BUREAU OF RECLAMATION

Technical Memorandum 1 – Project Definition and Summary of Workshop #1

Exploration of Quantification Methods for Agricultural Water Savings in the Lower Colorado River Basin

U.S. Department of the Interior

January 2021

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Technical Memorandum 1 – Project Definition and Summary of Workshop #1

Exploration of Quantification Methods for Agricultural Water Savings in the Lower Colorado River Basin

prepared by

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Jacobs Engineering Group Inc.

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Project Definition

The Exploration of Quantification Methods for Agricultural Water Savings in the Lower Colorado River Basin Pilot Study (Pilot Study) is a logical next step in the long-standing commitment of United States Bureau of Reclamation (Reclamation) and the Lower Colorado River Basin (LCRB, Lower Basin) stakeholders to ensure the resiliency, reliability, and sustainability of the Colorado River. The objective of this study is to work collaboratively with a diversity of stakeholders to explore the current methods used to quantify certain agricultural water conservation activities in the Lower Basin, including the relationship of those quantification methods to the Lower Basin consumptive use accounting, and to recommend approaches to improve agricultural water conservation quantification methods.

Background

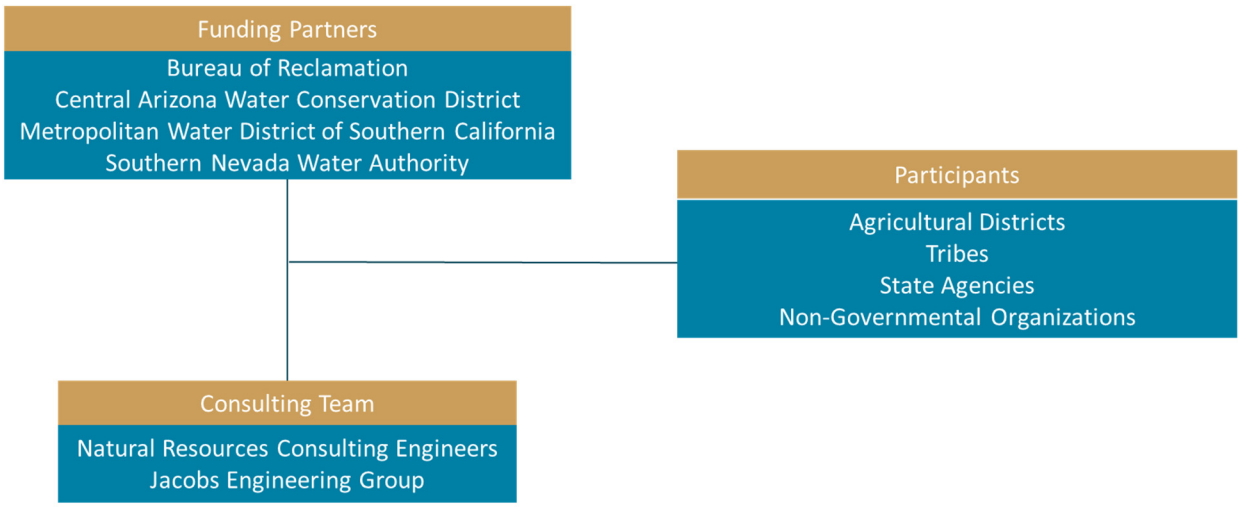
Since 2007, numerous efforts such as the Intentionally Created Surplus (ICS) Program and the Pilot System Conservation Program have been implemented, with the goal of bolstering the Colorado River System. In 2010, an unprecedented effort was started to define current and future (50-year) imbalances in water supply and demand in the Colorado River Basin and the adjacent areas of the Basin States that receive Colorado River water. In the Colorado River Basin Supply and Demand Study (Basin Study), strategies were identified to address the evolving supply-demand imbalance, including agricultural water conservation. In response to the findings of the Basin Study, Reclamation and the Basin States, in collaboration with the Ten Tribes Partnership and conservation organizations, initiated the Moving Forward effort in 2013 to build on future considerations and next steps identified in the Basin Study. Three multi-stakeholder workgroups were created to document past and projected future trends and explore the opportunities and challenges of various water management actions. The Agricultural Water Conservation, Productivity, and Transfers Workgroup identified accurate quantification of agricultural water conservation savings as a challenge warranting further exploration.

In 2019, Reclamation began pursuing funding for a new activity under the WaterSMART (Sustain and Manage America's Resources for Tomorrow) Program called Water Management Options Pilots. The goal of these pilots is to identify water management solutions to issues identified in recently completed efforts. In 2020, WaterSMART selected and provided funding for this Pilot Study, which was financially matched by the non-Federal partners to explore methods of quantifying agricultural water savings through knowledge shared by participants and an evaluation of existing case studies. Natural Resources Consulting Engineers, Inc. (NRCE) and Jacobs Engineering Group Inc. (Jacobs) were selected to assist Reclamation and the non-Federal partners in this effort. The funding window, and therefore the schedule for completion of this Pilot Study is the end of 2021.

Project Team Organization

The Pilot Study project coordination team consists of some key LCRB stakeholders but other participants, particularly from the agricultural districts and tribes, are key to the success of this project. The project team organization is presented in ***Figure 1***.

Figure 1 Project Team Organization



Objectives

The specific objectives of this Pilot Study are as follows:

- Identify and describe methods currently in use to quantify agricultural water conservation.
- Evaluate those methods for consistency and accuracy with Reclamation's Lower Colorado River water accounting methods.
- Evaluate existing case studies using a combination of research and applied science.
- Recommend approaches to improve methods of quantifying agricultural water conservation in the LCRB.

While it is important to identify the objectives of this Pilot Study, it is also important to clarify what this study is not:

- It is not a policy study.
- Participation is not mandatory.
- It is not an attempt to change accounting practices.
- It is not a hypothetical analysis of potential future application or savings.
- It is not a water use/efficiency audit.

The results of this study will be used to:

- Document and share information and experiences to promote a common understanding.

- Identify best methods/practices for quantifying agricultural water savings to the extent possible. It is important to note that the intent of this study is not to impose a standard methodology for quantification; instead it is necessary to recognize that differing soil, drainage, irrigation methodology, crop, crop growing season, and other factors affect the

application of agricultural water savings methodologies and quantification of the amount of water saved.

- Address the need for transparency between project partners and help answer potential questions about quantitative benefits.

Summary of Workshop #1

Workshop #1 was conducted virtually over the course of two half-day sessions on November 9 and 10, 2020. The purpose of this workshop was to review the 2012 Basin Study and the follow-on 2015 Moving Forward Effort to ensure that the Pilot Study builds on and does not duplicate the results of those two efforts. The proposed Pilot Study tasks, milestones, and schedule were reviewed and workshop participants were encouraged to help refine the scope of the Pilot Study. In addition, the project team described how consumptive use savings from conservation measures are administratively accounted for by Reclamation in the annually published *Colorado River Accounting and Water Use Report: Arizona, California and Nevada* required by the Decree of the Supreme Court of the United States in *Arizona v. California* 547 U.S. 150 (2006). Finally, the project team presented the Pilot Study case study concept and requested participants help frame the process.

The following sections summarize the shared information and discussions in the workshop. A copy of the presentation slides is included in the Appendix.

Participants

Over 50 people participated in Workshop #1. ***Table 1*** is a list of the workshop attendees. All attendees participated on both days unless otherwise indicated.

Table 1 Workshop 1 Participants

Funding Partners			
Reclamation Dan Bunk Jeremy Dodds John Shields Amber Cunningham Nancy DiDonato Pam Adams Chris Wallis (day 1 only) KayLee Nelson Nohemi Olbert	**CAWCD** Chuck Cullom Deanna Ikeya	**MWD** Aaron Mead Larry Lai Noosha Razavian Jessica Arm (day 1 only) Kira Alonzo Laura Lamdin	**SNWA** Seth Shanahan Casey Collins
Agricultural Districts/Cities			
IID Tina Shields Dylan Mohamed Ben Brock	**PVID** Andrew Slagan Bert Bell JR Echard	**MSIDD** Tony Solano Shelly Walker	**City of Yuma** Douglas Nicholls (day 1)
WMIID Ken Baughman	**Bard Water District** Nicholas Bahr	**Noble Law** Wade Noble Meghan Scott	
Tribal Representatives			
Bureau of Indian Affairs Jonathan Cody Johnita Whiteman (day 1) Denni Shields (day 1)	**Quechan Tribe** Frank Venegas Jay Weiner	**CRIT** Margaret Vick (day 1) Zach Stevens (day 2)	**Ak-Chin Indian Community** Tom Harbour
Navajo Nation Crystal Tulley-Cordova	**Cocopah Tribe** Michael Smith	**Fort McDowell Yavapai Nation** Gerry Walker (day 1)	
State Agencies			
ADWR Bret Esslin Vineetha Kartha	**Colorado River Board of California** Rich Juricich	**University of California Cooperative Extension** Ali Montazar (day 1)	
Consultants			
NRCE Tom Ley Ryan McBride Burdette Barker Miles Daly	**Jacobs** Lela Perkins Armin Munever Chris Kurtz Jason Smesrud		

Overview of Previous Planning Studies

Armin Munever, Global Technologist of Integrated Water Resource Management with Jacobs, provided an overview of related previous planning studies, focusing on the 2012 Basin Study and the subsequent 2015 Moving Forward Effort. Armin was the Project Manager and Technical Lead for both projects.

2012 Basin Study

The objectives of the 2012 Basin Study were to assess the current and future water supply and demand imbalances in the Colorado River Basin (see ***Figure 2*** ***Figure 2***) through 2060, and to develop and evaluate opportunities for resolving those imbalances. The study was conducted by Reclamation and the Basin States in collaboration with stakeholders throughout the Basin. As a planning study, it did not result in decisions, but provided a technical foundation for future activities.

Figure 2 Colorado River Basin Map

A unique scenario planning approach evaluating multiple potential water supply and demand trajectories was utilized in the study, and it was determined that imbalances are likely in the future due to both declining supplies and increasing demands.

A broad assessment of options to address long-term reliability was undertaken using multiple criteria evaluation and decision analysis to develop water management portfolios of strategies for long-term sustainable solutions. Potential agricultural activities identified to address the supply/demand imbalance included:

- Advanced irrigation scheduling
- Deficit irrigation
- On-farm irrigation system improvements
- Controlled environment agriculture
- Conveyance system efficiency improvements
- Fallowing of irrigated lands

The potential Colorado River water savings associated with these activities were estimated to be up to 1 million acre-feet (MAF)/year by 2060.

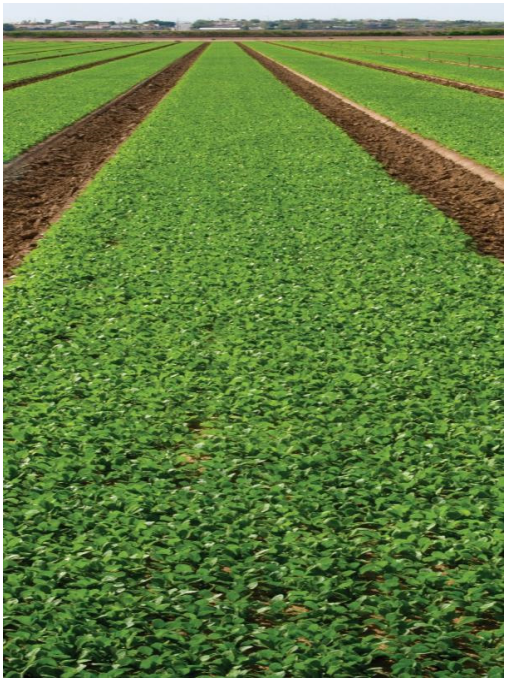
Key findings from the Basin Study that are valuable to consider for future planning include:

- Potential climate impacts, growing demand, and multiple competing resources will challenge the system in the future. The system is vulnerable under status-quo operations. Action greatly reduces that vulnerability and makes the system more resilient but does not eliminate vulnerability.

- A wide range of solutions are needed to mitigate and adapt to such shortfalls, which are likely to affect each sector (agricultural, municipal, energy, and environmental, for example) dependent on the Colorado River and its tributaries.

- In the near term, all portfolios considered in this study show that water conservation and reuse are cost-effective ways to reduce vulnerability. However, in the longer term (2040 to 2060), more tradeoffs emerge in terms of acceptable level of risk and the options to mitigate that risk.

2015 Moving Forward Effort



Phase 1 of the Moving Forward Effort was initiated in 2013 and funded by Reclamation and the Basin States to build on the technical foundation established by the Basin Study in addressing the challenges identified for the Basin. In the Moving Forward Effort, an even broader stakeholder framework was utilized. That framework included the formation of a Coordination Team and three multi-stakeholder workgroups that focused on: municipal and industrial water conservation and reuse; agricultural water conservation, productivity, and transfers; and environmental and recreational flows.

In the study, it was determined that no one sector can provide solutions for ensuring long-term sustainability. To respond to future challenges, diligent planning is required to find adaptable solutions that build resiliency and apply a wide variety of ideas at local, state, regional, and Basin-wide levels. Central to this process are partnerships and the recognition that future actions must be done collaboratively by relying on the inclusive stakeholder process conducted successfully in the Basin Study.

The Agricultural Water Conservation, Productivity, & Transfers Workgroup objectives were to:

- Quantify historical trends in agricultural conservation and transfers of Colorado River water (both inside and outside of the Basin).
- Document agricultural water conservation programs that have been successful to date. Fifteen case studies were examined as examples of ongoing or planned projects (eight of the case studies were located in the Lower Basin).
- Identify existing future plans for these types of activities and estimate what potential savings could come from these existing plans.

The workgroup documented the following findings:

- 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.

- Many agricultural conservation advances have been achieved as part of a variety of Federal, state, and local stakeholder programs working toward mutually beneficial solutions.

- Agricultural producers have implemented a wide range of conservation and efficiency measures and have often increased productivity as a result.

- 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 (e.g., in or out of the hydrologic basin).

- Opportunities exist for additional agricultural water conservation, transfers, and productivity enhancements, but may become more difficult and costly as they are implemented.

- Data gaps and reporting variations—including variations in the methods used to quantify agricultural water conservation savings—make analysis of agricultural water use difficult.

Pilot Study Scope, Schedule, and Milestones

Tom Ley, Senior Supervising Engineer with NRCE Inc., provided an overview of the proposed Pilot Study Scope, Schedule, and Milestones in order to inform the workshop participants and solicit feedback on any suggested refinements. The major scope items include:

- Review relevant previous/on-going efforts in order to avoid duplication.
- Conduct a literature review of agricultural water conservation activities.
- Focus on activities in the LCRB with an emphasis on quantification methodologies.
- Identify LCRB case studies for potential analysis.
- Conduct site visits/interviews for selected case studies.
- Document the conservation activity implemented and the quantification method(s) used to estimate conserved water.
- Compare the estimate of conserved water with Reclamation's methods and calculations.
- Assess opportunities to improve the quantification method(s).
- Document efforts throughout process.

During the second day of the workshop, the following topics were reviewed in detail to confirm alignment of the remaining major scope items with expectations:

General Considerations

Input and feedback from all interested parties is critical and valued. Project participants are encouraged to provide leads for the literature review as well as information on conservation

activities they have applied and tested or that are part of current and on-going efforts to improve efficiency/conserve water. A project website has been created for the Pilot Study: https://LCRBPilotStudy.com/. Project participants can post comments, ask questions, and upload/download project reports and other documents.

This study will focus on conservation measures that include both consumptive use reductions (e.g. fallowing, deficit irrigation, crop mix changes, etc.) and efficiency improvements (on-farm irrigation improvements, and conveyance system improvements).

In order to fully characterize water conservation, it is essential to perform a water balance-- the inflows, outflows, and change of storage for a given system. Each component of the water balance (inflows, uses that remove water from the system, or return flows) are identified, characterized, measured, or estimated. The ultimate fate and disposition of the return flows (losses due to inefficiencies) are important factors in determining if there is a water savings or not. Accurate quantification requires that the water balance be performed prior to any efficiency improvement to understand the baseline condition.

Consumptive use reductions occur at the farm field level. Similar to efficiency improvements, accurate measurement or estimation of actual consumptive use under pre-intervention conditions is necessary. Quantification methods must consider measuring or estimating actual consumptive use versus potential consumptive use to avoid overstating consumptive use savings.

Tasks 3 and 4 – Literature Review

A review of academic and technical literature (studies, research, reports, journals) will be conducted to determine what agricultural water conservation technologies are being implemented and what methodologies are being used to quantify conservation in the LCRB, including:

- Full-year agricultural cropland fallowing
- Seasonal or partial-year cropland fallowing
- Deficit irrigation
- Switching crops or crop rotations requiring less irrigation water
- Irrigation methodology conversions

The literature review effort will focus on information, data, reports, research, and results since the completion of the Basin Study and the Moving Forward Effort. Literature addressing conservation activities and topics applied in the Lower Basin will be prioritized.

Task 5 – Workshop 2

A list of recent or on-going irrigation water conservation efforts that could serve as potential case studies will be identified using information from the project participants and the literature review effort.

