Chapter 4

Agricultural Water Conservation, Productivity, and Transfers

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

Contents

Page

Tables

Figures

Appendices

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.

Workgroup Co-Chairs:

- Kenneth Nowak, Bureau of Reclamation
- Tina Shields, Imperial Irrigation District
- Reagan Waskom, Colorado State University

Workgroup Members:

- Jeanine Jones, California Department of Water Resources
- Chuck Cullom, Central Arizona Project
- Mohammed Mahmoud, Central Arizona Project
- Greg Gates, CH2M HILL (contractor team)
- Steve Shultz, CH2M HILL (contractor team)
- Dan Charlton, Coachella Valley Water District
- Robert Cheng, Coachella Valley Water District
- Angela Rashid, Colorado River Board of California
- Tanya Trujillo, Colorado River Board of California
- Warren Turkett, Colorado River Commission of Nevada
- Doug Bonamici, Colorado River Indian Tribes
- Ed Yava, Colorado River Indian Tribes
- Grant Buma, Colorado River Indian Tribes
- Dave Kanzer, Colorado River Water Conservation District
- Erin Wilson, Colorado Water Users Representative
- Aaron Citron, Environmental Defense Fund
- Dan Keppen, Family Farm Alliance
- Pat O'Toole, Family Farm Alliance
- Anisa Divine, Imperial Irrigation District
- Autumn Plourd, Imperial Irrigation District
- Joanna Smith, Imperial Irrigation District
- Delon Kwan, Los Angeles Department of Water and Power
- Grant Ward, Maricopa-Stanfield Irrigation and Drainage District
- Jan Matusak, The Metropolitan Water District of Southern California
- Kate Greenberg, National Young Farmers Coalition
- John Longworth, New Mexico Office of the State Engineer
- Brad Wind, Northern Colorado Water Conservancy District
- Ed Smith, Palo Verde Irrigation District
- Randy Kirkpatrick, San Juan Water Commission
- Lee Miller, Southeastern Colorado Water Conservancy District
- Bob Johnson, Southern Nevada Water Authority
- Jeff Johnson, Southern Nevada Water Authority
- Aaron Derwingson, The Nature Conservancy
- Russ Schnitzer, Trout Unlimited
- Don Ostler, Upper Colorado River Commission
- Eric Klotz, Utah Division of Water Resources
- Elston Grubaugh, Wellton-Mohawk Irrigation & Drainage District
- Wade Noble, Yuma County Agricultural Water Coalition

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.

