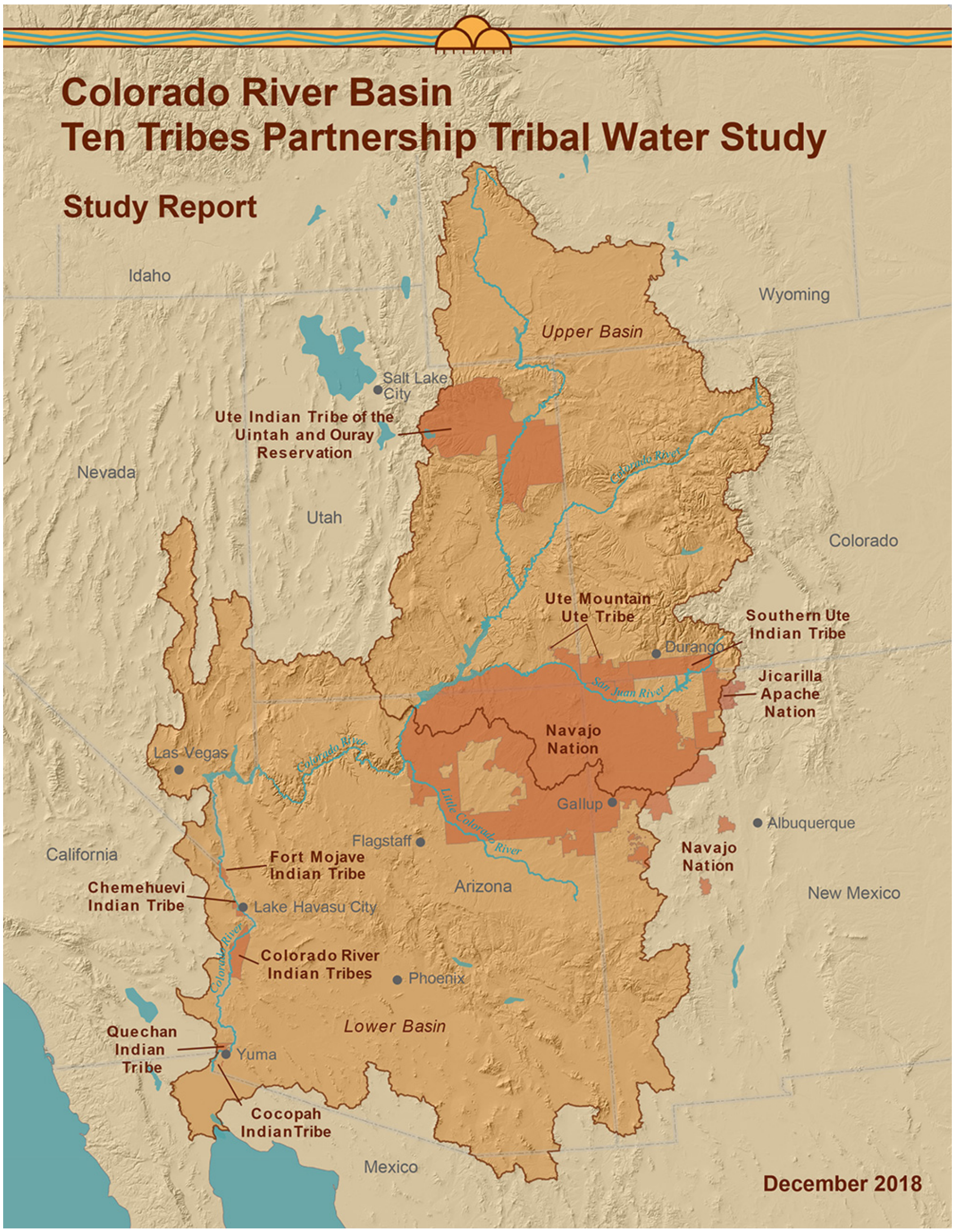
Reclamation Releases Colorado River Basin Ten Tribes Partnership Tribal Water Study

Media Contact: Patti Aaron, 702-293-8189, paaron@usbr.gov

For Release: December 13, 2018



Colorado River Basin Ten Tribes Partnership Tribal Water Study Study Report

WASHINGTON – Bureau of Reclamation Commissioner Brenda Burman announced today the release of the Colorado River Basin Ten Tribes Partnership Tribal Water Study that was conducted collaboratively with the member tribes of the Ten Tribes Partnership.

The study documents how Partnership Tribes currently use their water, projects how future water development could occur and describes the potential effects of future tribal water development on the Colorado River System. The study also identifies challenges related to the use of tribal water and explores opportunities that provide a wide range of benefits to both Partnership Tribes and other water users.

"We face a prolonged drought that represents one of the driest 20-year periods on the Colorado River in the last 1,200 years," said Commissioner Burman. "This study is an important step forward that furthers our understanding of the challenges facing the Colorado River Basin and the actions we can take to collaboratively address them."

While not all federally-recognized tribes in the basin are members of the Ten Tribes Partnership, the Partnership Tribes have reserved water rights, including unresolved claims, to potentially divert nearly 2.8 million acre-feet of water per year from the Colorado River and its tributaries. In many cases, these rights are senior to other uses.

The study is the outcome of a commitment between Reclamation and the Partnership Tribes to engage in a joint study to build on the scientific foundation of the Colorado River Basin Water Supply and Demand Study, published by Reclamation in 2012.

"Reclamation recognized the need for additional analyses and work following the 2012 Colorado River Basin Study," said Reclamation Lower Colorado Regional Director Terry Fulp. "Working together, the Ten Tribes Partnership and Reclamation have produced a valuable reference that is the first of its kind in the Colorado River Basin."

The study highlights tribal observations and concerns, including lack of water security, incomplete distribution systems and regulatory and economic challenges to developing water systems in geographically diverse areas.

"In light of the importance of tribal water rights in the Colorado River Basin, the Partnership and Reclamation collaborated to contribute crucial tribal-specific information to the discussions regarding Colorado River management," said Lorelei Cloud, Chairman of the Ten Tribes Partnership. "Without the hard work and dedication of Reclamation, tribal leaders, and tribal staff, this critical project would not have been possible."

The Ten Tribes Partnership was formed in 1992 by ten federally recognized tribes with federal Indian reserved water rights in the Colorado River or its tributaries. Five member tribes are located in the Upper Basin (Ute Mountain Ute Tribe, Southern Ute Indian Tribe, Ute Indian Tribe, Jicarilla Apache Nation and Navajo Nation) and five are in the Lower Basin (Fort Mojave Indian Tribe, Colorado River Indian Tribes, Chemehuevi Indian Tribe, Quechan Indian Tribe and Cocopah Indian Tribe).

The study is available at:
https://www.usbr.gov/lc/region/programs/crbstudy/tribalwaterstudy.html

# # #

Colorado River Basin
Ten Tribes Partnership Tribal Water Study

Study Report

December 2018

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

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.

The mission of the Colorado River Basin Tribes Partnership is to assist in developing, protecting, and maximizing the water rights of the member Tribes. To that end, the Partnership Tribes shall:

- **Consult, Collaborate, and Coordinate** with each other, the United States, and other affected governmental agencies and user groups on matters concerning Tribal water rights, including but not limited to proposed legislative, administrative, or other actions that may affect the water supplies and demands of the Colorado River Basin, its management, or the administration of Colorado River water entitlements.
- **Educate** the United States, state and local agencies, and the public as to the nature and extent of Tribal water rights and the concerns of the Partnership with respect to matters affecting such rights.

Colorado River Basin
Ten Tribes Partnership Tribal Water Study

Study Report

U.S. Department of the Interior **Bureau of Reclamation** **Ten Tribes Partnership**

December 2018

Commissioner of Reclamation Foreword

Traveling over 1,400 miles from its headwaters in Wyoming and Colorado to the Gulf of California, the Colorado River is a lifeline to seven states within the United States, 29 Native American Reservations, and two states in northern Mexico.

Within the Colorado River Basin, ten tribes have come together to form the Ten Tribes Partnership. The Partnership Tribes[1] have reserved water rights, including unresolved claims, to the Colorado River and its tributaries. In many cases, these rights are senior to other uses. Recognizing the importance of furthering the understanding of tribal water (both currently and in the decades ahead), the Bureau of Reclamation and the Ten Tribes Partnership collaborated in this Study to document Partnership Tribes' water use and potential future water development to better facilitate planning and decision-making throughout the Basin.

The comprehensive, Basin-wide analysis of tribal water in the Colorado River Basin Ten Tribes Partnership Tribal Water Study builds on the 2012 Colorado River Basin Study, and allows each of the tribes to provide, from their own perspective, their views on the challenges and opportunities ahead. The Tribal Water Study strengthens a Department of the Interior commitment to address water issues facing tribes and recognizes that the Colorado River is an essential foundation for the physical, economic, and cultural sustenance of tribes in the Basin.

Today, we face a prolonged drought that represents one of the driest 20-year periods in the last 1,200 years. This Study is an important next step in understanding the Colorado River, its resources, and the demands that will likely be placed on it. In addition, this Study explores ways to provide a wide range of benefits to both Partnership Tribes and other water users. The partnerships forged and strengthened during this Study will prove to be critical as we collaboratively address the significant challenges ahead.

Brenda Burman

Commissioner, Bureau of Reclamation

[1] Chemehuevi Indian Tribe, Cocopah Indian Tribe, Colorado River Indian Tribes, Fort Mojave Indian Tribe, Jicarilla Apache Nation, Navajo Nation, Quechan Indian Tribe, Southern Ute Indian Tribe, Ute Indian Tribe, Ute Mountain Ute Tribe

Ten Tribes Partnership Foreword

The concepts and values conveyed by the well-known phrase "water is life" are neither unique to tribes, nor to this century:

> In the debate leading to approval of the first congressional appropriation for irrigation of the Colorado River Indian Reservation, the delegate from the Territory of Arizona made this statement: "Irrigating canals are essential to the prosperity of these Indians. Without water, there can be no production, no life."[1]

The Colorado River Basin Tribes Partnership (a.k.a. Ten Tribes Partnership) and the Bureau of Reclamation (Reclamation) initially undertook the Colorado River Basin Tribal Water Study to augment the data produced for the Colorado River Basin Supply and Demand Study of 2012. With five tribes in the Upper Basin and five tribes in the Lower Basin, and between us, holding rights to more than 2.8 million acre-feet per year of water from the Colorado River and its tributaries, the Ten Tribes Partnership was uniquely positioned to explore these issues. However, in so doing, we learned that the effort would also serve to facilitate a broader and, we hope, a better understanding of the role tribal water plays, and will play, in the Colorado River Basin over the coming decades.

In addition to producing technical information, the Tribes had other goals. First, we wanted to better understand how, at present, each of our individual water use scenarios fits into the overall scheme of Colorado River Basin management. Second, we wanted to know how future development of tribal water resources will alter Basin operations and affect other water users who are now using water to which a tribe may hold legal title, but which the title-holding tribe has not yet developed for its own use. Finally, we wanted to assess – to the extent present information allows – the role future development of tribal water rights will have on Basin operations.

Along the way, we encountered data gaps, modeling limitations, and uncertainties, but nonetheless, with the support of Reclamation, we managed to address those issues sufficiently that we now provide this Report. If there is a 'take-away' that was surprising, it is that, even under the most favorable of circumstances for rapid tribal water development, the amount of water that will be used by the Tribes is dramatically overshadowed by the effect of climatic conditions on the overall supply of water in the Basin. Nature is still in charge.

Challenges remain, but opportunities are in the offing. We hope this Report informs, resolves some uncertainty about how tribes perceive the future for their water uses, and establishes a baseline for discussions and development of relationships among tribes, states, the federal government, water managers, and water users throughout the Basin.

---

[1] CONG.GLOBE, 38th Cong., 2d Sess. 1321 (1865). *Arizona v. California,* 373 U.S. 546, 598-599 (1963).

Acknowledgement

Funding, time, and expertise provided by the Department of Interior, the Bureau of Reclamation, and the member Tribes of the Ten Tribes Partnership made the Colorado River Basin Ten Tribes Partnership Tribal Water Study possible.

Contents

Chapter 5 – Assessment of Current Tribal Water Use and Projected Future Water Development

Chapter 6 – Assessment of System Effects Resulting from Development of Tribal Water

Chapter 7 – Challenges and Opportunities Related to Development of Tribal Water

Chapter 8 – Study Limitations

Chapter 9 – Future Considerations and Next Steps

Disclaimer

References

Glossary

Acronyms and Abbreviations

ADWR	Arizona Department of Water Resources
AF	acre-foot (feet)
AFY	acre-foot (feet) per year
AG	irrigated agriculture and livestock
A-LP	Animas-La Plata
Basin	Colorado River Basin
Basin States	Colorado River Basin States
Basin Study	Colorado River Basin Water Supply and Demand Study
BIA	Bureau of Indian Affairs
cfs	cubic foot (feet) per second
CHIA	Cumulative Hydrologic Impact Assessment
CRIP	Colorado River Irrigation Project
CRIR	Colorado River Indian Reservation
CRIT	Colorado River Indian Tribes
CRSS	Colorado River Simulation System
CUP	Central Utah Project
CUPCA	Central Utah Project Completion Act
CUWCD	Central Utah Water Conservancy District
CWCB	Colorado Water Conservation Board
DCMI	domestic, commercial, municipal, and industrial
DNR	Department of Natural Resources
DOI	U.S. Department of the Interior
DWCD	Dolores Water Conservancy District
ENV	environmental, cultural, and recreational
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ESA	U.S. Endangered Species Act
°F	degree(s) Fahrenheit

FRE	Farm and Ranch Enterprise
GCM	Global Climate Model
gpm	gallons per minute
ICS	Intentionally Created Surplus
IHS	Indian Health Service
KAF	thousand acre-feet
KAFY	thousand acre-feet per year
kWh	kilowatt-hours
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
MAF	million acre-feet
MAFY	million acre-feet per year
Mexico	United Mexican States
mg/L	milligrams per liter
msl	above mean sea level
MVIC	Montezuma Valley Irrigation Company
MWD	Metropolitan Water District of Southern California
M&I	municipal and industrial
NAPI	Navajo Agricultural Products Industry
NAWMAs	Native American Water Masters Associations
NDOH	Navajo Department of Health
NDWR	Navajo Department of Water Resources
NEPA	National Environmental Policy Act
NGWSP	Navajo-Gallup Water Supply Project
NIIP	Navajo Indian Irrigation Project
NMISC	New Mexico Interstate Stream Commission
NNDA	Navajo Nation Department of Agriculture
NNEPA	Navajo Nation Environmental Protection Agency
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NTUA	Navajo Tribal Utility Authority

ONF	Observed Natural Flow
O&M	operation & maintenance
Partnership	Colorado River Basin Tribes Partnership
PNM	Public Service Company of New Mexico
PPR	Present Perfected Right
PRIIP	Pine River Indian Irrigation Project
PWCC	Peabody Western Coal Company
Reclamation	Bureau of Reclamation
ROD	Record of Decision
SCADA	Supervisory Control and Data Acquisition
SCS	Soil Conservation Service
SJRBRIP	San Juan River Basin Recovery Implementation Program
TTP	Ten Tribes Partnership
TRAN	transfers, leases, and exchanges
Tribal Water Study	Colorado River Basin Ten Tribes Partnership Tribal Water Study
UCRC	Upper Colorado River Commission
UIIP	Uintah Indian Irrigation Project
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

1 | Introduction

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

In response to the findings of the Basin Study, in 2014, Reclamation's Upper and Lower Colorado Regions, in collaboration with member tribes of the Ten Tribes Partnership[2] (Partnership Tribes), undertook the Colorado River Basin Ten Tribes Partnership Tribal Water Study (Tribal Water Study). The Tribal Water Study built on the technical foundation of the Basin Study and advanced critical information beyond the limited assessment of tribal water in the Basin Study. In recognition of the importance of bringing tribal[3] perspectives to bear in addressing Colorado River planning and management challenges, Reclamation and the Ten Tribes Partnership committed to completion of the Tribal Water Study as documented in the *Agreement Regarding the Importance of the Colorado River Basin Tribal Water Study* provided in *Appendix 1A, Plan of Study*.

The Colorado River Basin Tribes Partnership, also known as the Ten Tribes Partnership (Partnership), is an organization formed in 1992 by ten federally recognized tribes with federal Indian reserved water rights in the Colorado River or its tributaries (Figure 1-A). Not all federally recognized tribes in the Basin are members of the Partnership. Partnership Tribes have reserved water rights, including unresolved claims, to divert nearly 2.8 million acre-feet of water per year from the Colorado River and its tributaries.

Colorado River Ten Tribes Partnership Vision Statement

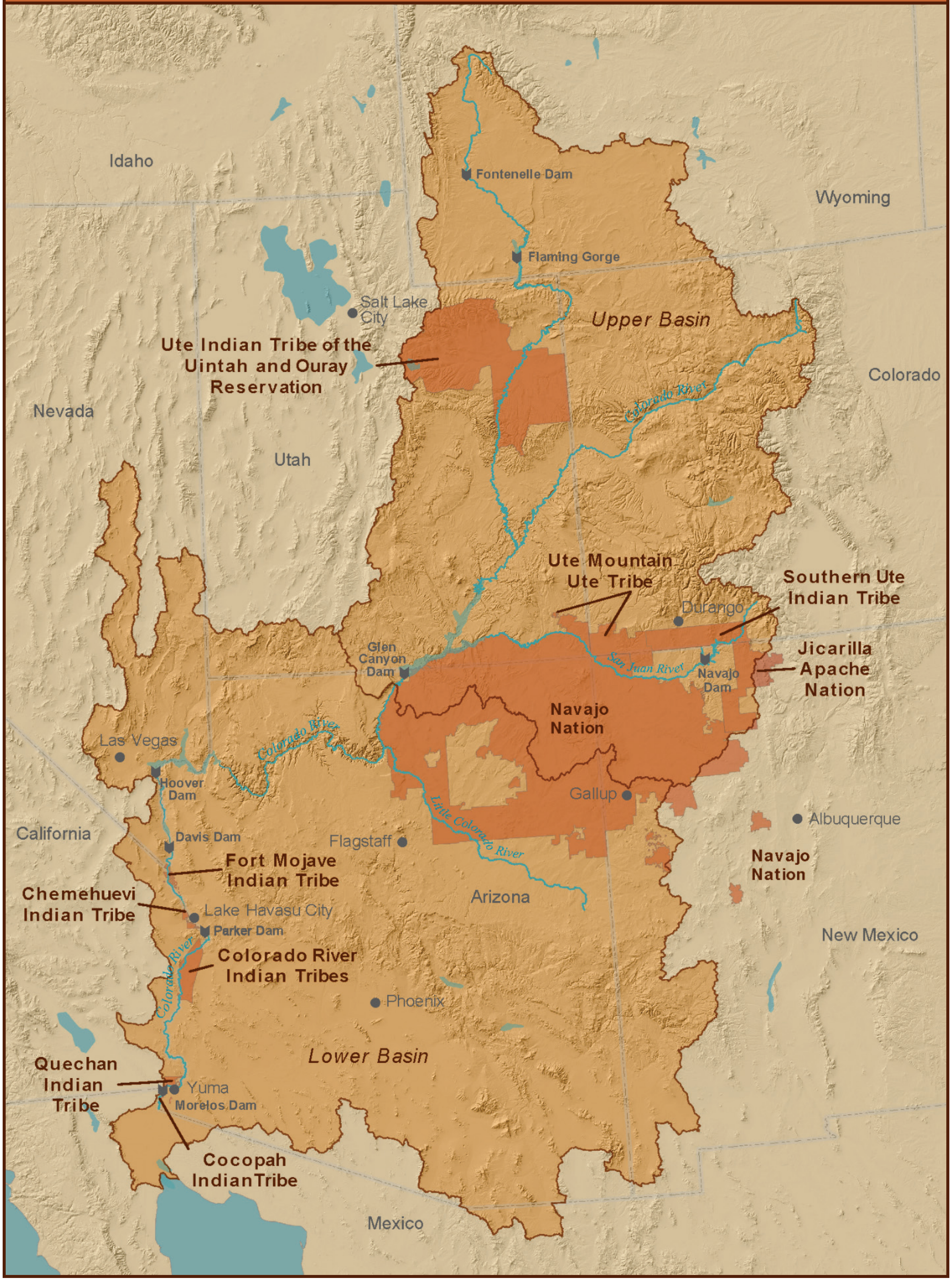
Water is life. Water is the giver and sustainer of life. Water is a sacred and spiritual element to the Tribes of the Partnership. The Creator instilled in the First Peoples the responsibility of protecting the delicate, beautiful balance of Mother Earth for the benefit of all living creatures. The Partnership will embrace and own the stewardship of the Colorado River and lead from a spiritual mandate to ensure that this sacred water will always be protected, available and sufficient.

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

[2] Chemehuevi Indian Tribe, Cocopah Indian Tribe, Colorado River Indian Tribes, Fort Mojave Indian Tribe, Jicarilla Apache Nation, Navajo Nation, Quechan Indian Tribe, Southern Ute Indian Tribe, Ute Indian Tribe, Ute Mountain Ute Tribe

[3] For purposes of the Study, "tribal" generally refers to the member tribes of the Ten Tribes Partnership, unless the context expresses otherwise.

FIGURE 1-A
Map of the Colorado River Basin Showing Reservations of the Members of the Ten Tribes Partnership



The United States has a trust responsibility to protect federal Indian reserved water rights. Each tribe's water rights are unique; the information provided in this report is not intended to provide an interpretation of the water rights of any tribe or to establish federal policy related to federal Indian reserved water rights.

This report provides the outcomes of Tribal Water Study efforts conducted between January 2014 and November 2017. Information in this report was developed and written jointly by Reclamation and the Partnership Tribes. Both Reclamation and the Partnership Tribes went to great effort to present information that is accurate and descriptive of the views of the Partnership Tribes. Neither the United States nor the Partnership Tribes are bound or foreclosed by the views stated in this report. This report consists of the following chapters:

- Chapter 1 – Introduction
- Chapter 2 – Background on Federal Indian Reserved Water Rights
- Chapter 3 – The Tribes of the Ten Tribes Partnership
- Chapter 4 – Methodology for Assessing Current Tribal Water Use and Projected Future Water Development
- Chapter 5 – Assessment of Current Tribal Water Use and Projected Future Water Development
- Chapter 6 – Assessment of System Effects Resulting from Development of Tribal Water
- Chapter 7 – Challenges and Opportunities Related to Development of Tribal Water
- Chapter 8 – Study Limitations
- Chapter 9 – Future Considerations and Next Steps

1.0 Overview of Colorado River Basin

Today, between 35 and 40 million people in the seven Basin States rely on the Colorado River and its tributaries for some, if not all, of their municipal water needs. These same water sources irrigate nearly 4.5 million acres of land in the Basin and the adjacent areas that receive Colorado River water, generating many billions of dollars a year in agricultural and economic benefits (Reclamation, 2015). The Colorado River and its tributaries are essential physical, economic, and cultural resources to all of the federally recognized tribes in the Basin (see *Appendix 1B, Federally Recognized Tribes in the Colorado River Basin*). In addition, the Colorado River is vital to the United Mexican States (Mexico).

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

Total consumptive use and loss in the Basin has averaged approximately 15 million acre-feet per year (MAFY)[5] over the past decade. Agriculture is the dominant use of Colorado River water,

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

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

with approximately 70 percent of total Colorado River water used to support agriculture. Of the total consumptive use, 40 percent is exported outside the Basin's hydrologic boundaries for use in adjacent areas, including major metropolitan areas located outside the Basin's hydrologic boundaries that receive Colorado River water: Albuquerque, Denver, Los Angeles, Salt Lake City, and San Diego.

The Colorado River System is administered in accordance with the Law of the River[6] and, of particular relevance to the Tribal Water Study, the federal Indian reserved water rights doctrine. Apportioned water in the Basin exceeds the average long-term (1906 to 2015) historical natural flow of approximately 16.1 MAFY. Up to this point, the imbalance has been managed, and all requested deliveries were met in the Lower Basin as a result of the considerable amount of reservoir storage capacity in the System (approximately 60 MAF or nearly four years of average natural flow of the river). This is due in part to the fact that tribes are still developing into their water rights. Another factor is that Upper Basin States are still developing into their apportionments. In addition, some of the Lower Basin States have been relying on unused tribal water. Finally, Basin States are continuing to reduce their demand for Colorado River water.

Drought conditions have been experienced in the Basin since 2000. Although Basin inflow in 2017 was above average, it was one of only four years with above average inflow since 2000. The average inflow over this 19-year period is approximately 15 percent below the long-term average. The Colorado River reservoir System was near full at the start of this drought but declined to approximately 50 percent capacity in the first five years, and has continued to hover around 50 percent full over the past 12 years. The duration of this ongoing, extended drought is unknown. This uncertainty coupled with a marked decline in System storage poses significant challenges to Basin water users.

Over the past twenty years, collaboration between Reclamation, federally recognized tribes, the Basin States, and others has resulted in significant success in collaboratively addressing water resources challenges across the Basin. The Tribal Water Study is an important next step in the understanding of Colorado River uncertainties and the exploration of opportunities that provide a wide-range of benefits to both Partnership Tribes and water users to help meet the significant challenges ahead.

2.0 Study Objectives and Approach

The *Plan of Study*, provided in Appendix 1A, states that the purpose of the Tribal Water Study is to conduct a comprehensive study that would assess, for Partnership Tribes, their tribal water supplies, document current tribal water use on Partnership Tribe Reservations, project future development of tribal water, and identify tribal challenges and opportunities associated with the development of tribal water considering the future projected water supply and demand imbalances documented in the Basin Study. Specific objectives of the Study include:

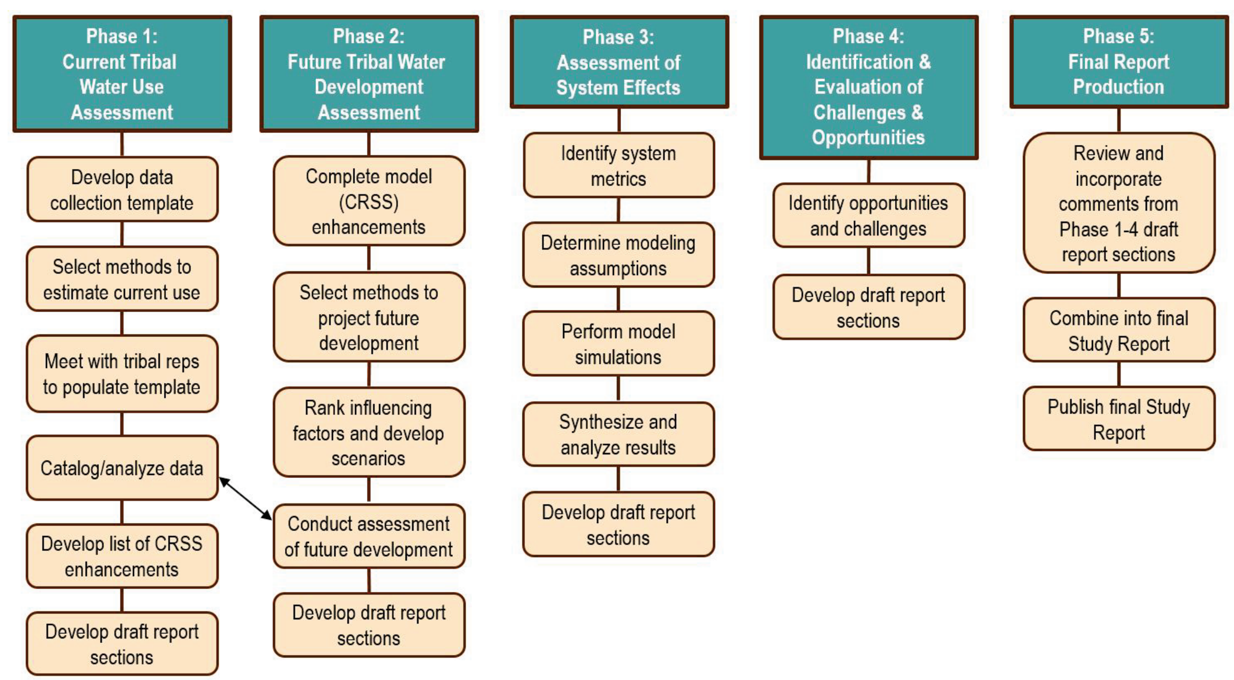
- Improve the understanding of the role of tribal water throughout the Colorado River System using existing data

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

- Enhance the Colorado River Simulation System (CRSS) to improve its simulation of tribal water use
- Characterize current tribal water use by each Partnership Tribe
- Characterize a range of future tribal water development for each Partnership Tribe
- Identify potential future effects to specific users, or groups of users, presently relying on unused tribal water
- Identify tribal water development challenges both specific to Partnership Tribes and in general Basin-wide
- Identify opportunities for Partnership Tribes that can help reduce future uncertainty and future water imbalances

The Tribal Water Study was conducted in four major phases: 1) Current Tribal Water Use Assessment; 2) Future Tribal Water Development Assessment; 3) Assessment of System Effects Resulting from the Development of Tribal Water; and 4) Identification and Evaluation of Challenges and Opportunities Related to the Development of Tribal Water. Figure 1-B illustrates these phases and some of their inter-relationships. Although the Tribal Water Study identified potential legal and policy issues related to tribal water development and potential opportunities related to the future development of tribal water and future Colorado River uncertainties, the Study viewed tribal water in the context of the current Law of the River.

FIGURE 1-B
Study Phases and Tasks



2.1 Study Organization

As envisioned by the *Plan of Study*, a Study Team led and was responsible for the overall direction and management of the Tribal Water Study. Members of the Study Team provided the expertise, experience, and knowledge that related to the Tribal Water Study's scope and objectives. Study Team members included the members of the Partnership's Legal/Technical Committee and designated Reclamation staff from the Upper Colorado and Lower Colorado Regions. Study Team members were responsible for communicating the Tribal Water Study's progress and issues to, and receiving input from, their respective Partnership Tribes and organizations. Members of the Study Team are listed in *Appendix 1C – Study Team Members.*

Appendix 1A
Plan of Study

Appendix 1A – Plan of Study

Colorado River Basin Ten Tribes Partnership Tribal Water Study Plan of Study

(Finalized March 2014)

1.0 Introduction

The Bureau of Reclamation's (Reclamation) Upper and Lower Colorado Regions (UC and LC Regions), in collaboration with representatives of the Ten Tribes Partnership[1] (Partnership) are undertaking the Colorado River Basin Ten Tribes Partnership Tribal Water Study (Study) to build on the technical foundation of the Colorado River Basin Water Supply and Demand Study (Basin Study) and advance critical information beyond the limited assessment of tribal water in that study. The estimated cost for the Study is $500,000 which consists of a $100,000 grant to the Partnership from Reclamation and $400,000 for Reclamation's participation. In addition, the Partnership is expected to contribute to the Study beyond the anticipated $500,000 cost through staff time contributions in excess of what may be covered by the $100,000 grant. The Study will be conducted over a period of approximately two years with an anticipated completion by December 2015.

The tribes of the Ten Tribes Partnership hold a significant amount of quantified and unquantified Federal reserved water rights to the Colorado River and its tributaries. In addition, there are unresolved reserved rights claims and many tribes hold water rights that are not Federal reserved water rights. Reclamation did not intend that the Basin Study be used to assess the future impacts to tribal water use in the Basin, and it did not fully account for tribal water demand, reflect the potential use of used tribal water by others, or show the potential impact on the Basin water supply if a substantial amount of the presently unused or unquantified tribal water is used by the tribal water rights holders prior to 2060. In recognition of the importance in bringing the tribal perspective to bear in furthering the understanding of these important matters, Reclamation and the Ten Tribes Partnership are committed to the thorough development and timely completion of the Study as documented in the *Agreement Regarding the Importance of the Colorado River Basin Tribal Water Study* provided in Appendix 1.

This Plan of Study contains: the Study's purpose and objectives; a description of the Study management structure; a description of the major phases of the Study and a breakdown of the major tasks and estimated timeline in each phase.

2.0 Study Purpose and Objectives

The purpose of the Study is to conduct a comprehensive study that will assess, for the tribes of the Ten Tribes Partnership, tribal[2] water supplies, document current tribal water use on

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

[2] For purposes of this plan of study "tribal" refers collectively to the tribes and only those tribes of the Ten Tribes Partnership

Partnership reservations, project future water demand on Partnership reservations, document use of unused tribal water by others, and identify tribal opportunities and challenges associated with the development of tribal water considering the future projected water supply and demand imbalances documented in the Basin Study. Specific objectives of the Study include:

- Improve the understanding of the role of tribal water throughout the Colorado River system using existing data
- Enhance the Colorado River Simulation System (CRSS) to improve its simulation of tribal water use
- Characterize current tribal water use by each of the tribes in the Partnership
- Characterize a range of future tribal water demand for each of the tribes in the Partnership
- Identify potential future impacts to specific users, or groups of users, presently relying on unused tribal water
- Identify tribal water development challenges both specific to the tribes in the Partnership and in general Basin-wide
- Identify opportunities for tribes to participate in potential opportunities that can help reduce future uncertainty and future water imbalances

The Study will be conducted collaboratively with involvement by the seven Colorado River Basin States and other interested stakeholders. Although the Study may identify potential legal and policy issues related to tribal water development and potential solutions to water imbalances, the Study is intended to view tribal water in the context of the current Law of the River[3].

3.0 Study Management

Management of the Study will be accomplished as described in the following sections.

3.1 Study Team

The Study Team will ensure that the tasks that related to the Study are completed in an effective, efficient manner, are technically sound, and are within the Study's financial and time constraints. Members of the Study Team provide the expertise, experience, and knowledge that relate to the Study's scope and objectives. Study Team members include the members of the Partnership's Legal/Technical Committee and designated Reclamation staff from the Upper Colorado (UC) and Lower Colorado (LC) Regions. Study Team members will be responsible for communicating Study progress and issues to their respective management such as the Partnership and Reclamation management. Representatives of individual tribes are expected to participate in the study as part of sub-teams in areas where information specific to the individual tribes is critical.

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

3.2 Sub-Teams

Various sub-teams may be formed as needed to perform certain tasks. Sub-team members would provide the specific expertise required to perform those tasks. The Study Team will determine when a specific sub-team should be formed, that sub-team's tasks, and the expertise required of that sub-team. Members may include Study Team members, additional staff from the UC and LC Regions, tribal representatives, and representatives from other groups with a particular expertise sought by the Study Team.

4.0 Study Schedule, Phases, & Products

The Study will build from the analysis done in the Basin Study to advance the knowledge of tribal water resources in the Basin.

4.1 Schedule

The Study will be conducted over a period of two years with an anticipated completion of December 2015. The Study will consist of five major phases: Current Tribal Water Use Assessment, Future Tribal Water Demand Assessment, Assessment of System Impacts resulting from the development of tribal water, Evaluation of Opportunities and Challenges related to the development of tribal water. A draft report will be developed for each phase and will be combined into a final report in a fifth phase. The projected timeline for these phases and the major Study milestones are displayed in the following tables.

Table 1
Projected Study Timeline

	2013	2014												2015										
Phase Name	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
1. Current Tribal Water Use Assessment																								
2. Future Tribal Water Demand Assessment																								
3. Assessment of System Impacts resulting from the development of tribal water																								
4. Identification and Evaluation of Opportunities and Challenges related to the development of tribal water																								
5. Final Report Production																								

Table 2
Projected Study Milestones & Products

Phase Name	Milestones		Products
1. Current Tribal Water Use Assessment	2014	Feb	Completion of data and information collection meetings with each of the Ten Tribes
		Apr	Draft report describing findings from the assessment of current tribal water use and workplan for CRSS enhancements
2. Future Tribal Water Demand Assessment	2014	Dec	Draft report describing findings from the assessment of future tribal demand
		Dec	Completion of CRSS enhancments
3. Assessment of System Impacts resulting from the development of tribal water	2015	May	Draft report describing findings from system dependence assessment
4. Identification and Evaluation of Opportunities and Challenges related to the development of tribal water		Jul	Draft report describing findings from opportunities/challenges evaluation
5. Final Report Production	2015	Oct	Draft final report that combines reports from previous phases
		Dec	Final report

4.2 Phases

The following sections describe the work to be completed in each of the five major Study phases.

Phase 1. Current Tribal Water Use Assessment

For each of the tribes in the Partnership, an assessment of current water use will be conducted. The assessment will include a description of the amount of water currently used by the tribe, the locations and types of use, additional water supplies beyond Colorado River water (e.g. groundwater), and any major diversions or infrastructure. For the purpose of the Study, current use may include analysis of multiple years of use data and is intended to provide a baseline of use rather than to quantify an absolute amount of current use. This information will be used to develop recommendations for CRSS enhancements as well as serve as the base information for which the future demand assessment will be conducted in Phase 2. Tribal background information that includes a description of each of the tribes in the Partnership will also be collected. Major tasks and sub-tasks for this phase are as follows.

Tasks:

Task 1: Develop template for data collection including, but not limited to:
- a. Nature and priority of water rights
- b. Current water use
- c. Shortages if known
- d. Type of use
- e. Additional water supplies other than Colorado River surface water
- f. Major diversion or infrastructure
  - i. Location
  - ii. Operating constraints

Task 2: Review and select methods to estimate current use

Task 3: Meet with representatives from each of tribe in the Partnership to populate template developed in Task 1

Task 4: Catalog/analyze data
- a. Develop maps for locations of diversions/uses

Task 5: Develop prioritized list of enhancements for CRSS guided by Task 4

Task 6: Develop draft report
- a. Present findings from the assessment of current tribal water use including tribal background information
- b. Include workplan for CRSS enhancements

Task 7: Develop draft final report
- a. Incorporate and address comments on draft report

Phase 2. Future Tribal Water Demand Assessment

Two major activities will be conducted in this phase simultaneously. In the first activity, enhancements to CRSS will be performed such that tribal water use can be more accurately simulated, which will be performed in Phase 3. In the second activity, for each of the tribes in the Partnership, future tribal water demand scenarios will be developed that better reflect likely tribal development scenarios than those developed and used in the Basin Study.

Tasks:

Task 1: Complete CRSS enhancements identified in Phase 1

Task 2: Review and select methods to project future demands

Task 3: Conduct assessment of future demands

  a. Identify and address discrepancies with demands of non-tribal entities from the Basin Study resulting from any changes in tribal demand

Task 4: Develop draft report

  a. Present findings from the assessment of future tribal demand

Task 5: Develop draft final report

  a. Incorporate and address comments on draft report

Phase 3. Assessment of System Impacts resulting from the development of tribal water

In this phase, using the modified version of CRSS developed in Phase 2, a series of modeling simulations will be performed in order to quantify system impacts resulting from a range of future tribal water demand scenarios. A set of system metrics (e.g. key reservoir elevations, water deliveries to non-tribal entities) will be identified that will be used to indicate the Basin effects resulting from the future development of water by the tribes.

Tasks:

Task 1: Identify system metrics

  a. Incorporate system metrics in CRSS or as post-processing tool

Task 2: Determine modeling assumptions to support assessment

  a. Input modeling assumptions into CRSS

  b. Input future demand scenarios developed in Phase 2 into CRSS

Task 3: Perform model simulations

Task 4: Synthesize and analyze simulation results

Task 5: Develop draft report

  a. Present findings and results of assessment

Task 6: Develop draft final report

  a. Incorporate and address comments on draft report

Phase 4. Identification and Evaluation of Opportunities and Challenges related to the development of tribal water

This phase will consist of a discussion of issues related to future use and/or development of tribal water and may include additional CRSS assessments that build on the findings in Phase 3. Current arrangements such as transfers, leases, exchanges, forbearance, etc. that tribes or others currently have in place and the opportunities and challenges associated with those arrangements will be discussed.

Potential future opportunities, and the associated challenges, for tribes will also be discussed. The opportunities may include, but are not limited to:

- Transfers, leases, water banking, exchanges, forbearance, or other arrangements that offer potential opportunities for tribes
- Funding for infrastructure development
- Funding for infrastructure rehabilitation
- Storage projects
- Improved efficiencies and re-use
- Additional stream gaging on Colorado River tributaries

Tasks:

Task 1: Review Phase 3 findings and modify Phase 4 tasks as appropriate

Task 2: Develop draft final report

a. Describe findings from opportunities/challenges evaluation

Phase 5. Final Report Production

This phase will consist of the development of the final Study report. Draft reports from each of the previous phases will be finalized and combined to result in a final Study report.

Tasks:

Task 1: Review and incorporate comments on draft final reports from Phases 1-4

Task 2: Combine reports from Phases 1-4 into final Study report

a. Develop any supporting documents, e.g. executive summary

Task 3: Publish final Study report

4.3 Products

The primary products of the Study will be draft reports of each phase's activities that will be synthesized into a final report including the following elements:

- Assessment of current tribal water use
- Assessment of future tribal demand
- Findings from the system impacts assessment
- Findings from opportunities/challenges evaluation

A work plan for enhancements to CRSS and a modified version of CRSS will be additional Study products.

5.0 References

Bureau of Reclamation, 2012. *Colorado River Basin Water Supply and Demand Study – Study Report*

6.0 Appendices

Appendix 1 - *Agreement Regarding the Importance of the Colorado River Basin Ten Tribes Partnership Tribal Water Study*

Agreement Regarding Importance of the Colorado River Basin Tribal Water Study
As Identified in the Colorado River Basin Water Supply and Demand Study

Whereas, As part of its implementation of the SECURE Water Act of 2009, Subtitle F, The Omnibus Public Land Management Act of 2009 (Public Law 111-11, March 30, 2009), the Bureau of Reclamation (Reclamation) has established a program of Basin Studies within the western United States to address the growing need for information and tools to aid water resource managers; and,

Whereas, the purpose of this effort is to undertake comprehensive water studies that define options for meeting future water demands in river basins in the western United States where imbalances in water supply and demand exist or are projected; and,

Whereas, the studies performed under the SECURE Water Act (P.L. 111-11) should include consideration of actions to address the projected impacts of drought and climate change; and,

Whereas, one of the first basins examined under the Basin Study Program was the Colorado River Basin; and,

Whereas, during the development and preparation of the Colorado River Basin Water Supply and Demand Study (Study), Reclamation and participating tribal representatives recognized that:

The Indian Reserved Water Rights of the tribes of the Colorado River Basin are unique and have attributes that must be recognized under federal law and distinguished from state law water rights; and,

The Indian Reserved Water Rights of the tribes of the Colorado River Basin account for approximately 2.9 million acre-feet of annual diversion rights of the total apportionment of the Colorado River in the United States; and,

The Study does not fully account for tribal water demand nor reflect the potential use of tribal water by others nor show the potential impact on Colorado River Basin water supply if a substantial amount of the presently unused or unquantified tribal water is used by the tribal water rights holders prior to 2060; and,

Whereas, In the final Study Report, Reclamation and the Colorado River Basin Tribes Partnership (Ten Tribes Partnership) identified their commitment to joint future planning efforts that build on the scientific foundation of the Study and advance critical information beyond the limited assessment of tribal water in the Study.

Therefore, the undersigned representatives of the Department of the Interior and Ten Tribes Partnership state and agree,

In recognition of the aforementioned, the Department of the Interior (acting through Reclamation) and the Ten Tribes Partnership agree to undertake the Colorado River Basin Tribal Water Study. Both parties acknowledge the importance of prompt initiation, thorough development, and timely completion of this study. Work on the study will begin in 2013 with anticipated completion by December 2015. Reclamation and the Ten Tribes Partnership commit to work together in this endeavor in the spirit of collaboration and partnership. By doing so, Reclamation and the Ten Tribes Partnership hope to bring the tribal perspective to bear in identifying, analyzing, and documenting these important matters.

T. Darryl Vigil
Chairman
Colorado River Basin Tribes Partnership

Anne J. Castle
Assistant Secretary - Water and Science
U.S. Department of the Interior

Appendix 1B
Federally Recognized Tribes in the Colorado River Basin

Appendix 1B – Federally Recognized Tribes in the Colorado River Basin

The Indian lands of federally recognized tribes in the Colorado River Basin are presented in Figure 1B-A.