The case studies to be evaluated as part of this study will be selected through a collaborative workshop process (Workshop #2) with the project participants. Potential considerations in selecting case studies include:

- Representation of a diversity of agricultural conservation activities (to the extent possible)
- Representation of a diversity of water savings quantification methods (to the extent possible)
- Representation of a diversity of geographies within the LCRB (to the extent possible)

Tasks 6 and 7 – Case Study Investigations

The following data and information will be documented for each case study through site visits and interviews:

- The conservation activity that was/is being implemented
- The water savings quantification methodologies and approaches utilized
- The observed results, findings, constraints and limitations of the conservation activity
- Any unanticipated consequences and lessons learned
- The final outcome(s) of the quantification of consumptive use savings or water use efficiency
- A comparison of the quantification with Reclamation's methods and calculations
- Recommendations for improving quantification methods

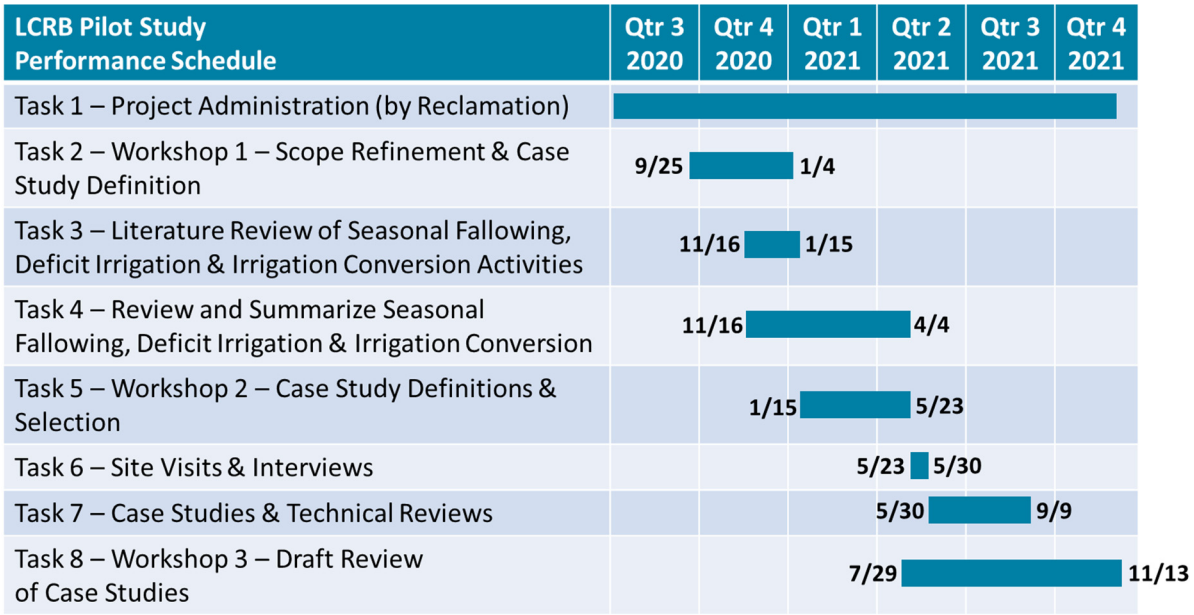
Task 8 – Workshop 3

A third workshop (Workshop #3) will be held with the project participants. The purpose of this workshop will be to present and discuss the results of the case studies and the proposed Pilot Study recommendations.

No significant scope refinements were suggested by the workshop participants. It was noted that, where possible, the study should highlight the success of agricultural efficiency improvements in the LCRB, the impacts of conservation on productivity, and non-consumptive use benefits.

The proposed project schedule is shown in *Figure 3*.

Figure 3 Proposed Project Schedule



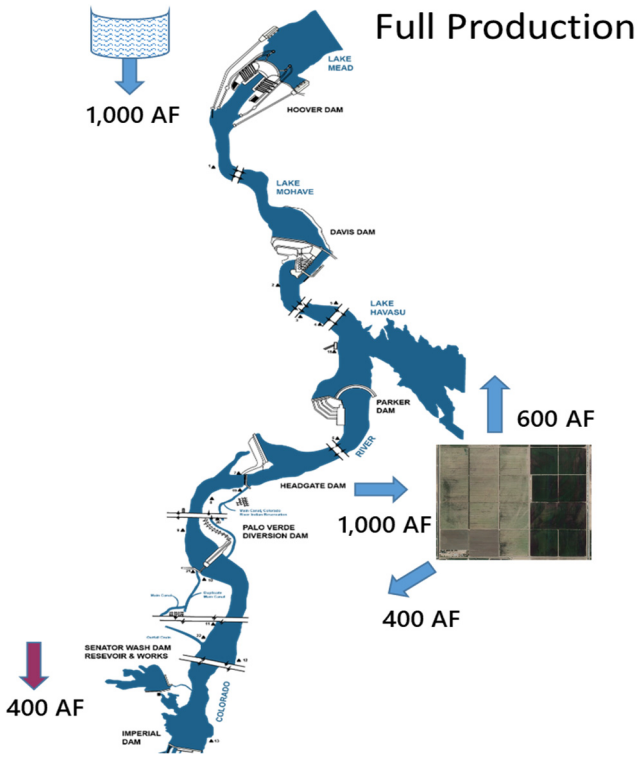
Key milestones are as follows:

- Workshop 1 – November 9-10, 2020
- Milestone 1: Draft Technical Memorandum 1 – Project Definition and Summary of Workshop #1 – December 2020
- Milestone 2: Draft Technical Memorandum 2 – Summary of Significant Findings from Literature Review & Recent/Current Activities in the Lower Basin – February 2021
- Workshop 2 – March 2021
- Milestone 3: Draft Technical Memorandum 3 – Summary of Case Study Definition, Site Selection & Evaluation Process – April 2021
- Site Visits/Interviews – May 2021
- Milestone 4: Draft Report – Case Studies and Technical Reviews – August 2021
- Workshop 3 – September 2021
- Milestone 5: Final Report –November 2021
- Presentation at CRWUA – December 2021

Conservation Measures and Quantification of Consumptive Use in Colorado River Water Accounting

Jeremy Dodds, Water Conservation and Accounting Group Manager with Reclamation, provided an overview of Reclamation's consumptive use water accounting methodology and how it relates to conservation measures. Pursuant to 1964 U.S. Supreme Court Decree (Consolidated in 2006), Reclamation is required to account for Colorado River water use including providing an official record of mainstream diversions, returns and consumptive uses, and the annual Colorado River Accounting & Water Use Report.

Figure 4 Consumptive Use Calculation Example



The fundamental premise of the methodology is that conservation activities must result in a measurable reduction in mainstream Colorado River consumptive use. Examples of conservation activities include:

- Fallowing (seasonal or full-year)
- On-farm efficiency improvements (e.g. drip irrigation, tailwater return systems, center pivot)
- Delivery system improvements (e.g. seepage recovery, canal lining)

Jeremy provided examples (see ***Figure 4***) of consumptive use calculations for various activities (full production, fallowing, efficiency improvements, and exported water) to demonstrate the impact on conservation savings quantification. He also highlighted that various quantification methods are currently used in the Lower Basin due to the uniqueness of each water user and that historically water users have proposed the method to be utilized to Reclamation.

Case Study Definition and Approach

To lead the workshop participants in a discussion of the case study definition and approach process, Tom Ley provided the following working definition of a case study (emphasis added)[1]:

> An applied research method involving an *up-close, in-depth, and detailed examination of a particular phenomenon*, like a person, group, or situation. The phenomenon is studied and analyzed in detail and *solutions or interpretations are presented to provide a deeper understanding* of a complex topic or assists in *gaining experience about a certain historical situation*.

Defining the Phenomenon

The first step in the case study definition and approach process is to define the phenomenon. The phenomena to be examined through this study are the agricultural water conservation technologies being implemented and the methodologies being used to quantify conservation in the LCRB.

Detailed Examination of the Phenomenon

These phenomena will be studied and analyzed in detail through both the literature review and case study process. The literature review will identify recent water conservation quantification methodologies and approaches under various relevant conservation measures, and annotated bibliographies will be developed. Potential recent/current case studies will be identified by project participants. Case studies will be selected for evaluation through a collaborative workshop process with the goals of representing of a diversity of agricultural conservation activities, water savings quantification methods, and geographies within the LCRB (to the extent possible).

Solutions/Interpretations to Provide a Deeper Understanding

Pertinent data and information will be collected through site visits and interviews and analyzed for each case study. In addition, an assessment of opportunities to improve or enhance quantification methods will be conducted and recommendations will be provided. The results of this effort will be documented in technical memoranda and a final report and will be shared with the project participants through collaborative workshops throughout the process.

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[1] Paraphrased from: Stephanie Glen. "Case Studies: Case Study Definition and Steps" From StatisticsHowTo.com: Elementary Statistics for the rest of us! https://www.statisticshowto.com/case-studies/

Workshop Participant Perspectives

A facilitated discussion was held among the workshop participants in order to solicit insights to better inform the study process. The following questions were asked of the group:

- What actions have led to successful collaboration in previous Reclamation studies?
- What would be the ideal outcome of the Pilot Study for the various participants?
- Are there concerns about participating in this study? If so, what can be done to address/minimize the concerns?

A participant inquired how Reclamation and the non-Federal funding partners will use the results of this study. The following responses were provided:

- From Reclamation's standpoint, this effort will benefit everyone by promoting a common understanding and better quantification of agricultural conservation savings. However, this study will not make other quantification methods "unusable" even if they are not identified as "best".
- SNWA indicated that the benefit of this study is obtaining, documenting, and sharing information (the collective experience) and identifying the best methods for quantification.
- MWD agreed with SNWA's sentiment of identifying best methods/practices.
- CAWCD added that the study addresses the need for transparency between project partners, could help answer questions of quantitative benefit posed by Upper Basin, and helps document the success of efficiency efforts in the Lower Basin.

A participant commented that incentives to improve water efficiency vary across the basin and need to be developed. For example, CRIT is focused on canal lining and re-regulation of reservoirs. Incentives to implement these projects are currently not available to CRIT.

A participant asked what the definition of conservation is for this study. Reclamation indicated that conservation of applied water and actual water use will both be considered. CAWCD added that the definition should relate to water use reductions that can be tracked by water levels in Lake Mead, which will be largely geography dependent. The participant agreed that the conservation definition should consider both applied water and consumptive use.

A member of the consultant team asked the group how this study could be best crafted to benefit agricultural districts. A participant expressed concern about salinity and desertification, and that even moderate deficit irrigation reduces crop yield, and results in declining productivity. Agricultural producers would be more willing to conserve but need to be compensated for lost crop productivity. This is different than other conservation practices which do not necessarily result in crop yield loss.

Reclamation reiterated that Reclamation would like to hear about any concerns with the study as soon as possible.

Appendix: Workshop 1 Presentation Slides

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Exploration of Quantification Methods for Agricultural Water Savings in the Lower Colorado River Basin

Workshop #1

November 9-10, 2020

Agenda – Day 1

- Welcome and Introductions
- Pilot Study Overview and Objectives
- Overview of Previous Planning Studies
- Overview of Pilot Study-Scope, Schedule and Milestones
- Workshop Participant Perspectives
- Wrap-up and Preview of Day 2

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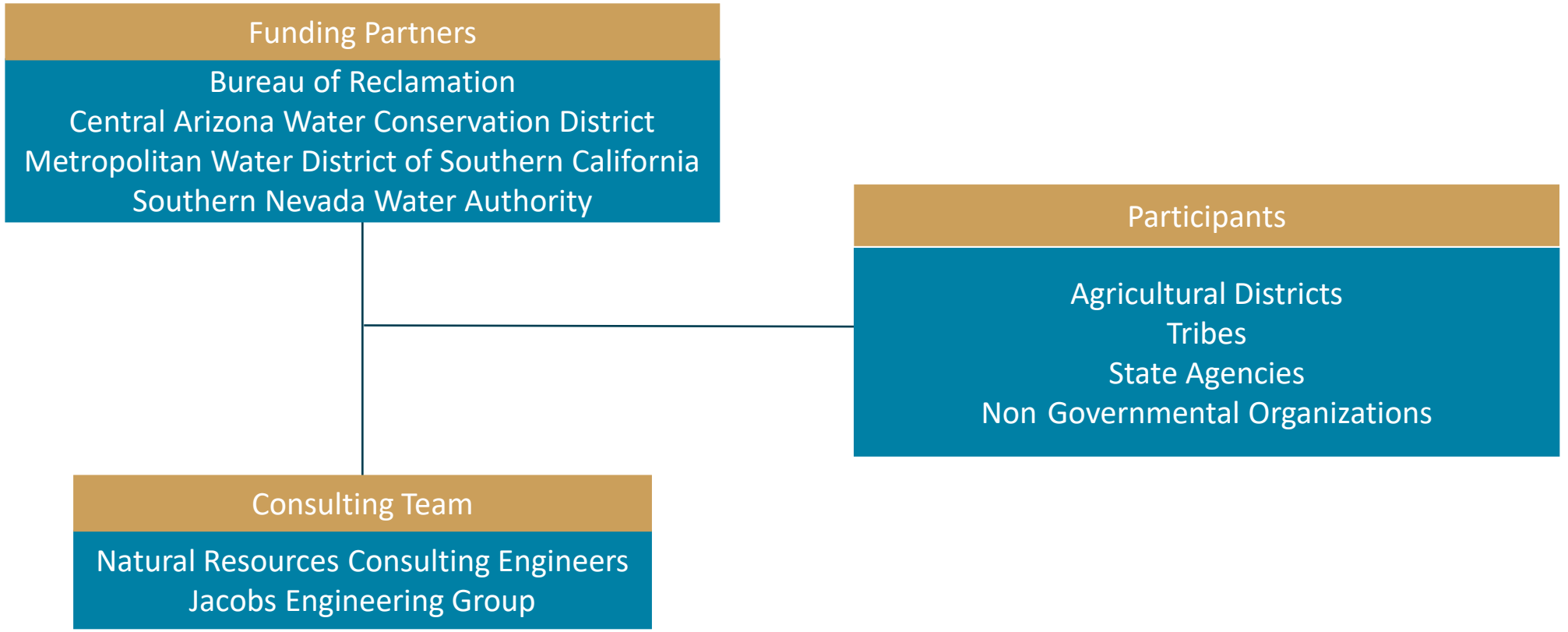
Welcome/Introductions

Project Team Organization



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Pilot Study Overview and Objectives

Background

- The 2012 Colorado River Basin Supply and Demand Study identified strategies to address the evolving supply-demand imbalance
- The subsequent Moving Forward effort identified quantification of agricultural conservation water savings as a challenge
- In 2019, Reclamation began funding a new activity under the Basin Study Program called Water Management Options Pilots
  - The goal is to identify solutions to water management issues by building on completed basin studies
- Reclamation and partners awarded funding for proposal for pilot study to quantify agricultural water conservation and demand management methodologies for the Lower Colorado River Basin

Pilot Study Objectives

- Explore methods currently in use to quantify agricultural water conservation
- Evaluate methods for consistency and accuracy with Reclamation's Lower Colorado River water accounting methods
- Recommend approaches to improve methods of quantifying agricultural water conservation in the Lower Basin
- Evaluate case studies using a combination of research and applied science
- Participant input and feedback is critical to the success of the Study

What this Study is Not

- This is not a policy study
- Participation is not mandatory
- Not an attempt to change accounting practices
- Not a hypothetical analysis of potential future application or savings
- Not a water use/efficiency audit

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Overview of Previous Planning Studies

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Colorado River Basin Water Supply and Demand Study

Integrated, Long-Term Planning in the Face of Uncertainty

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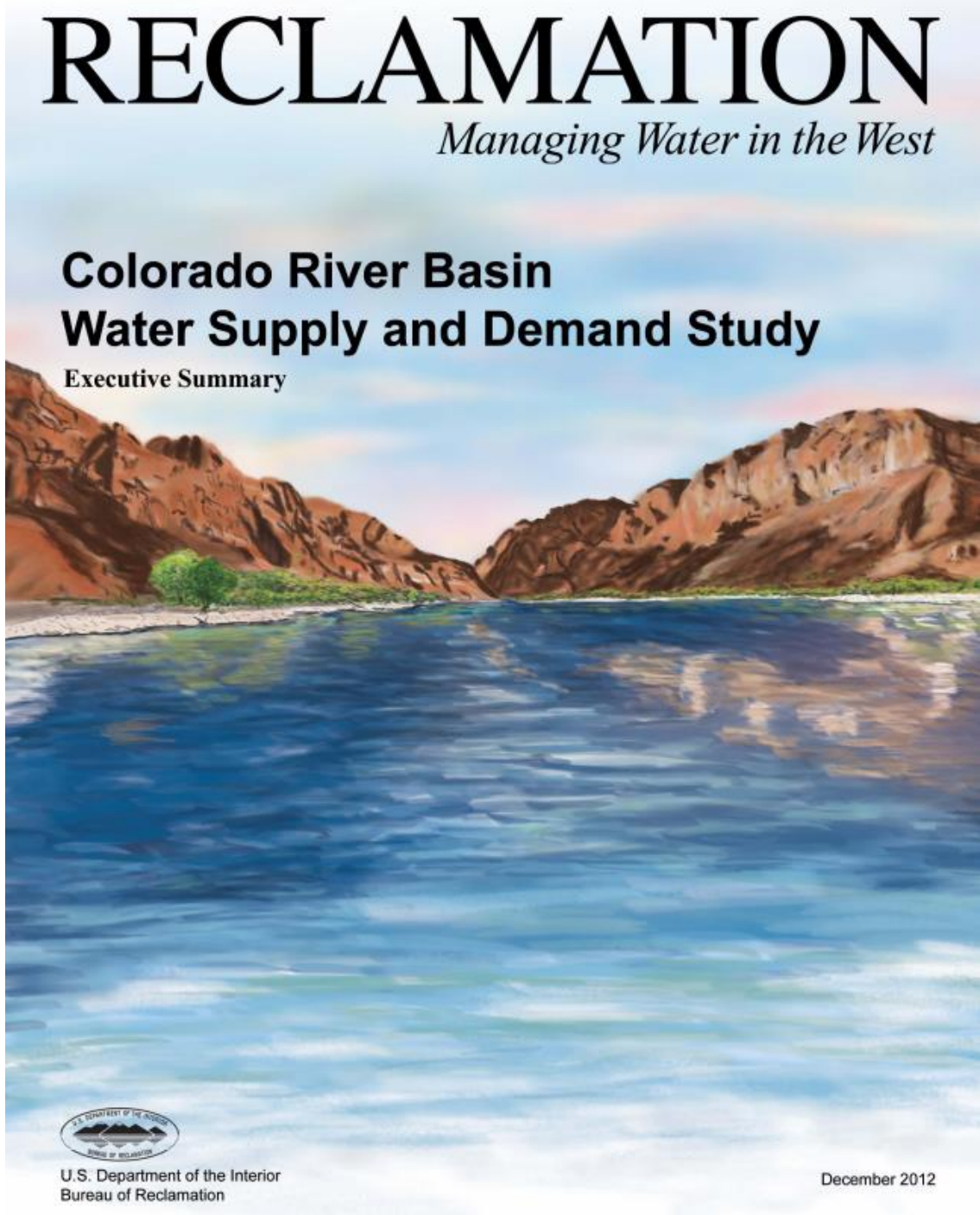
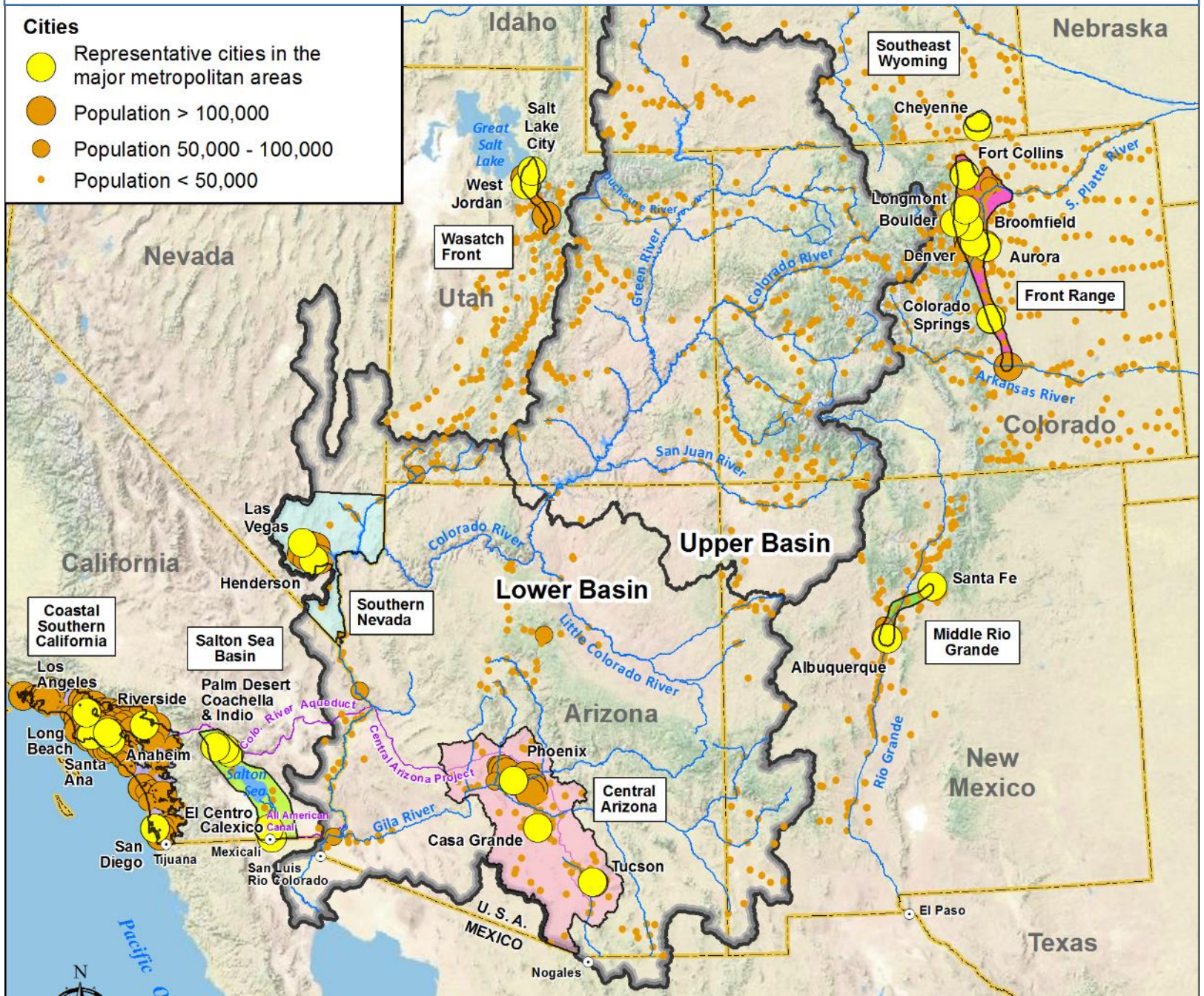


