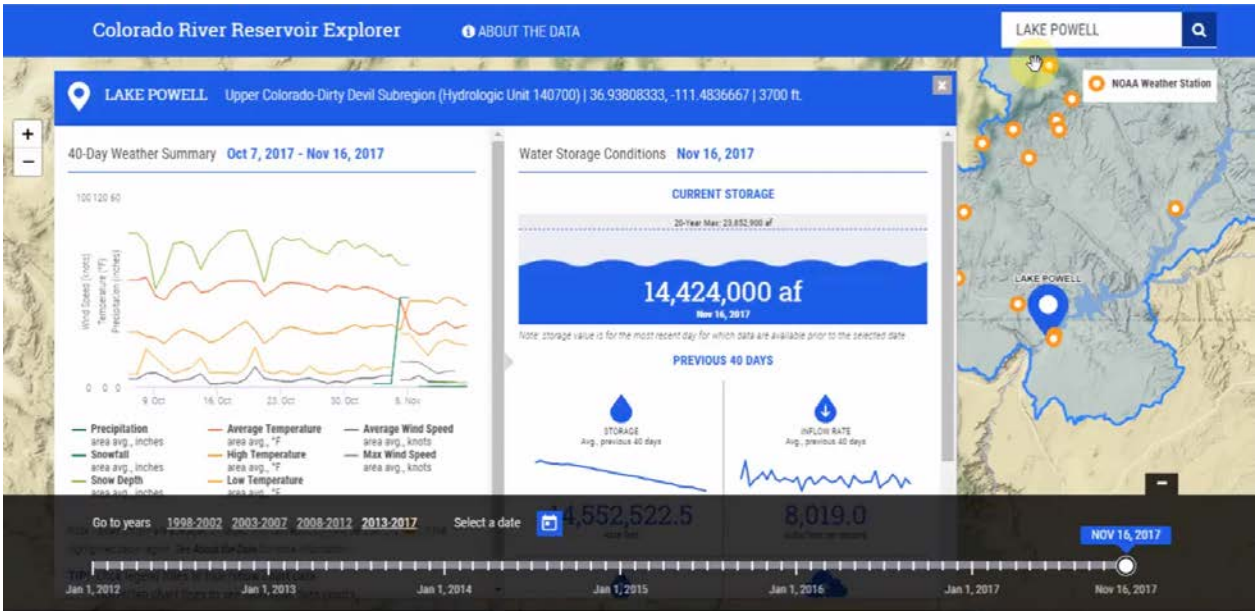
RECLAMATION

Managing Water in the West

Developing a Sustainable Framework to Support Open Data for Reclamation's Colorado River Basin Decision Support Systems

Research and Development Office
Science and Technology Program
Final Report ST-2015-5541-01



U.S. Department of the Interior
Bureau of Reclamation
Research and Development Office

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Mission Statements

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

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14. ABSTRACT *(Maximum 200 words)* The goal of the Colorado River Basin Open Data Tool Project was to explore and document a process to make water data used by Reclamation and its stakeholders available in open format through development of a web-based data visualization tool for the Colorado River Basin. The first task of the project was to develop a concept for the tool. The Preferred Alternative Tool Concept was a tool that would allow users to explore Colorado River Basin water operations, with a focus on past operations and on near-term future projections (0-2 years). Next a dataset catalog of 68 datasets was developed based on the datasets needed for the tool. Third, the project focused on publishing a subset of the datasets, including screening the datasets for security and privacy concerns, developing metadata to describe the datasets, and posting the datasets on the web in machine readable formats. The final task was to develop the visualization tool components. This was accomplished through a prize competition hosted through Reclamation's Water Prize Competition Center. The next steps are to design and develop the tool and continue to make datasets available in open formats.		
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Developing a Sustainable Framework to Support Open Data for Reclamation's Colorado River Basin Decision Support Systems

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Acronyms and Abbreviations

BCOO	Boulder Canyon Operations Office
CRB	Colorado River Basin
CRB Open Data Tool Project	The project funded as Project ID 5541 "Developing a Sustainable Framework to Support Open Data for Reclamation's Colorado River Basin Decision Support Systems"
CRSS	Colorado River Simulation System
FOIA	Freedom of Information Act
FY	Fiscal Year
HDB	Hydrologic Database
IP	Intellectual Property
IT	Information Technology
JSON	JavaScript Object Notation
LC	Lower Colorado
OWDI	Open Water Data Initiative
NTIS	National Technical Information Service
PI	Principal Investigator
Reclamation	Bureau of Reclamation
RISE	Reclamation Information Sharing Environment
RWIS	Reclamation Water Information System
S&T	Science and Technology Program
SME	Subject Matter Expert
UC	Upper Colorado
YAO	Yuma Area Office

Executive Summary

The goal of the Colorado River Basin Open Data Tool Project was to explore and document a process to make water data used by Reclamation and its stakeholders available in open format through development of a web-based data visualization and analysis tool that illustrates and/or supports decision-making in the Colorado River Basin. According to the Open Data Handbook, open data, or data published in an open format, is data that can be freely used, re-used and redistributed by anyone (Open Knowledge Foundation). Open data is similar to FAIR (Findable, Accessible, Interoperable, and Reusable) data (Wilkinson, et al., 2016).

The first task of the project was to develop a detailed description of the concept for the end-product tool. This tool concept could then be used to guide identification of candidate datasets for the tool, enabling prioritization of datasets that were specifically desired for use in the tool. The tool concept was developed through a brainstorming process that resulted in a Preferred Alternative Tool Concept that would allow users to explore Colorado River Basin water operations, with a focus on past operations and on near-term future projections (0-2 years).

Next a catalog of 68 datasets was developed based on the datasets needed for the tool. The datasets in the catalog were evaluated against two criteria: ease of making open and value for the tool, which were used to select datasets to make open as part of the project.

The next portion of the project focused on publishing a subset of the datasets identified in the catalog. This task included screening the datasets for security and privacy concerns, developing metadata to describe the datasets, and posting the datasets on the web in machine readable formats. The processes and methods for making datasets open will inform future efforts to make additional Reclamation datasets available in open formats.

Two methods were used for posting datasets in machine-readable formats: the Reclamation Water Information System (funded through a separate S&T project) and a website called CRB Automated Web Reports developed specifically for this project. To screen the datasets, the team developed and implemented a screening process consisting of a series of meetings and independent activities involving data stewards and security, privacy, and other subject matter experts. For metadata, the team defined the specific elements (fields) to be included in each type of metadata based on existing schemas, and populated metadata records for each dataset being made open.

The final task of the CRB Open Data Tool Project was to develop the visualization tool components. This was accomplished through a prize competition hosted through Reclamation's Water Prize Competition Center. The prize competition resulted in several innovative, interactive, user-driven visualization concepts that could potentially be used as the basis for a web-based data visualization tool or incorporated as elements of such a tool.

The next steps to follow this project are to design and develop the tool and continue to make datasets available in open formats.

Contents

Appendices

Tables

Figures

Introduction

Background and Purpose

The Colorado River Basin Open Data Tool Project was funded through the Bureau of Reclamation's Science and Technology (S&T) Program as Project ID 5541 "Developing a Sustainable Framework to Support Open Data for Reclamation's Colorado River Basin Decision Support Systems." The project goal was to explore and document a process to make water data used by Reclamation and its stakeholders available in open format through development of a web-based data visualization and analysis tool that illustrates and/or supports decision-making in the Colorado River Basin. According to the Open Data Handbook (Open Knowledge Foundation), "open data is data that can be freely used, re-used and redistributed by anyone - subject only, at most, to the requirement to attribute and sharealike." Open data, or data published in an open format, shares many similarities with FAIR (Findable, Accessible, Interoperable, and Reusable data[1] (Wilkinson, et al., 2016). Findability and accessibility are achieved with data that is included in a searchable online data catalog and documented with appropriate metadata. Machine-readability, or whether a dataset is semantically structured for computer processing, is a key aspect of interoperability. Reusability is achieved with metadata that includes its relevant attributes and describes the provenance of the data. Open data and data publication systems that support FAIR principles can provide a variety of benefits including enhancing transparency and accountability, encouraging civic engagement, enabling innovation, and supporting economic development and entrepreneurship.

Data is central to the Bureau of Reclamation's core mission responsibilities of delivering water and power in an economically and environmentally sound manner. Reclamation relies on many datasets to track river flows, reservoir operations, and power deliveries, which drive Reclamation's real-time operations and future planning. State, regional, and local partners use Reclamation's data to support operations, planning, and forecasting efforts, and the educational community and general public have broad and varied interests in Reclamation's data. While Reclamation shares some of its data via public websites, the data can be difficult to find or may not be published in open formats, and many other datasets are not published at all.

Executive Order 13642, "Making Open and Machine Readable Data the New Default for Government Information," directed federal agencies to implement OMB Memorandum M-13-13, the "Open Data Policy--Managing Government Data as an Asset." The Open Data Policy

> "…requires agencies to collect or create information in a way that supports downstream information processing and dissemination activities. This includes using machine-readable and open formats, data standards, and common core and extensible metadata for all new information creation and collection efforts. It also includes agencies ensuring information stewardship through the use of open licenses and review of information for

[1] In common practice, open data and FAIR data are often used interchangeably. However, a key difference between open data and FAIR data is that true open data is accessible by everyone, while FAIR data is accessible only to defined people (Ask Open Science; Luque).

> privacy, confidentiality, security, or other restrictions to release. Additionally, it involves agencies building or modernizing information systems in a way that maximizes interoperability and information accessibility, maintains internal and external data asset inventories, enhances information safeguards, and clarifies information management responsibilities."

The Open, Public, Electronic and Necessary (OPEN) Government Data Act, signed into law in January 2019, made key aspects of the Open Data Policy into law (Public Law No: 115-435, 2019).

This S&T project has evolved to focus on development of a web-based visualization and analysis tool for the Colorado River Basin that supports information sharing and illustrates and/or supports decision-making, with an emphasis on water and drought.

The CRB Open Data Tool Project is one of Reclamation's foundational open data efforts, providing an opportunity for Reclamation to explore the technical and organization aspects of open data. From 2013 through 2015, Reclamation participated in the Open Water Data Initiative (OWDI), a multi-agency effort to integrate water information into a connected, national water data framework (see Figure 1. Open Water Web) through a series of Use Cases (Advisory Committee on Water Information, 2014). Reclamation was a lead agency for the OWDI Drought Use Case, which developed a visualization of drought in the Colorado River Basin (https://www.doi.gov/water/owdi.cr.drought/en/index.html). To develop the visualization, the agencies and organizations partnering on the use case worked collaboratively to find relevant datasets, convert them to open formats, and integrate them into a publicly accessible visualization. Through the work to develop the use case, Reclamation staff recognized a number of areas that would need to be addressed to integrate open data publication into its business processes, including development of a data catalog and data portal for hosting open datasets, development of a screening process for evaluating security and privacy risks, and identifying metadata needs for Reclamation's open datasets. The CRB Open Data Tool Project was envisioned as a second phase of the OWDI Drought Use Case that would allow Reclamation to begin developing these processes and tools for publishing data in open formats.

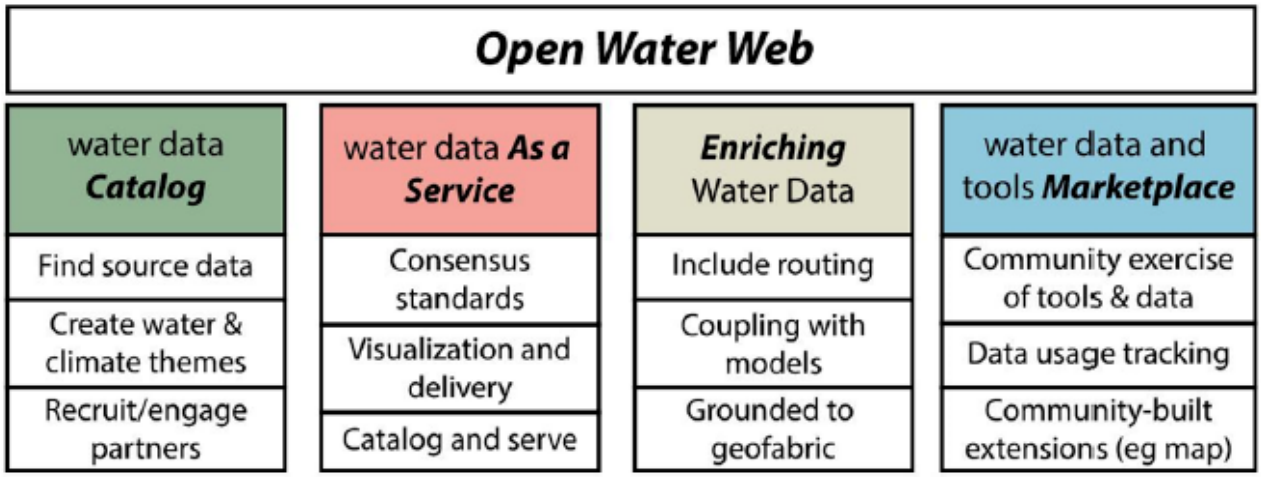

Figure 1. Open Water Web diagram (Advisory Committee on Water Information, 2014).

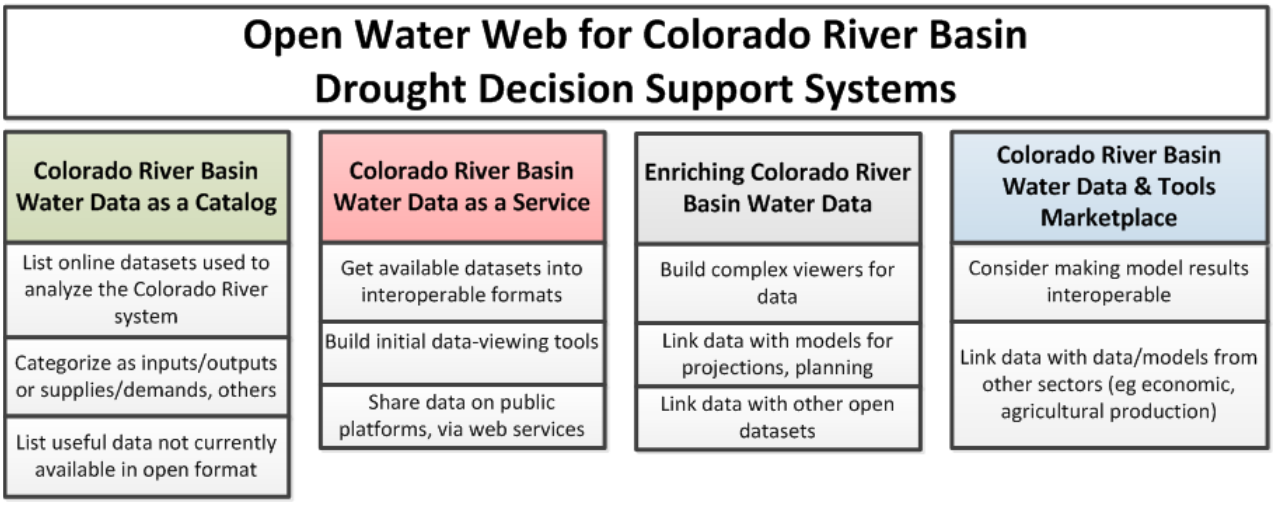

Figure 2. Open Water Web model applied to Colorado River Basin Decision Support Systems

Since the initiation of the CRB Open Data Tool project in 2015, Reclamation has also undertaken other open data efforts, including the development of the Reclamation Water Information System (RWIS), which launched in fall 2017, and the Reclamation Information Sharing Environment (RISE), which is anticipated to launch in November 2019. RWIS is a pilot system for publishing a subset of Reclamation's water-related time series datasets in open formats through a centralized portal. RISE will be a centralized portal for publishing all types of mission-related data.

Project Overview

The expected end-product of the CRB Open Data Tool project was a publicly available visualization tool focused on the Colorado River Basin. Through the development of this tool and the associated work of making the required datasets available in open formats, the goal of the project was to explore both the technical dimensions of open data, as well as attitudes related to open data and organizational dynamics associated with making data open and developing tools for using open data. Technical dimensions included deciding which datasets to make open, screening datasets for sensitivity prior to publishing them, determining appropriate data formats and methods of making data available, developing metadata, coding and developing software for the visualization and analysis tool, and performing analytics on use of the tool and its data. Consideration of attitudes examined how people prioritize desirable datasets and barriers to sharing data, such as hesitancy or resistance to making data openly available, lack of understanding of the benefits of open data, lack of awareness of methods for making data available, and concerns about data security. Examination of organizational dynamics considered factors such as meeting and communication structures and processes, facilitation effectiveness, and resource and time constraints.

Although the end-product visualization tool was not fully realized, over the course of the project, the project participants gained a deeper understanding of the work involved in open data, developed preliminary methodologies for publishing open datasets, obtained visualization concepts that could be further developed into a visualization tool, and gained greater understanding of social considerations involved in making data open.

Work on the project was divided into four tasks:

- Task 1: Development of Tool Concept (FY16)
- Task 2: Development of Data Catalog (FY 17-FY18)
- Task 3: Making Datasets Open (FY17-FY18)
- Task 4: Development of Tool Component (FY18)

Specific tasks in FY16 were to identify the tool concept and candidate datasets through a series of brainstorming sessions and review. Tasks in FY17 and FY18 included developing the data catalog to support the tool, developing a method for making datasets publicly available, performing dataset screening, developing metadata, and working with internal and external stakeholders to identify dataset priorities. Tasks in FY18 centered on hosting a prize competition to gather conceptual designs and software code for tool components. Work in FY19 consisted of reporting on the results of the project.

Project Team

Contributors to the project included two co-principal investigators (PIs, reduced to one PI after February 2017), a Data Steward Team that included technical staff from Reclamation's Upper Colorado (UC) Region Water Resources Group, Lower Colorado (LC) Region Boulder Canyon Operations Office, and LC Region's Yuma Area Office, a Steering Committee of managers from each group/office, a group of Screening Subject Matter Experts (SMEs) who participated in the screening process in Task 3, a prize competition Design Team and a prize competition Judging

Team. Others participated periodically in project activities. A list of team members and roles is included in Appendix A – Project Team.

Task 1: Development of Tool Concept

The first task of the project was to develop a detailed description of the concept for the end-product tool. This tool concept could then be used to guide identification of candidate datasets for the tool, enabling the team to prioritize making datasets available that were specifically desired for use in the tool. This prioritization was necessary due to the large number of datasets that Reclamation collects and maintains.

Development of the tool concept was based on a generic description of the tool, its intended audience, and its data scope: It would consist of a web interface bringing together multiple water- and drought-related datasets from multiple sources (internal and possibly external to Reclamation) with graphical information displays and interactive features. The tool's audience was intended to be both internal (within Reclamation) and/or external (Basin water management agencies, other Federal agencies, state and local agencies, and/or the general public). This tool could leverage existing open datasets, as well as datasets that would be made open as part of the project.

The tool concept was developed through a brainstorming session followed by a series of Steering Committee meetings to refine and select a "Preferred Alternative Tool Concept."

Brainstorming

The brainstorming exercise was held via an in-person meeting with a phone/webinar option for remote participation. Participants were first given a wide range of information related to open water data, the S&T project, tool examples, and drought as part of an "information gathering" step, and then they participated in a guided brainstorming session led by facilitators. After brainstorming, the participants gathered for a final discussion of the results of the brainstorming session.

Participants and Facilitators

Four facilitators (the two co-PIs and two others) led the participants in the brainstorming activities. Participants were drawn from the Upper Colorado and Lower Colorado Regional Offices, the Yuma Area Office, and the Denver Office and were invited based on their knowledge and experience with data and Colorado River Basin topics. Because a significant number of participants could not attend in person, the facilitators took extra care in structuring the meeting to encourage active participation by remote participants. Presenters used a webinar to share presentation screens, encouraged participants to bring and use laptops to help capture discussion points during the meeting, and encouraged phone-participants to have a voice in small-group breakout discussions.

To help capture information about open data attitudes and organizational dynamics of the brainstorming session, a notetaker/observer had the specific responsibility to "float" to multiple groups and observe and/or listen in on the activities to identify any cross-cutting trends in discussion and/or behaviors.

Pre-Brainstorming Information Gathering Presentation

During the pre-brainstorming presentation, the facilitators presented an overview of the S&T project and described specific information related to the development of tool concepts, including general examples of types of tools, the potential audience of the tool, example datasets that could be used, and "seed ideas" to get participants thinking. The amount of information provided was intentionally large, so that it could not all be quickly assimilated by the participants. The facilitators told participants that they should not be overwhelmed by the amount of information, but that they should pay attention to what was sparking their interest and use it to inspire tool ideas.

At the end of the presentation, the facilitators introduced guiding questions for the brainstorming session, to be explored via small breakout groups. Each guiding question had a title, main question, and a number of subsidiary questions. The guiding questions addressed the following topics related to the Colorado River Basin:

1. additional functionality or tools to improve understanding of CRB operations/water supply/water demand/drought;
2. visualization/analysis tool to improve communications with stakeholders;
3. scope of a tool to improve understanding of supply/demand issues in the CRB; and
4. scope of a tool to address questions related to drought in the CRB.

Brainstorming Session

For brainstorming, participants split into groups focused around one of the four guiding questions. Each group had a facilitator and a Google Doc to record ideas. The participants were given one hour to brainstorm tool concepts, and facilitators announced 15-minute intervals to help participants track their time. Participants were able to select which group to participate in. Although they were given the option to freely move between groups, all participants opted to stay in a single group for the entire hour. Facilitators started the initial discussion, kept the groups focused on their guiding questions, and recorded ideas that were proposed. All participants were encouraged to bring and use laptops to add information directly to meeting notes.

