RECLAMATION
Managing Water in the West

Interim Report No. 1

Colorado River Basin Water Supply and Demand Study

Status Report

U.S. Department of the Interior
Bureau of Reclamation

June 2011

Mission Statements

Protecting America's Great Outdoors and Powering Our Future
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.

Interim Report No. 1

Colorado River Basin Water Supply and Demand Study

Status Report

Prepared by:

Colorado River Basin Water Supply and Demand Study Study Team

U. S. Department of the Interior
Bureau of Reclamation

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1.0 Introduction

The Colorado River Basin Water Supply and Demand Study (Study), initiated in January 2010, is being conducted by the Bureau of Reclamation's (Reclamation) Upper Colorado (UC) and Lower Colorado (LC) regions, and agencies representing the seven Colorado River Basin States[1] (Basin States). The purpose of the Study is to define current and future imbalances in water supply and demand in the Colorado River Basin (Basin) and the adjacent areas of the Basin States that receive Colorado River water over the next 50 years (through 2060), and to develop and analyze adaptation and mitigation strategies to resolve those imbalances.

Due to the complexity of the Study and the diverse interests throughout the Basin, a dynamic reporting approach that integrates continuous technical developments and the ongoing input of stakeholders has been adopted. This approach consists of the issuance of interim reports, which are "snapshots" of the Study's progress as of a particular date. Interim reports describe work completed, work in progress, and interim findings for the Study through a particular date and are organized in three major parts: an Executive Summary, a Status Report (including appendices), and Technical Reports (including appendices).

Interim Report No. 1, which documents the Study progress through January 31, 2011, is the first interim report to be issued. It is anticipated that there will be two additional interim reports released during the course of the Study, as well as the release of a final report.

This Status Report provides information about the status of the Study as of January 31, 2011, and includes four appendices: 1) *Plan of Study*, 2) Steering Team, Project Team, and Study Team Members, 3) Public Involvement Plan, and 4) Outreach Activities. Members of various technical sub-teams are listed in the appendices of the appropriate Technical Reports.

This Status Report also provides summaries of the four Technical Reports included in Interim Report No. 1, listed below:

- **Technical Report A - Scenario Development.** This report describes the scenario planning approach used to incorporate uncertainty in future water supply and water demand.
- **Technical Report B - Water Supply Assessment.** This report describes the water supply scenarios and presents the analysis and comparison of those scenarios.
- **Technical Report C - Water Demand Assessment.** This report describes the water demand scenarios currently under development and presents historical consumptive use information.

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

- **Technical Report D - System Reliability Metrics.** This report describes the metrics that have been identified for use in the assessment of the reliability of the system to meet the needs of the resources under future supply and demand scenarios.

Project participants and stakeholders are encouraged to comment on the information provided in this Interim Report No. 1 and subsequent reports. Written comments should be submitted within 30 days following the release of each interim report and will be incorporated into subsequent interim reports, as appropriate. Comments may be submitted in the following ways:

1. Via the Study website at: http://www.usbr.gov/lc/region/programs/crbstudy.html
2. E-mail to ColoradoRiverBasinStudy@usbr.gov
3. U.S. mail to: U.S. Bureau of Reclamation, Attention: Ms. Pam Adams, LC-2721, P.O. Box 61470, Boulder City, NV 89006-1470
4. By facsimile transmission to 702-293-8418

2.0 Background and Need

Today, more than 30 million people in the seven western states of Arizona, California, Nevada (Lower Division States) and Colorado, New Mexico, Utah and Wyoming (Upper Division States), collectively referred to as the Basin States, rely on the Colorado River and its tributaries to provide some, if not all, of their municipal water needs. That same water source irrigates nearly 4 million acres of land in the Basin—producing some 15 percent of the nation's crops and about 13 percent of its livestock, which combined generate more than $3 billion a year in agricultural benefits. The Colorado River is also the lifeblood for at least 15 Native American tribes and communities, 7 National Wildlife Refuges, 4 National Recreation Areas, and 11 National Parks. Hydropower facilities along the Colorado River provide more than 4,200 megawatts of capacity providing vitally important electricity to help meet the power needs of the West and offset the use of fossil fuels. The Colorado River is also vital to Mexico. The river supports a thriving agricultural industry in the Mexicali Valley and provides municipal water supplies for communities as far away as Tijuana.

Based on the approximately 100-year historical record[2], the natural inflow[3] into the Basin, which represents the Basin-wide water supply, has averaged about 16.4 million acre-feet[4] (maf). This value is comprised of approximately 15.0 maf of natural flow into the Upper Basin and approximately 1.4 maf of natural flow into the Lower Basin. Paleo reconstructions of streamflow indicate that the long-term average natural flow at Lees Ferry is likely lower, with the most recent study suggesting it may be closer to 14.7 maf, or 2 percent lower (Meko

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[2] The current natural flow record extends from 1906-2008 for a period of 103 years. The record does not extend to the current year due to an approximate 2-year lag in the availability of data needed to compute natural flow.

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

[4] In the current natural flow record, historical inflows based on U.S. Geological Survey gaged records are used for the Paria River, Little Colorado River, Virgin River, and Bill Williams River. Additionally, the Gila River is not included in the natural flow record. See *Technical Report C – Water Demand Assessment, Appendix C5,* for additional detail.

et al., 2007). The period from 2000 through 2010[5] represents the lowest 11-year average natural flow at Lees Ferry in recorded history, averaging 12.1 maf per year, approximately 20% below the 103-year average. Although an 11-year drought of this magnitude is unprecedented in over 100 years, the same paleo reconstructions of streamflow studies show that droughts of this severity or greater have occurred in the past.

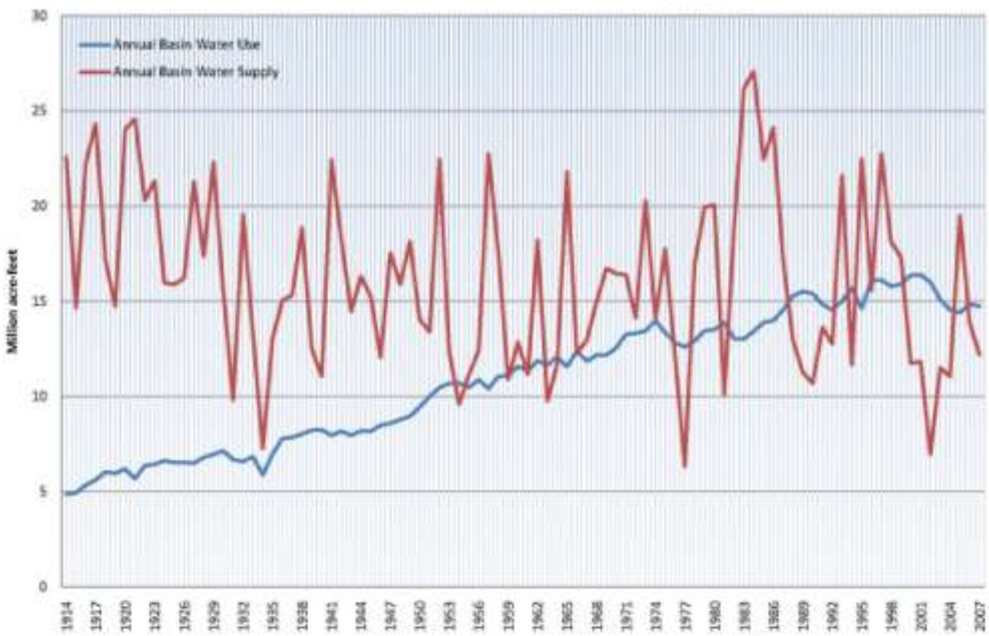
Based on the inflows observed over the last century, the Colorado River is over-allocated. The Colorado River Compact of 1922 apportioned 7.5 maf each to the Upper and Lower Division States, and the 1944 Treaty with Mexico allotted 1.5 maf to Mexico. Total Basin use for municipal, industrial, agricultural, tribal, recreational, and environmental purposes in the United States and the delivery to Mexico (including system losses such as reservoir evaporation) averaged 16.0 maf in 1999, prior to the start of the recent drought.

Figure 1 shows the historical annual Basin water supply (estimated using the natural flow record) and water use[6]. This figure shows that there have been multiple years when use was greater than the supply. Due to the considerable amount of reservoir storage capacity in the system (approximately 60 maf of storage, or roughly four times the average annual natural inflow), most water demands were met during those times. During droughts, however, significant use reductions routinely occur due to a lack of available supply, particularly in the headwater areas in the Upper Basin.

[5] Provisional estimates of natural flow at Lees Ferry are available for 2009 and 2010.

[6] Historical use (as shown in Figure 1) does not necessarily reflect historical water demand, particularly for periods of drought. A decrease in reported use during a drought period may reflect the lack of available supply at the point of use rather than a decrease in the demand for water.

FIGURE 1
Historical Annual Colorado River Basin Water Supply and Use



NOTE:
Natural flow is used as an estimate of water supply in the Basin. In the current natural flow record, historical flows based on U.S. Geological Survey gaged records are used for the Paria River, Little Colorado River, Virgin River, and the Bill Williams River. Additionally, the Gila River is not included in the natural flow record. Historical water use is the total use of water throughout the Basin for agricultural, municipal and industrial, and other consumptive uses including Mexico, plus losses due to evaporation at mainstream reservoirs and use by native and non-native vegetation. In the current natural flow record, historical inflows based on USGS gaged records are used as estimates of natural flow for the Paria River, Little Colorado River, Virgin River, and Bill Williams River. Additionally, the Gila River is not included in the natural flow record. As such, the use reported here excludes consumptive uses on these tributaries. See Technical Report C – Water Demand Assessment, Appendix C5 for additional detail regarding the treatment of these tributaries in the Study.

Throughout the 20th-century, the challenges and complexities of ensuring a sustainable water supply and meeting future demand have been recognized. These challenges are documented in several studies conducted by Reclamation and the Basin States over the past 60 years. In particular, these studies discussed future water supply and demand imbalances and in some cases proposed solutions to dealing with these imbalances. Notable examples of such studies are:

- *Colorado River Storage Project and Participating Projects; Upper Colorado River Basin.* (Reclamation, 1950). This report combined various individual Upper Basin reservoir proposals into a comprehensive plan to increase long-term carryover water storage.
- *Pacific Southwest Water Plan*. (Reclamation, 1964). This report projected a Lower Basin water supply and demand imbalance and proposed a comprehensive plan to improve water supply and distribution, including the importation of water from the northern California coastal area.
- *Comprehensive Framework Study, Lower Colorado Region* (Pacific Southwest Inter-agency Committee, 1971a). This federal-state study projected a Lower Basin water

supply and demand imbalance and concluded that that a future water import program would be needed as part of a proposed framework program for the development and management of Lower Basin water resources to 2020.

- *Comprehensive Framework Study, Upper Colorado Region* (Pacific Southwest Inter-agency Committee, 1971b). This federal-state study presented a framework program for the development and management of the water and related land resources of the Upper Basin to 2020, including alternative plans with emphases on differing water uses, some of which were dependent upon water importation.
- *Westwide Study Report on Critical Water Problems Facing the Eleven Western United States*, (Reclamation, 1975). This federal-state study described key factors affecting future water needs, formulated alternative future demand scenarios, and identified options for dealing with anticipated shortages. The study concluded that in spite of conservation, the Basin faces future water shortages unless its natural flows are augmented or water-dependent Basin development is curtailed.

These studies clearly recognized the challenges facing the Basin. The Colorado River Basin Project Act of 1968, which authorized the construction of the Central Arizona Project, the Southern Nevada Water Project, and other projects in the Lower Basin, further discussed the need for augmentation[7].

In the latter part of the 20th-century, the focus changed from developing available water resources to an emphasis on improving the efficiency of the operation of Colorado River reservoirs and increasing the level of predictability needed by entities that receive Colorado River water to better plan for and manage available water supplies. Two notable examples from this period are the *Operation of Glen Canyon Dam Final Environmental Impact Statement* (Reclamation, 1996) and the *Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations of Lake Powell and Lake Mead Final Environmental Impact Statement* (Interim Guidelines EIS, Reclamation, 2007). Both of these resulted in the adoption of new reservoir operating policies.

2.1 The Need for the Study

Concerns regarding the reliability of the Colorado River system to meet future needs are even more apparent today. The Basin States include some of the fastest growing urban and industrial areas in the United States. Nevada, Arizona, and Utah are each ranked among the five fastest growing states in the country. The continued growth and sustainability of the communities and economies of metropolitan areas such as Albuquerque, Denver, Las Vegas, Los Angeles, Phoenix, Salt Lake City, and San Diego is tied to future water availability from the Colorado River. Demand for water for other uses, including the environment, recreation, and Native American water rights settlements, also continues to increase. Potential future increases in temperatures in the Basin, as observed in most of the Basin over the past 30 to

[7] Section 202 of the Colorado River Basin Project Act provides in part that "The satisfaction of the requirements of the Mexican Water Treaty, shall be from the waters of the Colorado River pursuant to the treaties, laws, and compacts presently relating thereto, until such time as a feasible plan showing the most economical means of augmenting the water supply available in the Colorado River below Lee Ferry by two and one-half million acre-feet shall be authorized by the Congress and is in operation as provided in this Act."

40 years (National Research Council, 2007), would increase evapotranspiration from vegetation, as well as water lost from evaporation from reservoirs.

How climate change and variability might affect the Basin water supply has been the focus of many scientific studies. Climate experts expect the Southwestern United States to be drier in the future and droughts to occur of greater severity than those seen in the past. Recent studies have postulated that the average yield of the Colorado River could be reduced by as much as 20 percent due to climate change (Hoerling et al., 2009). Increasing demands, coupled with decreasing supplies, will certainly exacerbate imbalances throughout the Basin.

Although a shortage to the Lower Division States (i.e., insufficient water available to satisfy annual consumptive use of 7.5 maf) has not been determined to date, some water agencies are experiencing shortages in water deliveries to their customers in recent years. In California, drought conditions, along with increased regulatory restrictions, caused the Metropolitan Water District of Southern California to ration water to its customers in 2009 for the first time in nearly 20 years. These water shortages increase costs to businesses already stressed by the current economic downturn. In addition, to help meet critical water supply needs in the urban areas, programs have been implemented to fallow land in agricultural areas and transfer the conserved water to urban areas. Although this has helped to meet the water needs of the urban areas, it has also reduced the food and fiber production from the region.