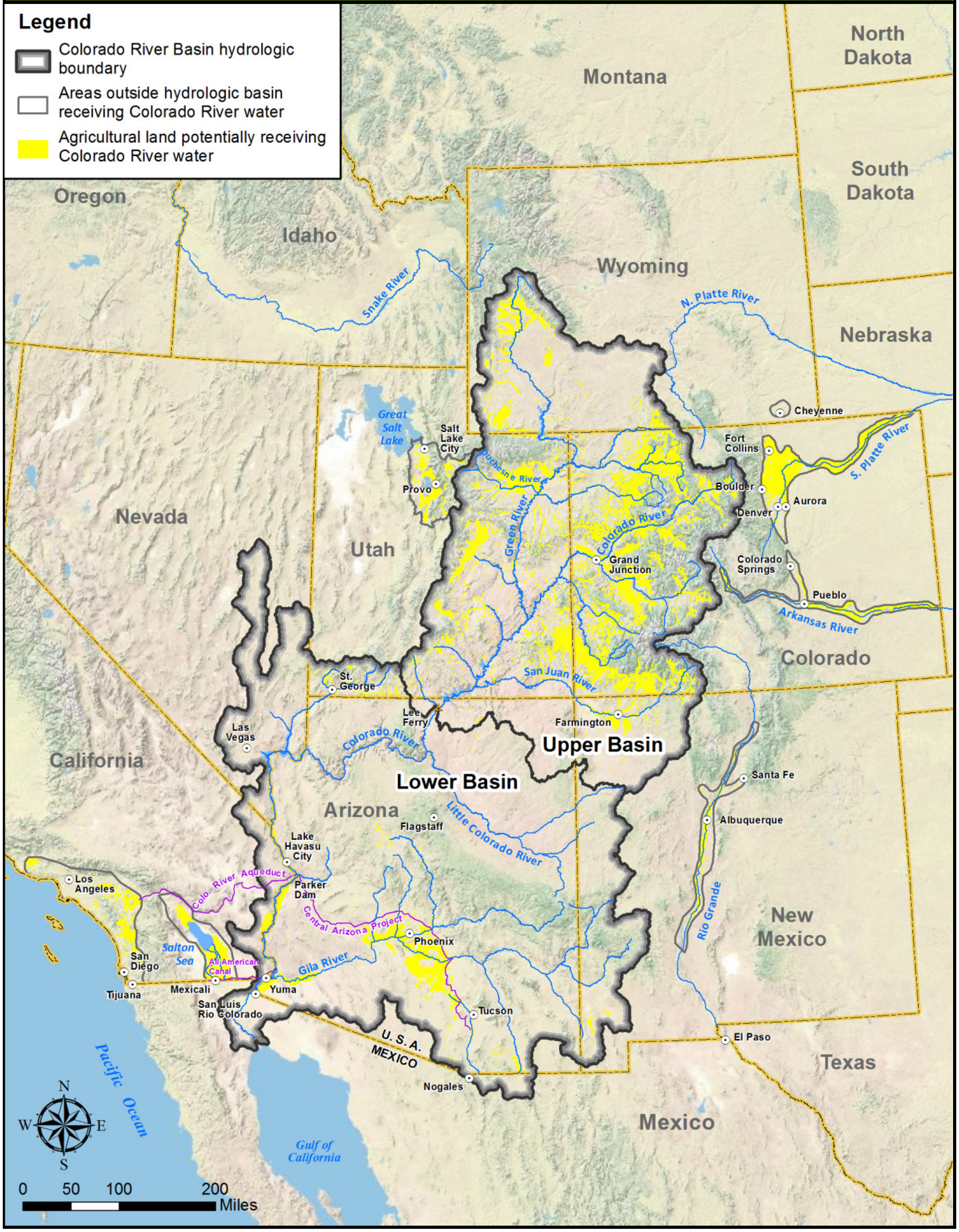
Data Collection and Analysis

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

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[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).

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.

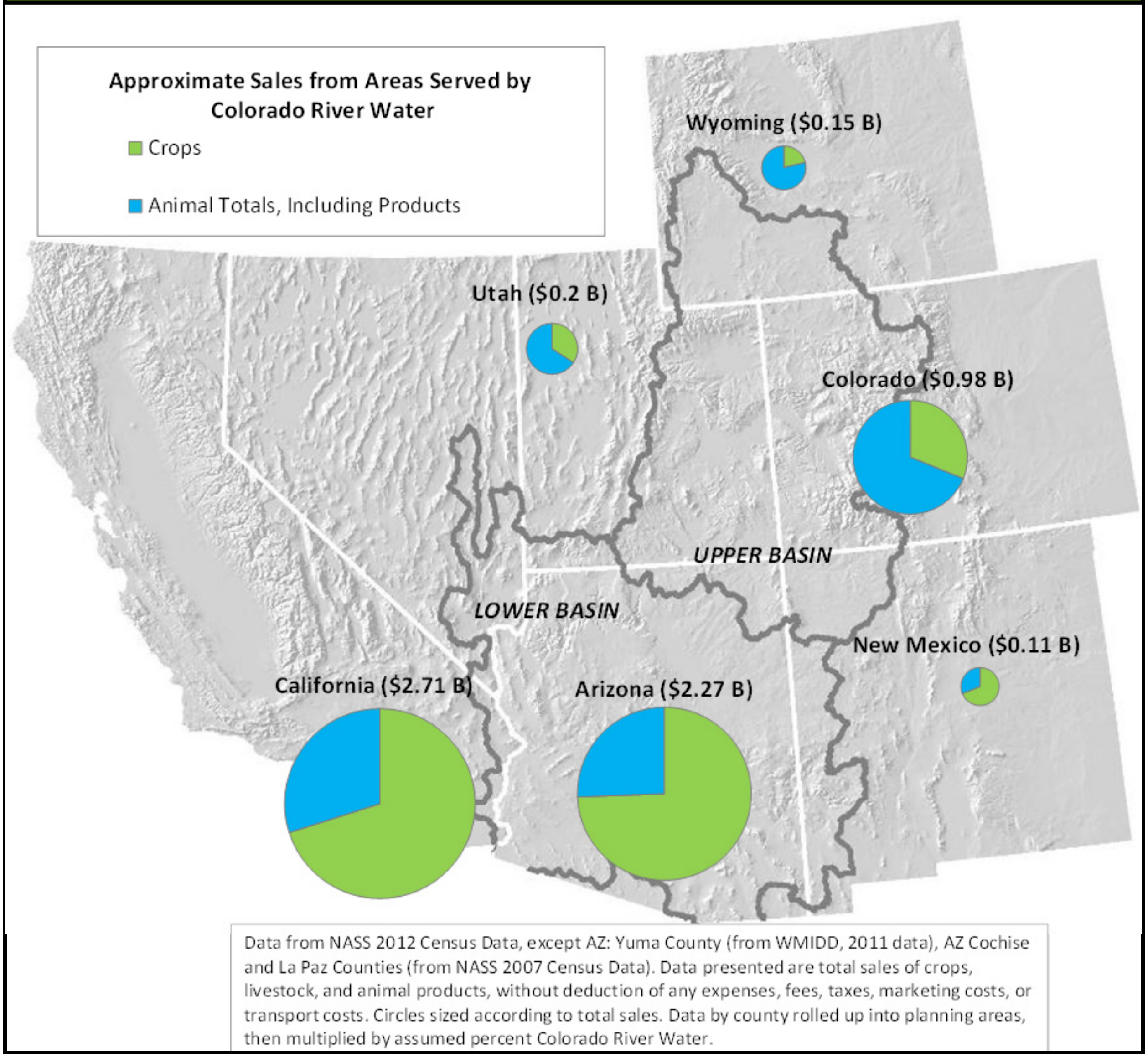
Food Security

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).

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.

