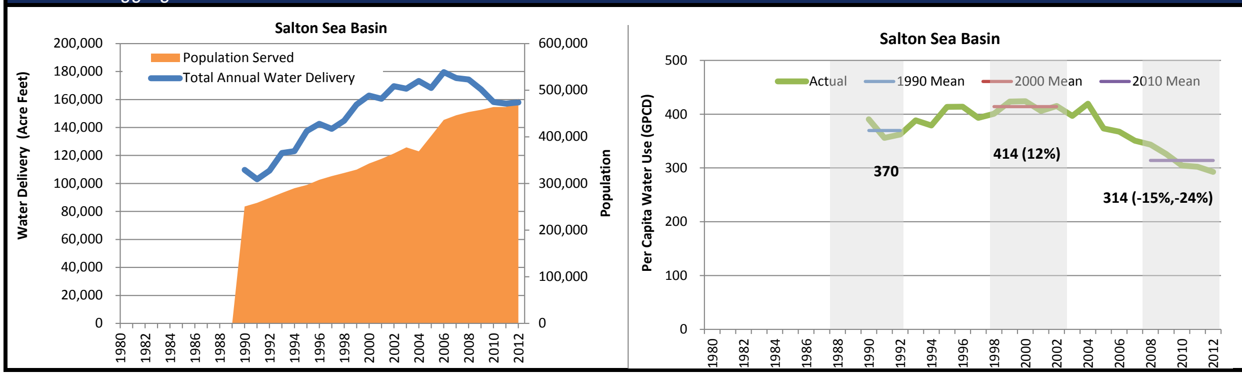
The water conservation efforts in this area are mainly driven by the California state reduction target requirements to follow demand management measures and California Urban Water Conservation Council (CUWCC) Best Management Practices (CUWCC, 2011). In El Centro, conservation programs such as school education, public information, and landscape design and water use standards are being implemented.

CVWD implemented a water conservation program in the 1960s. However, as a desert resort community having a large transient population, per capita water use tends to be much higher than other portions of California. Special emphasis has been placed on landscape irrigation demand reductions. New and rehabilitated landscape sites are required to submit water conserving landscape plans to CVWD's Water Management Department for a plan check prior to construction. The cost to CVWD to implement this program is approximately $81,000 per year, and annual water savings generated by this program is approximately 1,644 AFY (CVWD, 2011).

In terms of water reuse, the City of El Centro provides sewer service and has a wastewater treatment plant but it is not currently being recycled. It is not currently financially feasible for the City to provide the facilities for recycling wastewater but some recycled water projects have been proposed in the Imperial Valley for use in solar and geothermal plants (City of El Centro, 2011). Recycled wastewater has been used for irrigation of golf courses and municipal landscaping in the Coachella Valley since 1968.

The historical population, total M&I water deliveries, and the gross per capita water use for the Salton Sea Basin metropolitan area are shown on Figure 3-10. The metropolitan area population has almost doubled since 1990, adding more than 230,000 to the municipal water service area population. Total annual water use increased by approximately 143 percent over the same period. However, average per capita water use rates have decreased by approximately 15 percent since 1990 (1988-1992 average) and by approximately 24 percent since 2000 (1998-2002 average). The most recent annual average (2008-2012 average) per capita use was estimated at 314 GPCD. The high per capita use rates for this metropolitan area are generally associated with large-scale turf irrigation in resort areas of the Coachella Valley and reflect much higher rates than the M&I areas in the Imperial Valley.

FIGURE 3-10
Water Delivery, Population, and Per Capita Water Use Trends in the Salton Sea Basin Metropolitan Area
Includes aggregated service areas of CVWD and IID



Note:
The 1990 mean represents the average period from 1990 to 1992.

3.4.3 Summary of Trends in Municipal and Industrial Water Use

Trends in M&I water use and water reuse are summarized in the following sections.

3.4.3.1 Municipal and Industrial Water Use Trends

As discussed in the preceding sections, each major metropolitan area that receives Colorado River water is unique in its climate, population and demographics, industries, water conservation efforts, and available water supplies. These characteristics influence M&I water use, water management, and historical and future approaches for M&I water conservation and reuse. For example, areas with high potential evapotranspiration and low rainfall often provide a larger share of their overall water use for outdoor irrigation. Rapidly growing cities with new residential development have had success in improving the efficiency of residential use through a variety of codes and programs encouraging, for example, more efficient indoor fixtures and outdoor landscaping.

For most major metropolitan areas, M&I water use has increased over the past two decades as a result of continued population growth. The populations in the major metropolitan areas have increased significantly since 1990, adding nearly 8 million to the municipal water service area population. While population has increased over the recent decades, the per capita water use has decreased over the same period, partially attenuating the effect of population growth on M&I water use. The changes in per capita water use, represented as GPCD, are used to examine gross trends over time in each major metropolitan area. It is important to understand that differences in GPCD rates are not a measure of the success of conservation efforts from one area to another. On average, per capita water use rates have decreased by 12 percent to 38 percent since 1990 (1988-1992 average), and the most recent annual average (2008-2012) per capita uses ranges from 152 GPCD to 314 GPCD (Table 3-5).

TABLE 3-5
5-Year Annual Average, 2008-2012: Water Use and Trend for Major Metropolitan Areas

Major Metropolitan Area	Population Served	Annual Water Delivery (AF)	Percent Colorado River Water (%)	Climate Index: Potential Evapo-transpiration minus Precipitation (inches)	GPCD (% reduction from 1990, 2000)	Residential[1] (%)	CII[1] (%)
Front Range	2,461,600	491,300	46	28	178 (22%, 18%)	79.4	14.6
Wasatch Front	978,600	245,200	27	29	224 (NA, 15%)[2]	70.6[3]	21.3[3]
Middle Rio Grande	685,800	117,000	36[4]	43	152 (38%, 24%)	68.8	22.2
Southern Nevada	1,932,900	493,400	91	86	228 (33%, 26%)	55.7	25.5
Central Arizona	4,725,100	1,029,800	46	68	195 (14%, 15%)	60.0	30.4
Coastal Southern California	17,983,400	3,422,200	34	34	170 (11%, 10%)	70.2	26.0
Salton Sea Basin	464,000	166,300	NA	65	314 (15%, 24%)	NA	NA

Not available (NA)

[1] Residential and CII use may not sum to 100 percent due to other uses.
[2] GPCD values and percent reductions developed from 5-year averages centered around 1990, 2000, and 2010. Percentage reductions from 1990 represent the change over 20 years, while percentage reductions from 2000 represent the change over 10 years.
[3] 2010 values, data not available for the 5-year period.
[4] 2009-2012 average, data not available for 2008.

Since 2000, M&I water use has either remained stable or decreased for many of the major metropolitan areas that receive Colorado River water, despite increases in population. Per capita water use rates for the these areas decreased by 10 percent to 26 percent since 2000 (1998-2002 average). During this period, the U.S. experienced a steep economic downturn (known as the Great Recession), the Basin experienced its most severe drought in the past 100 years, and some water providers increased water conservation efforts to reduce water use in response to reduced water availability. These factors have each contributed to recent decreases in per capita water use.

Over the longer term, reductions in per capita water use are due to a variety of factors including water conservation programs, more efficient water use in new developments, replacement of appliances and fixtures with more efficient models, changes in urban development, water supply reliability concerns,

While population has increased over the recent decades, the per capita water use has decreased, partially attenuating the effect of population growth on M&I water use. Since 2000, M&I water use has either remained stable or decreased for many major metropolitan areas that receive Colorado River water, despite increases in population. Per capita water use rates for the major metropolitan areas receiving Colorado River water decreased by 10 percent to 26 percent since 2000 (1998-2002 average). During this period, the U.S. experienced a steep economic downturn and the Colorado River Basin experienced its most severe drought in the past 100 years, influencing water use.

behavioral shifts toward increasing efficiencies, and the increase in the price of water. The "landscapeable areas" of single-family homes have decreased as home sizes, garages, and other impervious spaces increase, and lot sizes have become smaller. There is also a significant increase in the percentage of new homes with high-efficiency indoor fixtures (such as low-flow toilets and showerheads and high-efficiency appliances). The median construction date of homes in California and Colorado is about 1975 (1960 for Los Angeles), while Arizona has newer homes with a median construction date of 1987. About one third of Utah housing units were built after 2000. Moreover, many cities are seeing an ongoing transition away from water-intensive landscaping toward more native or low-water-use landscaping, partially in response to ongoing drought and rebate programs, landscape development codes, and also in response to long-running educational efforts that have greatly influenced acceptance.

Numerous water conservation and reuse programs have been put in place over the past several decades in the major metropolitan areas that receive Colorado River water. Although it is often difficult to determine the effectiveness of individual water conservation measures, M&I water conservation and water reuse have played a significant role in reducing water demand in these areas.

The available data demonstrate that municipal providers in the major metropolitan areas that receive Colorado River water have implemented a wide range of conservation measures that have increased water use efficiency and reduced per capita demand. Comprehensive data on conservation and reuse programs implemented to date in the major metropolitan areas that receive Colorado River water are not available. It is often difficult or impossible to attribute quantifiable savings to specific programs or measures.

Using the information collected during Phase 1, and assuming 1990 per capita water use rates and 2010 population, the M&I water demand would have been 1.7 million AFY higher in 2010. Water conservation has played an important role in these savings; however, other factors such as economic, social, and behavioral changes also influence changes over time. While this is a relatively simple measure of the volumetric savings due to historical per capita use reductions, it does provide a sense of the magnitude of these historical trends.

Each state and metropolitan area has taken different approaches to M&I conservation and water reuse; and many are at different stages of implementation. In some of these metropolitan areas, specific water conservation measures have been widely adopted and implementing additional measures may be increasingly costly and yield less incremental benefit. However, in many metropolitan areas, certain categories of conservation measures, such as outdoor landscaping and system water loss reduction, may offer greater potential for continued reductions in M&I water demand.

Residential water use accounts for approximately 55 to 80 percent of total M&I water use in the major metropolitan areas that receive Colorado River water (Table 3-5). The residential use commonly includes both indoor and outdoor uses in single- and multi-family dwellings. While not typically metered independently, agencies estimate that on average about 50 to 60 percent of the total residential use is for outdoor landscape irrigation. However, the proportion of indoor versus outdoor use depends on household demographics, lot size, amount of irrigated landscape, type of landscape, household income, and efficiency improvements already in place.

CII water use represents approximately 25 percent of the total use in the major metropolitan areas that receive Colorado River water. In some areas with large institutional and industrial users, the CII sector can account for more than 30 percent of the total M&I water use.

In most major metropolitan areas, the M&I deliveries for irrigation only use represents only a small percentage of the total use. Overall, this use represents less than 2 percent of the total M&I use because most water is delivered to urban and industrial uses. However, in the Wasatch Front metropolitan area this irrigation only use represents about 10 percent of the total use, because unmetered water systems deliver raw water (secondary water) to large landscapes through older distribution systems. In other major metropolitan areas, delivery for golf courses, parks, nurseries, or turf-related water uses is significant, but is typically reported under CII use.

3.4.3.2 Municipal and Industrial Water Reuse Trends

Reuse of wastewater occurs through a variety of methods in the major metropolitan areas that receive Colorado River water. The type of reuse practiced in any particular area depends on the hydrologic conditions, regulatory environment, and water management objectives.

> *Municipal water providers in the major metropolitan areas that receive Colorado River water have implemented water reuse to varying degrees depending on geographic, legal, regulatory, and other considerations.*

Reuse has been categorized in this report based on the method in which reclaimed water is developed and used. Based on a review of the reuse practices in each of the major metropolitan areas, the following categories of reuse were identified:

- **Direct Non-Potable Reuse**
  - *Reuse through direct delivery for non-potable uses*

    This type of reuse occurs largely in Coastal Southern California and Central Arizona as reclaimed water is delivered directly for non-potable uses such as landscaping irrigation (for example, purple pipe systems), delivered directly to industrial uses (for example, power plant cooling), or delivered directly to agricultural uses (for example, generally non-food crops).
  - *Reuse through exchange with non-potable uses*

    This type of reuse is most prominent in Colorado's Front Range. Treated wastewater that comes from the importation of Colorado River water is used as an exchange supply for downstream agricultural water users. Through exchange, the upstream M&I user can increase the quantity of diverted surface supply for non-potable uses, while the downstream agricultural users make use of the treated wastewater supply.
- **Indirect Potable Reuse**
  - *Reuse through recharge to groundwater or surface storage*

    This type of reuse occurs in most of the Basin States. Treated wastewater is stored underground or added to surface storage and subsequently (sometimes years after storage) used as source water for M&I purposes. This is the case in Central Arizona (underground storage), Southern Nevada (returns to the Colorado River at Lake Mead), and many areas of Coastal Southern California (groundwater and local surface storage).
  - *Reuse through exchange for subsequent potable use*

Treated wastewater that comes from the importation of Colorado River water is used as an exchange supply for downstream agricultural water users. Through exchange, the upstream M&I user can increase the quantity of diverted surface supply for potable uses, while the downstream agricultural users make use of the treated wastewater supply.

The trends in M&I water deliveries of untreated water, potable water, and reuse water supply are shown on Figures 3-11A through 3-11C. As the figures show, M&I water providers have increased the amount of wastewater reuse included in the water distributed to customers. Wastewater reuse is practiced in nearly every major metropolitan area that receives Colorado River supply and the quantity is growing in its percentage of the total water supply.

The reported water reuse that is used as a water supply for the M&I sector for the major metropolitan areas that receive Colorado River water is summarized in Table 3-6. Water reuse was found to be practiced in nearly all of the Basin States. A total of 709,000 AFY of reuse supply was identified as M&I supply in 2012. In many of the metropolitan areas, a significant portion of the treated wastewater flows are put toward non-M&I beneficial uses such as delivery to groundwater recharge, agricultural uses, or wetland habitats.

In some of the major metropolitan areas, more than 90 percent of the reusable supply is currently being reused.

Water reuse represents an important source of supply in many metropolitan areas, but varies significantly across geographic regions. The percentage of total M&I water delivered that is derived from reuse ranges from about 1 percent in the Wasatch Front and Middle Rio Grande metropolitan areas to approximately 40 percent in the Southern Nevada metropolitan area. Water reuse represents between 9 and 12 percent of the total water delivered to M&I users in the Coastal Southern California, Central Arizona, and Front Range metropolitan areas. Reuse for non-potable end uses represents the most common method employed, with the exception of those metropolitan areas where reclaimed water can be used for return flow credits or for exchanges.

Along the Wasatch Front, heavy use of secondary water has helped to defer expensive reuse projects. However, reuse project plans are now underway to meet CUPCA reuse goals and requirements under CUPCA repayment and water sales agreements.

In Coastal Southern California, it is estimated that nearly 315,000 AFY of M&I supply is generated from wastewater reuse, with the majority being used for direct non-potable uses. MWD has invested $356 million for incentive programs for water recycling (MWD, 2014). It is estimated that about one quarter of all wastewater flows in this metropolitan area are currently being reclaimed, and many reuse projects are currently being planned. .

In Central Arizona, it is estimated that 95 percent of wastewater is reclaimed to serve beneficial purposes (Thomure, 2013). Of that, about 95,000 AFY of reclaimed wastewater is delivered by municipal providers for M&I uses. In addition, about 70,000 AFY of reclaimed wastewater is contractually supplied by Phoenix metropolitan areas cities to the Palo Verde Nuclear Generating Station, providing the plant's entire cooling water supply.

FIGURE 3-11A
Trends in Water Deliveries by Type and Percentage of Colorado River Water
Selected aggregated service areas

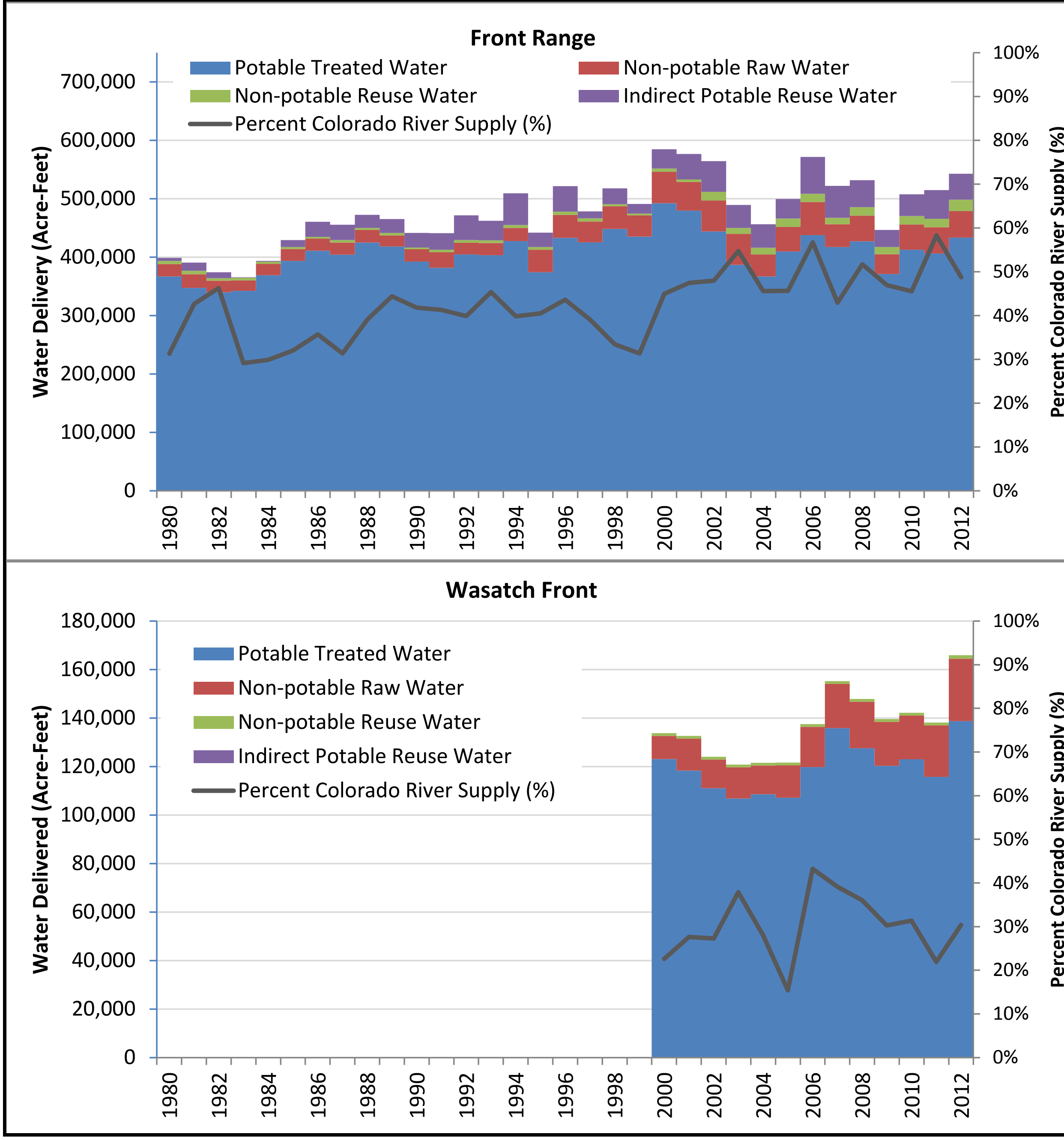


FIGURE 3-11B
Trends in Water Deliveries by Type and Percentage of Colorado River Water
Selected aggregated service areas

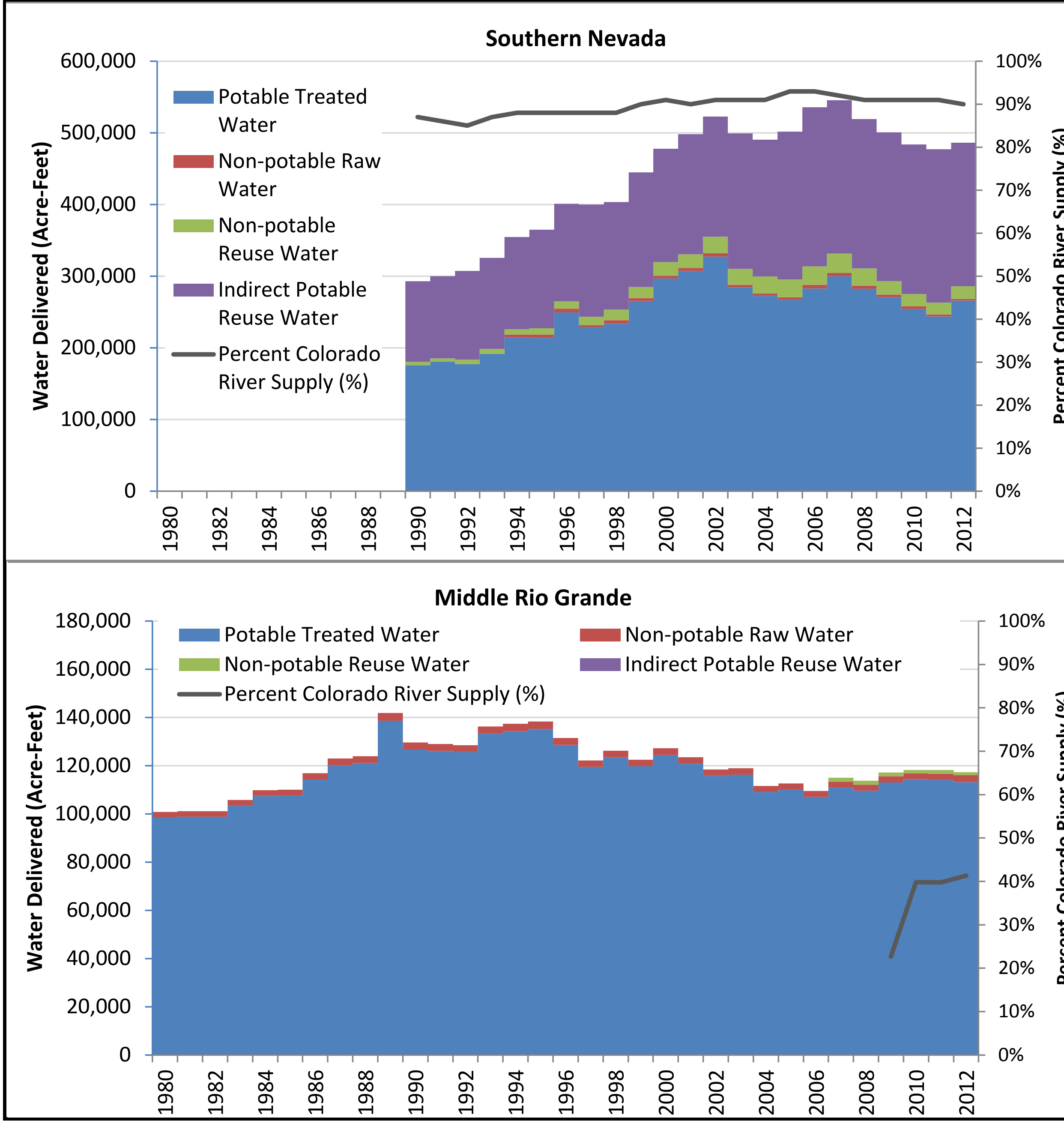
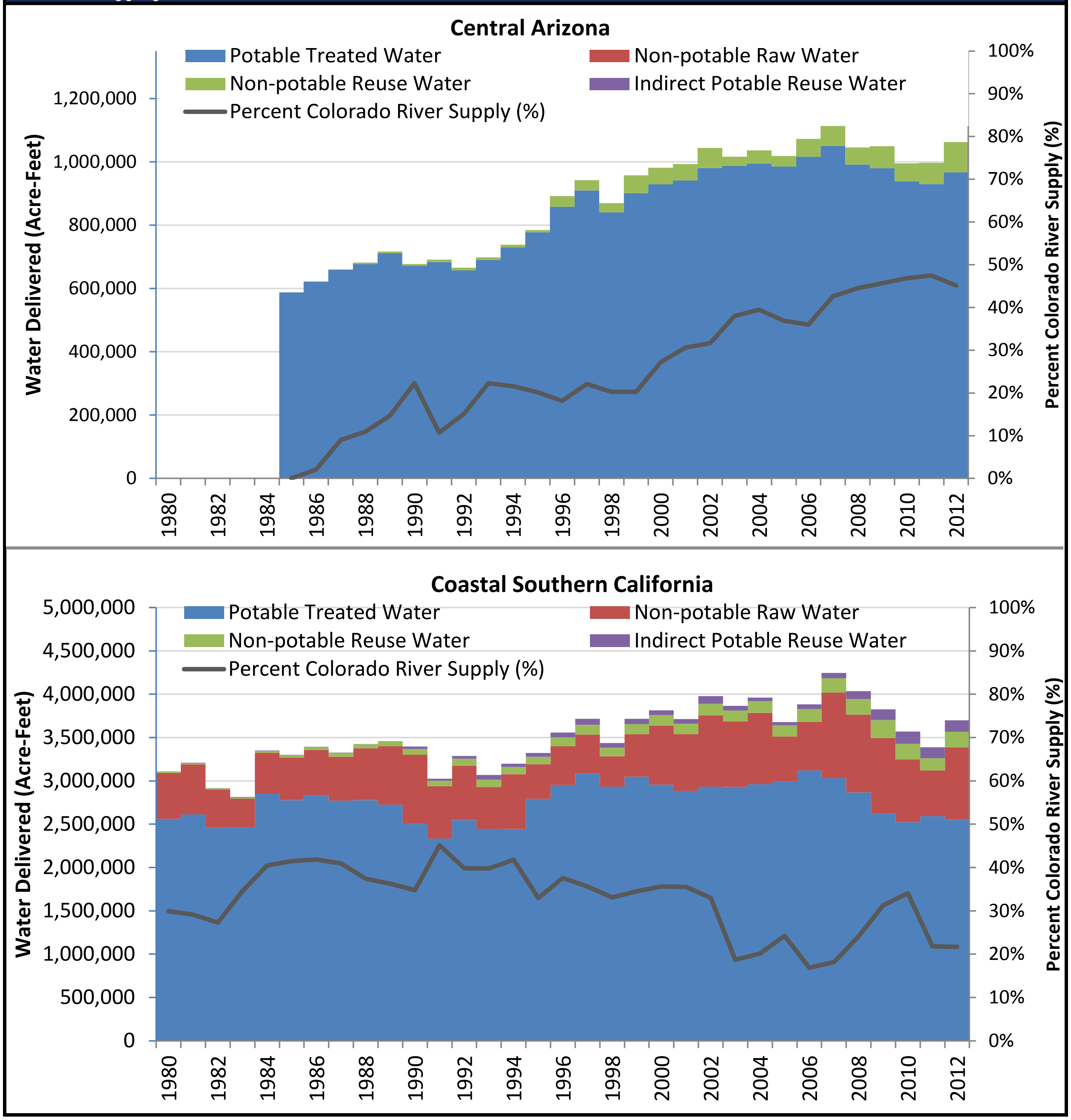


FIGURE 3-11C
Trends in Water Deliveries by Type and Percentage of Colorado River Water
Selected aggregated service areas



Note:
Coastal Southern California percentage Colorado River water includes water delivered through MWD's Colorado River Aqueduct for exchange with Desert Water Agency and CVWD.

TABLE 3-6
M&I Water Reuse in the Major Metropolitan Areas: Volume (AF) and Percentage (%) of Total M&I Water Supply Derived from Reclaimed Water (2012)

State	Major Metropolitan Areas	M&I Reuse				Total Reuse for All Uses as % of Reusable Supply
		Non-potable Reuse Water	Indirect Potable Reuse Water	Total M&I Reuse		
		AF	AF	AF	%	
WY	Cheyenne	600	0	600	4	9
CO	Front Range	19,300	44,300	63,600	12	80
UT	Wasatch Front	1,500	0	1,500	0.6	1
NM	Middle Rio Grande	1,300	0	1,300	1	100
NV	Southern Nevada	17,500	200,400	217,900	45	99
AZ	Central Arizona	95,000	0	95,000	9	95
CA	Coastal Southern California	179,200	134,900	314,100	9	24
CA	Salton Sea Basin	8,700	0	8,700	6	65
	Total	328,400	379,600	708,800		

Note:
Table presents reclaimed water that is delivered by municipal providers for M&I purposes only. Values do not represent the full amount of reclaimed water that may be used by industrial users, agricultural users or put to other beneficial purposes.

Southern Nevada currently reclaims nearly all of its wastewater, with return-flow credits and direct reuse (SNWA, 2009) totaling approximately 217,900 AFY in 2012. The return flow credits mechanism represents a particular case where indirect reuse is possible.

In the Front Range metropolitan area, approximately 64,000 AFY of reuse was reported in 2012. A significant portion of the reuse is developed through exchanges in which municipal return flows are provided to downstream agricultural users and exchanged for native river supply. It is estimated that about 80 percent of the reusable portion of the Front Range cities' wastewater is reused. Approximately 60 percent is reused for non-potable and potable M&I uses, while approximately 20 percent of the reusable portion of wastewater is used by downstream agricultural users.

Indirect potable reuse accounts for approximately 52 percent of all M&I reuse in the major metropolitan areas that receive Colorado River water, while direct non-potable reuse accounts for the remaining 48 percent. There are currently no known direct potable reuse facilities in operation in the major metropolitan areas that receive Colorado River water.

Accounting for both changes in per capita use and water reuse, M&I water demand could have been nearly 2.4 million AFY higher in 2010. This finding points to the considerable efforts that municipal water providers have made to reduce overall water demand.

While many of the M&I users receiving Colorado River water have diversified water supplies, implemented increasing water reuse, and aggressively implemented water conservation, dependence on Colorado River water appears to be growing. All major major metropolitan areas except Southern California reported the same or greater percentage of the total supply from the Colorado River in 2010 than in 1990. In many areas, the reliance on Colorado River water is due to the limited alternative water supplies. However, in California and Arizona, users have come to use their full apportionment of Colorado River water, so new growth in demand is being supplied by other water supplies or through conservation and reuse efforts.

3.5 Municipal and Industrial Water Conservation and Reuse Programs and Practices

The sections below describe M&I water conservation and reuse programs and practices.

3.5.1 Overview of Programs and Practices

Water conservation and reuse is practiced in all of the major metropolitan areas that receive Colorado River water. However, the types of water conservation and reuse practices and the extent to which they have been implemented vary among water providers and depend on many regionally specific factors such as climate, demographics, funding availability, water supply portfolios, and reliability.

The types of water conservation measures and the extent to which they have been implemented vary extensively among municipal providers and among major metropolitan areas that receive Colorado River water based on water supply portfolios and reliability, climate, demographics, and available funding.

Information about innovative or successful M&I water conservation and reuse programs and practices was provided by the Workgroup members. This effort did not intend to collect information on all of the programs and practices implemented in the Basin, but to solicit information on efforts that water providers felt were innovative or particularly effective for their service areas. From the information received, 33 programs were selected as case studies to represent the breadth of innovative water conservation and reuse efforts throughout the major metropolitan areas. The geographic locations and types of conservation or reuse practices represented in the case studies are shown on Figure 3-12 and detailed descriptions can be found in Appendix 3B.

This section begins with a summary of federal programs and activities that support or drive local-level implementation of water conservation and reuse activities. Then, based on information provided by the Workgroup, an overview of the types of M&I water conservation and reuse activites along with examples of programs and practices implemented throughout the Basin, including those selected as case studies, is provided. The programs and practices were organized into six categories of conservation: metering and billing, public education and outreach, water loss characterization and reduction practices, residential indoor practices, CII practices, outdoor landscaping practices, and one category for reuse.

3.5.2 Federal and State Assistance Programs

Federal and state governments provide leadership for water conservation and reuse programs and are an important source of technical and financial assistance for many water providers. Some agencies address regulatory mandates while others are voluntary programs, and the funding mainly comes in the form of loans or grant opportunities. According to the Workgroup, the federal programs providing the most support for M&I conservation and reuse in the major metropolitan areas that receive Colorado River water are the EPA's WaterSense Program and the U.S. Department of Interior (DOI)'s WaterSMART (Sustain and Manage America's Resources for Tomorrow) Program.

WaterSense, an EPA partnership program, seeks to help consumers make smart water choices that save money and maintain high environmental standards without compromising performance. Products and services that have earned the WaterSense label have been independently certified to be at least 20 percent more efficient without sacrificing performance. Products currently certified by the WaterSense program are toilets, bathroom sink faucets, urinals, new homes, showerheads, weather-based irrigation controllers, and commercial pre-rinse spray valves. New products soon to be certified include water softeners, sprinkler heads, soil moisture-based control technologies, and flushometer-valve toilets. Professional services such as certification programs for landscape irrigation professionals are also provided.

WaterSMART allows DOI agencies to work with States, tribes, water users, local governments, and nongovernmental organizations to pursue a sustainable water supply for the U.S. by establishing a framework to provide federal leadership and assistance on the efficient use of water, integrating water and energy policies to support the sustainable use of all natural resources, and coordinating the water conservation activities of the various DOI agencies. Reclamation plays a key role in the WaterSMART program as DOI's main water management agency. Focused on improving water conservation and helping water and resource managers make wise decisions about water use, Reclamation's portion of the WaterSMART program is achieved through the administration of grants, scientific studies, technical assistance, and scientific expertise.

Additional information on relevant federal and state programs related to water conservation is included in Appendix 3C.

3.5.3 Water Conservation Programs

M&I water conservation programs address areas of water use and delineate specific measures to help reduce water use. The following sections describe each of the program categories and include associated examples and case studies. While only a few examples are included for each program category, they serve as a good representation of the efforts many,water providers have implemented.

3.5.3.1 Metering and Billing

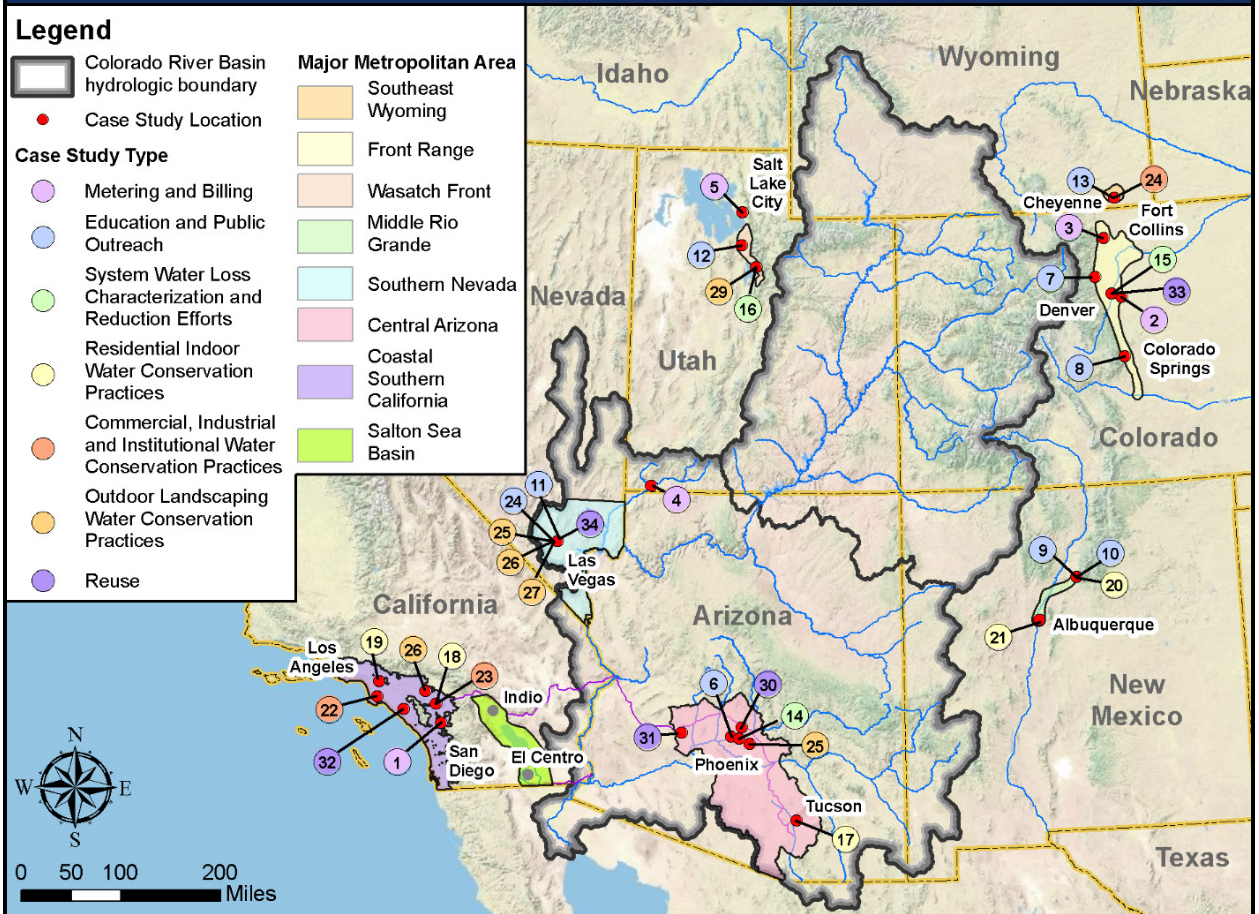
The conservation programs in this category use meters, billing structures, and consumer water use information to promote reductions in water use. Water metering is an essential element for water conservation because it improves understanding of water use, can support leak detection, informs billing structures, and can serve as a platform for communicating water use and conservation messages with consumers. The American Water Works Association's (AWWA) Water Conservation Program Operation and Management Standard (AWWA, 2013) recommends universal metering to best manage water resources.

Approximately, 95 percent of the users in the major metropolitan areas are metered. The City of Tempe in Arizona started metering water use in the 1930s, Colorado Springs was fully metered in the 1940s, and others such as Denver Water completed metering all customer water use in the 1980s. Similarly, SNWA and MWD members meter all customer water use. However, some water delivery service areas that receive Colorado River water are not fully metered. Current efforts focus on adding new meters to the system and upgrading existing metering infrastructure.

New metering systems are especially relevant in Utah's Weber Basin Water Conservancy District where a secondary system delivers untreated river water for residential irrigation. Historically, this secondary system has not been metered and water allocation and use was estimated based on parcel size. In 2010, the District began a program to install meters. To date, approximately 10 percent of Weber Basin's secondary connections are metered and the District anticipates 100 percent of the retail secondary water users to be metered within the next 10 years (Case Study 5).

Secondary Water Meter with Radio Transmitter
Source: Weber Basin Water Conservancy District.

FIGURE 3-12
Selected Water Conservation and Reuse Program Case Studies



1	Water Budget-Based Tiered Rates	18	High Efficiency Clothes Washers
2	Water Use Efficiency Mapping and Identification Integrated with the System Incentive Program Project	19	Innovative Conservation Program
3	Home Water Reports	20	Albuquerque Bernalillo Water Conservation Program[2]
4	Water Conservation Easement	21	City Rebate and Water Bank Program
5	Secondary Water Metering (untreated residential irrigation)	22	Cash for Kitchens
6	Water—Use It Wisely®	23	Public School Retrofit Program
7	Commercial, Industrial, Institutional Water Audit Tool	24	National Center for Atmospheric Research – Wyoming Supercomputing Center Conservation Program
8	WaterSense® New Homes Builder Incentive Program	25	Parkway Improvement Districts Water Conservation Program
9	Water Conservation Planning Guide for Public Water Suppliers	26	Free Sprinkler Nozzles
10	Southwest Plant Selector Application	27	Water Smart Landscape
11	WaterSmart Innovations Conference and Exposition	28	Water Use Restrictions and Land Development Code
12	Slow the Flow, Save H_2O	29	Central Utah Gardens[3]
13	Recycled Water Public Information and Outreach Campaign[1]	30	Reclaimed Water Distribution System
14	Distribution System Replacement and Repair	31	Zero Discharge: Palo Verde Nuclear Generating Station and Redhawk Power Plant
15	Denver Water Pipe Replacement Program	32	Crean Lutheran High School
16	Provo Reservoir Canal Enclosure Project	33	Denver Zoo Recycled Water
17	Conserve2Enhance™ [2]	34	Southern Nevada Water Reuse

[1] Also relevant as a water reuse program case study.
[2] Also implemented in the CII and outdoor landscaping water use sectors.
[3] Also relevant as a public education and outreach program case study.

Most of the existing water meters in the metropolitan areas that receive Colorado River water are mechanical devices that lose accuracy with time and have a replacement cycle of 15 to 20 years. The AWWA Manual M6 (AWWA, 2012) recommends a planned meter replacement program to be implemented over a specified number of years to upgrade meters and incorporate new technology. For example, 10 percent of the meters could be replaced each year over a 10-year period.

- The cities of Buckeye and Peoria, and the town of Gilbert, in Arizona, are among those implementing such replacement programs. During the replacement process, some water utilities are opting to upgrade the meters to advanced or automated meter infrastructure.
- In the Colorado Springs Utility, starting in 2005, virtually all electric, gas, and water meters used for billing were converted from a manual meter reading system to an automated system.
- In New Mexico, the City of Santa Fe operates metering technology that stores usage profile data to pinpoint where water is being wasted to improve conservation efforts and save customers money.
- JVWCD, a Wasatch Front water supplier, is installing Advanced Metering Infrastructure in its retail service area.

Many municipal water providers that receive Colorado River water implement conservation-oriented rate structures, including tiered billing or budget-based rate structures, seasonal billing rates, and additional fees. In addition, some water providers have implemented billing information mapping and management systems to incentivize consumers' behavior to use less water because they save money and avoid being identified as a high water user.

Across Southern California, several agencies (such as Eastern Municipal Water District, Rancho California Water District, Irvine Ranch Water District, and Western Municipal Water District) have implemented budget-based tiered rates (Case Study 1). The billing systems use customer-specific information related to the number of persons per household and the size of the irrigated area to establish a water budget and develop tiered rates based on water use in relation to the water budget. Some places even integrate the condition of service-based water waste penalties into their water billing such as purveyors in SNWA's service area. This enhances conservation signaling through billing and in this particular area the penalties multiply if a customer fails to address the infraction.

In places where the metering infrastructure has been automated and billing information is being managed, successful programs have been identified. For example, the Home Water Report program in Fort Collins, Colorado (Case Study 3), is proving to be an effective way to help the city reach its water reduction goals. This program is based on research on social norms marketing; the idea is that much behavior is influenced by people's perceptions of what is "normal" or "typical."

In Colorado, Aurora Water's billing information management program is a good example of a sophisticated program. This program maps water efficiency to identify inefficient water consumers who are then offered incentives to reduce their water consumption (Case Study 2). Similarly, since 2009 the City of Goodyear in Arizona has sent letters to the top 1 percent of water users (based on use) to offer resources that may help them reduce their use; these resources include classes and home irrigation audits.

3.5.3.2 Public Education and Community Outreach

Conservation programs under the public education and outreach category often represent low-cost efforts to develop a conservation ethic among water consumers. Conservation programming and messaging work best when they are locally relevant and promote conservation behaviors as a community norm or way of life. These programs can support water conservation across all customer types such as residential or commercial users and have been implemented in all of the major metropolitan areas.

As expected, the intensity of public awareness campaigns increases during drought periods. The Drought Response Information Project was initiated by the City of Grand Junction, Colorado, in 2003 in response to a 2002 drought and has expanded to cover a broad spectrum of water conservation outreach. The City of Boulder, Colorado, partnered with a local non-profit to augment water conservation staff during drought, enhancing public outreach efforts when water restrictions were in effect.

Conservation education and training courses for professionals have been widely implemented in the major metropolitan areas that receive Colorado River water. Programs range from those targeting education for school children to irrigation workshops for property managers and landscape maintenance supervisors. For example, since 2006, the Water Watcher Youth Education Program has provided interactive classroom demonstrations for more than 120 classrooms and 3,560 elementary school students in Glendale, Arizona. Also, SNWA's Water Smart Contractor program provides partnering professional landscapers with training in best practices for installing water-conscious landscaping and features required proficiency examinations and ongoing monitoring of adherence to program expectations. In turn, SNWA provides brand labeling and promotional assistance and places the contractor in a list on its website which local residential and commercial property owners then may use.

The development and distribution of water conservation information has been important since at least the late 1970s. The method of disseminating water conservation information has changed with the use of social media, Web-based platforms, and software applications for hand-held devices, making it easier for customers to obtain relevant and timely material. Several examples of modern programs include:

- The Water–Use It Wisely® program (Case Study 6) developed by coalition partners in Arizona,
- The New Mexico Office of State Engineer's Water Conservation Planning Guide for Public Water Suppliers (Case Study 9) that provides tools and step-by-step water conservation planning directions and the Southwest Plant Selector application for identifying native plants for landscapes (Case Study 10),
- San Diego County Water Authority's eGuide to a WaterSmart Lifestyle for single-family homeowners is a resource for water use efficiency,
- The Slow the Flow, Save H2O campaign in Utah (Case Study 12).

Another tool used for public education and community outreach is the implementation of pilot-scale projects and public demonstration gardens to inform customers and the public about landscaping with low-water-use plants. Some new initiatives such as the Linen Exchange program in Southern Nevada that aim to reduce the linen washing water use at hotels, and the use of rainwater harvesting water for toilet flushing in Arizona, are being implemented as pilot projects to assess program effectiveness and to explore implementation at a larger scale.

The implementation of audits, certifications, and awards oriented to specific water use sectors has been used as an opportunity to perform strategic outreach and water use education. Examples of this type of program are the CII Water Audit Tool developed by the City of Boulder (Case Study 7).

There have been efforts in the Basin to link municipal water conservation with environmental benefits, creating opportunities for individuals to invest in watershed health and water resources. For example, the Water Resources Research Center's Conserve2Enhance program in partnership with Tucson Water allows residential and commercial participants to save water and then donate the value of their saved water to a program fund that provides funding for local and regional environmental enhancement projects (Case Study 17). Another example is the City of Santa Fe's Water Bank Program in which water saving credits derived from this program are deposited in the City's Water Bank and may be allocated for programs including affordable housing and the "living river" (Case Study 21).

3.5.3.3 Water Loss Characterization and Reduction Efforts

Water losses occur in water distribution systems and are unavoidable. Obvious major breaks are addressed quickly, but smaller leaks can go undetected, resulting in significant water loss if not corrected. Various measures and actions are being taken throughout areas that receive Colorado River water to quantify and characterize these yet undetected losses and when economically feasible, eliminate these losses.

The AWWA has developed an industry standard best practices process for completing a water distribution system water audit (AWWA, 2009). Water losses are defined as the difference between (1) water supplied to the distribution system and (2) authorized consumption. Losses are further disaggregated into real losses and apparent losses. Real losses may include leakage from pipes and storage overflow. Apparent losses may include inaccurate metering, data handling errors, and theft. The AWWA audit process provides a systematic approach for identifying real and apparent losses and suggests ways of improving water loss characterization and reduction efforts.

The AWWA M36 manual (AWWA, 2009) outlines four pillars to reduce these water losses: pressure reduction, leak detection, pipe replacement, and speed and quality of repairs. A fundamental component of any water loss control program is an understanding of the existing levels of leakage and losses. The AWWA Free Water Audit Software© is considered an industry best practice for loss assessments, and the software is recommended by Colorado, New Mexico, and California. Arizona sets requirements for maximum allowable loss and unaccounted for water. In the other Basin States, water purveyors are conducting audits ahead of state recommendations.

Water distribution system leak detection
Source: M.E. Simpson Co., Inc.

Many municipal water providers in the major metropolitan areas that receive Colorado River water are substantially reducing their water losses. For example, the City of Tempe, Arizona, is conducting leak detection on approximately 200 miles of their distribution system annually, or approximately 20 percent of the total system. The program pays for itself through the reduction of water leakage (Case Study 14).

To reduce leakage, an active control program must be in place continuously, and methods such as acoustic leak detection must be applied. Denver Water is working to reduce real losses by proactively replacing pipe with the highest risk of failure. Denver has allocated approximately 10 percent of its total funds in capital programs toward pipe replacement to help reduce real losses. This program increases the reliability of its system by reducing failure of existing pipes and reducing leakage in the distribution system (Case Study 15).

Meter replacement reduces apparent losses by increasing the accuracy of new meters, which actually may increase revenue. Meter replacement also has a water conservation effect because appropriate water rates are applied and customers are charged for what they consume. The City of Tempe has a regular meter testing and replacement program that is focused on reducing water loss.

3.5.3.4 Residential Indoor Water Conservation Practices

Conservation practices for reducing residential indoor water use often include ordinances, and incentives for plumbing and fixture retrofits and the encouragement of the purchase of water/energy-efficient appliances.

Some cities receive Colorado River water began revising ordinances and initiating incentive programs to install low-flow toilets and fixtures in the 1980s. In 1986, the City of Glendale, Arizona, was the nation's first city to offer a toilet rebate program. Today most rebate programs are oriented toward homes constructed before 1994 when current federal plumbing standards for low-flow showerheads, faucets, and toilets were passed.

Most Basin states have adopted more restrictive standards (Appendix 3C) and have ordinances in place for new construction or home remodels to include changes to the existing plumbing system.

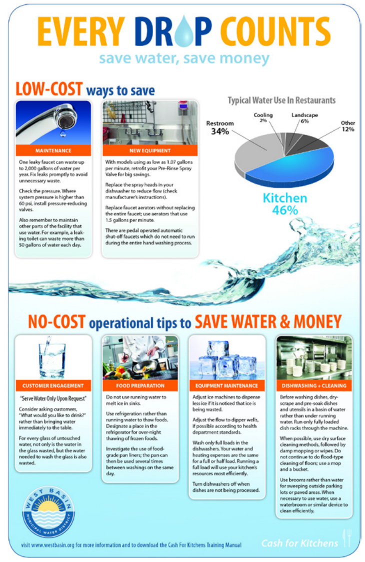
The changes in federal, state, and local construction standards or ordinances over the last decades helped to drive the rapid rate of installation of water-conserving devices and appliances. For example, in California the current standard for high-efficiency toilets (1.28 gallons or less per flush) is 20 percent lower than the national plumbing standard. These high-efficiency fixtures are the only toilets allowed to be purchased or installed in California. In response to statewide drought, the MWD increased its annual conservation and outreach budget from $20 million in fiscal year 2013-14 to $100 million in fiscal year 2014-15, providing additional rebate incentives for Southern Californians to purchase water-saving devices and to help meet the state's goal of a per capita water use reduction of 20 percent by 2020.

Most water providers receiving Colorado River water are partners in EPA's WaterSense Program, which encourages consumers to purchase water-efficient products and ensures consumer confidence in those products with a label backed by independent certification. Products carrying the WaterSense label are 20 percent more efficient than average products by reducing water and energy use, as well as meeting performance criteria.

For metropolitan areas that also support EPA's ENERGY STAR program, which promotes energy-efficient products and buildings, water-energy efficiency synergies can be realized. For example, Colorado Springs Utilities has implemented the WaterSense New Home Builder incentive program (Case Study 8) that builds on and complements the existing EPA ENERGY STAR New Home Builder Incentive Program. Through SNWA's successful Water Smart Homes program, partnering builders have constructed over 10,000 new highly water efficient residences. Another example is the Eastern Municipal Water District's program to help fund the installation of high-efficiency clothes washers through the Southern California Gas Company's energy savings assistance program (Case Study 18).

3.5.3.5 Commercial, Industrial, and Institutional Water Conservation Practices

Similar to residential indoor water conservation programs, retrofits and incentive programs to replace CII fixtures are also main components of water conservation programs. Many of the programs in this category are targeted to specific industries, commercial activities, or institutional users. For example, Arizona's Pre-Rinse Spray Valve Program (installing high efficiency pre-rinse spray values in the food industry) has been successfully implemented, saving both water and energy. Similarly, the West Basin Municipal Water District in California has implemented the Cash for Kitchens audit program (Case Study 22) that seeks to increase water efficiency with the introduction of water-saving devices, such as a pre-rinse sprayer and water broom, in more than 600 commercial kitchens.



Source: West Basin Municipal Water District

These types of programs have also been implemented in hotels, hospitals, corrections facilities, and schools. For example, the Public School Retrofit Program in California (Case Study 23), partially funded through the CALFED Water Use Efficiency Grant Program, was launched by the Eastern Municipal Water District to save water in public schools through the installation of water-efficient devices.

In industrial and commercial buildings with cooling towers, standards to reduce the volume of water used in the cooling process have been introduced. The National Center for Atmospheric Research Wyoming Supercomputing Center has reduced cooling energy used by up to 89 percent over typical data center configurations and reduced water use from evaporative cooling towers by 40 percent (Case Study 24). Similarly, the City of Tempe, Arizona, runs the Industrial Grants Program to offer incentives to businesses to make sustainable reductions in their water use. As part of this program, businesses must reduce their water use by at least 15 percent and sustain these levels of savings to qualify for the grants.

Another effort in the Basin has been the development of CII audit tools to support water agency efforts to reduce water use. The City of Boulder has developed a CII auditing tool that references EPA and U.S. Department of Energy standards for water and energy and seeks to produce simple reports to show savings and implement efficiencies (Case Study 7).

3.5.3.6 Outdoor Landscaping Water Conservation Practices

Outdoor landscape irrigation is the single largest consumptive water use in the M&I sector. Outdoor water use can be as high as 60 percent of the total residential customer use and as much as 50 percent of the total M&I water use (EPA, 2014; California Department of Water Resources, 2010). Water conservation practices include water conservation demonstration gardens, landscape consultations and audits, landscape irrigation budgets, rebates, and incentives to use smart irrigation technology and/or convert landscaping and restrictions on irrigation amount and timing.

Outdoor landscaping irrigation efficiency measures have been the focus of many water providers. These measures seek to reduce excess irrigation and allow for improved irrigation efficiencies through best practices and new technologies. For example, the California Sprinkler Adjustment Notification System allows urban irrigators to voluntarily register to receive regular emails containing updated irrigation index factors specific to their sites. The factor is used to make global scheduling adjustments on irrigation timers that have a percentage adjustment feature. In Las Vegas, rebates have been implemented to increase the use of smart irrigation infrastructure such as pressure-reduction valves, backflow preventers, rain sensors, multi-setting sprinkler timers, and multi-stream rotor sprinkler heads. The town of Gilbert, Arizona, has reported about a 30 percent reduction in outdoor landscape water use resulting from a program in which water conservation staff worked directly with local parks and recreation staff, street right-of-way contractors, and Parkway Improvement Districts maintenance staff on water budgeting and irrigation maintenance best practices (Case Study 25). Onsite landscape consultation and development of water budgets for homeowners associations have also been implemented in multi-family buildings as a requirement to qualify for rebates.

Conversion of landscapes to low-water-use plants is an effective method for reducing water use. These programs seek to encourage conversion to attractive, low-water-use landscapes. For example, in Southern Nevada, an aggressive outdoor landscaping water use efficiency program has been implemented. SNWA has invested over $200 million in its Water Smart Landscapes program that offers up to $1.50 for every square foot of grass that is removed and replaced with low-water use landscaping (Case Study 27). A legally recorded covenant and grant of conservation easement and annual monitoring helps assure the long-term retention of the landscape. Similar programs encouraging landscape conversions have been implemented in MWD's service areas.

Finally, ordinances and regulations have been enacted in many of the major metropolitan areas to reduce outdoor water use. Ordinances and new development codes have been enacted to limit the amount of irrigated turf that can be included in new developments. Typically, they have been applied only to new developments for which the regulatory authority exists to adopt such limits. However, under drought conditions some states and water providers, through drought management plans, have implemented water use restrictions for the broader community.

Facing a 2003 drought, agencies in Southern Nevada enacted more stringent policies including limitations on installation of turf at new properties (Case Study 28). These include prohibiting installation of turf in most new developments. In multi-family units, turf was limited to private parks and at single-family homes, front yard-turf was prohibited with it limited to 50 percent of the backyard landscapeable area. Additional restrictions included seasonal watering restrictions, limitations on surface and vehicle washing, operation of water features and misters, and golf course water budgets. These limitations have now been placed into permanence in the interest of long-term sustainability goals.

No lawn in front yards of new homes
Source: Southern Nevada Water Authority

Similarly, local water agencies across California took action in the face of dry conditions in 2014, the state's third consecutive dry year. Many water providers called on customers to step up conservation efforts, while some have implemented mandatory restrictions on water use such as prohibiting watering lawns on consecutive days, refilling swimming pools, or using a hose to clean. An drought-related emergency regulation to increase conservation practices for all Californians was adopted by the California State Water Resources Control Board (CSWRCB, 2014). In 2014, the Governor of California's goal was to reduce overall statewide water use by 205 (State of California, 2014) percent during these drought conditions.

While these drought management measures are distinct from the long-term water conservation programs, some carryover impacts are often realized in years following droughts as landscapes are modified or technologies are adopted. The persistence of these drought-induced changes is an area of active study.

3.5.4 Reuse Programs

Municipal providers have implemented a range of reuse programs in the Basin. As water demands have increased in the past decades, water supplies available to water providers have not substantially increased. The potential for imbalances has led to increasing focus on reuse to meet existing or future demands. Three general categories of reuse describe the method in which reclaimed water is developed and used: direct non-potable reuse, indirect potable reuse, and direct potable reuse. The reuse categories are described in the following sections. Direct Non-Potable Reuse Programs

Direct non-potable reuse is the most widely applied type of reuse in the metropolitan areas that receive Colorado River water. In direct non-potable reuse, treated municipal wastewater is reused for non-potable purposes such as landscape irrigation, dust control, and power production and cooling. When agriculture is near municipal areas, treated wastewater can sometimes be used for irrigation of non-food crops. The reuse supply can also be used for some non-potable CII and residential uses, but dual plumbing is required, which substantially increases construction costs, so its current use is limited. Regardless of final end use, direct non-potable reuse water is distributed through a separate piping system from the municipal treated drinking water, requiring substantial investment. Direct non-potable reuse reduces the demand for treated water and helps avoid or defer the need to develop additional water supplies.

A range of direct non-potable reuse programs has been identified in the major metropolitan areas that receive Colorado River water, including the following.

- Colorado Springs has practiced wastewater reuse since 1961 through a program that serves numerous commercial, industrial, and municipal customers. Uses include turf irrigation at parks, cemeteries, schools, and commercial buildings; industrial uses include power production and process water. The water is used through a central distribution system and through customer-operated standalone reuse facilities.
- To address declining groundwater levels, the City of Scottsdale in 1989 required certain golf courses to begin using reclaimed wastewater, rather than groundwater or potable water, for irrigation. An innovative partnership between the City and the golf courses was formed to expand the reclaimed delivery system and enhance the City's wastewater treatment process with advanced treatment techniques including microfiltration and reverse osmosis.

Reverse Osmosis Train
Source: Kathy Rall, Water Resources Advisor

- The City of San Diego has built and operates two reclamation plants capable of producing 50,000 AFY combined. The supply is primarily used for landscape irrigation on roadways, golf courses, and parks. The reuse supply reduces the City's dependence on imported supplies.
- Denver Water moved forward with a non-potable reuse system in 2004. The system currently serves more than 80 customers with a distribution system

in excess of 50 miles of purple pipe; this is the largest project in the Front Range. The project is expected to have a build-out demand of 17,500 AF by about 2030. Since 2004, Denver Water's recycled wastewater is used in the Denver Zoo for animal exhibits (for example, outdoor pools), as well as for landscape irrigation and cleaning (Case Study 33).

- Santa Fe's wastewater treatment plant produces reclaimed water that is used for irrigating turf at golf courses and recreational playing fields, watering educational landscaping, construction and dust control, and livestock. The reclaimed water also makes up the majority of the flows in the Santa Fe River downstream of the wastewater treatment plant.
- Arizona's Palo Verde Nuclear Generating Station and the Redhawk gas-fired power plants annually use for cooling purposes about 70,000 AFY of reclaimed water purchased from the cities of Phoenix, Mesa, Tempe, Scottsdale, and Glendale which jointly own and operate the 91st Avenue Wastewater Treatment Plant in southwest Phoenix. Palo Verde is the only nuclear generating facility in the world that uses reclaimed water for cooling water (Case Study 31).
- The cities of Mesa and Chandler, Arizona, have water exchange agreements with the Gila River Indian Community to provide reclaimed water for agriculture use. The cities receive a portion of the community's CAP water in exchange for reclaimed water. Five AF of reclaimed water are provided in exchange for 4 AF of CAP water.
- Crean Lutheran High School is the first high school in the Irvine Ranch Water District service area and in California with dual-plumbed buildings. The dual system serves two buildings with more than 500 students and 30 staff members. The recycled water is also used to irrigate its 9 acres of landscaped area. The District encourages the use of recycled water for non-potable purposes through customers discounts (of 10 to 40 percent) when purchasing recycled water (Case Study 32).
- The Phoenix Rio Salado Habitat Restoration Project opened in 2005. A series of five reclaimed water wells is the main source of water for the vegetation and wetland areas in the Rio Salado Habitat area. The wells recover reclaimed water stored underground at the Roosevelt Irrigation District Groundwater Savings Facility. The expected project requirement is about 4,000 AFY.
- In the Wasatch Front, water reuse projects are currently in the planning stages with implementation expected within the next 5 years to satisfy CUWCD reuse requirements under CUP repayment and water sales agreements. Heavy use of secondary (non-potable) water systems for outdoor irrigation purposes has helped to defer expensive water reuse projects. In JVWCD's service area, secondary water is delivered through the use of Utah Lake water that was historically diverted into myriad canal systems for agricultural irrigation purposes. As agricultural lands are developed for urban purposes, this water is being converted to secondary use purposes and placed into separate secondary water systems. Future reuse water is expected to be of similar water quality to the current Utah Lake water used in secondary systems.
- In Southern Nevada, the City of Boulder City, City of Las Vegas, City of North Las Vegas, and Clark County Water Reclamation District operate central and satellite wastewater treatment plants providing approximately 19,000 AF of water for direct non-potable reuse annually for the period 2008 through 2011.

Another method for direct non-potable reuse is through exchange agreements or water rights trades with downstream users. For example, Denver Water uses its reusable wastewater flows and lawn irrigation return flows in water rights river exchanges to increase its diversion of upstream water.

3.5.4.1 Indirect Potable Reuse Programs

Indirect potable reuse programs include treated wastewater that is stored underground or in surface water reservoirs for subsequent use as a raw water supply to be treated again for potable purposes. In some cases, local exchange programs are used to recapture reusable wastewater, and credits are accrued through the delivery of effluent to storage facilities from which reclaimed water is indirectly used.

Unique indirect potable reuse programs within the major metropolitan areas include the following:

- In Central Arizona, indirect potable reuse has been widely implemented through underground storage of reclaimed water for future use to replace the use of the non-renewable groundwater supplies. The Salt River Project, working with partnering cities, has developed two underground storage facilities to ensure a reliable and adequate water supply for several cities near Phoenix: the 93,000 AFY Granite Reef Underground Storage Project (GRUSP) and the 75,000 AFY New River-Agua Fria River Underground Storage Project (NAUSP). In addition to water from the Salt and Verde Rivers and CAP water, the GRUSP receives reclaimed water via pipeline from the City of Mesa water reclamation facility, and the NAUSP receives reclaimed water from reclamation facilities of Glendale and Peoria. GRUSP was the state's first major underground storage facility, and one of the largest of its kind in the U.S.

- Indirect potable reuse is accomplished through the Colorado Springs Exchange program. The Southern Delivery System was built to increase the ability to deliver exchanged water from Pueblo Reservoir back to Colorado Springs, making the system a massive indirect potable reuse project. Colorado Springs, through the exchange program, currently reuses 100 percent of its legally reusable return flows and has done so for many years. Colorado Springs Utilities has also invested in water rights and infrastructure to recapture and reuse much of its reusable wastewater and outdoor irrigation return flows through exchanges on the Arkansas River. The Prairie Waters Project in Aurora, Colorado uses both natural cleansing processes and state-of-the-art purification technology to deliver an additional 10,000 AFY to its users. In most cases, Aurora's water rights in the South Platte allow the city to use the water "to extinction." Essentially, this means that the water residents use for washing, laundry, showering, as well as some of the water from lawn watering, can be recovered by diverting an equivalent amount from wells adjacent to the South Platte River.
- Southern Nevada currently reclaims most of its wastewater through Colorado River return-flow credits (Case Study 34). By treating Colorado River water after it is used and returning it to Lake Mead, via the Las Vegas Wash, SNWA is able to extend its Colorado River resources. For every gallon of treated Colorado River water returned to the Colorado River, SNWA can withdraw and use an additional gallon beyond Nevada's base allocation (SNWA, 2009).

3.5.4.2 Direct Potable Reuse Programs

By definition, direct potable reuse is the direct injection of purified municipal wastewater into either the drinking water distribution system or the intake of a water treatment plant without first subjecting the water to an environmental barrier such as an aquifer or reservoir. Direct potable reuse has been a topic of discussion for 50 years and numerous research studies, including two performed in San Diego County over the last 15 years, have provided evidence that it can be done safely. However, despite this fact, the U.S. currently has only two large public agency direct potable reuse treatment projects, and these projects have only recently been commissioned (Martin, 2014).

Studies are underway in some states to establish the feasibility and criteria for permitting direct potable reuse. For example, California Water Code Sections 13560 through 13569 require the California Department of Public Health in consultation with the California State Water Resources Control Board to investigate and report to the Legislature on the feasibility of developing uniform water recycling criteria for direct potable reuse by December 31, 2016. The law also requires an expert panel to be appointed to perform the following.

- Assess what, if any, additional areas of research are needed to be able to establish uniform water recycling criteria for direct potable reuse
- Advise the Department of Public Health on public health issues and scientific and technical matters regarding development of uniform water recycling criteria for indirect potable reuse through surface water augmentation
- Advise the Department of Public Health on public health issues and scientific and technical matters regarding the feasibility of developing uniform water recycling criteria for direct potable reuse

As a result of the Governor's Blue Ribbon Panel on Water Sustainability (2009-2010), WateReuse Arizona launched the Steering Committee on Arizona Potable Reuse in 2012 to identify opportunities to enhance the State's regulatory framework for potable reuse and develop a roadmap for communities to use in developing future water reuse projects. The Steering

Committee completed its Phase I efforts in 2014, including:

- Completion of advisory panel workshops on treatment technologies, unregulated constituents, public acceptance, and regulatory frameworks; and
- Planning for Phase II activities, which will include a public forum on potable reuse for small communities.

3.6 Planned Conservation and Reuse

This section evaluates the effects of future plans for water conservation and reuse in the Basin. Planned water conservation efforts were identified by reviewing water resource plans from major municipal water suppliers and estimating the potential overall impact of the programs or associated per capita water use targets. The total potential water savings by 2060 was estimated conservatively by assuming that planned targets would be met but that no other additional efforts would continue after meeting the established targets.

M&I water providers will continue to increase the efficiency of water use and reuse in the Basin and these efforts play an important role in reliably meeting future demand. Most water providers in the Basin have established long-range water management strategies that include both supply enhancement and demand reduction measures. Water reuse is practiced widely in these metropolitan areas as a supply augmentation or enhancement measure, while water conservation is generally described as a water demand reduction measure.

State water resource planning efforts and conservation targets are commonly used as the minimum conservation and reuse levels for water provider resource planning. The M&I water conservation and reuse tools included in these plans generally consist of programs and practices described in Section 3.5 of this report. The water reuse levels being targeted in each area are region-specific and are generally balanced with the increased water demands, available supplies, water rights and regulatory framework, and the costs associated with meeting the water needs of these individual communities.

The most relevant water resource and conservation planning documents for the metropolitan areas are summarized in the sections below. Comprehensive information on future water conservation goals was not identified for the Southeast Wyoming and Salton Sea Basin metropolitan areas.

3.6.1 Front Range

In 2006, Denver Water set a conservation goal to reduce water use to 165 GPCD by 2016. This reduction represents a 22 percent reduction from average pre-2002 drought use of 211 gallons per person per day. The estimated annual water conservation savings are approximately 55,000 AF. Denver Water is currently in the process of setting new conservation goals for beyond 2016. The Denver Water master plan identifies almost 300 potential customers (up from 100 in the 2004 update), which will help Denver Water reach its goal of delivering 17,500 AF of recycled water each year. The recycled water system will free up enough drinking water to serve nearly 43,000 homes by 2020. In addition to conservation and reuse practices, Denver Water has partnered with 17 other entities to form the Water, Infrastructure, and Supply Efficiency partnership that will provide new supply by combining unused capacities in Aurora Water's Prairie Waters Project with unused reclaimed water supply from Denver and Aurora. Then, during years when Denver and Aurora do not need all of the reclaimed water, the 15 Douglas County entities (South Metro Water Supply Authority) can buy the unused water to help reduce their reliance on nonrenewable groundwater.

Colorado Springs Utilities estimates that the amount of water that will be saved when the 2008-2012 Water Conservation Plan is fully implemented will equal approximately 7.6 percent of the 2007 demand forecast. The water conservation goals established for the 2008-2012 Water Conservation Plan include maintaining low residential use per capita, already among the lowest in Colorado. For the commercial market, the primary goal is to gain a better understanding of how commercial customers use water in an effort to reduce commercial use.

From 2005 through 2007, Colorado Springs Utilities went through the rigorous process of identifying and selecting water conservation programs for implementation. Colorado Springs Utilities developed and managed a portfolio of 23 water conservation programs starting in 2008. Colorado Revised Statute Section 37-60-126 requires that Colorado Springs Utilities consider nine specific measures and programs in the 2008-2012 Water Conservation Plan:

- Water-efficient fixtures and appliances, including toilets, urinals, showerheads, and faucets
- Low-water-use landscapes, drought-resistant vegetation, and removal of phreatophytes and efficient irrigation
- Water-efficient commercial and industrial water-using processes
- Water reuse systems
- Distribution system leak identification and repair
- Dissemination of information about water use efficiency measures, including public education, customer water use audits, and water-savings demonstrations
- Water rate structures and billing systems designed to encourage water use efficiency in a fiscally responsible manner
- Regulatory measures designed to encourage water conservation
- Incentives to implement water conservation techniques, including rebates to customers to encourage the installation of water conservation measures

Colorado Springs Utilities develops and maintains long-range plans for all water system facilities. Specific to water supply, they use an integrated resource approach to plan for facility improvements and additions.

In its 1996 Water Resource Plan, Colorado Springs Utilities identified four major components to help meet future water needs for Colorado Springs: conservation, non-potable water development, existing system improvements, and a new major water delivery system. The Southern Delivery System is a regional water project that transports stored water in Pueblo Reservoir to Colorado Springs and its project partners, Pueblo West, Security, and Fountain. With all major approvals and permits secured, construction of Phase 1 of the Southern Delivery System began in 2010.

3.6.2 Wasatch Front

Along the Wasatch Front and throughout Utah, the largest water districts have formed partnerships and combined resources to implement water conservation initiatives benefiting the State. These partners include JVWCD, CUWCD, Weber Basin Water Conservancy District, MWDSLS, Washington County Water Conservancy District, and the State Division of Water Resources. Examples of programs implemented include (1) a statewide water conservation education media campaign called Slow the Flow, Save H2O, and (2) a residential and large-user water audit program.

In 2012, JVWCD established a water conservation goal of reducing water use 25 percent by 2025, using 2000 as the baseline year for measurement purposes. If this goal is achieved in the JVWCD service area, water use will be reduced from 255 GPCD to 191 GPCD by 2025, facilitating a water savings of 52,000 AFY by 2025 and 71,000 AFY by 2050.

In Utah, state law provides that every water provider with more than 500 connections prepare a water conservation plan, update the plan every 5 years, and submit the plan to the Utah Division of Water Resources. JVWCD recently completed its 2014 Water Conservation Plan Update, which included a rigorous process of identifying water conservation programs and measures to implement over the next 5 to 10 years as it aggressively pursues its water conservation goal. JVWCD identified the following eight programs or measures to implement:

- Continue to build on and enhance existing programs including; provide leadership on the statewide Slow the Flow, Save H2O public education and media campaign; JVWCD's local public relations outreach and education programming efforts; continued expansion and development of the water conservation education gardens, known as the Conservation Garden Park; the homeowner and large-user water audit program; and the Member Agency Grant Program.
- Encourage and incentivize member agencies to meter and provide for volumetric billing of all secondary water use.
- Assist and provide incentives for the construction of water reuse projects achieving 7,000 AFY in reuse of CUP water by 2025.
- Install Advanced Metering Infrastructure (AMI) in the JVWCD retail service area providing for effective customer feedback on water use, social norming, and high-use targeting.
- Encourage and incentivize all member agencies to install advanced metering infrastructure through

the grant program and JVWCD technical assistance.

- Pursue wide-scale adoption of water-wise landscape ordinances by member agencies.
- Provide additional JVWCD-operated service area-wide water conservation programs including high-flush toilet replacement programs, water-wise landscaping incentive programs, and a large-user water-efficiency grant program.
- Provide for increased water conservation staffing needs by adding approximately four new staff over the next 5 years.

To meet each of these initiatives, JVWCD projects increasing water conservation-related expenditures from an annual cost of about $1 million to $1.8 million over the next 5 years.

The CUWCD is the federal government's administrator for the CUP. Among other water delivery contracts, CUWCD has current contracts in place to deliver nearly 100,000 AF of CUP water to the service areas of JVWCD and MWDSLS.

Under the CUP Completion Act (CUPCA), CUWCD is empowered to administer and manage the completion of the CUP. Section 207 of the CUPCA authorizes a comprehensive program to study and improve water management within CUWCD and to achieve yearly water conservation goals through implementation of various water conservation measures.

These water conservation measures are implemented through the CUPCA Conservation Credit Program, which has now completed its 16th year of operation. Thirty-seven projects have been implemented. In 2013, 134,489 AF of conservation was realized, greatly surpassing the 2013 water conservation goal of 49,622 AF under the current CUPCA Water Management Improvement Plan. The program has provided partial funding for several JVWCD water conservation programs. In the near future, the program is expected to assist in funding reuse projects to meet goals and requirements in CUPCA repayment and water sales agreements.

Similarly, the Weber Basin Water Conservancy District has asked each member agency in its entire service area to reduce per capita consumption by at least the state conservation goal. Because the District has such a large secondary component, a separate conservation goal has been established for indoor and outdoor water use. Because outdoor water use has a larger potential for conservation, the District established a goal of reducing per capita outdoor water use by 34 percent by 2025. Correspondingly, the District established a goal of reducing per capita indoor water use by 10 percent by 2025. Based on the historical distribution of water use between indoors and outdoors, achieving these two goals will result in a total reduction in water use of 25 percent.

The Weber Basin Water Conservation District is actively pursuing opportunities for wastewater reuse. Based on preliminary discussions with each major wastewater treatment plant in the District, potential reuse projects could result in 8,000 AF of additional water supply. This water would be used in existing secondary systems and would yield the same amount of water in both dry and average water years. Even with the full development of all additional water supply sources currently being considered by the District, supply will be inadequate to meet projected demands without conservation. Therefore, conservation is essential to the District's supply plan. The water supply plan depends on significant agricultural water conversion and growth in the use of supplies from secondary water providers. This and the reduction in existing demand through conservation will allow a portion of Weber Basin Project water to be removed from secondary usage and transferred to potable use. Even if this goal is met, population in the District's service area is expected to double during the next 45 years and expensive, new water sources will be required. Conservation will help minimize and postpone the need for these new sources.

3.6.3 Middle Rio Grande

The ABCWUA's water conservation goals for 2024 are lower than those previously established because the Authority has already made significant reductions in water usage. The original conservation goal was to reduce use by 30 percent from 250 GPCD to 175 GPCD from 1995 to 2005. However, once the goal was reached in 2011, a further goal of reducing use by another 14 percent in 10 years was established with a GPCD goal of 150 by 2014. The current goal is to reduce use 10 percent over the next 10 years to reach a GPCD of 135 by 2024. The ABCWUA will begin implementation of six programs in fiscal year 2014 based on customer input. Programs that were not ranked in the top six may be considered for implementation in the future after the top six programs have been implemented and evaluated. The programs considered for immediate actions are:

- Increase education: Expand education programs to serve the Middle Rio Grande metropolitan area and a larger number of students in the service areas.
- Building codes: Work with state, municipal, and county agencies and area stakeholder groups to develop legislation to require updates to current building codes that will benefit conservation without being financially burdensome to new development.
- Test your toilet month campaign: Promote a month when all customers are encouraged to test their toilets for leaks and make repairs, with particular emphasis on multi-family housing.
- Rebate donation program: Provide customers the option to donate 10 to 100 percent of their water conservation rebate to help fund new conservation programs.
- Toilet rebate program: Have a licensed plumber sign off on the rebate form or have an ABCWUA inspection of the new toilet installation.
- Xeriscape rebate program changes:
  - Increase the rebate for commercial, institutional and industrial customers to $1.50 per square foot for all projects and to $2 per square foot for slopes and small areas.
  - Offer a rebate of $0.75 per square foot for converting high water use grass to lower water use grass, even if it uses spray irrigation.
  - Increase the rebate for landscapes irrigated with harvested rainwater to $2 per square foot.
  - Provide an additional $50 per tree credit to cover the cost of tree irrigation systems when xeriscape is installed and offer rebates for tree moisture sensors.

3.6.4 Southern Nevada

SNWA has a demonstrated record of establishing and achieving regional water conservation goals since the 1990s. The pace of conservation slowed in 2000, and SNWA launched additional conservation planning efforts. In the early 2000's, for the first time, Nevada needed its full Colorado River allocation as well as its return flow credits to meet demands. At the same time, drought conditions had been occurring for several years, so SNWA's conservation planning efforts evolved into a drought planning initiative. This drought planning effort resulted in the adoption of a drought plan and a suite of aggressive drought conservation measures. In 2005, SNWA made the major temporary drought measures permanent, and these programs remain in place as a means to achieve SNWA's water conservation goals.

SNWA's current water conservation goal adopted in its 2009 Water Resource Plan (SNWA, 2009) is to achieve a goal of 199 GPCD by 2035. The estimated total savings are 276,000 AF per year by 2035, including projected water reuse relative to historical water use patterns. A sampling of SNWA conservation programs is summarized below. Additional details are available in SNWA planning documents (SNWA, 2009 and SNWA, 2014).

- Water Pricing: SNWA's member agencies set water rates independently; all use similar principles to implement conservation-oriented water rates to encourage water conservation.
- Incentive Programs: SNWA offers rebates to assist residents with the purchase of pool covers, smart irrigation controllers, and rain sensors. SNWA also provides a Water Efficient Technologies Program with financial incentives available for commercial and multi-family customers for installation of water-efficient devices saving at least 250,000 gallons. The SNWA Water Smart Landscapes program developed in 1999 offers $1.50 per square foot to convert lawn to water-efficient landscaping. Since 1999, the program has resulted in the conversion of more than 170 million square feet at a $190 million savings, resulting in an estimated savings of 29,000 AF annually, with a total of nearly $200 million for all incentive programs.
- Regulations: SNWA and the member agencies adopted landscape and plumbing codes in the mid-1990s to limit water use. In 2003, the code adoptions were followed by drought-related policies limiting landscape watering schedules, vehicle washing, misting systems, golf course water budgets, and turf installation in new development. In 2009, based on input from a citizen's advisory committee, SNWA and member

agencies permanently adopted the 2003 drought-related policies as long-term conservation measures.

- Education: SNWA maintains an education and public outreach campaign to assist residents and businesses with conservation efforts. This campaign includes the Water Conservation Coalition, WaterSmart Innovations Conference (Case Study 11), H2O University, a conservation helpline, and several demonstration gardens.

Water reuse in Southern Nevada is driven by SNWA's ability to use the return of its treated wastewater to Lake Mead as return flow credits. These credits constitute approximately 40 percent of the area's Colorado River supply. The Las Vegas Valley returns most of its treated wastewater back to the Colorado River via the Las Vegas Wash for indirect reuse as return-flow credits. Treated wastewater is also directly reused for golf course and other turf irrigation as well as other non-potable uses. Although this direct reuse means the reclaimed water is not returned to treatment facilities and cannot be used for return flow credits, it does replace the use of potable water for purposes such as irrigation.

SNWA's shortage response plan outlines several scenarios to offset drought impacts based on the severity of Colorado River supply conditions. The plan includes tools to increase alternative water supplies such as Intentionally Created Surplus, banked resources, heightened conservation measures, and development of in-state groundwater resources. Meeting projected demands through 2060 will require both the efficient use of existing and future supplies and the development of additional water resources.

3.6.5 Central Arizona

In 1980, Arizona passed the Groundwater Management Act to reduce the state's heavy reliance on groundwater. As required by the Act, the ADWR is currently developing the management plans for the Fourth Management Period (2010- 2020) for the state's AMAs. The Central Arizona metropolitan area covers the Phoenix, Tucson, and Pinal AMAs, where all M&I uses of Colorado River water delivered by the CAP occur. The management plans are designed to reach the goal of each AMA by increasing conservation requirements for all water users. The management goal for the Phoenix and Tucson AMAs is safe-yield by 2025. Safe-yield is a long-term balance between the amount of groundwater pumped in the AMA and the amount of recharge in the AMA.

Because of decreased funding in recent years, ADWR is still drafting the Fourth Management Plans. Once ADWR formally proposes the plans, it will hold public hearings prior to plan adoption. ADWR's findings after the hearing and its order adopting a plan are subject to judicial review.

Projecting future water demand based on yet to be formalized management plans may seem speculative, but recent research has revealed that nearly all municipal water providers have been experiencing large, and often unanticipated, drops in demand over the last 15 to 25 years (Woodard, 2014a). Several cities have greatly exceeded their conservation targets set by ADWR's Third Management Plans.

Detailed analysis has revealed an array of factors that reduces indoor demand, including voluntary ENERGY STAR and WaterSense standards for appliances and fixtures, and state-enacted mandatory efficiency standards that appear to be causing retailers to stock only more efficient fixtures and appliances.

Outdoor demand has also dropped, reflecting the reduction of turf and number of backyard pools. In rapidly growing areas, average residential water demand has been reduced by the addition of new, more water-efficient homes to the housing stock.

Nearly every city analyzed has experienced annual household water use declines of 1.5 to 2.5 percent over the past 10 to 15 years. Tucson Water has seen an annual average decline of 2.3 percent in per-household demand, with nearby providers experiencing similar rates of decline. The figure for the Phoenix metropolitan area, based on analysis of demand patterns in Chandler, Gilbert, Glendale, Mesa, Peoria, Phoenix, Scottsdale, and Tempe, is 2.1 percent per year in per-household demand (Woodward, 2014b).

Some of these declines in demand can be attributed to specific conservation measures, but demand is also being reduced because of preferences for water-efficient fixtures, appliances, and landscapes. These changes in preferences have certainly been influenced, and even driven, by conservation measures designed and implemented to alter perceptions and facilitate the adoption of more efficient landscapes, fixtures, and appliances.

Despite a 29 percent increase in the number of homes, total deliveries to single-family residences in Maricopa County were 2 percent lower in 2013 than in 2000. Tucson Water's 2013 deliveries to single-family residences in 2013 equaled deliveries in 1989. Demand has become decoupled from population, and the downward trends will almost certainly continue for some time to come (Woodard, 2014b).

3.6.6 Coastal Southern California

Consistent with the State of California's municipal water provider reduction targets, MWD has established a conservation target based on a GPCD reduction of 20 percent by 2020. MWD's strategy for ensuring regional reliability is embodied in the 2010 update to the Integrated Water Resources Plan (IRP) (MWD, 2010). The IRP seeks to stabilize MWD's traditional imported water supplies and meet needs for the region's growth through a successful adaptive management approach with emphasis on conservation and local supply development. In fiscal year 1990, conservation and recycling represented 7 percent of supply, in fiscal year 2014, 28 percent, and by 2035, the planned share is 33 percent. Combined with the increase of other local supplies, the imported Colorado River share would decrease from 26 to 14 percent. The estimated annual conservation target is about 860,000 AF. Most of the previously described conservation and reuse programs will continue.

In 2011, MWD's Board of Directors adopted a Long-Term Conservation Plan that was developed in collaboration with its member agencies, retailers, and other stakeholders. The goals of the plan are to (1) achieve the conservation target in the 2010 IRP Update, (2) pursue innovation that will advance water-use efficiency, and (3) transform the public's perception of the value of water within the region. The plan identifies five key strategies to achieve these goals: use catalysts for market transformation, encourage action through outreach and education, develop regional technical capability, build strategic alliances, and advance water efficiency standards.

In 2013, MWD issued a request for proposals to its member agencies for technical studies and pilot projects that facilitate future production of recycled water, stormwater capture, seawater desalination, and groundwater resources. As an outgrowth of the MWD IRP, this "Foundational Actions Funding Program" involves low-risk actions that ensure the area's readiness to implement new water supply projects, if and when necessary. MWD entered into 13 contracts for technical studies and pilot projects totaling $3 million in matching funds. These projects are due to MWD in early 2016.

3.6.7 Summary of Planned Conservation and Reuse

Water providers in the metropolitan areas that receive Colorado River water have invested significantly in M&I water conservation and reuse programs over the past decades. As discussed in Section 3.4, M&I water conservation and reuse have played an important role in reducing demand by nearly 2.4 million AFY when comparing 1990 and 2010 use rates. Looking to the next several decades, water providers are planning to continue to advance water conservation and reuse programs to reduce water demand and more effectively manage their water supplies.

The main conservation and reuse targets for several water providers in the major metropolitan areas that receive Colorado River water are summarized in Table 3-7. These providers serve a population of more than 28 million, which represents nearly 85 percent of the population that receives Colorado River water for M&I purposes.

Many water providers establish conservation targets that include both overall per capita reduction goals and a suite of water conservation and reuse best management practices. As shown in Table 3-7, several water providers are reaching the end of their current water conservation planning periods, while others have targets that extend through mid-century. Plans are periodically updated to continue to advance water conservation through the next planning periods for these water providers. Per capita water use reductions of up to 25 percent by 2025 are planned by some water providers.

TABLE 3-7
Water Provider Planned Water Conservation Targets

Agency or Management Area	Population Served (2010)	Projected Population Served (2030)	GPCD Reduction Target	Baseline Year	Target Year	Best Management Practices Target
Denver Water[1]	1,310,000	1,733,900	22% (165 GPCD)	2002	2016	
Colorado Springs Utilities[2]	445,700	626,400	19%* (149* GPCD)	2010	2050	No
Aurora Water[3]	325,100	456,900	10% (140 GPCD)	2002	2030	
JWVCD[4]	585,400	762,200	25% (191 GPCD)	2000	2025	Yes
MWDSLS[5]	385,300	464,100	25% (228 GPCD)	2000	2025	No
ABCWUA[6]	606,800	809,400	10% (135 GPCD)	2011	2024	No
SNWA[7]	1,956,900	2,422,700	20%* (199 GPCD)	2009	2035	No
Phoenix AMA	3,701,600	5,197,300	*Conservation requirements in the Third Management Plans have been met. New requirements will be set in the Fourth Management Plan, currently under development.*			
Tucson AMA	835,600	1,059,600				
MWD[8]	17,977,900	20,753,600	20% (145 GPCD)	1995-2005	2020	Yes

*Estimated values based on water plan documents because specific values were not provided.
[1] Denver Water, 2014
[2] Colorado Springs Utilities, 2008
[3] City of Aurora, 2007
[4] JVWCD, 2014
[5] MWDSLS, 2014
[6] ABCWUA, 2013
[7] SNWA, 2009
[8] MWD, 2014

Based solely on the reported conservation targets and population projections through 2030 (U.S. Census Bureau, 2013e), it is conservatively estimated that for the water providers for which numeric targets were identified, water demand in 2030 will be about 700,000 AFY lower than those estimated with 2010 per capita water use rates. Additionally, based on a national survey of planned water reuse programs (Association of California Water Agencies et al., 2013), it is estimated that approximately 400,000 AFY of new reuse supply may be added by 2030 to the water portfolios of water providers that receive Colorado River water. However, in some states such as California, reuse is included when calculating per capita water use, so adding the 2030 water conservation savings and reuse values for a total water use reduction may not be appropriate.

Based solely on the reported conservation targets and population projections from the U.S. Census through 2030, for the water providers for which numeric targets were identified, water demand in 2030 will be approximately 700 KAFY lower than that estimated with 2010 per capita water use rates. Additionally, based on a national survey of planned water reuse programs, approximately 400 KAFY of new reuse supply may be added by 2030 to the water portfolios of water providers that receive Colorado River water.

The M&I water conservation estimates provided here are considered conservative in that no further reductions in per capita water use were assumed after achieving the stated targets even if the time period for the achievement of the target was earlier than 2030. For example, MWD's conservation target is based on achievement by 2020. For this analysis, it is assumed that, after achieving the target in 2020, no further reductions in per capita use would be implemented for the next 10 years. M&I water providers that receive Colorado River water will continue to update and advance water conservation and reuse, and subsequently reduce water demands, over the coming decades and in response to evolving water supply conditions.

Although conservation and reuse is critical to helping ensure reliable water supplies in the Basin, their direct impact on the demand for Colorado River water is uncertain. The impact depends on economic, policy, legal, and environmental considerations that are integral to state and local water management decisions. Most of the major metropolitan areas in the Basin have multiple sources in their water supply portfolio. In total, Colorado River water constitutes less than half of the total supplies available to the major metropolitan areas that are situated outside of the hydrologic basin. M&I water conservation and reuse have reduced the growth in demand, despite large population growth in the major metropolitan areas that receive Colorado River water, and in some cases, M&I water use has not increased in the past decade. These efforts have reduced the amount of new water supply that may have been needed from the Colorado River or other sources. In some cases, groundwater management objectives or economic factors are the principal drivers in the selection of which of the water supplies are not used when demand levels do not increase as rapidly as projected. In other cases, water quality considerations may influence the selection of water sources.

Municipal providers in the major metropolitan areas that receive Colorado River water manage their water supplies conjunctively and some must use surface water supplies first to protect groundwater or prevent groundwater mining and its consequences. Additional M&I conservation and reuse has the potential to reduce the amount of future development of Colorado River water. However, in many major metropolitan areas, conservation and reuse may not result in substantial reductions in diversions of Colorado River water because conservation is typically used to either meet future growth or offset/delay the need for future water supplies. Municipal water providers with entitlements to Colorado River water are planning to use their full entitlements, or already do so, though the future reliability is uncertain.

Importantly, municipal providers with entitlements to Colorado River water are planning to use their full entitlements, or already do so, though future reliability is uncertain. In these areas, conservation and reuse have already been fully incorporated into the water supply portfolios of providers and are typically expected to slow the rate of growth in demands and provide a component of supply that will be needed in the future for these providers.

The Workgroup recognizes that M&I conservation and reuse efforts play a critical role in meeting future demands, reducing or delaying needs for additional water supplies, and increasing the future reliability of water delivery to M&I water providers that receive Colorado River water. Due to the complexities described above, the Workgroup did not attempt to quantify future water conservation and reuse savings beyond that described here for existing and planned programs, and a direct comparison with the findings of the Basin Study was not attempted.

M&I water providers in the major metropolitan areas that receive Colorado River water will continue to increase water use efficiency and reuse. These efforts play an important role in meeting future demands, reducing or delaying needs for additional water supplies, and increasing the future reliability of water supplies.

3.7 Opportunities and Challenges for Expanding Successful Conservation and Reuse Programs

M&I water conservation and reuse has been practiced widely throughout the Basin, but opportunities exist to expand successful programs and implement new programs in the future. The Workgroup was charged with identifying opportunities that could advance water conservation and reuse, describing the challenges associated with these opportunities based on their collective experience, and identifying potential future actions that would advance the opportunities. Potential actions related to the identified opportunities were developed for further consideration by the Coordination Team or other parties interested in advancing water conservation and reuse opportunities in areas that receive Colorado River water. The Workgroup did not prioritize its opportunities or potential actions, therefore the ordering of the following list or lists in subsequent sections does not imply a prioritization.

The Workgroup identified 11 major opportunities to advance water conservation and reuse within the major metropolitan areas that receive Colorado River water:

1. Increase outdoor water use efficiency through technology improvements and behavior change, and increase the adoption of low-water-use landscapes.
2. Increase the end-user understanding of individual, community, and regional water use.
3. Increase the integration of water/energy-efficiency programs and resource planning.
4. Expand local and state goal setting and tracking to assist providers in structuring programs.
5. Increase funding for water use efficiency and reuse.
6. Increase integration of water and land use planning.
7. Develop and expand resources to assist water providers in water conservation efforts.
8. Implement measures to reduce system water loss with specific metrics and benchmarking.
9. Increase commercial, institutional, and industrial water use efficiency and reuse through targeted outreach and partnerships.
10. Expand adoption of conservation-oriented rates and incentives.
11. Expand adoption of regulations and ordinances to increase water use efficiency and reuse.

The Workgroup explored each opportunity to identify significant considerations and identify specific actions that could be taken in the future. The sections below describe each opportunity in greater detail.

3.7.1 Opportunity 1: Increase outdoor water use efficiency through technology improvements and behavior change, and increase the adoption of low-water-use landscapes

Outdoor water use represents the single largest use of water in the M&I sector. Reducing outdoor water use through technology improvements, behavior changes, and adoption of regionally appropriate, low-water-use landscapes will be one of the biggest opportunities to stretch the use of limited supplies.

3.7.1.1 Considerations

Adoption of improved technology and/or changes to landscapes depends in large part on municipal water customer decisions and behavior. The landscape types adopted, the density of plantings, maintenance practices, irrigation system efficiency, and irrigation practices all influence actual water savings. Turf conversion rebate programs are relatively expensive for water agencies to implement. However, other measures that can promote turf conversion and low water use landscaping in new developments, can reduce or eliminate the costs to water agencies. While education, improved technology (such as climate-based irrigation controllers), and good system maintenance can reduce the amount of water applied to landscapes that have been historically over-irrigated, there is a growing recognition that proper irrigation scheduling based on plant requirements and the installation of improved technology often leads to increases in water use in instances where landscapes have been historically deficit-irrigated.

Low-Water-Use Landscaping
Source: CH2M HILL

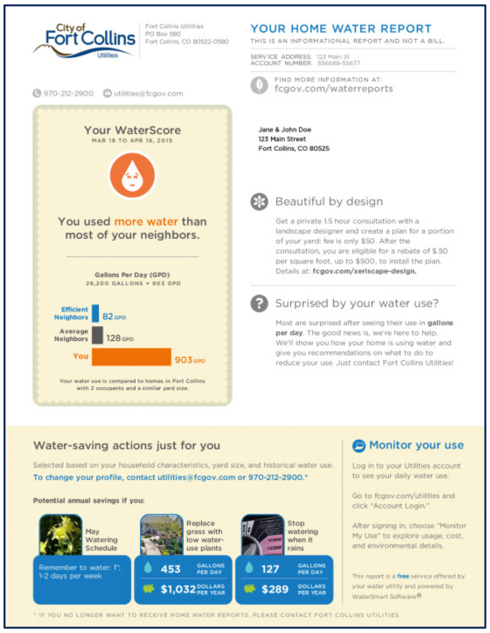
Successful programs have adopted a multi-pronged approach that includes improved information on water use to the end-user, conservation-oriented pricing, model landscapes, community and landscape professional outreach and training, rebates, and ordinances. Ordinances and technology improvements have been implemented in many communities to reduce outdoor water use in new developments. Some of the challenges associated with implementing such changes in existing developments are identifying and setting the appropriate price point for incentives, overcoming negative social perceptions of alternative landscapes, and limited municipal provider control over water use in some of the major metropolitan areas (Central Arizona and Wastach Front) due to vested water rights. Despite current education efforts, there is a knowledge gap for some end-users of how to reduce water use for outdoor landscaping. The preferred landscape choice in some communities continues to be turf even though there has been an increase in the number of contractor xeriscape companies. In some instances homeowner associations or other factors may limit adoption. The penetration of landscape conservation programs varies depending on socioeconomic situations and climate within cities and major metropolitan areas, as well as water reliability and the persistence of dry conditions.

3.7.1.2 Potential Actions

- Expand social norming and budget-based pricing to reduce or improve the efficiency of outdoor water use of the most inefficient and largest users (examples: Fort Collins social norming and Eastern Municipal Water District budget-based).
- Develop a database of recommended outdoor landscape and outdoor irrigation best practices, including the cost effectiveness and application of each best practice for sharing across the major metropolitan areas that receive Colorado River water (example: California Urban Water Conservation Council).
- Promote model city landscapes in each major metropolitan area along with public outreach and education, demonstration gardens, best practices, professional training, and technical assistance.
- Actively encourage the application of model new development codes and regulations for outdoor landscape irrigation (example: SNWA land development codes).
- Develop revolving fund to provide matching grants for low-water-use landscape programs.

3.7.2 Opportunity 2: Increase the end-user understanding of individual, community, and regional water use

Water conservation is more effectively implemented with improved customer understanding. M&I users may not fully understand their water use, how it compares to others, and what can be done to reduce the use. This opportunity recognizes the importance of providing timely and customized water use information for end-users to support active water use reductions at the consumer level. Innovative use of the billing system provides an opportunity for tailored individual consumer educational information related to water use and resources and actions available to increase water conservation.



Home Water Report
Source: City of Fort Collins Utilities

3.7.2.1 Considerations

The majority of M&I water conservation ultimately occurs at the end-user level. While water agencies can educate and incentivize water conservation, it is consumers who must make decisions to increase their efficiency or reduce water use. Behaviors and cultural and social norms may be difficult and slow to change. However, in many of the major metropolitan areas discussed in this report, consumers have responded quickly to water agencies' drought advisories and requests to decrease water use, often exceeding agency goals; many of these water use reductions have continued even after the advisories were lifted. The persistence of such reductions is an area of active research.

The public may lack awareness, understanding, and knowledge about water use, supply, distribution, or potential conservation measures (for example, low-water-use landscapes). It often takes a concerted and extended process to overcome this challenge.

The concept of "social norming" is growing in its application to water conservation. The central idea of social norming is that much behavior is influenced by people's perceptions of what is normal or typical; if consumers view their behavior as outside of the norm, they will be motivated to change the way they behave so they conform more closely to the norm. Moreover, it is believed the effect can be enhanced by coupling information on social norms with actionable information that facilitates the desired behavioral change (Mitchell et al,. 2013). A growing number of water providers are using social norming concepts to encourage reductions in customer water use.

Installation of advanced metering and information systems, updated billing systems, and outreach requires funding and staffing at the water provider level. Successful water conservation programs will result in reduced water sales and potentially less total revenue for the provider despite providing similar or increased levels of service. In many cases, water conservation staffing requirements are not being met. Nonetheless, investments in water conservation often result in lower water costs to water providers and their customers than do investments in new capital-intensive water supply projects (AWE, 2013).

3.7.2.2 Potential Actions

- Promote adoption of advanced metering infrastructure technology in each major metropolitan area to improve data collection, understanding of demand trends, identification of high water use, facilitate improved feedback to customers regarding their water use, and improve leak detection (example: Fort Collins).
- Expand application of social norming (providing customers with water use information, comparisons, and possible reduction measures) to reduce water use.
- Speed implementation towards 100 percent metering.
- Increase access in all of the major metropolitan areas for direct water audits by water conservation staff to provide information on water use and savings potential.

- Provide funding and financial support for additional water conservation staff at water agencies.

3.7.3 Opportunity 3: Increase the integration of water/energy-efficiency programs and resource planning

Water and energy are significantly interrelated, yet the resources are rarely managed in an integrated fashion. While both water conservation and energy-efficiency programs are continuing in many of the major metropolitan areas, there is a general lack of coordinated effort among water and energy resource management agencies and utilities. Opportunities exist to increase the integration of water/energy-efficiency programs for the benefit of reduced intensity of use of both resources and economic benefits.

3.7.3.1 Considerations

Despite significant efforts by both water and energy utilities to improve water and energy use efficiencies, little integrated planning exists for water, wastewater, and energy production and distribution systems. Federal and state policy to promote water-energy integration is limited and little integration occurs between local or regional water and energy utilities. Water utilities generally consider energy as an external cost, while energy utilities consider water as an external cost. However, investments in water conservation almost always yield energy efficiencies (through reduced pumping and treatment) and investments in energy conservation can lead to reduced water needs (for example, reduced thermoelectric cooling water needs).

There are many more water providers than energy providers and each provider has separate regulatory and governance structures that make integration or coordination of programs challenging. Existing financial and staffing hurdles limit the coordinated effort that is required to identify and implement synergistic conservation programs.

3.7.3.2 Potential Actions

- Improve integration of federal and state water and energy programs that are simultaneously attempting to conserve resources (such as WaterSense, ENERGY STAR, WaterSMART, and Property Assessed Clean Energy programs) to reduce financial hurdles and create synergy for water-energy conservation programs.
- Develop partnerships between water and energy utilities, and their respective regulatory bodies, on synergistic programs, rebates and incentives, and customer outreach to more effectively target customers (example: Central Basin Municipal Water District partnership with U.S. Department of Energy).
- Continue research and development of alternative cooling and water treatment technologies.
- Document the financial, water, and energy benefits realized when water and energy conservation programs are integrated.

3.7.4 Opportunity 4: Expand local and state goal-setting and tracking to assist providers in structuring programs

Several states and many municipal water agencies have established water conservation targets that serve as guidance for measuring, monitoring, and encouraging M&I water use reductions over time. Expansion of these efforts, improved coordination and goal setting can lead to more effective incentives to increase water conservation and reuse.

3.7.4.1 Considerations

Local and state targets for per capita water use may assist providers and communities in structuring programs to achieve increased efficiency and measure progress over time. For example, California's 20 percent by 2020 reduction goals have helped utilities in that state measure and plan for future per capita water use. Most state and local water conservation targets are essentially incentivized goal setting with reporting mandates and funding opportunities available to those who plan to meet per capita use targets.

Per capita water use and targets are often measured inconsistently across the Basin, within states, and among municipalities. In some states, reuse of wastewater (alternative supply) is accounted for as a water use reduction when computing per capita water use. In addition, some municipalities include only residential water use when computing per capita water use, while others also include the industrial and institutional components. There are also significant variations in how water use is categorized and tracked by providers and agencies. These inconsistencies, along with climate and demographic differences, make Basin-wide comparisons of water use difficult. More beneficial, however, are targets of reductions in water use and adoption of locally relevant water conservation best practices. Regional, state, and local water conservation targets should acknowledge the local differences and provide for local flexibility in achieving the targets.

3.7.4.2 Potential Actions

- Encourage establishment of state-wide, locally appropriate, or possibly regionally appropriate, reduction-based targets.
- Support the development of standard methods for water providers to quantify, monitor, and evaluate water conservation measures and actual savings.
- Encourage adoption of locally relevant water conservation practices.

3.7.5 Opportunity 5: Increase funding for water use efficiency and reuse

The lack of continuous, sustainable funding for water use efficiency and reuse is a factor limiting more rapid implementation. While sources of funding are available, these sources are limited and often narrow in application. Sustainable funding ensures that sufficient and stable revenue streams are available over the long term to accomplish a program's goals and help address the range of measures (from public education to infrastructure) necessary for water conservation and reuse.

3.7.5.1 Considerations

Procuring sustainable funding from traditional federal and state sources for water conservation and reuse is challenging because funds are typically limited, competitive, and funding is often contingent upon prevailing economic conditions, the political climate, and uncertainties associated with the appropriations process (Mathieu, 2011). For instance, education and messaging measures are generally not supported through current funding programs.

Funding strategies for M&I water conservation and reuse should address municipality and water agency needs related to rate stabilization and long-term financial stability. Financial stability and rate structures are often challenged because water conservation programs typically result in reduced income from water sales, while requiring similar levels of service and requiring funding for the conservation program itself. However, properly designed conservation-oriented rate structures have been successful at managing the financial risks of reduced water sales. Some of the most successful programs have combined federal, state, and local funding with user-based incentives to reduce or delay the need for alternative supplies or infrastructure improvements. The insertion of increased outside funding allows these types of programs to be expanded.

3.7.5.2 Potential Actions

- Document and publicize innovative funding and financing programs including public-private partnerships to provide incentives or funding of conservation programs (example: MWD's rate-based incentive program).
- Explore the establishment of a Basin Trust Fund for low-interest loans for specifically targeted water conservation programs.
- Investigate and implement a Basin-wide current database of available federal, state, and other funding sources for water conservation.
- Explore funding mechanisms to help providers minimize system water losses.
- Implement alternative rate structures to reduce financial risks associated with reduced water sales.

3.7.6 Opportunity 6: Increase integration of water and land use planning

Water and land use are highly interrelated; however, planning of water and land use is not typically integrated. Improved integration of water and land use planning would allow a better understanding of the effects of land use decisions on future water (and energy) use and would support a higher level of information to be made available to decision makers related to the tradeoffs of various land use decisions. Some of the most effective improvements in water use efficiency can be implemented in the design, layout, landscape choices, and codes associated with new developments or industries. Early integration of water use efficiency concepts can have long-term benefits.