Absent the development of additional water supplies, the Upper Basin likely cannot realize full development of its Colorado River Compact apportionment with any level of certainty. Shortages in the Upper Basin are a reality today. Unlike the Lower Basin, which draws its supply from storage in Lake Mead, the Upper Basin is more dependent on annual streamflow to meet its needs.

As of January 31, 2011, Lake Mead is at approximately 42 percent capacity, with a water surface elevation of approximately 1,092 feet. If the current drought continues and water levels in Lake Mead fall below 1,025 feet, pursuant to the Interim Guidelines, the Central Arizona Project, which delivers Colorado River water to the Phoenix and Tucson metropolitan areas, would see its supply cut by nearly a third. Under the same circumstance, the Southern Nevada Water Authority's supplies, of which 90 percent come from the Colorado River and serve about 2 million people in the Las Vegas area, would be curtailed by 20,000 acre-feet annually, nearly 7 percent of Nevada's annual apportionment.

Figure 2 presents the data from Figure 1 as a 10-year running average to smooth out the annual variability so that trends are more visible. This figure illustrates clearly that a supply and demand imbalance currently exists in the Basin. This imbalance will grow in the future if the potential effects of climate change are realized and demands continue to increase. A combination of options, including conservation and reuse, development of local groundwater supplies, desalination, augmentation, and the transfer of water from agricultural to urban uses, will likely be needed. The Study will assess these and other options for resolving the projected imbalances in both the Upper and Lower Basins, and develop recommendations to sustain the environment, people, and economy of this region.

FIGURE 2
Historical 10-Year Running Average Colorado River Basin Water Supply and Use

NOTE:
Natural flow is used as an estimate of water supply in the Basin. In the current natural flow record, historical flows based on U.S. Geological Survey gaged records are used for the Paria River, Little Colorado River, Virgin River, and the Bill Williams River. Additionally, the Gila River is not included in the natural flow record. Historical water use is the total use of water throughout the Basin for agricultural, municipal and industrial, and other consumptive uses including Mexico, plus losses due to evaporation at mainstream reservoirs and use by native and non-native vegetation. In the current natural flow record, historical inflows based on USGS gaged records are used as estimates of natural flow for the Paria River, Little Colorado River, Virgin River, and Bill Williams River. Additionally, the Gila River is not included in the natural flow record. As such, the use reported here excludes consumptive uses on these tributaries. See Technical Report C – Water Demand Assessment, Appendix C5 for additional detail regarding the treatment of these tributaries in the Study.

3.0 Basin Study Program

The Basin Study Program is part of the Department of the Interior's WaterSMART Program[8], which addresses 21st-century water supply challenges such as population growth, increased competition for finite water supplies, and climate change. The establishment of the WaterSMART Program addresses the authorities within the SECURE Water Act (Subtitle F of the Omnibus Public Land Management Act of 2009, Public Law 111-11), which was passed into law on March 30, 2009. The SECURE Water Act provides authority for federal water and science agencies to work together with state and local water managers to plan for climate change and other threats to water supplies, and take action to secure water resources for the communities, economies, and the ecosystems they support.

In 2008, Reclamation initiated the Basin Study Program to fund comprehensive studies to define options for meeting future water demands in river basins in the West where imbalances in supply and demand exist or are projected. At that time, it was envisioned that a

[8] Additional information regarding this program can be found at http://www.usbr.gov/WaterSMART/.

Basin Study would quantify current and future water supply and demand imbalances, assess the resulting risks to the basin resources, and assess options to resolve those imbalances. Since that time, the Basin Study Program has evolved to focus on the development and analysis of options to address water supply and demand imbalances. The quantification of imbalances and the subsequent risk assessment is now done through an activity known as the West-wide Climate Risk Assessments (another activity under the WaterSMART Program) and is used to inform subsequent Basin studies.

In March 2011, a report (SECURE Report) to Congress was released to respond to requirements of the SECURE Water Act (Reclamation, 2011). The SECURE Report provides information on the future risks to water supply in the 8 major Reclamation River Basins, whereas this study is focused on a more detailed, basin-wide risk assessment with a focus on the development and evaluation of opportunities to mitigate and adapt to those risks. Minor differences exist in the streamflow projections based on global climate models presented in the SECURE Report as compared to the projections presented in this report. These differences are due to methodological and reporting differences between the two efforts. These differences are summarized in a later section of this report and in *Technical Report B – Water Supply Assessment*.

4.0 Study Objectives and Approach

Representatives of the seven Basin States submitted a letter of intent in February 2009, under the Basin Study Program, to help fund and participate in a study of the Basin. Based on that letter of intent, Reclamation's UC and LC regions, in collaboration with the Basin States, developed and submitted a proposal in June 2009 to fund the Study. The proposal was selected for funding in September 2009, and a financial agreement between the Basin States and Reclamation for the Study was signed in February 2010. Reclamation entered into a contract with CH2M HILL (including Black & Veatch and Cardno-ENTRIX) in April 2010 to provide technical and administrative support for the Study.

The *Plan of Study*, provided in Appendix 1, states that the purpose of the Study is to define current and future imbalances in water supply and demand in the Basin and the adjacent areas of the Basin States that receive Colorado River water over the next 50 years (through 2060), and to develop and analyze adaptation and mitigation strategies to resolve those imbalances. The *Plan of Study* lays out specific objectives that have been or will be addressed through the Study, including:

- Characterization of the current water supply and demand imbalances in the Basin and the assessment of the risks to Basin resources from historical climate variability
- Characterization of future water supply and demand imbalances under varying water supply and demand conditions in the Basin and the assessment of the risks to Basin resources from possible future impacts of climate change
- Identification of potential strategies and options to resolve Basin-wide water supply and demand imbalances, including:
  - Modifications to the operating guidelines or procedures of water supply systems

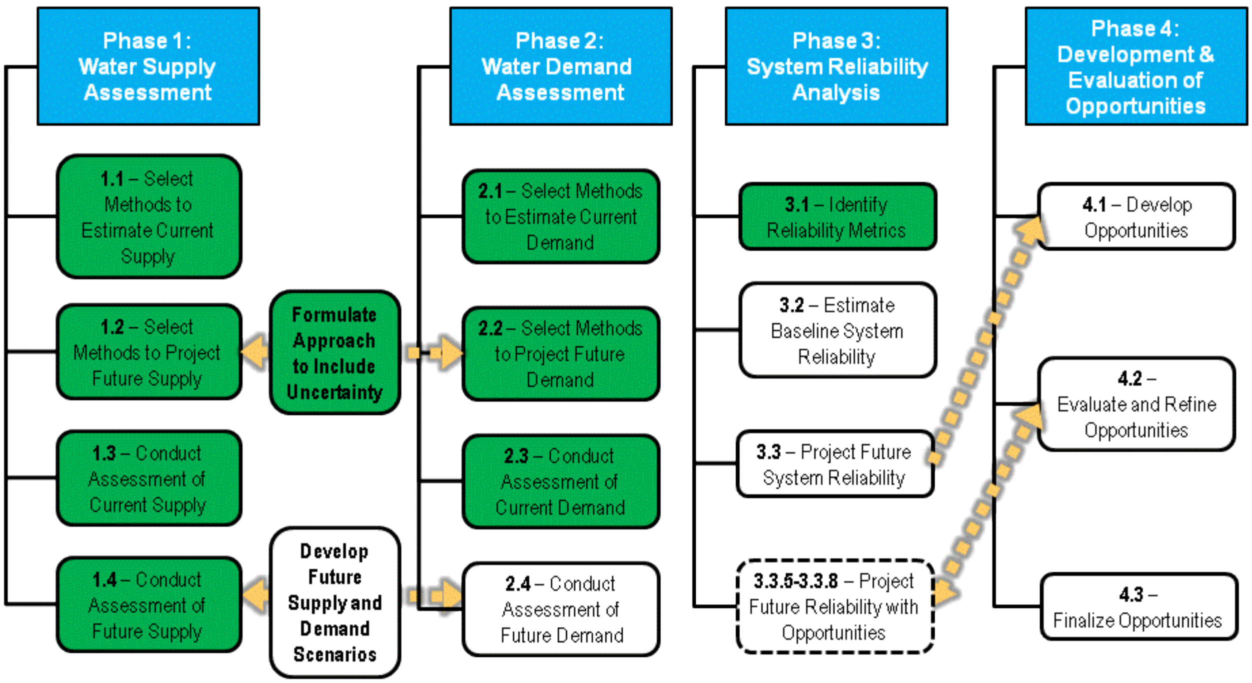
  - Modifications to existing facilities and development of new facilities
  - Modifications to existing water conservation and management programs and development of new programs
  - Modifications to existing water supply enhancement programs and development of new programs
  - Other structural and non-structural solutions
- Identification of potential legal and regulatory constraints and analysis of potential impacts to water users and Basin resources for the strategies and options considered
- Prioritization of identified strategies and options and the recommendation for potential future actions, including feasibility studies, environmental compliance activities, demonstration programs, and/or implementation as appropriate

The Study area is defined by the hydrologic boundaries of the Colorado River Basin, plus the adjacent areas of the Basin States that receive Colorado River water, and is depicted in Figure 3.

FIGURE 3
The Study Area

The Study contains four major phases: Water Supply Assessment, Water Demand Assessment, System Reliability Analysis, and Development and Evaluation of Opportunities for balancing supply and demand. Figure 4 illustrates these phases and some of their interrelationships. Tasks that are essentially completed as of January 31, 2011, are shaded.

FIGURE 4
Study Phases and Tasks



4.1 Study Organization

As envisioned by the *Plan of Study*, two Co-Study Managers (one from Reclamation and the other representing the Basin States) lead and are responsible for the overall direction and management of the Study. In addition, the following teams have been established to facilitate the completion of the Study. Members of the Steering, Project, and Study Teams are listed in Appendix 2:

- Steering Team (one member from each of Reclamation's UC and LC regions, one member from each of the seven Basin States, and one member from the Upper Colorado River Commission) steers and guides the efforts of the Project Team such that the objectives of the Study are met in an effective, efficient manner, and within the Study's financial and time constraints.
- Project Team (composed of staff from the Basin States, Reclamation's UC and LC regions, and from the consulting team) ensures that the tasks that relate to the Study are completed in a cost-effective, timely manner and are technically sound.
- Study Team (composed of key staff from the UC and LC regions and the consulting entities) completes the Study tasks.

The *Plan of Study* also envisioned the formation of various sub-teams (comprised of staff from the Project Team and other interested parties with expertise) to perform specific work and tasks. In addition to Project Team members, sub-teams include staff from various environmental groups, Native American tribes and communities, other federal agencies, and other stakeholders. The following sub-teams participated in the development of the technical information and analytical approaches documented in Interim Report No. 1:

- Water Supply Sub-Team
- Water Demand Sub-Team
- System Reliability Metrics Sub-Team

Members of the sub-teams are listed in appendices to the respective Technical Reports.

4.2 Study Outreach

The Study is being conducted in collaboration with stakeholders throughout the Basin. Interest is broad and includes Native American tribes and communities, agricultural users, purveyors of municipal and industrial water, power users, and environmental groups. Through outreach efforts, interested parties are informed about the Study and input is received that reflects their concerns and thoughts about the future reliability of the Colorado River. Broad participation and input is critical to the Study's success. Interested parties are encouraged to become involved in the Study and are provided a variety of options to do so. These options, which are not mutually exclusive, range from attending public meetings and informational webinars to participating directly in the development of work products through Study's technical sub-teams. The tools and the processes employed in outreach activities are detailed in Appendix 3, *Public Involvement Plan*. In accordance with the *Public Involvement Plan*, outreach activities have included:

- Establishing a Study website to provide on-line information. The Study web page is: http://www.usbr.gov/lc/region/programs/crbstudy.html.
- Establishing an e-mail address to distribute information and receive input. The Study email address is ColoradoRiverBasinStudy@usbr.gov.
- Establishing a facsimile number (702-293-8418) to allow input by fax.
- Establishing a mailing list to ensure that all interested parties receive information, particularly concerning the scheduling and access to public meetings.
- Scheduling public meetings for strategic times during the Study. As of January 31, 2011, public meetings have been conducted in March 2010 and September 2010.
- Holding additional meetings with interested parties during the Study period.

As of January 31, 2011, more than 40 outreach events regarding the Study have occurred. These activities are listed in Appendix 4, Outreach Activities.

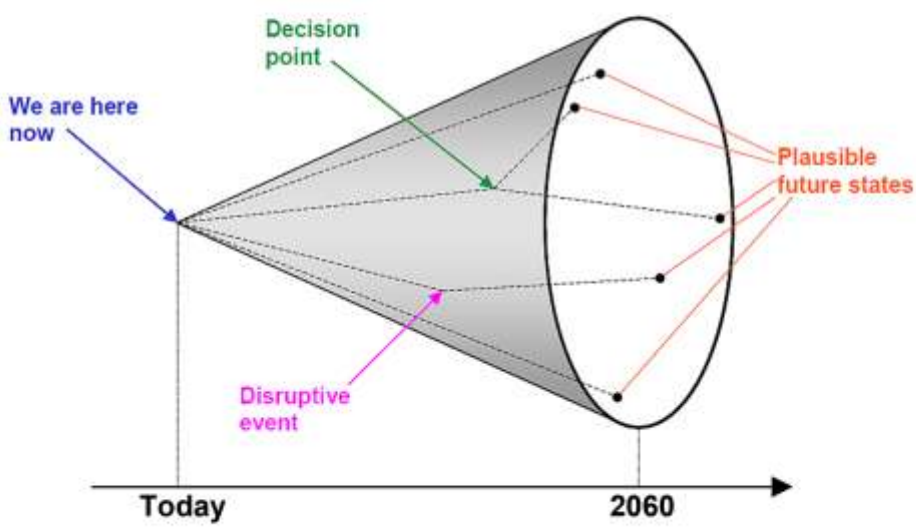
5.0 Summary of Technical Reports

5.1 Summary of Technical Report A – Scenario Development

5.1.1 Objective and Approach

The amount of water available and the progression of demand for water throughout the Basin over the next 50 years are highly uncertain and depend on a number of other factors. The potential impacts of future climate variability and climate change further contribute to these uncertainties. To analyze the future reliability of the Colorado River system, with and without adaptation and mitigation strategies, projections of water supply and demand are necessary. These projections must be sufficiently broad to capture the plausible ranges of uncertainty in future water supply and water demand to ensure that the reliability of the Colorado River system is adequately analyzed. Figure 5 shows this concept. At the present time, an understanding of the state of the Colorado River system exists as indicated by the single point labeled “Today” on the x-axis. A range of plausible futures, represented by the funnel, can be identified. The suite of scenarios used in the planning effort should be sufficiently broad to span the plausible range of the funnel.