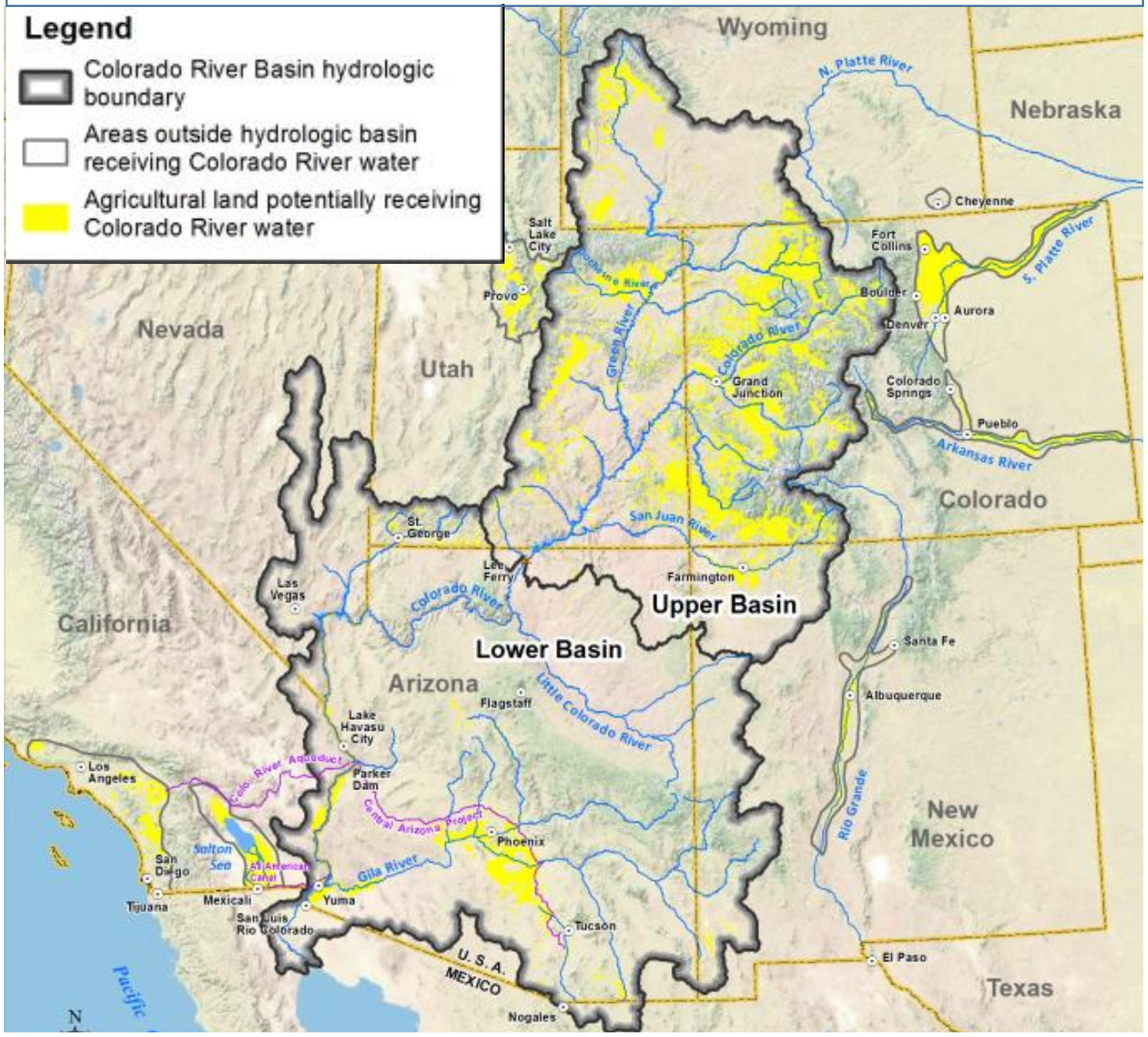
Colorado River Basin Water Supply and Demand Study (2012)

- Study Objective
  - Assess future water supply and demand imbalances over next 50 years
  - Develop and evaluate opportunities for resolving imbalances
- Study conducted by Reclamation and the Basin States in collaboration with stakeholders throughout the Basin
- A planning study – did not result in any decisions, but provided the technical foundation for future activities

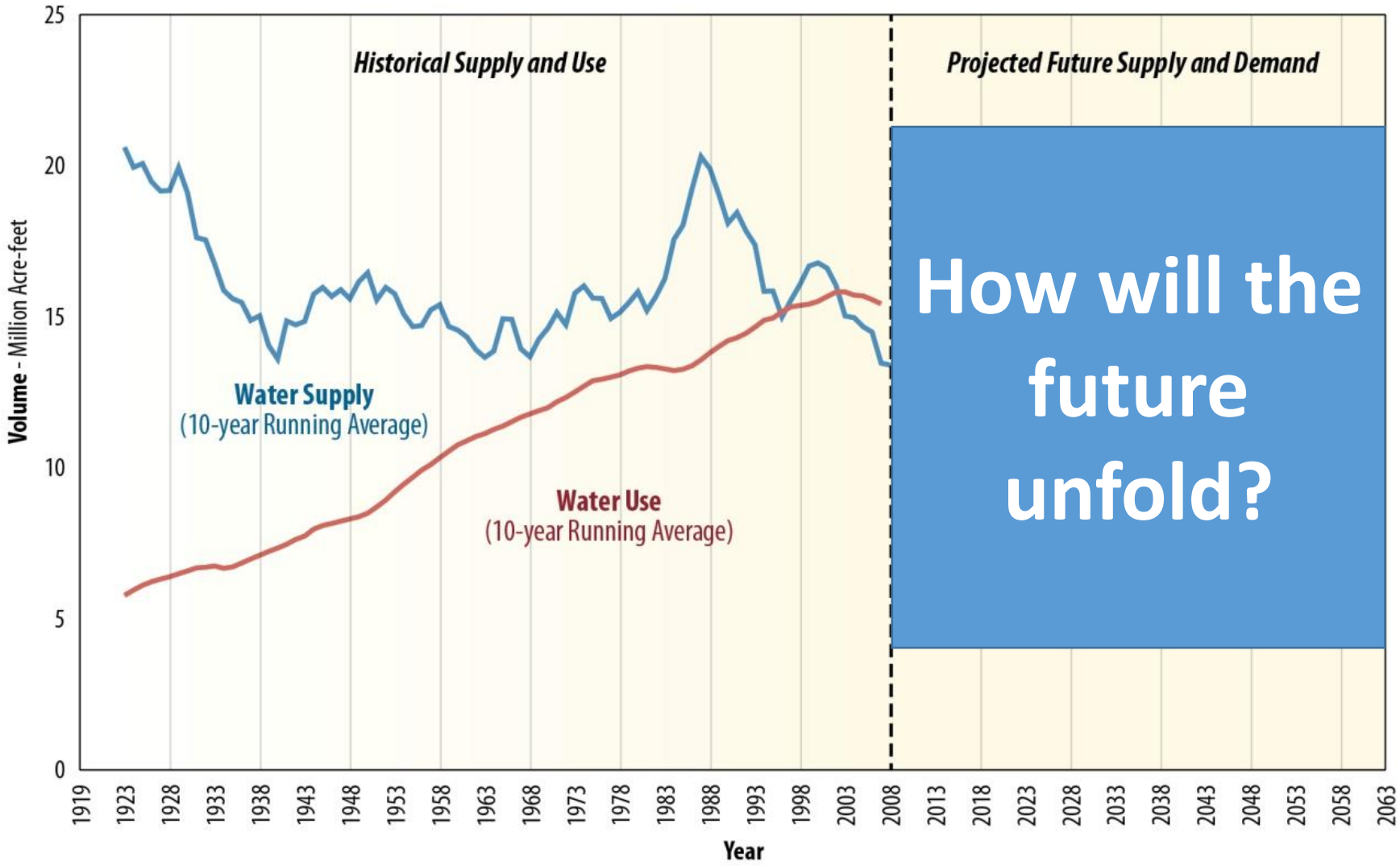
Colorado River Basin and Major US Metropolitan Areas



Colorado River Basin and U.S. Agricultural Areas

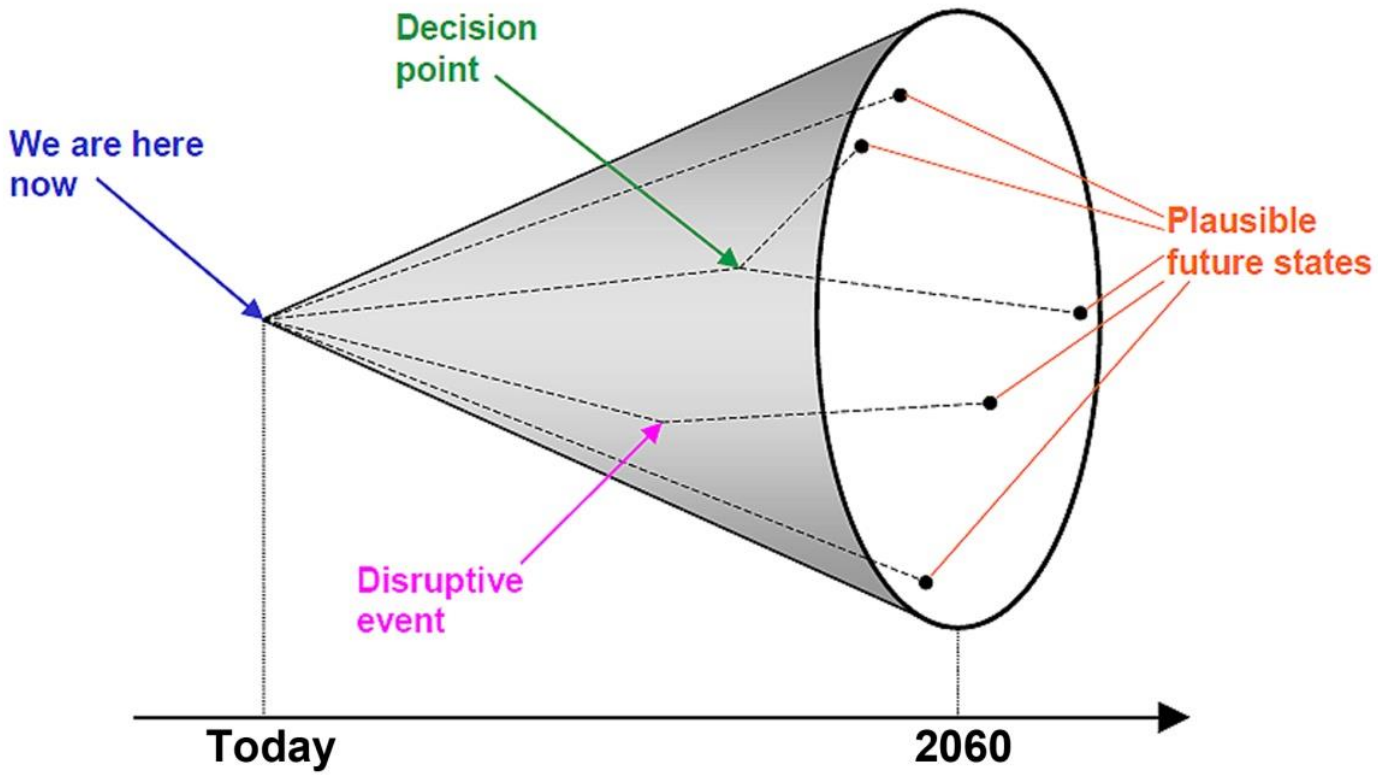


Colorado River Basin Study: The Challenge



Scenario Planning: Addressing an Uncertain Future

- The path of major influences on the Colorado River system is uncertain and cannot be represented by a single view



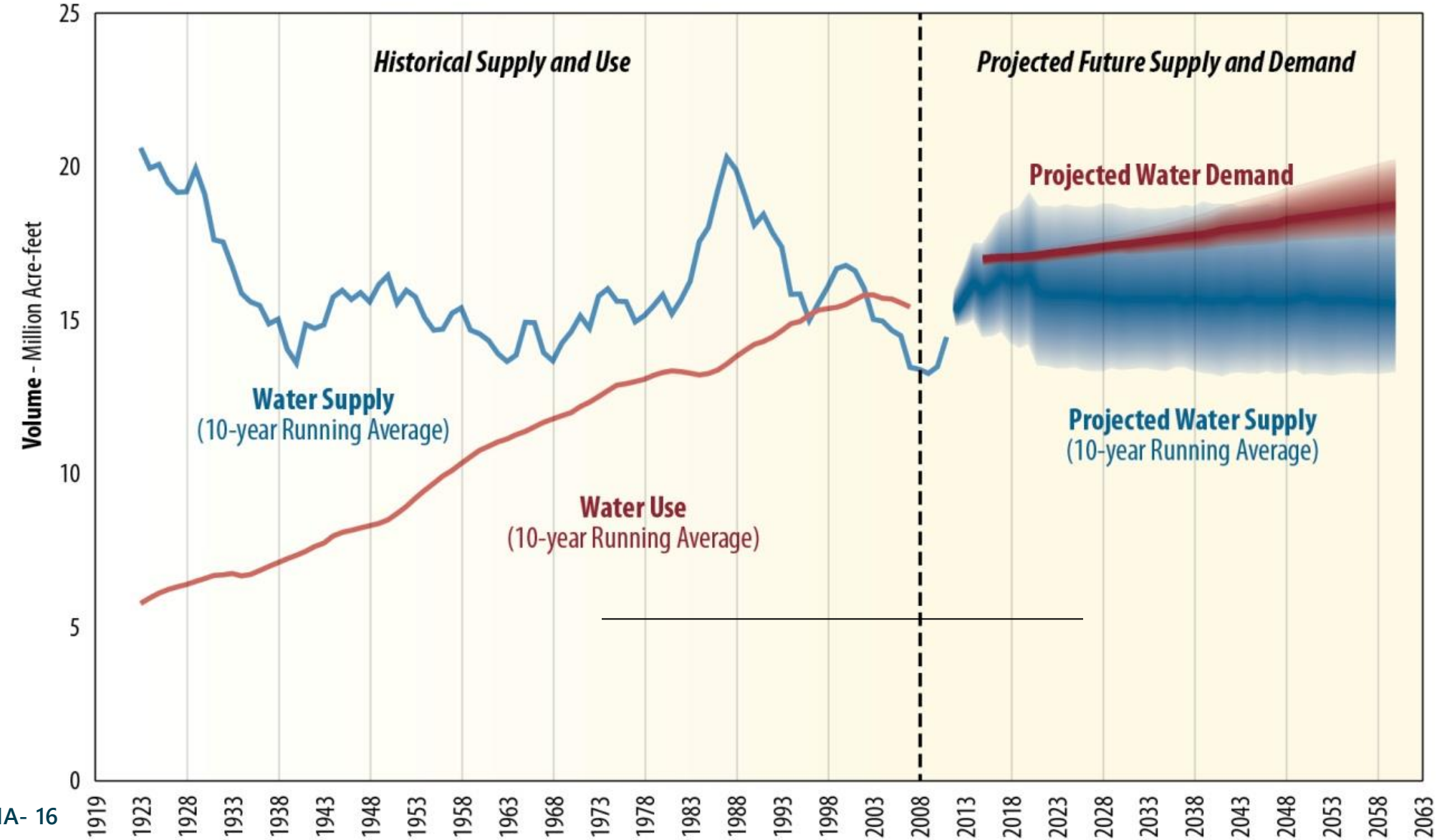
Water Supply Scenarios

- Observed Resampled
- Paleo Resampled
- Paleo Conditioned
- Downscaled GCM Projected