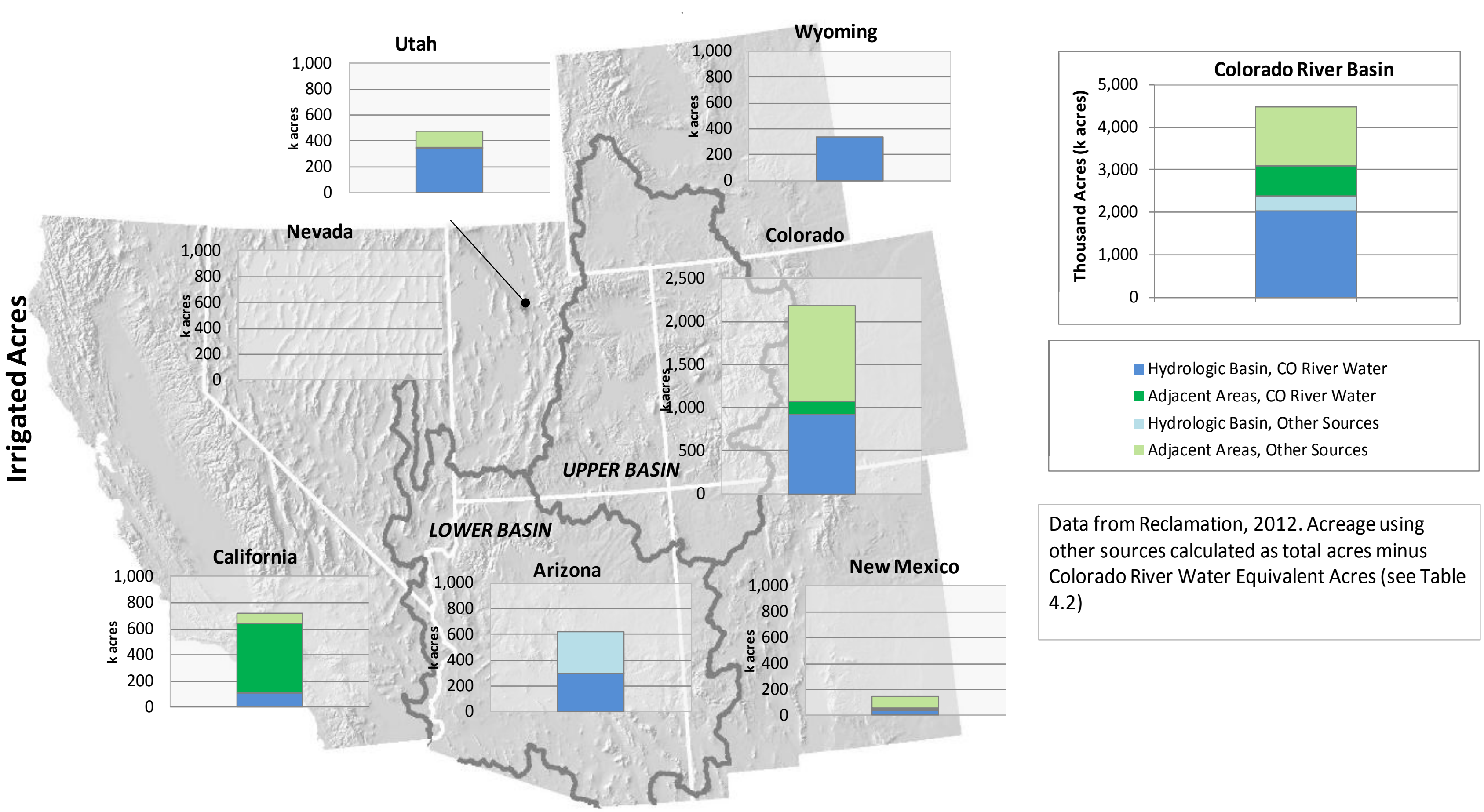
Crop selection is largely driven by crop prices and climate. Farmers generally grow the highest-value crops that can be grown in a given climate with the least risk and/or highest probability of successful cultivation, taking existing infrastructure into consideration. Figure 4-4 shows the cooler temperatures 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