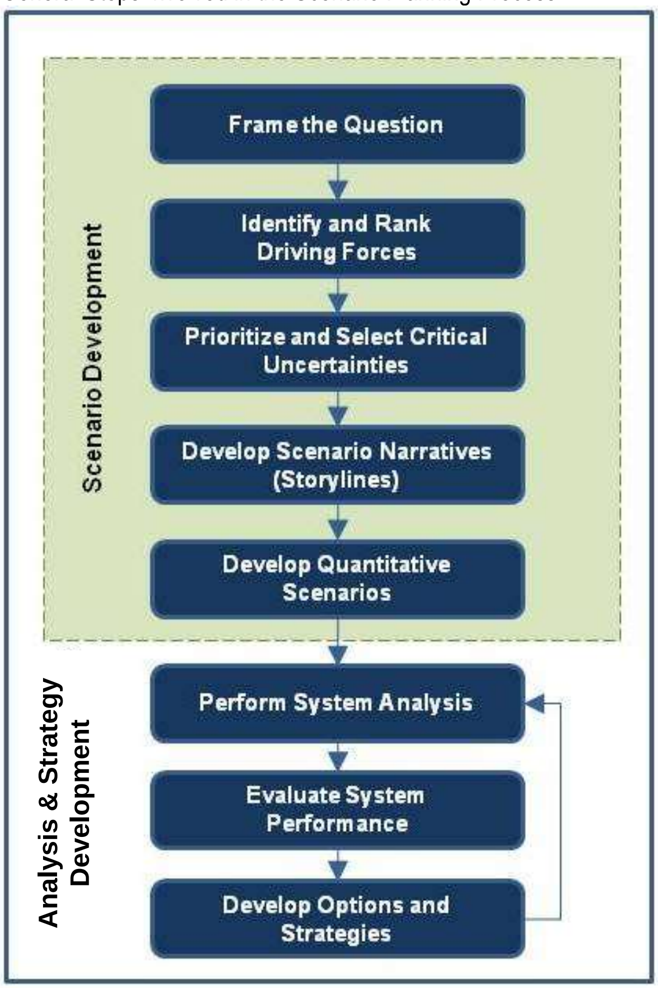
FIGURE 5
Conceptual Representation of the Uncertain Future of a System, also known as “The Scenario Funnel”
Adapted from Timpe and Scheepers, 2003



A scenario planning process has been used to guide the development of scenarios that provide a broad range of projections of future water supply and demand. A scenario is an alternative view of how the future might unfold. Scenarios are not predictions or forecasts of the future. The process involves the identification of the key forces that will likely drive future water supply and water demand, ranking of the driving forces (the factors that will likely have the greatest influence on the future state of the system and thereby the performance of the system over time) as to their relative importance and uncertainty, and using the most highly uncertain and highly important driving forces (“critical uncertainties”) to identify various themes and “storylines” (narrative descriptions of scenarios) that describe how water supply and water demand may evolve in the future. Quantification of the storylines results in water supply and water demand scenarios that will be used to assess future system reliability and inform the development of options and strategies to resolve imbalances between water supply and demands.

Figure 6 presents the general steps involved in the scenario planning process as applied to a water resource planning study, from the initial point of framing the focal question(s) that is (are) being addressed by the Study through the development and analysis of options and strategies to improve system performance. This general approach was customized to meet the needs of the Study and details of that implementation are described in *Technical Report A – Scenario Development.*

FIGURE 6
General Steps Involved in the Scenario Planning Process



The approach included input from a broad sampling of stakeholders, experts, and others interested in the management of the system. This input is crucial throughout the development of scenarios and ensures that the resulting scenarios are representative of the plausible range of futures in the view of those who best know the system.

The purpose and objectives defined in the *Plan of Study* (Appendix 1) were used to frame the focal questions that the Study must address:

1. What is the future reliability of the Colorado River system to meet the needs of Basin resources through 2060?
2. What are the options and strategies to mitigate future risks to these resources?

The first question requires an understanding of the underlying components of future reliability: water supply and water demand. Specifically, what are the factors that will determine the future availability of water and what are the factors that will determine the future demand for water? The scenario development process addresses these questions and results in scenarios of the future that define a range of plausible water supply and water demand outcomes. The second question relates to water management responses to mitigate and adapt to the potential impacts to Basin resources under future scenarios and is the focus of the Development and Evaluation of Opportunities phase of the Study.

Driving forces are the factors that will likely have the greatest influence on the future state of the system and thereby the performance of the system over time. In the Study, 18 specific driving forces representing the following categories were considered:

- Natural Systems
- Demographic
- Economic
- Technological
- Social
- Governance

Because not all driving forces influence the system to the same degree or contribute the same level of uncertainty, additional stakeholder and other expert input was collected regarding the relative importance and uncertainty associated with each driving force in relation to the reliability of the system to meet the needs of the resources through 2060. Each of the driving forces was ranked, and critical uncertainties (those driving forces that were ranked as both highly important and highly uncertain) were identified. Twelve critical uncertainties were identified, and each was associated with the factor (either water supply or water demand) thought to be most affected by that critical uncertainty. After determining these associations, additional stakeholder and subject matter expertise was sought to complete the scenario development process through the Water Supply and Water Demand Sub-Teams.

5.1.2 Summary of Results

The scenario planning process implemented in the Study identified two critical uncertainties primarily affecting the future of water supply: 1) changes in streamflow variability and trends and 2) changes in climate variability and trends.

A set of four scenarios focused around these critical uncertainties was constructed that represent a broad range of plausible future conditions with respect to water supply in the Basin through the next 50 years. The scenarios are informed by the past, present, and projections of the future through the incorporation of the paleo-reconstructed streamflow record, the observed historical streamflow record, and projections of streamflow using climate projections from global climate models (GCMs). The four water supply scenarios and associated themes are:

- **Observed Record Trends and Variability (Observed Resampled):** Future hydrologic trends and variability are similar to the past approximately 100 years.
- **Paleo Record Trends and Variability (Paleo Resampled):** Future hydrologic trends and variability are represented by reconstructions of streamflow for a much longer period in the past (nearly 1,250 years) that show expanded variability.
- **Observed Record Trends and Increased Variability (Paleo Conditioned):** Future hydrologic trends and variability are represented by a blend of the wet-dry states of the longer paleo-reconstructed period (nearly 1,250 years), but magnitudes are more similar to the observed period (about 100 years).
- **Downscaled GCM Projected Trends and Variability (Downscaled GCM Projected):** Future climate will continue to warm with regional precipitation and temperature trends represented through an ensemble of future downscaled GCM projections.

Each of these scenarios has been quantified and analyzed. That work, including the approach and key results, is documented in *Technical Report B – Water Supply Assessment* and is summarized in the next section of this report.

The scenario development approach identified 10 critical uncertainties primarily affecting the future of water demand. These critical uncertainties are displayed in Table 1.

TABLE 1
Critical Uncertainties Affecting Water Demand Scenarios

Critical Uncertainty Identified in Survey	General Driving Force Category
Changes in population and distribution Changes in agricultural land use (e.g., irrigated agricultural areas, crop mixes, etc.)	Demographics & Land Use
Changes in agricultural water use efficiency Changes in municipal and industrial water use efficiency Changes in water needs for energy generation (e.g., solar, oil shale, thermal, nuclear, etc.)	Technology & Economics
Changes in institutional and regulatory conditions (e.g., laws, regulations, etc.) Changes in flow-dependent ecosystem needs for Endangered Species Act-listed species Changes in other flow-dependent ecosystem needs Changes in social values affecting water use Changes in water availability due to tribal water use and settlement of tribal water rights claims	Social & Governance

Based on the process previously described, these critical uncertainties were combined into four water demand storylines. These storylines and their associated themes are:

- **Current Trends:** growth, development patterns, and institutions continue along recent trends
- **Economic Slowdown**: low growth with emphasis on economic efficiency
- **Expansive Growth**: economic resurgence (population and energy) and current preferences toward human and environmental values
- **Enhanced Environment and Healthy Economy**: expanded environmental awareness and stewardship with growing economy

The quantification of these scenarios is ongoing. A description of the methodology being used to quantify these scenarios, as well as an assessment of historical consumptive uses and losses, are presented in *Technical Report C – Water Demand Assessment* and summarized in a subsequent section of this report.

5.2 Summary of Technical Report B – Water Supply Assessment

5.2.1 Objective and Approach

The objective of the Water Supply Assessment is to assess the probable magnitude and variability of historical and future natural flow in the Basin. Natural flow represents the flow that would have occurred at a location had depletions and reservoir regulation not been present upstream of that location. The assessment includes the potential effects of future climate variability and climate change and provides quantified projections of future hydrology.

Four water supply scenarios were identified and quantified, each representing a plausible future of water supply conditions. These water supply scenarios and their associated themes are presented in *Technical Report B – Water Supply Assessment* and were summarized previously in this report.

In 2004, Reclamation initiated a multi-faceted research and development program to enable the use of methods beyond those that use the observed record for projecting possible future inflow sequences for Basin planning studies. Through this effort, two additional water supply scenarios were developed and have been used in previous Basin planning studies that assume the observed and paleo-reconstructed streamflow records are representative of future streamflow variability and trends. These scenarios have most recently been detailed in the Interim Guidelines EIS, Appendix N (Reclamation, 2007). The three scenarios previously utilized are encompassed by the Observed Resampled, Paleo Resampled and Paleo Conditioned scenarios.

A resampling technique known as the Indexed Sequential Method (Ouarda et al., 1997) is applied to the observed and paleo-streamflow records to generate multiple sequences of future streamflow in the Observed Resampled (102 sequences) and Paleo Resampled (1,244 sequences) scenarios. Sequences for the Paleo Conditioned scenario are generated by applying a non-parametric technique to “blend” the observed and paleo streamflow records (1,000 sequences).

To ensure that the water supply scenarios encompass a sufficiently broad range of future water supply conditions, a fourth scenario was developed that uses downscaled GCM projections and is titled the Downscaled GCM Projected scenario.

The Downscaled GCM Projected scenario entails a method in which climate forcings (primarily temperature and precipitation) from 112 climate projections used in the Intergovernmental Panel on Climate Change Fourth Assessment Report (Intergovernmental Panel on Climate Change, 2007), subsequently bias-corrected and statistically downscaled (Maurer et al., 2007), are input to the Variable Infiltration Capacity (VIC) hydrologic model (Christensen and Lettenmaier, 2009) to simulate streamflow. The 112 climate projections comprise projections assuming 3 independent greenhouse gas emission scenarios, 16 distinct GCMs, and multiple starting conditions. The Downscaled GMC Projected scenario consists of 112 sequences of future streamflow.

5.2.2 Summary of Results

The key findings related to projected changes in temperature, precipitation, and snowpack over the next 50 years that may be expected under the Downscaled GCM Projected scenario are presented below. These findings are based on the assessment described in *Technical Report B – Water Supply Assessment.*

- Warming is projected to increase across the Basin, with the largest changes in spring and summer and with larger changes in the Upper Basin than in the Lower Basin. Annual Basin-wide average temperature increases are projected to be approximately 1.3 and 2.4 degrees Celsius over the periods 2011-2040 and 2041-2070, respectively. Increases are measured relative to the 30-year historical period of 1971-2000.

- Precipitation patterns continue to be spatially and temporally complex, but projected seasonal trends toward drying are significant in certain regions. A general trend towards drying is present in the Basin, although increases in precipitation are projected for some higher elevation and hydrologically productive regions. Consistent and expansive drying conditions are projected for the spring throughout the Basin. For much of the Basin, drying conditions are also projected in the summer, although some areas of the Lower Basin are projected to experience slight increases in precipitation, which may be due to the monsoonal influence in this region. Upper Basin precipitation is projected to increase in the fall and winter and the Lower Basin is projected to experience decreases.

- Snowpack is projected to decrease as more precipitation falls as rain rather than snow and warmer temperatures cause an earlier melt. Decreases of snowpack in the fall and early winter are projected in areas where precipitation is not changed or is increased, and is caused by a greater liquid form of precipitation due to warming. Substantial decreases in spring snowpack are projected to be widespread, due to earlier melt or sublimation of snowpack.

Figure 7 shows the range of annual flows for the Colorado River at Lees Ferry for each of the scenarios over the Study period.

Mean annual natural flows for the Colorado River at Lees Ferry over the next 50 years range from 14.7 maf to 15.0 maf for the Observed Resampled, Paleo Resampled, and Paleo Conditioned scenarios. The Downscaled GCM Projected scenario results in mean annual flows of approximately 13.6 maf, a 9 percent reduction from the observed mean. The range of mean flows is greatest under the Downscaled GCM Projected scenario, with the inter-quartile range spanning roughly 12.5 to 15 maf and the minimum-maximum range covering 10 to 17 maf.

A skew of zero implies a perfectly “normal” distribution, in which wetter years and magnitudes are evenly balanced with drier years. Most scenarios have a positive skew, suggesting a bias to the drier side of the distribution. This is particularly noticeable in the Downscaled GCM Projected scenario.

The minimum annual flows are fairly consistent across the scenarios, with the Paleo Resampled scenario exhibiting the most extreme low flow condition. The Downscaled GCM Projected scenario exhibits a range of maximum annual flows not seen in any of the other scenarios.

FIGURE 7

Summary Statistics for Annual Colorado River at Lees Ferry Natural Flows for Supply Scenarios

Figure shows the median (dash), 25th – 75th percentile band (box), and max/min (line).