FIGURE 1B-A
Map of Federally Recognized Tribes in the Colorado River Basin

ID	Tribe Name	ID	Tribe Name	ID	Tribe Name	ID	Tribe Name
1	Ute Indian Tribe of the Uintah and Ouray Reservation	9	Havasupai Tribe	15	Chemehuevi Indian Tribe	23	Salt River Pima-Maricopa Indian Community
		10	Hualapai Indian Tribe	16	Colorado River Indian Tribes		
2	Southern Ute Indian Tribe	11	Shivwits Band of Paiute Indian Tribe	17	Yavapai-Apache Nation	24	Gila River Indian Community
3	Ute Mountain Ute Tribe			18	Yavapai-Prescott Indian Tribe	25	Ak-Chin Indian Community
4	Jicarilla Apache Nation	12	Moapa Band of Paiute Indians	19	Tonto Apache Tribe	26	Quechan Indian Tribe
5	Navajo Nation			20	White Mountain Apache Tribe	27	Cocopah Indian Tribe
6	Zuni Tribe	13	Las Vegas Tribe of Paiute Indians	21	San Carlos Apache Tribe	28	Tohono O'odham Nation
7	Hopi Tribe			22	Fort McDowell Yavapai Nation	29	Pascua Yaqui Tribe
8	Kaibab Band of Paiute Indians	14	Fort Mojave Indian Tribe				

Appendix 1C
Study Team Members

Appendix 1C – Study Team Members

A list of Study Members and their affiliation is listed in Table 1.3-A.

TABLE 1.3-A
Study Team Members

Affiliation	Study Team Member
Ute Indian Tribe of the Uintah and Ouray Reservations	Ute Tribal Business Committee
	Ute Indian Tribe Water Rights Commission
	Duane Moss, Director of Water Rights
	Joanne Curry, General Counsel
	Dr. Wold Mesghinna, Tribal Water Engineer
Southern Ute Indian Tribe	Southern Ute Indian Tribal Council
	Lena Atencio, Director, Department of Natural Resources
	Peter Waugh, Water Resources Division Head
	Andrew Straub-Heidke, Water Resources Specialist
	Catherine Condon, Special Counsel for Water
	Erin Wilson, Civil Engineer
	Theresa Ancell, Water Resources Division Head (former)
	Chuck Lawler, Water Resources Division Head (former)
	Travis Wheeler, Water Resources Specialist (former)
Ute Mountain Ute Tribe	Ute Mountain Ute Tribal Council
	Leland Begay, Associate General Counsel
	Peter Foster, Engineer
	Celene Hawkins, Associate General Counsel (former)
Jicarilla Apache Nation	Jicarilla Apache Nation Tribal Council
	Jicarilla Apache Nation Water Commission
	Darryl Vigil, Water Administrator
	Jenny Dumas, Attorney
Navajo Nation	Navajo Nation Council
	Jason John, Navajo Department of Water Resources
	Ray Benally, Director, Navajo Department of Water Resources
	Lisa Yellow Eagle, Attorney, Navajo Department of Justice
	Stanley Pollack, Assistant Attorney General, Navajo Department of Justice (former)
Fort Mojave Indian Tribe	Fort Mojave Indian Tribal Council
	Russell Ray, Land Use Planner
Chemehuevi Indian Tribe	Chemehuevi Indian Tribal Council
	Steven Escobar, Director, Environmental Program
Colorado River Indian Tribes	CRIT Tribal Council
	Margaret Vick, Special Counsel for Water
	Doug Bonamici, Law Clerk
	Marty Pretends Eagle, GIS Specialist
	Maria De Los Angeles Ingram, Water Resources Acting Director

TABLE 1.3-A
Study Team Members

	Rebecca Loudbear, Attorney General
	Grant Buma, Director, Water Resources Department (former)
Quechan Indian Tribe	Quechan Indian Tribal Council
	Jay Weiner, Attorney
	Mason Morisset, Attorney (former)
Cocopah Indian Tribe	Cocopah Indian Tribal Council
	W. Michael Smith, Attorney
Bureau of Reclamation	Pam Adams
	Alan Butler
	Carly Jerla
	KayLee Nelson
	James Prairie
	Jessica Khaya

2 Background on Federal Indian Reserved Water Rights

2.0 Introduction

This section presents a short description of the legal basis for and characteristics of Indian water rights, and the important differences between those rights and state law-based water rights. This background section includes the general principles of federal Indian water law and western prior appropriation law and is not intended to describe or affect any particular tribe's water rights.

2.1 The Origin of Federal Indian Reserved Water Rights

The seminal Indian reserved water rights case is *Winters v. United States*.[1] In *Winters*, the United States initiated a lawsuit to restrain settlers from constructing and maintaining water works to divert water from the Milk River which would prevent water from flowing to irrigate Indian lands on the Fort Belknap Indian Reservation in Montana. The Court found that the agreement creating the Fort Belknap Reservation sought to transition the Gros Ventre and Assiniboine Indians from a pastoral to an agrarian lifestyle, but that the reservation lands "were arid, and, without irrigation, were practically valueless."[2] Accordingly, the Court held that the establishment of the reservation impliedly reserved the amount of water necessary to irrigate its lands and to provide water for other purposes.[3] The Court also held that these reserved waters are exempted from appropriation under state law.[4] Federal Indian reserved water rights are often referred to as *Winters* rights.

As the trustee and holder of title to federal Indian reserved water rights, the United States has an obligation to protect Indian water rights and water resources for each beneficiary tribe.

2.2 Basic Characteristics of Federal Indian Reserved Water Rights

2.2.1 Priority Date: Date of Reservation or Time Immemorial

Federal Indian reserved water rights generally have one of two priority dates: date of reservation or time immemorial. Where the reserved rights are necessary to fulfill purposes created by the establishing document,[5] the priority date is the date of establishment of the reservation.[6] If, however, water is reserved so a tribe can continue its aboriginal uses, such water may have a time immemorial priority date.[7]

---

[1] 207 U.S. 564 (1908).

[2] *Id.* at 576.

[3] *Id.* at 576-77.

[4] *Id.*; *see also United States v. Rio Grande Dam & Irrigation Dist.*, 174 U.S. 690, 703 (1899) (holding that the states' power to create water rights is subject to two limitations: (1) a state cannot "destroy the right of the United States, as the owner of lands bordering on a stream, to the continued flow of the waters. . . ."; and (2) a state is limited by the federal navigation servitude).

[5] All reservations possess *Winters* rights whether established by treaty, statute, or executive order. *Arizona v. California,* 373 U.S. 546, 595-601 (1963) (*Arizona I*).

[6] *See Winters*; *Arizona I*.

[7] *See, e.g. United States v. Adair*, 723 F.2d 1394, 1412-15 (9th Cir. 1983), *Joint Board of Control v. United States*, 832 F.2d 1127, 1131-32 (9th Cir. 1987).

2.2.2 Quantification: The Amount Necessary to Fulfill the Reservation's Purposes

Federal Indian reserved water rights entitle tribes to the amount of water that is necessary to fulfill their reservation's purposes.[8] This includes a right to surface water and groundwater sources.[9] Various approaches are used to quantify federal Indian reserved water rights. In *Arizona v. California*, the United States Supreme Court established the "practicably irrigable acreage" (PIA) standard.[10] Under this standard, if land within a reservation can be cultivated through irrigation and if such irrigation is practicable applying relevant economic measures, then the tribe is entitled to the amount of water necessary for such irrigation. Another prominent measure for quantifying federal Indian reserved water rights is the "homeland" standard.[11] Under this standard, federal Indian reserved water rights are quantified based on the tribe's past, present, and future water needs, not just those needs tied to agriculture.[12] This can include water for a wide range of purposes, including hunting and fishing and commercial and other economic development purposes.[13] The Supreme Court rejected an "equitable apportionment" standard, used in some water cases, to allocate water between states, and adopted a "variable" standard of quantification based upon "reasonably foreseeable needs."[14]

2.3 Reserved Water Rights are Not Subject to State Law

Federal Indian reserved water rights are defined primarily by federal common law. Indian "[r]eserved water rights are 'federal water rights' and 'are not dependent upon state law or state procedures.'"[15] Although federal Indian reserved water rights are often adjudicated in state courts, state courts must apply federal law.[16]

These rights differ from state water rights in several respects. Water rights based on state law are largely fixed by the date and quantity of the landowner's initial use or appropriation of water. Laws of the western states (and the federal Reclamation laws) also require the "beneficial use" of

---

8 *In re the General Adjudication of All Rights to Use Water in the Gila River System and Source*, 201 Ariz. 307, 320, 35 P.3d 68, 81 (2001) ("*Gila V*") ("When an Indian reservation is created, the government impliedly reserves water to carry out its purpose as a permanent homeland. *See Winters*, 207 U.S. at 566-67, 577.").

9 *Agua Caliente Band v. Coachella Valley Water Dist.*, 849 F.3d 1262, 1271 (9th Cir. 2017), *cert. denied*, 138 S.Ct. 468 (2017) ("We hold that the Winters doctrine encompasses both surface water and groundwater appurtenant to reserved land."); *In re the General Adjudication of All Rights to Use Water in the Gila River System and Source,* 989 P.2d 739, 750 (Ariz. 1999) ("We have held that the federal reserved right extends to groundwater when groundwater is necessary to accomplish the purpose of a federal reservation."); COHEN'S HANDBOOK OF FEDERAL INDIAN LAW § 19.03[2][a] ("Reserved rights presumably attach to all water sources—groundwater, streams, lakes, and springs—that arise on, border, traverse, underlie, or are encompassed within Indian reservations."). The Supreme Court specifically held that "the United States can protect its water from subsequent diversion, whether the diversion is of surface or groundwater." *Cappaert v. United States*, 426 U.S. 128, 143 (1976).

10 *Arizona I*, 373 U.S. at 595-601.

11 See *Gila V*, 201 Ariz.at 318, 35 P.3d at 79 ("[W]e decline to approve the use of PIA as the exclusive quantification measure for determining water rights on Indian lands.").

12 *See id.* at 79-80 (identifying a multitude of factors to be considered in this analysis including history, culture, geography, natural resources, economic base, past water use, and present and projected future population).

13 *See id.* at 80 (". . . the court should look to a tribe's economic base in determining its water rights . . . [e]conomic development and its attendant water use must be tied, in some manner, to a tribe's current economic station.").

14 *Arizona I,* 373 U.S. at 597-601.

15 *Colville Confederated Tribes v. Walton* (*Walton III*), 752 F.2d 397, 400 (9th Cir. 1985) (quoting *Cappaert,* 426 U.S. at 145 and citing *Adair*, 723 F.2d at 1411 n. 19).

16 *Arizona v. San Carlos Apache Tribe*, 463 U.S. 545, 571 (1983) ("State courts, as much as federal courts, have a solemn obligation to follow federal law.")

water (for example, for mining, irrigation, domestic, municipal, industrial, power production, stock watering, wildlife preservation, and recreation) and typically require the water to be diverted from its source. Failure to use the water for a period of time could result in loss of the right under state forfeiture or abandonment laws.

Conversely, federal Indian reserved water rights are quantified based on what is needed to accomplish the reservation's purposes, including past, present, and future uses, not on initial or current use of water.[17] These rights may be used for any lawful purpose on the reservation.[18] Federal Indian reserved water rights also cannot be lost because of non-use under state-law concepts such as abandonment and forfeiture.[19]

2.4 The Colorado River Compact

The 1922 Colorado River Compact apportioned the Colorado River between the Upper and Lower Colorado River Basins. The extent to which the Compact affects the rights of the Tribes is unclear. The Compact recognized and protected present perfected rights in the Colorado River system declaring such rights as unimpaired by the Compact.[20] The priority dates of most of the water rights of the Tribes predate the Compact and should be considered "present perfected rights" as that term is used in the Compact. In addition, the Compact also provided that "[n]othing in this compact shall be construed as affecting the obligations of the United States of America to Indian tribes."[21]

[17] *Arizona I*, 373 U.S. at 598, 600-01, 605; *Colville Confederated Tribes v. Walton* (*Walton II*), 647 F.2d 42, 47 (9th Cir. 1981).

[18] *Arizona v. California* (*Arizona II*), 439 U.S. 419, 422 (1979); *Walton II*, 647 F.2d at 48-49; *but see In re General Adjudication of the Big Horn River System*, 835 P.2d 273, 278-80, 285 (Wyo. 1992) (plurality and concurring opinion held 3-2 that tribes cannot devote *Winters* water for agricultural purposes instream to support fish).

[19] *Winters*, 207 U.S. at 577; *Hackford v. Babbitt*, 14 F.3d 1457, 1461 n.3 (10th Cir. 1994); *Walton II*, 647 F.2d at 51. Only Congress can diminish Indian rights. *Minnesota v. Mille Lacs Band of Chippewa Indians*, 526 U.S. 172, 202-03 (1999); *United States v. Dion,* 476 U.S. 734, 738-40 (1986); *Washington v. Washington State Commercial Passenger Fishing Vessel Ass'n,* 443 U.S. 658, 690 (1979).

[20] Colorado River Compact, 1922, Nov. 24, 1922, Art. VIII.

[21] *Id*. at Art. VII.

3 The Tribes of the Ten Tribes Partnership

3.0 Introduction

The Colorado River Basin Tribes Partnership, also known as the Ten Tribes Partnership (Partnership), is an organization formed in 1992 by ten federally recognized tribes with federal Indian reserved water rights in the Basin. The member tribes, listed in order from north to south in the Basin, are: Ute Indian Tribe, Southern Ute Indian Tribe, Ute Mountain Ute Tribe, Jicarilla Apache Nation, Navajo Nation, Fort Mojave Indian Tribe, Chemehuevi Indian Tribe, Colorado River Indian Tribes, Quechan Indian Tribe, and Cocopah Indian Tribe.

Partnership Tribes have reserved water rights, including unresolved claims, to divert nearly 2.8 million acre-feet of water per year from the Colorado River and its tributaries. In the Upper Basin, Partnership Tribes have Federal Indian reserved diversion rights of 1,060,781 AFY and unresolved diversion claims of 762,345 AFY. In the Lower Basin, the Partnership Tribes have decreed diversion rights to Colorado River water of 952,190 AFY and unresolved diversion claims of 22,928 AFY. For additional detail, see Section 5.11 of *Chapter 5 – Assessment of Current Tribal Water Use and Projected Future Water Development.*

The ten tribes formed the Partnership for the purpose of strengthening tribal influence among the seven Basin States over the management and utilization of Colorado River water resources. Specifically, the Partnership supports Partnership Tribes in their efforts to develop and protect tribal water resources and to address technical, legal, economic, and practical issues related to the management and operation of the Colorado River. The Partnership joined the Colorado River Water Users Association in 1996 in an effort to more actively participate with the seven Basin States and the federal government with policy and management decisions for the Colorado River.

3.1 Overview of Partnership Tribes' Reserved Water Rights

The federal Indian reserved water rights for the five tribes with direct mainstream diversions below Hoover Dam were decreed in *Arizona v. California*. The five tribes are: the Fort Mojave Indian Tribe; the Chemehuevi Indian Tribe; the Colorado River Indian Tribes; the Quechan Indian Tribe; and the Cocopah Indian Tribe.[1] In that case, the Supreme Court found that the Secretary of the Interior had a statutory duty to respect the present perfected rights established prior to the date Congress passed the Boulder Canyon Project Act. The reserved water rights of these Tribes are included as present perfected rights and have priority based on the establishment date of each reservation and on subsequent dates of related boundary adjustments.[2]

---

[1] The Court first determined the federal Indian reserved rights of the five Lower Basin Tribes in *Arizona v California*, 373 U.S. 546 (1963) and quantified the rights in the first Decree, *Arizona v. California,* 376 U.S. 340 (1964). Subsequent decisions by the Supreme Court altered the original 1964 Decree. All rights are currently set forth in the 2006 Consolidated Decree, *Arizona v. California,* 574 U.S. 150 (2006).

[2] *Arizona v. California*, 373 U.S. 546, 600 (1963). *Arizona v. California,* 574 U.S. 150 (2006).

A portion of the Ute Indian Tribe's reserved water rights was decreed in 1923[3] with a senior priority date of 1861, based on the establishment date of the Uintah Valley Reservation, pursuant to *Winters v. United States*.[4] In 1965, the United States, the Central Utah Water Conservancy District, the State of Utah (by Joint Resolution of the Legislature), and the Ute Indian Tribe agreed to the quantification of the remainder of the Tribe's reserved water rights by contractual agreement. The state and federal governments are currently in negotiations with the Tribe to complete the Ute Indian Water Compact.

The reserved water rights for the four remaining Partnership Tribes have been determined to a certain extent through various settlements; however, not all Indian water rights claims have been resolved. The 1988 Colorado Ute Settlement Act, as amended by the 2000 Amendments and the Colorado state court consent decrees, quantified the water rights of the Southern Ute Indian Tribe and the Ute Mountain Ute Tribe in the state of Colorado. The 1992 Jicarilla Apache Tribe Water Rights Settlement Act represents a full and final settlement of the future use water rights claims of the Jicarilla Apache Nation to the water of the Colorado River. In 2009, Congress approved the Navajo Nation's settlement of its San Juan River federal Indian reserved water rights that was reached with the state of New Mexico and the United States. However, the Navajo Nation has not resolved its water rights claims in the states of Arizona and Utah, or outside of the San Juan River basin in New Mexico. The Ute Mountain Ute Tribe has not resolved its water rights claims in the states of New Mexico and Utah.

Detailed information regarding each Partnership Tribe's water rights is available in *Chapter 5 – Assessment of Current Tribal Water Use and Projected Future Water Development*.

3.2 Partnership Objectives

The Partnership's objectives are to ensure that, within the next decade:

(1) Each Partnership Tribe has settled or otherwise resolved its Indian reserved water rights claims;

(2) Each Partnership Tribe has the ability to maximize its on-reservation use of water and the flexibility to explore, facilitate and implement off-reservation use and transfers;

(3) Each Partnership Tribe benefits from water infrastructure projects promised or obtained through Congressional actions and/or settlements with state and federal governments and partners in a timely fashion; and

(4) The federal government firmly asserts and exercises its trust responsibility to protect the Partnership Tribes' reserved water rights in all its management actions related to the Colorado River.

[3] *United States v. Cedarview Irrigation Company et al.*, No. 4427 (D. Utah 1923), and *United States v. Dry Gulch Irrigation Company, et al.*, No. 4418 (D. Utah 1923).

[4] 207 U.S. 564 (1908).

4 Methodology for Assessing Current Tribal Water Use and Projected Future Water Development

4.0 Introduction

This chapter describes the methodology used to assess the Partnership Tribes' current water use and potential future water development. The current water use assessment includes the Partnership Tribes' water or unresolved claims; the amount, types and locations of current use; additional water supplies beyond Colorado River water; and major diversions or infrastructure that deliver water to the Tribes' reservations. The current water use assessment served as a foundation from which future water development was analyzed. Four scenarios for future tribal water development were created to provide a range of possible future outcomes. Each step of the methodology is explained in detail below.

> **Key Terms**
>
> Key terms used in this chapter are defined below.
>
> **Colorado River System** – The portion of the Colorado River and its tributaries within the United States.
>
> **Importance** – Being of great significance or value. Used to rate the importance of an influencing factor to tribal development and the use of water from the Colorado River and its tributaries relative to the remaining influencing factors.
>
> **Influencing factor** – Factors that will likely have the greatest influence on the future of tribal development and use of water from the Colorado River and its tributaries over time.
>
> **Key influencing factors** – The key driving forces that are identified as both highly uncertain and highly important.
>
> **Uncertainty** – Imperfect or unknown information. Used to rate the uncertainty of an influencing factor to tribal development and the use of water from the Colorado River and its tributaries relative to the remaining influencing factors.

4.1 Approach for Assessing Current Tribal Water Use

Each Partnership Tribe provided information on the current use and management of water on its reservation. This information included, as appropriate: water supplies; the amount, types and location of use; infrastructure components; operations, including efficiencies and conservation activities; and historical use and cultural importance of water. Because of the differences among the Partnership Tribes in the availability and quality of data, current water use was considered either as an average water use of five recent years or a single recent representative year. This methodology did not provide a lengthy historical record of tribal water use, but is a good snapshot of recent water use, by sector, for each Partnership Tribe and advances the understanding of tribal water use in the Basin.

The Partnership Tribes in the Upper Basin provided water supply and use information primarily at the tributary or sub-basin level, depending on the tribe's reserved water rights or unresolved claims. Water use data for some of the Upper Basin Partnership Tribes is sporadic and of low quality, which led the Navajo Nation to report a one-year "snapshot" of uses. The Southern Ute Indian Tribe used 2009 through 2013 data as a guide to provide updated current water use information. For Partnership Tribes in the Lower Basin, records of diversions, return flows, and consumptive use of water diverted from the mainstream of the Colorado River below Lee Ferry are compiled by Reclamation in the Colorado River Accounting and Water Use Reports: Arizona, California, and Nevada (Water Accounting Report) (Reclamation, 2017). The Water Accounting Reports for 2009 through 2013 were averaged and used for the Lower Basin Partnership Tribes, except for the Chemehuevi Indian Tribe, which averaged the years 2010 through 2013. Existing Reclamation data were supplemented with additional information provided by each of the tribes.

For purposes of the Tribal Water Study, water use was grouped into four categories:

- Domestic, Commercial, Municipal, and Industrial (DCMI);
- Irrigated Agriculture and Livestock (AG);
- Environmental, Cultural, and Recreational (ENV); and
- Transfers, Leases, and Exchanges (TRAN).

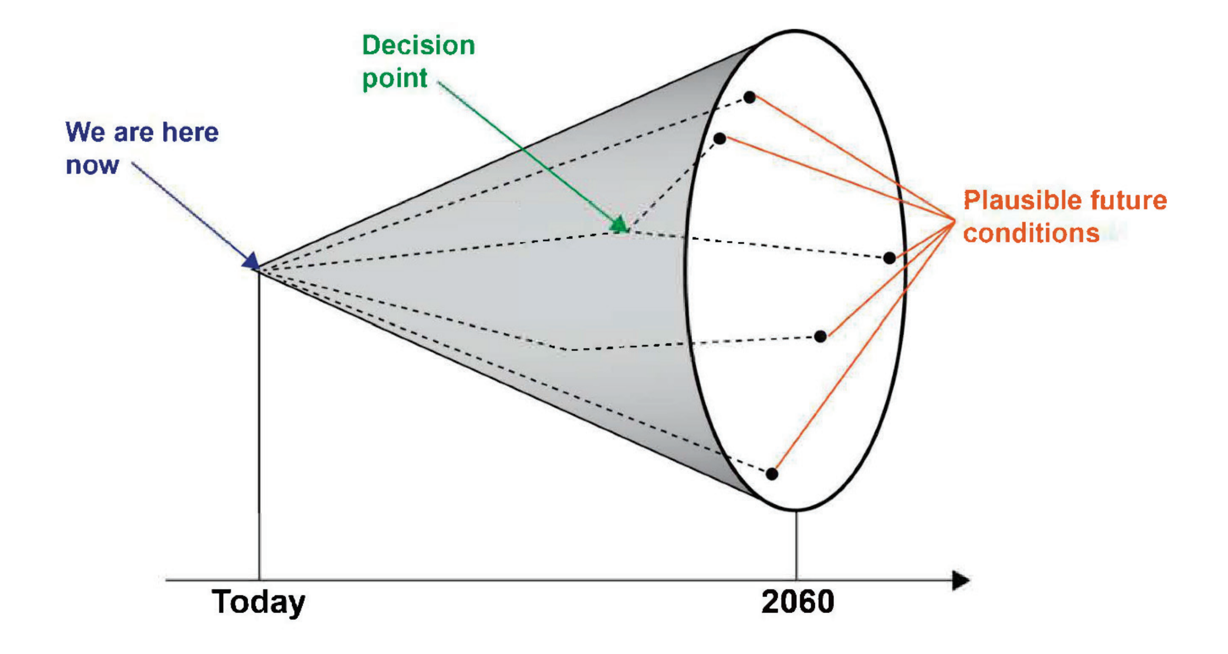
Each Partnership Tribe prepared a description of the water supply and use on its reservation, which is presented in *Chapter 5 – Assessment of Current Tribal Water Use and Projected Future Water Development.*

4.2 Approach for Assessing Future Tribal Water Development

There is an extensive understanding of the current hydrology of the Colorado River System and water use by tribal and other water users. However, there is much uncertainty related to future Basin conditions and no single estimate of a future that can account for the System's complexity or provide flexibility to address future challenges. By adopting a scenario planning approach, a broad range of plausible futures was evaluated using a manageable number of scenarios depicting alternative views of how the future might unfold. The scenarios are not predictions or forecasts of the future; rather they represent a range of plausible futures that assisted in assessing future risks when considering long-term planning options. Figure 4-A represents a range of plausible futures. Nevertheless, it is important to recognize that under federal law, Indian reserved water rights are perfected water rights and include the future use of those water rights in perpetuity. In reality, the Partnership Tribes' water use planning is not bound by an approach that considers water development up to a specific point in time.

The Basin Study (Reclamation, 2012) used a scenario planning approach to project future water demand in the Basin. However, feedback from Partnership Tribes during the Basin Study process highlighted the concern that the scenarios used in the Basin Study did not capture how the Partnership Tribes will fully develop and use their reserved water rights. The Partnership Tribes voiced concern that the factors that drive non-tribal demand, such as population growth, are not the same factors that influence tribal water development. A similar scenario planning approach, focused on tribal water development factors, was used in the Tribal Water Study to develop a range of how the Partnership Tribes may develop and use water through 2060. Throughout the scenario planning process, the Partnership Tribes were substantially involved in determining the factors that influence future tribal water development. The scenario planning process and its outcomes reflect the perspectives that the Partnership Tribes determined are critical to their future water development.

FIGURE 4-A
Conceptual Representation of the Uncertain Future of a System, also known as "The Scenario Funnel" (adapted from Timpe and Scheepers, 2003)

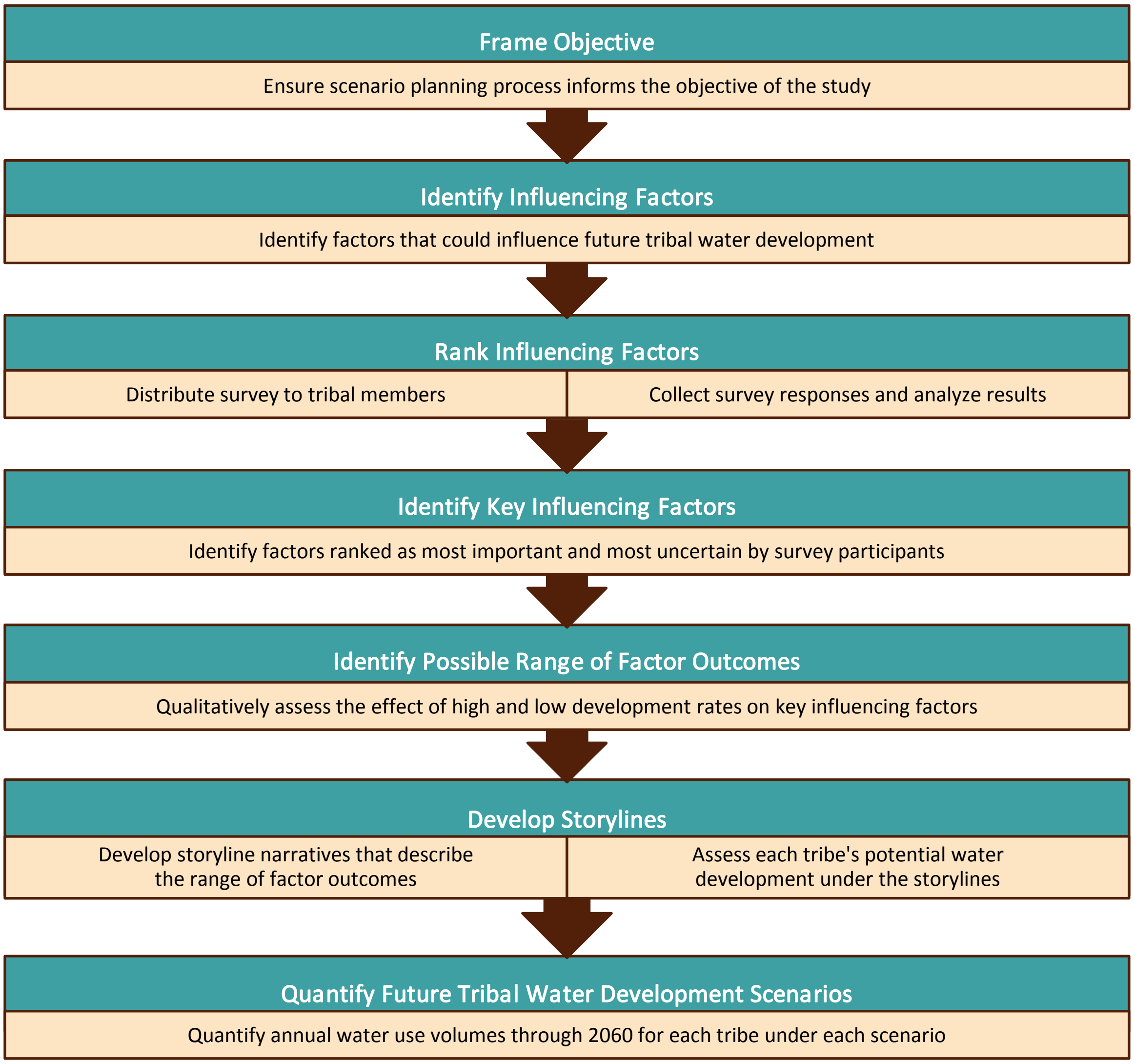


The scenario planning process is shown in Figure 4-B and described below. The process began by framing or identifying the objectives of the planning process. Influencing factors, or factors that drive the development of tribal water were then identified and ranked in terms of importance and uncertainty. The range of outcomes for the key factors was explored and woven into plausible storylines about future tribal water development. The final step in the process was to "quantify" the storylines to estimate how tribal water use may change according to each storyline. The following sections describe each of these steps and their outcomes in more detail.

4.2.1 Frame the Objectives

The Study Team reviewed the objectives of the Tribal Water Study to ensure that the scenario planning process would inform the Study. The specific objectives are outlined in the Plan of Study, which can be found in *Chapter 1 – Introduction, Appendix 1A – Plan of Study.* The Study Team also recalled these objectives when identifying the factors influencing tribal water development and throughout the scenario planning process.

FIGURE 4-B
Scenario Planning Process



4.2.2 Identify Influencing Factors to Tribal Water Development

The Study Team identified 28 factors that could influence future tribal water development, presented in Table 4-A. These factors were organized into six categories:

- Demographic;
- Land Use and Natural Systems;
- Infrastructure Development;
- Economic Development;
- Social; and
- Governance.

During factor identification, it was recognized that the infrastructure development factors are dependent on both tribal and federal financial resources. Consequently, these factors were subdivided to allow for the consideration of the source of funds.

TABLE 4-A
List of Factors Influencing Tribal Water Development

Demographic	
1	Changes in reservation populations and their distribution
2	Changes in non-Indian populations adjacent to reservations
Land Use and Natural Systems	
3	Changes in agricultural land use (*e.g.,* irrigated agricultural areas, crop mixes, etc.)
4	Changes in agricultural irrigation practices *Description: This factor could include changes in the irrigation of agricultural lands by the adoption of new methods or technologies to improve the efficiency of irrigation systems when using water.*
5	Changes in the needs of environmental resources that are dependent on water (*e.g.,* fish and aquatic wildlife, riparian habitat, etc.) including those related to Endangered Species Act (ESA)-listed species
6	Changes in water quality (including those that are physical, biological, and chemical in nature)
7	Changes in the resources and technology available to treat poor quality tribal water
8	Changes in patterns of use and/or water supply sources (*e.g.,* springs, groundwater, streams, etc.) due to drought and/or climate variability
Infrastructure Development	
9	Changes in tribal/federal financial resources available to expand tribal housing and related infrastructure *Description: This factor could include changes in tribal housing and related municipal and domestic water delivery infrastructure serving users such as tribal members, schools, community centers, parks, etc.*
	9a. Changes in tribal financial resources
	9b. Changes in federal financial resources
10	Changes in tribal/federal financial resources available to operate and maintain existing water delivery systems and storage for irrigation purposes (includes repairing, rehabilitating, and replacing agricultural and storage infrastructure) *Description: This factor could include influences such as the ability of the tribe to operate, maintain and improve on- and off-reservation irrigation and related water delivery systems, including storage facilities.*
	10a. Changes in tribal financial resources
	10b. Changes in federal financial resources
11	Changes in tribal/federal financial resources available to construct new water delivery systems and storage for irrigation purposes *Description: This factor could include influences such as the ability of the tribe to construct new on- and off-reservation irrigation and related water delivery systems, including storage facilities.*
	11a. Changes in tribal financial resources
	11b. Changes in federal financial resources
12	Changes in tribal/federal financial resources available to operate and maintain existing water delivery systems and storage for domestic and municipal purposes (includes repairing, rehabilitating, and replacing delivery, distribution, and storage infrastructure) *Description: This factor could include influences such as the ability of the tribe to operate, maintain and improve on- and off-reservation domestic and municipal delivery systems, including storage facilities.*
	12a. Changes in tribal financial resources
	12b. Changes in federal financial resources

TABLE 4-A
List of Factors Influencing Tribal Water Development

13	Changes in tribal/federal financial resources available to construct new water delivery systems and storage for domestic and municipal purposes *Description: This factor could include influences such as the ability of the tribe to construct new domestic and municipal delivery systems, including storage facilities.*
	13a. Changes in tribal financial resources
	13b. Changes in federal financial resources
Economic Development	
14	Changes in water needs for energy generation (*e.g.,* solar, oil shale, thermal, nuclear, hydroelectric, etc.)
15	Changes in water needs to support tribal economic development (*e.g.,* eco and cultural tourism, commercial and business centers, etc.)
16	Changes in the local and regional market “value” (*i.e.*, cost) of water (as it relates to different uses, such as the cost of generating energy, commodity prices, cost to pump, leasing, municipal use, etc.)
Social	
17	Changes in cultural and spiritual uses of tribal water
18	Changes in tribal values affecting water use *Description: This factor could include changes in tribal member priorities related to water use such as in-stream flows, recreation, domestic use, etc.*
Governance	
19	Changes in tribal water availability and use due to the resolution and settlement of tribal water rights claims *Description: This factor could include changes in the time it takes to complete Indian water settlements and in tribal member support for these settlements and water development plans.*
20	Changes in the laws, policies, and/or regulations to provide increased flexibility to tribes to use tribal water *Description: This factor could include changes to provide for increased use of water banking, water marketing, leasing, etc., and changes that further support and facilitate use of tribal water to support tribal economic development.*
21	Changes in federal, state, and/or regional water administration practices *Description: This factor could include changes in the accounting of tribal water in the Colorado River System, and tracking and ensuring deliveries during all hydrologic conditions, and changes in the ability to ensure water is delivered to a specific entity or location.*
22	Changes in tribal expertise and resources available for tribal water use planning *Description: This factor could include changes in tribal economic and other resources for tribal water resources planning and management, changes in Congressional appropriations to support water use development and planning, and changes in cooperative efforts with State and regional non-Indian water development planning.*
23	Changes in the understanding of tribal reserved water rights by federal, state, other governmental agencies and the public at large (*e.g.,* external education)

4.2.3 Rank Influencing Factors

The list of influencing factors was compiled and organized into a survey format, see *Appendix 4A – Influencing Factors Survey*. Study Team members facilitated the survey responses with their respective Partnership Tribe based upon tribal preferences. Respondents included Tribal Council members, tribal members, water and environmental resources staff, and tribal attorneys.

Survey respondents were asked to rank each factor in terms of relative importance and relative uncertainty, as described below:

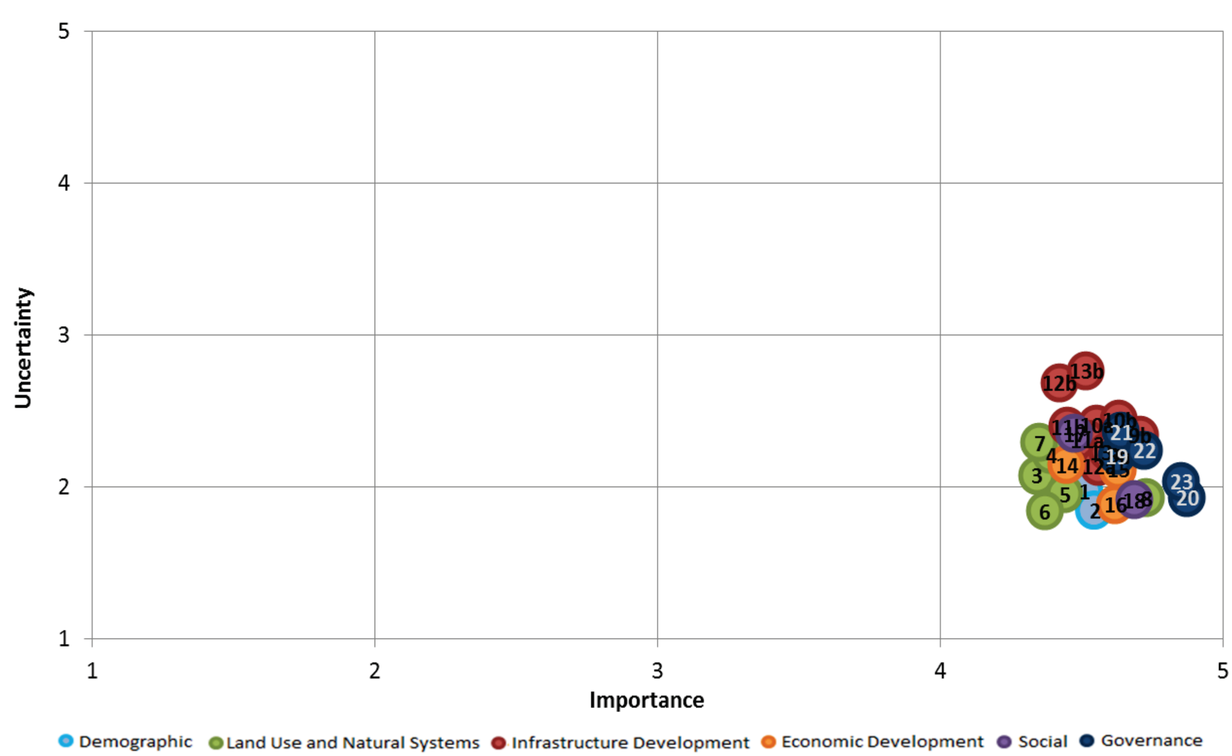
> **Importance** (1 through 5, with 5 being greatest importance): Rate how important the factor will be in influencing tribal development and use of water (from the Colorado River and its tributaries) through 2060.
>
> **Uncertainty** (1 through 5, with 5 being greatest uncertainty): Rate how certain you are regarding how that factor will change between now and 2060.

At least one survey was received from each Partnership Tribe for a total of 76 responses, 12 of which were incomplete and removed from the analysis. Multiple responses from a Partnership Tribe were averaged to produce a representative response from that Tribe. This process ensured that each Partnership Tribe received equal weight when analyzing the importance and uncertainty of the factors. The mean and standard deviation were computed for each influencing factor response. In general, all the factors ranked as important, while uncertainties ranked as moderate within a relatively narrow range. The Study Team discussed the clustered nature of the importance of the factors and concluded that the clustering reflects the process that was used to identify the list of factors. The Partnership Tribes recognized that every factor identified is inherently important when contemplating how tribal water will be developed in the future.

The survey results were averaged for the Lower Basin Partnership Tribes, the Upper Basin Partnership Tribes, and for all Partnership Tribes. The averages were plotted to illustrate the relative importance and relative uncertainty of the mean of each factor (see Table 4-A above for factor numbers). Influencing factors that plotted to the upper right of the graph were viewed to be highly important and highly uncertain, and those that plotted to the lower left were perceived to be of lesser importance and lower uncertainty. The influencing factors that plotted to the lower right were perceived to be of high importance, but with less uncertainty.

The averaged factor plots for the Upper Basin Partnership Tribes are presented in Figure 4-C. The factors clustered closely in the highly important, moderately uncertain range. Nonetheless, the governance factor related to future flexibility in laws, policies, and regulations (No. 20) and the factor related to the understanding of Indian reserved water rights by others plotted as the most important (No. 23). The infrastructure factors related to federal financial resources available to operate and maintain existing domestic and municipal infrastructure, as well as build new infrastructure, ranked as the most uncertain factors (Nos. 12b and 13b).

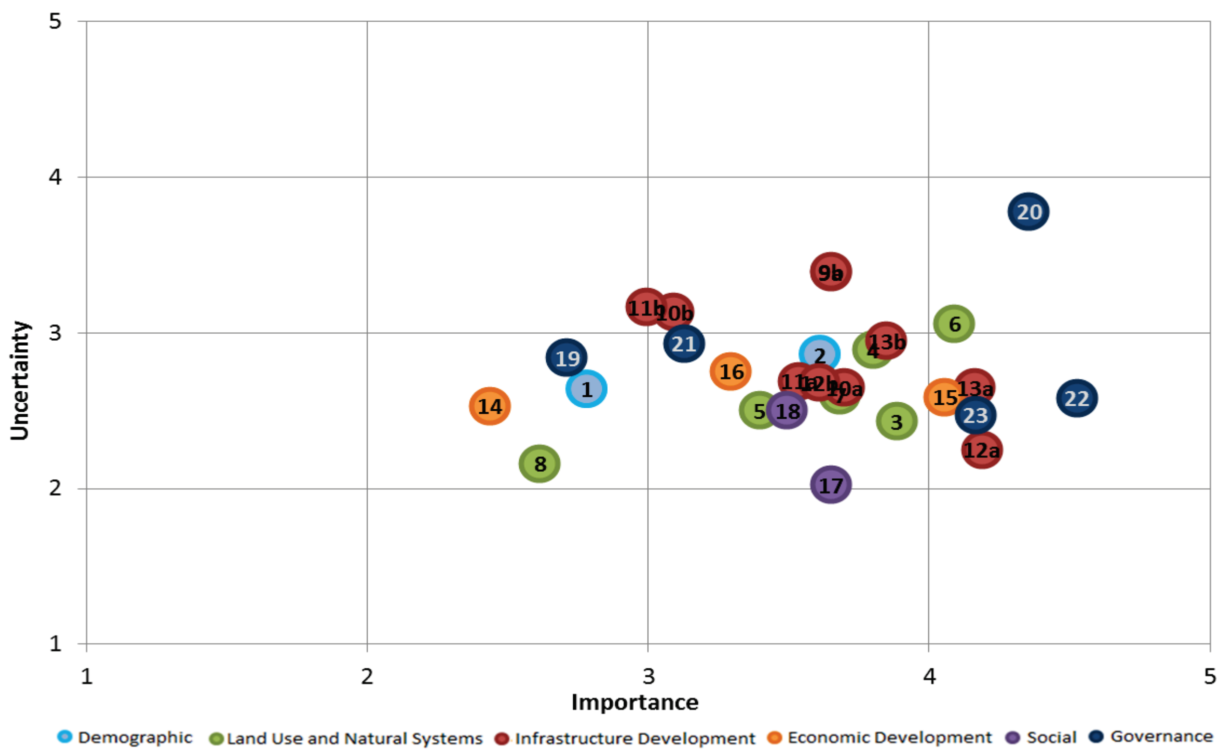
FIGURE 4-C
Influencing Factor Survey Results, Upper Basin Partnership Tribes[1, 2]



[1] Ute Indian Tribe, Southern Ute Indian Tribe, Ute Mountain Ute Tribe, Jicarilla Apache Nation, and Navajo Nation.
[2] Each point corresponds with one of the influencing factor categories as indicated by the color of the point.

The factor survey results presented a wider range of importance and uncertainty for the Lower Basin Partnership Tribes (Figure 4-D); however, as in the Upper Basin, factors related to governance were most important (Nos. 20, 22, and 23), and those related to the availability of federal financial resources for infrastructure were most uncertain (Nos. 9b, 10b, and 11b).

FIGURE 4-D
Influencing Factor Survey Results, Lower Basin Partnership Tribes[1, 2]



[1] Fort Mojave Indian Tribe, Chemehuevi Indian Tribe, Colorado River Indian Tribes, Quechan Indian Tribe, and Cocopah Indian Tribe.

[2] Each point corresponds with one of the influencing factor categories, indicated by the color of the point.