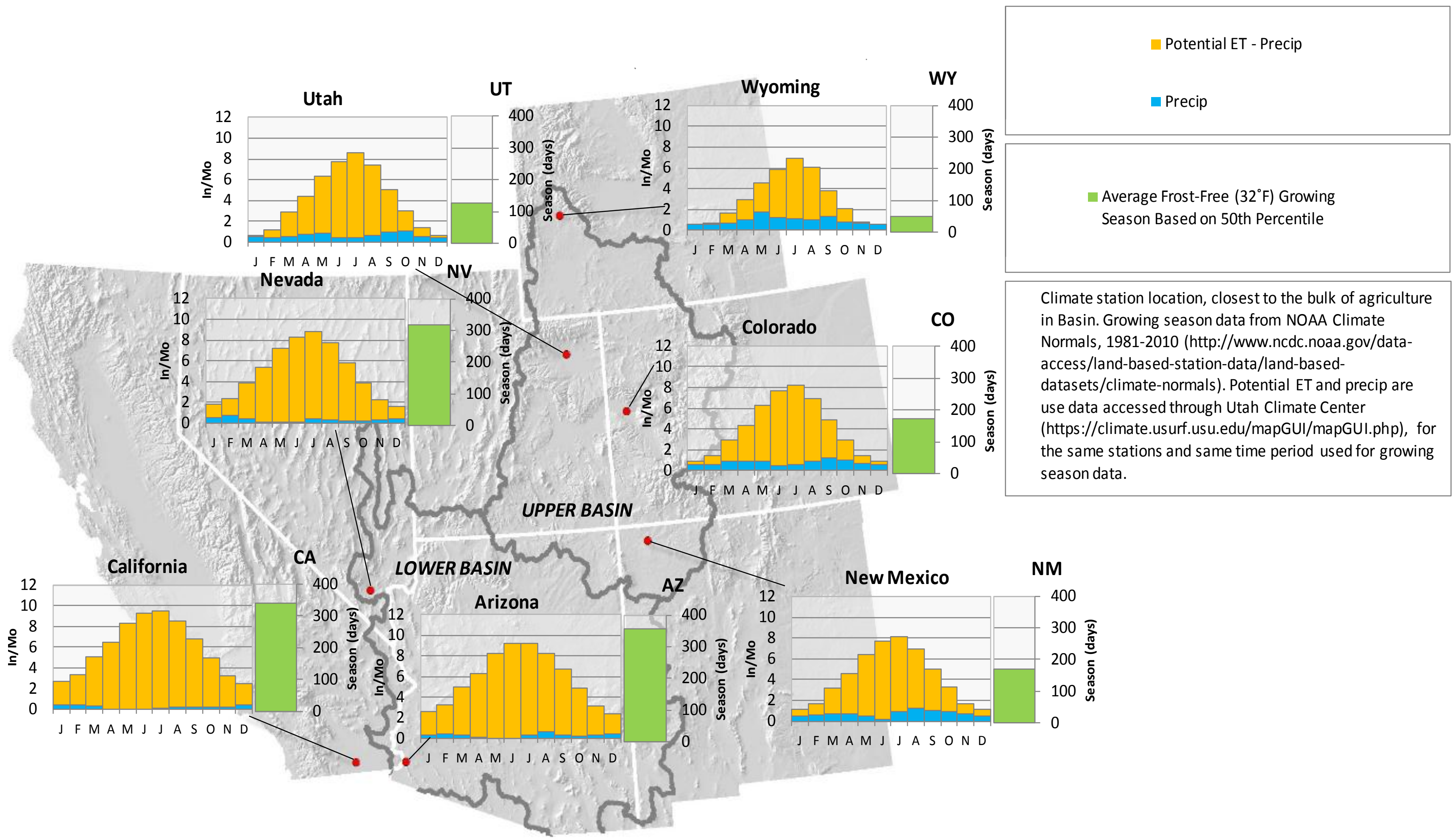


FIGURE 4-5
Crop Types by State

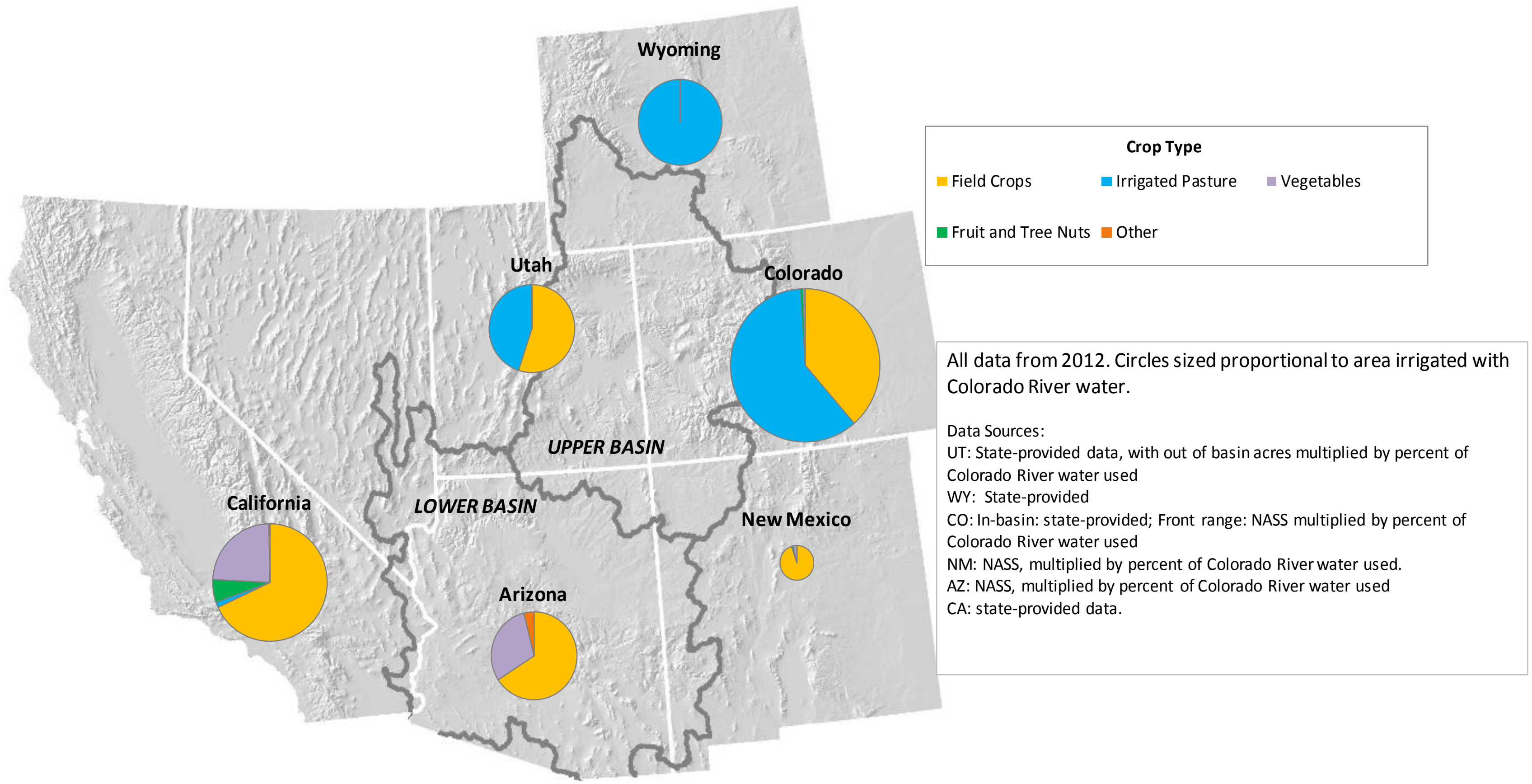