Discussion

After the 1-hour brainstorming session, the groups reconvened to discuss the ideas that had been proposed. Each facilitator described the ideas that their group had proposed, with input from the group members. The participants shared thoughts about the tool ideas and suggested additions or changes to the ideas.

Brainstorming Results: Tool Concepts

The brainstorming groups identified 29 tool ideas during the brainstorming session. After the meeting, the PIs reviewed the ideas and synthesized them into a set of nine tool concepts. The

initial and synthesized tool concepts are summarized in Table 1 and shown in Appendix B – Tool Concepts.

Table 1. Synthesized Tool Concepts

	Name	Description
A	Exploration of Colorado River Operational Modeling and Decision-Making	This tool would allow users to explore how Reclamation uses models to make decisions regarding Colorado River Basin operations at various time scales. It would include background on the available modeling tools, as well as provide access to observed operations and model results.
B	Near-Term Colorado River Conditions Viewer	This tool would allow users to view and explore current and short-term forecasted conditions for Colorado River Basin rivers and reservoirs
C	Learning About the Colorado River Basin	This tool would allow users to learn about Colorado River Basin geography, hydrology, policy and water operations.
D	Colorado River Basin Dictionary/Glossary	This tool would help users understand terminology related to the Colorado River Basin such as “natural flow”, “observed flow”, “consumptive use”, “shortage”, “forecast”, “projection”, and “paleo reconstructed streamflow”.
E	Colorado River Basin Interactive Reports	This tool would allow users to interactively explore official Reclamation operational projections, reports, and operational information.
F	Colorado River Basin Drought Impacts Explorer	This tool would allow users to explore the impacts of drought on the Colorado River Basin
G	Colorado River Basin Water Quality Tool	This tool would allow users to explore water quality in the Colorado River Basin
H	Colorado River Basin Water Demand and Use Explorer	This tool would allow users to explore water demand and use in the Colorado River Basin. It would allow users to look at where and how water is used, historical water use, current water use, and projected future demands. It would allow users to explore Reclamation’s water accounting calculations and retrieve data, and explore the differences in how Reclamation and USGS report water use.
I	Colorado River Basin Water Supply and Demand Planning Explorer	This tool would allow users to explore long-term supply and demand projections for the Colorado River Basin and test options for balancing supply and demand in the future.

Preferred Alternative Development

Review of Synthesized Concepts and Development of Preferred Alternative

Following the development of the synthesized tool concepts, the Steering Committee convened to discuss the concepts and develop a Preferred Alternative Tool Concept using a matrix of nine criteria for consideration:

- Value for internal use - applicability to current mission-related activities
- Value for external use - education, communication with stakeholders
- Value for advancing open data goals
- Data availability (is data available, ready to use)
- Resource considerations (budget, staff time and skillsets)
- Security/data sensitivity considerations
- Desired audience(s)
- Priorities for making datasets open
- Alignment with other open water data activities/efforts

Comments and questions on the synthesized concepts highlighted the overlapping themes and components of the concepts. The Steering Committee had difficulty discerning the differences between Concepts A, B, C, and E. The Steering Committee saw the value in communicating information about drought and water quality (Concepts F and G), but expressed concern that Reclamation does not control the data, and that developing a tool in one of those focus areas would require extensive external coordination. For the drought tool, the Steering Committee also wondered if the information was outside of Reclamation's mission. The Steering Committee saw the value in a dictionary/glossary, and recommended that it be included in the tool, but recognized that it would not work as a standalone tool. They suggested that it could be made into a useful mobile app. For Concept H (Colorado River Basin Water Demand and Use Explorer) the Steering Committee warned that it would be very difficult to obtain demand data from water users. For the Water Supply and Demand Planning Explorer (Concept I) the Steering Committee thought that the Colorado River Basin Study data would be out of date by the time the tool would be published, and that there are no concrete plans to update the results in light of updated data. They also thought that it would likely take longer to release any long-term projections because of the explanation of results that would be required to go along with the data. The data is in the process of being released, but the timeline would not align with the timeline of the CRB Tool.

The Steering Committee recommended that the tool be focused on near-term data (historical and 0-2 year projections) and that it incorporate aspects of synthesized concepts A, B, C, D, E, and H. The Steering Committee felt that the preferred alternative should be kept broad, so that it would represent a vision of what such a tool could eventually look like, rather than a specific design.

Review and Refinement of Preferred Alternative

Based on the Steering Committee's input, the PIs drafted the Preferred Alternative Tool Concept. The Preferred Alternative Tool Concept consisted of a tool that would allow users to explore Colorado River Basin water operations, with a focus on past operations and on near-term future projections (0-2 years). It would provide:

- Basic background information about the Colorado River Basin, including facilities and Law of the River.
- Access to the observed and modeled data that Reclamation uses to make operational decisions via maps and data download tools.
- Information in graphical formats and interactive reports that can be used by management or provided to stakeholders in place of paper reports, emails, or PDF documents.

The final Preferred Alternative Tool Concept is shown in Appendix B – Tool Concepts.

Next the PIs met again with the Steering Committee to discuss whether it adequately captured the purpose, features, data, audience, and other aspects of the desired tool, and to prioritize components of the tool into three categories:

- Critical Components: The tool would not succeed without these components
- High Value Components: Components that would significantly enhance the usability and/or value of the tool
- Other components

The components identified as "Critical" were considered to be mandatory due to the need to have basic ways to view and download data, as well as a need for basic explanatory text/information. Components prioritized as "High Value" fell into that category because they would present information in a useful way or provide further understanding of the system to users. Components prioritized as "Other" did not fall into either of the first two categories, but were considered to be useful to retain in the concepts. Additional components were also added to the concepts during the meeting.

The discussion during the tool component prioritization meeting led to a number of valuable thoughts and questions from the Steering Committee members, including the following points.

- Steering Committee members noted that it was challenging to prioritize without a clear idea of who the highest priority audience is. A public audience was suggested as possibly the highest priority due to the need to make data open and publicly available.
- The PIs noted that the audience has not been dictated by Reclamation leadership or an executive sponsor, and that open data does not have to mean that the datasets made open must be understandable by everyone; it is okay for datasets to be focused toward specialists.
- Steering Committee members had questions about what the tool components would look like (what features they will have). At this point of the project, the exact features were unknown, since they would be developed through project activities. One Steering Committee member also wondered whether the tool needs to be completely new, or whether it can build upon existing tools.
- The Steering Committee questioned which datasets will be included in the tool and wondered if the datasets themselves should be listed in the prioritization columns. The PIs noted that each of the components will encompass multiple datasets, and that the datasets would be identified in the next phase of the project.

Task 1 Discussion and Conclusions

Technical

Each of the synthesized tool concepts has a unique focus, but there were many commonalities among the proposed tool ideas. Many of the ideas rely on the same types of data. For example, river and reservoir data was mentioned for nearly all of the ideas, and would be used in almost all of the concepts. In addition, all the concepts would employ visual communication through maps or graphical displays. A few participants specifically mentioned the software package Tableau as a way to produce the graphical data displays. A number of participants described the tool ideas as "dashboards." This language is most likely related to one of the seed ideas, which was a "Colorado River Basin Dashboard."

During brainstorming, there was also discussion as to how the tool should function. Participants expressed a desire for the tool to be extensible, so that features could be added or modified without impacting the whole tool. Participants also suggested that using readily available software packages and tools would be desirable over use of custom-developed software. Participants thought that using open-source or commercial software that is already available would reduce software maintenance requirements and facilitate the ability of multiple staff members to update and manage the tool, rather than a single developer of a custom software tool. They hoped this would eliminate situations in which the developer of a custom software tool leaves Reclamation and the software becomes no longer usable.

Participants expressed interest in using the same types of graphical displays for multiple types of data to create visual identity and unity. Participants also stated that the tool should be responsive to user needs. They thought it should allow users to enter and access the tool from multiple pathways or points of view, and should cater the information displayed to the users' needs. This type of flexibility was mentioned, in particular, for tool concepts related to modeling and decision-making. There are multiple decision timescales that users might be interested in, and different users are likely to have different needs for the amount and type of information that is available.

Of the prioritization metrics, Steering Committee members appeared to rely more heavily on the relation to Reclamation's mission and data availability than on other metrics. The tool concepts that the Steering Committee expressed the most interest in were tools related to operational decision-making, while tools related to drought and water quality were of less interest. Water operations are key to Reclamation's work, while drought and water quality, although important, were seen as potentially outside of Reclamation's direct mission responsibility. The Steering Committee felt that there was already a lot of information available to a public, non-technical audience, so duplicating that would have less value than some of the other components that were not currently available.

Data availability considerations resulted in Steering Committee members viewing short- to medium-term projections (e.g. the 24-month study model) as more promising than long-term projections (CRSS model). Although both sets of projections are currently in the process of being released, the short-term projections were seen as potentially easier to release. The Steering Committee noted that the long-term projections would require significant explanation and interpretation because of the assumptions that must be made for long-term planning. In addition,

the 24-month study projections are already published in a non-open format on a monthly basis, while the long-term projections that have been published are part of the Colorado River Basin Study, which is becoming out-of-date as new climate change projections are developed.

Attitudes Towards Open Data

A goal of this S&T project is to explore barriers and supports to making data open and creating tools for displaying and using open data. Because the objective of Task 1 was to brainstorm a visualization tool concept, the meeting did not explicitly focus on barriers, and participants were asked to refrain from discussing challenges related to open data.

Participants were generally supportive of open data, interested in the S&T project, and engaged in the brainstorming process. Questions asked during the presentations focused on clarifying the information presented rather than questioning the project or process. Participants appeared to be excited by the possibility of creating a tool to display and share data in a useful way.

The Steering Committee members generally expressed support for making datasets open. The tone of discussions was positive and showed excitement for greater data availability. For example, one Steering Committee member saw an open data tool as valuable for succession planning, noting that it could be useful for helping new employees become familiar with the Colorado River Basin, and would increase their awareness that the data that is available.

Steering Committee members also agreed that moving to open data is a paradigm shift in how Reclamation presents and shares data, and that building this tool and making datasets open could fundamentally change how Reclamation provides data. This was not a negative observation, but it highlighted the fact that planning would be necessary for the sustainability of the tool and the data. Some of the considerations for sustainability that were mentioned were staff skills and time for maintaining the system.

Organizational Dynamics

The makeup of the Steering Committee likely has an influence on the tool concept selected and the attitudes related to open data. The Steering Committee is made up of Reclamation staff members whose work focuses on Colorado River water operations and modeling, with little representation by higher-level decision-makers or others whose concerns may be more policy-related.

The Steering Committee members were very familiar with the data required to perform these functions, and less familiar with other data types, such as data related to drought or water quality. As operations staff who use data to perform their work, the Steering Committee members were also more likely to understand the value of data and to recognize how providing access to data could have a positive impact on Reclamation. These factors contribute to the generally positive attitudes toward the project and open data.

Lessons Learned

1. Brainstorming session leaders can influence participant thinking with word choice: Many participants described various types of “dashboards” after hearing the suggestion as part of the seed ideas.

2. The role and job description of meeting participants within the organization can lead to development of dominant idea themes. For example, if a participant focuses on system operations modeling in their daily work assignments, the ideas that they propose may be more focused on operations and modeling rather than on other topics such as policy, drought, or water quality. Therefore, it is important to have representatives with a range of roles and job descriptions to promote development of a wide range of ideas.
3. Remote participation of participants can be enhanced by small groups and collaborative tools such as Google docs, etc., and should be supplemented by intentional facilitation tactics from session leaders.
4. Uncertainty in what the tool will be like was necessary to allow the Steering Committee to conceptualize the tool, but was uncomfortable for some Steering Committee members.
5. Involving the Steering Committee in developing the tool concept and prioritizing tool components resulted in strong support for the project, but also took considerably more time than anticipated due to scheduling difficulties resulting from their demanding roles.

Task 2: Development of Data Catalog

With the preferred alternative developed, the focus shifted from the end-product visualization and analysis tool to the datasets needed to create the tool. The Data Steward Team held a series of work sessions to develop and refine a dataset catalog, including descriptive information about the datasets. The team evaluated the datasets against two criteria: ease of making open and value for the tool. The Steering Committee then used the evaluations to determine which datasets to make open as part of the project.

Data Catalog Development

Catalog development began with the construction of an initial list of datasets to be used in the tool. After reviewing the features of the Preferred Alternative Tool Concept, the Data Steward Team brainstormed a list of the datasets that would be needed to build the components of the tool. This was done collaboratively using a Google Sheet. After the group identified the list of initial datasets to include in the catalog, the Team began documenting each dataset with a variety of descriptive information organized in columns in the catalog spreadsheet. During this process, the group also refined the list of datasets by adding additional datasets, combining separate entries into a single dataset, or breaking datasets into component datasets that could be made open. The goal was that each row of the catalog should have a dataset that could be made open as a unit (in the same format, by the same process, available in the same location online, described by the same metadata, screened together). The result was a catalog of 69 datasets.

Next the group began prioritizing catalog datasets that would be made open. Due to limited staff time and uncertainty about the amount of work involved in making datasets open, the Data Steward Team and Steering Committee focused on a smaller number of datasets than was contained in the full catalog. The Data Steward Team used two criteria to prioritize the datasets: value for the tool (critical, high, low) and ease of making open (easy, hard). The criteria "ease of making open" included the concept of data quality and completeness. Six datasets were classified as critical to the tool's success, and 15 were classified as highly valuable.

The Data Steward Team then determined which datasets they believed should be made open and when this could occur. The team categorized the datasets as “Round 1,” “Round 2,” “Future,” “N/A” (already released), or “Do Not Release.” For external datasets in the catalog, the release timing represented when the Data Steward Team would coordinate with the external partners to encourage them to provide the datasets in open format.

To aid in the decisions regarding release timing, the Preferred Alternative Tool Concept was used as a reference to ensure that the critical components of the tool could be developed with the datasets identified for making open. This led to refinement of the dataset list, including clarifying the necessary weather data and YAO groundwater data to include. After the refinement, the dataset catalog contained 68 datasets (Appendix C – Dataset Catalog).

The recommendations of the Data Steward Team for datasets to make open in Round 1 were reviewed with the Steering Committee and then finalized.

Task 2 Discussion and Conclusions

Technical

The process of developing the dataset catalog took a significant amount of time, spanning three meetings over approximately three months and requiring work by Data Steward Team members between meetings. Team members easily identified many useful datasets for the tools, but found the process of appropriately dividing and describing them more challenging. It was not clear to many of the Data Steward Team members how detailed and granular the dataset catalog should be. The PIs provided some guidance by telling them that each row in the catalog represents a dataset that could be made open as a unit (in the same format, by the same process, available in the same location online, described by the same metadata, screened together), but it still took a number of iterations to obtain the final list.

Throughout the process of developing the catalog, it was important for the Data Steward Team to continue to refer to the Preferred Alternative Tool Concept in order to verify that the components of the tool concept could be built with the datasets included in the catalog. The team used the Preferred Alternative as guidance when adding datasets to the list in the initial catalog and as reference when refining the list into datasets with the potential to make open.

Attitudes Towards Open Data

Although the Steering Committee and Data Steward Team continued to strongly support release of data, the resources and staff time involved in making datasets open were a concern. When deciding how many datasets to make open in Round 1, the Steering Committee had to consider whether staff was available to work on the tasks associated with making the data open. For the Yuma Area Office, it was decided that only one dataset would be made open in the remainder of 2016 due to limited staff availability and uncertainty about the effort required.

Sensitivity of data, in particular political sensitivity of data, emerged as a possible concern during the selection process. One Steering Committee member raised the question of whether politically sensitive datasets such as YAO’s salinity data should be released, and whether sensitivity should be a criterion for the decision of which datasets to make open. It was suggested that Freedom of Information Act (FOIA) criteria could help clarify this issue: If a dataset could

be released through FOIA, would there be any reason not to release it as part of the project? After discussion, the group agreed that dataset sensitivity should not be considered as a criterion for selecting datasets to make open in Round 1. Those concerns would be addressed during the dataset screening process, which would include consideration of FOIA.

In response to the concerns about FOIA, the PIs met with YAO management to gather input on potential political concerns related to the data. No potential political concerns were identified, and the briefing indicated continued management support for the project and for open data. One item mentioned was that some consideration should be given to how the system would be sustained long-term after the conclusion of the S&T project; one idea proposed was for involved groups to put line items in the 2019 budget requests for maintaining and further developing the tool and the open datasets.

Organizational Dynamics

Work sessions were well attended by the Data Steward Team, and the team indicated that the sessions were helpful for making progress on project tasks.

Participation via phone and webinar continued to be valuable. Team members in UC and YAO were able to take part in meetings without travel, and team members in LC also occasionally used the remote options to participate from alternate locations when they had other commitments. This allowed the project to progress and for a larger number of people to be included in the process.

Collaborative tools were very valuable for building the data catalog. The Google Sheet could be accessed and edited by anyone on the Data Steward Team at any time. During the meeting, team members were editing rows in real-time in small groups, and after the meeting they were able to continue to work without having to worry about file sharing and version control issues.

Lessons Learned

1. Identifying datasets is an iterative process. It first involves identifying the types of information needed and the data that meets those needs. For example, the tool to be developed will show information about water use, so water accounting data will be needed. Next, the data list must be refined to catalog the datasets at an appropriate level of detail, so discussion about what constitutes a dataset is likely. Some data may be identified initially in broad categories or groupings (e.g. water accounting data), and other data may be identified in very granular ways (e.g. diversions and return flows). The group needs to come to a joint agreement on the granularity of datasets.
2. Each dataset catalog listing should be analyzed to determine whether it should be grouped with another listing or disaggregated to identify datasets that can be made open as units. Criteria for determining whether a dataset can be made open as a unit are that the data is produced in the same format, published by the same process, will be available in the same online catalog, can be described by the same metadata, and can screened together.
3. Group work sessions are a useful method for engaging participants and encouraging work on the project. Participants expressed support for the opportunity to gather in a semi-structured environment to work on a particular task related to the project. Tasks started in the work sessions could be continued after the meeting.

4. Collaborative tools are valuable for engaging participants both during and between group meetings. The Data Steward Team used Google Sheets to develop the data catalog, which facilitated collaboration during the work sessions, as well as when individual team members had time available to work on the project between meetings.
5. The quality of datasets relates to the effort involved in making them open; dataset managers were hesitant to commit to working on specific datasets that would entail significant effort to ensure quality prior to making them open.
6. Concerns about data sensitivity may not need to be considered in dataset prioritization, because those concerns are able to be addressed through the data screening process (see Task 3).
7. Offices should consider including budget request line items for making datasets open, developing visualization tools, and maintaining existing datasets and tools.

Task 3: Making Datasets Open

The next portion of the project focused on publishing the datasets identified to make open in "Round 1," including posting the datasets on the web in machine-readable formats, screening the datasets for security and privacy concerns, and developing metadata to describe the datasets. Later in the project, the Data Steward Team began work towards making the "Round 2" datasets open, but staff availability limited the team's progress and the work was put on hold or pursued separately by individual work groups rather than as a project team. Although all catalog datasets were not able to be released as part of the project, the Project Team developed and tested processes and methods for making datasets open, which will inform future efforts to make additional Reclamation datasets available in open formats.

Web Accessibility

A key aspect of open data is that datasets are available on the web in machine-readable formats. At the time that the CRB Open Data Tool Project started, many Reclamation datasets were not published, others were published in non-machine readable formats, and Reclamation had no centralized way to publish datasets. A number of Reclamation offices host websites publishing various datasets, but the websites do not necessarily use similar formats and users are required to navigate to each website rather than access data from a central portal. In early 2016, Reclamation began development of the Reclamation Water Information System (RWIS), the pilot version of Reclamation's open data portal. The goal of RWIS was to make a selection of water-related daily time series data available to public users through a central portal. Focusing on a limited set of water-related time-series data, RWIS demonstrated the ability to create a unifying data standard that allows data to be harvested from regional sources, copied to a central database, and made available to the public. RWIS launched in April 2017 with a selection of water data from each of the five Reclamation regions, providing it in human and machine-readable formats via a map interface, data query, and web services.

The datasets in RWIS included some of the datasets identified for inclusion in the CRB Open Data Tool, but other CRB Open Data Tool datasets were not able to be hosted in the RWIS

system, including modeled data and data at timesteps other than daily. Therefore, the Project Team also built the CRB Automated Web Reports website to post additional open format datasets for the project, and serve as an interim solution until Reclamation completes development of its full-featured consolidated web portal (RISE). Web Reports is a custom-built program that connects to the source hydrologic databases (HDB) within the LC, UC, and YAO offices, and generates output files based on configuration files and user inputs.

Web Reports can be found at https://www.usbr.gov/lc/region/g4000/riverops/webreports/. The site has two main menus: "Select a Data Set" and "Select a Record Set." The "Select a Data Set" menu allows users to select one of the eight datasets using a drop-down menu. Once a dataset is selected, the user can select one of the many data records available under each dataset using the "Select a Record Set" menu. The interface allows the user to view and download the web reports in text or JavaScript Object Notation (JSON) format.