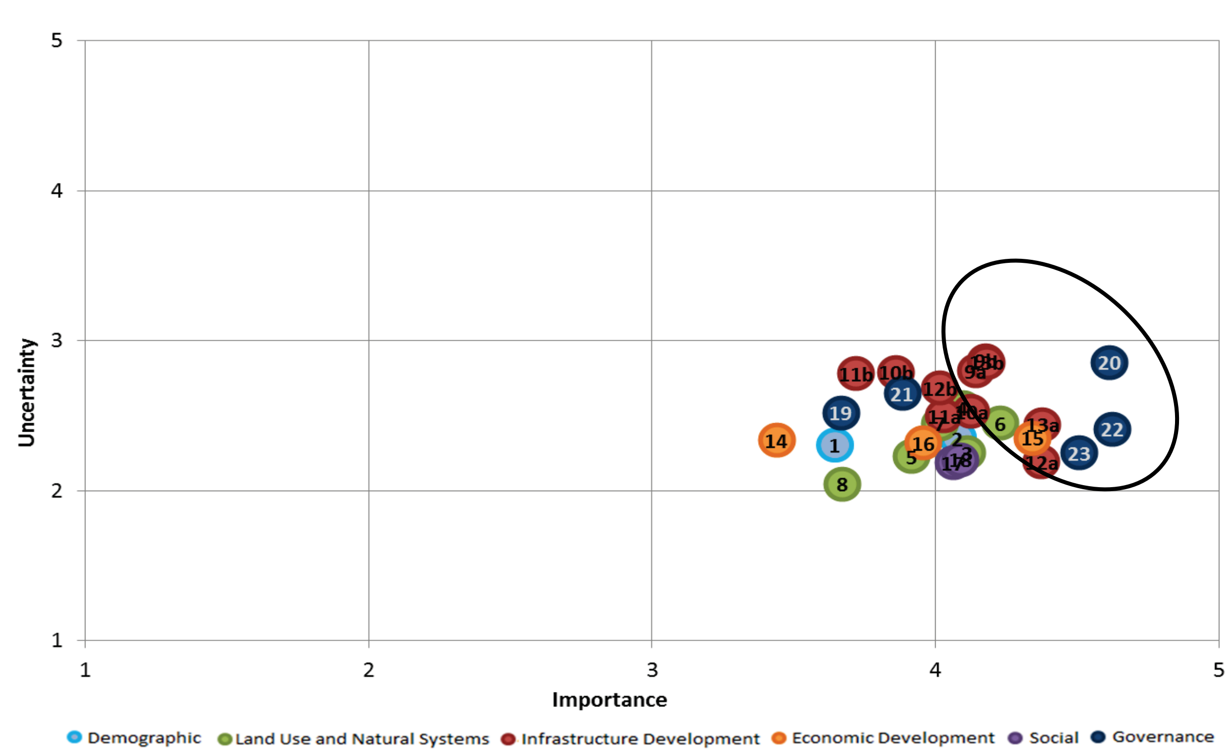
The commonalities between the Partnership Tribes' rankings in the Upper Basin and Lower Basin relate to governance factors (No. 20-23) and the availability of federal financial resources for infrastructure (No. 9-13). There were understandable differences in the key factors that influence tribal water development based on reservation geography and the status of infrastructure systems including:

- The Upper Basin Partnership Tribes consider irrigation infrastructure to be more important than domestic and municipal infrastructure; the Lower Basin Tribes consider the opposite.
- The Upper Basin Partnership Tribes consider federal funding for infrastructure to be more important than tribal financial resources; the Lower Basin Tribes consider the opposite.
- The Lower Basin Partnership Tribes consider non-tribal population growth adjacent to reservations more important than on-reservation population growth; the Upper Basin Tribes consider both to be equally important.
- The Upper Basin Partnership Tribes consider changes in patterns of use due to drought and/or climate variability more important than do the Lower Basin Tribes.

4.2.4 Identify Key Influencing Factors

The Tribal Water Study's key influencing factors were those the survey participants considered most important and most uncertain. The averaged factor results for all Partnership Tribes were plotted (Figure 4-E) with those ranked as more important and more uncertain (located towards the upper right portion of the graph) selected as key influencing factors. These are represented within the black oval. For other factors that appeared to have similar relative rankings, the Study Team used its judgment and expertise to determine whether the factor should be considered as a key influencing factor. The key influencing factors selected for the Study are listed in Table 4-B.

FIGURE 4-E
Influencing Factor Survey Results, All Partnership Tribes[1, 2]



[1] Ute Indian Tribe, Southern Ute Indian Tribe, Ute Mountain Ute Tribe, Jicarilla Apache Nation and Navajo Nation Fort Mojave Indian Tribe, Chemehuevi Indian Tribe, Colorado River Indian Tribes, Quechan Indian Tribe, and Cocopah Indian Tribe.

[2] Each point corresponds with one of the influencing factor categories, indicated by the color of the point.

TABLE 4-B
Key Factors Influencing Future Tribal Water Development

Demographic	
Changes in non-Indian populations adjacent to reservations [Factor No. 2]	
Land Use and Natural Systems	
Changes in agricultural irrigation practices [Factor No. 4]	
Changes in water quality (including those that are physical, biological, and chemical in nature) [No. 6]	
Infrastructure Development	
Changes in tribal/federal financial resources available to expand tribal housing and related infrastructure [Factor No. 9]	
	9a. Changes in tribal financial resources
	9b. Changes in federal financial resources
Changes in tribal/federal financial resources available to operate and maintain existing water delivery systems and storage for irrigation purposes (includes repairing, rehabilitating, and replacing agricultural and storage infrastructure) [Factor No. 10]	
	10a. Changes in tribal financial resources
	10b. Changes in federal financial resources
Changes in tribal/federal financial resources available to construct new water delivery systems and storage for irrigation purposes [Factor No. 11]	
	11a. Changes in tribal financial resources
	11b. Changes in federal financial resources
Changes in tribal/federal financial resources available to operate and maintain existing water delivery systems and storage for domestic and municipal purposes (includes repairing, rehabilitating, and replacing delivery, distribution, and storage infrastructure) [Factor No.12]	
	12a. Changes in tribal financial resources
Changes in tribal/federal financial resources available to construct new water delivery systems and storage for domestic and municipal purposes [Factor No. 13]	
	13a. Changes in tribal financial resources
	13b. Changes in federal financial resources
Economic Development	
Changes in water needs to support tribal economic development (*e.g.*, eco and cultural tourism, commercial and business centers, etc.) [Factor No. 15]	
Governance	
Changes in tribal water availability and use due to the resolution and settlement of tribal water rights claims [Factor No. 19]	
Changes in the laws, policies, and/or regulations to provide increased flexibility to tribes to use tribal water [Factor No. 20]	
Changes in federal, state, and/or regional water administration practices [Factor No. 21]	
Changes in tribal expertise and resources available for tribal water use planning [Factor No. 22]	
Changes in the understanding of tribal reserved water rights by federal, state, other governmental agencies and the public at large (*e.g.*, external education) [Factor No. 23]	

4.2.5 Identify Possible Range of Key Influencing Factor Outcomes

The Study Team considered a potential future range for each key influencing factor. Using current societal and governance trends, the Study Team discussed how tribal water development could unfold if these trends continue through 2060. For example, the current trend for one factor considers changes in agricultural irrigation practices (Factor No. 4) by accounting for the time it takes tribes to adopt new irrigation methods or technologies which may improve efficiencies. The Study Team also qualitatively assessed each key influencing factor to determine a fast (high) and slow (low) water development rate above and below the current trend. This effort provided a full range of potential future outcomes for each key influencing factor, see *Appendix 4B – Potential Ranges of Key Influencing Factor Outcomes.*

4.2.6 Develop Storylines

The Study Team developed storylines that capture the range of potential future water development for four scenarios. The storylines provide a narrative description of the effect on the key influencing factors under the scenario. The scenarios and associated themes are listed below, and the storylines are presented in *Appendix 4C – Tribal Water Development Scenario Storylines*.

- **Current Water Development Trends (Scenario A):** Current trends in on-reservation water development, governance, funding, and resolution of tribal claims remain the same.
- **Slow Water Development Trends (Scenario B):** Decreased flexibility in governance of tribal water, decreased levels of funding, and slower resolution of tribal claims all slow tribal economic development. This results in a decline in the standard of living and delays resolution of tribal claims.
- **Rapid Water Development Trends (Scenarios C1 and C2):** Increased flexibility in governance of tribal water allows innovative water development opportunities and increased funding availability leads to tribal economic development. This results in an increase in the standard of living, thereby contributing to the fulfilment of the purpose of the reservation as a homeland and supporting the future needs of tribal communities. Scenario C1 considers partial resolution of claims and/or implementation of decreed or settled rights; and Scenario C2 considers complete resolution of claims and implementation of decreed or settled rights.

4.2.7 Quantify Future Tribal Water Development Scenarios

Each Partnership Tribe considered its reservation's water development through 2060 by reviewing its current water use and reflecting upon how it might change under the four scenarios. Through extensive communications with Reclamation, each Partnership Tribe prepared future water development schedules associated with the scenarios. During this effort, the Partnership Tribes were asked to consider such elements as the conditions described in the storyline narratives, current or future planned projects, anticipated changes in sector water use, and existing or new infrastructure needed to support water development on their reservations.

Each Partnership Tribe assessed future water development if current trends (Scenario A) continued through 2060. Because of complexities with reserved water rights and unresolved claims, the Upper Basin Partnership Tribes generally assessed their future development at the tributary or sub-basin level, while the Lower Basin Partnership Tribes did so at a state level.[1]

Working from the Current Water Development Trends (Scenario A) schedule, each Partnership Tribe prepared schedules to reflect how the other scenario storylines (Scenarios B, C1, and C2) could affect future water development. The future water development schedules were then modeled using Colorado River Simulation System (CRSS) to assess changes to the Colorado River System. The quantified future water development schedules and the supporting considerations are tribe-specific and documented for each Partnership Tribe in *Chapter 5 – Assessment of Current Tribal Water Use and Projected Future Water Development*.

[1] For additional information, see *Chapter 5 – Assessment of Current Tribal Water Use and Projected Future Water Development.*

Appendix 4A
Influencing Factors Survey

Appendix 4A – Influencing Factors Survey

Colorado River Basin Ten Tribes Partnership Tribal Water Study Influencing Factors Survey

(Finalized January 2016)

Instructions and Guidance for Completing the Influencing Factors Survey

As part of the Colorado River Basin Ten Tribes Partnership Tribal Water Study (Study), the Study Team (the Bureau of Reclamation and the Ten Tribes Partnership) is undertaking a planning process to develop scenarios regarding how the tribes of the Ten Tribes Partnership may develop and use their water over the next approximately 50 years. Important steps in this process are to identify the key factors that are likely to impact how such development and use will occur (called "influencing factors"), and then to survey tribal representatives to identify those influencing factors that are both highly important and highly uncertain (known as "critical uncertainties"). These critical uncertainties will form the basis for the Study's tribal water development and use scenarios.

The Study is being conducted by both Reclamation and the Ten Tribes Partnership, and the list of influencing factors in the attached survey was jointly developed. The purpose of the survey is to receive input from tribal representatives on the relative "importance" (how important the factor will be in influencing future tribal development and use) and "uncertainty" (how certain the changes in the factor are over time) of each of the influencing factors through 2060. This input will be used to identify which influencing factors are critical uncertainties. Additionally, this input will help inform subsequent phases of the Study where issues related to future use and/or development of tribal water will be discussed.

The purpose of the Study is to identify, for the tribes of the Ten Tribes Partnership, tribal water supplies, document current tribal water use on Partnership reservations, project future water development on Partnership reservations, document use of unused tribal water by others, and identify tribal opportunities and challenges associated with the development of tribal water, considering the future projected water supply and demand imbalances documented in the Colorado River Basin Study. Specific objectives of the Study that will be addressed through the scenario planning process include:

- Characterize a range of future tribal water development and use for each of the tribes in the Partnership
- Identify potential future impacts to specific users, or groups of users, presently relying on unused tribal water
- Identify tribal water development challenges both specific to the tribes in the Partnership and in general Basin-wide

Survey Format

The survey includes a list of factors that influence how tribal water will be developed and used in the future. Each respondent is requested to independently rate (using a scale of 1 through 5, with 5 being the highest) the relative "importance" and "uncertainty" associated with each factor with respect to the objectives of the Study being addressed through the scenario planning process:

> **Importance** (1 through 5): Rate how important the factor will be in influencing tribal development and use of its water (from the Colorado River and its tributaries) through 2060.
>
> **Uncertainty** (1 through 5): Rate how certain you are regarding how that factor will change between now and 2060.

Respondents are encouraged to provide comments related to each response. These comments will help the Study Team better analyze the input received, particularly for high and low ratings.

Guidance for Completing the Survey

The list of influencing factors is intended to be relatively broad to capture the large-scale mechanisms that influence how tribal water will be developed and used in the future. Not every variation of influencing factors is necessary at this point, as details of the critical uncertainties will be explored in the next steps of the scenario planning process. However, please provide any comments you have that may help us better understand your views regarding a particular influencing factor. Some additional guidance may be helpful in the completion of the survey:

1. Relate all ratings to the relevant Study objectives:
    a. Characterize a range of future tribal water development and use for each of the tribes in the Partnership
    b. Identify potential future impacts to specific users, or groups of users, presently relying on unused tribal water
    c. Identify tribal water development challenges both specific to the tribes in the Partnership and in general Basin-wide
2. Consider the current impact of the influencing factors on tribal water development and use in addition to evolving trends and the range of effects of the factors through 2060
    a. How important is the influencing factor on development and use today? What are the current trends in these factors? Are the future trends likely to following the same trajectory? What is the magnitude of these influences? How may future changes in a factor impact development and use?
3. Keep your ratings of importance and uncertainty separate
    a. Importance is a relative measure of the magnitude of impact of the influencing factor on Tribal water development and use.
    b. Uncertainty is a relative measure of how certain you are regarding how the factor will change between now and 2060.
4. Keep in mind that the survey is a relative comparison of the listed influencing factors
    a. You may wish to make two or more passes through the survey—the first to gauge an initial response and baseline and subsequent passes to compare and identify the <u>relative</u> rating of all influencing factors.

Influencing Factors Survey
Importance and Uncertainty of Factors Influencing Tribal Water Development and Use

Please return completed survey by January 29, 2016

Name (optional):		**Title (optional):**	
Tribe (optional):			
Importance (1–5): Rate how important the factor will be in influencing tribal development and use of water from the Colorado River and its tributaries through 2060. 1=Unimportant, 3=Important, 5=Very Important			
Uncertainty (1–5): Rate how certain you are regarding how that factor will change between now and 2060. 1=Certain, 3=Uncertain, 5=Very Uncertain			
Enter "NA" if you are unfamiliar with the influencing factor (Note: will not be included in final rating)			

No.	**Influencing Factors**	**Importance**	**Uncertainty**	**Comment**
Demographic				
1.	Changes in reservation populations and their distribution			
2.	Changes in non-Indian populations adjacent to reservations			
Land Use and Natural Systems				
3.	Changes in agricultural land use (e.g. irrigated agricultural areas, crop mixes, etc.)			
4.	Changes in agricultural irrigation practices *Description: This factor could include changes in the irrigation of agricultural lands by the adoption of new methods or technologies to improve the efficiency of irrigation systems when using water.*			
5.	Changes in the needs of environmental resources that are dependent on water (e.g. fish and aquatic wildlife, riparian habitat, etc.) including those related to Endangered Species Act (ESA)-listed species			
6.	Changes in water quality (including those that are physical, biological, and chemical in nature)			

Influencing Factors Survey
Importance and Uncertainty of Factors Influencing Tribal Water Development and Use

Please return completed survey by January 29, 2016

No.	Influencing Factors	Importance	Uncertainty	Comment
7.	Changes in the resources and technology available to treat poor quality tribal water			
8.	Changes in patterns of use and/or water supply sources (e.g. springs, groundwater, streams, etc.) due to drought and/or climate variability			
Infrastructure Development				
9.	Changes in tribal/federal financial resources available to expand Tribal housing and related infrastructure *Description: This factor could include changes in Tribal housing and related municipal and domestic water delivery infrastructure serving users such as tribal members, schools, community centers, parks, etc.*			
	9a. Changes in tribal financial resources			
	9b. Changes in federal financial resources			
10.	Changes in tribal/federal financial resources available to **operate and maintain existing** water delivery systems and storage for **irrigation purposes** (includes repairing, rehabilitating, and replacing agricultural and storage infrastructure) *Description: This factor could include influences such as the ability of the tribe to operate, maintain and improve on-and off reservation irrigation and related water delivery systems, including storage facilities.*			
	10a. Changes in tribal financial resources			
	10b. Changes in federal financial resources			
11.	Changes in tribal/federal financial resources available to **construct new** water delivery systems and storage for **irrigation purposes** *Description: This factor could include influences such as the ability of the tribe to construct new on-and off reservation irrigation and related water delivery systems, including storage facilities.*			
	11a. Changes in tribal financial resources			
	11b. Changes in federal financial resources			

Influencing Factors Survey
Importance and Uncertainty of Factors Influencing Tribal Water Development and Use

Please return completed survey by January 29, 2016

No.	Influencing Factors	Importance	Uncertainty	Comment
12.	Changes in tribal/federal financial resources available to **operate and maintain existing** water delivery systems and storage for **domestic and municipal purposes** (includes repairing, rehabilitating, and replacing delivery, distribution, and storage infrastructure) *Description: This factor could include influences such as the ability of the tribe to operate, maintain and improve on-and off reservation domestic and municipal delivery systems, including storage facilities.*			
	12a. Changes in tribal financial resources			
	12b. Changes in federal financial resources			
13.	Changes in tribal/federal financial resources available to **construct new** water delivery systems and storage for **domestic and municipal purposes** *Description: This factor could include influences such as the ability of the tribe to construct new domestic and municipal delivery systems, including storage facilities.*			
	13a. Changes in tribal financial resources			
	13b. Changes in federal financial resources			
Economic Development				
14.	Changes in water needs for energy generation (e.g. solar, oil shale, thermal, nuclear, hydroelectric, etc.)			
15.	Changes in water needs to support tribal economic development (e.g. eco and cultural tourism, commercial and business centers, etc.)			
16.	Changes in the local and regional market "value" (i.e., cost) of water (as it relates to different uses, such as the cost of generating energy, commodity prices, cost to pump, leasing, municipal use, etc.)			
Social				
17.	Changes in cultural and spiritual uses of tribal water			
18.	Changes in tribal values affecting water use *Description: This factor could include changes in tribal member priorities related to water use such as in-stream flows, recreation, domestic use, etc.*			

Influencing Factors Survey
Importance and Uncertainty of Factors Influencing Tribal Water Development and Use

Please return completed survey by January 29, 2016

No.	Influencing Factors	Importance	Uncertainty	Comment
Governance				
19.	Changes in tribal water availability and use due to the resolution and settlement of tribal water rights claims *Description: This factor could include changes in the time it takes to complete Indian water settlements and in tribal member support for these settlements and water development plans.*			
20.	Changes in the laws, policies, and/or regulations to provide increased flexibility to tribes to use tribal water *Description: This factor could include changes to provide for increased use of water banking, water marketing, leasing, etc. and changes that further support and facilitate use of tribal water to support tribal economic development.*			
21.	Changes in federal, state, and/or regional water administration practices *Description: This factor could include changes in the accounting of tribal water in the Colorado River system, and tracking and ensuring deliveries during all hydrologic conditions, and changes in the ability to ensure water is delivered to a specific entity or location.*			
22.	Changes in tribal expertise and resources available for tribal water use planning *Description: This factor could include changes in tribal economic and other resources for tribal water resources planning and management, changes in Congressional appropriations to support water use development and planning, and changes in cooperative efforts with State and regional non-Indian water development planning.*			
23.	Changes in the understanding of tribal reserved water rights by Federal, State, other governmental agencies and the public at large (e.g. external education)			

Appendix 4B
Potential Ranges of
Key Influencing Factor Outcomes

Appendix 4B – Potential Ranges of Key Influencing Factor Outcomes

(Finalized June 2016)

A full range of potential future outcomes for each key influencing factor is presented in Table 4B-A.

TABLE 4B-A
Key Factors Influencing Future Tribal Water Development

Influencing Factor Categories	TWS Critical Uncertainties Identified in Survey	Affected Water Use Category[1]	Description of Influencing Factors if Current Trends Continues	Plausible Low End of Range	Plausible High End of Range
Demographic	Changes in non-Indian populations adjacent to reservations [2]	AG: No DCMI: Yes (Lower Basin focus) ENV: Yes (Lower Basin focus) TRAN: No	DCMI: Steady growth along river corridors and gradual increase in demands for tribal water.	DCMI: No or slow growth in off-reservation population would leave demand steady.	DCMI: Rapid growth increasing demand, contamination, and environmental impact.
Land Use and Natural Systems	Changes in agricultural irrigation practices [4] *Description: This factor could include changes in the irrigation of agricultural lands by the adoption of new methods or technologies to improve the efficiency of irrigation systems when using water.*	AG: Yes (Lower Basin focus) DCMI: No ENV: Yes (Lower Basin focus) TRAN: Yes (Lower Basin focus)	AG: Current trend is for slow adoption of new irrigation methods or technologies, which may improve efficiencies.	AG: No change in AG irrigation practices.	AG: Aggressive adoption of more efficient methods or technologies leading to increased productivity and potentially making water available for additional uses.
	Changes in water quality (including those that are physical, biological, and chemical in nature) [6]	All	Slow deterioration of water quality throughout the Basin from contamination leading to more regulation of drinking water and increasing treatment costs and impacts to ecosystems.	Rapid deterioration of water quality throughout the Basin from concentrated contamination leading to more regulation of drinking water and increasing treatment costs and impacts to ecosystems.	Improved water quality throughout the Basin possibly increasing efficiencies and reducing treatment costs and impacts to ecosystems.

[1] AG – Irrigated Agriculture and Livestock; DCMI – Domestic, Commercial, Municipal, and Industrial; ENV – Environmental, Cultural, and Recreational; TRAN – Transfers, Leases, and Exchanges

TABLE 4B-A
Key Factors Influencing Future Tribal Water Development

Influencing Factor Categories	TWS Critical Uncertainties Identified in Survey	Affected Water Use Category[1]	Description of Influencing Factors if Current Trends Continues	Plausible Low End of Range	Plausible High End of Range
Infrastructure Development	Changes in tribal financial resources available to expand Tribal housing and related infrastructure [9a] *Description: This factor could include changes in Tribal housing and related municipal and domestic water delivery infrastructure serving users such as tribal members, schools, community centers, parks, etc.*	AG: No DCMI: Yes ENV: No TRAN: No	DCMI: Tribes maintain current funding levels. Tribes maintain current tribal housing trends – development of tribal homelands increases gradually over time.	DCMI: Tribal funding stops. Development of tribal homelands decreases over time leading to an increase in multi-family housing and/or more families moving off reservation for housing.	DCMI: Tribal funding increases. More housing projects funded. Rate of tribal water development increases as tribal homelands develop to provide more tribal housing and allowing an increased standard of living and higher per capita water use.
	Changes in federal financial resources available to expand Tribal housing and related infrastructure [9b] *Description: This factor could include changes in Tribal housing and related municipal and domestic water delivery infrastructure serving users such as tribal members, schools, community centers, parks, etc.*	AG: No DCMI: Yes ENV: No TRAN: No	DCMI: Federal financial resources continue to decline. Development of tribal homelands continues to decline and families move off reservation for housing.	DCMI: Federal funding stops. Development of tribal homelands declines at a faster rate leading to an increase in multi-family housing and/or more families moving off reservation for housing.	DCMI: Increase in federal funds. More housing projects funded. Rate of tribal water development increases as tribal homelands develop to provide more tribal housing and allowing an increased standard of living and higher per capita water use.
	Changes in tribal financial resources available to operate and maintain existing water delivery systems and storage for irrigation purposes (includes repairing, rehabilitation, and replacing agricultural and storage infrastructure) [10a] *Description: This factor could include influences such as the ability of the tribe to operate, maintain and improve on- and off-reservation irrigation and related water delivery systems, including storage facilities.*	AG: Yes DCMI: No ENV: No TRAN: No	AG: Tribes maintain current funding levels for OMR. Tribes maintain current water use trends.	AG: Tribal funding decreases. Efficiencies and productivity decrease as systems decline.	AG: Tribal funding increases leading to increased efficiencies and productivity.

TABLE 4B-A
Key Factors Influencing Future Tribal Water Development

Influencing Factor Categories	TWS Critical Uncertainties Identified in Survey	Affected Water Use Category[1]	Description of Influencing Factors if Current Trends Continues	Plausible Low End of Range	Plausible High End of Range
Infrastructure Development	Changes in federal financial resources available to operate and maintain existing water delivery systems and storage for irrigation purposes (includes repairing, rehabilitating, and replacing agricultural and storage infrastructure) [10b] *Description: This factor could include influences such as the ability of the tribe to operate, maintain and improve on-and off reservation irrigation and related water delivery systems, including storage facilities.*	AG: Yes DCMI: No ENV: No TRAN: No	AG: Federal funding levels continue to decline leading to a gradual deterioration of irrigation systems and efficiency.	AG: Federal funding stops leading to a deterioration of irrigation systems and a decrease in efficiency of water use leading to a potential decline in crop production.	AG: Federal funding increases and irrigation systems become more efficient leading to improved crop production.
	Changes in tribal financial resources available to construct new water delivery systems and storage for irrigation purposes [11a] *Description: This factor could include influences such as the ability of the tribe to construct new on- and off-reservation irrigation and related water delivery systems including storage facilities*	AG: Yes DCMI: No ENV: No TRAN: No	AG: Tribes maintain current funding levels for new construction. Tribes maintain current water use trends.	AG: Tribal funding decreases or remains at $0. New construction activities remain stagnant or decline.	AG: Tribal funding increases leading to an increase in new construction activities, increase water use and crop production.
	Changes in federal financial resources available to construct new water delivery systems and storage for irrigation purposes [11b] *Description: This factor could include influences such as the ability of the tribe to construct new on- and off-reservation irrigation and related water delivery systems including storage facilities*	AG: Yes DCMI: No ENV: No TRAN: No	AG: Federal funding levels continue to decline leading to stagnant development.	AG: Federal funding stops leading to no new development.	AG: Federal funding levels increase leading to an increase in new construction activities, increase water use and crop production leading to robust development.

TABLE 4B-A
Key Factors Influencing Future Tribal Water Development

Influencing Factor Categories	TWS Critical Uncertainties Identified in Survey	Affected Water Use Category[1]	Description of Influencing Factors if Current Trends Continues	Plausible Low End of Range	Plausible High End of Range
Infrastructure Development	Changes in tribal financial resources available to operate and maintain existing water delivery systems and storage for domestic and municipal purposes (includes repairing, rehabilitating, and replacing delivery, distribution, and storage infrastructure) [12a] *Description: This factor could include influences such as the ability of the tribe to operate, maintain and improve on-and off reservation domestic and municipal delivery systems, including storage facilities.*	AG: No DCMI: Yes ENV: No TRAN: No	DCMI: Tribes maintain current funding levels. Current tribal water development trends maintained.	DCMI: Tribes' funding decreases or remains at $0. Deliveries decrease over time as systems deteriorate, emergency situations increase, reliance on private wells increases and per capita water use decreases.	DCMI: Tribes' funding increases. Deliveries increase and systems improve over time leading to higher per capita water use.
	Changes in tribal financial resources available to construct new water delivery systems and storage for domestic and municipal purposes [13a] *Description: This factor could include influences such as the ability of the tribe to construct new domestic and municipal delivery systems, including storage facilities.*	AG: No DCMI: Yes (Upper Basin focus) ENV: No TRAN: No	DCMI: Tribes maintain current funding levels. Current rate of tribal infrastructure projects and water development maintained.	DCMI: Reduction in tribal financial resources or remain at $0; unable to fund water infrastructure projects. Reduced availability to safe and accessible water leading to decreased per capita water use, decreased standard of living, slower economic growth, and increased poverty.	DCMI: Increase in tribal financial resources; more water infrastructure projects funded. Rate of tribal water development increases leading to higher per capita water use, increased standard of living, higher economic growth, and decreased poverty.
	Changes in federal financial resources available to construct new water delivery systems and storage for domestic and municipal purposes [13b] *Description: This factor could include influences such as the ability of the tribe to construct new domestic and municipal delivery systems, including storage facilities.*	1) AG: No 2) DCMI: Yes (Lower Basin focus) 3) ENV: No 4) TRAN: No	2) DCMI: Federal financial resources continue to decline. Tribal water development trends continue to decline.	2) DCMI: Federal financial resources are stopped; unable to fund water infrastructure projects. Reduced availability to safe and accessible water leading to decreased per capita water use, decreased standard of living, slower economic growth, and increased poverty.	2) DCMI: Increase in federal financial resources; more water infrastructure projects funded. Rate of tribal water development increases leading to higher per capita water use, increased standard of living, higher economic growth, and decreased poverty.

TABLE 4B-A
Key Factors Influencing Future Tribal Water Development

Influencing Factor Categories	TWS Critical Uncertainties Identified in Survey	Affected Water Use Category[1]	Description of Influencing Factors if Current Trends Continues	Plausible Low End of Range	Plausible High End of Range
Economic Development	Changes in water needs to support tribal economic development (e.g. eco and cultural tourism, commercial and business centers, etc.) [15]	1) AG: Yes 2) DCMI: Yes (varied by tribe) 3) ENV: Yes 4) TRAN: No	1) AG: 2) DCMI: 3) ENV: Current water needs maintained – economic development trend slightly up leading to a slow increase in per capita water use, standard of living, economic growth.	1) AG: 2) DCMI: 3) ENV: Current water needs maintained – economic development trend slightly up leading to a slow increase in per capita water use, standard of living, economic growth.	1) AG: 2) DCMI: 3) ENV: Rate of water development increases leading to higher water use, increased standard of living, higher economic growth, and decreased poverty.
Governance	Changes in tribal water availability and use due to the resolution and settlement of tribal water rights claims [19] *Description: This factor could include changes in the time it takes to complete Indian water settlements and in tribal member support for these settlements and water development plans.*	All (Upper Basin focus)	Current rate of progress in resolution and settlement of tribal water claims continues.	Decrease in rate of resolution and settlement of water right claims leaving tribes with uncertainty as to their ability to fully develop tribal economies.	Increase in rate of resolution and settlement of tribal water rights claims leaving tribes with more certainty as to their ability to fully develop tribal economies and improved system-wide understanding of delivery risks.
	Changes in the laws, policies, and/or regulations to provide increased flexibility to tribes to use tribal water [20] *Description: This factor could include changes to provide for increased use of water banking, water marketing, leasing, etc. and changes that further support and facilitate use of tribal water to support tribal economic development.*	All	Gradual increase in flexibility; current water development trends maintained.	Decreased flexibility in existing policies and regulations limits off-reservation use of tribal water leading to increased on-reservation tribal water use.	Increased flexibility in existing policies and regulations leads to innovative uses and increased off-reservation development of tribal water throughout Basin.

TABLE 4B-A
Key Factors Influencing Future Tribal Water Development

Influencing Factor Categories	TWS Critical Uncertainties Identified in Survey	Affected Water Use Category[1]	Description of Influencing Factors if Current Trends Continues	Plausible Low End of Range	Plausible High End of Range
Governance	Changes in federal, state, and/or regional water administration practices [21] *Description: This factor could include changes in the accounting of tribal water in the Colorado River System, and tracking and ensuring deliveries during all hydrologic conditions, and changes in the ability to ensure water is delivered to a specific entity or location.*	All (Upper Basin focus)	Current trends in administration of water use varies from stringent to minimal leading to challenges in coordinating administration among federal, state and tribal users and increased uncertainty and conflict.	Severe decrease in administration of water use leading to uncertainty in tribal water rights and increase in conflicts.	Upper Basin: Increase in cooperation and coordination in state and tribal water administration leads to less conflict and certainty in tribal water rights. Lower Basin: Increase in cooperation and coordination in federal and tribal water administration leads to less conflict and certainty in tribal water rights.
	Changes in tribal expertise and resources available for tribal water use planning [22] *Description: This factor could include changes in tribal economic and other resources for tribal water resources planning and management, changes in Congressional appropriations to support water use development and planning, and changes in cooperative efforts with State and regional non-Indian water development planning.*	All	Gradual increase in tribal expertise - gradual increase in tribal water planning and development.	Loss of tribal expertise; loss of federal funding to support tribal water resources planning - gradual decrease in tribal water planning and development.	More tribal expertise for water resources planning and management leads to faster increase in tribal water planning and development.
	Changes in the understanding of tribal reserved water rights by Federal, State, other governmental agencies and the public at large (e.g. external education) [23]	All	Current understanding is maintained leads to restricted water development.	Decreased understanding of tribal water rights leads to litigation and increased conflict.	Increased understanding of tribal reserved water rights leads to increased flexibility in Basin water development and use.

Appendix 4C
Tribal Water Development Scenario Storylines

Appendix 4C – Tribal Water Development Scenario Storylines

Storyline for the Current Water Development Trends (Scenario A)

(Finalized June 2016)

THEME: *Current trends in on-Reservation water development, governance, funding, and resolution of Tribal claims remain the same.*

Demographics

Population Adjacent to Reservation (non-Tribal)

Recent decades have seen steady growth of non-Tribal populations along both the lower main stem Colorado River and tributary river corridors. Where these population centers adjoin or overlap Tribal communities, demand on Tribal water resources typically increases to service the needs of the additional residential, municipal and industrial or agricultural activity.

Despite the high current demand, certain legal, structural and social impediments prevent rapid increase of Tribal water usage by non-Tribal users. Legally, many Tribes are constrained from engaging in marketing and transfer opportunities enjoyed by other water rights holders in the Colorado River Basin.

Land Use and Natural Systems

Agricultural Irrigation Efficiencies

Current on-reservation development includes slow adoption of new irrigation methods and/or technologies, which may improve water efficiencies.

Traditional irrigation practices - ditch and turn-out 'flood irrigation' - remains the most common approach to large-scale agricultural enterprises on Tribal lands within the Colorado River Basin. Adoption of higher-efficiency delivery technologies (e.g., sprinkler and drip irrigation systems) may result in some additional quantities of water being made available for expansion of cropped acreage, and alternative uses.

Water Quality

Slow deterioration of water quality from contamination leads to increasing regulation of drinking water, increasing treatment costs and adverse environmental impacts. Slow deterioration of water quality may also lead to a slow decrease in agricultural productivity.

A potential limiting factor for increased development of Tribal water resources is evident in the gradual deterioration of water quality within the Colorado River Basin. The current trend shows increasing contamination of system water as it cycles through the Basin to Mexico. As supplies now fall well short of demand, little system water passes through without being utilized multiple times. No 'flushing' or dilution water remains in the system to offset salt and contaminant loading that occurs both naturally and as a byproduct of current municipal, industrial and agricultural practices. Drought conditions exacerbate the water quality problems faced by users throughout the system.

Infrastructure Development

Across the basin a decline in federal funding to support Tribal development is observed, leading to a higher dependency on Tribal funds to support water infrastructure development, operation and maintenance. Tribal funding is maintained at current levels, but is not enough to offset the loss of federal funding. Current infrastructure limitations also prevent economically viable use of full apportionments in many Tribal communities.

Financial Resources Available to Expand Tribal Housing and Related Infrastructure

Tribal Funding

Tribal funding levels and housing trends are maintained continuing the gradual development of Tribal housing and related infrastructure over time. On-reservation Tribal population grows gradually, but is underserved generally, at present; thus demand exists for expanded Tribal-funded housing and related water infrastructure. Funds availability is a limiting factor in determining whether and at what rate Tribal-funded housing expands.

Federal Funding

Federal funding continues to decline, leading to a decrease in the development of Tribal housing and increasing inter-generational family housing and/or off-reservation housing. Tribes generally lack sufficient internal funds to keep pace with demand for housing. Without continued access to federal low-cost loans or grant funding, Tribal housing will slow to a rate dependent solely on Tribal economic sustainability. Water usage will remain similar to current patterns, as will existing efficiency values. Adoption of water-saving technologies is slowed.

Financial Resources Available to Operate and Maintain Existing Irrigation Infrastructure

Tribal Funding

Tribal funding is maintained for the operation, maintenance, and repair of irrigation systems and storage facilities. Water use remains similar to present patterns, and costs of system maintenance, repairs, rehabilitation and replacement increase gradually over time or are deferred altogether where the cumulative costs of maintaining the system may begin to outweigh the benefits.

Federal Funding

Federal funding continues to decline, leading to continued deterioration of irrigation systems, storage facilities, and efficiency. Water use increases over time to the extent systems remain operable, but efficiency decreases as systems age without sufficient funding for maintenance, repairs, rehabilitation and replacement.

Financial Resources Available to Construct New Irrigation Infrastructure

Tribal Funding

Tribal funding is maintained for construction of new irrigation systems and storage facilities. The ability of tribes to self-fund major irrigation infrastructure projects remains uncertain, but where possible, a gradual increase in developed water resources can be expected.

Federal Funding

Federal funding continues to decline, leading to minimal construction of new irrigation systems and storage. Tribes remain less able to develop their agricultural resources to improve the reservation economy. There may be a gradual increase in developed water resources where Tribal funds remain available to continue development.

Tribal Funds to Operate and Maintain Existing Domestic and Municipal Infrastructure

Tribal funding is maintained to operate and maintain existing Domestic, Commercial, Municipal and Industrial (DCMI) infrastructure. No increase in usage, but efficiencies possible where O&M replacements adopt and utilize newer technologies. Lack of economic development puts pressure on existing domestic water customers to fund operation, maintenance and replacement costs.

Financial Resources Available to Construct New Domestic and Municipal Infrastructure

Tribal Funding

Tribal funding is maintained for construction of new DCMI infrastructure. There is a gradual increase in water usage - depending on rate of population growth and economic factors. There is also the potential for improved efficiencies where new technologies can be utilized.

Federal Funding

Federal funding continues to decline, leading to a decrease in DCMI water development. Water usage remains at current levels, or gradually increases as population rises, or where Tribal funding is available for DCMI development. There is a strong possibility of increased usage as systems deteriorate due to inefficiencies.

Economic Development

Economic Development

Current water needs are maintained resulting in a slight increase in economic development and eco-tourism leading to a slow increase in per capita water use, and associated with a slow increase in the standard of living, and Tribal economic growth.

Social

The cultural and spiritual values of water ranked consistently very important for all Tribes. These values also ranked consistently low on the uncertainty scale indicating highly important values that are not likely to change over time. Each Tribe and the Tribal members maintain their own relationship to water for religious, cultural and spiritual purposes. In general, Tribal societies uniformly revere water for its life-giving, life-sustaining properties. This goes beyond mere recognition of the role water plays in the physical processes of life. Further, they recognize that water is a finite resource. The cultural knowledge of the natural cycles of water relate to the Tribal identity and sense of place.

Governance

Resolution and Settlement of Tribal Water Rights Claims

Upper Basin: The current gradual rate of progress to resolve and settle Tribal water claims is maintained resulting in uncertainty towards fully developing Tribal economies. For most Tribes in the Upper Basin, full resolution and implementation of Tribal water rights involves quantification in numerous river basins, negotiations with multiple states, consultation on Endangered Species issues, and the development of new storage facilities.

Lower Basin: The water rights claims for the five Lower Basin Tribes who are members of the Ten Tribes Partnership[1] were decreed in *Arizona v. California* (2006).

Flexibility in Utilization of Tribal Water

The current limited level of flexibility in existing policies and regulations leads to a gradual increase in Tribal water use. Some tribes in the upper and lower basins may provide water for off-reservation use in accordance with settlements but not all settlements and decrees provide the same flexibility within the Colorado River Basin.

[1] Fort Mojave Indian Tribe, Chemehuevi Indian Tribe, Colorado River Indian Tribes, Quechan Tribe and Cocopah Indian Tribe.

Water Administration Practices

Current trends in the administration of water use by federal, state, and Tribal entities varies from stringent to minimal, leading to challenges in coordinated administration, contributing to uncertainty among users and increased potential for conflict.

Expertise and Available Resources for Water Planning

Tribal expertise continues to gradually increase, which leads to an associated gradual increase in Tribal water planning, funding and development.

Understanding of Tribal Reserved Water Rights

The differences in the characteristics of federal reserved Tribal water rights and state based water rights result in misunderstandings that affect the management of water and its development. Therefore, if the current limited understanding of Tribal reserved water rights is maintained, restricted Tribal water development can be expected.

Storyline for the
Slow Water Development Trends (Scenario B)

(Finalized June 2016)

THEME: *Decreases flexibility in governance of Tribal water, levels of funding, and resolution of Tribal claims slow Tribal economic development. This results in a decline in the standard of living and delays resolution of Tribal claims.*

Demographics

Population Adjacent to Reservation (non-Tribal)

No or slow growth in off-reservation population leads to no change in the trend of demand for Tribal water by non-Tribal users. If the present trend of brisk non-Tribal population growth adjacent to Tribal communities, and in nearby urban centers, subsides or stalls altogether, water usage patterns will likely remain unaffected, increasing very slowly. If circumstance causes that population to substantially lessen (e.g., due to environmental degradation, climate variations, regional economic slowdown), some decrease in demand, commensurate with the reduction in population would be expected.

Land Use and Natural Systems

Agricultural Irrigation Efficiencies

Decreased funding leads to a lack of investment in Tribal agricultural operations. No change is seen in irrigation methods or technologies, resulting in agricultural water demand staying the same.

Water Quality

Rapid deterioration of water quality from contamination leads to increasing regulation of drinking water, increasing treatment costs, and adverse and longer term adverse environmental impacts. Rapid deterioration of water quality leads to a rapid decrease in agricultural productivity.

Deteriorating water quality results in increased costs of regulatory compliance, requiring enhanced treatment technologies to be employed in municipal and drinking water systems, and industrial water settings. Agricultural impacts include lower crop yield, and increased water use where it becomes necessary to dilute or leach contaminants from croplands. Overall economic efficiency is substantially lower, and water use is higher, as resources otherwise available for improvements to increase irrigation efficiency are instead siphoned off to address water quality problems.

Infrastructure Development

Federal funding for water infrastructure development stops and Tribal funding declines. As a result, infrastructure development slows.

Financial Resources Available to Expand Tribal Housing and Related Infrastructure

Tribal Funding

Tribal funding declines, leading to a decrease in the development of Tribal housing and related infrastructure, resulting in an increase in intergenerational family housing and/or off-reservation housing and related infrastructure.

Federal Funding

Federal funding stops, leading to a rapid decrease in the development of Tribal housing and related infrastructure and an increase in intergenerational family housing and/or off-reservation housing and related infrastructure.

Financial Resources Available to Operate and Maintain Existing Irrigation Infrastructure

Tribal Funding

Tribal funding decreases for operation, maintenance, and repair of irrigation systems and storage facilities leading to a deterioration of irrigation systems and storage facilities, a decrease in water use efficiency and a potential decline in crop production.

Federal Funding

Federal funding stops for operation, maintenance, and repair of irrigation systems and storage facilities, leading to a deterioration of irrigation systems and storage facilities, a decrease in water use efficiency and a potential decline in crop production.

Financial Resources Available to Construct New Irrigation Infrastructure

Tribal Funding

Tribal funding decreases and/or remains at $0.00, leading to stagnant or declining construction of new irrigation systems and storage facilities.

Federal Funding

Federal funding stops, leading to no new construction of irrigation systems and storage facilities. This further hinders the resolution and implementation of Tribal water settlements which often include large federal water projects.

Tribal Funds to Operate and Maintain Existing Domestic and Municipal Infrastructure

Tribal funding to operate and maintain existing Domestic, Commercial, Municipal and Industrial (DCMI) infrastructure decreases and/or remains at $0.00 leading to a decrease in deliveries as systems deteriorate, an increase in emergency situations, an increase in reliance on private wells, and a decrease in per capita water use.

Financial Resources Available to Construct New Domestic and Municipal Infrastructure

Tribal Funding

Tribal funding for construction of new DCMI infrastructure decreases and/or remains at $0.00, leading to a decrease in per capita water use, standard of living, and economic growth.

Federal Funding

Federal funding stops, leading to a decrease in the development of DCMI infrastructure projects resulting in a decrease in per capita water use, standard of living, and economic growth.

Economic Development

Economic Development

With Tribal economic development slowing as a result of decreased funding levels, little to no growth is seen in per capita water use.

