Appendix 7
Peer Review Summary Report

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1.0 Introduction

The Colorado River Basin Water Supply and Demand Study (Study), initiated in January 2010, was conducted by the Bureau of Reclamation (Reclamation) in collaboration with the seven Colorado River Basin States[1] (Basin States), conservation organizations, federally recognized tribes (tribes), and other interested parties. The *Plan of Study*, provided in appendix 1 of the *Study Report*, states that 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 seven 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 Study contains four major phases to accomplish this goal: Water Supply Assessment, Water Demand Assessment, System Reliability Analysis, and Development and Evaluation of Options and Strategies for Balancing Supply and Demand.

This document provides a summary of the Study's peer review.

1.1 Approach

The peer review was designed to ensure that assumptions, findings, and conclusions of the Study were clearly stated and supported; oversights, omissions, and inconsistencies were identified; and limitations and uncertainties were disclosed. The reviewers were provided with focused technical questions while also being directed to offer a broad evaluation of the overall product. Specifically, peer review goals included the following:

- Improve Study reports by ensuring that the methodologies, processes, assumptions, and limitations are thoroughly described and transparent
- Understand potential critiques to help in the development of Study next steps.
- Identify any significant errors.

Peer review comments were considered and incorporated into the *Study Report* and Technical Reports where relevant and appropriate. This summary report includes the views of the reviewers, without attribution of specific comments to specific reviewers, and an explanation of the actions undertaken (or not) to address the reviewers' comments.

1.2 Peer Reviewers

The peer reviewers for this Study, as a group, have expertise in climate science and associated hydrologic impacts and water management in the Basin. Individuals with the identified expertise who did not have formal involvement in the Study were asked to participate in the independent peer review. Peer review elements and reviewers are as follows:

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

1.2.1 Water Supply Assessment

- Kelly Redmond – Deputy Director and Regional Climatologist, Desert Research Institute/Western Regional Climate Center
- Jeff Arnold – Senior Climate Scientist, U.S. Army Corps of Engineers

1.2.2 Water Demand Assessment

- Jeannine Jones – Interstate Resources Manager, California Department of Water Resources
- Bonnie Colby – Department of Agricultural and Resource Economics, University of Arizona

1.2.3 Options and Strategies

- Tom Iseman – Program Director for Water Policy, Western Governors' Association
- James Heaney – Department of Environmental Engineering Sciences, University of Florida

1.2.4 System Reliability

- Rosalind Bark – Resource Ecological Economist, Australia's Commonwealth Scientific and Industrial Research Organization
- Holly Hartman – Director of Arid Lands Information Center, University of Arizona

2.0 Summary of Comments

The following sections list the specific focus questions asked of the reviewers. They provide a summary of comments received, without attribution of specific comments to specific reviewers, and an explanation of the actions undertaken (or not) to address the reviewers' comments.

2.1 Water Supply Assessment

The focus of the Water Supply Assessment peer review was whether the Water Supply Assessment met the intent of the Study. The reviewers were asked to consider the overall approach, the documentation of limitations and assumptions, and the scenario planning framework, with particular attention to secondary bias correction. The specific focus questions asked of the reviewers for the Water Supply Assessment are as follows:

1. Is purpose of the report clear?
2. Is the approach well-designed and executed?
3. Is the approach to quantifying scenarios clearly explained?
4. Has the assessment met the report goals?
5. Are the data and information appropriately cited?
6. Are assumptions and limitations explicit and justified?
7. Is the documentation accurate, understandable, clearly structured, and temperate in tone?
8. Are the reports compelling, useful, and relevant to stakeholders and decision makers?

In general, the reviewers thought the Water Supply Assessment, as detailed in *Technical Report B – Water Supply Assessment*, met all the requirements set out in the Study's focus questions. One reviewer wrote that the report was "impressively thorough, well-planned, and very professionally executed."