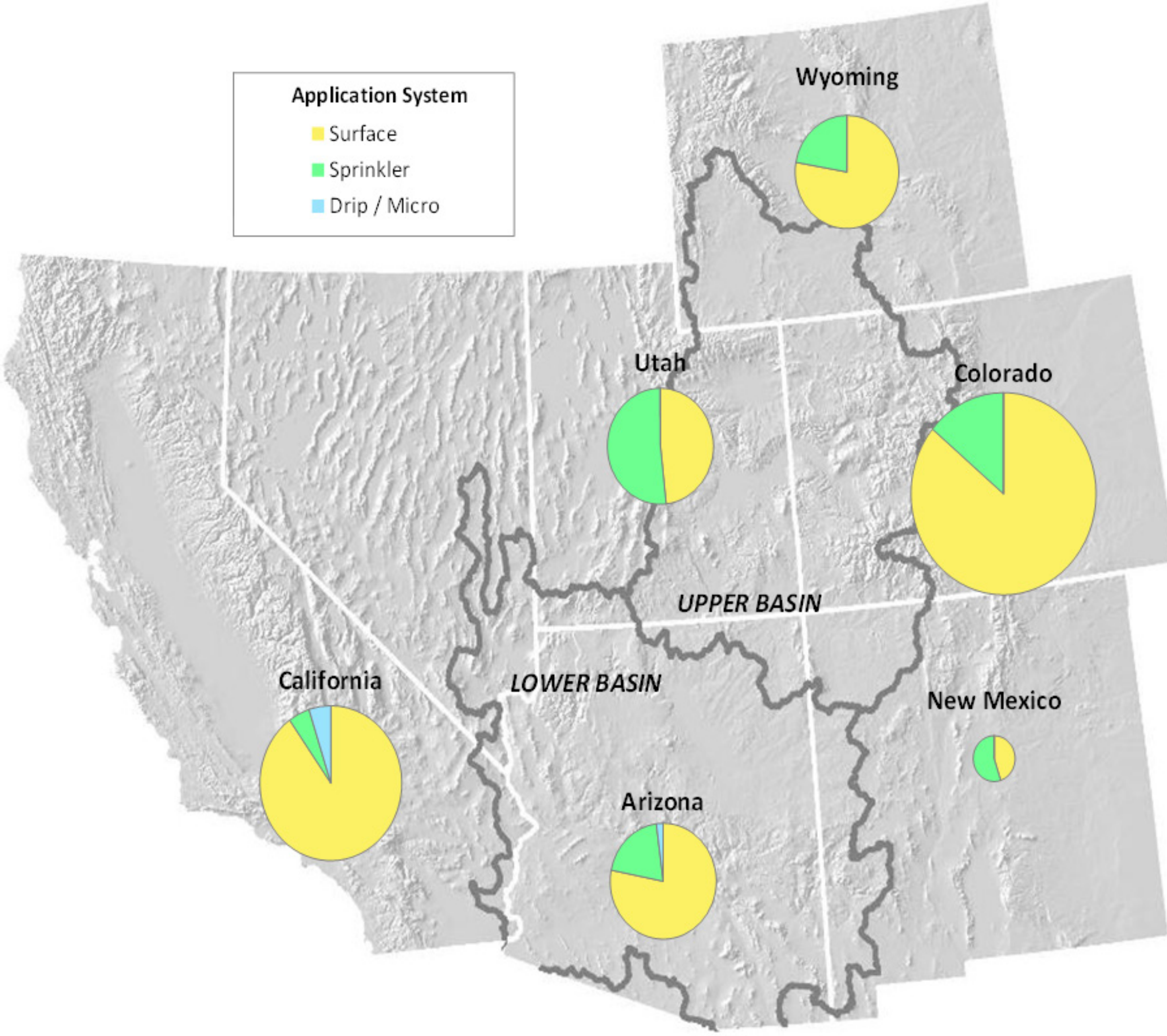


FIGURE 4-6
Irrigation Methods



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.

