



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

4.0 Introduction

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

4.1 Approach for Assessing Current Tribal Water Use

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

The Partnership Tribes in the Upper Basin provided water supply and use information primarily at the tributary or sub-basin level, depending on the tribe's reserved water rights or unresolved claims. Water use data for some of the Upper Basin Partnership Tribes is sporadic and of low quality, which led the Navajo Nation to report a one-year "snapshot" of uses. The Southern Ute Indian Tribe used 2009 through 2013 data as a guide to provide updated current water use information. For Partnership Tribes in the Lower Basin, records of diversions, return flows, and consumptive use of water diverted from the mainstream of the Colorado River below Lee Ferry

Key Terms

Key terms used in this chapter are defined below.

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

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

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

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

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

are compiled by Reclamation in the Colorado River Accounting and Water Use Reports: Arizona, California, and Nevada (Water Accounting Report) (Reclamation, 2017). The Water Accounting Reports for 2009 through 2013 were averaged and used for the Lower Basin Partnership Tribes, except for the Chemehuevi Indian Tribe, which averaged the years 2010 through 2013. Existing Reclamation data were supplemented with additional information provided by each of the tribes.

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

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

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

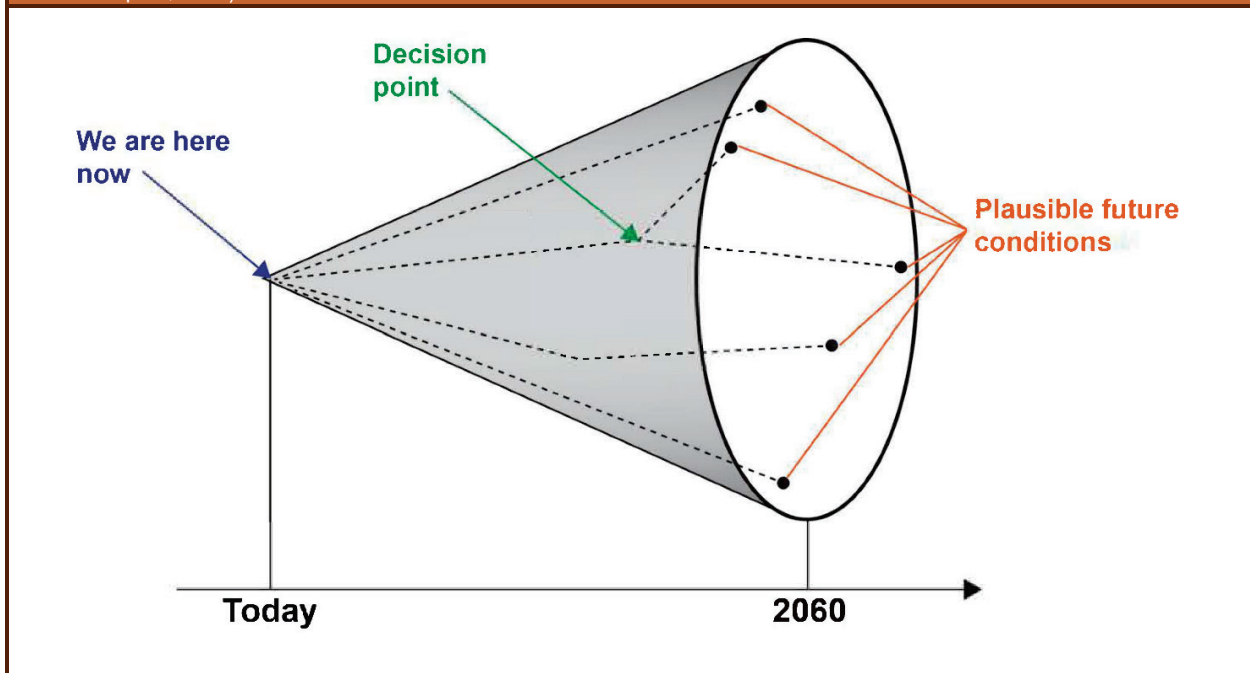
4.2 Approach for Assessing Future Tribal Water Development

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

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

FIGURE 4-A

Conceptual Representation of the Uncertain Future of a System, also known as “The Scenario Funnel” (adapted from Timpe and Scheepers, 2003)