Social

The cultural and spiritual values of water ranked consistently very important for all Tribes. These values also ranked consistently low on the uncertainty scale indicating highly important values that are not likely to change over time. Each Tribe and the Tribal members maintain their own relationship to water for religious, cultural and spiritual purposes. In general, Tribal societies uniformly revere water for its life-giving, life-sustaining properties. This goes beyond mere recognition of the role water plays in the physical processes of life. Further, they recognize that water is a finite resource. The cultural knowledge of the natural cycles of water relate to the Tribal identity and sense of place.

Governance

Resolution and Settlement of Tribal Water Rights Claims

Upper Basin: Rate of resolution and settlement of water rights claims decreases, leading to uncertainty as to the ability to fully develop Tribal economies. Slow resolution of Tribal water rights claims hinders the ability to create certainty for other water users in the Basin.

Lower Basin: Full implementation of settled water rights in the Lower Basin slows where federal and Tribal funding is restricted and development opportunities remain limited under the current and policy framework.

Flexibility in Utilization of Tribal Water

Decreased flexibility in existing policies and regulations limits off-reservation use of Tribal water leading to a gradual increase in on-reservation Tribal water use.

Water Administration Practices

A decrease in coordination and cooperation among water administrators leads to uncertainty in the implementation of Tribal water rights increasing the potential for conflicts over water.

Expertise and Available Resources for Water Planning

Loss of Tribal expertise and funding to support Tribal planning leads to a gradual decrease in Tribal water planning efforts which makes it more difficult to access funding and increase development.

Understanding of Tribal Reserved Water Rights

Decreased understanding of Tribal reserved water rights leads to litigation and increased conflict and uncertainty. This is most likely when there are changes in elected and appointed officials.

Storyline for the Rapid Water Development Trends (Scenarios C1 and C2)

(Finalized June 2016)

THEME: *Increased flexibility in governance of Tribal water allows innovative water development opportunities and increased funding availability leads to Tribal economic development. This results in an increase in the standard of living, thereby contributing to the fulfilment of the purpose of the Reservation as a homeland and supporting the future needs of Tribal communities. Scenario C1 (C1) considers partial resolution of claims and/or implementation of decreed or settled rights; and Scenario C2 (C2) considers complete resolution of claims and implementation of decreed or settled rights.*

Demographics

Population Adjacent to Reservation (non-Tribal)

(C1) Moderate off-reservation population growth leads to increased use of Tribal water by non-Tribal users, but slower resolution of claims and settlement implementation also slows full development of Tribal water resources. As a result, the additional demand and development raises the potential for increasing contamination and adverse environmental impacts, while opportunities for Tribal economic development are missed.

(C2) Rapid off-reservation population growth leads to increased demand for Tribal water by non-Tribal users; rapid implementation of settlement rights provides broader opportunity for Tribal water development; however, because of this the potential for increasing contamination and adverse environmental impacts rises as utilization reaches maximum limits throughout the Colorado River Basin system.

Land Use and Natural Systems

Agricultural Irrigation Efficiencies

(C1) Moderate adoption of more efficient irrigation methods and/or technologies leads to moderate increase in productivity and the potential for some water to be made available for additional uses. This development will be slowed to the extent that Tribal water rights remain unsettled, and the current structure of laws and regulatory policies continues to impede access to marketing opportunities for Tribes.

(C2) Rapid water development and increased flexibility for Tribes to market water leads to the aggressive adoption of more efficient irrigation methods and/or technologies, which in turn leads to increased productivity or the potential for water to be made available for additional uses.

Water Quality

(C1) Funding, flexibility, and economic development helps Tribes begin to address water quality issues, but slower resolution of claims and settlement implementation results in Tribes not having as many resources to dedicate to water quality issues. Somewhat improved water quality leads to moderately increased efficiencies, gradual increase in agricultural productivity, a decrease in treatment costs and fewer adverse environmental impacts.

(C2) Complete resolution and/or implementation of Tribal claims results in additional funding availability, increased governance flexibility, and stronger Tribal economies. This enables Tribes to have a more direct role in managing and regulating water quality. Improved water quality leads to increased efficiencies, gradual increase in agricultural productivity, a decrease in treatment costs and fewer adverse environmental impacts.

Infrastructure Development

(C1) Moderate funding increase from both Tribal and federal sources are available. As a result, moderate growth is seen in infrastructure development, operation and maintenance. Funding opportunities for some infrastructure types are dependent on the resolution of water claims.

(C2) Significant funding increase from both Tribal and federal sources are available. As a result, rapid growth is seen in infrastructure development, operation and maintenance which leads to an increase in the standard of living of Tribal populations and economic growth.

Financial Resources Available to Expand Tribal Housing and Related Infrastructure

Tribal Funding

(C1) Moderate increases in Tribal funding levels lead to moderate increases in housing trends providing moderate development of Tribal housing and related infrastructure over time.

(C2) Tribal funding increases rapidly which leads to rapid increase in housing resulting in development of Tribal housing and related infrastructure with an increased standard of living and higher per capita water use.

Federal Funding

(C1) Moderate increases in federal funding leads to moderate increases in housing trends providing a moderate development of Tribal housing resulting in a moderate increase in standard of living and somewhat higher per capita water use.

(C2) A significant increase in federal funding leads to rapid increases in housing trends and development of Tribal housing resulting in an increased standard of living and higher per capita water use.

Financial Resources Available to Operate and Maintain Existing Irrigation Infrastructure

Tribal Funding

(C1) Moderate increase in Tribal funding leads to moderate improvement of irrigation systems and storage facilities, and moderately improved water utilization, water efficiency and crop production.

(C2) Tribal funding rapidly increases leading to rapid improvement of irrigation systems and storage facilities. This leads to significantly improved water utilization, water efficiency and crop production.

Federal Funding

(C1) Federal funding moderately increases which leads to moderate improvement of irrigation systems and storage facilities, and moderately improved water utilization, water efficiency and crop production.

(C2) Federal funding rapidly increases which leads to rapid improvement of irrigation systems and storage facilities. This leads to significantly improved water utilization, water efficiency and crop production.

Financial Resources Available to Construct New Irrigation Infrastructure

Tribal Funding

(C1) Until claims are at least partially resolved, Tribes will likely not direct funding towards construction of new irrigation systems and storage facilities.

(C2) Tribal funding increases and the certainty provided by the full resolution of Tribal water claims leads to an increase in construction of new irrigation systems, and substantial increase in water utilization, water efficiency and crop production.

Federal Funding

(C1) Tribes will not receive federal funding for construction of new irrigation systems and storage facilities until at least partial resolution of water claims.

(C2) Federal funding increases and the certainty provided by the full resolution of Tribal water claims leads to an increase in construction of new irrigation systems and substantial increase in water utilization, water efficiency and crop production.

Tribal Funds to Operate and Maintain Existing Domestic and Municipal Infrastructure

(C1) Tribal funding to operate and maintain existing Domestic, Commercial, Municipal, and Industrial (DCMI) infrastructure moderately increases which leads to a moderate increase in deliveries and system improvements resulting in slightly higher per capita water use.

(C2) Tribal funding to operate and maintain existing DCMI infrastructure rapidly increases which leads to a rapid increase in deliveries and system improvements resulting in higher per capita water use.

Financial Resources Available to Construct New Domestic and Municipal Infrastructure

Tribal Funding

(C1) Tribal funding moderately increases which leads to a moderate increase in construction of new DCMI infrastructure and an increase in the rate of Tribal water development resulting in economic growth, higher per capita water use, increased standard of living, and decreased level of poverty.

(C2) Tribal funding rapidly increases which leads to a rapid increase in construction of new DCMI infrastructure and an increase in the rate of Tribal water development resulting in economic growth, higher per capita water use, increased standard of living, and decreased level of poverty.

Federal Funding

(C1) Federal funding moderately increases which leads to a moderate increase in development of DCMI infrastructure projects and a moderate increase in the rate of Tribal water development resulting in economic growth, slightly higher per capita water use, increased standard of living, and decreased level of poverty.

(C2) Federal funding rapidly increases which leads to a rapid increase in development of DCMI infrastructure projects and an increase in the rate of Tribal water development resulting in economic growth, higher per capita water use, increased standard of living, and decreased level of poverty.

Economic Development

Economic Development

(C1) Rate of water development moderately increases resulting in a moderate increase in the rate of economic development and eco-tourism which leads to slightly higher per capita water use, increased standard of living, and decreased level of poverty.

(C2) Rate of water development rapidly increases resulting in a rapid increase in the rate of economic development and eco-tourism which leads to higher per capita water use, increased standard of living, and decreased level of poverty.

Social

The cultural and spiritual values of water ranked consistently very important for all Tribes. These values also ranked consistently low on the uncertainty scale indicating highly important values that are not likely to change over time. Each Tribe and the Tribal members maintain their own relationship to water for religious, cultural and spiritual purposes. In general, Tribal societies uniformly revere water for its life-giving, life-sustaining properties. This goes beyond mere recognition of the role water plays in the physical processes of life. Further, they recognize that water is a finite resource. The cultural knowledge of the natural cycles of water relate to the Tribal identity and sense of place.

Governance

Resolution and Settlement of Tribal Water Rights Claims

(C1) Upper Basin: The rate of resolution and settlement of Tribal water rights claims moderately increases, providing some increase in the certainty of Tribal water supplies and opportunities for economic development as well as potential improvements in Tribal standard of living with some improved system wide understanding of Tribal delivery needs. However, the difficulty of obtaining implementation funding for Tribal water settlements prevents Tribes from realizing the full potential for economic development.

(C1) Lower Basin: Implementation of settled water rights moderately increases where federal and Tribal funding is moderately increased and development opportunities expand. However, the difficulty of obtaining implementation funding for decreed Tribal water rights prevents Tribes from realizing the full potential for economic development.

(C2) Upper Basin: The rate of resolution and settlement of Tribal water rights claims rapidly increases which leads to the ability to use Tribal water and greater certainty for the development of Tribal economies and improved system-wide understanding of Tribal delivery needs and decreases uncertainty for non-Tribal users which increases the understanding of water availability risks. Full Tribal water development results in a rapid increase in Tribal standard of living and more rapidly decreasing incidence and levels of poverty.

(C2) Lower Basin: Full implementation of settled water rights rapidly increases where federal and Tribal funding increases and development opportunities expand.

Flexibility in Utilization of Tribal Water

(C1) Increased flexibility in existing policies and regulations leads to gradual adoption of innovative development options such as water banking, water marketing, forbearance agreements and leasing which leads to increased utilization of Tribal water for off-reservation development and increased economic returns to Tribes. However, the slower resolution of Tribal claims prevents Tribes from realizing the full potential for economic growth.

(C2) The increased flexibility in existing policies and regulations leads to rapid adoption of innovative development options such as water banking, water marketing, forbearance agreements and leasing. This increased flexibility leads to increased utilization of Tribal water for off-reservation development and increased economic returns to Tribes, while also providing options for non-Tribal users to access more reliable water supplies.

Water Administration Practices

(C1 and C2) Upper Basin: Increase in cooperation and coordination in state and Tribal water administration leads to less conflict and greater certainty in Tribal water rights and Tribal water development. Potential opportunities for innovative water development expand under these consistent and coordinated administration practices. However, varying water administration practices continue to prevent Tribes from realizing the full potential for economic development.

(C1 and C2) Lower Basin: Increase in cooperation and coordination in federal and Tribal water administration leads to less conflict and greater certainty in Tribal water rights and Tribal water development. Potential opportunities for innovative water development expand under these consistent and coordinated administration practices. However, varying water administration practices continue to prevent Tribes from realizing the full potential for economic development.

Expertise and Available Resources for Water Planning

(C1 and C2) Steady increase in Tribal expertise leads to an increase in Tribal water planning and development, providing support for the implementation of Tribal water settlements and increasing opportunities for Tribal economic growth.

Understanding of Tribal Reserved Water Rights

(C1 and C2) An increased understanding of Tribal reserved water rights leads to increased flexibility in basin water development, reduced conflict over supply and increased economic opportunities for on and off-reservation development.

6 Assessment of System Effects Resulting from Development of Tribal Water

Contents

Figures

Tables

Appendix

6 Assessment of System Effects Resulting from Development of Tribal Water

6.0 Introduction

A series of modeling simulations were performed to quantify effects to the Colorado River System resulting from a range of future tribal water development scenarios. A set of system reliability metrics (for example, key reservoir elevations, water deliveries to non-tribal water users, etc.) were identified to indicate the effects to the Colorado River System resulting from future water development by the Partnership Tribes.

This chapter describes the approach for conducting the effects assessment and an analysis of the results.

Key Terms

Key terms used in this chapter are defined below.

Colorado River System – The portion of the Colorado River and its tributaries within the United States.

Diversion point – Location on the Colorado River or its tributaries at which water is diverted for depletion or consumptive use.

Hydrologic shortage – Unmet demand that is not the result of any policy, such as prescribed shortage delivery reductions.

Natural inflow – Calculated as gaged flow corrected for the effects of upstream reservoirs and depletions.

Policy shortage – Unmet demand that is the result of a policy, such as prescribed shortage delivery reductions.

Simulation set – A collection of model simulations that share the same Tribal Water Development Scenario, Water Supply Scenario, and Reservoir Operation Policy.

System reliability metrics – Measurements that indicate the ability of the Colorado River System to meet water delivery needs under multiple future conditions.

Trace – A single model simulation

6.1 Approach

A framework was developed to assess the effects on the Colorado River System from varying levels of future tribal water development based on the Partnership Tribes' water development scenarios coupled with different hydrologic supply scenarios. The assessment approach adopted for the Tribal Water Study is similar to that used in the Colorado River Basin Water Supply and Demand Study (Basin Study) (Reclamation, 2012). This assessment was performed by following a five-step approach:

1. Identify tribal water development scenarios
2. Develop metrics to measure system effects
3. Configure Colorado River Simulation System (CRSS)
4. Develop modeling assumptions
5. Analyze results

6.1.1 Colorado River Simulation System

The simulation of the Colorado River System under the tribal water development scenarios prepared for the Tribal Water Study was performed using CRSS. CRSS is Reclamation's primary long-term planning tool for studying river operations and projected future demand in the Basin. CRSS is implemented in the commercial modeling software RiverWare^{TM} developed by the University of Colorado (Zagona et al., 2001).

CRSS simulates the operation of the major reservoirs on the Colorado River and provides information regarding the projected future state of the system on a monthly basis. Output variables include the amount of water in storage, reservoir elevations, releases from the dams, the amount of water flowing at various points throughout the system, and diversions to and return flows from water users throughout the system. The simulation centers around a mass balance (or water budget) calculation which accounts for water entering the system, stored in the system, and leaving the system under different policy scenarios.

The model input for the Tribal Water Study included monthly natural inflows, various physical process parameters such as evaporation rates for each reservoir, and future diversion and depletion schedules for water users in the Basin States and the United Mexican States (Mexico). Policy "rulesets" allow CRSS to simulate the operation of the Colorado River mainstream reservoirs, including Lake Powell and Lake Mead, and allow projections of water depletion under different hydrologic scenarios.

6.1.2 Five-Step Approach

A five-step approach was used to assess potential effects to the Colorado River System resulting from future tribal water development. The following is a brief summary of each step and a description of how each fits within the overall assessment. These steps are described in detail in the identified sections.

Step 1 – Identify Tribal Water Development Scenarios (Section 6.2)

Four future water development planning scenarios were identified collaboratively with the Partnership Tribes as detailed in *Chapter 4 – Methodology for Assessing Current Tribal Water Use and Projected Future Water Development*. The identified planning scenarios were Current Water Development Trends (Scenario A), Slow Water Development Trends (Scenario B), and Rapid Water Development Trends (Scenarios C1 and C2). The tribal water development schedules were quantified to represent four plausible outcomes for future water development for the period from 2017 through 2060. The future water development schedules for each Partnership Tribe are presented in *Chapter 5 – Assessment of Current Tribal Water Use and Projected Future Water Development.*

Step 2 – Develop Metrics to Measure System Effects (Section 6.3)

Key system reliability metrics (metrics) that could be evaluated from CRSS output were identified to help understand effects to the system from future tribal water development. System reliability metrics considered in this Study included the ability to meet water delivery needs throughout the Basin under multiple future conditions.

Step 3 – Configure Colorado River Simulation System (Section 6.4)

CRSS and its associated inputs were configured to evaluate the Tribal Water Study metrics outlined in Step 2. These configurations included disaggregating the four tribal water development schedules for each Partnership Tribe as inputs in CRSS along with minor structural changes in CRSS to model Tribes' water use more accurately.

Step 4 – Develop Modeling Assumptions (Section 6.5)

Several modeling assumptions were needed to fully describe required model inputs. These assumptions included initial reservoir conditions, future water supply scenarios, reservoir operation policies, tribal water development schedules, and future water demand schedules for other water users.

Step 5 – Analyze Results (Section 6.6)

The metrics identified by Step 2 were evaluated and analyzed. To evaluate the metrics, CRSS was run using the Tribal Water Study's model configuration and assumptions. CRSS is a probabilistic model, so there are multiple future simulations analyzed for each metric. To understand the results, an analysis was conducted across the CRSS simulation outputs. Statistics for each metric were computed in order to explore how a metric changes in response to tribal water development, water supply, and reservoir operations policy.

6.2 Identify Tribal Water Development Scenarios

As previously described in *Chapter 4 – Methodology for Assessing Current Tribal Water Use and Projected Future Water Development*, four tribal water development scenarios were developed to capture the range of potential future water development for the Partnership Tribes. These scenarios incorporate the key influencing factors, and account for how these factors would be influenced under each scenario, given the scenario's respective theme. The scenarios and associated themes are listed below.

- **Current Water Development Trends (Scenario A)** – Current trends in on-reservation water development, governance, funding, and resolution of tribal claims remain the same.
- **Slow Water Development Trends (Scenario B)** – Decreased flexibility in governance of tribal water, levels of funding, and resolution of tribal claims slow tribal economic development. This results in a decline in the standard of living and delays resolution of tribal claims.
- **Rapid Water Development Trends (Scenarios C1 and C2)** – Increased flexibility in governance of tribal water allows innovative water development opportunities and increased funding availability leads to tribal economic development. This results in an increase in the standard of living, thereby contributing to the fulfilment of the purpose of the reservation as a homeland and supporting the future needs of tribal communities. Scenario C1 considers partial resolution of claims and/or implementation of decreed or settled rights; and Scenario C2 considers complete resolution of claims and implementation of decreed or settled rights within the Study timeframe.

6.3 Develop Metrics to Measure System Effects

Metrics were developed in collaboration with the Partnership Tribes to identify potential effects of tribal water development on the Colorado River System and non-tribal water users. Taking into account CRSS limitations, metrics were identified for both the Upper Basin and Lower Basin including water delivery shortages, Lake Powell inflow, Lake Powell elevation, Lake

Mead elevation, and water deliveries to non-tribal water users. Shortages were not evaluated on a per-tribe or a single water user basis, rather they are reported at the basin or sub-basin level. A majority of these metrics could be evaluated directly in CRSS; however, some required additional analysis of CRSS output or exploration of models other than CRSS such as StateMod, the State of Colorado's surface water allocation and accounting model capable of simulating various historical and future water management policies in a river basin (Colorado Water Conservation Board, 2017) .

The Tribal Water Study metrics are presented in Table 6-A, and described below.

TABLE 6-A
Metrics for Upper and Lower Basin System Effects Analysis

	Variable	Measurement	Source
Upper Basin Metrics	Inflow to Lake Powell	Volume in acre-feet per year	CRSS Output
	Lake Powell Elevation	Elevation in feet above mean sea level	CRSS Output
	Upper Basin Shortage	Volume in acre-feet per year Frequency of shortage volume per year	CRSS Output
	San Juan Sub-basin Historical Shortage Analysis	Volume in acre-feet per year	Additional Analysis
Lower Basin Metrics	Lake Mead Elevation	Elevation in feet above mean sea level	CRSS Output
	Lower Basin Hydrologic Shortage	Volume in acre-feet per year Frequency of shortage volume per year	CRSS Output
	Water Deliveries to Lower Basin Non-Tribal Users	Volume in acre-feet per year	CRSS Output
	Lower Basin Present Perfected Rights Analysis	N/A	Additional Analysis

6.3.1 Upper Basin Metrics and Analyses

Inflow to Lake Powell

The volume of water flowing into Lake Powell in acre-feet per year (AFY), as simulated by CRSS. This volume was calculated on an annual time step, at the end of each calendar year.

Lake Powell Elevation

The annual December 31st elevation at Lake Powell (feet above mean sea level [msl]).

Upper Basin Shortage

Upper Basin water delivery shortage was defined as the total requested diversion minus actual diversion in a given year for sub-basins that include water use by Partnership Tribes. These sub-basins include the Green River Basin, San Juan River Basin, and the sub-basin composed of intervening flows above Lake Powell and below the San Juan River, San Rafael River, Green River, and Colorado River Basin near Cisco, Utah. Upper Basin shortage was calculated with respect to total requested diversion because Indian reserved water rights are typically diversion-based in the Upper Basin. Shortages were tracked for both Partnership Tribes and non-tribal water users and analyzed as an aggregate annual percent shortage of the requested water diversion. This percent was calculated by dividing the shortage volume by the requested diversion and multiplying by 100. These annual percent shortages were evaluated by frequency across all traces and the annual minimum, median, and maximum percent shortage of total requested diversion.

San Juan Sub-basin Historical Shortage Analysis

A limitation of CRSS is that it does not represent individual water rights and therefore may not accurately represent the distribution of water delivery shortages to Partnership Tribes versus non-tribal water users.

The San Juan sub-basin and its tributaries were selected to illustrate what effects could occur in the Upper Basin in times of shortage because tribes in this sub-basin have complex reserved water rights as set forth in tribal decrees filed in Colorado Water Division 7 (see *Chapter 5 – Assessment of Current Tribal Water Use and Projected Future Water Development* for additional detail). Additional analysis was performed based on output from the State of Colorado's water allocation and accounting model, StateMod. Water deliveries in Colorado's portion of the San Juan sub-basin for calendar years 2008 and 2012, which represent recent years with relatively high and low water supplies in the Colorado River Basin, respectively, were modeled with StateMod to identify where shortages occurred and how Partnership Tribes, specifically the Southern Ute Indian Tribe and Ute Mountain Ute Tribe, and non-tribal water users were affected. Water demands for tribal users were then increased to each tribes' full San Juan sub-basin reserved water right, and the StateMod model was run again with the 2008 and 2012 hydrology. Results were analyzed to determine how water deliveries changed between the two model runs. New Mexico water deliveries from the San Juan sub-basin and its tributaries were not included in this analysis. *Appendix 6-1 – Methodology for Conducting San Juan Sub-basin Historical Shortage Analysis* describes the methodology used to estimate historical shortages under current and development of full Indian reserved water rights in the San Juan Sub-basin in Colorado.

6.3.2 Lower Basin Metrics and Analyses

Lake Mead Elevation

The annual December 31st elevation at Lake Mead (feet above mean sea level [msl]).

Lower Basin Hydrologic Shortage

In CRSS, shortage is divided into two portions, hydrologic shortage and policy shortage. Hydrologic shortage is defined as the unmet demand in the Lower Basin and Mexico that is not the result of any policy, such as the prescribed shortage delivery reductions in the *Record of Decision for Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead* (2007 Interim Guidelines) (DOI, 2007) or Intentionally Created Surplus (ICS) activity. For example, under the 2007 Interim Guidelines, policy shortages for the Lower Basin are based upon Lake Mead's elevation, which is divided into three levels. If there is demand for 9.0 million acre-feet per year (MAFY) of water from the Lower Basin States and Mexico, but Lake Mead is below 1,025 feet, and only able to deliver 8.0

MAF of water, there would be a total hydrologic shortage of 1.0 MAF. Under the 2007 Interim Guidelines, Lake Mead would be operating under a level three shortage and annual deliveries to the Lower Basin would be reduced by 625 thousand acre-feet (KAF). This policy shortage would account for 625 KAF of the 1.0 MAF shortage volume, and the remaining 375 KAF of shortage would be labeled hydrologic shortage. For the hydrologic shortage analysis, shortages were not broken out by state or by tribal and non-tribal water users but reported as total Lower Basin and Mexico shortage because CRSS does not account for how shortage would affect individual water users. Shortages in the Lower Basin are calculated with respect to total requested consumptive use. Shortages were analyzed as an aggregate annual percent shortage of the requested consumptive use. This percent was calculated by dividing the shortage volume by the requested consumptive use, and multiplying by 100. These annual percent shortages were evaluated by frequency across all traces and the annual minimum, median, and maximum percent shortage of total requested consumptive use.

Water Deliveries to Lower Basin Non-Tribal Users

Water deliveries to non-tribal water users are defined as consumptive use by non-tribal water users in the Lower Basin and Mexico. This metric was not broken out by water user but reported as a combined Lower Basin and Mexico value. Water deliveries to non-tribal users were computed by summing all consumptive use in the Lower Basin plus Mexico and subtracting the Lower Basin Partnership Tribes' consumptive use per the tribal water development schedules for that year.

Lower Basin Present Perfected Rights Analysis

In the Lower Basin, additional post processing was performed to better understand the Present Perfected Rights (PPRs) of Lower Basin Partnership Tribes, and the effect of water delivery shortages to Partnership Tribes. Analysis of this metric explored whether the hydrologic shortage magnitude is great enough to affect tribal PPR water rights holders and was performed as a qualitative discussion of potential effects on Partnership Tribes under existing law.

6.4 Configure Colorado River Simulation System

For use in CRSS, the Partnership Tribes' future water development schedules were disaggregated by each tribe's diversion points as currently represented in CRSS. The disaggregation was determined by analyzing tribal use by sub-basin in the Upper Basin, and by state in the Lower Basin, with the assistance of each tribe.

To include the Partnership Tribes' water development schedules in CRSS, each Upper Basin reach and Lower Basin State were matched to the corresponding tribal water diversion points within CRSS. For some Partnership Tribes, assumptions had to be used to disaggregate their water use because of a limited availability of information. The first disaggregation approach used a ratio methodology and was applied when future use information by reach was limited. In this case, water use schedules for Slow Water Development Trends (Scenario B), and Rapid Water Development Trends Scenarios (C1 and C2) were assigned for each diversion point by preserving the Current Water Development Trends (Scenario A) water use ratio. For example, if a tribe has two agricultural water diversions on a reach, under Scenario A, 30 percent of the total agricultural water use was assigned to the tribe's first diversion point and 70 percent to the tribe's second diversion point. For all other scenarios, the future agricultural water use was disaggregated over the two diversion points using this same ratio. The second disaggregation approach was used when there were multiple types of water use at a single diversion point for a tribe. This methodology maintained the ratios of water use types currently in the official CRSS model, which presently relies on the 2007 Upper Colorado River Commission (UCRC) schedule provided by the Upper Division States for all of the future water development scenarios. In both approaches, total water use in a given reach or state was not allowed to exceed the Partnership Tribe's quantified water right for that reach or state.

For non-tribal diversion points in CRSS, water use schedules were broken out from annual to monthly time steps by distributing annual water use to each month based on the monthly coefficients from the original CRSS water use schedules before adding the tribal water development schedules.

A structural change was made to CRSS to improve water delivery priority modeling on the Duchesne River, Utah. Because the Ute Indian Tribe has a senior water right on the Duchesne River, their diversion point was moved from the aggregate reach located below the Starvation Reservoir to the aggregate reach above the Starvation Reservoir. This configuration ensured that the Tribe's demands were met before non-tribal demands.

6.5 Develop Modeling Assumptions

As with any modeling effort, assumptions needed to be made to use the model. Some assumptions made for this analysis included the model simulation period and initial reservoir conditions. Key model simulation assumptions included future hydrology (using multiple future water supply scenarios, described below), water demands, and reservoir operations policy. These assumptions are similar to those incorporated into the Basin Study modeling efforts.

The modeling simulation period selected was from January 2017 through December 2060. CRSS simulations must begin in January due to model constraints and because it was not yet January 2017 when modeling occurred, a projection of Colorado River System conditions was needed. Reservoir starting conditions for CRSS were taken from Reclamation's *Operation Plan for Colorado River System Reservoirs, August 2016 24-Month Study Report* (Reclamation, 2016) and are consistent with the Lake Powell and Lake Mead initial reservoir conditions used for the August 2016 CRSS simulation as reported in, *The Colorado River System: Projected Future Conditions 2017-2021,* (Reclamation, 2016b).

Modeling assumptions included future water supply, water demands, and reservoir operations policy. The future water supply scenarios selected from the Basin Study for the Tribal Water Study were the Observed Natural Flow and the downscaled Global Climate Model scenarios. The Observed Natural Flow scenario was selected because it captures the recently updated observed historical flows. The Global Climate Model scenario was selected because it provides the largest plausible range of future natural flows in terms of both magnitude and length of sequences of wet and dry spells. The Observed Natural Flow water supply scenario assumes that future hydrologic trends and variability are similar to the past approximately 100 years. It uses the indexed sequential method (Ouarda et al., 1997) to resample the observed natural flow data from the historical natural flow record. This method can only generate hydrology inputs with observed flow magnitudes and sequences, and preserves historical data statistics. The Global Climate Model water supply scenario assumes that future climate will continue to warm with regional precipitation and temperature trends represented through an ensemble of future downscaled global climate model projections and simulated hydrology. The Global Climate Model scenario contains traces from 16 general circulation models with three emissions scenarios, and provides runoff projections based on the World Climate Research Program's Coupled Model Intercomparison Project Phase 3 (CMIP3) (Maurer et al., 2007) projected climate assumptions (see Basin Study, *Technical Report B – Water Supply Assessment* [Reclamation, 2012a]).

Water demands were represented for the Partnership Tribes and non-tribal water users. The Partnership Tribes used their individually-identified water development schedules (Current Water Development Trends [Scenario A]; Slow Water Development Trends [Scenario B]; Rapid Water Development Trends [Scenarios C1 and C2]). Non-tribal water users' demands were held consistent throughout all four water development scenarios ensuring that differences in model results between scenarios were only the result of future water development by the Partnership Tribes. The Upper Basin non-tribal demands were obtained from the 2007 UCRC schedule. The Lower Basin non-tribal demands were those used for the 2007 Interim Guidelines. Lower Basin non-tribal demands were increased or decreased for each tribal water development schedule to ensure consumptive use in the Lower Basin did not exceed the annual normal apportionment, giving the Lower Basin States an annual scheduled consumptive use volume of 7.5 MAF.

Two different reservoir operation policy sets were evaluated. Both policy sets operated Lake Powell and Lake Mead according to the 2007 Interim Guidelines between 2017 through 2026. After the expiration of the 2007 Interim Guidelines in 2026, two operational assumptions were considered. The first was that the Shortage, Surplus, and Coordinated Operations provisions of the 2007 Interim Guidelines would be extended through the Tribal Water Study's timeframe of 2060 (*Interim Guidelines Extended* policy). The second was that the operating rules revert to the rules of the No Action Alternative from the *Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead Final Environmental Impact Statement* (2007 Interim Guidelines Final EIS) (Reclamation, 2007) (*Interim Guidelines Expire in 2026* policy). These two reservoir operation policy sets were also used for the Basin Study analysis.

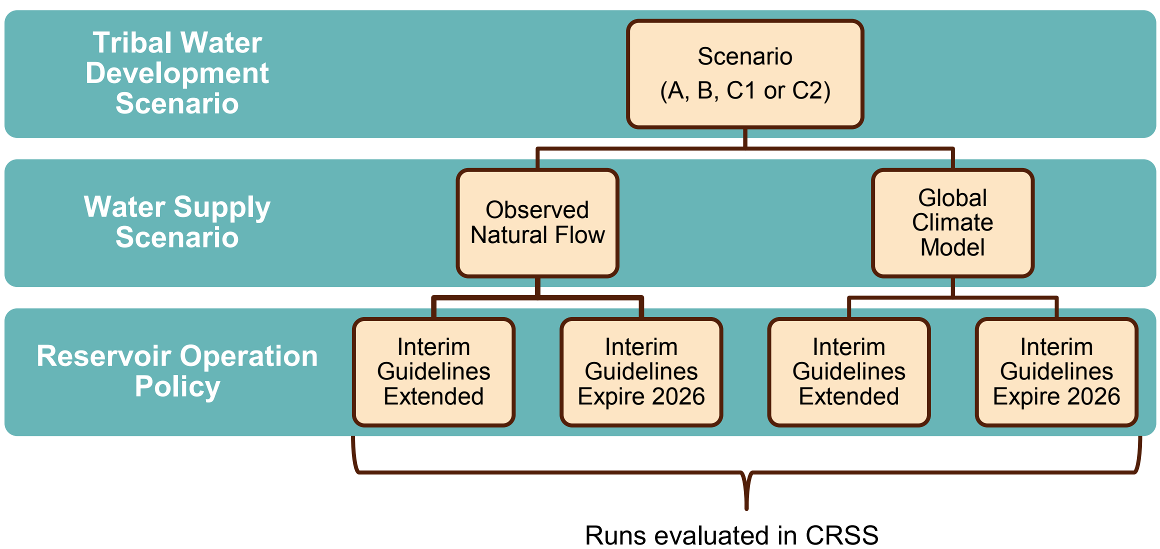
The reservoirs upstream of Lake Powell were operated to meet specific targets reflecting each reservoir's respective Record of Decision (ROD) for the entire modeling simulation period. Taylor Park, and Starvation reservoirs were operated in accordance with their existing rule curves (see *Appendix A, CRSS Model Documentation* [Reclamation, 2007]), but Fontenelle's operations rules in CRSS have been updated since the 2007 Interim Guidelines (Reclamation, 2012). In CRSS, the Aspinall Unit operations do not yet reflect the Record of Decision for the Aspinall Unit Operations Final Environmental Impact Statement (Reclamation, 2012b), and were operated in accordance with their previous rule curves, as published in the 2007 Interim Guidelines Final EIS) (see *Appendix A, CRSS Model Documentation* [Reclamation, 2007]). The operations rules for Navajo and Flaming Gorge reservoirs were modified in CRSS to meet specified downstream flow targets in accordance with the rules laid out in their respective RODs (Reclamation, 2006a and 2006b).

The four tribal water development scenarios were modeled with both water supply scenarios, and both reservoir operation policies, as shown in Figure 6-A. That is, each water development scenario was run with:

- Observed Natural Flow water supply scenario
    - *Interim Guidelines Extended* policy
    - *Interim Guidelines Expire in 2026* policy
- Global Climate Model water supply scenario
    - *Interim Guidelines Extended* policy
    - *Interim Guidelines Expire in 2026* policy

This provided a total of 4 simulation sets for each water development scenario. These four simulation sets were repeated for the four water development scenarios, which provided 16 simulation sets with a combined total of 1,752 simulations, also termed 'traces', which were evaluated in the analysis. Each trace reflected one combination of supply, development, and reservoir operation policy. Traces were grouped to explore the effects of tribal water development under the water supply scenarios, the tribal water development scenarios, and the reservoir operation policies.

FIGURE 6-A
Conceptual Representation of the Modeling Performed for a Given Development Scenario



6.6 Analyze Results

Upon configuring and simulating with the model, the 16 simulation sets provided 1,752 traces of data for analysis. These data were grouped by water supply scenario, tribal water development scenario, and reservoir operation policy and were analyzed for each metric to assess the effect of each tribal water development scenario. The following results are divided by Upper and Lower Basin, and contain the metrics and the results for the corresponding basin.

6.6.1 Upper Basin Modeling Results

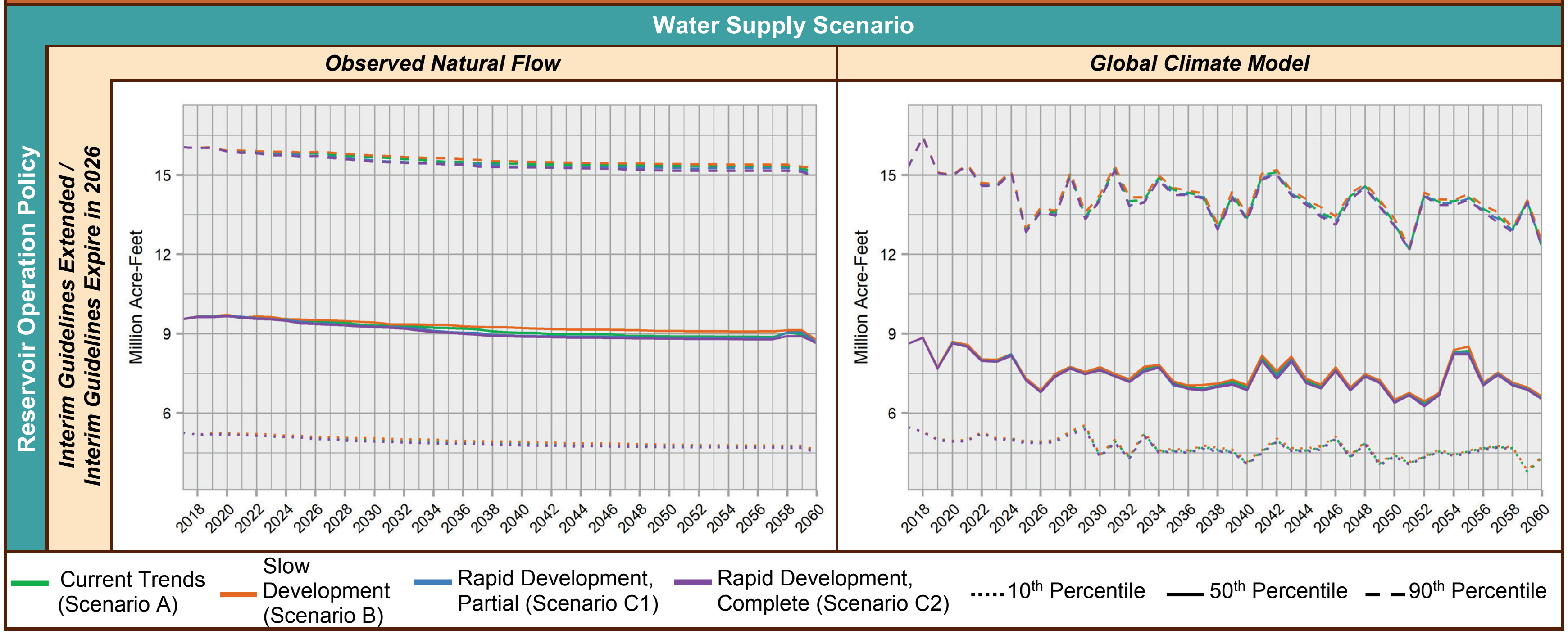
Figure 6-B is organized by supply scenario and Figure 6-C is organized by supply scenario and reservoir operations policy, with the Observed Natural Flow supply scenario used in the panels on the left, the Global Climate Model supply scenario used in the panels on the right, the *Interim Guidelines Extended* policy used in the panels on the top and the *Interim Guidelines Expire in 2026* policy used in the panels on the bottom. Figure 6-D is organized by supply scenario with the Observed Natural Flow supply scenario in the top panels and the Global Climate Model supply scenario in the bottom panels and further split by aggregate annual percent shortage as a frequency in the left panels, and as the minimum, median, and maximum aggregate annual shortage percent in the right panels.

Metric – Inflow to Lake Powell

Figure 6-B shows the inflow into Lake Powell across the model results. By 2060, the volume of water flowing into Lake Powell had annual ranges of 328 KAF for the Observed Natural Flow supply scenario (left panel) and 290 KAF (right panels) for the Global Climate Model supply scenario (right panels). These ranges resulted from differences between the inflow volume for Slow Water Development Trends (Scenario B), and Rapid Water Development Trends, Complete (Scenario C2). These scenarios define the range because they exhibit the slowest (Scenario B) and most rapid (Scenario C2) rates of tribal water development. A larger inflow volume range was experienced across water supply scenarios than across development scenarios, indicating the water supply scenarios exhibit more influence on inflow volume into Lake Powell than the tribal water development scenarios.

For this metric, the inflows for each water supply scenario do not vary by reservoir operating policy because these policies do not affect reservoir operations above Lake Powell. Therefore, Figure 6-B only shows results for the two water supply scenarios.

FIGURE 6-B
Annual Inflow into Lake Powell (2017 – 2060)



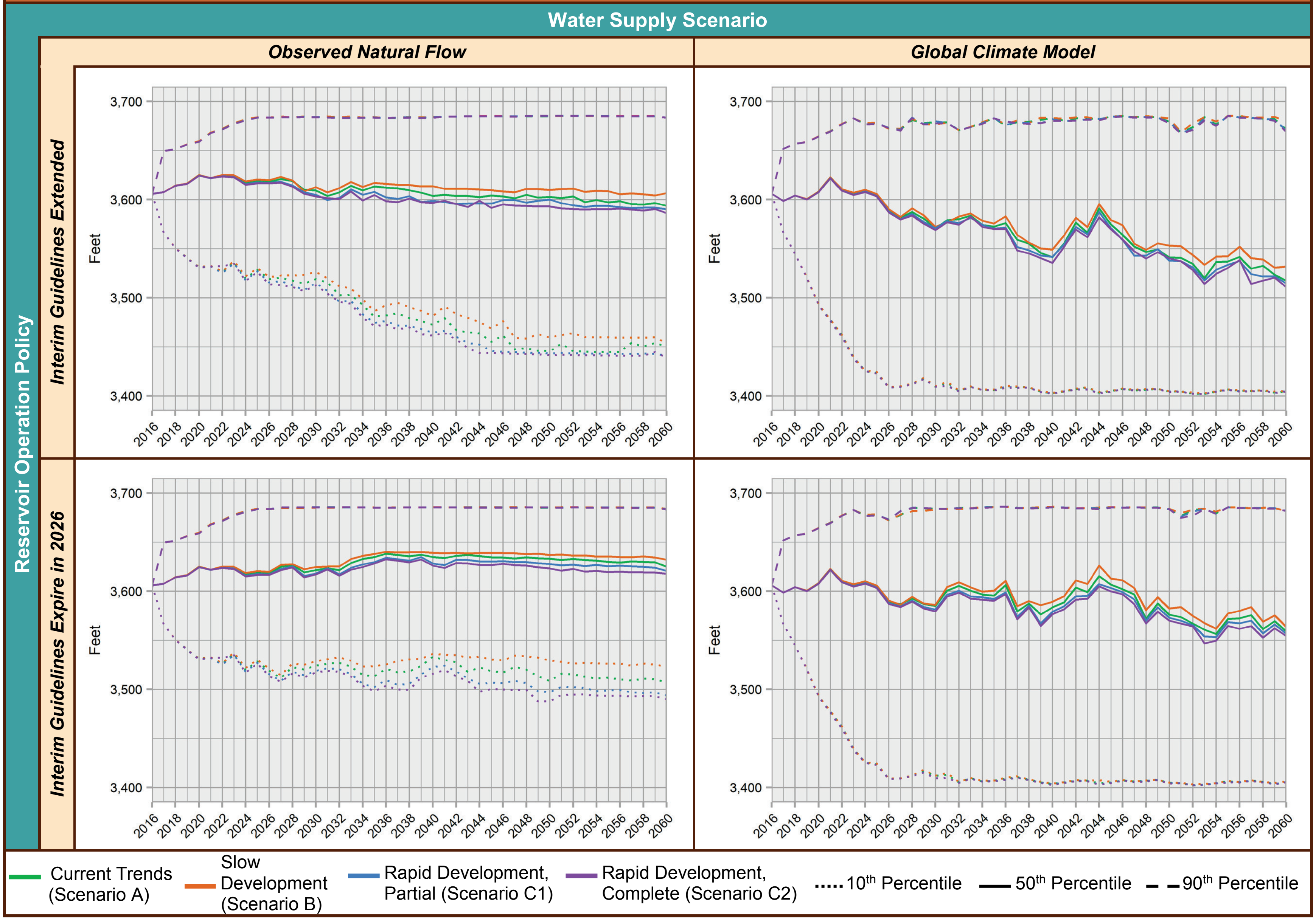
Metric – Lake Powell Elevation

Figure 6-C shows Lake Powell elevation across results. At the 50th percentile (solid line), the tribal water development schedules show a range of Lake Powell elevations. This range was bounded by Slow Water Development Trends (Scenario B), and Rapid Water Development Trends, Complete (Scenario C2), and displays differences in elevation as large as 21 feet by 2060. This difference was due to Upper Basin tribal water development.