Reviewers provided specific word choice edits to clarify language and additional comments, to further strengthen the overall presentation of material. These comments focused on two topics. First, comments related to clarifying the differences between the scenario including climate change projections and three other supply scenarios based on observed or paleo-reconstructed streamflow. Additional discussion was added to clarify that rising temperature and transient downward-trending supply were present only in the climate change scenario. In addition, discussion was added to further clarify the uncertainty associated with the future climate projections and the use of this information in water planning.

Second, comments focused on the treatment and discussion of climate teleconnections (such as the Southern Oscillation Index, El Niño Southern Oscillation, and Pacific Decadal Oscillation) and their impacts on Basin supply. In response to these comments, additional language was added to the report to elaborate and clarify the discussion on Pacific Decadal Oscillation in particular. To address general issues of clarity, additional descriptions for several figures were added, as was additional discussion on uncertainty.

2.2 Water Demand Assessment

The focus of the Water Demand Assessment peer review was whether the Water Demand Assessment met the intent of the Study. The reviewers were asked to consider the overall approach, the approach to quantifying scenarios, the documentation of limitations and assumptions, the scenario planning framework, and the assessment of climate impacts on demands. The specific focus questions asked of the reviewers for the water demand assessment are as follows:

1. Is purpose of the report clear?
2. Is the approach well-designed and executed?
3. Is the approach to quantifying scenarios clearly explained?
4. Has the assessment met the report goals?
5. Are the data and information appropriately cited?
6. Are assumptions and limitations explicit and justified?
7. Is the documentation accurate, understandable, clearly structured, and temperate in tone?
8. Are the reports compelling, useful, and relevant to stakeholders and decision makers?

In general, the reviewers thought the Water Demand Assessment, as detailed in *Technical Report C – Water Demand Assessment*, met all the requirements set out in the Study's focus questions. One reviewer wrote, "Commendable and formidable effort to account for numerous uncertainties confronting the Basin and to integrate information from many sources pertinent to changing demand by water use sector and geographic area."

The reviewers specified a number of perceived limitations in the Water Demand Assessment. First, reviewers pointed out that the use of conventional demographic forecasting did not consider impacts on population distribution resulting from climate change. Second, reviewers found it problematic that the use of the practically irrigable acreage approach did not consider

that agricultural production (i.e., acreage and crop types) is driven by crop markets. The reviewers thought an econometric evaluation would complement the approach used in the Study. In particular, the reviewers critiqued the exclusion of price elasticity with respect to demand, despite available studies that could have been referenced. These comments were not necessarily viewed as limitations, because the impacts on population distribution resulting from climate change, as well as the practically irrigable acreage approach, while used in academia, are not ready for use in Basin-wide planning. Although climate change was not explicitly considered with respect to demographics, the demand scenarios did include lower-growth scenarios and reflect a range of potential future populations and demographic models. The Basin States did not use practically irrigable acreage for development of agricultural demands. Agricultural demands were projected by state agencies and irrigation districts. In some cases, land use-based models were used that incorporated urban population growth and other factors. Demand elasticity was not considered explicitly in the Study; however, it was included implicitly as part of the water demand options included in the Study.

Additional comments were received requesting that the *Study Report* explain the reliance on demand information provided by the Basin States. Comments questioned whether limitations in the Study prevented gathering of independent information from sources other than state agencies on projected population, irrigated acreage, and other parameters. These comments suggested that Reclamation commit to future work to refine demand estimates through more-intensive modeling efforts of future water demands associated with agriculture and energy production. Although demand information provided by the Basin States was relied on heavily, it was not the only source of this information. Additional regional and local data were collected to supplement and support the information provided by the Basin States – particularly in consideration of alternative demand scenarios. Furthermore, the Basin States, specifically the Basin States' representatives who were formally involved in the Study, are entrusted with the responsibility of demand planning and management in the region, and therefore were the best available resource for demand planning.