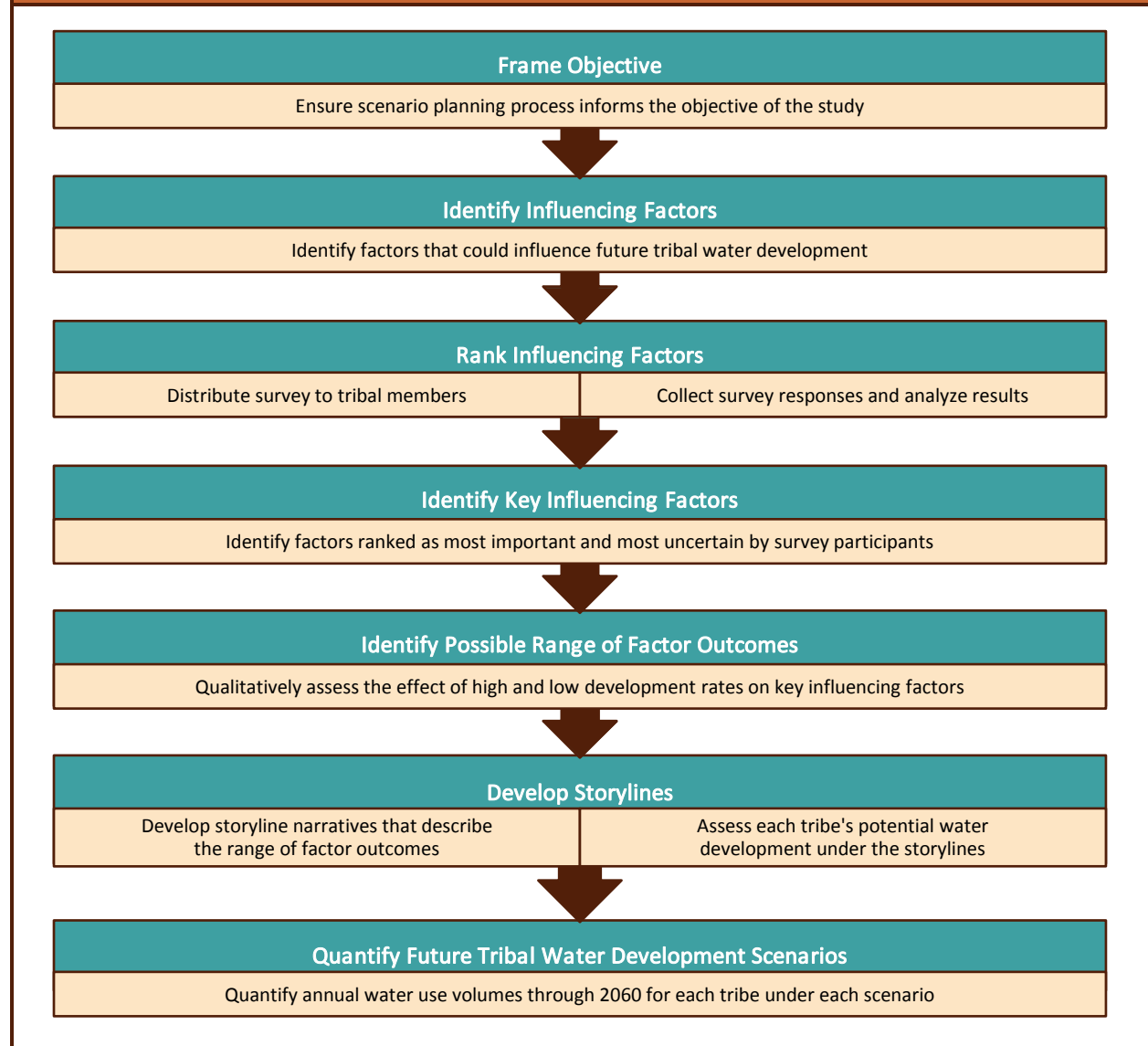


The scenario planning process is shown in Figure 4-B and described below. The process began by framing or identifying the objectives of the planning process. Influencing factors, or factors that drive the development of tribal water were then identified and ranked in terms of importance and uncertainty.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