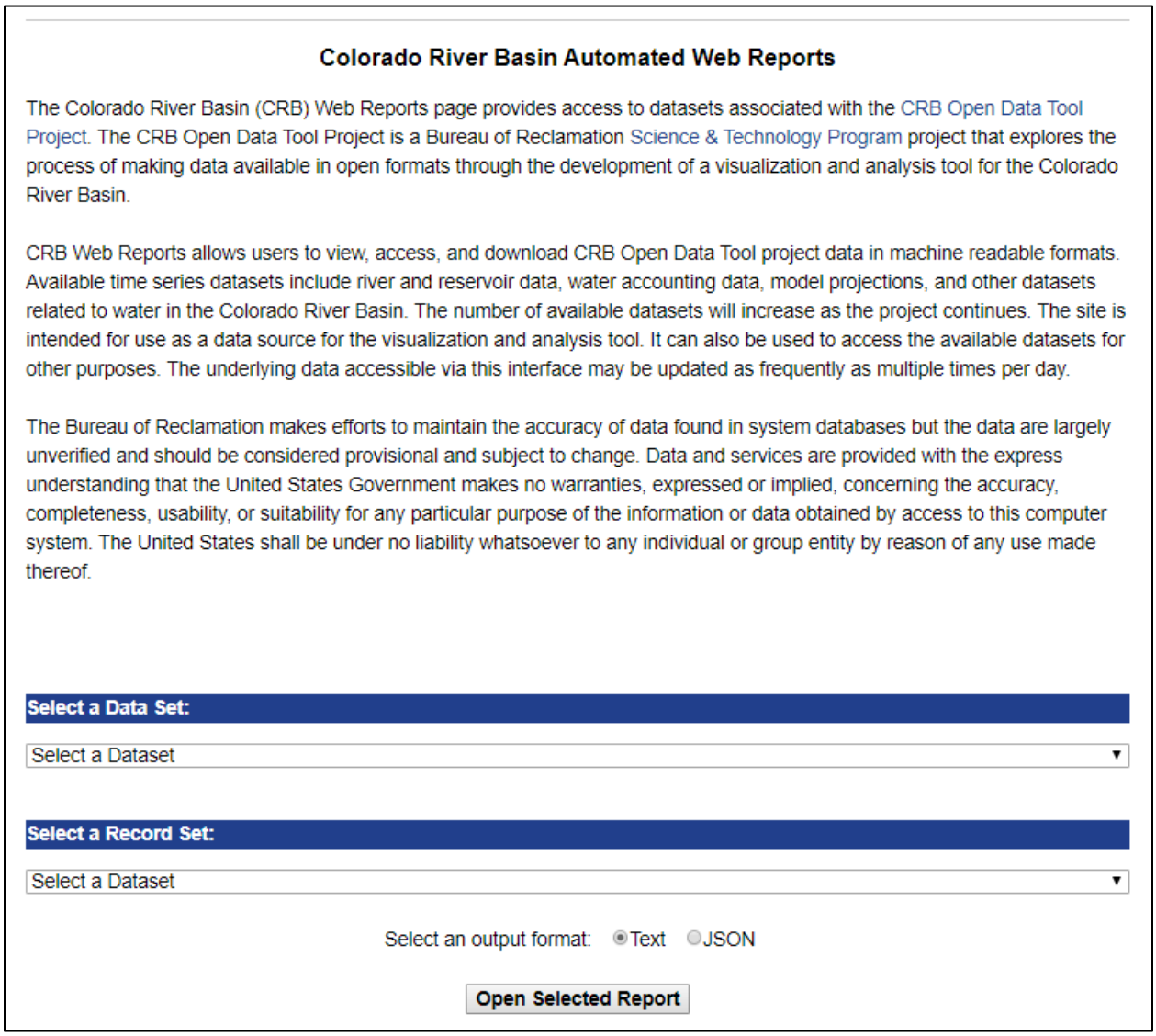

Figure 3. Screenshot of the CRB Web Reports website.

Screening Process

A second key aspect of open data is that the data has been reviewed for privacy, confidentiality and security issues prior to release. Federal policy and regulations require that datasets be reviewed prior to being made open to ensure they are shared in ways that appropriately protect Federal assets and information. OMB M-13-13, the Open Data Policy, states that, as part of efforts to create and manage data for broader use, agencies should ensure "…information stewardship through the use of open licenses and review of information for privacy, confidentiality, security, or other restrictions to release." In addition, OMB M-13-13 requires the implementation of a screening process, stating, "A key component of agencies' management of information resources involves working closely with the agency's Senior Agency Official for Privacy and other relevant officials to ensure that each stage of the planning process includes a full analysis of privacy, confidentiality, and security issues." Screening also provides a structured and objective way to address the concerns of data stewards regarding data sensitivity.

At the time of the CRB Open Data Tool Project, Reclamation had no established process for screening datasets for release in open formats. Therefore, a key portion of the Project was to develop a process that could fulfill this requirement and implement it with the group of datasets targeted to be made open in Round 1. The process was based on a pilot process tested by the Lower Colorado Region (LC) in 2014. It consisted of a series of screening meetings and independent activities involving the Data Steward Team and security, privacy, and other subject matter experts (SMEs) (Table 2). Through these meetings and activities, the participants were provided with information about open data, the Project, the datasets to be screened, and the criteria to be considered during screening. The screening criteria focused on data quality, FOIA exemptions to sharing data, privacy concerns, legal and proprietary restrictions to releasing data, Information Technology (IT) security, physical security, and potential creation of a mosaic of information that could increase vulnerability to privacy, security, or other risks (Figure 4). Other questions related to organizational sensitivities to releasing data, such as potential intentional or unintentional misuse of data and political sensitivity of data were also discussed to put the potential implications of release into broader context

Data Stewards and Screening SMEs were then guided through evaluation and discussion of the datasets against the screening criteria. They used the information gained through the discussions to inform their recommendations on whether to release the candidate datasets. Recommendations for releasing the datasets are listed in Table 3.

Table 2. Screening Process Schedule

Scheduled Days	Task
Day 1-14	Security SMEs review security and Open Data references
Day 14	Meeting 1: Security SME Open Data and Screening Orientation
Day 15-19	Security and Water Data SMEs Review Datasets and Screening references
Day 20	Meeting 2: Review Screening Process, Datasets; orientation on providing feedback on datasets
Day 21-26	Security and Water Data SMEs review datasets and provide feedback
Day 26	Meeting 3: Deeper dive into the datasets and initial feedback review

Scheduled Days	Task
Day 27-33	Security and Water Data SMEs review datasets and provide feedback
Day 34	Meeting 4: Review feedback on datasets and discuss recommendations for release
Day 35-45	CRB Tools Planning Team prepare recommendation memo and circulate to SMEs for review, feedback, approval

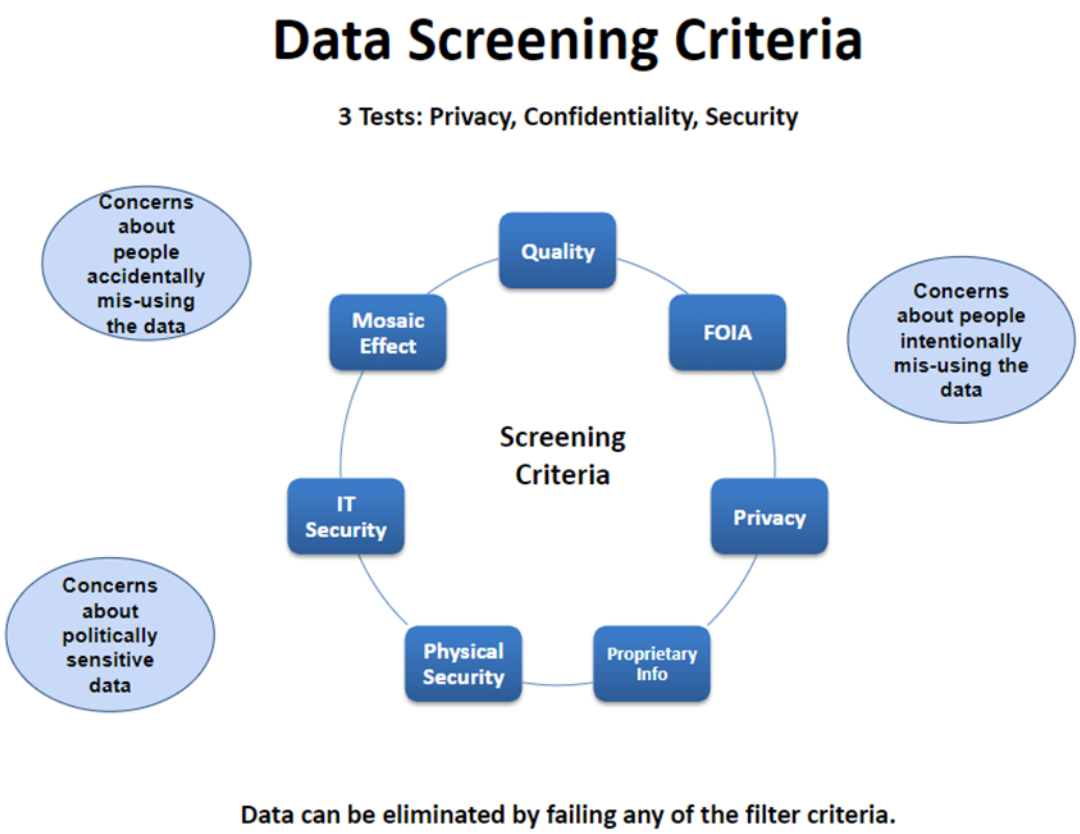

Figure 4. Data Screening Criteria Diagram

Table 3. Datasets screened during the screening process.

Dataset	Organizational Group	Mitigation Actions	Final Recommendation of Screeners
Reclamation Diversion & Return Flow Gages	LC-4800	Note that data is provisional	Release with Mitigation
LC River Gages	LC-4800	Note that data is provisional	Release with Mitigation
LC Reservoir Gages	LC-4800	Note that data is provisional	Release with Mitigation

Dataset	Organizational Group	Mitigation Actions	Final Recommendation of Screeners
UC River Gages operated by UC) (provisional, real-time)	UC-430	Note that data is provisional	Release with Mitigation
UC Reservoir Gages	UC-430	Note that data is provisional	Release with Mitigation
Reclamation Model Projections from 24-Month Study	UC-430 / LC-4600	Provide a disclaimer regarding uncertainty of projections Provide an explanation of the 24-month study model and its uses	Release with Mitigation
Reclamation Calculated Inflow from Major Reservoirs - Regulated and Unregulated Inflow	UC-430 / LC-4600	Note that data is provisional Note that the data is calculated (Provide metadata or links explaining how the calculation is done)	Release with Mitigation
Reclamation Evaporation Datasets estimated on Monthly Timestep	UC-430 / LC-4600	Note that data is provisional Note that the data is calculated (Provide metadata or links explaining how the calculation is done)	Release with Mitigation
Boulder Canyon Operations Office (BCOO) Daily Model Data for Davis & Parker Release and Elevation Projections	LC-4600	Provide disclaimer regarding uncertainty of projections	Release with Mitigation
BCOO Hourly Model Data for Davis & Parker Release and Energy Projections	LC-4600	Provide disclaimer regarding uncertainty of projections Only release 2-3 days of projections at a time	Release with Mitigation
YAO River Gages (Martinez Lake, Picacho)	YAO	Note that data is provisional	Release with Mitigation
Forecasted Water Use LC	LC-4200	N/A	Do Not Release
Decree Accounting Diversion Return Consumptive Use Data	LC-4200	N/A	Release
Decree Intentionally Created Surplus	LC-4200	N/A	Release

Metadata

A third key component of open data is that it is documented with metadata. Metadata is structured information that describes, explains, locates, and otherwise makes it easier to retrieve and use an information resource. It is data about the content, quality, condition, and other characteristics of data (Federal Geographic Data Committee, 1998). Metadata provides data users with information about the dataset, which facilitates appropriate data use and

reproducibility of the data. Metadata can be divided into a variety of types, such as descriptive, structural, administrative, technical, use, and preservation (Riley, 2017; Higgins, 2007).

- Descriptive Metadata: Metadata that describes a dataset for purposes of discovery and identification, such as creator, title, and subject. Enables identification, location and retrieval of information resources by users.
- Structural Metadata: Metadata that indicates how data is structured. Provided to support use of the data.
- Administrative Metadata: Metadata related to the use, management, and encoding processes of datasets. Includes the subsets of technical metadata, rights management metadata, and preservation metadata. Used to manage administrative aspects of the dataset, such as intellectual property rights and acquisition. Also documents information concerning the creation, alteration and version control of the metadata itself. This is sometimes known as meta-metadata.
- Technical Metadata: Metadata that describes the technical processes used to produce, or required to use a dataset.
- Use Metadata: Metadata that manages user access, user tracking and multi-versioning information.
- Preservation Metadata: Metadata that documents actions which have been undertaken to preserve a dataset, such as migrations and checksum calculations.

Because metadata can be defined and used in a variety of ways, the Data Steward Team began the development of metadata with a meeting to discuss the various definitions and types of metadata and build a foundational agreement on the definitions that would be used for the project. For the purposes of the CRB Open Data Tool, the team defined a data hierarchy with four levels (Figure 5):

- Data Element – a single data "point"
- Data Record (Series) – a grouping of data elements
- Dataset – a grouping of records.
- Dataset collection/data asset/ data catalog – a grouping of data sets.

The dataset and dataset collection hierarchy levels were discussed as being useful for organizing data for a specific project or research effort, or for sharing data as a unit (e.g. for the CRB Open Data Tool Project). These groupings may not be broadly applicable beyond their specific intended use. They were defined in intentionally imprecise terms to allow flexibility in using them.

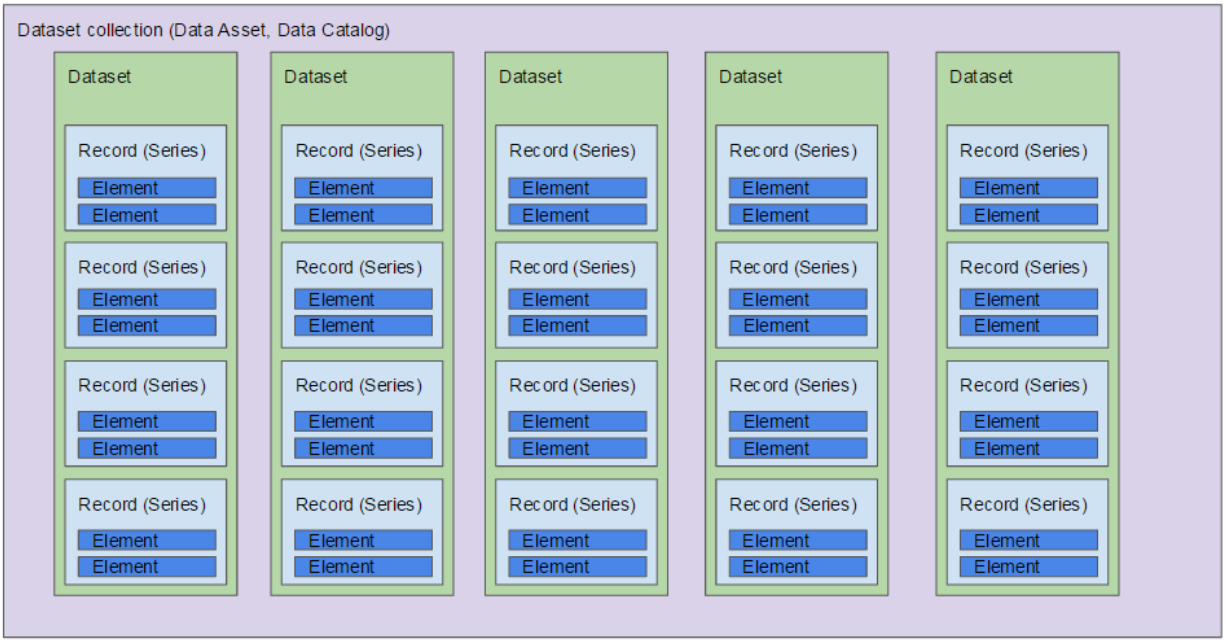

Figure 5. Data hierarchy for CRB Open Data Tool project.

The Data Steward Team also identified how metadata could be developed/applied at multiple levels of the data hierarchy:

- Data Element Metadata – metadata about a single data element (e.g. time of collection, value)
- Data Record Metadata – metadata about a data series (e.g. series name, site name, parameter name, timestep spacing)
- Dataset Metadata – metadata about a dataset (e.g. dataset name, manager, spatial and/or temporal domain, web URL)
- Data Collection Metadata – metadata about a data collection (e.g. data collection name, point of contact, web URL)

Following the identification of metadata definitions, the Data Steward Team determined that only two of the four types of metadata in the hierarchy were needed to support development of the CRB Open Data Tool: Record (Series) metadata and Dataset metadata. Next, the team defined the specific metadata elements (fields) to be included in each type of metadata based on existing metadata schemas. The Record (Series) was based on the Pisces Schema (Reclamation, Bureau of, 2016), which was also being adopted for RWIS. Record (Series) metadata would be automatically generated from source databases by RWIS and Web Reports, with some input from data stewards when fields could not be pulled directly from the database. The Dataset Metadata Schema was based on the Common Core Schema (Project Open Data, 2014). Dataset Metadata would be manually populated by the responsible organizational group. It was also discussed that, in the future, Dataset Collection Metadata for the entire catalog could be developed, but was unnecessary at the time.

Task 3 Discussion and Conclusions

Web Accessibility Discussion and Conclusions

Technical

A technical challenge faced during the development of Web Reports related to how to publish metadata. The metadata needs of the Project were relatively comprehensive and did not conform to the way metadata was stored and labeled within the source databases. As such, a custom work around for attaching metadata to the datasets had to be developed within the Web Reports system. Using the configuration files associated with the program was identified as the best non-intrusive solution for attaching these metadata items to the datasets. The data stewards were asked to populate the metadata within the configuration file, which then controls the metadata that is attached to every data report. An alternative would have been to populate the HDBs with this metadata. However, this solution would have raised ownership, access, and coordination issues between the HDBs, and was therefore determined to not be feasible.

Attitudes Towards Open Data

Attitudes towards open data were not specifically discussed as part of the development of the web accessibility method

Organizational Dynamics

Organizational dynamics were not specifically discussed as part of the development of the web accessibility method because most of the work was performed by a single staff member in coordination with the PIs, rather than as a team effort.

Screening Discussion and Conclusions

Technical

The primary concerns expressed by Data Stewards and Screening SMEs during screening were that data may be provisional and therefore subject to change, may involve calculations that would need to be explained to users, and may include model projections that should not be taken to guarantee future conditions. Mitigation actions identified by the participants for these concerns were the inclusion of disclaimers regarding the provisional nature of data and/or the uncertainty of projections and the inclusion of adequate metadata to explain the datasets. The datasets that require these mitigation actions are noted in Table 2 as 'Release with Mitigation.'

Other concerns raised during the screening meetings related to whether the data revealed vulnerabilities about Reclamation facilities and could potentially be used to plan or execute a physical attack on Reclamation's infrastructure and whether the data could be combined with other data to create a mosaic effect. For most datasets, the participants did not feel that these concerns warranted any additional mitigation actions, particularly since most are already available online. One additional mitigation action was identified for the "BCOO Hourly Model Data for Davis & Parker Release and Energy Projections" dataset. Screening SMEs recommended maintaining the current protocol of only publicly releasing three days of projections in order to limit the risk of giving a potential attacker enough time to prepare an attack.

Regarding the technical aspects of the screening process itself, the Screening SMEs wanted to have access to examples of the actual data that would be posted, rather than an example of the data that still required additional transformation or formatting. They also suggested that if an actual dataset could not be provided, that the SMEs receive a specific description of what aspects of the example data would be changed prior to release. SMEs also noted that some of the datasets being screened have been released in some form in the past, and that it would be helpful to have information about those previous releases of the data.

Attitudes Towards Open Data

Screening participants were generally supportive of open data and of the screening process. They felt that a thorough review of security and privacy with the SMEs was a critical step. Data stewards were sometimes hesitant to determine whether there was a threat associated with the data. This may be because they are not trained to automatically think in terms of threats the way a security SME would, which placed them in an unfamiliar and uncomfortable situation as they reviewed the datasets. Their insecurity seemed to be a result of good work ethics and not an attempt to avoid the work of making screening determinations. SMEs expressed appreciation for being included in the process and noted that it gave them a chance to see how data was being used in the "real world" rather than only discussing it in abstract terms.

Organizational Dynamics

At the end of the Screening Meeting 4, the participants were asked to share their thoughts on the screening process. They were asked to identify what worked about the process, what aspects should be kept for future versions of the process, and what opportunities for improvement they saw.

The screening participants identified the following items to keep in the process:

- Collaborative tools (e.g. Google Docs) – This enabled real-time collaboration and streamlined the review process because all participants' contributions were in one place rather than having to be combined from multiple documents later.
- Manageable number of datasets – Narrowing the list of datasets helped keep the process focused and efficient.
- Meetings for discussion among data stewards and SMEs. The SMEs appreciated having the data stewards explain the datasets prior to review because it allowed them to start their review with a better understanding of what information the data contains.
- Remote participation options – This allowed staff from multiple offices to participate without travel time.
- Group size – Size was large enough to benefit from cross-functional input, and small enough so that people felt comfortable sharing their opinions and sharing their perspectives.

The screening participants identified the following areas as opportunities for improvement:

- Restructure meetings and tighten-up the process – The process was structured such that there was an initial overview of the datasets, followed by the SMEs reviewing the datasets individually, and then there was a specific discussion of the dataset as a group. This resulted in lots of repetition of the dataset information for SMEs.

- Targeted discussion of screening issues rather than including the entire group – All SMEs and data stewards were included in most communications and meetings. The participants suggested that the process could be revised to consist of an initial conversation with all SMEs and then additional discussions with small groups of SMEs and data stewards as needed to resolve questions.
- Timing of screening – The screening meetings were held in August and September, which is the end of the Fiscal Year when many offices are very busy. Participants suggested avoiding those times for future screening activities.
- More time – The participants suggested that they needed more time to complete work outside of the meetings, but noted that the amount of time should not be increased too much to keep participants focused.