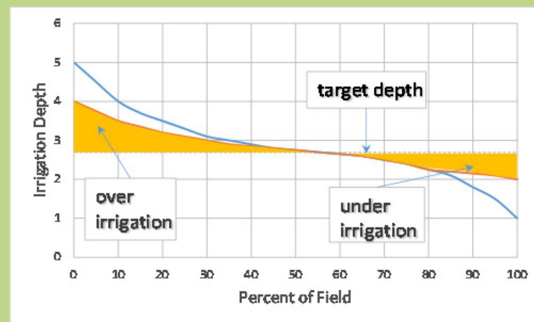
In the Upper Basin, most agriculture operates under water supply-limited conditions, meaning that the full demand of the crops grown cannot always be met with the available supply. These conditions are due in part to a lack of infrastructure to store, divert, deliver, and appropriately time the available 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.

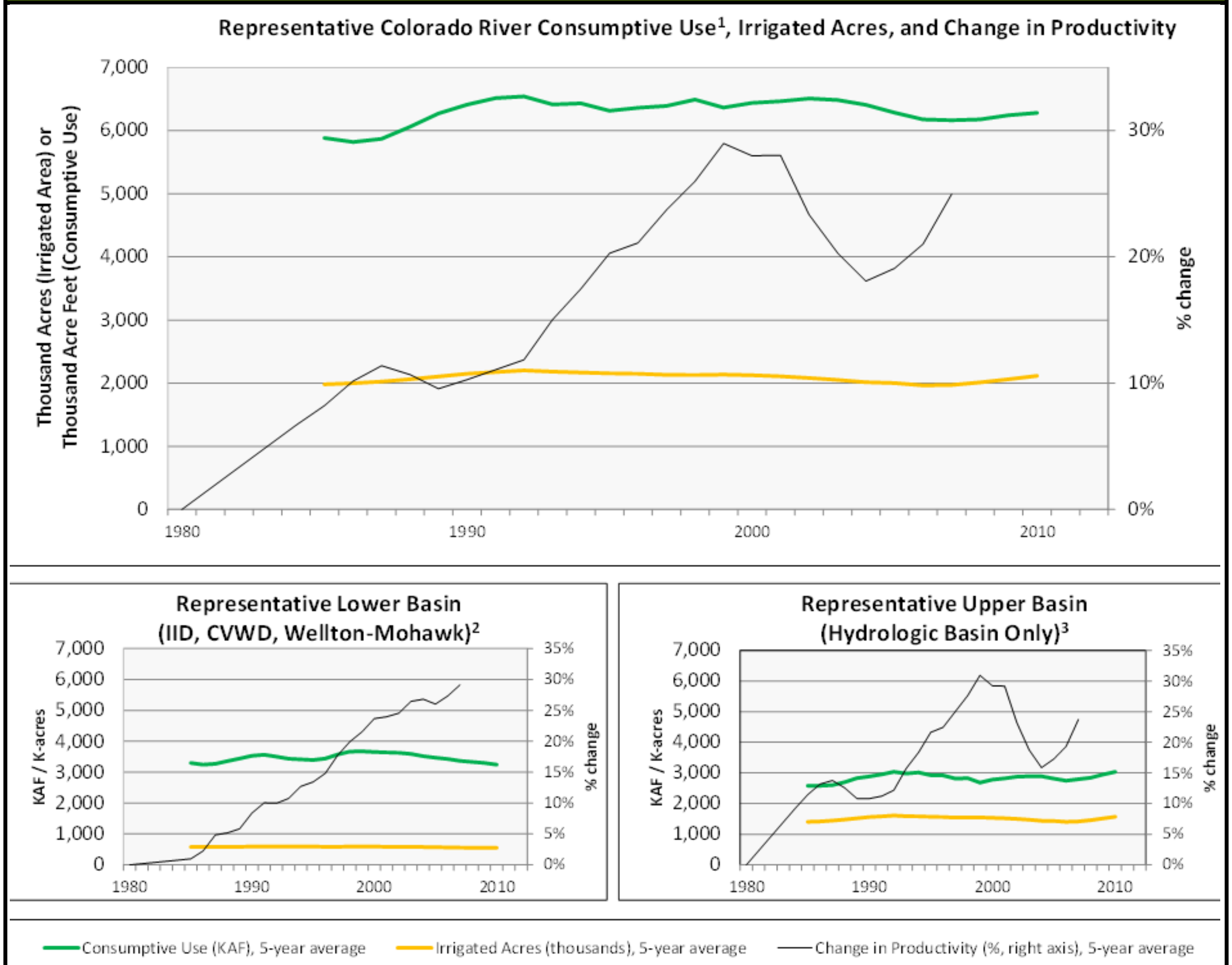


Source: Modified from Gollehon, 2014

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).