2.3 Options and Strategies for Balancing Supply and Demand

The primary focus of the peer review of the options and strategies was whether the analysis met the intent of the Study. Reviewers were asked to consider the overall approach taken for options, the development and use of characterization criteria, the development and use of portfolios, and the documentation of limitations and assumptions associated with characterization. The specific focus questions asked of the reviewers for the options and strategies are as follows:

1. Is purpose of the report clear?
2. Is the approach well-designed and executed?
3. Is the approach to option development clearly explained?
4. Is the development and use of characterization criteria clearly explained?
5. Is the development and use of portfolios clearly explained?
6. Are the data and information appropriately cited?
7. Are assumptions and limitations explicit and justified?
8. Is the documentation accurate, understandable, clearly structured, and temperate in tone?
9. Are the reports compelling, useful, and relevant to stakeholders and decision makers?

In general, the reviewers thought the options and strategies, as detailed in *Technical Report F – Development of Options and Strategies*, met all the requirements set out in the Study's focus questions. One reviewer wrote of a "sense that the Study was open-minded and receptive to new ideas and made an honest effort to provide an objective analysis."

A number of comments on this report related to the characterization of options and development of portfolios. Other comments focused on the general clarity of the report. Reviewers suggested that summary results be provided first in order to prevent the loss of the 'big picture.' They also thought the report would benefit from more citations, to help clarify assumptions. These changes were made to the final technical report.

The reviewers thought that the use of scoring criteria for the characterization of options was an overall useful exercise; however, the scoring of criteria felt "squishy" and overly precise. They pointed out that select options appeared to score more favorably than they might have deserved. For example, reviewers thought the yield estimates for weather modification and dust control options seemed high, and were surprised to see as much water yield in municipal reuse as in agricultural conservation. Additionally, reviewers thought it was not always clear which options were more tested and reliable than others. They believed that some options that had little, if any, testing or documentation scored better in terms of yield than the feasibility or reliability might suggest.

To address these comments, the report was modified to present additional summary information about the options, to aid in comparison and add clarity. With respect to specific options, in some cases, limited data were available to characterize items such as yield or cost, and there was significant uncertainty in these scores. However, the criteria associated with quantity of yield was specifically separated from those criteria associated with technical feasibility and long-term viability. Options with significant feasibility or long-term reliability concerns were rated low for these criteria, and were subsequently limited in their inclusion in portfolios that were analyzed. A risk-adjusted yield was not developed in the Study.

A number of the comments reflected a desire to know which option was "best;" however, the intent of Technical Report F was to enumerate and characterize the options without specific preferences or overall ratings. Preferences for certain option characteristics were included in the development of portfolios and the performance of these portfolios was evaluated in *Technical Report G – System Reliability Analysis and Evaluation of Options and Strategies*. In addition, the criteria were intended to be broad and represent a number of different viewpoints. Characterization alone could not determine which options were "best." The analytical framework applied in the Study was intended to be essentially preference-based.

Comments regarding the development of the portfolios requested that the report explicitly define reliability, risk, and uncertainty. Reviewers thought the report was missing discussion on the methodology used for filtering through the range of choices, and requested that the report better explain the use of the Portfolio Development Tool. Last, reviewers thought that unit costs needed to be defined more precisely by including the incidence of the benefits and costs.

In order to address comments on reliability, risk, and uncertainty, the text was modified to specifically define uncertainty and refined to replace references to "risk" with "uncertainty" where the intent was the same. Discussion on the methods employed to filter and characterize options was added, and references to the Portfolio Development Tool were removed and

replaced with discussion of the methods of filtering options based on the characterization criteria. As noted previously, this report did not attempt to define the efficacy or benefits of specific options, but rather provided an initial characterization that facilitated development of a set of exploratory portfolios reflecting different strategies for addressing potential future imbalances. The results of modeling the implementation of these options and strategies are defined in *Technical Report G – System Reliability Analysis and Evaluation of Options and Strategies*. In addition, significant additional text was added to clarify the cost discussion.

2.4 System Reliability Analysis

The primary focus of the System Reliability Analysis peer review was whether the analysis met the intent of the Study. Reviewers were asked to consider the overall approach; whether there was a broad-enough set of system reliability metrics, (resource metrics, indicator metrics, signposts, and vulnerable conditions); use of system reliability metrics; and the documentation of limitations and assumptions. The specific focus questions asked of the reviewers for the System Reliability Analysis are as follows:

1. Is purpose of the report clear?
2. Is the approach well-designed and executed?
3. Are a broad set of system reliability metrics presented?
4. Are the uses of indicator metrics, signposts, and vulnerable conditions clearly explained?
5. Has the analysis met the intent of the report?
6. Are the data and information appropriately cited?
7. Are assumptions and limitations explicit and justified?
8. Is the documentation accurate, understandable, clearly structured, and temperate in tone?
9. Are the reports compelling, useful, and relevant to stakeholders and decision makers?