Differences in elevations across the Observed Natural Flow supply scenario are more pronounced when Lake Powell is at lower water levels, such as those seen in the 10th percentile (dotted line). The 10th percentile represents the lowest 10% of elevations seen in the results for a given year. In Figure 6-C, the 10th percentile exhibits a range of 33 feet in the difference between Slow Water Development Trends (Scenario B) and Rapid Water Development Trends, Complete (Scenario C2), which again bound this range, by 2060. This comparison indicates that the system is more affected by Upper Basin tribal water development when water supplies are low.

Under the Global Climate Model scenario, the 10th percentile (dotted line) displays little effect from Upper Basin tribal water development, resulting in little to no range across the tribal water development scenarios. Under the Global Climate Model supply scenario this occurs because Lake Powell elevation is constrained as the reservoir approaches the dead pool elevation (3,370 feet), when the reservoir is unable to release water downstream.

FIGURE 6-C
Annual Lake Powell Elevation (2017 – 2060)

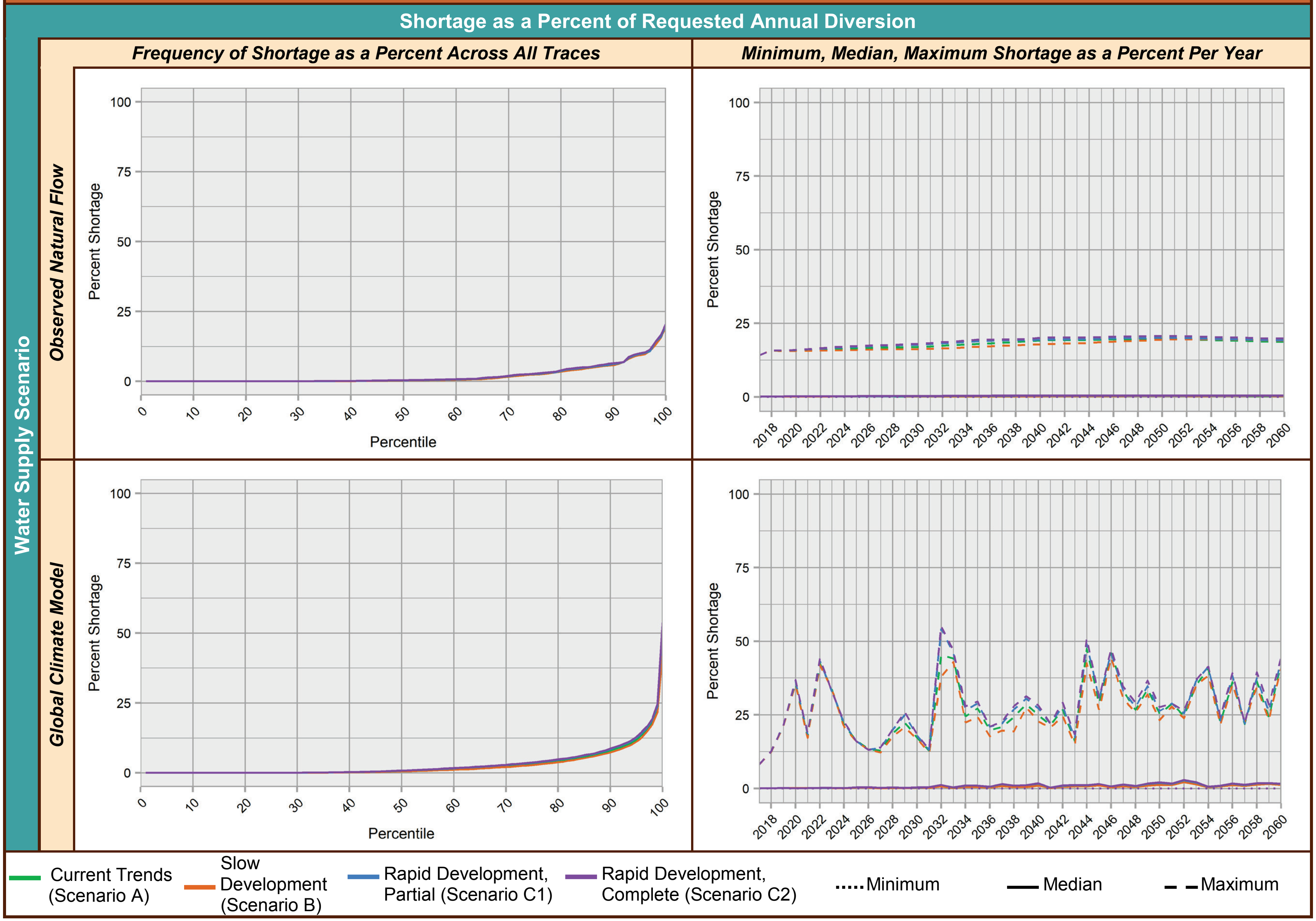


Metric – Upper Basin Shortage

Figure 6-D shows the aggregate annual percent shortage. The percent shortage represents the percent of the requested annual diversion that was not delivered. This metric provides context regarding the severity of the shortage volume with respect to demand. The left panels show the percent shortage as a frequency across all traces and the right panels show the annual minimum, median, and maximum percent shortage in the Upper Basin, seen across all impacted Upper Basin sub-basins. These sub-basins include the Green River and San Juan sub-basins, and their intervening flows. This shortage is shown as a percent of annual diversion requested. Results are further split out by supply scenario, with the Observed Natural Flow supply scenario in the top two panels and the Global Climate Model supply scenario in the bottom two panels. Because the modeled reservoir operation policies do not effect reservoir operations above Lake Powell, the results produced by both policy sets are identical for each supply scenario.

The Upper Basin experiences some level of shortage in all years because its water supplies are more dependent on natural streamflows, which are fed directly by snowpack and rainfall, and are affected by localized drought patterns. Across the development schedules, the Upper Basin Shortage metric showed greater variability due to water supply than to tribal water development, with little difference seen between the development schedules.

FIGURE 6-D
Upper Basin Percent Shortage of Diversion Requested



San Juan Sub-basin Historical Shortage Analysis

Tables 6-B and 6-C shows the depletion and shortage volumes for both tribal and non-tribal water use within Colorado's San Juan sub-basin for the years 2008 and 2012, respectively, as modeled using the State of Colorado's water allocation and accounting model, StateMod. Both the Southern Ute Indian Tribe and the Ute Mountain Ute Tribe have water rights in this sub-basin within the State of Colorado. Water uses within the New Mexico portion of the San Juan Basin were not considered for this analysis. Using each year's historical hydrology, water use was first modeled with the given year's actual tribal and non-tribal water use, and then a second model run was performed, in which tribal water use was increased to the Tribes' full reserved water right. This analysis was performed for both 2008 and 2012. The results were grouped geographically, with water use above the Archuleta USGS stream gage comprising one grouping, and water use between the Archuleta and Bluff USGS stream gage comprising the second grouping.

In the San Juan sub-basin, the year 2008 was a relatively wet year and the year 2012 was a relatively dry year. When compared to the average flow for the past 30 years (1985 to 2014), the year 2008 saw flows 134 percent greater than the average flow at the Archuleta stream gage and 122 percent greater at the Bluff stream gage. In contrast, the year 2012 saw flows 52 percent lower than average at the Archuleta stream gage and 48 percent lower at the Bluff stream gage. When moving from 2008 observed water use to the full development of tribal rights, the Tribes' water use increases, with depletions above Archuleta more than twice as large, and depletions from Archuleta to Bluff more than four times as large. Full development of tribal water rights did not cause additional tribal shortages above Archuleta; however non-tribal shortages increased by 246 acre-feet (AF) from the 2008 observed water use to the full development of tribal water rights, and increased by 6,310 AF in the 2012 analysis. From Archuleta to Bluff, the non-tribal shortages increased by 6,678 AF from the 2008 observed water use to the full development of tribal water rights, and increased by 13,571 AF in the 2012 analysis. Tribal shortages were also experienced in the Archuleta to Bluff reach when the Tribes' use was increased to full development of water rights, with the Ute Mountain Ute Tribe experiencing 3,681 AF of shortage in the 2008 and 2012 analyses. The non-tribal shortages seen in the 2012 analysis were larger than those seen in the 2008 analysis by approximately 20 to 24 percent, as the year 2012 experienced relatively dry conditions for the San Juan sub-basin.

TABLE 6-B
San Juan Basin in Colorado Depletion and Shortage Volumes for Tribal and Non-Tribal Water Users – 2008

Location	Tribal Depletions	Non-Tribal Depletions	Total Depletions	Tribal Shortages	Non-Tribal Shortages	Total Shortages
2008 Current Use Results – San Juan and tributaries in Colorado (AF)						
Above Archuleta	19,778[1]	128,121	147,889	0	3,155	3,155
Shortage as Percent of Use				*0%*	*14%*	*2%*
Archuleta to Bluff	15,808[2]	176,326	192,134	0	17,773	17,773
Shortage as Percent of Use				*0%*	*9%*	*8%*
2008 Tribal Full Water Right Use Results – San Juan and tributaries in Colorado (AF)						
Above Archuleta	42,656[1]	127,875	170,530	0	3,401	3,401
Shortage as Percent of Use				*0%*	*3%*	*2%*
Archuleta to Bluff	65,060[3]	168,648	233,708	3,681[4]	24,451	29,132
Shortage as Percent of Use				*5%*	*13%*	*11%*

[1] Southern Ute Indian Tribe
[2] 12,863 AF Ute Mountain Ute Tribe; 2,945 AF Southern Ute Indian Tribe
[3] 44,074 AF Ute Mountain Ute Tribe; 20,986 AF Southern Ute Indian Tribe
[4] Ute Mountain Ute Tribe Shortages

TABLE 6-C
San Juan Basin in Colorado Depletion and Shortage Volumes for Tribal and Non-Tribal Water Users – 2012

Location	Tribal Depletions	Non-Tribal Depletions	Total Depletions	Tribal Shortages	Non-Tribal Shortages	Total Shortages
2012 Current Use Results – San Juan and tributaries in Colorado (AF)						
Above Archuleta	19,778[1]	95,117	114,895	0	26,637	26,637
Shortage as Percent of Use				*0%*	*22%*	*19%*
Archuleta to Bluff	15,808[2]	148,619	164,427	0	59,727	59,727
Shortage as Percent of Use				*0%*	*29%*	*27%*
2012 Tribal Full Water Right Use Results – San Juan and tributaries in Colorado (AF)						
Above Archuleta	42,656[1]	88,807	131,463	0	32,947	32,947
Shortage as Percent of Use				*0%*	*27%*	*20%*
Archuleta to Bluff	65,060[3]	135,048	200,108	3,681[4]	73,298	76,979
Shortage as Percent of Use				*5%*	*35%*	*28%*

[1] Southern Ute Indian Tribe
[2] 12,863 AF Ute Mountain Ute Tribe; 2,945 AF Southern Ute Indian Tribe
[3] 44,074 AF Ute Mountain Ute Tribe; 20,986 AF Southern Ute Indian Tribe
[4] Ute Mountain Ute Tribe Shortages

6.6.2 Lower Basin Modeling Results

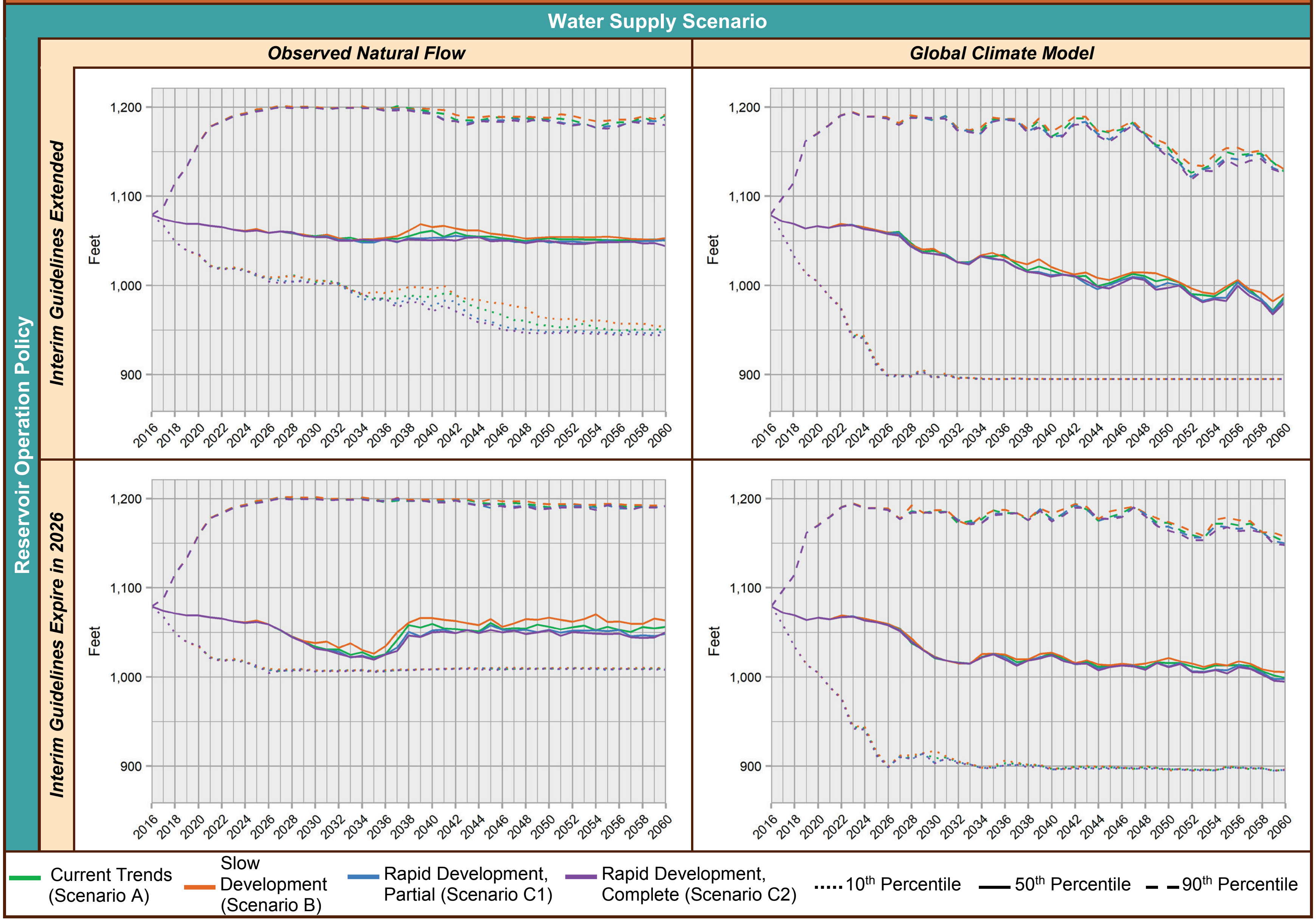
Metric – Lake Mead Elevation

Figure 6-E shows the Lake Mead elevations across the model results. The results were organized by supply scenario and reservoir operations policy, with the Observed Natural Flow supply scenario used in the panels on the left, the Global Climate Model supply scenario used in the panels on the right, the *Interim Guidelines Extended* policy used in the top panels and the *Interim Guidelines Expire in 2026* policy used in the bottom panels.

At the 50th percentile (solid line), the tribal water development schedules show a range of effects on Lake Mead elevations. This range was bounded by Slow Water Development Trends (Scenario B), and Rapid Water Development Trends, Complete (Scenario C2), and displays differences as large as 13 feet by 2060. This difference was driven by Upper Basin tribal water development, as was also seen at Lake Powell, because the Lower Basin uses its full normal apportionment and is not allowed to deplete above that apportionment. Tribal water development by the Lower Basin Partnership Tribes would move water use from non-tribal to tribal use as shown in Figure 6-H.

Lake Mead's elevation shows more differences as a result of water supply scenarios than it does as a result of Upper Basin tribal water development. At the 10th percentile (dotted line) there is generally little effect from Upper Basin tribal water development, resulting in little to no range across the tribal water development scenarios. Under the Global Climate Model supply scenario this occurs because Lake Mead elevation is constrained as the reservoir approaches the dead pool elevation (895 feet), when the reservoir is unable to release water downstream. When the Observed Natural Flow supply scenario is coupled with the *Interim Guidelines Expire in 2026* policy, this occurs because the elevation of 1,000 feet at Lake Mead is protected, constraining elevation variation after 2026. The Observed Natural Flow supply scenario under the *Interim Guidelines Extended* policy is the only scenario combination that does not exhibit these physical and policy constraints.

FIGURE 6-E
Annual Lake Mead Elevation (2017 – 2060)



Metric – Lower Basin Hydrologic Shortage

Figures 6-F and 6-G shows the aggregate annual percent of hydrologic shortage. The percent of hydrologic shortage represents the percent of the requested annual consumptive use that was not delivered. This metric provides context regarding the severity of the shortage volume with respect to demand. The left panels show the percent of hydrologic shortage as a frequency across all traces and the right panels show the annual minimum, median, and maximum percent of hydrologic shortage in the Lower Basin, seen across all Lower Basin States and Mexico, for the Observed Natural Flow supply scenario (Figure 6-F) and the Global Climate Model supply scenario (Figure 6-G). The results were further split by reservoir operations policy, with the *Interim Guidelines Extended* policy results in the top panels and the *Interim Guidelines Expire in 2026* policy results in the bottom panels.

For the Lower Basin generally, little change is seen in the percent of hydrologic shortage frequency and minimum, and median percent of hydrologic shortages due to tribal water development. Hydrologic shortage was more influenced by variations in water supply, with percent of hydrologic shortages seen at an increased frequency and magnitude under the Global Climate Model supply scenario (Figure 6-G) than the Observed Natural Flow supply scenario (Figure 6-F). This is because the Global Climate Model supply scenario's traces contain more low water supply years than contained in the Observed Natural Flow supply scenario.

Under the Observed Natural Flow supply scenario, hydrologic shortage only occurred under the *Interim Guidelines Extended* policy, and occurred less than five percent of the time. Hydrologic Shortage did not occur under the Interim Guidelines Expire 2026 policy because after 2026, the reservoir operating rules reverted to the rules of the No Action Alternative from the 2007 Interim Guidelines Final EIS. This alternative prevents Lake Mead's elevation from declining below 1,050 feet with approximately an 80 percent probability. Should Lake Mead's elevation continue to decline, the alternative imposes further reduction to keep Lake Mead's elevation above 1000 feet. This shortage is called a "policy" shortage (while not representing official policy of the Department of Interior with regard to future determinations). Because of the flexibility of this policy to reduce the volume of downstream deliveries as needed, hydrologic shortage was never achieved under the Observed Natural Flow supply scenario.

Further, under the Observed Natural Flow supply scenario, tribal water development affected the percent of maximum hydrologic shortage magnitude when it occurred, as seen in Figure 6-F (upper-right panel), providing a range of hydrologic shortage percentages at the maximum value for each year (dashed line). This range was bounded by Slow Water Development Trends (Scenario B), and Rapid Water Development Trends, Complete (Scenario C2), and displays a difference of approximately 23 percent (or 2.07 MAF) on average.

FIGURE 6-F
Lower Basin Hydrologic Shortage as Percent of Requested Consumptive Use, Observed Natural Flow Water Supply Scenario

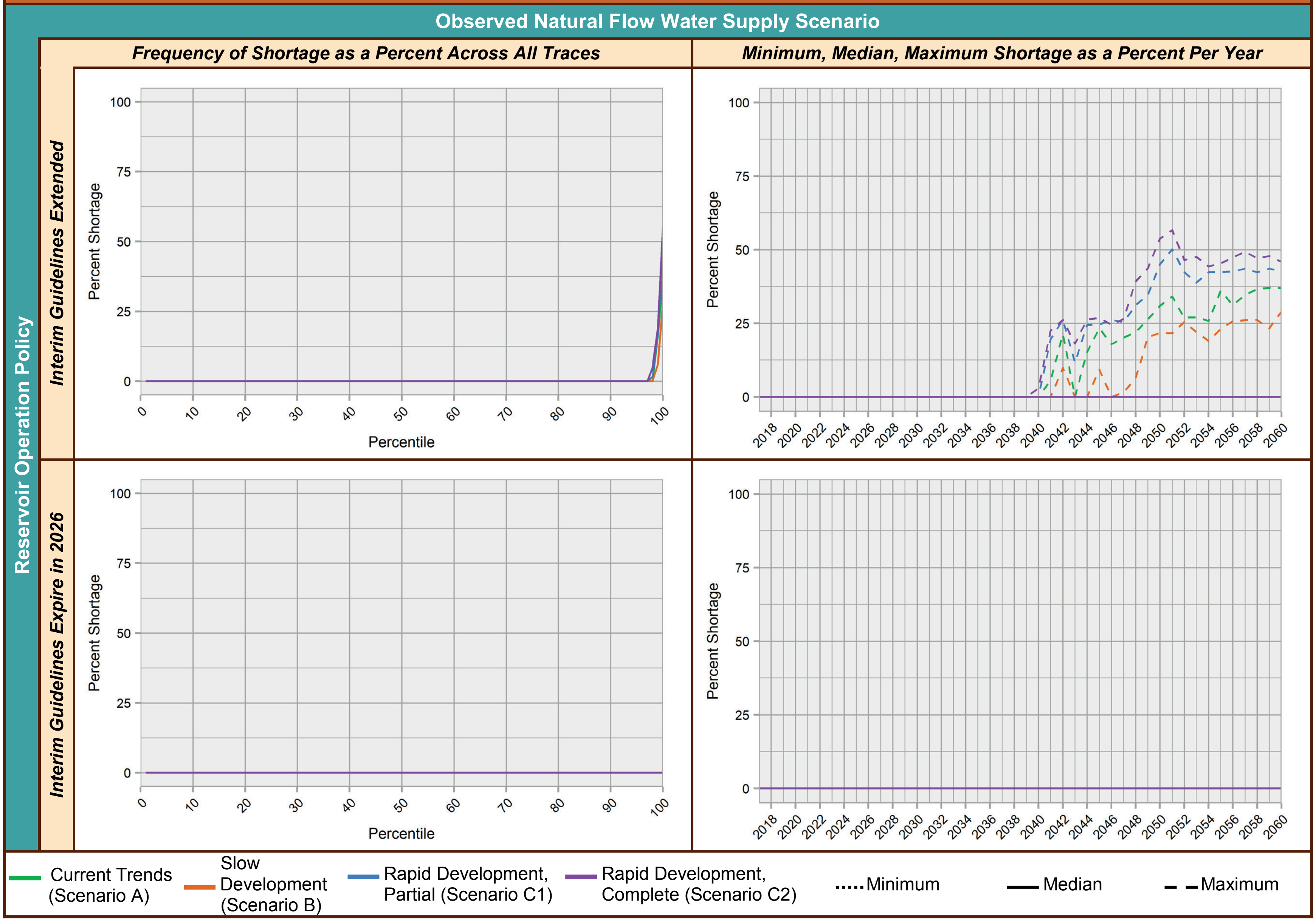
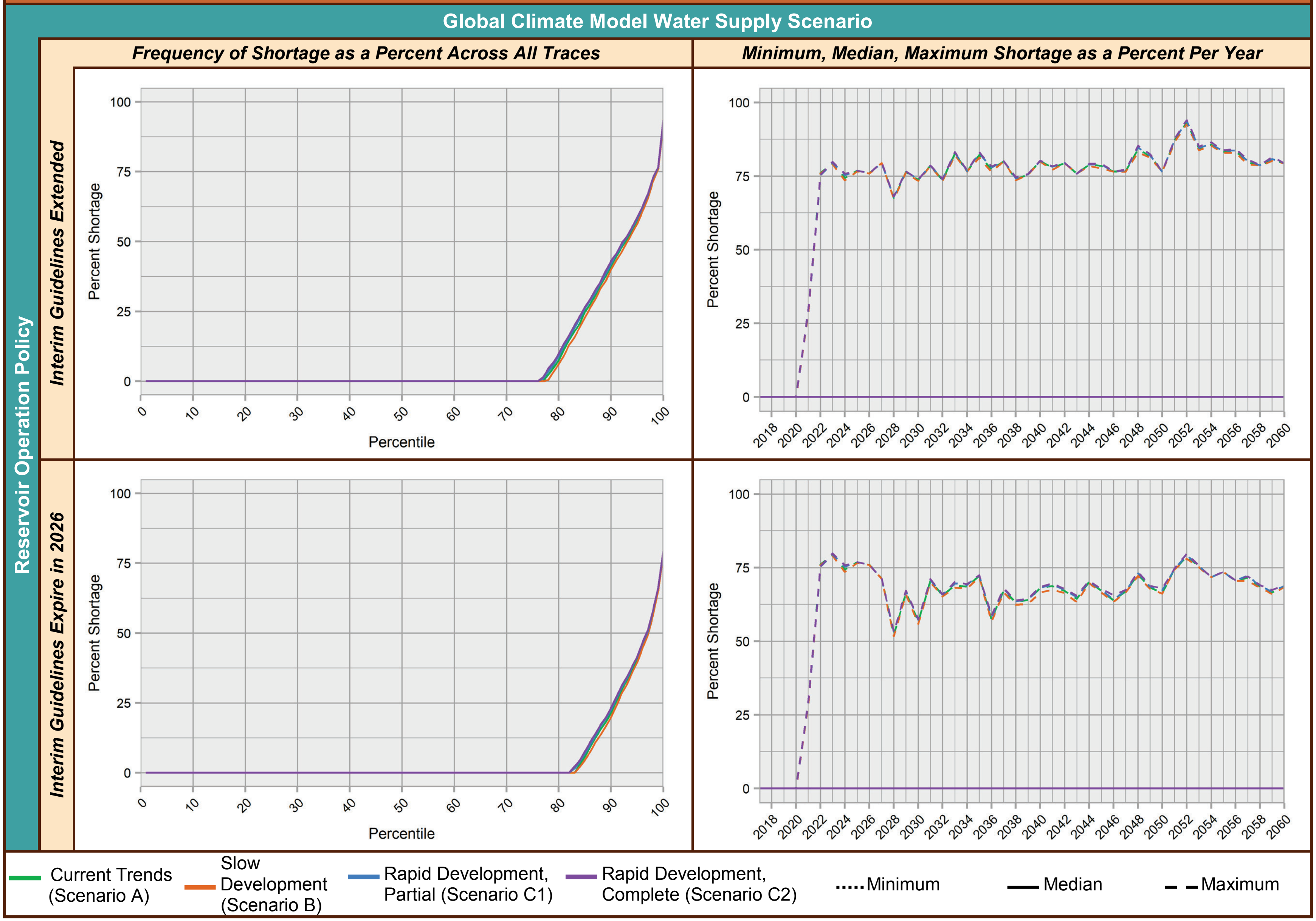


FIGURE 6-G
Lower Basin Hydrologic Shortage as Percent of Requested Consumptive Use, Global Climate Model Water Supply Scenario

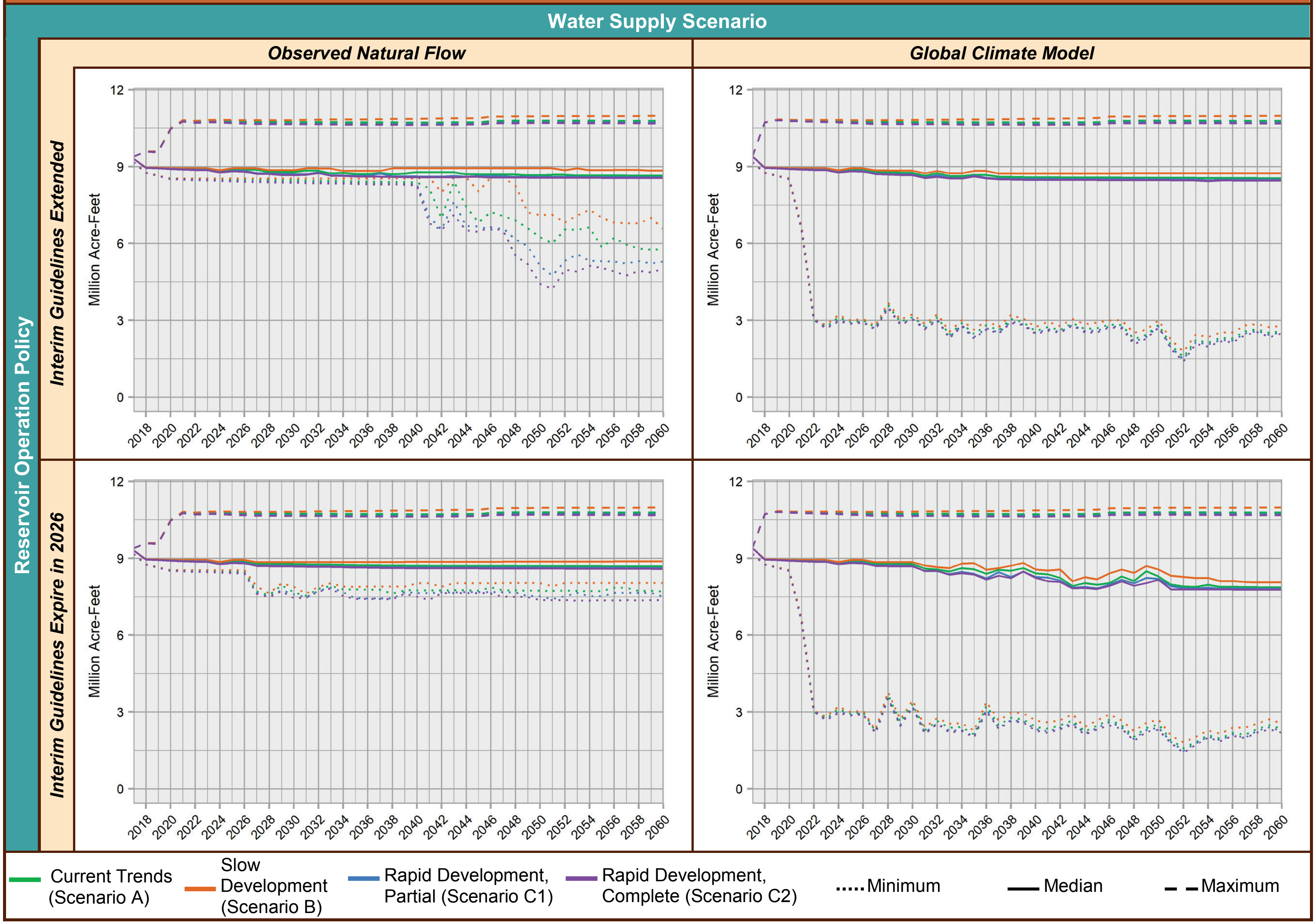


Metric – Water Deliveries to Lower Basin Non-Tribal Users

Figure 6-H shows the annual consumptive use of non-tribal water users in the Lower Basin and Mexico. Results are split out by supply scenario and reservoir operations policy, with the Observed Natural Flow supply scenario in the left panels, the Global Climate Model supply scenario in the right panels, the *Interim Guidelines Extended* policy in the top panels, and the *Interim Guidelines Expire in 2026* policy in the bottom panels.

Less of an effect was seen to non-tribal water users under Slow Water Development Trends (Scenario B) than seen in Current Water Development Trends (Scenario A), and Rapid Water Development Trends (Scenarios C1 and C2). This was because Scenarios A, C1, and C2 contain faster rates of tribal water development than Scenario B. In Figure 6-H, a slight decreasing trend is seen at the median non-tribal consumptive use across all water development scenarios, which corresponds with a shift in water use from non-tribal use to tribal use as the Lower Basin Partnership Tribes develop their water. Again, more variability was seen with respect to the Global Climate Model water supply scenario than with the tribal water development scenarios.

FIGURE 6-H
Lower Basin Non-Tribal Consumptive Use



Metric – Lower Basin Present Perfected Rights Analysis

The Partnership Tribes in the Lower Basin have some of the most senior water rights on the Colorado River, and in the event of insufficient mainstream water to satisfy all deliveries, the Secretary shall first provide for the satisfaction in full of all rights of the Chemehuevi Indian Reservation, Cocopah Indian Reservation, Fort Yuma Indian Reservation (Quechan Indian Tribe), Colorado River Indian Reservation, and Fort Mojave Indian Reservation.[1] Shortage effects on tribes are therefore dependent on the severity of the shortage in the Lower Basin versus the level of tribal water development. For example, if the Partnership Tribes developed their water to their full diversion rights and historical efficiencies were assumed, tribal water consumptive use would be 722 KAF. Therefore, the Lower Basin's shortage would have to exceed 6.78 MAF for the Partnership Tribes to be affected. Shortages greater than 6.78 MAF were seen in less than one percent of all years, and only occurred under Global Climate Model water supply scenario.

6.7 Summary

This analysis quantified the effects on the Colorado River System due to a range of future tribal water development scenarios. These water development scenarios were evaluated over two future water supply scenarios - one that assumes future streamflow will reflect what has been experienced in the past 107 years (1906-2012) and one that assumes lower average future streamflow and longer drought cycles as projected by global climate models.[2] While the Colorado River System was affected by the Partnership Tribes' development of tribal water, the future water supply scenarios had the greatest effect on the System.

In the Upper Basin, the tribal water development scenarios produced a range of Lake Powell inflow volumes by 2060, with the Observed Natural Flow supply scenario exhibiting an average annual inflow difference of 328 KAF across the tribal water development scenarios, and the Global Climate Model supply scenario exhibiting a range of 290 KAF. At Lake Powell, this translated into a 21-foot difference in elevation across the tribal water development scenarios at the 50th percentile. The effect of tribal water development on Lake Powell's elevation was more pronounced in traces that were water stressed, providing a 33 foot range across the tribal water development scenarios at the 10th percentile. However, Upper Basin shortage showed little variation due to tribal water development, and the shortage frequency and volume showed greater sensitivity to changes in water supply than it did to tribal water development.

In the Lower Basin, effects on water availability for all users due to tribal development were caused by tribal development in the Upper Basin. This is because the Lower Basin uses its full normal apportionment, and for this analysis, the Lower Basin was not allowed to deplete above that apportionment. The tribal water development in the Lower Basin was accounted for as a change in water use from non-tribal to tribal, and did not affect the overall water availability to the Lower Basin, but did affect the water availability to non-tribal users. Variations in Lake Mead elevation were seen across the tribal water development scenarios, with a 13-foot range in

---

[1] *Arizona v. California,* 547 U.S. 150, 167 (2006).

[2] Recent modeling efforts in the Colorado River Basin have focused on flows based on the climate from 1988 to 2015, which encompasses the current drought period. The average flow in the Colorado River at Lees Ferry used in the Tribal Water Study was 14.9 MAF, while the average flow for the 1988 to 2015 period was 13.2 MAF, which is 13 percent lower. The average flow 2017 through 2060 at Lees Ferry under the Global Climate Model was projected as 13.6 MAF.

elevation at the 50th percentile by 2060. Shortage volumes in the Lower Basin were primarily influenced by water supply, with little to no variation seen due to the tribal water development scenarios when modeled with the Global Climate Model supply scenario. The deliveries to non-tribal users were affected more by Current Water Development Trends (Scenario A) and two Rapid Water Development Trends (Scenarios C1 and C2) than they were by the Slow Water Development Trends (Scenario B). This is because Scenarios A, C1 and C2 included faster rates and larger volumes of tribal water development than did Scenario B.

The water supply scenarios had a noticeable influence on the metrics evaluated when the Colorado River System was water stressed. This was best exhibited with the Global Climate Model supply scenario, which contains more years of reduced supply than the Observed Natural Flow supply scenario. When the Colorado River System experienced high levels of water stress, the magnitude of shortages were large enough to minimize the influence of tribal water development seen on the metrics as compared with the water supply scenarios effects. In these instances water users in the Upper Basin, both the Partnership Tribes and non-tribal, could experience shortages regardless of the level of tribal water development. The effect of the water supply scenarios were particularly noticeable at Lake Powell. Under the Observed Natural Flow supply scenario, the range between the current, rapid, and slow water development scenarios was moderate for the Lake Powell inflow and elevation metrics. Under the Global Climate Model's supply scenario, water supplies were more stressed and the range between the tribal water scenarios for these same metrics was minimal because effects to the system were not due to tribal water development but rather due to restricted water availability.

Appendix 6A
Methodology for Conducting San Juan Sub-basin Historical Shortage Analysis

Appendix 6A – Methodology for Conducting San Juan Sub-basin Historical Shortage Analysis

The following methodology was used to estimate shortages under current and full tribal entitlement depletions in the San Juan sub-basin in Colorado for the Tribal Water Study. The State of Colorado's water resources planning model StateMod, developed as part of the Colorado Decision Support System, was used to represent the current water uses and water rights in Colorado (Colorado Water Conservation Board, 2017). StateMod is a water allocation model which determines availability of water to individual user demands and projects based on hydrology, water rights, and operational rules and practices.

StateMod's "historical" San Juan model data set, representing historical diversions and uses for the 1909 through 2013 hydrologic period, has been calibrated to confirm that the model adequately represents Colorado water administration, project operations, and water use practices. StateMod's "baseline" data set represents current uses and water rights as if they had been in place for the full 1909 through 2013 hydrologic study period. Current Southern Ute Indian Tribe and Ute Mountain Ute Tribe water uses are represented in the baseline model data based on their actual diversion location, irrigation water requirements, and water rights. Depletions and shortages are an output from the model simulation. Current depletions and shortages for both tribal and non-tribal water users were reported from the model output for the representative hydrologic years 2008 and 2012. The calibrated historical model, baseline model inputs, and results are presented in the San Juan/Dolores River Basin Water Resources Planning Model User's Manual, July 2016.

A "full tribal use" model was developed for the Tribal Water Study that included increased demands representing full use of the Southern Ute Indian Tribe's and Ute Mountain Ute Tribe's reserved water rights, with limitations based on their Consent Decrees. The non-tribal water demands were not changed from the baseline data set. Current depletions and shortages for both tribal and non-tribal water users were reported from the model output for the representative hydrologic years 2008 and 2012. Water uses under the Animas-La Plata Project are not represented in StateMod. These uses were added for the purposes of the Tribal Water Study analysis and full tribal depletion entitlements were assumed to be always met.

6 Assessment of System Effects Resulting from Development of Tribal Water

Contents

Page

Figures

Tables

Appendix

6 | Assessment of System Effects Resulting from Development of Tribal Water

6.0 Introduction

A series of modeling simulations were performed to quantify effects to the Colorado River System resulting from a range of future tribal water development scenarios. A set of system reliability metrics (for example, key reservoir elevations, water deliveries to non-tribal water users, etc.) were identified to indicate the effects to the Colorado River System resulting from future water development by the Partnership Tribes.

This chapter describes the approach for conducting the effects assessment and an analysis of the results.

Key Terms

Key terms used in this chapter are defined below.

Colorado River System – The portion of the Colorado River and its tributaries within the United States.

Diversion point – Location on the Colorado River or its tributaries at which water is diverted for depletion or consumptive use.

Hydrologic shortage – Unmet demand that is not the result of any policy, such as prescribed shortage delivery reductions.

Natural inflow – Calculated as gaged flow corrected for the effects of upstream reservoirs and depletions.

Policy shortage – Unmet demand that is the result of a policy, such as prescribed shortage delivery reductions.

Simulation set – A collection of model simulations that share the same Tribal Water Development Scenario, Water Supply Scenario, and Reservoir Operation Policy.

System reliability metrics – Measurements that indicate the ability of the Colorado River System to meet water delivery needs under multiple future conditions.

Trace – A single model simulation

6.1 Approach

A framework was developed to assess the effects on the Colorado River System from varying levels of future tribal water development based on the Partnership Tribes' water development scenarios coupled with different hydrologic supply scenarios. The assessment approach adopted for the Tribal Water Study is similar to that used in the Colorado River Basin Water Supply and Demand Study (Basin Study) (Reclamation, 2012). This assessment was performed by following a five-step approach:

1. Identify tribal water development scenarios
2. Develop metrics to measure system effects
3. Configure Colorado River Simulation System (CRSS)
4. Develop modeling assumptions
5. Analyze results

6.1.1 Colorado River Simulation System

The simulation of the Colorado River System under the tribal water development scenarios prepared for the Tribal Water Study was performed using CRSS. CRSS is Reclamation's primary long-term planning tool for studying river operations and projected future demand in the Basin. CRSS is implemented in the commercial modeling software RiverWare™ developed by the University of Colorado (Zagona et al., 2001).

CRSS simulates the operation of the major reservoirs on the Colorado River and provides information regarding the projected future state of the system on a monthly basis. Output variables include the amount of water in storage, reservoir elevations, releases from the dams, the amount of water flowing at various points throughout the system, and diversions to and return flows from water users throughout the system. The simulation centers around a mass balance (or water budget) calculation which accounts for water entering the system, stored in the system, and leaving the system under different policy scenarios.

The model input for the Tribal Water Study included monthly natural inflows, various physical process parameters such as evaporation rates for each reservoir, and future diversion and depletion schedules for water users in the Basin States and the United Mexican States (Mexico). Policy "rulesets" allow CRSS to simulate the operation of the Colorado River mainstream reservoirs, including Lake Powell and Lake Mead, and allow projections of water depletion under different hydrologic scenarios.

6.1.2 Five-Step Approach

A five-step approach was used to assess potential effects to the Colorado River System resulting from future tribal water development. The following is a brief summary of each step and a description of how each fits within the overall assessment. These steps are described in detail in the identified sections.

Step 1 – Identify Tribal Water Development Scenarios (Section 6.2)

Four future water development planning scenarios were identified collaboratively with the Partnership Tribes as detailed in *Chapter 4 – Methodology for Assessing Current Tribal Water Use and Projected Future Water Development*. The identified planning scenarios were Current Water Development Trends (Scenario A), Slow Water Development Trends (Scenario B), and Rapid Water Development Trends (Scenarios C1 and C2). The tribal water development schedules were quantified to represent four plausible outcomes for future water development for the period from 2017 through 2060. The future water development schedules for each Partnership Tribe are presented in *Chapter 5 – Assessment of Current Tribal Water Use and Projected Future Water Development.*

Step 2 – Develop Metrics to Measure System Effects (Section 6.3)

Key system reliability metrics (metrics) that could be evaluated from CRSS output were identified to help understand effects to the system from future tribal water development. System reliability metrics considered in this Study included the ability to meet water delivery needs throughout the Basin under multiple future conditions.

Step 3 – Configure Colorado River Simulation System (Section 6.4)

CRSS and its associated inputs were configured to evaluate the Tribal Water Study metrics outlined in Step 2. These configurations included disaggregating the four tribal water development schedules for each Partnership Tribe as inputs in CRSS along with minor structural changes in CRSS to model Tribes' water use more accurately.

Step 4 – Develop Modeling Assumptions (Section 6.5)

Several modeling assumptions were needed to fully describe required model inputs. These assumptions included initial reservoir conditions, future water supply scenarios, reservoir operation policies, tribal water development schedules, and future water demand schedules for other water users.

Step 5 – Analyze Results (Section 6.6)

The metrics identified by Step 2 were evaluated and analyzed. To evaluate the metrics, CRSS was run using the Tribal Water Study's model configuration and assumptions. CRSS is a probabilistic model, so there are multiple future simulations analyzed for each metric. To understand the results, an analysis was conducted across the CRSS simulation outputs. Statistics for each metric were computed in order to explore how a metric changes in response to tribal water development, water supply, and reservoir operations policy.

6.2 Identify Tribal Water Development Scenarios

As previously described in *Chapter 4 – Methodology for Assessing Current Tribal Water Use and Projected Future Water Development*, four tribal water development scenarios were developed to capture the range of potential future water development for the Partnership Tribes. These scenarios incorporate the key influencing factors, and account for how these factors would be influenced under each scenario, given the scenario's respective theme. The scenarios and associated themes are listed below.

- **Current Water Development Trends (Scenario A)** – Current trends in on-reservation water development, governance, funding, and resolution of tribal claims remain the same.
- **Slow Water Development Trends (Scenario B)** – Decreased flexibility in governance of tribal water, levels of funding, and resolution of tribal claims slow tribal economic development. This results in a decline in the standard of living and delays resolution of tribal claims.
- **Rapid Water Development Trends (Scenarios C1 and C2)** – Increased flexibility in governance of tribal water allows innovative water development opportunities and increased funding availability leads to tribal economic development. This results in an increase in the standard of living, thereby contributing to the fulfilment of the purpose of the reservation as a homeland and supporting the future needs of tribal communities. Scenario C1 considers partial resolution of claims and/or implementation of decreed or settled rights; and Scenario C2 considers complete resolution of claims and implementation of decreed or settled rights within the Study timeframe.