3.7.6.1 Considerations

Land use authority such as decision making related to subdividing lots, setting zoning rules, and issuing construction permits often falls within the jurisdiction of municipal and county governments. Meanwhile, the primary responsibility for water supply falls within the jurisdiction of local water utilities. The authorities for these two entities are usually distinct and separate, despite the strong land use-water relationship. While some states and metropolitan areas are pursuing improved integration of water and land use authorities, the current state of practice is that land use authorities "plan the community" and water providers "ensure the water is reliably available" with little integration.

In some cases, local land use planners may not have the knowledge or the information available to effectively integrate water use in their planning decisions. Developers, who are often preparing new development plans, may be resistant to implementing additional water efficiency and conservation measures because of the added cost. A variety of water conservation ordinances, regulations, and building and green codes have been applied to varying degrees to strengthen these ties, but these actions may be met with resistance if not accompanied by community education and support.

3.7.6.2 Potential Actions

- Encourage land use codes, regulations, and ordinances that ensure water is an integral consideration in land use planning (examples: SNWA land development codes and Arizona Assured Water Supply rules).
- Encourage development, application, and monitoring of locally appropriate best practices for integrated land use and water conservation measures.
- Encourage state and local ordinances for new developments that set efficiency requirements for indoor and outdoor water uses.
- Improve integration of water-efficient landscapes into the approval process for new developments based on public preferences.
- Develop a database of successful efforts and model ordinances.

3.7.7 Opportunity 7: Develop and expand resources to assist water providers in water conservation efforts

While the water conservation resources available to the water providers have expanded in the past decade, information about available resources, data, and tools to assist water providers in effectively selecting, designing, and implementing water conservation programs in not always readily accessible. Improving ease of access to existing local and regional resources, or an integrated Basin-wide clearinghouse of water conservation and reuse resources would facilitate information sharing and advance the effectiveness of these programs.

3.7.7.1 Considerations

Any opportunity to expand the water conservation and reuse resources available in the Basin should recognize that organizations such as AWWA and the Alliance for Water Efficiency have developed useful resources that could be leveraged. Workgroup members have acknowledged that any advancement for the Basin should not duplicate efforts of these organizations or others, but rather provide access to a region-specific clearinghouse of data and tools.

3.7.7.2 Potential Actions

- Support water providers to develop standard methods to quantify, monitor, and evaluate water conservation measures with respect to actual savings.

- Encourage providers to adopt AWWA standards for water conservation programs, integrated water resource planning, and water loss management.
- Work with the Alliance for Water Efficiency and AWWA to facilitate access to resources, tools, and data that would be particularly useful to Basin providers, perhaps creating a subsection within existing clearinghouses, and to identify and address gaps that may be identified.
- Support permanent authorization of the EPA's WaterSense Program, along with necessary staffing and funding for the program.
- Encourage active engagement in and support of national organizations or programs that are driving water use efficiency, including AWWA, Alliance for Water Efficiency, WaterSense, Irrigation Association, and Smart Water Application Technology. Regional organizations can have similar benefits.
- Develop a database of recommended outdoor landscape and outdoor irrigation best practices, cost effectiveness, and application for sharing across Basin communities (example: California Urban Water Conservation Council).
- Develop a Basin-wide current database of available federal, state, and other funding sources for water conservation.

3.7.8 Opportunity 8: Implement measures to reduce system water loss with specific metrics and benchmarking

Measures are being taken throughout the major metropolitan areas that receive Colorado River water to quantify and characterize water system losses and reduce these losses as economically feasible. The AWWA's water audit process and water loss mitigation measures (AWWA, 2009) have been implemented by some water providers; however, systematic auditing and asset management programs need to be further implemented to address aging infrastructure and metering devices. In many cases, reduction in system water losses can result in financial incentives to the water provider by recovering lost revenue. Minimizing conveyance and distribution system losses is a fundamental aspect of water providers' water infrastructure management and represents an opportunity to increase both water conservation and revenue.

3.7.8.1 Considerations

System water loss measurement and characterization is an area of growing focus for many water providers; however, leak detection, pipeline replacement, and enhanced metering are capital-intensive efforts that are often integrated with the water provider's asset management programs. These programs are sometimes limited or delayed due to budget constraints. Investment to improve conveyance and distribution infrastructure and metering devices commonly requires funding from external sources. In some cases, distribution systems were not originally equipped with metering and plans for metering are implemented in stages over the upcoming decade. Currently, the AWWA's water audit process and water loss mitigation measures manual is not widely implemented. Economic levels of leakage have not been established by most water providers.

3.7.8.2 Potential Actions

- Promote advanced metering infrastructure.
- Speed implementation towards 100 percent metering and automated meters.
- Encourage providers to adopt AWWA standards for water conservation programs, integrated water resource planning, and water loss management.
- Promote comprehensive implementation of AWWA water audit measures (M36) as a foundational best practice and increase ease of access to these resources.
- Implement funding measures to accelerate asset management programs and replace aging infrastructure.

3.7.9 Opportunity 9: Increase commercial, institutional, and industrial water use efficiency and reuse through targeted outreach and partnerships

The CII sector accounts for a relatively small percentage of total water use in most water service areas; however, individual CII customers represent some of the largest individual water users. Therefore, focused water conservation and reuse outreach and partnerships can be effective investments.

Investments in water use efficiency and increased reuse can often provide a more sustainable and cost-effective method to meet existing and growing demands. Most water use by industry is associated with cooling process. In Arizona, the Palo Verde Nuclear Generating Station and Redhawk Power Plant use reclaimed wastewater from nearby cities as cooling water. Water is routed through condensers and cooling towers an average of 25 cycles until total dissolved solids levels are too high for further use. In Wyoming, the Supercomputing Center facility of the National Center for Atmospheric Research implemented a water conservation and efficiency technology for cooling towers that allowed a reduction of the total water use by nearly 40 percent over comparable facilities and with a 3- to 5-year payback period. These water use efficiency and reuse measures could be expanded further to reduce water use by the CII sector.

Palo Verde Nuclear Generating Station
Source: Arizona Public Service Company

3.7.9.1 Considerations

Communities, through a range of planning decisions, determine the types and extent of CII uses within their jurisdictional boundaries. Water use differs across industry types and across the major metropolitan areas that receive Colorado River water. Water quantity and quality requirements for specific industries vary as do the types of technology improvements that could lead to higher water use efficiencies. The supply of reclaimed water for many industrial uses is promising, but additional conveyance and treatment costs are likely due to the distance of the industrial facilities from wastewater effluent sources.

3.7.9.2 Potential Actions

- Promote the development of a greener industrial sector with reuse pilot projects with short payback periods (examples: National Center for Atmospheric Research Wyoming Supercomputing Center in Wyoming and water use efficiency at Palo Verde and Redhawk plants in Arizona).
- Increase partnerships and outreach between water providers and the largest CII customers to increase efficiency or expand reuse.
- Improve understanding of cost-effective water use efficiency measures through consistent documentation and measurement of specific best practices applicable for different types of industries and regions.
- Encourage management of water supplies to optimize the matching of water quality to intended uses.

3.7.10 Opportunity 10: Expand adoption of conservation-oriented rates and incentives

Water providers are increasing incentives and adopting water rate structures designed to encourage water conservation. The price signals provided by increasing rates with higher use (negative signal) and incentives for water conservation (positive signal) are valuable tools for rapidly expanding water conservation in many municipal service areas. Expansion of these programs, based on experiences in areas that have already adopted them, provides an opportunity to increase water conservation throughout the major metropolitan areas that receive Colorado River water.

3.7.10.1 Considerations

Changing rate structures can be a lengthy process. Careful resource and financial planning is required to ensure that the financial stability of the water service provider is maintained even under the outcome of reduced water sales. Typically, water use is priced volumetrically. As water conservation efforts reduce the amount of water sold, water provider revenues will decline if providers do not adjust the method in which rates are set. Providers must still recover the fixed costs of treating and delivering the water, as well as funding the conservation staff and the program itself. Utilities must plan for the financial effects of increased conservation and design rate structures that collect sufficient revenue to cover costs in the short term as they incentivize conservation.

Educating consumers about the benefits of conservation, which could include reduced or avoided costs of new infrastructure or acquiring new supply (AWE, 2013) over the long-term, can help avoid the misperception that conservation is driving rate increases. Considerable public outreach is required to communicate the need for changes in rate structures and to assist in developing thresholds for tier setting, or user water budgets in the case of budget-based rates.

Incentives are often more adaptable in that they can be increased, removed, or tailored for other water use sectors as conditions change. However, a growing financial consideration among water providers is related to the provision of incentives to replace fixtures or to adopt changes that may occur even in the absence of the incentive.

3.7.10.2 Potential Actions

- Encourage the application of conservation-oriented rate structures (tiered or budget-based) that incentivize water use efficiency, while ensuring revenue stability, avoiding negative impacts, and accounting for public preferences.
- Increase the awareness of successful and unsuccessful approaches for implementation of conservation-oriented rate structures among water providers receiving Colorado River water.
- Develop model conservation-oriented rate structures that could be reviewed and expanded upon by water providers considering this option.
- Implement innovative funding programs to provide incentives or funding of conservation programs (example: MWD's rate-based incentive program).

3.7.11 Opportunity 11: Expand adoption of regulations and ordinances to increase water use efficiency and reuse

Many cities and some water providers have adopted regulations and ordinances related to low-water-use fixtures and landscapes in new development, at time of resale of existing homes, and for reducing water waste at existing developments. Regulations for new developments are increasingly encouraging or requiring the use of reclaimed water for outdoor landscape irrigation. Continued efforts for targeted regulations and ordinances at the local level can help achieve lower M&I water use with little or no financial investment from the water provider.

3.7.11.1 Considerations

One of the most important considerations for this opportunity is coordination among the water service provider and local regulatory authorities. Some water service providers lack jurisdiction or regulatory authority with respect to land development, building codes, zoning, and other local land use authorities; however, water providers understand the impact of these decisions on water use and often can inform regulating agencies on the effectiveness of a range of approaches. Some water providers have taken the innovative step of including some water conservation-related actions as part of the contract of provision of water service. Other considerations are the societal costs of regulations and ordinances that, while not having a direct cost to the water provider, may affect costs to the consumer or the regional economy.

3.7.11.2 Potential Actions

- Encourage land use codes, regulations, and ordinances to ensure that water is an integral consideration in land use planning (examples: SNWA land development codes and Arizona Assured Water Supply rules).
- Encourage state and local ordinances for new developments that set efficiency requirements for indoor and outdoor water uses (such as connection fees).
- Explore inclusion of specific water conservation measures such as water-efficient fixtures and low-water-use landscapes in provision of water service contracts with new customers.
- Develop and share model land use codes, regulations, and ordinances that can be reviewed and expanded upon by water providers considering this option.

3.7.12 Summary of Potential Opportunities and Actions

The potential M&I water conservation and reuse opportunities and actions indicated in the previous sections emphasize specific areas to increase water use efficiency, reduce system losses, and maximize reuse of supplies. The opportunities were developed with a recognition of the areas of greatest potential benefit. The Workgroup's collective experience allowed the identification of the most promising measures to facilitate expansion of existing successful programs or the development of new programs.

Opportunities were identified that specifically address the critical M&I water use sectors of outdoor landscape irrigation, water use in existing and new residential developments, CII water use, and system water loss. Several opportunities emphasize the end-user with actions targeting education, incentives and rates, and social norming to encourage customer water use behavioral changes. Others emphasize increasing the efficiency of infrastructure and water use measurement and monitoring to reduce water distribution system losses and to identify specific technologies related to reducing industrial water use. The interaction between water use, energy use, and land use was recognized. Several opportunities promote integrated resource planning and program development and encourage enhanced partnerships between resource management agencies and water and energy utilities. The role of ordinances, regulations, and local-regional water use reduction targets was recognized as important to facilitate common implementation of water use efficiency measures, establishing standard methods, and tracking progress over time. Improved access to existing or expanded networks of data, resources, and tools was identified as necessary to help select the most appropriate and efficient measures at the local water provider levels. Finally, the lack of funding and financing was recognized as a significant hurdle that currently limits the rate or extent at which M&I water conservation and reuse measures are taken, and innovative funding approaches were identified.

Many of the potential actions identified in this section can support multiple opportunities, to varying degrees. For example, several actions related to innovative funding and conservation-oriented pricing, additional or consolidated water conservation resources and tools, and improved integration across water, energy, and land use agencies support several of the opportunities that have been identified. The degree to which these actions are most appropriate for a particular metropolitan area will depend on factors such as the extent to which these measures have already been implemented in an area, cost of existing and new water supplies, public acceptance, laws and regulations, and other factors. The Workgroup was tasked with identifying promising opportunities and actions that could help expand successful M&I water conservation and reuse programs in the future. However, it was beyond the scope of the Workgroup to develop specific projects in specific geographies for implementation.

Opportunities and potential actions exist to increase water conservation and reuse by metropolitan areas that receive Colorado River water and, in many cases, are currently being pursued. However, these opportunities will vary depending on many factors, including the extent to which these measures have already been implemented in an area, the cost of these conservation measures, cost of existing and new water supplies, public acceptance, laws and regulations, and other factors.

3.8 Summary

The *Moving Forward* effort recognized the importance of M&I water conservation and reuse in the future planning and management of the Colorado River. The Workgroup documented historical trends in M&I water conservation and reuse in the major metropolitan areas that receive Colorado River water, identified current and planned efforts to continue these efforts, and identified opportunities and considerations associated with expansion of water conservation and reuse programs in the future.

The major metropolitan areas that currently receive Colorado River water include a population of more than 29 million, most of which (about 27 million) reside in areas located outside of the hydrologic basin or where water does not return to the mainstem Colorado River. These metropolitan areas have experienced significant population growth in the past decades and projections for future growth remain high. At the same time, climate conditions in most of these major metropolitan areas cause outdoor water uses to be relatively high. CII activities vary considerably among these metropolitan areas, but are expected to increase in the future to continue to support vibrant economies. Population and CII growth, and the semiarid climate of most of the metropolitan areas significantly influences M&I water demand.

For most major metropolitan areas that receive Colorado River water, the M&I water use has increased over the past two decades due to population increases. However, over the same period, water providers in these areas have implemented significant water conservation and reuse that has substantially decreased per capita water use. In some areas, this has allowed the total M&I water demand to remain relatively stable while the population has increased significantly.

On average, per capita water use rates have decreased by 12 to 38 percent since 1990 in these metropolitan areas. Water use in 2010, for the areas included in this report, would have been 1.7 million AFY higher had per capita use rates not been reduced. Water conservation has played an important role toward these savings; however, other factors such as economic, social, and behavioral changes also influence use changes over time. Water reuse was also found to be practiced in nearly all of the Basin states, and a total of 709,000 AFY of reuse supply was identified in 2012, reducing the need for development of new supplies.

Over the most recent decade, water use has either remained stable or decreased in many of the major metropolitan areas. During this period, the U.S. experienced a steep economic downturn, the Basin experienced its most severe drought in the past 100 years, and some water providers have increased water conservation efforts to reduce water use in response to reduced water availability.

Current and planned water conservation and reuse programs identified for the major water providers in these metropolitan areas will further improve the water-use efficiency. A review of the documented water conservation programs with numeric per capita targets suggests that more than 700,000 AFY of additional water conservation is planned by 2030, and an additional 400,000 AFY of water reuse is planned.

Based on the information compiled from water providers and from the deliberations of the Workgroup, several key findings were identified.

- Available data demonstrate that municipal providers in the major metropolitan areas that receive Colorado River water have implemented a wide range of conservation measures that have increased water use efficiency and reduced per capita demand. Comprehensive data on conservation and reuse programs implemented to date in the major metropolitan areas that receive Colorado River water are not available. It is often difficult or impossible to attribute quantifiable savings to specific programs or measures.
- While population has increased over the recent decades, the per capita water use has decreased, partially attenuating the effect of population growth on M&I water use. Since 2000, M&I water use has either remained stable or decreased for many of the major metropolitan areas that receive Colorado River water, despite increases in population. Per capita water use rates for these metropolitan areas decreased by 10 percent to 26 percent since 2000 (1998-2002 average). During this period, the U.S. experienced a steep economic downturn and the Colorado River Basin experienced its most severe drought in the past 100 years, influencing water use.
- The types of water conservation measures and the extent to which they have been implemented vary extensively among municipal providers and the major metropolitan areas that receive Colorado River water based on water supply portfolios and reliability, climate, demographics, and available funding.
- Municipal water providers in the major metropolitan areas that receive Colorado River water have also implemented water reuse to varying degrees depending on geographic, legal, regulatory, and other considerations.
- M&I water providers in the major metropolitan areas that receive Colorado River water will continue to increase water use efficiency and reuse. These efforts play an important role in meeting future demands, reducing or delaying needs for additional water supplies, and increasing the future reliability of water supplies.
- Municipal providers in the major metropolitan areas that receive Colorado River water manage their water supplies conjunctively and some must use surface supplies first to protect groundwater or prevent groundwater mining and its consequences. Additional M&I water conservation and reuse has the potential to reduce the amount of future development of Colorado River water. However, in many of the major metropolitan areas, conservation and reuse may not result in substantial reductions in diversions of Colorado River water because conservation and reuse are typically used to meet future growth or offset or delay the need

for future water supplies. Municipal water providers are planning to use their full entitlements to Colorado River water.

- Based solely on the reported conservation targets and population projections from the U.S. Census through 2030, for the water providers for which numeric targets were identified, water demand in 2030 will be about 700 KAFY lower than that estimated with 2010 per capita water use rates. Additionally, based on a national survey of planned water reuse programs, approximately 400 KAFY of new reuse supply may be added by 2030 to the water portfolios of water providers that receive Colorado River water.
- Opportunities and potential actions exist to increase water conservation and reuse in the major metropolitan areas that receive Colorado River water and, in many cases, are currently being pursued. However, these opportunities will vary depending on many factors, including the extent to which these measures have already been implemented in an area, the cost of these conservation measures, cost of existing and new water supplies, public acceptance, laws and regulations, and other factors.

Based on the collective experience of the Workgroup members and through exploration of the innovative case studies, the following 11 major opportunities were identified as having the potential to increase or expand M&I water conservation and reuse.

1. Increase outdoor water use efficiency through technology improvements and behavior change, and increase the adoption of low-water-use landscapes.
2. Increase the end-user understanding of individual, community, and regional water use.
3. Increase the integration of water- and energy-efficiency programs and resource planning.
4. Expand local and state goal-setting and tracking to assist providers in structuring programs.
5. Increase funding for water use efficiency and reuse.
6. Increase integration of water and land use planning.
7. Develop and expand resources to assist water providers in water conservation efforts.
8. Implement measures to reduce system water loss with specific metrics and benchmarking.
9. Increase commercial, institutional, and industrial water use efficiency and reuse through targeted outreach and partnerships.
10. Expand adoption of conservation-oriented rates and incentives.
11. Expand adoption of regulations and ordinances to increase water use efficiency and reuse.

Potential actions associated with each opportunity were identified and documented. Several actions related to innovative funding and conservation-oriented pricing, additional or consolidated water conservation resources and tools, and improved integration across water, energy, and land use agencies were found to support several opportunities that were identified. In many cases, the potential actions represent an acceleration of activities that have already begun in some of the major metropolitan areas, but require a significant investment in resources to increase the adoption of practices or to expand the geographic coverage. In other cases, significant gains are possible by changing end-user water use behavior through education and financial incentives. Still others require improved coordination across resource agencies from the local to national scale to provide more targeted information, funding, and tools to enable improvements in integrated resource planning.

This chapter represents the work product from a unique, Basin-wide collaboration of experts in the M&I water conservation and reuse fields. The considerable experience related to local and regional water conservation and reuse and genuine collaborative effort on technical and water management issues allowed this Workgroup to offer new insights into the state of, and possible future pathways for, M&I water conservation and reuse in the major metropolitan areas that receive Colorado River water.

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Appendix 3A
Municipal and Industrial Water Provider Data Collection Summary: Historical Water Use

May 2015

3A Municipal and Industrial Water Provider Data Collection Summary: Historical Water Use

As part of the *Moving Forward* effort, the Municipal and Industrial (M&I) Water Conservation and Reuse Workgroup collected information on historical M&I water use, conservation, and reuse from water providers within the major metropolitan areas that receive Colorado River water. This information supported an assessment of trends in water use, and current and past water conservation and reuse efforts. In this appendix, data used for the analysis of historical water use trends are summarized.

Historical M&I water use, conservation, and reuse information was solicited from the large water providers within the major metropolitan areas and representative cities with populations in excess of 100,000 for the period from 1980 through 2010. Smaller metropolitan areas and cities with population less than 100,000 were included in order to have representation from each of the Basin States and throughout the Basin.

Information was collected from various water providers and planning areas and summarized for the eight major metropolitan areas that receive Colorado River water. Because water supply and water use information is managed by different entities, which range from multiple local water providers to state planning agencies, the presentation of water use information at the appropriate geographic scale can be challenging. The locations of the major metropolitan areas and representative cities are shown on Figure 3A-1. The geographic areas refer to metropolitan areas within the hydrologic basin (such as Southern Nevada and Central Arizona) and also areas outside of the hydrologic basin where Colorado River water is used for M&I purposes (Front Range, Middle Rio Grande, Wasatch Front, Southeast Wyoming, Coastal Southern California, and Salton Sea Basin).

It was acknowledged that most water providers do not have complete or accessible records of historical M&I water use, conservation, or reuse information throughout this period and that data gaps exist. Additionally, water use data measurement and tracking varies between water providers, further complicating analysis. Table 3A-1 lists the water providers or planning area for which information was received, the population served, the period of data availability, and the associated major metropolitan area that receives Colorado River water. The total population served in these metropolitan areas is approximately 29 million, or more than 85 percent[1] of the total population served with Colorado River water supply.

Analysis of historical M&I water use was conducted at the major metropolitan area level within the period of available water use data. In some cases, water use or population data were missing for short periods in the information provided. To evaluate trends, missing water use or population data were estimated. For these short periods (less than one or two years), total annual water use was estimated based on an assumed linear trend in the per capita water use. Missing population data were estimated by either linear interpolation between given data or extrapolation estimated based on the growth rate for the county determined from United States (U.S.) Census data.

[1] Estimate based on the 2010 Census population data from cities within planning areas, as defined in the Colorado River Basin Water Supply and Demand Study (Basin Study), that receive Colorado River water and reported population served by water providers.

TABLE 3A-1
Summary of Annual Water Use Data Compiled for Areas that Receive Colorado River Water

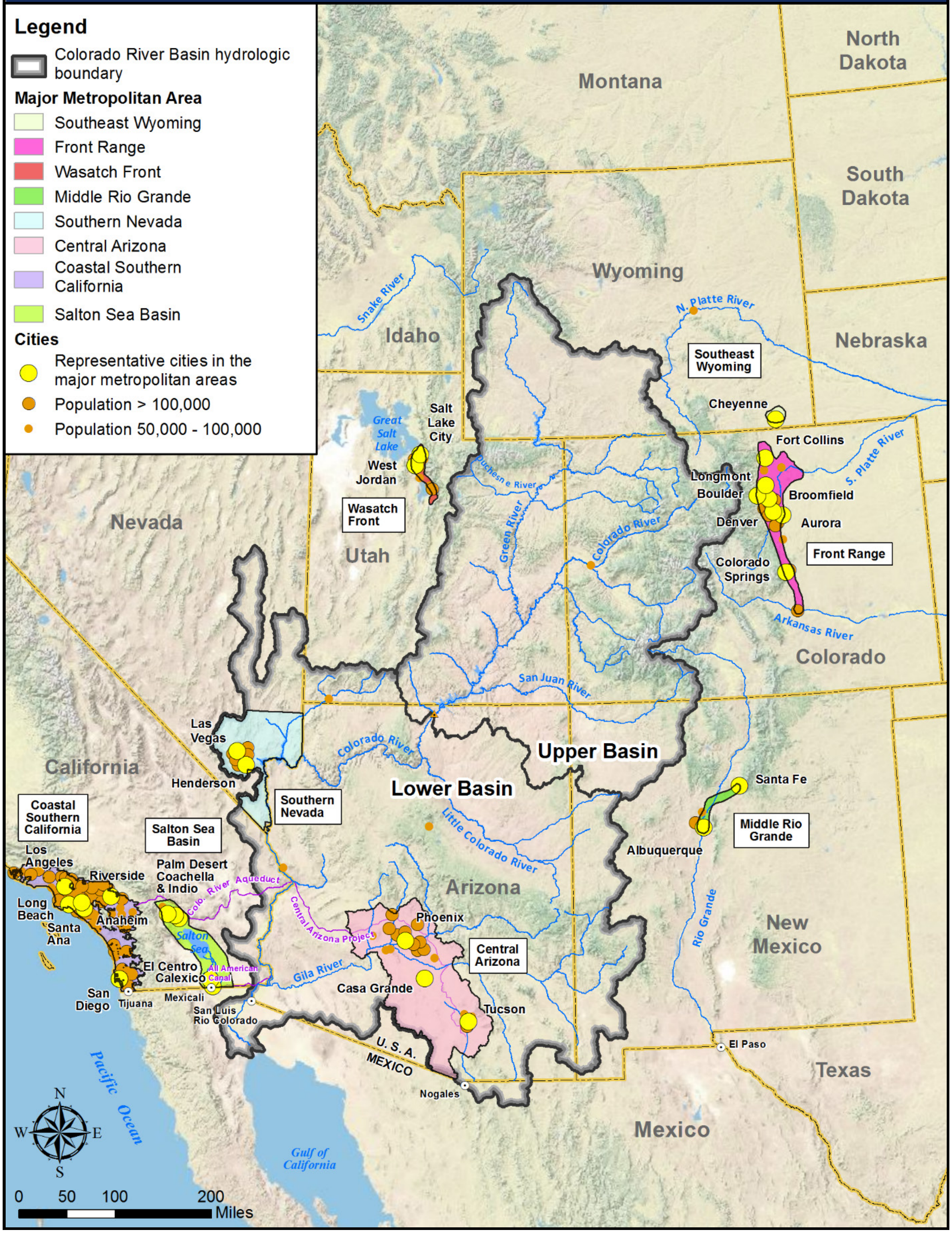
Basin State	Water Provider or Planning Area	Population Served (2010)	Water Use Period Data	Associated Major Metropolitan Area and Inclusion in Report Summaries
Wyoming	City of Cheyenne Board of Public Utilities	72,000	2003-2012	Southeast Wyoming
	Green River/Rock Springs/Sweetwater County Joint Powers Water Board	35,900	1990-2013[2]	None (not included[3])
Colorado	Denver Water	1,310,000	1980-2012	Front Range
	Colorado Springs Utilities	445,700	1990-2012	Front Range
	Aurora Water	325,100	1980-2012	Front Range
	Fort Collins Utilities	129,000	1980-2012	Front Range
	City of Boulder Public Works	109,600	1990-2012	Front Range
	City of Longmont	87,500	1980-2012	Front Range
	City and County of Broomfield Water Utility	56,500	1980-2012	Front Range
	City of Grand Junction	26,700	1999-2012	None (not included[3])
Utah	Jordan Valley Water Conservancy District	585,400	2000-2013	Wasatch Front
	Weber Basin Water Conservancy District	580,100	1992, 2001, 2005, 2010	Wasatch Front (not included[4])
	Metropolitan Water District of Salt Lake and Sandy	385,300	2000-2013	Wasatch Front
	Washington County Water Conservancy District	138,500	1997, 2002, 2005, 2010	Wasatch Front (not included[4])
New Mexico	Albuquerque Bernalillo County Water Utility Authority	606,800	1980-2013	Middle Rio Grande
	City of Santa Fe Water Division	79,200	1995-2012	Middle Rio Grande
	Self-Supplied Industrial: PNM (state electricity provider)	Not Applicable	2001-2013	Middle Rio Grande (not included[4])
Nevada	Southern Nevada Water Authority	1,956,900	1990-2012	Southern Nevada

TABLE 3A-1
Summary of Annual Water Use Data Compiled for Areas that Receive Colorado River Water

Basin State	Water Provider or Planning Area	Population Served (2010)	Water Use Period Data	Associated Major Metropolitan Area and Inclusion in Report Summaries
Arizona	Phoenix Active Management Area	3,701,600	1985-2012	Central Arizona
	Pinal Active Management Area	100,600	1985-2013	Central Arizona
	Tucson Active Management Area	835,000	1985-2013	Central Arizona
California	Metropolitan Water District of Southern California	17,977,900	1980-2012[2]	Coastal Southern California
	Coachella Valley Water District	286,200	1980-2013[1]	Salton Sea Basin
	Imperial Irrigation District	177,700	1980-2013	Salton Sea Basin

[1] Extracted from Volume 3 – Source Water Supply and Delivery 2013 Cheyenne Water and Wastewater Master Plans, Figure 3-3 Historic Potable Use and Service Population, Page 3-12. Retrieved from: http://www.cheyennecity.org/DocumentCenter/View/16309.
[2] Fiscal years, not calendar years.
[3] Population less than 100,000 and located outside of major metropolitan areas.
[4] Limited data available.

FIGURE 3A-1
Major Metropolitan Areas that Receive Colorado River Water, Representative Cities, and Populations



Note:
Similar to the Basin Study, the scope of the *Moving Forward* effort is limited to the portion of the Basin within the U.S.

Appendix 3B

Innovative Municipal and Industrial Water Conservation and Reuse Program Case Studies

May 2015

3B Innovative Municipal and Industrial Water Conservation and Reuse Program Case Studies

As part of the *Moving Forward* effort, the Municipal and Industrial (M&I) Water Conservation and Reuse Workgroup solicited information on innovative, unique, and successful M&I conservation and reuse efforts implemented within the metropolitan areas receiving Colorado River water. The intent of this effort was to highlight specific case studies and to provide a better understanding of the tools potentially available to expand successful efforts. This appendix includes case studies selected by the Workgroup members covering the major types of water conservation and reuse programs throughout the metropolitan areas receiving Colorado River water.

3B.1 Water Conservation and Reuse Program Categories

More than 400 programs were initially identified during the Workgroup's data collection process. These programs were grouped into 7 major categories of water conservation and reuse programs, as described below.

Metering and Billing

This category of conservation programs uses water meters, billing structures, and consumer water use information to promote reductions in water use. Water metering is an essential element for water conservation because it improves the understanding of water use, can support leak detection, informs billing structures, and can serve as platform for communicating water use and conservation messages with consumers.

Public Education and Community Outreach

Conservation programs in this category represent efforts to develop a conservation ethic among water consumers. Conservation programming and messaging works best when it is locally relevant and promotes conservation behaviors as a community norm or way of life. These programs can support water conservation across all customer types such as residential or commercial users and have been implemented in all major metropolitan areas.

Water Loss Characterization and Reduction Practices

Water losses occur in water distribution systems and are unavoidable. Obvious major breaks are addressed quickly, but smaller leaks can go undetected, resulting in significant water loss if not corrected. Various measures and actions are being taken throughout areas that receive Colorado River water to quantify and characterize these yet undetected losses and when economically feasible, eliminate these losses.

Residential Indoor Practices

Conservation practices for reducing residential indoor water use often include ordinances, and incentives for plumbing and fixture retrofits and the encouragement of the purchase of water/energy-efficient appliances. Some cities receiving Colorado River water began revising ordinances and initiating incentive programs to install low-flow toilets and fixtures in the 1980s.

Commercial, Industrial, and Institutional Practices

Similar to residential indoor water conservation programs, the retrofits and incentive programs to replace fixtures are also main components of Commercial, Industrial, and Institutional (CII) water conservation practices. Many of the programs in this category are targeted to specific industries, commercial activities, or institutional users.

Outdoor Landscaping Practices

Outdoor landscape irrigation is the single largest consumptive water use in the M&I sector. Water conservation practices to reduce water consumption include water conservation gardens, landscape consultations and audits, landscape irrigation budgets, rebates, and incentives to use smart irrigation technology and/or convert landscaping and restrictions on irrigation amount and timing. Outdoor landscaping irrigation efficiency measures have been the focus of many water providers. These measures seek to reduce excess irrigation and allow for improved irrigation efficiencies through best practices and new technologies.

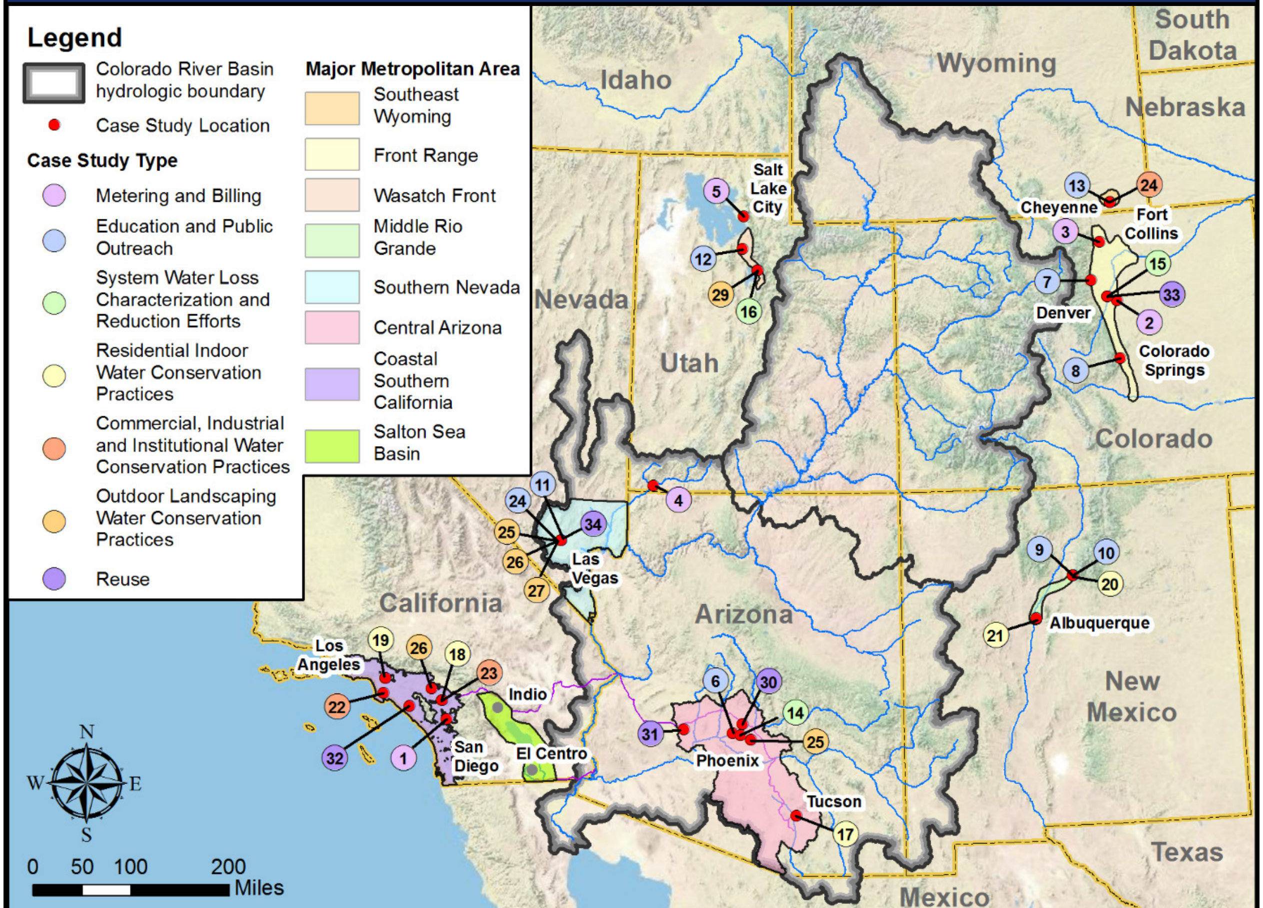
Reuse

Municipal providers have implemented a range of reuse programs throughout the metropolitan areas receiving Colorado River water. As water demands have increased in the past decades, water supplies available to water providers have not substantially increased. The potential for imbalances have led to increasing focus on reuse to meet existing or future demands. Three general categories of reuse describe the method in which reclaimed water is developed and used: direct non-potable reuse, indirect potable reuse, and direct potable reuse.

3B.2 Selected Case Studies from Water Conservation and Reuse Program Data Collection

From the identified programs, 34 were selected by the Workgroup as case studies to represent the breadth of innovative water conservation and reuse efforts throughout the major metropolitan areas. The locations of the selected programs are shown in Figure 3B-1.

FIGURE 3B-1
Selected Water Conservation and Reuse Program Case Studies



1	Water Budget-Based Tiered Rates	18	High Efficiency Clothes Washers
2	Water Use Efficiency Mapping and Identification Integrated with the System Incentive Program Project	19	Innovative Conservation Program
3	Home Water Reports	20	Albuquerque Bernalillo Water Conservation Program
4	Water Conservation Easement	21	City Rebate and Water Bank Program
5	Secondary Water Metering (Untreated Residential Irrigation)	22	Cash for Kitchens
6	Water—Use It Wisely®	23	Public School Retrofit Program
7	Commercial, Industrial, Institutional Water Audit Tool	24	National Center for Atmospheric Research – Wyoming Supercomputing Center Conservation Program
8	WaterSense® New Homes Builder Incentive Program	25	Parkway Improvement Districts Water Conservation Program
9	Water Conservation Planning Guide for Public Water Suppliers	26	Free Sprinkler Nozzles
10	Southwest Plant Selector Application	27	Water Smart Landscape
11	WaterSmart Innovations Conference and Exposition	28	Water Use Restrictions and Land Development Code
12	Slow the Fow, Save H_2O	29	Central Utah Gardens
13	Recycled Water Public Information and Outreach Campaign	30	Reclaimed Water Distribution System
14	Distribution System Replacement and Repair	31	Zero Discharge: Palo Verde Nuclear Generating Station and Redhawk Power Plant
15	Denver Water Pipe Replacement Program	32	Crean Lutheran High School
16	Provo Reservoir Canal Enclosure Project	33	Denver Zoo Recycled Water
17	Conserve2Enhance™	34	Southern Nevada Water Reuse

TABLE 3B-2
Selected Water Conservation and Reuse Program Case Studies

Type of Program	State	Agency/Institution	Program	ID
Metering and Billing	California	Eastern Municipal Water District, Rancho California Water District and Western Municipal Water	Water Budget-Based Tiered Rates	1
	Colorado	Aurora Water	Water Use Efficiency Mapping and Identification Integrated with the System Incentive Program Project	2
	Colorado	Fort Collins	Home Water Reports	3
	Utah	Washington County Water Conservancy District	Water Conservation Easement	4
	Utah	Weber Basin Water Conservancy District	Secondary Water Metering (untreated residential irrigation)	5
Public Education and Outreach	Arizona	Coalition Partners	Water—Use It Wisely	6
	Colorado	City of Boulder, Public Works Department	Commercial, Industrial, Institutional Water Audit Tool	7
	New Mexico	New Mexico Office of the State Engineer's	Water Conservation Planning Guide for Public Water Suppliers	9
	New Mexico	New Mexico Office of the State Engineer's and New Mexico State University	Southwest Plant Selector Application	10
	Nevada	Southern Nevada Water Authority	WaterSmart Innovations Conference and Exposition	11
	Utah	Jordan Valley Water Conservancy District/Governor's Water Conservation Team	Slow the Flow, Save H_2O	12
	Wyoming	City of Cheyenne	Recycled Water Public Information and Outreach Campaign[1]	13
System Water Loss	Arizona	City of Tempe	Distribution System Replacement and Repair	14
	Colorado	Denver Water	Denver Water Pipe Replacement Program	15
	Utah	Central Utah Water Conservancy District	Provo Reservoir Canal Enclosure Project	16
	Arizona	The University of Arizona, Water Resources Research Center	Conserve2Enhance™ (C2E)[2]	17
Residential Indoor	California	Eastern Municipal Water District	High Efficiency Clothes Washers	18
	California	Metropolitan Water District of Southern California	Innovative Conservation Program	19
	Colorado	Colorado Springs Utilities	WaterSense® New Homes Builder Incentive Program	8
	New Mexico	Albuquerque Bernalillo County Water Utility Authority	Albuquerque Bernalillo Water Conservation Program	20
	New Mexico	City of Santa Fe Water Division, Water Conservation Office	City Rebate and Water Bank Program	21
	California	West Basin Municipal Water District	Cash for Kitchens	22

TABLE 3B-2
Selected Water Conservation and Reuse Program Case Studies

Type of Program	State	Agency/Institution	Program	ID
Commercial, Industrial, and Institutional	California	Eastern Municipal Water District	Public School Retrofit Program	23
	Wyoming	National Center for Atmospheric Research Wyoming Supercomputing Center (NWSC)	NWSC Conservation Program	24
	Arizona	Parkway Improvement District (PKIDs)	PKIDs Water Conservation Program	25
Outdoor Landscaping	California	Metropolitan Water District of Southern California/Western Municipal Water District	Free Sprinkler Nozzles	26
	Nevada	Southern Nevada Water Authority	Water Smart Landscapes	27
	Nevada	Southern Nevada Water Authority	Water Use Restrictions and Land Development Code	28
	Utah	Central Utah Water Conservancy District	Central Utah Gardens[3]	29
	Arizona	City of Scottsdale	Reclaimed Water Distribution System	30
Reuse	Arizona	Palo Verde Nuclear Generating Station	Zero Discharge: Palo Verde Nuclear Generating Stations and Redhawk Power Plant	31
	California	Irvine Ranch Water District	Crean Lutheran High School	32
	Colorado	Denver Water	Denver Zoo Recycled Water	33
	Nevada	Southern Nevada Water Authority	Southern Nevada Water Reuse	34

[1] Also a Reuse Program
[2] Also a CII and Outdoor Landscaping Program
[3] Also a Public Education and Outreach Program

Case Study 1

Water Budget-Based Tiered Rates

Eastern Municipal Water District, Rancho California Water District, Western Municipal Water District, California

Program Overview

Between 2009 through 2011, Eastern Municipal Water District (EMWD), Rancho California Water District (RCWD), and Western Municipal Water District (Western) all implemented water budget-based rate programs. Under the programs, every customer receives a personalized water budget designed to meet their specific indoor and outdoor water needs. This personalized water budget means that no matter the size of a household or yard, users should be able to remain within their allotted water budget and pay the lowest available price.

Residential water budgets are calculated based on each customer's amount of landscaping, real-time localized weather data, and the number of residents in each home, among other factors. The water agencies are committed to seeing that everyone has a water budget that provides the water necessary to efficiently meet their needs. The water budget structure includes simple steps to adjust the budget established for an account, should the consumer have a legitimate need for more water.

Water use exceeding the budget is discouraged through steep pricing tiers. Most customers' water use regularly remains within specified water budgets, and users are billed at the lowest available rates. The only customers who are billed in the higher tiers (Tiers 3 through 5) are those whose use exceeds their water budget. The districts work closely with these customers to help reduce water use and lower water costs.

A water budget consists of two parts: indoor and outdoor. Western calculates the indoor budget at 60 gallons per day for each person in a household. Other factors such as licensed in-home child care are used to increase an individual indoor water budget. Sixty gallons per person per day provide adequate water for all indoor water uses such as cooking, cleaning, sanitation, and laundry. California Water Code Section 10608.20(b)(2)(A) states that 55 gallons per person per day is a provisional standard for determining an urban retail water supplier's urban water use target. Western's indoor water budgets provide for a minimum of three persons for every family residential household.

Agency

Eastern Municipal Water District, Rancho California Water District, Western Municipal Water Agency

Project Status

Ongoing

Targeted Use Sector

Residential

Estimated Annual Savings

0.04 to 0.07 acre-feet per year per single-family residential meter - estimated 15 percent savings

Estimated Annual Cost

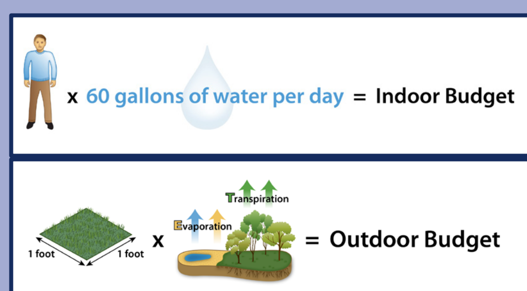
$20 to $35 per single-family residential meter

Estimated Unit Water Cost

$50 to $66 per acre-foot over 10 years; cost for water saved will continue to decrease as long as the rate is in place

Key Program Elements

- Set water budgets for customers based on lot size and on number of inhabitants per household
- Steep tiered rates discourage over-budget use
- Measurable water savings as total consumption reduction



Indoor and Outdoor Budget Graphic
Source: Western Municipal Water District

Western bases outdoor budgets on the square footage of irrigated area, a plant water-use factor, and microzone evapotranspiration data. Weather information is updated each day to calculate plant water needs in specific microzones. When temperatures increase, the outdoor water budget increases. When weather is cooler, the outdoor water budget decreases. University research and State law established maximum allowable water application to urban landscapes. The maximum was defined as 80 percent of the local evapotranspiration rate.

Outdoor water used within the water budget (Tier 2) is charged at the second lowest rate. The rate in Tier 2 is a blend of the costs to produce local water and purchase more expensive imported water.

Main Program Elements

Costs

Implementation costs varied for each agency and ranged from $0.8 million to $3.0 million. Costs include revising the agencies' billing software, budget development, consultant support, and customer support. The cost per meter ranges from $20 to $35.

Implementation Resources

- Involves staff across several departments.
- Customer outreach.
- Information on persons per household.
- Information to set landscape budgets.
- Staff must be available to process variances and customer resources.

Level of Participation

Participation varies from all customers to just landscape and residential customers. EMWD has over 130,000 connection on water budget-based rates. RCWD reports 41,304 water service connections.

Program Outcomes

Water Savings

Water saving varies for each agency. Agency estimates of water savings range from 4 percent to 20 percent for participants. The University of California, Riverside, completed an analysis of EMWD tiered rates that estimated a 15 percent water savings for residential customers.

Program Challenges

- Requires extensive customer outreach.
- Developing budgets may be challenging.
- Additional customer service is needed after initial implementation.
- The high level of variance requests requires processing.

Source

- Elizabeth Lovsted, Program Manager, Eastern Municipal Water District
- Western Municipal Water District, Understanding Water Budgets, retrieved from: http://yourwaterbudget.wmwd.com/understanding-water-budgets

Case Study 2

Water Use Efficiency Mapping and Identification Integrated with the System Incentive Program Project

Aurora, Colorado

Program Overview

The Water Use Efficiency Mapping and Identification Integrated with the System Incentive Program (SIP) project is being developed by Aurora Water in coordination with the Colorado Water Conservation Board through its grant program. The project is ongoing and will last approximately 3 years. The City of Aurora was mapped to determine pervious areas in each parcel. Inefficient customers can be identified by assigning water requirement values to each property and linking actual water consumption.

Once Aurora Water identifies the inefficient customers and contacts them, customers are requested to go through Aurora Water's water calculator, which allows them to input specific information to receive a prioritized list of actions they can take to become more water efficient. The SIP will include a rebate for the customer over time.

This program and mapping tool will be used to continue the new rebate program and slowly phase out existing rebates.

The goal is to identify inefficient water users and work with them to determine effective ways for them to become more water efficient through both retrofits and behavioral changes.

Main Program Elements

Costs

The total cost of the project is estimated at roughly $167,000, with additional need for about 850 staff hours. Funding has been supported by the Colorado Water Conservation Board grant program.

Implementation Resources

In addition to the project cost estimate, about 850 staff hours will be needed to complete the tools and program.

Level of Participation

The project is currently in the planning stages. It is estimated that up to 200 customers will have been contacted through the calculator and SIP program by 2014.

Agency

Aurora Water

Project Status

2013 – Ongoing

Targeted Use Sector

Residential, Commercial, Industrial, and Institutional, Residential Irrigation, Commercial and Industrial Irrigation

Estimated Annual Savings

Estimated savings of 44 acre-feet per year by targeting the top 200 most inefficient customers

Estimated Annual Cost

$63,729 (annualized capital investment plus operation and maintenance cost)

Estimated Unit Water Cost

$1,448 per acre-foot per year (based on the estimated annual cost)

Key Program Elements

- Program is in planning phase
- Established tool that identifies highly inefficient customers
- Uses grant sources to fund the program
- An estimated 200 customers are planned to use the tool and go through the SIP program by June 2014

Water Use Efficiency Map – Parcels can be analyzed and displayed by water use efficiency
Source: Aurora Water

Program Outcomes

Water Savings

To date, no water savings have been achieved because the project is still in the planning stages.

Program Challenges

Major classification errors during the automated land cover classification put the project behind schedule and added expense.

Sources

- Lyle Whitney, Water Conservation Supervisor, City of Aurora
- City of Aurora, March 2011, Grant Application to Colorado Water Conservation Board, Water Use Inefficiency Mapping and Identification Integrated with the System Incentive Program (SIP) Project, retrieved from: http://cwcbweblink.state.co.us/WebLink/ElectronicFile.aspx?docid=155952&&dbid=0

Case Study 3

Home Water Reports

Fort Collins, Colorado

Program Overview

In 2009, Fort Collins Utilities (Utilities) began distributing Home Energy Reports to single-family electric customers with an estimated electricity savings of 2.6 percent for those receiving them. Similarly, Home Water Reports were found by the Utilities to be a cost-effective method to save up to 5 percent of a customer's total water use. Utilities determined that delivering Home Water Reports would be an effective way to help the City of Fort Collins reach its water reduction goal established in the 2009 Water Conservation Plan.

In fall 2014, Utilities began delivering Home Water Reports to single-family water customers, alternating months with the delivery of Home Energy Reports. Utilities aims to motivate households to reduce their water use through changes in behavior or adoption of more water efficient technology. The approach is based on research on social norms marketing; the idea that much of people's behavior is influenced by their perceptions of what "normal" or "typical" is.

Main Program Elements

Implementation Resources

A control group has been established to allow an analysis of the water savings for households that receive the report. The reports provide information about current water usage and compare it to their past usage, the average of similar households, and the usage of the most efficient households. This data is coupled with actionable information on ways to more efficiently use water around the home.

Level of Participation

Starting in fall 2015, Utilities will expand the program to 15,000 customers and to 20,000 in 2016, reaching 75 percent of the households served water by Fort Collins.

Agency

Fort Collins Utilities

Project Status

2014 - Ongoing

Targeted Use Sector

Single Family Residential

Estimated Annual Savings

2-5 percent per family receiving the report

Key Program Elements

- Effective program to reach water reduction goals by motivating people to change water use patterns or adopt more efficient technology
- Partnership with electric utility
- Program approach based on social norms marketing; people's behavior is influenced by their perception of "normal" or "typical"

City of Fort Collins

Program Outcomes

Water Savings

Utilities found Home Water Reports to be a cost-effective method to reduce a customer's total water use. After delivery of two reports, water savings was estimated at 1.6 percent or 3.2 million gallons.

Sources

- City of Fort Collins, Home Energy Reports, retrieved from: http://www.fcgov.com/utilities/residential/conserve/home-water-reports/

Case Study 4

Water Conservation Easement

Washington County Water Conservancy District, Utah

Program Overview

Washington County Water Conservancy District (WCWCD) assesses impact fees for new development based on meter and lot size. If the lot is more than 10,000 square feet, the applicant can qualify for a minimum impact fee by signing a water conservation easement. This easement generally restricts the lot to 5,000 square feet of irrigated landscape. By assessing impact fees and requiring users to pay based on irrigated landscape area, incentives are provided for water conservation. Impact fees and water conservation easements apply to all culinary (potable) water users in the District's wholesale and retail systems, including residential and commercial users, so the incentives to reduce outdoor water use by limiting irrigated landscape are widespread.

The water conservation easement program is part of WCWCD's Regional Water Supply Agreement with its seven major municipal customers. This Agreement also encourages conservation by eliminating the "take-or-pay" contract incentive for municipal customers to sell water because they must pay for it whether or not it is used. Municipal customers pay only for water as it is delivered from the WCWCD system, allowing them to actively promote conservation without creating budget issues. Additional provisions call for water conservation rate structures, time of day water use and landscape ordinances, and maximum use of secondary irrigation and water reuse systems.

Agency
Washington County Water Conservancy District

Project Status
2006 – Ongoing

Targeted Use Sector
Residential/Commercial, Industrial irrigated landscape

Estimated Annual Savings
2,000 acre-feet per year

Estimated Annual Cost
Budget included in general staffing allocations

Key Program Elements

- Increased awareness of developers and lot owners of the costs of irrigated landscape
- Limits outdoor watering with every new connection
- Financial incentives to reduce irrigated landscape and consequently outdoor water us.
- WCWCD and municipal customers partner under terms of the Regional Water Supply Agreement with its seven municipal customers to eliminate the "take or pay" contract

Impact Fees in New Developments
Source: Washington County Water Conservancy District

Main Program Elements

Costs

The Agreement provides that impact fees will be paid at the time of platting or building permit issuance. Impact fees are paid by developers or lot owners and must be segregated to pay for system costs as set forth in WCWCD's Regional Water Capital Facilities Plan and Impact Fee Analysis. Accordingly, WCWCD does not budget separately for this program, but rather absorbs the costs of its operation into general staffing allocations.

Implementation Resources

The water conservation easement, which limits landscape area, is a benefit offered to avoid additional impact fee charges. This option is part of the processing of impact fees and is explained in published materials and on WCWCD's website (wcwcd.org). Because many unique circumstances are presented at the time impact fees are processed, WCWCD staff works with developers and lot owners to find ways to make the water conservation easement work in varying circumstances. The availability of the water conservation easement allows WCWCD to emphasize the importance of limiting outdoor watering with every new connection within its municipal customer boundaries, reaching 90 percent of Washington County's population.

Level of Participation

Since the program's inception in 2006, more than 3,000 water conservation easements have been executed, amounting to over 50 percent of the impact fees paid for lots more than 10,000 square feet.

Program Outcomes

Water Savings

WCWCD estimates that more than 15.5 million square feet of irrigated landscape have been eliminated by offering the water conservation easement for new connections. These benefits will continue for many years to come, both in terms of existing and future water conservation easements.

To date, this program has reduced annual demand by over 2,000 acre feet, and that number will continue to increase. Savings to municipal customers in terms of wholesale water costs amounted to almost $500,000 in 2013.

Program Challenges

- Administrative, legal, and management obligations associated with implementation of the program

Sources

- Barbara Hjelle, Associate General Manager/Counsel, Washington County Water Conservancy District
- Washington County Water Conservancy District, Impact Fees, retrieved from: http://www.wcwcd.org/customer-support/impact-fees

Case Study 5

Secondary Water Metering (Untreated Residential Irrigation)

Weber Basin Water Conservancy District, Utah

Agency
Weber Basin Water Conservancy District

Project Status
2010 – Ongoing

Targeted Use Sector
Residential Landscape Irrigation

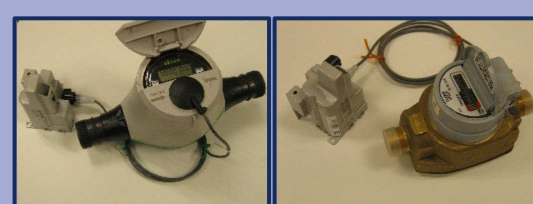
Estimated Annual Savings
0.25 acre-feet per year (average) per metered connection

Estimated Annual Cost
$500,000 budgeted annually until all connections are metered. Approximately $800 per metered connection (install only)

Estimated Unit Water Cost
$200 per acre-foot per year, based on 25 percent savings per connection at a cost of $800 per connection

Key Program Elements

- Accountability for all users will bring an overall reduction in water use - secondary irrigation water has been unmetered
- Providing use information with educational material and helpful tips helps reduce outdoor water use
- Objective is to delay future water development projects by reducing current water use through metering and end user accountability



Automated Meters
Source: Weber Basin Water Conservancy District

Program Overview

The Weber Basin Water Conservancy District (District) has been studying and tracking data on meters for secondary (untreated residential irrigation) water for the past decade. Metering residential secondary irrigation (untreated pressurized irrigation water) is now taking on importance because meters have not been reliable on systems with poor water quality. Historically, secondary water has been allocated and used based on parcel size, with the payment of that water being assessed once per year. Today, meters exist that can handle the poor water quality and deliver reliable water use data.

In 2010, the District partnered with the Bureau of Reclamation (Reclamation) to install 1,100 meters in the Uintah Bench and South Weber areas; this was the first large installation project for secondary water meters. Since 2010, the meter studies have continued with the adoption of additional meter types (there are now four types of meters in the field) and a total of 2,613 meters installed as of April 2015. It was also determined that there was a need to purchase an electronic read system that has the capability to collect data in hourly increments. The Itron Automated Meter Reading system, using the 100-Watt electronic radio transmitter, was selected because it could meet the data needs and was compatible with various brands of meters.

The District's long-term goal is to have all of its retail secondary water users (approximately 17,650) metered within the next 10 years. The District is also providing the metering data to other secondary irrigation systems throughout Davis and Weber Counties and encouraging them to begin implementing a metering program.

Main Program Elements

Costs

The initial meter project was funded with help from Reclamation and cost $784,175, of which $290,000 was funded through a WaterSMART Grant. Since that time, the total costs have risen to $1,700,000, and the projected annual budget going forward will be approximately $500,000. WBWCD will continue to seek grant funding to increase the rate at which meters can be installed as the District continues to budget for and install meters each year. The approximately cost per metered connection (parts and install only) is $800.

Implementation Resources

The potential conservation savings are large, and WBWCD recommended that all secondary connections have meters installed and begin conducting customer education on how to reduce their landscape water needs.

Some of the success of metering is associated with being able to address the users' questions, gather and use quantifiable data on usage and conservation, be able to incorporate Geographic Information Systems (GIS) and mapping technology to show on a larger scale where high use areas are, and indicate which users may struggle to understand proper landscape water needs.

Level of Participation

The District has been the primary agency involved in the metering project. The first phase of the project involved Reclamation with funding and Utah State University doing a parallel study on public perception about receiving a meter on previously unmetered irrigation water. Consultants were retained the first year to conduct open house events and provide public information targeted to those who would receive meters in an effort to educate and to eliminate rumors, skepticism, and other concerns. To date, fewer than 10 percent of Weber Basin's secondary connections have a meter. Additional participation will be necessary to continue the project and meet the goal of all secondary connections being metered.

The program will continue to be evaluated through analysis of water use data from existing meters. As more meters are installed and time passes, significant data will become available to confirm that water use will be reduced because users will know what they consume and will be accountable for it.

Program Outcomes

Water Savings

Overall, metering is proving to be effective in helping consumers understand how much they are using and how to adjust usage to meet target needs for their yards. It is difficult to calculate the total water savings at this point in the program because there was no baseline established at the beginning of the project. Going forward, usage data will show water savings specific to the landscape. These data can then be compared to other water savings and use programs. In the table below, meter group usage comparisons are presented for the years 2012-2014 based on data from 1,057 meters.

Year	2012	2013	2014
Used Gallons	284,912,371	220,146,962	205,346,968
Used Acre-Feet (AF)	874	675.3	629.9
Average Used AF/Gross Acre	2.69	2.08	1.94
Average Used AF/Landscape Area Acre	3.9	3	2.8
Average % of Allocation Used	83	64	59.6
Average % of Estimated Need Used	136.2	105.10	97.90
Average Allocation Per Parcel Per Year (average parcel size = 0.3 acres)	1	1	1

Program Challenges

- Repair and replacement of the metering systems.
- Ensuring consumers of the system's accuracy.
- Informing and educating the public about the metering system.
- Program costs and system items to retrofit for meters.
- Having all secondary water providers use the same program with their customers to provide a more unified message to achieve regional savings, not just from certain entities.

Sources

- Scott Paxman, Assistant General Manager, Weber Basin Water Conservancy District

Case Study 6

Water – Use It Wisely®

Coalition Partners, Arizona

Entities

Arizona Coalition Partners

Project Status

1999 – Ongoing

Targeted Use Sector

Residential: Women and Men, ages 25-54, Children, ages 8-14

Estimated Annual Impact & Engagement

Annual Media/Digital Impressions: 4.7 million; Website: 2,600 daily visitors; E-Newsletter subscribers: 2,750; Facebook followers: 2,880; Twitter followers: 5,559; Pinterest followers: 71, six boards.

Estimated Annual Cost

$300,000

Key Program Elements

- Comprehensive multi-media water conservation awareness campaign. Includes television, radio, print, Web, and social media advertising
- Universal water conservation message that provides an ongoing, visible, and regionally consistent call to action
- Partnership results in considerable savings of creative development costs

Program Overview

The Water – Use it Wisely® (WUIW) program is a comprehensive, multi-media water conservation awareness campaign that provides an ongoing, visible, and regionally consistent call to action. "Don't tell us to save water. Show us how." That was the sentiment of Arizona residents when local cities studied the best messages to use with water conservation outreach. Originally developed by the cities of Mesa, Scottsdale, and Phoenix, other municipalities, organizations, agencies, and private water providers soon joined the Arizona coalition to build the campaign regionally. The award-winning campaign has been adopted by 400 public and private entities nationwide. It includes television, radio, print, web, and social media advertising.

Since 1999, the WUIW conservation campaign has made smart water use fun, easy, and practical for everyone. This campaign is all about giving voice to water. The program has developed a variety of ways to use WUIW as a tool to help spread a unique water conservation message for business, home, classroom, or municipality audiences.

Partners of the regional campaign benefit significantly, as campaign monies are consolidated and used directly to purchase media space or time, bolstering the campaign's effectiveness. Partners have realized considerable savings in creative development costs, which a separate advertising program would otherwise incur.

The campaign includes a multi-media presence (TV, radio, print, web, movie theater slides) and social media presence, including a top-ranking consumer website for water conservation. Facebook, Twitter, Pinterest, YouTube and a website and blog round out the social media. Face-to-face outreach occurs three to five times a year with Earth Day, water conservation festivals, and other events. Non-traditional tactics include the Water – Use It Wisely® mascot, Wayne Drop, a life-sized, eye-catching blue water drop used for events and promotions. A travelling display is also shared by partners in the form of a 16-foot-tall pyramid built with 136 one-gallon empty milk containers, demonstrating the average amount of water that is used by an Arizonan each day.

By acting regionally, the partnership further provides greater marketing possibilities for sponsorship. Through the years, sponsors have included the Arizona

Diamondbacks, the Phoenix Coyotes, Reclamation, Salt River Project, Maracay Homes, Wells Fargo, and others.

Main Program Elements

Costs

The budget varies depending on the number of partners and funding availability. The WUIW campaign dollars have been as high as $475,000, but typically average $300,000 annually. Partners can participate for a minimum of $2,000 per year.

Implementation Resources

Advertising agency account executive and creative staff contribute approximately 800 to 900 hours per year. Steering Committee partners meet monthly to oversee and direct activities. The campaign includes a media presence, social media presence, and face-to-face outreach. The budget does not include the staff time of partner representatives who provide technical support or attend planning meetings.

Level of Participation

Partners include the cities of Mesa, Phoenix, Scottsdale, Tempe, Peoria, Chandler, Glendale, Avondale, Surprise, Fountain Hills, and Queen Creek, as well as the Arizona Municipal Water Users Association, Global Water Resources, EPCOR Water, and Salt River Project.

Following Arizona's lead, nearly 400 towns, cities, states, utilities, and private and public organizations have adopted the Water – Use It Wisely campaign, making it one of the world's largest conservation educational outreach programs.

The private sector has also joined in. Home Depot and Lowes have featured Water – Use It Wisely® in their stores throughout Arizona. Manufacturers such as Rain Bird, Fisher & Paykel, and Hinz Horticulture have also been active campaign sponsors.

Program Outcomes

Program Challenges

- Measuring success
- Funding
- Keeping the public engaged

Sources

- Water – Use It Wisely, retrieved from: http://wateruseitwisely.com

Case Study 7

Commercial, Industrial, Institutional Water Audit Tool

City of Boulder, Colorado

Program Overview

The City of Boulder has developed a Commercial, Industrial, and Institutional (CII) water audit tool in conjunction with Brendle Group who was contracted by the city based on similar CII work done with the non-profit, Colorado Water Wise. The tool references United States Environmental Protection Agency (EPA) and United States Department of Energy standards for water and energy and seeks to produce a simple report to show water, energy, and cost savings potential and encourage implementation of efficiency improvements. The tool is customizable for the Professional Engineer (PE) or utility professional who wants to make changes to the assumptions or add in a rate structure. However, it also has pre-populated assumptions on factors such as flow estimates, use frequencies, and costs to support the less experienced tool user in conducting a facility assessment and identifying opportunities. The City of Boulder worked with EPA to pilot the tool with a large group of users/stakeholders in the summer of 2014 and has since made the tool available free for use by water conservation professionals and CII facility representatives.

Main Program Elements

Costs

No budget was specified. The tool is available free of charge.

Implementation Resources

The City of Boulder and Brendle Group implemented a pilot with EPA to help vet and make updates to the tool. The revised version is now currently hosted and accessible from the Brendle Group website.

Level of Participation

Level of participation has not yet been identified and is dependent on the City of Boulder's coordination with EPA.

Program Outcomes

Water Savings

The tool is new to the EPA website and water savings have not yet occurred.

Agency

City of Boulder, Public Works Department

Project Status

2013 – Ongoing

Targeted Use Sector

Commercial, Industrial, and Institutional

Estimated Annual Savings

No reported savings yet - tool is newly developed

Key Program Elements

- CII auditing tool developed for free use
- Tool customizable and has the ability to be operated by both PEs and end users
- Piloted with EPA and a large group of users/stakeholders

Sources

- Russ Sands, City of Boulder Watershed Sustainability & Outreach Supervisor, City of Boulder
- MaryAnn Nason, City of Boulder Water Conservation & Outreach Coordinator, City of Boulder
- Beck Fedak, Principal Engineer, Brendle Group
- CII Water Assessment Tool: www.brendlegroup.com/water_conservation/cii_water_tool/cii-water-assessment-tool

Case Study 8

WaterSense® New Homes Builder Incentive Program

Colorado Springs, Colorado

Program Overview

The WaterSense® New Homes Builder Incentive Program is designed to provide financial incentives for residential builders to construct, inspect, and label new homes to meet the EPA WaterSense New Homes Criteria. These criteria are designed to be 20 percent more water-efficient than standard code-compliant new construction through indoor and outdoor conservation. The program builds on and complements Colorado Springs Utilities' existing EPA ENERGYSTAR New Home Builder Incentive Program.

The program was launched in 2013 and will be ending after 2015 due to statewide WaterSense Legislation which will make it obsolete. The program was designed to help transform the local home building market, and will be in place until reasonable penetration, yet to be determined, is achieved.

Main Program Elements

Costs

Builders receive an incentive of $750 per home upon successful inspection and certification. In 2015, 8 new homes have been certified and received the incentive at a total cost of $6,000. The source of funding was not specified.

Implementation Resources

In addition to annual cost, the program requires approximately 100 hours of staff time each year to manage. The operational cost is estimated to be $3,700.

Level of Participation

Since the program launched in June 2013, 19 homes have been certified.

Program Outcomes

Water Savings

If the 20 percent water savings goal is achieved, each new home will use about 24,000 gallons less each year than a standard new home. This savings equates to a potential annual water savings of more than 450 thousand gallons or about 1.5 acre-feet.

Agency
Colorado Springs Utilities

Project Status
2013 – 2015

Targeted Use Sector
Residential

Estimated Annual Savings
29.5 acre-feet per year

Estimated Annual Cost
$4,424

Estimated Unit Water Cost
$139 per acre-foot per year

Key Program Elements

- Water conservation goal is to reduce water consumption by 20 percent in new homes
- Program builds on and complements existing EPA ENERGYSTAR New Home Builder Incentive Program
- Builders receive incentives upon successful inspection and certification

Program Challenges

- Cost to builders of meeting WaterSense specifications.
- Convincing builders that the WaterSense label sells.
- State WaterSense legislation makes program obsolete.

Sources

- Scott Winter, Colorado Springs Utilities
- Colorado Springs Utility, Builder Incentive Program, retrieved from: https://www.csu.org/Pages/bip-rebate.aspx

Case Study 9

Water Conservation Planning Guide for Public Water Suppliers

Office of the State Engineer, New Mexico

Agency

New Mexico Office of the State Engineer

Project Status

The guidebook was published in September of 2013

Targeted Use Sector

Public Water Suppliers

Estimated Annual Savings

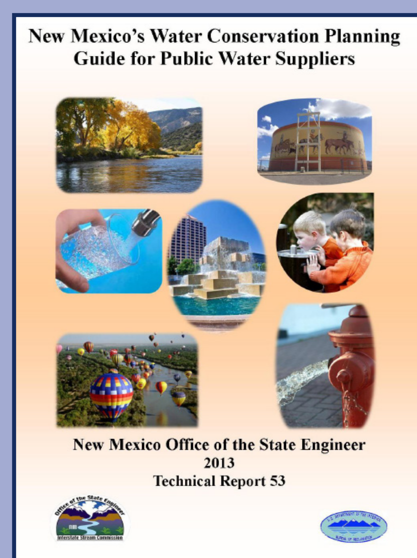
Varies by PWS; depends on audit results and implementation by Public Water Suppliers

Estimated Annual Cost

Varies, dependent on PWSs

Key Program Elements

- Data management tool for developing a water conservation plan
- Provides instructions to use two useful tools: AWWA Water Loss Control Committee Free Water Audit Software and NMOSE GPD Calculator
- Step-by-step directions for developing measureable and effective water conservation plan



Program Overview

The New Mexico's Water Conservation Planning Guide for Public Water Suppliers (Planning Guide) provides tools and step-by-step directions for developing a measureable and effective water conservation plan for public water suppliers (PWSs). Developing and implementing effective water conservation programs is a critical component of a water conservation plan. Implementation of a water conservation program is a key action that can achieve the objectives and goals articulated by PWSs. Programs are at the heart of any successful conservation effort.

Water conservation programs are particularly critical in New Mexico, which is located in the high desert of the Southwest where water has always been limited in quantity. The State Water Plan embraces the goal of ensuring a sustainable source of water for New Mexico through healthy watershed management. Water conservation is an essential part of this goal, and the process of water conservation planning is a continuous effort. Data management is fundamental to ensure a measurable and effective process.

The first tool presented in the Planning Guide is the American Water Works Association (AWWA) Water Loss Control Committee Free Water Audit Software© ("Audit"). This software, which is offered by AWWA at no charge, provides a nationally recognized systematic method to organize water diversion data and track its path through the distribution system. An important result of this analysis is "nonrevenue water," which is an estimation of water losses, theft, meter inaccuracies, and non-billed authorized consumption. The Audit requires financial data to help value nonrevenue water. The Audit also provides a measure of confidence in the output.

The second tool presented in the Planning Guide is the New Mexico Office of the State Engineer (NMOSE) Gallons per Capita per Day Calculator (GPCD Calculator). This tool, also available at no charge, provides a standard method for organizing water diversions and end use. The GPCD Calculator has been extensively tested in New Mexico and is incorporated into many PWSs NMOSE permit conditions.

The tool provides a breakdown of water use into end use categories that can provide baseline data and help to identify trends. This enables PWSs to compare the effectiveness of end-use (demand-side) conservation programs to baseline use patterns.

Main Program Elements

Costs

The total cost for the planning guide and GPCD Calculator was approximately $52,000, including in-kind labor. The NMOSE used grant funding from Reclamation to create the Planning Guide, which was developed through a research process. This process allowed NMOSE staff to present the best available methods and technologies in water conservation. The NMOSE began by researching existing regional and national water conservation planning documents, papers, reports, journals, and guidebooks. The planning guide presents the best data management tools available for developing a water conservation plan.

Implementation Resources

The Planning Guide was made available to the public in September 2013.

Level of Participation

The general concepts of the Planning Guide are used by many of the PWSs in New Mexico. An overhaul of New Mexico's PWSs grant and loan process requires compliance with the Planning Guide's principles. Additionally, as an ongoing effort, the NM State Engineer requires conservation planning as part of the water rights permitting process.

Program Outcomes

Water Savings

As noted, the Planning Guide and GPCD calculator concepts have been used by many of the PWSs in New Mexico. Two notable water conservation efforts have been implemented by the Albuquerque Bernalillo County Water Utility Authority and the City of Santa Fe. However, at this time, there is not a direct correlation between use of the guide and a reduction in water use.

NM PWSs requested guidance in developing an acceptable water conservation plan for funding processes and the NMOSE's permitting process. 2015 is the first year the Planning Guide was a requirement of the revamped funding process, many applicants have indicated that this has provided much-needed direction to ensure that they would have a complete application.

Program Challenges

The Guide has been promoted through regional presentations at Rural Water technical conferences and through informational meetings to community technical advisors. Wider promotion is limited by staff resources, but is part of the revamped PWS funding process and the NMOSE's permitting process. Another challenge is the collection of baseline data/information needed to complete the AWWA Audit and GPCD Calculator.

Sources

- Julie M. Valdez, Senior Water Resource Specialist, New Mexico Office of the State Engineer, Water Use & Conservation Bureau
- New Mexico Office of the State Engineer, 2013, New Mexico's Water Conservation Planning Guide for Public Water Suppliers, retrieved from: http://www.ose.state.nm.us/WUC/PDF/Planning%20Guide_Final_.pdf

Case Study 10

Southwest Plant Selector Application

Office of the State Engineer, New Mexico

Program Overview

The Southwest Plant Selector Application fills a critical need for more information on desert-adapted low water use landscape plants and is the only application of expert-recommended xeric landscape plants specifically for New Mexico, El Paso, and surrounding areas. This application was created from the New Mexico Office of the State Engineer's (NMOSE) online database of New Mexico landscape plants. It teaches homeowners and landscapers how xeriscape can be more than covering an area with gravel or rocks. The application includes references for hundreds of plants to choose from when designing low-water-use yards. All plants thrive on little or no supplemental water and are typically both available and used in regional xeriscapes. The Southwest Plant Selector Application is the first of its kind to deal specifically with plants that are both suitable to residential yards and commercially available in New Mexico.

Information and photos can be accessed for the wide variety of trees, shrubs, perennials, annuals, cacti, turf grasses, ornamental grasses, groundcover and vine plants in the database of water-wise plants developed by the NMOSE. Users can search by a plant's scientific or common name as well as other plant criteria such as plant type and category, region, and sun exposure. Water requirements are specified for each region as well as plant size, flower color and bloom time, soil needs, and brief descriptions to help with homeowners' landscape designs. Users can also build a list of favorite plants to use at a nursery or in discussion with a landscaper.

An upgrade to the Southwest Plant Selector was made available in 2013 as an application for mobile devices (app) for iPad, iPhone, and iPod Touch.

The app also allows users to sort by bloom color, in addition to the original sort criteria of plant name, region, sun requirements, and plant category and type. Users can still build a list of favorites for further research or for easy reference at a retail store or with a landscaper and new features include the ability to e-mail plant selections and, for industry people, the ability to work in a scientific mode.

Agency

The NMOSE, New Mexico State University's Center for Landscape Water Conservation, and NMSU Media Productions

Project Status

The app was launched in June 2012 and upgraded May 2013

Targeted Use Sectors

Residential and Commercial and Industrial Irrigation

Estimated Annual Savings

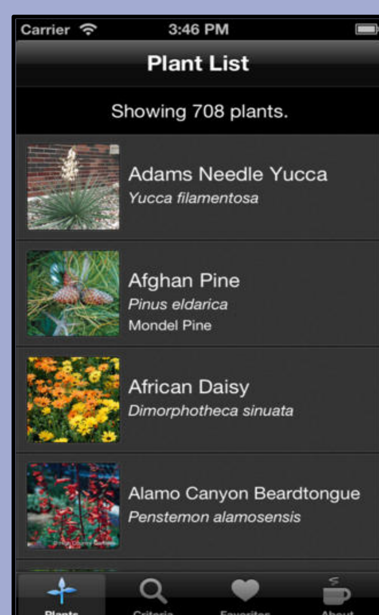
70 acre-feet (assuming 10 percent level of adoption and 50 percent water reduction)

Estimated Annual Cost

$52.80 per acre-foot per year (not including annual operation and maintenance cost)

Key Program Elements

- Users can browse through a database of 700+ plants or search based on specific criteria
- Useful to landscapers, but also understandable by general public
- Each plant includes photo(s) and relevant information on use and care
- A person's "favorites" can be marked for quick access at the nursery or in the yard



Users can also access an "Irrigation Calculator" web page to calculate more precise supplemental water applications for each plant.

Main Program Elements

Costs

The NMOSE used grant funding from Reclamation to create the Interactive Plant List, which provided all of the data for the application approximately $30,000, including in-kind labor, was spent on this project.

Implementation Resources

The State Engineer's database had a rich source of information and it made sense to put it in a mobile format where people could access it away from their computer. This app is the first data-driven app built by New Mexico State University media production. The goal of the design team was to build a resource that would be useful to landscapers, but also understandable by people who have less knowledge. The user can search with the scientific name or common name of the plant. It was important to make it accessible and fun to browse. Being able to browse the plants visually is a major feature of the app. The team spent a lot of time getting colorful photos of the plants that the user can browse through.

Level of Participation

As of February 2014, there were 6,794 downloads, with an average of about 50 downloads per week.

A Gold Medal Award was given by the Association of Communication Excellence (ACE) in Agriculture, Natural Resources, and Life and Human Sciences for the app. The ACE Critique and Awards program recognizes individuals and teams for excellence in communication and technology skills. The app also earned an Honorable Mention Award for Best Innovative Use of Communication Technology.

Program Outcomes

Water Savings

New Mexico's statewide average GPCD is 150. Generally, it is assumed that 50 percent of the GPCD is for outdoor water use. Using 75 GPCD as the existing landscape water use (excluding other outdoor uses), and assuming a 50 percent savings converting to a xeric landscape based on the app's plant list, and a 10 percent adoption rate for the existing users (6,800), it is estimated that 70 acre-feet per year have been saved.

Outdoor water use quantities are generally affected by climate and latitude. Given that New Mexico is about 370 miles in length and has elevation differences of 10,000 feet, the water savings, and potential water savings, vary significantly by location. Two locations were reviewed: a southern location at an elevation of approximately 4,200 feet (the warmer/southern latitude location or WSL), and a northern location at an elevation of 8,600 feet (the cooler/northern latitude location, or CNL). As a baseline, a Kentucky Bluegrass dominated landscape is considered. This is contrasted with a landscape that has equal parts of trees/shrubs, buffalo grass, and a xeric garden. The xeric profile is based on the plant types in the app's database. For the WSL, Kentucky Bluegrass consumes 56 gallons/square foot/year, compared to xeric at 30 gallons/square foot/year, roughly a 40 percent reduction. For the CNL, Kentucky Bluegrass consumes 12 gallons/square foot/year, compared to xeric at 4 gallons/square foot/year, roughly a 70 percent reduction.

Program Challenges

- Many of the original photos in the database were low resolution and need to be upgraded for the app.
- Publicizing the app; resources are not currently available to promote the use of the app by landscapers and their clients.

Sources

- Julie M. Valdez, Senior Water Resource Specialist New Mexico Office of the State Engineer, Water Use and Conservation Bureau
- Southwest Plant Selector, retrieved from: www.xericenter.com/swplants
- Sutherin, Stefan, Kevin Lombard, and Rolston St. Hilaire. "Southwest Plant Selector: A Mobile App." Horttechnology 23.5 (2015): 602-09. Print.
- Sutherin, Stefan, Kevin Lombard, and Rolston St. Hilaire. "Website? Video? Facebook? Mobile App? One Group's." *Journal of Extension* 1FEA1 53.1 (February 2015): 1-12. Print.

Case Study 11

WaterSmart Innovations Conference

Southern Nevada Water Authority, Nevada

Agency
Southern Nevada Water Authority

Project Status
2008 – Ongoing

Targeted Use Sector
Other Non-Categorized Use

Estimated Annual Cost
Approximately $300,000 annual budget. Costs are covered by event revenue

Key Program Elements

- World's largest urban-water efficiency conference
- Accelerates awareness and adoption of innovative water efficiency technologies and concepts
- Accessible and affordable
- Financially self-sustaining
- Interdisciplinary format with multiple professional content tracks

Program Overview

The Southern Nevada Water Authority (SNWA) hosts the annual WaterSmart Innovations Conference and Exposition (WSI) in Las Vegas each year. The event includes workshops, technical sessions, an exposition, an awards luncheon, tours, and other activities highlighting all aspects of urban water efficiency. WSI has a sustained standing as the world's largest Urban Water Efficiency conference. Since its inception in 2008, approximately 6,400 attendees from 45 states and 27 counties have participated in the conference. WSI is truly the first interdisciplinary event for urban water efficiency. The event leverages a broad array of national and international partnerships and allows exchange of ideas between product designers and manufacturers, irrigation and plumbing practitioners, facility engineers, policy-makers, academics, non-governmental organizations and water agencies,

The event provides entrepreneurs with connections to some of the most innovative water agencies and market partners in the world. Each year, new water-efficient technologies are introduced at the conference and research results are shared with the conservation community.

Main Program Elements

Costs

SNWA provided seed money to initiate the conference in 2008. The conference generates adequate registration and exhibition revenue to be financially sustainable. The annual budget is approximately $300,000.

Implementation Resources

A committee of nine SNWA professionals oversees the planning and implementation of the conference. More than 20 additional agency staff members provide operational support for one or more days during the four-day event. Collectively, the SNWA provides approximately 0.95 FTE of professional time to plan and host the event.

WSI has 12 national and international partner organizations that represent the most influential professional organizations in water management and policy-making. These partners are responsible to evaluate and rank presentation proposals. All proposals are rated "blind," without the speaker's name, to encourage diversity in presentations and topics.

Level of Participation

WSI attracts 900 to 1,100 attendees annually. From 2008 to 2013 approximately 6,400 attendees from 45 states and 27 countries have attended.

Program Outcomes

Water Savings

Not applicable.

Program Challenges

- Travel restrictions imposed by public agencies.
- Competition for limited travel dollars.
- Sustaining sponsorships.

Sources

- Doug Bennett, Conservation Manager
  Southern Nevada Water Authority
- WaterSmart Innovations Conference and Exposition, retrieved from: https://www.watersmartinnovations.com

Case Study 12

Slow the Flow, Save H_2O

Jordan Valley Water Conservancy District, Utah

Program Overview

In 1999, Jordan Valley Water Conservancy District (JVWCD) created a public education and media campaign named "Slow the Flow, Save H2O." The original purpose of the campaign was to increase water conservation awareness and education throughout JVWCD's service area, which lies within the fastest growing portions of Salt Lake County, Utah. During its inception, the campaign grew rapidly, receiving good brand recognition as its messaging was being heard throughout the state.

In 2001, the third consecutive year of a worsening drought, the governor recognized that water conservation savings would be needed not only in response to the drought, but also to provide for a long-term sustainable water supply. It was at that time that JVWCD's local Slow the Flow, Save H2O campaign was elevated to a statewide effort with the objective of creating a long-term water conservation ethic among all Utahns. Since then, input and direction for the campaign has been provided by the Governor's Water Conservation Team, comprised of managers from the State Division of Water Resources (DWRe) and the five largest water districts in Utah. Over the years, the campaign has continued to achieve successful brand recognition through the use of television and radio advertising, various social media avenues, conservation programs, and event promotion. With JVWCD's leadership, Slow the Flow, Save H2O has evolved into a media umbrella campaign for all water conservation messaging and advertising throughout the state.

Entities

Jordan Valley Water Conservancy District and Governor's Water Conservation Team

Project Status

1999 – Ongoing

Targeted Use Sector

Primarily Residential Irrigation

Estimated Annual Savings

365 acre-feet per year in JVWCD's service area

Estimated Annual Cost

$ 69,305 (annualized capital investment plus operation and maintenance cost)

Estimated Unit Water Cost

$190 per acre-foot per year

Key Program Elements

- Increased public awareness of water conservation throughout Utah
- Achieved brand recognition through television advertising, conservation program branding, and event promotion
- Provided a means of consistent and uniform water conservation messaging throughout Utah

Main Program Elements

Costs

The Slow the Flow, Save H2O campaign was initially funded by JVWCD at a cost of $400,000. Since 2001, the campaign cost has been jointly funded by the DWRe, the Metropolitan Water District of Salt Lake and Sandy, and the water conservancy districts of Jordan Valley, Central Utah, Weber Basin and Washington County.

To date, a total of approximately $4.0 million has been spent collectively on the campaign. Since 2002, JVWCD's cost share has averaged $50,000 annually.

Implementation Resources

Slow the Flow, Save H2O campaign messaging, advertising and programming is developed jointly by the campaign partners under an interlocal agreement. The campaign partners are assisted by a media consultant retained through a competitive process every 5 years. The media consultant contract is administered annually by the DWRe. The campaign partners meet several times each year to build consensus and provide direction for each year's campaign.

Level of Participation

The cooperative efforts and participation by the campaign partners has allowed for consistent water conservation messaging efforts for all water purveyors throughout Utah.

The Slow the Flow, Save H2O campaign is evaluated every year, either by a quantitative (telephone and online survey) or qualitative (focus groups) analysis. Four focus group sessions were recently completed to evaluate campaign effectiveness and to help design new campaign messaging. The focus groups were held with residents from four locations in the state:

- Weber and Davis Counties
- Salt Lake County
- Utah County
- Washington County

Based on recent survey results, 72 percent of all respondents recall Slow the Flow, Save H2O messaging, and 61 percent of respondents felt that the water conservation messaging they encountered had an impact on their water usage habits.

Program Outcomes

Water Savings

JVWCD established a goal to achieve a 2 percent reduction in water use due to its Slow the Flow, Save H2O campaign. Since 2000, JVWCD has achieved a total water conservation savings of approximately 15 percent due to all of its water conservation efforts and programs, as measured by per capita water use reduction. As such, a 2 percent savings is considered to be a conservatively low estimate of the savings achieved by the Slow the Flow, Save H2O campaign. Nonetheless, assuming a 2 percent reduction in water use due to the campaign, an average annual savings of 365 acre feet and a cumulative savings of 4,743 acre feet has been realized within JVWCD's service area since 1999.

Program Challenges

Building consensus and receiving timely approvals among the funding partners for annual program objectives and budget amounts.

Sources

- Bart Forsyth, Assistant General Manager, Jordan Valley Water Conservancy District
- Slow the Flow, Save H2O, retrieved from: http://slowtheflow.org

Case Study 13

Recycled Water Public Information and Outreach Campaign

City of Cheyenne, Wyoming

Program Overview

In the midst of a multi-year drought, and facing more stringent discharge regulations for their wastewater treatment plant to Crow Creek, the City of Cheyenne Board of Public Utilities (Board) saw an opportunity to fulfill a commitment made 50 years ago by a former Board president. That commitment was to use water so that 1 gallon of the supply provided by nature would perform the duty of 2 gallons as it is now used. Water reuse could simultaneously address supply concerns and help meet the more stringent discharge requirements. Today, this reuse system is affectionately called the recycled water system by Cheyenne residents.

A perceived challenge to this plan was garnering public support. For that reason, the Board launched an innovative public information and outreach campaign. For nearly a year, the campaign prepared elected officials, coaches, teachers, irrigators, and Board employees on how to respond to questions on the benefits, safety, and water quality of recycled water. These community leaders received presentations and tours. Board managers and design engineers responded to their questions. Ultimately, elected officials, coaches, teachers, irrigators, and employees became enthusiastic recycled water ambassadors. When the Board publicly announced plans to use recycled water, these leaders responded to questions and concerns from their patrons and publics. This response resolved concerns and recycled water use was embraced by the community. The campaign created community ownership and pride in Cheyenne's recycled water system.

The objectives of this program are:

- Communicate that recycled water is a drought-resistant source of water for irrigating parks, athletic fields, and green spaces.
- Describe the safeness of recycled water.
- Reinforce the Board's reputation as the source of water quality.
- Embrace Cheyenne's water heritage by communicating that the search for, and innovative use of, water is part of Cheyenne's history and is a common part of living in the arid West.

Agency

City of Cheyenne Board of Public Utilities

Project Status

2005 – Ongoing

Targeted Use Sector

Commercial, Industrial, and Institutional indoor and irrigation: park patrons, sports organizations, schools, recreation users, and elected officials

Estimated Annual Savings

510 acre-feet per year

Estimated Annual Cost

$737,500 (annualized capital investment plus operation and maintenance cost)

Estimated Unit Water Cost

$1,446 per acre-foot per year

Key Program Elements

- Successful outreach curriculum to educate end users and residents to use Cheyenne's water resources wisely by irrigating with recycled water
- Collaborative decision-making process bringing contractors, subcontractors, consultants, regulators, State Revolving Fund, and local representatives together prior to beginning the project for successful planning
- Use of community leaders, coaches, and employees as ambassadors of large-scale reuse programs during the development phase - these groups are considered experts by the general public

Recycled Water Sign at Dutcher Field
Source: City of Cheyenne Board of Public Utilities

Main Program Elements

Costs

Project funding was provided by the City of Cheyenne Water and Sewer Enterprise Funds, Wyoming State Loans, and Wyoming State Grants. Debt service on the loans is paid using revenue provided by water and sewer sales. The implementation timeframe included the following:

- 2002: Drought impacts Cheyenne's water system and improvements planned for the wastewater treatment plants to meet increasingly stringent discharge requirements.
- 2005: Public information and outreach campaign launched.
- 2006: Class A reuse capabilities added to Crow Creek Water Reclamation Facility.
- 2007: Phase I of recycled distribution system constructed and first recycled water delivered.
- 2009: Recycled distribution system expanded.

The cost associated with the construction of the plant and public outreach are shown below.

Construction and Outreach	Cost ($ million)
Information and Outreach	0.06
Treatment capabilities at Crow Creek Water Reclamation Facility	5.77
Phase I of distribution system	5.76
Phase II of distribution system	1.72
Total (through 2013)	13.31

Level of Participation

The information and outreach campaign was selected as the 2008 WateReuse Public Education Program of the Year by the WateReuse Association.

The recycled water system received the EPA Region 8 Performance and Innovation in the State Revolving Fund Creating Environmental Success (PISCES) award in 2006.

Program Outcomes

Water Savings

As of the end of 2013, Cheyenne's recycled water system irrigates approximately 300 acres of parks, athletic fields, and green spaces. The system produces up to 3 million gallons of Class A water per day reducing demand on potable water sources by 4 percent. Since startup in 2007, the recycled water system has saved 2,900 acre-feet of drinking water.

Program Challenges

- Funding for system expansions

Sources

- Clint Bassett, Water Conservation Specialist, City of Cheyenne Board of Public Utilities
- WateReuse Press Release, September 17. 2008, WateReuse Presents Annual Awards in Dallas, retrieved from: https://www.watereuse.org/information-resources/press-room/news-releases/news_091708
- EPA, Performance and Innovation in the SRF Creating Environmental Success (PISCES) Award, 2006, retrieved from: http://water.epa.gov/grants_funding/cwsrf/upload/2006_11_14_cwfinance_cwsrf_final_2006pisces.pdf

Case Study 14

Distribution System Replacement and Repair

City of Tempe, Arizona

Program Overview

The City of Tempe has implemented a comprehensive water audit and loss control program per standards set forth in the American Water Works Association (AWWA) M36 manual. All water consumption and loss within the city system is identified, measured, and verified. Detailed reporting of all water supplies, deliveries, and losses is submitted annually to the Arizona Department of Water Resources, per state requirements. Advanced billing system software includes checks and balances, flagging potential problems that are investigated and resolved by staff.

Accounts exhibiting abnormal patterns in water use, which might indicate leaks, excessive water use, or other problems, are identified and customers are notified and provided direct assistance by city staff to address the problem. The city regularly tests, repairs, and replaces water meters for the system's 43,000 connections (100 percent metering is required under state law). The city maintains a goal to replace all meters, residential and commercial, every 10 years. A program is currently underway to replace all the city's analog meters with Automatic Meter Readers within 5 years. Also, system pressure is monitored in real-time by a supervisory control and data acquisition (SCADA) system and managed around the clock to ensure it is maintained steadily across the system at 55 to 60 pounds per square inch.

Since 2002, the city's program has included a rigorous and methodical audit of 1,000 miles of mains, valves, and hydrants to assess system efficiency and uncover and eliminate losses. The process occasionally identifies leaks in customer service lines as well. At a minimum, the entire system is completely surveyed at least once every 10 years. As funding is available, additional miles are surveyed. 200 to 250 miles of the distribution system are audited annually and repairs are completed as necessary. The program pays for itself by recovering revenue that would have otherwise been lost.

Agency

City of Tempe

Project Status

2002 – Ongoing

Targeted Use Sector

Losses and Other Non-Categorized Use

Estimated Annual Savings

78 acre-feet per year (average value, savings varies depending on miles audited and volume of leaks. Approximately 0.59 acre-feet /audited mile)

Estimated Annual Cost

Estimated $35,000 for contractors plus the utility staff, resulting in approximately $360/mile or $36,000 - no initial investment required

Estimated Unit Water Cost

$462 per acre-foot per year

Key Program Elements

- Potential leak problems are flagged using advanced billing system and system pressure monitoring
- Partial system audits uncover potential savings and to make the case to continue the effort
- Program enables ongoing annual savings and essentially pays for itself through avoided revenue loss
- Hydrants have been identified as a key source of leaks

Using a Correlator Microprocessor Unit to Determine Leak Location

Source: M.E. Simpson Co., Inc.

Main Program Elements

Costs

The water utility department budgets $35,000 annually for the contract to audit the system. On average, approximately 130 contractor staff-hours are required to complete 100 miles.

Implementation Resources

The city currently contracts with a technical service company providing leak survey programs, large meter testing and repair programs, water main location, valve assessment, and computer mapping programs.

Surveys are conducted using state-of-the-art equipment. The leak detection systems are electronically enhanced listening devices that can determine the exact location of leaks in the pipeline network. All hydrants and accessible valves are used as listening points to identify leaks.

Level of Participation

Since the inception of the program, the city has covered the complete system. Every year fire hydrants that have not been closed properly and minor leaks are discovered. All leaks are addressed quickly, and fire hydrants are closed properly or replaced. From 2002 through 2013, 1,569 miles of the city's distribution system were audited and repairs were made to address losses. The city has committed to continuing to audit the entire 1,000 miles of its system, at a minimum, every 10 years, surveying as much as 20 percent or more of the distribution system annually.

Program Outcomes

Water Savings

Audits conducted between 2002 and 2013 resulted in a total estimated savings of 303,561,000 gallons (932 acre-feet) derived from 738 leaks detected and repaired within the 1,569 miles of the city's distribution system. Annual savings during that same period varied due to the number of miles audited and the number and volume of leaks identified. For the 12-year period, an estimated average of 25.3 million gallons have been saved annually. The table below shows the estimated savings by year since program inception.

Year[1]	Number of Miles Audited	Staff Hours	Number of Leaks Detected[2]	Estimated Annual Savings,afy[3]
2002	78.2	112	63	42
2003	71.5	97	63	194
2004	72.3	1111	84	18
2005	201.5	314	90	94
2006	193.7	217	138	127
2007	202.9	189	82	92
2008	69.2	71	8	8
2009	89.1	100	41	67
2010	130.0	2001	43	419
2011	50.0	771	12	23
2012	211.0	3251	28	76
2013	200.0	3081	86	126

Notes:
[1] Estimated assuming 130 staff-hours are required to complete 100 miles.
[2] Includes consumer side service lines, fire hydrants, and valves.
[3] Estimated based on gallons per day times 365.

Program Challenges

It was apparent from the first 2 years of auditing that the vast majority of leaks were due to fire hydrants that weren't completely closed after exercising or regular use. In 2004, the city's water conservation office purchased $6,000 of sounding equipment for the crew exercising the hydrants to ensure hydrants were properly closed. However, this clearly remains a challenge. At the end of the 12 years, 88 percent of the total leaks were due to leaking hydrants. Over the last 5 years, on average, 95 percent of the leaks were found in hydrants. This is likely because the fire department and others using the hydrants do not have sounding equipment and are not able to independently confirm that the hydrants are fully closed.

Location of Leak	Number	Percent of all leaks
Customer side service line	2	0.3%
Service line	13	1.8%
Valves	75	10.2%
Hydrants	648	87.8%

Sources

- Pete Smith, Water Conservation Coordinator, City of Tempe
- City of Tempe, Water Operations, retrieved from: http://www.tempe.gov/city-hall/public-works/water

Case Study 15

Denver Water Pipe Replacement Program

Denver Water, Colorado

Agency
Denver Water

Project Status
2003 – Ongoing

Targeted Use Sector
Losses and Other Non-Categorized Use

Estimated Annual Savings
There is no measurable metric available to estimate the reduction in pipe breaks using the proactive replacement method. Overall, there is the potential to save roughly several thousand acre-feet by reducing system losses. While the primary purpose of the proactive approach is to reduce inconvenience caused by main breaks, this new approach is expected to save more water per dollar spent on replacements compared to the traditional pipe replacement approach.

Estimated Annual Cost
$4 million for the proactive pipe replacement program

Key Program Elements

- Proactive system for pipe replacement
- Use of GIS system and statistical method to assign a risk score to each pipe segment in system
- Investment of 10 percent of total funds for capital programs on pipe replacement program

Program Overview

Denver Water has 2,428 miles of water main pipes in its water distribution systems, serving 1.3 million customers with drinking water. This major asset needs to be managed to minimize problems caused by pipe breaks. Compared to ongoing leaks that usually do not reach the surface, pipe main breaks can cause large holes and surface flows that not only interrupt water service but also cause traffic disruption, local damage, and other inconveniences, and are a significant loss of water. All water utilities suffer pipe breaks and have various methods for replacing pipes over time to reduce the impacts from breaks.

Since the 1970s, Denver Water has used a common "reactive" system based on actual previous breaks in a pipeline to determine which pipelines and segments of pipelines would be replaced to reduce break problems. In 2013, an innovative, "proactive" pipe replacement system was added to complement the ongoing reactive program.

Main Program Elements

Costs

The current cost of pipe replacement is about $770,000 per mile ($145 per foot). Denver Water crews install or replace an average of 60,000 feet of pipe a year. Depending on budget availability, the goal is to increase pipe main replacement by 3,500 feet per year for the next several years. The annual budget for pipe replacement is about $9 million. This is about 10 percent of the total funds for capital projects.

Implementation Resources

The proactive system uses a GIS system and statistical methods to estimate the probability of breakage, assess the consequences of breakage, and assign a risk score to each pipe segment in the distribution system. The probability of breakage is estimated from a statistical analysis of breaks of pipes of similar age and type of materials. The consequences of breakage are estimated from pipe location factors including how many and what type of customers would be affected by a break, the pressure within the pipe, traffic loading of the roadway, and any critical customers who would lose water service due to a break.

Level of Participation

The proactive main replacements make up about one-half of Denver Water's total annual pipe replacements. Crews install or replace an average of 60,000 feet of pipe a year. Depending on budget availability, the goal is to increase pipe main replacement by 3,500 feet per year for the next several years.

Program Outcomes

Water Savings

The new, proactive approach has substantially reduced the number of breaks in pipe mains and the problems caused by breaks, including the loss of water. So far there is not a measurable metric available to estimate the reduction in pipe breaks using the proactive method. Therefore a water savings estimate is not possible. There is an overall potential to save several thousand acre-feet per year through reducing water system losses. While the primary purpose of the proactive approach is to reduce the inconveniences caused by main breaks, it is expected to save more water per dollar spent on replacements compared to the traditional pipe replacement approach.

Program Challenges

- Aging distribution system that required increasing maintenance expenditures to maintain current standards and stringent regulations.
- Need to increase replacement and rehabilitation rates to keep up with its aging infrastructure.
- Rise of future maintenance needs with aging infrastructure. Deferral of replacement may mean an increased incidence of leaks, unscheduled disruption of service, and damage of property.

Sources

- Denver Water, Pipe Replacement, retrieved from: http://www.denverwater.org/WaterServiceSupport/TroubleshootingRepairs/PipeReplacement

Case Study 16

Provo Reservoir Canal Enclosure Project

Central Utah Water Conservancy District, Utah

Program Overview

The Provo Reservoir Canal Enclosure Project (PRCEP) consisted of the installation of 21 miles of 126-inch pipe to enclose the entire length of the canal and made minor modifications to the diversion from the Provo River into the canal. Two major siphons and the turnouts for users were replaced. Metering stations were installed to accurately report water usage.

Main Program Elements

Costs

The PRCEP was jointly funded by Provo River Water Users Association, Jordan Valley Water Conservancy District, Metropolitan Water District of Salt Lake and Sandy, and the Central Utah Water Conservancy District (CUWCD). A portion of the funding from CUWCD came through the Central Utah Water Completion Act Water Conservation Credit Program (WCCP), which receives federal funding through the Department of the Interior. The final cost of the PRCEP was $150 million. Under a Master Agreement for the PRCEP, CUWCD provided 50 percent of the cost, with $39 million of CUWCD's portion coming from the WCCP.

Implementation Resources

To facilitate construction of the pipeline, cooperating agreements were necessary with among the funding partners.

Level of Participation

The agencies worked closely together to formulate, design and construct the canal enclosure. Along with funding, the agencies provided technical expertise to the project.

Program Outcomes

Water Savings

The Master Agreement for the PRCEP provided that the water conserved by the project (8,000 acre-feet in average annual seepage savings) will be turned back to the Department of Interior through the WCCP for fishery flows in the Lower Provo River. The 2013 water year resulted in 11,185 acre-feet conserved.

Agency
Provo River Water Users Association

Project Status
In operation, constructed March 2010-April 2013

Targeted Use Sector
Losses and Other Non-Categorized Use

Estimated Annual Savings
8,000 acre-feet per year

Estimated Annual Cost
Initial Investment: $150 million

Operation Cost
Data not yet available, limited operational history

Key Program Elements

- Converted open channel canal to 126-inch steel pipe
- Water conservation
- Canal safety, security
- Conserved water used for endangered fish
- Reliable water delivery
- Restore canal capacity
- Improved water delivery efficiency

Provo Reservoir Canal Enclosure Project
Source: Jordan Valley Water Conservancy District

Program Challenges

- Large-scale construction project.
- Up-front capital costs.
- Maintaining water deliveries during construction.

Sources

- Heather Anderson, Public Information Officer, Central Utah Water Conservancy District
- Provo River Water Users Association, Provo Reservoir Canal Enclosure, retrieved from: http://www.prwua.org/master-plan-of-system-improvements/featured-project-prcep.php

Case Study 17

Conserve2Enhance™

University of Arizona, Arizona

Entities

University of Arizona Water Resources Research Center, Tucson Water, Sonoran Institute and Watershed Management Group

Project Status

2011 – Ongoing; Tucson C2E Pilot: 2011-2013

Targeted Use Sectors

Residential, Commercial, Industrial, & Institutional, Residential Irrigation, Commercial & Industrial Irrigation

Estimated Annual Savings

8.2 acre-feet in 2014 by 100 residential and commercial C2E participants

Estimated Annual Cost

Varies by community; about 15 percent FTE staff time

Key Program Elements

- Voluntary water efficiency program that links municipal water conservation with environmental benefits
- Well received by locals as the program ensures water savings benefit the community
- Provides funding for local and regional enhancement projects

Program Overview

Conserve2Enhance™ (C2E) connects voluntary water conservation to community action by linking participant donations, based on their water savings, to funding for environmental enhancement projects. Participating homes and businesses create accounts on the free C2E Water Use Dashboard (www.conserve2enhance.org) to track their water use, learn conservation tips, and donate to the C2E program of their choice. The Dashboard provides a suggested donation, but C2E participants are able to donate more or less than the suggested donation or set up a recurring donation. Projects funded through C2E are based on community priorities and can range from securing instream flows to green infrastructure development to riparian restoration. Working with utilities, non-governmental organizations, and businesses, C2E directly engages residential and commercial water users to save water.

The University of Arizona Water Resources Research Center (WRRC) developed and currently manages the C2E program. WRRC offers use of a C2E Program Development Toolkit, the C2E Water Use Dashboard, and technical assistance to communities and organizations interested in crafting their own program. C2E has been helping make conservation count since 2011, when a pilot program was launched in Tucson, Arizona through collaboration between the WRRC, the local water utility Tucson Water, and nonprofits Sonoran Institute and Watershed Management Group (WMG). Since that time, formal C2E programs have developed in Tucson and four other communities throughout the Southwest. This case study focuses on information from the Tucson C2E pilot (2011-2013); visit www.conserve2enhance.org to learn about all active C2E programs.

Main Program Elements

Costs

Funding for the WRRC's C2E program has been provided by Reclamation and the Walton Family Foundation to develop the program concept, marketing materials, and the C2E Water Use Dashboard. An initial program investment of $650,000 allowed C2E to develop a C2E Program Development Toolkit and the C2E Water Use Dashboard, as well as offer technical assistance to communities. The Tucson C2E pilot program benefited from these resources, which were made available to the community at no cost.