Water Demand Scenarios

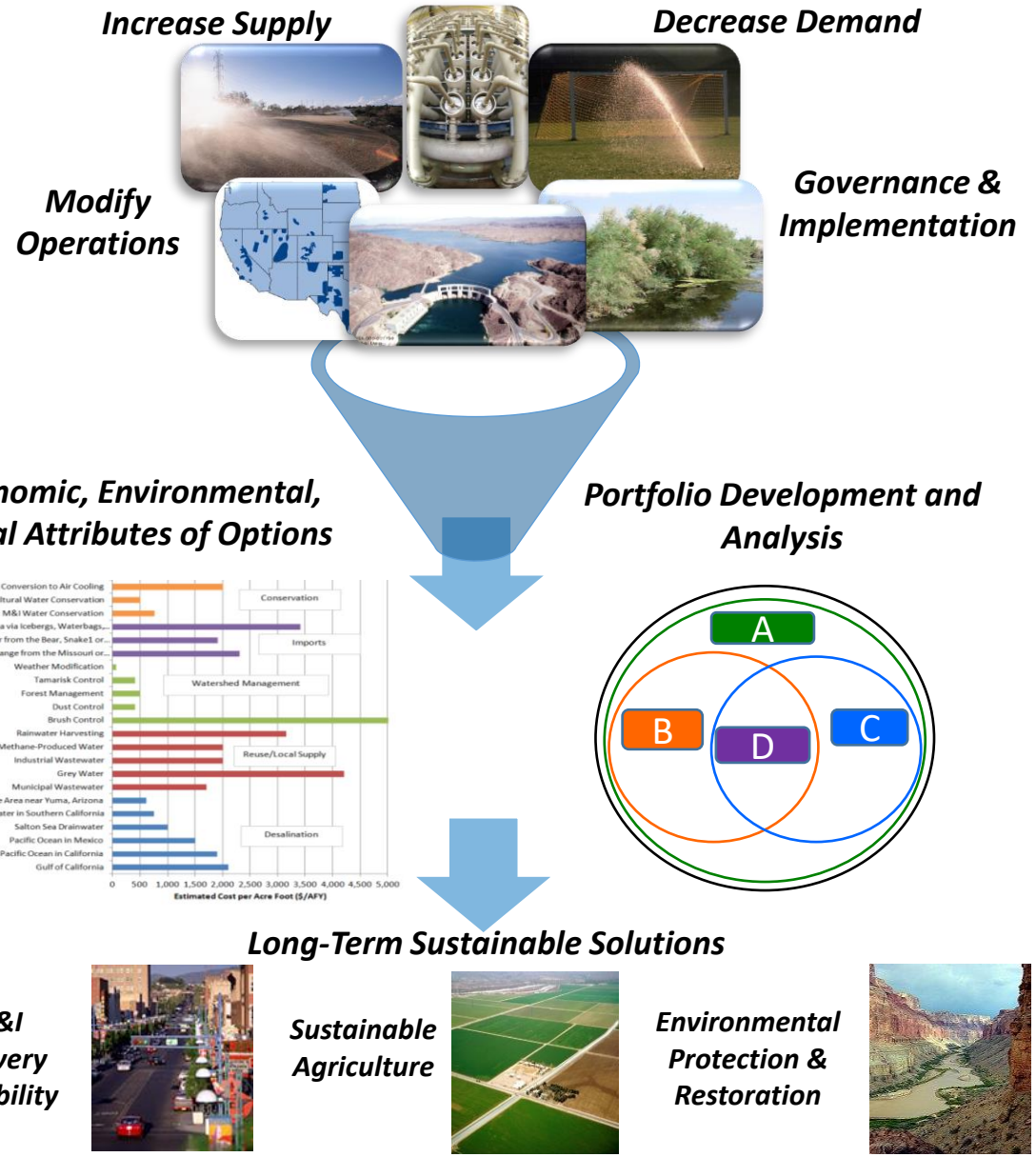
- Current Projected
- Slow Growth
- Rapid Growth
- Enhanced Environment

Potential for Significant Future Imbalances Exists



Analysis of Options and Strategies

- Broad assessment of options to address long-term reliability
- Multiple criteria evaluation and decision analysis
- Water management portfolio development and analysis
- Strategies for long-term sustainable solutions

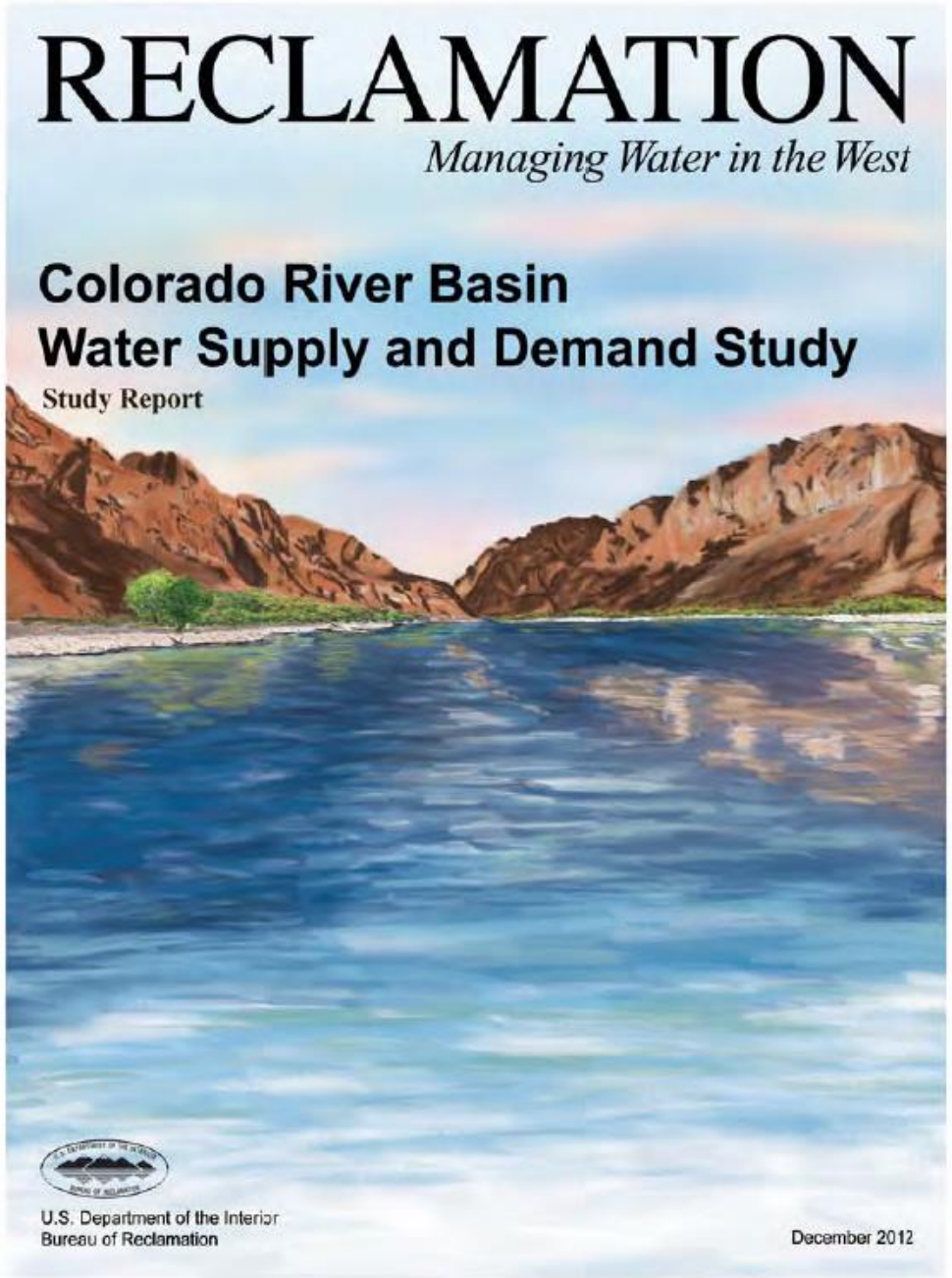


Agricultural Options Identified in Basin Study

- Nine options were submitted and classified into 6 categories
  - Advanced irrigation scheduling
  - Deficit irrigation
  - On-farm irrigation system improvements
  - Controlled environment agriculture
  - Conveyance system efficiency improvements
  - Fallowing of irrigated lands
- Estimated potential Colorado River water savings

Study Summary

- The system is vulnerable if we do nothing
- Action greatly reduces that vulnerability and makes the system more resilient, but does not eliminate vulnerability
- In the near term, all portfolios show that water conservation and reuse are cost-effective ways to reduce vulnerability



http://www.usbr.gov/lc/region/programs/crbstudy.html

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Moving Forward Effort (2015)

Building from the Basin Water Supply and Demand Study

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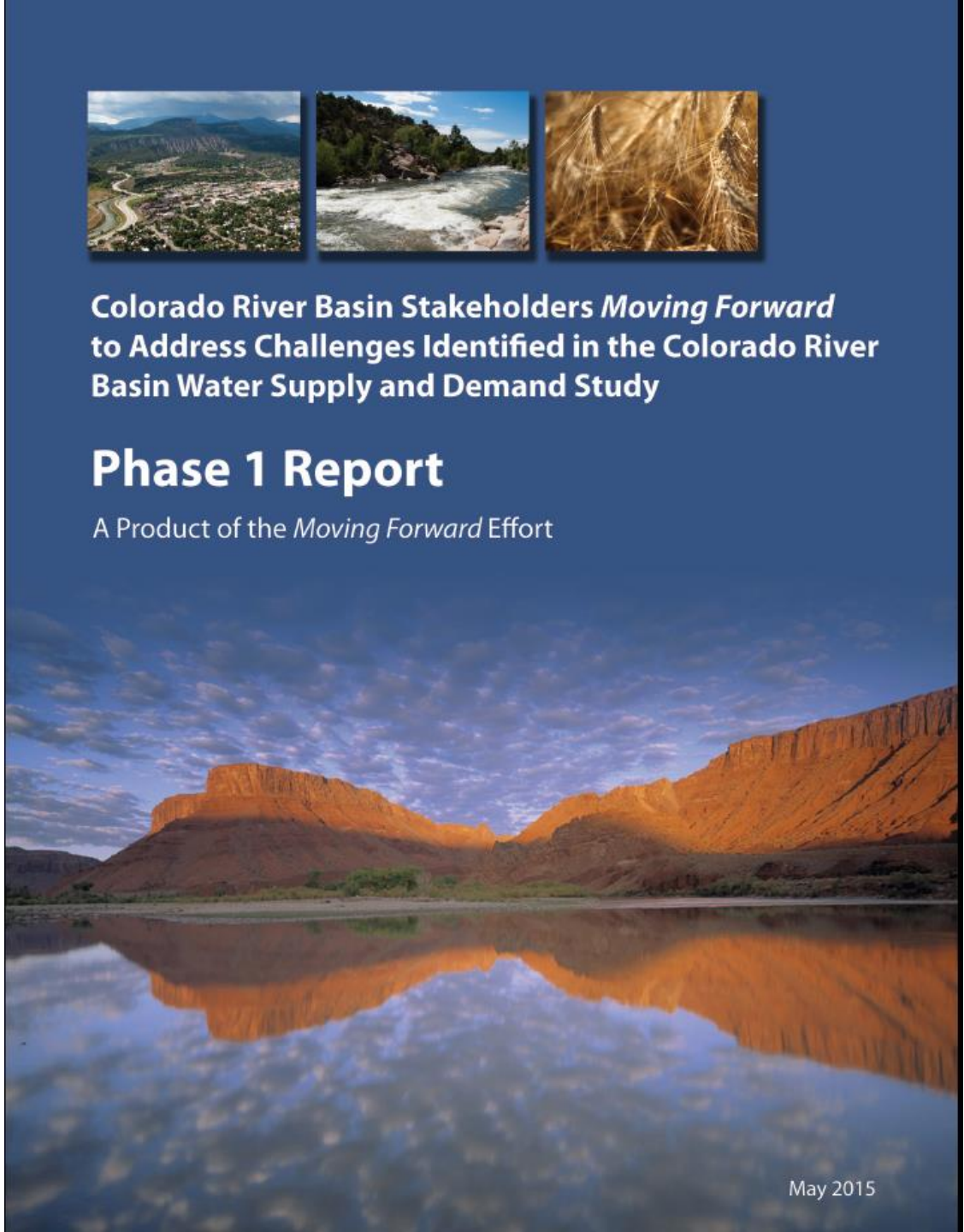
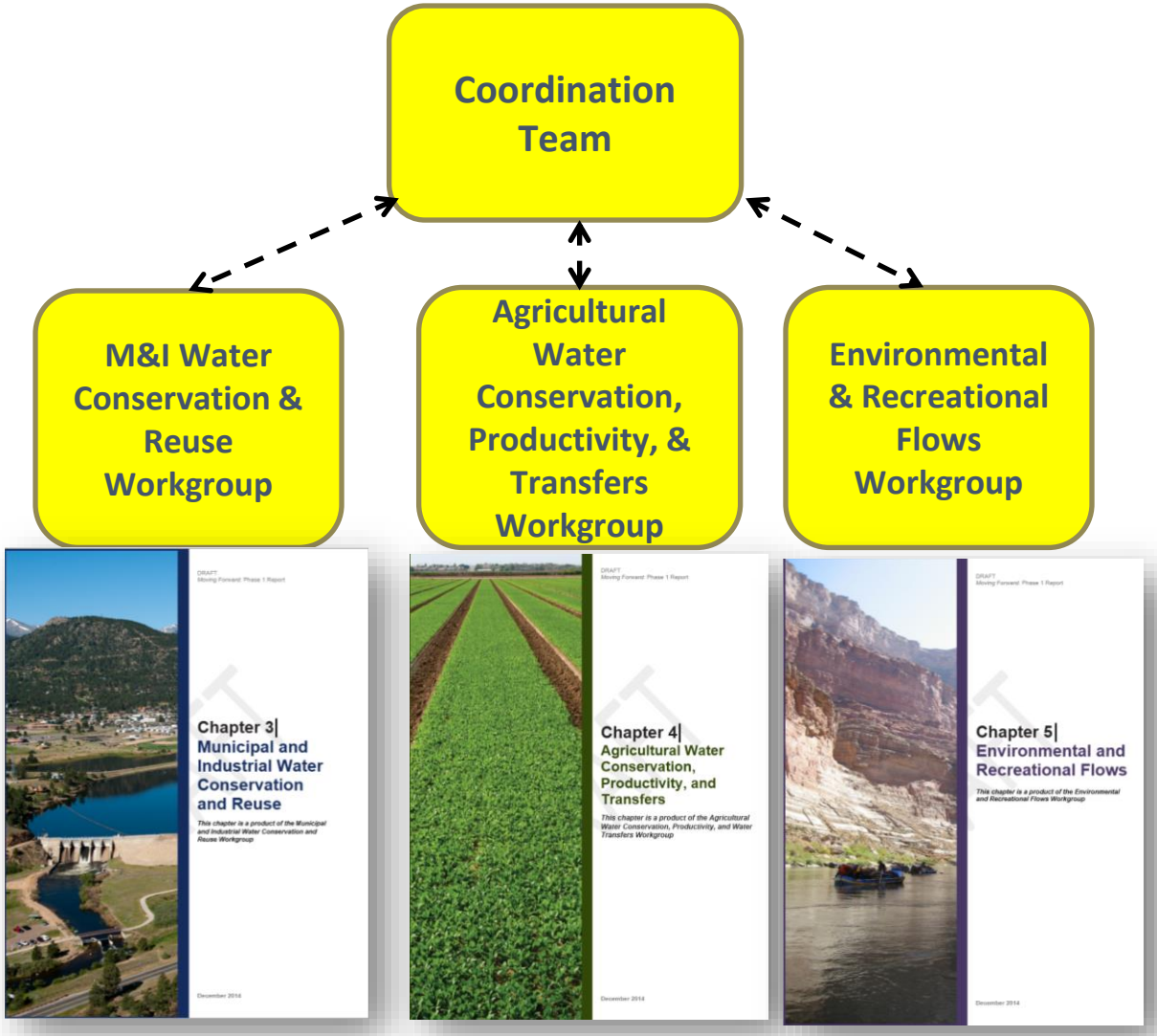


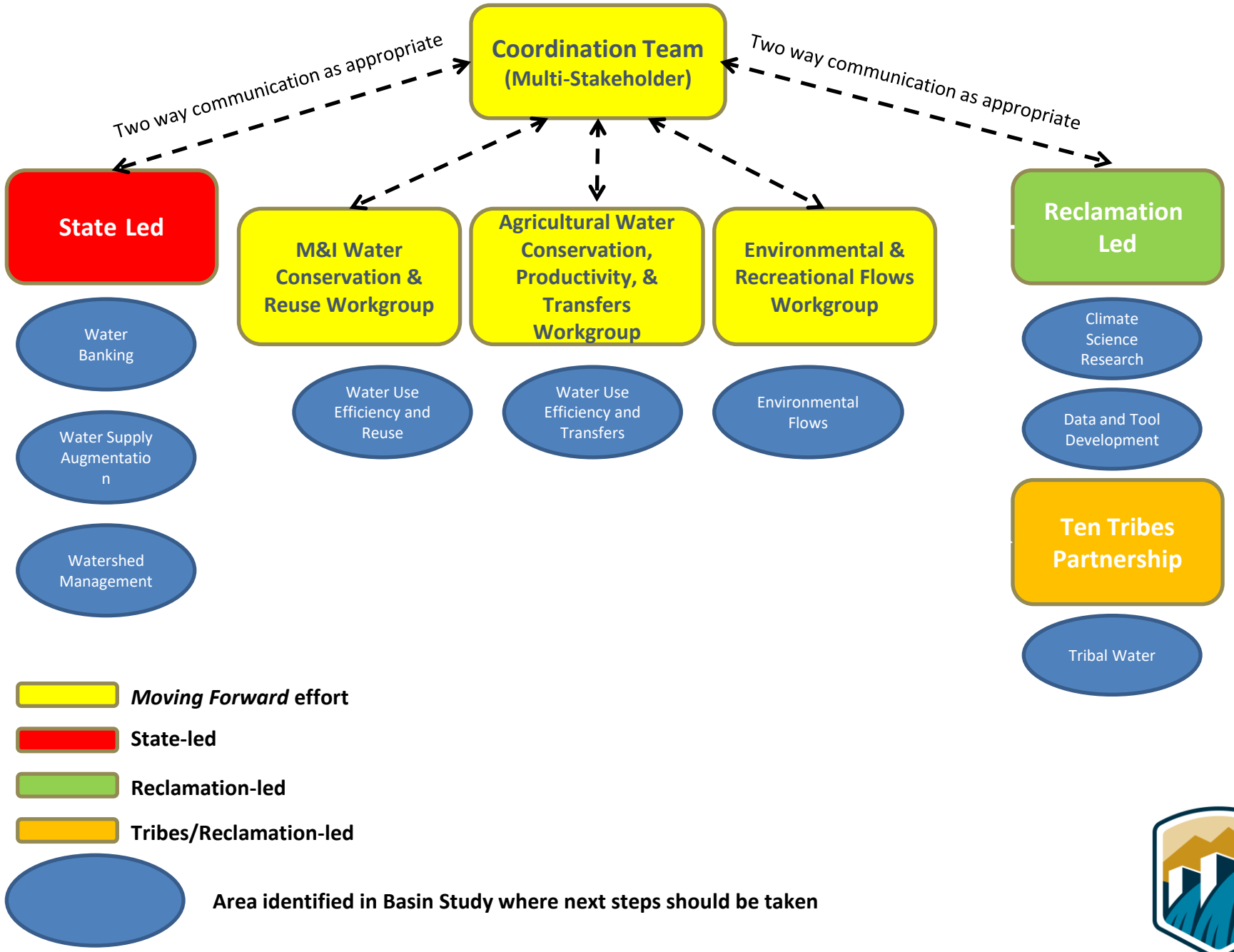
Moving Forward Effort

"...all that rely on the Colorado are taking initial steps — *working together* — to identify positive solutions that can be implemented to meet the challenges ahead."