6.3 Develop Metrics to Measure System Effects

Metrics were developed in collaboration with the Partnership Tribes to identify potential effects of tribal water development on the Colorado River System and non-tribal water users. Taking into account CRSS limitations, metrics were identified for both the Upper Basin and Lower Basin including water delivery shortages, Lake Powell inflow, Lake Powell elevation, Lake

Mead elevation, and water deliveries to non-tribal water users. Shortages were not evaluated on a per-tribe or a single water user basis, rather they are reported at the basin or sub-basin level. A majority of these metrics could be evaluated directly in CRSS; however, some required additional analysis of CRSS output or exploration of models other than CRSS such as StateMod, the State of Colorado's surface water allocation and accounting model capable of simulating various historical and future water management policies in a river basin (Colorado Water Conservation Board, 2017) .

The Tribal Water Study metrics are presented in Table 6-A, and described below.

TABLE 6-A
Metrics for Upper and Lower Basin System Effects Analysis

	Variable	Measurement	Source
Upper Basin Metrics	Inflow to Lake Powell	Volume in acre-feet per year	CRSS Output
	Lake Powell Elevation	Elevation in feet above mean sea level	CRSS Output
	Upper Basin Shortage	Volume in acre-feet per year Frequency of shortage volume per year	CRSS Output
	San Juan Sub-basin Historical Shortage Analysis	Volume in acre-feet per year	Additional Analysis
Lower Basin Metrics	Lake Mead Elevation	Elevation in feet above mean sea level	CRSS Output
	Lower Basin Hydrologic Shortage	Volume in acre-feet per year Frequency of shortage volume per year	CRSS Output
	Water Deliveries to Lower Basin Non-Tribal Users	Volume in acre-feet per year	CRSS Output
	Lower Basin Present Perfected Rights Analysis	N/A	Additional Analysis

6.3.1 Upper Basin Metrics and Analyses

Inflow to Lake Powell

The volume of water flowing into Lake Powell in acre-feet per year (AFY), as simulated by CRSS. This volume was calculated on an annual time step, at the end of each calendar year.

Lake Powell Elevation

The annual December 31st elevation at Lake Powell (feet above mean sea level [msl]).

Upper Basin Shortage

Upper Basin water delivery shortage was defined as the total requested diversion minus actual diversion in a given year for sub-basins that include water use by Partnership Tribes. These sub-basins include the Green River Basin, San Juan River Basin, and the sub-basin composed of intervening flows above Lake Powell and below the San Juan River, San Rafael River, Green River, and Colorado River Basin near Cisco, Utah. Upper Basin shortage was calculated with respect to total requested diversion because Indian reserved water rights are typically diversion-based in the Upper Basin. Shortages were tracked for both Partnership Tribes and non-tribal water users and analyzed as an aggregate annual percent shortage of the requested water diversion. This percent was calculated by dividing the shortage volume by the requested diversion and multiplying by 100. These annual percent shortages were evaluated by frequency across all traces and the annual minimum, median, and maximum percent shortage of total requested diversion.

San Juan Sub-basin Historical Shortage Analysis

A limitation of CRSS is that it does not represent individual water rights and therefore may not accurately represent the distribution of water delivery shortages to Partnership Tribes versus non-tribal water users.

The San Juan sub-basin and its tributaries were selected to illustrate what effects could occur in the Upper Basin in times of shortage because tribes in this sub-basin have complex reserved water rights as set forth in tribal decrees filed in Colorado Water Division 7 (see *Chapter 5 – Assessment of Current Tribal Water Use and Projected Future Water Development* for additional detail). Additional analysis was performed based on output from the State of Colorado's water allocation and accounting model, StateMod. Water deliveries in Colorado's portion of the San Juan sub-basin for calendar years 2008 and 2012, which represent recent years with relatively high and low water supplies in the Colorado River Basin, respectively, were modeled with StateMod to identify where shortages occurred and how Partnership Tribes, specifically the Southern Ute Indian Tribe and Ute Mountain Ute Tribe, and non-tribal water users were affected. Water demands for tribal users were then increased to each tribes' full San Juan sub-basin reserved water right, and the StateMod model was run again with the 2008 and 2012 hydrology. Results were analyzed to determine how water deliveries changed between the two model runs. New Mexico water deliveries from the San Juan sub-basin and its tributaries were not included in this analysis. *Appendix 6-1 – Methodology for Conducting San Juan Sub-basin Historical Shortage Analysis* describes the methodology used to estimate historical shortages under current and development of full Indian reserved water rights in the San Juan Sub-basin in Colorado.

6.3.2 Lower Basin Metrics and Analyses

Lake Mead Elevation

The annual December 31st elevation at Lake Mead (feet above mean sea level [msl]).

Lower Basin Hydrologic Shortage

In CRSS, shortage is divided into two portions, hydrologic shortage and policy shortage. Hydrologic shortage is defined as the unmet demand in the Lower Basin and Mexico that is not the result of any policy, such as the prescribed shortage delivery reductions in the *Record of Decision for Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead* (2007 Interim Guidelines) (DOI, 2007) or Intentionally Created Surplus (ICS) activity. For example, under the 2007 Interim Guidelines, policy shortages for the Lower Basin are based upon Lake Mead's elevation, which is divided into three levels. If there is demand for 9.0 million acre-feet per year (MAFY) of water from the Lower Basin States and Mexico, but Lake Mead is below 1,025 feet, and only able to deliver 8.0

MAF of water, there would be a total hydrologic shortage of 1.0 MAF. Under the 2007 Interim Guidelines, Lake Mead would be operating under a level three shortage and annual deliveries to the Lower Basin would be reduced by 625 thousand acre-feet (KAF). This policy shortage would account for 625 KAF of the 1.0 MAF shortage volume, and the remaining 375 KAF of shortage would be labeled hydrologic shortage. For the hydrologic shortage analysis, shortages were not broken out by state or by tribal and non-tribal water users but reported as total Lower Basin and Mexico shortage because CRSS does not account for how shortage would affect individual water users. Shortages in the Lower Basin are calculated with respect to total requested consumptive use. Shortages were analyzed as an aggregate annual percent shortage of the requested consumptive use. This percent was calculated by dividing the shortage volume by the requested consumptive use, and multiplying by 100. These annual percent shortages were evaluated by frequency across all traces and the annual minimum, median, and maximum percent shortage of total requested consumptive use.

Water Deliveries to Lower Basin Non-Tribal Users

Water deliveries to non-tribal water users are defined as consumptive use by non-tribal water users in the Lower Basin and Mexico. This metric was not broken out by water user but reported as a combined Lower Basin and Mexico value. Water deliveries to non-tribal users were computed by summing all consumptive use in the Lower Basin plus Mexico and subtracting the Lower Basin Partnership Tribes' consumptive use per the tribal water development schedules for that year.

Lower Basin Present Perfected Rights Analysis

In the Lower Basin, additional post processing was performed to better understand the Present Perfected Rights (PPRs) of Lower Basin Partnership Tribes, and the effect of water delivery shortages to Partnership Tribes. Analysis of this metric explored whether the hydrologic shortage magnitude is great enough to affect tribal PPR water rights holders and was performed as a qualitative discussion of potential effects on Partnership Tribes under existing law.

6.4 Configure Colorado River Simulation System

For use in CRSS, the Partnership Tribes' future water development schedules were disaggregated by each tribe's diversion points as currently represented in CRSS. The disaggregation was determined by analyzing tribal use by sub-basin in the Upper Basin, and by state in the Lower Basin, with the assistance of each tribe.

To include the Partnership Tribes' water development schedules in CRSS, each Upper Basin reach and Lower Basin State were matched to the corresponding tribal water diversion points within CRSS. For some Partnership Tribes, assumptions had to be used to disaggregate their water use because of a limited availability of information. The first disaggregation approach used a ratio methodology and was applied when future use information by reach was limited. In this case, water use schedules for Slow Water Development Trends (Scenario B), and Rapid Water Development Trends Scenarios (C1 and C2) were assigned for each diversion point by preserving the Current Water Development Trends (Scenario A) water use ratio. For example, if a tribe has two agricultural water diversions on a reach, under Scenario A, 30 percent of the total agricultural water use was assigned to the tribe's first diversion point and 70 percent to the tribe's second diversion point. For all other scenarios, the future agricultural water use was disaggregated over the two diversion points using this same ratio. The second disaggregation approach was used when there were multiple types of water use at a single diversion point for a tribe. This methodology maintained the ratios of water use types currently in the official CRSS model, which presently relies on the 2007 Upper Colorado River Commission (UCRC) schedule provided by the Upper Division States for all of the future water development scenarios. In both approaches, total water use in a given reach or state was not allowed to exceed the Partnership Tribe's quantified water right for that reach or state.

For non-tribal diversion points in CRSS, water use schedules were broken out from annual to monthly time steps by distributing annual water use to each month based on the monthly coefficients from the original CRSS water use schedules before adding the tribal water development schedules.

A structural change was made to CRSS to improve water delivery priority modeling on the Duchesne River, Utah. Because the Ute Indian Tribe has a senior water right on the Duchesne River, their diversion point was moved from the aggregate reach located below the Starvation Reservoir to the aggregate reach above the Starvation Reservoir. This configuration ensured that the Tribe's demands were met before non-tribal demands.

6.5 Develop Modeling Assumptions

As with any modeling effort, assumptions needed to be made to use the model. Some assumptions made for this analysis included the model simulation period and initial reservoir conditions. Key model simulation assumptions included future hydrology (using multiple future water supply scenarios, described below), water demands, and reservoir operations policy. These assumptions are similar to those incorporated into the Basin Study modeling efforts.

The modeling simulation period selected was from January 2017 through December 2060. CRSS simulations must begin in January due to model constraints and because it was not yet January 2017 when modeling occurred, a projection of Colorado River System conditions was needed. Reservoir starting conditions for CRSS were taken from Reclamation's *Operation Plan for Colorado River System Reservoirs, August 2016 24-Month Study Report* (Reclamation, 2016) and are consistent with the Lake Powell and Lake Mead initial reservoir conditions used for the August 2016 CRSS simulation as reported in, *The Colorado River System: Projected Future Conditions 2017-2021,* (Reclamation, 2016b).

Modeling assumptions included future water supply, water demands, and reservoir operations policy. The future water supply scenarios selected from the Basin Study for the Tribal Water Study were the Observed Natural Flow and the downscaled Global Climate Model scenarios. The Observed Natural Flow scenario was selected because it captures the recently updated observed historical flows. The Global Climate Model scenario was selected because it provides the largest plausible range of future natural flows in terms of both magnitude and length of sequences of wet and dry spells. The Observed Natural Flow water supply scenario assumes that future hydrologic trends and variability are similar to the past approximately 100 years. It uses the indexed sequential method (Ouarda et al., 1997) to resample the observed natural flow data from the historical natural flow record. This method can only generate hydrology inputs with observed flow magnitudes and sequences, and preserves historical data statistics. The Global Climate Model water supply scenario assumes that future climate will continue to warm with regional precipitation and temperature trends represented through an ensemble of future downscaled global climate model projections and simulated hydrology. The Global Climate Model scenario contains traces from 16 general circulation models with three emissions scenarios, and provides runoff projections based on the World Climate Research Program's Coupled Model Intercomparison Project Phase 3 (CMIP3) (Maurer et al., 2007) projected climate assumptions (see Basin Study, *Technical Report B – Water Supply Assessment* [Reclamation, 2012a]).

Water demands were represented for the Partnership Tribes and non-tribal water users. The Partnership Tribes used their individually-identified water development schedules (Current Water Development Trends [Scenario A]; Slow Water Development Trends [Scenario B]; Rapid Water Development Trends [Scenarios C1 and C2]). Non-tribal water users' demands were held consistent throughout all four water development scenarios ensuring that differences in model results between scenarios were only the result of future water development by the Partnership Tribes. The Upper Basin non-tribal demands were obtained from the 2007 UCRC schedule. The Lower Basin non-tribal demands were those used for the 2007 Interim Guidelines. Lower Basin non-tribal demands were increased or decreased for each tribal water development schedule to ensure consumptive use in the Lower Basin did not exceed the annual normal apportionment, giving the Lower Basin States an annual scheduled consumptive use volume of 7.5 MAF.

Two different reservoir operation policy sets were evaluated. Both policy sets operated Lake Powell and Lake Mead according to the 2007 Interim Guidelines between 2017 through 2026. After the expiration of the 2007 Interim Guidelines in 2026, two operational assumptions were considered. The first was that the Shortage, Surplus, and Coordinated Operations provisions of the 2007 Interim Guidelines would be extended through the Tribal Water Study's timeframe of 2060 (*Interim Guidelines Extended* policy). The second was that the operating rules revert to the rules of the No Action Alternative from the *Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead Final Environmental Impact Statement* (2007 Interim Guidelines Final EIS) (Reclamation, 2007) (*Interim Guidelines Expire in 2026* policy). These two reservoir operation policy sets were also used for the Basin Study analysis.

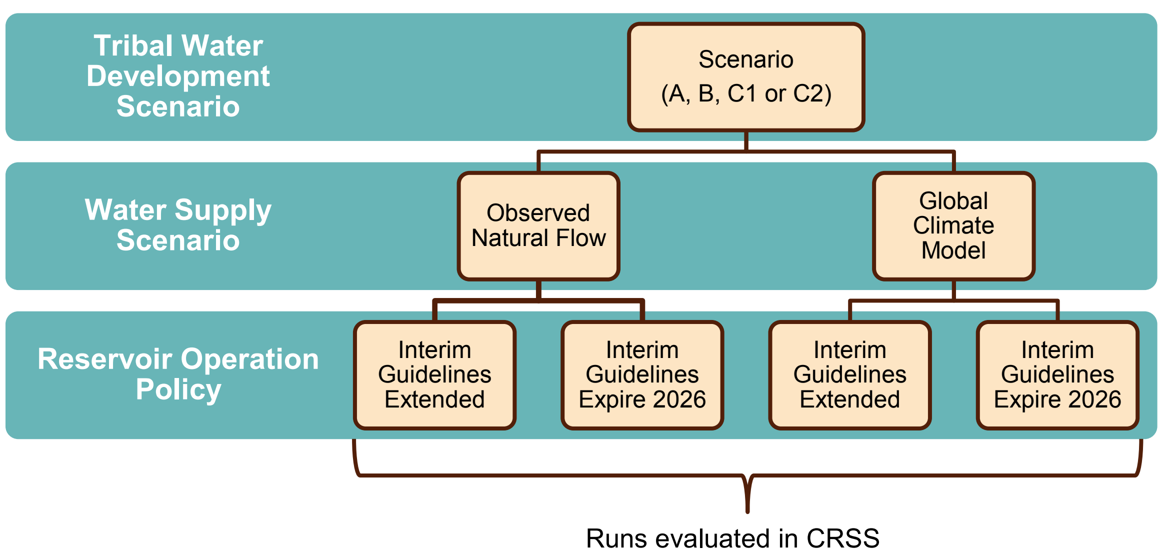
The reservoirs upstream of Lake Powell were operated to meet specific targets reflecting each reservoir's respective Record of Decision (ROD) for the entire modeling simulation period. Taylor Park, and Starvation reservoirs were operated in accordance with their existing rule curves (see *Appendix A, CRSS Model Documentation* [Reclamation, 2007]), but Fontenelle's operations rules in CRSS have been updated since the 2007 Interim Guidelines (Reclamation, 2012). In CRSS, the Aspinall Unit operations do not yet reflect the Record of Decision for the Aspinall Unit Operations Final Environmental Impact Statement (Reclamation, 2012b), and were operated in accordance with their previous rule curves, as published in the 2007 Interim Guidelines Final EIS) (see *Appendix A, CRSS Model Documentation* [Reclamation, 2007]). The operations rules for Navajo and Flaming Gorge reservoirs were modified in CRSS to meet specified downstream flow targets in accordance with the rules laid out in their respective RODs (Reclamation, 2006a and 2006b).

The four tribal water development scenarios were modeled with both water supply scenarios, and both reservoir operation policies, as shown in Figure 6-A. That is, each water development scenario was run with:

- Observed Natural Flow water supply scenario
  - *Interim Guidelines Extended* policy
  - *Interim Guidelines Expire in 2026* policy
- Global Climate Model water supply scenario
  - *Interim Guidelines Extended* policy
  - *Interim Guidelines Expire in 2026* policy

This provided a total of 4 simulation sets for each water development scenario. These four simulation sets were repeated for the four water development scenarios, which provided 16 simulation sets with a combined total of 1,752 simulations, also termed 'traces', which were evaluated in the analysis. Each trace reflected one combination of supply, development, and reservoir operation policy. Traces were grouped to explore the effects of tribal water development under the water supply scenarios, the tribal water development scenarios, and the reservoir operation policies.

FIGURE 6-A
Conceptual Representation of the Modeling Performed for a Given Development Scenario



6.6 Analyze Results

Upon configuring and simulating with the model, the 16 simulation sets provided 1,752 traces of data for analysis. These data were grouped by water supply scenario, tribal water development scenario, and reservoir operation policy and were analyzed for each metric to assess the effect of each tribal water development scenario. The following results are divided by Upper and Lower Basin, and contain the metrics and the results for the corresponding basin.

6.6.1 Upper Basin Modeling Results

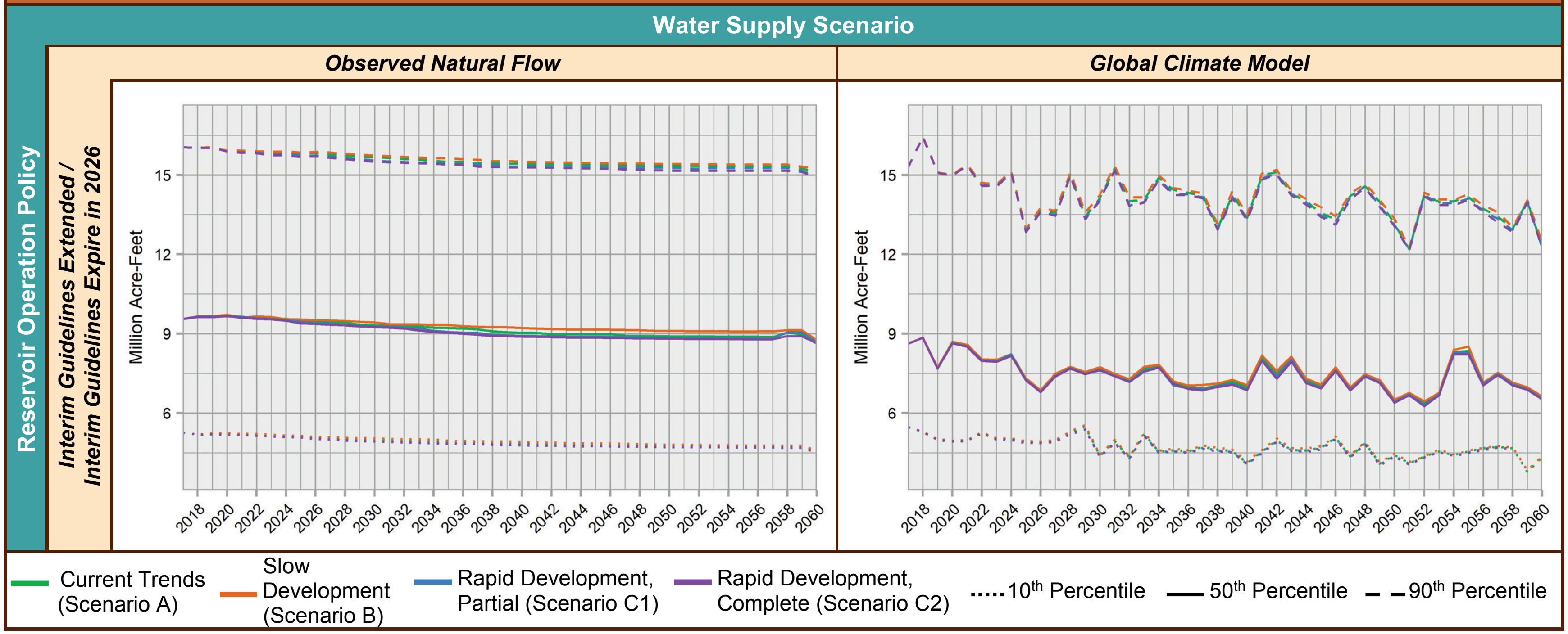
Figure 6-B is organized by supply scenario and Figure 6-C is organized by supply scenario and reservoir operations policy, with the Observed Natural Flow supply scenario used in the panels on the left, the Global Climate Model supply scenario used in the panels on the right, the *Interim Guidelines Extended* policy used in the panels on the top and the *Interim Guidelines Expire in 2026* policy used in the panels on the bottom. Figure 6-D is organized by supply scenario with the Observed Natural Flow supply scenario in the top panels and the Global Climate Model supply scenario in the bottom panels and further split by aggregate annual percent shortage as a frequency in the left panels, and as the minimum, median, and maximum aggregate annual shortage percent in the right panels.

Metric – Inflow to Lake Powell

Figure 6-B shows the inflow into Lake Powell across the model results. By 2060, the volume of water flowing into Lake Powell had annual ranges of 328 KAF for the Observed Natural Flow supply scenario (left panel) and 290 KAF (right panels) for the Global Climate Model supply scenario (right panels). These ranges resulted from differences between the inflow volume for Slow Water Development Trends (Scenario B), and Rapid Water Development Trends, Complete (Scenario C2). These scenarios define the range because they exhibit the slowest (Scenario B) and most rapid (Scenario C2) rates of tribal water development. A larger inflow volume range was experienced across water supply scenarios than across development scenarios, indicating the water supply scenarios exhibit more influence on inflow volume into Lake Powell than the tribal water development scenarios.

For this metric, the inflows for each water supply scenario do not vary by reservoir operating policy because these policies do not affect reservoir operations above Lake Powell. Therefore, Figure 6-B only shows results for the two water supply scenarios.

FIGURE 6-B
Annual Inflow into Lake Powell (2017 – 2060)



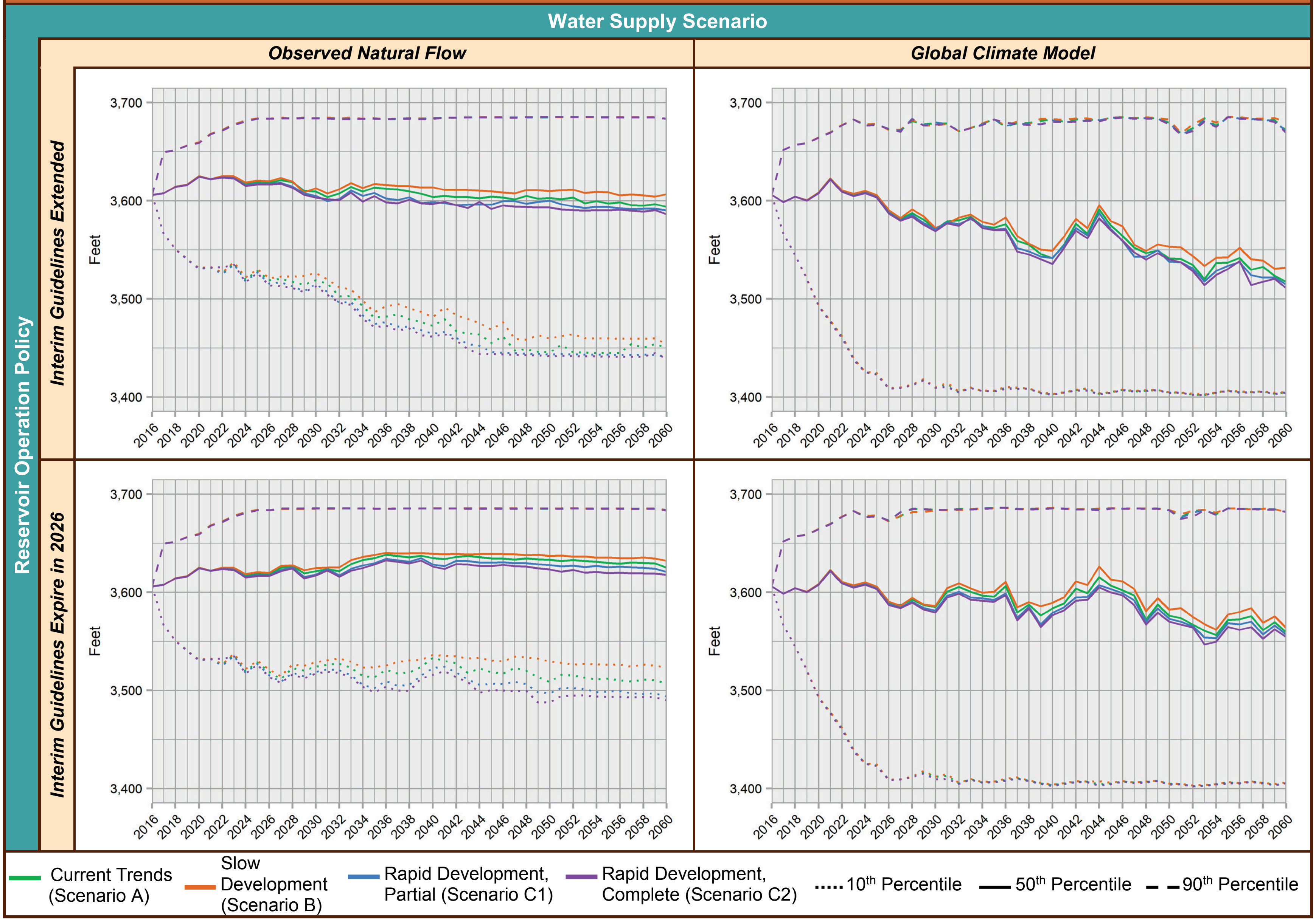
Metric – Lake Powell Elevation

Figure 6-C shows Lake Powell elevation across results. At the 50th percentile (solid line), the tribal water development schedules show a range of Lake Powell elevations. This range was bounded by Slow Water Development Trends (Scenario B), and Rapid Water Development Trends, Complete (Scenario C2), and displays differences in elevation as large as 21 feet by 2060. This difference was due to Upper Basin tribal water development.

Differences in elevations across the Observed Natural Flow supply scenario are more pronounced when Lake Powell is at lower water levels, such as those seen in the 10th percentile (dotted line). The 10th percentile represents the lowest 10% of elevations seen in the results for a given year. In Figure 6-C, the 10th percentile exhibits a range of 33 feet in the difference between Slow Water Development Trends (Scenario B) and Rapid Water Development Trends, Complete (Scenario C2), which again bound this range, by 2060. This comparison indicates that the system is more affected by Upper Basin tribal water development when water supplies are low.

Under the Global Climate Model scenario, the 10th percentile (dotted line) displays little effect from Upper Basin tribal water development, resulting in little to no range across the tribal water development scenarios. Under the Global Climate Model supply scenario this occurs because Lake Powell elevation is constrained as the reservoir approaches the dead pool elevation (3,370 feet), when the reservoir is unable to release water downstream.

FIGURE 6-C
Annual Lake Powell Elevation (2017 – 2060)

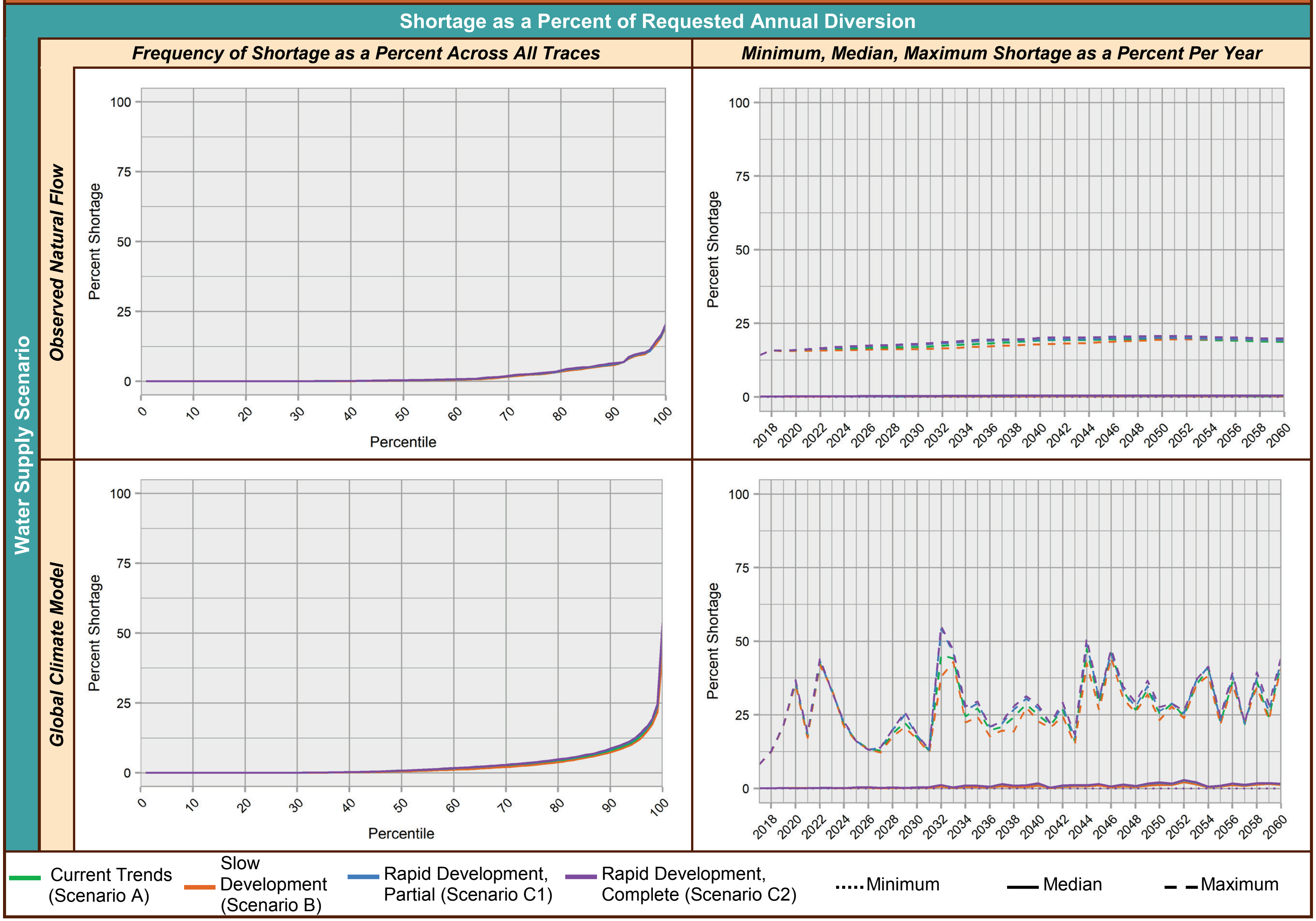


Metric – Upper Basin Shortage

Figure 6-D shows the aggregate annual percent shortage. The percent shortage represents the percent of the requested annual diversion that was not delivered. This metric provides context regarding the severity of the shortage volume with respect to demand. The left panels show the percent shortage as a frequency across all traces and the right panels show the annual minimum, median, and maximum percent shortage in the Upper Basin, seen across all impacted Upper Basin sub-basins. These sub-basins include the Green River and San Juan sub-basins, and their intervening flows. This shortage is shown as a percent of annual diversion requested. Results are further split out by supply scenario, with the Observed Natural Flow supply scenario in the top two panels and the Global Climate Model supply scenario in the bottom two panels. Because the modeled reservoir operation policies do not effect reservoir operations above Lake Powell, the results produced by both policy sets are identical for each supply scenario.

The Upper Basin experiences some level of shortage in all years because its water supplies are more dependent on natural streamflows, which are fed directly by snowpack and rainfall, and are affected by localized drought patterns. Across the development schedules, the Upper Basin Shortage metric showed greater variability due to water supply than to tribal water development, with little difference seen between the development schedules.

FIGURE 6-D
Upper Basin Percent Shortage of Diversion Requested



San Juan Sub-basin Historical Shortage Analysis

Tables 6-B and 6-C shows the depletion and shortage volumes for both tribal and non-tribal water use within Colorado's San Juan sub-basin for the years 2008 and 2012, respectively, as modeled using the State of Colorado's water allocation and accounting model, StateMod. Both the Southern Ute Indian Tribe and the Ute Mountain Ute Tribe have water rights in this sub-basin within the State of Colorado. Water uses within the New Mexico portion of the San Juan Basin were not considered for this analysis. Using each year's historical hydrology, water use was first modeled with the given year's actual tribal and non-tribal water use, and then a second model run was performed, in which tribal water use was increased to the Tribes' full reserved water right. This analysis was performed for both 2008 and 2012. The results were grouped geographically, with water use above the Archuleta USGS stream gage comprising one grouping, and water use between the Archuleta and Bluff USGS stream gage comprising the second grouping.

In the San Juan sub-basin, the year 2008 was a relatively wet year and the year 2012 was a relatively dry year. When compared to the average flow for the past 30 years (1985 to 2014), the year 2008 saw flows 134 percent greater than the average flow at the Archuleta stream gage and 122 percent greater at the Bluff stream gage. In contrast, the year 2012 saw flows 52 percent lower than average at the Archuleta stream gage and 48 percent lower at the Bluff stream gage. When moving from 2008 observed water use to the full development of tribal rights, the Tribes' water use increases, with depletions above Archuleta more than twice as large, and depletions from Archuleta to Bluff more than four times as large. Full development of tribal water rights did not cause additional tribal shortages above Archuleta; however non-tribal shortages increased by 246 acre-feet (AF) from the 2008 observed water use to the full development of tribal water rights, and increased by 6,310 AF in the 2012 analysis. From Archuleta to Bluff, the non-tribal shortages increased by 6,678 AF from the 2008 observed water use to the full development of tribal water rights, and increased by 13,571 AF in the 2012 analysis. Tribal shortages were also experienced in the Archuleta to Bluff reach when the Tribes' use was increased to full development of water rights, with the Ute Mountain Ute Tribe experiencing 3,681 AF of shortage in the 2008 and 2012 analyses. The non-tribal shortages seen in the 2012 analysis were larger than those seen in the 2008 analysis by approximately 20 to 24 percent, as the year 2012 experienced relatively dry conditions for the San Juan sub-basin.

TABLE 6-B
San Juan Basin in Colorado Depletion and Shortage Volumes for Tribal and Non-Tribal Water Users – 2008

Location	Tribal Depletions	Non-Tribal Depletions	Total Depletions	Tribal Shortages	Non-Tribal Shortages	Total Shortages
2008 Current Use Results – San Juan and tributaries in Colorado (AF)						
Above Archuleta	19,778[1]	128,121	147,889	0	3,155	3,155
Shortage as Percent of Use				*0%*	*14%*	*2%*
Archuleta to Bluff	15,808[2]	176,326	192,134	0	17,773	17,773
Shortage as Percent of Use				*0%*	*9%*	*8%*
2008 Tribal Full Water Right Use Results – San Juan and tributaries in Colorado (AF)						
Above Archuleta	42,656[1]	127,875	170,530	0	3,401	3,401
Shortage as Percent of Use				*0%*	*3%*	*2%*
Archuleta to Bluff	65,060[3]	168,648	233,708	3,681[4]	24,451	29,132
Shortage as Percent of Use				*5%*	*13%*	*11%*

[1] Southern Ute Indian Tribe
[2] 12,863 AF Ute Mountain Ute Tribe; 2,945 AF Southern Ute Indian Tribe
[3] 44,074 AF Ute Mountain Ute Tribe; 20,986 AF Southern Ute Indian Tribe
[4] Ute Mountain Ute Tribe Shortages

TABLE 6-C
San Juan Basin in Colorado Depletion and Shortage Volumes for Tribal and Non-Tribal Water Users – 2012

Location	Tribal Depletions	Non-Tribal Depletions	Total Depletions	Tribal Shortages	Non-Tribal Shortages	Total Shortages
2012 Current Use Results – San Juan and tributaries in Colorado (AF)						
Above Archuleta	19,778[1]	95,117	114,895	0	26,637	26,637
Shortage as Percent of Use				*0%*	*22%*	*19%*
Archuleta to Bluff	15,808[2]	148,619	164,427	0	59,727	59,727
Shortage as Percent of Use				*0%*	*29%*	*27%*
2012 Tribal Full Water Right Use Results – San Juan and tributaries in Colorado (AF)						
Above Archuleta	42,656[1]	88,807	131,463	0	32,947	32,947
Shortage as Percent of Use				*0%*	*27%*	*20%*
Archuleta to Bluff	65,060[3]	135,048	200,108	3,681[4]	73,298	76,979
Shortage as Percent of Use				*5%*	*35%*	*28%*

[1] Southern Ute Indian Tribe
[2] 12,863 AF Ute Mountain Ute Tribe; 2,945 AF Southern Ute Indian Tribe
[3] 44,074 AF Ute Mountain Ute Tribe; 20,986 AF Southern Ute Indian Tribe
[4] Ute Mountain Ute Tribe Shortages

6.6.2 Lower Basin Modeling Results

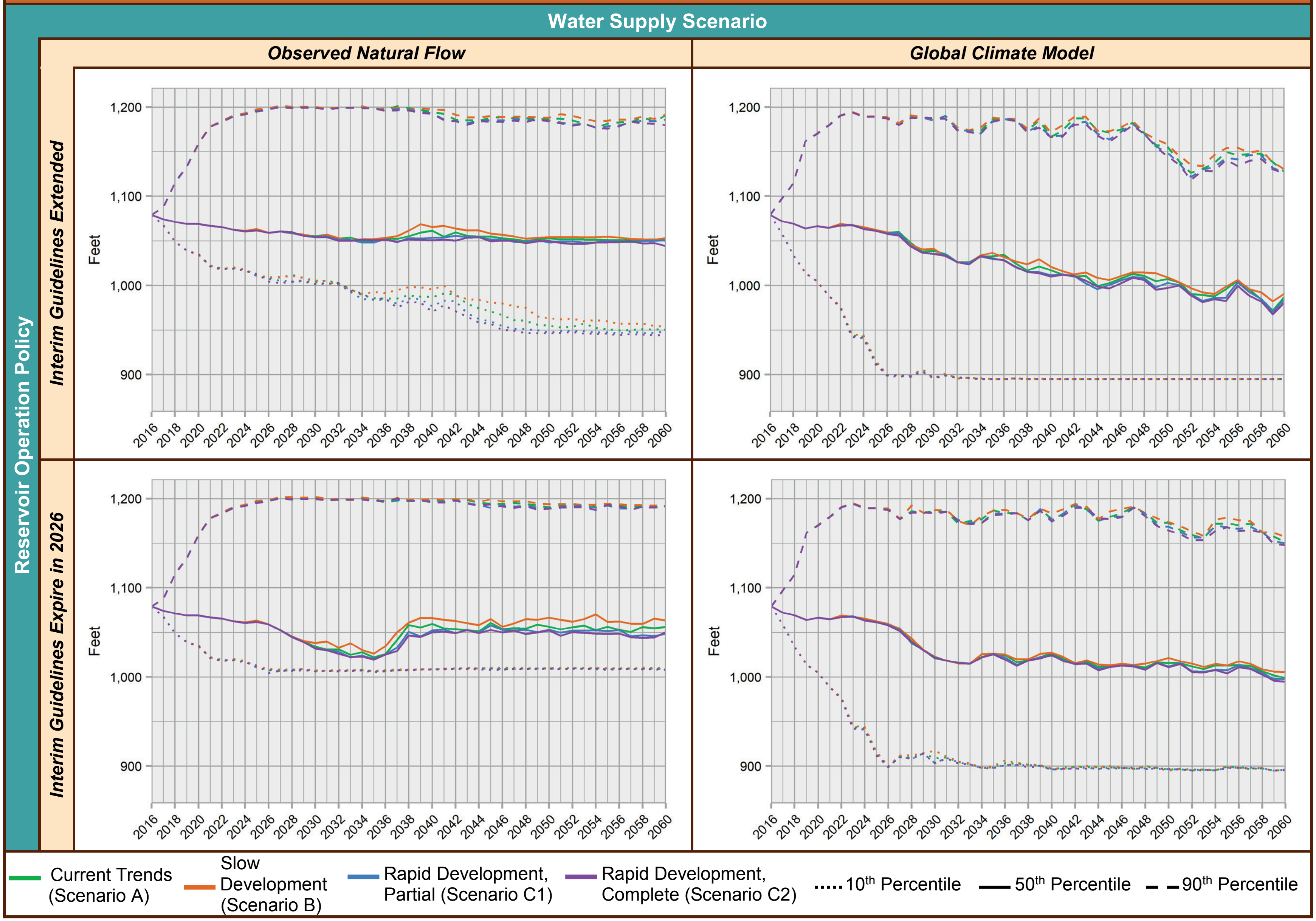
Metric – Lake Mead Elevation

Figure 6-E shows the Lake Mead elevations across the model results. The results were organized by supply scenario and reservoir operations policy, with the Observed Natural Flow supply scenario used in the panels on the left, the Global Climate Model supply scenario used in the panels on the right, the *Interim Guidelines Extended* policy used in the top panels and the *Interim Guidelines Expire in 2026* policy used in the bottom panels.

At the 50th percentile (solid line), the tribal water development schedules show a range of effects on Lake Mead elevations. This range was bounded by Slow Water Development Trends (Scenario B), and Rapid Water Development Trends, Complete (Scenario C2), and displays differences as large as 13 feet by 2060. This difference was driven by Upper Basin tribal water development, as was also seen at Lake Powell, because the Lower Basin uses its full normal apportionment and is not allowed to deplete above that apportionment. Tribal water development by the Lower Basin Partnership Tribes would move water use from non-tribal to tribal use as shown in Figure 6-H.

Lake Mead's elevation shows more differences as a result of water supply scenarios than it does as a result of Upper Basin tribal water development. At the 10th percentile (dotted line) there is generally little effect from Upper Basin tribal water development, resulting in little to no range across the tribal water development scenarios. Under the Global Climate Model supply scenario this occurs because Lake Mead elevation is constrained as the reservoir approaches the dead pool elevation (895 feet), when the reservoir is unable to release water downstream. When the Observed Natural Flow supply scenario is coupled with the *Interim Guidelines Expire in 2026* policy, this occurs because the elevation of 1,000 feet at Lake Mead is protected, constraining elevation variation after 2026. The Observed Natural Flow supply scenario under the *Interim Guidelines Extended* policy is the only scenario combination that does not exhibit these physical and policy constraints.

FIGURE 6-E
Annual Lake Mead Elevation (2017 – 2060)



Metric – Lower Basin Hydrologic Shortage

Figures 6-F and 6-G shows the aggregate annual percent of hydrologic shortage. The percent of hydrologic shortage represents the percent of the requested annual consumptive use that was not delivered. This metric provides context regarding the severity of the shortage volume with respect to demand. The left panels show the percent of hydrologic shortage as a frequency across all traces and the right panels show the annual minimum, median, and maximum percent of hydrologic shortage in the Lower Basin, seen across all Lower Basin States and Mexico, for the Observed Natural Flow supply scenario (Figure 6-F) and the Global Climate Model supply scenario (Figure 6-G). The results were further split by reservoir operations policy, with the *Interim Guidelines Extended* policy results in the top panels and the *Interim Guidelines Expire in 2026* policy results in the bottom panels.

For the Lower Basin generally, little change is seen in the percent of hydrologic shortage frequency and minimum, and median percent of hydrologic shortages due to tribal water development. Hydrologic shortage was more influenced by variations in water supply, with percent of hydrologic shortages seen at an increased frequency and magnitude under the Global Climate Model supply scenario (Figure 6-G) than the Observed Natural Flow supply scenario (Figure 6-F). This is because the Global Climate Model supply scenario’s traces contain more low water supply years than contained in the Observed Natural Flow supply scenario.

Under the Observed Natural Flow supply scenario, hydrologic shortage only occurred under the *Interim Guidelines Extended* policy, and occurred less than five percent of the time. Hydrologic Shortage did not occur under the Interim Guidelines Expire 2026 policy because after 2026, the reservoir operating rules reverted to the rules of the No Action Alternative from the 2007 Interim Guidelines Final EIS. This alternative prevents Lake Mead’s elevation from declining below 1,050 feet with approximately an 80 percent probability. Should Lake Mead’s elevation continue to decline, the alternative imposes further reduction to keep Lake Mead’s elevation above 1000 feet. This shortage is called a “policy” shortage (while not representing official policy of the Department of Interior with regard to future determinations). Because of the flexibility of this policy to reduce the volume of downstream deliveries as needed, hydrologic shortage was never achieved under the Observed Natural Flow supply scenario.