Metadata Discussion and Conclusions

Technical

One of the major technical challenges faced by the Data Steward Team during metadata creation was determining how to group datasets for publication, which determined how the dataset metadata would be written. The draft data catalog (see Task 2) had been developed based on initial assumptions about dataset grouping, and this topic was revisited at the time of metadata creation. Even with shared definitions of records and datasets, Data Steward Team members had different opinions on how best to aggregate or split the data. For example, they wondered whether a dataset should be limited to only one parameter for a particular site (e.g. only reservoir elevation or reservoir storage for Lake Mead) or whether the dataset should include all the parameters for that site (e.g. all Lake Mead parameters). The RWIS system had no defined groupings of records into datasets, but the Data Steward Team felt that grouping by dataset would make the data easier for users to find and understand how it was related to other datasets.

Discussion of groupings also led to discussion of which metadata fields were appropriate at each level of the data hierarchy and whether a given field could include more than one value in order to fully capture the data in a dataset. For example, if the Data Steward Team decided that the "units" metadata field needed to be included in the dataset metadata, could the field include a list of all the units used by the records in that dataset (e.g. both feet for reservoir elevation and acre-feet for reservoir storage)? These discussions helped clarify how to classify the data into records and datasets, and how to decide which fields to include in the metadata schemas.

Attitudes Towards Open Data

Metadata was seen by the Data Steward Team as both one of the most important and most time-consuming parts of creating open datasets. Sorting through the various options for metadata to arrive at a metadata schema that would work for the CRB Open Data Tool required team members to think about the types of information that data consumers would need in order to understand and use the data. The Data Steward Team discussed how a member of the general public would want to look up specific information and which information they would want. It was determined that the information needed by the public would be different than what internal staff need, so creating open datasets would require work to modify the current information for public use. Data Steward Team members were supportive of this effort, but also concerned about their ability to perform the work along with their other job responsibilities.

Organizational Dynamics

The complexity of agreeing on a metadata standard for the project was not anticipated by the PIs. The initial Data Steward Team meeting to discuss metadata was intended to be a review of a proposed metadata schema drafted by the PIs. However, during the meeting it became clear that the team members were not all working with a shared understanding of basic data and metadata terminology, resulting in more confusion and frustration than clarity. This prompted the PIs to pause the metadata schema development in order to perform additional research and develop a set of data and metadata definitions to share with the group. The initial meeting was followed with a second meeting in which the Data Steward Team discussed and agreed on the shared vocabulary for future metadata discussions. With this shared vocabulary, the team was able to focus on the technical aspects of building the metadata schema.

Lessons Learned

- Grouping data into datasets is a challenging task that may require multiple iterations to find a satisfactory grouping
- A shared vocabulary is critical for discussing complex topics such as metadata. It is worthwhile to take some time to develop the vocabulary prior to beginning work on a complex subject like metadata
- Data stewards need adequate time to develop metadata, as the creation of metadata requires considerable thought and effort.

Task 4: Development of Tool Components

The final task of the CRB Open Data Tool Project was to develop the visualization tool components. This was accomplished through a prize competition hosted through Reclamation's Water Prize Competition Center. Prize competitions, also referred to as challenges, are authorized under the America COMPETES Reauthorization Act of 2010. They are used to spur innovation by crowdsourcing ideas for solving challenging problems. Prizes are awarded to winning solvers to incentivize the submission of solutions from a national, non-Federal solver community including citizens, businesses, and other organizations. The purpose of the prize competition for the CRB Open Data Tool project was to gather a wide variety of innovative concepts and approaches for visualizing Colorado River Basin data. It also provided an opportunity to publicize Reclamation's progress toward making data available in open formats.

Competition Planning and Design

Planning for the prize competition took approximately one year from the initial planning discussions in August 2016 to the competition posting in September 2017. Over that year, members of the competition Design Team worked with InnoCentive, Inc., Reclamation's prize competition contractor, to design the competition materials. The Design Team was made up of 20 members representing both Reclamation and other partner Federal agencies. Partner agencies were included in the Design Team because it was anticipated that the visualization tool would leverage data not only from Reclamation, but also from other agencies, and that their input into the competition design process would result in better overall competition materials, which would

lead to better submissions. The Design Team consisted of six representatives from the Data Steward Team, the Reclamation prize competition program coordinator, two representatives of the Reclamation Research & Development Office, the PI, three representatives from the U. S. Geological Survey (USGS), one representative from the U.S. Department of Agriculture's Natural Resources Conservation Services (NRCS), three representatives from the Colorado Basin River Forecast Center (CBRFC), one representative from the International Boundary Water Commission (IBWC), and two project management assistants.

Competition Materials

The role of the Design Team was to develop the competition materials, which consisted of a briefing paper and the prize competition document. The briefing paper provided a summary description of the prize competition. The competition document provided complete details of the prize competition for InnoCentive to post on the competition website. The competition document included an abstract, overview, background information, statement of the challenge, solution requirements, judging and evaluation criteria, description of the available prizes, and detailed descriptions of the submission deliverables. Design discussions kicked off with a review of the Preferred Alternative Tool Concept from Task 1 and examples of results from other data visualization competitions. Initially the statement of the challenge and solution requirements drafted by the Design Team were very detailed and specific, reflecting the details in the Preferred Alternative Tool Concept. However, through team discussion and with feedback from the prize competition program coordinator, the Design Team recognized that, in order to allow innovation and creativity by the solvers, the requirements needed to be broader and more flexible. This resulted in the Design Team narrowing the challenge statement to a few brief paragraphs and requiring that solvers include at least one of three broad elements in their solution:

- Integrated visualization of multiple relevant CRB data types and/or ancillary information. This may include mashups of data from multiple sources, combination of multiple data types, and/or integration of data with ancillary information.
- User-customizable visualization of data and/or ancillary information. This may include user-driven selection of data parameters, time periods, or geographical range, or configuration of visualization layout or content to meet user needs and preferences.
- Interactive visualization of data and/or ancillary information. This may include zooming or panning around a visualization, drilling down into data, clicking through animations, inputting information, and/or responding to queries or requests from the visualization.

The project deliverables identified by the Design Team were a data visualization and a written description of how the visualization was intended to support improved understanding and interpretation of CRB data, and improved analysis and decision making by internal and external users. No specific requirement for the type of visualization was stated, but solvers were directed that if the visualization was a website, web app, or video, the solver had to upload and/or host the visualization on an external website and provide a link to the visualization in the written description. Solutions could combine existing components and could use commercially available components such as proprietary software packages and/or novel solver-derived components to develop visualizations. However, visualizations could not rely on proprietary software packages for users to display visualizations or to use interactive features.

In addition to the required components of the competition document, the Design Team added example use cases that described key datasets and data uses for three types of potential users of the tool: Water Manager, Public River User, and Academic Researcher. Solvers were required to address one or more of these use cases with their visualization submission, or they could develop an alternate use case to present with their solution.

To support the competition document, the Design Team also worked with the Data Steward Team to prepare a data catalog for the solvers to use and a list of reference materials to help solvers become familiar with the Colorado River Basin. The catalog consisted of the Reclamation datasets that had been made publicly available in open format in Task 3, other Reclamation datasets that were already publicly available (both machine-readable and non-machine-readable), publicly available datasets from other agencies (machine-readable), and non-publicly available datasets provided for the purposes of the competition in anticipation that they would be released at some future time.

For the description of judging and evaluation in the competition document, the Design Team kept the criteria relatively brief, recognizing that the Judging Team would develop a more detailed evaluation rubric to use in scoring the submissions. The Design Team identified four criteria:

- The degree to which they met the Solution Requirements
- How well each submission supported the use case(s) selected/proposed by the Solver.
- Ease of use
- Innovation and creativity

The total cash prize purse was $60,000, to be divided among multiple solvers. The Design Team decided that the top submissions that met or exceeded the solution requirements should receive cash prize awards no less than $5,000, with a single cash prize award being as high as $20,000. The Design Team also decided to allow partial cash prizes for solutions that met some, but not all, the requirements. Lastly, the Design Team recognized that some solvers might be motivated by recognition rather than cash, so a potential opportunity to present the visualization to a group of stakeholders was offered for the top three submissions.

Outreach and Publicity

To make CRB stakeholders and potential solvers aware of the prize competition, the Design Team worked with Reclamation's Denver Public Affairs Office and Research & Development Office to develop and distribute a number of outreach and publicity materials, including a poster, a video, a news release, emails to CRB stakeholders, and social media posts on Reclamation's Facebook and Twitter feeds. Many of these materials can be viewed on the competition website: https://www.usbr.gov/research/challenges/datavis.html. During the development of the competition materials, the Steering Committee also hosted two webinars targeted towards CRB stakeholders to gather their input on the visualization tool goals and available datasets, and to promote the competition.

Competition Administration

The prize competition was posted on September 7, 2017 and closed on November 17, 2017 (71-day submission period) on the following forums:

1. The Water Pavilion on the InnoCentive Challenge Center website: www.innocentive.com/ar/challenge/browse.
2. U.S. Federal Government Challenge Platform (hosted by the General Services Administration): www.Challenge.gov.

InnoCentive, Inc. administered the posting, interacted with the solver community, and received submissions. Solvers were able to submit questions to InnoCentive through the Challenge Center and InnoCentive forwarded the questions to Reclamation, received Reclamation's responses, and provided responses to the solvers.

The Challenge was advertised as a "Theoretical Challenge," meaning that Reclamation would receive rights only to the solutions that received awards. Solvers could make up to five submissions, with each submission consisting of a distinctly different visualization with an accompanying written description.

A total of 254 solvers signed up to view the Challenge. A total of 24 solutions was submitted; four submissions were screened out by InnoCentive as not meriting review and the remaining 20 submissions were forwarded for judging. InnoCentive assigned a number to each submission so that the identity of the Solvers was not shared with the judges.

Judging

The Judging Team consisted of 12 subject matter experts from Reclamation, CBRFC, USGS, and the NRCS. The team included members with a broad range of knowledge, roles, and experience, including staff members who had experience in data stewardship, data analysis, water forecasting, and water operations.

Judging Materials

The judging materials consisted of a judging rubric, a statement of the Judging Team's approach to judging, a spreadsheet for submitting scores, and step-by-step instructions. The Judging Team collaboratively developed the judging rubric and approach prior to reviewing any of the submissions, and the spreadsheet and instructions were developed by the PI and project management assistants.

The approach to judging agreed upon by the team was that scores would be based on assessment of how well each solution met the requirements and criteria detailed in the challenge document. The Judging Team recognized that the assessment would involve a combination of objective criteria and professional judgement, meaning that scores would represent both subjective and objective evaluations.

The judging rubric described the judging criteria and corresponding numerical scores. It was developed by the Judging Team based on the solution requirements and criteria detailed in the

challenge document. The rubric consisted of six Criteria. Each Criterion had one or more Measures. For each Measure, judges could select a numerical score of 0, 1, 2, or 3. Each numerical score was accompanied by a description of what the score meant to facilitate consistency between judges. Each Measure was assigned a weight based on the relative importance of its associated Criterion. In addition to numerical scores, judges were also asked to identify "Innovative Nuggets" within the submissions and were encouraged to provide notes and comments to help document the judging process and facilitate discussion of the scores.

Judging Process

Judges were provided with scoring spreadsheets to be completed independently after reviewing each solution against the requirements and criteria stated in the prize competition posting document. Judges began their independent reviews on December 13, 2017. A check-in meeting occurred on December 21 to address any questions from the judges regarding the scoring spreadsheet or how to apply the scoring rubric to individual solutions. Another check-in meeting was conducted on January 5, 2018 to clarify questions regarding scoring, such as inability to access visualizations samples, scoring of submissions that did not seem to match the solution requirements, and scoring submissions with multiple visualizations. At the end of the independent review period, the individual scores were tallied and combined. The combined scores were used to guide discussion during five judges' meetings (conference calls) on January 26, January 30, February 7, February 8, and February 9. The goals of the judge's meetings were to discuss the strengths and weaknesses of the submissions relative to the requirements and criteria detailed in the challenge posting, and to make a final recommendation for the winners of the cash prize awards.

Results

Among the solutions that were submitted, almost all met one or more of the solution requirements defined in the Challenge, and some of the submissions met all and also exceeded some of the solution requirements. However, none exceeded all the solution requirements. The judging panel therefore recommended a range of awards from $5,250 to $15,750 for the solutions meeting all or exceeding some of the solution requirements, with no solution recommended to receive the maximum award of $20,000. Based on detailed discussion during the Judging Team meetings, six solutions were identified as warranting awards for meeting all or exceeding some of the solution requirements. Three additional solutions were identified as providing unique and highly innovative ideas, or "Innovative Nuggets", with respect to one or more criteria, but without meeting or exceeding all of the solution requirements. Innovative Nuggets received partial awards of less than the $5,000 minimum.

Table 4. Prize Competition Submissions and Summary of Awards.

Submission Number	Description	Award Amount	Award Type
S009	An interactive map and data display with a wide variety of information about Colorado River Basin reservoirs.	$15,750	Full Award
S014	An ArcGIS Online web map showing river, reservoir, and stream gage data, plus popups for more information.	$10,750	Full Award
S018	An interactive map for the western United States displaying data from RWIS.	$7,750	Full Award
S020	A ShinyApps site with a vertical scrolling layout with multiple components, including water users in the Lower Colorado River Basin.	$7,750	Full Award
S008	An interactive map allowing exploration of water supply in the Lower Colorado River Basin	$5,250	Full Award
S021	A Tableau dashboard focused on fishing. It provided an easy to use, intuitive, and attractive website that could effectively support recreational fishing users.	$5,250	Full Award
S012	A group of interactive maps that allow the user to explore the stream network of the NHDPlus	$2,500	Innovative Nugget
S013	A data dashboard tailored to fishing or white water rafting.	$2,500	Innovative Nugget
S023	An animated visualization of hourly streamflow at multiple locations.	$2,500	Innovative Nugget
S004	A series of graphs based on Visualizing Water, a graphical illustration of water use developed by TRUTHStudio and The Nature Conservancy.	$0	No award
S005	Three example visualizations developed for other purposes.	$0	No award
S006	A proposal for developing an interactive visualization consisting of a main map and widgets.	$0	No award
S007	A method for making short-term streamflow predictions.	$0	No award
S010	A static image of 3D bar graphs and a discussion of "The Natural Flow Regime."	$0	No award
S011	A Tableau map showing streamflow and weather conditions.	$0	No award
S015	A Tableau dashboard with a map and graphs.	$0	No award
S016	A description of an Amazon Alexa interface for retrieving Colorado River Basin data.	$0	No award
S017	A map with data layers.	$0	No award
S022	A 3D dashboard for use with virtual reality.	$0	No award
S024	An animated visualization of hourly projected reservoir releases and energy.	$0	No award

Prize Recommendations

Six submissions were given awards based on each submission's overall quality in meeting or exceeding the solution requirements and criteria ("overall solution" awards). Each submission received a cash prize award as follows:

- Submission 009: $15,750
- Submission 014: $10,750
- Submission 018: $7,750
- Submission 020: $7,750
- Submission 008: $5,250
- Submission 021: $5,250

The solution with the largest award was the Colorado River Reservoir Explorer. It consisted of an interactive map allowing users to locate and view Colorado River Basin reservoirs and display a wide variety of information about those reservoirs. It included a simple but informative display of reservoir storage, inflow, release, and evaporation in the context of historical data, plus a weather summary linked to each reservoir based on USGS hydrologic units. It was the most comprehensive submission with respect to the datasets utilized, drawing on both Reclamation reservoir data and weather data from the National Oceanographic and Atmospheric Administration.

In addition, the following three submissions contained one or more Innovative Nuggets and received a cash prize award of $2,500:

- Submission 013
- Submission 012
- Submission 023

A summary of all awards and solutions that did not receive awards is included in Appendix H – Prize Competition Results.

Task 4 Discussion and Conclusions

Technical

The CRB Data Visualization Challenge resulted in several innovative, interactive, user-driven visualization concepts that could potentially be used as the basis for a web-based data visualization tool or incorporated as elements of such a tool. However, the Design Team and Judging Team also identified a number of challenges faced during the competition process.

One challenge faced by the Design Team was trying to get everyone to think about the product in terms of the competition. Initially, there were too many requirements and components in the design, and the requirements narrative appeared more like a software services specification than a competition document. After some discussion with Reclamation's prize competition program coordinator, the Design Team decided to focus on writing use cases that would help solvers understand the possible uses of a visualization tool

Opinions on the results of the prize competition were mixed. The Judging Team felt that the solutions that received awards were good, but that none of the submissions could be directly adopted as a visualization tool. All submissions would take a significant level of modification and development to transform them into a component of a usable tool. The Judging Team acknowledged that the competition design was very broad and flexible, and suggested that a clearer design document could have helped improve the results. Another barrier to getting immediately usable results was the lack of Colorado River Basin understanding among solvers, although the Judging Team recognized that even those who work in the CRB have difficulty fully understanding all the complexities of the system.

The Judging Team recommended that more outreach could help expand the pool of potential solvers to those with relevant data analysis and software programming experience. For this competition, outreach consisted of a press release, an email to CRB stakeholders, two conference calls with CRB stakeholders, and social media posts on Reclamation's Twitter and Facebook feeds. The Judging Team felt that these outlets likely included mostly those with interest in the Colorado River, but may not have included many people who could develop a visualization. There are many other outreach platforms that focus on data analysts and software developers, and a different challenge provider may have had access to a more relevant group of solvers. However, with this suggestion, the Judging Team again raised the concern that solvers with relevant data and software skills may not have had the relevant understanding of the Colorado River to develop useful visualizations.

The Judging Team also felt that the organization of the challenge document could have been improved, which may have resulted in better submissions. Team members noted that the requirements, evaluation criteria and use cases were dispersed throughout the document rather than being included in one location to make it clear to solvers what their submission needed to include. This made developing the rubric more difficult and the Judging Team felt that this likely impacted the quality of submissions.

Attitudes Towards Open Data

The prize competition contributed towards building wider awareness and support of open data. Team members and stakeholders were able to see how open datasets could be used to create tools that would be accessible and useful for a variety of purposes, even purposes beyond those envisioned for the CRB Open Data Tool. For example, while reviewing one of the visualization submissions, one member of the Judging Team noted that even if that submission was not incorporated into the CRB Open Data Tool itself, his office would be interested in using the idea for another purpose.

One concern related to open data identified during the development of the prize competition materials centered on the importance of screening data prior to public release. This concern was mainly focused on quality assurance/quality control (QA/QC) procedures, rather than a privacy or security restriction. The Data Steward Team identified a small number of datasets in the data catalog that had not yet been made open (in Task 3 or through other methods), but which were desirable for potential inclusion in the tool. The Data Steward Team wanted to make the datasets available to solvers, but did not want to release data that had not gone through standard QA/QC procedures. To allow solvers to access these 'non-public' datasets , the Design Team worked with InnoCentive to include a confidentiality agreement in the "competition specific agreement"

that solvers had to accept when viewing the competition on InnoCentive's website. In addition, only a representative sample of the non-public data was made available to the solvers for the competition.

Organizational Dynamics

Competition Design Process

Overall the Design Team felt that the design process went smoothly and the team worked together well. A challenge the team faced was identifying specifically what was being requested, and deciding how to pose the problem in a way that would be clear to solvers. It was suggested that techniques from Value Engineering, such as function analysis and creating Function Analysis System Technique (FAST) diagrams, could help address some of these challenges. Representatives of the Reclamation Prize Competition Program met with Kristi Evans from the Value Program to discuss this idea and decided to work with Kristi to test it for one or more future competitions.

Competition Judging Process

The Judging Team generally liked the judging methodology and tools. The judging process was structured with a series of one- to two-hour conference calls plus independent scoring and review. A downside to the conference calls was that some team members had difficulty speaking up to share opinions. The Judging Team felt that the meeting facilitator (the PI) gave ample opportunity for all to engage, but that some personalities avoid sharing in conference call situations. They suggested that an initial in-person meeting may have been beneficial to begin the judging process, followed by shorter conference calls to have further discussion and make decisions on awards. The in-person meeting could have helped the judges meet each other and get to know individual personalities.

The Judging Team felt that the judging spreadsheet was very useful and clear, but noted that it was also very large. They thought that using the spreadsheet was straightforward, even through multiple iterations of scoring. When the individual scores were aggregated and provided to the team as a summary in the spreadsheet, the Judging Team thought that it was helpful to be able to see the aggregated results as well as the individual scores during the process of determining the final rankings of the solutions.

Lessons Learned

1. Ensure the solution and submission requirements are clear and concise in the challenge document, so solvers have a clear understanding of what is needed to meet the full requirements.
2. Select a prize competition administrator with a relevant solver community and experience in the type of prize competition products that are desired. For the CRB Open Data Visualization competition, a solver community with a greater number of software developers or data scientists may have resulted in a broader range of submissions.
3. Target outreach to reach relevant potential solver communities including those that have relevant technical skills (e.g. software development, data analysis, data visualization) and an understanding of the setting and constraints of the project (e.g. water management, Colorado River issues).

4. For judging, the initial meeting of the judging team should be an in-person meeting to introduce all the Judging Team members and ease communication during later remote meetings (conference calls). The in-person meeting could focus on the criteria and an initial review of the solutions, while the following meeting would be used to discuss the solutions after individual evaluation and scoring. The Judging Team also recommended longer follow-up meetings to allow sufficient time for discussion without being rushed.

Next Steps

Tool Design

Shortly after the finalization of awards, the winning prize competition submissions were shared with the Steering Committee and the Data Steward Team for evaluation and discussion of next steps. It was initially anticipated that tool development would immediately follow the completion of the prize competition. However, due to staff availability and desire to coordinate with other open data efforts underway (i.e. RISE), it was decided to close out the S&T project and design and develop the tool when more open datasets become available.