- Initiated in May 2013 and consisted of the formation of three multi-stakeholder groups
- Expanded to an even broader stakeholder group with the necessary expertise to explore specific topics identified in the Study and Phase 1
- More detailed analysis and discussion than was considered in the Basin Study

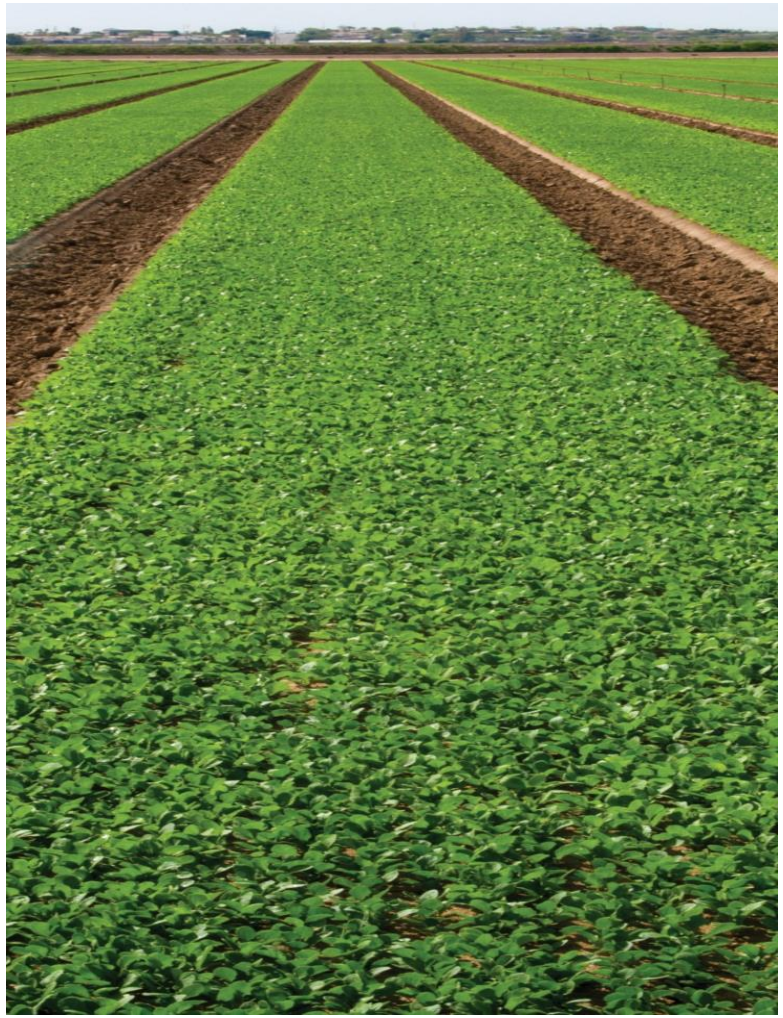


Workgroups Part of Broader Next Steps Effort



Agricultural Options Identified in Basin Study

- Co-Chairs – Colorado State University, IID, BOR
- Workgroup tasks:
  - Quantify historical trends in agricultural conservation and transfers of Colorado River water (both inside and outside of the Basin)
  - Document agricultural water conservation programs that have been successful to date
  - Identify existing future plans for these types of activities, and estimate what potential savings could come from these existing plans
- Challenges – concern about preservation of agricultural productivity