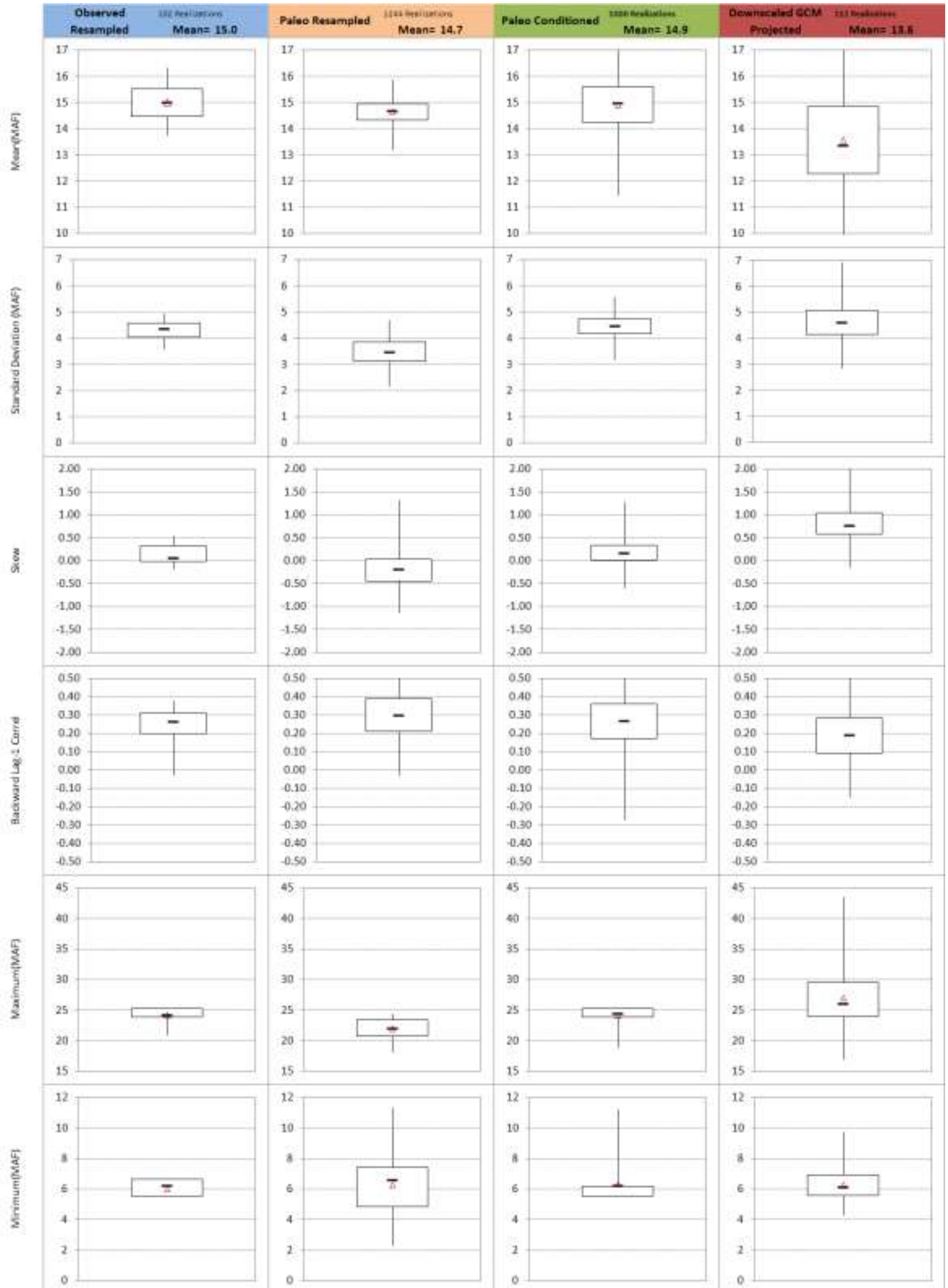


Table 2 presents a comparison of several key streamflow statistics for each scenario. The statistics are grouped by annual, monthly, deficit, and surplus period statistics. For the purpose of the Study, deficit and surplus periods occur whenever the running 2-year average flow falls below (deficit) or above (surplus) 15.0 maf, the observed mean. Deficit and surplus period statistics indicate the range of inter-annual variability of streamflow across the scenarios.

In comparison to the Observed Resampled scenario, the other scenarios exhibit a substantial increase in inter-annual variability, both in sustained deficits and surpluses. The maximum length of sustained deficit in the Observed Resampled scenario is 8 years, while the maximum sustained surplus is 7 years. The Paleo Resampled, Paleo Conditioned, and Downscaled GCM Projected scenarios all produce deficit and surplus periods that are much longer. The frequency of deficit spells that are 5 years or longer is also higher under these scenarios, with the Downscaled GCM Projected indicating a likelihood of 40 percent over the next 50 years. However, the frequency of surplus spells that are 5 years or longer is highest under the Observed Resampled scenario.

The results suggest that under sequences in the Downscaled GCM Projected scenario, sustained periods of dryness will occur (deficit lengths of greater than 40 years). Most projections result in long-term mean annual flows that are less than the 15 maf observed mean, and other projections result in long-term mean annual flows that are greater than the 15 maf observed mean. The future climate essentially arrives at a new mean state.

Some minor methodological differences with respect to the technical approach to develop streamflow projections informed by GCMs and the analysis of those projections exist between the results presented here and those presented in the SECURE Report. The methodological differences consist primarily of the application of a different technique to generate daily weather forcings. Although a secondary bias-correction has not been applied to the results presented here, the investigation of such a correction is ongoing and will be applied and reported in a subsequent interim report. Reporting differences consist due to the selection of baseline conditions for comparison and the future analysis period. Specifically, the SECURE Report computes future decadal changes from a 1991-2000 baseline condition, whereas the change statistics reported here are computed between the observed record and the Study period of 2011-2060. Therefore, results of the Study and those in the SECURE Report are not identical.

TABLE 2
Summary of Key Streamflow Statistics for Each Water Supply Scenario

	Statistic[a]	Scenario			
		Observed Resampled	Paleo Resampled	Paleo Conditioned	Downscaled GCM Projected
Annual (Water Year)	Average Annual Flow (maf)	15.0	14.7	14.9	13.6
	Percent Change from Long-Term Mean (1906-2007)	0%	-2%	-1%	-9%
	Median (maf)	15.0	14.7	15.0	13.3
	25th Percentile (maf)	14.5	14.3	14.2	12.3
	75th Percentile (maf)	15.5	15.0	15.6	14.8
	Minimum Year Flow (maf)	5.6	2.3	5.6	4.3
	Maximum Year Flow (maf)	25.2	24.3	25.2	43.5
Monthly	Peak Month	June	June	June	May
	Peak Month Mean Flow (kaf)	4,007	3,914	4,000	3,549
	Peak Month Maximum Flow (kaf)	8,467	8,531	8,678	12,542
	Month at Which Half of Annual Flow (Water Year) is Exceeded	June	June	June	May
Deficit Periods[b]	Maximum Deficit (maf)	28.2	38.4	98.5	254.2
	Maximum Spell Length (years)	8	17	24	48
	Intensity (Deficit/Length) (maf/year)	3.5	2.3	4.1	5.3
	Frequency of 5+ Year Spell Length (percent)	22%	30%	25%	40%
	Maximum 8-year Deficit (longest in 1906-2007 observed record, maf)	28.2	29.8	50	52.2
Surplus Periods[c]	Maximum Surplus (maf)	22.2	36.2	88	61.1
	Maximum Spell Length (years)	7	15	25	12
	Intensity (Surplus/Length) (maf/year)	3.2	2.4	3.5	5.1
	Frequency of 5+ Year Spell Length (percent)	28%	15%	18%	<1%
	Maximum 7-year Surplus (longest in 1906-2007 observed record, maf)	22.2	29.2	44	35.3

NOTE:
[a] Statistics are computed over the Study period, 2011-2060.
[b] A deficit period occurs whenever the running 2-year average flow is below the observed average from 1906-2007 of 15.0 maf.
[c] A surplus period occurs whenever the running 2-year flow is above the observed mean from 1906-2007 of 15.0 maf.

5.2.3 Status and Next Steps

Additional analysis and investigation of the Downscaled GCM Projected scenario is ongoing and will be included in the next interim report. Two areas in particular are being investigated, and the streamflow projections under this scenario will be updated based on the findings.

The first area under investigation is the application of a secondary bias-correction to the streamflows produced by the VIC hydrologic model. Preliminary analyses have indicated that the application of this bias correction is warranted because there appear to be inconsistencies in the long-term trends in the observed climate and the historical GCM-projected climate. The second area under investigation relates to further analyzing sequences that exhibit annual runoff conditions that far exceed any maximum in the observed or paleo records. Although it is possible that the future climate will expand the magnitude and frequency of extreme events, it is also possible that some projections are simply extreme outliers.

5.3 Summary of Technical Report C – Water Demand Assessment

5.3.1 Objective and Approach

The objective of the Water Demand Assessment is to assess the quantity and location of current and future water demands in the Study Area (i.e., the hydrologic boundaries of the Basin plus the adjacent areas of the Basin States that receive Colorado River water) to meet the needs of Basin resources, including municipal and irrigation (M&I) use, hydropower generation, recreation, and fish and wildlife habitat. In addition, losses in the Basin due to evaporation and other factors will be assessed. Because future water supply and demand throughout the Basin are uncertain, scenarios are being developed that are sufficiently broad to span that uncertainty, including the potential effects of future climate change. Future demands are a function of socioeconomic parameters such as future population, irrigated land area, municipal, industrial, and agricultural water use efficiency, tribal water use, energy growth and associated water use, and others. Through the scenario planning process applied in the Study, the most critical uncertainties affecting future demand were identified, and a range of future demand scenarios was envisioned. Narrative descriptions of these scenarios (storylines) were developed and provide a rational basis for consideration of a wide array of future conditions.

The process to develop the critical uncertainties, demand storylines, and quantify scenarios has engaged a wide array of stakeholders and reflects a broad range of plausible conditions considering differing views of the future. In order to establish a solid foundation relating to methods and assumptions for quantifying future demands, the Study is focusing initial efforts on quantifying the Current Trends scenario. The Current Trends scenario provides the basis for consideration of departures from these assumptions, leading to the quantification of the Economic Slowdown, Expansive Growth, and Enhanced Environment and Healthy Economy demand scenarios. These water demand scenarios and their associated themes are presented in *Technical Report C – Water Demand Assessment* and were summarized earlier in this report.

Future demands may be affected by climate change, primarily changes in ambient temperature and the amount and distribution of precipitation. As such, the possible effects of changing temperature and precipitation on evapotranspiration, which impacts agriculture and outdoor M&I demand, and on phreatophyte and reservoir evaporation losses will be assessed in the Study. The potential impacts to evapotranspiration rates affecting agricultural demand were assessed by Reclamation's Technical Services Center (TSC). This assessment consisted of applying the modified Blaney-Criddle method (Stephens and Stewart, circa 1960) coupled with the Soil Conservation Service effective precipitation method. Changes in reservoir evaporation due to potential changes in temperature and precipitation will be assessed using open water surface evaporation rates from the VIC model to adjust historical evaporation rates to reflect higher temperatures. These results will be included in the next interim report.

5.3.2 Summary of Results

As previously mentioned, the scenarios currently under consideration are: Current Trends, Economic Slowdown, Expansive Growth and Enhanced Environment and Health Economy. Storylines for these scenarios are provided in *Technical Report C – Water Demand Assessment.* Work is ongoing to quantify the scenarios. The quantification of the Current Trends scenario will be used as a starting point for the quantification of the remaining scenarios. Additional information regarding the approach to quantify the scenarios is also provided in *Technical Report C – Water Demand Assessment.* The approach entails quantifying the characteristics associated with the parameters of the critical uncertainties; for example, irrigated acreage is a parameter of the critical uncertainty, changes in agricultural land use, and under the Current Trends scenario, "nominal increase" is the characteristic associated with this parameter.

Historical consumptive use and loss information may be used in conjunction with future planning data (e.g., land use, policy, population growth, economic conditions) to inform the development of projected demand. Although current trends are not direct mathematical projections of historical data, the Current Trends scenario in particular relies on knowledge of historical consumptive uses and losses as well as planning data and expertise to estimate future trends in water demands. Therefore, historical consumptive uses and losses data were compiled.

Figures 8, 9, and 10 present the range of historical Colorado River water consumptive use and loss compiled by state, basin, and category. This information was compiled from Reclamation's Colorado River System Consumptive Uses and Losses Reports (CU&L Reports[9]), Reclamation's Colorado River Accounting and Water Use Reports[10], and additional input from the Basin States. The categories of consumptive uses and losses presented consist of the following: agriculture; M&I; energy; minerals; fish, wildlife, and recreation; exports; reservoir evaporation; and other losses. Estimates of potential future demands rely on an understanding of the parameters that make up individual categories (e.g., population growth and efficiency for the M&I category). Similar information was compiled and presented for individual states in *Technical Report C – Water Demand Assessment*.

There are data and methodological inconsistencies in the CU&L Reports with respect to the Lower Basin tributaries (the Little Colorado, Virgin, Bill Williams and Gila rivers). These

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9 http://www.usbr.gov/uc/library/envdocs/reports/crs/crsul.html

10 http://www.usbr.gov/lc/region/g4000/wtracct.html

inconsistencies consist primarily as a result of changing methodologies between the 5-year reporting periods. Similar inconsistencies were found in these reports with respect to the Upper Basin until Reclamation undertook a multi-year effort to resolve them. This effort has not occurred for the Lower Basin tributaries, and the quality of information has suffered. Independent of the Study, Reclamation will engage in efforts to resolve and correct, in collaboration with the Basin States, the methodological and data inconsistencies in the CU&L Reports pertaining to all of the Lower Basin tributaries. Refer to *Technical Report C – Water Demand Assessment, Appendix C-5,* for a description of these issues and commitments.

Consumptive uses and losses in the Basin have increased from 1971 to the start of the current drought in 2000. The information presented in Figure 8 indicates that from 1971 through 1999, Basin-wide consumptive uses and losses (including deliveries to Mexico pursuant to the 1944 treaty[11] have grown from approximately 13 maf in 1971 to 16 maf in 1999, an increase of about 23 percent. Over the same period, as shown in Figure 9, Upper Basin uses have grown from approximately 3.0 maf in 1971 to 3.3 maf in 1999, an increase of about 10 percent. Lower Basin uses have grown from approximately 6.6 maf in 1971 to 8.0[12] maf in 1999, an increase of about 21 percent.

Agricultural and M&I uses have also grown over this period, as have reservoir evaporation losses. As shown in Figure 10, agricultural uses have grown from approximately 7.7 maf in 1971 to 8 maf in 1999, an increase of about 4 percent. M&I uses have grown from approximately 1.4 maf in 1971 to 2.2 maf in 1999, an increase of about 57 percent. Reservoir evaporation losses have grown from 1.7 maf in 1971 to 2.3 maf in 1999, an increase of 35 percent.