The first phase of developing the visualization tool will be to design the overall tool and identify the specific components and datasets that will be included. During discussion of the prize competition results, the Steering Committee noted that the competition had produced a number of conceptual designs that could be used to develop a complete visualization tool for the Colorado River Basin. They recommended forming a Tool Design Team consisting of a multidisciplinary group of staff members from the LC, UC, and YAO offices to design the visualization tool. As no one solution was seen as being a complete visualization tool, it was expected that the tool would consist of component visualizations drawn from some or all of the winning Challenge submissions as well as visualizations created during the tool development process. The Judging Team identified many opportunities within the submissions to add additional data, refine data usage and interpretation, or adapt the visualization concepts to meet the specific needs of the CRB visualization tool. The Tool Design Team could review the Preferred Alternative Tool Concept along with the winning submissions and determine which components and datasets should be included. It would also be valuable to invite the solver(s) whose solutions would be included in the tool to participate at some level of the design and/or development process.

Tool Development

Once the tool design is complete, the tool development phase can begin. At this stage, the Tool Design Team would select a software developer and work with that developer to implement the tool and link the CRB datasets.

Three options for the development of the visualization tool were identified in the initial discussions following the prize competition: 1) outsource development, 2) Reclamation development, or 3) sole source with solver.

1. **Outsource development**: Hire an outside contractor to complete the development of the tool. If this option is selected, it would be important to ensure the contractor follows Reclamation IT security requirements and application design standards. It would also be important for the contractor to provide training for Reclamation staff in order to facilitate a smooth transition to Reclamation operation and maintenance of the tool when the contract is complete.
2. **Reclamation development**: Utilize Reclamation staff to develop the visualization tool. One consideration with this option is the availability and skill-sets of staff to work on the project.
3. **Sole source with the solver**: Initiate a sole source contract with a solver for development of the tool. This option would be dependent on whether the solver possesses the skills and resources to accomplish this task. A potential issue for this option would be the justification of sole source. There are also concerns surrounding Intellectual Property (IP) if the contract is competed for since it is the solver that developed the aspect of the visualization. It was suggested that the Department of Commerce's National Technical Information Service (NTIS) could help streamline the process to sole source with the solver for further development, but after further investigation, the contract cost threshold of NTIS may be too high to make this a feasible option.

The selected software developer would use the design and requirements prepared by the Tool Design Team to develop the tool. This could involve direct use of the code associated with the winning prize competition submissions, or could involve drawing on the conceptual designs from the winning submissions to develop similar visualizations in the software platform(s) chosen by the developer in coordination with the Tool Design Team.

A few intellectual property considerations for tool development were identified during the discussion of next steps that should be considered before tool development begins. A question was raised regarding whether a contractor hired to develop the visualization tool for Reclamation could also contract with the solver to create a marketable software application. The group also wondered about intellectual property considerations related to the software used by solvers to develop the visualizations. To protect intellectual property rights, the group recommended further consultation with the Solicitor's Office to determine if additional licensing with the solvers and/or limitations for development by software developers is required.

In addition to designing and developing the tool, the Tool Design and Development Teams will also identify ongoing tool operations and maintenance, and security support needs to plan ahead for funding and resources.

Open Data for the Colorado River Basin

After the "Round 1" datasets were made open as part of this project, the Data Steward Team continued to work on making other datasets available in open formats and visualizing CRB datasets. Some of the accomplishments to date include the development of internal and public Application Programming Interfaces (APIs) to make HDB data available via web services, development of public visualizations that use the new public API, and ongoing work to review existing datasets and transfer them to HDB so that those datasets can be more easily published.

Related Work, Benefits, and Impacts of the CRB Open Data Tool Project

The CRB Open Data Tool Project was successful in its goal of documenting a process for making datasets open. Work is ongoing on Reclamation's enterprise open data publication platform, the Reclamation Information Sharing Environment (RISE), which will replace RWIS. The PI of the CRB Open Data Tool Project is the Project Manager for RISE, and many of the processes and tools for RISE were based on the work of the CRB Open Data Tool Project. For example, the RISE screening process was developed from the CRB Open Data Tool Project screening process. It incorporates many of the same considerations and screening subject areas, but has improved on the process implementation based on the lessons learned from the CRB Open Data Tool screening process. Rather than implementing the process as a series of meetings, the RISE process includes an initial questionnaire for data stewards along with optional consultation with screening SMEs as needed. The structure of the RISE database and the specific metadata fields included in the database were also based in part on the metadata concepts developed for the CRB Open Data Tool. RISE will have a catalog with a hierarchical structure of Records (parallel to CRB Datasets) and Items (parallel to CRB Records) described by various metadata fields. The understanding of open data attitudes and organizational dynamics has also greatly benefited the RISE project, leading to more effective communication among the RISE Planning Team, data stewards, and stakeholders.

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Appendix A – Project Team

Name	Affiliation	Role/Area of Expertise	Principal Investigator/ Project Management	Steering Committee	Task 1 Brainstorming Participants	Screening SME	Data Steward Team	Competition Design Team	Judging Team
Aaron Alton	Reclamation (LC)	FOIA/Privacy				X			
Adrien Cortez	International Boundary and Water Commission	Hydrologist						X	
Allison (Danner) Odell	Reclamation (LC, ESO)	Principal Investigator	X					X	X
Andy Wood	Reclamation (UC)	Physical Security				X			
Angela Adams	Reclamation (LC, ESO)	Principle Investigator (October 2015 to February 2017)	X						
Angela Anderson	Reclamation (LC, ESO - detailed)	Project Management Support (May 2017 to May 2018)	X						
Brian Kitt	Reclamation (LC, BCOO)	Operations Support Group		X (acting)			X	X	
Carly Jerla	Reclamation (LC, BCOO)	River Operations Group		X (FY16)					

Name	Affiliation	Role/Area of Expertise	Principal Investigator/ Project Management	Steering Committee	Task 1 Brainstorming Participants	Screening SME	Data Steward Team	Competition Design Team	Judging Team
Chris Watt	Reclamation (UC)	Public Affairs							X
Chuck Hennig	Reclamation (Denver, R&D)	Prize Competition Program Coordinator (through September 2017)						X	
Dan Bunk	Reclamation (LC, BCOO)	River Operations Group		X	X		X		
Dan Cowden	Reclamation (LC, Security Office)	Physical Security				X			
Emily Read	USGS	Web Communications Branch Chief						X	X
Gary Krzisnik	Reclamation (LC, Security Office)	Physical Security				X			
Gary McDanel	Reclamation (Denver, IRO)	FOIA/Privacy				X			
Geoff Hall	Reclamation (LC, Security Office)	Physical Security				X			
Gus Goodbody	NRCS	Forecast Hydrologist						X	X

Name	Affiliation	Role/Area of Expertise	Principal Investigator/ Project Management	Steering Committee	Task 1 Brainstorming Participants	Screening SME	Data Steward Team	Competition Design Team	Judging Team
Hong Nguyen-DeCorse	Reclamation (YAO)	Water Operations Group Supervisor		X	X		X		X
Ian Ferguson	Reclamation (Denver, TSC)	Water Resources Engineering & Management Group						X	X
Janet Belcher	Reclamation (UC)	FOIA/Privacy				X			
Janet Kirsch	Reclamation (LC, Resources Management Office)	Water Quality Specialist			X				
Jeremy Dodds	Reclamation (LC, BCOO)	Water Accounting & Verification Group					X		
Jessie Doering	Reclamation (YAO)	IT Security				X			
Jim Prairie	Reclamation (UC, Water Quality Group)	Water Quality Group			X				
Jim Nagode	Reclamation (Denver, Information Resources Office)	Data Resource Manager				X			

Name	Affiliation	Role/Area of Expertise	Principal Investigator/ Project Management	Steering Committee	Task 1 Brainstorming Participants	Screening SME	Data Steward Team	Competition Design Team	Judging Team
John Lhotak	CBRFC	Development and Operations Hydrologist						X	
Jon Rocha	Reclamation (LC, BCOO)	River Operations Group			X		X		X
Justin Wright	USGS	Computer Scientist, Core Science Systems						X	
Katharine Dahm	Reclamation (Denver, Policy & Analysis)	Water Resources and Planning			X				
Katrina Grantz	Reclamation (UC)	Water Resources Group			X				
Ken Nowak	Reclamation (LC, BCOO / Denver, R&D)	Civil Engineer			X				
Kerry Whitford	Reclamation (Denver, R&D)	Prize Competition Program Coordinator (Through April 2018)							
Kyle Cavalier	Reclamation (LC, BCOO)	Operations Support Group			X		X		
Lorraine Coroneos	Reclamation (LC, BCOO)	Water Accounting & Verification Group			X		X		

Name	Affiliation	Role/Area of Expertise	Principal Investigator/ Project Management	Steering Committee	Task 1 Brainstorming Participants	Screening SME	Data Steward Team	Competition Design Team	Judging Team
Malcolm Wilson	Reclamation (UC)	Water Resources Group		X					
Marlon Duke	Reclamation (UC)	Public Affairs				X			
Michelle Escobar	Reclamation (LC)	FOIA/Privacy				X			
Michelle Stokes	CBRFC	Hydrologist						X	
Mike Frame	USGS	Core Science Analytics & Synthesis						X	
Nicole Everett	Reclamation (LC, BCOO)	Water Accounting & Verification Group					X		
Olivier Clavel	Reclamation (LC, ESO)	Project Management Support	X						
Owen Fulsome	Reclamation (YAO)	FOIA/Privacy				X			
Paul Miller	CBRFC	Service Coordination Hydrologist						X	X
Paul Davidson	Reclamation (UC)	Water Resources Group			X				

Name	Affiliation	Role/Area of Expertise	Principal Investigator/ Project Management	Steering Committee	Task 1 Brainstorming Participants	Screening SME	Data Steward Team	Competition Design Team	Judging Team
Paul Matuska	Reclamation (LC, BCOO)	Water Accounting & Verification Group Manager		X			X		
Peter Harbauer	Reclamation (LC, BCOO)	River Operations Group			X		X		
Rick Clayton	Reclamation (UC)	Water Resources Group					X	X	X
Roy Henry	Reclamation (LC, BCOO)	Water Accounting & Verification Group					X		X
Samson Agbebi	Reclamation (UC)	IT Security				X			
Seth Ostrowski	Reclamation (LC)	Operations Support Group		X					
Shana Tighi	Reclamation (LC, BCOO)	River Operations Group			X		X	X	X
Stephen Shiverts	Reclamation (YAO)	IT Security				X			
Steve Belew	Reclamation (LC, RMO / Denver, TSC)	Geographical Information Systems			X				
Toni Linenberger	Reclamation (Denver)	Physical Security				X			

Name	Affiliation	Role/Area of Expertise	Principal Investigator/ Project Management	Steering Committee	Task 1 Brainstorming Participants	Screening SME	Data Steward Team	Competition Design Team	Judging Team
Tracy Callen-Young	Reclamation (LC)	IT Security				X			
Veronica Welch	Reclamation (YAO)	IT Specialist (HDB)					X		X

Appendix B – Tool Concepts

Initial List of Tool Concepts

Idea Number	Tool Concept Description	Tool Audience	Synthesized Tool Concept
1-1	Other S&T Projects - water.usbr.gov. Outward looking web interface is needed, more robust than LC HDB site, for sharing with the public - data like pool elevation data. HDBPoet has lots of the features that would be useful. Gives you a good view of whole database and quickly access data. Public may need different type of information. Information specific to a reservoir. Like NWIS.	Not Identified	N/A This concept is a foundational idea, already being implemented in the water.usbr.gov project
1-2	Tessel - Map that pulls data from HDB - use ArcGIS online. Prettier version of 1-1. Like NWIS mapper. This may be Tessel? For now, Tessel is internal, but plan is to make it external.	Not Identified	N/A This concept is a foundational idea, already being implemented through Tessel and ArcGIS Online
1-3	Single tool with multiple dashboards for different scales of modeling. e.g. 24month study/CRSS. Start at map interface to navigate through different levels of decision timeframes. Explore conditions of reservoirs(current conditions from 24-mo study - inflow, storage, projected releases) Historical data of reservoir performance. Also would unify visual identity of model information. Make messages clear. Mid-term - snowpack, %precip, critical parameters for operations. Long-term - historic consumptive use, projected demands. Dashboard caters to datasets that are important at that decision-scale. Categories - current conditions, projected operations. Map with sites - click on site to find out what you are interested in. Could bring up a Tableau graph that lets you visualize three different scenarios for natural flow. Looking at Lake Powell outflows, what are the near-term projects. then if you want to find out why they look like that, you pull up the near-term dashboard. How would it look? Map of current conditions (inflow, projected releases (24-month study), historical data). Dashboard to click through	Not Identified	A

Idea Number	Tool Concept Description	Tool Audience	Synthesized Tool Concept
	different months to see how things change. Similar to YAO dashboard - what are the releases from the reservoirs, recreation elevations for weekend. Forecasts of elevation for Senator Wash for weekend to help public. Help public know about how flows are going to change so they don't get stuck in the river. Can also potentially address Mexico interests. Include an Intro section saying how decisions are made (near-, mid- and long-terms) to reach the resulting data. User can select from various databases (or skip over intro) Plugable. Base template. Multiple uses within Reclamation datasets. External data could also be included.		
1-4	Data Dictionary/Glossary - Could be standalone tool or one component/Add-on to a tool: Issues with people not understanding inputs to models (e.g. unregulated, regulated, natural flows). Need to have an off-ramp to learn more about what the data is (viz/animation to help people understand). Some datasets are straightforward. Visual dictionary of data? e.g. superscript that tells you what the data is. Model/future data vs real/current data - need to understand/explain nuances. Not primary function as dictionary, but needed for understanding the data that is posted. People often want to take the data and do their own thing, but to do that, they need to have a good understanding of what the data is. May also need a user form to submit further questions. Required if you make a dashboard. Include examples of data and what it could be used for	Not Identified	D
1-5	How are decisions made in Reclamation- would eventually lead you to the 24-month study so you could drill down into the data. Operational hierarchy roadmap for operational decisions. Opportunity to educate public. May enter different ways/for different reasons. What data is important for those who look at midterm operations? This may be overarching goal of tool - need to be able to adapt to different needs and allow users to get to the data multiple ways. e.g. explanatory website for general uses, then graphics for people with more detailed questions, then ability to download/drill down to do analysis.	Not Identified	A

Idea Number	Tool Concept Description	Tool Audience	Synthesized Tool Concept
	Tool should be smart enough know what users need information about. may tie to flow chart feature of a potential dashboard		
1-6	Colorado Basin Wide Reclamation Dashboard - similar to YAO dashboard. Could be internal only, but may want to share. Sensitive data may need to stay internal only. One-stop shop for operations and projections for operating river on real-time and near-term timeframe. Could also leverage same dashboard for mid-term and long-term projections. Elevations, inflows, releases, diversions, salinity	Not Identified	A, B, E
1-7	Repository of tools used throughout Reclamation to prepare, manipulate and analyze data (e.g., LC's Data Doctor). Could be part of water.usbr.gov (e.g. listing YAO dashboard, other dashboards, TSTool, HDBPoet, Data Doctor)	Not Identified	N/A This is outside the scope of this project
1-8	Something like/using Tableau - display model results in interactive manner. One or two from Basin Study are already posted on web. Planned to have the ongoing modeling data posted in about a year. Tableau workbooks can be shared with stakeholders. Builds capacity among stakeholders and reduces requests for data. Standardize across modeling (24 month study, MTOM, CRSS). Tableau is nice because it is a professionally supported software package - reduces maintenance and prevents loss of knowledge/ out of date legacy products	Not Identified	N/A Tableau is a method for displaying information - this idea goes more toward infrastructure of the tool than on what info would be displayed.
1-9	Flow chart of interim guidelines - steps through the if-then flow chart for the interim guidelines	Not Identified	C

2-1	• One stop dashboard to show multiple data sets for information purposes
	• Desktop accessible
	• Water supply, forecasting, current elevations, current forecasted hydrology or releases, precip to date, inflow.
	• One-pager, in our back pocket, not manually updated.
	  o Two versions, summary as well as detailed
	  ▪ Include visuals of the data in the detailed
		Managers, internal agency, general public, Mexico	E

Idea Number	Tool Concept Description	Tool Audience	Synthesized Tool Concept

	• Standard slides to be leveraged in presentations (example: BCOO's weekly hydrology update)
	• Interactive tools, including graphs, charts, maps
	  o Multiple tabs, such as supply, demand, elevation projections, summary reports
	  o In format of app, allow for mobile access
	• Be able to toggle between US vs. metric units to present easier information/data to Mexico
	  o Yuma communicating w/ IBWC frequently
	  o Minute 319 hydrology updates		

2-2	• Way to access the raw data from model runs and historical
	• Presenting model data using Tableau
	• Water accounting reports, show analysis of water users over period of time
	  o Graph, tables, searchable
	• Geographical representation of specific water users, include forecasted use, historic use, average historic use, contract right
	  o value: consumptive use vs diversion, not over using http://lcgis/LC_Gages/default.html
		Water Users	H

2-3	• Way to access the raw data from model runs and historical • Presenting model data using Tableau	Misc. data requesters (students, consultants, research and analysis)	A

2-4	• Interactive tool specifically for education to play and illustrate the inflow and outflow
	  o Inflow is policy, not natural (for Mead)
	• Teach about the water balance, what caused reservoirs to increase/decrease
	  o Slider bars to show different inflow and outflows for example this is what happens when it rains
	• More geographic visuals
		Educational	C

Idea Number	Tool Concept Description	Tool Audience	Synthesized Tool Concept
	• California Groundwater tool sample: data dictionary, flows at reservoir points		
3-1	Put CRSS results on line - providing inflow data sets and output data sets (spreadsheets). Interactive data sets with shading can look at single trace	Internal Management, external water managers	A, I
3-2	Make 24-month data sets available in open format, including visualization, e.g. comparing 24-mon. studies to actual record	Internal Management, external water managers	A
3-3	C.R. dashboard - unregulated and nat'l flow, CRSS, 24-month. Interactive historical data. Factually based rather than interpretively based, visualization down the river. (note that water managers sometimes want people/public to come to them to give a full interpretation of data [thru Q&A with the requestor/researcher] versus attempting to have the numbers 'stand alone' even with some text interpretation of the data)	Internal Management, external water managers, public	A
3-4	Interactive "option selection" of Basin Study options to let people pick various options to see how they impact imbalance	Public	I
3-5	Interactive Basin-wide Map of current data, e.g. flows, reservoir levels, rec facilities, water quality data, SNOTEL data, evap. Could have multiple sources, different agencies	Public	N/A This concept is a foundational idea and is already being implemented through Tessel and ArcGIS Online
3-6	Dashboard for CRB that focuses on tables/graphics- maybe have interactions like the Rand site/report (Tableau): http://www.rand.org/jie/projects/colorado-river-basin/interactive-brief.html (note that graphics lead to text versus vice versa)		E
3-7	Fly over of the river		C
4-1	Tool to allow users to see how many customers to be served [in an area affected by drought], where located and what is their water supply infrastructure - ppl on a well and gw is gone so they had to leave -- way to access [e.g., Clark County population demographics]. * How many	water managers data nerds ecosystem community irrigators/districts municipalities	F, H

Idea Number	Tool Concept Description	Tool Audience	Synthesized Tool Concept
	customers served and what types of conservation rules would need to be imposed.*		
4-2	Tool for LandSat data - from flyovers - to allow users to see the change in (1) footprint population over time - some kind of tool that allows users to do before/after or progression in population change over time; (2) change in vegetative cover: progression toward desertification/decrease in green areas	water managers data nerds ecosystem community irrigators/districts municipalities	H
4-3	Tool to allow users to see what kinds of green infrastructure cities like Portland are using and where - such as green pavement, green roofs? Where can we use more of it to augment, replenish supply, reduce impacts on gw. (ex. permeable pavement allows contaminants into runoff - impacting groundwater quality)	water managers data nerds ecosystem community irrigators/districts municipalities	N/A This tool is outside the scope of the project
4-4	Tool that allows users to view changes in water quality parameters in a water body over time [janet is on a group to work on "training" satellites - through water sampling and data processing - to recognize light signals associated with harmful algal blooms]	water managers data nerds ecosystem community irrigators/districts municipalities	G
4-5	Tool for viewing wildland fire risk change in areas affected by drought and what happens to an area after the fire goes through - impacts on erosion, post-rainstorm water quality impacts -- cycle of intensive storms, land erosion, decreased water quality, decreased water quantity - more run-off right into the ocean and less into surrounding permeable (riparian) soils, increased treatment costs, possible impacts to water treatment plant operations, then impacts to communities	water managers data nerds ecosystem community irrigators/districts municipalities	F
4-6	Tool using UC and LC data to see how changing lake levels affect water quality (temperatures, salinity and other contaminants of interest) - observed data do not support what people thought would happen: people thought when lake levels fell, saltier water would be reached - but the lower water is not saltier; **Janet's chart + Lake Mead and Lake Powell Surface elevations **Question: is the change in WQ in Lake Mead an operational condition or is it something else, which we can/cannot affect? What is the overall condition of WQ in the lower basin mainstream,	water managers data nerds water quality community irrigators/districts municipalities	G

Idea Number	Tool Concept Description	Tool Audience	Synthesized Tool Concept
	in relation to our numeric targets and health criteria.		
4-7	What things are drying out when there's less water? Depletions/impacts to groundwater aquifers: LandSat, GRACE, land subsidence data	water managers data nerds ecosystem community irrigators/districts municipalities	F
4-8	Tool to see how are riparian areas affected by drought? **intensive storms and or lower water levels - more channeling, less percolation, more drainage of groundwater, less saturated zone to support riparian habitat; warmer water - fish habitat degrades; change in ecosystem makeup: change in phytoplankton community/zooplankton community, more harmful algal blooms; colder water holds more dissolved oxygen - less DO to go around in warmer water	water managers data nerds ecosystem community irrigators/districts municipalities	F
4-9	Tool to pull up all WQ data that has been collected since 2005 - bor, usgs, nps, snwa; [snwa has a public database; not qc'd data -- Janet has access info]; would like easy way to get data out; options for formats and graphical presentation, tabular presentation; easy way to build powerful graphic/charts; integrates photos and maps	water managers data nerds ecosystem community irrigators/districts municipalities	G

Synthetized Tool Concepts

A. Exploration of Colorado River Operational Modeling and Decision-Making

This tool would allow users to explore how Reclamation uses models to make decisions regarding Colorado River Basin operations at various time scales. It would include background on the available modeling tools, as well as provide access to observed operations and model results.