Colorado River Agriculture Acreage & Climate

Irrigated Acreage

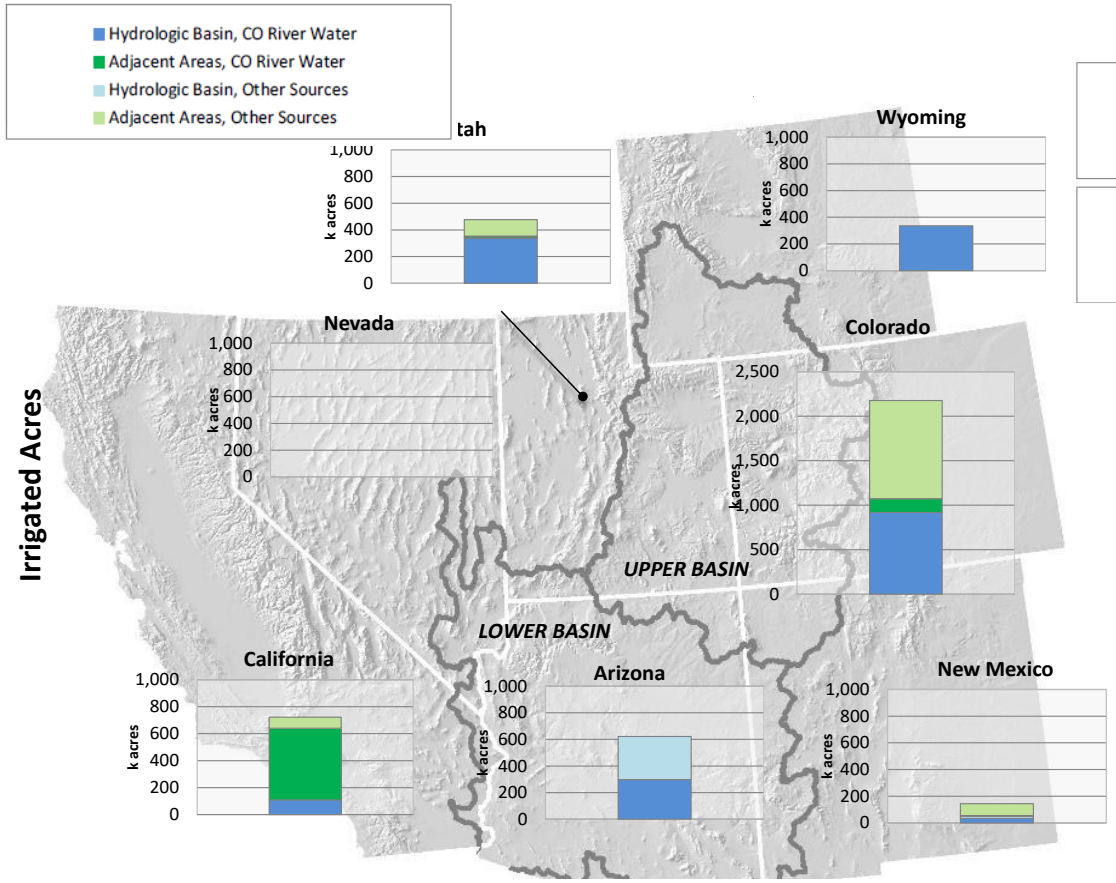


Figure 4-3. Agricultural Production Acreage and Water Supply Source

Climate

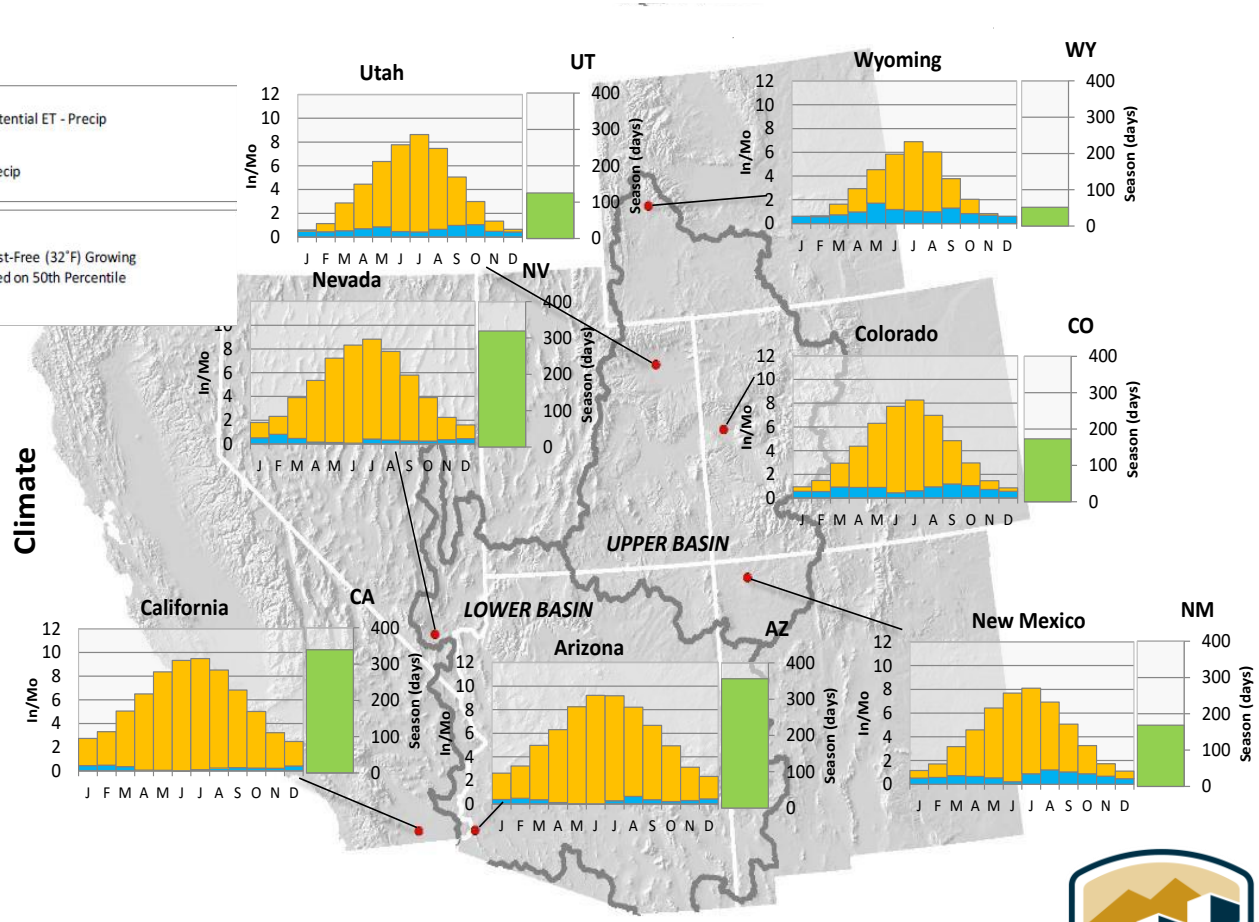


Figure 4-4. Climate Information by State

Colorado River Agriculture Crops and Sales

Crop Type

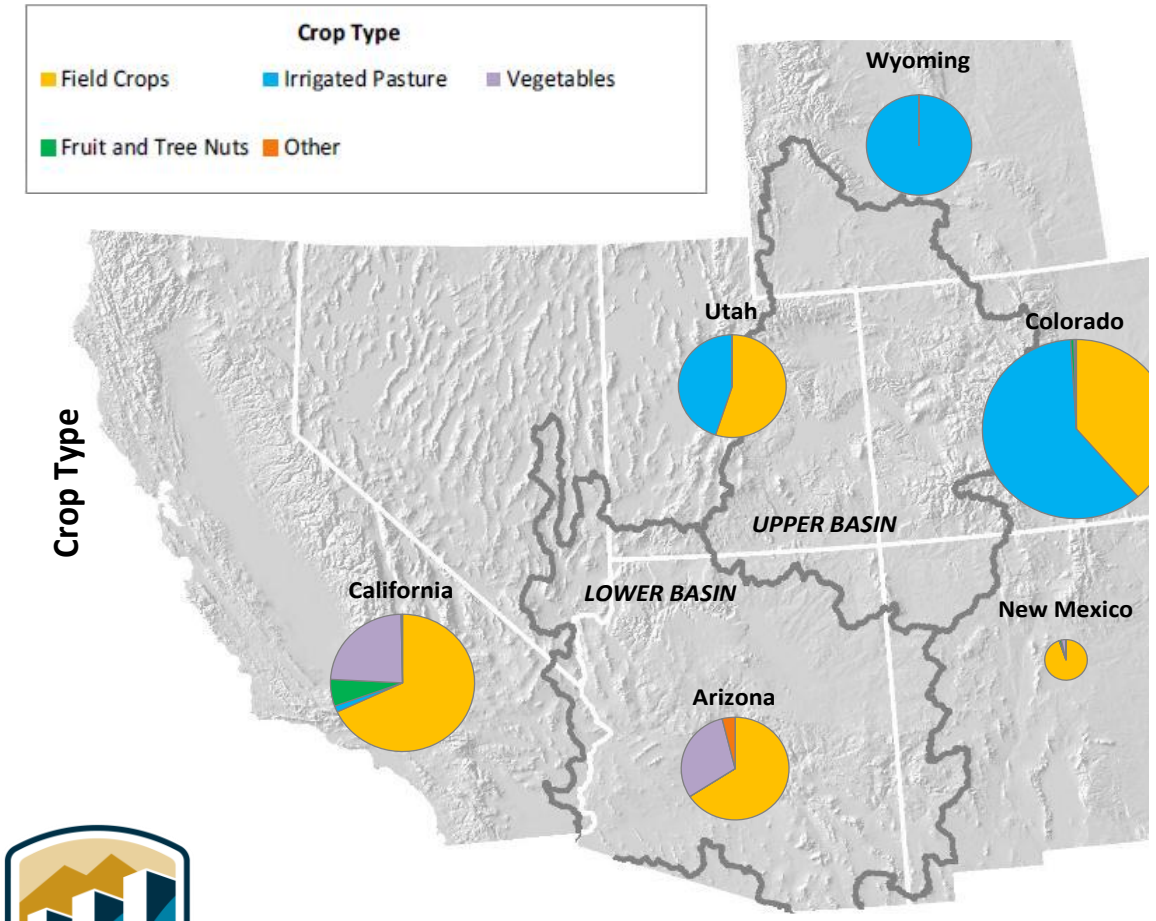


Figure 4-5. Crop Types by State

Agricultural Sales

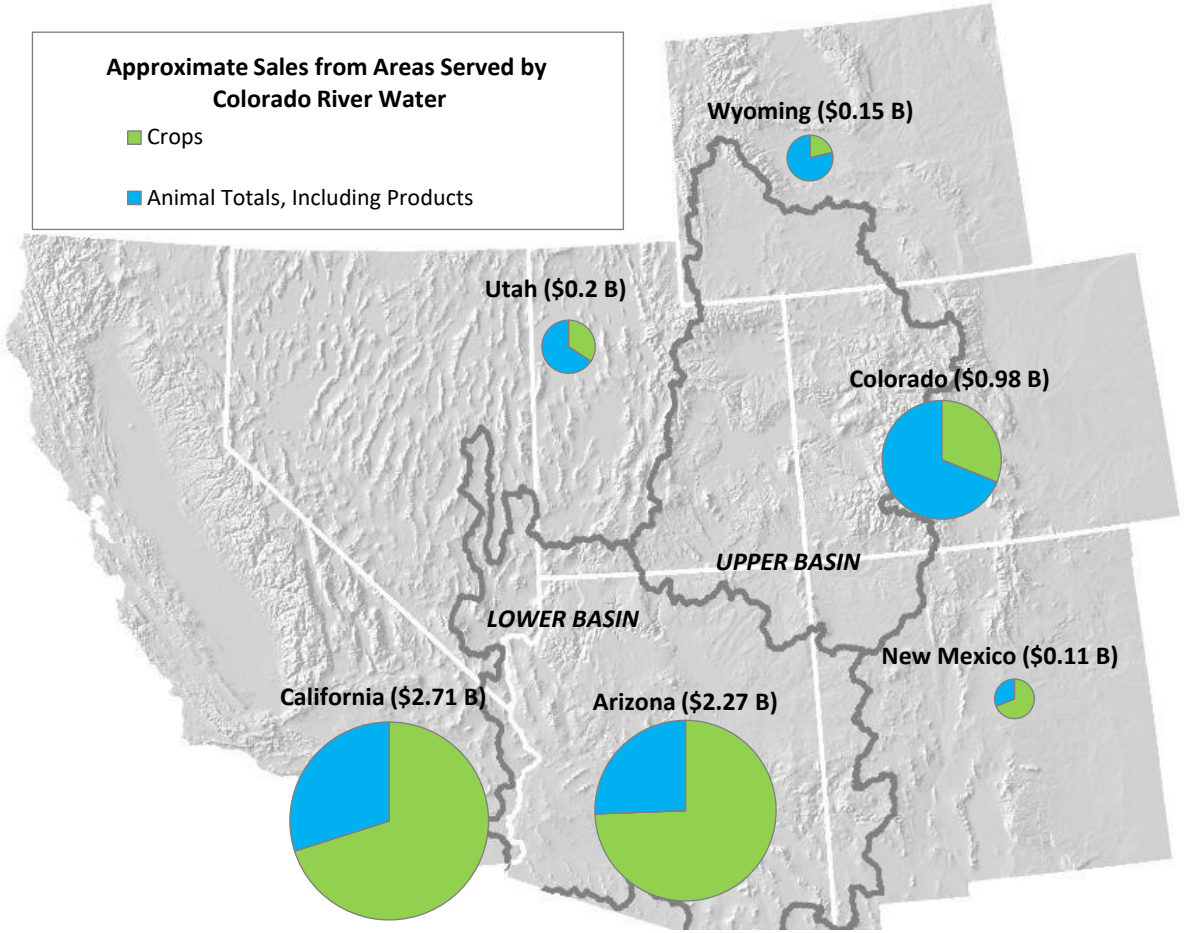


Figure 4-2. Agricultural Sales that Rely on Colorado River System Water

Agriculture Productivity in the Basin

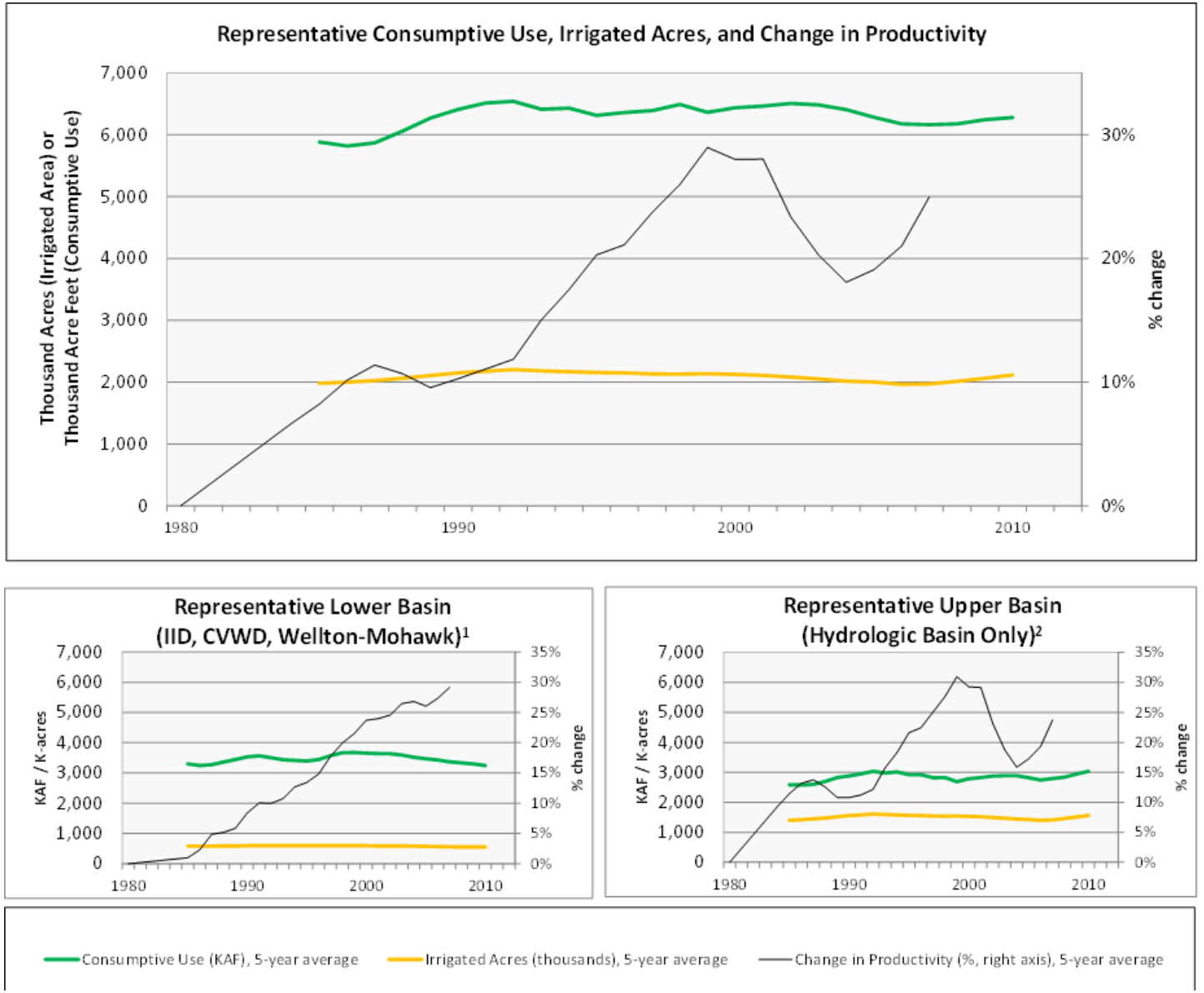
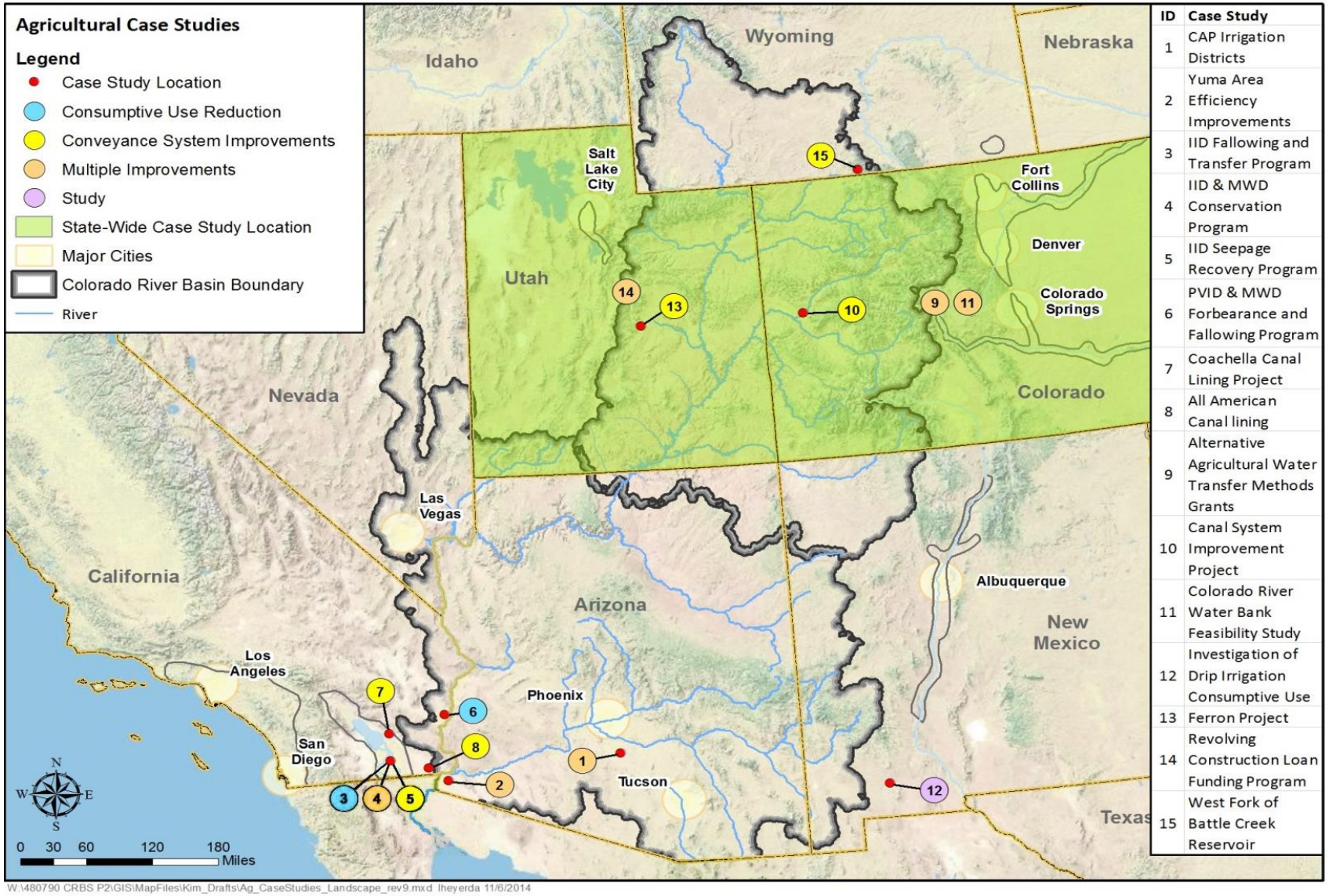


Figure 4-7. Acreage and Consumptive Use of Colorado River Water Compared to Change in Productivity

Case Studies

- Workgroup identified 15 case studies as examples of ongoing or planned projects
- 8 case studies in the Lower Basin



ID	Case Study
1	CAP Irrigation Districts
2	Yuma Area Efficiency Improvements
3	IID Fallowing and Transfer Program
4	IID & MWD Conservation Program
5	IID Seepage Recovery Program
6	PVID & MWD Forbearance and Fallowing Program
7	Coachella Canal Lining Project
8	All American Canal lining
9	Alternative Agricultural Water Transfer Methods Grants
10	Canal System Improvement Project
11	Colorado River Water Bank Feasibility Study
12	Investigation of Drip Irrigation Consumptive Use
13	Ferron Project
14	Revolving Construction Loan Funding Program
15	West Fork of Battle Creek Reservoir

Case Studies Suggest Considerable Conservation and Efficiency Improvements

- Available data demonstrate that producers have implemented a wide range of conservation and efficiency measures and often increased productivity as a result

TABLE 4-4
Summary of Select Agricultural 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	

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Potential Opportunities

Opportunity 1: Increase and/or maintain productivity through more efficient on-farm activities.

Opportunity 2: Reduce losses and improve operational efficiency through improved conveyance infrastructure.

Opportunity 3: Pursue flexibility associated with strategic consumptive use reductions.

Opportunity 4: Enhance and use mechanisms to facilitate flexible water management

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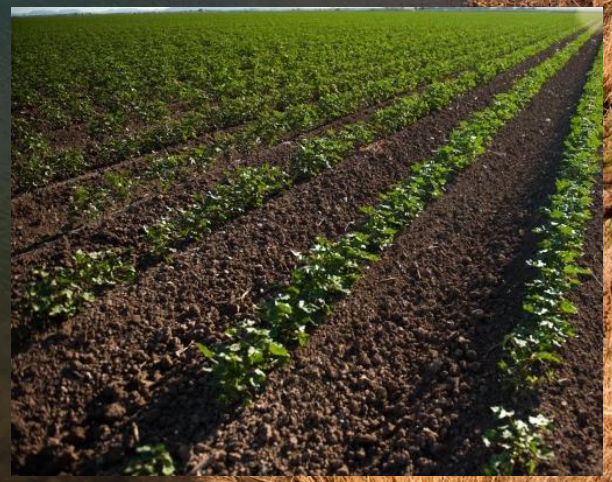
Potential Opportunities (cont'd)

Opportunity 5: Encourage efficient water management through conservation planning and reporting, data management, and tools development.

Opportunity 6: Foster efficient agricultural water use through sustainable funding and incentive programs.

Opportunity 7: Increase or maintain productivity and improve water management through soil health



Workgroup Key Findings and Messages

- Data gaps and reporting variations make analysis of agricultural water use difficult.
- 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 (e.g. in or out of the hydrologic basin).
- Water use per acre has remained relatively constant historically while productivity has increased Basin-wide by about 25 percent since 1980.
- 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.

Workgroup Key Findings and Messages (cont'd)

- Many of the advances in agricultural conservation have been achieved as part of programs with a variety of federal, state, and local stakeholders working toward mutually beneficial solutions.
- Available data demonstrate that producers have implemented a wide range of conservation and efficiency measures and often increased productivity as a result.
- Agricultural producers will continue to increase the efficiency of water use 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 demand.
- Opportunities exist for additional agricultural water conservation, transfers, and productivity enhancements, but may become more difficult and costly as they are implemented.

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Role of Water Savings Pilot Study in Relation to Past and Current Efforts

Progression of Past/Current Efforts

Colorado River Basin Study (2012)

The Basin Study documented the basin-wide water supply-demand imbalance and identified agricultural water use efficiency and transfers as areas where next steps should be taken (among others).

Moving Forward Study (2015)

The Agricultural Conservation, Productivity, and Transfers workgroup identified opportunities for potential future actions and considerations of those actions. Accurate quantification of agricultural conservation savings was identified as a concern.

Conservation Programs (2007-present)

Implementation of proposed pilot projects, such as ICS and the System Conservation Pilot Program. Several program projects were agricultural consumptive use reduction and on-farm efficiency projects.

Ag Water Savings Pilot Study (2020)

Assess current quantification practices and potentially inform future concepts and opportunities through the review of recent/current literature and evaluation of existing case studies.

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Pilot Study – Scope, Schedule, and Milestones

Scope Overview

- Review relevant previous/on-going efforts
  - Avoid duplication
- Refine Pilot Study scope—an exploration of quantification methods
- Conduct literature review of agricultural water conservation
- Focus on activities in the LCRB with an emphasis on quantification methodologies
  - Full-year and seasonal (partial year) fallowing
  - Deficit irrigation
  - Irrigation conversion
  - Crop mix changes
  - Other
- Identify potential case studies in the LCRB

Scope Overview

- Conduct site visits/interviews for selected case studies
  - Conservation activity implemented
  - Quantification method(s) used to estimate conserved water
  - Comparison with Reclamation's methods and calculations
  - Assessment of opportunities to improve the quantification method(s)
- Document efforts throughout process
- Prepare draft and final reports
- Geographic scope – LCRB (in the US) and the areas in Arizona and California outside the physiographic boundary of the Lower Basin that are supplied with imported Colorado River water

Pilot Study Schedule

LCRB Pilot Study Performance Schedule	Qtr 3 2020	Qtr 4 2020	Qtr 1 2021	Qtr 2 2021	Qtr 3 2021	Qtr 4 2021
Task 1 – Project Administration (by Reclamation)						
Task 2 – Workshop 1 – Scope Refinement & Case Study Definition	9/25		1/4			
Task 3 – Literature Review of Seasonal Fallowing, Deficit Irrigation & Irrigation Conversion Activities		11/16	1/15			
Task 4 – Review and Summarize Seasonal Fallowing, Deficit Irrigation & Irrigation Conversion		11/16		4/4		
Task 5 – Workshop 2 – Case Study Definitions & Selection			1/15	5/23		
Task 6 – Site Visits & Interviews				5/23	5/30	
Task 7 – Case Studies & Technical Reviews				5/30	9/9	
Task 8 – Workshop 3 – Draft Review of Case Studies				7/29		11/13

Pilot Study Milestones

- Workshop 1 – November 9-10, 2020
- Milestone 1: Technical Memorandum 1 – Summary of Refined Scope & Case Study Definition – Draft for Review – Early December 2020
- Milestone 2: Technical Memorandum 2 – Summary of Significant Findings from Literature Review & Recent/Current Activities in the Lower Basin – Draft for Review Late February 2021
- Workshop 2 – Mid-March 2021
- Milestone 3: Technical Memorandum 3 – Summary of Case Study Definition, Site Selection & Evaluation Process – Draft for Review Late April 2021
- Site Visits/Interviews – Late May 2021
- Milestone 4: Draft Report – Case Studies and Technical Reviews– Draft for Review Mid-August 2021

Pilot Study Milestones (cont'd)

- Workshop 3 – Early September 2021
- Milestone 5: Pilot Study Final Report – Draft for Review Mid to Late October 2021
- Pilot Study Final Report – Mid November 2021
- Presentation at CRWUA – December 2021

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Workshop Participant Perspectives

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Day 1 Wrap-up and Preview of Day 2

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Exploration of Quantification Methods for Agricultural Water Savings in the Lower Colorado River Basin

Workshop #1

November 9-10, 2020

Agenda – Day 2

- Brief Review of Day 1
- Pilot Study Scope Refinement
- Conservation Measures and Quantification of Consumptive Use in Colorado River Water Accounting
- Case Study Definition and Approach
- Wrap-up and Next Steps

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Review of Day 1

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Pilot Study Scope Refinement – Discussion and Feedback

Pilot Study Scope Refinement

- Conservation actions
- Available literature – studies, reports
- Recent, on-going and planned efforts
- Data and information sharing

Conservation Actions

- *Basin Study* – options organized into 6 categories "…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"
- *Moving Forward* Ag Water Conservation Workgroup focused on four topics:
  - Consumptive use reductions
  - On-farm efficiencies
  - Conveyance system improvements
  - Water transfers

Conservation Actions (continued)

"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"