During the pilot phase of the Tucson C2E program, community project funding was raised from an "Open Space and Riparian Enhancement" check box on the Tucson Water bill as well as direct C2E participant donations made to WMG. Combined check box and participant donations between 2011-2013 raised nearly

$40,000 for Tucson C2E and supported an annual grant program. The average annual water savings achieved by Tucson C2E pilot participants (residential users only) was 21,000 gallons per household. This led to participants achieving an annual water bill savings of $47.40 per household, which they were then encouraged to donate to the Tucson C2E program. Moderate staffing was needed for operation of the pilot program; this continues to be true for the fully implemented Tucson C2E program, which presently utilizes the Tucson Water check box as well as the C2E Dashboard's integrated donation portal to raise funds. The annual cost of developing a C2E program will vary depending on the organizational structure established, existing partnerships, and identified priority projects.

Implementation Resources

Laying the foundation for a C2E Program takes approximately six months to one year; program development involves establishing a local program manager, a fiscal agent, and priority projects. Once the program is in place using the C2E Water Use Dashboard, a program requires staff time to message participants, run data queries, and, if partnering with a local utility, upload water use data. Staff time may be needed to market the program to water customers and can vary depending on existing partnership and project opportunities. The Tucson C2E pilot program development was resource intensive, but new C2E programs can expedite the process by utilizing the C2E Program Development Toolkit. This newly developed resource allows programs to achieve a much lower estimated unit water cost than the Tucson C2E program.

Level of Participation

The Tucson C2E pilot program has been well received, and a growing number of communities throughout the Colorado River Basin have begun to develop their own C2E programs to encourage conservation. For the Tucson pilot program, around 850 participants donated to the local C2E fund through the Tucson Water bill check box or as active C2E participants to WMG.

Program Outcomes

Water Savings

Since the development of the Tucson C2E pilot program, C2E participants employing conservation strategies ranging from behavioral changes to rainwater harvesting installations have conserved 20 acre-feet of water and supported seven community-led environmental enhancement projects.

Program Challenges

- Water customer messaging to build the connection between water conservation and enhancements that benefit the community.
- Gaining endorsement by municipalities.
- Identifying opportunities for local environmental enhancement.

Sources

- Brittany Xiu and Kelly Mott Lacroix, University of Arizona, Water Resources Research Center
- Conserve2Enhance, retrieved from: www.conserve2enhance.org

Case Study 18

High Efficiency Clothes Washers

Eastern Municipal Water District, California

Program Overview

In 2010, the Eastern Municipal Water District EMWD, implemented a program to help fund the installation of high-efficiency clothes washers through the Southern California Gas Company (SoCalGas) energy savings assistance program. Through this program, EMWD, in partnership with Reclamation and the Metropolitan Water District of Southern California (MWD) helped retrofit 1,700 clothes washers for low income households in EMWD's service area.

Main Program Elements

Costs

The program was funded through Reclamation's WaterSmart Water and Energy Grant, and through the MWD-funded, Member Agency Administered funding program. EMWD and SoCal Gas coordinated on advertising the program, identifying customers, and encouraging participation. EMWD also verified the EMWD retail customers with washers installed and complete reporting and invoice requirements for MWD and Reclamation. Total project costs were $1,236,257 during the period of 2010-2013.

The Reclamation grant agreement was completed in June 2013. Now EMWD has moved forward to continue offering supplemental funding for water saving devices installed through the SoCalGas energy savings assistance program. Currently, EMWD and SoCal Gas are updating their agreement.

Implementation Resources

- Staff time to administer invoices.
- Agreement between agencies.
- Budget.
- No marketing required by water agency.

Level of Participation

Approximately 6 percent of eligible homes in Riverside County have participated.

Agency
Eastern Municipal Water District

Project Status
2010- 2013

Targeted Use Sector
Residential Indoor

Estimated Annual Savings
57.8 acre-feet per year for 1,700 Washers

Estimated Annual Cost
$412,100

Estimated Unit Water Cost
$1,528 per acre-foot per year

Key Program Elements

- Water and energy savings
- 20 percent water savings by 2020 requirement
- Creates partnership between water and energy agencies
- Assists low-income families

Residential High Efficiency Clothes Washer
Source: Eastern Municipal Water District

Program Outcomes

Water Savings

The program replaced washers that use an average of 42 gallons or more per 3-cubic-foot load of clothes, with high-efficiency clothes washers that use a maximum of 12 gallons for the same size load. The project produced a quantifiable reduction of demand by single-family residential customers participating in the program of 57.80 acre-feet per year.

Program Challenges

- Lengthy agreement process.
- Customer data reconciliation (for example, customers may be on well).
- Multiple water agencies within Gas Company's boundary.

Sources

- Elizabeth Lovsted, Program Manager
  Eastern Municipal Water District
- Eastern Municipal Water District, Residential Programs & Rebates, retrieved from: http://www.emwd.org/use-water-wisely/residential-programs-rebates
- SoCalGas Energy Savings Assistance Program, retrieved from: http://www.socalgas.com/for-your-home/assistance-programs/esap

Case Study 19

Innovative Conservation Program

The Metropolitan Water District of Southern California, California

Program Overview

The Innovative Conservation Program (ICP) began in 2001. This competitive grant process provides a way to have water saving ideas from entrepreneurs and water agencies evaluated against one other. The ICP is open to everyone including colleges, universities, entrepreneurs, and water agencies. It is available throughout The Metropolitan Water District of Southern California (MWD) service area and beyond, and applications are accepted from inside and outside the U.S. For the 2013/2014 cycle, the program partners with Reclamation, the Southern Nevada Water Authority (SNWA), and the Central Arizona Project. The goal is to test new technologies and theories; if they prove out, then they are added to the MWD rebate program.

The ICP provides funding in cooperation with Reclamation, SNWA, and the Central Arizona Project for research that will document water savings and reliability of innovative water-saving devices. The objective is to evaluate the water-saving potential and reliability of innovative water-saving devices, technologies, and strategies.

New projects are identified and evaluated every other year. The next round of funding is scheduled for July 2015. All interested parties including public, private, or non-profit organizations are eligible for funding.

Main Program Elements

Costs

Funding consist of MWD contributions of $250,000 per grant cycle (every other year), $100,000 from Reclamation, $50,000 from SNWA and $50,000 from CAP. Total funding for this round of ICP was $450,000.

Implementation Resources

The grant, which is open for a few months, is advertised by MWD, Reclamation, SNWA, and the Central Arizona Project to their customers. Grant applications are filled out online. When the grant period closes, the applications are reviewed and scored by an independent panel made up of the funding partners and outside groups including NGOs. The projects rated highest by the panel are funded.

Agency

The Metropolitan Water District of Southern California

Project Status

2013/14 ICP Grant completed; fifty applications received and 13 projects selected; contracts vary from 1 to 2 years, depending on the project

Targeted Use Sector

2013/14 grants targeted landscape and commercial projects; however, all projects were accepted - each round of grants may target different areas

Estimated Annual Cost

$125,000 ($250,000 per grant cycle) for MWD

Key Program Elements

- Because the program is applicable in every state, other states are joining the program. Smaller states or water agencies can have smaller grant amounts - agencies can target grant to any specific areas
- New technologies have emerged from the ICP grant program and into the mainstream rebate program; examples include connectionless food steamers, x-ray film processing, water brooms, and irrigation nozzles

ICP
INNOVATIVE CONSERVATION PROGRAM
Metropolitan Water District of Southern California

Level of Participation

During the 2013/14 ICP grant period, 50 applications were received requesting more than $2 million. Since 2001, the MWD has funded more than $1.5 million in grants.

Program Outcomes

Program Challenges

- Contract management

2013 Innovative Conservation Program Awarded Projects

Project Title	Entity	Project Description
Biochar: Waste-to-Energy by Product	California Turf Grass and Landscape Foundation (Non-Profit)	Study the effectiveness of BioChar as a soil amendment that reduces irrigation needs. BioChar is a charcoal by-product of waste-to-energy conversions.
CII water audit mobile application and web based database (AquaDx)	Proteus Consulting	Study the effectiveness of a new mobile application that performs commercial water use audits both indoors and outdoors.
Conserving Water Using Aqua Smart	AquaSmart Enterprises (Business)	Study the water savings of AquaSmart, a polymer coated sand that holds water around the root zone.
Evaluating rain water harvesting conservation savings and strategies in coastal regions	Santa Monica Bay Restoration Foundation (Non-Profit)	Study of comprehensive rainwater harvesting approaches used in residential sites.
Hydrogels Injected Below the Root Zone of Existing Turf	Aqua Cents Management (Business)	Study the water saving of a hydrogel that is injected underneath existing turf potentially
Development and Evaluation of a Landscape Drip Schedule Application	University of Arizona (Higher Education)	Develop a computer program that assists customers in scheduling their drip irrigation systems for trees and shrubs.
Landscape Water Savings using SoilFoodWeb BMP	Green Gardens Group (Business)	Study the effectiveness of Actively Aerated Compost Tea (AACT) as a soil amendment that reduces irrigation needs. AACT is a byproduct of composting with worms.
Nexus reCycler Innovative Grey Water Treatment and Resuse System	NEXUS eater (Business)	Study the effectiveness of the first whole home greywater system that adheres to California Plumbing Code.
ECCO wireless soil moisture sensors	Digital Spring (Business)	Study effectiveness of a novel moisture sensor that is wireless, enclosed in plastic, shaped like a spike for easy install and regulates irrigation per zone.
Plant sensing approach to improving irrigation in agriculture	Fruition Sciences (Business)	Study the water saving potential of a sensor for vineyards plants that bases irrigation on sap flow through plant.
Project Pressure Regulating Stem (PRS)	Rain Bird Corporation (Business)	Study the effects of pressure regulation on rotors and spray heads in "real world" scenarios.
High Efficiency Conveyer Dishwater Study	Fisher-Nickel (Business)	Study the water savings potential of a conveyer dishwashing product with optimized spray nozzles and multiple rinse stages.
Sprinkler Flow Control Study	Sprinkler Flow Control (Business)	Study the savings of a product that reduces over-pressurization and breakage of irrigation nozzles.

Sources

- William P. McDonnell, The Metropolitan Water District of Southern California
- The Metropolitan Water District of Southern California, bewaterwise.com, retrieved from: http://www.bewaterwise.com/icp.html

Case Study 20

Albuquerque Bernalillo Water Conservation Program

Albuquerque Bernalillo County Water Utility Authority, New Mexico

Program Overview

The Albuquerque Bernalillo County Water Utility Authority (ABCWUA) began this program in 1995 with a per capita use of more than 250 GPCD; the per capital use is now 134 GPCD. The program targets all customer classes and is a blend of mandatory measures and incentive programs. Rebates are offered to all customer classes for reducing indoor and outdoor water use through high-efficiency toilets, xeriscape, washing machines, rain barrels, and more. Residential construction since 1995 is allowed only 20 percent of the irrigable area of the lot to be planted in high water use (sprinkler-irrigated) plants. New non-residential is prohibited from installing turf. The ABCWUA uses a tiered rate structure during the irrigation season from April through October that increases as water use increases. The objective of all programs is to reduce overall water use and thus build up the groundwater supply. Particular emphasis is placed on consumptive (outdoor) water use.

Main Program Elements

Costs

The annual budget is $1.3 million which is funded from a dedicated rate increase to customer water bills. $1 million is returned to customers annually as rebates and remaining funds are for advertising, public relations, and K-12 education programs.

Level of Participation

All customer classes participated in the conservation efforts, including residential, commercial, multi-family, industrial, institutional, and irrigation-only. Residential customers have already reduced their water use by more than 40 percent and will be expected to contribute less to future conservation efforts. About 23 percent of customers have participated in a least one aspect of the conservation program. To continue to reduce water consumption, educational outreach efforts will need to increase.

Program Outcomes

Water Savings

Since 1995, the ABCWUA has decreased customer consumption from 250 GPCD to 134 GPCD.

Agency
Albuquerque Bernalillo County Water Utility Authority, New Mexico

Project Status
1995 – Ongoing

Targeted Use Sectors
Residential, Commercial, Industrial, Institutional and Irrigation

Estimated Annual Savings
82,859 acre-feet per year

Estimated Annual Cost
$1,400,000 (operation costs)

Estimated Unit Water Cost
$661 per acre-foot per year

Key Program Elements

- Since 1995, the program has helped decrease consumer consumption rates from 250 to 134 GPCD
- Uses a blend of mandatory requirements and incentive programs
- Program success is directly linked to customer education and involvement - using a broad range of customer education campaigns has helped achieve success
- Program success is evaluated annually based on water savings achieved both overall and by customer class
- The University of New Mexico Department of Economics conducted a study on the efficiency of individual rebate programs; the conservation program was retooled based on the results

Providing rebates for replacement of turf with desert-friendly plants (i.e., xeriscaping) is just one way the Water Authority is encouraging conservation in its service area.
Source: Albuquerque Bernalillo County Water Utility Authority

In addition, peak daily demand has been reduced from about 205 million gallons per day to about 143 million gallons per day since 1995. 27 billion gallons are saved annually (82,859 acre-feet) when compared to annual water use without conservation. Cumulative water savings exceed 280 billion gallons (859,288 acre-feet) since the program began. Participation and water savings has been highest among residential users, followed by commercial and multi-family customers.

Program Challenges

- Ensuring steady revenue while continuing to reduce water usage.
- Maintaining the tree canopy while encouraging a reduction on outdoor water use.

Sources

- John M. Stomp III, Chief Operating Officer, Albuquerque Bernalillo County Water Utility Authority
- Albuquerque Bernalillo County Water Utility Authority, Conservation and Rebates, retrieved from: http://abcwua.org/Conservation_and_Rebates.aspx

Case Study 21

City Rebate and Water Bank Program

City of Santa Fe Water Division, New Mexico

Agency

City of Santa Fe Water Division, Water Conservation Office

Project Status

2010 – Ongoing

Targeted Use Sectors

Residential, Commercial

Estimated Annual Savings

7.6 acre-feet (2011-2013 average)

Estimated Annual Cost

$350,000

Key Program Elements

- Rebate aspect of program was grant funded in first year, enabling larger dollar amounts rebated and higher participation numbers
- Targeted marketing should be done to ensure continued participation in program
- Water saving credits are deposited in the City's Water Bank and may be allocated for programs including affordable housing, the "living river" and may also be available for purchase by developers

Program Overview

The Water Conservation Rebate aspect of the City of Santa Fe Water Bank Program quantifies and "banks" water savings garnered from water conservation rebates. The program provides reimbursement for replacement of existing fixtures with new, high-efficiency fixtures. Currently, the program provides rebates for high-efficiency toilets, Tier 3 washing machines (highest level of water use efficiency issued by the Consortium for Energy Efficiency), waterless urinals, and rainwater harvesting.

The intent of the program is to increase system-wide conservation to facilitate offsetting impacts on the city's water supply system from new development and to supply water for other municipal uses by replacing less efficient uses with higher-end water saving devices and appliances. This program applies to City of Santa Fe Water Utility customers. Water saving credits derived from this program are deposited in the City's Water Bank and may be allocated for programs including affordable housing and the "living river." Some of the credits may also be available for purchase by developers.

Main Program Elements

Costs

Although a rebate program existed prior to 2010, the program was revamped with funding in part with a grant from the American Recovery and Reinvestment Act of 2009, and per Resolution 2010-20, the water savings resulting from the new rebate program were banked. The initial program ended in July 2010 due to depletion of funds. The program was reestablished in fiscal year 2010/2011 using funding from the City's Water Conservation Fund that is funded through an annual charge to all customers in the city's service area. The city has invested approximately $1.3 million in this project since 2010. All of this funding has come directly from grants or from the water conservation fund mil-levy. The city allocates about $350,000 per year for this program, which includes the credited amount of rebates awarded to customers and the direct marketing and outreach budgeted. Not included in the cost estimates is budget for dedicated staff time to process rebates.

Implementation Resources

The program is marketed through fairly standard channels: the city website, the Water Conservation Office website, print ads, press releases, and community outreach at water-related events.

Local retailers provide support by allowing the Water Conservation Office to place information and rebate forms in their stores. Retailers are trained by Water Conservation Staff about terms and conditions of rebate programs.

The Water Conservation Office has worked with managers of several large commercial customers, primarily in the hotel/ motel industry, to facilitate large projects requiring replacement of more than 50 toilets or the installation of water recycling systems found at commercial laundries. Additional resources needed for this effort includes staff dedicated to implementation of these tasks and effective public outreach, both purchased and earned media.

Level of Participation

A total of 2,425 water division customers have participated in the program over the last 3 years. Both residential and commercial customers have participated. The success of these efforts is manifested in a steady year-over-year decline in annual gallons per capita per day use rates.

Program Outcomes

Water Savings

The program has resulted in a total water savings of 55.26 acre feet since 2010:

- 2010: 32.4626 acre-feet (primarily due to American Recovery and Reinvestment Act of 2009 funding to support this rebate. The State of New Mexico also offered a rebate for clothes washers so customers were allowed to take advantage of both rebates at the same time).
- 2011: 9.0402 acre-feet
- 2012: 7.1504 acre-feet
- 2013: 6.6061 acre-feet

Banked water can be used for three main purposes:

- Santa Fe's "Living River" program, set via ordinance allocates 1,000 acre-feet of water to be used for summertime flows in the river.
- Conserved water from rebates are used for affordable housing developments within Santa Fe.
- The banked water can be purchased by independent developers to offset water use for new developments.

Program Challenges

- Continued promotion and increased participation.
- Need for improved rebates processing and documents management systems.
- Continued coordination between Water Division and Land Use staff on the amount of water allocated to the bank.
- Water bank challenges include adequacy of consistent and accurate record keeping and database management.

Sources

- Laurie Trevizo, Water Conservation Manager, City of Santa Fe
- Save Water Santa Fe, Water Conservation Rebates and Incentives, retrieved from: http://savewatersantafe.com/rebates

Case Study 22

Cash for Kitchens

West Basin Municipal Water District, California

Program Overview

In 2009, the West Basin Municipal Water District (WBMWD) was awarded funding by The Metropolitan Water District of Southern California (MWD) under the Enhanced Conservation Program to create Cash for Kitchens (C4K or the Program), specifically designed to address inefficiencies and to increase water awareness and water efficiency in the food service sector. West Basin, together with the South Bay Environmental Services Center (SBESC) and funding partner, the Water Replenishment District of Southern California, provide restaurants and other food service facilities (corporate kitchens and hotels) with a water-use assessment. The assessment provides information about current water usage, strategies on how to conserve water, and free materials to assist management in training their employees to be more water-efficient.

The program offers free audits and free high-efficiency devices such as faucet aerators, faucet-flow restrictors, pre-rinse spray valves, and water brooms to replace older, high-volume equipment and to improve indoor and outdoor cleaning practices. Program auditors also provide water and energy rebate information related to commercial kitchens/restaurants and training materials, including a water efficiency manual and a poster with tips on low-cost and no-cost ways to save water.

Main Program Elements

Costs

In 2012, an average of 5 to 7 hours per week for an annual total of about 315 hours were spent administering the program by scheduling visits, performing audits and follow-up, and maintaining the inventory of devices and other items such as the training poster. The annual budget for the entire program is about $40,000 including labor and materials.

The program was initially funded with seed money from MWD and a match from WBMWD. This grant paid for the water-saving devices as well as the development of marketing and outreach materials. Now that the materials are created, the program is relatively

Entities

West Basin Municipal Water District, South Bay Environmental Services Center, Southern California Gas Company, City of Torrance Municipal Water Department

Project Status

2009 - Ongoing

Targeted Use Sectors

Commercial, Industrial and Institutional

Estimated Annual Savings

Approximately 25 acre-feet per year (2010-2013 average)

Estimated Annual Cost

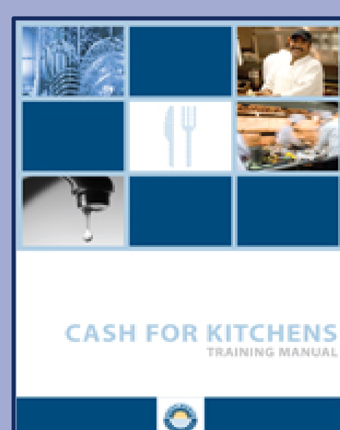
$40,000 (initial investment, no operational cost included)

Estimated Unit Water Cost

$360 per acre-foot per year

Key Program Elements

- Successful means of outreach to a targeted business sector - well suited for areas with large commercial kitchen sector
- Visits scheduled for 60 minutes within optimal timeframe for food service sector; visits are conducted in both English and Spanish and are documented with photos for website or social media outlets to promote participating businesses
- The direct device distribution method works well with these customers - devices easy to install; Program includes training sessions upon request to encourage behavioral change. Training available in English and Spanish; materials available in English, Spanish and Mandarin.



The program is currently funded by WBMWD. WBMWD pays SBESC for a variety of tasks related to promoting water conservation and efficiency, including administering various aspects of WBMWD's efficiency programs, organizing public outreach events, and running social media campaigns.

Implementation Resources

WBMWD coordinates closely with the SBESC, the City of Torrance, and the Southern California Gas Company (SoCalGas) to implement C4K. Each partner brings a particular expertise to benefit commercial kitchen owners/managers and help them save water, energy, and money. A bilingual outreach strategy developed by the SBESC targets the common Spanish-speaking staff. In 2011, the SoCalGas collaboration brought additional energy efficiency benefits that have greatly improved customers' experience with the program. Further outreach to restaurant associations and Chambers of Commerce helped gain more recognition for the program.

Level of Participation

Between 2009 and 2013, SBESC staff distributed more than 900 devices to more than 250 participants. Additionally, over 70 percent of the audits were combined gas and water audits. C4K has been meeting its goal to audit 75 facilities per year. SBESC staff perform follow-up activities for 20 to 25 percent of all past participating sites annually to gauge program effectiveness.

Program Outcomes

Water Savings

The water savings for the program is estimated to be 28 million gallons from the 900+ devices distributed over the past 4 years. Water savings are assumed as 0.07 acre-feet per year for the faucet aerators and flow restrictors and 0.153 acre-feet per year for the water broom and pre-rinse spray valve.

The pre-rinse spray valve device retrofits alone account for 0.88 million gallons per year, 35 percent of annual program savings, with only 113 devices (11 percent of total retrofit installed). This device uses large amounts of hot water and therefore saves customers both water and energy.

Number of Devices Distributed

Device	Faucet Aerators	Faucet Flow Restrictors	Water-Broom	Pre-Rinse Spray Valve
2009/2010	76	18	19	13
2010/2011	180	62	33	48
2011/2012	154	70	23	34
2012/2013	146	62	25	18
Total	556	212	100	113

Program Challenges

- Convincing owners/managers to change equipment and make other significant changes was difficult due to the economy.
- Time is of the essence in commercial kitchen facilities and the quicker information and devices can be distributed, the better. Recommendations are made and devices distributed to owners/managers during the initial visit.
- The combined water-energy audit is beneficial to customers, but there are limitations to the SoCalGas role. Their participation is currently free; therefore, the realized benefits come at no cost. However, because the water-saving devices are only distributed rather than directly installed, SoCalGas is not allowed to claim the estimated energy savings from those devices. As a result, the benefit of their participation in the program is mostly limited to increased customer satisfaction, greater customer outreach, and reduced staff time. There has been discussion about hiring a third party to install the devices, although this option has been cost-prohibitive.
- Larger, national chain restaurants often require permission from their corporate headquarters to make changes and do not seem as interested in the program.

Sources

- Cash for Kitchens Enhanced Conservation Program Final Report, December 2011, retrieved from: http://www.westbasin.org/files/c4k/west-basin-cash-for-kitchens-final-report-to-mwd-including-appendices.pdf
- Elise Goldman, Water Efficiency/Recycled Water Program Specialist for West Basin Municipal Water District

Case Study 23

Public School Retrofit Program

Eastern Municipal Water District, California

Agency
Eastern Municipal Water District

Project Status
2008 – 2011

Targeted Use Sector
Commercial, Industrial, & Institutional

Estimated Annual Savings
205.6 acre-feet per year

Estimated Annual Cost
$227,000 (not including operation and maintenance costs)

Estimated Unit Water Cost
$379 per acre-feet per year (not including operation and maintenance costs)

Key Program Elements

- Provided direct installation of water efficient devices to 48 schools, at no cost to the schools
- Program goals were to save water, encourage water use efficiency, and remove barriers limiting conservation
- Program was extended beyond the EMWD boundaries; one community college district qualified to participate

Public School Retrofit Program Banner
Source: Eastern Municipal Water District

Program Overview

The Public School Retrofit Program was launched to save water in public schools through the installation of water-efficient devices. The program provided the direct installation of water-efficient devices at no cost to schools. Devices installed include toilets, urinals, faucets, aerators, pre-rinse spray valves, irrigation controllers, and sprinkler nozzles. The program allowed schools to participate in regional conservation programs by eliminating the need for up-front funding and lengthy forms and applications. The program had three goals: save water, encourage water use efficiency, and remove barriers limiting school participation in conservation programs. The program was implemented over a period of 3 years, from August 2008 to August 2011.

Main Program Elements

Costs

The program was jointly funded by Eastern Municipal Water District (EMWD, Reclamation, the CALFED Bay Delta Program, and the MWD with a budget of $670,000. The final program cost amounted to $682,000; of which Reclamation with CALFED contributed $300,000 and the MWD rebates amounted to $262,000. EMWD invested both monetary and in-kind services amounting to $122,000.

Implementation Resources

EMWD staff dedicated more than 300 hours to implementing the program. Staff performed landscape evaluations, shared knowledge of irrigation technology, processed paperwork, and prepared reports for funding partners. Additional partnering with the City of Perris and the Rancho California Water District enabled the program to be extended beyond the EMWD boundaries.

Level of Participation

EMWD staff met with school district facility planners to communicate the goals and objectives of the program. With input from school districts, 11 eligible schools were targeted and 8 schools chose to participate. Each school received a site evaluation, resulting in a list of devices to be installed. Devices selected for installation were based on evaluation results, savings assumptions, lifespan of devices, and average cost per acre-foot saved. Upon completion of the initial eight schools, the program was made available to all schools within the EMWD service area. EMWD staff began educating schools on the benefits of water-efficient technology available to encourage participation in the program. By the end of the program, 48 schools participated, receiving varying combinations of high efficiency nozzles, evapotranspirative controllers, and indoor water conservation devices.

Program Outcomes

Water Savings

Initially, the program estimated water savings for 11 schools receiving indoor and outdoor retrofits at 79.63 acre-feet per year with a lifetime savings of 1,050 acre-feet. After the initial schools were completed, funds were used to retrofit additional schools, primarily focusing on outdoor measures. Outdoor devices included irrigation controllers and high-efficiency sprinkler nozzles. By the end of the program, approximately 30 percent of eligible schools received varying combinations of water conservation devices, with estimated water savings of 206 acre-feet per year and lifetime savings of 2,195 acre-feet.

Program Challenges

- Motivating schools to participate.
- The need to have school staff onsite during device installation affected by the school's ability to participate.

Sources

- Elizabeth Lovsted, Program Manager,
  Eastern Municipal Water District
- Eastern Municipal Water District, Public School Retrofit Program Report, retrieved from: http://www.usbr.gov/lc/socal/reports/PublicSchoolRetrofitRiversideCty.pdf

Case Study 24

National Center for Atmospheric Research – Wyoming Supercomputing Center Conservation Program

Cheyenne, Wyoming

Program Overview

The National Center for Atmospheric Research (NCAR) Wyoming Supercomputing Center (NWSC) was designed with energy efficiency and sustainability in mind, setting it up to be 89 percent more efficient than typical data centers, and up to 10 percent more efficient than state-of–the-art facilitates operating today. Almost 92 percent of the NWSC energy is going directly to its core purpose as a data center powering supercomputers to enable scientific discovery. The design of the NWSC utilized a holistic sustainability approach that went well beyond energy efficiency. The facility implemented a water conservation and efficiency effort that has resulted in a reduction of the total water use by nearly 40 percent over comparable facilities that utilized cooling towers.

Evaporative cooling towers for the Rocky Mountain West region are an exceptionally efficient method for cooling but do evaporate a considerable amount of water. Two primary methods were employed to increase the water efficiency for the NWSC. The first method is a computer-based control scheme (see figure) that allows the facility to optimize water use by sensing outside conditions: on very cold days water simply is cycled outside and does not evaporate at all, on moderate temperature days water runs over the cooling tower but is not forced with fans, and in the heat of summer, the cooling tower behaves like a conventional cooling tower, with fans continuously circulating the air for maximum evaporation. The second method that saves a great deal of water is the implementation of a near-zero blowdown non-chemical water treatment of condenser water. The water treatment system for near-zero cooling tower blowdown is used. The cooling tower water treatment system creates a high total dissolved solids (TDS) and high pH to maintain biostatic conditions without scaling issues. Cooling tower sump sweep piping/nozzles and a filtration system with solids separator with 0.35 micron filtration allows for zero water purge, eliminating impacts on the municipal sewer system and the flushing of towers to maintain TDS and pH.

Agency

National Center for Atmospheric Research

Project Status

2011 – Ongoing

Targeted Use Sector

Commercial, Industrial, & Institutional

Estimated Annual Savings

16.9 acre-feet per year

Estimated Annual Cost

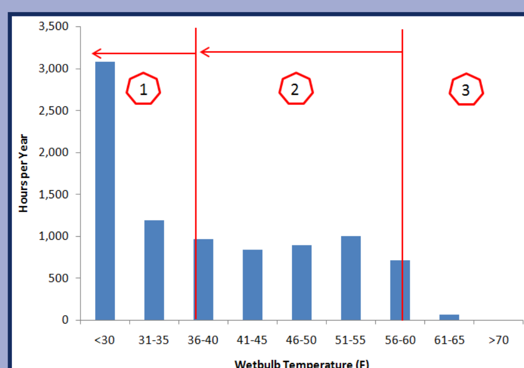
$12,452 (without operation & maintenance costs)

Estimated Unit Water Cost

$738 per acre-foot per year (without operation & maintenance costs)

Key Program Elements

- This project demonstrates and implements technologies that enhance efficiency and have three- to five-year payback periods
- Project reduces cooling energy use by up to 89 percent over typical data center configurations and water use from evaporative cooling towers by 40 percent



Optimization of Water Use based on Outside Temperature

Source: University Corporation for Atmospheric Research

Notes: Region 1: Cooling tower without fans, 46 percent of the year; Region 2: Cooling tower with fans, 48 percent of the year; Region 3: Chiller operates, 7 percent of the year

The objectives of this project are to:

- Reduce cooling energy use by up to 89 percent over typical data center configurations.
- Reduce water use from evaporative cooling towers by 40 percent.
- Ensure that all overhead costs and waste are minimized, assuring value for taxpayer dollars
- Demonstrate and implement technologies that enhance efficiency and have three- to five-year payback periods.

Main Program Elements

Costs

The complete supercomputing facility investment approached $70 million. The total investment for the zero blowdown water treatment system is $ 258,000.

The NWSC is the result of a broad public-private partnership between the University Corporation for Atmospheric Research (UCAR), the State of Wyoming, the University of Wyoming, Cheyenne LEADs and Wyoming Business Council

The implementation timeframe included the following:

- 2008-2009: Design
- 2010: Construction
- 2011: Building completion and commissioning
- 2012: Supercomputing installation and production computing

Implementation Resources

The NWSC is operated by the National Center for Atmospheric Research under sponsorship of the National Science Foundation

Level of Participation

The NWSC has achieved all of the design parameters and in some cases is poised to exceed them. The application of this approach to water optimization can be applied to any industry that has significant cooling requirements ranging from data centers, hospitals and industrial applications.

The facility has been recognized for its sustainable design and operation, including:

- Leadership in Energy and Environmental Design (LEED TM) Gold Certification
- Green Datacenter of the Year 2013 – Data Center Dynamics
- Winner Green Enterprise IT Awards 2013 – Uptime Institute

Program Outcomes

Water Savings

Estimated water savings is about 5.5 million gallons (16.9 acre-feet) of water annually.

Program Challenges

Data centers like many industrial applications tend to be risk averse and want to stay with tried and true technologies. The NWSC offers an example of what can be done with tried and true technologies but applied in a different way.

Sources

- Aaron Andersen, Deputy Director Operation and Services, National Center for Atmospheric Research, Computational and Information Lab
- NCAR-Wyoming Supercomputing Center, green technology, retrieved from: http://www.nwsc.ucar.edu/green
- Water Conservation Technology International, Inc, retrieved from: http://www.water-cti.com/published-papers.html

Case Study 25

Parkway Improvement Districts Water Conservation Program

Town of Gilbert, Arizona

Program Overview

Eleven Gilbert neighborhoods are organized into separate Parkway Improvement Districts (PKIDs) to maintain their own common areas such as parks, retention areas, entryways, and street rights-of-way. The PKIDs include 39.8 acres of turf and 19.8 acres of decomposed granite planted areas.

Partnerships between PKID neighborhoods and Gilbert have resulted in changes to landscaping, playground enhancements, and improvements requested by residents. The PKID conservation program has included water budgeting for irrigation and turf conversion to low-water-use plant material and the retrofitting/replacement of aging irrigation systems to increase efficiency, requiring less water while still maintaining the health of the landscape plant material.

In 2009, the Water Conservation Office and Parks Department personnel partnered to explore whether there were any potential water savings at the PKIDs. The landscape water requirement was calculated based on the square footage of the irrigated areas for each of the PKID communities and compared to historical water use. This allowed consumption to be compared to the anticipated requirement, rather than just what had been used in the past.

A monthly meeting was established to monitor water consumption and identify anomalies at each PKID community. When unexpected water consumption was detected, individual meters and the corresponding irrigation systems were inspected and corrective actions were determined.

In addition to the enhanced water management program already in place, an improvement program included the conversion of 145,716 square feet of turf to low-water-use plant material, and the retrofitting/ replacement of aging irrigation systems was developed to increase efficiency while maintaining the health of the landscape plant material.

Agency
Arizona Coalition Partners

Project Status
2009 – Ongoing

Targeted Use Sector
Commercial & Industrial Irrigation

Estimated Annual Savings
76.7 acre-feet per year

Estimated Annual Cost
$6,360

Estimated Unit Water Cost
$83 per acre-foot per year

Key Program Elements

- Potential water savings from irrigation was tracked by in-house trained personnel, which allowed more control in implementing the program
- Healthy landscape has been maintained while enhancing irrigation efficiency
- Staff performance and service to residents has improved significantly because problems are now more thoroughly identified and investigated

Ryan Morasch, Senior Grounds Maintenance Worker, improving landscape irrigation to achieve the water use reductions.
Source: Town of Gilbert

Main Program Elements

Costs

While Gilbert owns the common area properties, State law requires the Town to levy taxes on all homes in the PKIDs to fund annual expenses to maintain and improve these areas.

PKID projects are funded by taxing neighborhood property owners. The funds for operation and maintenance of the PKID are collected as a special assessment tax district based on the property tax bill. The annual budget amount is developed by staff (including any input from the neighborhood) and then adopted by the Council. An annual mailing to every address in each PKID informs residents about the proposed assessment and the budget. The annual labor cost to run and compile the reports and the Park's personnel time to attend the meetings is estimated to be $6,360. This amount includes salaries only (if full benefit packages were included, it would be approximately double). The operational cost is still considered to be very low.

Implementation Resources

While neighborhoods that are PKIDs may have covenants, codes, and restrictions (CC&Rs), most do not have homeowners associations (HOAs) that are organized to enforce them. As with all land CC&Rs, PKID CC&Rs may be enforced by private individuals. Unlike HOAs, PKID neighborhoods do not own common property and do not hire property management companies to maintain their neighborhoods. The Gilbert Community Services hires and oversees contractors who bid for individual contracts for each of the 11 neighborhoods.

Level of Participation

The eleven Gilbert neighborhoods participating are Cassia Place, Circle G Meadows II, Circle G Meadows III, Circle Ranches VI, Circle Ranches VII, Madera Park, Morning Ridge, Park Village, Spring Meadows, Templeton Place, and Val Vista Park.

Program Outcomes

Water Savings

The calculated water requirement for landscape, based on the square footage for all of the PKIDs, was 49,482,000 gallons per year. The calculated expected water requirements are based on historical weather to account for yearly weather fluctuations and to account for irrigation system hardware malfunctions. The goal is to be within 20 percent of these calculated water requirements. Being within 10 percent of these calculated water requirements is considered to be exceptional landscape water management.

The table below shows the estimated savings by calendar year since program inception.

Year[1]	Water Require-ments[2]	Water Used[2]	Over-irrigation[3]	Water Savings[4]
2010	49.5	55.9	13%	-27%
2011	49.4	50.4	2%	-34%
2012	49.4	51.9	5%	-32%
2013	46.5	47.9	3%	-37%

Notes:
[1] Calendar year
[2] Millions of gallons
[3] Deviation from water requirement estimate
[4] Savings from 2009 water use level

In 2009, 76,552 million gallons of water were used to irrigate the PKID landscapes. The enhanced PKID landscape water management partnership between the Parks Department and the Water Conservation Office has saved a total of 100.2 million gallons from 2010 through 2013. The bulk of the savings (97 percent) was realized by measuring and monitoring water use, as well as quick response to spikes in water use identified in the monthly update meetings. A small portion of the savings can be attributed to the conversion of turf to xeriscape in 2013. In the first year, water use was reduced to be within the standards for effective landscape water management. In the next three years, water use has been managed well into the standards for exceptional landscape water management.

Program Challenges

- Overlap with other conservation programs such as turf conversion and irrigation system upgrades that changed the planned water requirements and resulted in unexpected changes in water demand made quantification of water savings tricky.
- Program effectiveness to reduce water consumption may be less when landscape maintenance is contracted out, as it normally includes the programming of irrigation controllers and the irrigation inspection.

Sources

- Jeff Lee, Water Conservation Specialist; Town of Gilbert
- Gilbert, Arizona PKID process, retrieved from: http://www.gilbertaz.gov/departments/development-services/engineering-services/pkid/pkid-process

Case Study 26

Free Sprinkler Nozzles

Western Municipal Water District, California

Program Overview

Western Municipal Water District (Western) targets landscape water use by offering vouchers for efficient sprinkler nozzles through its FreeSprinklerNozzles.com website. The nozzles offered are designed to reduce landscape water use through lower precipitation rates as well as increase efficiency through improved distribution uniformity. By pairing a web-based public interface with state-of-the-art water saving technology, the FreeSprinklerNozzles.com program offers an effective and innovative approach to landscape water conservation. Residential water customers are eligible to receive up to 25 nozzles for free; commercial customers can receive 100 nozzles or more based upon the number of existing spray nozzles at the site. Vouchers for free nozzles are delivered to customers via email only after the customer has reviewed a series of educational online videos. The videos explain how the nozzles work, describe the installation process, and teach the customer how to perform an irrigation system survey prior to redeeming their free nozzle voucher and installing their new nozzles.

Agency
Western Municipal Water District

Project Status
2010 – Ongoing

Targeted Use Sector
Residential Irrigation, & Commercial and Industrial Irrigation

Estimated Annual Savings
4,112 acre-feet per year

Estimated Annual Cost
$1,043,340

Estimated Unit Water Cost
$180 per acre-foot

Key Program Elements

- Western offers vouchers for efficient sprinkler nozzles through its website FreeSprinklerNozzles.com
- Program generates cost-effective water savings, educates consumers, is simple to expand, and readily accepts new partners to the program
- Each nozzle provided by the program is estimated to save 0.004 acre-feet per year

Main Program Elements

Costs

The program costs an estimated $180 per acre-foot of water conserved.

Implementation Resources

The program is offered by Western as a turn-key design and costs water agencies $3.25 per nozzle. Agencies sign a Memorandum of Understanding with Western and provide customer data, sample bills, and agency logo. Western administers all program operations including website development, updates, maintenance, and hosting, customer support as well as supplier management and payments. In addition, Western develops template marketing materials and conducts outreach to landscape industry professionals and large landscape customers.

Toro conducts supplier recruitment and training and provides customer technical support. Western secures purchase orders with participating suppliers and pays supplier invoices. Western, in turn, invoices the participating agencies and provides regular reporting. Agencies are expected to market the program to their customers.

Level of Participation

Because of the program's success, Western expanded the scope to include 25 additional participating water agencies, both within and outside of Western's service area. Since its inception in the summer of 2010, the FreeSprinklerNozzles.com program has distributed 1,028,000 nozzles throughout California.

Program Outcomes

Water Savings

Since its inception in the summer of 2010, the FreeSprinklerNozzles.com program has distributed 1,028,000 nozzles (3-year period) throughout California with an estimated water savings of 20,554 acre-feet over the life of the nozzles. Annual water savings estimates for the program were calculated using The Metropolitan Water District of Southern California's (MWD) estimation of the amount of water saved through the installation of high efficiency nozzles.

Program Challenges

As part of the FreeSprinklernozzles.com program, customers are responsible for installation and any payment required. For larger landscape sites, many customers do not understand the return on investment for any landscape upgrades. Paying for the installations can be a barrier that impacts participation.

Sources

- Tim Barr, Water Use Efficiency Manager, Western Municipal Water District
- Free Sprinkler Nozzles, retrieved from: http://freesprinklernozzles.com

Case Study 27

Water Smart Landscape

Southern Nevada Water Authority, Nevada

Program Overview

Landscape irrigation is the single largest consumptive water use in southern Nevada. A Southern Nevada Water Authority (SNWA) joint study with Reclamation determined that lawns receive four times as much water as desert-adapted landscapes. The Water Smart Landscapes Rebate Program offers financial incentives to replace water-thirsty lawn with water-efficient landscaping. The current program rebate is $1.50 per square foot for the first 5,000 square feet of lawn converted and $1 for each additional square foot, up to $300,000 per year, per customer. Since program inception, nearly $200 million in rebates have been issued for conversion of 168 million square feet of landscape. As of April 2014, the program produces more than 9 billion gallons of annual water savings and has a cumulative savings of nearly 69 billion gallons.

In Fiscal Year 2013, SNWA issued more than $7.3 million in rebates for conversion of over 5.85 million square feet of turf on more than 2,400 properties. The estimated annual savings from this year's projects alone is over 1,002 acre-feet, which will be sustained perpetually.

Agency
Southern Nevada Water Authority

Project Status
2000 – Ongoing

Targeted Use Sector
Landscape Irrigation (all customer classes)

Estimated Annual Savings
28,740 acre-feet per year

Estimated Unit Water Cost
$454 per acre-foot per year

Key Program Elements

- Financial incentives to replace turf with water-efficient landscaping
- Targets consumptive demand
- Sustains quality of life and economic uses
- Cumulative savings of more than 78 billion gallons of water to date
- Covenant and easement protects water savings in perpetuity

Conversion to water efficient landscaping
Source: Southern Nevada Water Authority

Main Program Elements

Costs

In Fiscal Year 2013, SNWA invested more than $7.36 million dollars in customer rebates for conversion of turf to water efficient landscaping. Since program inception, $190 million has been spent to date on landscape rebates. In addition to rebate monies, the SNWA estimates approximately 15 percent more on overhead costs to administer the program. Between 2010 and 2014, SNWA used $2.6 million in grants awarded by Reclamation to expand the program.

From 2000 to 2008, operating funds were used to pay rebates. Since 2009, the SNWA has capitalized the costs by using bond proceeds. To ensure compliance with the requirements for use of bond proceeds, the SNWA requires property owners to convey an easement that guarantees the conversion will be sustained in perpetuity.

Implementation Resources

Implementation requires field and office staff, vehicles, geographic information systems (GIS), and other data management systems and marketing. The SNWA created a custom database to manage conservation programs that include scheduling functions, customer management, and financial processing.

Staff conduct pre-conversion and post-conversion visits at each project. Field measurements are combined with GIS measurements to document project areas to calculate the rebate amount and produce project documentation.

A partnership program with the landscape industry (Water Smart Contractor) assures that a pool of qualified contractors trained by SNWA in installation of water efficient landscapes and knowledgeable of the Water Smart Landscapes Program is available to serve the community. SNWA, by maintaining a listing of these contractors on the website allows customers to easily find firms they can feel confident in hiring to perform the landscape conversions.

Aerial multi-spectral imagery is used annually to conduct community-wide vegetation change detection and to target potential program clients for direct marketing.

Level of Participation

The program is available to all customer classes. More than 51,000 individual projects have been completed between 2000 and April 2014. Although single-family homes comprise 90 percent of the projects, they account for just 35 percent of all square footage converted. Sixty-five percent of conversion areas are attributable to commercial, industrial, institutional, and multi-family properties. Golf courses and Home Owners' Associations (HOAs) have been very active, converting tens of millions of square feet through large-scale, multi-phase projects that may encompass more than 6 acres per project. Many large property owners conduct multiple phases as a result of the maximum $300,000 annual rebate cap.

A survey conducted in 2009 determined that the SNWA program converted more than 10 times as much landscape as all other similar programs in the United State combined.

Participation in the program peaked twice; once in 2004 during the height of drought awareness and again in 2007 when the SNWA offered a temporary promotional rebate of up to $2.00 per square foot.

Program Outcomes

Water Savings

As of April 2014, total program savings exceeds 28,740 acre-feet (9.4 billion gallons) annually and more than 210,000 acre-feet (68.4 billion gallons) since program inception. Research shows a per square foot savings from converted turf of 55.8 gallons per year (Soyocool et al, 2002). SNWA has used conserved water as an asset for local and interstate water banking.

Program Challenges

- Easement requirement may deter some clients.
- Seasonal program demand characteristics (heavy spring, light winter).
- Market saturation and resistant late adopters (turf has been limited in new development since 2003, thus there is a fixed market for the incentive program).

Sources

- Doug Bennett, Conservation Manager, Southern Nevada Water Authority
- Southern Nevada Water Authority, Water Smart Landscape Rebate, retrieved from: http://www.snwa.com/rebates/wsl.html
- Southern Nevada Water Authority, 2005, Xeriscape Conversion Study, Final Report
- Sovocool, Kent A., Mitchell Morgan, and Doug Bennett. 2002. An in-depth investigation of Xeriscape. Journal of the American Water Works Association. 98:2. February 2002.

Case Study 28

Water Use Restrictions and Development Code

Southern Nevada Water Authority, Nevada

Program Overview

The first modern water conservation policies were enacted in Southern Nevada Water Authority (SNWA) in the early 1990s. In 2003, as a response to severe drought in the Basin, SNWA's seven-member agencies and Clark County cooperatively developed stronger, more effective water conservation oriented policies including:

- Prohibition on lawn grass (turf) in non-residential development and restriction on turf use in residential development (no lawn in new home front yards, 50 percent in residential backyards).
- Mandatory, seasonal assigned watering schedules.
- Prohibition and fee assessments for waste of water.
- Restrictions on creation and use of ornamental water features.
- Restrictions on vehicle and surface washing.
- Restrictions on use of mist systems for human comfort.
- Golf course turf limitations and water budgets.

In 2009, these drought restrictions were adopted into permanence to support long-term resource management.

The most significant of these policies limit use of turf grass for new development. A prior joint study by SNWA and Reclamation determined that lawn grass irrigation used four times as much water as the irrigation of water-efficient landscapes. The development code has been essential to current and future water conservation savings and seeking to achieve regional water conservation goals by improving per capita water use performance and ensuring WaterSmart Landscapes rebate dollars are applied to pre-2003 properties.

Water waste prohibitions and mandatory watering schedules were implemented through water utility service rules as a "condition of service." When compared to the issuance of citations, this approach streamlines enforcement, reduces complexity, and

Agency

Southern Nevada Water Authority

Project Status

2003 – Ongoing

Targeted Use Sector

Landscape irrigation (all customer classes), other consumptive uses, and inefficiency

Estimated Annual Savings

Landscape Development Codes: 25 percent in Single-Family Sector. Unknown for other sectors.

Golf Course water Budgets: 14 percent

Estimated Annual Cost

No hard costs were associated directly with implementation

Key Program Elements

- Effective water conservation oriented policies to limit use of turf grass for new developments and golf courses
- Development of uniform policy between allied jurisdictions
- Focus on consumptive uses and reduction of waste
- Equity among customer sectors

No Lawn in Front Yards of New Homes

Source: Southern Nevada Water Authority preserves relationships between the utilities and their customers. Customers with violations are afforded due process and a right to an objective hearing. Violation fees are assessed directly to the water bill and increase dramatically with each successive violation.

Main Program Elements

Budget

No direct costs were incurred in the development and implementation of these policies. Significant person-hours were invested by agency staff and stakeholder groups in the development of the policies and implementation processes.

Implementation Resources

An environment that fosters collaboration between jurisdictional parties is necessary to develop common provisions. In this case, the drought provided political capital to develop and implement highly-effective policy.

Significant stakeholder processes and work with code officials is needed to develop prohibitions on water use.

SNWA adhered to the following principles in development of its drought response measures:

- Reduce consumptive uses.
- Avoid restricting non-consumptive uses unnecessarily.
- Wherever possible, sustain economic vitality.
- Reduce non-essential uses and waste.
- Provide reasonable opportunities for large consumptive water users to determine their own operational strategies within a water budget.
- Consider the positive public perception of limiting highly visible uses of water even if they produce nominal efficiency gains.
- Pursue equity among various sectors' contributions.
- Provide special emphasis on the need for extraordinary, visible leadership from government-sector water users.
- Seek high levels of citizen and stakeholder involvement, particularly from sectors impacted by the policies and provisions.

Level of Participation

All jurisdictions participated. Compliance was mandatory and largely accomplished through the existing development and inspection process.

Many stakeholder interactions occurred.

Program Outcomes

Water Savings

SNWA has found that these policies significantly contributed to a 33 percent reduction in GPCD between 2002 and 2013. SNWA research has found that turf grass limits in Southern Nevada reduce outdoor use an average of 25 to 28 percent at single-family homes. Prior studies show water efficient landscaping uses 75 percent less water than lawn grass (SNWA). In another SNWA study, the Golf Course Water Use Under Water Budgets, indicated that the golf course water budgets reduced sector demand by 14.4 percent (1.3 billion gallons or 4000 acre-feet per year).

Program Challenges

- Limitations on outdoor water features, misters, and vehicle washing yield minimal water savings, but created the largest portion of public concern.
- Developing uniform policy and enforcement is challenging among multiple jurisdictions.
- Some grandfathered master development plans limit the applicability of new restrictions.
- Unintentional system demand shifts had to be considered in the development of assigned watering days

Sources

- Doug Bennett, Conservation Manager, Southern Nevada Water Authority
- Southern Nevada Water Authority restrictions, retrieved from: www.snwa.com/consv/restrictions.html

Case Study 29

Central Utah Gardens

Central Utah Water Conservancy District, Utah

Program Overview

Central Utah Water Conservancy District's (CUWCD) ongoing commitment to water conservation has put the District at the forefront of Utah's water management and conservation efforts. Central Utah Gardens is a natural extension and expression of that commitment and leadership.

Section 207 of the 1992 federal legislation known as the Central Utah Project Completion Act directed that CUWCD institute a variety of measures to encourage the conservation and wise use of water and achieve beneficial reductions in water use and system costs. After submission of a feasibility study and review by the Water Conservation Credit Program Prioritization Committee and a public hearing, Central Utah Gardens was granted Section 207 funds for a portion of its construction costs.

Central Utah Gardens began construction in 2006 and the gardens officially opened to the public on May 17, 2007. The education garden demonstrates the 7 principles of water-efficient landscaping and educates visitors about the importance of water conservation. Approximately 67 percent of Utah residents' water is used to irrigate outdoor landscapes. Trained interns use garden demonstrations to teach the public how to reduce their outdoor water use without sacrificing landscape beauty. Before the education garden existed, the water district's property was covered chiefly in Kentucky Bluegrass lawn. Following the construction and establishment of the education garden, water use was decreased by 50 percent. Home owners are encouraged to follow this example in their own yards.

7 Steps of Water-Efficiency Landscaping

1. Planning and Design
2. Soil Analysis
3. Plant Selection
4. Lawn Areas
5. Efficient Watering
6. Use of Mulches
7. Proper Yard Care

Agency
Central Utah Water Conservation District

Project Status
2007 – Ongoing

Targeted Use Sector
Primarily residential water use

Estimated Annual Cost
Initial investment: $1.3 million; annual cost: $90,000

Key Program Elements

- Increased public awareness of outdoor water conservation throughout Utah
- Educate members of the public about the steps of water-efficient landscaping in a way that allows them to put them into action in their own landscapes
- Eliminate the false concept that low-water landscaping is sparse and unattractive

Main Program Elements

Costs

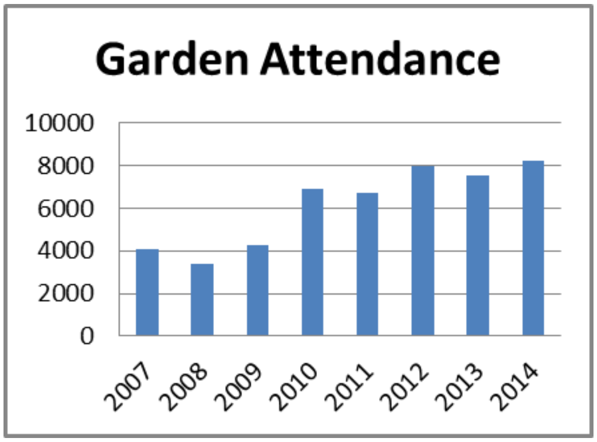
Funding for Central Utah Gardens came from Section 207 of the Central Utah Project Completion Act and from the CUWCD. The initial cost for the education garden was $1.3 million dollars. The education garden has an annual budget of approximately $90,000.

Implementation Resources

Central Utah Gardens messaging, classes and events are advertised mainly through an outdoor digital sign, mailers and postcards. Education garden visitors are informed about outdoor water conservation through viewing demonstrated plant material and designs, gardening classes, children's' classes, seasonal events, summer concerts and garden tours.

Level of Participation

Since the education garden's opening in 2007, there have been significant increases in program participation and attendance. The average class attendance during the first season was 11 individuals. In 2014, the attendance average was 97 per class. Event attendance also increased from 100 to 300 people at events in the first few years to 1,000 to 2,200 people at events in recent years. Total garden attendance has doubled since the gardens first opened, going from 4,100 in 2007 up to 8,250 in 2014.



Program Outcomes

Program Challenges

Helping members of the public overcome preconceived ideas about outdoor water conservation. Many people believe that low-water landscaping involves rock, cactus, and very little plant material.

Sources

- Heather Anderson, Public Information Officer, Central Utah Water Conservancy District
- Central Utah Gardens, retrieved from: http://www.centralutahgardens.org

Case Study 30

Reclaimed Water Distribution System

City of Scottsdale, Arizona

Program Overview

In 1989, the City of Scottsdale mandated that golf courses begin using reclaimed wastewater for irrigation instead of groundwater or potable water to address declining groundwater levels. The key to the Reclaimed Water Distribution System Project is an ongoing public-private partnership to expand and enhance infrastructure, treatment process, and reuse. The project allows the majority of Scottsdale's golf courses to utilize reclaimed water to meet their daily turf and landscape irrigation needs. This innovative partnership between the city and the 22 golf courses provides a solution that benefits the golf courses, the economy, the aquifer, and the sustainability of the city's water supplies.

Main Program Elements

Costs

An initial infrastructure investment of $27.8 million was funded entirely by the golf courses. The city operates and maintains the system with capital replacement and annual operating and maintenance costs paid by the courses through an annual rate setting process. The treatment, distribution, operation and maintenance costs are $8,420,828 per year.

Implementation Resources

The infrastructure required to provide reclaimed water to these golf courses is extensive and includes approximately 14 miles of reclaimed water trunk-line, plus numerous turnout lines to individual golf courses. Additionally, the system has an 8 million gallon storage reservoir, four mainline booster stations, and 20 million gallons per day of treatment and conveyance capacity.

Level of Participation

Since 1989, the majority of Scottsdale's golf courses have used reclaimed water to meet their daily irrigation needs. Today, approximately two dozen golf courses receive reclaimed water through the Reclaimed Water Distribution System to irrigate the turf and landscape areas of these courses.

Agency
City of Scottsdale

Project Status
1989 – Ongoing

Targeted Use Sector
Commercial and Industrial Irrigation

Estimated Annual Savings
22,403 acre-feet per year

Estimated Annual Cost
$8,420,828

Estimated Unit Water Cost
$ 436 per acre-foot per year

Key Program Elements

- Partnered with private sector to assist in funding the project
- Successfully implemented reclaimed water irrigation for the majority of Scottsdale golf courses
- Excess reclaimed water is used to recharge groundwater aquifer

Reverse Osmosis Train
Source: City of Scottsdale

Program Outcomes

Water Savings

Up to 20 million gallons per day of reclaimed water is conveyed to golf courses for irrigation purposes. If the irrigation demand is lower, excess water is recharged into the underlying vadose zone at the city's Water Campus. Adding this continuous and renewable water source to Scottsdale's portfolio is one of the many ways the city is making the most of its water use every day.

By meeting golf course irrigation needs through the use of reclaimed water, the city preserves Colorado River water for its current and future municipal demand.

Program Challenges

- Salinity of reclaimed supplies poses difficulties for turfgrass management.
- Extensive infrastructure expansion and upgrades was needed at the city's Advanced Water Treatment Facility to reduce salinity. This includes microfiltration, reverse osmosis and advanced oxidation processes to help reduce the salt content in the reclaimed water.
- The resulting salinity reduction allows the golf courses to more efficiently manage their water use.
- The city is undertaking a multi-year pilot project to reduce salinity levels throughout the community's wastewater stream.

Sources

- Kathy Rall, Water Resources Advisor, City of Scottsdale Water Resources Division
- City of Scottsdale, reclaimed water, retrieved from: http://www.scottsdaleaz.gov/Water/Water_Supply_Planning/Sustainable_Supply/Reclaimed_Water

Case Study 31

Zero Discharge: Palo Verde Nuclear Generating Station and Redhawk Power Plant

Wintersburg, Arizona

Program Overview

Palo Verde is the only nuclear plant in the United States that does not sit on a large body of water. Most plants use large natural bodies of water such as lakes, oceans, or large rivers as the source of cooling water, but Palo Verde is located in the dry Sonoran Desert, where water is precious. It is the only nuclear power plant in the world that uses reclaimed wastewater from surrounding cities as its cooling water. Wastewater is transported to Palo Verde through 36 miles of underground pipe from the 91st Avenue and Tolleson Wastewater Treatment Facilities.

Unlike other nuclear plants, Palo Verde maintains “zero discharge,” with no water being discharged to rivers, streams, or oceans. Instead, it recycles more than 20 billion gallons of municipal effluent each year to meet its cooling needs. The treated water is piped to two storage reservoirs with a combined capacity of approximately 1 billion gallons. The reservoirs provide about 14 days storage of makeup water for the three nuclear units operating at full capacity during peak conditions in the hot, summertime weather. Water is routed through condensers and cooling towers for an average of 25 cycles until the total dissolved solids levels approach 30,000 milligrams per liter, then the blowdown is discharged to evaporation ponds (220 acres, 250 acres, and 180 acres) for final disposal on site.

Entity
Palo Verde Nuclear Generating Station

Project Status
Ongoing

Targeted Use Sector
Self-Supplied Industrial

Estimated Annual Savings
61,400 acre-feet per year

Initial Investment
$685 million

Key Program Elements

- Zero discharge plants, no water is being discharged to rivers, stream or oceans
- Uses treated wastewater effluent from surrounding cities for cooling purposes
- Limits the use of groundwater and Colorado River water
- Partnership with nearby cities to purchase treated effluent wastewater

Palo Verde Nuclear Generating Station
Source: Arizona Public Service Company

Main Program Elements

Costs

Due to location, both Palo Verde and Redhawk are not located near a large body of water; therefore, a sizable investment was made in the Water Reclamation Facility (WRF) to use treated effluent. The total investment of the WRF, if it were built today and not including the cost of purchasing the effluent, would be approximately $685 million. Some of the large expenditures for the WRF included land acquisition, storage reservoirs, evaporation ponds, pipeline, and all necessary equipment needed to construct a WRF.

Implementation Resources

To secure the water needed for Palo Verde and Redhawk into the future, Arizona Public Service on behalf of the owners of Palo Verde, negotiated a contract with the City of Phoenix, City of Mesa, City of Tempe, City of Scottsdale, and the City of Glendale (collectively referred to as the Subregional Operating Group) to purchase their effluent. A separate agreement with the City of Tolleson was also negotiated to purchase their treated effluent. Pursuant to the Subregional Operating Group Agreement, the cities are committed to make available up to 80,000 acre-feet per year of effluent until December 31, 2050, unless extended by mutual agreement of the parties. These arrangements benefit the local economy through the purchase of 20 billion gallons of effluent each year. It also conserves higher quality groundwater and surface water for other uses like drinking water for local residents.

Level of Participation

The Palo Verde Nuclear Generating Station and the Redhawk Power Plant both use treated effluent as a cooling source. The effluent produced by the cities could be utilized by other power plants but both the Palo Verde conveyance pipeline and the WRF are at full capacity.

Program Outcomes

Water Savings

At Palo Verde, the water undergoes further treatment at the site's WRF — one of the world's largest advanced water treatment facilities. Treated water is stored in the site's 85-acre and 45-acre reservoirs for use in the cooling towers. Palo Verde also uses groundwater for site potable demands, as well as a source of supply for the production of ultra-pure water that is used in the primary and secondary systems of the plant. Palo Verde's 2012 water use was 2,269 acre-feet of groundwater and 70,170 acre-feet of effluent, for a total water use of 72,439 acre-feet.

Redhawk uses 100 percent tertiary effluent from the Water Reclamation Plant at Palo Verde for cooling water but has the option to use groundwater, if necessary. Redhawk is also a zero liquid discharge plant. Redhawk's 2012 water use was 521 acre-feet of groundwater and 3,713 acre-feet of effluent for a total water use of 4,234 acre-feet.

Program Challenges

- Sizable investment required for the WRF.
- Large expenditures required for land acquisition, storage reservoirs, evaporation ponds, and pipeline.

Sources

- Scott Miller, Water Resources Analyst, Water Resources Management
- Presentation by Bob Lotts, June 20, 2014, Water and Energy in Arizona, retrieved from: http://www.azenergy.gov/doclib/6-20-14_AMC-PVNGS_B.Lotts.pdf

Case study 32

Crean Lutheran High School

Irvine Ranch Water District, California

Program Overview

The project goal is to incorporate a conservation principle by conserving potable water. Crean Lutheran, a private high school, uses recycled water for toilets, urinals, and priming floor drains in its buildings. Crean Lutheran was the first high school in the Irvine Ranch Water District (IRWD) service area and possibly the State of California to use recycled water for indoor plumbing. Its two dual-plumbed buildings serve more than 500 students and 30 staff members. The two dual-plumbed buildings are its classroom building and the gym, which is a tensioned fabric membrane structure. The school also uses recycled water to irrigate its 9 acres of landscaped area.

Agency
Irvine Ranch Water District

Project Status
Completed in November 2010

Targeted Use Sector
Institutional: School

Estimated Annual Savings
31 acre-feet per year

Key Program Elements

- First high school in California to use recycled water for indoor plumbing
- Toilets and urinals flush with recycled water in the classroom building and gymnasium building
- Landscape irrigated with recycled water
- Fully integrates recycled water into campus life

Irrigation with Recycled Water
Source: Crean Lutheran High School

Main Program Elements

Costs

Cost to install the irrigation system and dual-plumbing was funded by the project proponent, and operation and maintenance costs are covered by the Crean Lutheran High School.

Implementation Resources

Title 22 of the California Code of Regulations allows for the use of disinfected tertiary recycled water in toilets and urinals at schools. The California Plumbing Code provides the required measures to dual-plumb a building.

The school's dual-plumbed, two-story modular classroom building was constructed differently from other dual-plumbed buildings. The modules were constructed in numerous sections in Perris, California, and then brought to the Irvine location and assembled.

Level of Participation

In order to get the participant schools, it is important that the project proponent supports the project and the additional measures to fulfill the regulatory requirements. The success of this project led to the construction of another new dual-plumbed high school and the dual-plumbing of a new building at Irvine Valley College. In 2012 IRWD began serving the Cypress Recreational Center, a public facility, the first such dual-plumbed facility in IRWD's service area.

Program Outcomes

Water Savings

The combined use of recycled water used in the dual-plumbed buildings and the school's landscaping saves more than 10 million gallons (31 acre-feet) of drinking water per year. Crean Lutheran High School was honored by California WateReuse as a 2012 Recycled Water Customer of the Year.

In addition to water savings, the high school also saves money. The IRWD's base rate for potable water is currently $1.27 per 100 cubic feet. IRWD's base rate for recycled water for irrigation uses is $1.11 per 100 cubic feet (~10 percent savings), and the base rate for recycled water for non-irrigation uses (toilets/urinals) is $0.76 per 100 cubic feet (40 percent savings).

Program Challenges

- Staying in contact with Crean Lutheran High School, their contractors, and the regulatory agencies throughout the project.

Sources

- Gabriel Vargas, Recycled Water Project Specialist, Irvine Ranch Water District
- WateReuse Award Press release, March 29, 2012, retrieved from: https://www.watereuse.org/press-release/032912
- Elizabeth Lovsted, 2013, Watershed Recycled Water Demands and Projections

Case Study 33

Denver Zoo Recycled Water

Denver, Colorado

Program Overview

The zoo has successfully used recycled water since 2004 and now aims to replace 75 percent of its potable water demand with recycled water. The Denver Zoo's Toyota Elephant Passage exhibit achieved Leadership in Energy and Environmental Design (LEED™) certification at the platinum level, the highest level granted, for a number of "green" design components including the use of recycled water to fill outdoor pools. Toyota Elephant Passage is the first large animal exhibit complex in the country to achieve the certification

In 2011, the Denver Zoo was recognized as WateReuse "Customer of the Year," in recognition of the zoo's innovative use of recycled water. In that same year, Denver Zoo became the first recipient of the Association of Zoos and Aquariums' Green Award recognizing the Zoo's progressive sustainability practices.

Agency
Denver Water

Project Status
2004 – Ongoing

Targeted Use Sector
Commercial & Industrial Irrigation

Key Program Elements

- The Denver Zoo uses recycled water for animal exhibits, landscape irrigation, and cleaning
- Zoo hopes to convert more than 75 percent of the campus water infrastructure to recycled water
- Received LEED™ Platinum certification for Toyota Elephant Passage
- Received AZA Green Award in 2011

Denver Zoo Elephant Exhibit
Denver Zoological Foundation

Main Program Elements

Level of Participation

The Zoo's Toyota Elephant Passage exhibit, uses 1.1 million gallons of water. The deepest foundation of the elephant passage includes 20 foot deep settling chambers for the 900,000 gallons of water re-circulated to the outdoor pools. The source of the water for the outdoor pools Denver Water's recycled water system.

As of 2012, over $ 1 million has been committed to connect approximately 30 percent of zoo's water infrastructure to non-potable, recycled water supply from Denver Water.

Program Outcomes

Water Savings

Through improvements and innovations in our water filtration systems, maximizing the use of reuse water, and utilizing water wise landscaping, Denver Zoo has saved on average 214 million gallons annually over the last 15 years. These projects, as well as operational changes have reduced overall annual water usage from approximately 380 million gallons in 1999 to approximately 152 million gallons in 2014, a 60 percent reduction in overall water use.

In the future, the zoo hopes to convert more than 75 percent of the campus water infrastructure to recycled water.

Sources

- Denver Zoo, retrieved from: http://www.denverzoo.org/awards-list, and http://www.denverzoo.org/save-world-sustainability
- Your Water Colorado blog, September 17, 2012, retrieved from: http://www.denverzoo.org/save-world-sustainability

Case Study 34

Southern Nevada Water Reuse

Southern Nevada Water Authority, Nevada

Program Overview

The Southern Nevada Water Authority (SNWA) is a cooperative, not-for-profit agency formed in 1991 to address Southern Nevada's water needs on a regional basis. SNWA has 7 member agencies that include Big Bend Water District, Boulder City, Clark County Water Reclamation District, Henderson, Las Vegas, Las Vegas Valley Water District, and North Las Vegas. These member agencies collectively reclaim and treat water that flows through taps and down the drain and use it as a resource in Southern Nevada. Reclaimed water accounts for roughly 40 percent of the water used, making it Southern Nevada's second-largest water resource. The reclaimed water is either returned to the Colorado River for indirect reuse as return flow credits, or delivered to other municipal uses for direct non-potable reuse, such as irrigation at golf courses, street medians, parks, and industrial uses.

In 2008, the SNWA Board of Directors adopted a policy for the Continued Development of Water Recycling to continue to maximize the use of recycled water. Nevada's 300,000 acre-feet per year allocation of Colorado River water currently supplies about 90 percent of the region's water and is defined in consumptive use terms. For each acre-foot of Colorado River water the SNWA member agencies treat and return to the Colorado River, Southern Nevada receives an equal amount of return flow credits that allows Nevada to divert more than 300,000 acre-feet per year of water from the Colorado River.

Agency
Southern Nevada Water Authority

Project Status
Ongoing

Targeted Use Sectors
All sectors

Estimated Annual Savings
Approximately 200,000 acre-feet per year in return flow credits to the Colorado River and 21,000 acre-feet in direct reuse

Estimated Annual Cost
Varies from agency to agency

Estimated Unit Water Cost
Varies from agency to agency

Key Program Elements

- Direct non-potable reuse by high treated effluent for use in industry and outdoor irrigation
- Indirect reuse in Southern Nevada is represented by highly treated wastewater returned to the Colorado River for return flow credits and comprise the dominant portion of reuse in Southern Nevada
- Additional direct reuse where return flow credits are available do not increase the SNWA resource portfolio, as this would offset or reduce indirect reuse through Colorado River return flow credits

Source: Southern Nevada Water Authority

Main Program Elements

Costs

SNWA member agencies fund wastewater treatment within their corresponding service areas. In addition, a number of purveyors entered into interagency wastewater treatment agreements. Due to complexity of accounting for capital and operating expenses, and multiple (cost-sharing) agreements made over the past half-a-century, it is not currently feasible to estimate the budget of reuse programs among the SNWA member agencies.

Implementation Resources

The SNWA agencies work in concert with state and federal (Reclamation) agencies to manage and oversee water reuse. Resources vary from agency to agency.

Level of Participation

SNWA member agencies recycle nearly 99 percent of indoor water use. The treatment plants and recycling sites in Las Vegas Valley have a maximum treatment capacity of over 300,000 acre-feet per year as listed in table below.

Las Vegas Valley Water Recycling Facilities Maximum Treatment Capacity

Facility	Capacity (mgd)	Primary Use
City of Las Vegas Water Pollution Control Facility	91	Return to Colorado River, golf courses, power plant cooling, construction water
Clark County Water Reclamation District Flamingo Water Resource Center	150	Return to Colorado River, golf courses, wetlands park power plant cooling, Silver Bowl Park, streetscape
City of Henderson Kurt R. Segler Water Reclamation Facility	32	Return to Colorado River, golf courses, construction water, median irrigation, cemetery irrigation
City of Las Vegas Bonanza Mojave Water Reclamation Facility	1	Golf courses
City of Las Vegas Durango Hills Water Resource Center	10	Golf courses
Clark County Water Reclamation District Desert Breeze Water Resource Center	5	Golf courses, public park
City of North Las Vegas Water Reclamation Facility	25 to 50	Return to Colorado River, golf courses, industrial uses
City of Henderson Southwest Water Reclamation Facility	8	Golf courses, construction water, median irrigation

Program Outcomes

Water Savings

Recycling through direct non-potable and indirect reuse extends overall resources by supplying approximately 40 percent of the communities water use. See the "Southern Nevada Regional Water Recycling Study" for additional information on regional recycling practices.

Program Challenges

- Continued maximization of the use of recycled water may warrant additional direct reuse, where return flow to the Colorado River water is not practical.

Sources

- Jeff Johnson, Division Manager, Water Management & Planning, Southern Nevada Water Authority
- Southern Nevada Water Authority, Reclaimed Water and Reuse, retrieved from: http://www.snwa.com/ws/reclaimed.html
- Southern Nevada Water Authority, Clean Water Coalition, Black & Veatch, March 2009, Southern Nevada Regional Water Recycling Study

Appendix 3C
Federal, State, and Other Municipal and Industrial Water Conservation and Reuse Programs and Resources

May 2015

3C Federal, State, and Other Municipal and Industrial Water Conservation and Reuse Programs and Resources

This appendix provides information related to municipal and industrial (M&I) water conservation and reuse programs and resources occurring at a federal agency level, Basin States level, and programs occurring outside of the Basin States. The following compilation is illustrative of the types of programs that have been implemented at various locations and resources that are available to support conservation and reuse programs. It is not intended to be an exhaustive list, nor is it an endorsement of any particular program.

The appendix is organized into sections based on federal agency programs and resources, non-governmental programs and resources, state programs and resources, and finally programs implemented outside of the Basin States.

3C.1 Federal Programs and Resources

Multiple federal agencies provide technical assistance and funding related to M&I water conservation and reuse. Some programs were initiated as a result of legal and regulatory mandates; others were established to promote agency policy related to M&I water management, conservation, and reuse. Funding generally comes in the form of loans or grant opportunities.

According to the M&I Water Conservation and Reuse Workgroup, the federal programs most influencing M&I conservation and reuse in the major metropolitan areas that receive Colorado River water are the U.S. Department of the Interior's (DOI) WaterSMART (Sustain and Manage America's Resources for Tomorrow) program and the U.S. Environmental Protection Agency's (EPA) WaterSense program, ENERGY STAR program, Drinking Water State Revolving Fund Program, and Clean Water State Revolving Fund Program. These programs are described in the following sections. Table 3C-1 summarizes these programs as well as other selected programs that provide funding or technical assistance related to M&I conservation and reuse.

3C.1.1 WaterSMART

In 2009, Congress passed the Omnibus Public Land Management Act of 2009 (Public Law 111-11). Title IX, Subtitle F of the Act – SECURE Water, directed the DOI to develop a sustainable water management policy. In 2010, Secretary of the Interior Ken Salazar established WaterSMART, combining existing programs with new initiatives to create a broad framework to manage the nation's water supplies. Through these programs, DOI is actively working with tribal, state, regional, and local water managers to address a range of issues associated with water scarcity. WaterSMART has enabled DOI and its partners to act in response to near-term and immediate water shortages and to plan for longer-term needs.

The Bureau of Reclamation's (Reclamation) WaterSMART goal is to further enable capability to increase available water supply for agricultural, municipal, industrial, and environmental uses in the western U.S. by 840,000 acre-feet (AF) by the end of 2015 through Reclamation's water conservation programs. WaterSMART consists of the following elements.

- WaterSMART Water and Energy Efficiency Grants: Provides funding to irrigation and water districts, tribes, states and other entities with water or power delivery authority. Projects should seek to conserve and use water more efficiently, increase the use of renewable energy, protect endangered species, or facilitate water markets. Projects are selected through a competitive process, and the focus is on projects that can be completed within 24 months and that will help sustainable water supplies in the western U.S.
- System Optimization Review: Provides an analysis of system-wide efficiency that focuses on improving the effectiveness and operations of a delivery system, district, or watershed. The review results in a plan of action that focuses on future water management improvements. Improvements

that are recommended in the review may then be eligible for funding under WaterSMART water and energy efficiency grants or other WaterSMART grant categories.

- Advanced Water Treatment Pilot and Demonstration Grants: Encourage pilot and demonstration projects that address the technical, economic, and environmental viability of treating and using brackish groundwater, seawater, impaired waters, or otherwise create new water supplies in a specific location.
- Grants to Develop Climate Analysis Tools: Provides financial assistance opportunities to universities, nonprofits, and other organizations with water or power delivery authority. Proposals will be invited to leverage non-federal money in a 50-50 cost-share manner with Reclamation on projects designed to enhance the management of water resources, including developing tools to assess the impacts of climate change on water resources and inform management decisions with respect to those impacts.
- Basin Studies: Reclamation partners with basin stakeholders to comprehensively assess current and potential water supply imbalances in river basins and impacts from climate change and to identify mitigation and adaptation strategies to address those potential impacts.
- Title XVI of Public Law 102-575 Water Reclamation and Reuse Program: Reclamation identifies and investigates opportunities to reclaim and reuse wastewaters and naturally impaired groundwater and surface water in the 17 western states and Hawaii.
- Cooperative Watershed Management Program: Provides financial assistance to establish and expand collaborative watershed groups. The purpose is to improve water quality and ecological resilience and to reduce conflicts over water through collaborative conservation efforts in the management of local watersheds.
- Drought Response Program: Provides funding for drought response and comprehensive drought plans to help avoid drought-related crises in the short term, while laying a foundation for climate resiliency in the long term.
- Resilient Infrastructure Program: Provides funding to prepare for new climate extremes and support healthy and resilient watersheds by proactively maintaining and improving existing infrastructure for system reliability, safety, and efficiency.
- Water Conservation Field Services Program: Provides funding and technical services in the areas of water management planning, demonstrations of innovative technologies, and implementation of conservation measures.

For additional information:
- www.usbr.gov/WaterSMART

3C.1.2 WaterSense Program

WaterSense is an EPA partnership program started in 2006 that seeks to help consumers make smart water choices that save money and maintain high environmental standards without compromising performance. Products and services that have earned the WaterSense label have been certified to be at least 20 percent more efficient without sacrificing performance. Products currently certified by WaterSense are new homes, toilets, bathroom sink faucets, urinals, showerheads, weather-based irrigation controllers, and commercial pre-rinse spray valves.

For additional information:
- www.epa.gov/watersense

3C.1.3 ENERGY STAR Program

ENERGY STAR is a voluntary, public-private partnership designed to reduce energy use and related greenhouse gas emissions. The program, administered by the EPA and the U.S. Department of Energy (DOE), has an extensive network of partners including equipment manufacturers, retails, home builders, energy service companies, private business, and public sector organization and is well recognized by energy consumers.

Since the 1990's, EPA and DOE have worked with utilities, state energy offices, and regional nonprofit organizations to offer them ENERGY STAR tools, strategies, and materials to enhance their local energy efficiency programs. Many of the energy saving efforts also result in water savings, and Energy Star qualifying major appliances can include clothes washers, dishwashers, and water heaters.

For additional information:
- www.energystar.gov

3C.1.4 Drinking Water State Revolving Fund Program and Clean Water State Revolving Fund

The 1996 Amendments to the Safe Drinking Water Act created the Drinking Water State Revolving Fund (DWSRF) program. The DWSRF is a multifaceted tool for states to use to achieve the public health protection objectives of the Safe Drinking Water Act. States operate their own DWSRF programs and receive annual capitalization grants from EPA which they use to support low-interest loans and other types of assistance to public water systems. Additional provisions also allow state DWSRF programs to target extra assistance to communities with the greatest economic need.

For additional information:
- water.epa.gov/grants_funding/dwsrf

3C.1.5 Clean Water State Revolving Fund Program

Through the Clean Water State Revolving Fund (CWSRF), states and Puerto Rico maintain revolving loan funds to provide independent and permanent sources of low-cost financing for a wide range of water quality infrastructure projects. Funds to establish or capitalize the CWSRF programs are provided through federal government grants and state matching funds (equal to 20 percent of federal government grants). Today, all 50 states and Puerto Rico are operating successful CWSRF programs. Building on a federal investment of more than $36.2 billion, the CWSRFs have provided more than $100 billion in funding to communities to meet environmental standards, protect valuable resources, and ensure public health.

CWSRF programs operate much like environmental infrastructure banks that are capitalized with federal and state contributions. CWSRF monies are loaned to communities, and loan repayments are recycled back into the program to fund additional water quality protection projects. The revolving nature of these programs provides for an ongoing funding source that will last far into the future.

The CWSRFs fund a wide range of water quality projects including all types of nonpoint source, watershed protection or restoration, and estuary management projects, as well as more traditional municipal wastewater treatment projects.

For additional information:
- water.epa.gov/grants_funding/cwsrf/cwsrf_index.cfm

TABLE 3C-1
Selected Federal Funding and Technical Assistance Sources related to M&I Water Conservation and Reuse

Program Name	Eligible Applicants	Funding Level	Description
Bureau of Reclamation			
Water and Energy Efficiency Grants	States, tribes, irrigation districts, water districts, or water organizations with water or power delivery authority in the 17 western states.	Under Funding Group I, up to $300,000. Under Funding Group II, up to $1 million. Maximum federal cost-share is 50 percent.	Cost-shared assistance for projects that conserve and use water more efficiently, increase the use of renewable energy and improve energy efficiency, benefit endangered and threatened species, facilitate water markets, or carry out other activities to address climate-related impacts on water.
System Optimization Review	States, tribes, irrigation districts, water districts, or water organizations with water or power delivery authority in the 17 western states.	Up to $300,000 in federal cost-share will be available per project. Maximum federal cost-share is 50 percent.	An analysis of system-wide efficiency that focuses on improving the effectiveness and operations of a delivery system, district, or watershed. The review results in a plan of action that focuses on future water management improvements. Improvements that are recommended in the System Optimization Review may then be eligible for funding under WaterSMART Water and Energy Efficiency grants or other WaterSMART grant categories.
Advanced Water Treatment Pilot and Demonstration Grants	States, tribes, irrigation districts, water districts, or water organizations with water or power delivery authority in the 17 western states.	Varies.	Encourage pilot and demonstration projects that address technical, economic, and environmental viability of treating and using brackish groundwater, seawater, impaired waters, or otherwise create new water supplies in a specific location.
Grants to Develop Climate Analysis Tools	Universities, nonprofits, and other organizations with water or power delivery authority.	Maximum federal cost-share is 50 percent.	Projects designed to enhance the management of water resources, including developing tools to assess the impacts of climate change on water resources and inform management decisions with respect to those impacts.

TABLE 3C-1
Selected Federal Funding and Technical Assistance Sources related to M&I Water Conservation and Reuse

Program Name	Eligible Applicants	Funding Level	Description
Basin Studies	Studies focus on river basins or sub-basins in the 17 western states where imbalances in water supply and demand exist or are projected.	Maximum federal cost-share is 50 percent.	Reclamation partners with Basin stakeholders to comprehensively assess current and potential water supply imbalances in river basins and impacts from climate change and to identify mitigation and adaptation strategies to address those potential impacts.
Title XVI Projects	Sponsors of congressionally authorized Title XVI Projects in the 17 western states and Hawaii; typically municipalities and water districts.	Maximum congressional authorization is $20 million. Maximum federal share 25 percent.	Provides funding for planning studies and the construction of water recycling projects on a project-specific basis, in partnership with local entities.
Cooperative Watershed Management Program	Varies.	Up to $100,000 to first-phase grant recipients for a period of not more than 3 years. The federal share of expenditures accrued in first-phase grant activities will be funded 100 percent. Second- and third-phase grants will not exceed 50 percent of the total cost of the activities.	Provides financial assistance to establish and expand collaborative watershed groups. The purpose is to improve water quality and ecological resilience and to reduce conflicts over water through collaborative conservation efforts in the management of local watersheds.
Drought Response Program	To be determined – new program	To be determined – new program	Provides funding for drought response and comprehensive drought plans to help avoid drought-related crises in the short term, while laying a foundation for climate resiliency in the long term.
Resilient Infrastructure Program	States, tribes, irrigation districts, water districts, or water organizations with water or power delivery authority in the 17 western states.	To be determined – new program	Provides funding to prepare for new climate extremes and support healthy and resilient watersheds by proactively maintaining and improving existing infrastructure for system reliability, safety, and efficiency.

TABLE 3C-1
Selected Federal Funding and Technical Assistance Sources related to M&I Water Conservation and Reuse

Program Name	Eligible Applicants	Funding Level	Description
Water Conservation Field Services Program	State and local governments, irrigation districts, tribal communities, schools, and companies.	Varies.	Assists water agencies in the development of quality water conservation plans. In many cases, this technical assistance is provided by Reclamation staff. In other cases, it may be financial assistance through cost-sharing to support the entity in development of its plan.
U.S. Environmental Protection Agency			
Drinking Water State Revolving Fund	Community water systems, whether publicly or privately owned, and not-for-profit, non-community water systems. Federally owned systems are not eligible.	Varies per state formulas.	Capitalization grants to states, which are then authorized to provide low-cost loans and other types of assistance to public water systems to finance the cost of infrastructure projects. EPA grants each state with considerable flexibility to determine the design of its Drinking Water State Revolving Fund program and to establish funding priorities to reflect state water resource issues.
Clean Water State Revolving Fund	Any municipality, inter-municipal, interstate, or state agency for point source (§212) projects.	Varies per state formulas.	EPA provides grants or seed money to all 50 states to replenish the funds. The states, in turn, make loans to communities to finance improvements to their wastewater infrastructure. Water conservation and reuse loans have been made for the installation of meters, plumbing retrofits, recycling gray water, reuse, public education programs, and rate changes.

TABLE 3C-1
Selected Federal Funding and Technical Assistance Sources related to M&I Water Conservation and Reuse

Program Name	Eligible Applicants	Funding Level	Description
U.S. Army Corps of Engineers			
Planning Assistance to States	States, local governments, other non-federal entities, and eligible tribes.	Varies. Ranges have been from $20,000 to $150,000.	Similar to the Basin Studies offered through WaterSMART. Typical studies provide only planning level of detail; recently has focused on water supply/demand, water conservation, water quality, environmental restoration, dam safety, and flood damage reduction.
U.S. Department of Agriculture Rural Development, Rural Utilities Service			
Water and Waste Disposal Direct Loans and Grants for Rural Communities	Local governments, tribes, and nonprofit associations.	Loans or loan guarantees up to 90 percent of value, repayable in not more than 40 years or the usable life of the funded facility, whichever is less. The maximum grant amount is 75 percent of the project costs.	The Water and Environmental Program provides funding for the construction of water and waste facilities in rural communities with populations of 10,000 or fewer. The program primarily funds the construction of drinking water and wastewater infrastructure. Also funds conservation measures including meters, leak detection and control equipment, gray water recycling, wastewater reclamation, and reuse.
Emergency Community Water Assistance Grants	Public bodies or governmental entities, private nonprofit corporations, political subdivisions of a state, and tribes.	$150,000 or $500,000, depending on category.	
Water and Waste Revolving Fund Grants	Qualified private nonprofit organizations.		Recipients use grant funds to establish a revolving loan fund. The loans will be made to eligible entities to finance pre-development costs of water and wastewater projects or short-term small capital improvement projects. Financing capped at $100,000 repayable in 10 years or less.

TABLE 3C-1
Selected Federal Funding and Technical Assistance Sources related to M&I Water Conservation and Reuse

Program Name	Eligible Applicants	Funding Level	Description
Department of Housing and Urban Development			
Community Development Block Grants	Principal cities of Metropolitan Statistical Areas, other metropolitan cities with populations of at least 50,000, and qualified urban counties with populations of at least 200,000.	No designated set-aside or limits for water infrastructure.	Funds available for planning and management efforts, as long as they are part of a community economic development project. Eligible water conservation measures include water meters, leak detection, water-efficient appliances, plumbing retrofits, gray water recycling, development of non-promotional water rate structures, wastewater reclamation, industrial reuse, and developing water use regulations.
Community Development Block Grants, State-Administered Community Development Block Grants	Cities with populations of less than 50,000 (except cities that are designated principal cities of Metropolitan Statistical Areas), and counties with populations of fewer than 200,000.	No designated set-aside or limits for water infrastructure.	Eligible activities for funding include the construction and improvement of water and sewer infrastructure. These improvements include water conservation measures such as plumbing fixture retrofits, gray water recycling, leak detection and control, and water-efficient appliances.
Department of Commerce, Economic Development Administration			
Public Works and Development Facilities Grants Program	States, cities, counties, and other political subdivisions of states, institutions of higher education, or a consortium of such institutions, and private or public not-for-profit organizations acting in cooperation with officials of a local government.	$500,000 to $2.5 million with a 50 percent local match required.	Funds public works infrastructure and development facilities, including improvements to drinking water systems and wastewater systems. Eligible water conservation measures include water meter leak detection, plumbing retrofits, gray water recycling, industrial reuse, wastewater reclamation, and reuse.

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3C.2 Non-Governmental Programs and Resources

The sections below describe non-governmental programs and resources.

3C.2.1 National Organizations

3C.2.1.1 Alliance for Water Efficiency

The Alliance for Water Efficiency is a stakeholder-based nonprofit organization dedicated to the efficient and sustainable use of water. The Alliance serves as a North American advocate for water-efficient products and programs and provides information and assistance on water conservation efforts. The Alliance has embarked on the following seven key tasks to support and enhance water conservation efforts, providing benefit to water utilities, water conservation professionals, planners, regulators, and consumers.

- Stand as a clear and authoritative national voice for water efficiency.
- Provide comprehensive information about water-efficient products, practices, and programs; what works and what does not work.
- Represent the interest of water efficiency in the development of codes and standards.
- Transform the market for fixtures and appliances.
- Coordinate with green building initiatives to institutionalize water efficiency.
- Train water conservation professionals.
- Educate water users.

For additional information:
- www.allianceforwaterefficiency.org

3C.2.1.2 American Water Works Association

Established in 1881, the American Water Works Association (AWWA) is the largest nonprofit, scientific, and educational association dedicated to managing and treating water. With approximately 50,000 members, AWWA provides solutions to improve public health, protect the environment, strengthen the economy, and enhance the quality of life. AWWA provides technical assistance through studies, standards, conferences, and manuals of practice to the potable water industry. One example of resources available from AWWA is the Water Loss Control Committee Free Water Audit Software©. This free software provides a nationally recognized systematic method to organize water diversion data and track its path through the distribution system.

For additional information:
- www.awwa.org

3C.2.1.3 WateReuse Association

The WateReuse Association is a nonprofit organization whose mission is to advance the beneficial and efficient uses of high-quality, locally produced, sustainable water sources for the betterment of society and the environment through advocacy, education and outreach, research, and membership. They provide technical assistance through studies, standards, conferences, and guidance to the water reuse industry.

For additional information:
- www.watereuse.org

3C.2.2 Other Resources

3C.2.2.1 Certification Programs

Voluntary certification programs for buildings seek to increase efficiency in energy and water usage. These programs include the U.S. Green Building Council's Leadership in Energy & Environmental Design program, the International Code Council's International Green Construction Code, the International Association of Plumbing and Mechanical Officials, Green Building Mechanical and Plumbing Code Supplement, CALGreen, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), and others.

For additional information:
- Leadership in Energy & Environmental Design
  www.usgbc.org/leed
- International Green Construction Code
  www.iccsafe.org/CS/IGCC
- International Association of Plumbing and Mechanical Officials
  www.iapmo.org/pages/iapmo_Sustainability.aspx
- ASHRAE Green Building Standards
  www.ashrae.org/greenstandard

3C.2.2.2 Research Foundations

Nonprofit research foundations continue to advance knowledge and understanding in the fields of water conservation and reuse. These foundations include the Water Research Foundation (WaterRF), Water Environment Research Foundation (WERF), and the WateReuse Research Foundation. These organizations provide valuable technical information through their completed and ongoing research.

For additional information:

- Water Research Foundation
  www.waterrf.org
- Water Environment Research Foundation
  www.werf.org
- WateReuse Research Foundation
  www.watereuse.org/foundation

3C.2.2.3 Alternative Funding Resources

In addition to federal and state resources that provide funding, additional funding opportunities are available through the use of private funding and nonprofit foundations. Private funding can come through the use of performance contracting and public-private partnerships, which provide alternate ways to fund improvement projects. Nonprofit foundations provide grants for projects they deem in agreement with their missions.

Existing water revenue streams can be supplemented by local programs that leverage public and private investments. While "non-traditional" financing approaches that access and mobilize private capital are still relatively underutilized and unfamiliar to many water providers, they offer an, as yet, untapped resource for implementing sustainable water management practices such as water conservation and efficiency. Examples of these innovative approaches include the following.

- Business Improvement Districts, Community Improvement Districts and other special assessment districts may be capable of providing municipalities (and water/sewer districts) with either revenue streams for water conservation, efficiency, reuse or green infrastructure improvements or self-financed partners capable of undertaking projects.

  Example: Wilshire Center BID's "Green Wilshire Center" program
  - www.wilshirecenter.com/green/building.htm

- The Property Assessed Clean Energy (PACE) program is a means of financing energy efficiency upgrades or renewable energy installations for buildings. Examples of upgrades range from adding more attic insulation to installing rooftop solar panels. In areas with PACE legislation in place, municipal governments offer a specific bond to investors and in turn loan the money to consumers and businesses to put toward energy retrofits. The loans are repaid over the assigned term (typically 15 or 20 years) via an annual assessment on their property tax bill. PACE bonds can be issued by municipal financing districts or finance companies and the proceeds can be used to retrofit both commercial and residential properties. A notable characteristic of PACE programs is that the loan is attached to the property rather than to an individual.

  For additional information:
  - www.pacenow.org

- Public-private partnerships may provide cost-effective capacity for conservation/efficiency/reuse and green infrastructure projects or programs.

  Example: West Coast Infrastructure Exchange
  - www.westcoastx.com

- Water conservation credit (or offset) programs are a method for reducing overall water demand through private party actions or market transactions. In these programs, property developers are required to offset increased or new water use through purchases or creation of "credits."

  Example: City of Santa Fe Water Demand Offset program
  - www.santafenm.gov/development_water_budgets

- "On-bill" programs include specific "service fees" added to water customers' bills and allocated to conservation, efficiency and watershed protection activities. While some on-bill programs create a mandatory contribution or fee, others rely on voluntary contributions to fund watershed health or conservation programs.

  Example: Windsor Efficiency PAYS program
  - www.townofwindsor.com/index.aspx?NID=819

- Dedicated leverage funds can be established combining various revenue sources to pay for watershed management or conservation programs.

  Example: North Bay Water Reuse Program
  - www.nbwra.org/costs-and-funding

3C.3 State Programs and Resources

In addition to federal and non-governmental programs, each Basin State has a statewide water planning process that generally includes conservation programs and targets to meet anticipated future water demand. These processes typically involve legal changes, such as ordinances and regulations, and state-funded programs that have been implemented to reduce M&I water demand.

As indicated in the overview of water planning in western states (New Mexico Office of the State Engineer (OSE), 2009), states in the Basin have completed formal water plans that include varying degrees of detail. Also, most states carry out water planning on a regional basis, allowing technical studies and communication among stakeholders to occur at a local level. Others have not completed regional plans for their entire state but have done some regional planning in key areas. Table 3C-2 is an overview of the ongoing statewide water planning process and conservation targets. The following sections provide an overview of the planning efforts occurring in the Basin States and summarize the legal framework and programs related to water conservation.

3C.3.1 Wyoming

The Wyoming State Engineer's Office is charged with regulating and administering water resources in Wyoming. The Wyoming Water Development Commission (WWDC) provides grant and loan funding for water supply reconnaissance and feasibility studies and construction projects. From 1997 to 2006, the WWDC, in conjunction with the State Engineer and the University of Wyoming, completed seven individual basin water plans, one for each major drainage basin of the state. In 2007, the results of these plans were summarized in the Statewide Framework Water Plan and recommendations for future updates were provided (WWDC, 2007).

The 2007 Wyoming Framework Water Plan has two objectives, each presented in a volume. Volume I inventories the state's water resources and related lands, summarizes the state's current water uses, projections future water needs, and identifies alternative decisions to meet indicated future water needs. Volume I presents information from the separate basin reports on a statewide basis. The second objective, and the subject of Volume II, is to provide future water resource planning direction to the State of Wyoming. This current plan provides information for decision making for a 30-year planning horizon.

As part of the river basin studies, water conservation opportunities available today were identified and their applicability discussed. Opportunities with the best economic, practical, and political components for implementation were recommended. For the Green River basin, which is part of the Upper Colorado River Basin, it was recommended to make conservation an opportunity that is evaluated in WWDC municipal master plans and watershed planning studies, to continue to monitor the conservation studies and efforts of other basins, to continue to widen public education and outreach programs, and to commit to discovering and implementing best management practices (BMPs) (WWDC, 2009).

A summary of the existing water conservation programs and resources in Wyoming is presented in the following sections.

3C.3.1.1 State Water Management and Conservation Program

The WWDC and the Wyoming State Engineer's Office, in partnership with Reclamation, initiated the development of a water conservation program for the state beginning August 1998. The purpose of this effort is to develop options for a water conservation program with targets of addressing water conservation practices, investigating strategies, evaluating methodology, analyzing implementation ramifications, evaluating impacts, and identifying sources of assistance.

The water conservation program has developed a directory of assistance programs available to water users and the public. Currently, 25 participating local, state, and federal agencies and organizations provide educational, technical, financial, planning, and policy assistance to water users and the public in pursuing voluntary water management and conservation implementation.

TABLE 3C-2
Water Resources Planning and Conservation Efforts Framework at State Level

Basin State	Water Planning Level	Latest Water Resource Plan (Year, Previous Efforts)	Institution Leading Conservation Regulatory Framework	Most Recent Statewide Water Conservation Plan and Target
Wyoming[1]	State and Seven River Basins	State: The Wyoming Framework Water Plan (2007, last published 1973). River Basin within the Colorado River Basin: Green River Basin Water Plan: 2010 (previous completed in 2001)	Wyoming State Engineer's Office and Wyoming Water Development Commission	Not available. General conservation opportunities are recommended.
Colorado[2]	State and Nine Basin Compact Commissions	State: Colorado's Water Plan (ongoing effort scheduled to be completed by December 2015). This work is being based on the Statewide Water Supply Initiative (SWSI) (2010, currently being updated), Interbasin Compact Committee, (IBCC) (ongoing), Basin Implementation Plans (scheduled to be completed in 2014), and Basin Roundtables (ongoing) results.	Colorado Water Conservation Board (CWCB)	SWSI 2010: No targets developed yet; 2050 gallons per capital per day (GPCD) demand projections for three conservation scenarios that included active and passive conservation (natural replacement of domestic fixtures): 142 (low); 126 (medium); and, 113 (high).
Utah[3]	State and 11 Major Hydrologic River Basins	State: Utah's Water Resources Planning for the Future (2001, last published in 1990). River Basins within the Colorado River Basin: Uintah (1999), West Colorado River (2000), Southeast Colorado River (2000), Kanab Creek/Virgin River (1993).	Utah Division of Water Resources (DWRe)	2003 Utah's M&I Water Conservation Plan: 25% by the year 2050: 220 GPCD Utah's M&I Water Conservation Plan: 25% by the year 2050: 220 GPCD
New Mexico[4]	State	State: Working Toward Solutions: Integrating Our Water and Our Economy, State Water Plan 2013 Review (New Mexico State Water Plan published in 2003).	OSE	Not available.
Nevada[5]	State and Major Suppliers	State: Nevada State Water Plan (1999, last published 1973). Water Conservation Statutes exist in Nevada that require Conservation Plans from suppliers as covered NRS 540.121 through NRS 540.151	Department of Conservation and Natural Resources, Nevada Division of Water Resources	Not available at state level. 2014 Southern Nevada Water Authority Conservation Program: 199 GPCD by 2035.

TABLE 3C-2
Water Resources Planning and Conservation Efforts Framework at State Level

Basin State	Water Planning Level	Latest Water Resource Plan (Year, Previous Efforts)	Institution Leading Conservation Regulatory Framework	Most Recent Statewide Water Conservation Plan and Target
Arizona[6]	State, Active Management Areas (AMA) and Community Water Systems	State: 2014 Arizona's Next Century: A Strategic Vision for Water Supply Sustainability by the Arizona Department of Water Resources (ADWR). Prior statewide planning efforts include the State Water Plan by the Arizona Water Commission (1975-1978), the 1994 Arizona Water Resources Assessment by ADWR, the 2010 Arizona Water Atlas by ADWR, the 2010 Governor's Blue Ribbon Panel on Water Sustainability Final Report, the 2011 Water Resources Development Commission Final Report, the 2012 Water Resources Development Commission Supplemental Report AMA: Active Management Assessment by ADWR; series of 5 Management Plans are required from 1980-2025, the Third Management Plans, 2000-2010 by ADWR are the most recent. Community Water Systems: 2009, System Water Plans update every 5 years	Arizona Department of Water Resources	Not available at state level. Management Plans set provider-specific targets. Third Management Plans (2000-2010) targets have been met. The Fourth Management Plans are in development and will set new requirements.
California[7]	Statewide and 12 regions	State: California Water Plan Update 2013 (updated every 5 years).	Department of Water Resources	2010 California 20X2020 Water Conservation Plan: 20% percent by 2020.

[1] Wyoming Water Development Commission, 2007.
[2] Colorado Water Conservation Board, 2011.
[3] Utah Division of Water Resources, 2001.
[4] New Mexico Office of the State Engineer, 2003, 2013
[5] Southern Nevada Water Authority, 2014.
[6] Arizona Department of Water Resources, 1994, 2010, 2011, 2015, 2015a, 2015b; ADWR/ADEQ, ACC, 2010.
[7] California Department of Water Resources, 2010, 2013.

The WWDC provides grant and loan funding for water supply reconnaissance and feasibility studies and construction projects. Applicants must be public entities such as municipalities, irrigation districts, service and improvement districts, or joint power boards. The existing programs are for project planning, construction, river basin planning, groundwater, and small projects.

For additional information:

- wwdc.state.wy.us/wconsprog

3C.3.1.2 Other Programs

Available water conservation resources for the state, as listed in the Water Management and Conservation Assistance Program Directory (WWDC, 2009a and WWDC, 2014) as follows:

- University of Wyoming Cooperative Extension is an educational and technical resource.
  - ces.uwyo.edu
- Wyoming Association of Conservation Districts is implementing a program to increase and enhance locally driven watershed planning and implementation efforts.
  - www.conservewy.com/WATER.html
- The Wyoming Water Association, a nonprofit corporation, is the only statewide water resources association. Founded in 1933 with the objectives of promoting the development, conservation, and utilization of water resources of Wyoming for the benefit of Wyoming people, the Association provides current information about state and federal funding programs that are necessary to maintain their facilities and develop other uses. The Association holds an annual conference (education seminar and annual meeting).
  - www.wyomingwater.org

3C.3.2 Colorado

Colorado has developed a unique approach to public involvement in water planning. Governor Hickenlooper issued an Executive Order in May 2013 directing the CWCB to develop Colorado's Water Plan (CWP). Creation of this plan is a grassroots effort drawing upon 8 years of unprecedented work, dialogue, and consensus building that water leaders from across the state have engaged in through the Interbasin Compact Committee and Basin Roundtable process (CWCB, 2014). Each of the eight[1] Basin Roundtables is developing a Basin Implementation Plan that has been incorporated into draft sections of the CWP. The draft CWP was released December 2014 (CWCB, 2014a) for public comments, and a final CWP will be submitted by December 2015. The Committee is composed of 27 members representing every water basin and water interest in Colorado. The group facilitates dialogue across basins and works on the list of near-term actions, around which there is consensus, to secure water for the future. The technical foundation for the Basin Implementation Plans and CWP is the SWSI. Since the 2002-2003 drought, the CWCB has been leading the most comprehensive analysis of Colorado water ever undertaken through the SWSI, which is regularly updated.

The CWCB is leading the CWP process in conjunction with other state water agencies (SEO, Water Quality Control Commission, Water Quality Control Division, and Division of Parks & Wildlife). Also, the CWCB is consulting with the Colorado General Assembly and the State Engineer (Colorado Division of Water Resources) and soliciting their input and guidance.

The CWCB is also responsible for approving water efficiency plans and provides technical assistance as well as grant money to develop or update these plans. The institutional framework driving these efforts and main programs is described below. Programs from other institutions have also been included.

3C.3.2.1 Water Conservation Act of 2004: (House Bill 04-1365)

In the Water Conservation Act of 1991 (House Bill [HB] 91-1154), the Office of Water Conservation within the CWCB was created to increase water use efficiency. The Water Conservation Act of 2004 (HB 04-1365) amends the previous act and changes the law to mandate that all covered entities must develop water conservation plans to be approved by the CWCB; expands the duties of the Office of Water Conservation, changing the name to the Office of Water Conservation and Drought Planning; and provides a funding source for water conservation and drought mitigation planning

[1] The eight river basins are as follows: (1) Arkansas Basin; Basins of the Colorado River System; (2) Mainsteam Colorado River Basin; (3) Gunnison River Basin; (3) Yampa River, White River, and Green River Basin; (4) Dolores River, San Juan River, and San Miguel Basins; (5) South Platte River Basin; (6) Republican River Basin; (7) North Platte River Basin; and (8) Rio Grande Basin (CWP, 2014a).

projects. According to the Water Conservation Act of 2004, all covered entities – retail water providers who sell 2,000 AF or more of water annually – must have a water efficiency plan on file with the state that has been approved by the CWCB. Each plan must include the minimum required plan elements as outlined in the Act. In addition, entities seeking financial assistance from the State must estimate and report the water savings from water conservation programs and measures and define water conservation goals (in terms of quantifiable savings).

For additional information:

- cwcb.state.co.us/water-management/waterEfficiency

3C.3.2.2 New Developments Permit Applications (House Bill 08-1141)

In 2008, recognizing the importance of integrating water conservation into water supply planning, Colorado adopted HB08-1141. The bill stated "...land use and development approval decisions are matters of local concern, but to ensure adequacy of water for new developments is a statewide concern and necessary for preservation of public health, safety, welfare, and the environment of Colorado." The new statute requires that all development permit applications, with the support of water supply experts, include information about the proposed development's water supply requirements, physical source, yield under various hydrologic conditions, conservation measures, and demand management.