Target Audience:

- Reclamation staff needing convenient access to observed data, model results in a user-friendly view
- External stakeholders who need convenient access to observed data and model results in a user-friendly view
- General public interested in Reclamation decision-making and forecasts

A. Exploration of Colorado River Operational Modeling and Decision-Making

Components:

- Text overview of Reclamation's Colorado River Basin models
- Dashboard for each model to view background information, model inputs, and model results that are relevant for decision-making at that time scale
    - Short-term
        - Current and projected river and reservoir conditions
        - Planned reservoir releases
        - Weather forecasts
    - Mid-term
        - Climate forecast
        - Current and forecasted snowpack and precipitation
        - Current and forecasted water supply
    - Long-term
        - Historical consumptive use
        - Projected future demands
        - Projected future climate
- Interactive map allowing users to click on sites to view observed and model data for the site
- Database query tool allowing users to view and download observed and model data for a particular site or set of sites
- Charts/graphics allowing comparison of model runs/scenarios

Data:

- River flow, stage
- Reservoir pool elevation, storage, inflow, releases
- Climate and weather forecasts
- Snowpack and precipitation
- Water supply forecasts (CBRFC, NRCS)
- Reclamation model projections: 24-month study, MTOM, CRSS

Notes:

- Lots of group excitement/support for this option
- Long time horizon to implement due to complexities associated w/opening Reclamation model data? Possible organizational sensitivities?
- Could utilize other tools under development (ArcGIS Online, Tessel, water.usbr.gov)

B. Near-Term Colorado River Conditions Viewer

This tool would allow users to view and explore current and short-term forecasted conditions for Colorado River Basin rivers and reservoirs

Target Audience:

- Recreational users of Colorado River Basin rivers and reservoirs
- Professional users of Colorado River Basin rivers and reservoirs, e.g. construction workers needing to do work in a riparian area or reservoir and scientists needing to do fieldwork in rivers or reservoirs

Components:

B. Near-Term Colorado River Conditions Viewer

- Interactive map allowing users to click on sites and view past, current, and short-term future river and reservoir conditions. Conditions would include river flow rates, river stages, reservoir releases, and reservoir elevations.
- Database query tool allowing users to view and download past, current, and short-term future river and reservoir conditions. Conditions would include river flow rates, river stages, reservoir releases, and reservoir elevations.
- Charts/graphics displaying river and reservoir conditions relative to relevant location, such as boat ramp elevations, rafting flow requirements, flood stages, and water intakes.

Data:

- River flow, stage,
- Reservoir pool elevation, storage, inflow, releases

Notes:

- Yuma Area Office has a graphical dashboard with this type of info, could serve as example
- Could utilize other existing tools (e.g., CRB Drought Viz Story Map), and those being developed (UC's water data query pages)
- Could utilize other tools under development (ArcGIS Online, Tessel, water.usbr.gov)

C. Learning About the Colorado River Basin

This tool would allow users to learn about Colorado River Basin geography, hydrology, policy and water operations.

Target Audience:

- General public
- Students (primary, secondary, college)
- New Reclamation employees

Components:

- Interactive Illustration of reservoir water balance to provide understanding of the interaction between hydrology and operational policy. Explain how inflows, diversions, evaporation, releases, operational tiers, etc determine how much water is in a reservoir.
- Story map of Colorado River Basin facilities and important hydrologic features (e.g. where snow accumulates, Colorado River Delta)
- Video/animated flyover of the Colorado River
- Interactive graphical explanation of the Law of the River
    - Flow chart of interim guidelines
    - Timeline of significant laws, regs, policies, river developments relative to supply/demand
- Interactive map/graphic showing users where their water comes from

Data:

- River flow, stage,
- Reservoir pool elevation, storage, inflow, releases
- Climate and weather forecasts
- Snowpack and precipitation
- Water supply forecasts

C. Learning About the Colorado River Basin

- Water entitlements, consumptive use, water user locations
- Law of the River components

Notes:

- Probably not organizationally sensitive
- Lots of narrative info that could be used to create graphical info
- Limited internal application?
- Could use existing tools (e.g., CRB Drought Viz Story Map, water user map)
- Could utilize other tools under development (ArcGIS Online, Tessel, water.usbr.gov)

D. Colorado River Basin Dictionary/Glossary

This tool would help users understand terminology related to the Colorado River Basin such as “natural flow”, “observed flow”, “consumptive use”, “shortage”, “forecast”, “projection”, and “paleo reconstructed streamflow”.

Target Audience:

- Reclamation staff
- External Colorado River Basin stakeholders
- General public
- Students

Components:

- Searchable list of terms
- Text definitions of terms and links to supporting documentation
- Graphical illustration of terms

Data:

- N/A

Notes:

- This tool would not directly use open data, but would support the use of open data. It could be incorporated as a component of other tools
- Could be considered a foundational element for many of the other tools

E. Colorado River Basin Interactive Reports

This tool would allow users to interactively explore official Reclamation operational projections, reports, and operational information.

Target Audience:

- Reclamation managers
- External stakeholders

E. Colorado River Basin Interactive Reports

- General public

Components:

- Interactive versions of official Reclamation reports/publications, including graphics and ability to download data.
    - 24-month study reports
    - Colorado River Basin Study
- Toggle for display in either US or metric units
- Standardized, auto-generated 1-page summary of current operational conditions and most recent projections that can be viewed online and printed for use in meetings
- Standardized, auto-generated graphics for use in presentations
- Interactive graphical display of current conditions
- Interactive map display of current conditions

Data:

- 24-month study projections
- CRSS projections
- River flow, stage
- Reservoir pool elevation, storage, inflow, releases
- Climate and weather forecasts
- Snowpack and precipitation
- Water supply forecasts
- Historical and projected water use?
- Water quality data?

Notes:

- More informational than analytical
- Pretty close to one-stop-shop for CR data
- Could require intensive work to prioritize key messages and convert high-priority materials to graphical format
- Similar purpose to System Status presentations that are currently emailed by BCOO
- Could utilize other tools under development (ArcGIS Online, Tessel, water.usbr.gov)

F. Colorado River Basin Drought Impacts Explorer

This tool would allow users to explore the impacts of drought on the Colorado River Basin

Target Audience:

- Reclamation staff/managers needing information about drought impacts
- External stakeholders needing information about drought impacts
- General public

Components:

- Definition of drought
- Graphical description of current drought
    - Relative to historical hydrology
    - Relative to paleo hydrology

F. Colorado River Basin Drought Impacts Explorer

    - Relative to climate change projections
- Climate and weather projections for near future
- Map display of areas that dry out during drought
- Map displaying change in land-use/cover over time
- Map showing impacts to groundwater aquifers
- Graphical exploration of drought impacts on riparian areas and water quality, including ecosystem makeup, phytoplankton/zooplankton communities, algal blooms, dissolved oxygen concentrations
- Interactive map showing wildfire risk related to drought, and impacts of wildfire on water quality and soil erosion
- Map or graphic showing changes in water use related to drought, such as wells that dry up

Data:

- Natural flow (observed, paleo)
- Climate change projections
- Groundwater data (wells, GRACE, etc)
- Ecological/water quality data
- Fire data
- Land usage/cover
- LCRAS data - changes in cropping patterns

Notes:

- Potential tool for policy makers
- Could expand on existing CRB Drought Viz
- Could utilize other tools under development (ArcGIS Online, Tessel, water.usbr.gov)

G. Colorado River Basin Water Quality Tool

This tool would allow users to explore water quality in the Colorado River Basin

Target Audience:

- Reclamation staff/managers needing information about water quality
- External stakeholders needing information about water quality
- General public

Components:

- Water quality database and data portal for cataloging and accessing water quality data, including map-based, and query interfaces for finding data
- Graphical interactive tool allowing users to explore impacts of changing lake levels on water quality (temperature, salinity, dissolved oxygen, microbes, and contaminants)
- Graphical display allowing users to explore how water quality parameters have changed over time for a site or waterbody

Data:

- River temperature, salinity, dissolved oxygen, microbes, and contaminants
- Lake/reservoir temperature, salinity, dissolved oxygen, microbes, and contaminants
- River flow, stage,

G. Colorado River Basin Water Quality Tool

- Reservoir pool elevation, storage, inflow, releases

Notes:

- Could be both politically sensitive as well as desirable to the public (Gold King mine spill)
- CR water quality hasn't been much explored in data visualizations
- Connecting water quality datasets would entail working with a variety of data owners
- Could utilize other tools under development (ArcGIS Online, Tessel, water.usbr.gov)

H. Colorado River Basin Water Demand and Use Explorer

This tool would allow users to explore water demand and use in the Colorado River Basin. It would allow users to look at where and how water is used, historical water use, current water use, and projected future demands. It would allow users to explore Reclamation's water accounting calculations and retrieve data, and explore the differences in how Reclamation and USGS report water use.

Target Audience:

- Reclamation staff needing information about water use and demands
- Reclamation managers needing information about water use and demands
- External stakeholders needing information about water use and demands
- General public

Components:

- Map display of land use and land cover data, with ability to show change over time
- Map display of population and demographic data allowing users to explore M&I demands and conservation needs
- Interactive maps and graphics for water accounting reports, including analysis of water users over time, locations of water users, historical use, forecasted use, contracted rights
- Portal for viewing and downloading water use and accounting data

Data:

- Water user locations
- Water entitlements
- Historical consumptive use
- USGS water use statistics
- Projected future demands
- Water accounting reports
- Irrigated acreage
- Points of diversion

Notes:

- Could be a tool to explore/explain the differences between how BOR & USGS report use

I. Colorado River Basin Water Supply and Demand Planning Explorer

This tool would allow users to explore long-term supply and demand projections for the Colorado River Basin and test options for balancing supply and demand in the future.

Target Audience:

- General public, particularly those interested in future water supply in the Colorado River Basin
- External Reclamation stakeholders interested in water supply and demand options

Components:

- Portal for viewing, graphing, downloading Colorado River Basin Study/CRSS inputs and results
- Interactive "option selection" tool for exploring how water supply and demand options affect the water balance
- Possible scenario explorer like Denver Water's Dillon Reservoir game

Data:

- Historical consumptive use
- Projected future demands
- Projected future climate
- CRSS model runs of future supply/demand scenarios and options

Notes:

- Could potentially use the updated Basin Study info being generated by using the CMIP5 projections

Preferred Alternative Tool Concept

Preferred Alternative: Dashboard for Historical and Near Term Future Water Operations Information

This tool would allow users to explore Colorado River Basin water operations, with a focus on past operations and on near-term future projections (0-2 years). It would provide:

- Basic background information about the Colorado River Basin, including facilities and Law of the River.
- Access to the observed and modeled data that Reclamation uses to make operational decisions via maps and data download tools.
- Information in graphical formats and interactive reports that can be used by management or provided to stakeholders in place of paper reports, emails, or PDF documents.

Target Audiences:

Internal

- New Reclamation employees
- Reclamation staff needing convenient access to historical use, observed data and model results in a user-friendly view
- Reclamation managers who need standardized, easy to access and understand information about CRB operations

External

- External stakeholders who need convenient access to historical use, observed data and model results in a user-friendly view
- General public interested in Reclamation operations, accounting decision-making, and operational projections
- Students (primary, secondary, college)
- Academic/Research Community

Critical Components:

Data Viewing and Download

- Dashboard to view data and reports
    - Historical
        - Historical observed river and reservoir conditions
        - Historical water use by entitlement holders
        - Observed water use
    - Current Conditions
        - Current river and reservoir conditions
        - Diversions and water use to date
    - Operational plans and forecasts (0-10 days)
        - Forecasted river and reservoir conditions
        - Planned reservoir releases
        - Weather forecasts
    - Short-term Projections (0-2 years)
        - Climate forecast
        - Daily end of year water use forecast
        - Current and forecasted snowpack and precipitation
        - Current and forecasted water supply
        - Projected operations
        - Forecasted water use
        - Charts/graphics allowing comparison of various projections and observed data

Preferred Alternative: Dashboard for Historical and Near Term Future Water Operations Information

- Database query tool allowing users to view and download observed, forecast and model data (river, reservoir, water use) for a particular site or set of sites
- Toggle in dashboard view for display in either US or metric units

Background Information

- Text overviews of
  - Reclamation's short-term Colorado River Basin model (24-month study)
  - Reclamation's Part 417, Forecasting and Accounting functions
- Basic explanation of how the system works - concise for understanding the data

Reports and Summaries

- Reports that we currently produce - the PDF reports - 24-month study, system status, water use and accounting, Yuma groundwater maps
- Get the data for the reports that we already produce-- get the downloadable data for those reports

High Value Components

Data Viewing and Download

- Interactive map allowing users to click on dams, water user polygons, and flow measurement sites to view observed and model data (river, reservoir, water use) for the site
- Toggle for display in either US or metric units

Background Information

- Colorado River Basin Dictionary/Glossary
  - Searchable list of terms
  - Text definitions of terms and links to supporting documentation
  - Graphical illustration of terms
- Further explanation of how the system works - Interactive illustration of reservoir water balance to provide understanding of the interaction between hydrology and operational policy. Explain how inflows, diversions, evaporation, releases, operational tiers, etc determine how much water is in a reservoir.
- Story map of Colorado River Basin facilities and important hydrologic features (e.g. where snow accumulates, major dams, Colorado River Delta)

Reports and Summaries

- Interactive versions of official Reclamation reports/publications, including graphics and ability to download data.
  - 24-month study reports
  - System status presentations
  - Water Use and accounting
  - Annual Operating Plans (?)
  - Interactive versions of Yuma groundwater maps
- Standardized, auto-generated graphics of observed operations and most recent projections for use in presentations
- Standardized, auto-generated 1-page summary of water use/ water accounting report, including analysis of water users over time, locations of water users, historical use, forecasted use, contracted rights

Preferred Alternative: Dashboard for Historical and Near Term Future Water Operations Information

- Standardized, auto-generated 1-page summary of current operational conditions and most recent projections that can be viewed online and printed for use in meetings

Other Components

Background Information

- Interactive graphical explanation of the Law of the River
- Flow chart of interim guidelines
- Timeline of significant laws, regs, policies, river developments relative to supply/demand

Data:

- USGS River Gages
- USGS Reservoir Gages
- LC River gages - Observed parameters: river flow, stage
- UC River gages - Observed parameters: river flow, stage
- YAO River gages
- UC Reservoir gages - Obs. parameters: reservoir pool elevation, storage, inflow, releases
- LC Reservoir gages - Obs. parameters: reservoir pool elevation, storage, inflow, releases
- YAO Reservoir gages - Obs. parameters: reservoir pool elevation, storage, inflow, releases
- CBRFC Ensemble Streamflow Predictions (ESP) traces
- NRCS: water supply volume forecasts
- NWS: weather forecasts of precip and temperature and snow for CRB
- NRCS SNOTEL data
- Reclamation model operations projections: 24-month study
- Historical consumptive use
- Forecasted water use: Yuma Groundwater maps: groundwater model data and GIS basemaps

Notes:

- Combines aspects of Synthesized Concepts A, B, C,D, E, and H
- Can utilize materials/apps already under development elsewhere in Reclamation

Appendix C – Dataset Catalog

Short Description	Release Status	Release Timing	Organizational Group	Ease of Making Open	Value for Tool	Internal or External	Screening Recommendation	Comments/Notes/Descriptive Info
Boat ramp locations and elevations on the Colorado river mainstem and tributaries	Unknown	Future	N/A (External)	N/A (External)	Low	External	Not Screened	Lake Mead and Lake Mohave Work with NPS (these shorelines are part of the Lake Mead National Recreation Area). Lake Havasu, work with USFWS, the state of Arizona, the state of California, and Lake Havasu City.
CBRFC forecast data - daily ESP results	Released by External Agency	N/A	N/A (External)	N/A (External)	Low	External	N/A (External)	Ensemble Streamflow Prediction (ESP) is a hydrologic modeling system used by the CBRFC. To project future river flow and reservoir inflow conditions. The modeling system applies 30 equally possible future climatological conditions to current hydrological conditions to produce 30 equally possible river flow or reservoir inflow conditions at specific forecast points within the CRB. The CBRFC uses this modeling system to produce a variety of statistical forecast products to describe future hydrologic conditions at specific forecast points within the CRB. For many of these forecast points, CBRFC has set up online data portals that are updated daily indicating how ESP results are changing through time as actual weather conditions occur. ESP updates are useful for tracking and predicting how future inflow forecasts for CBR reservoir may change.
CBRFC Official Water Supply Forecasts	Released by External Agency	N/A	N/A (External)	N/A (External)	Medium to High	External	N/A (External)	The CBRFC official water supply forecasts are volumes of unregulated inflow forecasted to flow into the mainstem CRB reservoirs during the period from April 1st to July 31st. This period is referred to as the water supply season. We receive official forecasts beginning January (at the beginning of the month) and these updated each month through July. Official forecasts issued at the beginning of each month are updated mid-month. Reclamation only uses the official forecasts in it modeling runs for the 24-Month Study.
CHIRPS (Climate Hazards Group InfraRed Precipitation with Station) data	Released by External Agency	N/A	N/A (External)	N/A (External)	N/A (External)	External	N/A (External)	Precipitation Also available via Google Earth Engine (Cloud)

Short Description	Release Status	Release Timing	Organizational Group	Ease of Making Open	Value for Tool	Internal or External	Screening Recommendation	Comments/Notes/Descriptive Info
Colorado Basin River Forecast Center (CBRFC) ESP Forecast Traces for the Colorado River Mid-Term Operations Model.	Released by External Agency	N/A	N/A (External)	N/A (External)	Medium	External	N/A (External)	This link is maintained by the CBRFC at this link and updated monthly. Old traces are not saved online. Reclamation receives 35 unregulated inflow scenarios each month that have equal probabilities of occurrence based on potential future weather and climate conditions. These 35 unregulated inflow scenarios make up the hydrological universe for Reclamation's Colorado River Mid-Term Operational Model (MTOM). The MTOM model provides 35 equally probable potential operational conditions for the CRB reservoir system looking into the future. From this data Reclamation can provide the probabilities of specific conditions occurring over a 5-year future period. These forecasts and MTOM data is updated monthly.
Colorado River Consumptive use and loss reports - LC	Not Yet Released	Future	Denver / LC-4200	Hard	Low to Medium	Internal	Not Screened	N/A
Colorado River Consumptive use and loss reports - UC	Not Yet Released	Round 2 for UC Phase 1 Round 3 for LC Phase 1	Denver / LC-4200	Hard	Low to Medium	Internal	Not Screened	These reports reflect the Department of the Interior's best estimate of actual consumptive uses and losses for each year within the Colorado River Basin. The reliability of the estimates is affected by the availability of data and the current capabilities of data evaluation. The reports include a breakdown of the beneficial consumptive use by major types of use (except mainstream reservoir evaporation), by major tributary streams, and, where possible, by individual States.
Daily model data for Hoover Dam, Davis Dam, and Parker Dam release and elevation projections	Released (as part of project)	Round 1	LC-4600	Easy	Critical	Internal	Release with mitigation	Daily projections for end-of-day reservoir elevation and average daily release from Lake Mead, Lake Mohave, and Lake Havasu for present to 30 days in the future. Projections are updated daily.
Decree - ICMA / deferred water	Not Yet Released	Round 2	LC-4200	N/A (External)	High	Internal	N/A (External)	Intentionally Created Mexican Allocation (ICMA) and other water deferred by Mexico and stored in Lake Mead - yearly balances as recorded in the Water Accounting Reports.
Decree - Intentionally Created Surplus (ICS)	Released (as part of project)	Round 1	LC-4200	Medium	High	Internal	Release	Intentionally Created Surplus (ICS) yearly balances for Lower Basin states and individual water users as recorded in the Water Accounting Reports.
Decree - IOPP Total payback and remaining balances	Not Yet Released	Round 2	LC-4200	Medium	Medium	Internal	Not Screened	Inadvertent Overruns and Paybacks for Lower Basin water users - yearly balances as recorded in the Water Accounting Reports
Decree Accounting-Div/Return/CU data (final report)	Released (as part of project)	Round 1	LC-4200	Medium	Critical	Internal	Release	Lower Basin Water Accounting Data; includes diversions, return flows, and consumptive use. Currently, 2003 -present is available. Additional years as far back as 1993 may soon become available.
Drought monitor	Not Released by External Agency	Future	N/A(External)	N/A (External)	Low	External	N/A (External)	Graphical view of current drought conditions in the Colorado River Basin, provided by the National Integrated Drought Information System (NIDIS)

Short Description	Release Status	Release Timing	Organizational Group	Ease of Making Open	Value for Tool	Internal or External	Screening Recommendation	Comments/Notes/Descriptive Info
Estimates of Evapotranspiration and Evaporation Along the Lower Colorado River – acreage and water use	Not Yet Released	Round 2: Do 2010-2011, and maybe 2012	LC-4200	Hard	Low	Internal	Not Screened	The "Estimates of Evapotranspiration and Evaporation Along the Lower Colorado River" report provides estimates of annual agricultural, riparian vegetation, and open water acreages and water uses along the lower Colorado River from Hoover Dam to the Southerly International Boundary with Mexico. Reclamation has reported this data since 1995, in reports previously called the “Lower Colorado River Accounting System (LCRAS) Evapotranspiration and Evaporation Calculation. Beginning with the 2009 report, Reclamation reformatted the report to provide a more user-friendly product.
ET stations - California and AZ	Released by External Agency	N/A	N/A (External)	N/A (External)	Medium	External	N/A (External)	N/A
ET stations - DRI	Released by External Agency	N/A	LC-4200	N/A (External)	Medium	External	N/A (External)	N/A
Flow arriving at Imperial Dam	Not Yet Released	Future	LC-YAO	Easy	Medium	Internal	Not Screened	Data on inflows arriving at Imperial Dam in the Lower Colorado River. Example is a PDF screenshot of a dashboard currently only accessible within the Reclamation network. Example of dataset provided.
Forecasted water use	Not Yet Released	Round 2	LC-4200	Medium	High	Internal	Not Screened	Forecasted water use in the Lower Colorado Basin, updated every business day and posted to the web as a pdf. The example file provides the data for the first 6 charts for days throughout the year that the forecast was run. The first column is the date the forecast was run. The next columns are daily forecasted end of year consumptive use values in Acre-Feet for their respective charts in the PDF 2016 report.
Gridded Climate Data	Released by External Agency	N/A	N/A (External)	N/A (External)	Low	External	N/A (External)	A variety of geographic datasets pertaining to climate variables of interest. Data sets provided by the Earth Systems Research Laboratory.
Groundwater - salinity manually collected and reported in HDB	Not Yet Released	Future	LC-YAO	Easy	High	Internal	Not Screened	https://www.ibwc.gov/EMD/reports_studies.html#Salinity
Groundwater - SCADA / hourly/daily flow data that goes to HDB	Not Yet Released	Future	LC-YAO	Easy	High	Internal	Not Screened	TBD-further internal discussion needed https://www.usbr.gov/lc/yuma/programs/YAWMS/SCADA.html
Groundwater basemaps (data, shapefile)	Not Yet Released	Round 2	LC-YAO	Medium	High	Internal	Not Screened	GIS data (shapefiles) and groundwater data in the lower Colorado River basin near Yuma, AZ
Historical and Real Time IBWC Data (NIB, SIB, others)	In Progress by External Agency	Round 2	N/A (External)	N/A (External)	High	External	N/A (External)	N/A
Hourly model data for Davis Dam and Parker Dam release and energy projections	Released (as part of project)	Round 1	LC-4600	Easy	High to Critical	Internal	Release with mitigation	Hourly projections for average release and total energy generation at Davis and Parker Dams for 3 days. Projections are updated daily.