4.2.1 Frame the Objectives

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

FIGURE 4-B
Scenario Planning Process



4.2.2 Identify Influencing Factors to Tribal Water Development

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

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

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

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

TABLE 4-A List of Factors Influencing Tribal Water Development	
13	Changes in tribal/federal financial resources available to construct new water delivery systems and storage for domestic and municipal purposes <i>Description: This factor could include influences such as the ability of the tribe to construct new domestic and municipal delivery systems, including storage facilities.</i>
	13a. Changes in tribal financial resources
	13b. Changes in federal financial resources
Economic Development	
14	Changes in water needs for energy generation (e.g., solar, oil shale, thermal, nuclear, hydroelectric, etc.)
15	Changes in water needs to support tribal economic development (e.g., eco and cultural tourism, commercial and business centers, etc.)
16	Changes in the local and regional market “value” (i.e., cost) of water (as it relates to different uses, such as the cost of generating energy, commodity prices, cost to pump, leasing, municipal use, etc.)
Social	
17	Changes in cultural and spiritual uses of tribal water
18	Changes in tribal values affecting water use <i>Description: This factor could include changes in tribal member priorities related to water use such as in-stream flows, recreation, domestic use, etc.</i>
Governance	
19	Changes in tribal water availability and use due to the resolution and settlement of tribal water rights claims <i>Description: This factor could include changes in the time it takes to complete Indian water settlements and in tribal member support for these settlements and water development plans.</i>
20	Changes in the laws, policies, and/or regulations to provide increased flexibility to tribes to use tribal water <i>Description: This factor could include changes to provide for increased use of water banking, water marketing, leasing, etc., and changes that further support and facilitate use of tribal water to support tribal economic development.</i>
21	Changes in federal, state, and/or regional water administration practices <i>Description: This factor could include changes in the accounting of tribal water in the Colorado River System, and tracking and ensuring deliveries during all hydrologic conditions, and changes in the ability to ensure water is delivered to a specific entity or location.</i>
22	Changes in tribal expertise and resources available for tribal water use planning <i>Description: This factor could include changes in tribal economic and other resources for tribal water resources planning and management, changes in Congressional appropriations to support water use development and planning, and changes in cooperative efforts with State and regional non-Indian water development planning.</i>
23	Changes in the understanding of tribal reserved water rights by federal, state, other governmental agencies and the public at large (e.g., external education)

4.2.3 Rank Influencing Factors

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

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

Importance (1 through 5, with 5 being greatest importance): Rate how important the factor will be in influencing tribal development and use of water (from the Colorado River and its tributaries) through 2060.

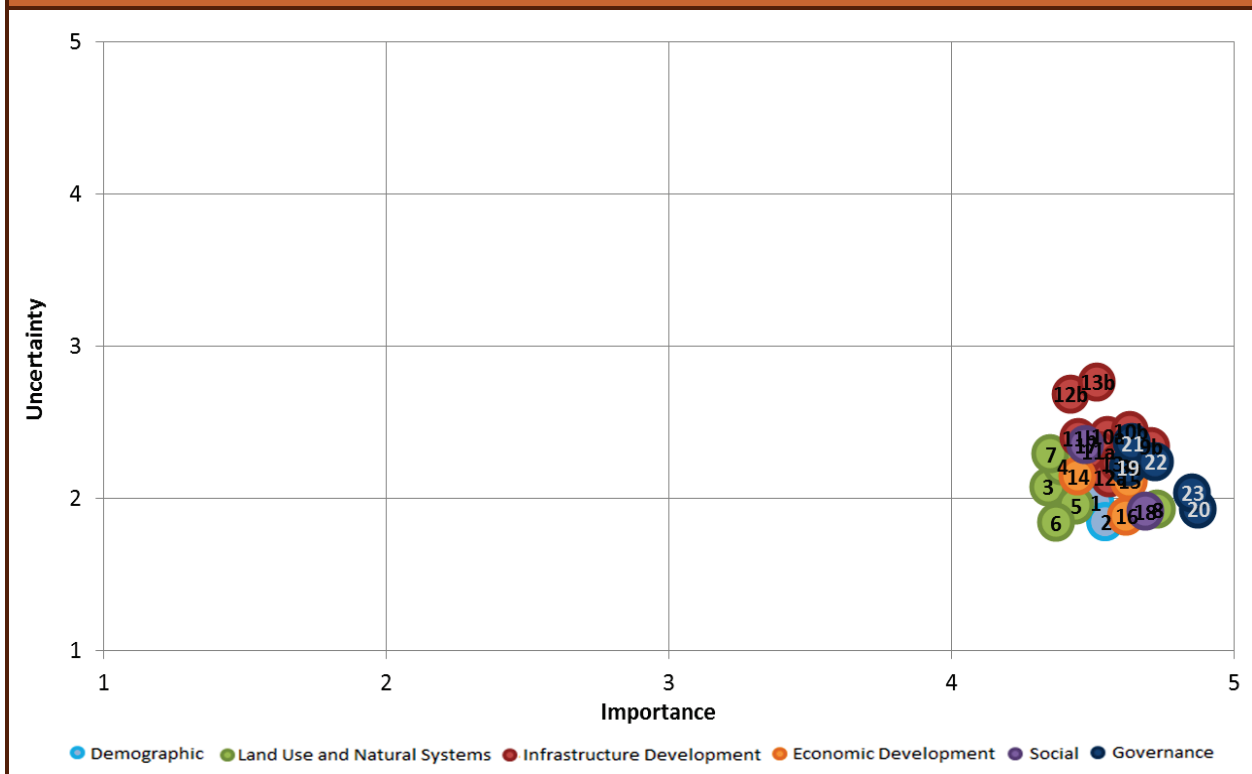
Uncertainty (1 through 5, with 5 being greatest uncertainty): Rate how certain you are regarding how that factor will change between now and 2060.