3C.3.2.3 Reporting of Water Use and Water Conservation Data (House Bill 10-1051)

In 2010, the Colorado General Assembly adopted HB10-1051, which requires covered entities (retail water providers who sell 2,000 AF or more of water annually) to annually report water use and conservation data to be used for statewide water supply planning. The bill directed the CWCB to adopt guidelines regarding the reporting of water use and conservation data by covered entities (Guidelines) and to report to the legislature regarding the Guidelines. HB10-1051 directed the CWCB to develop reporting guidelines through a public participation process that included outreach to stakeholders from water providers with geographic and demographic diversity, nongovernmental organizations, and water conservation professionals. The reporting guidelines include clear descriptions of customer categories, uses, and measurements; how the guidelines will be implemented; and how data will be reported to the Board. Data reported under HB10-1051 will further support statewide water supply planning efforts by improving the quantity and quality of data available and improving consistency in the data reporting.

3C.3.2.4 New Housing Stock and Plumbing Code (House Bills 10-1358 and 10-1204)

The Colorado legislature adopted two new bills in 2010 related to new housing stock. HB10-1358 concerns a requirement for new home builders to offer home buyers water-efficient options. Effective January 1, 2011, builders must offer every buyer of a new single-family detached residence the opportunity to select one or more water-smart home options described further in the bill, which include water-efficient fixtures and landscaping. HB10-1204 adds the word "conservation" to the Colorado state plumbing code and allows the state plumbing board to be able to consider water conservation and efficiency standards when recommending changes to the code.

3C.3.2.5 Limit Use of Agriculture Water for Lawn Irrigation (Senate Bill 14-017)

In April 2014, the governor signed Senate Bill (SB) 14-017 concerning a limitation on the approval of real estate developments that use water rights decreed for agricultural purposes to irrigate lawn grass. The bill seeks to identify and quantify the types of best practices that could be used to limit municipal outdoor water consumption and to determine whether proposed legislation is needed to facilitate the implementation of those practices.

3C.3.2.6 Phase-In High- Efficiency Water Fixture Options (Senate Bill 14-103)

In June 2014, the governor signed SB14-103 concerning the phase-out of the sale of certain low-efficiency plumbing fixtures. Plumbing fixtures addressed by this bill are not WaterSense-listed (that is, lavatory faucets, shower heads, flushing urinals, tank-type toilets, tank-type water closets). Effective September 1, 2016, new low-efficiency plumbing fixtures shall not be sold in Colorado.

3C.3.2.7 2010 Statewide Water Supply Initiative, Portfolios, and Strategies to Address the M&I Gap

The Statewide Water Supply Initiative 2010 (CWCB, 2011) is a statewide planning tool that provides comprehensive information to water providers, state policymakers, and the General Assembly. Colorado faces a significant M&I water supply gap in 2050. This gap is defined as the difference between the projected M&I water demands and supplies from existing sources and the supplies from the Identified Projects and Processes. The M&I gap varies between 190,000 and 630,000 AF, depending on the success rate of the Institutional Provider Programs. By 2050, Colorado's M&I gap could be between 32 and 66 percent of new demands (CWCB, 2011).

Water conservation will be one of several important tools for meeting future M&I demands. The SWSI 2010 report (Section 7) provides reconnaissance-level estimates of the statewide water conservation potential (CWCB, 2011). It provides information about technical potential for water savings but does not determine how the saved water may be used or how much of the conserved water will be available to meet future needs. This is determined at a local level by water providers taking into account the economic feasibility as well as the political will necessary to accomplish higher savings. The Municipal and Industrial Water Conservation Strategies Report, Appendix L (CWCB, 2011) represents the latest effort by the CWCB to integrate water conservation into overall water supply planning and to estimate the statewide water conservation potential up to 2050.

3C.3.2.8 Draft No and Low Regrets Action Plan: Interbasin Compact Committee

In 2013, the Interbasin Compact Committee (IBCC) developed a draft No and Low Regrets Action Plan for water conservation (CWCB, 2013). The IBCC members developed a menu of options that received initial screening by the IBCC. The IBCC was asked to eliminate any potential specific actions that they "could not live with" as options and to add any missing items. Additional input from stakeholders was sought before the actions described in the draft plan were incorporated into the draft Colorado Water Plan or other planning documents. In addition, detail on how and with what funds a specific action will be implemented will be necessary for any action to be realized.

The No/Low Regrets Action Plan is based on the foundation of the Scenario Planning and Portfolio work conducted by the IBCC and the Basin Roundtables. This work has been incorporated into the draft copy of SWSI Chapter 7 update: Scenario Planning and Adaptive Management. This work indicates that the following strategies are necessary in preparation for any future scenario.

- Improve tracking and quantification of conservation.
- Establish a statewide conservation goal with intermittent benchmarks.
- Continue to support local implementation of best practices.
- Promote enabling conditions for use of conserved water.
- Develop new incentives for conservation.
- Explore legislative concepts and develop support.
- Implement education and outreach efforts.

3C.3.2.9 Guidebook of Best Practices for Municipal Water Conservation: Colorado WaterWise

The Colorado WaterWise is a nonprofit organization that promotes the efficient use of Colorado's water (Colorado Waterwise, 2010). The Xeriscape Colorado program is affiliated with this organization and is a leading source of information on low-water landscapes. With funds from the CWCB, they published the Guidebook of Best Practices for Municipal Water Conservation in Colorado, which includes water conservation best practices to assist urban water providers with selecting and implementing effective water conservation programs and measures. Colorado WaterWise also developed quality online resources for commercial, institutional, and industrial water conservation. Using the best practice as a basis, SWSI 2010 estimated low, medium, and high strategies for active water conservation savings.

3C.3.2.10 Memorandum of Understanding of Water Conservation and Stewardship and Best Management Practices: Metro Mayor Caucus

The Metro Mayor Caucus (Caucus) is a voluntary and collaborative regional organization composed of mayors from throughout the Denver metropolitan area. This organization started working on water issues in. In January 2005, a Memorandum of Understanding (MOU) on Water Conservation and Stewardship was signed by 28 jurisdictions and endorsed by 16 organizations (Metro Mayors, 2005) After signing the MOU, the Caucus teamed with the Colorado WaterWise Council to draft BMPs for water conservation (Metro Mayors and Colorado WaterWise Council, 2005). The BMPs are specifically intended to serve as a menu of options to water providers that want to enhance water conservation by reducing demand among their customers. In June 2005, these BMPs were adopted as an appendix to the Colorado Model Water Conservation Plan by the CWCB.

3C.3.2.11 Other Programs

For the State of Colorado, three agencies play key financing roles: the CWCB, the Colorado Water Resources and Power Development Authority (CWRPDA), and the Colorado Department of Public Health and Environment. These agencies award grants and loans to help local groups finance water projects, with revenues obtained through taxes and bond sales. Water conservation funds administered by the CWCB are the Construction Fund and the Severance Tax Trust Fund Perpetual Base Account that can be used for water supply systems rehabilitation. The Water Efficiency Grant Program, created in 2004 under HB05-1254[2], is also administered by the CWCB's Office of Water Conservation & Drought Planning. This grant program provides financial assistance to communities, water providers, and eligible entities statewide for water conservation and implementation as well as drought planning and implementation projects. This program was expanded under SB07-008 to include water conservation planning and implementation, education and public outreach, and drought mitigation and implementation as well as increased funding through June 30, 2020.

[2] HB05-1254; SB07-008 Expansion of the Water Efficiency Grant Program

The major CWRPDA funding programs are the Small Water Resources Project Program and the Water Pollution Control Revolving Fund that could be used for reuse programs. Finally, the Colorado Department of Public Health and Environment and the CWRPDA work together in the administration and funding of the Drinking Water Revolving Fund.

For additional information:

- CWCB Severance Tax Trust Fund
  www.cwcb.state.co.us/LoansGrants/severance-tax-trust-fund-operational-account-grants
- CWCB Construction Fund
  www.cwcb.state.co.us/loansgrants/non-reimbursable-project-investment-grants
- CWCB Water Efficiency Grant Program
  www.cwcb.state.co.us/LoansGrants/water-efficiency-grants

3C.3.3 Utah

The Utah Division of Water Resources (DWRe) has advocated water conservation and efficiency for all water users in its state water planning efforts since the early 1980s. The DWRe is responsible for the state comprehensive water planning, which entails a statewide water plan and individual water plan for each of the state's 11 major hydrologic river basins. The DWRe also promotes water conservation through its water education program and the policies and recommendations of the Board of Water Resources and the Utah Water Conservation Advisory Board. The Division has also produced a model water conservation plan and a model time-of-day watering and rate ordinance for use by interested entities.

The institutional framework driving Utah's conservation efforts and main programs are listed below.

3C.3.3.1 Water Conservation Plan Act (Utah Code §73-10-32)

With the initial passage of Utah's Water Conservation Plan Act in 1998 and later revisions, (as codified in Utah Code §73-10-32), water conservation planning became law for municipal providers with more than 500 connections. This act requires Utah water suppliers to submit a water conservation plan to the DWRe every 5 years outlining the efforts they will use to conserve water within their systems. The methods used to achieve each system's goals are left up to the individual public water system and they choose the methods most suitable to their community and budgetary constraints. This requirement covered systems that provide water to about 93 percent of Utah's population. As of June 2001, 99 out of 150 water retailers and conservancy districts which were to submit plans have done so. State water funding boards have further stipulated that a plan must be in place prior to any funds being awarded. The legislation also directs the Board of Water Resources to study ways to implement the plans, develop recommendations on implementation, and report to the legislature (DWRe, 2001).

The Act was revised in 1999 and 2004 to include provisions that provided for publishing a report that identified entities that do not have a current water conservation plan; required that water conservation plans contain existing and proposed water conservation measures; required that water conservation plans describe the extent to which a retail provider will use certain measures to achieve its conservation goals; required that water conservation plans contain a clearly stated water use reduction goal and implementation plan for each conservation measure, including a timeline for action and an evaluation process to measure progress; and required that the Board of Water Resources report be presented to the Natural Resources, Agriculture, and Environment Interim Committee at its November 2004 meeting.

3C.3.3.2 2003 Utah's Water Conservation Plan

Utah completed its second Water Conservation Plan in 2001 (DWRe, 2001) and prepared an M&I Water Conservation Plan in 2003 (DWRe, 2003). The M&I Water Conservation Plan includes eight steps to meet Utah's water conservation goal to reduce the 1995 per capita water demand from public community systems by at least 25 percent before 2050; this would be a total decrease in demand of about 400,000 AF per year by 2050. Included in the 8 steps are the following 13 recommended BMPs for implementation by state water providers.

- Comprehensive water conservation plans
- Universal metering
- Incentive water conservation pricing
- Water conservation ordinances
- Water conservation coordinator
- Public information programs
- System water audits and leak detection and repair
- Large landscape conservation program and incentives
- Water survey programs for residential customers
- Plumbing standards
- School education programs
- Conservation programs for commercial, industrial, and institutional customers
- Reclaimed water use

3C.3.3.3 State Water Education Program

The DWRe manages the state water education program. The program helps teachers and students realize their places in the water cycle and enables them to make informed decisions about water and how they use it. By developing awareness and knowledge of water resources, the state is equipping the leaders of the future with the skills they will need to make sound water management decisions. The focus areas are teacher education, student outreach, the young artists' water education posters contest, and a banquet.

For additional information:
- www.watereducation.utah.gov

3C.3.3.4 Governor's Water Conservation Team

This program is designed to inform the public by providing water conservation information. Created in 2000, this team is composed of key water officials from the state's five largest water conservancy and metropolitan water districts, the DWRe Director, a representative from the Governor's Office of Planning and Budget, Rural Water Association of Utah, Utah Water Users Association, and the landscape industry. Thus far, the top priority of the Governor's Water Conservation Team has been the joint funding and production of a statewide media campaign, which includes radio and television ads, printed materials, and presentations.

For additional information:
- www.slowtheflow.org/index.php/governor-s-water-conservation-team

3C.3.3.5 Other Programs

Other state water conservation resources are the Center for Water Efficient Landscaping, Water Wise Utah, and the Utah Water Conservation Forum. The Center for Water Efficient Landscaping is a research and outreach center designed to improve efficient use of water for landscape irrigation. The Water Wise Utah partnership is a unique collaborative project where public broadcasting, museums, and libraries work together for greater impact and to leverage the skills of each partner. The Utah Water Conservation Forum supports federal, state, and local water agencies and professionals in sustaining a statewide water conservation movement. They organize a water efficiency conference in the state and have demonstration gardens and a scholarship program for post-secondary students in Utah pursuing research or educational training related to water conservation or a water management related field.

For additional information:

- Center for Water Efficient Landscaping
  cwel.usu.edu
- Water Wise Utah
  waterwiseutah.org
- Water Conservation Forum
  utahwaterconservationforum.org

3C.3.4 New Mexico

The New Mexico Office of the State Engineer (OSE) is charged with administering the state's water resources. The State Engineer has power over the supervision, measurement, appropriation, and distribution of all surface and groundwater in New Mexico, including streams and rivers that cross state boundaries. The State Engineer is also Secretary of the Interstate Stream Commission, which is charged with protecting New Mexico's right to water under eight interstate stream compacts, ensuring the state complies with each of those compacts, and ensuring that the state complies with water planning efforts.

New Mexico has a well-defined ongoing program involving periodic updates of state and regional plans. The New Mexico Statutes 72-14-3.1 (C) (5) instructs the Interstate Stream Commission in collaboration with the OSE and in consultation with other government agencies as appropriate, to develop water conservation strategies and policies to maximize beneficial use. This use includes the reuse and recycling by conjunctive management of water resources and, by doing so, promoting non-forfeiture of water rights in a comprehensive and coordinated state water plan.

3C.3.4.1 Office of State Engineer Water Conservation Program

The Water Conservation Program coordinates water conservation activities for New Mexico. Program goals are to increase awareness about the value of water resources; provide assistance to entities initiating water conservation plans and programs; and to assist in the development of state government policies that will encourage the implementation of water conservation measures in various water use sectors.

The OSE has been working with municipalities to conduct water system audits and develop daily per capita use protocols. The OSE has developed a standardized methodology for GPCD calculations in New Mexico. This standardized tool is used for water use reporting. The GPCD methodology will be required for applications when requesting to hold water unused (40-Year Plans), for water conservation plans, and for mandated water use reporting. It may also be required as a permit condition for sensitive hydrologic basins, for emergency permits, and for large or excessive users. This type of data is also requested as part of the Uniform Funding Application that is used to evaluate water and wastewater loan fund requests.

The OSE also provides technical support and promotes conservation programs such as the Fix a Leak Program and WaterWise Building. The OSE published a complete planning guide (the New Mexico Water Conservation Planning Guide for Public Water Suppliers), which provides tools and step-by-step instructions for developing a measureable and effective water conservation plan for public water suppliers. Another technical resource is the food service water audit program, which is designed for restaurants and cafeterias within the public water supplier's water supply systems. It provides instructions, questionnaires, evaluations, reporting information, and supplemental resources about how to conduct a food service industry water audit program within a utility.

For additional information:

- www.ose.state.nm.us/WUC

3C.3.4.2 Other Programs

The New Mexico Environment Department provides assistance for communities through its Community

Service Group of the Drinking Water Bureau to secure funding for water and wastewater infrastructure projects. The Department's Division of Water and Waste Water Infrastructure Development works with the Governor's Water Cabinet to align state water policy and create consistency in funding through the Water Trust Fund.

The Water Trust Fund became a permanent fund by constitutional amendment in 2006 and receives continuing funding. A water project's inclusion in a regional water plan is a consideration for funding. Also, in the New Mexico Finance Authority's Water Project Fund, projects are recommended by the Water Trust Board to the Legislature. Projects fall under five categories: (1) water conservation or reuse; (2) flood prevention; (3) Endangered Species Act collaborative efforts; (4) water storage, conveyance, and delivery infrastructure improvements; and (5) watershed restoration and management initiatives.

Other nonprofit organizations statewide significantly support water conservation efforts. The New Mexico Water Conservation Alliance is a nonprofit dedicated to water conservation issues. Individuals from municipal, industrial, institutional, and commercial sectors have joined together in an effort to exchange information, provide education, and work collaboratively to help ensure a positive water future for the state. Another organization is the Xeriscape Council of New Mexico formed in 1986 by green-industry professionals interested in water conservation to offer educational programs, training sessions, and conferences on resource-efficient landscaping and related subjects. The Xeriscape Council of New Mexico's primary project is an annual conference that focuses on water, people, and landscape.

For additional information:

- New Mexico Finance Authority, Water Project Fund
  www.nmfa.net/financing/water-programs/water-project-fund
- New Mexico Water Conservation Alliance
  www.nmwca.org
- Xeriscape Council of New Mexico
  www.xeriscapenm.com

3C.3.5 Nevada

Local and regional planning in Nevada has been done by major suppliers (such as the Southern Nevada Water Authority) in key urban areas. Water conservation statutes, programs and the institutional framework as presented in the Nevada State Water Plan (NDWR, 1999) are described below.

3C.3.5.1 Conservation Plans

In Nevada, each "supplier of water" for municipal, industrial or domestic purposes must submit conservation plans to the State of Nevada Division of Water Resources for review and approval. The State Engineer's authority for review of the plans is derived in Nevada Revised Statutes (NRS) 540, with NRS 540.121 through NRS 540.151 covering conservation specifically. The statutes require the following.

- Public education about water conservation.
- Encouraging reduction in sizes of lawns and use of desert adapted plants.
- Leak identification and reduction.
- Reuse of effluent.
- Contingency plans for assuring potable supplies.
- Conservation-oriented rate structures and analyses of how rate structures will maximize water consumption.
- Fines for violation of water conservation related ordinances.
- Metrics for evaluating of success of elements of the plans, including requirements for stating estimated GPCD yield for each conservation measure in the plans.
- A schedule for carrying out plans and requirements for update every 5 years.
- Transparency of plans and online publication of plans

3C.3.5.2 Service Connection Metering Ordinances

A majority of the public water system withdrawals (in terms of volume) are metered; however, not all deliveries to each service connection are metered. Water meters were initially prohibited in Reno and Sparks by a 1919 statute (NRS 704.230). Since that time, gradual changes have occurred that (1) require meters on all businesses (1977) and on all new homes built after 1988 and (2) allow meters on residences upon owner request and under certain conditions tied to the Negotiated Settlement (1990) (NDWR, 1999).

3C.3.5.3 Low-Flow Plumbing Standards: Assembly Bill 359

The Nevada Legislature passed AB359 in 1991 thereby imposing certain minimum standards for plumbing fixtures (toilets, showers, faucets, and urinals) in new construction and expansions in residential, industrial, commercial, and public buildings. Each county and city was required to include these requirements in its building code or to adopt these requirements by ordinance, and to prohibit by ordinance the sale and installation of any plumbing fixture that does not meet the minimum standards (NDWR, 1999).

3C.3.5.4 Other Programs

The Nevada Division of Environmental Protection, Office of Financial Assistance Water Grants Program to provide grants to purveyors of water to assist with the costs of capital improvements to publicly owned community water systems and publicly owned nontransient water systems as required, or made necessary by, the state health board or made necessary by the Federal Safe Drinking Water Act. The program is commonly referred to as the AB 198 Grant Program, after Assembly Bill 198 which established the program. Grants may also be made to eligible recipients to pay for the cost of improvements to conserve water such as in the case of irrigation districts.

Another example of state financial support administered by the Division of Water Resources Planning is the Channel Clearance Program. The program provides funding for channel clearance maintenance, restoration, surveying and monumenting. Local communities, including counties, cities, irrigation districts, and flood control districts can apply for matching funds to maintain channels of navigable rivers within their jurisdictional boundaries (NDWR, 1999).

For additional information:

- www.ndep.nv.gov/bffwp/grants01.htm

3C.3.6 Arizona

In 1980, the ADWR was established with the passage of the Groundwater Management Act. The ADWR administers state laws governing the use of surface water and groundwater (except those related to water quality), underground storage of water, and dam safety. It explores methods of augmenting water supplies to meet future demands, and works to develop public policies and regulations that promote conservation and reuse of water. The ADWR is authorized, for and on behalf of the state of Arizona to consult with and advise the Secretary of the Interior on matters affecting Arizona's entitlement to Colorado River water, and to prosecute and defend Arizona's rights to Colorado River water.

Considerable investment in water resource development and planning has occurred in many parts of Arizona. The State Water Plan developed from 1975 to 1978 by the Arizona Water Commission (predecessor to the ADWR) was the first statewide water planning effort in the state (AWC, 1978). The Arizona Water Resources Assessment (ADWR, 1994) was built upon this document and The Final Report of the Governor’s Blue Ribbon Panel on Water Sustainability (ADWR/ADEQ/ACC, 2010) identified obstacles to increased water sustainability and recommendations on the technical, legal, and policy aspects of promoting increased water conservation and recycling of reclaimed water, gray water, industrial process water, and storm water.

Also in 2010, the Arizona State Legislature passed House Bill 2661 that established the Water Resources Development Commission (WRDC). The WRDC was tasked with assessing Arizona’s demand for water and the supplies available to meet those demands for the next 25, 50, and 100 years. The WRDC comprised 17 commission members with knowledge regarding a variety of water resource and water management issues in the state. Five committees were formed to meet the statutory obligations of the WRDC, each generating a detailed written report. The WRDC Final Report was released in 2011 (WRDC, 2011). The WRDC continued discussions through August of 2012 to develop recommendations aimed at providing local communities with the tools necessary to reduce or prevent future water supply and demand imbalances.

The WRDC Supplemental Report (WRDC, 2012) is a result of these discussions. The Arizona Water Atlas, a separate endeavor from the 1994 assessment, provides a broad overview of water supply and demand conditions as well as an analysis of water resource management issues. The Atlas divides Arizona into seven planning areas composed of groundwater basins and is an organizational concept that provides for a regional perspective on water supply, demand, and resource issues (ADWR, 2010).

In January 2014, the ADWR released Arizona's Strategic Vision for Water Supply Sustainability (ADWR, 2014). The Strategic Vision assessed current and projected demands and water supplies that have been identified in recent reports, and organized the state into twenty-two solution-oriented Planning Areas to facilitate the process of identifying potential strategies that will help Arizona meet its future needs. According to this document, one of the strategies for meeting future demand is the continuation of water conservation programs. The mandatory conservation programs implemented through the Management Plans under the Groundwater Code and complementary voluntary water conservation efforts have resulted in significant increases in water use efficiency throughout the planning area. Continuation and expansion of these efforts to further and continuously increase water use efficiency will be an important element of leveraging existing available supplies and increasing the relative yield of water augmentation alternatives (ADWR, 2015b).

The sections below describe the regulatory framework and relevant programs managed by the ADWR Water Planning Division. Programs and efforts from other institutions are also included.

3C.3.6.1 Arizona Groundwater Management Code

In Arizona, efforts to protect non-renewable groundwater resources led to the passing of a hallmark legislation in 1980 known as the Arizona Groundwater Management Code. The goal of the Code is to control severe groundwater depletion and to provide the means for allocating Arizona's limited groundwater resources to most effectively meet the state's changing water needs.

In 1986, the Ford Foundation selected Arizona's Groundwater Management Code as one of the 10 most innovative programs in state and local government. For nearly 35 years, the 1980 Groundwater Management Act has shaped Arizona's approach to water management. Enacted in response to decades of depletion of the state's limited groundwater supplies, the Act aims to halt groundwater mining in the state's most heavily populated areas, known as AMAs. The Act established the ADWR and gave it extensive authority to regulate water uses and consumption. Within AMAs, the Act prohibits the expansion of agricultural irrigation, requires a permit to drill a new well, mandates that ADWR quantify all rights to withdraw groundwater, requires groundwater users to measure their withdrawals and file annual reports with ADWR, and prohibits new residential growth without a proven 100-year assured water supply.

The Code established three levels of water management to respond to different groundwater conditions. The lowest level of management includes general provisions that apply statewide. The next level of management applies to irrigation non-expansion areas. The highest level of management, with the most extensive provisions, is applied to AMAs where groundwater overdraft is most severe.

To meet the statutory requirements of the Code, management goals were established for each AMA. In the Phoenix, Prescott, Tucson, and Santa Cruz AMAs, the management goal is to achieve safe-yield by 2025. Safe-yield is accomplished when, on average no more groundwater is being withdrawn than is being replaced annually. In the Pinal AMA, where the economy is primarily agricultural, the management goal is to preserve that economy for as long as feasible, while considering the need to preserve groundwater for future non-irrigation uses. In addition to maintaining its safe-yield status, the Santa Cruz AMA goal is to prevent local water tables from experiencing long-term decline. Each AMA carries out its programs in a manner consistent with these goals while considering and incorporating the unique character of each AMA and its water users.

For additional information:

- www.azwater.gov/AzDWR/WaterManagement/documents/Groundwater_Code.pdf

3C.3.6.2 Third Management Plan

Management plans reflect the evolution of regulation under the Groundwater Code, assisting in moving each AMA toward its long-term water management goals. Through the management plans, ADWR establishes conservation goals for each water use sector: agriculture, municipal (includes cities, towns, and private water companies by statute), and industrial (mining, golf course, electric power generation, dairies, and feedlots). Each AMA implements management plans corresponding to five management periods, every 10 years from 1980 through 2025.

The AMAs are currently in the Third Management Plan (2000-2010) and are in the initial stages of formulating the Fourth Management Plan (2010-2020)[3], delayed due to decreased funding in recent years. Once ADWR formally proposes a plan, it must hold a public hearing on the plan prior to final adoption. ADWR's findings after the hearing and its order adopting a plan are subject to judicial review.

A brief description of conservation programs currently implemented as part of the Third Management Plan follows. Conservation requirements in the Third Management Plans have been met. The management plans must include increasing conservation requirements for all water users designed to reach the management goal of each AMA. For municipal uses, the conservation requirements are based on reductions in per capita use and other appropriate measures. Large municipal providers are required to meter all connections and limit system losses to no more than 10 percent. Landscaping in public medians and rights-of-way is restricted to low-water-use plants identified in Regulatory Plant Lists. Many jurisdictions within the AMAs have officially adopted the local regulatory list and incorporated it into ordinances and design guidelines for development. More than 90 percent of the population of this region is served by municipal providers implementing a wide range of BMPs in the categories of public awareness, education and training, outreach service, system evaluation and improvement, ordinances/conditions of service/tariffs, rebates and incentives, and research and innovation. Most large providers have conservation rate structures. Conservation requirements have also been established for persons or entities receiving water from a municipal provider for a non-agriculture use. These uses include turf-related facilities, large-scale cooling facilities, and publicly owned rights-of-way.

[3] Available documentation of the process is at: http://www.azwater.gov/AzDWR/WaterManagement/AMAs/FourthManagementPlan.htm.

For additional information:

- Third Management Planwww.azwater.gov/AzDWR/WaterManagement/AMAs/ThirdManagementPlan3.htm
- Conservation Planning Support to water planners and providers www.azwater.gov/azdwr/StatewidePlanning/Conservation2/Planners/WaterPlanners_Providers_Planning.htm

GPCD: Per-Capita Requirements for Large Municipal Providers

This base program established in the Groundwater Code was first implemented 1987 as part of the First Management Plan. Large municipal providers are those that serve more than 250 AF of water per year for non-irrigation use. Providers are assigned an annual total GPCD allotment that is calculated using the component method (including single-family, multi-family, non-residential, and lost-and-unaccounted-for water).

Non-Per Capita Conservation Program

Established in 1992, the Non-Per Capita Conservation Program (NPCCP) requires implementation of "reasonable conservation measures" from the Third Management Plan and a reduction in groundwater use. Providers must have a designation of assured water supply or be a member of a groundwater replenishment district. In 1992, the Legislature enacted legislation requiring the Department to include in the management plans an NPCCP as an optional, alternative program to the Total GPCD Program requiring reasonable reductions in per capita use. Each provider regulated under the NPCCP is required to implement specific residential and non-residential conservation programs for interior and exterior water use, a public education program relating to water conservation, and a program to meter service area connections. Additionally, providers who are regulated under the NPCCP are required to either reduce their groundwater pumping consistent with the Assured and Adequate Water Supply (AAWS) Rules (Arizona Administrative Code R12-15-701, et seq.) or eliminate their use of mined groundwater by 2010. The NPCCP is a performance-based program with compliance determined by the effective implementation of stipulated conservation measures and required groundwater reductions. For the Third Management Plan, the statutory requirement for the NPCCP are found in Arizona Revised Statues § 45-566.01. (From 2000-2010 Third Management Plan.)

Modified Non-Per Capita Conservation Program

Established in 2008 and first implemented in January 2010. The Modified Non-Per Capita Conservation Program (MNPCCP) came about as a result of the need to consider alternatives to the municipal regulatory program that would better meet the needs and capabilities of the regulated municipal water providers, as well as ADWR. Between 2006 and 2008, ADWR evaluated the regulatory programs for large municipal water providers in the Third Management Plan. This program is mandatory for all large municipal water providers in AMAs that do not have a Designation of Assured Water Supply; it is optional for those that do. The MNPCCP requires providers to implement the following measures:

- Public Education Program: Communicate to customers about water conservation and provide free written water conservation material.
- BMPs: Providers with up to 5,000 connections must implement 1 BMP, 5 BMPs for 5001-30,000 connections and 10 BMPs for > 30,000 connections. BMPs are selected based service area characteristics and/or water use patterns from a list of 53 BMPs.
- Provider Profile: Due within 6 months of notice date and resubmit every 3 years. If service connections increase to a higher tier, a new profile is due within 60 days.
- Conservations efforts report: Submit with the provider's Annual Water Withdrawal and Use Report on or before March 31st
- Rate Structure: Submit with the provider profile.

According to the program annual report (ADWR, 2011), the conservation effort reports by water providers indicated that the BMP related to outreach services and physical system improvements were selected most frequently. BMPs related to ordinances, conditions of service, and tariffs, were selected least frequently. The three most popular BMPs selected by the 55 providers are meter repair and replacement (49 percent), high water use inquiry resolution (33 percent), and high water use notification (25 percent).

For additional information:

- Modified Non-Per Capita Conservation Program www.azwater.gov/azdwr/WaterManagement/AMAs/ModifiedNon-PerCapita.htm
- Suggestions for matching service area characteristics with best management practices www.azwater.gov/azdwr/WaterManagement/AMAs/documents/BMPMatrix.pdf

Alternative Conservation Program

The Alternative Conservation Program, first established in the Second Management Plan, continued into the Third Management Plan. This program is a blend of the GPCD and the NPCCP.

Institutional Provider Program

This program is for large institutional facilities such as prisons, military installations, schools, and airparks that use more than 90 percent of their water deliveries for non-residential purposes. The Institutional Provider Program assigns a GPCD requirement for residential use and conservation measures for the specific institutional water uses in the provider's service area.

Large Untreated Provider Program

This program is for cities, towns, and irrigation districts that deliver non-potable water for landscape irrigation to at least 500 people or at least 100 AF of water. Providers must limit the amount of water delivered in a year. (Note: A provider could be regulated under this program in addition to one of the others above.)

Conservation Requirements for Distribution System

Each large municipal water provider must maintain its distribution system and properly meter and account for all deliveries. Water losses may not exceed 10 percent. Small providers must maintain their systems such that losses do not exceed 15 percent.

3C.3.6.3 Water Management Assistance Program

Beginning in 1990, the Management Plans have required the provision of funding and technical support for programs that help water users in AMAs to achieve the efficient use of water supplies and meet the AMA's water management goal. Funding is primarily from groundwater withdrawal fees collected from each entity withdrawing groundwater in an AMA from a nonexempt well, and is used for purposes that benefit that AMA. To date, hundreds of funded projects have assisted water users in the development and implementation of conservation programs, augmentation, renewable water supply utilization and the acquisition of information on hydrologic conditions and water availability in the AMAs.

ADWR's conservation assistance helps water users plan and undertake conservation programs and lessens the number of enforcement actions related to conservation requirements. It is used for information and education services, including services that increase public awareness about of the importance of water conservation and the AMA's groundwater supplies. It also provides technical support designed to increase water use efficiency across the AMAs. Conservation assistance supports ADWR's role as a central source for information on water conservation, augmentation, and recharge. These efforts have included a variety of projects, such as educational programs for adults and children, evaluation of conservation measures and residential water use, horticulture and irrigation research, and technical workshops and incentive programs for the industrial/commercial sector. Examples include the Patch the Pipe program, which assists water providers in reducing their distribution system losses, and the RinseSmart program, implemented in partnership with providers to save both water and energy in the food service industry.

3C.3.6.4 Assured and Adequate Water Supply Programs

Other ADWR major statutory programs are the Assured and Adequate Water Supply Programs. The Assured Water Supply Program protects consumers inside AMAs by ensuring that people buying or leasing subdivided land in AMAs have sufficient water. A new subdivision will not be approved and homes may not be sold or leased in an AMA unless the applicant can demonstrate that there is sufficient water of adequate quality for at least 100 years. The applicant must apply for and receive a Certificate of Assured Water Supply from the Department.

The Adequate Water Supply Program ensures that people buying or leasing subdivided land outside of AMAs are notified of whether their water supply is adequate or inadequate for at least 100 years. However, subdivisions may be approved and homes may be sold outside of an AMA even if an inadequate water supply determination is made. New subdivisions apply to ADWR for a Water Report (Letter of Adequate Water Supply) prior to lot sales and must share the findings with the public. The Water Report indicates whether water supplies are adequate or inadequate.

The Assured and Adequate Water Supply Programs apply when a subdivision is being developed and thus are driven by the definition of a subdivision from the Arizona Department of Real Estate. A subdivision is six or more parcels with at least one parcel having an area less than 36 acres. This includes residential or commercial subdivisions, stock cooperatives, condominiums, and all lands subdivided as part of a common promotional plan (including golf courses, parks, schools, and other amenities). Short-term leases (12 months or less) and subdivisions where all parcels are greater than 36 acres do not fall under this definition. Both the Assured and Adequate Water Supply Programs are based on demonstration of a 100-year water supply considering current and committed demand as well as growth projections.

For additional information:

- www.azwater.gov/AzDWR/WaterManagement/AAWS

3C.3.6.5 Recharge and Recovery Program

The purpose of this program is to encourage the delivery, storage, and use of renewable water supplies (surface water and treated wastewater). The program includes water supplies that are stored underground, water supplies that are released into natural stream channels to recharge the aquifer, and farms or irrigation districts that use a renewable water supply instead of groundwater that would have otherwise been pumped.

For additional information:

- www.azwater.gov/azdwr/WaterManagement/Recharge

3C.3.6.6 Compliance and Enforcement Program

ADWR has statutory authority to enforce the provisions of the Groundwater Management Act, including the conservation requirements of the Management Plans. A.R.S. Title 45, Chapter 3, Article 12. ADWR developed a compliance and enforcement program to ensure that conservation requirements are met. Annual water withdrawal and use reports are one part of this program. Audits are conducted to determine whether water users are in compliance with conservation requirements. If a water user is found to be out of compliance, ADWR sends out a notice of non-compliance, conducts post audit meetings with the water user, and attempts to negotiate a settlement for the excess water used.

For additional information:

- www.azwater.gov/AzDWR/WaterManagement/AMAs/PhoenixAMA/Compliance.htm

3C.3.6.7 Arizona Water Awareness Portal

The ADWR and the Arizona Municipal Water Users Association, working with other water conservation partners throughout the state that have a role in educating the public about water efficiency and conservation, developed the Arizona Water Awareness web portal as a central source of information on Arizona water resources and water conservation and stewardship. The Central Arizona Project and the Salt River Project have provided funding assistance to the project. The site includes ideas, tips, resources and events about water conservation. The portal sprang from the Water Awareness Month campaign, a result of a 2008 Executive Order that designates April as Water Awareness Month and the Water Awareness Month website that was first launched in 2011.

For additional information:

- Arizona Water Awarenesswww.arizonawaterawareness.com
- Water Awareness Month www.waterawarenessmonth.com

3C.3.6.8 Regional Conservation Programs

Listed below are well-established examples of regional and statewide collaboration and information sharing among water providers, agencies, universities, and others in Arizona.

- The Arizona Statewide Conservation Information Sharing Group (InfoShare) was established circa 2000 to facilitate the exchange of information, research, resources, and funding opportunities. Staff from public and private utilities; federal, state, and local agencies and organizations; universities; and the private sector meet twice a year or more to discuss water conservation, efficiency, and reuse programs, technologies, and strategies. Between meetings, information and updates are disseminated via a volunteer coordinator who maintains a master email list of participants.

  For additional information:

  - Contact Community Water Resource Manager, Liberty Water.

- The Arizona Municipal Water Users Association (AMWUA) Regional Conservation Program is a collaborative effort of the conservation staffs of the ten AMWUA member municipalities—Avondale, Chandler, Gilbert, Glendale, Goodyear, Mesa, Peoria, Phoenix, Scottsdale, and Tempe—working with local, state and federal agencies, trade associations, universities and AMWUA staff, to advance water use efficiency and conservation across the Phoenix metropolitan area. Established in 1982, the Regional Program complements, expands, and supports individual member programs that serve more than 3.2 million residents. By pooling funding and the diverse expertise of its membership and partners, AMWUA has assembled an expansive toolbox of educational materials and websites, training, outreach, messaging, and research that its members, partners, and many others use to inform, educate, and assist their customers and constituents to manage water resources efficiently.

  For additional information:

  - www.amwua.org

- The Water Conservation Alliance of Southern Arizona (Water CASA) has provided since 1997 a means for member water providers to augment their individual conservation programs and to improve the region's overall water conservation efforts. Members include Community Water Company of Green Valley, Flowing Wells Irrigation District, Town of Marana Water Department, Metropolitan Water Domestic Improvement District, Town of Oro Valley Water Department, Voyager Water, and Farmers Investment Co. Water CASA uses economies of scale to provide services to its members and their customers, engages in research to increase effectiveness of water conservation programs, and provides a voice on regional and state water resource management issues.

  For additional information:

  - www.watercasa.org

- The Cochise Water Project (TCWP) is non-governmental 501c3 established in 2012 and dedicated to the reduction of groundwater use in the Sierra Vista sub-watershed by decreasing water use in both residential and commercial sectors. Overseen by a board made up of prominent community leaders, the organization has acquired funding and introduced a wide range of programs and initiatives since its inception. In particular, a major push has been made through rebates and grants to encourage more people to install rainwater harvesting tanks to capitalize on the mountainous region's annual monsoon season which can result in an additional 12 inches of rainfall.

  For additional information:
  - www.thecochisewaterproject.com

3C.3.6.9 Other Programs

Through its Community Investment Program, the Central Arizona Project offers funding and programs in support of water education and the environment in central and southern Arizona. The Salt River Project provides funding for educational projects and programs and provides conservation resources and programs to students, teachers, and residents in the SRP service area.

3C.3.7 California

California has a well-defined ongoing water management program involving periodic updates of state and regional plans. Every 5 years, the Department of Water Resources (DWR) issues the California Water Plan (DWR, 2013), a policy document that includes an analysis of the current status of water supply and demand, examines future water availability scenarios, and identifies strategies that guide state investments in technological innovation, infrastructure, and integrated water management. The DWR is also responsible for administering the Urban Water Management Planning Act of 1983, which requires urban suppliers to prepare and update their Urban Water Management Plans every 5 years.

The California Water Plan provides a collaborative planning framework for elected officials, agencies, tribes, water and resource managers, businesses, academia, stakeholders, and the public to develop findings and recommendations and make informed decisions for California's water future. The plan presents the status and trends of California's water-dependent natural resources; water supplies; and agricultural, urban, and environmental water demands for a range of plausible future scenarios. The California Water Plan also evaluates different combinations of regional and statewide resource management strategies to reduce water demand, increase water supply, reduce flood risk, improve water quality, and enhance environmental and resource stewardship. The evaluations and assessments performed for the plan help identify effective actions and policies to meet California's resource management objectives in the near term and for several decades to come.

The goal for each California Water Plan update is to receive broad input and support from Californians in producing a strategic water plan that meets California Water Code requirements, guides state investments in innovation and infrastructure, and advances integrated water management and sustainable outcomes.

3C.3.7.1 20x2020 Water Conservation Plan

The 20x2020 Water Conservation Plan (DWR, 2010) sets forth a statewide road map to maximize the state's urban water efficiency and conservation opportunities between 2009 and 2020 and beyond. It aims to set in motion a range of activities designed to achieve the 20 percent per capita reduction in urban water demand by 2020. The potential conservation savings analysis of current actions and additional selected measures indicates that California can reduce its per capita use 20 percent, from the current 192 GPCD to 154 GPCD; this amounts to an annual savings of about 1.59 million AF based on the savings achieved by California's 2005 population of 37 million. In November 2009, California placed the 20x2020 goal into statute (California Water Code Section 10608.16) with the enactment of SBX7-7.

As part of the 2009 state legislation, regional and local water districts were required to provide incentives to enact conservation and other measures to develop "diverse regional water supply portfolios that will increase water supply reliability and reduce dependence on the Delta" (California Water Code Section 10608(c)). Thus, this legislation, in addition to setting conservation targets, also urges water agencies to develop their own sources of water supply. SB X7-7 also required urban water suppliers to report in their Urban Water Management Plans beginning with their

2010 plans, baseline daily per capita water use, their urban water use target, and compliance with daily per capita water use, including technical bases and supporting data for these calculations. The preparation of an Urban Water Management Plan now requires greater analyses of management tools and options that will maximize resources and minimize the need to import water from other regions (Blanco et al, 2012). The current conservation actions include codes related to plumbing and appliance efficiency, regulatory activities, BMPs, and new technologies already having an impact.

3C.3.7.2 Updated Model Water-Efficient Landscape Ordinance

In 1990, California enacted the Water Conservation in Landscaping Act (amended in 2004 and 2006), directing the state's DWR to develop and adopt a Model Water-Efficient Landscape Ordinance (MWELO) (California Code of Regulations, Title 23, Division 2, Chapter 2.7 § 490-494) and requiring all cities and counties to adopt a water-efficient landscape ordinance (DWR, 2009). The ordinance calls for the development of landscape water budgets and performance standards, among other provisions. Landscapes planted under the ordinance are allowed a water budget with an evapotranspiration adjustment factor that decreased in 2010 from 0.8 to 0.7.

By regulation, California Government Code Section 65595 required DWR to update the MWELO in accordance with specified requirements, reflecting many of the recommendations of the Landscape Task Force as documented in the report Water Smart Landscapes for California. Local agencies, not later than January 1, 2010, were required to adopt the updated MWELO or, a local landscape ordinance that was at least as effective in conserving water as the updated model ordinance. If the local agency had not adopted the updated MWELO, or a local ordinance, the MWELO would be applicable within the jurisdiction of the local agency, including charter cities and charter counties. The law required each local agency to notify DWR by January 31, 2010, of their intent of adopting DWR's MWELO, or if not, submit a copy of their adopted water efficient landscape ordinance and include findings and evidence in the record that the local ordinance is at least as effective as the state MWELO. This law directed DWR to submit a report to the Legislature relating to the status of water-efficient landscape ordinances adopted by local agencies. DWR has kept a comprehensive and an ongoing record of responses from local agencies.

Table 3C-3 shows the cities, counties, and water purveyors that responded to the model water-efficient landscape ordinance.

TABLE 3C-3
Number of Cities, Counties, and Water Purveyors that Responded to the Model Water-Efficient Landscape Ordinance

Type	Number of Notices Sent	Number Responded	% of Response
City[1]	456	298	65
County[1]	58	34	59
Water Districts[2]		5	
Other Land Use Authority (Joint Powers Authority)	1	1	100

[1] Cities and counties may have dual responsibility of planning function and water purveyor.
[2] Water purveyors were not required by statute to adopt a water-efficient landscape ordinance; some agencies did so voluntarily.

3C.3.7.3 California Urban Water Conservation Council's Memorandum of Understanding Regarding Urban Water Conservation

The California Urban Water Conservation Council (CUWCC) was created to increase efficient water use statewide through partnerships among urban water agencies, public interest organizations, and private entities (CUWCC, 2011). The Council's goal is to integrate urban water conservation BMPs into the planning and management of California's water resources.

In 1991, many urban water suppliers initiated water conservation programs identified as BMPs after adopting the Council's MOU Regarding Urban Water Conservation.

By 2006 more than 190 urban water suppliers—representing two-thirds of all Californians— had signed the MOU and annual water savings tied to implementation of urban BMPs have increased by 15 percent to 20 percent annually since 1991. The CUWCC's 14 BMPs are organized into five categories. Two categories, Utility Operations Programs and Education, are "Foundational BMPs", because they are considered to be essential water conservation activities by any utility and are adopted for implementation by all signatories to the MOU as ongoing practices with no time limits. The remaining BMPs are "Programmatic BMPs" and are organized into Residential, Commercial, Industrial, and Institutional (CII), and Landscape categories. Utility Operations Programs subcategories are Operations Practices, Water Loss Control, and Metering with Commodity Rates for All New Connections, and Retrofit of Existing Connections, and Retail Conservation Pricing. Education Programs subcategories are Public Information Programs and School Education Programs.

3C.3.7.4 Water Efficiency Standards: California Energy Commission

In 2002, the California Legislature ordered the California Energy Commission (CEC) to establish water-efficiency standards for residential clothes washers. Accounting for a reported 22 percent of an average household's water usage (WaterRF, 1999), washing machines are prime candidates for increased water-efficiency regulation. The 2014 Appliance Efficiency Regulations Section 1605.1(p) (CEC, 2014), provides standards for residential clothes washers manufactured on or after January 1, 2007, and manufactured before March 7, 2015, for a certain maximum water factor. This section also provides a standard for residential clothes washers manufactured on or after March 7, 2015, to meet a maximum integrated water factor by March 7, 2015 and another for January 1, 2018. Similarly, for commercial clothes washers, the section provides standards to comply with a maximum water factor, effective January 1, 2007, and January 8, 2013. Although the federal Energy Policy and Conservation Act expressly pre-empts states from regulating "energy efficiency, energy use, or water use of any product covered by federal energy efficiency standards," the CEC requested a waiver from the U.S. Department of Energy that would allow California to regulate water-efficiency standards for residential washing machines. The CEC won its request for a waiver in 2009 (Proctor, 2010).

3C.3.7.5 High-Efficiency Toilets and Urinals (Assembly Bill 715)

Assembly Bill (AB) 715, signed in 2007, requires that, on or after January 1, 2014, all low-flush toilets and urinals sold or installed in California must be high-efficiency, as codified in California Health and Safety Code Section 17921.3,) requires that, on or after January 1, 2014, all low-flush toilets and urinals sold or installed in California must be high-efficiency. The maximum gallons per flush for high-efficiency toilets and high-efficiency urinals are not to exceed 1.28 gallons and 0.5 gallon, respectively. The bill also requires manufacturers selling toilets or urinals in California to offer high-efficiency models for sale in a specified percentage of all models offered.

By virtue of the 100 percent requirement relating to sales after January 1, 2014, all commercial and residential renovations involving toilet and/or urinal replacement would be subject to the high-efficiency toilet and high-efficiency urinal requirements. As such, the expectation is for natural turnover/replacement to ultimately lead to the replacement of all toilets and urinals throughout the state over time.

3C.3.7.6 2013 California Green Buildings Standards Code: Title 24, Part 11

The California Green Buildings Standards Code is the 11th of 12 parts of the official compilation and publication of the adoptions, amendments, and repeal of regulations to the California Code of Regulations, Title 24. This component is known as the California Green Building Standards Code (CALGreen). The CALGreen Code is published in its entirety every 3 years by order of the California Legislature. The California Legislature delegated authority to various state agencies, boards, commissions, and departments to create building regulations to implement state statutes. These building regulations or standards have the same force of law, and take effect 180 days after their publication unless otherwise stipulated.

The residential mandatory measures related to water efficiency and conservation are included under Division 4.3. CALGreen prescriptive provisions to establish the means of conserving water used indoor are summarized in Table 3C-4. Plumbing fixtures and fittings shall be

TABLE 3C-4
2013 California Green Building Standards Code (CALGreen) Prescriptive Provisions for Maximum Indoor Water Use: Section 4.303

Fixture/Fitting	High-Efficiency Consumption (Tables 4.303.2 and 5.303.2.3)
Fixture/Fitting	High-Efficiency Consumption (Tables 4.303.2 and 5.303.2.3)
Water closet (toilet)	1.28 gallons per flush
Urinal	0.5 gallon per flush
Residential lavatory faucet	Maximum 1.5 gallons per minute at 60 pounds per square inch (psi) Minimum: 0.8 gallon per minute at 20 psi
Common and public lavatory faucet	0.5 gallon per minute at 60 psi
Metering faucet	0.25 gallon per cycle
Kitchen faucet	1.8 gallons per minute (may temporarily increase the flow above maximum rate, but not to exceed 2.2 gallons per minute at 60 psi)
Non-residential lavatory faucet	0.4 gallon per minute

installed in accordance with the California Plumbing Code and shall meet the applicable standards referenced in Table 1401.1 of the California Plumbing Code.

The outdoor water use (Section 4.304) provides the standards for the automatic irrigation system controllers for landscaping providers by the builder and installed at the time of final inspection. It is indicated that these shall be weather- or soil moisture-based controllers that adjust irrigation amounts. The weather-based controllers shall account for local rainfall.

This code covers new construction and renovations, and does not cover property resales, seller disclosures, or product sales. Indoor provisions of CALGreen include commercial sub-metering, excess consumption sub-metering, efficient fixtures, faucet aerators, toilets, urinals, lavatory and metering faucets, multiple showerheads, and nonpotable water use systems. Outdoor considerations include water budgets, landscape sub-metering, and irrigation design (including rain sensors and evapotranspiration controllers).

For additional information:
- www.bsc.ca.gov/Home/CALGreen.aspx

3C.3.7.7 Other Programs

DWR has also partnered with nonprofit organizations such as the Association of California Water Agencies to support conservation efforts. In 2009, the Save Our Water program was created with the alliance of the agency to raise public awareness about the ongoing drought. Today, the Save Our Water program aims to help Californians adopt permanent water conservation behaviors.

For additional information:
- Association of California Water Agencies
  www.acwa.com
- Save Our Water
  www.saveourwater.com

3C.4 Programs Outside of the Basin States

International and national water conservation and reuse program examples are presented in this section. These programs, while not intended to be comprehensive, represent a good reference for successful water conservation efforts that have been implemented outside the Basin States and could serve as additional resources for planning water conservation within the Basin States.

3C.4.1 International Examples

3C.4.1.1 Australia: South East Queensland

In the South East Queensland region, with a population of about 3 million, a severe drought in the middle of the last decade prompted an intensive campaign to reduce water demand. In response, residential water consumption dropped from about 85 GPCD in 2005 to less than 35 GPCD in 2008 during the most severe drought restrictions. Total urban demand, including losses and non-residential consumption, fell from about 130 GPCD in 2005 to about 80 GPCD in 2010.

The drought restriction campaign included many programs. In one notable program, the water utility found that 6.4 percent of residential water users consumed 15.9 percent of the total residential water used, and that 0.4 percent of households was responsible for 5.6 percent of total residential water use. In response, the utility instituted the Residential Excessive Water Users Compliance Program, targeting these high water users with audits and increased scrutiny. Despite the end of the drought, public relations efforts maintain the message to Target 200, which encourages consumers to limit water consumption to 200 liters (about 50 gallons) per day, well above the Target 140 (less than 40 GPCD) campaign implemented during the height of the drought. New homes and most new commercial and industrial building must now capture and store stormwater via rainwater tanks and related infrastructure.

For additional information:
- www.qld.gov.au/environment/water/restrictions

3C.4.1.2 Israel

Israel, home to about 8 million people, faces intense water scarcity. Water management and decision making in Israel occurs at the national level. The government owns the water and sells it to water providers offering retail services.

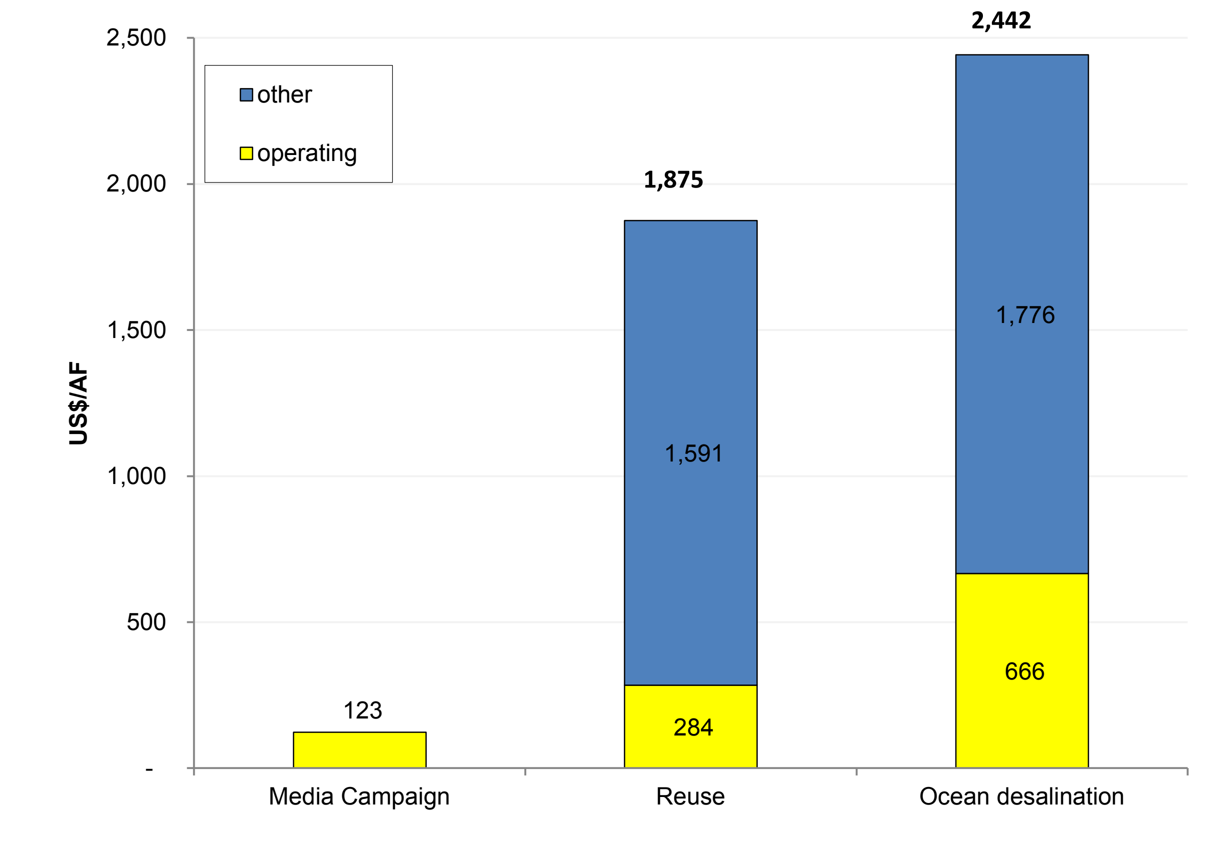
Household water use in Israel is different from that in the Colorado River Basin states, as roughly 35 percent of total household use is consumed by toilet flushing and only about 5 percent by outdoor irrigation; total household use in 2005-2007 averaged about 44 GPCD (total urban use those years, including commercial uses and system losses, was about 72 GPCD). Approximately 84 percent of Israel's domestic wastewater is reclaimed for irrigation in the agricultural sector, supplying about 38 percent of irrigation requirements.

To account for system losses, the state does not charge for 8 percent of the water sold, providing a price signal and incentives to reduce system losses at the provider level. Metering for all water provision in the country is required, enabling detection of system losses; the country is in the process of installing automated meter reading technology. The state also allows providers to reduce water pressure in the pipes to further reduce system losses; such reductions in water pressure are projected to reduce total water use by as much as 5 percent. A multimedia campaign that began in mid-2008, repeating the slogan "Israel is drying up," combined with a roughly 350 percent price increase (a "drought tax") imposed on third-tier water use, decreased M&I water consumption by 18.5 percent and reportedly reduced total urban per capita water consumption by 10 percent just in 2009, to about 65 GPCD. In 2010, the country increased M&I water rates by 40 percent in 1 year because of concerns about rapidly decreasing water storage due to an ongoing drought, promoting water conservation but prompting a public outcry.

The country also implemented a new policy requiring separate meters for each of three classes of vegetation in public gardens and parks and required that the surface area of each vegetation class be reported. One related water conservation program opportunity identified by a local organization is to replace water-intensive plants in municipal parks and gardens with other varieties that have low water needs, potentially saving 20,000 to 50,000 AF per year. Figure C3-1 compares the unit costs of three ongoing water supply and efficiency initiatives in Israel, as reported by the national authority.

For additional information:
- http://www.water.gov.il/Hebrew/Pages/Water-Authority-Info.aspx

FIGURE 3C-1
Total Unit Costs of a Sample of Three Water Supply/Efficiency Initiatives in Israel



Notes:
1. Costs converted from US$/m^3 to US$/AF. The cost of effluent conveyance from wastewater treatment facilities to the agricultural sector and nature ("reuse") ($284/AF) is distinguished from the remaining wastewater treatment costs and the costs of conveyance to the treatment facilities from the domestic sector ($1,591/AF).
2. Desalination operating costs ($666/AF) are distinguished from all other costs of desalination (construction and conveyance; $1,776/AF).
3. "Media Campaign," labeled "Demand Management" (FoEME, 2010). reflects total 18-month campaign costs divided by volume of reported savings in 2009 only, though water savings continued at a similar rate in 2010; therefore, these costs were actually lower when amortized over total water savings.
4. Data from FoEME, 2010.

3C.4.2 National Examples

3C.4.2.1 San Antonio Water System: Drought Restrictions and Conservation Programs

The San Antonio Water System (SAWS) is a public utility owned by the City of San Antonio that serves about 1.6 million people in Texas. It was created in May 1992 through the consolidation of its three predecessor agencies: City Water Board; City Wastewater Department; Alamo Water Conservation and Reuse District. Since the formation of SAWS, San Antonio has been recognized nationally for its novel conservation efforts and proactive water management planning. SAWS claims to have the nation's largest direct-use recycled water system, saving energy and conserving up to 75 KAF per year.

Per capita use in the SAWS service area was 143 GPCD in 2011, a historically dry year, down from a high of 225 GPCD in the mid-1980s. The SAWS 2012 water management plan sets a target of 135 GPCD, which would result in a savings of 16.5 thousand acre-feet (KAF) per year by 2020.

SAWS distinguishes between its short-term drought restrictions and its medium- and long-term water conservation programs. In response to the multi-year drought plaguing Texas, the City's Conservation

Ordinance was updated in 2014 to help better align conservation goals with population growth and long-term water supply strategies. In May 2015, SAWS is enforcing Stage II drought restrictions, limiting sprinkler or soaker-hose irrigation to limited hours and only once per week and imposing limitations on washing cars and on filling private pools, among other restrictions. SAWS issues 200 water citations per week for over-watering and other violations of its drought restrictions; it estimates that a citation reduces the consumer's water use by 24 percent. SAWS estimates that its drought restrictions have saved from 3 KAF to 11 KAF, at a cost of $22 per AF to $73 per AF SAWS runs residential and commercial water conservation programs featuring water audits, outreach and training, coupons, and rebates. In 2015, SAWS is offering a turf replacement program: SAWS will provide a $100 or $200 coupon (depending on irrigation) to homeowners for the conversion of 200 square feet of grass per coupon to "patioscapes," or a water saving garden bed. SAWS offers rebates for water-efficient fixtures such as toilets, pool filters, and residential irrigation conversions. SAWS's commercial rebates include compensation for installing water-saving equipment, and irrigation design.

For additional information:
- www.saws.org/conservation

3C.4.2.2 Seattle Public Utilities: Saving Water Partnership Program

The Seattle area has a regional water conservation program known as the Saving Water Partnership that includes 19 water utilities with a total service area population of about 1.17 million. Actual retail water use in the Saving Water Partnership service area fell from a high of 117.8 million gallons per day in 1994 to 92.5 million gallons per day in 2012, a 21 percent decline in total retail water use despite a population increase of more than 15 percent over that period. Per capita use fell from 116 GPCD in 1994 to 79 GPCD in 2012.

Seattle Public Utilities reports that about half of the reduction in water demand in its service area came from changes in rates and codes, about a third from water conservation programs, and the remainder from system operation improvements. The current water conservation program includes the following programs and measures: distribution of efficient showerheads; toilet rebates; educational programs; online weather data, watering index, water budgeting, and irrigation scheduling tools; trainings and classes; and benchmarking. The Saving Water Partnership has worked with larger institutional users such as the University of Washington to reduce water demand by implementing a suite of water conservation projects, as described in the online video at their Website.

For additional information:
- www.savingwater.org

3C.4.2.3 Tampa Bay Water: Reclaimed Water Use

Tampa Bay Water is a wholesale distributor providing water to several member agencies that in turn serve about 2.4 million people in three counties and three cities in the region.

Potable water demand in its service area has fallen by more than 30 KAF per year since the development of the utility's master water plan conservation goals in 1995, primarily due to savings from reclaimed water use. Pasco County Utilities, one of Tampa Bay Water's member agencies, has retrofitted all 11,000+ reclaimed water meters in its service area with automated meter reading technology. The utility is in the process of retrofitting roughly 96,000 potable water meters with automated meter reading, with the goal of increasing water efficiency by improving water usage data collection, enabling the rapid detection of leaks.

Other programs in the Tampa Bay Water service area include sprinkler system evaluations, high-efficiency clothes washer and toilet rebates, distribution of free rain sensors and pre-rinse commercial spray valves, restrictions limiting sprinkler use to twice a week, prohibiting irrigation between 8:00 a.m. and 6:00 p.m., and adding a fifth (punitive) water charge tier with a volumetric rate double that of the fourth tier.

For additional information:
- www.tampabaywater.org

3C.4.2.4 DeKalb County, Georgia: Retrofit on Reconnect

As of June 1, 2008, any residential properties built prior to 1993 in unincorporated DeKalb County, Georgia must have lowflow toilet and plumbing fixtures installed upon resale before the new homeowner can obtain water service from the County.

All low-flow plumbing fixtures must meet the appropriate American National Standards Institute (ANSI) guidelines and new homeowners must submit a certificate of compliance signed by a licensed home inspector or licensed plumber. Penalties for violating the laws include a warning for the first offense, $250 for the second offense, and $500 for the third offense.

This law went into effect on January 1, 2009 for commercial properties upon resale.

For additional information:

- http://www.dekalbwatershed.com/PDF/low_flow_info.pdf

3C.4.2.5 Florida Moisture Sensors

In 2009, Florida Statutes 373.62(1) was revised to require that soil moisture sensors, evapotranspiration-based controllers or rain sensors be installed on automatic irrigation systems to prevent irrigation during periods of sufficient moisture.

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Chapter 4 | Agricultural Water Conservation, Productivity, and Transfers

This chapter is a product of the Agricultural Water Conservation, Productivity, and Transfers Workgroup

May 2015

4 Agricultural Water Conservation, Productivity, and Transfers

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Acronyms and Abbreviations

AF	acre-foot (feet)
AFY	acre-foot (feet) per year
AMA	active management area
ATM	agricultural water transfer method
Basin	Colorado River Basin
Basin Study	Colorado River Basin Water Supply and Demand Study
BMP	best management practice
CA DWR	California Department of Water Resources
CAP	Central Arizona Project
Compact	Colorado River Compact
CRWCD	Colorado River Water Conservation District
CU&L Reports	Reclamation's Colorado River System Consumptive Uses and Losses Reports
CVC	Conservation Verification Consultants
CVWD	Coachella Valley Water District
CCB	Colorado Water Conservation Board
DOI	U.S. Department of the Interior
DWRe	Division of Water Resources
EQIP	Environmental Quality Incentives Program
GMA	Groundwater Management Act
IID	Imperial Irrigation District
ISC	Interstate Stream Commission
KAF	thousand acre-feet
KAFY	thousand acre-feet per year
M&I	municipal and industrial
MAF	million acre-feet
MAFY	million acre-feet per year
MWD	The Metropolitan Water District of Southern California
N/A	not available
NASS	National Agricultural Statistics Service

NEPA	National Environmental Policy Act
NGO	nongovernmental organization
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
O&M	operation and maintenance
OMID	Orchard Mesa Irrigation District
PCC	Program Coordinating Committee
PVID	Palo Verde Irrigation District
QSA	Quantification Settlement Agreement
RCPP	Regional Conservation Partnership Program
Reclamation	Bureau of Reclamation
SCADA	supervisory control and data acquisition
SDCWA	San Diego County Water Authority
U.S.	United States
USDA	U.S. Department of Agriculture
WCMC	Water Conservation Measurement Committee
WMIDD	Wellton-Mohawk Irrigation and Drainage District
Workgroup	Agricultural Water Conservation, Productivity, and Transfers Workgroup
YCAWC	Yuma County Agricultural Water Coalition

This chapter is a product of the Agricultural Water Conservation, Productivity, and Transfers Workgroup.

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4 Agricultural Water Conservation, Productivity and Transfers

4.1 Introduction

The Colorado River Basin Water Supply and Demand Study (Basin Study) confirmed that, in the absence of timely action, there are likely to be significant shortfalls between projected water supplies and demands in the Basin in coming decades (Bureau of Reclamation [Reclamation], 2012a). Such future action will require diligent planning, collaboration, and the need to apply a variety of ideas at local, state, regional, and Basin-wide levels. In May 2013 Phase 1 of the *Moving Forward* effort was initiated to build on findings for critical next investigations described in the Basin Study and to do so in a manner that continues to facilitate and build upon the broad, inclusive stakeholder process demonstrated in the Basin Study.

The Agricultural Water Conservation, Productivity, and Transfers Workgroup (Workgroup) was convened as part of the *Moving Forward* effort, initiated by Reclamation and the seven Colorado River Basin States[1] in collaboration with the Ten Tribes Partnership and conservation organizations. Efficient water management and conservation for agricultural water use has long been recognized by Colorado River water managers and stakeholders as essential for adapting to and mitigating the impacts of current and future shortfalls between water supply and demand throughout the Colorado River Basin (Basin) and the areas that receive Colorado River water. The Basin Study confirmed the importance of agricultural water conservation, but did so taking a broad-based Basin-wide approach. Recommended by the Basin Study, the Workgroup was established to identify current and potential future opportunities to improve water use efficiency in the agricultural sector but to do so by taking a more detailed and localized approach.

The Workgroup is composed of leaders and experts in the agricultural sector who represent a broad range of perspectives. The objective of the Workgroup was not to confirm, verify, or revise the approach or assumptions used in the Basin Study. Rather, the Workgroup strove to highlight and describe the important regional differences in agricultural water conservation programs, document trends in and programs directed toward water use for agricultural purposes, highlight innovative and successful programs and practices, and identify opportunities to continue to build from such successes.

This chapter is a product of the Workgroup and documents activities and findings from the approximately 18-month Phase 1 of the *Moving Forward* effort. This chapter provides information about the Workgroup's structure and specific objectives, background on agricultural water use in the Basin, past and planned future agricultural water conservation programs and practices in areas served by Colorado River water, opportunities and challenges for expanding successful programs, and a suite of ideas that may be considered for potential future action.

4.2 Background on Agricultural Water Conservation Considered in the Basin Study

To identify a broad range of potential options to resolve water supply and demand imbalances, Reclamation solicited input from Basin Study participants, interested stakeholders, and the general public. More than 150 options to help resolve the imbalance were received and considered in the Basin Study, and nine of the options related to agricultural water conservation. The options were organized into six agricultural water conservation mechanisms that could generate water savings in the agricultural sector. The agricultural water conservation mechanisms consisted of advanced irrigation scheduling, deficit irrigation, on-farm irrigation system improvements, controlled environment agriculture, conveyance system efficiency improvements, and fallowing of irrigated lands. Additional information on the options and strategies evaluated in the Basin Study can be found in the Basin Study, *Technical Report F* (Reclamation, 2012b).

[1] Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming

For purposes of the Basin Study, each of the various agricultural water conservation and fallowing mechanisms were examined at a Basin-wide level; however, the mechanisms have important regional limitations and in some cases may be mutually exclusive. The Basin Study estimated that up to 1 million acre-feet per year (MAFY) of potential savings are possible by 2060. The approach to estimating potential agricultural water conservation, fallowing, and water transfers did not fully reflect important local differences in conservation potential; neither did it completely reflect the legal issues associated with various state water policies. It is noteworthy that approximately 75 percent of the potential agricultural water savings were associated with some form of fallowing, and proper consideration of the aforementioned factors is important in considering potential water savings.

4.3 Workgroup Objectives and Approach

The Workgroup objectives were to document trends in agricultural water conservation and transfers of Colorado River water and to identify opportunities and challenges for expanding agricultural water conservation to address projected future imbalances and enhance overall resiliency. The Workgroup objective was not to confirm, verify, or revise the approach or assumptions used in the Basin Study. As such, the Workgroup did not attempt to quantify future conservation or other water savings, and a direct comparison with the findings of the Basin Study was not attempted.

The Phase 1 tasks performed by the Workgroup are listed in Table 4-1 and are described in the following sections.

TABLE 4-1
Workgroup Task Summary

Task Number	Task
1	Quantify the effects of efficiency projects, conservation, and transfers to date
2	Compile information on successful projects and programs
3	Identify existing plans, agreements, and potential opportunities for future conservation and transfers
4	Document potential impacts, costs, and funding/incentive programs associated with conservation and transfer programs
5	Describe third-party impacts of conservation and transfers
6	Identify opportunities and challenges for expanding successful agricultural water conservation and transfer programs and identify potential solutions
7	Prepare Phase 1 Workgroup Chapter

4.3.1 Workgroup Process and Approach

The Workgroup is composed of approximately 40 members representing a broad range of perspectives related to the agricultural sector. Workgroup members include representatives of the farming community, water purveyors, conservation organizations, state agencies, federal agencies, and academics. Three Co-Chairs, representing Reclamation, Colorado State University, and the Imperial Irrigation District (IID), were selected to lead the Workgroup. The Co-Chairs facilitated discussion and helped to define the Phase 1 tasks. The Workgroup was supported by resource personnel from Reclamation and the *Moving Forward* consulting team led by CH2M HILL. The Workgroup met monthly, either in-person or by conference calls, between September 2013 and November 2014.

A variety of methods to explore agricultural water conservation was employed to maximize the Workgroup's input and obtain differing points of view. The following steps were included in the process:

1. Collect and analyze data.
2. Select and develop case studies.
3. Explore focused conservation topics.
4. Identify opportunities and challenges.

Geographical Representation and Considerations

The Workgroup members represent a significant portion of the total irrigated acreage in the areas receiving Colorado River water. For the purposes of this report, areas receiving Colorado River water means both the hydrologic basin and areas outside of the hydrologic basin that use Colorado River water. Figure 4-1 shows irrigated acreage in areas receiving Colorado River water from the 2011 National Land Cover Database (Jin et. al., 2013). Table 4-2 shows the irrigated acreage that could potentially receive Colorado River water associated with each state. Figure 4-1 and Table 4-2 show that agriculture is prominent in areas receiving Colorado River water and is present at a variety of elevations and locations. See Appendix 4A for additional detail on agricultural acreage in the Basin. Areas within the hydrologic basin rely almost solely on Colorado River water, whereas areas outside of the hydrologic basin often have other water supply sources. As corollary, the location of water use with respect to the basin's hydrologic delineation has implications for the impacts of conservation.

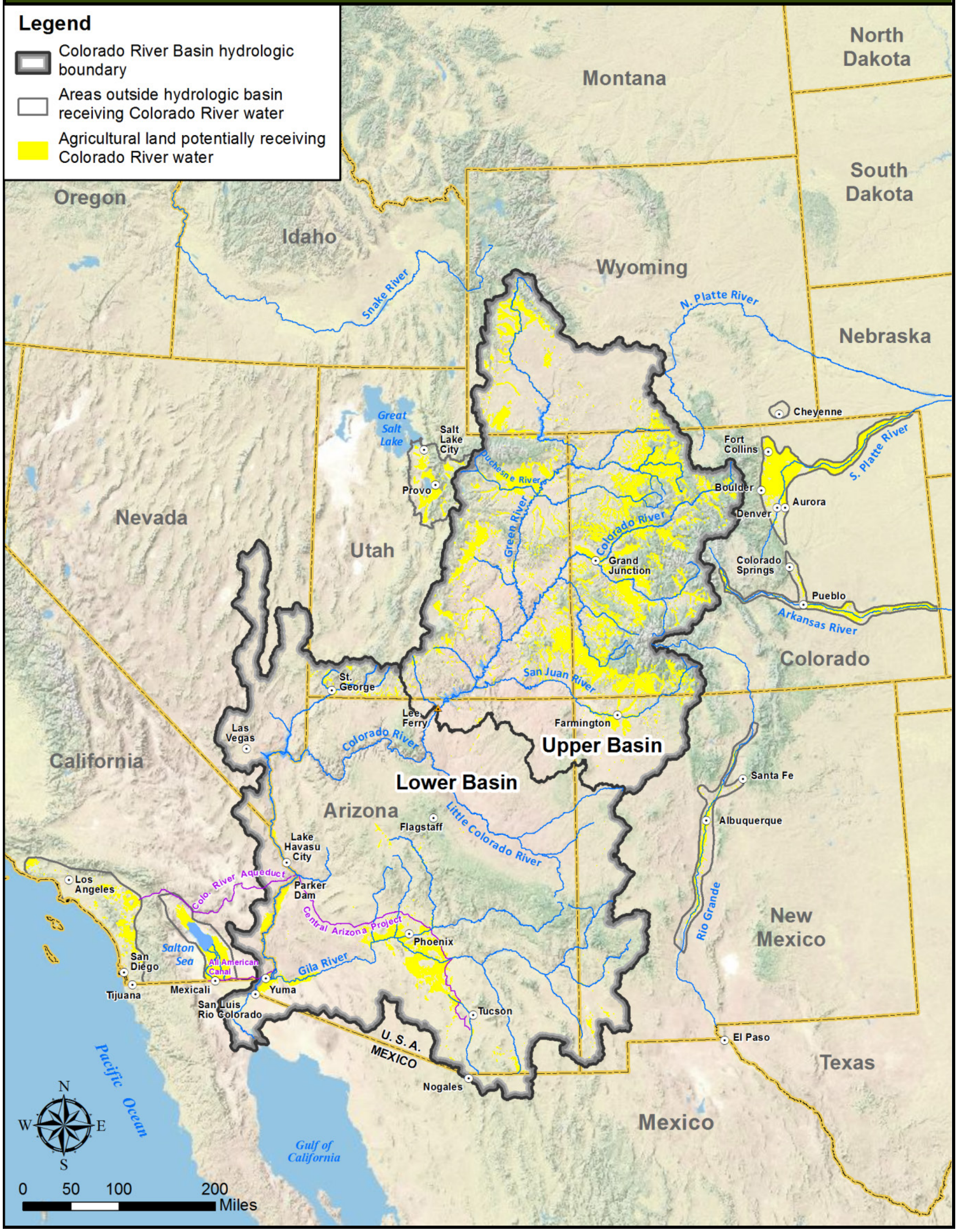
Data Collection and Analysis

Information related to historical agricultural water use, water conservation, and transfer programs as well as future planned water conservation and transfer programs was solicited from Workgroup members to support the assessment of historical agricultural trends. Information was compiled in two phases through an initial survey and through a detailed data collection template. Because the collected data were not fully inclusive of all agricultural activities and were at times inconsistent between entities, national datasets (for example, the National Agricultural Statistics Service [NASS]) were also collected to fill gaps and provide consistency. Information compiled from these and other efforts was summarized at a regional level to illustrate the recent, current, and planned state of agricultural water use in areas receiving Colorado River water. The data collected included:

- Annual water use
- Supplemental information
- Conservation and efficiency programs
- Transfers
- Programs to highlight

The data collection process proceeded differently in the Upper and Lower Basins. In the Upper Basin, data collection was generally completed by representatives of state agencies. In the Lower Basin, many of the major agricultural water users are represented in the Workgroup, so data were collected by district or service area. Data were supplemented by publicly available datasets as needed and when available.

FIGURE 4-1
Agriculture Potentially Served by Colorado River Water



Notes:

1. Irrigated acres from National Land Cover Database; may not reflect all acreage.
2. Some of the agricultural lands shown may not receive Colorado River water or may receive mixed supplies (for example, non-tributary groundwater, diversions from Lower Basin tributaries, or other supplies).
3. Similar to the Basin Study, the scope of the *Moving Forward* effort is limited to the portion of the Basin within the United States (U.S.).

TABLE 4-2
Agriculture in Areas Receiving Colorado River Water[1]

State	Total Irrigated Acres Potentially Using Colorado River Water (2011)[2]	Colorado River Water Equivalent Irrigated Acres[3]
Arizona	614,950	298,087
California	723,037	640,357
Colorado	2,177,450	1,073,194
New Mexico	144,838	38,179
Utah	476,000	352,200
Wyoming	335,540	335,540
Total	4,471,815[4]	2,737,557

[1] Total acreage is generally exclusive of tribal agriculture acreage except in Colorado. The majority of tribal water use is for agriculture. Basin Study tribal demand for 2015 is approximately 10-15 percent as compared to the basin-wide consumptive use and loss average from the past decade.
[2] Sources: Basin Study (Reclamation, 2012). Acreage data from 2011. Utah acreage provided by Utah Division of Water Resources. Wyoming acreage modified from Basin Study to reflect areas currently receiving Colorado River water. Acres are generally exclusive of agriculture supplied by sources other than Colorado River apportionment.
[3] "Equivalent Irrigated Acres." The total acreage was prorated to reflect the portion of supply that comes from the Colorado River when multiple sources are available. For example, if total acreage for a given geography was 100,000 and that area received 40 percent of its supply from the Colorado River, it was assumed that approximately 40 percent of the acreage, or 40,000 acres, would be attributable to the Colorado River supply.
[4] Acreage presented could potentially receive Colorado River water; however, in many cases Colorado River water is supplemental.

It is acknowledged that the full range of data sought was not universally available, either geographically or temporally, and that the dataset contains significant gaps. These gaps are due to a variety of factors including but not limited to record timelines, frequency of reporting, methods employed, level of detail, and information documented by local, state, and federal agencies. Nonetheless, the Workgroup believes that these data portray the trends in current agricultural practices, document past achievements, and provide a baseline for consideration of future programs.

Data reporting and availability reflect the varying nature and evolution of agriculture across the Basin. Accordingly, consistent water use analyses may not be feasible.

Selection and Development of Case Studies

Based on the information provided during the data collection effort, case studies were developed to document successful agricultural water conservation and water transfer programs. These studies, which are provided in Appendix 4B of this report, document the achievements as well as the challenges in implementing successful agricultural water conservation programs.

Focused Conservation Topic Exploration

To facilitate input from Workgroup members on the degree to which agricultural-related activities could play a role in addressing water supply and demand imbalances in areas receiving Colorado River water, four sub-teams were formed. The objective of these sub-teams was to discuss and document issues and challenges related to each team's topic and to explore avenues to overcome these challenges. Each sub-team had approximately three conference calls between February and March 2014 and addressed one of the following conservation topics:

- Consumptive use reductions
- On-farm efficiencies
- Conveyance system improvements
- Water transfers

4.4 Agricultural Water Use in Areas Receiving Colorado River Water

4.4.1 Overview

Native peoples have practiced agriculture in the Southwest for millennia, long before the advent of modern agricultural techniques. Because of the variable nature of climate in the Southwest, farmers, from pre-historic to modern, have modified crop production methods over time, generally increasing the reliability of production and water-use efficiency.

The modern history of agriculture in the Southwest begins with the need to feed booming communities in the late 1800s. Generally, agricultural production was initially focused in the areas of greatest population growth, including areas of the Wasatch front in Utah, the Salt River Valley of Arizona, the High Country of Colorado, and the Imperial and Palo Verde Valleys, both in Southern California. The Reclamation Act of 1902 resulted in the construction of numerous impoundments and delivery systems and ultimately the irrigation of hundreds of thousands of acres with Colorado River Water (Colorado River Water Users Association, 2014).

The initial apportionment of Colorado River water use was determined as part of the 1922 Colorado River Compact (Compact), which divided the Colorado River system into two sub-basins: the Upper Basin and the Lower Basin. These basins are delineated as those regions from which runoff drains to the river upstream and downstream of Lee Ferry, AZ, respectively. Specifically, the Upper Basin includes parts of Arizona, Colorado, New Mexico, Utah, and Wyoming; the Lower Basin includes parts of Arizona, California, Nevada, New Mexico, and Utah.

The Compact apportioned to the Lower Basin States and the Upper Basin States, in perpetuity, the exclusive beneficial consumptive use of 7.5 MAFY. In addition to this apportionment, the Lower Basin States are given the right to increase their beneficial consumptive use by 1.0 MAFY. In the decades following the signing of the Compact, state apportionments were established within the two basins and a treaty was signed with Mexico. These apportionments, along with the broader "Law of the River,"[2] are important to understanding the water management in the Basin.

Based on the approximately 100-year record of Colorado River natural flow[3], the apportioned right to use water in the Basin exceeds the long-term annual average yield of 16.4 million acre-feet (MAF). By the early 1990s Lower Basin consumptive use began to reach its normal annual apportionment, while the Upper Basin developed at a comparatively slower pace. As recently as 2010, Upper Basin Colorado River consumptive use remained less than 4 MAFY. Over the past decade, total annual consumptive use and losses have averaged approximately 15.3 MAF. It is acknowledged that Upper Basin demands are rarely met in full due to the proximity of their headwaters and the variable nature of flows. Nonetheless, even if all current Upper Basin demands were met in full, consumptive use would be considerably less than the 7.5 MAFY apportionment.

Common to both basins is agriculture's large portion of consumptive use; when combined, agriculture is approximately 70 percent of domestic Colorado River consumptive use (excluding reservoir evaporation and other losses). Thus, understanding agriculture served by the Colorado River is also important to understanding water management in the Basin.

4.4.2 Agricultural Production and Sales

Agricultural production in areas receiving Colorado River water is a vital part of both national and local food security and economies. According to the 2007 Agricultural Census, agriculture and animal production from counties served by Colorado River water resulted in upward of $5 billion in sales.[4] It is important to include

[2] Although no formal definition exists, the Law of the River generally refers to the collective body of treaties, compacts, decrees, statutes, regulations, contracts, and other legal documents and agreements applicable to the allocation, appropriation, development, exportation, and management of the waters of the Colorado River.

[3] Additional information, documentation, and the natural flow data are available at http://www.usbr.gov/lc/region/g4000/NaturalFlow/index.html.

[4] The total production in areas served by Colorado River water is greater than this amount. The total amount was prorated to reflect the portion of supply that comes from the Colorado River when multiple sources are available. For example, if total sales for a given geography were $1 billion and that area received 40 percent of its supply from the Colorado River, it was assumed that approximately 40 percent of the sales, or $400 million, would be attributable to the Colorado River.

the sale of animals and animal products when characterizing economic impacts of agriculture. For example, hay or alfalfa may be grown as feed at a dairy or a cattle ranch and would not generate sales directly. Figure 4-2 shows the 2007 agricultural census data by state. While these data reflect a little more than 2 percent of national sales, a significant percentage of a number of crops (such as winter greens) are grown in areas receiving Colorado River water, particularly during certain seasons. Likewise, the relative economic importance of agriculture is very high in many areas receiving Colorado River water. In 2007, Yuma County ranked in in the top 0.1 percent of counties for production of vegetables and melons and in the top 1 percent of counties for all agricultural sales. In addition, agriculture is Yuma County's dominate economic engine, providing significant employment and economic activity (Yuma County Agricultural Water Coalition [YCAWC], 2015).

Food Security

Food security refers to the collective ability of a nation to feed itself. In the U.S., agricultural productivity per unit of water applied and per acre has increased over time. These increases have largely offset increases in population and continued to allow for an overall net export of agricultural products. In this way, the nation has been relatively "secure" with respect to agricultural production. In particular, Colorado River agriculture produces a significant portion of U.S. winter fruits and vegetables, making it vital in domestic food security. Additionally, the U.S. agricultural production occurs in a mature regulatory environment, resulting in a relatively safe food supply; further demonstrating the importance of domestic production in national food security.

Source: Bureau of Reclamation

However, the agricultural community continues to experience greater competition for water resources and in many areas loss of production lands due to urban encroachment. These factors coupled with the potential for production losses due to climate change result in a need to examine the potential long-term impacts of loss of agricultural lands both to national food security and food safety (Western Governors' Association, 2012).

4.4.3 Current Agricultural Setting

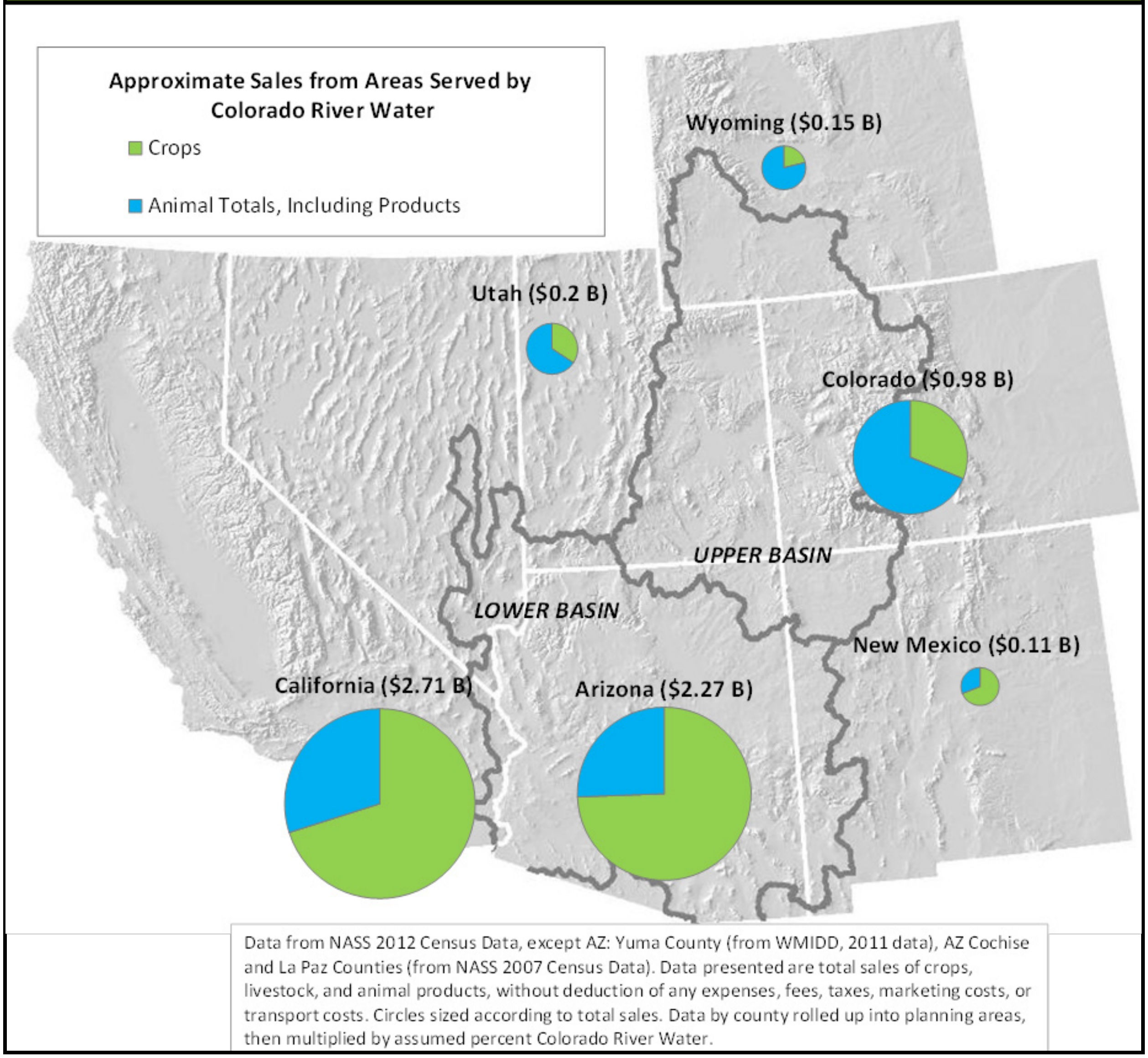
As expected for such a large and varied geography, conditions vary greatly, resulting in vastly different production potentials and subsequently a varied crop mix. Figures 4-3, 4-4, and 4-5 provide an overview of production acreage and water supply source, climate, and crop types by state for areas served by the Colorado River.

About 4.5 million acres of irrigated land is within areas served by Colorado River water. Of this, 2.3 million acres of irrigated land are within the hydrologic basin, while 2.2 million acres are outside the hydrologic basin (primarily Colorado's Front Range, Utah's Wasatch Front and Sevier Regions, and Southern California). In some of these areas other water supplies are used in conjunction with Colorado River water to satisfy total agricultural demand. In general, "other supplies" satisfy approximately 45 percent of the total agricultural water demand.

In the Upper Basin, most agricultural production areas are at higher elevations relative to the Lower Basin and there tends to be more precipitation, colder temperatures, and a shorter growing season. These conditions result in less potential evapotranspiration. The shorter growing season also limits flexibility with respect to crop types and generally a lower demand for irrigation water per acre. The majority of agriculture in the Upper Basin is either field crops or irrigated pasture (Figure 4-5). A significant portion of these crops are used for local animal feed, resulting in approximately three quarters of Upper Basin agricultural sales being from animal products (Figure 4-2).

In contrast, the Lower Basin tends to have hotter temperatures and a longer growing season, which affords the potential to produce a wide variety of crops. Higher potential evapotranspiration and lower precipitation generally lead to greater irrigation water demands per acre. However, Lower Basin agriculture still produces considerable feed crops, supporting the growing demand for beef and dairy products in recent decades.

FIGURE 4-2
Agricultural Sales that Rely on Colorado River System Water



Note:
Animal sales are included to represent crops grown for animal production that are not directly sold. For example, areas of irrigated pasture may support livestock sales but are likely not reflected in crop sales.

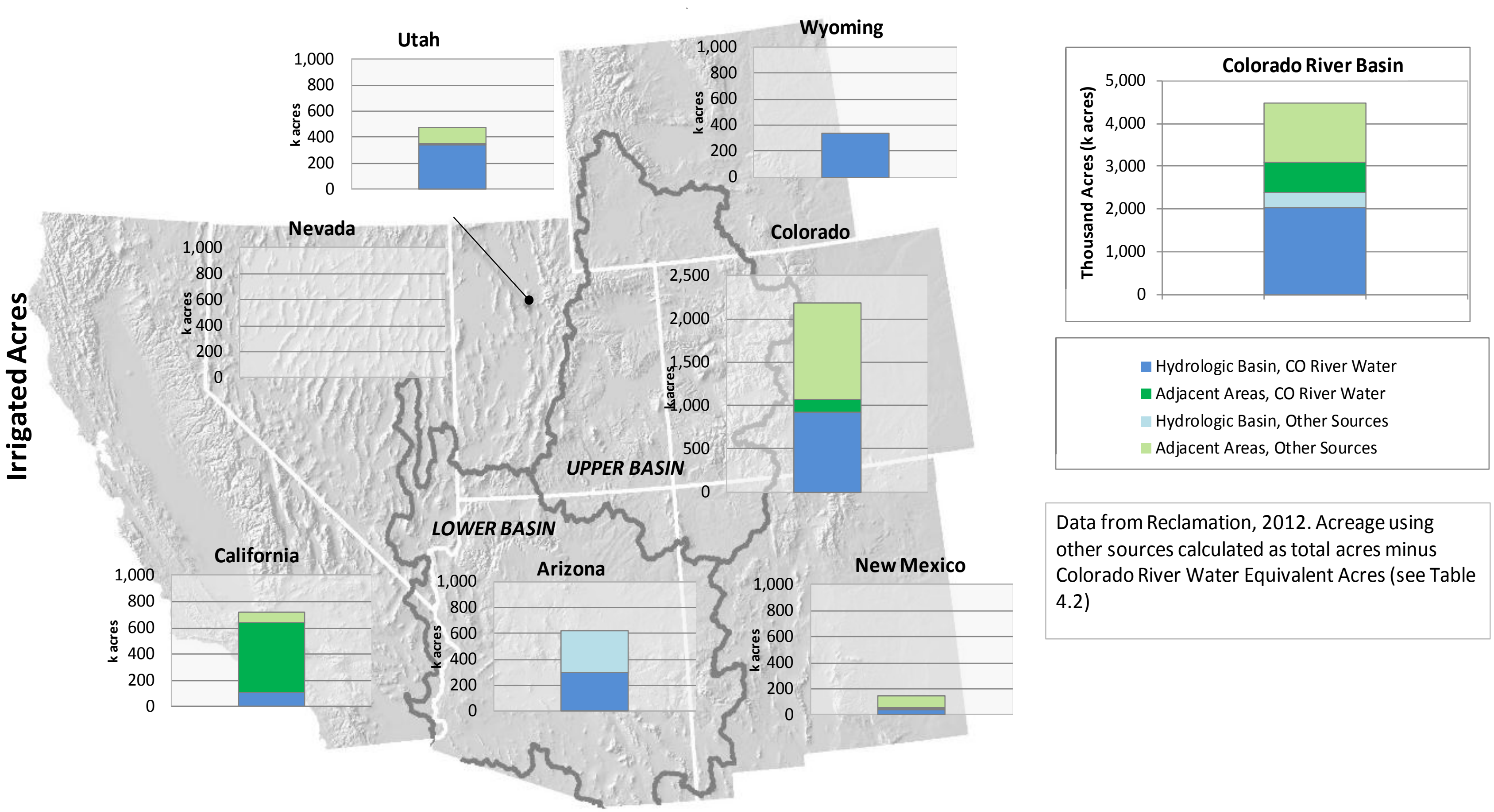
Crop selection is largely driven by crop prices and climate. Farmers generally grow the highest-value crops that can be grown in a given climate with the least risk and/or highest probability of successful cultivation, taking existing infrastructure into consideration. Figure 4-4 shows the cooler temperatures and shorter growing season in the Upper Basin that result in significant amounts of irrigated pasture, with the remaining irrigated area used for field crops. In contrast, the Lower Basin has significantly more vegetables and fruit and tree nuts as compared with the Upper Basin, primarily because the long growing season in the Lower Basin is suitable for these higher-value crops. Figure 4-6 presents the general irrigation methods practiced in areas receiving Colorado River water according to the 2005 U.S. Geological Survey Water Supply Study (2009). Methods in areas receiving Colorado River water include surface[5] irrigation, sprinkler irrigation, and drip or micro-irrigation. Surface irrigation is prevalent throughout the areas

[5] Surface irrigation is defined as irrigation by flood, furrow, or gravity. Note that the terms "flood irrigation" and "surface irrigation" are commonly used interchangeably with the term "flood irrigation" used in the Upper Basin.

receiving Colorado River water. The type of surface irrigation practiced varies significantly, from floods to border basins to precise applications that use regulated gates on laser-leveled fields. Much of the surface-irrigated areas, particularly in the Lower Basin, are laser-leveled fields, resulting in relatively high irrigation efficiencies. For example, more than 80 percent of irrigated agriculture served by the Central Arizona Project (CAP) is irrigated with some form of surface irrigation. Of this portion, about 83 percent is laser-leveled. CAP staff members have observed that laser-leveled fields are about 85 percent efficient (Cullom, 2014). Likewise, sprinkler irrigation methods range from high-pressure sprinkler systems on pasture to efficient low-pressure techniques on row crops. Drip or micro-irrigation is practiced on a small portion of the Colorado River irrigated acreage, primarily in the Lower Basin where climactic conditions allow for production of high-value row crops and for some orchard and vine crops where this method is applicable. For example, approximately 36,000 acres in the Coachella Valley use some form of drip or micro-irrigation techniques.

Types of water conservation measures and the extent of implementation vary extensively among producers and geographies depending on water supply portfolios, climate, crop mix, and available funding.

FIGURE 4-3
Agricultural Production Acreage and Water Supply Source



Data from Reclamation, 2012. Acreage using other sources calculated as total acres minus Colorado River Water Equivalent Acres (see Table 4.2)

FIGURE 4-4
Climate Information by State

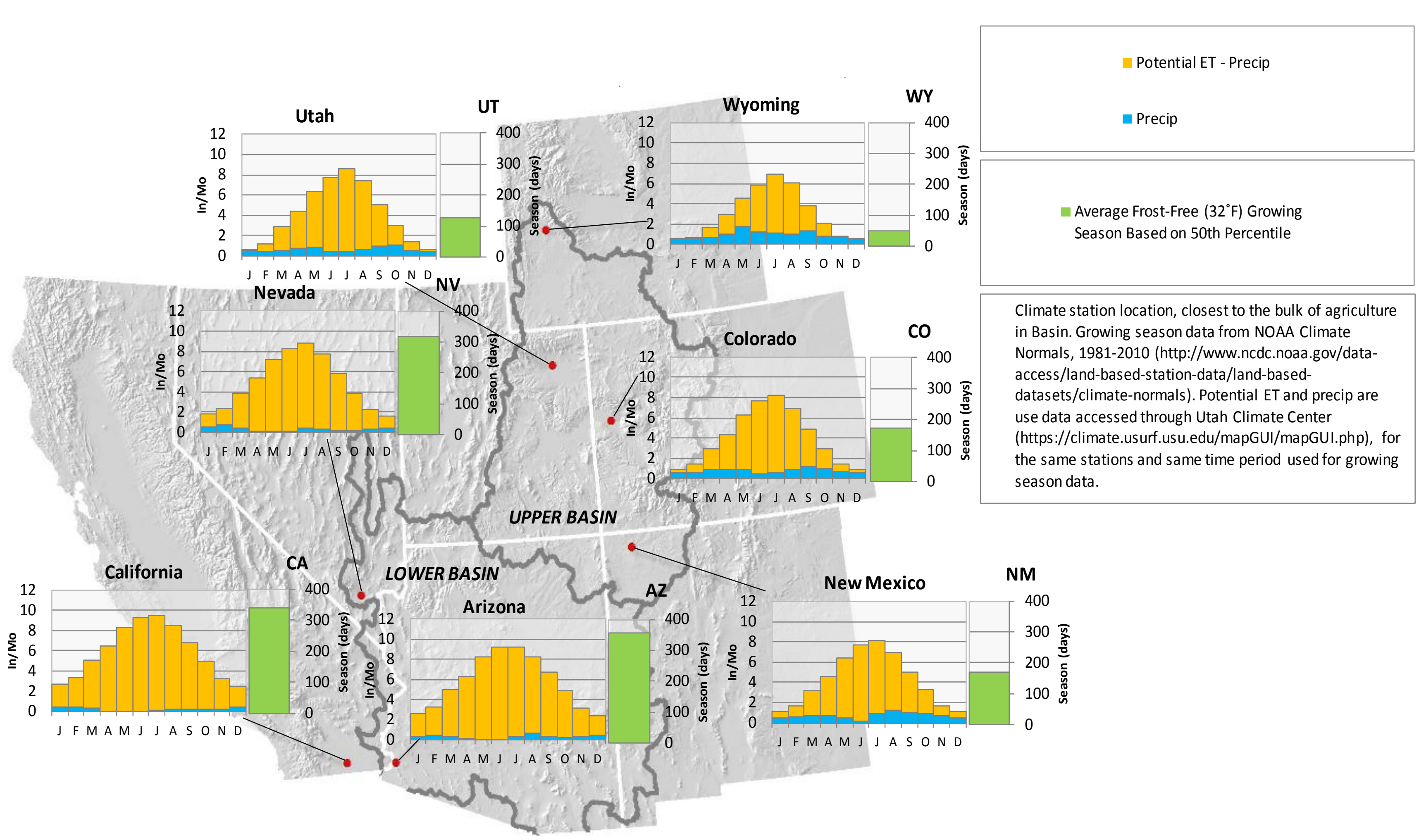


FIGURE 4-5
Crop Types by State

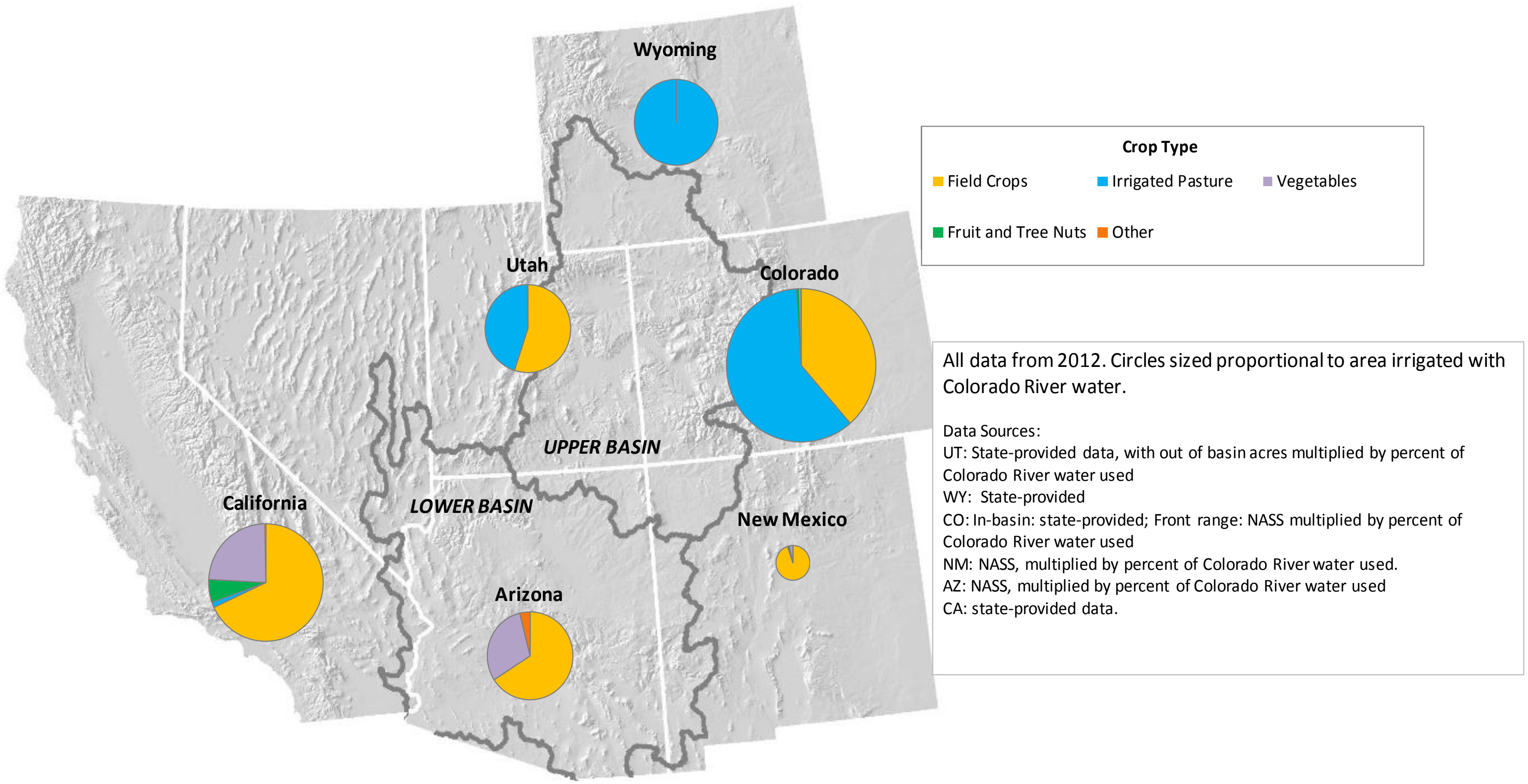
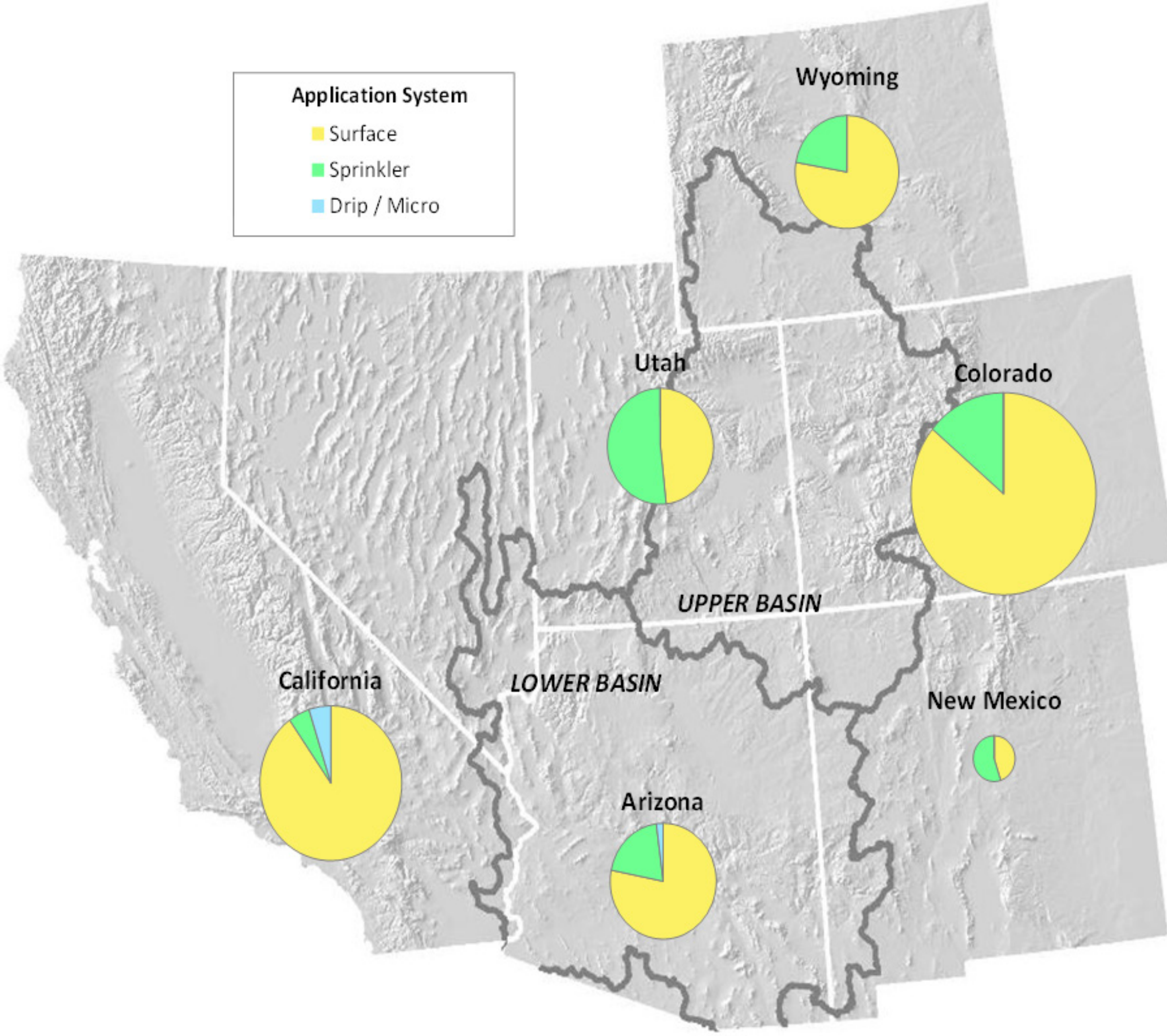


FIGURE 4-6
Irrigation Methods



Data from USGS Circular 1344, 2005 data. Circles sized proportional to area irrigated with Colorado River water. Data by county rolled up into planning areas, then multiplied by assumed percent Colorado River Water.