Short Description	Release Status	Release Timing	Organizational Group	Ease of Making Open	Value for Tool	Internal or External	Screening Recommendation	Comments/Notes/Descriptive Info
IBWC Data (NIB) - data that they post online (real-time)	In Progress by External Agency	Round 2	N/A (External)	N/A (External)	High	External	N/A (External)	N/A
IBWC Mexico data (Morelos, other gages in Mexico, collected by Mexican IBWC)	Not Yet Released	Future	N/A (External)	N/A (External)	Low	External	Not Screened	N/A
IBWC River Gage Data	Released by External Agency	N/A	N/A (External)	N/A (External)	High to Critical	External	N/A (External)	N/A
Landsat remote sensing data	Released by External Agency	N/A	N/A (External)	N/A (External)	N/A (External)	External	N/A (External)	Land surface temperature, vegetation, snow, water Also available via Google Earth Engine (Cloud)
LC Reservoir Data	Released (as part of project)	Round 1	LC-4800	Easy	High	Internal	Release with mitigation	Observed reservoir data for mainstream reservoirs. Provisional real-time data is available through Web Reports. Final approved data is available in PDF from Lower Colorado River Historical Stream Flow Reports page.
LC River gages	Released (as part of project)	Round 1	LC-4800	Easy	High	Internal	Release with mitigation	Observed river gage data along the lower Colorado River. Web Reports contains provisional data. Final data for river stage and flow can be found in the linked PDF reports.
LC: USBR calculated inflow for major reservoirs - regulated inflow	Not Yet Released	Round 2	LC-4600	Medium	High	Internal	Release with mitigation	One year of historical monthly data and two years of projected monthly data are included in the 24MS pdf report for major reservoirs. Additional historical data are available in HDB. http://www.usbr.gov/lc/region/g4000/24mo.pdf
LC: USBR evaporation datasets - estimated on monthly timestep	Not Yet Released	Round 2	LC-4600	N/A (External)	Medium	Internal	Release with mitigation	Data is written to HDB on a monthly basis. It appears as a column in the Mead, Mohave, and Havasu in 24 month study as 12 months of historic data. Currently have ~40 years of historic data in HDB.
MODIS remote sensing data	Released by External Agency	N/A	N/A (External)	N/A (External)	N/A (External)	External	N/A (External)	Land surface temperature, vegetation, snow, water Also available via Google Earth Engine (Cloud)
MSCP microclimate data and populations of endangered species or invasives - MSCP survey data	Unknown	Future	LC-MSCP	Hard	Low	Internal	Not Screened	N/A
Natural flow data	Unofficially Released (Pre-Project)	Round 2	UC-430 / LC-4600 / Denver / Boulder CO	Easy to Medium	High	Internal	Not Screened	Natural flow at a specific location is defined as what would flow past that location if there was no human influence on the hydrologic system. For a specific location, natural flow is the observed flow adjusted for all upstream change in storage in man-made reservoirs , all upstream reservoir evaporation in manmade reservoirs and all upstream human based consumptive use and loss of water. While observed flows are collected in real time, and reservoir storage and evaporation are easily retrieved, human based consumptive use and loss is very difficult to measure. Often times, it takes several years to collect the data required to estimate human based consumptive use and loss. For this reason, natural flow datasets lag by 3-5 years behind the current year.
NWS: weather forecasts of precip and temperature and snow for CRB	Released by External Agency	N/A	N/A (External)	N/A (External)	Low to Medium	External	N/A (External)	N/A

Short Description	Release Status	Release Timing	Organizational Group	Ease of Making Open	Value for Tool	Internal or External	Screening Recommendation	Comments/Notes/Descriptive Info
Observed Temperature and Precipitation	Released by External Agency	N/A	N/A (External)	N/A (External)	Low	External	N/A (External)	Observed Temperature and Precipitation data provided by the Climate Prediction Center (CPC)
Operational water use schedules in the 24-Month Study	Not Yet Released	Round 2: Do the six water users plus Mexico that are in the PDF report	LC-4600 / UC - 430	Medium	Low to Medium	Internal	Not Screened	Monthly operational diversion schedules for select water users in the upper and lower basins that are included in the 24-Month Study report. For LC: SNWA water use schedules ("SNWP Use") are on page 11 of the report and MWD, CAP, and Mexico water use schedules ("MWD Diversion", "CAP Diversion", and "Flow to Mexico", respectively) are on page 13. For UC: Azotea and NIIP on page 9 and Tunnel diversions are on page 7.
Phoenix Area Office data sets	Unknown	Future	LC-PXAO	Hard	Low	Internal	Not Screened	Will need to determine what datasets Phoenix Area Office has and would be interested in making open
Pilot System Conservation Program	Not Yet Released	Future	LC-4200 / LC-4600 / LC-4400	Easy to Medium	Medium	Internal	Not Screened	Data pertaining to the Pilot System Conservation Program in the lower basin. Data includes conserved water volumes and other related data.
Populations of endangered species or invasives - MSCP survey data	Unknown	Future	LC-MSCP	N/A (External)	Low	Internal	Not Screened	N/A
PRISM Datasets	Released by External Agency	N/A	N/A (External)	N/A (External)	Low	External	N/A (External)	http://www.prism.oregonstate.edu/ Climate observations which incorporate a variety of modeling techniques and are available at multiple spatial/temporal resolutions, covering the period from 1895 to the present.
Projected daily releases based on requests (spreadsheets) from Western	Keep Internal	Do Not Release	UC-94000	Hard	High	Internal	Not Screened	N/A
SCAO reuse project Title XVI	Unknown	Future	LC-SCAO	Hard	Low	Internal	Not Screened	N/A
Seasonal snowpack Observed snow and SWE from NRCS SNOTEL sites	Released by External Agency	Round 1	N/A (External)	N/A (External)	High	External	N/A (External)	The Natural Resources Conservation Service (NRCS) maintains a network of snow measurement stations throughout the West. These stations provide real time snowpack conditions at 100s of locations where snowpack accumulates during the winter months. This data is a primary indicator for future potential inflow conditions into CRB reservoirs during the runoff season.
Spatial precipitation and temperature forecasts provided by the CBRFC	Released by External Agency	N/A	N/A (External)	N/A (External)	Critical	External	N/A (External)	N/A
SRP reservoir data (in basin but outside of mainstem)	Not Released by External Agency	Future	LC-PXAO	Easy	Low	Internal	Not Screened	Available online in non-machine-readable format now
Surface Water Salinity reports	Not Yet Released	Round 2	LC-YAO			Internal	Not Screened	Data on surface water salinity in the lower Colorado River
Surface Water Salinity reports (Lake salinity data, Blythe crew collected) [ec, tds below hoover, parker]	Unknown	Future	LC-RMO	Medium	Low	Internal	Not Screened	N/A

Short Description	Release Status	Release Timing	Organizational Group	Ease of Making Open	Value for Tool	Internal or External	Screening Recommendation	Comments/Notes/Descriptive Info
The 24-Month Study Report - Monthly model data for UC and LC operations (Reclamation's official projection of future operations of the CRB reservoir system)	In Progress	Round 1 - Current Study Future - Additional Past Studies	UC-94000 / LC-4600	Medium	Critical	Internal	Release with mitigation	The 24-Month Study Report describes Reclamation's most likely future operations of the CRB reservoir system. Reclamation receives CRB reservoir unregulated inflow forecasts from the CBRFC which are then extended to 24-32 months per the inflow matrix (see data set #39). Reclamation uses these extended inflow scenarios in the 24-Month Study Model by routing them through the modeled CRB reservoir system. Reclamation applies all environmental and resource management policies for each reservoir to project future reservoir release conditions over a 24-32 month future time horizon. The 24-Month Study Model provides a consolidated outlook of the CRB reservoir and river conditions over this future time horizon. The 24-Month Study Model and Report are updated monthly.
U.S. Army Corps of Engineers (USACE) reservoir data for Alamo (Bill Williams River) and Painted Rock (lower Gila River)	Released by External Agency	N/A	N/A(External)	N/A (External)	Low	External	N/A (External)	Reservoir elevation, storage, and release data for Alamo Dam and Painted Rock Dam, flood control facilities operated by the U.S. Army Corps of Engineers. Releases from these facilities provide inflow into the Colorado River system via lower basin tributaries. Painted Rock reservoir is usually empty and receives inflow only rarely (i.e., it's occurred only 4-5 times since 1990).
UC 24-Month Study Inflow Matrix	Keep Internal	Do Not Release	UC-94000 / LC-4600	Hard	Low	Internal	Not Screened	This matrix describes how Reclamation interfaces forecasts provided by the CBRFC, with statistical unregulated inflow data to create 24-32 month inflow scenarios which are modeled in the 24-Month Study
UC critical operations data Pearson statistics - unregulated inflow data statistics which get used to build scenarios for 24 month study to extend forecast from CBRFC out to 24-32 months	Not Yet Released	Future	UC-94000	Easy	Low	Internal	Not Screened	Reclamation does not publish these but do provide them as excel spreadsheets upon request. Links at left are to Vallecito, Taylor Park and Navajo. All mainstem CRB reservoir statistics are uploaded to: https://drive.google.com/open?id=0B6hTV59UOTP1S2JpMWtaejd2cTg These spreadsheets represent the official inflow or unregulated inflow statistics for the major Upper Colorado River reservoirs. They are based on 30 water years of data from 1981 through 2010. Every 10 years these are updated so that the most recent 3 completed decades are used in the generation of the statistics. For example after water year 2020 is complete Reclamation will recompute our statistics based on the period from 1991 through 2020. This is one way in which Reclamation adopts changing climate conditions because only the most recent 3 decades are used in the statistics that are used in our hydrological outlooks. The term unregulated inflow is based on the observed inflow adjusted for upstream change in reservoir storage and upstream evaporation. This unregulated inflow is what would flow into the reservoir if upstream reservoirs did not exist. We only account for major upstream reservoirs
UC daily or hourly models	Keep Internal	Do Not Release	UC-94000	Easy to Medium	Medium to High	Internal	Not Screened	N/A

Short Description	Release Status	Release Timing	Organizational Group	Ease of Making Open	Value for Tool	Internal or External	Screening Recommendation	Comments/Notes/Descriptive Info
UC Reservoir Data	Released (as part of project)	Round 1	UC-94000	Easy	Critical	Internal	Release with mitigation	These datasets are the basic parameters Reclamation collects and maintains for all reservoirs in the Upper Colorado Basin (i.e. above and including Lake Powell). Datasets are either measured through gaging systems or computed from other measured data parameters. For several smaller reservoirs evaporation is assumed to be insignificant and is therefore omitted. The UC Historical Data Application, while menu driven, can be used to create URLs which can be saved and modified for automated data retrievals.
UI METDATA/gridMET (Surface meteorological dataset based on PRISM and NLDAS-2)	Released by External Agency	N/A	N/A (External)	N/A (External)	N/A (External)	External	N/A (External)	Temperature, precipitation, relative humidity, specific humidity, solar radiation, potential ET, near surface wind velocity Also available via Google Earth Engine (Cloud)
USBR Lower Basin real-time diversion and return flow gages	Not Yet Released	Round 2	LC-4800	Easy	High	Internal	Not Screened	N/A
USGS Lake Mead evaporation dataset	Released by External Agency	N/A	N/A(External)	Hard	Low	Internal	N/A (External)	Report and data from Phase 1 of a U.S. Geological Survey (USGS) study on Lake Mead evaporation.
USGS Lower Basin real-time diversion and return flow gages	Released by External Agency	N/A	N/A(External)	N/A (External)	High	External	N/A (External)	These are the USGS sites that accounting uses.
USGS NWIS Gages	Released by External Agency	N/A	N/A(External)	N/A (External)	High	External	N/A (External)	Data provided via the USGS National Water Information System
USGS-Remote Sensing derived Consumptive Use (SSEBop) - Field or Regional scale ET ranges	Released by External Agency	N/A	N/A(External)	N/A (External)	Low	External	N/A (External)	N/A
Water contracts	Not Yet Released	Future	LC-4400	Easy to Medium	Low	Internal	Not Screened	http://www.usbr.gov/lc/region/g4000/contracts/entitlements.html
Water entitlement holder boundaries	Not Yet Released	Round 2	LC-4200	Not determined	Not Determined	Internal		GIS boundaries of entitlement holders.
Water quality data (sediment)	Unknown	Future	RMO / Seth / Hong	Hard	Low	Internal	Not Screened	Suspended solids data. Collected by RMO and Blythe (on behalf of Yuma)
Weather forecast data	Released by External Agency	N/A	LC-4600 / UC-94000 / YAO	N/A (External)	Critical	External	N/A (External)	Suggested forecast points, provided by the National Weather Service (NWS): Upper Basin - Fontenelle, Flaming Gorge, Upper Colorado Mainstem, Aspinal, Navajo, Powell near Glen Canyon Dam Lower Basin - Mead near Hoover Dam, Mohave, Havasu, Imperial Dam, Imperial Valley

Short Description	Release Status	Release Timing	Organizational Group	Ease of Making Open	Value for Tool	Internal or External	Screening Recommendation	Comments/Notes/Descriptive Info
YAO hourly model projected flows at gaged points on river	Not Yet Released	Do Not Release	LC-YAO	N/A (External)	High to Critical	Internal	Not Screened	N/A
YAO Reservoir Data	Not Yet Released	Round 2	LC-YAO	Easy	High	Internal	Not Screened	Reservoir elevation, storage, and release data for Imperial Dam, Senator Wash, and Brock Reservoir, facilities operated by the Lower Colorado Region, Yuma Area Office (YAO).
YAO River Gage Data	Released (as part of project)	Round 1	LC-YAO	Easy	Critical	Internal	Yes with mitigation	River gage data for sites on the lower Colorado River operated by the YAO, including Martinez Lake and Picacho

Appendix D – Screening Process

Dataset Screening Process and References

Compiled August 2016

This document provides background references about open data and outlines the topics that will be discussed during the screening meeting. Screening meeting participants are responsible for reviewing and understanding the information in the references that correspond to their role(s) prior to the screening meeting.

Background Information

General: Background on open data and screening	***Responsibility:*** All
Executive Order 13642 Making Open and Machine Readable the New Default for Government Information	Web Link
OMB Memo 13-13 Open Data Policy-Managing Information as an Asset	Drive Link
National Strategy for Information Sharing and Safeguarding	Drive Link
Project Open Data Implementation Guide	Web Link

Screening Process

During the Screening Meeting, discuss each of the following topics for each dataset being screened.

1. ***Sufficient Quality:*** Are there any concerns about the accuracy/quality of the data? Describe any mitigation actions needed.	***Responsibility:*** Data Stewards
Bureau of Reclamation Quality of Information Guidelines	Web Link
DOI Information Quality Guidelines	Web Link

	OMB Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by Federal Agencies	Web Link
2. Proprietary: Is any of the data in any way proprietary? Are there any laws, regulations, or policies prohibiting release of the data? Do contractual/data ownership issues arise from sharing the data? Describe any mitigation actions needed.		***Responsibility:*** Data Stewards
	Reclamation Manual SLE 02-01 (Identifying and Safeguarding For Official Use Only [FOUO] Information)	Web Link
	National/Homeland Security and Privacy/Confidentiality Checklist and Guidance	Web Link
3. FOIA: Is any of the data exempt from release under FOIA regulations?		***Responsibility:*** Privacy/FOIA
	What Is FOIA?	Web Link
	FOIA Exemption List	Web Link
4. Privacy: Will releasing the data have any privacy/confidentiality implications?		***Responsibility:*** Privacy/FOIA
	OMB Memo 11-02 Sharing Data while Protecting Privacy	Drive Link
	National/Homeland Security and Privacy/Confidentiality Checklist and Guidance - Part B	Web Link
5. Physical Security: Does sharing this data cause any risks/threats to Reclamation's physical infrastructure? Describe any mitigation actions needed.		***Responsibility:*** Physical Security
	National/Homeland Security and Privacy/Confidentiality Checklist and Guidance - Part A	Web Link
	Reclamation Operational Security Information *OPSEC 5-Step Process* *Properly Identifying and Labeling Sensitive Information*	Drive Link

	Distributing Sensitive Information	
	Reclamation Information Security Topic Classifications	Drive Link
	Reclamation Manual SLE 02-01 (Identifying and Safeguarding For Official Use Only [FOUO] Information)	Drive Link Web Link
6. IT Security: Does sharing this data cause any risks/threats to Reclamation's information security? Describe any mitigation actions needed.		***Responsibility:*** IT Security
	National/Homeland Security and Privacy/Confidentiality Checklist and Guidance - Part A	Drive Link Web Link
	Reclamation Operational Security Information *OPSEC 5-Step Process* *Properly Identifying and Labeling Sensitive Information* *Distributing Sensitive Information*	Drive Link
	Reclamation Information Security Topic Classifications	Drive Link
	Reclamation Manual SLE 02-01 (Identifying and Safeguarding For Official Use Only [FOUO] Information)	Drive Link Web Link
7. Public Affairs: Does sharing this data raise any concerns related to public affairs, such as communication questions or political sensitivities? Describe any mitigation actions needed.		***Responsibility:*** Public Affairs
	DOI Social Media Policy	Drive Link Web Link
	DOI Information Quality Guidelines	Drive Link Web Link

8. Mosaic effect: Mosaic/Aggregation/Compilation Risk Assessment. Would a person who exercises average care, skill, and judgment be able to identify or exploit privacy or security risks associated with the dataset?		***Responsibility:*** All
	Article: Beware the Mosaic Effect	Drive Link Web Link
	Report: Minimizing Disclosure Risk in HHS Open Data Initiatives	Drive Link Web Link

Appendix E – Metadata Schemas

Table 1-E. Record (Series) Metadata Schema

Record (Series) Metadata Element Name	Metadata Element Label (Human-readable)	Metadata Element Description	Possible Values / Required format	Example (source data)
<title>	Title	Human readable name of the data series	Freeform text	Fontenelle Reservoir Regulated Inflow August 2016 24-Month Study Most Probable
<description>	Description	Human readable description of the data series	Freeform text	Regulated inflow for Fontenelle Reservoir as modeled in the August 2016 24-Month Study Most Probable
<modified>	Last Update	Most recent date on which the dataset was changed, updated or modified.	YYYY-MM-DD HH:MM:SS	2016-08-05 12:15:00
<siteID>	Site ID	The identifier for the site	Unique text for this particular site	Fontenelle
<siteDescription>	Description	The human readable description of the site	Freeform text	Fontenelle Reservoir
<state>	State	State in which the site is located	Two letter state name abbreviation	WY
<latitude>	Latitude	Latitude of the site	XXX.XXXX Latitude in decimal degrees	42.02XX
<longitude>	Longitude	Longitude of the site	XXX.XXXX Longitude in decimal degrees	-110.04XX
<elevation>	Elevation	Elevation of the site	Site elevation in feet XXX.XXXX	Elevation at Hoover Dam

Record (Series) Metadata Element Name	Metadata Element Label (Human-readable)	Metadata Element Description	Possible Values / Required format	Example (source data)
<timeZone>	Time Zone	Time zone of the site	Name and UTC Offset of Time Zone	Mountain UTC – 7:00
<install>	Install	Date site started collecting data for this parameter	YYYY-MM-DD	1980-04-16
<horizontalDatum>	Horizontal Datum	The horizontal datum used for measuring site location	A valid geospatial datum	WGS84
<verticalDatum>	Vertical Datum	The vertical datum used for measuring site elevation	A valid geospatial datum	WGS84
<verticalAccuracy>	Vertical Accuracy	The accuracy (plus-or-minus) of the method used to generate the elevation value in feet	A valid number	10
<elevationMethod>	Elevation Method	The method used to measure the elevation of the site. Either specify measurement/surveying method or identify source.	Text	Google KMZ
<timeZoneOffset>	Time Zone Offset	Time zone offset from UTC-00	Value between -12 & +14	-7 for PST
<activeFlag>	Active Flag	Flag to signify whether the Record is active	Boolean value	True
<type>	Type	The type of physical feature, infrastructure element, or data collection station	Example Options: Reservoir Stream Canal	Reservoir