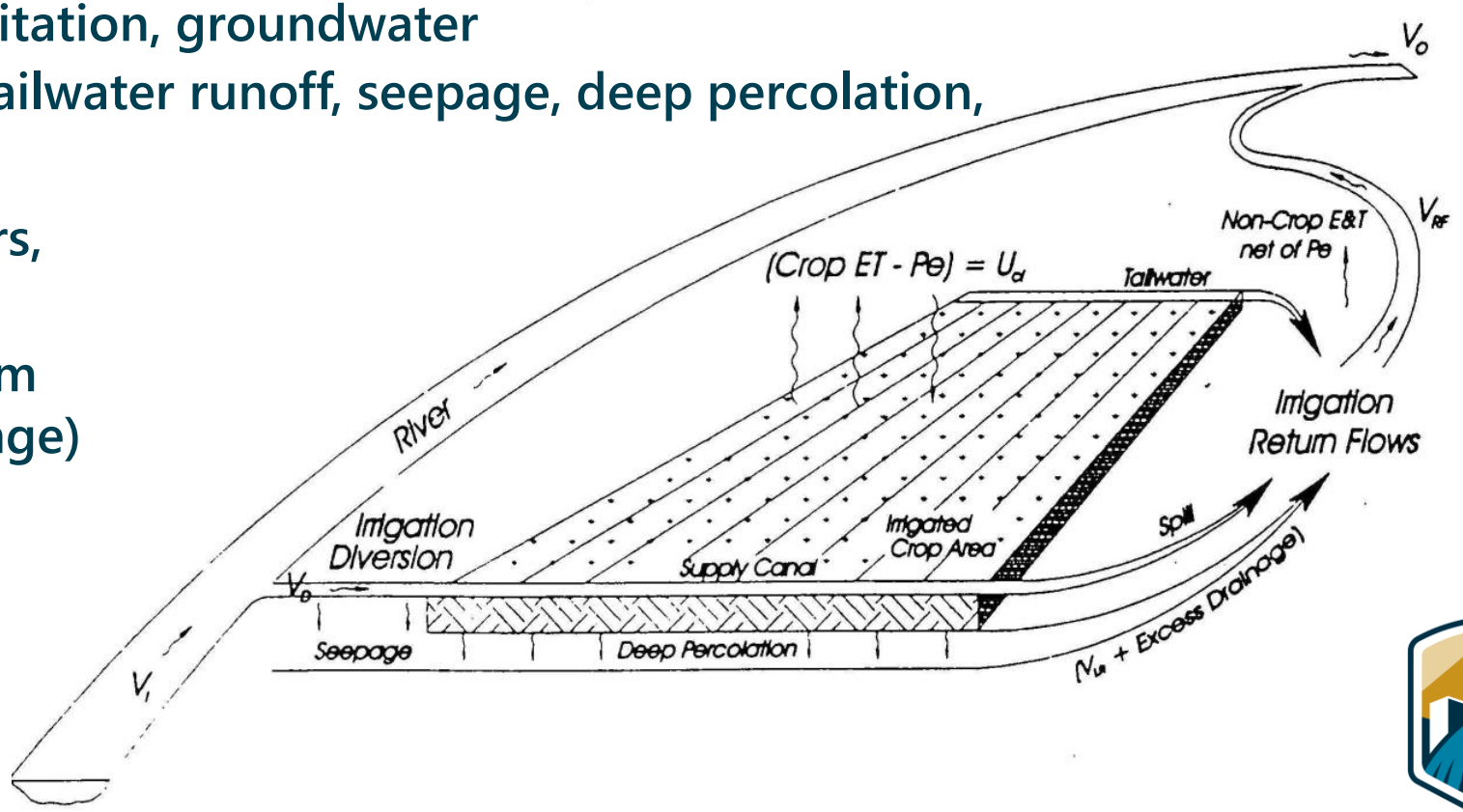
-Moving Forward Phase 1 Report

Efficiency Analyses and Estimation of Conserved Water

Water budget/ water balance analyses

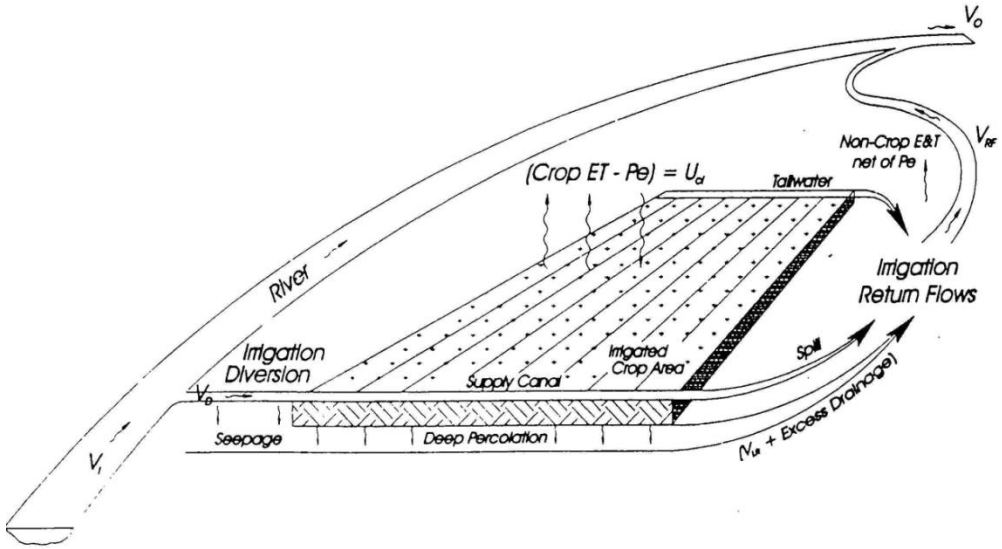
Inflows - Outflows ± ΔStorage = 0

- Water budget/ water balance analyses
  - Inflows→ diversions, precipitation, groundwater
  - Outflows→ crop ET, spills, tailwater runoff, seepage, deep percolation, groundwater
  - Storage→ surface reservoirs, soil water
  - Conveyance/delivery system level (losses to spills, seepage)
  - Farm system level (deep percolation, tailwater runoff)
  - Crop ET



Efficiency Analyses and Estimation of Conserved Water (continued)

- Overall Efficiency =
  Crop ET ÷ Total Diversions
- Conveyance Efficiency =
  Total Farm Deliveries ÷ Total Diversions
- On-farm Efficiency =
  Crop ET ÷ Total Farm Deliveries



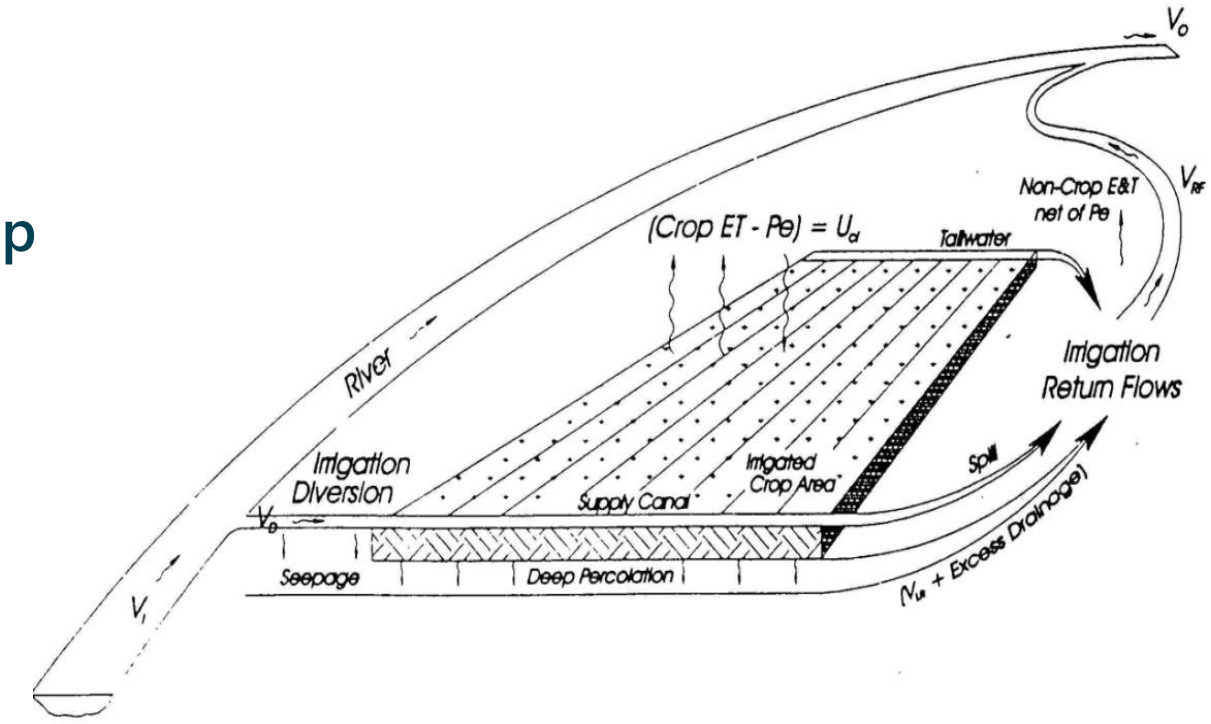
- Identify where water is going, how much is going there, and when
- Identify potential improvements and how much water can be saved
  - Varies from location to location across the project
  - Varies during the season or during the year
  - May vary from year to year (dry years, wet years, climate change)

Efficiency Analyses and Estimation of Conserved Water (continued)

- Efficiency Improvements
  - Conveyance/Delivery System
    - Re-regulation to capture and use operational spills
    - Lining or replacement with pipe to reduce canal seepage losses
  - On-farm System
    - Irrigation method conversion to reduce on-farm losses – tailwater runoff, deep percolation, evaporation
    - Improve on-farm water management – tools and instrumentation to help with decisons of when to irrigate and how much needs to be applied
  - Drainage System
    - Capture and re-use drain water (quality is acceptable)
    - Reduce non-beneficial plant water use (assuming desirable habitat is not destroyed)
- Water losses (return flows) are reduced thereby allowing less water to be diverted and applied while meeting same level of crop demand

Consumptive Use Reduction and Estimation of Conserved Water

- Demand reduction
  - Fallowing – permanent, temporary, rotational, seasonal
  - Switch to lower water use crops or crop mix
  - Deficit irrigation
- Occurs on-farm at the field level
- Requires estimation of associated diversion reduction based on:
  - On-farm efficiency
  - Conveyance efficiency



Literature Review

- Review of academic and technical literature – studies, reports, journals
- Consumptive use quantification methodologies and approaches to quantification of water conserved
  - Full-year agricultural cropland fallowing
  - Seasonal or partial-year cropland fallowing
  - Deficit irrigation
  - Switching crops or crop rotations to alternate crops requiring less irrigation water
  - Irrigation methodology conversions

Literature Review (continued)

- The water conservation methodologies drive the literature review
- Focus on information, data, reports, and results since the completion of the Basin Study and the Moving Forward Phase 1 report
- Prioritize literature addressing conservation activities and topics applied in the Lower Basin
- Document all literature reviewed and prepare an annotated bibliography

Recent, On-going, and Planned Efforts

- Review irrigation water conservation efforts in the Lower Basin
- Document the conservation activity
- Document the quantification methodologies and approaches
- Observed results, findings, constraints and limitations of the activity
- Unanticipated consequences… lessons learned
- What was the final outcome(s) of the quantification of consumptive use savings
- Recommendations for improving quantification methods
- Other factors – accuracy, cost, effectiveness…

Data and Information Sharing

- Input and feedback from all interested parties is critical and valued
- We want to know about your ideas and experiences

- Pilot Study website:

https://LCRBPilotStudy.com/

-Post comments

-Ask questions

-Upload/download project reports and other documents

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Conservation Measures and Quantification of Consumptive Use in Colorado River Water Accounting

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Colorado River Water Accounting

- The Secretary of the Interior serves as Water Master for the Lower Colorado River
- Pursuant to 1964 U.S. Supreme Court Decree (Consolidated in 2006) Reclamation is required to account for Colorado River water use
  - Official record of mainstream diversions, returns & consumptive uses
  - Colorado River Accounting & Water Use Report

Decree Definitions

- Diversions: Colorado River Water diverted from the mainstream, including underground pumping
- Returns: Return flow of such water to the stream as is available for consumptive use in the United States or in satisfaction of the 1944 Mexican Treaty obligation
- Consumptive Use: "…diversions from the stream less such return flow thereto as is available for consumptive use in the United States or in satisfaction of the Mexican Treaty obligation"
  - Consumptive Use = Diversions – Returns

Fundamental Principle of Conservation

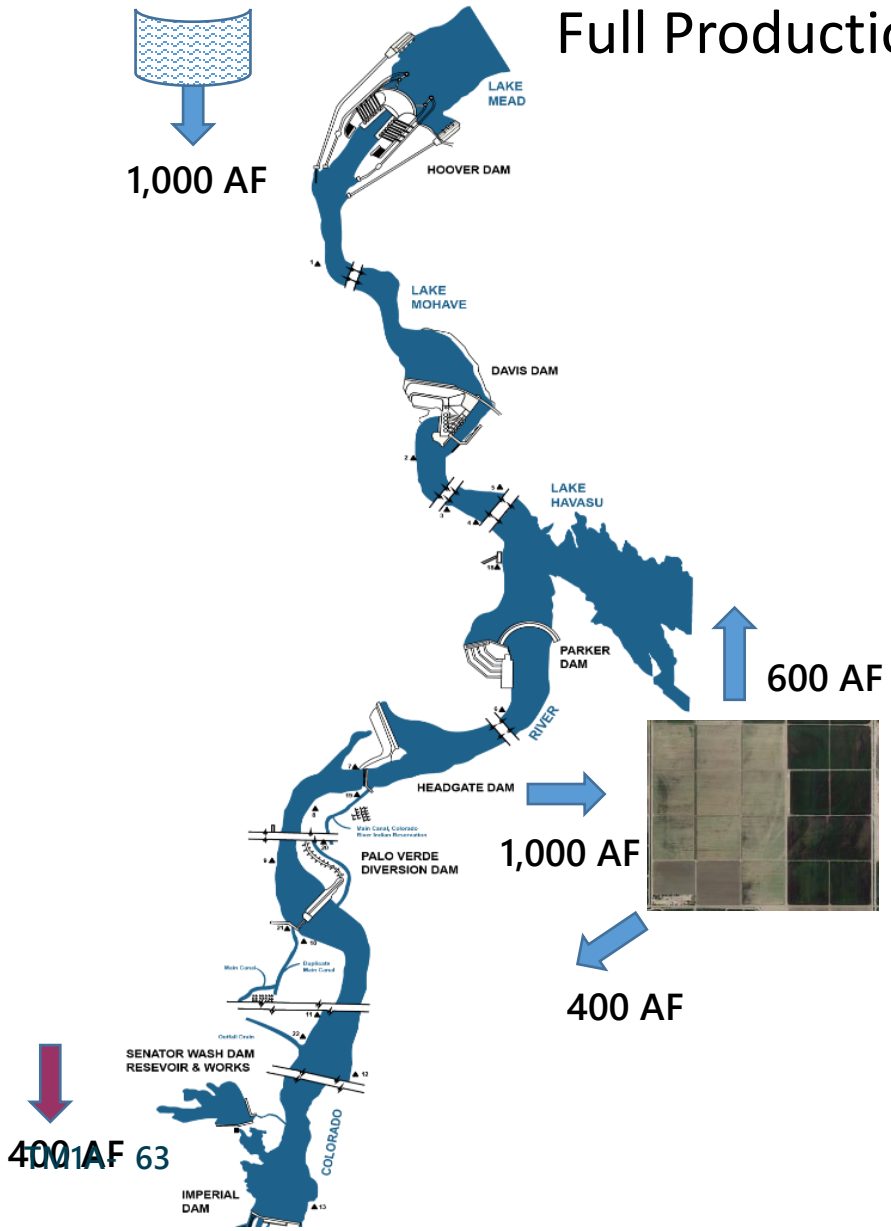
- Must be a measurable reduction in mainstream Colorado River consumptive use
  - Potential for water savings varies by location (for example, in or out of the hydrologic basin)

Conservation Measures Implemented in the Lower Basin

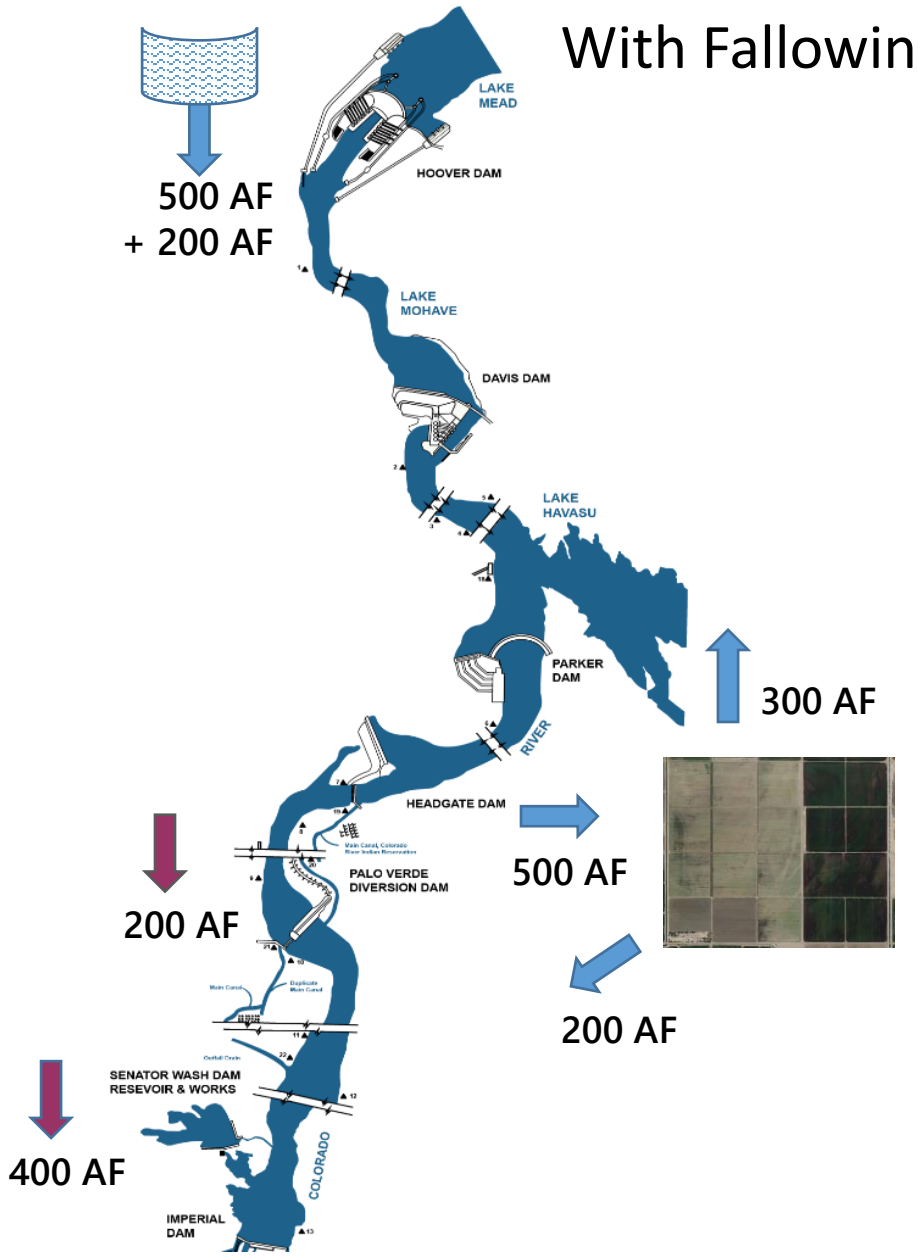
- Fallowing
  - Seasonal/Full-Year
- On-Farm Efficiency
  - Drip Irrigation
  - Tailwater Return Systems
  - Center Pivot
- Delivery System Improvements
- Seepage Recovery
- Canal Lining