Further, under the Observed Natural Flow supply scenario, tribal water development affected the percent of maximum hydrologic shortage magnitude when it occurred, as seen in Figure 6-F (upper-right panel), providing a range of hydrologic shortage percentages at the maximum value for each year (dashed line). This range was bounded by Slow Water Development Trends (Scenario B), and Rapid Water Development Trends, Complete (Scenario C2), and displays a difference of approximately 23 percent (or 2.07 MAF) on average.

FIGURE 6-F
Lower Basin Hydrologic Shortage as Percent of Requested Consumptive Use, Observed Natural Flow Water Supply Scenario

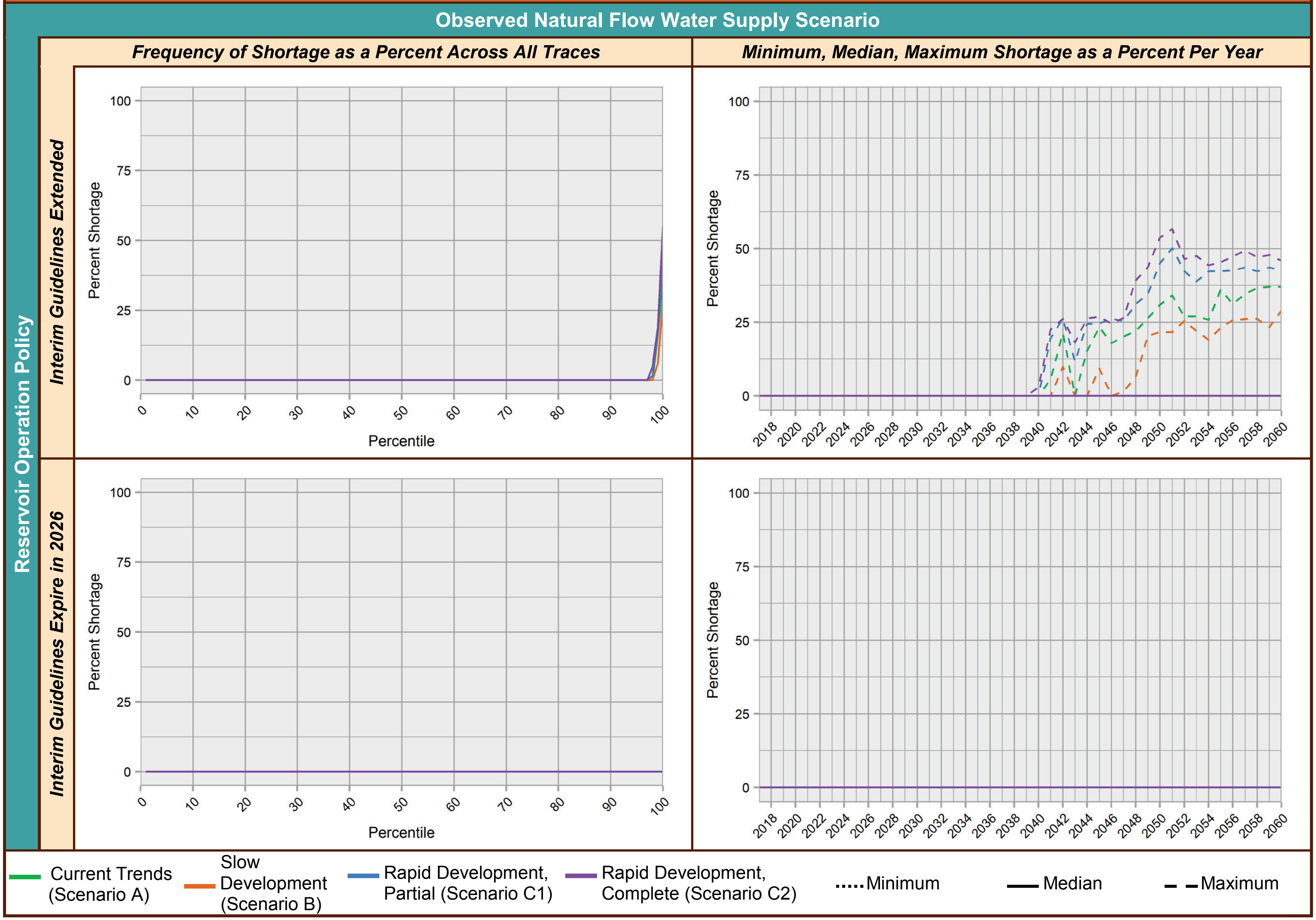
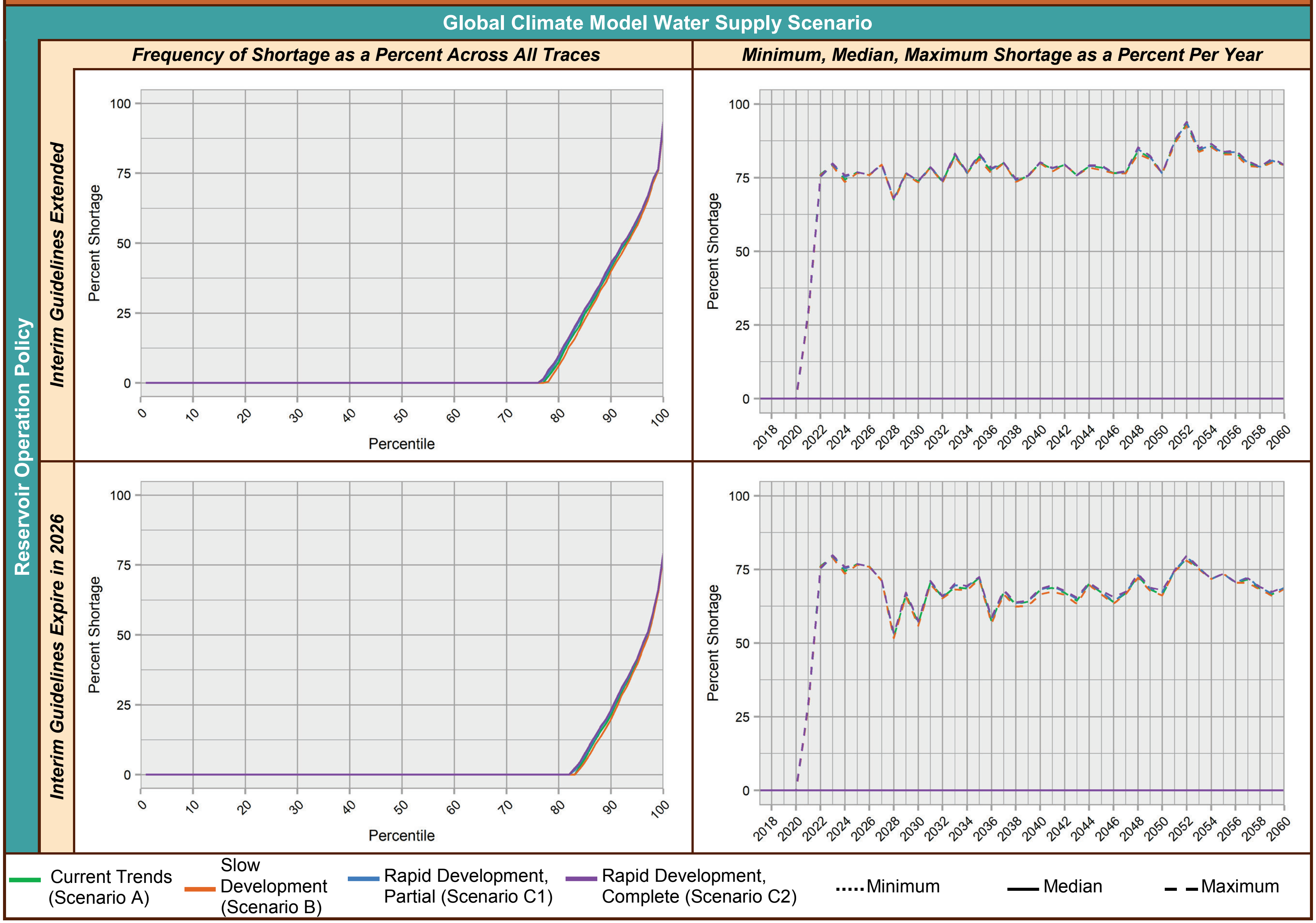


FIGURE 6-G
Lower Basin Hydrologic Shortage as Percent of Requested Consumptive Use, Global Climate Model Water Supply Scenario

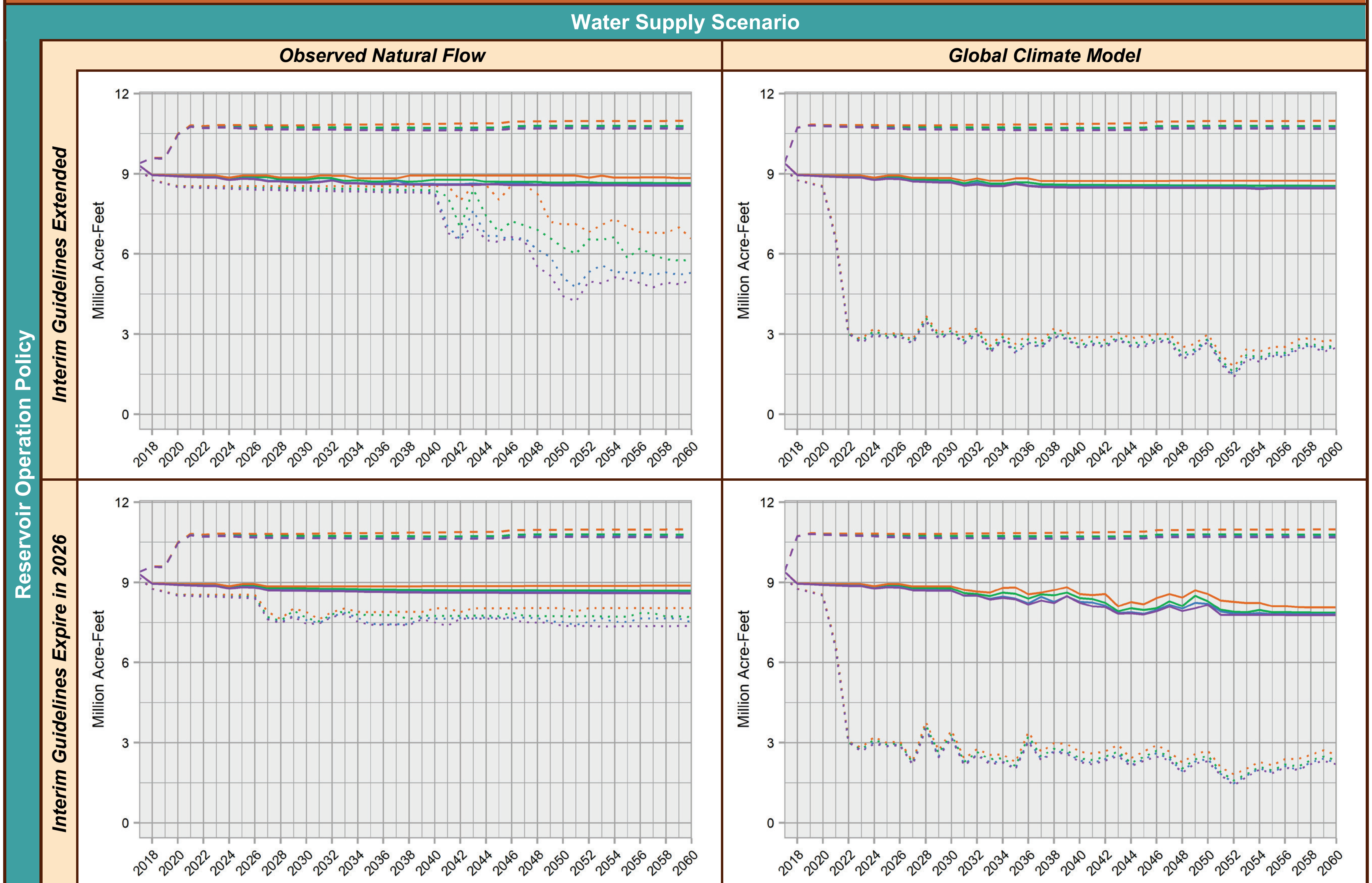


Metric – Water Deliveries to Lower Basin Non-Tribal Users

Figure 6-H shows the annual consumptive use of non-tribal water users in the Lower Basin and Mexico. Results are split out by supply scenario and reservoir operations policy, with the Observed Natural Flow supply scenario in the left panels, the Global Climate Model supply scenario in the right panels, the *Interim Guidelines Extended* policy in the top panels, and the *Interim Guidelines Expire in 2026* policy in the bottom panels.

Less of an effect was seen to non-tribal water users under Slow Water Development Trends (Scenario B) than seen in Current Water Development Trends (Scenario A), and Rapid Water Development Trends (Scenarios C1 and C2). This was because Scenarios A, C1, and C2 contain faster rates of tribal water development than Scenario B. In Figure 6-H, a slight decreasing trend is seen at the median non-tribal consumptive use across all water development scenarios, which corresponds with a shift in water use from non-tribal use to tribal use as the Lower Basin Partnership Tribes develop their water. Again, more variability was seen with respect to the Global Climate Model water supply scenario than with the tribal water development scenarios.

FIGURE 6-H
Lower Basin Non-Tribal Consumptive Use



Current Trends (Scenario A) | Slow Development (Scenario B) | Rapid Development, Partial (Scenario C1) | Rapid Development, Complete (Scenario C2) | Minimum | Median | Maximum

Metric – Lower Basin Present Perfected Rights Analysis

The Partnership Tribes in the Lower Basin have some of the most senior water rights on the Colorado River, and in the event of insufficient mainstream water to satisfy all deliveries, the Secretary shall first provide for the satisfaction in full of all rights of the Chemehuevi Indian Reservation, Cocopah Indian Reservation, Fort Yuma Indian Reservation (Quechan Indian Tribe), Colorado River Indian Reservation, and Fort Mojave Indian Reservation.[1] Shortage effects on tribes are therefore dependent on the severity of the shortage in the Lower Basin versus the level of tribal water development. For example, if the Partnership Tribes developed their water to their full diversion rights and historical efficiencies were assumed, tribal water consumptive use would be 722 KAF. Therefore, the Lower Basin's shortage would have to exceed 6.78 MAF for the Partnership Tribes to be affected. Shortages greater than 6.78 MAF were seen in less than one percent of all years, and only occurred under Global Climate Model water supply scenario.

6.7 Summary

This analysis quantified the effects on the Colorado River System due to a range of future tribal water development scenarios. These water development scenarios were evaluated over two future water supply scenarios - one that assumes future streamflow will reflect what has been experienced in the past 107 years (1906-2012) and one that assumes lower average future streamflow and longer drought cycles as projected by global climate models.[2] While the Colorado River System was affected by the Partnership Tribes' development of tribal water, the future water supply scenarios had the greatest effect on the System.

In the Upper Basin, the tribal water development scenarios produced a range of Lake Powell inflow volumes by 2060, with the Observed Natural Flow supply scenario exhibiting an average annual inflow difference of 328 KAF across the tribal water development scenarios, and the Global Climate Model supply scenario exhibiting a range of 290 KAF. At Lake Powell, this translated into a 21-foot difference in elevation across the tribal water development scenarios at the 50th percentile. The effect of tribal water development on Lake Powell's elevation was more pronounced in traces that were water stressed, providing a 33 foot range across the tribal water development scenarios at the 10th percentile. However, Upper Basin shortage showed little variation due to tribal water development, and the shortage frequency and volume showed greater sensitivity to changes in water supply than it did to tribal water development.

In the Lower Basin, effects on water availability for all users due to tribal development were caused by tribal development in the Upper Basin. This is because the Lower Basin uses its full normal apportionment, and for this analysis, the Lower Basin was not allowed to deplete above that apportionment. The tribal water development in the Lower Basin was accounted for as a change in water use from non-tribal to tribal, and did not affect the overall water availability to the Lower Basin, but did affect the water availability to non-tribal users. Variations in Lake Mead elevation were seen across the tribal water development scenarios, with a 13-foot range in

---

[1] *Arizona v. California,* 547 U.S. 150, 167 (2006).

[2] Recent modeling efforts in the Colorado River Basin have focused on flows based on the climate from 1988 to 2015, which encompasses the current drought period. The average flow in the Colorado River at Lees Ferry used in the Tribal Water Study was 14.9 MAF, while the average flow for the 1988 to 2015 period was 13.2 MAF, which is 13 percent lower. The average flow 2017 through 2060 at Lees Ferry under the Global Climate Model was projected as 13.6 MAF.

elevation at the 50th percentile by 2060. Shortage volumes in the Lower Basin were primarily influenced by water supply, with little to no variation seen due to the tribal water development scenarios when modeled with the Global Climate Model supply scenario. The deliveries to non-tribal users were affected more by Current Water Development Trends (Scenario A) and two Rapid Water Development Trends (Scenarios C1 and C2) than they were by the Slow Water Development Trends (Scenario B). This is because Scenarios A, C1 and C2 included faster rates and larger volumes of tribal water development than did Scenario B.

The water supply scenarios had a noticeable influence on the metrics evaluated when the Colorado River System was water stressed. This was best exhibited with the Global Climate Model supply scenario, which contains more years of reduced supply than the Observed Natural Flow supply scenario. When the Colorado River System experienced high levels of water stress, the magnitude of shortages were large enough to minimize the influence of tribal water development seen on the metrics as compared with the water supply scenarios effects. In these instances water users in the Upper Basin, both the Partnership Tribes and non-tribal, could experience shortages regardless of the level of tribal water development. The effect of the water supply scenarios were particularly noticeable at Lake Powell. Under the Observed Natural Flow supply scenario, the range between the current, rapid, and slow water development scenarios was moderate for the Lake Powell inflow and elevation metrics. Under the Global Climate Model's supply scenario, water supplies were more stressed and the range between the tribal water scenarios for these same metrics was minimal because effects to the system were not due to tribal water development but rather due to restricted water availability.

Appendix 6A
Methodology for Conducting San Juan Sub-basin Historical Shortage Analysis

Appendix 6A – Methodology for Conducting San Juan Sub-basin Historical Shortage Analysis

The following methodology was used to estimate shortages under current and full tribal entitlement depletions in the San Juan sub-basin in Colorado for the Tribal Water Study. The State of Colorado's water resources planning model StateMod, developed as part of the Colorado Decision Support System, was used to represent the current water uses and water rights in Colorado (Colorado Water Conservation Board, 2017). StateMod is a water allocation model which determines availability of water to individual user demands and projects based on hydrology, water rights, and operational rules and practices.

StateMod's "historical" San Juan model data set, representing historical diversions and uses for the 1909 through 2013 hydrologic period, has been calibrated to confirm that the model adequately represents Colorado water administration, project operations, and water use practices. StateMod's "baseline" data set represents current uses and water rights as if they had been in place for the full 1909 through 2013 hydrologic study period. Current Southern Ute Indian Tribe and Ute Mountain Ute Tribe water uses are represented in the baseline model data based on their actual diversion location, irrigation water requirements, and water rights. Depletions and shortages are an output from the model simulation. Current depletions and shortages for both tribal and non-tribal water users were reported from the model output for the representative hydrologic years 2008 and 2012. The calibrated historical model, baseline model inputs, and results are presented in the San Juan/Dolores River Basin Water Resources Planning Model User's Manual, July 2016.

A "full tribal use" model was developed for the Tribal Water Study that included increased demands representing full use of the Southern Ute Indian Tribe's and Ute Mountain Ute Tribe's reserved water rights, with limitations based on their Consent Decrees. The non-tribal water demands were not changed from the baseline data set. Current depletions and shortages for both tribal and non-tribal water users were reported from the model output for the representative hydrologic years 2008 and 2012. Water uses under the Animas-La Plata Project are not represented in StateMod. These uses were added for the purposes of the Tribal Water Study analysis and full tribal depletion entitlements were assumed to be always met.

7 Challenges and Opportunities Related to Development of Tribal Water

7.0 Introduction

The Partnership Tribes hold a significant amount of federal Indian reserved water rights, including unresolved claims, from the Colorado River and its tributaries.[1] Also, some tribes hold rights that are not federal reserved water rights. Although each Partnership Tribe has a unique water use history and specific water use barriers, through the Tribal Water Study process, the Partnership Tribes identified nine categories of challenges to currently using reserved water rights as well as challenges to future water development. Describing the challenges fostered the collective exploration of opportunities to overcome the challenges and potential future actions that could advance the opportunities.

This chapter presents and describes the nine categories of challenges, discusses the associated opportunities and identifies future potential actions. The challenges categories are as follows:

- Administrative and Legal Constraints
- Responding to Colorado River Basin Water Supply Challenges
- Data Collection and Tools for Water Management
- Agricultural Water Use Challenges
- Domestic, Commercial, Municipal, and Industrial Water Use
- Establishment of Continuous, Sustainable Funding
- Diverse Geography of Tribal Reservations
- Cultural and Environmental Challenges to the Use of Tribal Water
- Socioeconomic Considerations

7.1 Administrative and Legal Constraints

7.1.1 Challenges

Over the past 150 years, the Partnership Tribes have experienced challenges gaining recognition of and, in some instances, understanding their reserved water rights by federal regulators, federal and state water managers, and the public at large. This has present implications, both for the Partnership Tribes and for all other Basin stakeholders. For instance, Partnership Tribes in the Basin have a significant claim to a substantial amount of water, which they fully intend to develop and use, but which junior users are currently using; once Partnership Tribes fully use and develop their reserved water rights, those junior water users will be affected.

The doctrine of Indian reserved water rights, also known as the *Winters* doctrine, holds that when Congress reserves land for an Indian reservation, Congress also impliedly reserves water to fulfill the purpose of the reservation. *Winters v. United States*, 207 U.S. 564, 577 (1908). This 1908 United States Supreme Court decision affects the water rights of nearly everyone in the Basin due to the fact that Indian reserved water rights have a priority date of either the date the

[1] See Section 3.0 of *Chapter 3 – The Tribes of the Ten Tribes Partnership*.

reservation was created or time immemorial which makes them senior to almost every other water right in the Basin.

Although *Winters* recognized federal Indian reserved water rights and set the stage for resolving Indian water rights claims, these claims are being resolved at a slow pace. Indeed, fewer than half of the tribes in the Basin have fully settled or adjudicated their reserved water rights. One challenge preventing tribes from fully settling or adjudicating their reserved water rights in the Basin is the slow resolution of water claims in general – whether that is through an adjudicatory or settlement process. Another challenge is obtaining sufficient funding necessary to facilitate a comprehensive negotiated resolution of a tribe's reserved water rights. The fact that many tribes have yet to resolve their water rights claims creates many challenges for both tribal and other water users in the Basin, the most significant of which is the uncertainty it creates in regard to water availability to water users.

Moreover, while some Partnership Tribes have successfully navigated the process for obtaining quantified water rights either through adjudication or settlement, significant issues remain in fully using those water rights. Partnership Tribes may not have the expertise, funding or resources for comprehensive water management planning and implementation. Local entities may be hesitant to partner with tribes on water development opportunities because of differing regulations, taxation options, and sovereign immunity considerations. Even within a reservation, the various forms of land status such as trust allotments, restricted fee, and individual assignments may complicate an otherwise straightforward water development opportunity and further slow progress towards water development.

When a Partnership Tribe's reservation is located in more than one state, complicated issues of how and where the tribe can use its water arise. The state line is an arbitrary boundary to tribes. Indeed tribal member's homes may be located on the reservation but within two states. Partnership Tribes contend they have the right to use their water anywhere within their reservation regardless of state lines. However, if the reservation crosses state lines, the tribe is often restricted in its ability to use its full reserved water rights. Water management among states is not coordinated, which complicates permitting, water accounting and other administrative processes. In addition, the tribe may be subject to multiple state adjudications or settlement processes, which may result in a portion of the tribe's reserved water rights being fully adjudicated in one state, but not in another.

Other challenges arise when a tribe's reservation consists of areas within both the Upper Basin and the Lower Basin. The tribe may be restricted from using its water across Basin boundaries within the reservation. Because the Navajo Reservation covers areas of Utah, Arizona and New Mexico, the Navajo Nation has reserved water rights in the Upper Basin and unresolved claims to water in both the Upper Basin and the Lower Basin but may not use water allocated to the Upper Basin in the Lower Basin and vice versa.

Another challenge involves the ability to voluntarily transfer (such as through transfers, leases, water banking, exchanges, and deferral and forbearance agreements) a portion of a tribe's reserved water rights for off-reservation uses. This could provide a potential source of revenue for a tribe in water short areas, but there are obstacles to such transfers.

7.1.2 Opportunities

To address these challenges, Congress, federal and state agencies, and the general public will need to consider more fully the nature and importance of Indian reserved water rights not just in general but also with regard to (1) the intricacies of each tribe's settled or adjudicated water rights and (2) unresolved claims. The Partnership Tribes intend to take advantage of more opportunities to educate other partners in the Basin and elsewhere about the importance of Indian reserved water rights and how timely and full recognition and understanding of these rights can assist with addressing water challenges in the Basin as a whole. An increased understanding of reserved water rights could help reduce conflict, highlight opportunities for collaboration and lead to innovative partnerships between tribes and state or federal agencies.

There are currently successful water transfer arrangements in place in the Basin involving Indian reserved water rights and other communities. For example, the United States Supreme Court's Consolidated Decree in *Arizona v. California*, 547 U.S. 150 (2006), included a recognition of the Quechan Indian Tribe's right to choose to forebear the development of some of its then- unused federal Indian reserved water rights in California in favor of allowing that water to flow to the Metropolitan Water District of Southern California (MWD). In exchange for obtaining this additional water supply for its customers, MWD agreed to pay the Quechan Tribe on a per acre-foot (AF) basis for the amount of water forborne by the Tribe each year, up to 13,000 AF per year.

The Colorado River Indian Tribes (CRIT) fallow farm land to leave water in Lake Mead as part of the Pilot System Conservation Program. The CRIT entered a forbearance agreement with Reclamation that includes the methodology for measuring reduced consumptive use and corresponding reductions in diversions to the reservation, field verification of fallowed lands, and payment schedules. Funding is provided by Reclamation, Central Arizona Water Conservation District, Metropolitan Water District of Southern California, Southern Nevada Water Authority and Denver Water under the terms of the 2014 Funding Agreement.[2]

The Jicarilla Apache Nation (Jicarilla), too, has reserved water rights that it subleases to a number of different entities for off reservation use subject to the approval authority of the Secretary of the Interior. Jicarilla subleases water to a variety of entities and for a variety of purposes including energy production, private industry, recreation, and conservation.[3] Jicarilla also takes delivery of 6,500 AF of Colorado River water via the San Juan-Chama Project for use in the Rio Grande Basin. Marketing its water provides a source of revenue for Jicarilla; at the same time, downstream users in water short areas benefit as well.

These examples demonstrate that voluntary modifications of tribal water use patterns can be used to help meet the demands of other water users. The Partnership Tribes are hopeful that the information obtained through the Tribal Water Study will provide an opportunity to evaluate and pursue establishing a variety of voluntary use options such as transfers, leases, water banking, exchanges, and deferral and forbearance agreements, which offer opportunities for Partnership Tribes as well as other communities to develop mutually beneficial use of tribal water. Certainly, treating recognition of Indian reserved water rights as a high priority can lead to

[2] Retrieved from: https://www.usbr.gov/lc/region/programs/PilotSysConsProg/pilotsystem.html

[3] Jicarilla Apache Tribe Water Rights Settlement, Public Law No. 102-441, 106 Stat. 2237 (1992) and Contract between the Jicarilla Apache Tribe and the United States (Dec. 8, 1992).

solutions in the Basin in a time when water is scarce and the Basin as a whole is faced with serious imbalances in supply and demand.

The Partnership Tribes are also hopeful that the Tribal Water Study will provide an opportunity for them to be included in regional water planning in order to facilitate tribal water development, minimize conflict, and improve overall reliability of the Colorado River System.

The Partnership Tribes plan to work on structuring grant funding opportunities to support the development of internal technical and legal expertise to assist with tribal water planning and management.

7.1.3 Potential Actions

- Pursue the full resolution of all Indian water rights claims
- Explore the development of a permanent funding mechanism for implementation of tribal water settlements
- Explore revising DOI Criteria and Procedures for Indian Water Rights Settlements to place greater emphasis on the federal trust responsibility and less emphasis on potential federal liability
- Work with federal and state agencies to prioritize the identification of legal and regulatory constraints to full use of tribal water, and to design ways to overcome constraints and to broaden opportunities that enable Partnership Tribes to put their water to full beneficial and economic use
- Address statutory and regulatory prohibitions to interstate water management and use
- Inform other communities that a substantial amount of tribal water is going to be re-directed for tribal use and coordinate efforts to work with Partnership Tribes to develop regional solutions, thereby reducing the likelihood of conflict
- Develop and draft proposed policy changes addressing legal and regulatory constraints, as well as proposed legislation that allows for water management flexibility for Partnership Tribes
- Explore opportunities for federal agencies and Partnership Tribes to work together to develop the expertise, funding and/or resources for comprehensive water management planning and implementation
- Explore ways for Partnership Tribes to use their water that otherwise may be constrained by the Law of the River

7.2 Responding to Colorado River Basin Water Supply Challenges

7.2.1 Challenges

For decades, Reclamation and others have recognized and documented the challenges and complexities of ensuring a sustainable water supply and meeting future demands in an over-allocated and highly variable system such as the Colorado River. This challenge is magnified for the Partnership Tribes who seek to fully use their reserved water rights. Future challenges arise from the likelihood of continued population growth and the significant uncertainty regarding an adequate future water supply. As water demand for municipal and agricultural uses increases to serve the demands of growing populations, ensuring the availability of water for non-consumptive uses such as the environment, recreation, and hydropower becomes increasingly challenging, especially because water supply uncertainty is further compounded by the potential effects of climate variability. Evidence indicates increased future climate variability in the Southwest, which may include longer, more extreme dry (and wet) periods than previously observed.

In addition to the long-term challenges identified in the Basin Study (Reclamation, 2012), current extended drought conditions in the Basin have further highlighted the urgency for ensuring Colorado River sustainability for the Partnership Tribes. The past 19 years of drought in the Basin has resulted in increased water management challenges with total Basin storage declining from nearly full to about 50 percent of capacity. The risk of reaching critically low elevations at Lake Powell and Lake Mead over the next decade nearly doubled over the past 10 years.

In the Upper Basin, most tribes depend on water supplies that are more reliant on the natural stream flows fed directly by snowpack than rainfall. These supplies are more likely to be impacted by localized drought patterns. Therefore, Partnership Tribes in this area experience seasonal and yearly flow variations that can result in reduced water deliveries. Upper Basin tribal lands frequently experience an insufficient water supply. In addition, Partnership Tribes with land in multiple sub-basins do not have the infrastructure to move or use water on all parts of their reservations. Indeed, for Partnership Tribes whose reservations are located in multiple states, the current Law of the River and the terms of Indian water rights settlements may result in limitations on their ability to move water where needed on their own reservation lands.

These challenges demonstrate the critical need for on-reservation water storage facilities throughout the Upper Basin. The construction of reservoirs or water projects in the Upper Basin helps provide a more reliable annual water supply. Still, the lack of adequate precipitation to fill the reservoirs coupled with high temperatures can lead to water shortages, especially in late summer. In watersheds without storage facilities, seasonal flow variations frequently do not correspond with crop water demands. Risks related to the imbalance between water supply and the timing of the supply could increase with continuing climate variability.

Partnership Tribes in the Lower Basin have some of the most senior water rights on the Colorado River. In the event of insufficient mainstream water to satisfy all deliveries, the United States Supreme Court held:

> [T]he Secretary of the Interior shall, before providing for the satisfaction of any of the other present perfected rights except for those listed herein . . . first provide for the satisfaction in full or all rights of the Chemehuevi Indian Reservation, Cocopah Indian Reservation, Fort Yuma Indian Reservation [Quechan Indian Tribe], Colorado River Indian Reservation and Fort Mojave Indian Reservation . . . .[4]

Often supply shortages are experienced locally on various parts of the reservations. The Partnership Tribes frequently do not have the internal financial or technical resources to construct needed, large-scale watershed storage facilities. Federal Indian irrigation projects have failed to construct the proper infrastructure, including storage facilities, on many reservations to ensure an adequate and reliable water supply. Further, little infrastructure exists on reservations

[4] *Arizona v. California,* 547 U.S. 150, 167 (2006).

to move water between basins within the reservation or, where authorized, to move water off reservation.

7.2.2 Opportunities

Addressing current and future water supply challenges will require diligent planning and will not be resolved through any single approach. Because Partnership Tribes hold senior water rights, opportunities exist at local, reservation, regional, and Basin-wide levels for tribes to help other Basin water users balance the many competing interests to ensure adequate, reliable water supplies throughout the Colorado River System, while creating economic benefits for their respective communities. Local efforts could include encouraging water reuse, increased agricultural and domestic, commercial, municipal, and industrial conservation, and relatively simple actions such as rainwater harvesting. Reservation-wide efforts such as new or improved storage, stormwater capture, or groundwater recharge facilities would help reduce supply risks. Developing innovative funding and partnership structures could help address the resource and funding needs for these types of projects. Broader efforts such as the Navajo-Gallup Water Supply Project provide long-term sustainable water supplies for multiple communities and support regional economies, and serve as an example of how the needs of tribal and other water users may be addressed in the years ahead.

Future opportunities could include flexibility in the management and operation of reservoirs to help maintain reliable water deliveries and power generation, support environmental needs, and manage flood control. Partnership Tribes, in conjunction with federal, state and independent water authorities, researchers and economists can study the societal and environmental benefits attributable to non-consumptive uses to identify an economic value for those uses which will lend itself to more apt comparison with other use types. This in turn will aid more informed policy development. Policy and management flexibility may also aid significantly in the ability of Partnership Tribes to leverage early priority water rights, creating cooperative opportunities for greater Colorado River System efficiency, reliability and economic benefits for users throughout the Basin.

7.2.3 Potential Actions

- Repair, rehabilitate or improve aging infrastructure
- Develop and fund on-reservation conservation measures
- Construct/improve storage facilities to permit or enhance tribal access to storage
- Pursue tribal representation on the Upper Colorado River Commission and greater tribal input on Reclamation’s long-term planning in the Lower Basin
- Pursue tribal representation in state-wide agencies (such as the Interstate Stream Commission in New Mexico)
- Draft and propose appropriate legislation to authorize the interstate use of a tribe’s reserved water rights
- Initiate efforts to value benefits accruing from non-consumptive uses in monetary terms Basin wide

7.3 Data Collection and Tools for Water Management

7.3.1 Challenges

Tribal governments and communities face significant challenges in improving tools and methods for effective management of their water resources. The Partnership Tribes divert their water allocations directly from the Colorado River and its tributaries, from hydrologically-connected groundwater, from federal water projects, or from a combination of these sources. Regardless of the water delivery source, the Partnership Tribes cannot effectively manage what they do not monitor.

Data collection and other tools available to measure water flows and monitor water quality for water management should be enhanced in both the Upper and Lower Basins. Water use accounting in the Upper Basin is currently inconsistent and measuring capabilities are limited or nonexistent in some tributaries. While water accounting on the Colorado River in the Lower Basin is more robust and is updated with new modeling approaches and systems for integrated gaging pursuant to the Secretary of the Interior's mandated Watermaster responsibilities in that Basin, there is always room for improvement and refinement in any hydrologic accounting system. Data collections, quality control, review, and publication of associated data have significantly improved over past record keeping. However, use of similar measurement technologies and the availability of quality data on some tribal lands are limited at this time.

Water monitoring for the Partnership Tribes is especially challenging given the cost constraints and the general remoteness of reservation lands. These challenges make it difficult to automate water meters, monitor water quality and flow conditions, detect leaks, and ensure pipeline integrity, all of which can generally improve delivery efficiency. Tribal infrastructure systems in rural areas also require remote monitoring and automation. Partnership Tribes see a critical need for additional stream gaging stations in the Basin, especially on tributaries in the Upper Basin, to monitor proper delivery and use. Likewise, the measurement of on-farm water deliveries at federal and state authorized irrigation projects needs improvement.

7.3.2 Opportunities

Partnership Tribes can address some of these challenges by applying technological improvements that can make water monitoring in remote locations more feasible and cost-effective. Such improvements would make data available that could contribute to enhanced decision-making for rural tribal communities in efficiently using their finite water resources. Appropriately located stream gaging stations are crucial for managing and protecting tribal water resources. These sites provide the data necessary to model natural flows, develop river management plans and properly administer water diversions and storage water deliveries based on their seniority. Because the data often benefits other users, as well as tribes, it can be possible to enter into cooperative funding agreements between several entities to help offset the financial burden of installing gage stations. Better measurement and data collection, such as that currently employed in the Lower Basin, can allow for greater transparency and foster cooperative opportunities while reducing potential conflicts among users with different, but necessarily interrelated, interests.

To better reflect the needs of the Partnership Tribes, more tribal information and data could be incorporated into existing water-management systems and models. With significant allocations in the Basin, the Partnership Tribes continue their efforts to foster cooperation with adjacent communities, but a lack of tribal information in data systems is problematic for the tribes and other water users. Information on how tribes are affected by long-term trends and extreme events, such as droughts or floods, would be useful in evaluating water availability when it is most needed and in ensuring that water is not lost or wasted. Integrating accurate and up-to-date information from the Partnership Tribes would certainly allow for better management of the water.

7.3.3 Potential Actions

- Develop coordinated accounting among state entities in the Upper Basin
- Explore the installation of more gages using cost-sharing agreements among Partnership Tribes, U.S. Geological Survey, Reclamation, and state entities
- Install instream gages and water meters where appropriate
- Implement water quality data collection on tribal lands generally and in response to events such as the Gold King Mine spill (while exploring the need for similar monitoring at sites throughout the Basin)
- Support rigorous accounting of water use throughout the Basin
- Encourage the use of measurement-based automation to help with the priority-based administration of diversions

7.4 Agricultural Water Use Challenges

7.4.1 Challenges

Agriculture is the dominant use of Colorado River water, with approximately 70 percent of total Colorado River water used to support agriculture (Reclamation, 2015). Irrigated lands are an essential component for Partnership Tribes in pursuing economic development and self-determination using their water resources. These benefits are manifested in the form of individual tribal member farms, tribally-owned farm enterprise operations, or revenue generated through leasing tribal water and croplands to other producers. In order for agricultural operations to be economically viable and reach full potential yield, they must have access to reliable irrigation water deliveries in the amounts needed to satisfy crop demand.

Many federally operated Indian irrigation projects throughout the Basin struggle with outdated or poorly maintained infrastructure, inadequate staffing levels, and a lack of knowledgeable operators. Several of these projects started out in the late 19th century as primitive ditches serving only small tracts of land. These ditch systems evolved into larger irrigation projects, but often without the benefit of coordinated planning and use of modern engineering design. The result is that water delivery to project irrigators is often inefficient, inadequate, and unreliable. This, in turn, reduces crop yields, puts the overall economic viability of the operation at risk, and ultimately decreases the revenue of Partnership Tribes.

Also, significant competition for limited BIA and/or Reclamation funding available for irrigation rehabilitation work means that many systems must significantly raise operations and maintenance rates in order to address the maintenance issues. But tribal producers with agricultural operations already economically handicapped by backlogged deferred maintenance on these aging systems often cannot bear the higher operations and maintenance rates, leading to an economic stalemate.

Partnership Tribes often lack the monetary resources and/or technical expertise to independently maintain or rehabilitate major agricultural infrastructure, whether the projects are federally or tribally managed. Even if they have the capability, regulations governing federally owned projects make it difficult for tribes to perform their own improvements or install water efficiency measures on such projects. Partnership Tribes are hesitant to assume full operational responsibility for these projects without funding to address the large maintenance backlogs. Additionally, even if tribal irrigation infrastructure is not owned by the government, it can be difficult for tribes to finance the rehabilitation of existing or development of new agricultural facilities due to challenges in accessing capital markets. With most of their lands and natural resources held in trust by the federal government, tribes often lack the collateral or revenue streams necessary to establish credit ratings, issue bonds or secure loans.

One final challenge is that posed by water quality issues, both real and perceived. Salinity and selenium are both real concerns in the Basin. Often, significant amounts of water are required to “flush” fields to prevent salinity buildup. Plus, concerns regarding heavy metals from mine discharge and contamination from radioactive mine tailings are also a problem in the Basin and can hurt the market value of area crops due to perceived risk on the part of consumers.

7.4.2 Opportunities

Given the senior priority of most federal Indian reserved water rights and the economic importance of agriculture in the Basin, there is significant opportunity for Partnership Tribes to leverage their irrigation resources for purposes of economic development. The senior nature of these water rights sustains or increases the value of tribal agriculture operations in times of water scarcity. Tribal farmlands equipped with modern, efficient irrigation infrastructure and data gathering equipment can allow Partnership Tribes to take advantage of market forces and obtain premium lease rates from tenant farmers or maximize their own production of high-value crops.

Partnerships with tenant-farming enterprises under development or improvement leases may require installation of irrigation efficiency measures. These measures will help upgrade Indian irrigation projects, increase yields for both tribal and other producers, and help bolster the economies of area communities. The Colorado River Indian Tribes’ Irrigation Committee has been able to install on-farm irrigation improvements by accessing tribal-specific funds through the cost-share U.S. Department of Agriculture Natural Resources Conservation Service Environmental Quality Incentives Program (EQIP), and by partnering with tenant farmers to cover the user portion of the cost-share. Opportunities may also exist to partner with other water sectors to pay for irrigation improvements to boost production and lower water consumption in exchange for transfer of the conserved water.

Investing in irrigation system modernization and efficiency improvements could help increase yields, expand agricultural operations, or augment other uses – both on- or off-reservation. Allowing Partnership Tribes the ability to transfer or lease their water to producers with less reliable supplies could provide economic benefits to both parties by allowing non-tribal producers to use the water directly on their own lands, using existing irrigation infrastructure, while also generating revenue that Partnership Tribes could use to fund irrigation improvements on their lands. Developing tribal loan programs or capitalization mechanisms might allow revenue streams to be leveraged to finance larger irrigation investments.

Independent evaluation of each irrigation system's economic and operational potential might be advisable to help prioritize infrastructure needs, ensure that the proposed upgrades use appropriate, cost-effective, and resilient technologies, and that the project can reasonably support the ongoing maintenance of the upgrades. Indian irrigation projects were built for the benefit of the tribes and their members, yet they are often operated in a manner that does not reflect the tribes' best interests. Greater coordination among the Partnership Tribes, individual water users, and irrigation project staff can help ensure that project operations align with tribal goals, while also helping irrigators understand the physical and regulatory limitations of the Colorado River System. Contracts authorized under the Indian Self-Determination and Education Assistance Act of 1975 (Public Law 93-638), as amended, can help provide tribes with a direct role in the operation of tribal/federal irrigation projects as well as limited funding for project improvement.

Protecting water quality is crucial to sustaining the economic contributions of agriculture throughout the Basin. Continued support of the salinity control program, ongoing clean-up of old mine sites, and regular monitoring of water quality by independent entities are all important to ensure both the protection of Basin water and the transparency of those efforts.

7.4.3 Potential Actions

- Ensure operations and maintenance fees and project funding for tribal and BIA-managed facilities are adequate to maintain irrigation facilities
- Increase tribal management and oversight of BIA Indian irrigation projects
- Explore the potential for removing barriers to or expanding contracts authorized under the Indian Self Determination and Education Assistance Act (Public Law 93-638) to allow Partnership Tribes to assume operational control of federally owned irrigation projects
- Engage outside/independent expertise to conduct economic analysis of Indian irrigation projects where needed to prioritize or evaluate the feasibility of further investment
- Examine and, if deemed helpful, propose changes to 25 CFR Part 171 to improve tribal participation in BIA irrigation operations
- Increase efficiency by implementing new technology and farming methods where practicable
- Seek ways to collaborate with other water users to increase irrigation system efficiencies
- Explore ways to work with the financial sector to create specific avenues for Partnership Tribes to better access capital markets
- Consider developing a tribal loan program specifically for agricultural infrastructure development, rehabilitation, and storage development

7.5 Domestic, Commercial, Municipal, and Industrial Water Use

7.5.1 Challenges

Access to a clean, reliable supply of water is basic to human health and limited on some Partnership Reservations. The lack of water infrastructure, limited economic development, and sustained poverty can be correlated with the availability and use of tribal water supplies. Low per capita water use on some Partnership Reservations is often part of a larger pattern reflecting a lower economic standard of living compared to non-tribal communities. Reasons for inadequate supplies include the rural nature of some reservations, water infrastructure deficiencies, and contaminated or poor quality water supplies.