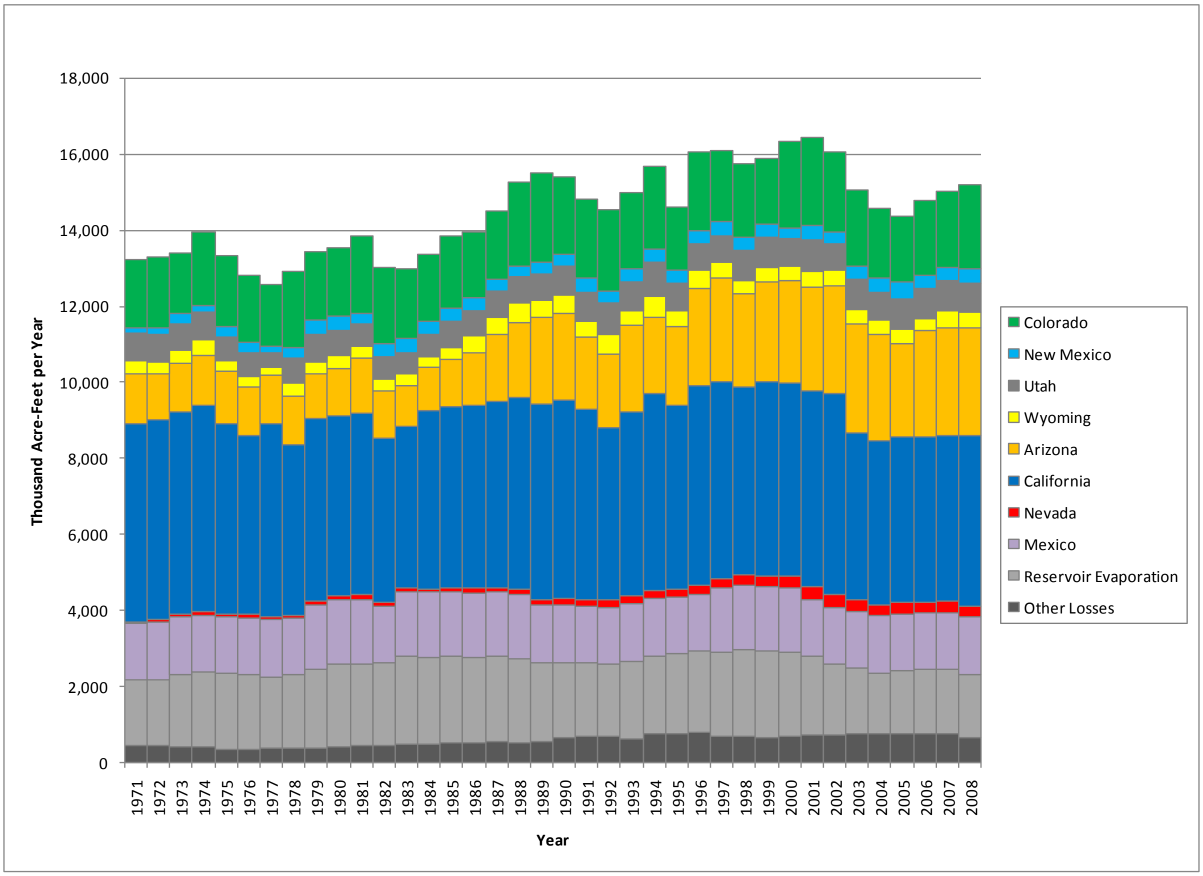
In the assessment of the possible impacts to agricultural demands due to changes in precipitation and temperature, agricultural demands increased by approximately 5 percent for each °C increase in temperature, and by approximately 1 percent for each 5 percent reduction in precipitation.

[11] Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, Treaty between the United States and Mexico, 1944

[12] Uses in the Lower Basin greater than 7.5 maf are due to the surplus water supply conditions for the Lower Division States.

FIGURE 8

Historical Colorado River Water Consumptive Use[1] by State, Delivery to Mexico, Reservoir Evaporation, and Other Losses[2] 1971-2008



NOTE:

[1]Excluding consumptive use in Lower Basin tributaries.

[2] Phreatophyte and operational inefficiency losses.

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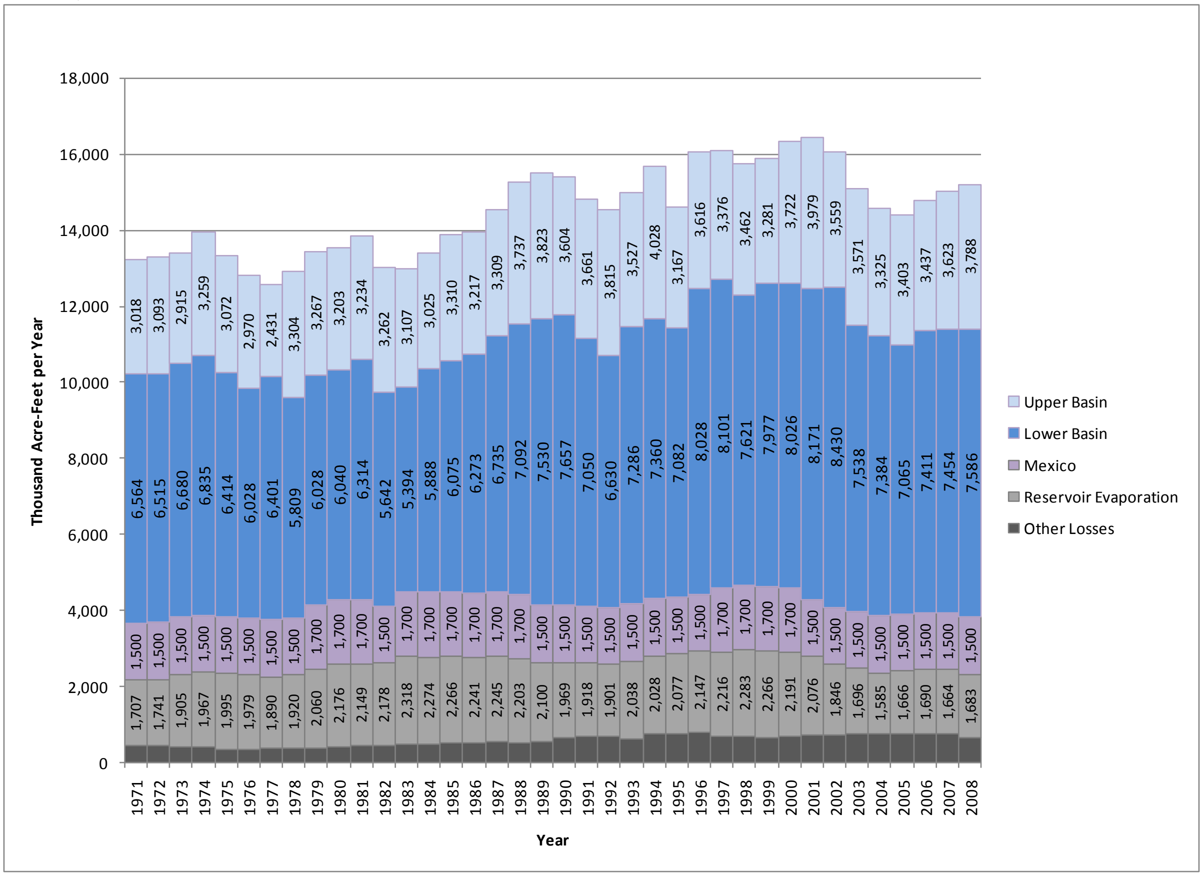
FIGURE 9

Historical Colorado River Water Consumptive Use[1] by Basin[2], Delivery to Mexico, Reservoir Evaporation, and Other Losses[3], 1971-2008



NOTE:

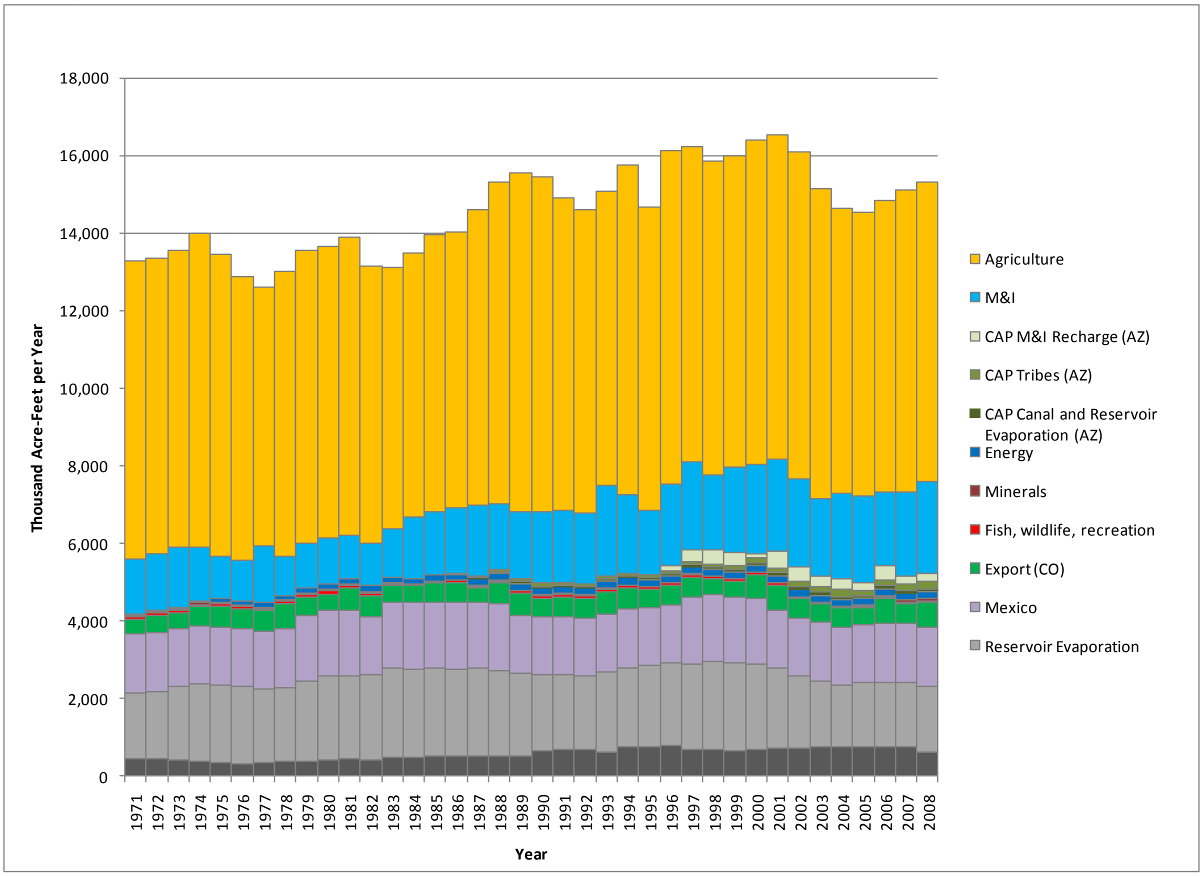
[1]Excluding consumptive use in Lower Basin tributaries.

[2]Lower Basin use greater than 7.5 maf is due to surplus water supply conditions for the Lower Division states.

[3]Phreatophyte and operational inefficiency losses.

FIGURE 10

Historical Colorado River Water Consumptive Use[1] by Use Category[2], Delivery to Mexico, Reservoir Evaporation, and Other Losses[3], 1971-2008



NOTE:

[1]Excluding consumptive use in Lower Basin tributaries

[2]Data for “M&I Recharge” and “Tribes” categories were provided by AZ for CAP deliveries and are preliminary. Colorado did not provide additional information regarding the use categories for exports for this report.

[3]Phreatophyte and operational inefficiency losses.

5.3.3 Status and Next Steps

In the coming months, additional review of the consumptive uses and losses data will occur, particularly with regard to the disaggregation of data into use categories. Any modifications in the data and information will be included in future interim reports.

Quantifying the scenarios will be the primary the focus of the coming months. A significant quantity of data has been collected to date to quantify the Current Trends scenario, and that work will be completed. Following completion of the quantification of the Current Tends scenario, the remaining scenarios that derive from it (Economic Slowdown, Expansive Growth, and Enhanced Environment and Healthy Economy) will be quantified. The scenarios will then be analyzed and presented in future interim reports, including the assumptions used to quantify those scenarios.

The demand scenarios will then be coupled with the water supply scenarios and used to analyze the future reliability of the Colorado River system, with and without future adaptation and mitigation strategies.

Also ongoing is a sensitivity analysis to compare the changes in evapotranspiration and its potential effects on agricultural demand, computed by using the modified Blaney-Criddle method and the Penman-Monteith method. The Penman-Monteith method determines potential evapotranspiration based on a more-explicit physical process method than the Blaney-Criddle method. The assessment of the potential changes in reservoir evaporation rates is also ongoing and will be included in the next interim report.

5.4 Summary of Technical Report D – System Reliability Metrics

5.4.1 Objective and Approach

System reliability metrics (metrics) are measures that indicate the ability of the Colorado River system to meet the needs of Basin resources under multiple future conditions. Metrics will be used to measure the potential impacts to Basin resources from future supply and demand imbalances and to measure the effectiveness of options and strategies to address those imbalances. The first task of the System Reliability Analysis (Task 3.1 in Figure 4), includes the development of the metrics identification process and the identification of a comprehensive set of metrics. Metrics developed in Task 3.1 will be used in the remaining tasks of Phases 3 and 4 to compare the effects of options and strategies to address supply and demand imbalances under multiple future scenarios.

5.4.2 Summary of Results

A process has been developed for metric identification and used to craft a detailed set of metrics for Basin resources. The process is detailed in *Technical Report D – System Reliability Metrics*, particularly Figure D-1. The process began with the identification of resource categories. Based on the *Plan of Study* and working closely with stakeholders, the resource categories presented in Table 1 were identified. Following the identification of the resource categories, several attributes of interest associated with each resource category were identified, presented in Table 3.