4.4.4 Trends in Agricultural Water Consumptive Use

Agricultural consumptive use of Colorado River water has remained relatively stable since about 1980, averaging about 8 MAFY, and ranging from about 7 MAFY to just less than 9 MAFY (Figure 4-7). Acreage potentially receiving Colorado River water has also remained relatively constant over that period.

4.4.5 Productivity Increases

Although water use and acreage, and therefore water use per acre, have remained relatively constant historically, productivity has increased in areas receiving Colorado River water by about 25 percent since 1980 (Figure 4-7). More crops are being grown using the same amount of water, on the same amount of land. The increase in productivity is generally consistent with estimates of increased productivity due to improvements in crop varieties (Beddington et al., 2012). A portion of the increased productivity is likely also due to better water management (for example, laser-leveled fields) and more efficient cropping patterns (such as switching to "double-cropping" or planting more than one crop on an acre in a given year), increasing productivity per acre per unit of water consumed. Additionally, in some areas, changes in climate may be contributing to increased productivity by extending the growing season.

A significant period of drought occurred beginning in 2000 in the Basin[6]. Productivity appears to have declined somewhat during this period; however, it remained significantly above levels in the recent past and quickly rebounded when additional supply was available. See Appendix 4C for additional discussion.

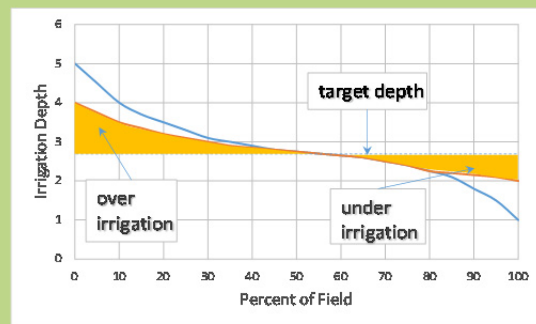
In the Upper Basin, most agriculture operates under water supply-limited conditions, meaning that the full demand of the crops grown cannot always be met with the available supply. These conditions are due in part to a lack of infrastructure to store, divert, deliver, and appropriately time the available supplies. As such, when measures are implemented to increase efficiency, they may result in more water available for farm use and subsequently higher productivity. For example, when growing alfalfa, additional supplies often extend the growing season, resulting in more cuttings and a greater yield.

[6] Natural flow for period from 2000-2014 was the lowest 15-year period in the approximately 100 year historical record.

A Note on "On-Farm Efficiency"

Efficiency is a measure of the total water applied to a field when compared to crop needs. Efficiency can be increased through methods that minimize seepage/infiltration, evaporation, and spillage.

Studies suggest that more efficient methods often result in greater productivity per acre. For example, after laser-leveling a field, crop yields often increase due to more uniform water application.

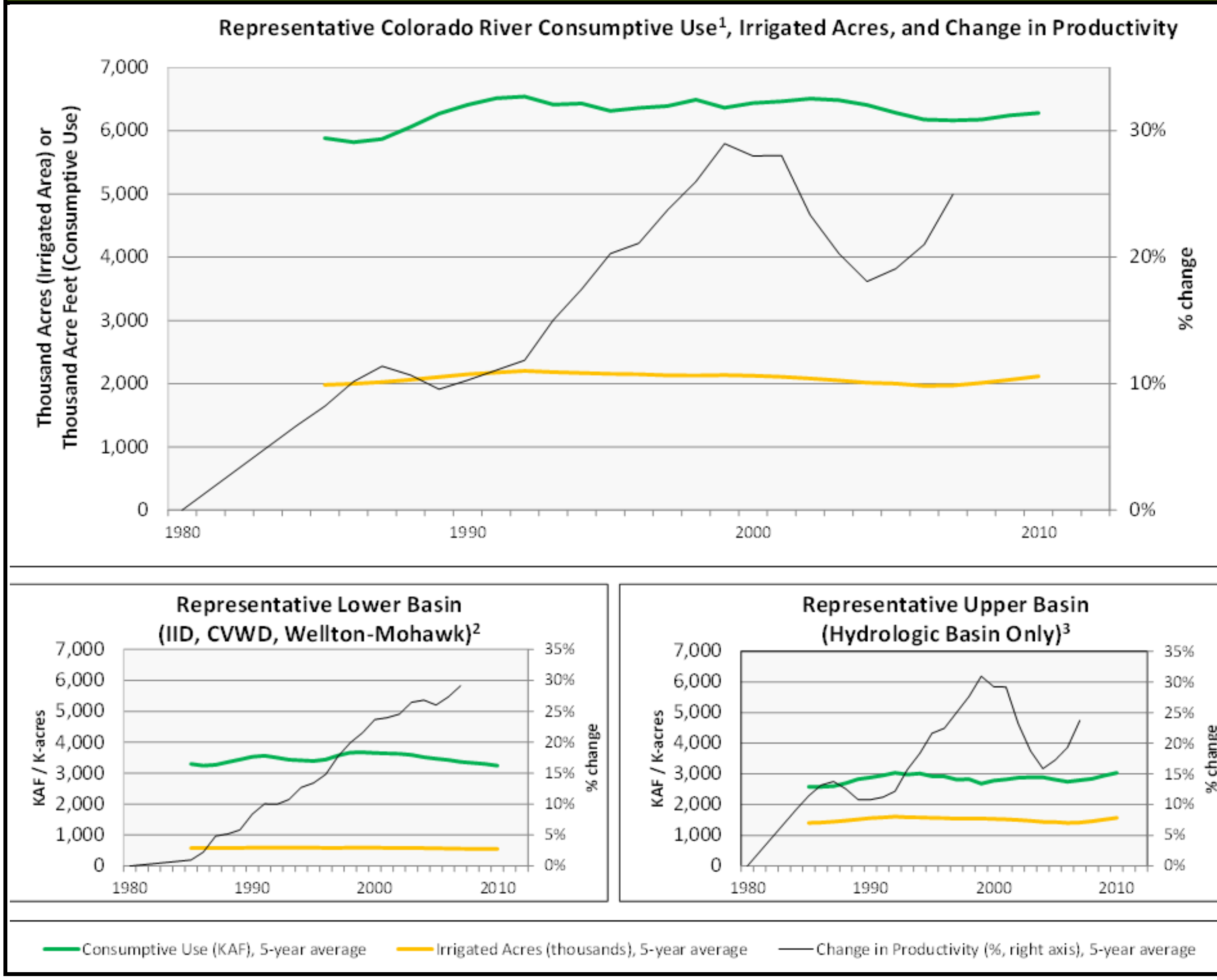


Source: Modified from Gollehon, 2014

The figure above shows such an irrigation improvement (so with efficiency improvements, one moves from the blue line to yellow blocks) that more uniformly applies water, thereby reducing over- and under-irrigation. The net effect is typically an increase in productivity and stable or increased consumptive use (Samani and Skaggs, 2006; Ward and Pulido-Velazquez, 2008; Martinez et al., 2013).

Increasing on-farm efficiency typically results in increased productivity. However, the potential for water savings from these changes varies by location. For example, locations that can reduce diversion and have no downstream delivery requirements may be able to store this water. Areas with downstream delivery requirements and/or limited capacity to retime flows may not be able to realize water savings or other benefits.

FIGURE 4-7
Acreage and Agricultural Consumptive Use of Colorado River Water Compared to Change in Productivity



Percent change in productivity is calculated as the weighted (acres) average of the percentage change in productivity per acre by individual crop (for example, Alfalfa acres% change in Alfalfa tons/acre production + cotton acreage * % change in cotton lbs/acres production + …) / total acreage), from NASS survey data. Units of productivity depend on the crop type (tons, lbs, etc.). A 5-year rolling average was then computed. This procedure was completed for crops included in the NASS survey over time. Note that these data do not reflect 100 percent of actual production and, as such, this plot can be considered generally representative, but not comprehensive. In addition, data are by county, so do not align exactly with areas irrigated with Colorado River water.*

[1] Colorado River water consumptive use from Reclamation's Colorado River System Consumptive Uses and Losses Reports (CU&L Reports). Note in some cases CU&L Reports data differ from data collected by the States.

[2] Lower Basin acres, consumptive use, and productivity presented for areas for which data was collected as part of this study: IID, CVWD, and WMIDD. Those areas represent approximately 65 percent of the Lower Basin's agricultural consumptive use of Colorado River Water.

[3] Upper Basin acres, agricultural consumptive use, and productivity presented for areas within the hydrologic basin, as compiled in CU&L Reports.

Alternatively, in areas with firm supplies and/or reservoir deliveries (for example, Grand Valley, Colorado; Green River, Utah; and Farsen/Eden, Wyoming), if diversions can be reduced due to an increase in on-farm efficiency while maintaining productivity, the un-diverted water left in-stream or in-reservoir may be available for downstream use. Under such conditions, water saved through on-farm efficiency or improved conveyance systems can result in greater crop production, may benefit environmental flows, meet water shortages to upstream or downstream junior water rights, or meet other uses. However, increased production or other uses likely increase overall depletions, potentially resulting in less water available downstream. If production is kept constant and there are not unmet needs of significant shortages, then water savings could potentially be realized.

Water use per acre has remained relatively constant historically while productivity has increased Basin-wide by about 25 percent since 1980.

Because the Lower Basin has significant upstream storage, releases can be timed to reflect crop needs over a given season. This is particularly true of the Lower Basin, but some upstream storage is also available in the Upper Basin. Where sufficient storage capacity exists, increases in efficiency may facilitate transfers, provide water for environmental use, and increase productivity. A 2014 study of Yuma County (YCAWC, 2015) noted that water use per acre has declined significantly while increasing overall sales and productivity. This trend since the 1970s is due primarily to changing crop types to high-value, low-water use crops that can be "double cropped." With double cropping, a single acre supports production multiple times throughout a given year, resulting in greater overall productivity per acre. Further, because these types of crops (such as lettuce) are relatively low-water users per unit of productivity and can be produced with drip irrigation systems, the application efficiency is extremely high, resulting in greater productivity and sales per unit of water consumed.

Increases in on-farm efficiency result in more uniform application of water and may improve productivity but may not result in consumptive use reduction, and the potential for water savings varies by location (for example, in or out of the hydrologic basin).

4.4.6 Future Agricultural and Productivity Considerations

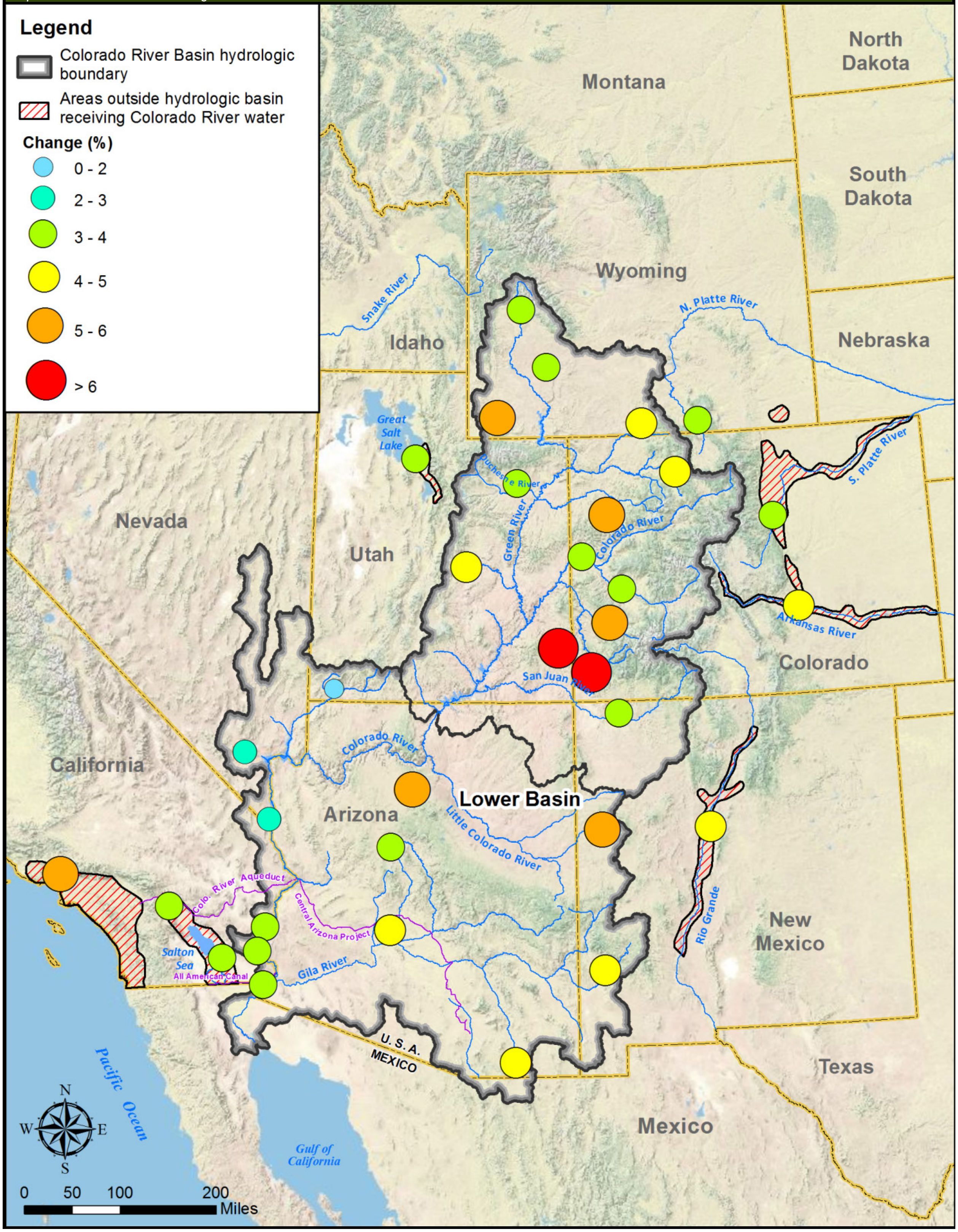
A range of factors are likely to influence the future extent and productivity of agriculture. These may include changes in production acreage, crop varieties, market forces, and climate change.

Changes in agricultural acreage and acreage in production are frequently driven by infrastructure and competing uses for agricultural land and water. Urban encroachment and water supply stress have resulted in the temporary and/or permanent transfer of water or water rights from agriculture to municipal and industrial (M&I), thereby reducing acreage in production. From the Basin Study, it is anticipated that urban encroachment on agricultural lands will continue, potentially resulting in significant permanent reductions in agricultural acreage in Central Arizona and the Front Range of Colorado. However, in some areas, agricultural acreage is anticipated to remain relatively stable with potential for modest growth as new infrastructure projects enhance water availability for agriculture (for example, New Mexico).

Historical productivity increases largely correspond with systematic genetic improvements in crop varieties. Further advances in agricultural production methods and varieties have the potential for enhanced productivity maintaining or reducing water consumption. For example, recent press reports have noted trials of the use of fungus with the seeds of a number of different crops in varying locations to enhance productivity while using less water (Campbell, 2014). As such, technological developments will likely continue to influence crop selection and growing practices.

Market conditions are also likely to influence crops grown, and as a result, have implications for agricultural water use. Fluctuations in supply and demand can have temporary to longer-term implications on the relative profitability of certain crops. As a result, growers may alter crop mixes in response. Related, market forces may also spur innovation to increase production of high-demand crops. This may be accomplished through technological advances in crop varieties, new growing methods, and potentially through genetically modified organisms.

FIGURE 4-8
Projected 2060 Increase in Agricultural Water Demand as Adjusted for Climate Change Effects
Projected percentage change in agricultural water demands by 2060 associated with changes in evapotranspiration. Results are median values from 112 climate simulations from Coupled Model Intercomparison Project 3 at Variable Infiltration Capacity model grid cells nearest to agricultural production for sites representative of areas receiving Colorado River water.



The potential impact of climate change on agricultural water demand was explicitly examined in the Basin Study. Projected temperature changes were used with other climate factors as input to the Variable Infiltration Capacity hydrology model's Penman-Monteith method to estimate potential increases or decreases in evapotranspiration. The results were applied to agricultural demands and are shown in Figure 4-8. It is noteworthy that these results are based on current growing season length and crops presently grown. However, climate change has the potential to further increase overall agricultural water demand through lengthening of the growing season and increases in growing degree days associated with projected warming. Conversely, some studies have also shown the potential for increased productivity and early season harvesting due to earlier crop production potentially reducing water consumption for similar production goals (Reclamation, 2014).

4.5 Agricultural Water Programs and Practices

A range of water conservation activities and programs has helped to enhance agricultural water use over the past century. Improvements have occurred in all major elements of the irrigation process, ranging from reservoir operations to water application methods. Programs to support these efforts have grown over the years and exist at the federal, state, and local levels. These efficiency investments are likely to continue as new technology is developed and water supplies become more strained.

4.5.1 Agricultural Water Conservation, Efficiency, and Transfer Practices

Modern irrigation practices are essential to the highly productive agriculture of the Southwest. Without regular water supply, some of the nation's most productive lands would lay unfarmed. This water supply requires considerable infrastructure, equipment, and management. Since 1902, Reclamation has constructed dams, power plants, and canals in the 17 western states, and these projects led to homesteading and promoted economic development of the West. In addition, many irrigation systems and reservoirs, especially in the Upper Basin, were developed with private funding. Through the creation of large reservoirs and canal systems, reliable water supply and conveyance infrastructure allowed farmers and districts to make their own investments and expand agricultural production to its current scale. Over the 100 or so years of Reclamation's existence, advances in infrastructure, water management, and equipment have facilitated further expansion of agriculture and productivity.

The irrigated agriculture water cycle begins with moisture falling as precipitation. In many cases, that water becomes runoff and enters a river system where it is diverted or detained by a reservoir. In the latter, eventually the water is diverted directly from the reservoir or released for downstream diversion and use. At the point of diversion, water flows by gravity or is pumped into canals or pipelines that may convey the water hundreds of miles from the river or reservoir. Distribution systems convey the water to fields and crops via various irrigation application methods. Irrigation water may evaporate, be consumed by the crop, become runoff, or infiltrate deep into the groundwater. Technology, infrastructure, and management all affect the efficiency of agricultural water use.

Davis Dam releases water for downstream users
Source: Bureau of Reclamation

4.5.1.1 Reservoirs and Operations

Reservoir operations and flow measurement technology have evolved significantly in recent decades. Irrigators have an increased understanding of crop water needs and use that information to determine the timing and magnitude of their diversion requirements. Increased communication between reservoir operators, downstream diverters, and water users has enabled better release determinations for operational scheduling. Related, improved measurement of releases and downstream gauging allows for precise releases and understanding of transmission time as well as losses. Further, with the advent of computer models, releases and schedules are quickly determined or modified if water orders change. All of these techniques can reduce over-releasing water. Additionally, many systems have some form of downstream storage to reregulate and thereby conserve possible excess deliveries. The result of these efforts is a more efficient system because water is stored, released, and diverted for irrigation in a more coordinated fashion. In general, portions of areas receiving Colorado River water that have not been able to fully capitalize on these more efficient operations are located in the headwater regions above any significant storage or regulation facility. Diversions by these irrigators are often driven more by water availability than by crop water needs. Storage and regulation might allow these growers to divert less by providing the necessary amount of water to crops when they need it. Alternatively, application of water "on-call" from storage may increase yields by allowing irrigation to continue late in the season when it was previously not feasible.

4.5.1.2 Conveyance Systems

Early canals and other elements of agricultural conveyance systems were almost exclusively earthen and many remain so today. However, through the years, canal lining, conversion to piped distribution systems, and canal automation have reduced water losses, lowered maintenance costs, improved water quality, and increased operational efficiencies. Recent advances in remote sensing and control (for example, supervisory control and data acquisition [SCADA]) have provided further opportunities to improve water management and control. The benefits of conveyance improvements vary by location and legal considerations. From the prior appropriation basis of western water law, within the hydrologic bounds of areas receiving Colorado River water, return flows from unlined canals and ditches are often relied upon by other downstream users. Therefore, a lined ditch or pipe does not necessarily enable additional water to be delivered to fields because the portion that would have infiltrated back to the river must remain in-stream for the downstream user. Thus, many of the conveyance improvements in the Upper Basin are motivated by operational efficiencies, reduced maintenance costs, and improved downstream water quality, not water quantity.

By reducing canal seepage, frequently less salinity is mobilized and transported to the stream or river. And, in some cases, reducing canal seepage may improve local streamflow for aquatic species and recreation. However, in areas outside the hydrologic basin, water savings are almost always the motivation for canal lining or pipe conversion projects. Once water has been diverted outside the hydrologic basin, that water is generally for the express use of the diverting entity and, therefore, water lost to infiltration or evaporation is water that potentially could be salvaged and used to grow crops or be applied to other uses. In summary, conveyance improvements can have benefits that make the investment appealing; however, benefits are not the same across areas receiving Colorado River water and in many cases do not result in water savings available for other uses.

Gravity furrow irrigation in Imperial Valley
Used by permission of IID

4.5.1.3 On-Farm Improvements

Once water reaches the field, a variety of application methods, water management information, and supporting technologies factor into the irrigation process. These methods typically vary by region and crop types, as do their efficiencies. The objective of an irrigation practice is to minimize inputs (such as water or overall cost) while maximizing outputs (yield). Applying water to meet crop needs while minimizing losses due to evaporation, runoff, or deep percolation minimizes water "inputs." Thus, two major elements of efficient water application are to (1) know the amount of water required and (2) efficiently and uniformly provide that water to the fields at the right time. Regarding the former, technology advances in monitoring of on-farm conditions, coupled with scientific studies on plant water needs, result in refined irrigation application rates. However, to benefit from such information, an efficient uniform application method is needed. Three broad categories of irrigation methods exist: surface, sprinkler, and micro-irrigation. Surface irrigation can be of a variety of forms, such as flood, leveled field, or gravity furrow. Flood irrigation is the application of irrigation water in which the entire soil surface is covered by ponded water. Furrow is a partial surface-flooding method of irrigation normally used with clean-tilled crops in which water is applied in furrows or rows of sufficient capacity to contain the design irrigation stream. Gravity is an irrigation method in which water is not pumped, but flows in ditches or pipes and is distributed by gravity (U.S. Geological Survey, 2009). Typical efficiencies associated with these practices are in the 60 to 70 percent range and can be higher or lower depending on specific practices and levels of maintenance. Sprinkler irrigation tends to be more efficient than surface irrigation because water can be applied at a rate that more closely matches soil intake rate and water holding capacity, thereby reducing standing water and evaporative losses (as well as runoff and deep percolation). These systems tend to have efficiencies in the 80 percent range. Finally, micro-irrigation involves water delivery close to the soil level or directly to the plant roots. These methods, sometimes referred to as drip irrigation or microspinklers, can almost entirely eliminate evaporative losses by slow, direct delivery to the soil, resulting in efficiencies of around 90 to 95 percent. By reducing losses through more efficient timing and application methods, growers can often maintain productivity while using less water. Efficiency measures may also reduce non-beneficial consumptive use such as water consumed by phreatophytes or lost to deep percolation or evaporation during conveyance. However, in a number of cases, this saved water is used to increase productivity; for example, by extending the irrigation season. Another on-farm efficiency measure that may be employed is tailwater recovery, whereby water that runs off the field is collected for reuse in the farm irrigation system. Tailwater recovery systems may be limited by state water law or food safety concerns.

4.5.1.4 Consumptive Use Reductions

While not a traditional efficiency measure, consumptive use reductions refer to a range of practices that aim to lower water use on a per irrigated area basis. One example is crop selection. If a producer can grow a different crop using less water but maintain a yield of similar value, the water savings could be used by another grower or another use. Alternatively, the water savings might be used to irrigate more acres, depending on local legal considerations. Another practice that reduces water consumption is regulated deficit irrigation. This practice is based on the principle that at some point in the season, yield per applied water reaches its peak, and the marginal benefit of continued irrigation declines. The aim is not to maximize overall yield, but to optimize yield per unit of applied water. This practice can make water available for other purposes or facilitate additional irrigated acres. A third way to reduce consumptive use is temporary or permanent fallowing, the practice of electing not to irrigate certain agricultural lands. It can be part of an agreement with another user to secure water or a practice to maintain and enhance soil health. These can be considered efficiency measures in a broader sense by not only using water as effectively as possible, but also considering the economic potential associated with irrigation and other uses. Related research has shown that temporary fallowing of fields has the potential to increase their unit productivity through improved soil health (Cusimano et al., 2014).

4.5.2 Programs and Implementation

To encourage these practices, a variety of federal, state, and district-level programs have been established. These programs offer technical assistance, funding, or other incentives to improve water use.

4.5.2.1 Federal Programs

The majority of federal programs to assist with agricultural water are administered through the U.S. Department of Agriculture (USDA) and the U.S. Department of the Interior (DOI). Specifically, the USDA programs are administered through the Natural Resources Conservation Service (NRCS), while Reclamation is the lead for the DOI.

Since the mid-1990s, the NRCS Environmental Quality Incentives Program (EQIP) has been a major source of financial and technical assistance to plan and implement agricultural water conservation practices. These investments address natural resource concerns through improvements to soil, water, plant, animal, air, energy conservation, and related resources. As part of the 2014 Farm Bill, the Agricultural Act of 2014 (Public Law 113-79), USDA has created a new funding opportunity, the Regional Conservation Partnership Program (RCPP). Through a competitive grant process,

$1.2 billon will be available over the next 5 years (from 2014 to 2019) to fund projects and NRCS expects to leverage an additional $1.2 billion through cost-share and in-kind services from applicants (USDA, 2014). For fiscal year 2014-2015, $394 million in NRCS funding is available. The RCPP promotes a collaborative approach to regional conservation by offering applicants all the capabilities of NRCS under one program. This affords partnership applicants the freedom to design a project that fits their needs and has the greatest potential through a concerted effort. The broad scope of the partnership concept, which could include agricultural districts, sportsmen's associations, municipal water providers, tribes, nongovernmental organizations, universities, or for-profit businesses, is intended to foster greater involvement in conservation activities. In June 2014, the Basin was named a Critical Conservation Area under the RCPP, making project proponents eligible to compete for an additional pool of RCPP funds. In particular, this program has resulted in the recent funding in two projects in the Basin. In the first, the NRCS has partnered with Reclamation and the Colorado River Water Conservation District to implement a large agricultural water efficiency project on the Gunnison River. In the second, the NRCS has partnered with The Nature Conservancy and project partners in the Verde River Valley of Arizona to improve irrigation water management and riparian habitat through conservation easements. Taking advantage of such funding programs as in these examples can not only result in overall greater funding potential but can result in important partnerships that may yield future benefits.

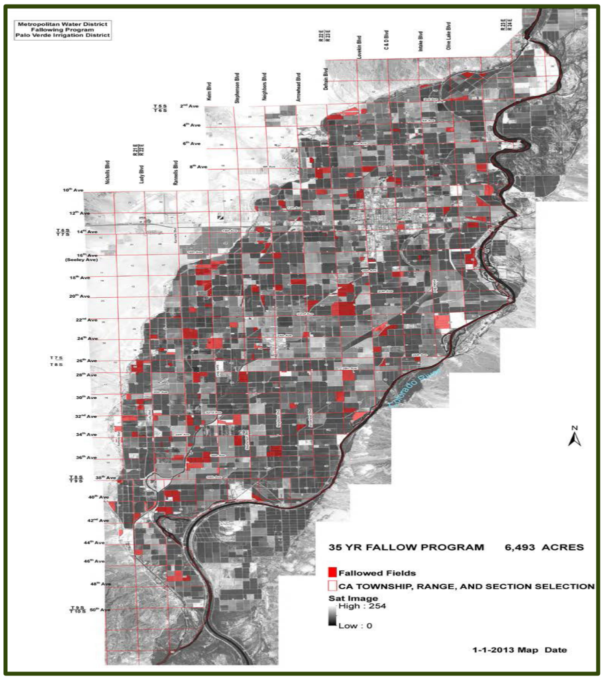
Reclamation supports a variety of programs that offer conservation and efficiency project funding. Through the Colorado River Basin Salinity Control Program, Reclamation has partnered with NRCS through EQIP and the Basin States to provide cost-share assistance to landowners who install salinity control measures. These projects typically involve off-farm conveyance work and on-farm efficiency measures to reduce deep percolation, which mobilize and transport salts back to the river system.

Reclamation's WaterSMART program offers a variety of grant opportunities that can assist with improvements to agricultural water efficiency. Water and Energy Efficiency Grants provide 50-50 cost-share funding to irrigation and water districts, Tribes, States, and other entities with water or power delivery authority. Projects conserve and use water more efficiently, increase the use of renewable energy, protect endangered species, or facilitate water markets. Examples include ditch lining, conversion to piped distribution systems, irrigation and conveyance automation, and soil moisture monitoring. System Optimization Reviews Grants offer a cost-shared analysis that focus on system-wide efficiency and improving water deliveries and operations of a delivery system, district, or watershed. Also part of WaterSMART, the Water Conservation Field Services Program can provide funding and technical assistance for planning, demonstration, and implementation of efficient infrastructure and practices.

4.5.2.2 State Programs

In addition to federal programs, most states provide technical, financial, or other incentives for agricultural water management, conservation, and efficiency. The following are select examples of such programs. In Utah, the state revolving construction loan fund offers low interest loans that often enable irrigation districts to meet cost-share requirements of federal programs. The Colorado Water Conservation Board (CWCB) offers a variety of water efficiency grants that can be used for conservation planning, conservation projects, or public outreach and education. Arizona's Department of Water Resources incentivizes efficiency measures with a Best Management Practices Program and offers technical assistance through the Water Conservation Management Program and the Irrigation Management Service. In California, agricultural water suppliers are to prepare, adopt, and periodically revise Agricultural Water Management Plans; compliance affords eligibility for a water grant or loan awarded or administered by the State. Additionally, California provides data through the California Irrigation

Management Information System, which was developed to assist irrigators in managing their water resources more efficiently so as to save water, energy, and money. Data include precipitation, wind speed, air temperature, soil temperature, and humidity from various stations around the state.



Fields in Palo Verde Irrigation District
From: Calendar Year 2013 Fallowed Land Verification Report (PVID et. al, 2014)

4.5.2.3 District or Local Programs

Agricultural water efficiency resources and opportunities also exist at the district or local level. Many irrigation districts have conservation programs and/or partnerships with university extension services. For example, Southern California's IID has its own program for system and on-farm conservation. In concert with this program, The Metropolitan Water District of Southern California (MWD) and San Diego County Water Authority have provided funding to IID to implement conservation. Colorado State University has county extension offices that provide a range of technical assistance to producers, including water conservation and irrigation management.

Many of the advances in agricultural water conservation have been achieved as part of programs with a variety of federal, state, and local stakeholders working toward mutually beneficial solutions.

4.6 Water Conservation, Productivity, and Water Transfer Case Studies

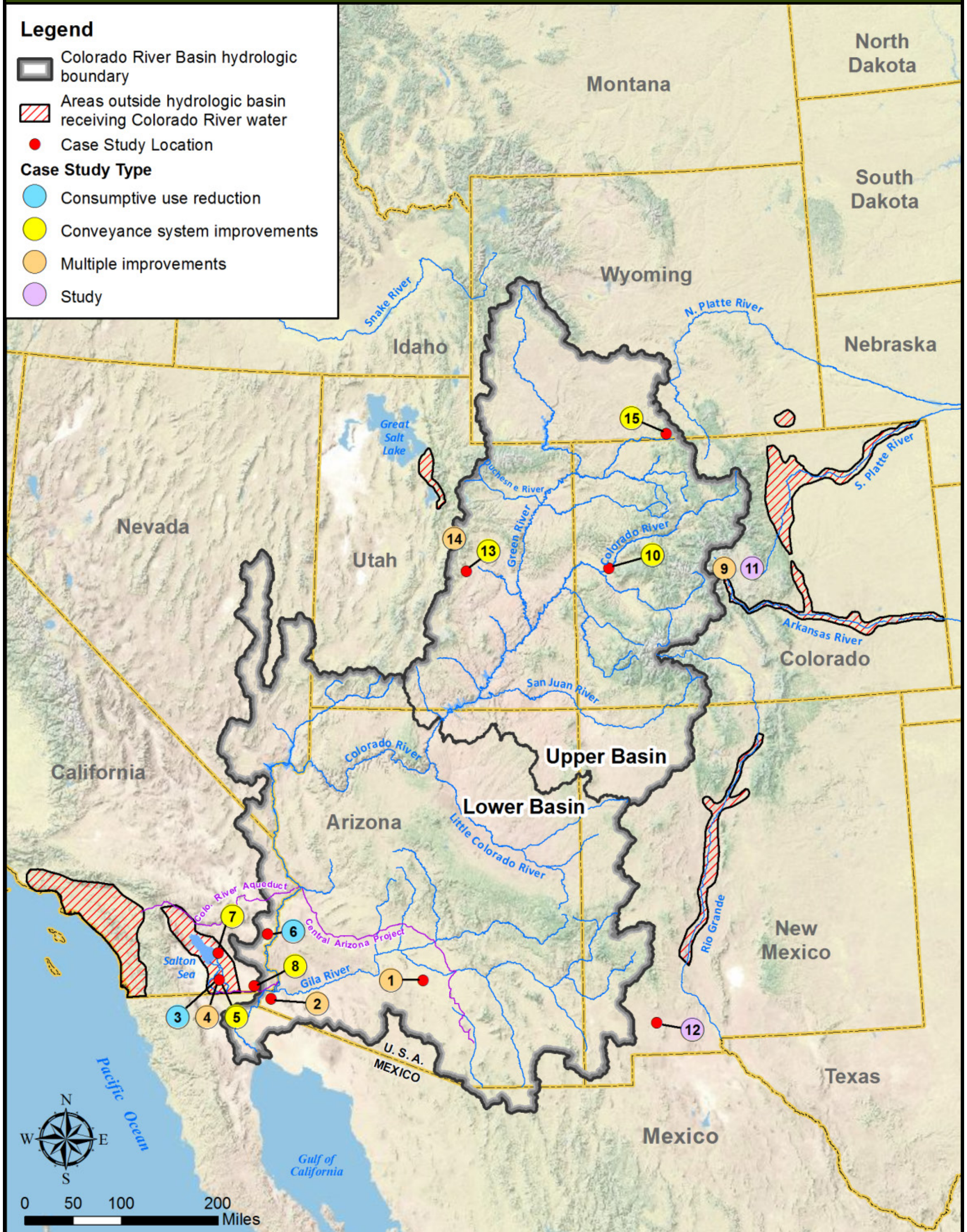
Case studies were developed to summarize agricultural water conservation projects that have taken place or are ongoing within the areas receiving Colorado River water. Case study locations are presented in Figure 4-9, and a summary is presented in Table 4-3. The case studies include fully implemented projects, planned projects, and feasibility studies. Topics cover funding programs, conveyance and on-farm enhancements, fallowing agreements, technical studies, and potential future water management tools such as new storage and water banking. Individual case study documentation can be found in Appendix 4B.

The sections below summarize each case study. Additional information is in Appendix 4B.

Case Study 1: Central Arizona Project Irrigation Districts and Arizona's Agricultural Conservation Incentives

In the CAP service area, growers and districts have improved water use efficiency over the past decades. Largely this has been a result of the 1980 Arizona Groundwater Management Act and the 2002 Best Management Practices Program. These have resulted in significant investments totaling more than $750 million in water-efficient practices and infrastructure. In particular, more than 150,000 acres have been converted to high-efficiency, laser-level basins with efficiencies estimated near 85 percent. The average per acre investment to date is approximately $3,700.

FIGURE 4-9
Case Study Locations



1	CAP Irrigation Districts	8	All-American Canal Lining Project
2	A Case Study in Efficiency - Agriculture and Water Use in the Yuma, Arizona, Area	9	Alternative Agricultural Water Transfer Methods Grants Program
		10	Orchard Mesa Canal System Improvement Project
3	IID QSA Conservation and Transfer Program	11	Colorado River Water Bank Feasibility Study
4	IID & MWD Water Conservation Program	12	Investigation of Drip Irrigation Consumptive Use
5	IID Seepage Recovery Program	13	Ferron Project
6	PVID & MWD Forbearance and Fallowing Program	14	Revolving Construction Loan Program
7	Coachella Canal Lining Project	15	West Fork Battle Creek Reservoir

TABLE 4-3
Case Study Summary

Map Label	State	Agencies	Case Study	Type	Forbearance, Exchange or Transfer Component?	Level of Implementation	Annual Water Savings (KAFY)
1	AZ	CAP	CAP Irrigation Districts	Multiple improvements	No	Ongoing	Not quantified
2	AZ	Yuma	A Case Study in Efficiency - Agriculture and Water Use in the Yuma, Arizona, Area	Multiple improvements	No	Ongoing	Not quantified
3	CA	IID, SDCWA	IID QSA Conservation and Transfer Program	Consumptive use reduction	To M&I	Implemented	Up to 150
4	CA	IID, MWD	IID & MWD Water Conservation Program	Multiple improvements	To M&I	Implemented	105
5	CA	IID	IID Seepage Recovery Program	Conveyance system improvements	To Ag and M&I	Implemented	40
6	CA	PVID, MWD	PVID & MWD Forbearance and Fallowing Program	Consumptive use reduction	To M&I	Implemented	Up to 122
7	CA	CVWD, SDCWA, CA DWR, MWD, San Luis Rey Indian Water Rights Settlement Parties	Coachella Canal Lining Project	Conveyance system improvements	To M&I and mitigation	Implemented	31
8	CA	IID, SDCWA, CA DWR, MWD, San Luis Rey Indian Water Rights Settlement Parties	All-American Canal Lining Project	Conveyance system improvements	To M&I	Implemented	68
9	CO	CWCB	Alternative Agricultural Water Transfer Methods Grants Program	Multiple improvements	To M&I, ag, and environment	Feasibility, including pilot programs	Not applicable
10	CO	OMID	Orchard Mesa Canal System Improvement Project	Conveyance system improvements	No	Planned operational in 2016	17
11	CO	CRWCD	Colorado River Water Bank Feasibility Study	Study	No (contemplates transfer component in future phases)	Feasibility study	200

TABLE 4-3
Case Study Summary

Map Label	State	Agencies	Case Study	Type	Forbearance, Exchange or Transfer Component?	Level of Implementation	Annual Water Savings (KAFY)
12	NM	NM ISC	Investigation of Drip Irrigation Consumptive Use	Study	No	Pilot Study	None; increase in consumptive use
13	UT	Ferron Canal and Reservoir Company	Ferron Project	Conveyance system improvements	No	Implemented	Not quantified
14	UT	DWRe	Revolving Construction Loan Program	Multiple improvements	No	Implemented	Not quantified
15	WY	Savery-Little Snake River Water Conservancy District	West Fork Battle Creek Reservoir	Conveyance system improvements	No	Feasibility study	Not applicable

California Department of Water Resources (CA DWR); Coachella Valley Water District (CVWD); Colorado River Water Conservation District (CRWCD); San Diego County Water Authority (SDCWA); thousand acre-feet (KAFY); Utah Division of Water Resources (DWRe)

Case Study 2: A Case Study in Efficiency – Agriculture and Water Use in the Yuma, Arizona, Area

Yuma area agricultural practices have changed considerably since the early 1900s. These changes came mainly as a result of food industry demand. Area growers adapted to consolidated production processes. Grower adaptation to food industry demand resulted in Yuma becoming the center for winter vegetable production in the U.S. Required efficiency and consistency improvements for quality, size, uniformity, and yield were met. By using more efficient infrastructure and irrigation practices, growers are producing higher crop yields with less water. In particular, the practice of multi-cropping has increased significantly; since 1970, growers are irrigating 50 percent more crop acres on about 20 percent less water.

Case Study 3: Imperial Irrigation District Quantification Settlement Agreement Conservation and Transfer Program

IID, as part of the Quantification Settlement Agreement (QSA), agreed to a 45- to 75-year conservation and transfer program that was supported initially (2003–2017) by a fallowing program that transitions over time (2008–2026) to efficiency-based conservation programs at full implementation. During the 15-year fallowing period, landowners and/or lessees voluntarily fallow fields to help IID meet water acquisition and transfer obligations, in exchange for compensation. Additionally, a $50 million community fund was set up and managed locally for mitigation of direct and indirect socioeconomic impacts caused by fallowing. For the on-farm conservation program, growers volunteer to implement field-level conservation measures they select, in exchange for compensation. Between December 2003 and June 2014, 1,242,283 acre-feet (AF) of Colorado River water were conserved as a result of fallowing, and 18,093 AF have been conserved through on-farm efficiency measures. An additional 125,213 AF have been conserved through system conservation measures.

Case Study 4: Imperial Irrigation District and Metropolitan Water District of Southern California Water Conservation Program

A water conservation agreement was signed in 1988 between IID and MWD. Under the agreement, MWD pays for the costs of water conservation measures in exchange for conserved water. Fifteen new projects and two augmentation projects were constructed and implemented between 1990 and 1998. Projects were primarily conveyance improvements and included lateral interceptors, reservoirs, concrete lining of main and lateral canals, non-leak gates, and system automation. Projects also included on-farm irrigation system improvements (tailwater return systems, irrigation evaluations, and pilot linear move and drip irrigation systems) and 12-hour delivery of irrigation water. In addition to MWD paying capital and annual direct costs, MWD provided IID with $23 million for the indirect costs of the program. In 2003, the agreement was amended to extend through 2041, or 270 days beyond the termination of the QSA, whichever is later, plus any extension pursuant to the terms of the agreement, and continues thereafter until terminated as specified in the agreement. Annual water savings between 1998 and 2013 averaged 105,009 acre-feet per year (AFY). Through 2013, 1,841,242 AF have been used by MWD, 159,381 AF have been stored in Lake Mead for MWD, and 137,156 AF have been used by the CVWD.

Case Study 5: Imperial Irrigation District Seepage Recovery Program

The seepage recovery program includes the installation of pump stations, collection sumps, and appurtenant structures in open drains that collect seepage along main canals. Water collected is pumped back into the All-American, East Highline, and West Side Main canals. The increased water in the main canals reduces IID's delivery needs at Imperial Dam and allows for acquisition of water by CVWD under the QSA and the related IID-CVWD Agreement for Acquisition of Conserved Water. Total seepage recovery capacity is up to about 40,000 AFY.

Case Study 6: Palo Verde Irrigation District and Metropolitan Water District of Southern California Forbearance and Fallowing Program

On January 1, 2005, the PVID and MWD began a 35-year Forbearance and Fallowing Program with landowners within PVID. The key component of the program is land fallowing, where participants fallow land in exchange for payments. The volume of water that becomes available to MWD is governed by the QSA and the 2003 Colorado River Water Delivery Agreement. Under these agreements:

MWD must reduce its consumptive use of Colorado River water by that volume of consumptive use by PVID and holders of Priority 2 that is greater than 420,000 AF in a calendar year, or

MWD may increase its consumptive use of Colorado River water by that volume of consumptive use by PVID and holders of Priority 2 that is less than 420,000 AF in a calendar year.

In both cases, each AF of reduced consumptive use by PVID is an additional AF that becomes available to MWD. A $6 million fund for local community improvement programs was established to mitigate third-party economic impacts. Annually, water saved has varied from about 32,750 AFY to 122,220 AFY.

In March 2014, a report was prepared for MWD by the natural resource policy consultant M. Cubed to assess the regional economic impacts of the Program for program years 2005-2012. It was estimated that the net effect of the Fallowing Program and Community Improvement Fund grant and loan activity on regional employment for the period 2005 to 2012 was positive, with a net gain to the regional economy of approximately 357,000 labor hours between 2005 and 2012. Over the period 2005 to 2012, the report estimated that the Fallowing Program payments by MWD and Community Improvement Fund grants and loans resulted in a net gain of $7.1 million in regional value added, due to a local expenditure of sign-up payments and Community Improvement Fund loans (Mitchell, 2014). Over the 35-year program, total water saved is estimated to be between 1.9 million AF and 3.7 million AF.

Case Study 7: Coachella Canal Lining Project

The Coachella Canal Lining Project was developed as a water conservation measure in response to Title II of Public Law 100-675. The project involved construction of 36.5 miles of concrete-lined canal directly adjacent to the original earthen portion of the Coachella Canal. CVWD was responsible for overall management of the project in collaboration with Reclamation and project funders. Consultants, designers, suppliers, contractors, and subcontractors were employed as part of the project. Additionally, federal, state, and tribal advisors provided input throughout the project. Implementation required considerable coordination through an agreed-upon project governance structure. Annually, water saved from the reduction of seepage and other losses is 30,850 AFY. Water savings from the canal lining are currently used to meet urban water demand in MWD and SDCWA's service areas.

Case Study 8: All-American Canal Lining Project

The All-American Canal Lining Project was developed as a water conservation measure in response to Title II of Public Law 100-675. The project involved construction of 23 miles of concrete-lined canal adjacent to the original earthen portion of the All-American Canal from 1 mile west of Pilot Knob to Drop 3. IID was responsible for overall management of the project in collaboration with Reclamation and project funders. Consultants, designers, suppliers, contractors, and subcontractors were employed as part of the project. Additionally, federal, state, and tribal advisors provided input throughout the project. Implementation required considerable coordination through an agreed-upon project governance structure. Annually, water saved from the reduction of seepage and other losses is 67,700 AFY. Water savings from the canal lining are used currently to meet urban water demand in MWD and SDCWA's service areas.

Case Study 9: Alternative Agricultural Water Transfer Methods Grants Program

In Colorado, agricultural-to-municipal water transfers have historically taken place through "buy-and-dry," in which irrigated farmland is either revegetated with native plants or converted to dryland farming. To reduce the burden on agricultural economies and communities associated with buy-and-dry transfers, efforts have been made to identify alternative agricultural water transfer methods (ATMs). The Colorado Water Conservation Board implemented the Alternative Agricultural Water Transfer Methods Grant Program to identify barriers to implement ATMs and to develop solutions to overcome barriers. This program has resulted in significant progress toward making ATMs a viable option for M&I providers and environmental uses. Several pilot projects have been initiated to examine how some of these projects could be implemented on a large scale. This program has resulted in new partnerships between cities, farmers, land conservancies, funding partners, and environmentalists.

Case Study 10: Orchard Mesa Canal System Improvement Project

The U.S. Fish and Wildlife Service identified the need for additional flows within a 15-mile reach of the Colorado River. The proposed project has been identified by the Upper Colorado River Endangered Fish Recovery Program as a source to provide additional flows along the 15-mile reach. The project consists of improving and automating the OMID canal system. Saved water, estimated to be up to 17,000 AFY, is then used to provide increased hydropower generation at the Grand Valley Power Plant, which may result in the augmentation of streamflows within the 15-mile reach. In addition to increasing in-stream flows and power generation, current water shortages to M&I providers and agricultural water users would be reduced. This project is planned to be complete in 2015.

Case Study 11: Colorado River Water Bank Feasibility Study

Under the Compact, the Upper Division States are obligated not to cause the flow of the Colorado River, at Lee Ferry, Arizona, be depleted below 75 MAF over any consecutive 10-year period. If the Upper Division States ever depleted the flow of the river at Lee Ferry causing it to fall below 75 MAF during a 10-year period, the Upper Division States may need to impose curtailments of certain water uses. One option being considered to avoid a Compact deficit and any related need to curtail water uses is a water bank. A study evaluating the feasibility of one particular water banking concept is in progress in Colorado. This study is examining whether a water bank could be used to prevent, delay, or reduce the negative effects of a Compact deficit. An effective water bank could help meet compact obligations, protect critical levels in Lake Powell, or allow continued water use in the event that curtailments would otherwise be needed to resolve a Compact deficit. Because pre-Compact water rights are unimpaired by the Compact, Phase 1 of this study made a general review of the volume, place and type of use of both pre- and post-Compact water rights in Colorado. Phase 1 found that a significant amount of pre-Compact consumptive use results from irrigation of forage crops such as pasture grass and alfalfa. Given the importance of irrigated pasture grass and alfalfa, Phase 2 is taking a closer look at the feasibility of deficit irrigation and fallowing on forage crops and on representative pre-Compact irrigation systems and is evaluating methods for measuring water savings. Phase 3 will examine economic and environmental considerations.

Case Study 12: Investigation of Drip Irrigation Consumptive Use

To promote water conservation, the New Mexico ISC has funded conversion from flood irrigation to drip irrigation in some locations to promote water conservation. However, in these areas, an increasing rate of decline in groundwater levels has been observed. To help quantify the broader effects of conversion to drip irrigation, the ISC undertook a study to compare consumptive use on drip-irrigated fields versus flood-irrigated fields. Study results suggest that consumptive use on drip-irrigated fields is greater than consumptive use on flood-irrigated fields, ranging from 8 to 16 percent, depending on the crop planted. While quantification of consumptive use was the primary study goal, some broader implications were explored. Because water rights in New Mexico are often administered based on diversion rates, not consumption rates, conversion to drip irrigation on existing farms has resulted in farmers increasing the number of annual plantings and returning previously fallowed land to production, thereby increasing overall consumptive use of water.

Case Study 13: Ferron Project

The Ferron Project serves to reduce Colorado River salinity loading through improved agricultural infrastructure and practices. Increasing water conveyance and application efficiency reduces deep percolation, limiting salt mobilization. Secondary outcomes, including increased yields and an extended irrigation season, have also benefited project participants. The project reduces Colorado River salt loading by an estimated 40,000 tons per year. Water savings were neither a goal, nor were they quantified; however, there have been anecdotal accounts of greater water availability between the local community and agriculture.

Case Study 14: Revolving Construction Loan Program

Section 73-10-1(7) of the Utah Code provides revolving funds to give technical and financial assistance to water users to achieve the highest beneficial use of water resources in the state. This financial assistance is provided by the Utah Board of

Water Resources (Board) through three revolving loan funds: the Revolving Construction Fund, the Cities Water Loan Fund, and the Conservation and Development Fund. Funding is available for projects that conserve, protect, or more efficiently use current water supplies, develop new water, or provide flood control. The Board requires that the revolving loans be repaid, making funds available for subsequent loans. The agricultural-based water development projects funded by the Board have resulted in improved farmland efficiencies, increased farmland productivity and yields, and improved water quality and water conservation. The conserved water and improved efficiencies have resulted in an extended irrigation season and therefore increased yields. Water savings as a result of these projects has not been quantified.

Case Study 15: West Fork Battle Creek Reservoir

The Savery-Little Snake River Water Conservancy District desires to construct a new reservoir on the West Fork of Battle Creek in Carbon County, Wyoming, to provide a firm supply to agricultural producers within the District. West Fork Battle Creek Reservoir will serve primarily as a supplemental irrigation supply to increase productivity while also providing environmental, recreational, and fishery benefits. The reservoir will have a total capacity of approximately 8,000 AF, a portion of which will be used as a minimum pool for flat-water recreation.

4.7 Effects on Water Use from Existing Programs and Practices

Select reported historical and existing agricultural water conservation and transfer programs and projects in areas receiving Colorado River water are summarized in Table 4-4. Program details are in Appendix 4D. Programs were generally classified into the following types.

- Conveyance – system-wide attempts at reducing conveyance loss through programs such as canal lining or conversion to pressure pipe
- On-farm – farm-scale changes to more efficient irrigation methods such as advanced irrigation scheduling, precision agriculture, and conversion from surface flood and furrow methods to laser-leveled fields or to sprinkler and/or drip systems
- Consumptive use – reductions in consumptive use due to deficit irrigation, change in crop mix, or temporary or permanent fallowing
- Transfers – temporary or permanent transfer of saved water or water rights between entities

These programs have resulted in water savings or changed use of nearly 1 million AFY. The types of conservation programs that have resulted in the greatest water savings are conveyance system improvements (456,000 AFY) and consumptive use reduction (400,000 AFY). However, some of these conservation programs result in a substitution for other supplies that are not always available to meet water uses in other sectors (for example, fallowing was generally done in conjunction with a provision of water for M&I and environmental uses, and savings from conveyance systems improvements were made available for M&I use), and/or reduction of groundwater recharge (lining canals).

Accordingly, the net effect of these programs was not quantified.
Historical data for conservation programs can provide insight into the efficacy of various types of programs with respect to water savings, change in consumptive use, and change in productivity. These are discussed further in Section 4.8.2.

Available data demonstrate that producers have implemented a wide range of conservation and efficiency measures and often increased productivity as a result.

Historical data also provide insight into relative costs of these programs. Reported historical cost of water savings ranges from about $20 per AFY for advanced irrigation scheduling to nearly $300 per AFY for on-farm irrigation system improvements.

TABLE 4-4
Summary of Select Agricultural Water Conservation Programs with Quantified Acres and Water Savings

Type	Acres	Annual Water Savings[1] (KAFY)	Unit cost ($ per AFY)[2]
Conveyance System Improvements	N/A	456	20–150
On-Farm Efficiency Improvements	362,227	124	285
Consumptive Use Reduction	73,601	400	30–246
Total		980	
Transfers	N/A	650	

Not available (N/A); operation and maintenance (O&M)

[1] Estimated program savings; however, savings were typically translated to other uses and therefore did not result in savings to the Colorado River. Savings compiled from tables in Appendix 4C. When range is presented in appendix tables, average is used for total. When values are "up to," maximum value is used. "Portion of" is parsed out into individual components. This approach results in a total savings that sums up all conservation programs through time and does not represent savings in a specific year. In particular, changing conservation programs in the QSA are quantified individually, although only certain programs are active at any given time.
[2] Cost per AF calculated as: (capital cost / 30 years + O&M)/AFY saved.

4.8 Planned and Potential Future Conservation and Transfer Programs and Projects

To assess the potential for future agricultural water conservation, it is useful to know about previously implemented programs, as well as programs currently planned. The sections below discuss planned programs and projects. The results of detailed discussions of potential opportunities and challenges by conservation type are also presented.

4.8.1 Ongoing and Future Planned Programs and Projects

Many ongoing and future planned activities relate to the 2003 QSA, which addresses certain disputes among California Colorado River water users. The agreement facilitates a decrease in California's use of Colorado River water to be within its 4.4 MAF annual basic apportionment when surplus water is not available. Mechanisms employed to achieve this end include fallowing and conservation as well as forbearance, acquisition, and transfers. The QSA's ongoing nature will maintain California's Colorado River water use at 4.4 MAF for years to come while providing funding and through 2017 water for mitigation of impacts on the Salton Sea. Over the life of the QSA through 2077, more than 27 MAF will be forborne by or transferred from agriculture to primarily M&I use, with some components transferred for irrigation use and environmental mitigation. The annual amount forborne or transferred will increase from 420,000 AF currently to 502,000 AF by 2026 and will switch from water savings that include fallowing to using only increases in water use efficiency beginning in 2018.

Outside of the QSA are two ongoing consumptive use reduction projects. The Wellton-Mohawk Irrigation and Drainage District in Arizona has implemented a project in which 3,000 acres are being fallowed to firm up current M&I use and provide water for future M&I use. This program started in 2000 and is expected to be completed by 2014, at which time 12,000 AFY will be available for current and future M&I use. The second project is Phase IIB of the water bank workgroup (see Appendix 4B) in Colorado. The water bank is intended to save and bank water in Lake Powell or other storage to help maintain Upper Basin Compact compliance and reduce the likelihood of a shortage declaration. Phase IIB will include quantification of potential saved consumptive use of specific crops under varying irrigation methods, including split season irrigation, and evaluate the long-term effects of reduced irrigation on alfalfa and grass pasture/hay.

Conveyance system improvements are planned in Colorado's OMID, where construction of regulating reservoir and check structures will save 17,000 AFY of water. The water will be used for in-stream flows to assist recovery of endangered fishes (see Appendix 4B).

On-farm efficiency improvements and other conservation programs are planned as part of CVWD's continued implementation of water conservation programs as part of its Water Management Plan Update 2010. The Water Management Plan Update 2010 sets a target of reducing agricultural demand on the water supply by 23,300 AFY by 2045. CVWD will institute programs such as irrigation scheduling, on-farm system improvements, salinity management, and education programs to achieve this goal.

In Wyoming, demand management analysis, including interruptible supply agreements[7] and water banking, is under preliminary review.

High-pressure sprinkler irrigation
Source: CH2M HILL

As ongoing programs and planned projects demonstrate, the potential exists for additional agricultural water conservation to build resiliency and potentially reduce agricultural water use. Some conservation programs have been widely implemented in discrete geographic areas; however, no programs have been applied throughout the areas receiving Colorado River water. Past and planned programs suggest that agricultural water use is typically supply limited and/or constrained by laws, agreements, or settlements requiring or resulting in reduced agricultural use to provide water for other sectors. For example, California's QSA required the majority of the water saved from agricultural use be available for M&I and environmental uses. Other programs, such as the Salinity Control Program, have defined goals such as water quality improvement but often have secondary benefits of increasing delivery efficiency, potentially providing more water for supply.

4.8.2 Potential Future Programs and Projects

Future programs that build resiliency or reduce water use could potentially make water available for agricultural use during drought, allow rapid response to favorable market conditions, or make water available for use by other sectors. To explore the role of agricultural water conservation in addressing water supply and demand imbalances in more detail, four sub-teams were formed as follows:

- Consumptive use reductions
- Conveyance system improvements
- On-farm efficiencies
- Transfers

Sub-team participants were Workgroup members who have specific interest and/or expertise in these methods or programs. The sub-teams included a lead from the Workgroup to facilitate discussions and a Co-Chair or member of the contractor team to facilitate discussions and sub-team management. Each sub-team had between three and six conference calls between February and mid-March 2014. The calls included discussions of the above topics with real world examples providing associated challenges and developing potential opportunities to mitigate said challenges and develop a successful program. During the first call, each sub-team focused on presenting

[7] Interruptible Supply Agreements are typically agreements between a water user, such as a farmer, and another water user, such as a municipality, whereby the water supply of one user can be called for or "interrupted" under specific circumstances (such as drought) and provided to the other user.

example programs. During the second call, the sub-team developed a hypothetical example of implementing the technique and explored associated challenges. During the remaining calls, the sub-teams identified opportunities to overcome these challenges to implementing successful agricultural water conservation programs. Each sub-team developed either one or two conceptual-level hypothetical programs. Sub-team information (including member names and call dates) and hypothetical programs are in Appendix 4E.

4.8.2.1 Consumptive Use Reductions

Consumptive use reductions include practices such as deficit irrigation, split season irrigation, and permanent and temporary fallowing. Deficit irrigation involves reducing applied water at particular points in the growing cycle ostensibly to maximize production per unit of water (and potentially net profit) while saving water not applied to the field. Split season irrigation is sometimes incorporated with perennial crops and involves fully irrigating through part of a season and completely ceasing irrigation in the latter half of a season. Fallowing involves either the permanent or temporary removal of lands from production.

Care must be taken with deficit irrigation to ensure long-term viability with respect to agricultural sustainability, including both productivity and economics. Soil health, salt accumulation, and secondary impacts (such as weed growth) along with overall productivity reduction must be balanced with appropriate compensation. Stressed crops are also more susceptible to disease and pests.

The water saving benefits of fallowing are conceptually straightforward; however, care must be taken to appropriately measure water use. Likewise, future maintenance of the fallowed land is a key consideration in ensuring water savings.

These options require thorough vetting of the total costs to producers versus the potential benefit to others. Comprehensive larger-community impacts of a given program are also important. For example, a large-scale fallowing program in a given community could have significant secondary impacts to the agricultural economy (for example, equipment sales), whereas a similar target savings could be spread geographically that minimizes the impact on any one area.

Agriculture irrigated by the Central Arizona Project
Source: Bureau of Reclamation

4.8.2.2 Conveyance System Improvements

Conveyance system improvements include lining canals, converting to piped delivery, improving canal control and/or constructing regulation reservoirs to reduce canal operational spills, incorporating delivery automation and/or SCADA, and implementing system-wide drainwater or tailwater[8] recovery systems.

Geographic and legal considerations are major challenges for those wishing to partner with an agricultural entity to recover water through conveyance improvements. The two primary factors associated with geography challenges are how much water the improvement will yield and the ability for saved water to be transferred, forborne, or exchanged to where the demand exists. A consequence of reducing conveyance leakage is that benefits (such as ecological) associated with water infiltrating back to the stream system during times of lower flows may be lost. In addition, there may be legal considerations under state laws if downstream users benefitted from the lagged returns of conveyance leakage.

These projects also typically involve significant modifications to infrastructure. As such, project funding, quantification of savings, and environmental impacts are key considerations. Further, improvements in delivery efficiency may have other benefits such as water quality enhancements and improved resiliency.

To mitigate noted challenges, geography and legal framework should be considered early in project development with provisions for appropriate regional

[8] Drainwater or tailwater is water that either runs off of irrigated fields or seeps into the shallow aquifer and is collected through a shallow drain system for further use downstream.

management and an agreed-upon method to quantify savings. Further, secondary benefits should be examined and quantified to the extent possible where geographic challenges provide limitations. For example, in areas where existing infrastructure is not strategically located, modifications to the system could provide benefits toward both system efficiency and resiliency. Water quality improvements and reduced maintenance also provide potential benefits and could be coupled with a larger conservation program to help promote win-win scenarios.

4.8.2.3 On-Farm Efficiency Improvements

On-farm irrigation system improvements include items such as conversion from surface (flood) irrigation methods to sprinkler and/or drip irrigation methods, laser-leveling fields, and advanced irrigation scheduling with soil moisture monitoring and real-time evapotranspiration data. Although crop consumptive use savings are not typically expected for this conservation method, reductions in total water diversions could occur, resulting in reduced tailwater and deep percolation return flows. This situation could result in enhanced environmental flows or, if storage is available, conservation and retiming of releases for other use.

Low-pressure sprinkler irrigation
Source: Bureau of Reclamation

Because a number of the improvements require initial input or buy-in and long-term maintenance from individual farmers, barriers include up-front commitment and the possibility that savings slip over time. As with other infrastructure improvement-type programs, funding and therefore measuring and metering of results is important. Geography also plays a role in the ability to realize savings because these programs may reduce tailwater and potentially affect downstream users. Some unintended consequences of improved farm efficiency may occur. For example, there can be ecological impacts associated with decreased water infiltrating back to the stream system during times of lower flows. There may also be legal considerations under state laws if downstream users have benefitted from and have a legal right to the lagged returns of inefficient on-farm practices.

These improvements build resiliency collectively and for individual farms by reducing nonproductive losses. Expanding available funding sources or working with partners who could potentially benefit from the changes (for example, nongovernmental organizations for environmental or recreational flows or municipal entities when stored water releases are re-timed or water is available for use elsewhere) are important in realizing savings.

4.8.2.4 Water Transfers

The term "water transfers" is used in this study to represent the legal transfer of water or water rights from one use to another, the acquisition of water by one agency from another agency, or the reduction in use of water by one agency to permit another agency to use the water. Within an agricultural water use framework, transfers can be implemented on a temporary basis (one growing season) from year to year or on a permanent basis, essentially through the acquisition of water or a permanent water right. Typically, water transfers are negotiated on a voluntary basis within a state and can be implemented directly or facilitated through a water bank. Payments can be based on measured volume of reduction in diversion or consumptive use or can be tied to observed practices, such as land fallowing or forbearance of all diversions. Within a state, priority systems for the use of water can affect the ability to implement a water transfer. Transfers are not a water conservation method in themselves but represent a mechanism for movement of saved water to another purpose or place of use.

It is noteworthy that there may be differences in the objectives of an agricultural producer or irrigation district and others with respect to water transfers. Agricultural producers may prefer temporary transfers, while M&I and environmental users typically require certainty in future planning and thus a more permanent program. This difference in interests can be offset to some extent through long-term programs that use short-term temporary agreements. This practice also tends to minimize the potential impact to an individual producer.

Large-scale programs have multiple stakeholders and often involve a number of conservation methods, which can create an unwieldy structure. Streamlining governance and agreeing to appropriate measurement criteria prior to program implementation can help facilitate process implementation.

Understanding the potential impacts of water transfers, both in terms of the individual producers and secondary impacts to supporting industries, is important to creating a successful program. Economic studies should be completed in advance of program implementation. These studies should examine the community impacts and establish a baseline for considering appropriate compensation for transfer and potential third-party impacts. Likewise, these studies can be used to help set program boundaries (for example, maximum and minimum portion of a given area fallowed) (Colby and Pittenger, 2005).

Agricultural producers will continue to increase the efficiency of water use as feasible. Feasibility depends on location, crops, economic, and other considerations. These efforts may play a role in improving reliability for agricultural producers and building flexibility for meeting additional demands.

4.9 Opportunities and Challenges for Expanding Successful Conservation and Transfers Programs

The Basin Study found a high likelihood for future supply and demand imbalances in areas receiving Colorado River water and reported that agricultural water savings can play a key role in mitigating system vulnerabilities. Specifically, the Basin Study estimated that by 2060, about 1 MAF of new agricultural water savings could be achieved. This estimate included significant fallowing. While technically feasible, the Basin Study did not examine the full range of impacts of this type of program. The magnitude of imbalances and the role potential agricultural water savings might play are uncertain. That said, uncertainty should not distract from the Basin Study's call to action. To prepare for future challenges, flexible institutions, strategic infrastructure changes, and efficient practices must be pursued today.

Agricultural water conservation and transfers are already practiced widely in areas receiving Colorado River water, but opportunities exist to expand or implement new programs. Historical solutions to supply imbalances have included permanent dry-up and transfer of agricultural water, specifically favoring transfer on less productive acreage. Therefore, better conservation practices that both increase productivity and minimize transfers are critical to the future of agricultural use in areas receiving Colorado River water. The Workgroup was charged with identifying opportunities that could advance agricultural water conservation in areas receiving Colorado River water, describing the challenges associated with these opportunities based on their collective experience, and identifying potential future actions that would advance the opportunities. Potential actions related to the identified opportunities were developed for further consideration by the Coordination Team or other parties interested in advancing agricultural water conservation opportunities in the areas receiving Colorado River water.

The Workgroup identified the following seven major opportunities to advance water conservation and agricultural productivity in areas receiving Colorado River water:

1. Increase and/or maintain productivity through more efficient on-farm activities.
2. Reduce losses and improve operational efficiency through improved conveyance infrastructure.
3. Pursue flexibility associated with strategic consumptive use reductions (for example, deficit irrigation, crop selection, or fallowing).
4. Enhance and use mechanisms to facilitate flexible water management (for example, banking, transfers, or exchanges).
5. Encourage efficient water management through conservation planning and reporting, data management, and tools development.
6. Foster efficient agricultural water use through sustainable funding and incentive programs.
7. Increase or maintain productivity and improve water management through soil health.

The Workgroup further explored each of these opportunities to identify the most significant considerations and to identify specific actions that could lead toward improved achievement of the opportunity. Two actions identified were found to have applicability across most opportunities: data collection and pursuit of funding. Generally, data are needed for efficient decision making and to help provide a reliable, transparent process for producers and agencies. Likewise, data coupled with sufficient funding allows producers to make the best choices in achieving efficient operations. While these actions are broadly applicable across the opportunities, they are generally only shown below where they are one of the key elements for a given opportunity. The sections below describe each opportunity in greater detail.

4.9.1 Opportunity 1: Increase and/or maintain productivity through more efficient on-farm activities

4.9.1.1 Description

More efficient management practices such as advanced scheduling, improved metering, soil moisture monitoring, and on-farm infrastructure (conversion to sprinkler or other efficient application techniques) have successfully built resiliency for agricultural communities. Outcomes have included increased productivity, regional economic growth, water available for other uses or users, and improved downstream water quality.

4.9.1.2 Considerations

To achieve meaningful adoption rates, on-farm efficiency improvements require a combination of sufficient funding and grower interest. State and federal programs currently exist to offer financial and other forms of assistance. However, these are competitive processes with limited funding that may prioritize certain regions or include cost-share requirements. Thus, other mechanisms may be needed to assist in meeting necessary matching funds.

Regional perspectives on applicability and benefits of new technology can make support for such efforts uncertain. Further, water supply seniority/security may factor into the appeal of pursuing such measures. Concerns over impacts to local communities and third parties should be appropriately studied and addressed.

The adoption of advanced irrigation management and precision agriculture techniques could include introducing to some regions new technologies (such as soil moisture monitoring networks, advanced scheduling, and metering) that require skill sets different from those associated with traditional production methods. Technical assistance and/or training may be needed to facilitate optimal return on investment.

4.9.1.3 Potential Actions

- Pursue funding and technical assistance opportunities through federal programs such as the USDA's RCPP.
- Explore the establishment of a Basin Trust Fund for low-interest loans for specifically targeted water conservation and efficiency programs/projects.
- Incorporate a broader range of economic and agronomic metrics into future federal (such as farm bill or salinity control) or other funding program evaluations to ensure that costs and benefits of efficiency improvements are better understood.
- Increase funding to efficiency programs to help irrigators build resiliency by maintaining productivity in the face of projections that generally show a more variable, hotter future.
- Coordinate site visits to successful projects or pursue demonstration pilots for recommended practices.

A farmer cultivates fields in Imperial Valley
Used by permission of IID

4.9.2 Opportunity 2: Reduce losses and improve operational efficiency through improved conveyance infrastructure

4.9.2.1 Description

Improved conveyance infrastructure (such as canal lining, pressure pipe, or increased storage) can reduce losses, reduce O&M costs, and facilitate other water-efficient investments. In upper watershed areas, diversion and subsequent irrigation is often driven by water availability rather than irrigation needs. Regulation and storage offer the ability to time and more efficiently apply water. Outcomes could include regional economic growth, improved community safety, increased water availability for other uses or users, and enhanced downstream water quality.

4.9.2.2 Considerations

Conveyance improvements have been successfully implemented across areas that receive Colorado River water. However, because conveyance improvements are typically capital construction projects, funding can be challenging. Motivations for improvements vary based on location and benefits. In some cases, improvements have been co-funded by entities with common interests to share in benefits. The programs are often competitive and may prioritize projects unrelated to water savings.

Implementation of infrastructure projects, particularly on a larger scale and involving multiple entities, likely requires an implementation plan that is well-structured and agreed upon by all involved parties. This plan should include O&M costs and responsibilities.

Related to planning for successful implementation, construction of conveyance improvements is generally well understood and considered technically feasible. However, projects often have unique considerations such as access, space, terrain, or other local considerations that may pose technical challenges.

Support for conveyance or other large projects may be varied due to concerns about cost and local impacts. Concerns could include, but are not limited to, water rights, environmental considerations, groundwater recharge, and other uses benefiting from seepage. These concerns should be appropriately studied and addressed.

4.9.2.3 Potential Actions

- Pursue funding and technical assistance opportunities through federal programs such as the USDA’s RCPP.
- Explore the establishment of a Basin Trust Fund for low-interest loans for specifically targeted water conservation and efficiency programs/projects.
- Incorporate a broader range of economic and agronomic metrics into future and existing federal programs (such as farm bill or salinity control) or other funding program evaluations to ensure that costs and benefits of efficiency improvements are better understood.
- In addition to canal/ditch lining/conversion to pipe, other conveyance improvements such as canal automation should be pursued to increase productivity and reduce operational costs.
- Coordinate site visits to successful projects or pursue demonstration pilots for recommended practices.

Dome Canal lining
Source: Kenneth Baughman, Wellton-Mohawk Irrigation and Drainage District

4.9.3 Opportunity 3: Pursue flexibility associated with strategic consumptive use reductions (for example, deficit irrigation, crop selection, or fallowing)

4.9.3.1 Description

By reducing consumptive use, agricultural water users can gain additional operational flexibility through increasing revenues by making water available on a voluntary basis for other purposes or growing a higher-value crop. This could be accomplished through deficit irrigation, crop selection, fallowing, or retirement of marginal lands. For marginal lands, irrigated lands vary in productivity due to issues such as salinity and other soil properties. In some instances, opportunities may exist that would allow growers to be compensated for voluntarily changing their use of less productive lands.

4.9.3.2 Considerations

Reduced consumptive use practices, particularly fallowing, can have impacts on growers and landowners that may not be well received. Impacts to local communities and third parties may also be a concern. This concern should be appropriately considered and addressed. Current successful programs can offer a basis for these considerations as well as overall structure. Well-defined agreements will allow growers to plan effectively and maximize benefits. Additional considerations may exist depending on the program type and scale.

In conjunction with an effective governance structure, the ability to track, monitor, and account for land and water use will be important for success. This ability may pose technical or logistical challenges and could make certain areas more or less appealing for implementing consumptive use reductions; this could be due to a combination of factors such as seasonal weather, gauging infrastructure, and variations in the application of water to crops.

The applicability of such programs, particularly the ability for partner entities to receive water or other benefits, will depend on physical location and federal or state water laws.

4.9.3.3 Potential Actions

- Explore opportunities to promote flexible water sharing and allow for necessary wheeling or exchange and storage agreements to put agreements into practice.
- Adopt standards and practices for regional remote sensing programs that aid in streamlined, voluntary water transactions, irrigation and productivity decision making, and Basin-wide water accounting.
- Provide sufficient funding to maintain current monitoring networks and datasets while expanding to new sites and technologies.
- Pursue a program for voluntary compensated retirement of less productive lands or alternative lands use that would share in reduced water diversion needs.

4.9.4 Opportunity 4: Enhance and use mechanisms to facilitate flexible water management (for example, banking, transfers, or exchanges)

4.9.4.1 Description

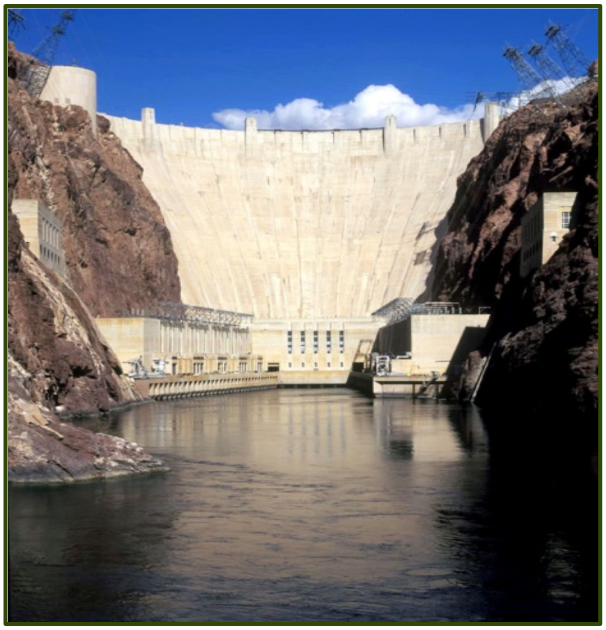
Flexible water management has the potential to be a useful tool in building water supply resiliency for agricultural water users in areas receiving Colorado River water. The Intentionally Created Surplus provision of the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lakes Powell and Mead has been well used and thus suggests consideration of new or expanded programs such as water banking, exchanges, and transfers.

4.9.4.2 Considerations

The applicability of such programs is likely dependent upon physical location and federal or state water law. Currently, existing programs in the Lower Basin could be used or modified as needed to expand participation. In the Upper Basin, such activities are soon expected to be in a pilot phase. The broader the geographic scale of a program, the greater the legal and policy considerations; however, the program would likely offer increased flexibility through more partnership opportunities.

Current successful programs can offer a basis for governance structure. Additional consideration may be needed depending on program type and scale. In conjunction with an effective governance structure, the ability to track, monitor, and account for water banked, exchanged, or transferred is critical.

The mechanism(s) by which water is developed for banking, exchange, or transfer will need to be vetted in consideration of local economies and related factors. This will need to be appropriately studied and addressed as part of a robust program.



Hoover Dam
Source: Bureau of Reclamation

4.9.4.3 Potential Actions

- Support efforts to facilitate more flexible water management for each state, as required.
- Adopt standards and practices for data collection that aid in streamlined, voluntary water transactions, irrigation and productivity decision making, and water accounting (such as data management or remote sensing).

4.9.5 Opportunity 5: Encourage efficient water management through conservation planning and reporting, data management, and tools development

4.9.5.1 Description

Water conservation planning and reporting, data management, and tools can promote more efficient water use by providing resources and data to growers. Datasets are the basis for numerous activities ranging from program administration to investments in water-efficient infrastructure. As new opportunities emerge and cost-effectiveness is evaluated, accurate and complete datasets will be important. As such, maintaining current datasets and reporting while expanding monitoring sites and technology will facilitate the pursuit of future programs, partnerships, and practices. The development of new tools can help foster planning and use of data.

4.9.5.2 Considerations

The development and implementation of a water management plan is time-consuming and potentially costly. Further, water management plans require regular updates to yield the most benefit. Resulting conservation activities could include the need for new skill sets and require training to facilitate optimal return on investment.

Regional perspectives on their applicability and benefits could make support for such efforts uncertain. Impacts to local communities and third parties may also be a concern. However, current successful programs can offer a basis for new or expanded programs.

Increased monitoring associated with the expansion of datasets may be met with varying degrees of support. Maintaining data continuity while adopting new technology or methods may pose technical or legal challenges.

4.9.5.3 Potential Actions

- Provide resources to assist districts in developing and adopting water management plans where such plans do not exist (to compile a database of agricultural water conservation/efficiency practices, cost effectiveness and applicability across areas receiving Colorado River water).
- Designate a water conservation coordinator at the district level where such a coordinator has not been designated to work with state and federal agencies; implement and track progress on water plans and related activities.
- Support the availability of water management services to water users (for example, irrigation system water loss evaluations, water quality testing, water pump testing, and general education).
- Encourage agricultural water management and standard use reporting.
- Improve public understanding of agriculture and tradeoffs of conservation and fallowing.
- Publish Reclamation’s Annual Summary Statistics, Water, Land, and Related Data report.

- Adopt standards for regional remote sensing that aid in voluntary water transactions, irrigation and productivity decision making, and Basin-wide water accounting.
- Provide sufficient funding to maintain current monitoring networks and datasets while expanding to new sites and technologies.

4.9.6 Opportunity 6: Foster efficient agricultural water use through sustainable funding and incentive programs

4.9.6.1 Description

Continuous, sustainable funding for agricultural water conservation programs is a factor limiting more widespread and rapid implementation. While sources of funding are available, these sources are limited and often narrow in application. Sustainable funding ensures that sufficient and stable revenue streams are available over the long term to accomplish a program's goals and can address the range of measures (from public education to infrastructure) necessary for agricultural water conservation. Likewise, efficient water use can be incentivized through policies that assist in efficiency improvements or by making more efficient water use cost effective for growers.

4.9.6.2 Considerations

Procuring sustainable funding from traditional federal, state, and local sources for agricultural water conservation is challenging because these sources are typically limited and competitive, and their availability is often contingent upon prevailing economic conditions, the political climate, and uncertainties associated with the appropriations process (Mathieu, 2011).

Some of the most successful programs have combined federal, state, and local funding with user-based incentives to increase efficiency and make water available for other uses. The insertion of increased outside funding allows these types of programs to be expanded while providing consistent funding and incentives.

Incentive programs of any type will need to be well-structured for successful administration and participation. For incentives that encourage the adoption of more efficient practices, verification and monitoring of those practices may be difficult. Reception of such programs may vary if incentives are seen as favoring certain regions or growers. Benefits and impacts to the local economy should be appropriately considered.

Sprinkler irrigation in the Imperial Valley
Used by permission of IID

4.9.6.3 Potential Actions

- Reduce state/federal program cost-share requirement if project meets multiple water management or other goals.
- Pursue funding partnerships to share in costs and benefits.
- Pursue funding and technical assistance opportunities through federal, state, and other programs such as the USDA's RCPP.
- Explore establishing a Basin Trust Fund for low-interest loans for specifically targeted water conservation and efficiency programs/projects.
- Compile a Basin-wide, current database on available federal, state, and other funding sources for agricultural water conservation and efficiency.
- Promote policies and/or programs that incentivize efficient water use. Examples include, but are not limited to, tiered rate structures; policies or rates as a function of hydrologic conditions; facilitation of transfer of water among irrigators; loans or funding for capital improvement projects; and providing growers with water use information, comparisons, and possible efficiency measures.

4.9.7 Opportunity 7: Increase or maintain productivity and improve water management through soil health

4.9.7.1 Description

Measures to increase the biological activity of soils have been shown to increase the long-term soil moisture-holding capacity, thereby reducing water demands over time and increasing crop quality, among other benefits.

4.9.7.2 Considerations

Managing soil health for long-term agricultural productivity and natural resource conservation priorities is also a technical skill that may require training similar to that required for other technological changes. Regional perspectives on applicability and benefits relative to current practices can make support and subsequent outcomes for such efforts uncertain. Providing funding for producer education and training or technical assistance may help to facilitate optimal return on investment.

4.9.7.3 Potential Actions

- Incorporate a broader range of economic and agronomic metrics into future and existing federal programs (such as farm bill or salinity control) or other funding program evaluations to ensure that costs and benefits of efficiency improvements are better understood.
- Increase funding to efficiency programs to help irrigators build resiliency by maintaining productivity in the face of projections that show a more variable, hotter future. Incentivize and leverage existing programs to integrate multi-species cover crops to protect and improve soil health into rotational fallowing or other alternative transfer projects.
- Encourage soil health measures in water conservation plans.

Cotton fields near Blythe, California
Source: Bureau of Reclamation

4.9.8 Summary of Potential Actions and Opportunities

Some potential actions described in the previous sections can support multiple opportunities to varying degrees. To summarize the potential future actions and opportunities, Table 4-5 identifies which opportunities could be supported by each potential future action. Funding limitations impact the potential for implementing actions, and while it is not the only factor, sustainable and reliable funding is key to program success. Partnerships address this issue to some extent and offer additional benefits, and it is anticipated that additional jointly developed programs will continue to be developed in the future.

Opportunities exist for additional agricultural water conservation, transfers, and productivity enhancements, but may become more difficult and costly as they are implemented.

TABLE 4-5
Future Potential Actions and Opportunities Supported

No.	Action	Opportunity 1: Increase on-farm efficiency and management	Opportunity 2: Increase conveyance efficiency	Opportunity 3: Reduce consumptive use	Opportunity 4: Enhance flexible water management	Opportunity 5: Conservation planning, data management, and tools	Opportunity 6: Facilitate funding and incentive programs	Opportunity 7: Enhance Soil health
1	Reduce program cost-share with mutual benefits.						●	
2	Pursue funding partnerships.						●	
3	Use RCPP	●	●				●	
4	Explore establishment of a Basin Trust Fund.	●	●					
5	Incorporate a broader range of metrics into funding program evaluations.	●	●					●
6	Increase funding to efficiency programs.	●	●					●
7	Incorporate conveyance improvements through canal automation.		●					
8	Update Reclamation project rules to promote efficient management.			●				
9	Promote outreach and education.				●			
10	Support efforts to facilitate more flexible water management.				●			
11	Provide resources for districts to aid in water planning.					●		
12	Designate a water conservation coordinator.					●		
13	Support water management services.					●		
14	Encourage agriculture water management and use reporting.					●		
15	Compile a Basin-wide database of currently available funding sources.							
16	Improve public understanding.					●		
17	Publish Annual Summary Statistics.					●		

TABLE 4-5
Future Potential Actions and Opportunities Supported

No.	Action	Opportunity 1: Increase on-farm efficiency and management	Opportunity 2: Increase conveyance efficiency	Opportunity 3: Reduce consumptive use	Opportunity 4: Enhance flexible water management	Opportunity 5: Conservation planning, data management, and tools	Opportunity 6: Facilitate funding and incentive programs	Opportunity 7: Enhance Soil health
18	Adopt standards and practices for regional remote sensing programs.			●	●	●		
19	Fund and expand current monitoring networks and data collection.			●		●		
20	Voluntarily retire less productive lands.			●				
21	Facilitate alternative land use.			●				
22	Promote policies and/or programs that incentivize efficient water use.						●	
23	Protect and improve soil health in alternative transfer projects.							●
24	Encourage soil health measures in water conservation plans.							●

4.10 Summary and Key Findings

The Basin Study evaluated several strategies to address system vulnerabilities associated with the projected supply and demand imbalances. Common to all strategies was considerable agricultural water conservation beyond current levels. By 2060, it was estimated that an additional 1 MAFY of water savings could be achieved through conservation and fallowing. Although agriculture is the largest Colorado River water use, to achieve such savings would be a considerable task; thus, savings of this magnitude have been a point of considerable debate.

The Workgroup task was broadly to provide context to the Basin Study estimate of agricultural water conservation opportunities. This was done by documenting past and future planned efforts, considering nuances associated with future conservation, and discussing opportunities to overcome challenges to successes. From data collected through the Workgroup and highlighted with case studies, a range of successful programs and projects has been implemented, resulting in a variety of benefits. In the Ferron Project, downstream water quality was enhanced by reducing salt/salinity loading. In addition, efficiency improvements led to greater water availability enabling an additional late season cutting of alfalfa. Another case study, the Coachella Canal Lining Project, saves roughly 30,000 AF of water per year that is made available for other uses, notably municipal supply. In return, the District received an expensive infrastructure enhancement that offers maintenance savings and operational benefits. In PVID, a fallowing program was established with MWD that provides financial benefits to farmers and the local community while helping to supplement water supply for urban areas.

Building upon the insights gleaned from data collected and case studies, sub-teams were formed to further discuss challenges and potential opportunities to enable success in four areas: consumptive use reductions, conveyance system improvements, on-farm efficiencies, and transfers. From the discussions of those sub-teams, the following opportunities to facilitate successful future water saving or productivity enhancements were identified:

- Increase and/or maintain productivity through more efficient on-farm activities.
- Reduce losses and improve operational efficiency through improved conveyance infrastructure.
- Pursue flexibility associated with strategic consumptive use reductions (for example, deficit irrigation, crop selection, or fallowing).
- Enhance and use mechanisms to facilitate flexible water management (for example, banking, transfers, or exchanges).
- Encourage efficient water management through conservation planning and reporting, data management, and tools development.
- Foster efficient agricultural water use through sustainable funding and incentive programs.
- Increase or maintain productivity and improve water management through soil health.

Potential actions associated with each opportunity were identified and documented. While the potential actions are varied and reflect the range of opportunities, two were found to be more broadly relevant, with some degree of applicability for all opportunities. These potential actions focus on standards and practices for data collection (for example, remote sensing) and the pursuit of funding through sources such as the NRCS RCPP. From case studies and sub-team discussions, funding and data were often the crux of successful programs and projects.

Colorado River agriculture and ranching are foundational institutions of the Southwest, with implications ranging from local economies to national food security. Amid an ongoing 15-year drought and climate projections of hotter conditions, water use and demands are increasingly important for the sustainability of all Colorado River water use sectors. In the Basin Study, additional agricultural water conservation and fallowing were estimated to potentially yield approximately 1 MAF of water savings by 2060. Embedded in that estimation were a variety of Basin-wide assumptions for complex factors over a 50-year period. It is acknowledged that altered assumptions could produce different, but equally defensible, estimates. Ultimately, the extent to which additional agricultural water conservation or fallowing may play a role in meeting broader demand growth will depend largely on how those factors unfold in the decades to come. Also significant are the agricultural investments that have occurred to date. Through formal programs and customary adoption of new practices, these enhancements have enabled productivity to increase across areas receiving Colorado River water and in some cases to make water available for other uses. As a corollary, additional conservation/efficiency/fallowing will become more challenging and costly, but opportunities currently exist, given that the necessary resources are brought to bear in a manner that builds upon past successes.

4.11 References

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Appendix 4A
Planning Area Data

May 2015

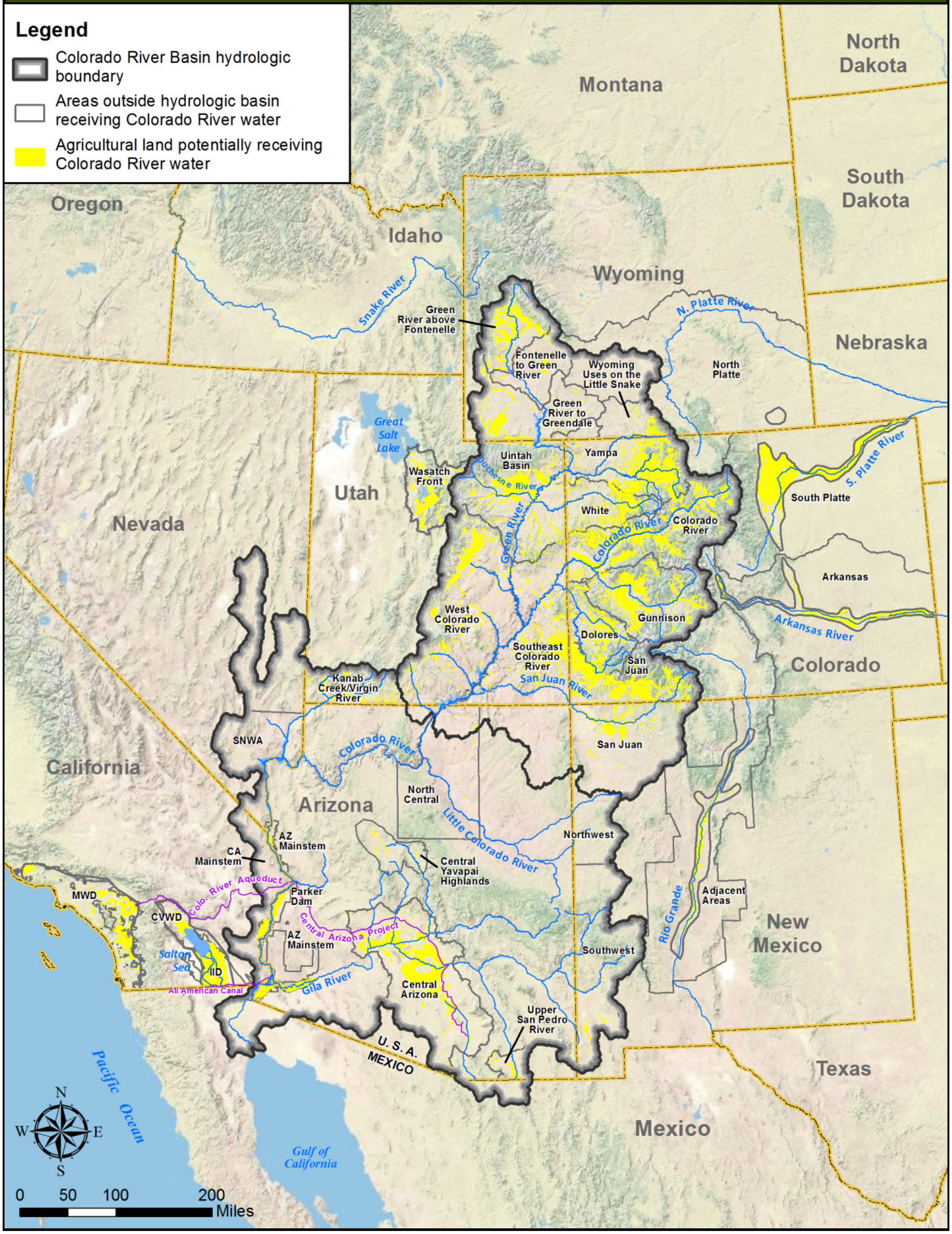
4A | Planning Area Data

Figure 4A-1 presents the planning areas used as part of the Colorado River Basin Water Supply and Demand Study (Basin Study) as well as evapotranspiration stations nearest areas of irrigated agriculture for each planning area. Figure 4A-1 also includes irrigated acreage in the study area from the 2011 National Land Cover Database (Jin et al., 2013). Table 4A-1 shows the irrigated acreage associated with each planning area. Figure 4A-1 and Table 4A-1 provide insight as to the geographic variability of agricultural production intensity including a wide variety of elevations and locations throughout the Colorado River Basin.

Note that areas within the hydrologic basin rely almost solely on Colorado River system water, whereas some areas outside of the hydrologic basin also rely on other water supply sources and use Colorado River water as a supplemental supply.

Note that planning areas were developed as part of the Basin Study to quantify potential future demands. In several cases, these areas reflected a potential future demand where Colorado River water is not currently used. As such, some of these areas have little or no agricultural use of Colorado River water.

FIGURE 4A-1
Agriculture Potentially Served by Colorado River Water



Note:
Planning areas are based on those used in the Basin Study. The Wasatch Front planning area has been modified from the Basin Study per data provided by Utah Division of Water Resources.

TABLE 4A-1
Agriculture in the Areas Receiving Colorado River Water

State	Planning Area	Total Irrigated Acres Potentially Using Colorado River Water[1]	Colorado River Water Equivalent Irrigated Acres[2]
Arizona		614,950	298,087
	Central Arizona	446,610	129,747
	Central Yavapai Highlands	–	–
	Mainstem	168,340	168,340
	Upper San Pedro River	–	–
California		723,037	640,357
	CVWD	78,530	55,838
	IID	475,000	475,000
	Mainstem	5,518	5,518
	MWD	59,989	–
	PVID	104,000	104,000
Colorado		2,177,450	1,073,194
	Arkansas	428,000	41,416
	Colorado River	270,350	270,350
	Dolores	39,800	39,800
	Gunnison	268,950	268,950
	San Juan	219,650	219,650
	South Platte	831,000	113,328
	White	26,900	26,900
	Yampa	92,800	92,800
New Mexico		144,838	38,179
	Adjacent Areas	93,301	3,879
	San Juan	34,300	34,300
	Southwest	17,237	–
Utah		476,000	352,200
	Kanab Creek/Virgin River	18,000	17,900
	Southeast Colorado River	14,800	13,600
	Uintah Basin	212,700	212,700
	Wasatch Front	135,500	13,000
	West Colorado River	95,000	95,000
Wyoming		335,540	335,540
	Fontenelle to Green River	19,374	19,374
	Green River above Fontenelle	194,080	194,080
	Green River to Greendale	107,421	107,421
	Little Snake River	14,665	14,665
	North Platte	–	–
Total		**4,471,815**	**2,737,557**

Coachella Valley Water District (CVWD); Imperial Irrigation District (IID); Metropolitan Water District of Southern California (MWD); Palo Verde Irrigation District (PVID)

[1] “Adjacent Areas” – Areas receiving Colorado River water that are outside of the hydrologic basin. Acreage is approximate and will vary from year to year.

[2] Equivalent Irrigated Acres” – The total acreage was prorated to reflect the portion of supply that comes from the Colorado River when multiple sources are available. For example, if total acreage for a given geography was 100,000 and that area received 40 percent of its supply from the Colorado River, it was assumed that approximately 40 percent of the acreage, or 40,000 acres, would be attributable to the Colorado River.

4A.1 References

Jin, S., L. Yang, P. Danielson, C. Homer, J. Fry, and G. Xian, 2013. *A comprehensive change detection method for updating the National Land Cover Database to circa 2011*. Remote Sensing of Environment, 132: 159 – 175.

Appendix 4B
Case Studies

May 2015

4B | Case Studies

Case Study 1

Central Arizona Project Service Area Irrigation Districts' Agricultural Conservation Activities

Arizona

Overview

Agricultural water users are among the most junior served by the Central Arizona Project (CAP). Since the 1980 Arizona Groundwater Management Act and subsequent authorizations such as the 2002 Agricultural Best Management Practices Program, irrigation districts and individual water users in the CAP service area have invested in a range of water conservation measures.

Description

Within the CAP service area, Arizona's water management framework requires mandatory agricultural water conservation by all districts and limits the expansion of agricultural lands. This has resulted in a general decline in agricultural water use over the past 30 years. During this period, more than 150,000 acres were converted to high-efficiency, laser-level basins with efficiencies estimated near 85 percent, along with the adoption of other highly efficient technologies such as sprinkler and micro-irrigation practices. As a complement, conveyance improvements have reduced delivery losses from approximately 10 percent to near 3 percent in many areas.

Outcome

Irrigation districts in the CAP service area have made significant investments, totaling over $750 million in water-efficient practices and infrastructure. This represents an average per acre of $3,700 (2013 dollars), of which roughly $2,700 was attributed to reducing losses through conveyance improvements. Similar investments have and continue to be adopted across agriculture served by the Colorado River. This case study serves to highlight the cost associated with implementing common efficiency enhancements and illustrates the types of measures that have been implemented by irrigators throughout the Basin.

Agencies
Central Arizona Project, Arizona Department of Water Resources

Project Status
Ongoing

Key Program Elements
Growers and districts are incentivized to improve water use efficiency

Budget
More than $750 million invested in agricultural efficiency improvements

Water Savings
Much of the agriculture in the CAP service area exceeds 80% water use efficiency

The Central Arizona Project delivers Colorado River water to users in the Phoenix area and beyond
Source: Central Arizona Project

Sources

- Cullom, Chuck. 2014. “Case Study Example Central Arizona Project Irrigation Districts.” Presentation to the Agricultural Conservation, Productivity, and Transfers Work Group. March 26.
- Evaluation of the Best Management Practices Agricultural Water Conservation Program: http://www.azwater.gov/azdwr/WaterManagement/AMAs/PinalAMA/documents/EvaloftheBMPReport.pdf

Case Study 2

A Case Study in Efficiency – Agriculture and Water Use in the Yuma, Arizona Area

Yuma County Agricultural Water Coalition, Arizona

Overview

Yuma area agricultural practices have changed considerably since the early 1900s. These changes came mainly as a result of food industry demand. Area growers adapted to consolidated production processes. Grower adaptation to food industry demand resulted in Yuma becoming the center for winter vegetable production in the U.S. Required efficiency and consistency improvements for quality, size, uniformity, and yield were met. Using more efficient infrastructure and irrigation practices, growers are producing higher-crop yields with less water.

Entity

Yuma County Agricultural Water Coalition

Project Status

Agricultural water use efficiency and productivity continue to be a priority in the area

Key Program Elements

- Infrastructure improvements
- Adoption of practices such as multi-cropping

Budget

Many efficiency and productivity enhancements have been made by individual growers in response to market demands

Water Savings

Since 1970, growers are irrigating 50% more crop acres with about 20% less water

Description

Before 1975, agricultural production occurred largely on single cropped acreage. During the last 40 years, multi-crop production has increased almost 600 percent. Multi-cropping is the practice of growing multiple vegetable crops on the same land in the same season. Growers also multi-crop both vegetable and non-vegetable crops on the same land in the same year. Multi-cropping takes place on more than 80 percent of the cultivated acreage in the area.

The increase in multi-cropping reflects the emphasis on increasing yield (see Figure 4B-1). Vegetable production acreage expanded from 30,000 acres in 1970 to more than 130,000 acres in 2010. Vegetable production increased more than 400 percent in the same period.

The long growing season and infrastructure unique to the area make multi-cropping possible. Yuma area agriculture also developed the capability of growing, harvesting, cooling, storing, and shipping winter vegetables. Those winter vegetables (iceberg, leaf, romaine lettuce, broccoli, cauliflower, and spinach) along with cantaloupe and honeydew melons have the largest crop acreage footprint in the region, more than 80 percent.

The irrigated acreage increase occurred in conjunction with an overall reduction of on-farm water deliveries (see Figure 4B-2). In 1970, using more than 1 million acre-feet, growers produced 187,000 acres of crops. In 2010, growers produced 270,000 acres of crops on 150,000 acres of land using 880,000 acre-feet of water.

Outcome

Infrastructure improvements and practices such as multi-cropping have notably enhanced Yuma area agricultural productivity. For example, the area ranks in the top 0.1 percent of counties in vegetable and melon sales nationally. Other rankings include the top 0.5 percent in sales of all crops and the top 1 percent in combined sales of crop and livestock products. Correspondingly, this high agriculture productivity has had a significant influence on local economic growth, both overall and for ancillary sectors. It is estimated that agriculture and related industries contribute to one in four area jobs. The combination of national prominence and local significance highlights the universal value of agriculture in highly productive areas such as Yuma County.