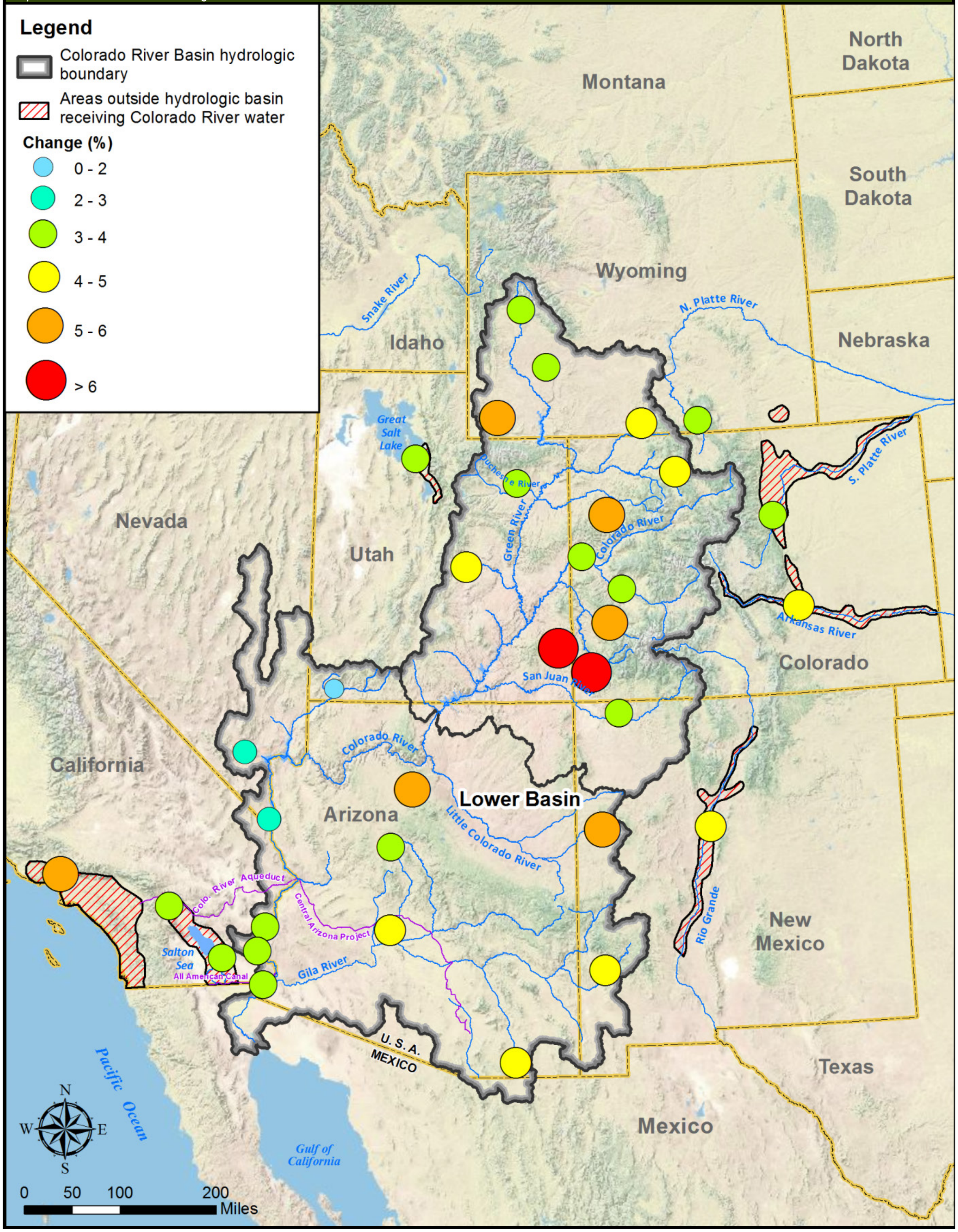
Historical productivity increases largely correspond with systematic genetic improvements in crop varieties. Further advances in agricultural production methods and varieties have the potential for enhanced productivity maintaining or reducing water consumption. For example, recent press reports have 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.

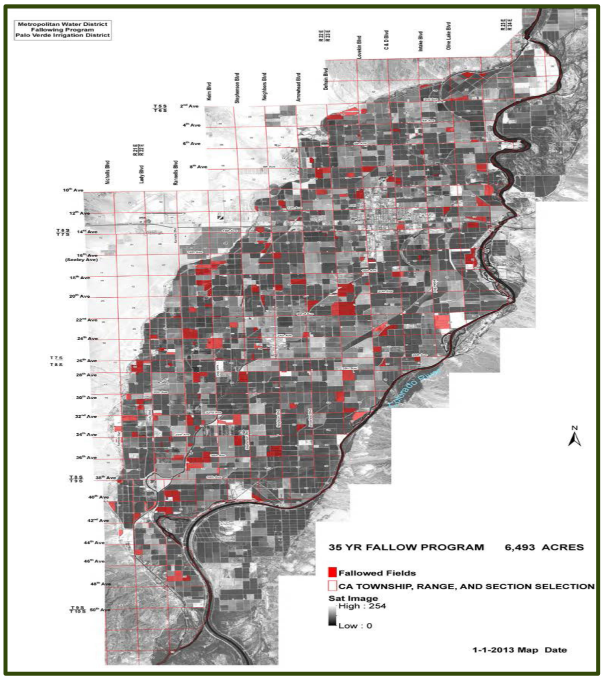
Reclamation supports a variety of programs that offer conservation and efficiency project funding. Through the Colorado River Basin Salinity Control Program, Reclamation has partnered with NRCS through EQIP and the Basin States to provide cost-share assistance to landowners who install salinity control 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