TABLE 3
Resource Categories and Attributes of Interest

Resource Category	Attribute of Interest
Water Deliveries	• Consumptive Uses and Shortages • Water Levels Related to Intake Facilities • Socioeconomic Impacts Related to Shortages
Electrical Power Resources	• Electrical Power Generated • Economic Value of Electrical Power Generated • Available Generation Capacity • Impact on Power Rates • Water Supply System Pumping Costs • Impacts on the Upper Colorado River Basin Fund and the Lower Colorado River Basin Development Fund
Water Quality	• Salinity • Sediment Transport • Temperature • Other Water Quality Attributes • Socioeconomic Impacts Related to Salinity
Flood Control	• Flood Control Releases and Reservoir Spills • Critical River Stages with Flooding Risk
Recreational Resources	• Shoreline Public Use Facilities • River and Whitewater Boating • Other Recreational Attributes • Socioeconomic Impacts Related to Recreation
Ecological Resources	• Threatened and Endangered Species • Aquatic and Riparian Habitats • Wildlife Refuges and Fish Hatcheries

To further define metrics associated with attributes of interest, locations in the Basin were selected where metrics can offer information about the performance of the system. Metrics will be evaluated in either a quantitative or qualitative fashion. A metric will be evaluated quantitatively if: a) direct evaluation is possible using output from the Colorado River Simulation System (CRSS)[13] or results from post-processing of CRSS output data, or b) an indirect indicator of the attribute of interest at the specified location can be developed, based on output from CRSS or post-processing of CRSS output data.

The spatial and temporal detail of the data and/or tools available will limit the ability to assess some metrices quantitatively. In these cases, metrics will be either assessed in a

[13] CRSS is the primary modeling tool that will be used in the Study. It simulates the operation of the major Colorado River system reservoirs on a monthly time step and provides information regarding the projected future state of the system in terms of output variables. Outputs include the amount of water in storage, reservoir elevations, releases from the dams, hydropower generation, the amount of water flowing at various points throughout the system, the total dissolved solids content, and diversions to and return flows from the water users throughout the system.

qualitative manner, or, where time and resources permit, additional analysis may be performed to result in a quantitative assessment.

5.4.3 Status and Next Steps

Many metrics have been defined, and descriptions of these metrics are provided in *Technical Report D – System Reliability Metrics*. Other metrics have been identified but have not yet been fully defined. This is particularly the case for metrics related to the Ecological Resources category. Additional definition will be provided in subsequent interim reports. It is also possible that some defined metrics may not prove to be informative or further analysis may identify the need for other metrics. These types of adjustments will be made in the next phase of the Study (System Reliability) and documented in future interim reports.

6.0 Study Limitations

6.1 Study Limitations

As stated previously, the focal questions being addressed by the Study are:

- What is the future reliability of the Colorado River system to meet the needs of Basin resources through 2060?
- What are the options and strategies to mitigate future risks to these resources?

Although the technical approach of the Study has and will continue to be based on the best science and information available, as with all studies, there are limitations.

The detail at which results are reported or the depth to which analyses are performed in the Study is limited by the availability of reliable data, methods, and the capability of existing models. Many of these limitations cannot be overcome for purposes of the Study due to time and resource constraints. In some cases, these limitations present opportunities for additional research and development and the improvement of available data. These opportunities will be pursued in efforts independent of the Study.

Limitations exist in the areas noted below. As the Study progresses, additional limitations will inevitably emerge and will be disclosed in subsequent interim reports.

6.1.1 Treatment of Lower Basin Tributaries

For four of the inflow points below Lees Ferry (the Paria , Little Colorado, Virgin, and Bill Williams rivers), CRSS uses historical inflows (not natural flows) based on USGS streamflow records. In addition, the Gila River is not included in CRSS.

Many Colorado River planning studies have been completed over the past two decades where this treatment of the major Lower Basin tributaries was used; however, questions regarding the adequacy of the treatment of the Lower Basin tributaries in CRSS for the Study arose during the phases focused on assessing future water supply and demand. The current treatment of these tributaries limits the ability of the Study to fully assess the natural supply of the Basin, and the data and methodological inconsistencies present in the CU&L Reports limits the ability of the Study to gain a more complete understanding of historical consumptive use in the Basin.

Despite these limitations, other approaches are being taken in the Study to examine several important issues, including potential climate change impacts on the tributaries represented in CRSS, future demand scenarios on those tributaries, and future demand scenarios for the Colorado River from the Gila River Basin, factoring in other water supplies within that basin.

Reclamation will engage in efforts independent of the Study to: 1) resolve and correct, in collaboration with the Basin States, the methodological and data inconsistencies in the CU&L Reports pertaining to all of the Lower Basin tributaries; 2) develop natural flows for the Little Colorado, Virgin and Bill Williams rivers and modify CRSS to use natural flows for those tributaries; and 3) explore the feasibility and usefulness of computing natural flows for the Gila River Basin and the feasibility and usefulness of adding that basin to CRSS. Refer to *Technical Report C – Water Demand Assessment Appendix C5* for a more detailed discussion of these issues.

6.1.2 Ability to Assess Impacts to Basin Resources

The ability to assess impacts to Basin resources is limited by the spatial and temporal detail of CRSS. Described further in *Technical Report D – System Reliability Metrics*, some metrics have limitations in their ability to be assessed quantitatively and in some cases will be assessed qualitatively. For example, CRSS tracks shortages in the Upper Basin when the flow is insufficient to meet the local demands as opposed to simulating the complex water rights system in each state that would be needed to appropriately model shortages to individual water rights holders. This representation affects the ability of the Study to assess the impacts to deliveries in the Upper Basin. Another example is that several ecological resources metrics will be evaluated through approximations at larger spatial scales and longer timesteps, e.g., monthly versus daily, than preferred because of model limitations.

Although limits are placed on the ability to assess impacts to these and other resources by the utilization of CRSS, where time and resources permit, additional resources and analysis may be used to overcome some of these limitations.

7.0 Conclusions and Next Steps

This Interim Report No. 1 documents the progress of the Study through January 31, 2011. Through this date, Phases 1 and 2 and the first task in Phase 3 of the *Plan of Study* (Figure 4) are near completion. Project participants and stakeholders are encouraged to comment on the information provided in this Interim Report No. 1. Written comments should be submitted within 30 days following the release of each interim report and will be incorporated into subsequent interim reports, as appropriate. Comments may be submitted in the following ways:

1. Via the Study website at: http://www.usbr.gov/lc/region/programs/crbstudy.html
2. Email to ColoradoRiverBasinStudy@usbr.gov
3. U.S. mail to: U.S. Bureau of Reclamation, Attention: Ms. Pam Adams, LC-2721, P.O. Box 61470, Boulder City, NV 89006-1470
4. By facsimile transmission to 702-293-8418

Work is ongoing to complete Phases 1, 2, and 3 (System Reliability Analysis) and initiate Phase 4 (Development and Evaluation of Opportunities) of the *Plan of Study*. Key to moving forward in Phases 3 and 4 is the remaining work in Phases 1 and 2—completion of quantification of future water supply and demand scenarios. Once the future supply and demand scenarios are fully quantified, the analysis of the reliability of the Colorado River system to meet the needs of Basin resources over the next 50 years can be completed (Phase 3). This System Reliability Analysis will first be performed independent of the consideration of opportunities for resolving imbalances in order to inform the Development and Evaluation of Opportunities (Phase 4).

Ongoing work from February 1, 2011 will be documented in the next interim report and includes:

- Completion of the quantification of the Downscaled GCM Projected scenario
- Quantification of the water demand scenarios, including the effects of climate change on demand
- Refinement of system reliability metrics
- Assessment of system reliability to determine the magnitude and location of future supply and demand imbalances and the impact to Basin resources
- Initiation of the development and evaluation of opportunities for resolving supply and demand imbalances

An updated timeline for the Study, outlining the major activities through the end of the Study in July 2012, is provided in Table 4. As the Study progresses, opportunities for stakeholder participation will continue to be provided through a variety of outreach activities, particularly with respect to the development and evaluation of opportunities for resolving supply and demand imbalances.

TABLE 4
Study Timeline

Timeframe	Activity
February – August 2011	Quantify Demand Scenarios
July – September 2011	Perform “Baseline” System Reliability Analysis
September – December 2011	Develop Options and Strategies
October 2011	Publish Interim Report Number 2
November 2011 – February 2012	Perform System Reliability Analysis with Options and Strategies
March 2012	Publish Interim Report Number 3
April – May 2012	Finalize and Evaluate Options and Strategies
June 2012	Publish Draft Final Study Report for Comment
July 2012	Publish Final Study Report

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Disclaimer

The Colorado River Basin Water Supply and Demand Study (Study) is funded jointly by the Bureau of Reclamation (Reclamation) and the seven Colorado River Basin States (Basin States). The purpose of the Study is to analyze water supply and demand imbalances throughout the Colorado River Basin and those adjacent areas of the Basin States that receive Colorado River water through 2060; and develop, assess and evaluate options and strategies to address the current and projected imbalances.

Reclamation and the Basin States intend that this Study will promote and facilitate cooperation and communication throughout the Basin regarding the reliability of the system to continue to meet Basin needs and the strategies that may be considered to ensure that reliability. Reclamation and the Basin States recognize the Study will have to be constrained by funding, timing and technological and other limitations, which may present specific policy questions and issues, particularly related to modeling and interpretation of the provisions of the Law of the River during the course of the Study. In such cases, Reclamation and the Basin States will develop and incorporate assumptions to further complete the Study. Where possible, a range of assumptions will typically be used to identify the sensitivity of the results to those assumptions.

Nothing in the Study, however, is intended for use against any Basin State, the Federal government or the Upper Colorado River Commission in administrative, judicial or other proceedings to evidence legal interpretations of the law of the river. As such, assumptions contained in the Study or any reports generated during the Study do not, and shall not, represent a legal position or interpretation by the Basin States, Federal government or Upper Colorado River Commission as it relates to the law of the river. Furthermore, nothing in this Study is intended to, nor shall this Study be construed so as to, interpret, diminish or modify the rights of any Basin State, the Federal government, or the Upper Colorado River Commission under federal or state law or administrative rule, regulation or guideline, including without limitation the Colorado River Compact, (45 Stat. 1057), the Upper Colorado River Basin Compact (63 Stat. 31), the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, Treaty Between the United States of America and Mexico (Treaty Series 994, 59 Stat. 1219), the United States/Mexico agreement in Minute No. 242 of August 30, 1973, (Treaty Series 7708; 24 UST 1968) or Minute No. 314 of November 26, 2008, or Minute No. 318 of December 17, 2010, the Consolidated Decree entered by the Supreme Court of the United States in Arizona v. California (547 U.S 150 (2006)), the Boulder Canyon Project Act (45 Stat. 1057), the Boulder Canyon Project Adjustment Act (54 Stat. 774; 43 U.S.C. 618a), the Colorado River Storage Project Act of 1956 (70 Stat. 105; 43 U.S.C. 620), the Colorado River Basin Project Act of 1968 (82 Stat. 885; 43 U.S.C. 1501), the Colorado River Basin Salinity Control Act (88 Stat. 266; 43 U.S.C. 1951), the Hoover Power Plant Act of 1984 (98 Stat. 1333), the Colorado River Floodway Protection Act (100 Stat. 1129; 43 U.S.C. 1600), or the Grand Canyon Protection Act of 1992 (Title XVIII of Public Law 102-575, 106 Stat. 4669). Reclamation and the Basin States continue to recognize the entitlement and right of each State under existing law to use and develop the water of the Colorado River system.[14]

[14] Reclamation and the Basin States have exchanged letters and are in the process of amending the Contributors' funding agreement to, among other things, document and clarify the intent of the Parties consistent with the above disclaimer.

Appendix 1
Plan of Study

Appendix 1—Plan of Study

Note: This document was originally published with two attachments which are not included in this appendix.

1.0 Introduction

The Bureau of Reclamation's Upper Colorado and Lower Colorado Regions (UC and LC Regions), in collaboration with representatives of the seven Colorado River Basin States (Basin States), submitted a proposal in June 2009 to fund the "Colorado River Basin Water Supply and Demand Study" (Study) under the Basin Study Program (Program). In September 2009, the Study was selected for funding under the Program. The estimated total cost of the Study is $2 million, with an equal cost-share of 50 percent by Reclamation and 50 percent by agencies in the Basin States (the non-Federal Cost-Share Partners). The Study will be conducted over a period of two years, beginning in January 2010.

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 in each phase; a plan for public involvement throughout the Study (Attachment 1); and the June 2009 proposal (Attachment 2).

2.0 Study Purpose & Objectives

The purpose of the Study is to conduct a comprehensive study to define current and future imbalances in water supply and demand in the Colorado River Basin (Basin) and the adjacent areas of the Basin States that receive Colorado River water for approximately the next 50 years, and to develop and analyze adaptation and mitigation strategies to resolve those imbalances.

The Study will characterize current and future water supply and demand imbalances in the Basin and assess the risks to Basin resources. Resources include water allocations and deliveries consistent with the apportionments under the Law of the River[1]; hydroelectric power generation; recreation; fish, wildlife, and their habitats (including candidate, threatened, and endangered species); water quality including salinity; flow and water dependent ecological systems; and flood control. Specific objectives of the Study include:

- Characterization of the current water supply and demand imbalances in the Basin including the assessment of the risks to Basin resources from historical climate variability.
- Characterization of future water supply and demand imbalances under varying water supply and demand conditions in the Basin including the assessment of the risks to Basin resources from possible future impacts of climate change.
- Identification of potential strategies and options to resolve Basin-wide water supply and demand imbalances including:

[1] 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.

- Modifications to the operating guidelines or procedures of water supply systems;
- Modifications to existing facilities and development of new facilities;
- Modifications to existing water conservation and management programs and development of new programs;
- Modifications to existing water supply enhancement programs and development of new programs; and
- Other structural and non-structural solutions.

- Identification of potential legal and regulatory constraints and analysis of potential impacts to water users and Basin resources for the strategies and options considered.
- Prioritization of identified strategies and options and the recommendation for potential future actions, including feasibility studies, Congressional authorization, environmental compliance activities, demonstration programs, and/or implementation as appropriate.

3.0 Study Management

Management of the Study by the UC and LC Regions and the non-Federal Cost-Share Partners will be accomplished as described in the following sections.

3.1 Co-Study Managers

One Co-Study Manager will be designated from Reclamation and one Co-Study Manager will be designated from the Non-Federal Cost Share Partners. The Co-Study Managers will sit on and lead the Steering Team.