Sources

- Wade Noble/Yuma County Agriculture Water Coalition, personal communication. October 31, 2014.
- Yuma County Agriculture Water Coalition. 2015. A Case Study in Efficiency – Agriculture and Water Use in the Yuma, Arizona Area. www.agwateryuma.com

FIGURE 4B-1
Yuma County Crop Acreage

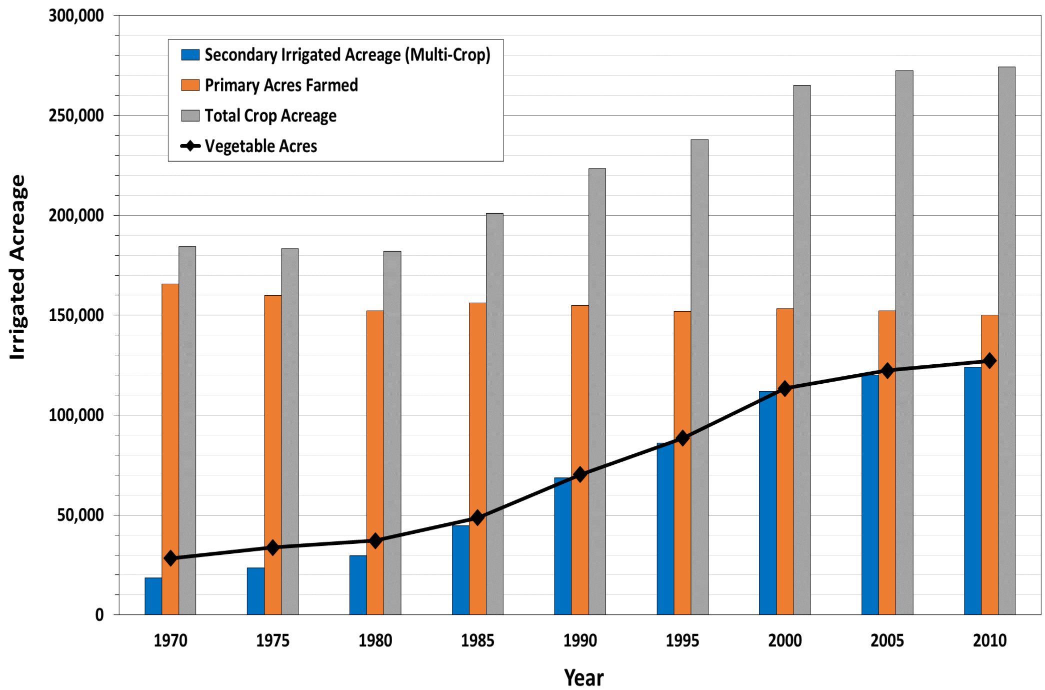
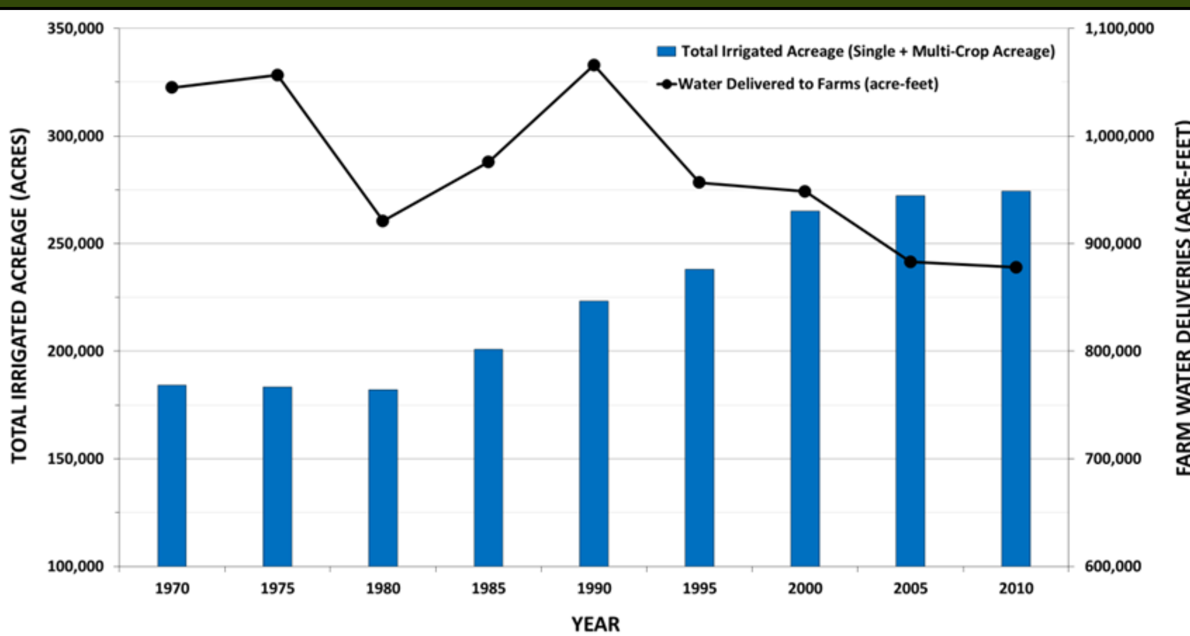


FIGURE 4B-2
Irrigated Acres Farmed in Yuma County and Water Deliveries (1970-2010)



Case Study 3

Imperial Irrigation District Quantification Settlement Agreement Conservation and Transfer Program

Imperial Irrigation District, California

Overview

As part of the Quantification Settlement Agreement (QSA), the Imperial Irrigation District (IID) agreed to a 45- to 75-year conservation and transfer program. The program has been supported initially (2003 to 2017) by fallowing programs that transition over time (2008 to 2026) to efficiency-based conservation programs at full implementation. During the 15-year fallowing period, landowners and/or lessees voluntarily let their fields lie fallow to help IID meet water transfer obligations to a funding partner, Salton Sea mitigation delivery requirements, and as needed, Colorado River overrun paybacks. The fallowing programs were largely implemented to offset potential impacts to the Salton Sea resulting from conserved water that is transferred out of Imperial Valley to the San Diego County Water Authority (SDCWA), consistent with the refined Salton Sea Habitat Conservation Strategy, as defined in the Amended and Restated Addendum to the Final Environmental Impact Report for the IID Water Conservation and Transfer Project (September 2003).

In 2008, IID began implementing system conservation projects with a main canal seepage recovery system (see Case Study 5). At full implementation, system conservation improvements may exceed 100,000 acre-feet per year (AFY).

In 2013, IID initiated a voluntary on-farm conservation program to begin the process of converting from fallowing to efficiency-based conservation measures. The on-farm conservation program began at 20,000 AFY and ramps up until fully implemented, with a minimum conservation goal of 130,000 AFY.

Description

Based on the quantity of conserved water attributed to each field, landowners/lessees are compensated for voluntarily fallowing fields they would have otherwise farmed.

Agencies

- Implementation (Transferor) – Imperial Irrigation District
- Funding (Transferees) – SDCWA and Coachella Valley Water District

Project Status

The fallowing program runs from 2003 through 2017 and then will be mostly replaced with efficiency based on-farm and system conservation programs. Full implementation of the 303,000 AFY of conservation and transfer program is scheduled in 2026.

Key Program Elements

- Land fallowing, without permanent change in water rights or retirement of agricultural lands
- System conservation projects implemented within the District's half-million irrigated acre service area
- On-farm conservation program funds field-level conservation measures implemented by growers
- Conserved water is transferred to the funding partner for 45 years without permanent change in water rights. Option for a 30-year renewal with mutual agreement

Budget

$136 million, 2003 to 2014 ($90.7 million paid to participants, plus $50 million community fund) for fallowing. Significantly increased budgets are anticipated in future years to fund efficiency-based conservation programs.

Water Savings

1,220,441 AF, 2003 to 2013, ramping up to 303,000 AFY post 2026 (not including All-American Canal Lining Project that conserves 67,700 AFY)

Fallowed field and dry lateral
Source: Amy Loper

For the on-farm conservation program, growers volunteer to implement field-level conservation measures they select, with conservation yields calculated from water delivery reductions determined from pre-established field and crop-specific baselines.

Additional system conservation projects are still being prioritized, but current planning efforts are focused on system automation, main canal concrete lining, reservoirs, and integrated information management systems.

The schedule of water transfers and mitigation water requirements is defined in the QSA and related agreements and, when combined with varying annual payback requirements, results in a mix of water conservation and fallowing target volumes each year.

The IID Board of Directors sets conservation payment rates each year. The price per AF paid to fallowing participants has been as low as $60 per AF and as high as $175 per AF (2014). The price per AF paid to on-farm conservation participants was set at $285 per AF in 2013 and 2014. When combined with system efficiency project costs and conservation targets, there can be significant annual variances in the program budget.

From December 2003 through June 2015, the total to be paid to fallowing participants is about $90.7 million.

Additionally, a $50 million community fund was set up and managed locally for mitigation of direct and indirect socioeconomic impacts caused by fallowing. The fund is used to compensate businesses and organizations, such as farm service providers, who have been negatively impacted by fallowing. Competitive funds are also distributed for job training services and programs that provide an economic stimulus in Imperial County.

Outcome

Between December 2003 and June 2014, a total of 1,242,283 AF of Colorado River water was conserved as a result of fallowing.

Since the QSA's 2003 implementation, IID has generated 143,306 AF of efficiency-based conservation for transfer and payback purposes. A total of 125,213 AF resulted from system conservation measures and 18,093 AF from growers participating in IID-funded on-farm conservation programs.

Sources

- Imperial Irrigation District Fallowing Program Status Report, October 2013: http://www.iid.com/Modules/ShowDocument.aspx?documentid=8383
- IID Fallowing Programs: http://www.iid.com/index.aspx?page=190
- Annual Implementation Report. 2009. Quantification Settlement Agreement, Imperial Irrigation District, Water Conservation and Transfer Project: http://www.iid.com/Modules/ShowDocument.aspx?documentid=4644
- 2010 Annual Water Report. Imperial Irrigation District: http://www.iid.com/Modules/ShowDocument.aspx?documentid=5057
- Revised Fourth Amendment to Agreement between Imperial Irrigation District and San Diego County Water Authority for Transfer of Conserved Water: http://www.iid.com/Modules/ShowDocument.aspx?documentid=886

Case Study 4

Imperial Irrigation District and Metropolitan Water District of Southern California Water Conservation Program

Imperial Irrigation District, California

Overview

A 35-year water conservation agreement was signed in 1988 between the Imperial Irrigation District (IID) and the Metropolitan Water District of Southern California (MWD). Under the agreement, MWD pays for the costs of water conservation measures in exchange for conserved water. The 1988 IID-MWD agreement was amended in 2003 at the time of the Quantification Settlement Agreement (QSA) and extended to 2041 or through the QSA term, whichever is later.

Agencies

Implementation – Imperial Irrigation District
Funding – MWD

Project Status

Project construction complete. Associated water conservation and transfer is ongoing

Key Program Elements

- Conveyance system improvements
- On-farm irrigation system improvements
- Water conserved to be used by MWD and Coachella Valley Water District
- Conservation verification

Budget

$112.5 million capital, $23 million indirect, plus $157.5 million in cumulative annual O&M costs (through July 2014)

Water Savings

2,242,779 acre-feet (AF), 1990-2014; 105,000 acre-feet per year (AFY) through at least 2041

Canal lining
Source: Bureau of Reclamation

Description

Fifteen new projects were constructed between 1990 and 1998 and water conserved by two augmentation projects was made available beginning in 1990. Projects were primarily conveyance improvements and included lateral interceptors, reservoirs, concrete lining of main and lateral canals, non-leak gates, and system automation. Projects also included on-farm irrigation system improvements (tailwater return systems, irrigation evaluations, and pilot linear move and drip irrigation systems) and 12-hour delivery of irrigation water. The total capital cost was about $112.5 million, with indirect payments to IID of $23 million, and cumulative annual operation and maintenance (O&M) costs totaling $157.5 million through July 2014. MWD has paid all of the costs associated with the 15 projects and will continue to pay the annual costs until the agreement terminates. In return, MWD is allowed to divert the saved Colorado River water through the Colorado River Aqueduct or store it in Lake Mead.

A Program Coordinating Committee (PCC) facilitates cooperation and information exchange between IID and MWD related to the program's various financial, economic, administrative, and technical aspects.

A consultant group, called the Conservation Verification Consultants (CVC), prepared an annual report on the estimated amount of water conserved by the program for the Water Conservation Measurement Committee (WCMC) through 2006, which verified the amount of water conserved. IID now provides this information using procedures developed by the CVC and approved by the WCMC and the PCC.

Outcome

Annual water savings between 1998 and 2013 averaged 105,009 AFY and ranged between 101,940 and 109,460 AFY. Through 2013, 1,841,242 AF have been used by MWD, 159,381 AF have been stored in Lake Mead for MWD, and 137,156 AF have been used by the Coachella Valley Water District.

The program also resulted in greater water management flexibility for Imperial Valley farmers and opportunities for farmers to apply water more effectively. Distribution system and on-farm management improvements were related and often resulted in greater overall program improvements than would be expected than when considered individually.

Sources

- MWD Plan for the Creation of Extraordinary Conservation Intentionally Created Surplus, Calendar Year 2015
- Imperial Irrigation District and Metropolitan Water District of Southern California Water Conservation Program Final Program Construction Report, IID Water Resources Unit, April 2000: http://www.iid.com/Modules/ShowDocument.aspx?documentid=4060
- IID, Water Conservation: http://www.iid.com/index.aspx?page=121
- IID & MWD Water Conservation Program: http://www.iid.com/index.aspx?page=201

Case Study 5

Imperial Irrigation District Seepage Recovery Program

Imperial Irrigation District, California

Overview

Open drains were constructed along main canals some time ago to intercept canal seepage that was flowing to the Salton Sea and to reduce water tables on adjacent agricultural lands. The seepage recovery program includes the installation of pump stations, collection sumps, and appurtenant structures in the open drains to pump water back into the All-American, East Highline, and West Side Main Canals. The increased water returned to the main canals reduces Imperial Irrigation District's (IID) delivery needs at Imperial Dam and allows for transfer under the Quantification Settlement Agreement (QSA).

Agencies

Imperial Irrigation District, Coachella Valley Water District, San Diego County Water Authority

Project Status

Pump stations completed in 2009. Associated water conservation continues today

Key Program Elements

- Conveyance improvements
- Acquisition of conserved water

Budget

$7.29 million capital cost, plus average $500,000 per year O&M

Water Savings

Up to 40,000 AFY

Seepage interception pump
Used by permission of IID

Description

In total, 22 pumping stations were constructed at the lower ends of interceptor drains. These pump stations are operated to maintain drain water levels within 6 inches of historical levels to prevent interference with normal drainage and induction of additional seepage from the main canals.

The total capital cost was $7.29 million, and annual operation and maintenance (O&M) costs average about $500,000.

Intercepted seepage water pumped to the main canal is metered, and flow measurements are reported electronically to IID's Operations Center, where the information is subject to quality control procedures and stored in a relational database.

The Bureau of Reclamation verifies measurement accuracy and conducts semiannual visits to project facilities for verification of operability and data accuracy.

Outcome

Total seepage recovery capacity is up to about 40,000 acre-feet per year (AFY).

This seepage recovery project was developed to conserve water for acquisition by Coachella Valley Water District under the QSA. However, because of the timing of construction, this project is ahead of the conserved water delivery schedule required by the Acquisition Agreement, and the project may produce conserved water in excess of the acquisition requirements. Any excess conserved water is available for use by IID for other purposes, including obligations associated with the Inadvertent Overrun and Payback Policy and creation of Intentionally Created Surplus, until the full conservation yield of this program is needed under the QSA.

Sources

- IID 2014 Plan for the Creation of Extraordinary Conservation Intentionally Created Surplus
- 2010 Annual Water Report, Imperial Irrigation District: http://www.iid.com/Modules/ShowDocument.aspx?documentid=5057
- Status Report: Main Canals Seepage Interception Project, April 15, 2008: http://www.iid.com/Modules/ShowDocument.aspx?documentid=4057

Case Study 6

Palo Verde Irrigation District and Metropolitan Water District of Southern California Forbearance and Fallowing Program

Palo Verde Irrigation District, California

Overview

On January 1, 2005, the Palo Verde Irrigation District (PVID) and the Metropolitan Water District of Southern California (MWD) began a 35-year Forbearance and Fallowing Program with landowners within PVID. The key component of the program is land fallowing, where participants fallow land in exchange for payments. The volume of water that becomes available to MWD is governed by the federal Quantification Settlement Agreement (QSA), the 2003 Colorado River Water Delivery Agreement.[1] Under these agreements:

- MWD must reduce its consumptive use of Colorado River water by that volume of consumptive use by PVID and holders of Priority 2[2] that is greater than 420,000 acre-feet (AF) in a calendar year, or
- MWD may increase its consumptive use of Colorado River water by that volume of consumptive use by PVID and holders of Priority 2 that is less than 420,000 AF in a calendar year.

In both cases, each AF of reduced consumptive use by PVID is an additional AF that becomes available to MWD.

Agencies

Palo Verde Irrigation District and Metropolitan Water District of Southern California

Project Status

The program commenced on January 1, 2005, and is termed to end on July 31, 2040

Key Program Elements

- Land fallowing, without permanent change in water rights or retirement of agricultural lands
- Forbearance of diversion of saved water by PVID

Budget

$82.8 million capital cost, $115.6 million in cumulative annual costs through 2014, plus variable future annual costs depending on acreage fallowed ($752/acre in 2014, or $8.61 million total, for a 50% fallowing call)

Water Savings

32,750 to 122,216 acre-feet per year (AFY)

View of fallowed field
Source: Bureau of Reclamation

Description

Program participation is voluntary but requires participating landowners to sign a 35-year participation contract. A one-time sign-up payment was paid to participants for enrolling in the program. Annual payments are also made to participants in years when their land is fallowed. Land taken out of production is rotated every 1 to 5 years and maintained in accordance with approved soil and water management plans.

Fallowing amounts vary year to year, depending on MWD's water needs. MWD sets a fallowing "call" annually. The program sets a minimum of 6,487 acres for fallowing in a given year (7 percent of the District's acreage in the Palo Verde Valley) to a maximum of 25,947 acres (28 percent of acreage).

Capital cost were $82.8 million, including $73.5 million for one-time payments to landowners upon enrollment, $3.3 million for program environmental documentation and implementation, and $6 million for local community improvement programs, which are discussed below. Through 2014, cumulative annual payments to landowners have totaled $112.2 million and $3.4 million to PVID for administrative costs.

[1] The parties to the Colorado River Water Delivery Agreement are the U.S., Imperial Irrigation District, Coachella Valley Water District, MWD, and the San Diego County Water Authority.

[2] The Yuma Project Reservation Division holds California's Priority 2.

Annual operating costs vary according to acreage fallowed. In 2014, payments to landowners are $752 per acre, totaling about $8.61 million to fallow at a 50 percent fallowing call. In addition, PVID program administrative costs are covered through an annual payment ($0.27 million in 2014), which includes funding for staff to verify that land is fallowed, calculate water savings, and document calculations of water saved.

A $6 million fund for local community improvement programs was established to mitigate third-party economic impacts. The fund is administered by a nonprofit public benefit corporation established by the community for this purpose. The fund has made available $5.27 million in loans to 16 local businesses and has provided more than $0.8 million in grants to various nonprofit entities serving the Blythe community.

Outcome

Annually, water saved has varied from between 32,750 AFY and 122,216 AFY. Over the 35-year program, total water saved is estimated to be between 1.9 million AF and 3.7 million AF.

Sources

- MWD Plan for the Creation of Extraordinary Conservation Intentionally Created Surplus, Calendar Year 2015
- Calendar Year 2013 Fallowed Land Verification Report. PVID/MWD Forbearance and Fallowing Program. PVID, MWD, Bureau of Reclamation. May 12, 2014
- Palo Verde Land Management, Crop Rotation and Water Supply Program…at a glance, MWD, June 2013: http://www.mwdh2o.com/mwdh2o/pages/news/at_a_glance/Palo-Verde-fact-Sheet.pdf
- Smith, MaryLou, and James Pritchett. 2010. Agricultural/Urban/Environmental Water Sharing: Innovative Strategies for the Colorado River Basin and the West, Colorado Water Institute Special Report Series No. 22. Colorado State University: http://cwi.colostate.edu/publications/sr/22.pdf

Case Study 7

Coachella Canal Lining Project

Coachella Valley Water District, California

Overview

The Coachella Canal carries Colorado River water 123 miles northwest from the All-American Canal to more than 85,000 acres of highly productive agricultural land in the Coachella Valley. The Canal Lining Project was developed as a water conservation measure in response to Title II of Public Law 100-675. Implementation of the project resulted in the construction of 36.5 miles of concrete-lined canal directly adjacent to the original earthen canal. Additionally, the project included a variety of check structures, canal crossings, flow measurement structures, and environmental mitigation measures. The contract was awarded in September 2004, and water began to flow through the new lined canal in November 2006.

Agencies

Coachella Valley Water District, California Department of Water Resources, San Diego County Water Authority

Project Status

Completed 2007

Key Program Elements

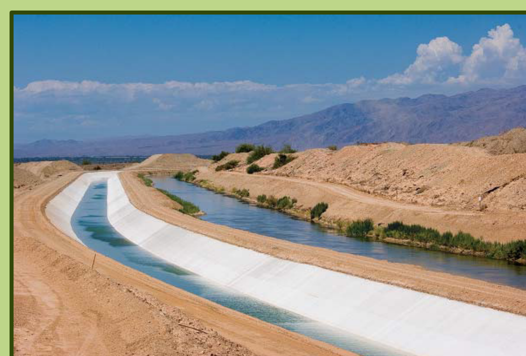
- Conveyance improvements
- Allocation of conserved water

Budget

$124 million, funded 30% by SDCWA and 70% by CDWR

Water Savings

30,850 acre-feet per year



Water begins to flow through the new canal adjacent to the original earthen structure
Source: Coachella Valley Water District

Description

Capital costs totaled approximately $124 million, with 70 percent funded by the California Department of Water Resources (CDWR) and 30 percent funded by the San Diego County Water Authority (SDCWA).

Annual operating costs are shared among the Coachella Valley Water District (CVWD), SDCWA, and the San Luis Rey Indian Water Rights Settlement Parties. As part of the project agreement, a baseline was derived from historical average operation, maintenance, and repair costs. The project beneficiaries pay for all operation, maintenance, and repair costs above that baseline and also agreed to pay for monitoring, operation, maintenance, and repair of project environmental mitigation features.

CVWD was responsible for overall management of the project in collaboration with the Bureau of Reclamation and project funders. A number of consultants, designers, suppliers, contractors, and subcontractors were employed as part of the project. Additionally, a variety of federal, state, and tribal advisors provided input throughout the project. Implementation required considerable coordination through an agreed-upon project governance structure.

Outcome

Annually, water saved from the reduction of seepage and other losses is 30,850 acre-feet per year. Water savings from the canal lining are used to meet urban water demand in San Diego County, and on the Southern California coastal plain until a San Luis Rey Indian water rights settlement agreement has been executed and a stipulated judgment or other final disposition has been entered in pending proceedings in the U.S. District Court for the Southern District of California.

Sources

- Coachella Canal Lining Project Construction Report.
- Canal Lining Projects: http://www.sdcwa.org/canal-lining-projects

Case Study 8

All-American Canal Lining Project

Imperial Irrigation District, California

Overview

The All-American Canal was authorized as part of the 1928 Boulder Canyon Project Act to provide reliable delivery of Colorado River water to burgeoning agriculture in the Imperial and Coachella Valleys. Deliveries of Colorado River Water to the Imperial Valley travel approximately 80 miles from the mainstem to irrigate nearly 500,000 acres of agricultural lands. In the 1990s, estimates indicated that nearly 70,000 acre-feet of water would be conserved by reducing seepage in the middle reaches of the canal. Ultimately, the canal lining project became an important piece of the 2003 Quantification Settlement and related agreements, which provide a framework to meet California's water needs within its basic Colorado River apportionment. Construction began in June 2007 and was completed in 2009.

Agencies

Imperial Irrigation District, State of California, San Diego County Water Authority, Bureau of Reclamation

Project Status

Completed in 2009

Key Program Elements

- Construction of 23 miles of lined canal to replace original earthen portion
- Environmental mitigation for wetlands impacts

Budget

Approximately $300 million shared by San Diego County Water Authority and the State of California

Water Savings

67,700 AF per year

All-American Canal lining in progress
Used by permission of IID

Description

Construction costs totaled approximately $300 million, shared by the San Diego County Water Authority and the State of California. The Imperial Irrigation District provided project management and continued operation and maintenance of the canal. To allow continuous water deliveries to the Imperial Valley, the project constructed a new, concrete-lined canal in parallel with the original earthen structure. This required moving more than 20 million cubic yards of material in addition to the concrete-lining activities. A phased implementation brought new sections of the canal online as they were completed, providing the first water savings in 2008. The project also included the construction of a 1,200 acre-foot (AF) off-line storage facility for use by the Imperial Irrigation District. Recognizing an anticipated loss of wetlands dependent on canal seepage, the project included monitoring of species and habitats potentially impacted as well as the creation and enhancement of wetlands.

Outcome

Hailed as a model of collaboration, the All-American Canal Lining Project has bolstered water supply reliability for communities in coastal Southern California. Annual water savings from seepage reduction total 67,700 AF. Water savings from the canal lining are used to meet urban water demand in San Diego County; and on the Southern California coastal plain until a San Luis Rey Indian water rights settlement agreement has been executed and a stipulated judgment or other final disposition has been entered in pending proceedings in the U.S. District Court for the Southern District of California.

Sources

- Imperial Irrigation District. 2008. Quantification Settlement Agreement Annual Implementation Report. http://www.iid.com/index.aspx?page=17

Case Study 9

Alternative Agricultural Water Transfer Methods Grants Program

Colorado

Agencies

Colorado Water Conservation Board, numerous partner agencies as recipients of grants

Project Status

First round of grants completed; Second round of grants issued in 2011-2012

Key Program Elements

- Grant program
- Water transfers, without permanent change in water rights or retirement of agricultural lands

Budget

$3 million

Water Savings

Not specifically targeted

Overview

In Colorado, agricultural-to-municipal water transfers have historically taken place through "buy-and-dry," in which irrigated farmland is either revegetated with native plants or converted to dryland farming.

To reduce the burden on agricultural economies and communities associated with buy-and-dry transfers, efforts have been made to identify alternative agricultural water transfer methods (ATMs). ATMs provide agricultural water for municipal and industrial (M&I) or environmental use on an as-needed basis while keeping farmlands irrigated and producing crops, avoiding traditional buy-and dry.

The Colorado Water Conservation Board (CWCB) implemented the ATM Grant Program to identify barriers to implement ATMs and to develop solutions to overcome barriers. Two rounds of grants occurred between 2009 and 2012.

Description

The first grants focused on interruptible supply agreements, rotational fallowing, water banks, reduced crop consumptive use, and purchase and lease-back.

Grants in the second round were used to primarily fund projects addressing challenges to implementation identified during the first round of grants.

Each of the first two rounds of grants was $1.5 million, for a total of $3 million. There were six project groups in the first series of grants, with funding ranging from $70,000 to $477,500 per project. The second round of grants included 10 project groups, with funding ranging from $10,000 to $320,000 per project.

Outcome

In the first round, four barriers to the implementation of ATMs in Colorado were identified: (1) potentially high transaction costs associated with water rights transfers, (2) water rights administration uncertainties and water rights accounting questions, (3) certainty of long-term supply and desire for water providers to have permanence of long-term supply, and (4) infrastructure needs and water quality issues.

In the second round, projects have ranged from research to conceptual implementation of ATMs.

This program has resulted in significant progress toward making ATMs a viable option for M&I providers and environmental uses. Several pilot projects have been initiated to examine how some of these projects could be implemented on a large scale. This program has resulted in successful partnerships between cities, farmers, land conservancies, funding partners, and environmentalists.

Recommendations

The CWCB made three primary recommendations for the ATM program for the west slope of Colorado:

1. Advance the Colorado River Compact Water Banking study and its focus on rotational fallowing by integration using the results from the Aspinall Water Bank study and the Yampa ATM study.
2. Continue the Yampa ATM study to determine the acceptability by ranchers of an ATM and the concurrent benefits to fish habitat. These identified lands and associated water can also be used for the Compact Water Banking project and should be integrated.
3. Continue the study by Colorado State University and others on the suitability of pasture grass for rotational fallowing.

Sources

- Alternative Agricultural Water Transfer Methods Grants, Colorado Water Conservation Board: http://cwcb.state.co.us/LoansGrants/alternative-agricultural-water-transfer-methods-grants/Pages/main.aspx

Case Study 10

Canal System Improvement Project

Orchard Mesa Irrigation District, Colorado

Overview

The U.S. Fish and Wildlife Service identified the need for additional flows within a 15-mile reach of the Colorado River. The proposed project has been identified by the Upper Colorado River Endangered Fish Recovery Program as a source to provide additional flows along the 15-mile reach. These flows are expected to aid in recovery of four endangered fishes.

The project consists of improving and automating the Orchard Mesa Irrigation District (OMID) canal system. Saved water is then used to provide increased hydropower generation at the Grand Valley Power Plant, which will often result in the augmentation of stream flows within the 15-mile reach. In addition to increasing instream flows and power generation, current water shortages to municipal and industrial (M&I) providers and agricultural water users would be reduced.

Agency

Orchard Mesa Irrigation District

Project Status

The project is expected to be fully operational in 2016

Key Program Elements

- Conveyance improvements
- Improve instream environmental flows

Budget

$16.5 million

Water Savings

17,000 AFY

Orchard Mesa Pumping Plant
Source: Bureau of Reclamation

Description

Proposed improvements include the following:

- Constructing a new 80- to 100-acre-foot (AF) regulating reservoir
- Improving water level control using check structures and other improvements
- Installing a simple remote monitoring system and electronic flow meters (supervisory control and data acquisition system)
- Increasing pump capacity at existing B ¼ Rd pump
- Constructing interties to help balance flows in the irrigation system and upgrades to canal end spills by rerouting end spill on Canal No. 2 to Canal No. 1 and modifying operations of the lower portion of Canal No. 1
- Reducing canal and lateral seepage through lining and piping
- Improving operational procedures

Project budget is $16.5 million. Check structures were completed in 2014, and the regulating reservoir is planned to be complete in 2015.

Outcome

The project is expected to result in an average of 17,000 acre-feet per year (AFY) in water savings. Project savings result from reduced main canal and lateral spills, recovering spills from main canals in urban areas, and elimination of spills from the Mutual Mesa lateral. Total savings of about 17,000 AFY on average are expected even while improving the equitable distribution and reliability of water service. This water would be available to manage irrigation supplies more efficiently. If the water is not needed for irrigation, it would be used for hydropower generation and the resulting augmentation of low flows in the 15-mile reach of the Colorado River upstream of the confluence with the Gunnison River.

In addition to more efficiently managing irrigation water demands, the project reduces hydraulic pumping by 28,000 AFY, which results in a reduction in energy demand for pumping.

Sources

- Orchard Mesa Irrigation District: http://www.irrigationprovidersgv.org/OMID.php
- Final Environmental Assessment, Orchard Mesa Irrigation District Canal System Improvement Project. U.S. Bureau of Reclamation, August 2013: http://www.usbr.gov/uc/envdocs/ea/OrchardMesa/final-EA.pdf

Case Study 11

Colorado River Water Bank Feasibility Study

Colorado

Overview

Under the Colorado River Compact, the Upper Division States are obligated not to cause the flow of the Colorado River, at Lee Ferry, Arizona, be depleted below 75 million acre-feet per year (MAF) over any consecutive 10-year period. If the Upper Division States ever depleted the flow of the river at Lee Ferry causing it to fall below 75 MAF during a 10-year period, the Upper Division States may need to impose curtailments of certain water uses. One option being considered to avoid a Compact deficit and any related need to curtail water uses is a water bank. A study evaluating the feasibility of one particular water banking concept is in progress in Colorado. This study is examining whether a water bank could be used to prevent, delay, or reduce the negative effects of a Compact deficit. An effective water bank could help meet compact obligations, protect critical levels in Lake Powell, or allow continued water use in the event that curtailments would otherwise be needed to resolve a Compact deficit

Agency

The Water Bank Group, which is composed of representatives of the Colorado River Water Conservation District, Colorado Water Conservation Board, Front Range Water Council, Southwestern Water Conservation District, and The Nature Conservancy

Project Status

Phase 1 is completed, and recommendations have been made for Phases 2 and 3

Key Program Elements

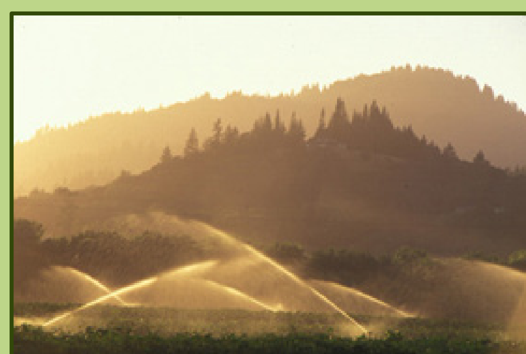
- Feasibility study
- Water transfers, without permanent change in water rights or retirement of agricultural lands

Budget

$180,000 for feasibility study

Water Savings

Up to 200,000 acre-feet per year (AFY) potentially feasible



View of sprinkler irrigation
Source: CH2M HILL

Description

The water bank would operate as follows. Voluntary agricultural participants in the water bank would be compensated to temporarily reduce their consumptive use through either deficit irrigation or split-season irrigation. The saved consumptive use would be available to a water bank. Post-Compact water users (of any type) would "subscribe" to the bank as a kind of insurance policy to offset or replace water use that would otherwise be curtailed by the Compact administration. Participating agricultural land may be part of the program temporarily or on a rotational basis. This approach may avoid permanent irrigation dry-up and minimize the economic and environmental impacts that can occur in surrounding communities and economies.

Financing for the feasibility study was provided by the Water Bank Work Group members (see list under Agency in text box above) and a $180,000 alternative agricultural water transfer method grant from the Colorado Water Conservation Board (see Case Study 9).

Outcome

During Phase 1 of the feasibility study, the Work Group quantified post-Compact water rights and potential water supply available to the water bank from pre-Compact agricultural rights. The timing and frequency of potential curtailments was evaluated, and several scenarios were considered to evaluate possible supply use combinations.

Study results indicated the maximum potential consumptive use reduction from fallowing of all irrigated lands with pre-Compact water rights is about

940,800 AFY. Assuming split season irrigation of alfalfa and grass pasture and by varying the level of participation and the level of reduced irrigation, up to 200,000 AFY from the water bank could be used. Current post-Compact consumptive use in Colorado is on the order of 1.2 million AFY (350,000 AFY of municipal and industrial use). The water bank could, therefore, not fully compensate for all potential Colorado River curtailments but could ensure a significant portion of critical post-Compact uses. A 25 to 50 percent participation rate would be required to meet significant east and west slope uses, likely entailing deficit irrigation or fallowing on 130,000 to 260,000 acres on the west slope.

Phase 2 of the study assessed the feasibility of deficit irrigation and fallowing for eight representative irrigation systems on the west slope of Colorado, and evaluated methods for measuring water savings. Phase IIB is performing a more detailed assessment of how a water bank could operate within three of these systems. It is also looking at the agronomic impacts of reduced irrigation and means to quantify water savings on the farm. Phase 3 will examine regional economic and environmental considerations.

Sources

- Colorado River Water Bank Feasibility Study, Phase 1. March 2012. Draft Report. Prepared for Colorado River Water Conservation District: http://www.crwcd.org/media/uploads/2012_Water_Bank_Phase1_Rept_draft.pdf

Case Study 12

Investigation of Drip Irrigation Consumptive Use

New Mexico Interstate Stream Commission, New Mexico

Agency
New Mexico Interstate Stream Commission

Project Status
Completed

Key Program Elements
- Study
- On-farm efficiency improvements

Budget
~$60,000

Water Savings
Not applicable

Overview

The New Mexico Interstate Stream Commission (ISC) has funded conversion from flood irrigation to drip irrigation in some locations to promote water conservation. However, in these areas, an increasing rate of decline in groundwater levels has been observed.

Description

To help quantify the broader effects of conversion to drip irrigation, the ISC commissioned a study to compare consumptive use on drip-irrigated fields with flood-irrigated fields.

Outcome

Results of the study suggest that consumptive use on drip-irrigated fields is greater than consumptive use on flood-irrigated fields by 8 to 16 percent. Yield was also observed to be greater on the drip-irrigated fields, but the increase in yield was not quantified.

While quantification of consumptive use was the primary goal of the study, some broader implications were explored. Considering that drip irrigation has a higher irrigation efficiency than flood irrigation (that is, a higher percentage of the applied water is consumed by crops), the net effect of switching to drip irrigation from flood irrigation appears to be that less water is applied to the fields, more water is consumed by the crops, and there is a greater yield.

However, water rights in New Mexico are administered based on diversion rates, not consumption rates. So, rather than resulting in less water being diverted, conversion to drip irrigation on existing farms has resulted in farmers increasing the number of annual plantings, often doubling or tripling the number of plantings each year. This means increased consumptive use of water, while maintaining the same legally prescribed diversion rates.

In addition, previously fallowed land is being returned to production, increasing diversions and further increasing consumptive use of water.

While the conversion to drip irrigation has resulted in increased yields and multiple cropping, the net effect has been an increase in the consumptive use of water and an accelerated decline of groundwater levels in the area. It is unclear at this time whether the accelerated groundwater decline is due to increased withdrawals from the aquifer to irrigate previously fallowed land and/or reduced recharge to the aquifer from more efficient irrigation.

The recommended next steps of the study are to investigate the nature and timing of how return flows recharge the aquifer to better assess the Basin-wide water budget implications of converting to drip irrigation from flood irrigation.

Sources

- Martinez, G., D. Jordan, A. Whittaker, and R. Allen. Remote-Sensing-Based Evaluation of Relative Consumptive Use Between Flood- and Drip-Irrigated Fields: http://nmawsa.org/ongoing-work/agricultural-water-use/impacts-of-drip-irrigation-abstract/view
- Remote-Sensing-Based Comparison of Water Consumption by Drip-Irrigated Versus Flood-Irrigated Fields. Deming, New Mexico. March 13, 2013. Final Report. Prepared for the New Mexico Interstate Stream Commission: http://nmawsa.org/ongoing-work/agricultural-water-use/comparison-of-water-consumption-by-drip-irrigated-versus-flood-irrigated-fields/view
- Jordan, D., G, Martinez, A. Whittaker, and R. Allen. Analysis of Relative Water Use Between Flood- and Drip-Irrigated Fields, Deming, New Mexico: http://nmawsa.org/meetings/01-14-2013-input-group-meeting/01-14-2013-intera-deming-et/view

Case Study 13

Ferron Project

Emery County, Utah

Overview

The Ferron Project serves to reduce Colorado River salinity loading through improved agricultural infrastructure and practices. Increasing water conveyance and application efficiency reduces deep percolation, limiting salt mobilization. Secondary benefits, which include increased yields and an extended irrigation season, have also helped project participants.

Description

The program consisted of the following:

- Two main pressurized 42-inch pipelines were installed to convey irrigation water stored in an existing reservoir.
- Six major laterals of pressurized pipe and three regulating ponds were constructed to deliver water to producers.
- About 175 miles of pipe were installed; pipes ranged in size from 2 to 42 inches.
- Approximately 10,000 acres of agricultural land was converted to use pressure sprinkler.

Funding for the Ferron Project came from the Bureau of Reclamation and the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program through the Colorado River Basin Salinity Control Program. Low interest loans from the Utah Board of Water Resources revolving loan funding program were used to meet cost-share requirements. The project cost is estimated to be approximately $20 million. Annual costs include annual loan repayments and maintenance.

The Ferron Canal and Reservoir Company formed a construction division and installed the project, reducing cost and increasing local "ownership." One hundred percent of the watershed producers participated in the project.

Outcome

The project reduces Colorado River salt loading by an estimated 40,000 tons per year. Additional benefits cited include water quality improvements, productivity increases, and community safety through removal of open ditches.

Water savings were not a goal and they were not quantified. However, anecdotal accounts tell of greater water availability between the local community and agriculture.

More efficient conveyance and application of water has allowed the irrigation season to be extended into the

Agency

Ferron Canal & Reservoir Co., San Rafael Soil Conservation District, Bureau of Reclamation, Natural Resources Conservation Service, Utah Board of Water Resources, Ferron City, Clawson Town, Emery County, Colorado River Basin Salinity Control Forum, Utah State University Extension Service, and the Utah Department of Agriculture and Food

Project Status

Completed 2006

Key Program Elements

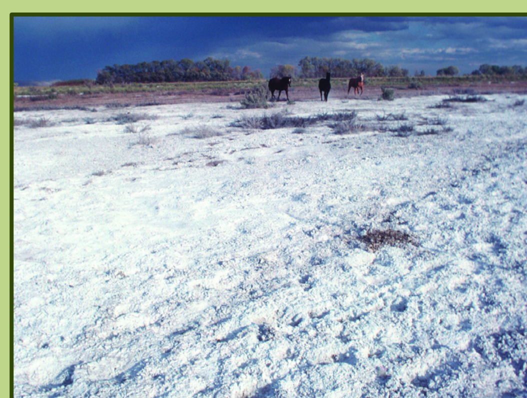
- Salinity control (primary)
- Conveyance improvements
- On-farm efficiency improvements

Budget

$20 million, plus additional annual loan repayments and maintenance

Water Savings

Not quantified; water savings was not a goal, but there are anecdotal reports of savings



Salinity challenges faced by landowners in Utah.
Photo courtesy of U.S. Department of Agriculture Natural Resources Conservation Service

fall. This extension results in a third crop for producers. Productivity increases were also noted due to increased cropable land per acre through the elimination of furrows. The net productivity increase is estimated to be an additional 2 to 3 tons per acre of hay or 30 percent with an additional improvement in crop quality.

NRCS expertise and outreach were used to address concerns related to program cost and sprinkler applicability to area crops. Example implementation in other agricultural communities with experience implementing these improvements was used.

Sources

- Eric Klotz/Utah Division of Water Resources, personal communication. March 25, 2014.

Case Study 14

Revolving Construction Loan Program

Utah

Overview

Section 73-10-1(7) of the Utah Code provides revolving funds to give technical and financial assistance to water users to achieve the highest beneficial use of water resources within the state. This financial assistance is provided by the Utah Board of Water Resources through three revolving loan funds: (1) the Revolving Construction Fund, (2) the Cities Water Loan Fund, and (3) the Conservation and Development Fund.

Funding is available for projects that conserve, protect, or more efficiently use present water supplies, develop new water, or provide flood control.

Description

Under the direction of the Board, the funding programs are administered through the Division of Water Resources (DWRe). The Board and DWRe plan for full use of water and power resources of the state. In the past 67 years, the Board and DWRe have been involved in the planning, design, construction, and financing of 1,406 water projects.

Since 1947, the Utah State Legislature has appropriated approximately $339 million for water development. The Board requires that the revolving loans be repaid, making funds available for subsequent loans. Using revolving funds, the Board has provided more than $743 million to water projects.

Outcome

The agricultural-based water development projects funded by the Board in both the Upper Colorado River and Lower Colorado River Basins have resulted in improved farmland efficiencies, increased farmland productivity and yields, improved water quality, and improved water conservation. The conserved water and improved efficiencies have resulted in an extended irrigation season and, therefore, increased yields. Water savings due to these projects has not been quantified.

Agency

Utah Board of Water Resources

Project Status

Ongoing, since 1947

Key Program Elements

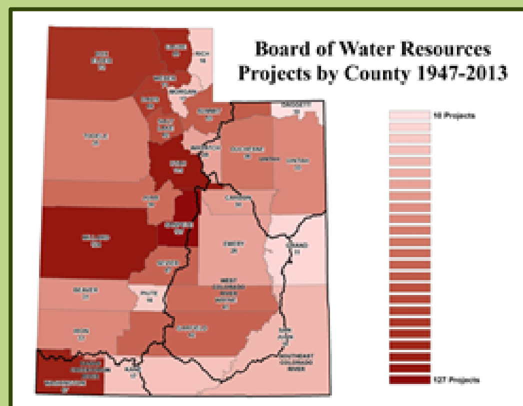
- Revolving loan fund supports various water conservation projects

Budget

$339 million appropriated; $743 million loans issued since 1947

Water Savings

Not quantified



Sources

- Eric Klotz/Utah Division of Water Resources, personal communication. March 25, 2014.

Case Study 15

West Fork of Battle Creek Reservoir

Carbon County, Wyoming

Overview

The Savery-Little Snake River Water Conservancy District desires to construct a new reservoir on the West Fork of Battle Creek in Carbon County, Wyoming, to provide a firm supply to agricultural producers within the District. The proposed reservoir will be filled with flows from Lost and Haggerty Creeks.

West Fork Battle Creek Reservoir will serve primarily as a supplemental irrigation supply, as well as provide environmental, recreational, and fishery benefits. The reservoir will have a total capacity of approximately 8,000 acre-feet, a portion of which will be used as a minimum pool for flat-water recreation.

Description

A total of $7 million has been budgeted for a study that will include preparation of final designs and initiation of the permitting process for the reservoir. The Wyoming Water Development Commission’s consultant is currently collecting water quality data for modeling of the proposed reservoir and downstream waterways. The consultant is also updating hydrology and exploring land acquisition opportunities with affected landowners, such as the U.S. Forest Service. Pending these efforts, final design, permitting, and related activities are anticipated to proceed.

Outcome

Current estimates of unmet demand (shortage) in the District are in the range of 5,000 acre-feet. With construction of the proposed West Fork Battle Creek Dam and Reservoir, the District will be able to better serve its members and address these shortages. The project will also provide storage water to areas that currently are not served by other District storage.

The project also includes measures that will abate copper concentrations, which currently exceed maximum contaminant levels in the drainage. The resulting improvement in water quality will encourage establishment of additional native fish habitat. Further, the dam will provide a barrier to non-native species that traditionally out-compete the native Colorado River cutthroat trout.

Agencies

Savery-Little Snake River Water Conservancy District, Wyoming Water Development Commission

Project Status

Proposed

Key Program Elements

- Storage improvements
- Ecological and recreational benefits

Budget

$7 million for design; construction to be determined

Water Savings

Storage and re-timing of runoff to meet unmet agricultural demands on the order of 5,000 acre-feet per year

Sources

- Dan Keppen and Pat O’Toole/Family Farm Alliance, personal communication. June 17, 2014.
- Wyoming Water Development Office Water News: http://wwdc.state.wy.us/newsletter/2013-1.pdf

Appendix 4C

Productivity, Hydrologic Conditions, and Consumptive Use

May 2015

4C | Productivity, Hydrologic Conditions, and Consumptive Use

The purpose of this appendix is to provide additional discussion of the interplay between productivity, hydrologic conditions, and consumptive use. Figure 4C-1 presents Upper Basin irrigated acres, consumptive use of Colorado River water, and agricultural productivity. With a 5-year moving average, the consumptive use and irrigated acres data are relatively constant through time, while the productivity data show an increasing trend. However, there is a short-term decrease in Upper Basin productivity from 2000 to 2004. This time period was noted as a historic drought and thus a reduction in productivity due to decreased water availability is not unexpected. In contrast, data for consumptive use of Colorado River water do not show a marked decline that might be expected as a result of drought conditions.

To ensure that the absence of a consumptive use decline during the period in question was not a result of the use of a 5-year average, Figures 4C-2 and 4C-3 show annual consumptive use and irrigated acreage. Year-to-year fluctuations in consumptive use of Colorado River water are relatively minor (average is approximately an 8 percent deviation from the 30-year average). Acreage data are also relatively constant. Further, productivity increases appear to be independent of acreage and consumptive use of Colorado River water.

In contrast, annual precipitation[1] and productivity correlate well with one another in the Upper Basin including, but not limited to, the period from 2000 to 2004 (Figures 4C-6 and 4C-5). Peaks in productivity in the late 1980s and late 1990s coincide with periods of high precipitation, whereas lows in productivity around 1990 and 2004 coincide with low precipitation periods. This suggests that in the Upper Basin, crop production relies on precipitation in addition to Colorado River water.

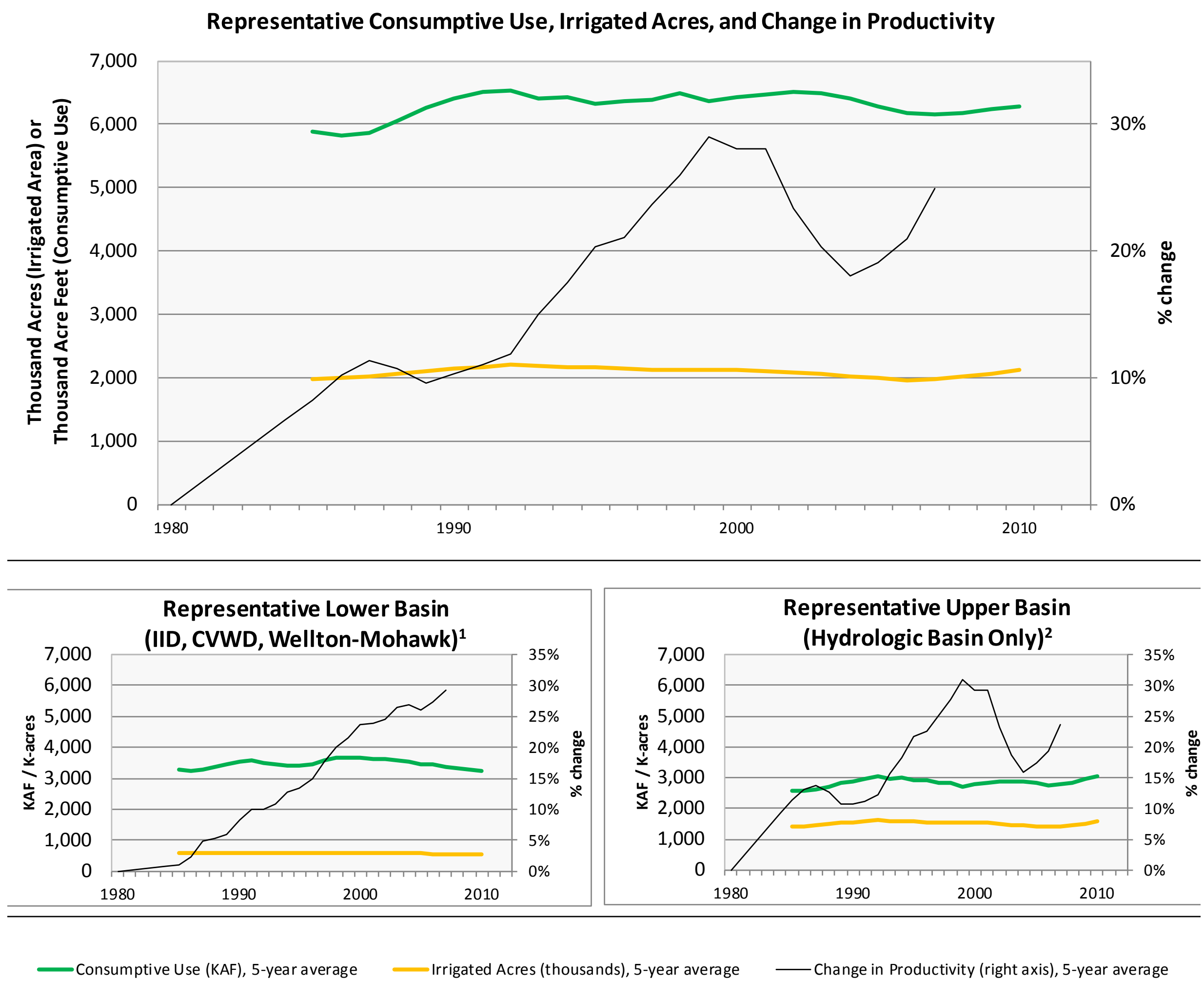
To further explore this relationship, a plot of Upper Basin irrigation season precipitation (April-August) is compared with productivity (Figure 4C-6). Precipitation during this time has the greatest impact on agricultural and water use. The magnitudes of productivity fluctuations during the late 1980s and early 2000s are consistent with their respective irrigation season precipitation anomalies. Given the apparent relationship between these two variables, Table 4C-1 estimates the significance of irrigation season precipitation in overall crop consumptive use, as detailed below.

During the irrigation season, precipitation in the Upper Basin is on average about 4.1 inches. If a consumptive factor of 75 percent is assumed for precipitation falling directly on fields, this would suggest that precipitation provides roughly 3.1 inches of consumptive use to crops in the Upper Basin. Furthermore, in the Upper Basin, consumptive use associated with irrigation averages 22.6 inches per irrigated acre. Thus, in the Upper Basin, annual consumptive use combined from direct precipitation and irrigation totals approximately 25.7 inches per acre. Therefore, consumptive use associated with direct precipitation is approximately 12 percent of the estimated total crop consumptive use. In contrast, for the Lower Basin, annual precipitation is about 4 percent of estimated total crop consumptive use and therefore has a less pronounced effect on productivity.

Given the drought in the early 2000s, it is anticipated that less Colorado River water would be available for diversion. However, Reclamation's Colorado River System Consumptive Uses and Losses Reports (CU&L Reports) suggest that on a 5-year average basis, a relatively constant supply was available for agricultural users. Note that some state-collected data sets differ from CU&L Reports, suggesting that Colorado River water was less available than in an "average" year. Regardless, during a drought, as shown, productivity in the Upper Basin could be expected to decline even if crops were receiving a typical supply of Colorado River water because overall crops are receiving and consuming less water due to the reduction in direct precipitation.

[1] Precipitation data presented are the average of the four Upper Basin meteorological stations used in Figure 4-3 of the main report.

FIGURE 4C-1
Acreage and Agricultural Consumptive Use of Colorado River Water Compared to Change in Productivity



These data do not reflect 100 percent of actual production and, as such, this plot can be considered generally representative, but not comprehensive.

[1] Lower Basin acres, consumptive use, and productivity presented for areas for which data was collected as part of this Study: Imperial Irrigation District, Coachella Valley Water District, and Wellton-Mohawk Irrigation and Drainage District. Those areas represent approximately 65 percent of the Lower Basin's agricultural consumptive use of Colorado River water.

[2] Upper Basin acres, agricultural consumptive use, and productivity presented for areas within the hydrologic basin, as compiled in CU&L Reports.

[3] Percent change in productivity is calculated as the weighted (acres) average of the percentage change in productivity per acre by individual crop (for example, Alfalfa acres*% change in Alfalfa tons/acre production + cotton acreage * % change in cotton lbs/acres production + …) / total acreage), from National Agricultural Statistics Service (NASS) survey data. Units of productivity depend on the crop type (such as tons or pounds). A 5-year rolling average was then computed. This procedure was completed for crops included in the NASS survey over time. Note that these data do not reflect 100 percent of actual production and, as such, this plot can be considered generally representative, but not comprehensive. In addition, data are by county, so do not align exactly with areas irrigated with Colorado River water.

FIGURE 4C-2
Change in Productivity and Agricultural Consumptive Use of Colorado River Water, Upper Basin Representative Area

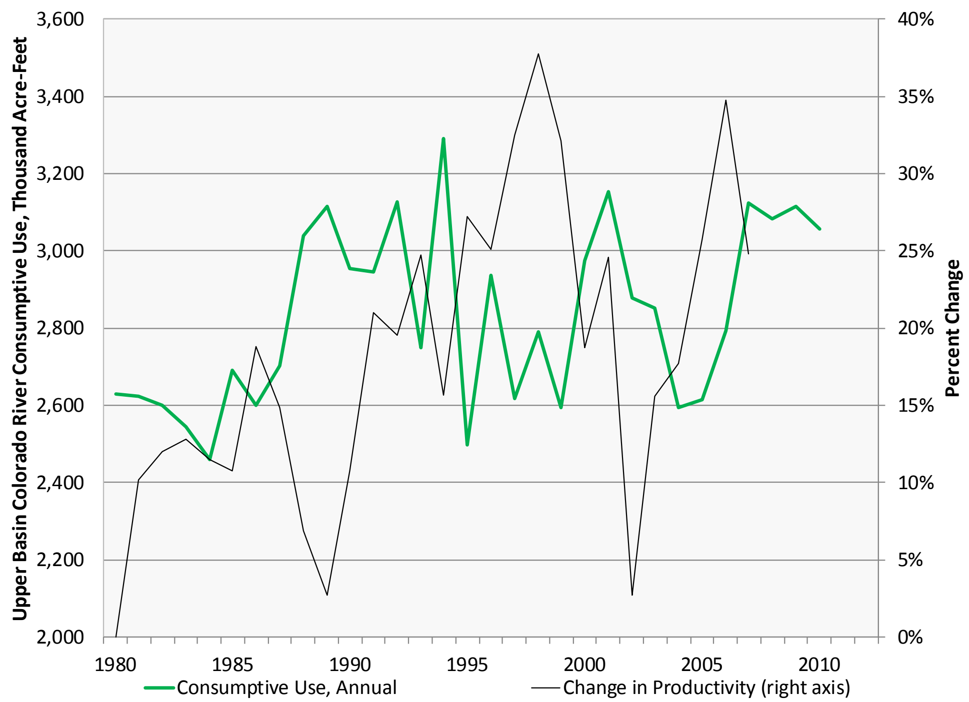


FIGURE 4C-3
Change in Productivity and Irrigated Acreage, Upper Basin Representative Area

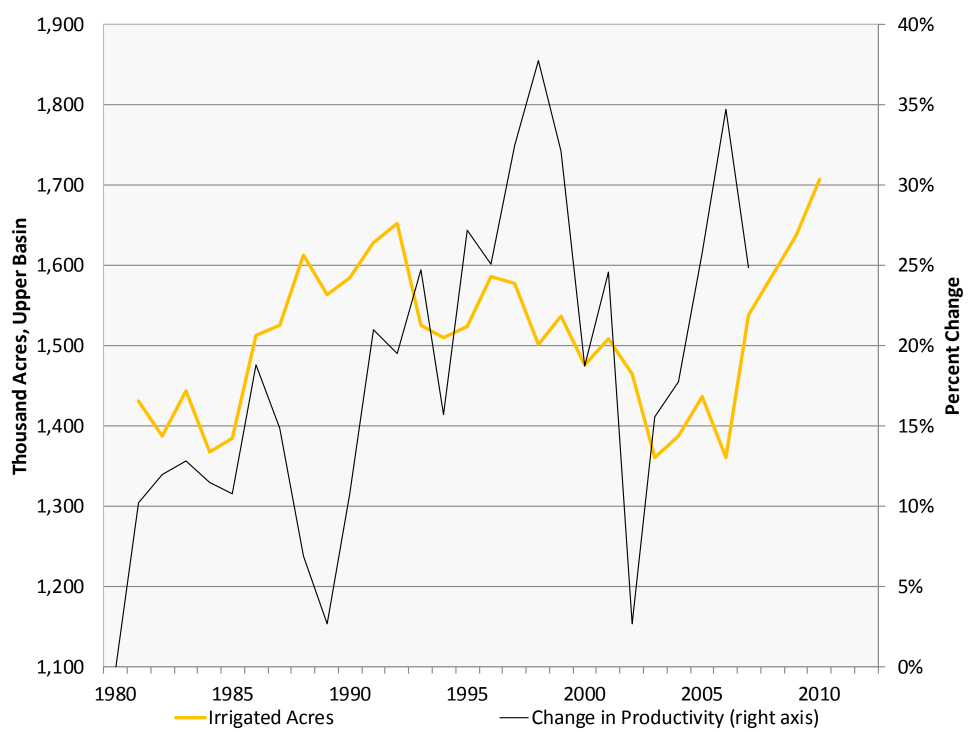


FIGURE 4C-4
Change in Productivity and Precipitation, Upper Basin Representative Area

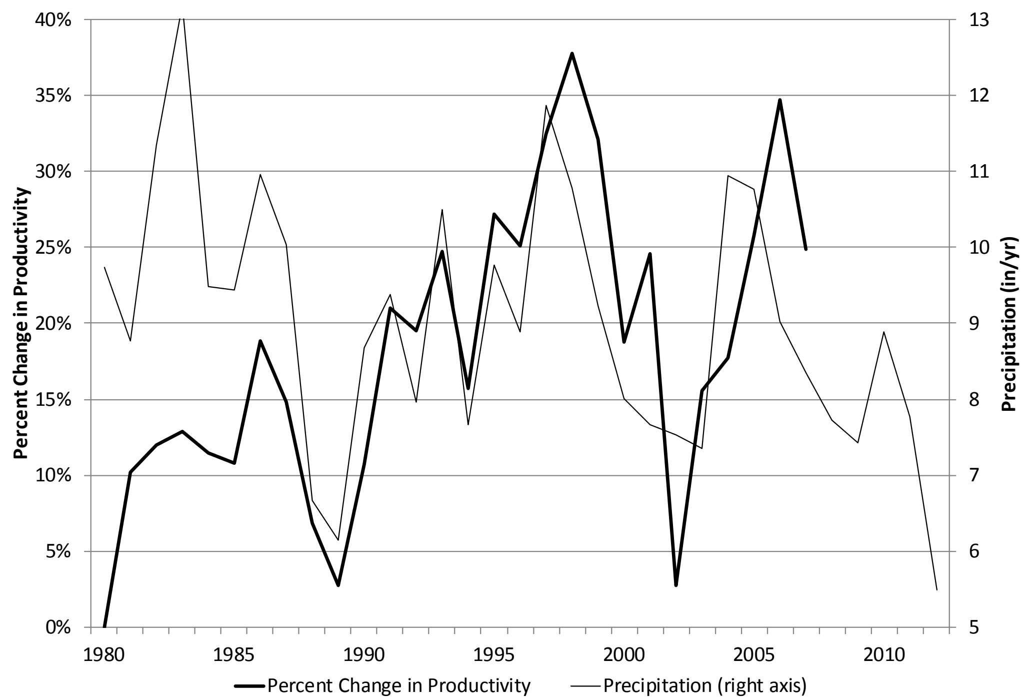


FIGURE 4C-5
Change in Productivity and Precipitation, 5-year Average, Upper Basin Representative Area

FIGURE 4C-6
Change in Productivity and Precipitation, Irrigation Season, 5-year Average, Upper Basin Representative Area

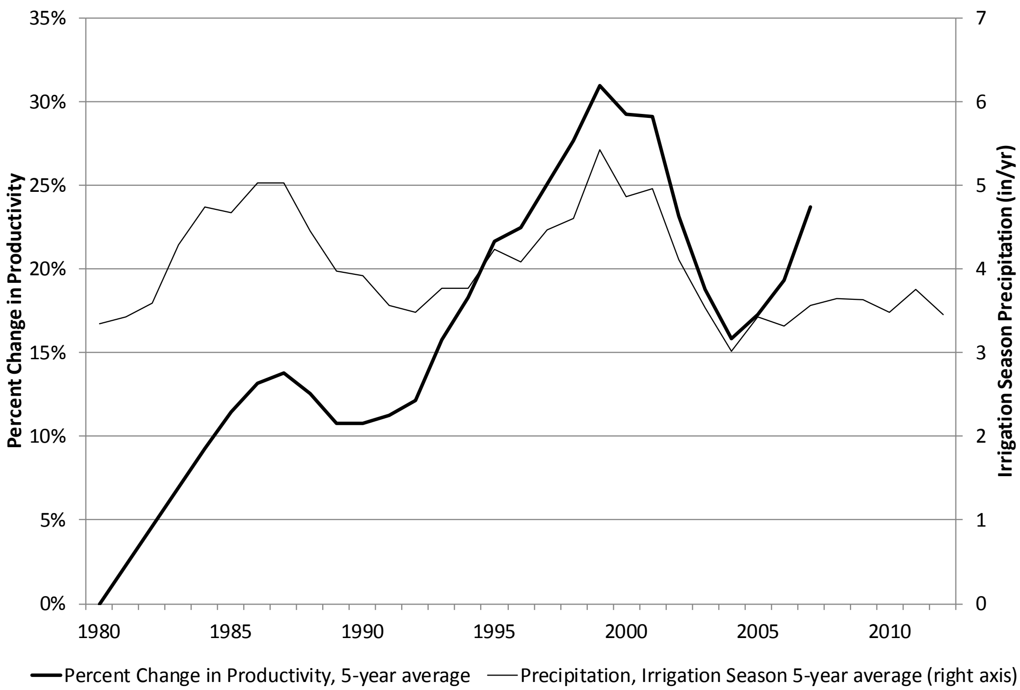


TABLE 4C-7
Contribution of Precipitation to Total Crop Consumptive Use

	Irrigation Season Precipitation[1] (in)	Consumptive Use			Consumptive Use of Precipitation, as Percent of Total Crop Consumptive Use
		Colorado River Water Consumptive Use (in)	Consumptive Use of Precipitation (in)[2]	Estimated Total Crop Consumptive Use (in)[3]	
Upper Basin Representative Area	4.1	22.6	3.1	25.7	12%
Lower Basin Representative Area	3.2	71.5	2.4	59.6	4%

[1] Average precipitation, 1980 to 2009, from meteorological stations shown on Figure 4-3 of the main report. Average of states used. Irrigation season defined as April through August in Upper Basin, and year-round in Lower Basin.
[2] Consumptive use assumed to be 75% of total precipitation.
[3] Consumptive use of precipitation, plus portion of Colorado River consumptive use assumed to be consumed by crops (100% in Upper Basin and Wellton-Mohawk Irrigation and Drainage District; 80% in Coachella Valley Water District and Imperial Irrigation District).

Appendix 4D

Historical Agricultural Water Conservation and Transfer Programs

May 2015

4D | Historical Agricultural Water Conservation and Transfer Programs

The Agricultural Water Conservation, Productivity, and Transfers Workgroup (Workgroup) recognized that existing conservation and operational programs, initiated either in the Colorado River Basin (Basin) or in other locations, include components that directly or indirectly benefit agricultural water conservation. To build upon these efforts and potentially expand these concepts, a list of programs was compiled for evaluating best practices and mechanisms based on the knowledge and experience of the Workgroup members. Tables 4D-1 through 4D-5 are not exhaustive lists, but they illustrate the types of programs and mechanisms previously implemented.

TABLE 4D-1
Historical Agricultural Water Conservation and Transfer Programs – Consumptive Use Reduction

State	Area	Year Initiated	Summary	Acres	Capital Cost[1] ($M)	Annual O&M Cost	Cost Share	Funding Support from Outside[2] Sources	Annual Water Savings (KAFY[3])	References[4]/ Notes	Unit Cost ($/AFY)[1]
AZ	Phoenix Active Manage-ment Area (AMA)	1989	Reduction in irrigated acreage has resulted in a decrease in consumptive use. Total agricultural deliveries decreased by 568,000 acre-feet per year (AFY) between 1989 and 2010, due in part to reduction in acreage and in part to implementation of best management practices.	–	–	–	–	–	–	–	–
AZ	Tucson AMA	1970s	The City of Tucson purchased significant farmlands in the 1970s for their water rights. Total agricultural water use declined by about 200,000 AFY in the late 1970s. A significant portion of this is assumed to be due to sale of water rights to Tucson.	–	–	–	–	–	–	–	–
AZ	Wellton-Mohawk Irrigation and Drainage District (WMIDD)	1974	Permanent fallowing. Funding provided by Salinity Control Act (Public Law 93-320).	10,000	–	–	Yes	$14M	40	–	–

TABLE 4D-1
Historical Agricultural Water Conservation and Transfer Programs – Consumptive Use Reduction

State	Area	Year Initiated	Summary	Acres	Capital Cost[1] ($M)	Annual O&M Cost	Cost Share	Funding Support from Outside[2] Sources	Annual Water Savings (KAFY[3])	References[4]/ Notes	Unit Cost ($/AFY)[1]
AZ	WMIDD	1980	Improved varieties of alfalfa, reducing consumptive use while maintaining yield.	25,000	$0	–	No	–	15	–	–
AZ	WMIDD	1988	Permanent fallowing. Funding provided pursuant to the Salt River-Pima-Maricopa Indian Community Water Rights Settlement Act (Public Law 100-512).	2,200	$9	–	Yes	–	8.8	–	$34
CA	Imperial Irrigation District (IID)	2003	Annual rotational fallowing program via the Quantification Settlement Agreement, Revised Fourth Amendment to Agreement between IID and San Diego County Water Authority for Transfer of Conserved Water and Inadvertent Overrun and Payback Policy. Varies each year. To be replaced by efficiency programs after 2017.	5,800-34,500	$50M socio-economic mitigation fund created	$125/AF	Yes	100%	Up to 200 through 2017	See case study; additional fallowing used for mitigation and payback purposes.	$60 to 175+
CA	Palo Verde Irrigation District (PVID)	2005	The Metropolitan Water District of Southern California (MWD)-PVID Forbearance and Fallowing Program. Land is fallowed, and water saved is forborne by PVID. Participants are compensated, and third-party impacts are addressed through a Community Improvement Program.	6,487 to 25,947	$82.8	$752/ acre in 2014	Yes	100%	33–122	See case study.	$138 to $178 based on an assumed range of future water savings and an assumed escalation of payments.

TABLE 4D-1
Historical Agricultural Water Conservation and Transfer Programs – Consumptive Use Reduction

State	Area	Year Initiated	Summary	Acres	Capital Cost[1] ($M)	Annual O&M Cost	Cost Share	Funding Support from Outside[2] Sources	Annual Water Savings (KAFY[3])	References[4]/ Notes	Unit Cost ($/AFY)[1]
CA	PVID	2008	Deficit irrigation sponsored by MWD.	34	–	~$200 to $400 per acre based on hay prices of $100 to $200 per ton	Yes	100%	~1.75 AFY/ acre	Operation and maintenance cost is due to reduced yield of about 2 tons/ acre, production cost savings, and reseeding costs. May 2010 Report: Deficit Irrigation of Alfalfa in the Palo Verde Valley, California.[5]	–
CO	Little Cimarron River Tributary to Gunnison	2008	Colorado Water Trust has purchased irrigated land and begun to irrigate only in the early season (one cutting). Water saved from additional cuttings remains as instream flow during the remainder of the season, generally starting in July.	177	$0.95	–	No	0%	~0.13	5.8 cubic feet per second can be donated during the late irrigation season to help meet a downstream instream flow right.	–

[1] Cost per acre-foot is generally calculated as follows: (capital cost/30 years + O&M)/AFY saved. However, individual programs may use different methods, and the costs shown may be from different years. Costs should not be viewed as directly comparable.
[2] Outside sources are entities not directly participating in the program; these would include federal, state, or other funds.
[3] Thousand acre-feet per year.
[4] All data are provided by Workgroup members through data collection template/process except where noted.
[5] Bali, K., University of California Cooperative Extension. 2010.

TABLE 4D-2
Historical Agricultural Water Conservation and Transfer Programs – Conveyance System Improvements

State	Area	Year Initiated	Summary	Acres	Capital Cost[1] ($M)	Annual O&M Cost	Cost Share	Funding Support from Outside[2] Sources	Annual Water Savings (KAFY)	References[3]/ Notes	Unit Cost ($/AFY)[4]
AZ	Central Arizona Project (CAP)	1987	Three programs have resulted in delivery losses consistently below 5.5% overall, with four districts that receive 77% of non-Indian CAP water reporting delivery losses of less than 3% in recent years. Programs include: (1) 1987 Base Program–water duties and annual allotments, (2) 1990-2000 Second Management Plan assigning a minimum irrigation efficiency and reduced water duties from Base Program, and (3) 2003 Third Management Plan–implementation of Best Management Practices.	207,497	$560	Included in capital cost	No	–	–	Acres reported represent the four largest irrigation districts served by CAP. These four districts receive 77% of non-Indian CAP water. Costs estimated based on unit costs applied to acreage.	–
AZ	Wellton-Mohawk Irrigation and Drainage District (WMIDD)	1951	372 miles of concrete-lined canals; 8 miles unlined.	–	$4.80	$1M	No	–	–	–	–
CA	Coachella Valley Water District (CVWD)	1980	Construction of a new concrete-lined canal to replace the initial 49-mile unlined section of the Coachella Canal.	–	$43.6	$300,000	Yes	$43.6M	132	Title 1 of Colorado River Basin Salinity Control Act.	–
CA	CVWD	2004	CVWD entered into an agreement with the U.S. and San Diego County Water Authority (SDCWA) for the construction of the 38-mile Coachella Canal Lining Project.	–	$124	$555,000	Yes	100%	30.85	See case study http://www.cvwd.org/news/newsarchive/2007_01_08_Canalliningdone.pdf.	$152

TABLE 4D-2
Historical Agricultural Water Conservation and Transfer Programs – Conveyance System Improvements

State	Area	Year Initiated	Summary	Acres	Capital Cost[1] ($M)	Annual O&M Cost	Cost Share	Funding Support from Outside[2] Sources	Annual Water Savings (KAFY)	References[3]/ Notes	Unit Cost ($/AFY)[4]
CA	CVWD	2012	Irrigation Lateral Automation Project. This project was partially (50%) funded by Reclamation through a water conservation grant. The federal cost share is $120,000.		$0.33	$5,000	Yes	50%	0.15	–	$106
CA	CVWD	1990	CVWD is committed to replacing aging irrigation infrastructure by replacing existing leaking irrigation laterals with polyvinyl chloride (PVC) pipelines. CVWD has also embarked on a Pilot Program to automate the turnouts to irrigation water customers.	–	$1.50	$16.5M	No	–	0.075	–	–
CA	Imperial Irrigation District (IID)	1990	Canal lining, reservoirs, lateral interceptors, non-leak gates, system automation, part of IID/Metropolitan Water District of Southern California (MWD) Conservation Agreements and amendments.	–	$108.2	$5.385M in 2014	Yes	100%	Volume con-served through 2006. After 2007, volume con-served up to 105 KAF.	See case study.	–
CA	IID	2008	System efficiency conservation program via the Quantification Settlement Agreement (QSA); ramps up through 2026.	–	TBD	TBD	Yes	100%	4-173+	Program ramps up to full implemen-tation in 2023.	TBD
CA	IID	2006	IID entered into an agreement with the U.S. and SDCWA for construction of the 23-mile All-American Canal Lining Project.	–	$304.5	$1.2M	Yes	100%, SDCWA and California Dept. of Water Resource s	67.7	Project completed in 2009.	$168

TABLE 4D-2
Historical Agricultural Water Conservation and Transfer Programs – Conveyance System Improvements

State	Area	Year Initiated	Summary	Acres	Capital Cost[1] ($M)	Annual O&M Cost	Cost Share	Funding Support from Outside[2] Sources	Annual Water Savings (KAFY)	References[3]/ Notes	Unit Cost ($/AFY)[4]
CA	IID	2009	Seepage Recovery Program via the QSA consists of intercepting canal seepage in drains and pumping back into the canals.	–	$7.29	$500,000	Yes	–	40	See case study.	$20-32
CO	Orchard Mesa Irrigation District	2014	Canal System Improvement Project consists of checking structures, regulating reservoir, and other improvements. Saved water is used to augment stream flows to aid in recovery of four endangered fish species.	–	$16.5	–	Yes	–	17	See case study.	$32
CO	San Miguel Tributary to Dolores River	2001	A cooperative partnership spearheaded by the Colorado Water Trust rehabilitated a diversion dam that historically dried up the river then spilled excess water downstream, now leaving water in the >1/2 mile reach.	–	–	–	Yes	–	–	Project included rehabilitation of diversion dam, construction of a low-flow channel in the river bed, and installation of a fish ladder.	–
WY	W. Fork of Battle Creek	In progress	The Savery-Little Snake River Water Conservancy District desires to construct a new reservoir to provide a firm supply to agricultural producers.	–	$7 design; construc -tion TBD.	–	–	–	–	See case study.	–
Multiple	Upper Basin Salinity Control Units Primarily	Salinity Control Act Passed 1974	Reclamation funds off-farm conveyance improvements as part of the Colorado River Salinity Control Program. Canal lining and pipe conversion reduce salinity loading by decreasing deep percolation that mobilizes salts.	–	Over $400 since 1988	–	Yes (30% of total cost)	–	Not quantified	$400M does not include cost share http://www.usbr.gov/uc/progact/salinity/	–

[1] Capital costs are specific to the year initiated or time reported. No effort was made to normalize costs to a single year.
[2] Outside sources are entities not directly participating in the program; these would include federal, state, or other funds.
[3] All data are provided by Workgroup members through data collection template/process except where noted.
[4] Cost per acre-foot is generally calculated as follows: (capital cost/30 years + O&M)/AFY saved. However, individual programs may use different methods, and the costs shown may be from different years. Costs should not be viewed as directly comparable.

TABLE 4D-3
Historical Agricultural Water Conservation and Transfer Programs – On-Farm Efficiency Improvements

State	Area	Year Initiated	Summary	Acres	Capital Cost[1] ($M)	Annual O&M Cost	Cost Share	Funding Support from Outside[2] Sources	Annual Water Savings (KAFY)	References[3]/ Notes	Unit Cost ($/AFY)[1]
AZ	Central Arizona Project (CAP)	1987	Three programs have resulted in irrigation efficiencies of greater than or equal to 80% for the four districts that receive 77% of non-Indian CAP water. See Table 4D-2 for listing of the three programs.	207,497	$198	Included in capital cost	No	–	–	Acres reported represent the four largest irrigation districts served by CAP. These four districts receive 77% of non-Indian CAP water. Costs estimated based on unit costs applied to acreage.	–
AZ	Wellton-Mohawk Irrigation and Drainage District (WMIDD)	1975	Irrigation system improvements: flood to level basin.	65,000	–	$15/acre	Yes	–	25–30	–	–
AZ	WMIDD	1975	Advanced irrigation scheduling and funding from Colorado River Basin Salinity Control Act.	60,000	–	–	Yes	–	10–15	–	–
CA	Coachella Valley Water District (CVWD)	2004	Advanced irrigation scheduling.	22,861	–	$430,000	No	0%	7	–	–

TABLE 4D-3
Historical Agricultural Water Conservation and Transfer Programs – On-Farm Efficiency Improvements

State	Area	Year Initiated	Summary	Acres	Capital Cost[1] ($M)	Annual O&M Cost	Cost Share	Funding Support from Outside[2] Sources	Annual Water Savings (KAFY)	References[3]/ Notes	Unit Cost ($/AFY)[1]
CA	CVWD	2007	Through a Water 2025 Challenge Grant, CVWD assisted with the conversion of 240 acres of farmland from furrow irrigation to sprinkler irrigation.	240	$0.85	–	Yes	–	0.36	–	–
CA	Imperial Irrigation District (IID)	1991	Tailwater pumpback systems and irrigation water management; part of IID/ Metropolitan Water District of Southern California (MWD) 1988 Conservation Agreement.	6,629 as of 1998	$4.15	$1,202,000 in 2014	Yes	100%	Amount conserved through 2006. From 2007, up to 3.5.	Final Program Construction Report http://www.iid.com /Modules/ShowDo cument.aspx?doc umentid=4060	–
CA	IID	2013	On-farm efficiency program via Quantification Settlement Agreement schedule.	–	$285/AF	Grower respon-sibility	yes	100%	17-130+	Full implementation in 2026 http://www.iid.com /index.aspx?page =600	$285
CO	Lower Colorado and Lower Gunnison	–	Through salinity and non-salinity Environmental Quality Incentives Program funding, Colorado has converted thousands of acres from flood to furrow/gated pipe (~80% efficiency) and sprinkler irrigation.	8,720	$0.95	–	–	–	–	–	–
Multiple	Upper Basin Salinity Control Units Primarily	Salinity Control Act Passed 1974	As part of the Colorado River Salinity Control Program, the Natural Resources Conservation Service (NRCS) funds on-farm efficiency projects that help manage salinity.	–	Over $300 since 1988	–	Yes (30% of total cost)	–	Not quantified; anecdotal evidence suggests water savings	$300M does not include cost share. http://www.usbr.g ov/uc/progact/sali nity/	–

[1] Cost per acre-foot is generally calculated as follows: (capital cost/30 years + O&M)/AFY saved. However, individual programs may use different methods, and the costs provided may be from different years. Costs should not be viewed as directly comparable.
[2] Outside sources are entities not directly participating in the program; these would include state, federal, or other funds.
[3] All data are provided by Workgroup members through the data collection template/process except where noted.

TABLE 4D-4
Historical Agricultural Water Conservation and Transfer Programs – Transfers, Exchanges, or Acquisitions[1]

State	Area	Year Initiated	Agreement	Transfer Amount (KAFY)	Transfer from, Water Use	Transfer to, Water Use	References[1]/Notes
AZ	Wellton- Mohawk Irrigation and Drainage District	1988		22	Ag	M&I	From fallowing program above.
CA	Imperial Irrigation District (IID) to the Metropolitan Water District of Southern California (MWD) to MWD	1990	1988 IID/MWD Conservation Agreement as amended; 1989 Approval Agreement, as amended; 1989 Agreement to Supplement Approval Agreement, as amended.	107	Ag	M&I	Water made available is from water conservation programs listed above. 107 KAFY is average amount of water made available 1998-2002.
CA	IID to MWD to Coachella Valley Water District (CVWD)	2003	1988 IID/Agreement Amendment, 1989 Approval Agreement Amendment.	20	Ag	Ag/M&I	Gives CVWD annual call rights on up to 20 KAF of the IID/MWD Conservation Agreement volume; extends term of the agreements to 2041 or 270 days after the termination of the Quantification Settlement Agreement (QSA), whichever is later.
CA	IID to MWD	2007	1988 IID/MWD Conservation Agreement Amendment.	Up to 85	Ag	M&I/Ag	Contractually fixes the annual variable volume at 103.5-105 KAF (less the volume that CVWD retains call rights to).
CA	IID to San Diego County Water Authority (SDCWA)	2003	1998 IID/SDCWA Agreement for Transfer of Conserved Water, as amended.	Up to 200	Ag	M&I	Term runs through 2047 with a mutual 30-year renewal option. Implementation ramps up through 2021 to 200 KAF; 100 KAF transferred in 2013.
CA	IID to CVWD	2003	2003 IID/CVWD Agreement for Acquisition of Conserved Water.	50–103	Ag	Ag/M&I	IID transfers 103 KAF from 2026 through 2047; MWD assumes 50 KAF of the transfer obligation starting in 2048. Implementation begins in 2008 and ramps up to 103 KAFY through 2026; 26 KAF transferred in 2013.
CA	IID to SDCWA, MWD, and San Luis Rey Settlement Parties	2006	2003 Allocation Agreement (All-American Canal Lining Project and Coachella Canal Lining Project).	96.2 in 2013	Ag	M&I	110 years; allocation of water for the benefit of the San Luis Rey Settlement Parties never terminates.
CA	Palo Verde Irrigation District (PVID) to MWD	2005	2004 PVID/MWD Forbearance and Fallowing Program Agreement and Landowner Agreements for Fallowing in PVID.	33 to 122	Ag	M&I	Water made available is from MWD-PVID Forbearance and Fallowing Program above.

[1] All data are provided by Workgroup members through the data collection template/process except where noted.

TABLE 4D-5
Historical Agriculture Conservation and Transfer Programs – Other / Multiple

State	Area	Year Initiated	Summary	Acres	Capital Cost[1] ($M)	Annual O&M Cost	Cost Share	Funding Support from Outside[2] Sources	Annual Water Savings (KAFY)	References[3]/ Notes	Unit Cost ($/AFY)[1]
CA	Imperial Irrigation District (IID)	1940	Other programs described in Tables 30 and 35 of the 2007 IID Water Conservation Plan.	Not quantified	Not quantified	Not quantified	No	No	143.25	http://www.iid.com/Modules/ShowDocument.aspx?documentid=4598	–
CA	IID	1990	12-Hour Delivery, part of IID/Metropolitan Water District of Southern California (MWD) 1988 Conservation Agreement.	–	$0.00	$4,360,000 in 2014 through Nov	No	–	Approx. 21,700 AFY (portion of 105)	Source: Final Program Construction Report http://www.iid.com/Modules/ShowDocument.aspx?documentid=4060	$201
UT	Ferron	2006	While fundamentally a salinity control project, this project included conveyance system improvements and on-farm irrigation system improvements (conversion to sprinkler).	Not quantified						See case study.	–
UT	Various	1947	Revolving Construction Loan program has been involved with over 1,400 water projects, resulting in improved farmland efficiencies, increased farmland productivity and yields, as well as improved water quality and water conservation.	Not quantified						See case study.	–

[1] Cost per acre-foot is generally calculated as follows: (capital cost/30 years + O&M)/AFY saved. However, individual programs may use different methods, and the costs shown may be from different years. Costs should not be viewed as directly comparable.
[2] Outside sources are entities not directly participating in the program; these would include federal, state, or other funds.
[3] All data are provided by Workgroup members through data collection template/process except where noted.

Appendix 4E

Sub-Team Activities

May 2015

4E | Sub-Team Activities

To facilitate a detailed discussion on key topics, four sub-teams were formed. The sub-teams explored conveyance system improvements, consumptive use reductions, on-farm efficiency improvements, and transfers. Each sub-team operated through a series of three to four calls. The first call allowed members to present topical example programs they were familiar with that were either particularly successful or provided lessons learned. Presenters were asked to convey any unique aspects of the example such as funding, timing, benefits, impacts, and legal considerations. The second call focused on developing the characteristics that are needed for a hypothetical successful program. The remaining calls examined challenges associated with implementation and potential opportunities to overcome said challenges.

Table 4E-1 lists the sub-team participants and call dates. Following the table are hypothetical programs associated with each sub-team. These were the results of the sub-team efforts.

TABLE 4E-1
Sub-Team Members and Meeting Dates

Sub-Team	Members	Call Dates
Conveyance System Improvements	Ken Nowak Angela Rashid Dan Charlton Dave Kanzer Grant Ward Greg Gates John Longworth Robert Cheng Russ Schnitzer	February 25, 2014 March 4, 2014 March 12, 2014 March 21, 2014
Consumptive Use Reduction	Reagan Waskom Chuck Cullom Dave Kanzer John Longworth Aaron Citron Dan Keppen Mohammed Mahmoud Angela Rashid Greg Gates	February 28, 2014 March 10, 2014 March 24, 2014
On-farm Efficiency Improvements	Reagan Waskom Tina Shields Dave Kanzer John Longworth Lee Miller Kate Greenberg Mohammed Mahmoud Angela Rashid Wade Noble Greg Gates	February 25, 2014 March 7, 2014 March 13, 2014
Transfers	Greg Gates Elston Grubaugh Aaron Derwingson John Longworth Dave Kanzer Jan Matusak Angela Rashid	February 26, 2014 March 7, 2014 March 17, 2014

4E.1 Conveyance System Improvements Sub-Team – Hypothetical Program Scoping

Improvements to water conveyance infrastructure have played a role in successfully meeting the growing demands for Colorado River water and show promise for building additional resilience. However, that potential depends on several considerations including, but not limited to, geographic location, desired outcome, involved parties, available funding, and general receptiveness. These major challenges associated with conveyance improvements can be explored from several perspectives, including a municipality seeking to bolster water supply for a growing population; an agricultural entity, such as a district or producer, interested in improving productivity and/or reducing operational costs; and a nongovernmental organization (NGO) intending to secure water for instream flow purposes. The hypotheticals below discuss the challenges from these different perspectives.

4E.1.1 Hypothetical Example 1 – Municipality Seeking Water for Growing Demands

Geographic considerations pose the greatest challenge for a municipality seeking to recover water from conveyance improvements by partnering with an agricultural entity. The two primary factors associated with geography are the potential for the improvements to yield salvageable water and the ability to transfer water savings to an area with growing demand.

A major concern associated with conveyance system improvements is that often limited water can be salvaged as a result of conveyance improvement projects. This is primarily an issue for projects within the hydrologic basin. By reducing transmission losses outside the hydrologic basin, a smaller diversion and subsequent export is required to deliver the same amount of water to growers, thereby keeping more water in the river, which could be repurposed. Accordingly, Southern California water districts have partnered to line considerable portions of canals serving agriculture outside the hydrologic basin. As a result, many of the most appealing opportunities have already been implemented.

Legal and accounting challenges can be significant. Legal considerations vary from state to state and limits on changing the timing, location, and beneficial use of diversions and subsequent return flows can render an otherwise appealing opportunity quite difficult. Closely tied to the legal considerations is the ability to accurately estimate the savings from the project and subsequently monitor/account for that salvaged water. Sufficient monitoring infrastructure is needed to evaluate a project's potential and upon completion, its performance.

Major Challenges Identified

1. Funding. Without ample funding for a program, participation will be limited.
2. Benefits. Within the hydrologic basin, conveyance improvements do not offer substantial "salvaged water."
3. Benefits. Legal hurdles exist to ensuring benefits accrue to the intended user/resource, such as instream benefits or water for a water bank.
4. Attitudes. It is difficult to change institutional practices, particularly in the Upper Basin where agriculture does not tend to be particularly water limited.
5. Environmental impacts. Because of its complexity, the National Environmental Policy Act (NEPA) process can be viewed as challenging.
6. Measurement/quantification of benefits. The salvaged water volume can be contentious.
7. Management and coordination. Particularly on large projects, with several entities involved, both construction and implementation management can be challenging.
8. Legal. While out of basin conveyance improvements offer a large potential benefit, the legal treatment of trans-basin water (for example, in Colorado) may reduce the appetite for participation in such a program.
9. Other limitations. In highly apportioned basins, such as the Arkansas, with a compact obligation, conveyance seepage and other "losses" may be heavily relied on (for example, groundwater pumping).

Potential Opportunities/Elements for Success

1. Project management and construction should be through a pre-agreed-upon framework.
2. Salvaged water and/or benefits should be well quantified and agreed upon by all parties in advance.
3. Where conveyance improvements may not yield significant salvaged water, these programs could serve as an incentive to participation in other programs (for example, a drought response rotational fallowing agreement).
4. Existing infrastructure may not be strategically designed or constructed. In making improvements, opportunities may exist to combine or improve conveyance networks, beyond simply lining or replacement with pipe.
5. Efforts to highlight benefits of conveyance improvements (for example, lower maintenance, improved efficiency, and productivity) can help to make others more receptive to programs.
6. Funding. The new farm bill (the Agricultural Act of 2014) allows districts to apply to the Environmental Quality Incentives Program (EQIP), whereas in the past, the program was limited to individual producers.
7. Funding. Additional incentives will ultimately make projects/programs more welcome (for example, Coachella Valley Water District [CVWD]) final canal lining was completed at no cost to the district).

4E.1.2 Hypothetical Example 2 – Agriculture Seeking to Improve Productivity and/or Reduce Operational Costs

By contrast, geography is not a major issue facing districts or growers wishing to improve their conveyance infrastructure. Funding and motivation tend to be larger hurdles in this case. Although benefits of conveyance improvements include increased reliability, reduced operational/maintenance costs, and higher productivity, this may not be sufficient motivation, particularly when coupled with available funding assistance.

Similar to the environmental considerations discussed earlier, improvements for within-district benefits are also likely to face environmental mitigation requirements for reduced seepage that had been supporting wetlands. These processes (for example, NEPA or the Endangered Species Act) can be cumbersome at times, further adding to project complexity. Mitigation in some form is often also required to ensure that canal/ditch lining or other activities do not adversely impact a downstream user's ability to divert and beneficially use water.

The planning and administration of a project likely comes with potential obstacles. While an "in-district" project likely has fewer layers of involved parties, most still require significant coordination. Challenges may arise with regard to planned improvements, specifically when they include changes to the existing paradigm (for example, the consolidation or moving of ditches/canals can be contentious among growers within a district). As noted, clear expectations and solid technical grounding at the onset of such an endeavor have been effective at mitigating these potential challenges.

Major Challenges Identified

1. Funding. Without ample program funding, participation will be limited.
2. Benefits. Within the hydrologic basin, conveyance improvements do not offer substantial salvaged water.
3. Benefits. There are legal hurdles to ensure benefits accrue to the intended user/resource (for example, instream benefits or water for water bank).
4. Attitudes. It is difficult to change institutional practices, particularly in the Upper Basin where agriculture does not tend to be particularly water limited.
5. Environmental impacts. The NEPA process can be viewed as a hindrance due to its involved nature.
6. Measurement/quantification of benefits. The salvaged water volume can be contentious.
7. Management and coordination. Particularly on large projects, with several entities involved, both construction and implementation management can be challenging.
8. Legal. While out of Basin conveyance improvements offer a large potential benefit, the legal treatment of trans-basin water (such as in

Colorado) may reduce the support for participation in such a program.

9. Other limitations. In highly apportioned basins, such as the Arkansas, with a compact obligation, conveyance seepage and other losses may be heavily relied on (such as for groundwater pumping).

Potential Opportunities/Elements for Success

1. Project management and construction should be through a pre-agreed-upon framework.
2. Salvaged water and/or benefits should be well quantified and agreed upon by all parties in advance.
3. Where conveyance improvements may not yield significant salvaged water, these programs could serve as an incentive to participation in other programs (for example, a drought response rotational fallowing agreement).
4. Existing infrastructure may not be strategically designed or constructed. In making improvements, opportunities may exist to combine or improve conveyance networks, beyond simply lining or replacement with pipe.
5. Efforts to highlight benefits of conveyance improvements (for example, lower maintenance and improved efficiency and productivity) can help to make others more receptive to programs.
6. Funding. The Agricultural Act of 2014 allows districts to apply to EQIP, whereas in the past, the program was limited to individual producers.
7. Funding. Additional incentives will ultimately make projects/programs more welcome. For example, CVWD final canal lining was completed at no cost to the district.

4E.1.3 Hypothetical Example 3 – Nongovernmental Organizations Seeking to Secure Water for Instream Purposes

Many NGOs are working in the Colorado River Basin whose interests may include securing water for environmental and or recreational purposes. Additionally, activities related to conveyance improvements can target other outcomes such as reduced fish entrainment through upgrades to infrastructure such as head gates. Most of the challenges facing an NGO are common with one or both of the previously discussed scenarios. However, some new challenges and nuances do exist.

Geographic considerations are certainly important if instream benefits are desired for a particular river reach. The ability to physically get water to the reach of interest is crucial to a project's success. Additionally, the same within and out of hydrologic basin considerations discussed earlier may have implications for securing instream flows. However, some legal/policy avenues have been suggested to address this challenge, particularly within the hydrologic basin. The basic premise is that if some activity were to reduce a within basin diversion need, seepage/return flows would be protected instream until reaching the downstream user with rights to beneficially use that water. This is not the case currently and serves to highlight another challenge, which is the protection of instream flows such that they reach and benefit the intended area. These types of legal hurdles are often one of the biggest challenges facing a potential program or project.

In addition to the challenges discussed above, funding is a major consideration in the scope and ability to develop such activities.

Major Challenges Identified

1. Funding. Without ample program funding, participation will be limited.
2. Benefits. Within the hydrologic basin, conveyance improvements do not offer substantial salvaged water.
3. Benefits. There are legal hurdles to ensure benefits accrue to the intended user/resource (for example, instream benefits or water for a water bank).
4. Attitudes. It is difficult to change institutional practices, particularly in the Upper Basin where agriculture does not tend to be particularly water limited.
5. Environmental impacts. The NEPA process can be viewed as a hindrance due to its involved nature.
6. Measurement/quantification of benefits. The salvaged water volume can be contentious.

7. Management and coordination. Particularly on large projects, with several entities involved, both construction and implementation management can be challenging.
8. Legal. While out of basin conveyance improvements offer a large potential benefit, the legal treatment of trans-basin water (for example, in Colorado) may reduce the appetite for participation in such a program.
9. Other limitations. In highly apportioned basins, such as the Arkansas, with a compact obligation, conveyance seepage and other losses may be heavily relied on (such as for groundwater pumping).

Potential Opportunities/Elements for Success

1. Project management and construction should be through a pre-agreed-upon framework.
2. Salvaged water and/or benefits should be well quantified and agreed upon by all parties in advance.
3. Where conveyance improvements may not yield significant salvaged water, these programs could serve as an incentive to participation in other programs (for example, a drought response rotational fallowing agreement).
4. Existing infrastructure may not be strategically designed or constructed. In making improvements, opportunities may exist to combine or improve conveyance networks, beyond simply lining or replacement with pipe.
5. Efforts to highlight benefits of conveyance improvements (for example, lower maintenance, improved efficiency, and productivity) can help to make others more receptive to programs.
6. Funding. The Agricultural Act of 2014 allows districts to apply to EQIP, whereas in the past, the program was limited to individual producers.
7. Funding. Additional incentives will ultimately make projects/programs more welcome. For example, CVWD final canal lining was completed at no cost to the district.

4E.2 Consumptive Use Reduction Sub-Team – Hypothetical Program Scoping

4E.2.1 Components of Hypothetical Example 1 – Deficit Irrigation

This example results in the development of a program that systematically encourages deficit irrigation through education and funding. This program intends to maximize sales per unit of water. Producers would enroll voluntarily and be compensated for loss of sales. The program would be widely distributed with limits on the number of participants in a given area. In addition, long-term crop and soil health would be considered.

The program would have good potential for quantifiable water savings, but baseline consumptive use needs to be quantified. Use of calculated potential crop evapotranspiration may lead to overestimation of saved water. Therefore, a method to assess actual evapotranspiration is required. Likewise, monitoring savings and yield over time as well as crop and soil health will be required. It is necessary to establish the variability or range of consumptive use values for a given scenario so that safety factors can be established to avoid overestimating savings.

Components of Hypothetical 1

1. Grass hay and alfalfa growers are diverting from the Colorado River.
2. Irrigation systems are predominantly gated pipe, siphon tubes, and corrugations, and a fair percentage are under overhead sprinkler on alfalfa; check dams with wild flooding and growing use of gated pipe on pasture.
3. Current irrigation efficiencies range from 35 to 70 percent.
4. Alfalfa growers will:
   - Irrigate for the first cutting only, then forego all irrigation for the remainder of the season.
   - Irrigate through the second cutting, then forego all irrigation for the remainder of the season.
5. Grass hay growers will irrigate for the first cutting only or once in the early season for grazed pasture,

then forego all irrigation for the remainder of the season, particularly at lower elevations.

6. There is potential to store saved consumptive use in reservoirs to re-time water to meet late-season needs or to directly lease saved water to meet other needs, including agriculture.

Major Challenges to Consider

1. Funding – what are the production economics and costs that must be included?
2. Producer time, interest, capacity – is deficit irrigation worth it for producers?
3. Impacts on productivity – how much yield is lost on average and during wet and dry years? Stressed crops are more susceptible to insect and disease pests.
4. Impacts on individual growers, including secondary field impacts (such as increased weeds), soil health, and salt accumulation.
5. Third-party and/or community impacts.
6. Environmental impacts – reduced leaching and runoff is positive; loss of wetlands may be negative.
7. Irrigation District impacts – district assessments must be maintained; operational issues for non-participating producers; "last man on the lateral."
8. Measurement/quantification of savings – issues with sub-irrigation; evapotranspiration from precipitation.
9. Persistence of consumptive use savings.
10. Legal and contractual.

Potential Opportunities/Elements for Success

1. Funding – examine impacts to producers in total net sales as well as potential third-party impacts.
2. Producer time, interest, capacity – provide educational programs and/or pilots to demonstrate process. Set incentives that are appropriate for both production loss and overall investment.
3. Impacts on productivity – include ongoing metering, measuring, and study of impacts so that the program can be adjusted over time to be sustainable.
4. Impacts on individual growers, including secondary field impacts (such as increased weeds), limit the number of growers that can participate in a given area to reduce local economic impacts. Include ongoing metering, measuring, and study of impacts so that the program can be adjusted over time to be sustainable.
5. Third-party and/or community impacts – include economic studies to estimate potential impacts. Set-up community funds as needed to mitigate impacts.
6. Environmental impacts – enact program in the context of the local system, considering potential positive and negative environmental impacts.
7. Irrigation District impacts – include economic studies to estimate potential impacts. Set up community funds as needed to mitigate impacts. Limit the number of growers who can participate in a given area to reduce local economic impacts.
8. Measurement/quantification of savings – issues with sub-irrigation; evapotranspiration from precipitation.
9. Persistence of consumptive use savings – include ongoing metering, measuring, and study of impacts so that the program can be adjusted over time to be sustainable.
10. Legal and contractual – examine specific local requirements and design programs within this framework.

Questions for Further Investigation

1. Practices along the full spectrum from regulated deficit irrigation to full season, temporary fallowing will likely need to be considered until many quantification, economic, and agronomic questions have been answered. Fallowing in the Upper Basin should also be explored. Can appropriate contractual forms be developed to provide certainty to all parties in a water bank or deficit irrigation/temporary fallowing water sharing program?
2. How can improvements in irrigation efficiency be connected to a water bank/fallowing/deficit irrigation program? That is, the challenge that individual participants create for water delivery at

the ditch company level could be addressed with more efficient conveyance and accounting.

3. What is the suite of agricultural best management practices that can reduce short- and long-term impacts associated with fallowing/deficit irrigation (for example, soil health, cover cropping, or minimum till)? How can these practices be used to maximize soil health and improve long-term agricultural viability?

4E.2.2 Components of Hypothetical Example 2 – Fallowing

This example results in the development of a program that systematically encourages temporary fallowing through education and funding. This program intends to consistently and effectively reduce overall water use while minimizing impacts to individual producers and communities. Producers would enroll voluntarily and be compensated for loss of sales. The program would be widely distributed with limits on the number of participants in a given area.

The program would have good potential for quantifiable water savings, but baseline consumptive use must be quantified. Because the use of calculated potential crop evapotranspiration may lead to overestimation of saved water, a method to assess actual evapotranspiration is required. Likewise, monitoring savings, yield over time, and crop and soil health will be required. It is necessary to establish the variability or range of consumptive use numbers for a given scenario so that safety factors can be established to avoid overestimating savings.

The return flow issue must be evaluated, and carriage losses must also be considered. Savings may not be 1 for 1; that is, 25 percent land fallowed may not yield 25 percent of consumptively used water. All lands are not equally productive, and farmers tend to set aside their least productive lands.

Weed and pest management, soil erosion, and dust management on fallowed lands must be considered. District assessments must be maintained to protect district interests and capacity. Regular maintenance of best management practices is critical to success.

Components of Hypothetical 2

1. Crop rotation includes field crops, vegetables, and perennial crops.
2. Irrigation system is predominantly gated pipe and level basins.
3. Current irrigation efficiencies range from 50 to 65 percent.
4. Twenty-five percent of irrigated lands within the district will be left idle for the entire year (either entire fields or some fraction thereof).
5. Crops may be produced on fallowed fields in subsequent years.
6. Saved consumptive use will be available for other uses, including agriculture.

Major Challenges to Consider

1. Program funding
2. Impacts on productivity – yield and economics must be evaluated; production after fallowing.
3. Impacts on individual growers.
4. Third-party and/or community impacts – Public perception is paramount. The politics can change during a conservation program.
5. Environmental impacts.
6. Irrigation District impacts.
7. Measurement/quantification of benefits.
8. Persistence of consumptive use savings.
9. Legal.

Potential Opportunities/Elements for Success

1. Funding – examine impacts to producers in total net sales as well as potential third-party impacts.
2. Impacts on productivity – include ongoing metering, measuring, and study of impacts so that the program can be adjusted over time to be sustainable.
3. Impacts on individual growers, including secondary field impacts (such as increased weeds), limit the number of growers that can participate in a given area to reduce local economic impacts. Include ongoing metering, measuring, and study of impacts so that the program can be adjusted over time to be sustainable. Provide tools and education for enacting best management practices to control weeds, pests, and dust.

4. Third-party and/or community impacts – include economic studies to estimate potential impacts. Set up community funds as needed to mitigate impacts. Provide public education so that impacts and mitigation are fully understood.
5. Environmental impacts – enact program in the context of the local system, considering potential positive and negative environmental impacts.
6. Irrigation District impacts – include economic studies to estimate potential impacts. Set up community funds as needed to mitigate impacts. Limit the number of growers who can participate in a given area to reduce local economic impacts.
7. Measurement/quantification of savings – issues with sub-irrigation; evapotranspiration from precipitation.
8. Persistence of consumptive use savings includes ongoing metering, measuring, and study of impacts so that the program can be adjusted over time to be sustainable.
9. Legal and contractual – examine specific local requirements and design programs within this framework.

Questions for Further Investigation

1. Have we evaluated all relevant scientific studies related to fallowing?
2. What are the positives and negatives in terms of socioeconomic impacts?
3. What is the business deal that works for farmers, holistically considering not just sales, but soil and crop health, long-term sustainability, and broader socioeconomic impacts?

4E.3 On-Farm Efficiency Improvements Sub-Team – Hypothetical Program Scoping

This example involves completing on-farm efficiency increases primarily through changes in irrigation methods to a farm in the Upper Basin. For farms in the hydrologic basin, it is likely that no transferable water savings will occur. However, if diversions are reduced, benefits associated with efficiencies could arise, such as increased production, improved environmental flows, and improved water quality. If water is scheduled for delivery from a reservoir or if the farm is outside of the hydrologic basin, there may be opportunities for moving the water to other users or storing the water for future use.

All practices will have costs including increased management and labor in the case of irrigation scheduling and monitoring. Cost sharing is important to producer adoption and buy-in. Any savings must be monitored and verified over time to ensure savings are maintained.

4E.3.1 Components of Hypothetical Example 1

1. Ditch company in the Upper Basin is diverting water from a tributary to the Colorado River.
2. Crop rotation primarily includes alfalfa, field corn, grass pasture, and spring grains.
3. Irrigation systems are predominantly siphon tubes and furrows on row crops, corrugations and tubes on alfalfa, and check dams with wild flooding on pasture.
4. Current irrigation efficiencies range from 30 to 60 percent.
5. On-farm efficiency improvements include converting to sprinkler and drip irrigation, irrigation scheduling using soil moisture monitoring and evapotranspiration data, installing pressurized pipe, and land leveling.
6. Crop consumptive use will not be reduced under these examples, but irrigation efficiencies will increase from 60 to 85 percent. In fields where irrigation uniformity is significantly improved, it is likely that crop consumptive use will increase.

Major Challenges Will Be Case-Specific, but Generally:

1. Funding support for practices will likely be needed. EQIP and other programs needed.
2. Producer time, interest, and capacity may be challenged initially to upgrade irrigation systems.
3. Impacts on productivity should be positive as greater uniformity and reduced leaching occur. Soil health may be improved.

4. Impacts on individual growers should be positive because improved irrigation systems may result in labor savings and more flexibility.
5. Environmental impacts should be positive in cases where leaching and surface runoff are reduced; however, irrigation-created wetlands may be lost or diminished.
6. Irrigation District operations may be impacted by reduced return flows.
7. Measurement/quantification of benefits is a significant challenge that must be addressed.
8. Persistence of water savings created by increased efficiency is likely where systems are upgraded but could slip where based on improved management such as for irrigation scheduling.
9. Legal barriers include lack of clarity in state laws about short- or long-term transferability of water saved through efficiency.

Potential Opportunities/Elements for Success

Producers can benefit if economic incentives are in place to fund or reward practices – labor savings, improved productivity, and potential for extending water later in the season. It is not clear that there are many situations where transferable water will be obtained through increased irrigation efficiency, but reduced diversion and subsequent environmental or recreational flows are a possibility.

Questions for Further Investigation

1. What are the optimal governance arrangements at the local, state, and federal levels to incentivize increased irrigation efficiencies to produce measurable savings?
2. What are the costs and benefits of efficiency measures?
3. What are the best methods to achieve producer adoption of practices?
4. How are efficiency programs targeted to get the most bang for the buck?