Low housing density on many reservations makes development of municipal systems economically and financially challenging. For example, on the Navajo Reservation, approximately 30 percent of the homes do not have access to drinking water systems and rely on water hauling to provide for everyday needs. During droughts, the population that hauls domestic water is at the greatest risk. They must travel longer distances to find public water systems that can provide water, or use non-potable water sources. These water haulers also create additional demands on the public water systems that maintain public water taps (Navajo Department of Water Resources, 2012).

Some Partnership Reservations have limited financial resources, making capital investments problematic and repayment capacities low. Widely dispersed reservation populations result in long distances between water sources and water users, and extremely high unit operation and maintenance costs. Typically, tribal water delivery systems have been severely underdeveloped and underfunded. Tribal municipal water projects have often been underfunded and go into disrepair due both to limited financial resources and a lack of technically trained individuals to operate and maintain these systems. Some federal funding programs, such as those offered by Reclamation, require the recipient to contribute matching funds that may exceed the financial resources available to Partnership Tribes. In addition, some reservations have not established funding mechanisms, such as a depreciation fund, to adequately repair and replace the existing water systems, many of which are at or near the end of their design life. These conditions result in expensive water and challenges generating adequate revenue to build and maintain water systems. Not only are Partnership Tribes unable to meet growing demands, they also struggle to operate and maintain existing systems. The inability to access or make full use of traditional forms of funding such as property taxes, rate increases, local or municipal assessments and municipal bonds also affects infrastructure development in tribal communities.

Water and infrastructure development within the Partnership Reservations for domestic, commercial, municipal or industrial use is often complicated by the different categories of land ownership. Checkerboard ownership patterns of fee and trust lands, fractionated ownership of allotted lands, varying tribal policies toward residential or individual land assignments, and other unique land designations within Partnership Reservations complicates the processes for obtaining infrastructure rights-of-way and satisfying other necessary clearances.

7.5.2 Opportunities

Improving access to safe and reliable water is important to the Partnership Tribes. Exploring new management opportunities and adopting emerging technologies may help build tribal capacity in operating, maintaining and managing sustainable drinking water systems.

New federal initiatives have been developed to improve access to safe drinking water in Indian Country, including an innovative strategy to boost water sustainability through the greater use of water-efficient and water reuse technologies, and to promote and invest in breakthrough research and development that reduces the price and energy costs of new water supply technology. At the federal level, many agencies have worked to improve access to safe drinking water and basic sanitation in Indian Country. In the past, a task force model has been used to coordinate federal efforts in developing water infrastructure, wastewater infrastructure, and solid waste management services in tribal communities. These efforts focused on streamlining agency policies, regulations and directives related to water services in order to reduce the administrative burden for tribal communities and facilitate access to funding. Other economic and training resources such as Tribal Economic Development Bonds, the Native American Water Association, and WaterOperator.org also assist Partnership Tribes in water management and infrastructure planning and funding.

Partnership Tribes can also take advantage of opportunities for innovation and wider adoption of technologies for more efficient water use. Providing assistance in rural, tribal areas with distributed water quality treatment systems, optimizing groundwater pumping times to lower energy costs, exploiting natural flows for small-scale hydro-generation energy projects, and using alternative energy sources such as solar power or other energy sources can help assure the availability of sufficient, high quality water supplies. For areas where distribution systems are not currently feasible, community wells and watering points can be upgraded or constructed to improve access for water haulers.

7.5.3 Potential Actions

- Work with BIA to develop programmatic right-of-way agreements to simplify obtaining rights-of-way for domestic, commercial, municipal, and industrial projects
- Work with existing professional associations related to the development of tribal utility authorities to facilitate communication and idea sharing among various Partnership Tribes
- Improve access to federal expertise for financing water infrastructure
- Advocate for tribal waivers of the requirement for matching funds in federal water-related funding programs
- Create and improve relations with the adjacent communities and establish a forum for bringing tribal and other communities together to discuss issues of mutual concern
- Use a water-hauling truck service to provide more distribution points in rural areas

7.6 Establishment of Continuous, Sustainable Funding

7.6.1 Challenges

Tribal governments and communities face unique challenges in their efforts to establish continuous and sustainable funding for water supply infrastructure and treatment. Partnership Tribes often face more difficulty than off-reservation state and local governments because they have limited access to traditional forms of funding such as property taxes, rate increases, assessments and municipal bonds.

The ownership status of tribal lands often makes it difficult to obtain funding. The land within a tribal reservation is titled to the United States and held in trust for the benefit of the tribe and its members; therefore, tribes do not assess property taxes against their own members or the United States as a state municipality might. Although tribal members and others living or engaging in business on the reservation may pay some fees to the tribal government, revenues from property taxes, fees for services, and assessments typically are not significant sources of revenue to support tribal infrastructure construction or maintenance. Additionally, there may be private holdings within a reservation, creating a checkerboard ownership pattern, but tribal jurisdiction to tax private land or impose assessments for services against those private land owners often is not clear and is therefore unlikely to generate significant reliable revenue.

Funding challenges faced by Partnership Tribes for water infrastructure are exacerbated by poverty in and around tribal lands. In turn, the lack of water infrastructure does little to ease, and often even prolongs already-existing levels of poverty.

Statistics about levels of poverty and employment for Native Americans on and off tribal lands are not compiled on a systematic basis. In addition, the information that is available may not accurately reflect how poverty and unemployment rates truly affect Native American populations.[5]

Since 2009 tribes have been authorized to issue tax-exempt economic development bonds that may be used for water infrastructure.[6] Tribes may also issue tax-exempt bonds for essential governmental functions. However, Partnership Tribes have difficulty accessing bond markets and obtaining favorable ratings because of the lack of property to pledge as collateral and the lack of traditional streams of revenue for repayment. Plus, there are national limits under federal law on the total amount of tribal bonds that may be issued each year.

Historically, tribal water-related infrastructure was funded by the Indian Health Service and the BIA with some funding from the U.S. Department of Housing and Urban Development. Over time, the budgets for these agencies for assistance to tribes have seen significant reductions even as the need for these services has grown in proportion to expanding on and off-reservation populations.

Federal water programs with funding available to tribal or non-tribal governments are often difficult for tribes to access. The particular tribe in need of funding may not have available matching funds or may not meet one or more of the criteria for eligibility, such as documented utility easements or the ability to impose user fees for repayment. Competition for these funds is intense and Partnership Tribes often lack the trained personnel to prepare competitive applications.

7.6.2 Opportunities

The Tribal Water Study provides the opportunity to broaden the understanding of the public about tribal water issues and to provide information to water managers throughout the Basin about tribal funding needs for water infrastructure. Little or inadequate attention is focused on the pressing needs for Native American populations in the United States.

---

[5] For instance, the 2013 American Indian Population and Labor Force Report, U.S. Department of the Interior, Office of the Secretary, Office of the Assistant Secretary – Indian Affairs, January 16, 2014, available at: http://www.bia.gov/cs/groups/public/documents/text/idc1-024782.pdf, accessed September 21, 2016 (2013 Report) provides some of this information; however, it must be noted that the assumptions and the accuracy of the census and other data have been disputed by tribes and tribal organizations. According to this Report, on a national scale, only 49 to 50 percent of Native Americans living on or near reservations ages 16 and older are employed. The majority of these jobs are with the tribal or the federal government or through federally funded programs. The 2013 Report estimated the rate of poverty for Native American families in Arizona is approximately 31 to 33 percent. Unemployment statistics are not compiled for tribal populations, but the 2013 Report indicates the average percentage of tribal population of workforce age working in civilian jobs in Arizona to be 39.6 percent and in Colorado to be 51.1 percent. A high percentage of the tribal population indicates they are willing and available to work, but are not working.

[6] American Recovery and Reinvestment Act of 2009, Public Law 111-5.

Partnership Tribes may explore opportunities to develop or expand infrastructure that serves both tribal and other populations, which in turn may also expand options to obtain funding. For example, the Colorado River Indian Tribes operate a joint venture wastewater treatment plant with the City of Parker. The Navajo-Gallup pipeline obtained funding from multiple sources to supply water to the Navajo Nation, Jicarilla Apache Nation, and the City of Gallup, New Mexico. In addition, the Animas-La Plata Project in southern Colorado serves both tribal and other communities.

Many Partnership Tribes have their own tribal utility authorities that function independently. Wider use of tribal utility authorities may expand the professional staff working for tribes and create more opportunities to access alternative funding.

Additionally, modern technology for water treatment at the tap or at a personal level may make poor quality groundwater useable in the remote and dispersed households on tribal lands. However, the current cost of the technology may limit its usefulness.

7.6.3 Potential Actions

- Conduct more detailed and comprehensive assessments of tribal water infrastructure demands to better inform funding agencies and promote increased funding through the federal budget process
- Formulate a strategy to build capacity within Partnership Tribes to write grants and to access assistance for grant writing
- Broaden the access to federal expertise to finance water infrastructure through specialized programs within the DOI and within the Environmental Protection Agency such as the Natural Resource Investment Center and Tribal Infrastructure Task Force
- Develop a tribal utility authority professional association to facilitate communication, training and the sharing of ideas among Partnership Tribes
- Solidify base funding and training opportunities for tribal program staff to develop and implement domestic and municipal water and waste water programs
- Identify business entities and neighboring non-tribal communities that may be able to facilitate tribal economic development that provides mutual benefits
- Explore options for generating on-reservation revenue that may be dedicated to infrastructure development, operation and maintenance costs, or as repayment for financing mechanisms

7.7 Diverse Geography of Tribal Reservations

7.7.1 Challenges

Moving water to where it is needed is both geographically challenging and expensive. Doing so on tribal lands is no exception. The United States Supreme Court has acknowledged that: "It can be said without overstatement that when the Indians were put on these reservations they were not considered to be located in the most desirable area of the Nation." *Arizona v. California*, 373 U.S. 546, 598 (1963). Consequently, the variable topography and geographic conditions of reservations can make conveyance and application of water uniquely difficult and expensive.

In addition, the sometimes uneven history of the creation of reservations, including the ‘islanding’ of some reservation lands and ‘checker-boarding’ of privately owned lands amid lands reserved for tribes, complicates infrastructure development.

Further, many tribal nations have lands within multiple states, counties or even, as is true for the Navajo Nation, lands in both the Upper and Lower Basins. Moving water from one part of a reservation to serve another can therefore encounter not only physical barriers such as long distances, mountains, and land-ownership/rights-of-way hurdles, but regulatory barriers as well.

7.7.2 Opportunities

Meeting these challenges while putting water resources to full beneficial use will involve seeking new water management efficiencies that can minimize the economic burden of trans-reservation development.

Going forward, Partnership Tribes can seek more joint venture opportunities with neighboring communities. For example, on the Colorado River Indian Reservation, a joint venture water treatment facility serves both the tribal community and the Town of Parker, Arizona. Water supply projects such as the Animas-La Plata Project, serving three tribes and numerous communities and water districts in two states, is another example of what the future will likely hold, as Partnership Tribes put their remaining water resources to work.

7.7.3 Potential Actions

- Explore the economics of on-reservation versus off-reservation water use where geography is a significant physical or jurisdictional impediment to tribal water development which increases funding requirements
- Explore joint venture opportunities with neighboring tribal and other communities and agencies

7.8 Cultural and Environmental Challenges to the Use of Tribal Water

7.8.1 Challenges

Partnership Tribes in the Basin, as elsewhere around the globe, face a number of competing concerns – both cultural and economic – when dealing with the use and stewardship of their water resources. The cultural significance of water in the worldview of native communities is captured by the shorthand phrase ‘water is life,’ some version of which can be heard in many languages, and in nearly every tribal nation. The reason for this is at once simple and profound; tribes everywhere recognize that water supports all life, and they genuinely respect this fact.

Water is also life to a number of different economic enterprises – from growing food, to raising livestock, to engaging modern commerce in the broader, and much more populous, marketplace of today. Modern tribal leaders balance these competing interests in concert with a resource management approach that respects tribal history, retains cultural values, supports the community’s existing and growing economies, and sustains these natural resources for future generations. This delicate balance is complex, and presents ongoing challenges for tribal leaders and resource managers alike.

Even in cases where cultural values are preserved while undertaking some form of water development, tribes must also address many environmental challenges. For example, where

Partnership Tribes wish to develop water resources for the benefit of their communities, compliance with the Endangered Species Act and other environmental regulations may restrict their flexibility in water use and development.

Partnership Tribes presently engaged in development of their water resources, or contemplating future water development, face a disproportionate burden for Endangered Species Act compliance. Past development has left the Colorado River and its tributaries in precarious environmental condition, as growing demands have left little of the River's resources available for environmental mitigation purposes. The Colorado River's ability to support remaining riparian habitat and native species is now extremely limited with no surplus water to serve as a buffer for species on the brink. Moreover, since all tribal projects may have a federal nexus, complying with the Endangered Species Act and the National Environmental Policy Act, including the associated compliance costs, complicates the development process and weighs heavily on tribal projects. Finally, for Partnership Tribes who share Colorado River water sources with water users operating within a state-based water rights system, improvements in the quality of the water, including in-stream flow commitments, are difficult to ensure where state water right schemes may not recognize in-stream flows as a valid water right use.

Protecting tribal cultural values and using reservation streams in ways that ensure their health and environmental viability will continue to challenge Partnership Tribes as they seek to make full use of their valuable water resources.

7.8.2 Opportunities

Partnership Tribes seek opportunities to maximize the use of their water resources for the benefit of their communities. The challenge posed by maintaining healthy flows can be alleviated somewhat by establishing environmental flow requirements with more certainty, identifying – through proven scientific data – both the quantity and quality of water required for environmental health. This reduces the 'trial and error' risk in developing practices to sustain endangered and threatened species and their habitats, and offers valuable information that can support sound decision-making in the design, development, and management of potential water projects.

Partnership Tribes may also improve the likelihood for success of their projects by supporting partnerships in inter-agency species programs, such as the Lower Colorado River Multi-Species Conservation Program, and minimize Endangered Species Act compliance costs by establishing tribal, state, and local river management plans to support minimum instream flow agreements. Similarly, partnering with non-government environmental organizations presents another area of opportunity for Partnership Tribes to address the needs of the environment along with the interests of their communities and other Basin water users.

Water development and management strategies on the Colorado River must engage all Basin users in recognizing the needs of the environment. The stakes are now too high for Partnership Tribes and all other water users to ignore these challenges.

7.8.3 Potential Actions

- Ensure water resources within reservations are managed to protect ecosystems, including wildlife, riparian areas, recreation areas, designated instream flow requirements and wetlands

- Expand the use of categorical exclusions to reduce the burden of National Environmental Policy Act compliance on Partnership Tribes
- Preserve and ensure that environmental flows are part of water management plans to help protect natural and cultural values
- Negotiate river management plans with minimum instream flow requirements
- Partner with environmental organizations to restore waterways, wetlands and other habitats, where possible
- Consider including all decreed tribal water rights in the environmental baselines developed as part of consultations with the U.S. Fish and Wildlife Service pursuant to Section 7 of the Endangered Species Act
- Engage in public outreach/education to demonstrate the economic value of healthy waterways – including commercial, environmental, cultural, and recreational values to foster support for in-stream flows

7.9 Socioeconomic Considerations

7.9.1 Challenges

Partnership Tribes seek to provide their community members with all necessary services and opportunities, and recognize that adequate water infrastructure is fundamental to virtually every aspect of community success. However, many tribal communities still struggle with poverty, and infrastructure development that has been historically delayed by the slow recognition, adjudication or settlement of Indian reserved water rights. Still, where water infrastructure has been completed, it usually serves as the economic heart of the community, supporting domestic, commercial, municipal and industrial activity, as well as significant agricultural enterprises. The tribal water infrastructure development that has occurred was usually built subject to the modest limits of each tribe's ability to pay for construction directly, and/or its ability to access federal funding when it was available for such projects.

Overall, there remains a lack of adequate water infrastructure across tribal lands. The limited availability of financial resources continues to delay construction of new water projects, and causes setbacks in addressing needed repairs or rehabilitation of existing infrastructure, further contributing to lingering poverty within tribal communities.

Inadequate, aging and poorly maintained water systems impede cost-effective delivery, increasing the unreliability of irrigation projects which are often the largest economic driver in tribal communities. Under these conditions, tribal farms may suffer from uncertain water availability, lower crop yields, or poorer quality agricultural end-products, forcing producers to seek ways to offset the additional costs these unfavorable conditions represent – either by paying less for cropland leases or simply taking their business elsewhere.

Likewise, where a tribe's economy relies on oil, gas, minerals, timber or gaming operations, the cyclical or irregular income stream from these enterprises complicates long-term water infrastructure planning, funding and construction.

Another complication is the lack of a steady, reliable pool of qualified personnel to operate the tribal water infrastructure and irrigation systems – even those built and operated by the federal government for the benefit of tribes. Reservations are often remote and, as in most rural areas, the available labor force is usually small. Federal funding, even when available to support additional personnel at prevailing wage and benefits rates, is not always a sufficient inducement to attract and retain a steady labor force. In many cases, education and training of tribal personnel have not provided sufficient numbers of qualified personnel to keep pace with the operational and maintenance needs of commercial-scale domestic and irrigation water systems.

7.9.2 Opportunities

Partnership Tribes may take greater advantage of federal grants for education and training in water infrastructure design, engineering, construction, management, operations and other related programs which target low income and tribal communities; this could be a significant factor in addressing these limitations in Indian Country.

Partnership Tribes can also benefit by focused efforts to develop a skilled labor force from within their communities. Such efforts may include mentoring and training youth interested in careers in hydrologic engineering, management or operational areas.

7.9.3 Potential Actions

- Develop educational programs to enhance farming/ranching techniques/opportunities
- Develop programs to encourage and train tribal participants in operating/monitoring irrigation systems
- Improve compliance with Tribal Employment Rights Office ordinances for tribal employment and job training
- Create and develop individual and collaborative tribal socioeconomic plans

7.10 Summary

The Partnership Tribes identified nine categories of challenges, opportunities, and potential future actions related to the current use of tribal water and potential future water development. It is recognized that the applicability of the opportunities and potential future actions are dependent upon the administrative management of each Partnership Tribe's water resources, the Tribe's physical location, and state and federal water law, and will need to be vetted in consideration of local economies and related factors[7]. However, the identified opportunities and potential actions are considered to have the potential to assist Partnership Tribes in overcoming water use challenges and benefiting water management throughout the Basin.

[7] Consistent with the purposes of this Study, the lists of potential future actions in this section are neither exhaustive nor constitute a statement of endorsement of any potential future action by Reclamation or the Department of Interior. Additionally, Reclamation recognizes that some potential future actions identified here could require substantial and meaningful discussions with all Basin stakeholders.

8 Study Limitations

8.0 Introduction

Although the technical approach of the Tribal Water Study was based on the best science and information available, as with all studies, there were limitations related to timeframes and resource constraints. The detail at which results are reported or the depth to which analyses were performed was also limited by the availability of data and the capability of existing models. However, these limitations present opportunities for additional research and development to improve available data, which may be pursued by Partnership Tribes and other interested parties as follow-up to or independent of the Tribal Water Study.

8.1 Ability to Assess Current Tribal Water Use

The availability of data related to current water use varies among the Partnership Tribes. For Partnership Tribes in the Lower Basin, Reclamation relied on recent annual records of diversions, returns and consumptive use data compiled in the annual *Colorado River Accounting and Water Use Reports: Arizona, California, and Nevada* (Reclamation, 2017). In the Upper Basin, water use is accounted for by each state. In some states, Indian water use accounting is conducted by BIA, particularly on federal Indian irrigation projects. Without a coordinated administration system, water use data are sometimes inconsistent or even nonexistent, particularly on tributaries, which often lack adequate stream gaging. This meant the Upper Basin Partnership Tribes had to rely on multiple sources for their water use data, including internal technical assessments used to develop consumptive use estimates.

The remoteness of some of the Partnership Tribes' reservations and the complexity of their water systems are two other factors that greatly affected the quality of the water use data. Most water administration still relies heavily on in-person site visits to record measurements and ensure the calibration of measurement devices. It is often not possible to visit remote sites with the frequency desired, leading to data that can still provide a reliable record of use, but lacks detail. For the purposes of the Tribal Water Study, each Partnership Tribe assessed its available data with input from local water managers and utility operators to determine current water use with as much accuracy as circumstances would allow. Because of the differences in the availability and reliability of use data, some Partnership Tribes chose to represent current water use by averaging use over a recent 5-year period. For others, a single recent representative year was selected. Although this methodology does not provide a lengthy historical record of tribal water use, it nonetheless is a good snapshot of recent water use, by sector, for each Partnership Tribe and advances the understanding of tribal water use in the Basin.

8.2 Ability to Assess Future Tribal Water Development and Effects on Colorado River Water Availability

The Partnership Tribes intend to make full use of their federal Indian reserved water rights (most of which are senior priority water rights) and have, or are in the process of, developing and implementing tribal water development plans. One of the objectives of the Tribal Water Study was to project future tribal water development and use through the year 2060 in order to provide other water users in the Basin with a better understanding of and more certainty about the future availability of Colorado River water with the full development of federal Indian reserved water rights. However, the ability to assess the effects on Colorado River water availability from the future development of tribal water was limited by the spatial resolution of Reclamation's Colorado River Simulation System (CRSS)[1], as discussed more thoroughly in *Chapter 6 – Assessment of System Effects Resulting from Development of Tribal Water.* The information provided by the Partnership Tribes accounted for water use on a much finer spatial resolution than is currently represented in CRSS. Therefore, the locations of tribal diversions within CRSS are estimated. This effort may provide an opportunity for future refinement of CRSS, and, as noted above, post-Study efforts to improve understanding of the specific areas of the Basin likely to experience those effects.

In addition, in the Upper Basin, Reclamation's CRSS model does not simulate the complex individual state water rights administration systems that would be needed to model shortages to individual water rights holders. In order to address whether the Partnership Tribes' unused federal Indian reserved water rights are used by other water users, CRSS would need to have water accounting abilities. CRSS is not a water accounting model, and therefore is not able to track senior priority federal Indian reserved water rights of the Partnership Tribes and their use on a per-user basis. Consequently, the ability to identify effects on a per-user basis was limited and results for the Upper Basin are reported at a sub-basin level. In the Lower Basin, CRSS does track shortages to individual water rights holders. However, uncertainties exist regarding its ability to accurately model operations at Lake Powell and Lake Mead if Lake Mead reaches elevation 1,025 feet, triggering consultation regarding water deliveries per the *Record of Decision for Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead* (DOI, 2007). Given this uncertainty, and to maintain a commensurate level of detail with reporting in the Upper Basin, impacts to users in the Lower Basin are reported at a Lower Basin level in this report.

Despite these limitations, the assessment of future tribal water development provides a plausible indicator of the effect of tribal water use on the water supply of the Colorado River. The assessment provides a useful advancement of Colorado River System knowledge for future planning efforts and for consideration when addressing future Colorado River water challenges.

[1] CRSS was the primary modeling tool used in the Tribal Water Study. It simulates the operation of the major Colorado River System reservoirs on a monthly time step and provides information regarding the projected state of the System in terms of output variables.

9 Future Considerations and Next Steps

The Tribal Water Study is the outcome of a commitment between Reclamation and the Partnership Tribes to engage in a joint study that would build on the scientific foundation of the Colorado River Basin Water Supply and Demand Study (Basin Study) (Reclamation, 2012). Based on the information jointly developed in the Tribal Water Study and through collaboration with Reclamation, this Study highlights the following observations, concerns, and considerations:

- The Tribal Water Study revealed disparities among the Partnership Tribes, and between the Partnership Tribes and other water users in the Basin. These disparities have created barriers to the full development of federal Indian reserved water rights that include access to funding and capital markets for development, the lack of - *and poor condition of* - existing infrastructure, the number of tribal members and reservation residents without access to clean drinking water and adequate sanitation, and legal restrictions.
- Partnership Tribes have reserved water rights, including unresolved claims, to divert nearly 2.8 million acre-feet of water per year from the Colorado River and its tributaries. These rights are, in general, the most senior water rights in the Basin and therefore some of the most protected from shortage. However, some tribal lands and many people living on the tribal reservations do not have water security. Tribal communities are among the most economically depressed and impoverished in the Basin. Water is only one factor in this economic disparity, but when thousands of residents on tribal lands lack access to clean water and adequate sanitation, the path out of poverty is more difficult.
- *Chapter 5 – Assessment of Current Tribal Water Use and Projected Future Water Development,* documented each Partnership Tribes' anticipated development and use of reserved water rights and identifies trends for full tribal water development. The different trends indicate the anticipated rate at which such development might proceed. None of the Partnership Tribes currently has the basic infrastructure or legal and administrative flexibility to fully use or realize the full economic value of its reserved water rights. It has been more than 50 years since the decision in *Arizona v. California,*[1] yet some Partnership Tribes still do not have their water rights fully quantified. However, the Partnership Tribes expect that all reserved water rights in the Basin will be recognized and resolved over time.
- The Tribal Water Study also provided a technical analysis of the potential effects of the full development of tribal water. The Partnership Tribes anticipate that this effort will promote cooperation and coordination with other Basin stakeholders as we address challenges related to growing demands and the potential for reduced supplies and imbalances in the Colorado River System. Government-to-government coordination among tribal, federal, and state governments and cooperation with other Basin water users are the preferred and most effective pathways to address these documented challenges and disparities in the coming years and decades.

[1] *Arizona v. California,* 373 U.S. 546 (1963).

- *Chapter 6 – Assessment of System Effects Resulting from Development of Tribal Water,* explains the methodology used to analyze the effects of the Partnership Tribes' water development within the Basin, as applied in the Colorado River Simulation System (CRSS), the commercial software *RiverWare*™, and the state of Colorado's *StateMod* program. The goal of the modeling was to provide a sound technical basis and projection of the likely future scenarios for tribal development in the Basin.

  Although many of the Partnership Tribes do not currently use all their reserved water rights and have not developed the yet unquantified water rights, such tribal water does not go unused. The Basin Study (Reclamation, 2012) 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. The full development of reserved water rights for tribal benefit will widen this gap; however, the modeling indicates that the effect of tribal water development in the Basin is not as significant as full development of the state apportionments in the Upper Basin and the projected effect of climate variability.

  A decade ago, Reclamation and the Basin States recognized the need for flexibility in the operations of the system with the adoption of the 2007 *Record of Decision for Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead* (DOI, 2007). Mechanisms developed for Reclamation contractors and state-based water rights do not easily adapt to federal Indian reserved water rights held by Tribes. The Tribal Water Study demonstrates the need to develop flexible mechanisms for the use of tribal water throughout the Basin, such as off-reservation use of tribal water, particularly in times of shortage. Some Upper Basin Tribes have this flexibility through their water settlements, and the Quechan Tribe has a forbearance agreement with a California contractor. After review of the Tribal Water Study's analysis, the Partnership Tribes strongly believe and conclude that all tribes need similar flexibility. Without such flexibility, other water users who currently rely on unused tribal water may be required to adjust to reduced supplies as tribes increase or fully develop their reserved water rights.

- *Chapter 7 – Challenges and Opportunities Related to Development of Tribal Water,* identifies challenges and opportunities for full development of reserved water rights. Addressing the administrative and legal constraints that create disparities in water development and use are priorities for the Partnership Tribes, as doing so holds the greatest potential to benefit the Partnership Tribes and other water users in the Basin.

  The Partnership Tribes are committed to – and will – develop their water resources and explore opportunities to partner with the federal government, states and other water users as opportunities arise. Where the Partnership Tribes are unable to develop their water resources to receive the full economic benefit of their rights within existing laws, the Tribes will work with other Basin stakeholders to pursue policy, regulatory, and statutory changes.

  Potential actions identified by Partnership Tribes to overcome the challenges to obtaining full development and use of each Partnership Tribe's reserved water rights for the economic, social, and cultural benefit of the Tribe and its members are identified in Chapter 7.

Table 9-A identifies the Partnership Tribes' priority actions to address the water use challenges identified in the Tribal Water Study. Potential future actions to fulfill Reclamation's commitments to increase opportunities for tribes to develop, manage, and protect their water and related resources are also identified. Reclamation will work with the Partnership Tribes to identify near-term activities to help address the water challenges in the Colorado River Basin.

TABLE 9-A
Opportunities for Potential Future Action Identified by the Ten Tribes Partnership and the Bureau of Reclamation
The ordering of these lists does not imply a priority

Category	Ten Tribes Partnership	Bureau of Reclamation
Recognition and Use of Federal Indian Reserved Water Rights in the Basin	• Fully adjudicate or otherwise secure full legal recognition of federal Indian reserved water rights in the Basin. • The Partnership Tribes will pursue appropriate legal, policy and regulatory avenues which allow tribes the flexibility to fully use their water and realize full economic benefit therefrom.	• Work with agencies and tribes to prioritize the identification of legal, policy, and regulatory constraints to full use of tribal water. • Explore opportunities that enhance tribes' ability to put their water to full beneficial and economic use.
Continuous and Sustainable Funding	• Use existing studies and conduct additional economic and engineering assessments as needed to determine long-term tribal water infrastructure needs. • Explore options for generating dedicated revenue to finance infrastructure development and operation, maintenance and replacement costs. This could include: ○ Determining whether operation and maintenance (O&M) fees and project funding for tribal and BIA-managed facilities are adequate to maintain irrigation facilities; and ○ Evaluating opportunities to increase tribal management and oversight of BIA Indian irrigation projects. • Enhance access of Partnership Tribes to WaterSMART and other federal funding programs, including establishing tribal waivers for cost-share matching funds.	• Conduct comprehensive outreach to ensure that tribes are informed of Reclamation's technical assistance programs and WaterSMART funding opportunities. • Partner with other federal agencies to understand and communicate funding opportunities available to tribes to develop the expertise, funding and/or resources for comprehensive water management planning and implementation. Facilitate enhanced coordination among existing programs, such as with U.S. Department of Agriculture. • Explore ability to build tribal capacity regarding grant writing to increase competitiveness when applying for federal assistance.
Environmental Water Uses	• Work with state and federal partners to ensure that environmental flows are included in water management plans to help protect ecosystems and cultural values. • Work with federal partners to address the Partnership Tribes' preferred approach of including existing Indian reserved water rights and future settlements in the environmental baselines developed as part of Endangered Species Act Section 7 consultations with the U.S. Fish and Wildlife Service so tribes are not disproportionately burdened with further compliance.	• Investigate opportunities for tribes to participate in water management for the protection or restoration of flows for environmental, recreational, and cultural purposes.

TABLE 9-A
Opportunities for Potential Future Action Identified by the Ten Tribes Partnership and the Bureau of Reclamation
The ordering of these lists does not imply a priority

Category	Ten Tribes Partnership	Bureau of Reclamation
Partnerships	• Establish mechanisms with federal partners to include tribes in the formal and informal discussions among the Basin States and between the Basin States and DOI concerning the management and operation of the Colorado River. • Work to obtain tribal participation with the Upper Colorado River Commission. • Work to obtain greater tribal input in Reclamation's long-term planning for the Lower Basin. • Work with federal, state and local governments to include tribal representation in water management agencies. • Foster and strengthen stakeholder relationships with non-governmental organizations working within the Basin. • Foster and strengthen stakeholder relationships to facilitate local and regional planning as future tribal water development occurs. • Create model programs for tribal development in cooperation with neighboring communities and entities.	• Build on the momentum and dialogue of the Tribal Water Study to increase the effectiveness of partnerships when new challenges and opportunities arise. • Facilitate planning efforts among Basin water users, stakeholders, and tribes to develop regional and local water management solutions, thereby reducing the likelihood of conflict. • Facilitate tribal involvement with DOI/Reclamation and Basin States discussions concerning management and operation of the Colorado River System. • Continue to improve relations with tribes at a regional and local level with respect to water issues of mutual concern. • Foster and strengthen stakeholder relationships with non-governmental organizations working within the Basin.
Conservation and Drought Management	• Develop and implement on-reservation conservation measures consistent with protecting the full extent of Indian reserved water rights for tribal benefit. • Develop tribal drought management plans including response actions consistent with tribal priorities for the use of their water rights.	• Continue to include tribes as additional drought mitigation tools are explored in the Basin, including infrastructure improvements. • Explore opportunities to assist tribes in water conservation efforts and system efficiency improvements, including targeted outreach and partnerships. • Increase the integration of water/energy-efficiency programs and resource planning.

TABLE 9-A
Opportunities for Potential Future Action Identified by the Ten Tribes Partnership and the Bureau of Reclamation
The ordering of these lists does not imply a priority

Category	Ten Tribes Partnership	Bureau of Reclamation
Data Collection and Tools for Water Management	• Seek to implement state-of-the-art technology for collecting tribal water supply and use data. • Develop coordinated and accurate water accounting systems among Partnership Tribes, state and federal entities in the Upper Basin. • Refine CRSS to account for water use by the Partnership Tribes on a finer spatial resolution and to improve the understanding of the specific areas of the Basin likely to experience effects of future state and tribal water development. • Work with state and federal partners to install additional stream flow gages using cost-sharing agreements among the Partnership Tribes, U.S. Geological Survey, Reclamation, BIA, and state entities to further the understanding of the effects of changing water supply on Partnership Tribes and future water development to non-tribal users.	• Explore developing or revising models to incorporate a finer spatial resolution than is currently represented in CRSS, which would more accurately locate tribal diversions. • Explore developing the capability to track senior priority federal Indian reserved water rights of the Partnership Tribes and their use on a per-user basis. • Facilitate coordinated and defensible water accounting throughout the Basin. • Assist tribes to develop state-of-the-art technology to help with monitoring and measuring water supply and use data.
Educational Opportunities	• Seek venues to educate all Basin stakeholders about Indian reserved water rights and development. • Partner with existing educational programs or develop new programs to teach or enhance farming and ranching techniques, and create related job opportunities. • Partner with existing programs or develop new programs to encourage and train tribal participants in operating, monitoring, maintaining and replacing agricultural irrigation systems and municipal sanitation and distribution systems. Existing programs include: ○ WaterOperator.org ○ Native American Water Masters Associations (NAWMAs) ○ BIA Water Resources Technician Training Program • Establish an online mechanism to provide a central location for Partnership Tribes to learn about educational and funding opportunities.	• Assist tribes to increase their capacity in water management, including partnering with other federal agencies providing water-related training and services for tribes.

Disclaimer

The Colorado River Basin Ten Tribes Partnership Water Study (Tribal Water Study) was funded jointly by the Bureau of Reclamation (Reclamation) and the ten federally recognized Indian tribes of the Ten Tribes Partnership (Partnership). The purpose of the Tribal Water Study was to conduct a comprehensive assessment of tribal water supplies for the Partnership Tribes. The Tribal Water Study includes documentation of the Partnership Tribes' current water use, projections of future water development, and the Basin-wide effects of full development of tribal water rights. The Tribal Water Study also identifies opportunities and challenges associated with the development of tribal water considering the future water supply and demand imbalances documented in the Colorado River Basin Water Supply and Demand Study. Although the Tribal Water Study identified potential legal and policy issues related to tribal water development and potential solutions to water imbalances, the Study was intended to view tribal water in the context of the federal Indian reserved water rights and current legal framework commonly and collectively referred to as the "Law of the River."

Reclamation and the Partnership expect the Tribal Water Study to encourage communication throughout the Basin and with the Partnership Tribes regarding system reliability challenges, the needs of all water users, and strategies that may be considered to meet demand equitably over time. Reclamation and the Partnership recognize the Tribal Water Study was constrained by funding, timing, technological and other limitations, which presented some policy questions and issues, particularly related to modeling, the treatment of federal Indian reserved water rights, and the provisions of the Law of the River. In such cases, Reclamation and the Partnership developed and incorporated assumptions to further complete the Tribal Water Study. Where possible, a range of assumptions were used to identify the sensitivity of the results to those assumptions.

Nothing in the Tribal Water Study, however, is intended for use against any of the tribes in the Colorado River Basin, including the Partnership Tribes; any Basin State; the federal government; or the Upper Colorado River Commission in any administrative, judicial or other proceeding for any purpose whatsoever, including, but not limited to evincing or supporting any legal interpretation of federal Indian reserved water rights or the Law of the River. As such, the assumptions contained in the Tribal Water Study or in any reports generated during the Study do not, and shall not, represent a legal position or interpretation of any of the water rights of the Partnership Tribes, by any Basin State, the federal government, or the Upper Colorado River Commission as it relates to the Law of the River. Furthermore, nothing in the Tribal Water Study is intended to, nor shall the Study be construed so as to, interpret, diminish or modify the water rights of any of the Partnership Tribes, any other tribe, any Basin State, the federal government, or the Upper Colorado River Commission under federal or state law or administrative rule, regulation or guideline. Reclamation and the Partnership continue to recognize the right of each of the Partnership Tribes and of each of the Basin States under existing law to use and develop the water of the Colorado River System.

References

Bureau of Reclamation (Reclamation). 2006a. Record of Decision for the Navajo Reservoir Operations, Navajo Unit–San Juan River New Mexico, Colorado, Utah, Final Environmental Impact Statement.

_____. 2006b. Record of Decision for the Operation of Flaming Gorge Dam Final Environmental Impact Statement.

_____. 2007. Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead Final Environmental Impact Statement.

_____. 2012a. Colorado River Basin Water Supply and Demand Study. December.

_____. 2012b. Colorado River Basin Water Supply and Demand Study, Technical Report B – Water Supply Assessment. December.

_____. 2012c. Colorado River Basin Water Supply and Demand Study, Technical Report C – Water Demand Assessment. December.

_____. 2012d. Record of Decision for the Aspinall Unit Operations, Final Environmental Impact Statement.

_____. 2015. Colorado River Basin Stakeholders Moving Forward to Address Challenges Identified in the Colorado River Basin Water Supply and Demand Study. May.

_____. 2016a. Operation Plan for Colorado River System Reservoirs, August 2016 24-Month Study.

_____. 2016b. The Colorado River System: Projected Future Conditions 2017-2021. August.

_____. 2017. Colorado River Accounting and Water Use Reports: Arizona, California, and Nevada.

Colorado River Water Users Association (CRWUA). 2017. Agriculture. Retrieved on August 4, 2017 from https://www.crwua.org/colorado-river/uses/agriculture.

Colorado Water Conservation Board. 2017. StateMod. Retrieved on June 27, 2017 from http://cdss.state.co.us/software/Pages/StateMod.aspx.

Federal Register (Fed. Reg.). 2008. Notice of Proposed Rulemaking Regulating the Use of Lower Colorado River Water Without an Entitlement. Federal Register/Vol. 73, No. 137/ Wednesday, July 16, 2008.

HDR Engineering Inc., 2003. Western Navajo Hopi Water Supply Study.

Jefferson, J., R.W. Delaney, and G.C. Thompson. 1972. The Southern Utes: A Tribal History.

Maurer, E. P., L. Brekke, T. Pruitt, and P.B. Duffy. 2007. "Fine-Resolution Climate Projections Enhance Regional Climate Change Impact Studies." Eos, Transactions, American Geophysical Union, 88 (47), 504.

Navajo Department of Health. 2013. Navajo Population Profile 2010 U.S. Census. December.

Navajo Division of Economic Development. 2010. 2009-2010 Comprehensive Economic Development Strategy.

Navajo Nation Department of Water Resources (NDWR). 2003. Navajo Nation Drought Contingency Plan.

______. 2012. Water Resource Development Strategy for the Navajo Nation.

Navajo Nation Environmental Protection Agency (NNEPA) 2017. Retrieved from: http://www.navajopublicwater.org/PWS.html

New Mexico Interstate Stream Commission. 2017. Northwest New Mexico Regional Water Plan. January.

Ouarda, T., J.W. Labadie, and D.G. Fontane. 1997. "Indexed sequential hydrologic modeling for hydropower capacity estimation." Journal of the American Water Resources Association, 33(6), 1337–1349.

Quintana, F.L. 2004. Ordeal of Change: The Southern Utes and Their Neighbors.

Schurz, C. 1877. Report of the Secretary of the Interior.

Southern Ute Indian Tribe (SUIT). 2012. Southern Ute Natural Resource Management Plan, Planning Period 2012-2023. August.

______. 2015. Southern Ute Tribal Information Services, Vital Statistics data.

Timpe, C. and M.J.J. Scheepers. 2003. SUSTELNET: A Look into the Future: Scenarios for Distributed Generation in Europe.

U.S. Department of Agriculture, Soil Conservation Service (USDA). 1986. Inventory of Navajo Indian Irrigation Projects.

U.S. Climate Data. 2017. Climate Needles – California. Retrieved from http://www.usclimatedata.com/climate/needles/california/united-states/usca0753.

U.S. Census Bureau. 2011. Population Distribution and Change: 2000 to 2010. 2010 Census Briefs.

U.S. Department of the Interior (DOI). 2007. Record of Decision for Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead. December.

U.S. Geological Survey (USGS). 1996. Dakota-Glen Canyon Aquifer System.

______. 2005. Lithology and Thickness of the Carmel Formation as Related to Leakage Between the D and N Aquifers, Black Mesa, Arizona.

Western Regional Climate Center. 2006. Yuma Valley, Arizona, Period of Record General Climate Summary – Precipitation. Retrieved from https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?azyuva.

Zagona, E., T. Fulp, R. Shane, T. Magee, and H. Goranflo. 2001. “RiverWareTM: A Generalized Tool for Complex Reservoir Systems Modeling.” Journal of the American Water Resources Association. 37(4):913–929.

Glossary

Colorado River System – The portion of the Colorado River and its tributaries within the United States of America

Demand – Water needed to meet identified uses

Depletion – A use of surface water or groundwater due to human-caused activity, including interbasin transfers. Also termed consumptive use.

Diversion – Water withdrawn from the river system

Diversion point – Location on the Colorado River or its tributaries at which water is diverted for depletion

Non-consumptive use – Water used without diminishing the available supply

Hydrologic shortage – Unmet demand that is not the result of any policy, such as prescribed shortage delivery reductions

Indian Country – Indian Country is defined at 18 U.S.C. § 1151 as:

a. all land within the limits of any Indian reservation under the jurisdiction of the United States Government, notwithstanding the issuance of any patent, and, including rights-of-way running through the reservation;
b. all dependent Indian communities within the borders of the United States whether within the original or subsequently acquired territory thereof, and whether within or without the limits of a state; and
c. all Indian allotments, the Indian titles to which have not been extinguished, including rights-of-way running through the same.

Consistent with the statutory definition of Indian Country, as well as federal case law interpreting this statutory language, lands held by the federal government in trust for Indian tribes that exist outside of formal reservations are informal reservations and, thus, are Indian Country.

Influencing factor – Factors that will likely have the greatest influence on the future of tribal development and use of water from the Colorado River and its tributaries over time

Importance – Being of great significance or value. Used to rate the importance of an influencing factor to tribal development and the use of water from the Colorado River and its tributaries relative to the remaining influencing factors.

Key influencing factors – The key driving forces that are identified as both highly uncertain and highly important

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

Mean sea level – Elevation as established by the U.S. Coast and Geodetic Survey (now superseded by the Environmental Science Service Administration) at the time of the construction of Hoover Dam and Glen Canyon Dam.

Natural inflow – Calculated as gaged flow corrected for the effects of upstream reservoirs and depletion

Policy shortage – Unmet demand that is the result of a policy, such as prescribed shortage delivery reductions

Return flow – Water diverted from and returned to the river system

Simulation set – A collection of model simulations that share the same Tribal Water Development Scenario, Water Supply Scenario, and Reservoir Operation Policy

System reliability metrics – Measurements that indicate the ability of the Colorado River System to meet water delivery needs under multiple future conditions

Trace – A single model simulation

Tribal – Generally refers to the member tribes of the Ten Tribes Partnership, unless the context expresses otherwise.

Uncertainty – Imperfect or unknown information. Used to rate the uncertainty of an influencing factor to tribal development and the use of water from the Colorado River and its tributaries relative to the remaining influencing factors.