3.2 Steering Team

The Steering Team will steer and guide the efforts of the Project Team such that the objectives of the Study are met in an effective, efficient manner, and within the Study's financial and time constraints. The Steering Team will be comprised of one member from the UC Region, one member from the LC Region, one member from each Basin State, and one member from the Upper Colorado River Commission, for a total of 10 members.

3.3 Project Team

The Project Team will ensure that the tasks that relate to the Study are completed in a cost-effective, timely manner and are technically sound. Members of the Project Team provide the expertise, experience, and knowledge that relate to the Study's scope and objectives. Members include staff from the UC and LC Regions, staff from the non-Federal Cost-Share Partners, and staff from other entities who may be contracted to provide specific information, knowledge, and support. The Co-Study Managers will lead the Project Team.

3.4 Sub-Teams

Various Sub-Teams will be formed as needed to perform specific tasks. Sub-Team members provide specific expertise required to perform those tasks. Members are comprised of Project

Team members, additional staff from the UC and LC Regions and the non-Federal Cost-Share Partners, and staff from contracted entities. Membership may also include representatives from other groups with a particular expertise sought by the Sub-Team.

3.5 Reclamation Management Structure

To facilitate Reclamation's oversight responsibilities and internal coordination, the proposed Study management structure includes a Reclamation Oversight Team (Oversight Team) and a Reclamation Study Team (Study Team). The Oversight Team provides oversight for the Study and will guide the efforts of the Study Team to ensure that the objectives of the Study are met within the financial and time constraints. Members of the Oversight Team are the Regional Directors of the UC and LC Regions and a senior member of the Office of Policy and Administration in Denver. Members of the Study Team include key staff from the UC and LC Regions.

4.0 Study Schedule, Phases, & Products

The Study will be technically oriented, incorporating information from the latest science, engineering technology, climate models, and innovations. The level of analysis of the strategies and options will be similar to an appraisal-level study to assist in justifying and preparing feasibility studies, Congressional authorization, environmental compliance activities, demonstration programs, and/or implementation as appropriate.

4.1 Schedule

The Study will be conducted over a period of two years, beginning in January 2010. The Study will consist of four major phases: Water Supply Assessment, Water Demand Assessment, System Reliability Analysis, and Development and Evaluation of Opportunities for Balancing Supply and Demand. The projected timeline for these phases is provided in Figure 1. The projected Study milestones are listed in Table 1.

FIGURE 1
Projected Study Timeline

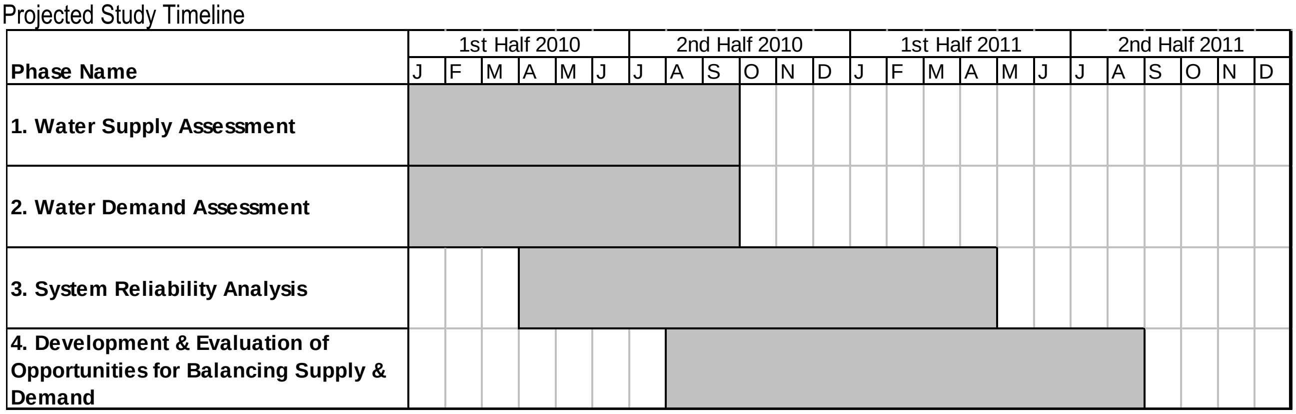


TABLE 1
Projected Study Milestones

Milestone	Deliverable Description
September 2010	Report describing findings from current and future water supply assessment
September 2010	Report describing findings from current and future water demand assessment
April 2011	Report describing findings from system reliability analysis
August 2011	Report describing findings of opportunities analysis
October 2011	Draft Study report and appendices available for review
December 2011	Final Study report and appendices complete

Development and review of the draft and final Study report will follow the completion of the fourth milestone as shown above.

4.2 Phases

Table 2 provides the tasks and sub-tasks associated with the major Study phases.

TABLE 2
Overview of Study Phases

Phase 1. Water Supply Assessment. Assess the quantity and location of current and future water supplies throughout the Basin, including the potential effects of climate variability and climate change. Major tasks and sub-tasks include:
1.1 Review & Select Methods to Estimate Current Supply 1.1.1 Historic Observed Record 1.1.2 Paleo Record 1.2 Review & Select Methods to Project Future Supply 1.3 Conduct Assessment of Current Supply 1.4 Conduct Assessment of Future Supply 1.5 Enhance Modeling Capability as Needed to Incorporate Methods to Project Future Supply 1.6 Conduct Sensitivity Analysis of Selected Methods to Project Future Supply 1.7 Prepare Draft Interim Report 1.8 Peer Review Report 1.9 Prepare & Publish Interim Report
Phase 2. Water Demand Assessment. Assess the quantity and location of current and future water demands, including the potential effects of climate variability and climate change. Major tasks and sub-tasks include:
2.1 Review & Select Methods to Estimate Current Demands 2.2 Review & Select Methods to Project Future Demands 2.3 Conduct Assessment of Current Demands 2.4 Assessment of Future Demands 2.4.1 Update State Demand Projections

TABLE 2
Overview of Study Phases

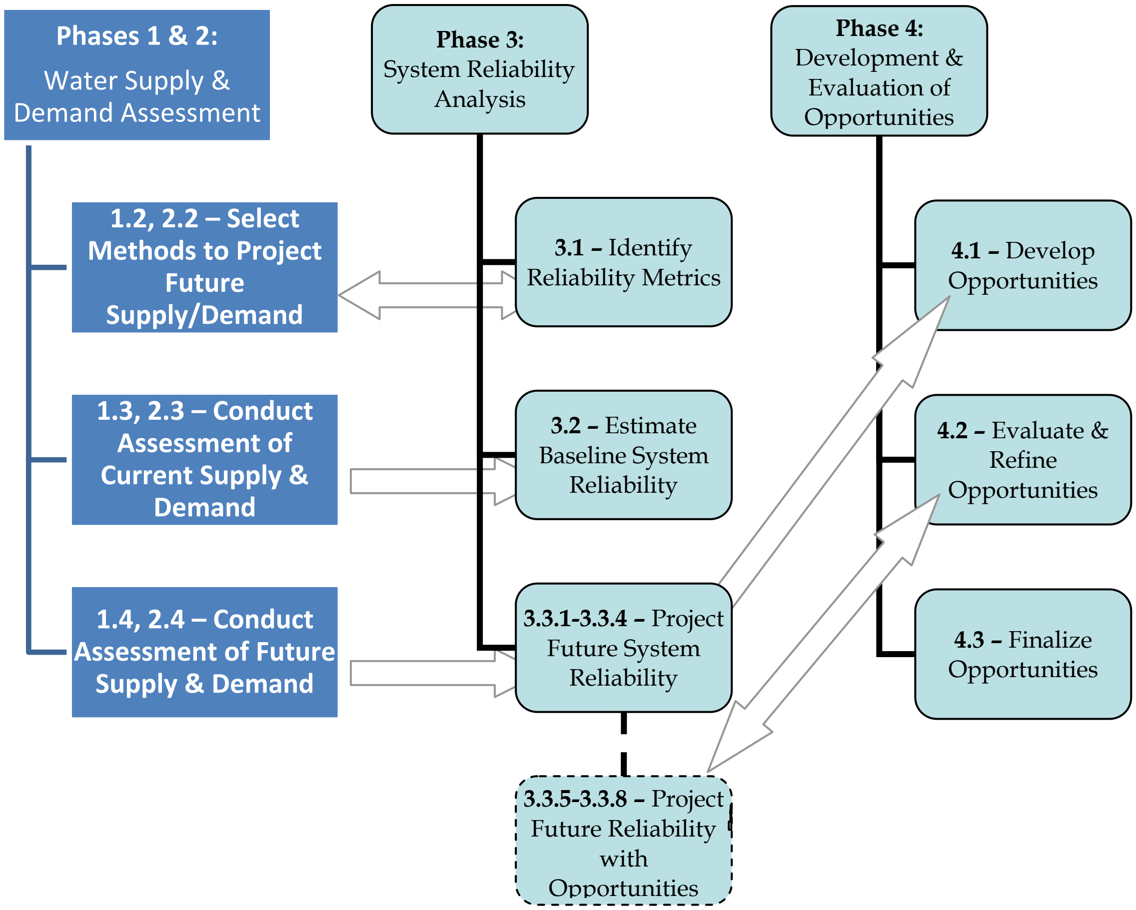
2.4.2 Analyze Temperature Effects on Projected Use 2.5 Enhance Modeling Capability to Better Represent Future Demands 2.5.1 Reservoir Evaporation 2.6 Prepare Draft Interim Report 2.7 Peer Review Report 2.8 Prepare & Publish Interim Report
Phase 3. System Reliability Analysis. Assess the capability of existing and proposed infrastructure and operations to meet future demands and water supply challenges. This analysis will include an assessment of the operational risk and reliability of the system currently and in the future. System reliability will be determined by describing the quantity and locations of supply/demand imbalances currently and in the future. Scenarios for baseline and future water supply and demand will be determined in Phases 1 and 2. Evaluate effectiveness of opportunities identified in Phase 4 in resolving imbalances. Major tasks and sub-tasks include:
3.1 Identify Model & System Reliability Metrics 3.2 Determine Baseline System Reliability 3.2.1 Determine Baseline Scenario Modeling Assumptions 3.2.2 Prepare Model to Simulate Baseline Scenario 3.2.3 Perform Model Simulations 3.2.4 Synthesize & Analyze Model Results 3.2.5 Summarize Model Results 3.3 Project Future System Reliability 3.3.1 Determine Future Scenario Modeling Assumptions 3.3.2 Prepare Model to Simulate Future Scenarios 3.3.3 Perform Model Simulations 3.3.4 Synthesize & Analyze Model Results 3.3.5 Determine Modeling Assumptions for Supply/Demand Opportunities 3.3.6 Prepare Model to Simulate Future Conditions Under Supply/Demand Opportunities 3.3.7 Perform Model Simulations with Supply/Demand Opportunities 3.3.8 Synthesize & Analyze Model Results 3.4 Prepare Draft Interim Report 3.5 Peer Review Report 3.6 Prepare & Publish Interim Report
Phase 4. Development & Evaluation of Opportunities for Balancing Supply & Demand. Identify and quantify potential opportunities to address imbalances in supply and demand in order to best meet future challenges. This analysis will include the identification and development of both structural and non-structural opportunities. As opportunities are refined, an iterative modeling process will be used to determine future system reliability under conditions where selected opportunities are assumed to be developed and/or implemented. Opportunities include but are not limited to: operational changes, legal and institutional changes, water conservation and efficiency, land fallowing and retirement, conjunctive use, upgrades, rehabilitation or replacement of existing facilities, water recycling and reuse, desalination, development of new conveyance and storage facilities, weather modification, vegetation management, dust abatement efforts, groundwater remediation, urban runoff management, and importation projects. Major tasks and sub-tasks include:
4.1 Develop Opportunities 4.1.1 Identify Opportunities 4.1.2 Determine Preliminary Opportunities for Evaluation 4.1.3 Analyze Opportunities (Preliminary)

TABLE 2
Overview of Study Phases

4.2	Evaluate & Refine Opportunities	
	4.2.1	Technical Feasibility
	4.2.2	Uniform Cost Comparison
	4.2.3	Environmental Impacts/Permitting Requirements
	4.2.4	Economic and Socioeconomic Impacts
	4.2.5	Legal and Public Policy Considerations
	4.2.6	Risk and Uncertainty
	4.2.7	Others
	4.2.8	Assessment of Effectiveness
	4.2.9	Potential Yield
	4.2.10	Timeframe for Implementation
	4.2.11	Agreements or Partnerships Needed
	4.2.12	Cost Allocation
	4.2.13	Siting
4.3	Finalize Opportunities	
	4.3.1	Determine Ability of Opportunities to Resolve Imbalances
4.4	Prepare Draft Interim Report	
4.5	Peer Review Report	
4.6	Prepare & Publish Interim Report	

Figure 2 illustrates the information transfer and coordination of tasks in the four major phases of the Study.

FIGURE 2
Flowchart of Major Study Phases



The first coordination occurs between Phases 1 and 2 and Phase 3 where the identification of the system reliability metrics in Task 3.1, in terms of spatial and temporal scale, depend upon the methods selected to project future supply and demand in Task 1.2 and Task 2.2. Baseline and future system reliability in Task 3.2 and Task 3.3, respectively, is determined based on the results of the assessment of current and future water supply and demand conditions in Task 1.3 (and Task 2.3) and Task 1.4 (and Task 2.4).

In Task 4.1, opportunities to resolve supply/demand imbalance will be identified considering the results of the projections of future system reliability in Tasks 3.3.1-3.3.4. The evaluation and refinement of those opportunities in Task 4.2 will be accomplished through re-projecting future system reliability under the identified opportunities in Tasks 3.3.5-3.3.8. After several iterations consisting of refining opportunities and projecting system reliability to determine the opportunities' performance, opportunities will be finalized in Task 4.3.

4.3 Products

The primary products of the Study will be interim written reports to be integrated into a final report that will include the following elements:

- Assessment of quantity and location of existing and future water supplies and demands throughout the Basin, including the potential effects of climate variability and climate change,
- Assessment of efforts currently being undertaken to reduce supply and demand imbalances throughout the Basin,
- Analysis of supply and demand relationships and quantification of imbalances in specific locations throughout the Basin,
- Development and evaluation of options for balancing supply and demand,
- Findings and recommendations,
- Description of methods and research processes, including assumptions, models and data used in the Study, and
- Description of stakeholder involvement.