4E.3.2 Components of Hypothetical Example 2

This example involves completing on-farm efficiency increases, primarily through changes in irrigation methods to a farm in the Lower Basin. For farms in the hydrologic basin, it is likely that no transferable water savings will occur. However, if diversions are reduced, benefits associated with efficiencies could arise, such as increased production, improved environmental flows, and improved water quality. If water is scheduled for delivery from a reservoir or if the farm is outside of the hydrologic basin, there may be opportunities for moving the water to other users.

Water can be saved but in some cases difficult to transfer out of the system. Outcomes will depend on the individual system/district; many Lower Basin farms have already installed many of these practices and the efficiency savings have been achieved. Many of these practices were installed to achieve crop timing and quality demanded by market. While some areas of the Lower Basin operate efficiently, in other cases mitigation for sandy soils cannot occur where efficiencies are lower. Salinity management must be maintained.

1. Irrigation District in Lower Basin is diverting from the Colorado River.
2. Crop rotation includes alfalfa, field corn, cotton, vegetable crops, and spring grains.
3. Irrigation system is predominantly gated pipe and level basins.
4. Current irrigation efficiencies range from 50 to 65 percent.
5. On-farm efficiency improvements include conversion of surface irrigation to pressurized sprinkler and drip irrigation, irrigation scheduling with soil moisture monitoring and evapotranspiration data, improving surface irrigation through tail water recovery, land leveling, and field reconfiguring to enhance application efficiency and uniformity.
6. Irrigation efficiencies will be increased from 75 to 85 percent through these measures but crop consumptive use will not be reduced.

Major Challenges

1. Funding
2. Producer time, interest, and capacity
3. Impacts on productivity
4. Impacts on individual growers
5. Environmental impacts

6. Irrigation District impacts
7. Measurement/quantification of benefits
8. Persistence of savings
9. Legal

Potential Opportunities/Elements for Success

Producers who have not already maximized efficiency can benefit if economic incentives are in place to fund or reward practices; these incentives could include labor savings, improved productivity, and potential for extending water later in the season. Legal consideration associated with any potential transfer of saved water is critical to program success.

Questions for Further Investigation

1. Uniform standards for determining efficiency on various farms and systems are needed.
2. Details on what saved water can be transferred under what situations.

4E.4 Transfers Sub-Team – Hypothetical Program Scoping

4E.4.1 Hypothetical Example 1

This example involves a community-run water bank on a local and/or regional scale (that is, not basin-wide). In exchange for compensation, farmers voluntarily and temporarily transfer water into a water bank for use by any local entity, such as agricultural users, municipal and industrial, and environmental. Funds from water purchases are managed by the community and invested back into the community to offset the economic impacts from the reduction of agriculture. A community fund based on an economic analysis would likely be required to start a community program.

Components of Hypothetical Example 1 (Local and/or Regional Scale)

1. Compensation is provided to farmers who voluntary allow their land to remain fallow to free up water for other uses within the region.
2. Economic studies are developed to help estimate appropriate compensation.
3. Niche crops such as intermediate crops in rotations are targeted.
4. Other water users may temporarily forego water usage in exchange for same payment.
5. Water rights are not permanently transferred.
6. Water is potentially stored as non-system water to allow for re-timing of deliveries or long-term reserve for drought use.
7. Transfers are recipient neutral. Anyone may purchase water from the bank. Combined with source-neutrality, this set-up facilitates many types of transfers: agriculture to urban, agriculture to agriculture, agriculture to environment, urban to agriculture, and urban to environment.
8. Water purchases are limited to local or regional entities.
9. Community fund is set up. The agricultural community would be directly involved in decisions on how to spend money. Money in excess of that paid to farmers or other depositors to the bank would be reserved for job creation and community development programs to offset the effects of reduction of agriculture in basin.

Major Challenges/Solutions Will Be Case-Specific, but in General:

1. Reliability of Supply – If transfer to urban, reliability of supply may be an issue due to the voluntary and temporary nature of transfers.
2. Education/community involvement – All parties need to understand the impacts as well as the costs and benefits (for example, not viewing agriculture as a "reservoir" or recognizing limitations). Urban stakeholders need to understand the local and/or regional impact of transfers to the agricultural community, including secondary and tertiary effects (for example, car dealerships, implement dealers, and economy of area).
3. Governance – Operations and effectiveness are impeded when too many stakeholders are engaged in decision making.
4. Economics – Recognizing the potential impact to communities, examining economic impacts, and designing an appropriate community/economic development fund.

Potential Opportunities/Elements for Success

1. Reliability of Supply – Look at long-term programs but limit calls to individual farmers. Depending on community acceptance and legal issues, consider permanent transfers.
2. Education/community involvement – Provide framework for community input and involvement.
3. Governance – Streamline organization; define oversight but have one agency and/or group in charge of day-to-day decision making.
4. Economics – Advance economic studies and/or model after existing community programs to estimate appropriate funding or programs.

Questions for Further Investigation

1. Best management practices for governance
2. Components of education program
3. Scope and scale of economic studies
4. Catalog of local/regional legal requirements

4E.4.2 Hypothetical Example 2

In this example, federal funding and matching local funds are used to compensate farmers who volunteer to temporarily transfer saved water without giving up water rights. Land is fallowed on a rotating basis, with multiple parties involved, allowing for a new long-term urban supply and a supplemental supply that could be purchased on an annual basis by any water user.

Components of Hypothetical Example 2 (Basin Scale)

1. A regional program for transferring water from agricultural areas to urban areas is established.
2. Federal pilot program is started and expanded where successful. Historically the federal government has brought together potential funding partners.
3. Open offers to exchange a defined amount of money for a defined quantity of transferred water are allowed.
4. Funding could be split 50-50 between federal funds and water recipients.
5. A basin-scale framework is set up for local and regional transfers and for system water savings.
6. Water generated is considered "system water" not targeted for a specific entity.
7. The U.S. Department of Agriculture could be a primary partner and advise on which crops are in surplus and which crops are in short supply. Focus on the surplus crops.
8. Regional committees set up to consider broader economic impacts of shifting water to urban areas.
9. Long-term supply is created for interested urban areas.

Major Challenges to Consider

1. Legal – Legal frameworks vary throughout the basin area.
2. Reliability of Supply – If transfer to urban, reliability of supply may be an issue. Can a basin-wide program facilitate local/regional transfers?
3. Education/community involvement – All parties need to understand the impacts as well as the costs and benefits (for example, not viewing agriculture as a "reservoir" or recognizing limitations).
4. Governance – Operations and effectiveness are impeded when too many stakeholders are engaged in decision making. Federal program may have additional limitations, such as NEPA or cost share.
5. Economics – Recognizing the potential impact to communities, examining economic impacts, and designing an appropriate community/economic development fund.

Potential Opportunities/Elements for Success

1. Legal – Develop a large-scale flexible program to accommodate regional differences.
2. Reliability of Supply – Look at long-term programs but limit calls to individual farmers (for example, rotate participation so as to not encourage permanent dry up). Depending on community acceptance and legal issues, consider permanent transfers.
3. Education/community involvement – Provide framework for community input and involvement. Possibly fund basin-wide education program.
4. Governance – Streamline organization; define oversight but have one agency and/or group in charge of day-to-day decision making. Develop federal program to allow for day-to-day decision making.

5. Economics – Advance economic studies and/or model after existing community programs to estimate appropriate funding or programs.

Questions for Further Investigation

1. Federal or basin-wide pilot program
2. Economic studies
3. Catalog of local/regional legal requirements

Chapter 5
Environmental and Recreational Flows

This chapter is a product of the Environmental and Recreational Flows Workgroup

May 2015

Cover photo source: Taylor Hawes

Disclaimer

The Basin Study Disclaimer, published December 2012, is incorporated by reference herein. Nothing in this disclaimer alters the Basin Study Disclaimer, which remains in full force and effect. All work products (draft and final) of the Environmental and Recreational Flows Workgroup (Workgroup) are therefore subject to the Basin Study Disclaimer and the following:

(1) With respect to the Basin Study, the Basin Study Coordination Team, which directs and reviews the efforts of the workgroups relating to Phase 1, including the Workgroup, shall have sole and exclusive discretion regarding how and whether to use any and all work products submitted by the Workgroup.

(2) The Workgroup has no force of law and no legal authority to establish statutory, regulatory, and/or administrative requirements regarding environmental, recreational, and/or hydropower flows.

(3) Workgroup work products are not intended to reflect, nor shall be evidence of, any of the Workgroup participants' interpretation of legal and/or administrative requirements on the use of Colorado River Basin water.

5 Environmental and Recreational Flows

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Acronyms and Abbreviations

Basin States	Colorado River Basin States
Basin Study	Colorado River Basin Water Supply and Demand Study
BLM	Bureau of Land Management
BWRCSC	Bill Williams River Corridor Steering Committee
cfs	cubic feet per second
CRSP	Colorado River Storage Project
CRSS	Colorado River Simulation System
EQIP	Environmental Quality Incentives Program
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
GCDAMP	Glen Canyon Dam Adaptive Management Program
ICS	Intentionally Created Surplus
kWh	kilowatt-hour
M&I	municipal and industrial
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
MW	megawatt
NFRIA	North Fork River Improvement Association
NGO	non-governmental organization
NPS	National Park Service
NRCS	Natural Resources Conservation Service
Reclamation	Bureau of Reclamation
Recovery Program	Upper Colorado River Endangered Fish Recovery Program
SJRRIP	San Juan River Basin Recovery Implementation Program
TNC	The Nature Conservancy
U.S.	United States
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
Workgroup	Environmental and Recreational Flows Workgroup
WRCC	Western Regional Climate Center

This chapter is a product of the Environmental and Recreational Flows Workgroup.

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5 Environmental and Recreational Flows

5.1 Introduction

The Colorado River Basin Water Supply and Demand Study (Basin Study) confirmed that, in the absence of timely action, there are likely to be significant shortfalls between projected water supplies and demands in the Basin in coming decades (Bureau of Reclamation [Reclamation], 2012a). Such future action will require diligent planning, collaboration, and the need to apply a variety of ideas at local, state, regional, and Basin-wide levels. In May 2013, Phase 1 of the *Moving Forward* effort was initiated to build on findings for critical next investigations described in the Basin Study and to do so in a manner that continues to facilitate and build upon the broad, inclusive stakeholder process demonstrated in the Basin Study.

The Environmental and Recreational Flows Workgroup (Workgroup) was convened as part of the *Moving Forward* effort initiated by Reclamation and the seven Colorado River Basin States[1] (Basin States) in collaboration with the Ten Tribes Partnership and conservation organizations. The Workgroup was formed to promote stakeholder dialogue to identify and assess options that provide multiple ecological, recreational, and hydropower generation benefits.

The Workgroup is composed of leaders and experts in the area of environmental and recreational flows who represent a broad range of perspectives. The primary objective of the Environmental and Recreational Flows Workgroup was to build upon the Basin Study's assessment of environmental and recreational flows to identify ideas for potential future voluntary, non-regulatory solutions that protect or improve ecological and recreational resources[2] while supporting other management goals to achieve integrated solutions that benefit multiple uses, both consumptive and non-consumptive, including hydropower.

This chapter is a product of the Workgroup and documents its activities and findings during the approximately 18-month Phase 1 of the *Moving Forward* effort. The chapter provides information on the Workgroup's structure, objective, and approach to achieving the objective, which includes the following tasks: the selection of focus reaches and an assessment of current conditions on those reaches, opportunities and challenges for implementing successful environmental and recreational flow programs, and a suite of ideas that may be considered for potential future action.

5.2 Background on Environmental and Recreational Flows Considered in the Basin Study

The Basin Study incorporated flow and water-dependent ecological systems, recreation, and hydropower generation through the inclusion of the Enhanced Environment water demand scenario, the adoption of system reliability metrics resources across scenarios, and the modeling of a conceptual Upper Basin water bank. Each of these approaches is described below.

A scenario planning approach was used in the Basin Study to examine uncertainties surrounding future water demand in the Colorado River Basin (Basin). The six water demand scenarios selected for evaluation in the Basin Study represented alternative views of how the future might unfold. The scenarios were used to quantify the potential effects of driving forces, for example, changes in population, social values, land use, and agricultural and municipal efficiencies, on consumptive demands. Non-consumptive demands, such as environmental and recreational flows, did not affect the total consumptive demand in any scenario; however, these demands were assessed across all scenarios through the evaluation of flow targets, characterized through ecological and recreational system reliability metrics.

[1] Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming

[2] Ecological and recreational resources include flows, water quality, temperature, etc. (see Guiding Principles). Flows are but one tool available that can be used to protect or improve ecological and recreational resources.

The demand scenarios evaluated in the Basin Study ranged from a Slow Growth scenario with the lowest population growth and highest agricultural demand to a Rapid Growth scenario with the highest population growth and lowest agricultural demand. The Enhanced Environment scenario assumed, in part, that changing social values would affect future water demand. This demand scenario had a lower consumptive demand than most other demand scenarios due to the assumption that changing social values led to faster adoption of municipal and industrial (M&I) conservation measures under the baseline, that is, without any options and strategies in place. Further details regarding the demand scenarios are available in the Basin Study, *Technical Report C* (Reclamation, 2012b).

In the Basin Study, system reliability metrics were defined as measures that indicated the ability of the Colorado River system to meet Basin resource needs under future conditions. System reliability metrics were developed for the Basin Study to measure, both quantitatively and qualitatively, the potential effects of current and future water supply and demand imbalances on Basin resources and to evaluate the effectiveness of options and strategies to resolve those imbalances. The metrics that approximated the flow-based conditions necessary to support ecological and recreational resources were developed for the Basin Study to facilitate an understanding of how varying hydrologic conditions may affect ecological and recreational resources under a range of future conditions. The ability to assess impacts to Basin resources was limited by the spatial and temporal details of Reclamation's Colorado River Simulation System (CRSS)[3]. For example, the geographic locations at which these metrics were applied did not represent all of the important locations for these resources in the Basin; rather, they represented locations that are explicitly represented in CRSS and have resource relevance. Additional system reliability metrics reported the potential effects of supply and demand imbalances to future hydropower generation. The Basin Study metrics are discussed in the Basin Study, *Technical Report D* (Reclamation, 2012c). The results of evaluating these metrics are discussed in the Basin Study, *Technical Report G* (Reclamation, 2012d).

Through a process described in the Basin Study, *Technical Report G* (Reclamation, 2012d), thresholds for which a resource was deemed vulnerable were established for some of the metrics. These metrics indicate all Basin resources are increasingly vulnerable, through time, due to increasing supply and demand imbalances. Options and strategies were shown to decrease the resource vulnerabilities, and certain options were more effective in reducing the ecological and recreational vulnerabilities, while also reducing other vulnerabilities such as hydropower and water delivery.

Basin Study modeling indicates Basin resources, including environmental, recreational, and hydropower resources, are increasingly vulnerable through time.

During the Basin Study, input was solicited from Basin Study participants, interested stakeholders, and the general public on options and strategies for helping to resolve future water supply and demand imbalances in the Basin. More than 150 options were submitted to the Basin Study, several of which had the explicit purpose of benefiting ecological and recreational resources that are dependent upon instream flows. For example, one of the strategies evaluated in the Basin Study was a conceptual Upper Basin water bank with objectives to (1) increase water delivery reliability and (2) use increased flow to improve the performance of ecological and recreational resource system reliability metrics. In this particular concept modeled in the Basin Study, it was assumed that various conservation (M&I, agricultural, and energy) efforts across the Upper Basin would be coordinated for the purpose of yielding water to store in the bank. An additional assumption was that the conserved water was routed to the bank; that is, protected from downstream diversion until it reached the bank. The routing of conserved water ensured that water reached the bank and increased flows for environmental and/or recreational purposes. Several related options that were submitted to the Basin Study, but not quantitatively assessed due to the legal, regulatory, or technical complexity, include an option to financially incentivize water conservation to supply a

[3] CRSS is the Bureau of Reclamation's long-term planning model used in the Basin Study. See Basin Study, *Technical Report G* for more information (Reclamation, 2012e).

water bank and several options to modify reservoir operations to restore downstream flows or maximize hydropower generation. Additional information about the options and strategies evaluated in the Basin Study are discussed in the Basin Study, *Technical Report F* (Reclamation, 2012e).

5.3 Workgroup Objective and Approach

Although the Basin Study resulted in a good additional step toward incorporating the needs of flow-dependent resources and evaluating concepts to better meet those needs under a range of future conditions, it was recognized that exploring ways to meet ecological and recreational needs should continue beyond the completion of the Basin Study. This Workgroup was convened to address the Basin Study recommendation that future efforts should strive to better understand the needs of these systems, better reflect those needs in a modeling framework, and further explore solutions considered in the Basin Study as well as other studies that promote the protection or improvement of environmental and recreational flows (Reclamation, 2012).

The primary objective of the Workgroup was to build upon the Basin Study's assessment of environmental and recreational flows to identify ideas for potential future voluntary, non-regulatory solutions that protect or improve ecological and recreational resources while supporting other management goals to achieve integrated solutions that benefit multiple uses, both consumptive and non-consumptive, including hydropower. Explicitly exploring potential opportunities to protect or improve hydropower resources was beyond the scope of the Workgroup and beyond the expertise of many Workgroup members. The Workgroup did strive to recognize the importance of hydropower resources within the Basin and the potential interrelationships between hydropower resources and river-based ecological and recreational resources.

5.3.1 Workgroup Process

The Workgroup is composed of approximately 40 members representing a broad range of perspectives related to environmental and recreational concerns from throughout the Basin. The Workgroup includes representatives of conservation, recreation, and federal power customer organizations; water purveyors; state agencies; and federal agencies. Three Co-Chairs, representing Reclamation, The Nature Conservancy (TNC), and the Colorado Water Conservation Board were selected to lead the Workgroup. The Co-Chairs facilitated discussion and helped to define the Phase 1 tasks. The Workgroup was supported by resource personnel from Reclamation and the *Moving Forward* consulting team led by CH2M HILL. The Workgroup met periodically, either in person or via conference calls, between June 2013 and October 2014.

5.3.2 Workgroup Approach

The Workgroup began by developing Guiding Principles to provide a common platform and ongoing guidance about how the Workgroup would approach the tasks and any issues encountered. Because issues pertaining to ecological and recreational resources are inherently site-specific (for example, necessary minimum flows to safely raft a river reach) but also broader in scale (for example, the recovery of endangered species), the Workgroup approach investigated both specific sites and the Basin more holistically. Because detailed assessments of all river reaches in the Basin were not feasible, the Workgroup selected several focus reaches to understand specific ecological and recreational issues and the programs already in place to help address these issues. This assessment examined the current conditions in the focus reaches and identified scientific uncertainties associated with understanding environmental, recreational, and hydropower resources in the focus reaches. A review of existing programs in the entire Basin and in other regions with similar issues was then conducted to help provide ideas for how future programs could be expanded to protect or improve ecological and recreational resources, both at specific sites and across the entire Basin. Consistent with the objective of the Workgroup and the Guiding Principles, the ideas for potential solutions include both flow- and non-flow-related solutions. Phase 1 tasks performed by the Workgroup are shown in Table 5-1 and are described in the following sections.

TABLE 5-1
Workgroup Task Summary

Task Number	Task
1	Identify Guiding Principles for the Workgroup
2	Develop selection criteria to identify focus reaches
3	Apply criteria to select focus reaches
4	Conduct assessment of current conditions in focus reaches
5	Identify scientific uncertainties and opportunities to address those uncertainties
6	Document mechanisms or programs that have been successful in protecting environmental and river-based recreational resources
7	Explore and document opportunities and potential solutions that might be applied on a scale larger than focus reaches
8	Prepare Phase 1 Workgroup Report

Environmental and Recreational Flows Workgroup Guiding Principles

1. Seek solutions and opportunities that promote environmental resiliency.[1]
2. Recognize the importance of biodiversity and ecosystem health:
   - Support actions that help recover flow-dependent endangered species and avoid future listings.
   - Strive to achieve diverse and healthy ecosystems that provide benefit in addition to recovering endangered species.
   - Recognize how forest and watershed health contributes to the sustainability of values associated with water supply and quality, including environmental and recreational flows.
3. Recognize the importance of river-based recreational benefits to local economies:
   - Support actions that help preserve and improve river boating opportunities, angling, and other river-based recreational activities.
   - Seek potential solutions that provide reliable and predictable recreational flows.
4. Recognize and support the environmental and recreational values of Colorado River Basin national park units.
5. Recognize the importance of hydropower resources within the Basin and how hydropower resources and river-based environmental and recreational resources affect one another.
6. Acknowledge tradeoffs among resource management actions:
   - Understand how flow-related and non-flow-related variables (such as temperature, water quality, riparian habitat, poor physical habitat in the river, impediments to fish passage, and invasive species) influence ecosystem resources.
   - Consider and recognize the inter-relationships, both positive and negative, among desired environmental flows and recreational flows, hydropower resources, and other uses of water.
   - Strive to develop potential solutions to protect ecological and recreational values that do not negatively affect other water uses. Seek potential solutions that are proactive and collaborative and that reduce vulnerabilities across the resource categories identified in the Basin Study with the objective of avoiding regulatory oversight and zero-sum outcomes.
   - Recognize that local solutions can impact other regional issues and that regional solutions might have local impacts.
   - Focus first on high-priority locations based on consideration of current river health and future vulnerability.
7. Observe and use the best available science appropriately:
   - Advance science to develop and improve knowledge base related to achieving the goals of species recovery and related to other ecological and recreational resources.
   - Recognize and seek to eliminate current limitations in data/models as they relate to environmental and recreational flows and other water uses.
8. Comport with current laws and governance:
   - Potential solutions will be consistent with the Law of the River.
9. Improve efficiencies through collaboration and cooperation:
   - In developing possible solutions, consider and promote solutions that complement the work being done in other workgroups.

[1] Environmental resiliency is defined as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker et al., 2004).

5.3.2.1 Focus Reaches

The Workgroup selected reaches of the Colorado River and its tributaries to explore and help complete the Phase 1 tasks. The goal of the focus reach assessment was to understand current conditions, ecological and recreational issues, and scientific uncertainties at a site-specific scale.

A process, which is further described in Section 5.5, was developed to narrow an initial list of possible reaches (29 in the Upper Basin, 8 in the Lower Basin, and 5 headwater reaches) (Figure 5-1) to 4 Phase 1 focus reaches. The reaches selected through this process were:

- Mainstem of the Colorado River between the confluence with the Gunnison River and the confluence with the Green River
- White River between Taylor Draw Dam and the confluence with the Green River
- Bill Williams River from Alamo Dam to the confluence with the Colorado River at Lake Havasu
- Henry's Fork headwaters area within parts of Utah and Wyoming.

5.3.2.2 Wider Geographic-Scale Opportunities and Potential Solutions

The Workgroup also reviewed existing programs operating both within the Basin and in other river basins worldwide to gain an understanding of current activities being undertaken to protect or improve ecological and recreational resources in a variety of contexts. The Workgroup then explored concepts that could benefit ecological and river-related recreational resources across a broader geography in the Basin (that is, not solely in the focus reaches). This review of current programs provided useful examples of approaches and practices that could potentially be applied to the focus reaches or provide opportunities in other parts of the Basin. Examples include sustainable funding mechanisms, agricultural programs that could benefit farmers and rivers, and a discussion of how cooperative, structured water markets could benefit rivers while fostering water security and flexibility for other users. This review generated ideas for actions that could potentially be taken in later phases of the *Moving Forward* effort or that could be undertaken by others in the Basin through different processes or on an ad hoc basis with willing funding partners and interested stake-holders. As subsequent phases of the *Moving Forward* effort (or other efforts) continue to identify and evaluate options to protect or improve ecological and recreational resources, the positive and negative effects to all resources, including hydropower, should be considered.

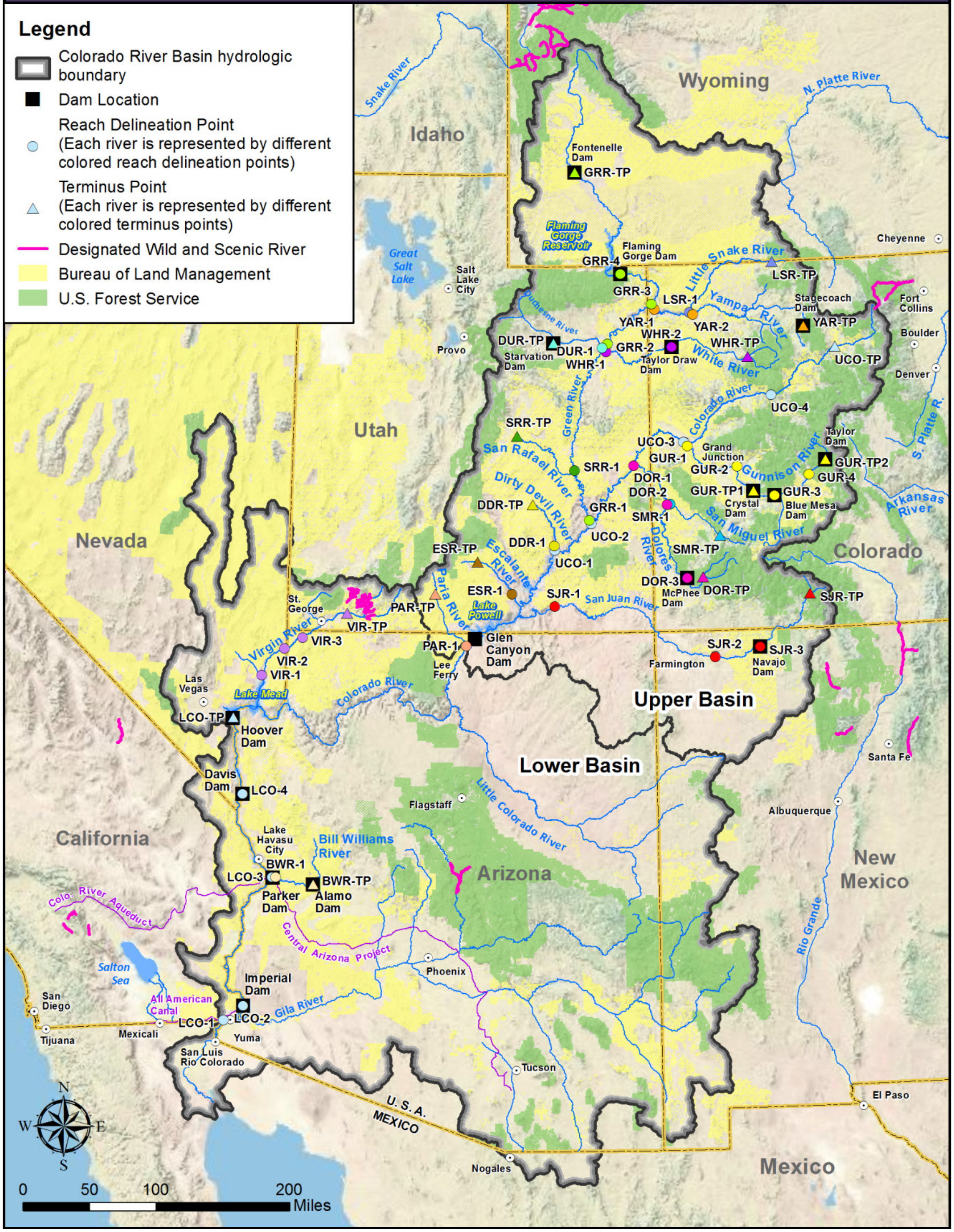
5.4 Ecological, Recreational, and Hydropower Resources in the Colorado River Basin

From its headwaters on the Continental Divide in Wyoming and Colorado to the deserts of the Southwest, the Colorado River and its tributaries flow through many regions with distinct geographic and ecological characteristics that have created a unique and varied river system. The Colorado River system supports important ecosystems, provides myriad recreation activities, and supplies electric power to many western states.

Although the Workgroup did not directly address hydropower resources, it did recognize the importance of hydropower resources within the Basin and the potential interrelationships between hydropower resources and river-based ecological and recreational resources. For this reason, a description of Basin hydropower resources is included in this section. While recreational opportunities provided by reservoirs—a valuable Basin resource—were considered in the Basin Study, the Workgroup did not consider flat-water recreation as part of its effort.

Potential interrelationships exist between environmental and recreational flows and hydropower resources; as options to protect or improve ecological and recreational resources are evaluated in any future efforts, the effects on all resources, including hydropower, should be considered.

FIGURE 5-1
River Reach Delineations



Notes:
1. Reaches do not include the impounded waters located upstream of dams.
2. Similar to the Basin Study, the scope of the *Moving Forward* effort is limited to the portion of the Basin within the United States (U.S.).

5.4.1 Ecological Resources

As the Colorado River flows from the Rocky Mountains, through the desert Southwest, and into Mexico, variations in climate, hydrology, and habitats create an impressive ecological diversity. Within the Basin, many distinct freshwater ecosystems have been identified from the headwaters to the Delta. In addition, the Colorado River flows through seven national wildlife refuges and nine national parks, lands that are prized and protected for their ecological complexity and natural beauty. Current conditions along the Colorado River and its tributaries differ significantly from historical conditions. Over the last century, riparian communities and instream habitats have been altered by water management, land development, and the introduction of nonnative species. In the future, ecosystems may be further challenged by higher temperatures and other projected effects of climate change, which are expected to affect both water demand and water supply.

In the Upper Basin, the Colorado River is joined by several tributaries flowing through five states and through varied geography and topography, resulting in a wide variety of ecosystems from mountain forests to desert canyons. The Upper Colorado River system supports significant biodiversity and is home to 14 native fish species, including 4 species listed as threatened or endangered under the Endangered Species Act (ESA): the Colorado pikeminnow, humpback chub, bonytail, and razorback sucker. The floodplains of the Colorado River and its tributaries harbor wetland riparian plant communities and associated wildlife such as birds and bats.

In many areas of the Upper Basin, human land and water uses have physically altered the river and caused changes in water flow patterns. These changes have affected plant and animal species that depend on rivers and the adjacent riparian habitat. These changes also pose key challenges to the ecological resources of the Basin, including altered flow regimes (temporal reductions and increases in flow), introduction of nonnative plant and fish species, and water quality degradation.

Reduced flows can affect aquatic habitat, for example, by reducing useable habitat for fish and isolating fish in small pools. Lack of flooding or flushing flows in the spring disrupts spawning cues of native fish (McAda, 2003) and affects germination of riparian plants (Mahoney and Rood, 1998). Flooding flows are also necessary to move sediment down the river and to create, destroy, and re-arrange riffles, pools, point-bars, and other critical habitats (Wilcox et al., 2013).

Alteration of natural flow regimes has also contributed significantly to the success of invasive, nonnative fish and plant species throughout the Basin. While all species compete to survive, invasive species often have functional traits that allow them to out-compete native species under the altered river conditions now present. Nonnative predatory fish, such as smallmouth bass and walleye, pose a serious threat to the recovery of endangered fish in the Upper Basin. To address this threat, the Upper Colorado River Endangered Fish Recovery Program (Recovery Program), along with the states of Colorado, Wyoming, and Utah, is taking action to remove nonnative fish and prevent them from entering areas inhabited by endangered fish.

Additionally, in the Upper Basin tamarisk and Russian olive have continued to spread and form dense stands in some areas. Research indicates that within the same lowland riparian area, the range of the amount of water consumed by both these invasive and native trees (such as cottonwoods) is similar such that restoration efforts undertaken for purposes of flow augmentation generally depend on replacing nonnative vegetation in more upland riparian areas with less consumptive native vegetation such as sacaton and mesquite (Tamarisk Coalition, 2009; Nagler et al., 2010). However, there are other reasons for removing tamarisk and Russian olive trees aside from flow augmentation, such as restoring native vegetation and river access. To address this concern, many stakeholders and agencies are working to remove tamarisk; for example, the Tamarisk Coalition has undertaken many tamarisk control projects in an effort to restore native riparian vegetation in the southwest (Tamarisk Coalition, 2014). Additionally, the U.S. Department of Agriculture introduced a tamarisk beetle into portions of Colorado, Nevada, Texas, Utah, and Wyoming during 2001–2009 to biologically control tamarisk. The beetle was not approved for release within 200 miles of habitat for the endangered southwestern willow flycatcher, which nests in tamarisk. However, the tamarisk beetle has spread farther south, into southwestern willow flycatcher habitat, than previously anticipated (U.S. Fish and Wildlife Service [USFWS], 2012). This has led to the defoliation of tamarisk stands along the river, but also may be negatively affecting habitat for an endangered species.

Maintaining water quality is another important challenge in the Upper Basin that affects aquatic and terrestrial species as well as people. A number of pollutants, including heavy metals, pesticides, fertilizers, selenium, and salt, are present in different areas of the Basin. Salinity is an important water quality concern in the Basin because of the potential impacts on U.S. and Mexican water users and the negative effects of salinity on aquatic and riparian plants and animals (Vandersande et al., 2001). The primary source of salinity loading to the river systems in the Upper Basin is water passing through underlying geologic formations that are high in salt content (Pillsbury, 1981). Drain water return flows from irrigation are another important contributing factor to salinity levels.

Stakeholders in the Upper Basin have implemented programs that are addressing several of these issues. For example, the Recovery Program and the San Juan River Basin Recovery Implementation Program (SJRRIP) were developed to coordinate the implementation of recovery plans for four endangered fish species in the Upper Basin. The programs are implemented collaboratively by federal, state, and local partner agencies and include activities such as native fish population augmentation, fish passage improvements, and eradication of nonnative species.

Downstream of Glen Canyon Dam and at the beginning of the Lower Basin lies the Grand Canyon, an iconic canyon that provides habitat for several threatened and endangered species. The Glen Canyon Dam Adaptive Management Program (GCDAMP) was established to provide for long-term research and monitoring of downstream resources with a goal of enhancing and improving downstream resources and dam operations (GCDAMP, 2014a). Through the adaptive management process, scientific experimentation provides information on the effects of the operations of Glen Canyon Dam on downstream resources in Glen and Grand Canyon. Based on information gathered through this process, adjustments to the operations of Glen Canyon Dam, consistent with existing laws, are recommended to the Department of the Interior (GCDAMP, 2014b).

In the Lower Basin, the Colorado River is highly regulated, and the riparian corridor bears little resemblance to the historical floodplain. The construction of Glen Canyon, Hoover, Davis, Parker, Palo Verde, Imperial, Laguna, and Morelos Dams on the Colorado River has created a managed flow system within the U.S., resulted in intermittent flows in the Colorado River Delta within Mexico, and altered natural habitat along the rest of the river. Resulting changes include loss of native riparian vegetation and floodplains; altered aquatic habitat structure and function; declining groundwater elevations resulting from the lack of surface water recharge and groundwater pumping; regulated flows; altered water quality (temperature, salinity/conductivity, pollutants); discontinuity of sediment and nutrient transport; and introduction of numerous nonnative species (plants and animals) (Reclamation, 2004).

The current vegetation mix along the Lower Colorado River mainstem differs significantly from historical conditions. Although woody riparian vegetation is present, the area is predominately tamarisk or tamarisk mixed with mesquite, and limited acreage of native vegetation remains. On the Bill Williams River, however, significant native riparian forests persist. Riparian ecosystems provide important habitat for many species, and the corridor supports many wildlife species (birds, mammals, fish, reptiles, and amphibians), including both resident species and migratory visitors (Reclamation, 2004). Over the past 40 years, several species native to the Lower Colorado River have been listed as endangered, including the Yuma clapper rail, Colorado pikeminnow, humpback chub, bonytail, razorback sucker, yellow-billed cuckoo, and southwestern willow flycatcher.

In response to these endangered species listings, representatives of the states of Arizona, California, and Nevada, U.S. Department of the Interior agencies, and other stakeholders along the Lower Colorado River formed the Lower Colorado River Multi-Species Conservation Program (LCR MSCP), a regional partnership created to balance the delivery and use of the Colorado River water resources and hydropower production with the conservation of native species and their habitats. The program area extends over 400 miles of the Lower Colorado River and includes Lake Mead, Lake Mohave, and Lake Havasu; the historic 100-year floodplain along the mainstem of the Lower Colorado River; and portions of the Muddy, Virgin, Gila, and Bill Williams Rivers. The program includes activities such as habitat creation and native fish augmentation (Reclamation, 2004).

Another major development related to the management of the Colorado River was the November 2012 signing of Minute 319 to the 1944 Treaty with Mexico, a historic binational agreement in effect through 2017. While assessing the ecological and recreational resources within Mexico is beyond the scope of the *Moving Forward* effort, Minute 319 provides a good example of multiple cooperative actions related to water conservation and system operations, which also provide water for environmental flows for the Colorado River Delta and funding for restoration activities. The pulse flow event, where water was released to flow downstream into the Colorado River Delta, was completed in the spring of 2014 with water that Mexico elected to use for the purpose of benefiting the Delta in coordination with the U.S. and Basin States. The pulse flow and a longer-lasting base flow are expected to provide for the restoration of approximately 2,300 acres of habitat by allowing native willow and cottonwood trees to germinate and water to sustain their growth. There is also an opportunity to gain important scientific information on the effectiveness of these flows (International Boundary and Water Commission, 2014).

The Colorado River and its tributaries provide important habitat for many native species, including several threatened or endangered species; some of these species are found nowhere else in the world. The Recovery Program, the SJRRIP, and the LCR MSCP are examples of existing critical and effective programs that focus on the recovery and protection of many species while allowing for continued water deliveries. This important work should continue.

5.4.2 Recreational Resources

The Colorado River and its tributaries are a world-renowned natural heritage where millions of visitors enjoy boating, fishing, camping, hiking, and other recreational activities annually. Tourism income generated by these activities provides major support to local economies. Much of the river and tributary corridor most intensively used for recreation is managed as national parks, national recreation areas, national forests, Bureau of Land Management (BLM) lands, or state and local parks. The nine[4] National Park Service (NPS) units along the Colorado River and its tributaries accounted for nearly 20 million visits in 2012, with a total visitor spending of more than $1.2 billion (NPS, 2014), and more than 20 million visits in 2013, with a total visitor spending of more than $1.5 billion (Cullinane et al., 2014). If areas in the Basin outside of NPS units are also considered, the contributions to local and regional economies would be even larger.

River boating opportunities in the Upper Basin range from stretches that provide a relaxing flat-water float to challenging whitewater runs in remote canyon settings. Cataract Canyon, Westwater Canyon, and many reaches in the Colorado headwaters are heavily used each year. The Upper Colorado River below Kremmling, Colorado, sees between 37,000 and 60,000 boaters each year (BLM, 2014), and boater numbers on the Colorado River through Glenwood Canyon are significantly higher. Many of the popular whitewater runs, including the coveted Grand Canyon section, are served by commercial outfitters. The Grand Canyon section is run by more than 22,000 people annually and is the only whitewater stretch on the mainstem in the Lower Basin. However, unique paddling trips through canyons and wildlife refuges exist below Hoover Dam. In fact, in June 2014, the Secretary of the Interior designated the 30-mile stretch of the Colorado River immediately downstream of Hoover Dam as the first National Water Trail in America's Southwest and the first that traverses a desert.

[4] Although there are 11 NPS units in the NPS' Colorado River Program, nine are considered to be directly linked to the Colorado River and its major tributaries: Rocky Mountain National Park, Dinosaur National Monument, Black Canyon of the Gunnison National Park, Curecanti National Recreation Area (managed jointly with Black Canyon of the Gunnison), Arches National Park, Canyonlands National Park, Glen Canyon National Recreation Area (Rainbow Bridge National Monument is managed jointly with Glen Canyon National Recreation Area), Grand Canyon National Park, and Lake Mead National Recreation Area. The other two units are Rainbow Bridge National Monument and Grand Canyon-Parashant National Monument.

The nine National Park units in the Basin accounted for nearly 20 million visits in 2012 and 2013, with total visitor spending exceeding $1.2 billion and $1.5 billion, respectively. These and other recreational opportunities contribute to local and regional economies.

In addition, the many reservoirs in the Basin provide opportunities for fishing, motor boating, and general recreation. For example, the Lake Mead National Recreation Area had 6.3 million visitors in 2012 and was the sixth most-visited site in the NPS system. The Glen Canyon National Recreation Area with Lake Powell had more than 2 million visitors that same year (NPS, 2014).

Most recreational resources in the Basin are affected directly or indirectly by variations in instream flows. Directly, changes to the river's flow can influence hydraulic conditions (for example, depth, velocity, and width) and determine the type and quantity of river-recreation opportunities. Over time, changes in stream flows can influence geomorphology and the density of riparian vegetation in the system—both of which may affect the condition of whitewater rapids and other features that are critical to various types of river recreation. For example, reservoir operations can decrease or increase instream flows downstream from storage facilities, influencing whether a river reach is boatable, fishable, or swimmable.

Abundant recreational opportunities are supported by the Colorado River and its tributaries, and variations in instream flows can directly affect recreational resources.

5.4.3 Hydropower Resources

Reclamation operates numerous facilities on the Colorado River and its tributaries that generate clean, renewable hydropower to meet a portion of the electrical energy needs in the Basin States and Nebraska. The hydropower plants in the Basin have a total generating capacity of more than 4,200 megawatts (MW).

In the Upper Basin, the Colorado River Storage Project (CRSP) facilities produce hydropower at five dams: Glen Canyon on the Colorado River; Flaming Gorge on the Green River; and Blue Mesa, Morrow Point, and Crystal on the Gunnison River. CRSP facilities provide power to 150 wholesale customers in Arizona, Colorado, Nebraska, Nevada, New Mexico, Utah, and Wyoming. The dams of the CRSP main storage units have a combined live storage capacity of 30.6 million acre-feet and hydropower generation capabilities to provide more than 5 billion kilowatt-hours (kWh) of energy annually, enough electricity to serve approximately 500,000 households.

On the Lower Colorado River, Reclamation manages, operates, and maintains Hoover, Davis, and Parker Dams and their associated power plants and facilities. Hoover and the Parker-Davis project provide power to 15 and 36 contractors, respectively, in Arizona, California, and Nevada. These dams have a combined live storage capacity of 29.8 million acre-feet. The three dams generate, on average, about 5.3 billion kWh of hydropower, enough to serve approximately 500,000 households.

The power generated from the Upper and Lower Basin facilities that is surplus to Reclamation project needs is marketed by the Western Area Power Administration of the U.S. Department of Energy. The power is sold primarily to non-profit entities such as municipal utilities, rural electric cooperatives, state and federal agencies, and tribes. Although Reclamation operates the hydropower facilities, Western develops rates and markets the power. Power rates are designed to recover all the federal investment, with interest, and operation and maintenance expenses and are not subsidized by the federal government. In addition, power rates in the Upper Basin pay for irrigation projects and are a source of major funding for important environmental programs. For example, power revenue generated from the CRSP provides approximately $20 million annually to the Recovery Program, the SJRRIP, the Colorado River Basin Salinity Control Program, and the GCDAMP.

Hydropower facilities in the Basin provide power to over 200 contractors and millions of people throughout eight western states (Arizona, California, Colorado, Nebraska, Nevada, New Mexico, Wyoming, and Utah), while helping support important environmental programs in the Basin in addition to repaying the federal investment in the facilities.

5.4.4 Summary of Resources

The Colorado River provides habitat to a wide range of species, including several federally endangered species. As the river flows through seven states, it provides recreational opportunities in the forms of boating, fishing, and hiking, all of which provide significant benefits to the regional economy. The hydropower generated throughout the Basin is a source of clean, renewable energy for millions of households. Finally, the river provides drinking water to 40 million people and irrigation water for about 5.5 million acres of farmland. Balancing the benefits of the system across these resources is a complex challenge. Each reach of the Colorado River and its tributaries contains a unique mix of these resources and issues that need to be considered when planning management strategies. In recognition of this complexity, the Workgroup developed a process to identify specific focus reaches that could be used in Phase 1 to explore opportunities and challenges on a local scale.

5.5 Focus Reach Selection Process

To understand particular environmental and recreational issues at specific locations and at a reasonable scale, the Workgroup selected several reaches to explore further. A customized focus reach selection process was undertaken to help the Workgroup come to a consensus on several reaches to use as focus reaches.[5] For the river reach selection process, the Workgroup completed four main steps:

1. Developed a list of rivers in the Upper and Lower Basins that could be suitable for Phase 1 of the *Moving Forward* effort and divided them into reaches.
2. Identified five goals for reach selection and developed specific criteria supporting each goal.
3. Characterized each river reach on the initial list based on the selection criteria.
4. Used the reach characterizations to narrow the initial list of reaches to the final list of focus reaches.

The following sections provide further explanation of each step. Details of the steps are in Appendix 5A.

5.5.1 River Reach Identification

The process of selecting focus reaches for Phase 1 was initiated by developing a list of major rivers and tributaries in the Upper and Lower Basins (Appendix 5A). A few rivers (for example, the Colorado River through the Grand Canyon) were not included on this list because of existing ongoing planning or legal processes. Rivers on the list were divided into reaches based on key physical attributes such as major river confluences and dam locations. The delineation process resulted in an initial list of 37 river reaches to be considered in the reach selection process, including 29 reaches in the Upper Basin and eight reaches in the Lower Basin, as shown on Figure 5-1.

Headwater river reaches were defined as a separate category to represent river reaches that are in the uppermost part of a watershed and typically above any dams or other major water control facilities. Five headwater areas were considered with the goal of selecting one as an additional focus reach. The delineated river reaches and headwater reaches considered in this process are listed in Appendix 5A.

5.5.2 River Reach Selection Criteria

The Workgroup aimed to select focus river reaches that would represent a diverse range of river reaches in terms of current river health, recreational value, geographic location, regional significance, and potential tradeoffs with other water uses. To accomplish this, reach selection criteria (Appendix 5A) were developed based on five distinct goals to narrow the initial list to two to six focus reaches (Figure 5-2).

[5] The focus reach selection process was undertaken to assist with the specific goals of the Workgroup and may not be appropriate for use in other settings.

The following five goals were used to develop the selection criteria:

1. Protect or improve river ecological health.
2. Protect or improve river recreational experiences.
3. Limit or manage tradeoffs with other water uses.
4. Consider geographic location and regional importance.
5. Consider constraints limiting flexibility of solutions.

5.5.3 River Reach Characterization

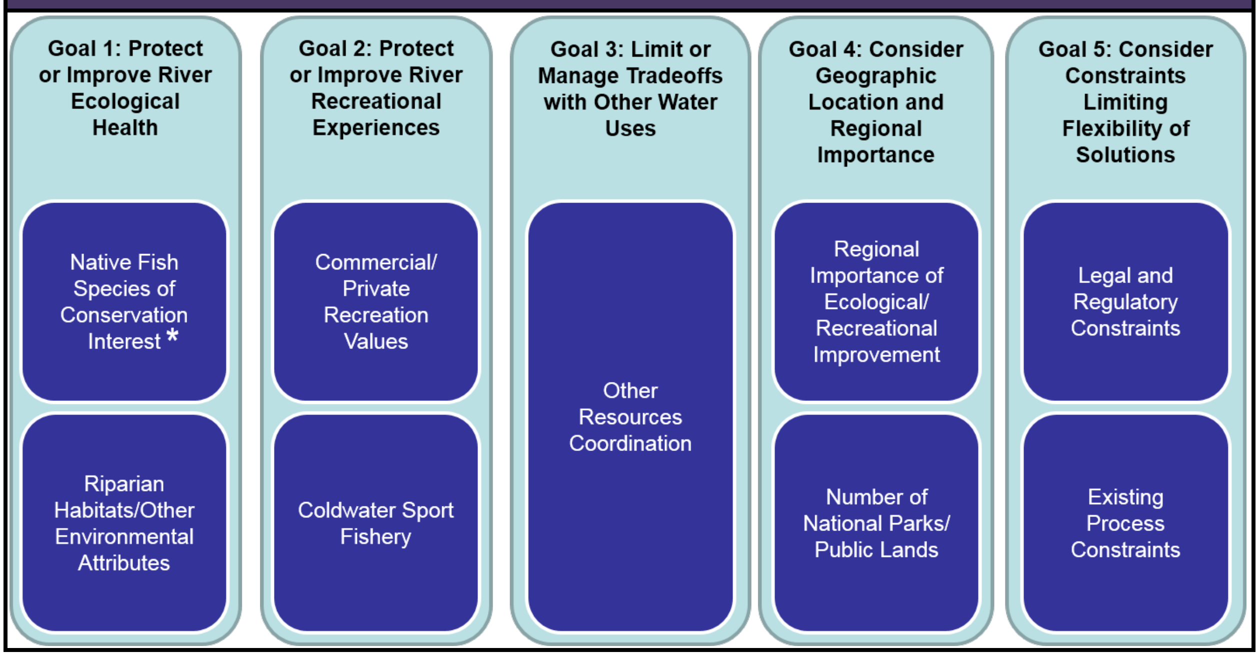
River reach characterization for each criterion was based on a series of information-gathering efforts. First, quantitative data, when available, were compiled for the criterion by reach. Next, data gaps were filled by Workgroup members with expertise or professional knowledge in the area. Finally, characterization ratings of A, B, or C were assigned based on the available information and Workgroup consensus. Details about the initial data collection effort and quantitative characterization methodologies are in Appendix 5A.

5.5.4 River Reach Selection

After the river reach characterization was complete, focus reaches were selected using a two-step process. First, a filtering process was used to identify a "decision point" for each criterion above which a reach would be retained and below which it would be dropped. For example, a filter could be applied that retained all reaches with a rating of A or B in the "native fish species of conservation interest" criteria. This filtering process resulted in reducing the number of reaches under active consideration from 37 to 18. The filtering process is described in Appendix 5A.

The Workgroup then selected the focus reaches from the filtered list of 18 reaches. During this step, while adhering to the Guiding Principles, Workgroup members discussed qualitative factors, such as political feasibility of working on a particular reach and diversity of reaches, based on their collective knowledge and best professional judgment to arrive at the list of focus reaches on a consensus basis. A similar qualitative process was used to select one headwater focus reach to represent headwater cold-water streams that are above dams and have primarily natural hydrology and runoff patterns.

FIGURE 5-2
River Reach Selection Goals and Criteria



* The phrase "of conservation interest" was developed by the Workgroup to be a general term and is not intended to correspond to specific regulatory or conservation definitions.

Using this process, the following reaches, including two Upper Basin reaches, one Lower Basin reach, and one headwater reach, were selected as focus reaches:

- Upper Colorado River Focus Reach (Upper Basin) – mainstem of the Colorado River between the confluence with the Gunnison River and the confluence with the Green River (Reach UCO-2)
- White River Focus Reach (Upper Basin) – White River between Taylor Draw Dam and the confluence with the Green River (Reach WHR-1)
- Bill Williams River Focus Reach (Lower Basin) – Bill Williams River from Alamo Dam to the confluence with the Colorado River at Lake Havasu (Reach BWR-1)
- Henry's Fork Headwaters Focus Reach

5.6 Focus Reach Assessment

This section assesses the current conditions of each of the four focus reaches selected for Phase 1. The assessment is not intended to be a comprehensive overview of the reach, but rather a general description identifying attributes and issues as they relate to the selection criteria that could present opportunities to protect or improve ecological and recreational resources in accordance with the Workgroup objective. The assessment also summarizes key programs currently in place on each focus reach to help understand existing efforts to protect or improve ecological and recreational resources. Finally, to identify potential needs, scientific uncertainties and data gaps are discussed.

Many environmental and recreational issues are site-specific, and addressing these issues would require site-specific measures. For this reason, the Workgroup selected four focus reaches to help understand site-specific issues.

5.6.1 Upper Colorado River Focus Reach

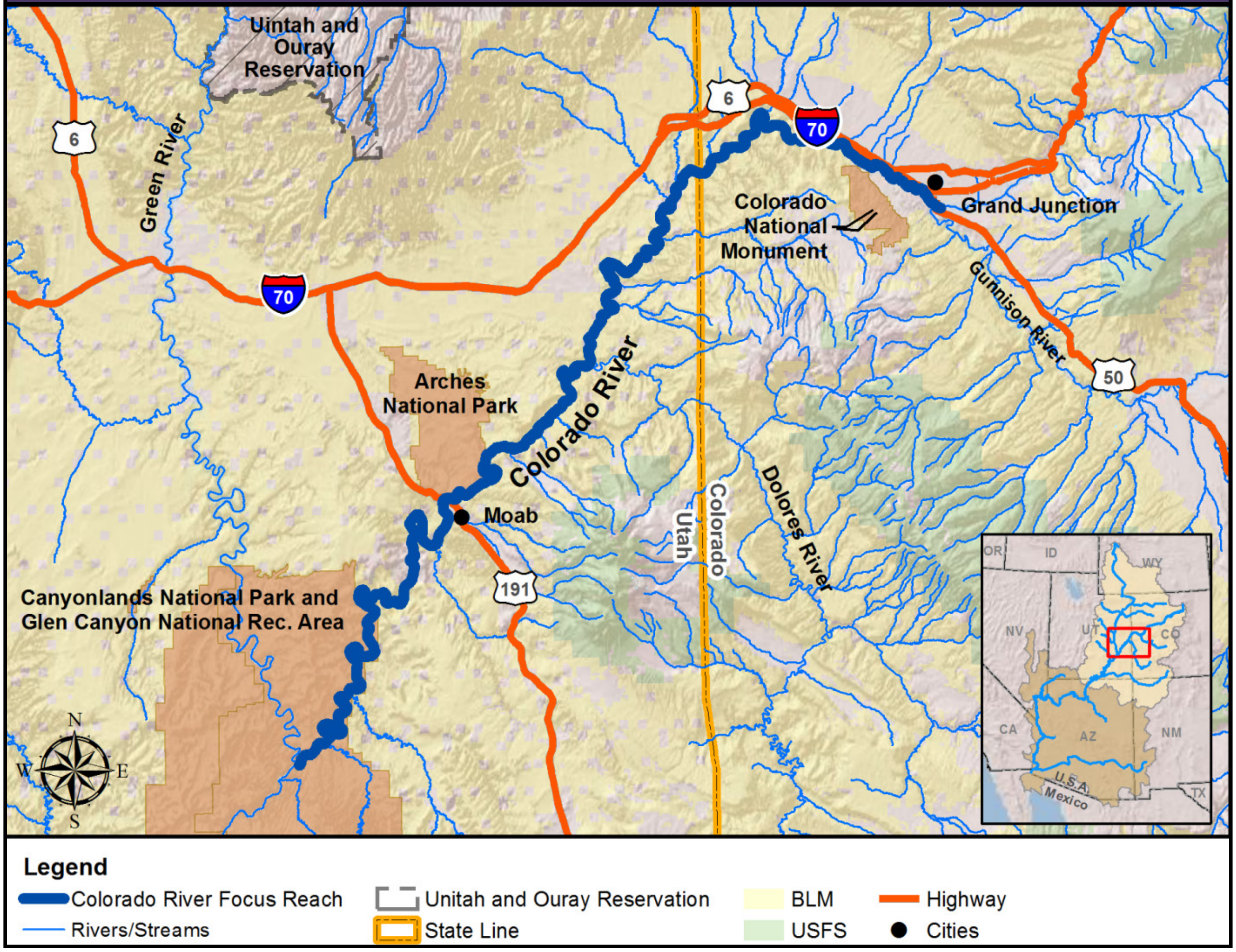
The Upper Colorado River Focus Reach begins at the confluence with the Gunnison River and flows downstream to the Green River confluence. This 132-mile reach of the Colorado River (Figure 5-3) receives water from the upstream watershed, including snowmelt runoff from higher elevation areas such as the tributaries of the Gunnison, Dolores, Roaring Fork, Eagle, and Blue Rivers. The many tributaries that flow into and above the focus reach range from small, unregulated tributaries to larger tributaries with substantial reservoir storage and water regulation. This reach is also below several exports to Colorado's Front Range, large irrigation areas on Colorado's West Slope, and several salinity control projects. Additionally, the Aspinall Unit reservoir complex on the Gunnison River upstream includes the Blue Mesa, Morrow Point, and Crystal Dams, which together are capable of generating up to 283 MW of hydropower.

Along its course, the Upper Colorado River Focus Reach flows through Grand Junction, Colorado; private and BLM land; and two national parks (Arches and Canyonlands). The average of all annual flows near Cisco, Utah, below the Dolores River, is 7,168 cubic feet per second (cfs); the average of the 10 percent lowest annual flows is 3,251 cfs; and the average of the 10 percent highest annual flows is 11,950 cfs (U.S. Geological Survey [USGS], 2014a). Annual precipitation in this region is about 9 inches (Western Regional Climate Center [WRCC], 2014).

5.6.1.1 Environmental and Recreational Attributes

The Upper Colorado River Focus Reach and its surrounding riparian corridor provides habitat for many plant and wildlife species. The focus reach contains critical habitat for humpback chub, Colorado pikeminnow, razorback sucker, and bonytail, all of which are federally endangered fish included in the Recovery Program. As part of the recovery effort for these fish, the USFWS has developed a biological basis for flow recommendations at the Colorado-Utah state line (above the confluence with the Dolores River) (McAda, 2003). Habitat restoration is another important issue for recovery of these species.

FIGURE 5-3
Extent of the Upper Colorado River Focus Reach



Levees and channel realignment in this area affect endangered fish by causing a lack of connectivity between the river system and adjacent floodplains that fish use for spawning (Bestgen et al., 2011). Several conservation elements, including native riparian vegetation and dependent species, are present on the reach from the Utah Colorado state line to the Green River confluence and are being addressed by a team of federal, state, and nongovernmental stakeholders. As part of its work, the program anticipates releasing databases, maps, spatial habitat suitability, and risk analyses.

Invasive species of concern along the focus reach include nonnative fish species such as smallmouth bass, largemouth bass, and walleye and the nonnative plants tamarisk and Russian olive. Nonnative fish in the Colorado River system have been identified as a major factor in the decline of protected species because they compete for food and space and also prey on endangered fishes (McAda, 2003). Tamarisk and Russian olive can be found along the majority of the Upper Colorado River Focus Reach (USGS, 2014b) and are of interest because of a number of concerns including competition with native vegetation and restriction of river access when stands are dense

Salinity is an important water quality issue with potential negative effects on plants and wildlife living in streams and the surrounding riparian zone.

A number of important recreational attributes along this focus reach include rafting opportunities for boaters of varying experience levels. Ruby-Horsethief Canyons, Westwater Canyon, and reaches around Moab and Cataract Canyon provide unique whitewater rafting opportunities, ranging from slow-moving floats to high-challenge whitewater trips. Some, but not all, of these reaches require permits. Businesses that support these recreational activities are an important part of the economy in Grand Junction, Colorado; Moab, Utah; and beyond.

5.6.1.2 Programs and Management

A number of existing programs are in place for the Colorado River that address ecological and recreational attributes on the Upper Colorado River Focus Reach. The Recovery Program is working to recover the endangered humpback chub, bonytail, Colorado pikeminnow, and razorback sucker, all of which inhabit the focus reach.

To remove nonnative invasive plant species in the focus reach, the Southeast Utah Riparian Partnership works with community partners to complete voluntary tamarisk removal and restoration projects in the Professor Valley and Moab areas. Salinity issues above the focus reach are being addressed by the Natural Resources Conservation Service (NRCS), Reclamation, and state agencies, which have implemented irrigation improvements upstream of the focus reach aimed at reducing salt load by reducing high salinity agricultural drain water return flows. In the focus reach, salinity is monitored below the confluence with the Dolores River as part of the Colorado River Basin Salinity Control Program to monitor the effectiveness of salinity control projects above this focus reach. Studies estimate that salinity control measures related to the Grand Valley, Lower Gunnison Basin, Silt, and Paradox Valley Salinity Control projects have helped to reduce salt load in the focus reach by more than 140,000 tons per year (NRCS, 2011; Colorado River Basin Salinity Control Forum, 2014).

Boating on the Colorado River (Ruby-Horsethief near Colorado/Utah State Line)
Source: Nathan Fey

5.6.1.3 Data Gaps and Scientific Uncertainty

Opportunities may exist to better understand the ecological and recreational values of the Upper Colorado River Focus Reach through additional study, data collection, and modeling. For example, the USFWS (McAda, 2003) provides peak flow recommendations for this focus reach at a daily timestep, and baseflow at an average monthly timestep, whereas CRSS uses a monthly timestep. As a result, the model may not be able to directly distinguish how changes in upstream management affect the ability to meet flow recommendations on this focus reach. It is possible to incorporate daily flow targets into a monthly model using different techniques, such as disaggregating monthly flows into daily flow patterns or aggregating daily flow targets into monthly volumetric targets.[6] The purpose of modeling the flow targets should be considered when deciding whether to incorporate the daily targets into a monthly model or to use a daily timestep model. No flow recommendations for endangered fish recovery on this focus reach currently account for inflows from the Dolores River, and the flow needs for other ecological benefits of the river ecosystem throughout this focus reach have not been specified.

Another area of research interest on this reach, and in many areas of the Basin, is the effect of nonnative plant species on instream flows. Studies designed to evaluate potential water savings from tamarisk removal have had mixed results, and a USGS study (Nagler et al., 2010) has indicated that additional, carefully structured research investigating the effects of tamarisk removal on flow increases could help to validate and focus tamarisk removal efforts.

Opportunities also exist to improve the understanding of recreational needs on this reach. For example, data identifying daily public and private floatboating visitation and an understanding of factors, such as flow, that influence visitation and use would assist in planning for improvement of flows for recreational uses. American Whitewater surveys of the relationship between flows and recreational quality in this reach, and a subsequent analysis of boatable days, already provide useful information, as documented in the Basin

[6] The Basin Study used such approaches to develop some of the ecological and recreational system reliability metrics. Details regarding the development of these metrics are in the Basin Study, *Technical Report D* (Reclamation, 2012c).

Study[7]. Additional research in this reach, by American Whitewater in 2014, compliments the information contained in the Basin Study and is available to help inform efforts to reduce recreation vulnerabilities. These data could also assist in quantifying the economic benefits of recreation in the area.

5.6.1.4 Summary

All of the factors upstream of the Upper Colorado River Focus Reach will have effects on its important ecological, recreational, and hydropower values. Concerns in the focus reach include endangered fish recovery, improved recreational boating, invasive fish species, tamarisk stands, and salinity levels. Additional data and analysis could improve the understanding of these issues, including the effect of tamarisk removal on flows, the relationship between flow and other factors on boating visitation and use, and the flow needs for endangered fish and other flow-dependent species below the Colorado-Utah state line.

5.6.2 White River Focus Reach

The White River Focus Reach flows from Taylor Draw Dam near Rangely, Colorado, downstream to the Green River confluence. This 105-mile focus reach of the White River (Figure 5-4) receives water primarily from the upstream watershed from snowmelt in higher elevation areas. Due to its relatively low water storage capacity, Taylor Draw Dam has a minimal influence on river flow downstream from the reservoir (Martinez et al., 1986). However, the reservoir, operated by the Rio Blanco Water Conservancy District, serves many purposes, including the generation of about 1.6 MW of hydroelectric power, recreation, fish and wildlife protection, and limited drinking and irrigation water. Along its course, this focus reach flows through private and BLM lands as well as the Ute Tribe's Uintah and Ouray Reservation. The average of all annual flows near Watson, Utah, is 686 cfs; the average of the 10 percent lowest annual flows is 381 cfs; and the average of the 10 percent highest annual flows is 1,128 cfs USGS, 2014a). Annual precipitation in this area ranges from 7 to 10 inches (WRCC, 2014).

5.6.2.1 Environmental and Recreational Attributes

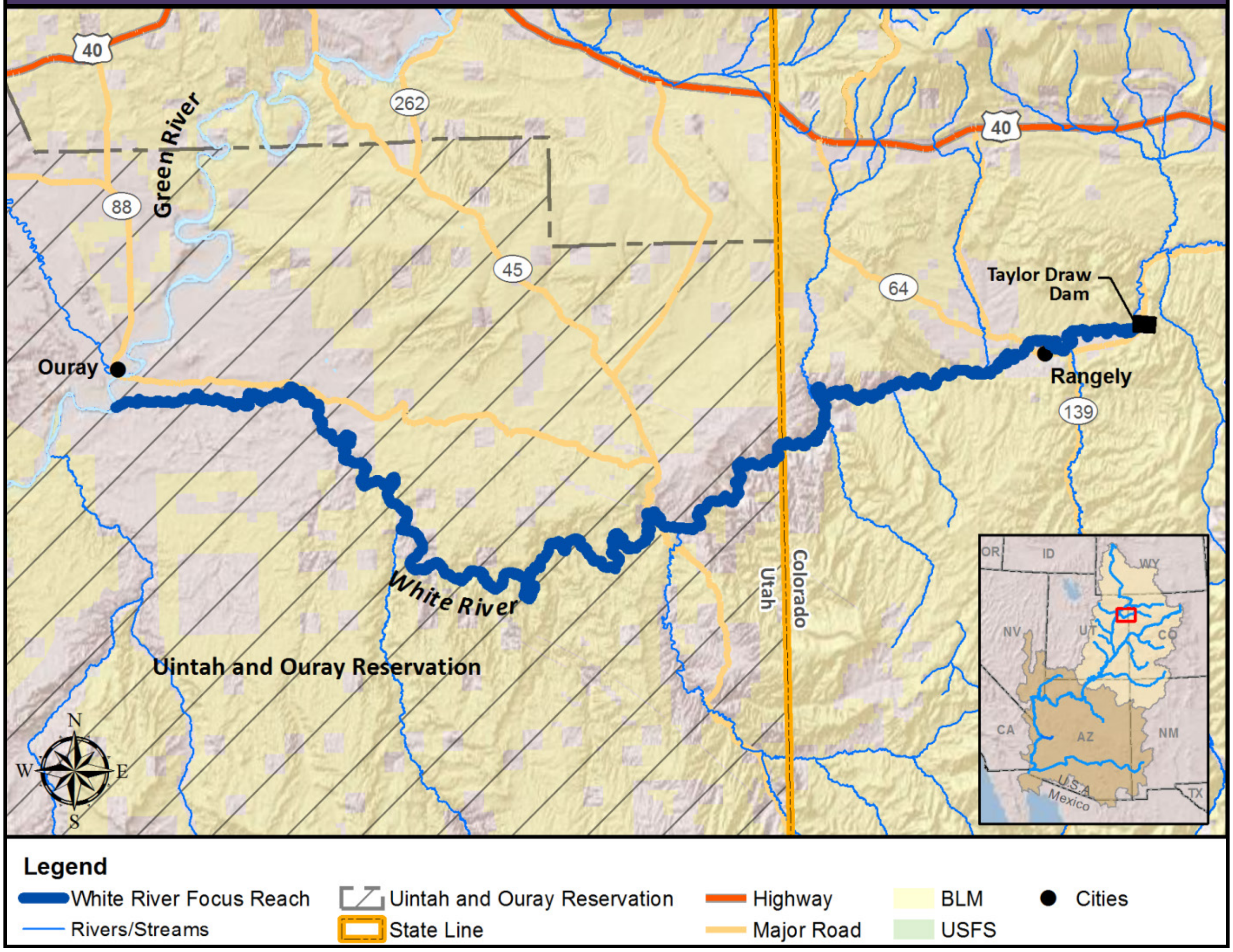
The White River Focus Reach includes critical habitat for two species included in the Recovery Program: the Colorado pikeminnow and the razorback sucker. Webber et al. (2013a) identified spawning of these fish in the river, indicating that the focus reach is important for spawning and rearing habitat for these two species. Nonnative invasive species are an issue in this focus reach. Nonnative smallmouth bass were introduced from the Green River and are a special concern due to steadily increasing populations of this predator of native fish (Webber et al., 2013b). The states of Utah, Wyoming, and Colorado are taking aggressive actions to curb this threat to recovery efforts in the Upper Basin.

Flows are generally too erratic in this focus reach for consistent whitewater boating use, although high-quality Class I and Class II multi-day whitewater boating trips are supported by local outfitters, equipment rental, and shuttle services. Most river trips occur during spring runoff from mid-April to mid-June when flows range between 1,000 and 2,400 cfs. Taylor Draw Dam does not provide a large amount of water storage; therefore, flow below the dam is subject to seasonal river variations, and erratic flows downstream are mainly due to natural variability. Other recreational activities in the reach include angling for channel catfish in the Rangely, Colorado area.

White River above Mt. Fuel
Source: Tim Palmer

[7] See Basin Study, *Technical Report D*, Appendix D2 for more information on this analysis (Reclamation, 2012c).

FIGURE 5-4
Extent of the White River Focus Reach



5.6.2.2 Programs and Management

Existing programs on the White River Focus Reach are working to protect endangered fish species. The 1982 Biological Opinion for Taylor Draw Dam (U.S. Army Corps of Engineers, 1982) concludes that flow releases planned for the project will meet the requirements of the various life stages of the Colorado pikeminnow. Conservation measures for Colorado pikeminnow included in the Biological Opinion are monitoring spawning locations, determining the feasibility of passage around or through the dam, and habitat enhancement projects.

Like the Upper Colorado River Focus Reach, the White River Focus Reach is included in the Recovery Program. As part of this program, research and planning activities, such as the development of interim flow recommendations (Haines et al., 2004) and removal of smallmouth bass, have been undertaken for the White River.

5.6.2.3 Data Gaps and Scientific Uncertainty

As part of the Recovery Program, a White River Management Plan is being developed that will include draft flow recommendations and a programmatic biological opinion. The plan, currently under development by the USFWS, will build on preliminary seasonal flow recommendations for endangered fish species by using new biological information to develop the Recovery Program's year-round flow recommendation.

To obtain information about recreational flow needs on the White River, American Whitewater has conducted a study of stream flows and recreational quality. This research, completed in December 2014,[8] identifies the range of flows that support the full array of boating

[8] The final report from the flow survey will be available at: http://www.americanwhitewater.org/.

opportunities for the mainstem and tributaries of the White River and how changes in streamflows affect recreation quality. Other opportunities may also exist for improving an understanding of recreational needs on this reach. For example, data describing commercial and private floatboating visitation and an understanding of the factors, including flow, that influence visitation and use would assist in planning for improving flows for recreational uses. These data could also assist in quantifying the economic benefits of recreation in the area.

5.6.2.4 Summary

The White River Focus Reach includes important ecological and recreational attributes, including critical habitat for the Colorado pikeminnow and the razorback sucker, and boating and fishing opportunities. Concerns in the focus reach include invasive fish species, especially the smallmouth bass, and erratic flows that make whitewater rafting conditions unpredictable. Additional data collection to improve understanding of these issues is underway through the White River Management Plan and the recreational flow study by American Whitewater.

Colorado Pikeminnow
Source: Bureau of Reclamation

5.6.3 Bill Williams River Focus Reach

The Bill Williams River Focus Reach begins downstream from Alamo Dam in west-central Arizona and flows to the Colorado River confluence at Lake Havasu, a distance of about 45 miles. Along its course, this focus reach flows through BLM land as well as the 6,100-acre Bill Williams River National Wildlife Refuge (Refuge), the 8,400-acre Planet Ranch, and the 1,000-acre Lincoln Ranch (Figure 5-5). Streamflow in the focus reach is primarily controlled by operations at Alamo Dam, with the average of all annual flows below the dam at around 114 cfs; the average of the 10 percent lowest annual flows at 5 cfs; and the average of the 10 percent highest annual flows at 731 cfs (USGS, 2014a). Weather conditions along the focus reach are dry, with an average precipitation of 9 inches annually near Alamo Dam and less downstream (WRCC, 2014).

Bill Williams River near Planet Ranch, AZ
Source: Andrew Hautzinger

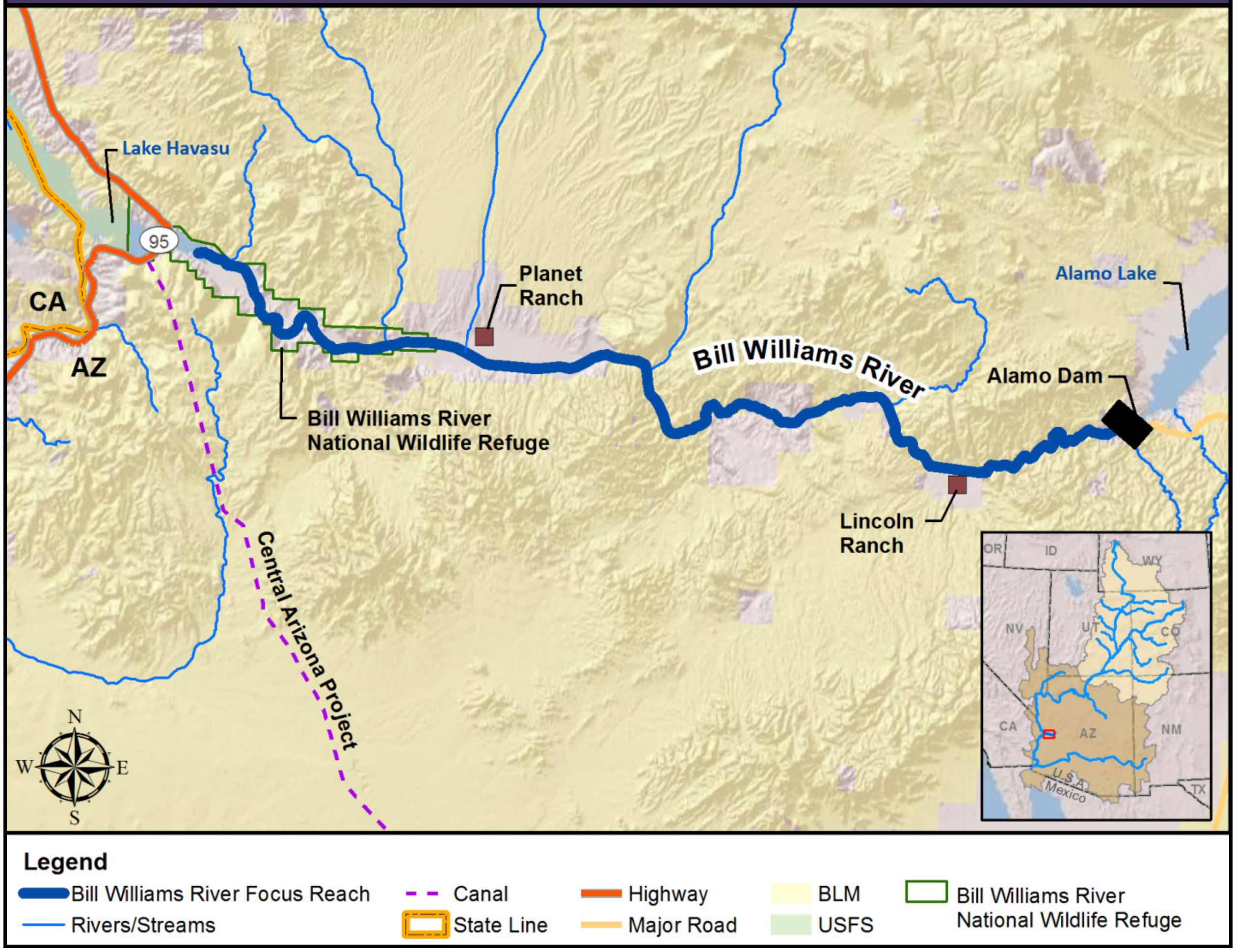
5.6.3.1 Environmental and Recreational Attributes

The Bill Williams River Focus Reach contains significant native woodland forests that provide habitat for many animal species. The Refuge, extending about 9 miles upstream from Lake Havasu, contains one of these important forests, which provides habitat for numerous plant and animal species. Because more than 348 bird species have been sighted in the Refuge, the Audubon Society has named the Bill Williams River an Important Bird Area. The ESA-listed southwestern willow flycatcher, Yuma clapper rail, and yellow-billed cuckoo are found along the focus reach.

The fish populations in this focus reach are dominated by nonnative and sport fish species, but bonytail populations (an ESA-listed species) are augmented by the USFWS and the LCR MSCP in the delta region of the Bill Williams River. Historically, the native longfin dace occurred throughout the river, and the endangered razorback sucker may also have inhabited the lower Bill Williams River (Lytle, 2006).

Sport fishing, hunting, wildlife watching, and camping are popular recreational activities along the focus reach and in the Refuge. Canoeing and kayaking are also present in the lower portions of the focus reach within some areas of the Refuge.

FIGURE 5-5
Extent of the Bill Williams River Focus Reach



5.6.3.2 Programs and Management

Overseen by the Bill Williams River Corridor Steering Committee (BWRCSC), the Bill Williams River is the focus of a concerted research and management effort that benefits many ecological and recreational values. The BWRCSC is a stakeholder group that includes regulatory agencies, non-governmental organizations (NGO), local jurisdictions, and scientists with management concerns and responsibilities related to the Bill Williams River (BWRCSC, 2014). This group works cooperatively to help fund and coordinate research and adaptive management of the river's resources.

The Sustainable Rivers Project, a national collaboration between TNC and the U.S. Army Corps of Engineers, is part of this cooperative effort. Through this project, flow releases from Alamo Dam are adjusted to meet natural resource objectives, including the enhancement of cottonwood-willow riparian areas and flood control.

The project incorporates adaptive management to facilitate the evaluation of management efforts and encourages making necessary adjustments to better achieve a balance between management objectives. As part of this effort, studies have been conducted to evaluate the relationship between flows below Alamo Dam and ecological and hydrological processes (for example, Shafroth et al., 2010; Simpson et al., 2013).

In addition to river-wide programs, other programs are in place on the focus reach to manage specific lands. Activities within the Refuge are governed by a Comprehensive Management Plan. The Refuge works with partners, including the BWRCSC, to help accomplish its wildlife management and conservation mission. The BLM also maintains a Resource Management Plan for its lands along the focus reach. Two segments of the Bill Williams River have been determined by BLM to be suitable for inclusion in the

National Wild and Scenic Rivers System due to their scenic, recreational, fish, and wildlife values.

5.6.3.3 Data Gaps and Scientific Uncertainty

Ongoing research is underway on the Bill Williams River Focus Reach to address flow-related ecological processes in an effort to improve flow management in the Bill Williams River. Numerous research activities sponsored by federal and state agencies, universities, and NGOs have been undertaken along this focus reach, such as impacts of managed floods on wildlife and habitat (Shafroth et al., 2010), hydrographic/geomorphic surveys (Wilcox et al., 2013), and research on fish, birds, and other wildlife habitats (Andersen and Shafroth, 2010). There is also interest in how pulse flow releases and turbidity could impact the Central Arizona Project water supply, which has intakes in the Bill Williams River arm of Lake Havasu (USGS, 2009).

To obtain information about recreational flow needs on the Bill Williams River Focus Reach, American Whitewater has conducted a study, completed in December 2014,[9] of streamflows and recreational quality. This research will help identify the range of flows that supports the full array of boating opportunities for the mainstem of the Bill Williams River, and identify opportunities to enhance recreational values in this focus reach.

Southwestern Willow Flycatcher
Source: Bureau of Reclamation

[9] The final report from the flow survey will be available at: http://www.americanwhitewater.org/.

5.6.3.4 Summary

The Bill Williams River Focus Reach contains important ecological and recreational values including significant native cottonwood-willow riparian forests that support many wildlife species. Recreational activities on the focus reach are largely related to enjoying these ecological assets. A flow-related research and management program is underway on this focus reach to protect and improve these ecological and recreational resources as is a recreational flow study by American Whitewater.

5.6.4 Henry's Fork Headwaters Focus Reach

The Henry's Fork Headwaters Focus Reach flows from Henry's Lake and headwater tributaries downstream into Flaming Gorge Reservoir. This focus reach includes about 400 perennial stream miles and drains a watershed that includes 520 square miles (Figure 5-6). Headwaters of the Henry's Fork Basin primarily originate in Utah on the north slopes of the Uinta Mountains at Henry's Fork Lake below King's Peak. It flows northeasterly through Utah, and then east across Wyoming before it dips down to reach Flaming Gorge Reservoir near Manila, Utah.

The water flowing through this focus reach is derived from runoff within the watershed. Hoop Lake and Beaver Meadows reservoirs provide water storage in the area, primarily for agriculture, and several perennial tributaries, including Poison Creek, Beaver Creek, and the Burnt Fork drain into Henry's Fork. The focus reach and its tributaries flow through BLM and U.S. Department of Agriculture land, Wyoming state land, and in Utah, through U.S. Forest Service land. In addition, some land is privately owned, including land used for ranching and agriculture. The average of all annual flows near Manila, Utah, is 80 cfs; the average of the 10 percent lowest annual flows is 24 cfs; and the average of the 10 percent highest annual flows is 186 cfs (USGS, 2014a). Annual precipitation in this area ranges from 7 to 14 inches (WRCC, 2014).

5.6.4.1 Environmental and Recreational Attributes

The Henry's Fork Headwaters Focus Reach provides habitat for many native fish species, including an important population of Colorado River cutthroat trout. This population is important because tributaries in the Henry's Fork watershed still contain 100 percent pure

Colorado River cutthroats. Studies have suggested that efforts should continue to restore and maintain populations of flannelmouth sucker and bluehead sucker in Henry's Fork, including sampling, monitoring, and removal of nonnatives (Gelwicks et al., 2009).

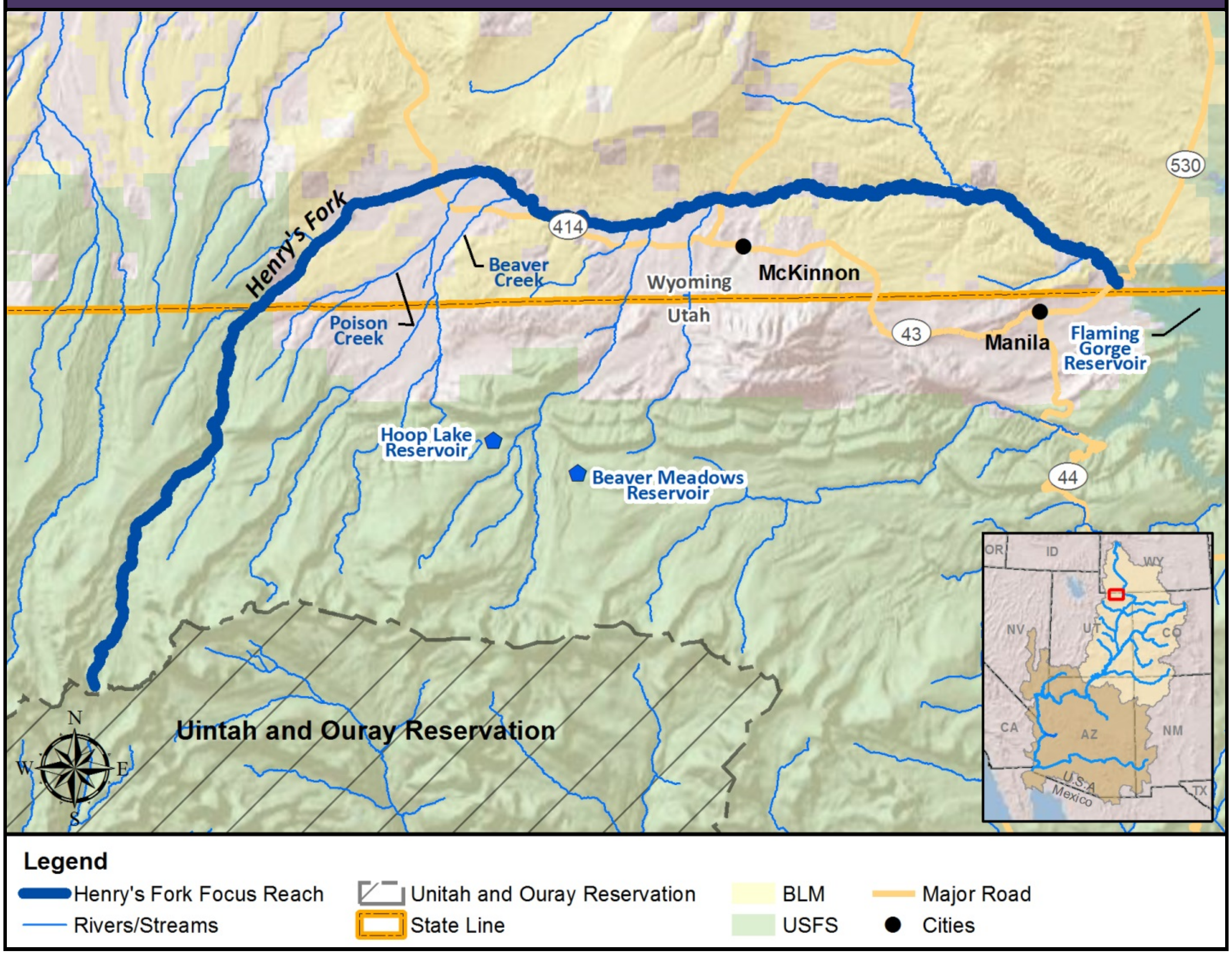
The Henry's Fork area also provides habitat for other wildlife species, including the yellow-billed cuckoo, greater sage grouse, whooping crane, and other bat, amphibian, and reptile species. This area also contains yearlong and winter range for moose, elk, pronghorn, and mule deer, and has been designated a Crucial Habitat Priority Area for the Wyoming Game and Fish Department. Cottonwood-willow riparian zones are found in tributary floodplains in this focus reach, as well as nonnative species including leafy spurge, tamarisk, and Russian olive.

Salinity is an important issue on this focus reach. On average, the Henry's Fork accumulates 37,200 tons of salt per year, of which 20,800 tons are associated with irrigation activities in the area. As a result, the lower portion of Henry's Fork was designated an NRCS Salinity Control Area in 2013 (NRCS, 2013). Recreational attributes along this focus reach include hiking trails and campsites maintained along the Henry's Fork and its tributaries. Many fishing opportunities exist in this focus reach and nearby high mountain lakes.

5.6.4.2 Programs and Management

The Henry's Fork drainage is managed for the benefit of Colorado River cutthroat trout through a conservation strategy developed by the wildlife agencies in Colorado, Utah, and Wyoming (Colorado River Cutthroat Trout Coordination Team, 2006). Issues addressed by the conservation strategy include isolation of upstream populations caused by land management practices.

FIGURE 5-6
Extent of the Henry's Fork Headwaters Focus Reach



Because of the combination of high fisheries values and salinity contributions within the Henry's Fork, the NRCS has created a partnership with Trout Unlimited to establish a watershed coordinator who will work with private landowners to improve irrigation efficiencies and increase crop yields, reduce labor and water requirements, and reduce salt loading in the drainage. The partnership will seek projects that improve water quality or enhance aquatic habitat for native fish species. For example, projects could work to reduce fish entrainment, promote fish passage, improve water availability, or augment riparian habitat for waterfowl and other associated species.

Beaver Creek, Wyoming
Source: Hillary Walrath

5.6.4.3 Data Gaps and Scientific Uncertainty

Opportunities to better understand ecological and recreational values in the Henry's Fork Headwaters Focus Reach include additional studies of the magnitude and duration of flows required to achieve ecological requirements and the connections between surface water, groundwater, and related biotic communities.

Other areas needing additional study are sediment budget and transport dynamics, nutrient cycling and decomposition, and the role of fire in the drainage. Physical inspections of areas where roads cross the headwater creeks would allow a better understanding of barriers to fish passage.

As part of Wyoming's consumptive use program, the State has been collecting continuous diversion and streamflow data in the drainage. The State also has remote sensing evapotranspiration data from 2011. The next step will be to install a weather station, which the State plans to do by 2015. A detailed understanding of the use within the focus reach is important when attempting to develop water resource management strategies and these data can be used for water management decisions by the watershed coordinator.

5.6.4.4 Summary

The Henry's Fork Headwaters Focus Reach has ecological attributes, such as important habitat for the Colorado River cutthroat trout and other wildlife species. Recreational opportunities in this focus reach are hiking, camping, and fishing. Concerns in the focus reach include invasive fish species, tamarisk stands, and high salinity levels. Additional data on ecological flow requirements, sediment transport, and the role of fire in drainage, as well as an inventory of fish barriers in the headwaters area, could improve the understanding of these issues.

River reaches face unique challenges associated with threatened and endangered species, threats from nonnative fish species, water quality concerns, understanding the relationship and effect of flows on ecological and recreational values, and the effect of invasive species removal and native vegetation restoration on flows.

5.7 Existing Ecological, Recreational, and Hydropower Programs

Recognizing that the existing programs in the focus reaches provide valuable resources for protecting or improving ecological and recreational resources and that other existing programs are in place across the Basin, the Workgroup reviewed existing programs in place beyond the focus reaches. To do this, the Workgroup first developed a list of 78 programs[10] operating in the Basin, in other parts of the U.S., and in international regions of interest that include mechanisms to benefit environmental and recreational

[10] The term "programs" refers to a variety of programs, laws, and stakeholder groups related to ecological, recreational, and hydropower resources. The list of 78 programs does not represent an exhaustive list, but rather a reasonable list appropriate for evaluating best practices and mechanisms based on the knowledge and experience of the Workgroup.

flows. Each program was then reviewed and analyzed to identify promising approaches and practices that could potentially be applied to the focus reaches or provide opportunities in other parts of the Basin. Finally, common approaches and practices were grouped and discussed by program type, including the mechanisms typically used by each program type.

Many programs and processes that use a range of effective mechanisms currently operate within the Basin to address ecological and recreational resources.

5.7.1 Programs and Mechanisms

The list of programs reviewed by the Workgroup is diverse in terms of both geographic location and approach to reaching program goals. Starting with the existing programs on the focus reaches, the list was developed by surveying existing programs in the remainder of the Basin, other parts of the U.S., and international regions of interest. Programs on the list involve a variety of organizations, including government agencies, environmental groups, power customer organizations, and local stakeholders. The survey of programs is neither exhaustive nor an endorsement of particular programs; rather, it illustrates the types of programs and mechanisms that have been implemented.

The Workgroup looked at many goals and approaches used by different programs. For example, the Workgroup reviewed several programs that do not have the specific goal of benefitting ecological and recreational flows but that do include activities that improve these flows as an ancillary benefit. These types of programs may provide an indirect benefit to ecological and recreational resources, while other programs directly benefit ecological and recreational resources consistent with the programs' specific goals.

As part of the review of this diverse group of programs, key mechanisms characterizing each program were identified. For the purpose of the review, mechanisms were defined as the activities and approaches used by a program to reach its goals. Although many types of programs were included in the review, a number of common mechanisms, goals, and resulting benefits were identified among them. Recognizing that many programs share common features, programs using similar mechanisms were grouped into five program types. The complete list of programs reviewed as part of this task is included in Appendix 5B, which also summarizes the goals and mechanisms of each program.

5.7.2 Description of Program Types

Project funding, water management enhancements, conservation and species recovery plans, water rights acquisitions, and stakeholder groups are the five program types identified by the Workgroup and are described below. The common mechanisms used by each are summarized, and an example of each program type is discussed.

5.7.2.1 Project Funding

Identifying a funding source is a key component of any management program. Several programs make funding available for projects that directly or indirectly provide environmental and recreational flow benefits. Some of these programs award competitive one-time grants, such as the conservation grants offered by the National Fish and Wildlife Foundation. WaterSMART Water and Energy Efficiency grants focus on water use efficiency, but they can also provide an indirect benefit to ecological and recreational resources by reducing the amount of water diverted for human use, thus potentially increasing instream flows. Other examples of funding programs are the Environmental Quality Incentives Program (EQIP), and the Regional Conservation Partnership Program implemented by the NRCS. These voluntary programs provide financial and technical assistance to agricultural producers to help plan and implement conservation practices that address natural resource concerns (NRCS, 2014). EQIP provides opportunities to improve soil, water, plant, animal, air, and related resources on agricultural land and non-industrial private forestland. EQIP practices indirectly benefit environmental and recreational flows by maintaining water in streams and rivers and also include improvements to irrigation efficiency such as installation of a sprinkler irrigation system or lining of irrigation ditches. EQIP is coordinated with funding from Reclamation and the states for the Colorado River Basin Salinity Control Program above Imperial Dam.

5.7.2.2 Water Management Enhancements

Many of the programs reviewed in Phase 1 can be considered water management enhancement programs. These programs provide direct or indirect environmental and recreational benefits through such mechanisms as flow routing (that is, ensuring water conserved or released from an upstream location is protected until it reaches a targeted downstream location), coordinated reservoir operations, or water banking. Coordinated reservoir operations, as part of a voluntary water management strategy, can orchestrate water release from different reservoirs to provide ecological and recreational benefits while simultaneously meeting other demands. The coordinated release from Alamo Dam on the Bill Williams River provides an example of such actions. Water banking provides an opportunity to meet water supply needs by allowing for the temporary storage of, and potential transfer of, water from one use to another, while possibly generating instream benefits along the way.

These programs require that both resource needs (including water delivery and hydropower needs) and environmental and recreational flows are met. Through careful coordination among stakeholders and perhaps incentivizing participation in the program, opportunities may exist to enhance environmental and recreational flows through water management alternatives.

For example, the Upper Colorado River Wild and Scenic Stakeholder Group is an independent, collaborative partnership that incorporates water management in their efforts to develop and implement a local alternative to Wild and Scenic River designation on the Upper Colorado River. The intent of the group is to balance permanent protection of the river's "outstandingly remarkable values," certainty for stakeholders, water project yield, and water use flexibility (Upper Colorado River Wild and Scenic Stakeholder Group, 2014). The group has developed a management plan that will protect river segments by relying on existing water management mechanisms. These mechanisms include instream flow water rights appropriated by the Colorado Water Conservation Board and the delivery of water through the protected river segments to senior downstream water users. They also include new cooperative efforts that can benefit the river without adversely impacting existing water users.

With careful consideration of the diverse water needs in the Basin, and recognizing that participation would be voluntary, the Workgroup identified water management enhancement as a potential opportunity to advance environmental and recreational benefits in the Basin.

5.7.2.3 Conservation and Species Recovery Plans

Conservation of plant and animal species and recovery of threatened and endangered species have resulted in programs that directly benefit the environment and indirectly benefit recreational values. These programs often include flow recommendations for the benefit of different species, most commonly fish. For example, the Upper Colorado Coordinated Reservoir Operations project works on a voluntary basis to provide suitable flows in the 15-mile reach of the Colorado River that includes important endangered native fish habitat (Recovery Program, 2006). Other mechanisms used by this type of program can include native fish population augmentation, fish passage improvements, eradication of nonnative species, and habitat preservation and restoration. These are all actions taken by the Recovery Program on the White River and Upper Colorado River focus reaches. Research and monitoring needed to establish fact-based recommendations are also often a feature of these programs.

Another example of this type of program in the Lower Basin is the LCR MSCP, which was created to balance the use of Colorado River water resources and hydropower production with conservation of native species and their habitats. The program contributes to the recovery of species currently listed under the ESA and focuses on habitat protection and creation to reduce the likelihood of additional species listings. Implemented over a 50-year period, the LCR MSCP accommodates current water diversions and power production and optimizes opportunities for future water and power development by providing ESA compliance through the implementation of the LCR MSCP Habitat Conservation Plan (Reclamation, 2013). The Habitat Conservation Plan calls for the creation of more than 8,100 acres of habitat for fish and wildlife species and the production of more than 1.2 million native fish to augment existing populations (Reclamation, 2004); more than 2,900 acres of native riparian habitat have been created to date (Reclamation, 2014). The plan will benefit at least 26 species, most of which are state or federally listed endangered, threatened, or sensitive species (Reclamation, 2004).

Species recovery plans typically focus on improvements to riparian and instream habitat for species of conservation interest. One common mechanism related to this type of program is a USFWS programmatic biological opinion. Activities associated with this program type can include flow recommendations, native fish augmentation, and habitat preservation or restoration.

The Recovery Program and its partners are recovering four species of endangered fish in the Upper Colorado River and its tributaries, while water use and development continues to meet human needs in compliance with interstate compacts and applicable federal and state laws. All water resources are managed in accordance with state water law, individual water rights, and interstate compacts to provide adequate instream flows for the endangered fish while meeting water needs of growing western communities. The Recovery Program provides ESA compliance for continued operation of federal water and power projects in accordance with project purposes through water leases and contracts, coordinated water releases from upstream reservoirs, efficiency improvements to irrigation systems, and re-operation of federal dams and reservoirs (Recovery Program, 2014a, 2014b).

While formal species conservation and recovery plans are typically within the purview of the USFWS, several mechanisms used by these programs, such as habitat conservation and eradication of nonnative species, do have promise as potential opportunities to advance environmental and recreational benefits in the Basin.

Sage Grouse with Chicks
Source: Hillary Walrath

5.7.2.4 Water Rights Acquisitions

The acquisition of water rights is a direct approach to providing environmental and recreational benefits. Programs that involve water rights acquisition are subject to state and federal legislation related to water rights and political and community sensitivity to water rights issues. Related programs can operate by purchasing or leasing water rights to establish instream flows for environmental and recreational benefits.

For example, the Utah Division of Water Resources now has authority to approve private water leases to benefit native trout. As part of this statute passed in 2010, private and non-profit groups can lease water for up to 10 years from willing landowners and irrigators if the water is dedicated for instream fishery benefits. By allowing these market-based transactions, this authority is expected to expand the scope of instream protection in Utah.

In another example, through its Instream Flow Program, the Colorado Water Conservation Board has the authority to appropriate instream flow water rights to preserve flows to a reasonable degree for the benefit of the natural environment (Colorado Water Conservation Board, 2014). Resources protected by this program include cold and warm water fisheries, riparian vegetation, unique hydrologic features, and critical habitat for threatened or endangered native fish. Through the Colorado Instream Flow Program, the State of Colorado has appropriated more than 1,800 water rights for instream flows, protecting more than 9,000 miles of streams. The State of Colorado also has entered into more than 25 transactions through its water acquisition program, under which it can purchase, lease, or accept donations of water rights for instream flow purposes, resulting in the protection of more than 900 cfs on various streams.

While the Colorado and Utah programs show that water acquisitions can provide ecological and recreational benefits, water rights legislation and political and community sensitivity pose significant challenges for implementation of water rights acquisition programs. Thus, while Phase 1 does not identify the acquisition of water rights as a specific opportunity, there may be future opportunities relating to water rights acquisitions that could improve ecological and recreational resources in the Basin.

5.7.2.5 Stakeholder Groups

Stakeholder groups throughout the Basin (such as the LCR MSCP, the Salinity Control Program, and GCDAMP) bring together representatives of groups that have an interest in the same river or watershed. These stakeholder groups employ a variety of mechanisms to pursue common goals. Often, process coordination and collaborative planning is a key aspect of stakeholder group activities that involve working together to address complex water management and natural resource conservation issues. Stakeholder groups may also participate in activities such as public outreach and education or research projects. Stakeholder groups may also build organizational capacity by forming partnerships with governmental entities and NGOs.

For example, the BWRCSC is a partnership effort that includes regulatory agencies, NGOs, local jurisdictions, and scientists with management concerns and responsibilities related to the Bill Williams River. The purpose of the BWRCSC is to facilitate and foster open communication and to promote a commitment to good science (BWRCSC, 2014). The committee's member agencies have funded and organized the majority of the research being conducted on this river system and have implemented an adaptive management approach based on the resulting data. Also, the Upper Colorado River Wild and Scenic Stakeholder Group represents a diverse range of interests in the Upper Basin such as recreation and conservation organizations, municipal water providers and county, state, and federal entities. The intent of the group is to balance permanent protection of the river's "outstandingly remarkable values," certainty for stakeholders, water project yield, and water use flexibility.

Coordination and collaboration among diverse stakeholders are key mechanisms that encourage the success of individual programs. Capacity-building can also help foster the establishment of new programs and ensure the continued success of well-established programs. Stakeholder coordination and capacity-building provide opportunities to advance environmental and recreational benefits in the Basin.

5.7.2.6 Summary

The Workgroup's review of existing programs resulted in the identification of program mechanisms that could provide additional opportunities on the focus reaches included in Phase 1 and potentially on other reaches across the Basin (Table 5-2). Because funding is an important element of any project, sustainable funding was identified as a good potential opportunity for improving ecological and recreational flows on focus reaches. Water management enhancement-related mechanisms such as water banking and flow routing were also recognized as important potential opportunities because of their ability to contribute to improving the amount and timing of instream flows. Though species conservation and recovery plans are typically under the jurisdiction of the USFWS, and are subject to specific regulations and situations, some mechanisms used by these programs could be considered as opportunities as part of Phase 1. Finally, key elements of many successful programs are a strong stakeholder base and the ability to build organizational capacity.

Cooperative, multi-interest/multi-party voluntary mechanisms have proven to be successful in protecting or improving ecological and recreational resources, and such mechanisms/programs normally benefit more from broader support among competing interests than mandatory, regulatory mechanisms do.

TABLE 5-2
Summary of Program Types and Mechanisms

Program Type	Mechanisms
Project Funding	• Competitive grants
	• Program grants
Water Management Enhancements	• Flow routing
	• Coordinated reservoir operations
	• Water banking
Conservation and Species Recovery Plans	• Species flow recommendations
	• Native fish population augmentation
	• Fish passage improvements
	• Habitat preservation and restoration
	• Research and monitoring
	• USFWS Programmatic Biological Opinion
Water Rights Acquisition	• Purchase of water rights
	• Lease of water rights
	• Establishment of instream flows
Stakeholder Groups	• Process coordination
	• Collaborative planning
	• Public outreach and education
	• Research projects
	• Creating synergies between multiple stakeholders

5.8 Opportunities and Challenges for Expanding Environmental and Recreational Flows Programs

Colorado River interests have taken meaningful steps to protect or improve ecological and recreational resources; however, opportunities exist to expand or implement new environmental and recreational flows programs in the context of addressing long-term imbalances in the Colorado River system. While assessing the future vulnerabilities at any particular reach, including the focus reaches, was beyond the scope of this effort, the Basin Study showed that all Basin resources are increasingly vulnerable, through time, due to increasing supply and demand imbalances.

Though meaningful and significant steps have been taken to protect or improve ecological and recreational resources, opportunities exist to expand or implement new environmental and recreational flow programs.

Options and strategies modeled as part of the Basin Study were shown to decrease resource vulnerabilities. The modeling demonstrated that options that were effective at reducing ecological and recreational vulnerabilities also reduced vulnerabilities of other resources. For this reason, the Workgroup explored opportunities that could provide ecological and recreational benefits in the Basin, while ideally benefitting other resources, or at the least, not harming other resources. The Workgroup was charged with describing the challenges associated with these opportunities based on their collective experience and identifying potential future actions that would advance the opportunities. Potential actions related to the identified opportunities were developed for further consideration by the Coordination Team or other parties interested in advancing environmental and recreational flow opportunities in the Basin. Potential actions may relate to a specific focus reach, but more often they are meant to apply more broadly to other reaches in the Basin if and when opportunities arise for implementation. The opportunities and the potential actions were developed to help meet the Workgroup's primary objective and to be consistent with the Workgroup's Guiding Principles. In many cases, the potential future actions suggest the modification of flows to help protect or improve ecological and recreational resources, but non-flow-related actions are also considered for several opportunities.

The Workgroup identified seven major opportunities to protect or improve ecological and recreational resources within the Basin. The Workgroup did not prioritize its opportunities or potential actions, therefore the ordering of the following list or lists in subsequent sections does not imply a prioritization.

1. Develop sources of sustainable funding for environmental and recreational flow projects.
2. Use structured and cooperative market-based mechanisms to provide benefits to multiple sectors including ecological and recreational resources.
3. Develop projects that incorporate watershed management.
4. Develop partnerships that achieve the protection or improvement of ecological and recreational resources through payment for protection of environmental attributes.
5. Investigate opportunities to use voluntary water management optimization for the protection or restoration of environmental and recreational flows.
6. Facilitate enhanced coordination among existing programs.
7. Support additional capacity-building for existing and new stakeholder coalitions.

The potential actions identified by the Workgroup include unique complexities and challenges that would necessitate further exploration and analysis to determine how each could be employed in the Basin.

In Phase 1 of the *Moving Forward* effort, the opportunities identified have been described in basic terms. Each of these options would include unique complexities and challenges, which would need further exploration and analysis to determine how each could be employed in the Basin. For example, additional scientific research may be necessary to understand effective and efficient mechanisms for implementation of possible options, quantify the benefits that may accrue, and reduce the likelihood of unintended harmful consequences. Models may need to be enhanced or developed to assist in analyzing the potential effects of any proposed actions, and data gaps may need to be filled before modeling activities can begin. Similarly, it will likely be necessary both to define metrics by which the success of any action can be evaluated and to implement monitoring programs necessary to collect the required information. The resources needed to fill these information gaps should be evaluated as potential actions are considered for implementation and the issues in the specific location will drive the selection of any of the potential actions. Additionally, it will be necessary to ensure that any potential action considered for implementation complies with existing laws and regulations. The following sections describe each opportunity in greater detail.

Future activities aimed at protecting or improving ecological and recreational resources should consider potential impacts to hydropower generation, when appropriate.