Consumptive Use Examples - Fallowing

Full Production

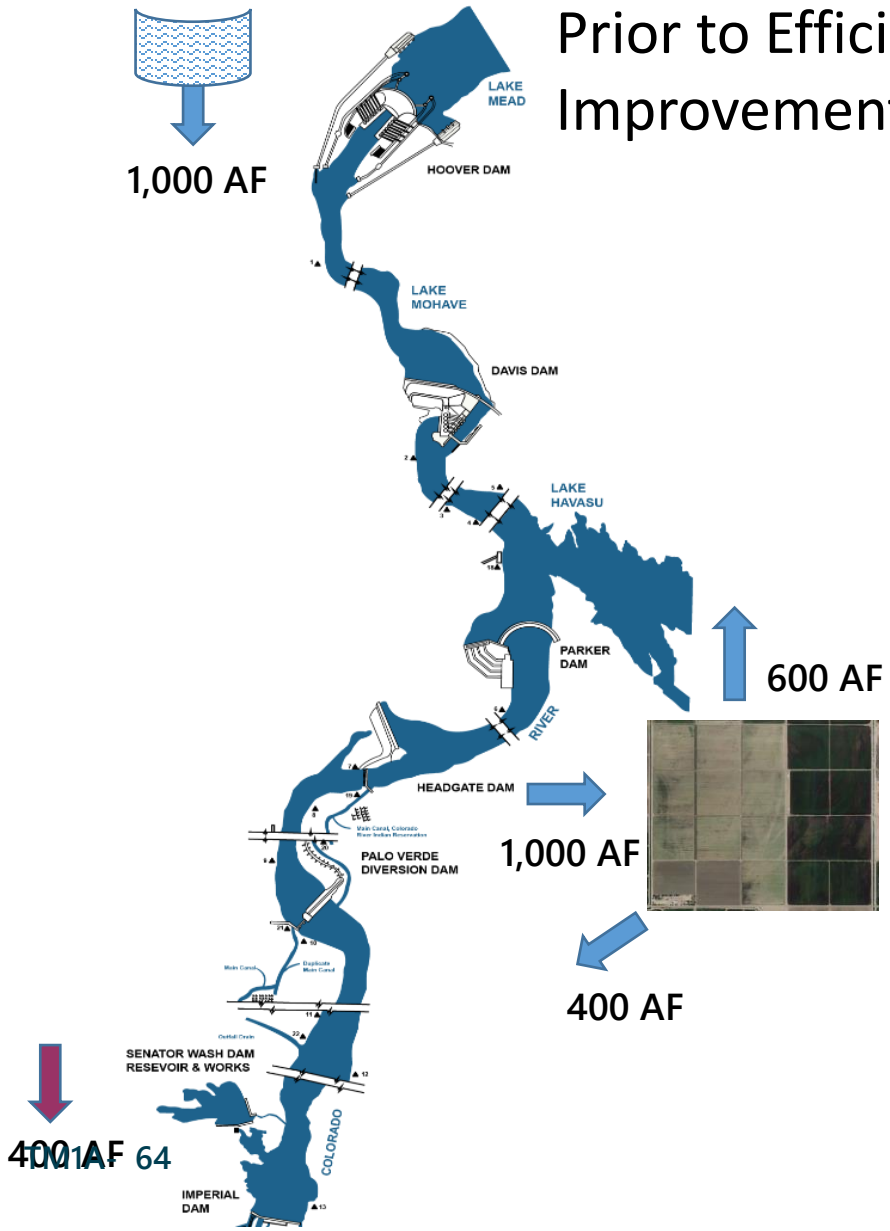


With Fallowing

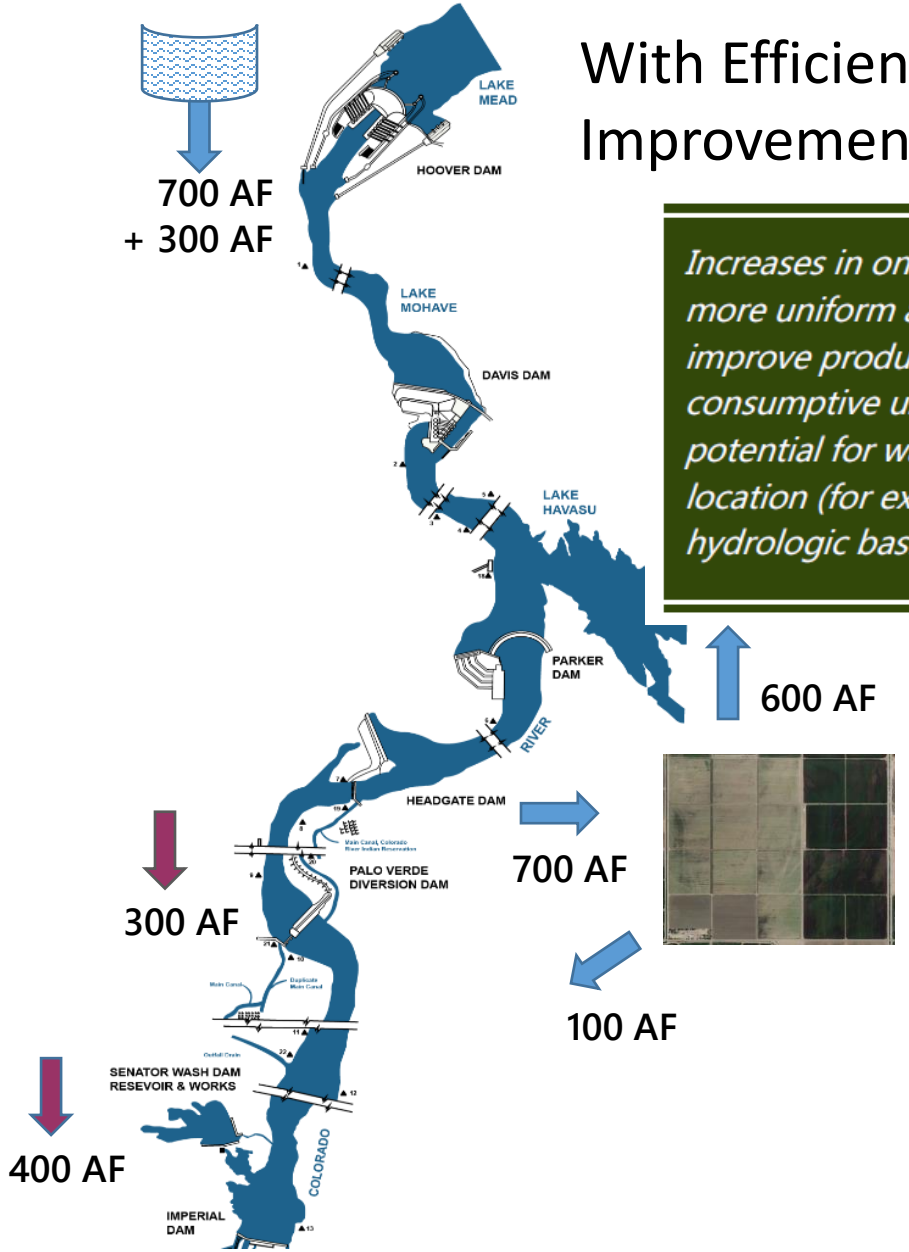


Consumptive Use Examples – Efficiency

Prior to Efficiency Improvements



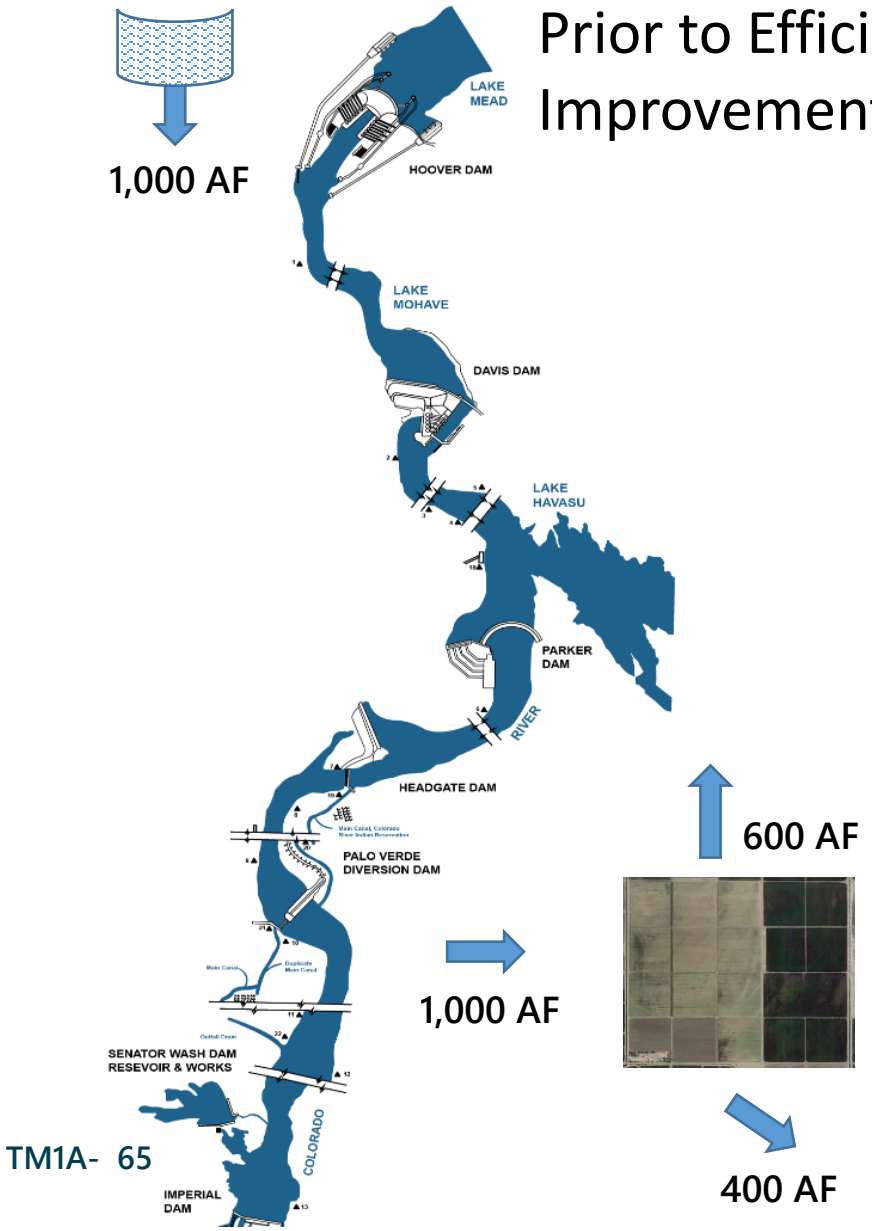
With Efficiency Improvements



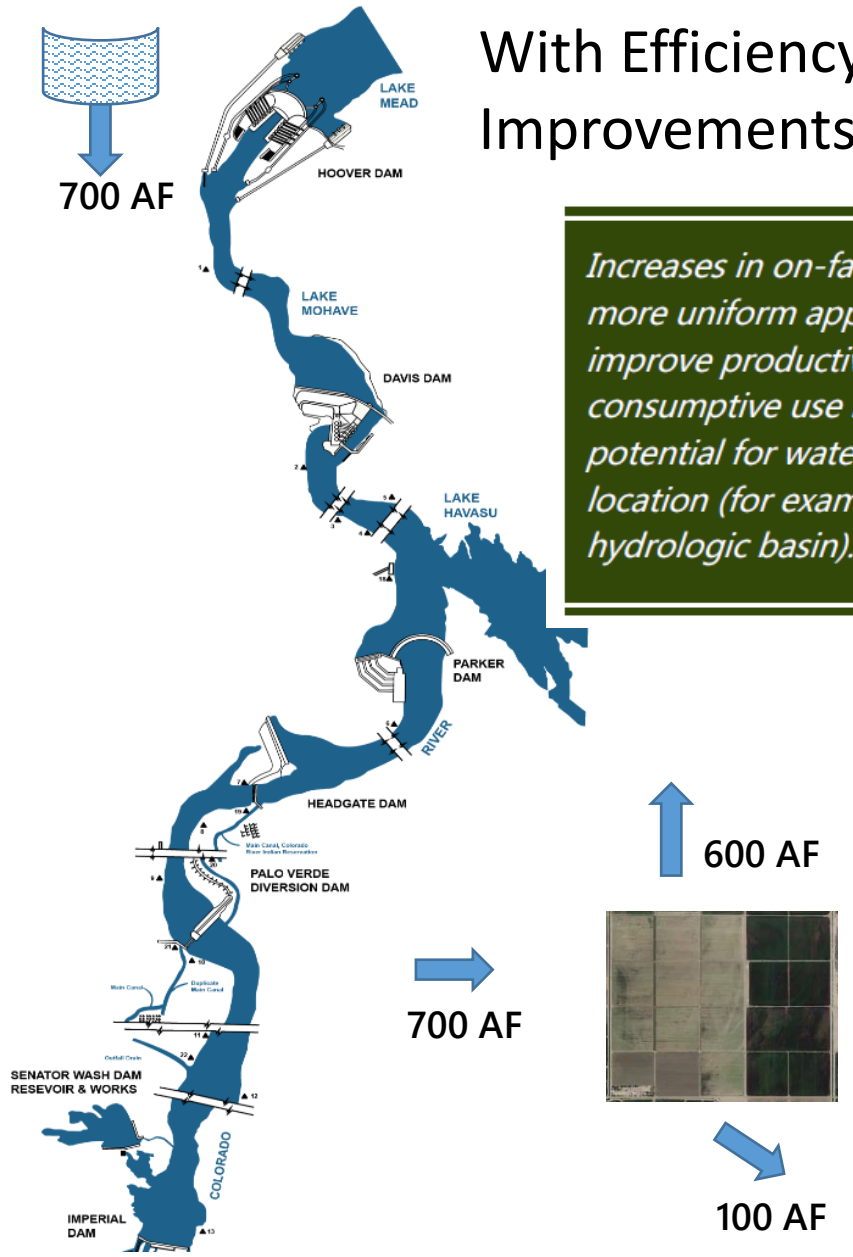
Increases in on-farm efficiency result in more uniform application of water and may improve productivity but may not result in consumptive use reduction, and the potential for water savings varies by location (for example, in or out of the hydrologic basin).

Consumptive Use Examples – Exported Water

Prior to Efficiency Improvements



With Efficiency Improvements



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).

Lower Basin Programs Administered by Reclamation

- Inadvertent Overrun and Payback Policy (IOPP)
  - Requires water users to payback overruns to the system through extraordinary conservation
    - 583 KAF paid back since initiation of the IOPP
- Intentionally Created Surplus (ICS)
  - Provides water users ability to store conserved water in Lake Mead for future delivery
    - Total ICS stored in Lake Mead was 2.3 MAF at end of CY 2019
- Pilot System Conservation Program (PSCP)
  - Funding provided for extraordinary conservation yielding water stored in Lake Mead as System Water
    - 165 KAF of created through CY 2019

Quantification Methods Used in the Lower Basin

- Quantification methods are unique to each water user
  - User proposes method to Reclamation
- Fallowing quantification methods include:
  - District average
    - Historical or actual year
  - Field specific
    - Water delivery records
    - ET estimates

Fallowed Field in Imperial Valley

Summary

- Consumptive Use = Diversions – Returns
- Conservation measures must result in a measurable reduction in mainstream Colorado River consumptive use
  - Potential for water savings varies by location (for example, in or out of the hydrologic basin)
- Various quantification methods are currently used in the Lower Basin

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Case Study Definition and Approach

Working Definition of Case Study

- An applied research method involving an up-close, in-depth, and detailed examination of a particular phenomenon, like a person, group, or situation
- The phenomenon is studied and analyzed in detail and solutions or interpretations are presented … provides a deeper understanding of a complex topic or assists in gaining experience about a certain historical situation

Paraphrased from: Stephanie Glen. "Case Studies: Case Study Definition and Steps" From StatisticsHowTo.com: Elementary Statistics for the rest of us! https://www.statisticshowto.com/case-studies/

Case Study Steps

- Determine the research question and carefully define it…
  - What agricultural water conservation technologies are being implemented and what methodologies are being used to quantify conservation in the Lower Colorado River Basin
- Choose the cases and state how data is to be gathered and which techniques for analysis will be used…
  - Which conservation activities will be focused on and where
    - Review of recent/current activities
    - Literature review

Case Study Identification Approach

- Potential case studies identified by project team and participants
- Through a collaborative workshop process, determine:
  - Agricultural conservation method(s) utilized
  - Locations in the LCRB
  - Quantification method employed
  - Available data/information
- Develop consensus recommendations for the case studies to be evaluated

Case Study Steps (continued)

- Prepare to collect the data…
  - Workshop to identify and recommend case studies
    - Opportunities, constraints, limitations
    - Sites
    - Evaluation process
- Collect the data…
  - Site visits and interviews – site specific perspectives on the impacts (positive and negative) of the identified activities, as well as limitations or constraints on quantification methods, and opportunities for improvements

Case Study Steps (continued)

- Analyze the data…
  - Technical review of the quantification methods used
  - Relationship with the quantification of consumptive use and Reclamation's Decree Accounting in the Lower Basin
  - Review and compare the applied quantification methods to the approaches identified in the literature review.
  - Provide an assessment of opportunities to improve or enhance quantification methods
- Report results…
  - Prepare draft report and review with participants at final workshop
  - Prepare final report

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Wrap-up and Next Steps