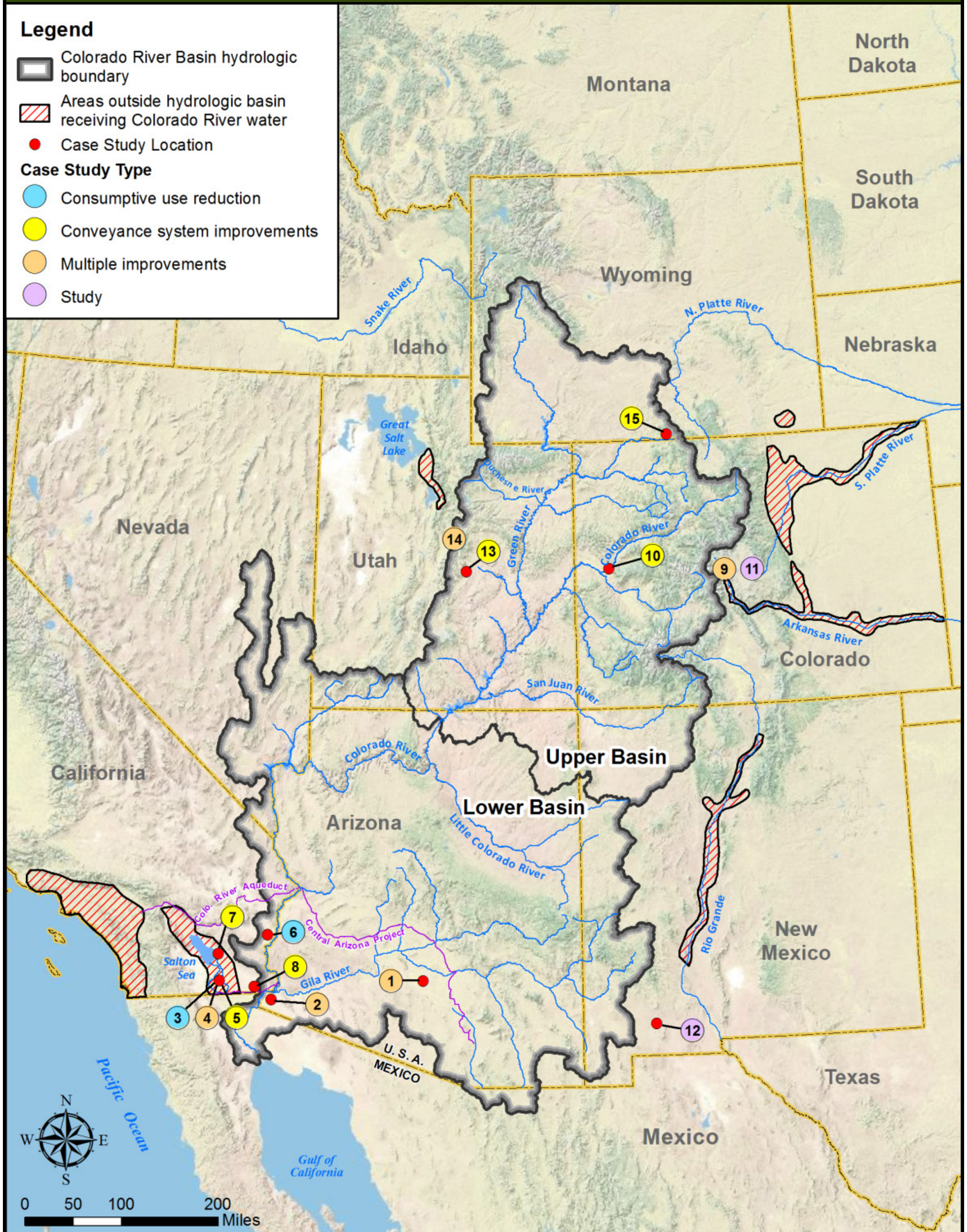
Case studies were developed to summarize agricultural water conservation projects that have taken place or are ongoing within the areas receiving Colorado River water. Case study locations are presented in Figure 4-9, and a summary is presented in Table 4-3. The case studies include fully implemented 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

[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.

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 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

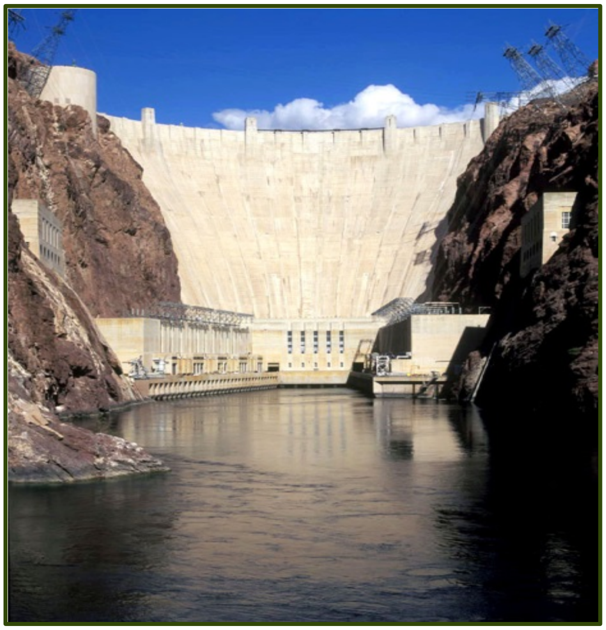
Flexible water management has the potential to be a useful tool in building water supply resiliency for agricultural water users in areas receiving Colorado River water. The Intentionally Created Surplus provision of the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated 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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