Other expected outcomes include the identification of collaborative strategies through the Study's stakeholder involvement process.

4.4 Public Involvement Plan

A Public Involvement Plan has been developed to ensure that all stakeholders in the Basin as well as the general public are informed and their input is sought and considered throughout the Study. The Public Involvement Plan is provided in Attachment 1.

Appendix 2
Steering Team, Project Team, and Study Team Members

Appendix 2 — Steering Team, Project Team, and Study Team Members

Steering Team, Project Team, and Study Team members as of May 1, 2011 are denoted by "X"s in Table 1.

TABLE 1
Team Members

Name	Organization	Steering Team Member	Project Team Member	Study Team Member
Abbas AmirTeymoori	Colorado River Board of California		X	
Pam Adams	Bureau of Reclamation		X	X
Perri Benemelis	Arizona Department of Water Resources	X	X	
John Carter	Imperial Irrigation District		X	
Chuck Cullom	Central Arizona Project		X	
Amy Cutler	Bureau of Reclamation		X	X
Martin Einert	Power Services		X	X
Kevin Flanigan	New Mexico Interstate Stream Commission		X	
Kathy Freas	CH2M HILL		X	X
Terry Fulp	Bureau of Reclamation	X	X	X
Greg Gates	CH2M HILL		X	X
Don Gross	Arizona Department of Water Resources		X	
Amy Haas	New Mexico Interstate Stream Commission		X	
Chris Harris	Colorado River Board of California	X	X	
Bill Hasencamp	Metropolitan Water District of Southern California		X	
Deanna Ikeya	Arizona Department of Water Resources		X	
Carly Jerla	Bureau of Reclamation		X	X
Bob Johnson	Water Consult Engineering and Planning Consultants		X	
Dave Kanzer	Colorado River Water Conservation District		X	
Mike King	Imperial Irrigation District		X	

TABLE 1
Team Members

Name	Organization	Steering Team Member	Project Team Member	Study Team Member
Robert King	Utah Division of Water Resources	X	X	
Ted Kowalski	Colorado Water Conservation Board	X	X	
Les Lampe	Black & Veatch		X	X
Estevan Lopez	New Mexico Interstate Stream Commission	X	X	
Tom Maher	Southern Nevada Water Authority		X	
Jan Matusak	Metropolitan Water District of Southern California		X	
Bruce Moore	Southern Nevada Water Authority		X	
Armin Munévar	CH2M HILL		X	X
Don Ostler	Upper Colorado River Commission	X	X	
Colby Pellegrino	Southern Nevada Water Authority		X	
Demetri Polyzos	Metropolitan Water District of Southern California		X	
James Prairie	Bureau of Reclamation		X	X
Bennet Raley	Front Range Water Council		X	
Halla Razak	San Diego County Water Authority		X	
Klint Reedy	Black & Veatch		X	X
Bill Rinne	Southern Nevada Water Authority	X	X	
John Shields	Wyoming State Engineer’s Office	X	X	
Bill Swan	Imperial Irrigation District		X	
David Trueman	Bureau of Reclamation	X	X	X
Erin Wilson	LRE Water		X	

Appendix 3
Public Involvement Plan

Appendix 3—Public Involvement Plan

Note: This document was originally published as an appendix to the Plan of Study.

1.0 Introduction

The Colorado River Basin Water Supply and Demand Study (Study) has been selected to be one of three, two-year studies funded through the Bureau of Reclamation's Basin Study Program. The Study will provide a comprehensive analysis of current and future imbalances in water supply and demand projected through 2060 in the Colorado River Basin (Basin) and the adjacent areas of the Basin States (Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming) that receive Colorado River water; potential impacts of climate variability and climate change on water supply and demand; and potential adaptation and mitigation strategies and options to resolve those imbalances. A primary objective of the Study is prioritization of identified strategies and options and the recommendation for potential future feasibility studies, Congressional authorization, environmental compliance activities, demonstration programs, and/or implementation.

The Study is cost-shared on a 50/50 basis between the Study partners: Reclamation (the Federal Cost-Share Partner) and agencies in the Basin States (the non-Federal Cost-Share Partners). Because the Colorado River Basin spans two Reclamation regions, Reclamation is represented by both the Upper Colorado Regional Office and the Lower Colorado Regional Office.

The Study partners will facilitate public involvement to solicit and incorporate stakeholder input throughout the study. This Public Involvement Plan (PIP) provides the framework for that effort.

2.0 Approach

Several communication methods will be employed to effectively maintain communication with all interested stakeholders and to provide, seek, and receive information. A response will be provided for all comments received. All information received regarding technical aspects of the Study will be considered and feedback regarding that consideration will be provided.

All outreach materials, information received, and feedback provided will be archived in a centralized electronic filing system. As the Study progresses, the effectiveness of the public involvement will be assessed periodically and adjustments will be made as necessary to ensure that appropriate communication and feedback is occurring.

3.0 Communication Methods

Effective communication is essential for the ongoing success of the Study. The methods of communication that will be used to disseminate information and accept input during the course of the Study include the following:

- Study website will be maintained to provide up-to-date, on-line information;
- E-mail address will be established to facilitate communication electronically;

- Facsimile (fax) telephone number will be established to allow communication by fax;
- Points-of-contact will be established in the Upper Colorado and the Lower Colorado Regions to facilitate additional information exchange;
- News releases and informational mailings will be provided as appropriate;
- Mailing list will be established and maintained to ensure that all interested stakeholders receive information;
- Public meetings will be held at strategic points throughout the Study; and
- Additional meetings with interested stakeholders groups will be held as appropriate.

Additional information on each of these methods is provided below.

4.0 Web Site

Reclamation's Study web site will be used to post up-to-date information. Web site content will be updated periodically, particularly at major milestones and prior to public meetings. In addition, the web site will be used as a tool for soliciting input from stakeholders. The following web page will be available no later than January 8, 2010: http://www.usbr.gov/lc/region/programs/crbstudy.html.

5.0 E-mail

Reclamation has established a Study e-mail address to disseminate information regarding the Study and to receive input. The Study e-mail address is: ColoradoRiverBasinStudy@usbr.gov.

6.0 Facsimile

Input may also be submitted by facsimile at: 702-293-8156.

7.0 Points-of-Contact

For additional information, questions, or comments on the Study, Reclamation has designated two Study Points of Contact:

Lower Colorado Region: Amber Cunningham at 702-293-8472 or ColoradoRiverBasinStudy@usbr.gov

Upper Colorado Region: Deborah Lawler at 801-524-3685 or ColoradoRiverBasinStudy@usbr.gov.

8.0 News Releases and Informational Mailings

News releases and other informational mailings will occur near major milestones throughout the Study to inform stakeholders and the public of the Study status, provide opportunities for input, and provide meeting information including dates and locations of the public meetings.

8.1 Mailing List

Informational mailings will be sent to interested stakeholders on the Study mailing list (either physically, electronically, or both). During each informational mailing, the recipient will be asked if he or she would like to remain on the list. Individuals will be added to the mailing list when requested through the Study e-mail address or through attendance at a public meeting captured on the sign-in sheet. An initial mailing will be made in January 2010 to a list of Colorado River stakeholders who were involved in similar prior studies.

8.2 Public Meetings

Public meetings will be held at strategic points throughout the Study, beginning with an initial meeting in the spring of 2010. Additionally, prior to completion of each Study phase, public meetings will be held to provide a summary of the results of the previous phase and to seek comments on the upcoming phase of the Study, thereby allowing consideration of information and suggestions by the public for incorporation in the Study.

Four public meetings are currently envisioned as follows:

1. *Targeted for March 2010* - Meeting to discuss the Study objectives, structure, schedule, PIP, the proposed approach for Phase 1 (assessment of current and future water supply), and Phase 2 (assessment of current and future water demand);
2. *Targeted for September 2010* – Meeting to discuss the results of Phases 1 and 2 and the proposed approach for Phase 3 (analysis of the current and future system reliability);
3. *Targeted for April 2011* – Meeting to discuss the results of Phase 3 and the proposed approach for Phase 4 (analysis of strategies and options for resolving supply/demand imbalances); and
4. *Targeted for August 2011* – Meeting to discuss the results of Phase 4.

8.3 Additional Meetings with Interested Stakeholder Groups

During the course of the Study, additional meetings may be held with interested stakeholder groups to solicit additional input, expertise, data, and information. As appropriate, representatives of interested stakeholder groups may participate in specific Study tasks to facilitate incorporation of such input into the Study.

Interested stakeholder groups may include, but are not limited to Federal agencies, Native American Tribes and communities, water districts, scientific research groups, hydropower agencies and other representatives of the energy industry, environmental groups, and representatives of the recreational industry. An initial mailing will be made in January 2010 to a list of interest groups who were involved in similar prior studies to gage their interest and capability for participating in the Study. Other interest groups are encouraged to provide their contact information via one of the communication methods listed above.

Appendix 4
Outreach Activities

Appendix 4—Outreach Activities

This appendix presents a chronology of stakeholder outreach activities conducted for the Colorado River Basin Water Supply and Demand Study as of January 31, 2011. The activities consisted of meetings held at locations convenient to stakeholder groups, Webinars transmitted on the Internet, and telephone conference calls as shown in Table 1.

TABLE 1
Stakeholder Outreach Events Conducted for Basin Study as of January 31, 2011

Meeting Date	Participant	Location	Mtg Type
3/31/2010	NGO Collaborative - Defenders of Wildlife, Environmental Defense Fund, The Nature Conservancy, Pacific Institute, Sonoran Institute, Trout Unlimited, Western Resource Advocates	Boulder, CO	Meeting
5/3/2010	NGO Collaborative - Defenders of Wildlife, Environmental Defense Fund, The Nature Conservancy, Pacific Institute, Sonoran Institute, The Nature Conservancy, Trout Unlimited, Western Resource Advocates		Conference Call
5/25/2010	Quechan Indian Tribe, Navajo Nation, Southern Ute Indian Tribe		Webinar
5/26/2010	Hualapai Tribal Nation, Bureau of Indian Affairs - Colorado River Agency	Parker, AZ	Meeting
5/27/2010	Navajo Nation	Window Rock, AZ	Meeting
5/27/2010	Fort McDowell Yavapai Nation, Inter Tribal Council of Arizona	Phoenix, AZ	Meeting
6/16/2010	WestCAS Annual Conference	Pacific Beach, CA	Conference
6/17/2010	U.S. Fish and Wildlife Service		Webinar
6/23/2010	Bureau of Land Management	Salt Lake City, UT	Meeting
6/24/2010	Western States Water Council, Western Governors' Association		Webinar
6/25/2010	National Park Service	Las Vegas, NV	Meeting
6/30/2010	Western Area Power Administration, Salt River Project	Boulder City, NV	Meeting/ Webinar
7/9/2010	NGO Collaborative - Defenders of Wildlife, Environmental Defense Fund, The Nature Conservancy, Sonoran Institute, Trout Unlimited, Western Resource Advocates		Webinar
7/15/2010	Bureau of Land Management	Denver, CO	Meeting
7/27/2010	NGO Collaborative - Defenders of Wildlife, Environmental Defense Fund, The Nature Conservancy, Pacific Institute, Sonoran Institute, Trout Unlimited, Western Resource Advocates		Webinar

TABLE 1
Stakeholder Outreach Events Conducted for Basin Study as of January 31, 2011

Meeting Date	Participant	Location	Mtg Type
7/29/2010	Fort McDowell Yavapai Nation Tribe		Conference Call
7/30/2010	NGO Collaborative - Defenders of Wildlife, Environmental Defense Fund, The Nature Conservancy, Sonoran Institute, Western Resource Advocates		Webinar
8/5/2010	Hualapai Tribal Nation	Boulder City, NV	Meeting
8/10/2010	Colorado River Fish and Wildlife Council	Saratoga, WY	Meeting
8/11/2010	Ute Indian Tribe of the Uinta & Ouray Reservation	Boulder, CO	Meeting
8/18/2010	NGO Collaborative - Defenders of Wildlife, Environmental Defense Fund, Trout Unlimited		Webinar
8/19/2010	Jicarilla Apache Nation, Ute Mountain Ute Tribe, Southern Ute Indian Tribe	Durango, CO	Meeting
8/19/2010	NGO Collaborative - Sonoran Institute, Trout Unlimited, Western Resource Advocates		Webinar
8/23/2010	U.S. Environmental Protection Agency		Webinar
9/1/2010	NGO Collaborative - Environmental Defense Fund, The Nature Conservancy		Conference Call
9/3/2010	U.S. Geological Survey	Denver, CO	Meeting
9/21/2010	Hualapai Tribal Nation	Peach Springs, AZ	Meeting
9/23/2010	Colorado River Basin Study Public Meeting		Webinar
10/5/2010	Colorado Water Conservation Board	Denver, CO	Meeting
10/5/2010	Denver Water	Denver, CO	Meeting
10/6/2010	Irrigation and Electrical Districts Association of Arizona		Conference Call
10/7/2010	Front Range Water Council	Denver, CO	Meeting
10/8/2010	Inter Tribal Council of Arizona	Phoenix, AZ	Meeting
10/20/2010	Virgin River Watershed Conference	Mesquite, NV	Conference
10/28/2010	Wyoming Water Association	Laramie, WY	Meeting
10/29/2010	Front Range Water Council	Denver, CO	Meeting
11/1/2010	NGO Collaborative - Environmental Defense Fund, The Nature Conservancy, Trout Unlimited, Western Resource Advocates		Conference Call
11/1/2010	NGO Collaborative - Defenders of Wildlife, Environmental Defense Fund, The Nature Conservancy, Western Resource Advocates		Webinar
12/30/2010	Layne Hydro		Conference Call

TABLE 1
Stakeholder Outreach Events Conducted for Basin Study as of January 31, 2011

Meeting Date	Participant	Location	Mtg Type
1/18/2011	NGO Collaborative - Defenders of Wildlife, Environmental Defense Fund, Hydros Consulting, The Nature Conservancy, Pacific Institute, Sonoran Institute, Trout Unlimited, Water Balance Consulting, Western Resource Advocates	Boulder, CO	Meeting
1/27/11	American Meteorological Society	Seattle, WA	Meeting
1/28/11	Tribal Leaders Water Policy Council of the Inter Tribal Council of Arizona	Tempe, AZ	Meeting