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

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

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

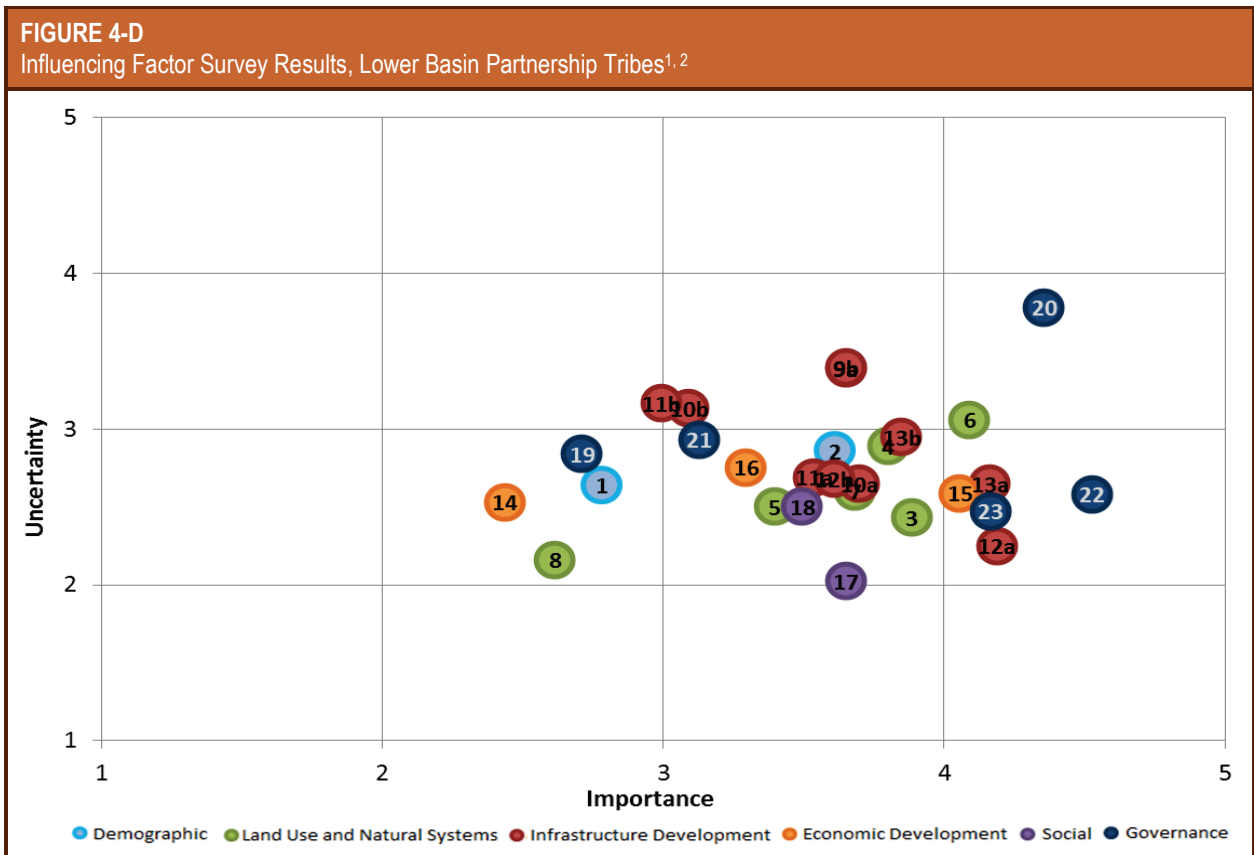
FIGURE 4-C
 Influencing Factor Survey Results, Upper Basin Partnership Tribes^{1,2}



¹ Ute Indian Tribe, Southern Ute Indian Tribe, Ute Mountain Ute Tribe, Jicarilla Apache Nation, and Navajo Nation.