5.8.1 Opportunity 1: Develop sources of sustainable funding for environmental and recreational flow projects

5.8.1.1 Description

Sustainable funding ensures that sufficient and stable revenue streams are available over the long-term to accomplish a program's goals and to implement desired projects. Sustainable funding strategies consider all potential sources of available funding, including government sources, private donors, corporations, NGOs, and revenues generated by user fees and other funding arrangements. A mix of traditional sources of state, local, and federal funding, as well as innovative market-based approaches, such as payment for protection of environmental attributes (see Opportunity 4), are a key part of this financial strategy. Successful implementation of long-term solutions to meet competing water needs in the Basin could, in part, be dependent upon the ability of stakeholders to identify and use sustainable funding strategies.

5.8.1.2 Considerations

Procuring sustainable funding from traditional local, state, and federal sources is challenging because they are typically limited and competitive, and their availability is often contingent upon prevailing economic conditions, the political climate, and uncertainties associated with the appropriations process (Mathieu, 2011). Programs may need to procure funding from multiple and diverse sources because these inherently pose less risk from funding limitations (Mathieu, 2011; World Wildlife Fund, 2009). Cost-share programs that require matching funds provide one alternative to seeking a sole funding source. While user fees provide an attractive source of continuous, sustainable revenue, they can be challenging to assess due to public perception. Power revenues that support the Upper Basin Fund provide an invaluable funding source. Legal limitations are in place on the use of these funds, and significant diversions of funds for new purposes could diminish the capacity for the funded programs to be successful. For example, the Upper Basin Fund provides power revenues for base funding for the Recovery Program and the SJRRIP under specific legislative authority. Relying on funding from a single source or stakeholder group may be insufficient and unsustainable to achieve program goals.

The Deschutes River Basin in Central Oregon has implemented multiple innovative agricultural/ municipal conservation and efficiency programs to restore and protect instream flows for ESA-listed species and recreational purposes (Dickinson et al., 2011). The Deschutes River Conservancy has coordinated most of these efforts, provided funding for these projects, and has helped parties obtain funding from a variety of traditional and market-based sources.

5.8.1.3 Potential Actions

- Use cost share programs (for example, the U.S. Department of Agriculture's Regional Conservation Partnership Program) to help fund projects.
- Investigate the feasibility of constructing small hydropower facilities that do not unduly impact river connectivity or flows but that provide a variety of benefits and potentially generate funds to support environmental and recreational flow projects.
- Educate the public about the benefits of user fees and build political support for user fees, where appropriate.

5.8.2 Opportunity 2: Use structured and cooperative market-based mechanisms to provide benefits to multiple sectors including ecological and recreational resources

5.8.2.1 Description

Structured water markets can create additional flexibility in the management of water in the West by allowing water to be voluntarily moved from one use to another on at least a temporary, compensated basis. Cooperative efforts to establish water markets and associated market-based mechanisms for water transfers can help meet and shore up water supply needs during drought conditions by allowing for the temporary storage or transfer of water. Such market-based mechanisms also have the potential to produce concurrent environmental and recreational benefits, while meeting water supply needs, by increasing or maintaining flows when making voluntary, compensated water transfers and by timing releases to supplement flows when necessary. Market mechanisms can also be structured to incentivize water conservation activities in geographies where flow improvements are needed to provide environmental and recreational benefits.

5.8.2.2 Considerations

The approach for implementing cooperative, market-based mechanisms is dependent on many factors. These factors include geographic location; availability of facilities; availability of funding to structure a water market and to compensate water lessors and, possibly, impacted communities; the existence of mechanisms that enable the temporary or permanent transfer of entitlements; administrative and accounting obstacles; and the availability of willing water lessees. The overall goals of using water markets can vary widely. For example, market-based mechanisms could be established to protect critical reservoir elevations, mitigate shortages, or provide water to junior users who would be more vulnerable to shortages or ecological and recreational resources during times of need. The conserved water could become system water, could be tracked and stored (banked) for later use, or could be a combination of the two.

Several cooperative efforts across the Basin, such as the NRCS Regional Conservation Partnership Program, have the potential to implement mechanisms that could provide multiple benefits through reductions in consumptive use and could potentially utilize market-based mechanisms. Such reductions in consumptive use may have indirect benefits to ecological and recreational resources. Results of these efforts can be reviewed to help establish best practices for this approach.

Colorado River near Moab, Utah
Source: Nathan Fey

The Deschutes Water Alliance Water Bank was established to ensure adequate water supplies for agriculture while also making water available for Central Oregon cities and rivers. The water bank operates in a voluntary, market-based manner using existing Oregon water law statutes under a cooperative agreement. The Deschutes River Conservancy administers and staffs the water bank as well as a separate groundwater mitigation bank where temporary mitigation credits can be obtained through the Instream Leasing Program.

A mechanism known as Intentionally Created Surplus (ICS) is already being used to enhance water management flexibility in the Lower Basin and is an example of tracking and storing conserved water for future use by municipal and agricultural water users. The ICS mechanism encourages and accounts for augmentation and conservation of water supplies (for example, fallowing of land, lining of canals, and other system efficiency improvements) by allowing this water to be stored in Lake Mead for later use. The use of ICS is limited to water entitlement holders in the Lower Basin. A similar concept was included in Minute 319 to the 1944 Treaty with Mexico, known as Intentionally Created Mexican Allocation, which will permit Mexico to store water that may be taken later, under conditions established in the Minute. In the Upper Basin, the Colorado Water Bank Working Group[11] has been investigating the potential for

[11] Participants in the Colorado Water Bank Working Group include the Colorado River District, Southwest River District, Front Range Water Council, Colorado Water Conservation Board, and TNC.

cooperatively banking conserved water based on a voluntary and compensated approach to avoid or mitigate compact deficits. The Basin Study modeled a version of this concept that routed conserved water to a downstream storage facility. By assuming that mechanisms are in place to protect the water generated through upstream conservation, the routed water increased river flows in the Upper Basin. Additional information about the assumptions and construct of this concept are in the Basin Study, *Technical Report G* (Reclamation, 2012d).

Numerous challenges would need to be addressed before market-based mechanisms could successfully be implemented in many parts of the Basin. While any program must be in compliance with existing state and federal laws and regulations, including water rights, other challenges would be specific to the locations and objectives of particular programs and could include the potential need to negotiate interstate agreements, the availability of infrastructure, and the administration of a water bank. The effects to hydropower and the locally impacted community would also need to be considered. Finally, participation in any water market must be incentivized properly to encourage participation or to target the benefits, for example, to protect reservoir levels or improve river flows.

Carpenter Ranch on the Yampa River
Source: Taylor Hawes

5.8.2.3 Potential Actions

- Explore opportunities to increase water efficiencies that reduce consumptive use and identify where and how water savings could maintain or improve river flows.
- Explore different incentive mechanisms to facilitate a reduction in consumptive use, including who can provide incentives.
- Encourage federal support for federal agency flexibility that may be required for the operation of cooperative water markets and market-based approaches.
- Identify storage projects where environmental and recreational water could be beneficially banked.
- Identify and document flow routing concepts and tools that may be necessary to route water when transferring water using a water bank or other water market program and consider the potential flow benefits, especially in the Upper Basin.
- Continue to explore opportunities for use of cooperative, market-based approaches and banking throughout the Basin at various geographic scales.

5.8.3 Opportunity 3: Develop projects that incorporate watershed management

5.8.3.1 Description

The health of a river system is often determined by the health of the contributing watershed. Management of ecological and water resources at the watershed level allows consideration of the interconnectivity between soil, surface water, groundwater, plants, animals, and other ecosystem functions and resources. Watershed management also incorporates consideration of human water use, including recreational river flows, coldwater sport fisheries, water supply, water rights, and other related factors and natural resources.

The U.S. Forest Service has a number of programs that focus on management and restoration of forested headwaters. These include the national Watershed Condition Framework, the Legacy Roads and Trails Program, the Aquatic Organism Passage Program, the national Best Management Practices Program, and the Collaborative Forest Landscape Restoration Program.

The Watershed Condition Framework has classified the condition of 15,034 watersheds on national forest systems lands using a consistent nationwide process. Work is currently proceeding to develop and implement restoration plans in selected priority watersheds (U.S. Forest Service, 2014).

5.8.3.2 Considerations

A healthy Colorado River watershed may require multiple facets of watershed management. The environmental and recreational needs along the river are directly affected by how the resources and risks in the watershed are managed. For example, nonnative tamarisk trees may result in consumptive use of Colorado River water and overrun native riparian vegetation, but they also provide important habitat for the endangered southwestern willow flycatcher; therefore, any removal of tamarisk may need to be replaced by native vegetation. Another potential resource management strategy could be the use of weather modification to increase the overall water supply in the watershed, for example, through cloud seeding to increase snowfall in mountain regions (Ryan, 2005). Watershed management is most successful when stakeholders come together with common goals and interests. Often, small watershed groups partner with state and federal agencies to combine resources, expertise, and funding, such as the partnership on the Henry's Fork with the NRCS to reduce salinity levels in the river through land management activities. Such partnerships are often needed both to promote watershed health and to comply with laws and regulations. For example, dust accumulation on snow changes its reflectivity and results in earlier snowmelt and more evaporative moisture losses (Painter et al., 2007, 2010, and 2012; Skiles et al., 2012). Watershed groups may benefit from partnering with landowners or land management agencies to investigate options to control land-based dust sources. Active forest management that replaces mature forests that have been cleared by harvesting, fires, or insect infestations with replacement growth, anticipated to generate favorable runoff, can provide temporary increases in runoff yield, however these gains are generally not sustainable and can result in other negative ecological impacts (National Research Council, 2008).

As populations grow and the demand for water increases, protection of the Colorado River watershed will become more important. Identifying the resources to protect, fostering awareness of potential threats and risks, and making progress toward opportunities for protection and restoration must be collectively managed. Successful watershed management will be built upon collaboration among municipal, industrial, agricultural, environmental, and recreational stakeholders and local, state, and federal government partners.

Colorado River in Ruby Canyon
Source: Tim Palmer

5.8.3.3 Potential Actions

- Investigate opportunities to expand Henry's Fork salinity control program.
- Support tamarisk removal pilot project (for example, in the Upper Colorado River Focus Reach) to evaluate removal benefits.
- Investigate opportunities to decrease impacts of dust on snow.
- Continue to investigate opportunities to use weather modification to increase water availability in the watershed along with the efficacy of this approach.

5.8.4 Opportunity 4: Develop partnerships that achieve the protection or improvement of ecological and recreational resources through payment for protection of environmental attributes

5.8.4.1 Description

The Basin's ecosystems provide multiple societal benefits. These benefits include the purification of air and water, flood and climate regulation, maintenance of biodiversity, food production, regulation of groundwater and surface water flows, and scenic landscapes for passive and active recreation (Kaval, 2011). Payment for protecting environmental attributes makes use of financial and market-based mechanisms to engage landowners on a voluntary, compensated basis to protect valuable attributes that benefit society. This concept is sometimes referred to as payment for ecosystem services (Stanton et al., 2010). These types of programs may be voluntary in nature, and they may also be undertaken in response to an existing regulatory requirement, such as requirements to undertake mitigation activities under the Clean Water Act or ESA. Buyers under these types of programs are typically downstream users who gain value or benefits from protecting environmental attributes, or who choose to address a regulatory requirement by working with upstream water or land users. Sellers are typically upstream landowners or groups that receive some form of compensation to implement conservation or land management practices that protect the quality and continued availability of desired environmental attributes (Mathieu, 2011). An example of such a program in the Basin is the seven-state Colorado River Basin Salinity Control Forum, which coordinates and implements a program throughout the Basin that uses federal and non-federal funds to improve the efficiency of irrigation systems to reduce seepage and return flows that carry salinity back to the Colorado River system.

5.8.4.2 Considerations

Challenges can be anticipated when considering opportunities to pay for the protection of environmental attributes in the Basin. For example, sellers may not be motivated to participate unless they feel adequately compensated for implementing conservation measures on their land. Buyers may be unwilling to participate unless the benefits associated with the program can be adequately demonstrated and quantified or unless the program can guarantee that a payment will generate the desired regulatory "credit" toward mitigation requirements or other obligations. The financial needs of potential sellers and the efficacy of existing regulatory frameworks, if applicable, to motivate buyers must be assessed when considering these types of opportunities in the Basin. Due to the diversity of ecosystems and land use patterns within the Basin, the costs to implement conservation practices will likely be site-specific and differ between landowners. Thus, payment programs would need to consider the differing costs associated with implementing conservation practices across the Basin. These types of programs in the Basin would also need to implement adequate performance measures, monitoring, and enforcement to ensure that watershed improvements are occurring as a result of conservation or land management practices (Mathieu, 2011). Finally, flow-related programs will need to comply with state and federal laws related to the use and administration of water.

Angler on the Upper Colorado River near Kremmling, CO
Source: Taylor Hawes

In the Tualatin River in Oregon, a wastewater utility has established a program to pay for the protection of environmental attributes to reduce the temperature of the river and help preserve and restore fish and aquatic wildlife habitat. The utility pays upstream landowners to implement land management practices that reduce thermal loading to the river. The utility has planted trees and shrubs along 35 miles of stream banks in the Basin and has secured conservation easements to maintain healthy stream corridors. The plantings and easements also provide other valuable ecosystem services such as habitat expansion, carbon sequestration, erosion control, and filtration of runoff. These efforts have proven to be less expensive for the utility than the proposed alternative, which involves building infrastructure to cool the effluent from its wastewater treatment facilities.

5.8.4.3 Potential Actions

- Review existing conservation programs (both those with and without regulatory foundations) to identify opportunities to initiate new program elements that can create benefits for ecological and recreational resources, and, if applicable, create new opportunities for regulated entities to meet their existing regulatory obligations through these types of approaches. (This potential action does not propose seeking new regulation.)
- Invest in efficiency projects that can enhance environmental attributes.

5.8.5 Opportunity 5: Investigate opportunities to use voluntary water management optimization for the protection or restoration of environmental and recreational flows

5.8.5.1 Description

Voluntary water management enhancements can be used to improve streamflows to maintain, protect, restore, or enhance ecological and recreational resources in river systems. These enhancements may include re-timing diversions and reservoir releases. Releases from reservoirs not only can meet a water supply or power generation need, but also can, for example, provide needed minimum flows for fish species or whitewater boating, be used to flush excess accumulated sediment and rebuild gravel bars and beaches, and help restore riparian vegetation.

5.8.5.2 Considerations

A voluntary water management enhancement has challenges, such as ensuring that the increased flows reach the intended downstream beneficiary. Any modifications to reservoir operations must be within existing operating criteria and legal requirements for that reservoir and should not interfere directly or indirectly with authorized project purposes. Further, opportunities for ecological and environmental benefits through voluntary flow releases or other measures will be constrained by existing water allocation entitlements, water rights, biological and physical conditions, socioeconomic limitations, political and legal requirements, and the physical features of existing dams, such as design of outlet structures, that can severely limit the rate at which controlled water releases from a dam can be managed (Richter and Thomas, 2007)

5.8.5.3 Potential Actions

- Beginning with focus reaches, explore existing flexibility in timing of diversions or reservoir releases that could be used to voluntarily enhance environmental and recreational flows.
- Identify and document flow routing concepts and tools currently available in the Basin.

Colorado Parks and Wildlife, Denver Water, and Aurora Water of Colorado are currently coordinating flow releases from 11 Mile Dam on the upper South Platte River to improve the coldwater sport fishery below the dam and for dozens of downstream river miles. Colorado Parks and Wildlife fisheries biologists have been conducting research on the wild rainbow trout's natural reproduction processes. They realized that flow releases from the dam could be re-timed so that the trout eggs and emerging trout fry haved additional time to hatch and then find refuge before the releases occur. Initial findings show are that the re-timing of flows has a direct and significant correlation to the recent increase in fish populations.

5.8.6 Opportunity 6: Facilitate enhanced coordination among existing programs

5.8.6.1 Description

Water management in the Basin is complex, as are the challenges associated with balancing competing needs such as water delivery, hydropower generation, and environmental protection. To meet such challenges, various stakeholders have implemented programs and initiatives, each with their own set of goals, objectives, approaches, and processes, in various parts of the Basin. Facilitating additional cross-program coordination and information exchange are important strategies that can allow such programs to work together and focus resources to address Basin-wide challenges.

5.8.6.2 Considerations

Significant challenges faced by existing programs in the Basin often transcend program boundaries. For example, species recovery goals often require implementation of measures to improve ecological conditions at multiple locations in the Basin. The recent spread of invasive mussels poses significant risks to the Basin's water quality and ecology. Climate change is projected to have Basin-wide impacts on water supply, water quality, and ecology. Such challenges highlight the need for increased coordination between these programs to exchange information, compare findings, and collaborate on data collection and other efforts to establish and address Basin-wide priorities (Melis et al., 2010).

The Recovery Program and the SJRRIP have many common goals and objectives, including the conservation of native fish and wildlife as mandated by the ESA. These two programs provide an example of inter-program coordination, collaboration and information sharing in the Upper Basin. The SJRRIP was, in fact, modelled after the Recovery Program, and the two programs share many common monitoring, research, and restoration strategies. The two programs coordinate and collaborate in four main areas: (1) preparing and presenting annual briefings jointly to Congress (based on common authorizing legislation); (2) sharing funding for, and participating jointly in public outreach efforts; (3) jointly developing species recovery goals; and (4) sharing a hatchery facility. There is also considerable overlap of program participants, and informal information sharing that occurs between the two programs as a result. Exchange of information on research and management activities related to species conservation efforts also occurs in a more formal setting at the Annual Researchers' Meeting held between these two programs (Kantola, 2014).

Bonytail Chub
Source: Bureau of Reclamation

Conferences can provide a valuable venue to exchange information on scientific advances, best practices, and effective policies for protecting and restoring ecological and recreational resources. One example of the many conferences[12] that occur each year was co-hosted by Reclamation and the Utton Center at the University of New Mexico School of Law on the social and institutional aspects of river restoration in 2011. This conference brought together policy makers, academics, and practitioners to discuss opportunities and challenges associated with institutional arrangements for large-scale river restoration.

The conference resulted in recommendations from the Utton Center and conference organizers to Reclamation on next steps to improve institutional arrangements for river restoration programs (Utton Center, 2011). Conferences that focus on a particular geographic region, such as the Colorado River Basin Science and Resource Management Symposium (USGS, 2008), can also be beneficial because experts and local practitioners can exchange information on regionally focused topics.

The efficient dissemination of relevant state-of-the-art ecological and recreational research and data can help promote coordination between researchers and practitioners and promote implementation of best practices. For example, the University of Arizona has established a database (University of Arizona, 2014) of studies on flow needs and flow responses of riparian and aquatic species in Arizona. The database provides a central location for researchers or practitioners to use when working on environmental flow-related projects.

The data.gov website provides another central location for the sharing of data, including flow and other hydrologic variables. The efficient dissemination of such data can aid in the coordination between activities by ensuring all efforts are using the best and most recent data. Additionally, the Department of the Interior Landscape Conservation Cooperatives bring together federal, state, and local governments, tribes, NGOs, and university researchers to better integrate science and management to address climate change and other landscape scale issues. The Landscape Conservation Cooperatives help disseminate information, connect researchers, identify science gaps, and avoid duplicate research.

Effective engagement of parties across programs is essential for successful cross-program coordination but can be quite challenging. Cross-program collaborative efforts also need to focus on implementation and ensure that any proposals or recommendations are feasible and, most importantly, fundable (Melis et al., 2010).

5.8.6.3 Potential Actions

- Identify and promote additional cross-program collaboration for multi-benefit opportunities.
- Sponsor a conference, session at an existing conference, or workshop where water managers/practitioners would focus on, for example, identifying data gaps and presenting

[12] Available at: http://uttoncenter.unm.edu/projects/river-restoration.php.

state-of-the-art best practices relating to environmental and recreational flows.

5.8.7 Opportunity 7: Support additional capacity-building for existing and new stakeholder coalitions

5.8.7.1 Description

Capacity-building is about providing the tools and resources needed by watershed and environmental conservation organizations so that they can effectively develop and fulfill their missions and achieve their goals. Newly formed and established conservation organizations and coalitions can procure funding specifically for capacity-building from both private and public sources.

Southwest Colorado
Source: © Tracey Murray/The Nature Conservancy

5.8.7.2 Considerations

Watershed/conservation groups typically begin as volunteer-driven efforts that involve local citizens and landowners who have a vested interest in the water resources within their area. To build capacity, these groups need adequate tools, resources, and knowledge to build their organization, develop their leaders, and solicit volunteers. They also need to establish partnerships with governmental entities and NGOs, build capital resources, obtain funding, and make effective use of technical and specialized resources. The groups need support to procure office space and equipment, develop new projects, and remain current with new approaches and technologies. Such capacity-building activities are critical to an organization's continued success. In fact, community-based organizations have been most successful in protecting and/or improving watershed resources when they have sought and received strong support to build capacity (U.S. Environmental Protection Agency [EPA], 2003). Yet, procuring funding for capacity-building activities often remains a challenge for organizations; grant makers often prefer to fund more high-profile, on-the-ground restoration or conservation projects that yield more immediate and directly measurable results (Lutz, 2007).

5.8.7.3 Potential Actions

- Support the building of technical and organizational capacity in newly established watershed/conservation programs within the Basin (for example, by using Reclamation's program for Cooperative Watershed Management).
- Support continuing education programs in technical, organizational, and leadership development for established watershed/ conservation organizations in the Basin.

The North Fork River Improvement Association (NFRIA) is a coalition of landowners, environmental groups, farmers and ranchers, irrigation companies, outdoor groups, gravel mining companies, and concerned citizens that has benefited greatly from capacity-building support for its restoration and community education projects. NFRIA was originally formed in 1996 as a group of local landowners to investigate ways to reduce bank erosion on their properties along the North Fork of the Gunnison River in Colorado. By 2010, NFRIA had transformed into a vigorous watershed organization aimed at river restoration and water quality monitoring projects in the North Fork watershed. Funds for NFRIA's projects have been provided by the EPA, National Fish and Wildlife Foundation, National Forest Foundation, Colorado Water Conservation Board, and other state and federal agencies (EPA, 2003).

Opportunities exist to protect and improve ecological and recreational resources through programs designed to benefit other Basin resources.

5.9 Summary

The Basin Study, completed in 2012, considered flow- and water-dependent ecological systems, recreation, and hydropower generation through the inclusion of the Enhanced Environment water demand scenario, the adoption of metrics used to compare the performance of these resources across scenarios, and the modeling of a conceptual Upper Basin water bank. The metrics indicate all Basin resources are increasingly vulnerable, through time, due to increasing supply and demand imbalances, but options and strategies can reduce those vulnerabilities. Certain options and strategies that were effective at reducing ecological and recreational resource vulnerabilities also reduced other resource vulnerabilities.

The primary objective of the Workgroup was to build upon the Basin Study's assessment of environmental and recreational flows to identify ideas for potential future voluntary, non-regulatory solutions that protect or improve ecological and recreational resources while supporting other management goals to achieve integrated solutions that benefit multiple uses, both consumptive and non-consumptive, including hydropower. As issues pertaining to ecological and recreational resources are inherently site-specific (for example, necessary minimum flows to safely raft a river reach) but also broader in scale (for example, recovery of endangered species), the Workgroup took an approach that investigated both specific sites and the Basin more holistically.

To understand site-specific issues, the Workgroup selected four focus reaches using an analytical and consensus-based process in the Basin and completed an assessment of each focus reach. These assessments helped the Workgroup understand current conditions, ecological and recreational issues, and scientific uncertainties at a site-specific scale. The reaches selected by the Workgroup were as follows:

- Mainstem of the Colorado River between the confluence with the Gunnison River and the confluence with the Green River
- White River between Taylor Draw Dam and the confluence with the Green River
- Bill Williams River from Alamo Dam to the confluence with the Colorado River at Lake Havasu
- Henry's Fork headwaters from Henry's Lake and headwater tributaries downstream into Flaming Gorge Reservoir.

Though each reach faces unique challenges, some commonalities exist among the reaches assessed by the Workgroup. The recovery of endangered species, the threat that nonnative fish pose to the recovery of endangered and other native species, and water quality concerns are common issues among the four focus reaches. In addition, common scientific uncertainties relate to understanding the relationship between flow and ecological and recreational resources, for example, refining an understanding of flow requirements for fish species. Other uncertainties relate to the effect of invasive species removal and native vegetation restoration on flows.

A survey of 78 existing programs helped provide useful examples of existing mechanisms for the protection or restoration of ecological and recreational resources. The Workgroup identified five program types to broadly categorize the existing programs: project funding, water management enhancements, conservation species recovery plans, water rights acquisition, and stakeholder groups. Programs of each type are currently operating in the Basin. Understanding the existing mechanisms used by each program type helped the Workgroup identify future opportunities.

The Workgroup identified seven major opportunities to advance environmental and recreational benefits within the Basin:

1. Develop sources of sustainable funding for environmental and recreational flow projects.
2. Use structured and cooperative market-based mechanisms to provide benefits to multiple sectors, including ecological and recreational resources.
3. Develop projects that incorporate watershed management.
4. Develop partnerships that achieve the protection or improvement of ecological and recreational resources through payment for protection of environmental attributes.
5. Investigate opportunities to use voluntary water management optimization for the protection or restoration of environmental and recreational flows.
6. Facilitate enhanced coordination among existing programs.
7. Support additional capacity-building for existing and new stakeholder coalitions.

Each opportunity includes several ideas for potential future actions that can be considered by the Coordination Team for potential later phases of the *Moving Forward* effort, undertaken by others in the Basin through different processes, or undertaken on an ad hoc basis with willing funding partners and interested stakeholders. The undertaking of any of these activities has the potential to help protect or improve ecological resources in the Basin to varying degrees. However, these potential future actions may require additional information before they are implementable, including additional scientific research, tool and model development, feasibility level analyses, and the development of monitoring plans. Also, there should be recognition of the complexities associated with ensuring actions have the intended effects and of the tradeoffs that may exist between these actions and effects on other Basin resources.

5.10 References

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Appendix 5A
Focus Reach Selection Process

May 2015

5A | Focus Reach Selection Process

Because issues pertaining to environmental and recreational resources are inherently site-specific (for example, necessary minimum flows to safely raft a river reach) but can also be broader in scale (for example, the recovery of endangered species), the Environmental and Recreational Flows Workgroup (Workgroup) approach investigated both specific sites and the Colorado River Basin (Basin) more holistically. Because detailed assessments of all river reaches in the Basin were not feasible, the Workgroup decided to select several "focus reaches" to understand specific ecological and recreational issues and the programs already in place to help address these issues. A customized focus reach selection process was undertaken to help the Workgroup come to a consensus on several reaches to use as focus reaches.[1] For the river reach selection process, the Workgroup completed four main steps:

1. Developed a list of rivers in the Upper and Lower Basins that could be suitable for Phase 1 of the *Moving Forward* effort and divided them into reaches.
2. Identified five goals for reach selection and developed specific criteria supporting each goal.
3. Characterized each river reach on the initial list based on the selection criteria.
4. Used the reach characterizations to narrow the initial list of reaches to the final list of focus reaches.

The following sections provide further explanation of each step.

5A.1 River Reach Identification

The process of selecting focus reaches was initiated by developing a list of major rivers and tributaries in the Upper and Lower Basins. A few rivers (for example, the Colorado River through the Grand Canyon) were not included on this list because of existing ongoing planning or legal processes. Table 5A-1 presents the list of rivers considered in the focus reach selection process.

Each river shown in Table 5A-1 was divided into reaches based on the following attributes:

- Major river/tributary confluences
- Breakpoints between warmwater and coldwater fisheries
- Locations of dams, major diversions, and fish passage or barrier structures
- Major recreation reaches (such as whitewater boating and high-use areas)
- Exclusion of the impounded waters located upstream of dams

The delineation process resulted in an initial list of 37 river reaches to be considered in the reach selection process, including 29 reaches in the Upper Basin and eight reaches in the Lower Basin.

Headwater river reaches were defined as a separate category to represent river reaches that are in the uppermost parts of a watershed and typically above any dams or other major water control facilities. Five headwater areas were considered with the goal of selecting one as an additional focus reach.

Table 5A-2 lists the river and headwater reaches delineated for each river. Figure 5A-1 shows the locations of the reaches.

[1] The focus reach selection process was undertaken to assist with the specific Workgroup goals and may not be appropriate for use in other settings.

TABLE 5A-1
Initial List of Rivers

Upper Basin Rivers		Lower Basin Rivers
Colorado mainstem above Lake Powell	San Miguel	Virgin
Gunnison	Duchesne	Colorado mainstem below Lake Mead in the U.S.
Dolores	San Rafael	Bill Williams
Green	Dirty Devil	
Yampa	Escalante	
Little Snake	San Juan	
White	Paria	

5A.2 River Reach Selection Criteria

The Workgroup aimed to select focus reaches that would represent a diverse range of river reaches in terms of current river health, recreational value, geographic location, regional significance, and potential tradeoffs with other water uses. To accomplish this, reach selection criteria (Figure 5A-2 and Table 5A-3) were developed based on five distinct goals in order to narrow down the initial list (Table 5A-2) to two to six focus reaches. The following five goals were used to develop the selection criteria:

1. Protect or improve river ecological health.
2. Protect or improve river recreational experiences.
3. Limit or manage tradeoffs with other water uses.
4. Consider geographic location and regional importance.
5. Consider constraints limiting flexibility of solutions.

Criteria were developed to support each of the five selection goals, as shown on Figure 5A-2. Each criterion was defined and a rating was determined according to three characterization categories: A, B, or C. Table 5A-3 lists the River Reach Selection Criteria, along with the basis for rating and definitions of A, B, and C categories for each.

5A.3 River Reach Characterization

River reach characterization for each criterion was based on a series of information-gathering efforts. First, readily quantitative data, when available, were compiled for the criterion by reach. For criteria having no readily available data, Workgroup members with expertise in the area assigned ratings based on professional knowledge. Characterization ratings of A, B, or C were assigned based on the available information and Workgroup consensus. The sections below describe the quantitative and qualitative characterization processes in more detail. The headwater reaches were not characterized because a manageable number of reaches from which to select were already available.

5A.3.1 Quantitative Criteria Characterization

Readily available quantitative data were collected, compiled, and used to characterize the reaches as appropriate. The quantitative methods used to characterize the reaches for each applicable criterion are described below.

Criterion 1A: Native Fish Species of Conservation Interest

Native fish data for each reach was collected from several sources. Lower Colorado River Multi-Species Conservation Program (LCR MSCP) data

TABLE 5A-2
River Reach Delineations

			Reach Number (downstream limit of the reach[1])			
No.	**River**	**River Code**	**1**	**2**	**3**	**4**
Upper Basin						
1	Green River	GRR	Colorado River Confluence	White River Confluence	Yampa River	Flaming Gorge Dam (to TP at Fontenelle Dam)
2	Yampa	YAR	Green River Confluence	Little Snake Confluence (to TP at Stagecoach Dam)		
3	Little Snake	LSR	Yampa River Confluence (to TP at Battle Creek, Wyoming)			
4	Duchesne	DUR	Green River Confluence (to TP at Starvation Dam)			
5	White	WHR	Green River Confluence	Taylor Draw Dam (to TP at Confluence of N and S Forks)		
6	San Rafael	SRR	Green River Confluence (to TP at Ferron Creek)			
7	Gunnison	GUR	Colorado River Confluence	North Fork Confluence (to TP1 at Crystal Dam)	Blue Mesa Dam	East River and Taylor River Confluence (to TP2 at Taylor Dam)
8	Dolores	DOR	Colorado River Confluence	San Miguel Confluence	McPhee Dam (to TP at West Fork of Dolores)	
9	San Miguel	SMR	Dolores River Confluence (to TP at Specie Creek)			
10	Dirty Devil	DDR	Lake Powell (to TP at Confluence of N and S Forks)			
11	Escalante	ESR	Lake Powell (to TP at Sweetwater Creek)			
12	San Juan	SJR	Lake Powell	Animas River Confluence	Navajo Dam (to TP at West Fork Confluence)	

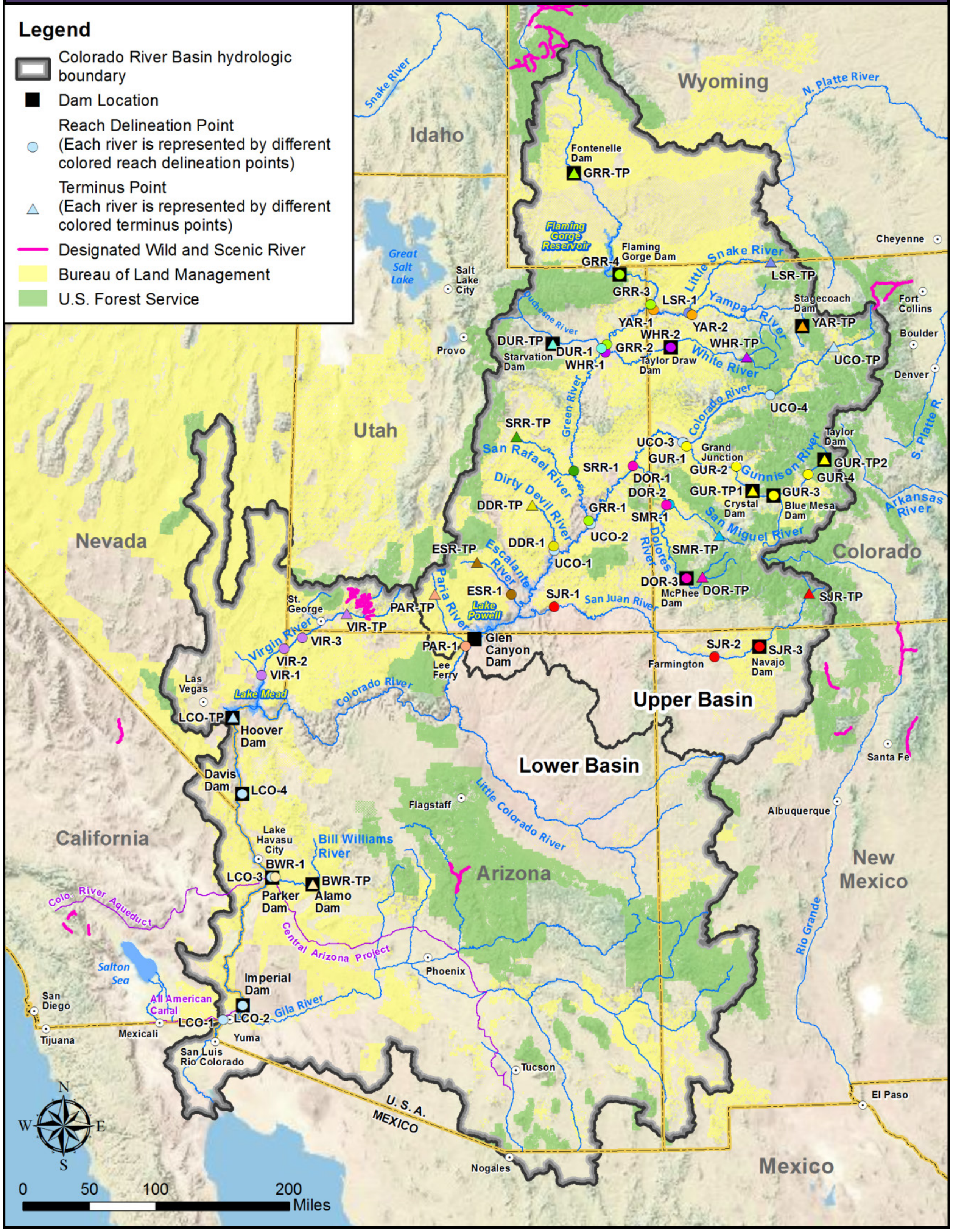
TABLE 5A-2
River Reach Delineations

			Reach Number (downstream limit of the reach[1])			
No.	**River**	**River Code**	**1**	**2**	**3**	**4**
13	Paria River	PAR	Colorado River Confluence (to TP at Sheep Creek)			
14	Upper CO Mainstem above Lake Powell	UCO	Lake Powell	Green River Confluence	Gunnison River Confluence	Roaring Fork River (to TP at Blue River Confluence)
15	Virgin	VIR	Lake Mead	Mesquite Diversion	Narrows Fish Control Structure (to TP at Quail Creek Diversion)	
16	Bill Williams	BWR	Lake Havasu (to TP at Alamo Dam)			
17	Lower CO Mainstem to NIB	LCO	NIB with Mexico	Imperial Dam	Parker Dam	Davis Dam (to TP at Hoover Dam)
18	Henry's Fork					
19	Muddy Creek (Black Fork)					
20	Little Snake					
21	Escalante					
22	Upper Muddy Creek					

Colorado (CO); North (N); Northerly International Boundary (NIB); South (S); Terminus Point (TP)

[1] Reaches do not include the impounded waters located upstream of dams.

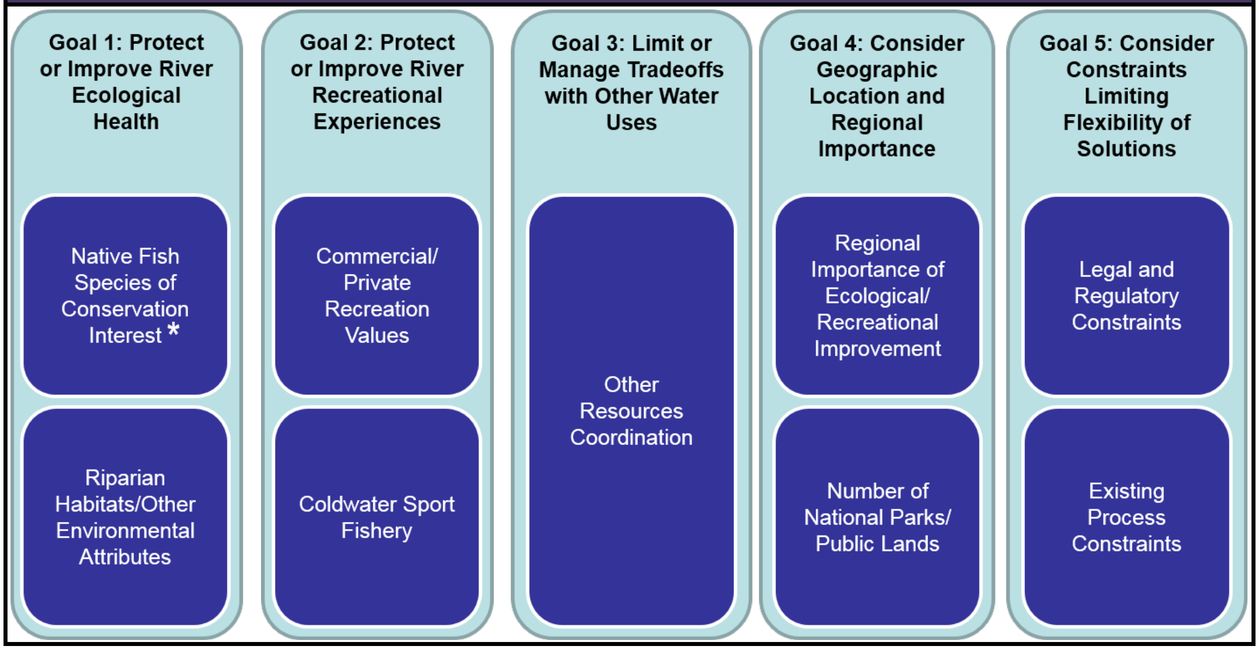
FIGURE 5A-1
River Reach Delineations



Notes:

1. Reaches do not include the impounded waters located upstream of dams.
2. Similar to the Basin Study, the scope of the *Moving Forward* effort is limited to the portion of the Basin within the U.S.

FIGURE 5A-2
River Reach Selection Goals and Criteria



* The phrase "of conservation interest" was developed by the Workgroup to be a general term, and is not intended to correspond to specific regulatory or conservation definitions.

include fish species ranges, and the number of species within a given reach was counted to obtain the number of fish species used for characterization for the Lower Basin mainstem reaches (LCR MSCP, 2013b). The number of fish species for the Bill Williams River was obtained from Shafroth and Beauchamp (2006). The Nature Conservancy (TNC) (2009a) data are expressed as a range of values for the number of "imperiled" species, so the highest number in the range was used. The numbers from TNC (2009a) were combined with other sources to result in a total number of fish species of conservation interest for each reach. A characterization of A was assigned for reaches with no fish species of conservation interest, a B was assigned for reaches with one to three fish species of conservation interest, and a C was assigned for reaches with four or more fish species of conservation interest.

Criterion 1B: Riparian Habitats and Other Environmental Attributes

Reach characterization for this criterion was based on a "riparian index" that was calculated based on two factors: the number of non-fish species of conservation interest present on the reach (TNC, 2009b; LCR MSCP 2013a) and the relative amount of woody wetlands and tamarisk estimated to be present on a reach.

The quality of riparian vegetation was estimated on each reach by estimating both the amount of tamarisk present on the reach and the amount of woody wetlands. The approximate coverage of tamarisk was estimated based on Tamarisk Coalition data (2009). Woody wetlands coverage was estimated using data from the National Land Cover Database 2006 (Fry et al., 2011). For both tamarisk and woody wetlands coverage, the following designations were used: dense, partial, sparse or none. Based on these designations, a reach scored 0 or 1 for riparian vegetation based on the combinations shown in Table 5A-4.

The riparian vegetation score and the number of non-fish species of conservation concern were totaled to calculate the riparian index. A characterization of A was assigned for reaches with a riparian index of 0, a B was assigned for reaches with a riparian index of 1-2, and a C was assigned for reaches with a riparian index of 3 or more.

TABLE 5A-3
River Reach Selection Criteria

Criterion No.	Criterion Title	Selection Criteria	Definition of Criterion	Basis for Rating: Data or Lead(s) for Qualitative Rating[1]	Characterization Rating		
					A	B	C
Goal 1: Protect or Improve River Ecological Health							
1A	Native Fish Species of Conservation Interest[2]	Are fish species of conservation interest located in this reach?	Reaches with fish species of conservation interest are considered to be of higher priority for protection or improvement and thus are characterized more favorably than those that have no species of concern. Such species are expected to likely benefit from any potential solutions to improve ecological conditions in this reach.	Number of native fish species of conservation interest – threatened, endangered, species of concern, and other related categorizations.	0 fish species	1 to 3 fish species	4 or more fish species
1B	Riparian Habitats and Other Environ-mental Attributes	Is a native riparian vegetation and riparian-dependent native species of conservation interest located in this reach or other environmental attributes that are unique or important that are not captured in criterion 1A for native fish located in this reach?	Reaches with native riparian vegetation and associated riparian-dependent native species, including those with unique or important environmental attributes (e.g., high biodiversity of river-dependent species) that are not captured in criterion 1A are considered to be of higher priority for protection or improvement and thus are assigned higher scores than those that do not have such resources. Such species or environmental attributes are expected to likely benefit from any potential solutions to improve ecological conditions in this reach. Reaches with invasive plants such as tamarisk are also assigned lower scores than reaches with no invasive vegetation.	A riparian index scoring system was developed based on presence and density of tamarisk and associated riparian vegetation, as well as counts of associated riparian-dependent non-fish species of conservation interest.[2]	Poor riparian habitat/ other important attributes (Riparian Index of 0)	Moderate riparian habitat/ other important attributes (Riparian Index of 1-2)	Good riparian habitat/ other important attributes (Riparian Index of 3 or more)

TABLE 5A-3
River Reach Selection Criteria

Criterion No.	Criterion Title	Selection Criteria	Definition of Criterion	Basis for Rating: Data or Lead(s) for Qualitative Rating[1]	Characterization Rating		
					A	B	C
Goal 2: Protect or Improve River Recreational Experiences							
2A	Commercial/ Private Recreation Values	Are commercial/ private recreational values associated with this reach?	Commercial/private recreation is an indicator of the level of use and economic impact. Managing flows that support recreational uses is a high priority.	Based on known popularity of the reach. Recreation use can include the following: • Whitewater boating • Float fishing • Other related activities	Low popularity/ use	Moderate popularity/ use	High popularity/ use
2B	Coldwater Sport Fishery	Is a significant coldwater sport fishery in this reach?	Reaches with significant coldwater sport fisheries are considered to be of higher priority for protection or improvement and thus are assigned higher scores than those that have no coldwater sport fish populations. Coldwater sport fishery species are expected to likely benefit from any potential solutions to improve ecological conditions in this reach. It is realized that coldwater sport fishery and native fishery habitats may conflict.	Based on: • General knowledge of the river reaches • Coordination and discussions with Trout Unlimited staff • Research on guide, angler, and state agency websites, including reports and fish/use data	Low quality/ popularity	Moderate quality/ popularity	High quality/ popularity
Goal 3: Limit or Manage Tradeoffs with Other Water Uses							
3A	Other Resources Coordination	How many resources, other than recreational and ecological (e.g., lake elevations, hydropower, etc.) are associated with this reach?	Managing tradeoffs with other water users is a key factor when considering which potential solutions are practical for implementation. As the number of users, stakeholders, and other resources increase, so does the complexity of implementing solutions.	Number of other resources for coordination and magnitude of use: • Hydropower • Regional municipal water supply diversion/intake • Regional agricultural water supply intake/diversion • Energy	Significant other resources	Moderate other resources	Minimal other resources

TABLE 5A-3
River Reach Selection Criteria

Criterion No.	Criterion Title	Selection Criteria	Definition of Criterion	Basis for Rating: Data or Lead(s) for Qualitative Rating[1]	Characterization Rating		
					A	B	C
4A	Ecological/ Recreational Improvement: Regional Importance	Would improvements in flow or non-flow ecological or recreational conditions in this reach benefit more than one reach (as opposed to only one reach)?	If improvement in a particular reach could benefit multiple other reaches, then that reach would have greater potential regional ecological or recreational significance and would have a higher priority compared to isolated reaches where improvements may have only local benefits. For example, dams are considered operational control points related to flow management. If reoperation at one dam can benefit multiple reaches in addition to the targeted reach in question, that reach will score higher.	Reach count between upstream and downstream dams (dams are considered to be operational control points). Count all reaches starting from first dam upstream of target reach to first dam downstream of target reach. If more than one dam is upstream (on any tributary), include separate count starting from each. If no dam upstream, count = 0.	No upstream dam to allow flow control	1 to 2 connected reaches between dams	3 or more connected reaches between dams
4B	Number of National Parks/Public Lands	How many national park lands or other significant public land values are adjacent to the reach?	The number of national parks or other significant lands represent the existing value of the land. These lands are considered higher priority for protection or improvement through potential solutions.	Count one point for each of the following: • National or State Park • National or State Refuge • Wilderness Area • Reach considered Eligible for Wild and Scenic Designation	None	1 to 2	3 or more

TABLE 5A-3
River Reach Selection Criteria

Criterion No.	Criterion Title	Selection Criteria	Definition of Criterion	Basis for Rating: Data or Lead(s) for Qualitative Rating[1]	Characterization Rating A	B	C
Goal 5: Consider Constraints Limiting Flexibility of Solutions							
5A	Legal and Regulatory Constraints	Do legal or regulatory constraints in this reach leave sufficient flexibility for development of alternate solutions?	Legal or regulatory constraints may limit the flexibility or practicality of potential solutions. Regulatory constraints could be associated with existing or future federal, state, or significant local permits, Records of Decision, hydropower constraints, private land ownership, pending litigation, etc.	Significant legal or regulatory constraints, which may include: • Settled court cases • Ongoing litigation • Regulated flow management programs • Other related items	Significant legal or regulatory constraints	Moderate legal or regulatory constraints	Minimal legal or regulatory constraints
5B	Existing Process Constraints	Are existing process constraints related to this reach that could inhibit the development of solutions?	Process constraints may limit the flexibility or practicality of potential solutions. Process constraints could be associated with existing or future flow management programs, species recovery programs, or similar commitments or programs.	Process constraints, which may include: • Recreation programs • Recovery programs (e.g., species, habitat, ecology, etc.) • Other related items	Significant process constraints	Moderate process constraints	Minimal process constraints

[1] Quantitative and qualitative characterization methodologies for each criterion are described in more detail in Section 5A.3.
[2] The phrase “of conservation interest” was developed by the Workgroup to be a general term and is not intended to correspond to specific regulatory or conservation definitions.

TABLE 5A-4
Designations Used for Tamarisk and Woody Wetlands

Tamarisk Designation	Woody Wetlands Designation	Riparian Vegetation Score (0/1)
Dense	Dense	1
Dense	Partial/sparse	0
Partial/sparse/none	Dense/partial/sparse	1
Any	None	0

Criterion 4A: Ecological/Recreational Improvement: Regional Importance

Characterization for this criterion was based on the number of reaches that would be affected if flows were modified on a given reach. To determine this, the number of contiguous reaches, based on the reach delineation of this process, was counted from the first dam upstream of the target reach to the first dam downstream of the target reach. Only the dams included in Figure 5A-1 were used, which does not account for other, smaller dams. If more than one dam was located upstream from a reach, a separate count was included starting from each, and the highest total was used for the characterization. For reaches with no dam located upstream, the count was 0. A characterization of A was assigned for reaches with a count of 0, a B was assigned for reaches with a count of 1 to 2, and a C was assigned for reaches with a count of 3 or more contiguous reaches between dams.

Criterion 4B: Number of National Parks/Public Lands

This criterion was scored by summing the total number of surrounding National Parks and wilderness areas along the reach (National Park Service, 2013; University of Montana, 2013). If the reach has been designated eligible as a Wild and Scenic River[2], then the total score was increased by one (American Whitewater, 2013; National Wild and Scenic Rivers System, 2013). A characterization of A was assigned for reaches with a count of 0, a B was assigned for reaches with a count of 1 to 2, and a C was assigned for reaches with a count of 3 or more.

[2] The source includes only lands managed by the U.S. Forest Service that have been designated eligible as a Wild and Scenic River; lands managed by the U.S. Bureau of Land Management were not included.

5A.3.2 Qualitative and Consensus-Based Criteria Characterization

After the quantitative data were collected and reviewed, it was determined that sufficient data were not available for some criteria or that collection of the data would require a level of effort that could not be completed during Phase 1 of the *Moving Forward* effort. For the criteria listed below, the Workgroup determined consensus-based characterizations for the river reaches based on their expert knowledge and judgment. Criterion 2B used information prepared by Colorado, New Mexico, Utah, and Arizona; this information includes the Colorado Fishing Network (2014), Colorado Parks and Wildlife (2014), the Utah Division of Wildlife Resources (2014), New Mexico Game and Fish (Castell, 2009), and the Arizona Game and Fish Department (2008), but was ultimately a qualitative characterization based on Workgroup members' knowledge.

- Criterion 2A: Commercial/Private Recreation Values
- Criterion 2B: Coldwater Sport Fishery
- Criterion 3A: Other Resources Coordination
- Criterion 5A: Legal and Regulatory Constraints
- Criterion 5B: Existing Process Constraints

5A.4 River Reach Selection

After the river reach characterization was complete, focus reaches were selected using a two-step process. First, a filtering process, based on the characterizations, was used to narrow the initial list of reaches. The Workgroup then selected the focus reaches from the narrowed list to be assessed during Phase 1 of the *Moving Forward* effort. The headwater reaches were not filtered and the focus reach was selected solely using the qualitative selection step.

5A.4.1 Step 1: Reach Selection Process

To identify focus reaches, a filtering process was used that identified a "decision point" for each criterion above which a reach would be retained and below which it would be dropped, for that criterion. For example, a filter could be applied that retained all reaches with a rating of A or B in the "native fish species of conservation interest" criteria.

Four filtering scenarios were developed to represent a range of decision points that reflected different Workgroup viewpoints. The scenarios used the following decision points:

- Scenario 1: For each criterion, retain only reaches that scored a C.
- Scenario 2: For each criterion, retain only reaches that scored a C, except for criterion 3A and criterion 5B, where only reaches that scored an A are retained.
- Scenario 3: For each criterion, retain only reaches that scored a B or a C.
- Scenario 4: For each criterion, retain only reaches that scored a B or a C, except criterion 3A and criterion 5B, where only reaches that scored an A are retained.

Once filtering was completed, the total number of criteria for which a reach had been retained was summed for each scenario, and an average across all scenarios was calculated. For example, if a reach was retained for 4 criteria in the first scenario, 5 criteria in the second scenario, and 6 criteria in the third and fourth scenarios, its average score would be 5.25. The reaches were then ranked in order of their average score across all scenarios, with Upper Basin and Lower Basin reaches ranked separately. The top 12 scoring reaches in the Upper Basin were closely grouped with averages between 5 and 6, and in the Lower Basin, the top six reaches had averages between 4 and 5. This filtering process resulted in reducing the number of reaches under active consideration from 37 to 18; these top scoring reaches for each basin are shown in Table 5A-5.

5A.4.2 Step 2: Reach Selection Process

The Workgroup then selected focus reaches from the filtered list of reaches (Table 5A-5). During this step, while adhering to the Guiding Principles, Workgroup members discussed qualitative factors, such as political feasibility of working on a particular reach and diversity of reaches, based on their collective knowledge and best professional judgment to arrive at the list of focus reaches on a consensus basis. A similar qualitative process was used to select one headwater focus reach, to represent upper headwater coldwater streams that are above dams and have primarily natural hydrology and runoff patterns.

Using this process, the following reaches, including two Upper Basin reaches, one Lower Basin reach, and one headwater reach, were selected as focus reaches:

- The Upper Colorado River Focus Reach (Upper Basin) – mainstem of the Colorado River between the confluence with the Gunnison River and the confluence with the Green River (Reach UCO-2)
- The White River Focus Reach (Upper Basin) – White River between Taylor Draw Dam and the confluence with the Green River (Reach WHR-1)
- Bill Williams River Focus Reach (Lower Basin) – Bill Williams River from Alamo Dam to the confluence with the Colorado River at Lake Havasu (Reach BWR-1)
- The Henry's Fork Headwaters Focus Reach

TABLE 5A-5
Top Scoring Reaches in the Upper and Lower Basins

Upper Basin Reach	Average Score	Lower Basin Reach	Average Score
Green (GRR 2)	6.00	Bill Williams (BWR 1)	5.25
Green (GRR 3)	5.75	Lower Colorado Mainstem (LCO 4)	4.75
Green (GRR 1)	5.50	Virgin (VIR 1)	4.25
Yampa (YAR 2)	5.50	Virgin (VIR 2)	4.25
Gunnison (GUR1)	5.50	Lower Colorado Mainstem (LCO2)	4.25
Gunnison (GUR 2)	5.50	Virgin (VIR 3)	4.00
Yampa (YAR 1)	5.25		
Upper Colorado Mainstem (UCO 1)	5.25		
Upper Colorado Mainstem (UCO 2)	5.25		
White (WHR 1)	5.00		
Gunnison (GUR 4)	5.00		
Dolores (DOR 3)	5.00		

5A.5 References

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Appendix 5B

Existing Ecological, Recreational, and Hydropower Programs

May 2015

5B | Existing Ecological, Recreational, and Hydropower Programs

The Environmental and Recreational Flows Workgroup (Workgroup) recognized that existing programs,[1] initiated either in the Colorado River Basin (Basin) or in other locations around the world, include components that directly or indirectly benefit ecological and recreational resources. To learn from these programs and to acknowledge how environmental and recreational flows have been addressed in other settings, the Workgroup compiled a list of programs.

The following compilation of programs is neither an exhaustive list, nor is it an endorsement of a particular program; rather, it is illustrative of the types of programs and mechanisms that have been implemented.

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
1	Aspinall Unit Working Group	The Aspinall Unit Working Group provides an open forum for public and interested party input and for information exchange on the operation of the Aspinall Unit through meetings held three times a year. Participants include the Bureau of Reclamation (Reclamation), other government agencies, and public and special interest groups.	Upper
2	Colorado Healthy Rivers Grant Program	Established jointly by the Colorado Water Conservation Board and the Water Quality Control Commission, in cooperation with the Colorado Watershed Assembly, the Colorado Healthy Rivers Grant Program helps support local watershed organizations in their efforts to provide clean water, protect habitat, and improve recreation and accessibility. The program is financed by the Colorado Individual Income Tax Refund Check-off Program, which gives taxpayers the opportunity to contribute a portion of their taxes or to make a donation to assist locally based conservation groups in their efforts to protect our land and water resources.	Upper

[1] The term “programs” refers to a variety of programs, laws, and stakeholder groups related to ecological, recreational, and hydropower resources.

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
3	Colorado Instream Flow Program	Through the Instream Flow Program, the Colorado Water Conservation Board is responsible for the appropriation, acquisition, protection, and monitoring of instream flow and natural lake level water rights to preserve and improve the natural environment to a reasonable degree. These water rights are nonconsumptive, in-channel, or in-lake uses of water for minimum flows between specific points on a stream or levels in natural lakes. Since 1973, through the Colorado Instream Flow Program, the State of Colorado has appropriated more than 1,800 water rights covering more than 9,000 miles of stream and 477 natural lakes. The State of Colorado has entered into more than 25 transactions through its water acquisition program, under which it can purchase, lease, or accept donations of water rights for instream flow purposes, resulting in protection of more than 900 cubic feet per second on various streams.	Upper
4	Colorado Recovery and Conservation Plans	Colorado has a number of recovery and conservation plans that work to protect amphibians, birds, fish, and mammals.	Upper
5	Colorado Recreational In-Channel Diversions	The Colorado Water Conservation Board reviews all applications for recreational in-channel diversions, which limit water rights to the minimum stream flow necessary for a reasonable recreational experience in and on the water.	Upper
6	Colorado River Cooperative Agreement	The Colorado River Cooperative Agreement is a long-term partnership between Denver Water and the West Slope. The agreement is a framework for numerous actions by the parties to benefit water supply, water quality, recreation, and the environment on both sides of the Continental Divide. Several key components provide for bypasses of diversion structures and reservoir releases that are intended to benefit the environment and recreation in the headwaters of the Colorado River Basin.	Upper
7	Colorado Water Banking Working Group	The Colorado Water Banking Working Group is an informal group composed of representatives of the Colorado River Water Conservation District, Colorado Water Conservation Board, Front Range Water Council, Southwestern Water Conservation District, and The Nature Conservancy. The group is investigating the development of a “Water Bank” that may prevent, delay, or avoid a compact deficit, or allow continued water use in the event of a compact deficit.	Upper

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
8	Colorado Watershed Protection and Restoration Efforts	The Colorado Water Conservation Board supports watershed planning as well as projects designed to restore and protect watersheds through the administration of: • The Colorado Watershed Restoration Program, which provides grants for watershed/stream restoration and flood mitigation projects throughout the state • The Colorado Healthy Rivers Fund, which helps support local watershed organizations in their efforts to provide clean water, protect habitat, and improve recreation and accessibility • The Fish and Wildlife Resources Fund, which provides grant money to mitigate the impacts of existing water supply facilities and help preserve a balance between development of the state's resources and the protection of the state's fish and wildlife resources • The Invasive Phreatophyte Control Program	Upper
9	Dolores River Dialogue and Implementation Team for the Dolores River below McPhee Dam	The Dolores River Dialogue (DRD) is a coalition of diverse interests whose purpose is to explore management opportunities, build support for and take action to improve the ecological conditions downstream of McPhee Reservoir while honoring water rights, protecting agricultural and municipal water supplies, and the continued enjoyment of rafting and fishing. Two full Dolores River Dialogue meetings occur each year, generally in the spring and fall. A DRD Steering Committee meets monthly (or as necessary), and the DRD Science and Hydrology Committees meet when needed to review documents or complete projects. The Implementation Team was formed in July 2011 to study and potentially pursue nine opportunities to improve the status of native fish.	Upper
10	Duchesne River Working Group	The informal Duchesne River Working Group was formed in 2004 to address issues involved with the implementation of flow recommendations, including water availability, water management, and protection of instream flows. Workgroup members include representatives of federal, state, and local agencies, Native American tribes, and affected stakeholders.	Upper
11	Escalante River Watershed Partnership	The Escalante River Watershed Partnership (ERWP) was formed in 2009 to restore and maintain the natural ecological conditions of the Escalante River and its watershed and involve local communities in promoting and implementing sustainable land and water use practices. The ERWP consists of more than 30 participating partners, including local landowners, local business owners, city and county municipalities, non-profit organizations, conservation corps, and federal and state land agencies.	Upper

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
12	Flaming Gorge Technical Working Group	The Flaming Gorge Technical Working Group (FGTWG) was established pursuant to the Operation of Flaming Gorge Dam Final Environmental Impact Statement as recommended in the Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam. FGTWG members include biologists and hydrologists from Reclamation, the U.S. Fish and Wildlife Service, and the Western Area Power Administration. The purpose of the FGTWG is limited to proposing specific flow and temperature targets for each year's operations based on current year hydrologic conditions and the conditions of the endangered fish. The FGTWG is also charged with integrating, to the extent possible, any flow requests from the Upper Colorado River Endangered Fish Recovery Program (Recovery Program) into the flow proposal so that Recovery Program research can also be facilitated.	Upper
13	Great Outdoors Colorado	Great Outdoors Colorado (GOCO) invests a portion of Colorado Lottery proceeds to help preserve and enhance the state's parks, trails, wildlife, rivers, and open spaces. An independent board awards competitive grants to local governments and land trusts and makes investments through Colorado Parks and Wildlife. Created by voters in 1992, GOCO has committed more than $825 million in lottery proceeds to more than 3,500 projects without tax dollar support.	Upper
14	San Juan River Basin Recovery Implementation Program	The purpose of the San Juan River Basin Recovery Implementation Program is to protect and recover endangered fish in the San Juan River Basin while water development proceeds in compliance with all applicable federal and state laws. Endangered species include the pikeminnow (formerly known as the Colorado squawfish) and the razorback sucker.	Upper
15	Upper Colorado River Basin Fund	The Upper Colorado River Basin Fund was established under the Colorado River Storage Project (CRSP) Act. Revenues derived from operation of the CRSP and participating projects (mostly revenues from sales of hydroelectric power and transmission services) are deposited in the Basin Fund. In addition to repaying costs associated with the CRSP units and designated irrigation projects, the Fund supports the Colorado River Basin Salinity Control Program, the Glen Canyon Adaptive Management Program, the Upper Colorado Endangered Fish Recovery Implementation Program, and the San Juan River Recovery Implementation Program.	Upper

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
16	Upper Colorado River Coordinated Reservoir Operations	The Upper Colorado River Coordinated Reservoir Operations project involves voluntary operational coordination of selected reservoirs in the Colorado River Basin upstream from the confluence of the Colorado and Gunnison Rivers. The goal is to enhance spring peak flows to improve endangered fish species habitat in the 15-Mile Reach of the Colorado River without diminishing reservoir yields, affecting the timing of reservoir filling, or causing flows to exceed flood stage. Participating reservoirs in the past have included Willow Creek; Granby, Green Mountain, and Ruedi (Reclamation); Wolford Mountain (Colorado River Water Conservation District); Dillon and Williams Fork (Denver Water); and Windy Gap (Northern Colorado Water Conservancy District). Coordinated reservoir operations occur in years when runoff conditions allow participating reservoirs to contribute without affecting their yield. The intent of coordinated reservoir operations is to attempt to coordinate bypasses of inflow to enhance the natural peak flows on the Colorado River for 10 days to 2 weeks. This typically occurs during the last week of May and the first week of June.	Upper
17	Upper Colorado River Endangered Fish Recovery Program	The Upper Colorado River Endangered Fish Recovery Program provides Endangered Species Act compliance for continued operation of federal water and power projects in accordance with project purposes by working to recover four species of endangered fish in the Upper Colorado River Basin while water use and development continues to meet human needs in compliance with interstate compacts and applicable federal and state laws.	Upper
18	Upper Colorado River Managing Entities for the 15-Mile Reach in Grand Junction, Colorado	Coordination of releases in the Grand Valley provides for management of the Historic Users Pool for its beneficiaries and assists in maintaining target flows in the 15-Mile Reach of the Colorado River for the Upper Colorado River Endangered Fish Recovery Program. Flow coordination for the 15-Mile Reach is done weekly by phone during base flows. The call includes the operators of all major headwater reservoirs in the upper mainstem of the Colorado River: Green Mountain, Ruedi, Granby, Wolford, Williams Fork, and Dillon Reservoirs. Directly involved are the irrigation companies; federal, state, city, and county governments; National Weather Service; U.S. Geological Survey; utility companies; representatives for environmentalist, rafting, and fishing groups; and others.	Upper
19	Upper Colorado River Wild and Scenic Stakeholder Group	The Upper Colorado River Wild and Scenic Stakeholder Group is composed of more than 100 individuals representing state agencies, local governments, environmental and recreational interests, landowners, anglers, and water providers. They have formed an independent, collaborative partnership to develop and implement a local management alternative to Wild and Scenic designation on the Upper Colorado River. Since coming together in 2007, the Stakeholder Group has worked both as a large group and in smaller work groups to develop a management plan that recognizes the interests of each representative while also protecting and enhancing the Upper Colorado River's outstanding biological, social, and recreational value.	Upper

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
20	Utah Green River Water Acquisition Team	Functioning under the Utah Department of Natural Resources, with participation by the U.S. Fish and Wildlife Service, Reclamation, Western Resource Advocates, and The Nature Conservancy, the Utah Green River Water Acquisition Team addresses flow protection for endangered fish recovery on the Green River below Flaming Gorge Dam. A model of the Green River has been created, and future development scenarios are currently being analyzed to provide solutions for flow protection.	Upper
21	Utah Species Recovery Plans and Conservation Agreements	Utah has developed several species recovery plans and conservation agreements based on a three-tiered system to group species in order of greatest conservation need. The tiered ranking system defines and prioritizes Utah's animal species according to conservation need. Tier I includes federally threatened and endangered, federal candidate, and conservation agreement species. These species are listed on the Utah Sensitive Species List. Most Tier I species have recovery plans or conservation agreements and associated strategies. Most of the fish from the Colorado River Basin belong under Tier I.	Upper
22	Utah Watershed Restoration Initiative	The Utah Watershed Restoration Initiative is a partnership-driven effort to conserve, restore, and manage ecosystems in priority areas across the state to enhance Utah's: • Wildlife and biological diversity • Water quality and yield for all uses • Opportunities for sustainable uses Utah's watershed restoration initiative is a Utah Partners for Conservation and Development-sponsored initiative that serves as a clearinghouse to coordinate and share participants' conservation concerns and priorities, discuss and implement solutions, and promote an atmosphere of collaboration among landowners, private organizations, and state and federal agencies.	Upper

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
23	White River Work Group	A White River Work Group composed of Water Users (Ute Indian Tribe, Upper Colorado River Endangered Fish Recovery Program [Recovery Program], water user representatives, Colorado Water Conservation Board, Utah Water Resources); environmental groups (The Nature Conservancy and Western Resource Advocates); U.S. Fish and Wildlife Service; and the Program Director's Office was formed to assist with the development of the White River Water Management Plan. The Recovery Program oversees the development of the Management Plan, which will: • Model proposed future water development scenarios to understand effects on White River hydrology and the Recovery Program's draft endangered fish flow recommendations • Assist with scheduling, facilitating, and summarizing Work Group and public outreach meetings • Draft and revise (as needed) a Management Plan • Assist with Endangered Species Act compliance for the associated water depletion impacts and formulation of a Programmatic Biological Opinion	Upper
24	Wyoming Water Development Commission River Basin Plans	Through the Wyoming Water Development Commission River Basin Plans, Basin Advisory Groups assist the Wyoming Water Development Office (WWDO) and the state planning team by identifying water- related issues, problems, and concerns in the individual river basins. Through public participation, the group advises the WWDO and planning team on local issue priorities, data needs, and regional concerns. The Basin Advisory Groups also assist decision makers though the review of basin planning products.	Upper
25	Wyoming Wildlife and Natural Resource Trust	The Wyoming Legislature created the Wildlife and Natural Resource Trust in 2005. Funded by interest earned on a permanent account, donations and legislative appropriation, the purpose of the program is to enhance and conserve wildlife habitat and natural resource values throughout the state. Any project designed to improve wildlife habitat or natural resource values is eligible for funding.	Upper
26	Yampa River Users Group	The Yampa River Users Group coordinates augmentation of Yampa River base flows from Elkhead Reservoir in accordance with the Yampa River flow recommendations. The Upper Colorado River Endangered Fish Recovery Program (Recovery Program) funded a 5,000 acre-foot (AF) pool of permanent storage out of the 12,000 AF Elkhead enlargement and may lease up to an additional 2,000 AF on an as-needed basis. In the summer, coordination occurs during a weekly call with Tri-State Power Co., the Colorado River District, the District Engineer's office, the Recovery Program, and other local water users.	Upper

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
27	Agricultural Act of 2014	The Agricultural Act of 2014 was signed into law in February 2014. The Congressional Budget Office projects that 6 percent of outlays under the Act will fund conservation programs. The Act provides assistance to producers and landowners to adopt conservation activities on agricultural and forest lands to protect and improve water quality and quantity, soil health, wildlife habitat, and air quality. Program practices range from conservation activities that address natural resource issues and benefit productivity of agricultural working lands, forestlands, and grasslands to wetlands restoration, and temporary or permanent land retirement.	Upper and Lower
28	American Whitewater Flow Studies	Flow studies conducted by the non-profit organization American Whitewater are conducted to assist in identifying a specific range of flows that optimize whitewater recreation. Whitewater flow studies endeavor to accurately and precisely identify the range of flows suitable for whitewater recreation and to document the range of whitewater flows between minimum, acceptable, and optimum, using scientific methodologies to obtain the supporting preference data. These flow studies have been used as a component in the hydropower relicensing process in areas outside the Colorado River Basin.	Upper and Lower
29	America's Great Outdoors Initiative	President Obama launched the America's Great Outdoors (AGO) Initiative to develop a 21st Century approach to conservation and outdoor recreation. AGO brings together many federal agencies to work with state and local partners nationwide. The Rivers portion of the AGO has two opportunities: the National Water Trails System and the All American River Demonstration Projects. The stretch of the Colorado River below Hoover Dam through Black and Eldorado Canyons was designated a National Water Trail in June 2014. The All-American Rivers Demonstration Projects designate one river project in each state and the District of Columbia to serve as models for conserving rivers across the nation, expanding outdoor recreational opportunities, and supporting jobs in local communities.	Upper and Lower
30	Colorado River Basin Chubs Recovery Plan	The Colorado River Basin Chubs Recovery Plan was developed under the authority of the New Mexico Wildlife Conservation Act (WCA) amendments of 1995, which direct the New Mexico Department of Game and Fish to develop recovery plans for species listed as threatened or endangered by the State. This Recovery Plan addresses the chubs in the Colorado River Basin in New Mexico, roundtail chub, Gila chub, and headwater chub, listed as endangered in New Mexico.	Upper and Lower
31	Colorado River Basin Salinity Control Forum	Created in 1973, the Colorado River Basin Salinity Control Forum (Forum) is an organization of the seven Colorado River Basin states. The purposes of the Forum are to coordinate salinity control efforts among the states, coordinate with federal agencies on the implementation of the Colorado River Basin Salinity Control Program (Program), work with Congress on the authorization and funding of the Program, act to disseminate information on salinity control, and otherwise promote efforts to reduce the salt loading to the Colorado River.	Upper and Lower

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
32	Glen Canyon Dam Adaptive Management Program	The Glen Canyon Dam Adaptive Management Program was developed to provide an organization and process for cooperative integration of dam operations, downstream resource protection and management, and monitoring and research information, as well as to improve the values for which the Glen Canyon National Recreation Area and Grand Canyon National Park were established. This program is implemented in a manner fully consistent with and subject to the Colorado River Compact and Law of the River. Adaptive management is a dynamic process where people of many talents and disciplines come together to make the right decision in the best interests of the resources.	Upper and Lower
33	International Boundary and Water Commission Minute 306	Minute 306 was signed in December 2000 and provides for cooperation between the United States and Mexico in the development of studies and recommendations regarding the ecology of the Colorado River limitrophe and delta.	Upper and Lower
34	International Boundary and Water Commission Minute 316	Minute 316 was signed in April 2010 and provides, among other items related to delivery and accounting, that the United States, Mexico, and nongovernmental organizations will provide water to the Cienega de Santa Clara during the Yuma Desalting Plant pilot run. Each group committed to providing 10,000 acre-feet over the course of the pilot run.	Upper and Lower
35	International Boundary and Water Commission Minute 319	Minute 319 was signed in November 2012 and provides interim approaches, lasting through 2017, to resolving shared Colorado River issues, in addition to providing multiple cooperative actions related to water conservation and system operations. Minute 319 also provides water for environmental flows for the Colorado River Delta. Through a one-time pulse flow event that was completed in the spring of 2014, and a longer-lasting base flow, Minute 319 is expected to help restore approximately 2,300 acres of habitat while gaining important scientific information on the effectiveness of flows to the Delta.	Upper and Lower
36	Landscape Conservation Cooperatives	With the signing of Secretarial Order No. 3289, the U.S. Department of the Interior launched the Landscape Conservation Cooperatives (LCCs) to better integrate science and management to address climate change and other landscape scale issues. By building a network that is holistic, collaborative, adaptive, and grounded in science, LCCs are working to ensure the sustainability of our economy, land, water, wildlife, and cultural resources. The LCCs are partnerships of governmental (federal, state, tribal, and local) and nongovernmental entities. The two LCCs in the Colorado River Basin are the Southern Rockies LCC and the Desert LCC.	Upper and Lower

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
37	National Fish and Wildlife Foundation	The National Fish and Wildlife Foundation (NFWF) was created by Congress in 1984 as a non-profit organization to build partnerships between the public and private sectors to support conservation across the nation. NFWF receives funding from federal and state agencies, corporations, foundations, and individual donors to create partnerships to help protect and restore imperiled species, promote healthy oceans and estuaries, improve working landscapes for wildlife, advance sustainable fisheries, and conserve water for wildlife and people. NFWF currently works with 14 federal partners and more than 50 corporate and foundation partners, and the Impact-Directed Environmental Account program manages more than $100 million in mitigations and settlement funds.	Upper and Lower
38	Natural Resources Conservation Service Emergency Watershed Protection Plan	The Natural Resources Conservation Service (NRCS) Emergency Watershed Protection Plan (EWP) is designed to help people and conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, windstorms, and other natural occurrences. EWP is an emergency recovery program. All projects undertaken, with the exception of the purchase of floodplain easements, must have a project sponsor. NRCS may bear up to 75 percent of the construction cost of emergency measures. The remaining 25 percent must come from local sources and can be in the form of cash or in-kind services. Funding is subject to Congressional approval.	Upper and Lower
39	Natural Resources Conservation Service Environmental Quality Incentives Program	The Natural Resources Conservation Service Environmental Quality Incentives Program (EQIP) is a voluntary program that provides financial and technical assistance to agricultural producers through contracts up to a maximum term of 10 years. These contracts provide financial assistance to help plan and implement conservation practices that address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, reduced soil erosion and sedimentation, or improved and created wildlife habitat on agricultural land and non-industrial private forestland. In addition, a purpose of EQIP is to help producers meet federal, state, tribal, and local environmental regulations.	Upper and Lower
40	Rangewide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker	In 2006, the Rangewide Conservation Agreement and Strategy for Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker was signed by Arizona, Colorado, Nevada, New Mexico, Wyoming, and Utah as well as federal, tribal, and nongovernment partners. These partners participate in a rangewide team that sets conservation action priorities and develops strategies for management of the three species.	Upper and Lower
41	Sustainable Rivers Project	The Sustainable Rivers Project is a U.S. Army Corps of Engineers (Corps) and The Nature Conservancy partnership. It represents an ongoing effort to re-operate Corps dams to achieve more ecologically sustainable flows, while maintaining or enhancing project benefits. The project is being carried out under a Memorandum of Understanding between the Corps and The Nature Conservancy.	Upper and Lower

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
42	Tamarisk Coalition	The Tamarisk Coalition helps the management of invasive plant species and restoration of native riparian vegetation throughout the Upper and Lower Basins. The Coalition acts as an information clearinghouse, empowers practitioners with problem-solving assistance, and enhances frameworks for restoration by helping to establish programs that support riparian restoration.	Upper and Lower
43	Title XVI of Public Law 102-575 – Water Reclamation and Reuse Program	Title XVI of Public Law 102-575, as amended, provides authority for Reclamation’s water recycling and reuse program, titled “Title XVI.” Through the Title XVI program, Reclamation identifies and investigates opportunities to reclaim and reuse wastewater and naturally impaired ground and surface water in the 17 western states and Hawaii. Title XVI is budgeted by Reclamation’s regional offices and includes funding for planning studies and the construction of water recycling projects, on a project-specific basis, in partnership with local governmental entities.	Upper and Lower
44	U.S. Fish and Wildlife Service National Fish Passage Program	The National Fish Passage Program was initiated in 1999. The program works with partners on a voluntary basis to help communities restore their natural resources by reconnecting aquatic habitats. The purpose of the program is to focus on aquatic species and habitat restoration to ensure self-sustaining populations on a landscape level within the context of the U.S. Fish and Wildlife Service’s overall resource conservation mission.	Upper and Lower
45	U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program	The Partners for Fish and Wildlife Program was established in 1987 and works through voluntary agreements to provide expert technical assistance and cost-share incentives directly to private landowners to restore fish and wildlife habitats. The program serves as a bridge to landowners to develop individual partnerships and habitat restoration projects for the benefit of fish and wildlife species.	Upper and Lower
46	WaterSense	WaterSense, a partnership program by the U.S. Environmental Protection Agency, seeks to protect the future of our nation’s water supply by offering people a simple way to use less water with water-efficient products, new homes, and services. The program partners with manufacturers, retailers, distributors, and utilities to bring WaterSense- labeled products to the marketplace and make it easy to purchase high-performing, water-efficient products. WaterSense also partners with irrigation professionals and irrigation certification programs to promote water-efficient landscape irrigation practices.	Upper and Lower
47	WaterSMART Water and Efficiency Grants	To implement the Omnibus Public Land Management Act of 2009, Subtitle F – SECURE Water, the U.S. Department of the Interior established the WaterSMART program in February 2010. Through the WaterSMART Water and Efficiency Grants (formerly Challenge Grants), Reclamation provides 50-50 cost-share funding to irrigation and water districts, tribes, states, and other entities with water or power delivery authority. Projects should seek to conserve and use water more efficiently, increase the use of renewable energy, protect endangered species, or facilitate water markets.	Upper and Lower

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
48	Wild and Scenic Rivers	The National Wild and Scenic Rivers System was created by Congress in 1968 (Public Law 90-542; 16 United States Code 1271 et seq.) to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of current and future generations. Rivers may be designated by Congress or, if certain requirements are met, the Secretary of the Interior. Each river is administered by either a federal or state agency.	Upper and Lower
49	Arizona Water Protection Fund	In 1994, the Arizona Water Protection Fund (AWPF) was established, as was the Arizona Water Protection Fund Commission to administer the AWPF (Arizona Revised Statutes § 45-2101 et seq.). The AWPF is a competitive state grant program that provides an annual source of funding for the development and implementation of measures that maintain, enhance, and restore rivers, streams, and riparian habitats, including projects that benefit fish and wildlife.	Lower
50	Bill Williams River Corridor Steering Committee	The Bill Williams River Corridor Steering Committee (BWRCSC) is a partnership effort with members possessing diverse management concerns and responsibilities that exist as a venue to address a wide range of matters. The purpose of the BWRCSC is to facilitate and foster the open communication of concerns and to promote a commitment to good science.	Lower
51	Las Vegas Wash Coordination Committee	The Las Vegas Wash Coordination Committee was formed in October 1998 and consists of 29 members. Its goal is to bring together all interested parties to address the many issues related to the Las Vegas Wash, which provides habitat to about 300 fish and wildlife species and more than 200 species of upland, riparian, and wetland plants. It also serves as a source of return flow credits to the Colorado River at Lake Mead.	Lower
52	Lower Colorado Multi-Species Conservation Program	The Lower Colorado River Multi-Species Conservation Program was created to balance the use of the Colorado River water resources with the conservation of native species and their habitats. The program works toward the protection of species currently listed under the Endangered Species Act (ESA). It also reduces the likelihood of additional species listings. Implemented over a 50-year period, the program accommodates current water diversions and power production and will optimize opportunities for future water and power development by providing ESA compliance through the implementation of a Habitat Conservation Plan.	Lower
53	Metropolitan Water District Integrated Resources Plan	Metropolitan Water District's long-term water plan, the Integrated Resources Plan (IRP), offers an innovative strategy to protect the region from future supply shortages, with an emphasis on water-use efficiency through conservation and local supply development. The IRP is intended as a regional water resource planning document that identifies potential supplies to meet future demands.	Lower

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
54	Upper San Pedro Partnership	The Upper San Pedro Partnership is a consortium of agencies and organizations working together to meet the long-term water needs of the Sierra Vista Subwatershed by achieving sustainable yield of the regional aquifer. The goals of the partnership are to preserve the San Pedro Riparian National Conservation Area, and ensure the long-term viability of Fort Huachuca. The purpose of the partnership is to coordinate and cooperate in the identification, prioritization, and implementation of comprehensive policies and projects to assist in meeting water needs in the Sierra Vista Subwatershed of the Upper San Pedro River Basin.	Lower
55	Verde River Basin Partnership	The Verde River Basin Partnership is a non-profit organization composed of both individual members and entity members (both public and private partners), whose goal is to support and preserve the long-term health of the Verde River and its watershed. The partnership is a scientific and educational resource raising awareness among residents and community leaders about the workings and limitations of the Verde River Basin's interconnected groundwater and surface water systems and the life they support.	Lower
56	Virgin River Resource Management and Recovery Program	The Virgin River Program is a collaborative effort between local, state, and federal partners to balance human interests along the Virgin River with the conservation of this unique ecosystem for future generations. The program goals are to implement actions to recover, conserve, enhance, and protect native species in the Virgin River Basin and to enhance the ability to provide adequate water supplies for sustaining human needs.The program scope is broad and includes species recovery, water management, floodplain protection, restoration, and community outreach.	Lower
57	Zuni Bluehead Sucker Recovery Plan	The Zuni Bluehead Sucker Recovery Plan was developed by the New Mexico Department of Game and Fish in 2004 under the authority of the New Mexico Wildlife Conservation Act (17-2-40.1 New Mexico Statutes Annotated 1978). This recovery plan addresses the Zuni bluehead sucker, listed as endangered in New Mexico and declared an endangered species on July 24, 2014, by the U.S. Fish and Wildlife Service.	Lower
58	Bay Delta Conservation Plan	The Bay Delta Conservation Plan (BDCP), being prepared by state and federal agencies, local water agencies, and environmental and conservation organizations, is a part of California's overall water management portfolio. It is being developed as a 50-year habitat conservation plan with the goals of restoring the Sacramento-San Joaquin Delta ecosystem and securing California water supplies. The BDCP would secure California's water supply by building new water delivery infrastructure and operating the system to improve the ecological health of the Delta. The BDCP would also restore or protect approximately 150,000 acres of habitat to address the Delta's environmental challenges.	Other – California

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
59	California Water Plan – California Department of Fish and Wildlife	The California Water Plan is developed by the Department of Water Resources (DWR) and other agencies, including California Department of Fish and Wildlife (CDFW), through rigorous public involvement and a state and federal agency coordination process. As trustee for California's fish and wildlife resources, CDFW has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and habitat necessary for biologically sustainable populations of those species. CDFW provides input to DWR on environmental water needs, including water use, and water quality. CDFW's role in the development of the Water Plan is to identify opportunities to increase fish, wildlife, and other environmental benefits associated with state programs.	Other – California
60	Central Valley Project Improvement Act	The Central Valley Project Improvement Act (CVPIA) was enacted in 1992. Its purposes are to: (1) protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California; (2) address impacts of the Central Valley Project (CVP) on fish, wildlife, and associated habitats, and improve operational flexibility; (3) increase water-related benefits provided by the CVP to the State of California through expanded use of voluntary water transfers and improved water conservation; (4) contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary; (5) achieve a reasonable balance among competing demands for use of CVP water, including the requirements of fish and wildlife, agricultural, municipal, industrial, and power contractors. The U.S. Fish and Wildlife Service works with Reclamation and other agencies to implement the CVPIA.	Other – California
61	San Joaquin River Restoration Program	The San Joaquin River Restoration Program is a comprehensive long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of the Merced River and restore a self-sustaining Chinook salmon fishery in the river while reducing or avoiding adverse water supply impacts from restoration flows. Through a Memorandum of Understanding, the following agencies are working together to implement the restoration activities: U.S. Departments of the Interior and Commerce, the Natural Resources Defense Council, the Friant Water Users Authority, California Department of Fish and Wildlife, California Department of Water Resources, and the California Environmental Protection Agency.	Other – California
62	Arkansas River Voluntary Flow Management Program	The Arkansas River Voluntary Flow Management Program (VFMP) is a cooperative program created in the 1990s with help from Trout Unlimited and the Arkansas River Outfitters Association. Administered by Reclamation, in cooperation with the Colorado Department of Natural Resources and Southeastern Colorado Water Conservancy District, the VFMP offers water management guidelines that provide for whitewater flows in the Arkansas River for recreation users in the summer months, while also protecting and enhancing the fishery by establishing minimum flow guidelines throughout the rest of the year.	Other – Colorado

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
63	Colorado Basin Roundtables	To facilitate discussions on water management issues and encourage locally driven collaborative solutions, nine basin roundtables were established by the Colorado Water for the 21st Century Act. These roundtables represent each of the state's eight major river basins and the Denver metropolitan area. Each basin roundtable is required to develop a basin-wide water needs assessment, consisting of four parts: (1) consumptive water needs (municipal, industrial, and agricultural); (2) nonconsumptive water needs (environmental and recreational); (3) available water supplies (surface and groundwater) and an analysis of any unappropriated waters; and (4) proposed projects or methods to meet identified water needs and achieve water supply sustainability over time.	Other – Colorado
64	Streamflow Management Plan for the Upper South Platte River, Colorado	The Streamflow Management Plan was cooperatively developed by local, state, and federal agencies and nongovernmental organizations to identify opportunities for operating water supply facilities in ways that protect, and in some instances, enhance the trout fisheries and whitewater recreation in the South Platte River while maintaining the current and future water supply functions of the river and facilities. The benefits for the fisheries include establishing minimum releases from Cheesman and Eleven Mile Reservoirs, moderating stream temperature when reservoirs spill, establishing guidelines for reservoir outflow fluctuations, managing streamflow during spawning periods, and allowing interested parties to participate in the establishment of annual operating plans for Spinney, Eleven Mile, and Cheesman Reservoirs. Consideration is also given to whitewater recreation for the North Fork.	Other – Colorado
65	Rio Chama Flow Optimization Project	The Rio Chama Flow Optimization Project is being developed by Rio Grande Restoration in partnership with the New Mexico Interstate Stream Commission, Reclamation, the U.S. Army Corps of Engineers, the Bureau of Land Management, the University of New Mexico, and others. The project is funded by a grant from the New Mexico River Ecosystem Restoration Initiative. The project team plans to assess institutional and socioeconomic needs, opportunities, and constraints; develop hypotheses for how modified operations can support ecosystem functions; and develop hydrographs for different hydrologic conditions that address ecological, social, and legal issues. The project will culminate in the creation of a decision support tool for Reclamation to optimize El Vado Dam water operations under a broad range of flow conditions.	Other – New Mexico

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
66	Nantahala Settlement Agreement	The Federal Energy Regulatory Commission has issued six hydroelectric licenses for the Nantahala area. These licenses kick start processes for a variety of public recreation and aquatic habitat enhancements for the region. The legally binding agreement, signed in 2003, is the work of stakeholder teams representing 30 organizations, including Duke Energy. Enhancements coming to the Nantahala River include: (1) adding kayak/canoe access areas with parking along the river and a handicapped-accessible fishing access area; (2) making land near Nantahala Powerhouse available to the U.S. Forest Service to improve public access for whitewater recreation; (3) releasing flows from Nantahala Dam into the old streambed to provide high-skill boating opportunities on 8 days during the recreations season; (4) increasing continuous minimum flows from the Nantahala Project to enhance stream habitat in the popular stretch of delayed harvest trout water in the Nantahala River Bypassed Reach; and (5) adding continuous minimum flows from Whiteoak Dam to enhance aquatic habitat in Whiteoak Creek and downstream into the Nantahala River Bypassed Reach.	Other – North Carolina
67	Deschutes Water Alliance	The Deschutes Water Alliance (DWA) was formed in 2004 to plan for long-term water resource management in the Deschutes Basin. The DWA believes it is possible to simultaneously meet new and existing demands for water in the Basin, whether they are from agriculture, cities, or rivers. This will happen through the cooperation and voluntary participation of key basin water suppliers and users.	Other – Oregon
68	Platte River Recovery Implementation Program and the South Platte Water Related Activities Program, Inc.	The Platte River Recovery Implementation Program, developed in 1997 by Colorado, Wyoming, Nebraska and the U.S. Department of the Interior, is a partnership with the goal of developing a shared approach for managing the Platte River. The program provides a programmatic approach for addressing the threatened and endangered species that have habitat in Nebraska in a way that allows water development to occur in Colorado, Wyoming, and Nebraska. Water users from the three states and local and national conservation groups helped to develop this innovative approach for improving the management of the Platte for the health of the ecosystem and the people who depend on it. The South Platte Water Related Activities Program, Inc., is a Colorado nonprofit corporation established by Colorado water users for the purpose of representing water users' interests and partnering with the State of Colorado to implement the Platte River Recovery Implementation Program in central Nebraska.	Other – South Platte

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
69	South Platte Enhancement Board and South Platte Protection Plan	The South Platte Enhancement Board (SPEB) was established to support and implement the South Platte Protection Plan, an alternative to the U.S. Forest Service study of sections of the Upper South Platte River and its North Fork for possible designation under the Wild and Scenic Rivers Act. SPEB works to enhance and preserve outstandingly remarkable values (such as fisheries and recreation) within portions of the South Platte. The SPEB is a 17-member stakeholder group charged with managing a $1 million endowment, advocating cooperative protection of the river corridor, distributing grant funds, building awareness of the South Platte's value as a major water source as well as a cherished resource legacy, and serving as a forum for public issues and concerns.	Other – South Platte
70	Ocoee Agreement	In the late 1970s, the Tennessee Valley Authority agreed to schedule 116 days of recreational whitewater releases per year on the Middle Ocoee River. The Ocoee has become one of the most popular whitewater rivers in the world, attracting more than 250,000 visitors annually.	Other – Tennessee
71	Yakima Basin Integrated Water Resource Management Plan	The Yakima Basin Integrated Water Resource Management Plan was developed by the Yakima River Basin Water Enhancement Project Working Group (Working Group) as a consensus-based solution to the basin's water problems. The Working Group is composed of representatives from the Department of Ecology; Reclamation; the Yakama Nation; irrigation districts; environmental organizations; and federal, state, county, and city governments. Plan elements include fish passage, fish habitat enhancement, modifying existing structures and operations, surface storage, market-based reallocation, groundwater storage, and enhanced water conservation.	Other – Washington
72	Aral Sea Basin – Interstate Commission for Water Coordination of Central Asia	After the collapse of the Soviet Union, to prevent conflicts and serious complications in water resources management and to put water allocation, limitation, and account in order, representatives of five Central Asian independent states (the Republic of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan, Turkmenistan, and the Republic of Uzbekistan) met to recognize that only joint actions in coordination and management can help to effectively solve the region's water problems in a context of increasing ecological and social tension. In February 1992, an agreement on cooperation in joint management, use, and protection of interstate sources of water resources was signed.	Other – International

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
73	Ebro River Basin Management Plan – Spain	The water planning process for the Ebro River Basin in Spain, described in the Ebro River Basin Management Plan, has contributed to the selection of a combination of projects aimed at restoring the aquatic environment. The projects include an ambitious program for water quality improvement through a mix of effluents treatment and water reuse projects combined with a zero tolerance program to monitor and control pollution discharges. Water-saving measures have also been identified, combining intake, transport, treatment, distribution, and efficiency projects throughout the entire river basin. These programs are accompanied by projects focused on the restoration of rivers and river banks, the recovery of wetlands, the restoration of sediment balances and hydrological regimes, the removal of polluted sediments, the control of invasive species, and other measures aimed at improving the ecological status of the river basin ecosystem.	Other – International
74	Murray-Darling Basin Plan – Australia	The Murray-Darling Basin Plan, developed under the Water Act 2007*,* provides a coordinated approach to water use across the basin's four states and the Australian Capital Territory. It limits water use at environmentally sustainable levels by determining long-term average Sustainable Diversion Limits for both surface water and groundwater resources. The plan is an adaptive framework and will be rolled out over 7 years. The plan aims to achieve a balance between environmental, economic, and social considerations and allows for further improvements in outcomes through a sustainable diversion limits adjustment mechanism and a constraints management strategy. The plan is supported by Commonwealth investment in modernizing irrigation infrastructure and voluntary water purchasing through the environmental water recovery strategy.	Other – International
75	Nile River Basin Cooperative Framework	The Nile River Basin Cooperative Framework applies to the use, development, protection, conservation, and management of the Nile River system and its resources and establishes an institutional mechanism for cooperation among the states of the Nile Basin (Egypt, Sudan, Ethiopia, Uganda, Kenya, Tanzania, Burundi, Rwanda, and the Democratic Republic of Congo).	Other – International
76	Danube River Protection Convention – Europe	The Danube River Protection Convention forms the overall legal instrument for cooperation on transboundary water management in the Danube River Basin. It was signed in 1994 by 11 of the Danube Riparian States (Austria, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Moldova, Romania, Slovakia, Slovenia, and Ukraine) and the European Community. The Convention aims to ensure that surface waters and groundwater within the Danube River Basin are managed and used sustainably and equitably.	Other – International

TABLE 5B-1
Existing Programs with Ecological and Recreational Resource Components

No.	Program	Program Summary	Upper/Lower/ Other Basin Program
77	International Commission for the Protection of the Rhine – Europe	For the benefit of the Rhine and of all of its tributaries, the members of the International Commission for the Protection of the Rhine (Switzerland, France, Germany, Luxemburg, Netherlands, and the European Commission) successfully cooperate with Austria, Liechtenstein, the Belgian region of Wallonia, and Italy. Focal points of work are sustainable development of the Rhine, its alluvial areas, and the good state of all waters in the watershed.	Other – International
78	Treaty between Uruguay and Argentina concerning the Rio Plata	The 1973 Rio Plata Treaty between Uruguay and Argentina developed a framework for cooperation between the two countries that describes agreed-upon uses of the river including navigation, fishing, and pollution control.	Other – International

Chapter 6

Summary and Next Steps

May 2015

6 Summary and Next Steps

The *Moving Forward* effort was initiated upon completion of the Colorado River Basin Water Supply and Demand Study (Basin Study) for the purpose of advancing critical next investigations and identifying opportunities and potential actions that have broad-based support to address challenges related to projected water imbalances and provide a wide range of benefits for the Colorado River Basin (Basin).

Phase 1 of the *Moving Forward* effort was comprised of three multi-stakeholder workgroups that represent a wide range of interests working to identify opportunities to enhance water use efficiency in the municipal and industrial (M&I) and agricultural sectors and promote and enhance environmental and recreational flows. The Phase 1 Report describes the activities and outcomes of the workgroups during the approximately 18-month Phase 1 effort. The objective of each workgroup was as follows:

- **M&I Water Conservation and Reuse Workgroup:** document trends in M&I water conservation and reuse in areas that receive Colorado River water, identify opportunities and challenges for expanding M&I water conservation and reuse programs to address projected future imbalances and to enhance the resiliency of the system.
- **Agricultural Water Conservation, Productivity, and Transfers Workgroup:** document trends in agricultural conservation and transfers of Colorado River water, identify opportunities and challenges for expanding agricultural conservation to address projected future imbalances and enhance overall resiliency.
- **Environmental and Recreational Flows Workgroup:** identify ideas for potential future voluntary, non-regulatory solutions that protect or improve ecological and recreational resources while supporting other management goals to achieve integrated solutions that benefit multiple uses, both consumptive and non-consumptive, including hydropower.

In accomplishing these objectives, the workgroups reviewed current and historical information to gain a collective understanding of both the successes and challenges associated with efforts currently underway. The workgroups also reviewed future planned efforts. From this information the workgroups identified opportunities and potential actions to expand successful programs or implement new programs in the future.

Several overarching themes related to water use, water management, and resource stewardship emerged from workgroup discussions, as reflected in Chapters 3 through 5 of this Report. While these themes were discussed separately amongst the workgroups and from differing perspectives, the following were discussed by two or more of the workgroups:

- Increase water use efficiency – Make the best use of supplies available for municipal, industrial, and agricultural purposes including aligning the management of these supplies with flows that provide environmental and recreational values where possible.
- Reduce system losses – Identify and reduce conveyance and distribution system losses. Minimizing such losses can reduce costs and increase water conservation, revenue, and water availability for other uses.
- Maximize reuse of supplies – Reuse supplies more than once, especially outside of the hydrologic Basin.
- Enhance environmental and recreational values – Recognize opportunities where improved water management could enhance the environmental and recreational values.
- Recognize existing benefits – Recognize existing benefits related to urban, agricultural, environmental, recreational, and hydropower uses and find integrated solutions that continue to benefit a range of uses.

6.1 Summary of Workgroup Key Messages and Outcomes

Each of the workgroups highlighted statements in their chapters to further the understanding of the roles of M&I or agricultural water use efficiency and environmental and recreational flows in building adaptable and resilient solutions to address potential future supply/demand imbalances. Several of those statements have commonalities across workgroups which are discussed below.

First, the workgroup's assessment of efforts underway made clear that much progress has already been made in M&I and agricultural water conservation, as well as protecting and enhancing environmental and recreational resources. For example, due in part to the efforts of water managers, and federal and state programs, per capita water use has decreased by 11 to 38 percent since 1990 and by 10 to 26 percent since 2000 in the major metropolitan areas that receive Colorado River water, leading to substantially reduced demand for water. It is estimated that over 2 million acre-feet per year of water has been saved from M&I water conservation and reuse efforts over the past two decades. In the agricultural sector, water use has remained relatively constant over the past two decades. Water use efficiency efforts in this sector have contributed to significant improvements in productivity (for example, greater yield per acre-foot of applied water) and in some cases, for example in California, have helped buffer potential shortfalls in urban water needs. At the same time, meaningful and significant steps have been taken to protect or improve ecological and recreational resources in a number of locations.

Second, building on past successes, water managers are accelerating efforts to increase water use efficiency and reuse. A review of the documented water conservation programs with numeric per capita targets suggests that over 700 thousand acre-feet per year (KAFY) of additional water conservation is planned by 2030, and an additional 400 KAFY of water reuse is planned. This will be a substantial contribution to meeting the imbalance projected by the Basin Study. In many regions, conservation and reuse may not result in substantial reductions in diversions of Colorado River water because conservation and reuse are typically used to meet future growth or offset/delay the need for additional water supplies. Similarly, improvements in efficiency in the agricultural sector will likely continue the trend of increased productivity. Water managers have been and will continue to adapt to uncertain future conditions, and will accelerate or expand programs in response to the unfolding Basin-wide conditions. However, it is likely that future water use efficiency actions will become increasingly more expensive and difficult as the least expensive and easier actions are implemented.

Third, there are no Basin-wide, silver bullet solutions for water use efficiency or protecting environmental and recreational resources. Solutions are often site-specific and in many regions, it is difficult to attribute all of the water savings to water use efficiency or reuse efforts. Other factors such as changes in hydrologic conditions, economic conditions and end-user behavior have contributed to recent water savings in the M&I and agricultural sectors. The Basin is diverse in terms of climate, location and types of irrigated agriculture, location of metropolitan areas, maturity of water conservation efforts, species needs, recreational opportunities, and other factors. Efforts that are effective and relevant in one location may not be as effective or acceptable in another. Improvements in water use efficiency and solutions to enhance ecological and recreational resources are dependent on local conditions and will vary regionally.

6.2 Summary of Opportunities and Potential Future Actions

Each of the workgroups explored opportunities and potential future actions which could help improve the long-term sustainability of the Basin resources and improve the resiliency of regions dependent on Colorado River water. The opportunities were developed to reflect the areas of greatest potential benefit, and the workgroups identified potential future actions to advance the opportunities. Several commonalities emerged from the individual sets of opportunities and actions identified by each workgroup. The groupings below were developed in an attempt to highlight these commonalities.

- ***Funding and Incentives:*** Each workgroup included an opportunity related to the development of sources of continuous, sustainable funding. Additionally, pursuing funding and technical assistance opportunities that leverage funds from multiple sources was encouraged. Such sources and opportunities could lead to more rapid, effective, and creative implementation of water use efficiency measures, reuse, and environmental and recreational flow projects. For example, programs such as the Natural Resources Conservation Service's (NRCS) Regional Conservation Partnership Program or Reclamation's WaterSMART Program where the NRCS or Reclamation, respectively, provides cost-share funding for conservation projects are and should continue to be utilized in the Basin. Further, sustainable and innovative funding programs would help ensure that sufficient and stable revenue streams are available over the long-term to accomplish a program's goals and to implement desired projects.

- ***Resources, Data, and Tools:*** Each workgroup recognized the importance of scientific research, reporting, data management, monitoring, and tool development in effectively and efficiently implementing water conservation programs and mechanisms to improving environmental and recreational resources. These items are critical to quantifying benefits and tradeoffs, evaluating cost-effectiveness, and facilitating information sharing. Directing and providing resources to assist districts to develop water management plans where such plans do not exist, compiling and regularly updating a Basin-wide database of available best practices and funding sources, and encouraging water providers to develop standard methods to quantify, monitor, and evaluate water conservation measures are a few examples of the many actions identified in pursuit of this opportunity.
- ***Outreach and Partnerships:*** Whether implementing a water conservation program or a project to improve ecological and recreational resources, these efforts are more effectively implemented with improved stakeholder understanding of the project's goals and constraints, broader stakeholder involvement, and stakeholder commitment to the project. Outreach and partnerships facilitate this understanding and encourage involvement and can lead to enhanced stakeholder commitment and the design of more innovative programs that have broad support. Additionally, outreach and partnerships may increase the availability of funding sources.
- ***Coordination and Integration:*** Water management in the Basin is complex. The complexities stem from the challenges associated with balancing competing needs such as deliveries for M&I and agricultural purposes, hydropower generation, and environmental protection. Each workgroup recognized the importance of facilitating cross-program coordination and information exchange to improve the outcomes and focus of resources. Specifically in the M&I sector, increased integration of water conservation and energy-efficiency programs was suggested. Among all workgroups, increased integration with watershed management and land use planning efforts was recognized.
- ***Infrastructure Improvements:*** Improved conveyance and distribution infrastructure and metering devices can reduce losses, reduce operation and maintenance costs, and facilitate other water-efficient investments. These activities provide significant opportunities to both the M&I and agricultural sectors. Both these workgroups identified potential actions to pursue funding measures to replace aging infrastructure, implement enhanced metering capabilities, and expand reuse. Infrastructure improvements can also yield ecological benefits by, for example, decreasing salinity levels.
- ***Flexible Water Management:*** Opportunities related to creating additional flexibility in water management were identified by both the Agricultural and Environmental and Recreational Flows Workgroups. Specifically, the expansion of existing or the addition of new programs such as water banking, exchanges, and transfers was identified as activities to enhance flexible water management. Flexible water management was identified as having the potential to be a useful tool in building water supply resiliency for agricultural users in the Basin in addition to facilitating multi-purpose solutions. The Environmental and Recreational Flows Workgroup found that the establishment of market-based mechanisms for such programs (e.g. water banking) has the potential to further promote multi-purpose

solutions, for example incentivizing water conservation activities in regions where flow improvements are needed to provide environmental and recreational benefits.

It was recognized that the applicability of such programs are dependent upon physical location and state and federal water law and will need to be vetted in consideration of local economies and related factors. However, such mechanisms are considered to have the potential to offer increased flexibility through partnership opportunities and could produce concurrent environmental and recreational benefits, while meeting water supply needs.

6.3 *Moving Forward* Next Steps

The *Moving Forward* effort builds upon and enhances the inclusive stakeholder process established during the Basin Study with an ultimate goal of identifying and implementing actionable steps to address projected water supply and demand imbalances that have broad-based support and provide a wide-range of benefits.

The Phase 1 Report completes Phase 1 of the *Moving Forward* effort. An outcome of this phase was a list of opportunities and potential future actions, compiled by each workgroup, which could help improve the long-term sustainability of Basin resources and improve the resiliency of regions dependent on Colorado River water. In Phase 2, which will commence in 2015, the Coordination Team, with input from the workgroups, will integrate and synthesize the Phase 1 opportunities and potential future actions identified by the workgroups and identify several proposed pilot projects. The goal of Phase 2 is the implementation of the proposed pilot projects. The structure of Phase 2 will be determined based on the nature of the pilot projects; however, the collaborative and inclusive approach demonstrated in the Basin Study and Phase 1 will be maintained. Additionally, it is the hope of the participants of the *Moving Forward* effort that the Phase 1 opportunities and potential future actions will be considered and undertaken by willing funding partners and interested stakeholders outside the *Moving Forward* effort.