Technical Report G – System Reliability Analysis and Evaluation of Options and Strategies received the most extensive comments from peer reviewers. Reviewers found it particularly problematic that qualitative evaluation and discussions lacked for topics that do not lend themselves to quantitative evaluation. One reviewer thought that next steps in the analysis should include discussion on governance feasibility of options, the United Mexican States (Mexico) particularly, its role in planning its future and the desire for collaborative work between the two countries, and outstanding water rights settlements associated with tribes. Another reviewer criticized the neglect of qualitative discussion of two classes of options: system operation and governance/implementation. This reviewer wrote, “This is a major short-coming because the report anchors discussion on the options that are quantitatively evaluated. Just because some options are more readily analyzed does not make them more preferred, more practical, or even more deserving of further investments (i.e., additional study), especially if choices have to be made about what options should be studied next.”

The Study acknowledges that certain options are more difficult to characterize in a structured rating approach and, in response to comments, expanded the discussion for those options that were qualitatively addressed in *Technical Report F – Development of Options and Strategies*. The *Study Report* also includes a broader discussion of the opportunities and constraints associated with the options that were qualitatively characterized in the Study. The *Study Report* includes a section on next steps that outlines the need for a cooperative approach in future efforts, including discussion on governance feasibility of options, to continue what could only be

discussed qualitatively in this Study. Including discussions with Mexico and tribes and communities will be critical to the success of such an approach. At the time of the peer reviews, the *Study Report* was not yet complete or available to reviewers.

Additional comments were received that were related to other areas. First, reviewers found it problematic that results were presented in probabilistic terms, when the analysis should focus on frequency. Second, reviewers found it problematic that the analysis combined scenarios and then evaluated results that use the median as a central tendency. The reviewers thought that the use of combined scenarios for simple screening was acceptable, but not for evaluations of median behavior. Last, reviewers believed there were unanswered questions in the report, such as who would pay for the options to reduce vulnerability. To address reviewers' comments and to improve the clarity of the discussion, results from the System Reliability Analysis were modified to ensure that they were presented from the point of view of a frequency analysis. References to probability were removed where inappropriately applied. Within the discussion of System Reliability Analysis without options and strategies, the combined analysis was removed and only the 48 individual scenario combinations for supply, demand, and post-2026 Lake Powell and Lake Mead operation assumptions were presented. Clarifying language was added through the report to ensure that readers understand that the results do not describe probabilistic outcomes. Instead, they describe plausible ranges and distributions for the Baseline or a portfolio corresponding to a wide range of plausible hydrologic, demand, and management traces. The underlying traces are the same across all portfolios and therefore enable a consistent comparison of outcome differences across the portfolios.

In addition, system reliability results were presented as summaries by water supply scenario and vulnerable conditions to allow for a broader understanding of the conditions that lead to good or poor performance. Technical Report G was substantially improved based on the peer review comments and subsequent revision and analysis.

3.0 Conclusions

The peer review process was found to be a useful exercise and provided good, independent review that resulted in improvements to the technical reports included in the Study. The documents were generally well-received; the only major change was the restructuring of Technical Report G. The peer review process may have been improved by incorporating a staged review process which would engage reviewers earlier in the development of technical approaches and methods.

In general, the peer review comments indicated that the assessments had been performed adequately and the analyses met the intent of the Study. Many comments dealt with the clarity of the discussion. To address issues of clarity, discussion was added to the reports and description was added to figures and tables as necessary. Study limitations (both in terms of scope and length) prevented the more in-depth supplemental analyses that were suggested by the reviewers. Several suggestions for additional analysis are incorporated in the next steps described in the *Study Report*.