² Each point corresponds with one of the influencing factor categories as indicated by the color of the point.

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



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

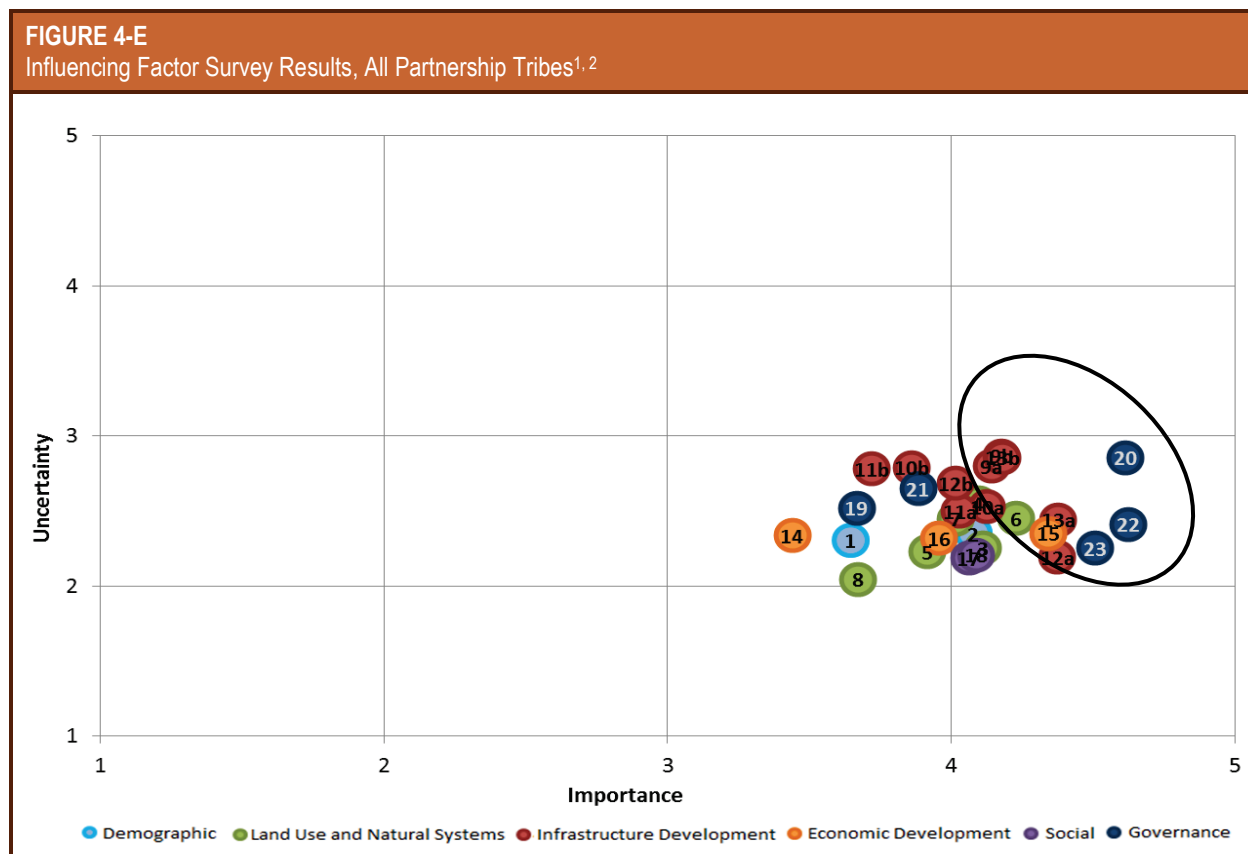
² Each point corresponds with one of the influencing factor categories, indicated by the color of the point.

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

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

4.2.4 Identify Key Influencing Factors

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



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

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

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

4.2.5 Identify Possible Range of Key Influencing Factor Outcomes

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

4.2.6 Develop Storylines

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

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

4.2.7 Quantify Future Tribal Water Development Scenarios

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

Each Partnership Tribe assessed future water development if current trends (Scenario A) continued through 2060. Because of complexities with reserved water rights and unresolved

claims, the Upper Basin Partnership Tribes generally assessed their future development at the tributary or sub-basin level, while the Lower Basin Partnership Tribes did so at a state level.¹

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

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