Record (Series) Metadata Element Name	Metadata Element Label (Human-readable)	Metadata Element Description	Possible Values / Required format	Example (source data)
			Agrimet Weather	
<responsibility>	Responsibility	The office that generated the data for this Record	Four letter official abbreviation for the Reclamation office that generated the record	BCOO
<agencyRegion>	Agency Region	The USBR region responsible for this Record	Two letter official abbreviation for the Reclamation region that generated the record	LC
<parameterID>	Parameter ID	This is a unique identifier for each parameter type	Generated by concatenating the rows below (timeInterval, statistic, & name)	Month.Inst.Reservoir Storage
<timeInterval>	timeInterval	The time interval between elements	Example Options: Calendar Year Water Year Month Day Hour 15-Minute	Month
<units>	Units	Units of the data element	Example Options AF ft cfs kWh	KAF
<statistic>	Statistic	Statistic used to aggregate data into elements	Example options: End-Of-Period Value (Instantaneous) Sum Average	Instantaneous

Record (Series) Metadata Element Name	Metadata Element Label (Human-readable)	Metadata Element Description	Possible Values / Required format	Example (source data)
			Mean Median Mode Standard Deviation 10-Day Running Average	
<name>	Public Parameter Name	The public name of the parameter.	Naming convention includes the object first and the data type after, such as, 'Canal Flow', where canal is the object and flow is the data type. A hyphen is included where more detail is needed to describe the data type, such as, 'Reservoir Release – Bypass', where bypass describes the type of reservoir release. Additionally, the first letter of each word in the names are capitalized. There may be situations where the name will not fit into this convention. In these cases, the name of the particular parameter can be developed at the individual's discretion. Example Options Reservoir Storage Volume Reservoir Elevation Streamflow Energy Generated	Reservoir Storage

Table 2-E. Dataset Metadata Schema

Dataset Metadata Element Name	Metadata Element Label (Human-readable)	Metadata Element Description	Possible Values/Required format	Example
<title>	Title	Human-readable name of the asset. Should be in plain English and include sufficient detail to facilitate search and discovery.	Freeform text	August 2016 24-Month Study Most Probable
<description>	Description	Human-readable description (e.g., an abstract) with sufficient detail to enable a user to quickly understand whether the asset is of interest.	Freeform text	The August 2016 24-Month Study is pursuant to the December 2007 Record of Decision on Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and Lake Mead (Interim Guidelines) and reflects the 2016 Annual Operating Plan (AOP). Pursuant to the Interim Guidelines, the August 2015 24-Month Study projections of the January 1, 2016, system storage and reservoir water surface elevations set the operational tier for the coordinated operation of Lake Powell and Lake Mead during 2016.
<keyword>	Tags	Tags (or keywords) help users discover your dataset; please include terms that would be used by technical and non-technical users.	Keywords separated by commas	water,reservoir, river, Colorado River, gage, 24-month study, most probable
<modified>	Last Update	Most recent date on which the dataset was changed, updated or modified.	YYYY-MM-DD	2016-08-05

Dataset Metadata Element Name	Metadata Element Label (Human-readable)	Metadata Element Description	Possible Values/Required format	Example
<publisher>	Publisher	The publishing entity.	Agency name	Bureau of Reclamation
<contactPoint>	Contact Name	Contact person's name for the asset.	Name of individual or group responsible for the dataset	Lower Colorado Region Boulder Canyon Operations Office River Operations Group
<mbox>	Contact Email	Contact person's email address.	_____@___.___	bcoowaterops@usbr.gov
<identifier>	Unique Identifier	A unique identifier for the dataset or API as maintained within an Agency catalog or database.	A unique number representing the dataset. Assigned in sequential order based on when the datasets are added to the catalog.	6
<accessLevel>	Public Access Level	The degree to which this dataset could be made publicly-available, regardless of whether it has been made available.	Public - Data asset is or could be made publicly available to all without restrictions), Restricted public - Data asset is available under certain use restrictions Non-public - Data asset is not available to members of the public)	Public
<spatial>	Spatial	The range of spatial applicability of a dataset.	Could include a spatial region like a bounding box or a named place.	Colorado River Basin
<temporal>	Temporal	The range of temporal applicability of a dataset (i.e., a start and end date of applicability for the data).	YYYY-MM-DD to YYYY-MM-DD Or text describing the temporal range	2015-08-01 to 2018-07-31

Dataset Metadata Element Name	Metadata Element Label (Human-readable)	Metadata Element Description	Possible Values/Required format	Example
<accessURL>	Download URL	URL providing direct access to the downloadable distribution of a dataset.	URL	http://www.usbr.gov/lc/region/g4000/24mo.pdf
<webService>	Endpoint	Endpoint of web service to access dataset.	URL	NA
<format>	Format	The file format or API type of the distribution.	File extension or file type	PDF

Appendix F – Colorado River Basin Data Visualization Challenge Materials

Abstract:

(Viewable by general public)

The Bureau of Reclamation (Reclamation), the Seeker for this Challenge, plays a significant role in managing the Colorado River. Reclamation relies on a broad range of Colorado River Basin (CRB) data to support short-term water management and long-term planning, including data on historical, current, and projected weather and climate conditions, reservoir storage and releases, streamflows, and diversions. Reclamation is currently working to make CRB data more easily accessible to both Reclamation staff and non-Reclamation users such as other Federal, State, and local agencies, water users, recreationists, researchers, and other stakeholders

As Reclamation works to improve data access, better approaches to visualizing CRB data are needed to improve data exploration, analysis, interpretation, and communication by Reclamation and non-Reclamation users. In particular, better visualization approaches are needed to improve understanding and communication of current and projected conditions in the basin and the water management actions that affect those conditions.

Reclamation and its Collaborators seek innovative, interactive, and user-driven visualizations to improve understanding of past, present, and projected conditions in the CRB and to support analysis and decision making by Reclamation and non-Reclamation users.

This Theoretical Challenge requires submission of a data visualization and corresponding written description.

Challenge Orientation Video: https://youtu.be/MQraxjryG0k

Privacy Advisory

This web site is hosted by a private entity and is not a service of the Bureau of Reclamation or the Department of the Interior (DOI). The solicitation and collection of your personal or individually identifiable information is subject to the host's privacy and security policies and will not be shared with Reclamation or DOI unless you win the Challenge. Challenge winners' personally identifiable information must be made available to Reclamation in order to collect an award. Please consult the Challenge Specific Agreement.

Eligibility Requirements

This Challenge is being conducted by the Seeker under the authority of 15 USC 3719, as amended, which states that cash prize purse awards for this prize competition may only be given to an individual that is a citizen or permanent resident of the United States, or an entity that is incorporated in and whose primary place of business is in the United States, subject to verification by the Seeker before cash prize purses are awarded.

Cash prize purse payments: Payments will be paid in full to the eligible registered individual, entity, or team selected as a winner.

Registering as a team: Teams must register to compete by having the Team Leader form a Team Project Room (https://www.innocentive.com/our-solvers/faqs/). The Team Leader must be a U.S. citizen, permanent U.S. resident,

or representing a U.S. entity eligible to receive a cash prize. In the case of a team registration, the cash prize purse can be split and paid directly to eligible team members as directed by the registered eligible team leader. The Seeker will not make payment to team members that are not eligible under 15 USC 3719 to receive a cash prize

Team Project Room requests must be made no later than 1 week prior to the Challenge deadline. Click on 'Form a Team' at the top of the page for further instructions.

Participation by those not eligible for cash prizes: Submissions can be entertained from all Solvers regardless of whether they are U.S. citizens, U.S. permanent residents, or U.S. entities and are eligible to receive non-cash prize awards, if any. Meritorious submissions from non-U.S. citizens, permanent residents, and entities will also be recognized in publications issued by the Seeker announcing the results of the competition, such as press releases.

Full eligibility details and other restrictions are detailed in the Challenge Specific Agreement.

Overview:

(Viewable by general public)

The Bureau of Reclamation (Reclamation) plays a significant role in managing the Colorado River, including operating dams and canals to deliver water and generate power, overseeing water allocations and water use, and protecting and restoring habitat for endangered and threatened species. Management of the Colorado River is governed by numerous compacts, laws, court decisions and decrees, and regulatory guidelines collectively known as the "Law of the River". Reclamation relies on a broad range of Colorado River Basin (CRB) data to support short-term water management and long-term planning, including data on historical, current, and projected weather and climate conditions, reservoir storage and releases, streamflows, and diversions. These datasets are produced, maintained, and shared by both Reclamation and partner agencies. State and local agencies, water users, recreationists, researchers and other stakeholders and partners also rely on CRB data for a wide variety of uses.

Reclamation is currently working to make its CRB data more easily accessible to both Reclamation and non-Reclamation users. These efforts include development of a Reclamation-wide data portal for viewing, querying, accessing, and downloading data (https://water.usbr.gov/), as well as basin-specific web-based tools for data analysis and decision support (https://www.usbr.gov/research/projects/detail.cfm?id=5541). Reclamation is also coordinating with partner agencies that produce CRB data as they work to make their CRB data more accessible.

In addition to modernizing how data are made available using machine-readable data formats, Reclamation needs better approaches for visualizing CRB data to improve data exploration, analysis, interpretation, and communication by Reclamation and non-Reclamation users. In particular, better visualization approaches are needed to improve understanding and communication of current and projected conditions in the basin and the water management actions that affect those conditions.

The Seeker and Collaborators seek innovative, interactive, and user-driven visualizations to improve understanding of past, present, and projected conditions in the CRB and to support analysis and decision making by Reclamation and non-Reclamation users.

This is a Theoretical Challenge that requires a data visualization and corresponding written description to be submitted. Solvers may make up to 5 submissions for this Challenge. Each submission should be a distinctly different visualization with an accompanying written description and should be made as a separate submission using the same Project Room. Each submission will be evaluated separately and Solvers are eligible to receive multiple awards if they make multiple submissions.

The Seeker has a **total cash prize purse of $60,000**. The Challenge cash prize awards will be contingent upon critical analysis and evaluation by the Seeker (Reclamation) and the judging panel appointed by the Seeker. The top submissions that meet or exceed the Solution Requirements will receive cash prize awards no less than $5,000 with a single cash prize award being as high as $20,000. No cash prizes are guaranteed unless they meet or exceed the Solution Requirements. Partial cash prizes will be considered for solutions that meet some, but not all, of the requirements. In addition, the Solvers with the top three submissions may be invited to present their visualizations for stakeholders online or at an in-person meeting. If the meeting is in-person, Reclamation will include an additional $1,500 for associated travel expenses if the winner agrees to present.

To receive an award, the Solvers will not have to transfer their exclusive IP rights to the Seeker. Instead, Solvers will grant to the Seeker a *non-exclusive license* to utilize their solutions. See the Challenge Specific Agreement for full details.

Submissions to this Challenge must be received by 11:59 PM (US Eastern Time) on November 17, 2017.
Late submissions will not be considered.

Detailed Description and Requirements:

(Viewable by Solvers who signed the competition specific agreement.)

BACKGROUND

The Bureau of Reclamation (Reclamation), the Seeker for this Challenge, plays a significant role in managing the Colorado River, including operating dams and canals to deliver water and generate power, overseeing water allocations and water use, and protecting and restoring habitat for endangered and threatened species. Management of the Colorado River is governed by numerous compacts, laws, court decisions and decrees, and regulatory guidelines collectively known as the "Law of the River". Reclamation relies on a broad range of Colorado River Basin (CRB) data to support short-term water management and long-term planning, including data on historical, current, and projected weather and climate conditions, reservoir storage and releases, streamflows, and diversions. These datasets are produced, maintained, and shared by both Reclamation and partner agencies. State and local agencies, water users, recreationists, researchers and other stakeholders and partners also rely on CRB data for a wide variety of uses.

Reclamation is currently working to make its CRB data more easily accessible to both Reclamation and non-Reclamation users. These efforts include development of a Reclamation-wide data portal for viewing, querying, accessing, and downloading data (https://water.usbr.gov/), as well as basin-specific web-based tools for data analysis and decision support (https://www.usbr.gov/research/projects/detail.cfm?id=5541). Reclamation is also coordinating with partner agencies that produce CRB data as they work to make their CRB data more accessible.

In addition to modernizing how data are made available using machine-readable formats, better approaches to visualizing CRB data are needed to improve data exploration, analysis, interpretation, and communication by Reclamation and non-Reclamation users that rely on the data to inform their decisions. In particular, better visualization approaches are needed to improve understanding and communication of current and projected conditions in the basin and the water management actions that affect those conditions.

Challenge Orientation Video: https://youtu.be/MQraxjryG0k

THE CHALLENGE

The Seeker and Collaborators seek innovative, interactive, and user-driven visualizations to improve understanding of past, present, and projected conditions in the CRB and to support analysis and decision making by Reclamation and non-Reclamation users.

Visualizations are needed to support exploration and understanding of climate, hydrology, river, and reservoir conditions across the basin and how these conditions vary in space and time. For example, visualizations could be created to allow users to explore how weather, river flows, and reservoir storage and releases vary between the mountainous regions of the Upper Basin and the arid deserts of the Lower Basin. Similarly, visualizations could allow users to explore how conditions at a given location vary over time, including comparisons between historical, current, and projected future conditions.

In addition to exploring climate, hydrology, river, and reservoir conditions across the basin, visualizations are needed to facilitate analysis and understanding of relationships between these conditions, water supply and demand, and management objectives and constraints. River and reservoir conditions depend on hydrologic and meteorologic conditions, which drive water supply and demand throughout the basin, and on management objectives and constraints (i.e., the Law of the River), which drive management actions such as water allocations, reservoir operations, and stream diversions. Visualizations could be created to allow users to explore and understand these relationships.

Ideally, visualizations should help users to understand how fluctuations in river and reservoir conditions over space and time relate to user interests such as water supply and use, water management actions, and recreational opportunities. Visualizations are anticipated to support analysis and decision making by water managers, including Reclamation staff and staff at other management agencies. In addition, visualizations are anticipated to help stakeholders, the public, and researchers understand the factors that affect river and reservoir conditions.

EXAMPLE USE CASES

Different users have different needs and interests with respect to analyzing, interpreting, and communicating CRB data. The Seeker and Collaborators have identified three potential use cases to guide Solvers in developing effective visualizations. These potential use cases are described below. Visualizations are **not** required to specifically address these potential use cases; Solvers may choose to identify and address one or more other use case(s) relevant to the CRB.

(1) Water Manager:
Water managers, including managers from Reclamation as well as state and local water agencies, require quantitative information on current conditions and projected future conditions to support short-term and mid-term operating decisions.
Key data considered by water managers include:

- Current conditions, including observed real-time snowpack, streamflows, reservoir elevations, and diversions;
- Water allocations and accounting, including current-year allocations, current-year water use to date, and projected water use for the year;
- Short-term forecast information (0-10 day lead time), including weather forecasts (precipitation and temperature), streamflow forecasts (snowmelt and rainfall runoff and streamflow at selected locations), reservoir inflow forecasts (e.g., inflow forecasts from the Colorado River Basin Forecast Center); and
- Mid-term projections (0-24 month lead time) of hydrologic conditions and water operations, including seasonal inflow forecasts and output from the 24-Month Study.[2]

Key data uses by water managers include:

- Develop situational awareness regarding current river and reservoir conditions;
- Develop insight into current conditions for stakeholder outreach and to facilitate coordination between water managers and local water boards;
- Create multi-dimensional analyses of current and projected conditions to facilitate understanding and communication of potential risks.
- Ensure local and state water agencies do not exceed approved water orders.

(2) Public River User:
The Colorado River draws a wide variety of public river users. Boating and fishing are extremely popular on the Colorado River and system reservoirs, as are a range of activities along the river corridor such as hiking, wildlife viewing, fishing, and camping. Public river users generally desire information relevant to planning a visit to the Colorado River.
Key data and information considered by public river users often includes:

- Overview of river conditions and recreational opportunities throughout the CRB;
- Quantitative and qualitative information on current conditions, including observed hourly and/or daily streamflows and water temperatures at various river locations;
- Short-term projections of reservoir releases (0-3 day lead time for hourly releases; 0-30 day lead time for

[2] The 24-Month Study is a model-based projection of future hydrologic conditions and water operations in the Colorado River Basin. Additional information on the 24 Month Study is available here: https://www.usbr.gov/uc/water/crsp/studies/

daily releases).

Key interpretation and decisions by public river users include:

- Understanding recreational opportunities at various locations, including relationships between river conditions and recreational opportunities (e.g., optimal river and reservoir conditions for boating or fishing at a given location);
- Understanding current and projected river conditions at various locations, including the impact of river conditions on recreational opportunities,
- Decisions regarding when and where to visit the Colorado River for recreational purposes, potentially including decisions regarding recreational activities during a given visit.

(3) Academic Researcher:

The Seeker and Collaborators frequently receive requests from academic researchers for data and information regarding historical and projected conditions through the CRB. Researchers consider a broad range of data and information, including reservoir elevations, storage, inflows, releases, and evaporation; streamflows, diversions, and return flows; and precipitation, temperature, and snowpack. Research objectives vary widely, but often involve analyzing and understanding relationships between climate, hydrology, water operations, and river conditions. In order to understand these relationships, researchers frequently request information regarding the policies and objectives that drive water management in the CRB—i.e., the Law of the River.

DATA SOURCES

The Seeker and Collaborators have identified relevant data types and potential data sources for use in visualizations. Relevant data types include various geospatial and historical (observed) data, as well as forecast and projection data at various lead times. A list of relevant data types is provided below; Solvers may identify and use additional relevant data types, as needed, to address a specific use case(s). Solvers may obtain data from a variety of sources, as described below.

Relevant Data Types

Geospatial Data:

- Stream network of Colorado River and major tributaries
- Locations and extent of reservoirs (e.g., dam location, extent at full pool, volume at full pool)
- Locations and extent of major diversions
- Locations and extent of major water conveyance facilities, including canals, pipelines, etc.
- Locations of measurement sites, including stream gages and weather stations
- Locations of recreational sites, facilities, and opportunities
- Geospatial information on population, socioeconomics, land use and land cover, geology and soils, topography/elevation, federal and state land ownership/management (e.g., national forest boundaries, national park boundaries, state park boundaries, federal and state recreation area boundaries, etc.)

Historical Climate and Water Data:

- Observed weather and climate conditions (e.g., precipitation and temperature)
- Observed snowpack (e.g., snow depth, snow extent, and snow water equivalent)
- Observed streamflows
- Observed reservoir elevations, storage, inflows, and releases
- Observed or calculated reservoir evaporation
- Observed or calculated evapotranspiration (e.g., reference ET and/or actual ET)
- Water accounting data (e.g., historical diversions and water use, including current year to date)

Short-Term Forecast Data (0-10 day lead times):

- Weather forecasts (e.g., NOAA NWS short- and medium-range weather forecasts)
- Streamflow forecasts (e.g., CBRFC river condition forecasts and outlooks)
- Operations forecasts (e.g., planned reservoir releases, forecasted reservoir conditions)

Mid-Term and Long-Term Forecast and Projection Data (0-24 month lead times):

- Climate forecasts (e.g., NOAA seasonal climate outlooks)
- Runoff forecasts (e.g., CBRFC seasonal water supply forecasts)
- Projected reservoir operations (e.g., 24 Month Study)
- Water supply projections
- Water use forecasts (e.g., diversions and consumptive use)

Data Sources for Developing Visualizations

Solvers may use any relevant data that are either made available as part of the challenge materials for this challenge (see below) or that are publicly available online from Federal, State, or local government agencies, peer reviewed scientific research, or other unbiased and reputable sources.

The Seeker has provided a data **catalog** in the challenge materials. The data catalog includes specific datasets that are available for use in developing visualizations. Three classes of data are included in the catalog:

(1) Datasets that are currently publicly available online in machine-readable formats.
For each Class 1 dataset, publicly available link(s) are provided. Class 1 datasets include datasets currently available through the CRB Web Reports website, the Reclamation Water Information System, or via other websites.

(2) Datasets that are currently publicly available online, but not in machine-readable formats.
For each Class 2 dataset, publicly available link(s) are provided. Class 2 datasets include datasets currently available in the form of static reports, graphics, or other non-machine-readable formats. The Seeker may make these Class 2 datasets publicly available online in machine-readable formats in the future. In some cases, machine-readable example files are provided in addition to the publicly available links to simplify use of these datasets by Solvers. The example files are provided for the sole purpose of participating in this InnoCentive Challenge; complete details regarding data use can be found in the Challenge Specific Agreement.

(3) Datasets that are not currently publicly available online in any format.
For each Class 3 dataset, example data files are provided in the challenge materials. The Seeker or other partners in the CRB may make Class 3 datasets publicly available online in machine-readable formats in the future.

Class 3 datasets are provided as sample data for the sole purpose of participating in this InnoCentive Challenge. Class 3 datasets are provisional and subject to revision. Subsequent review based on field inspections, measurements, or other verification procedures may result in significant revisions to the data. Final data shown in reports or publications may differ significantly from sample data. Complete details regarding data use can be found in the Challenge Specific Agreement.

In addition to the specific datasets included in the data catalog, Solvers may use any relevant dataset(s) that are publicly available online from Federal, State, or local government agencies, peer reviewed scientific research, or other unbiased, reputable sources. If datasets that are not included in the data catalog are used, Solvers must provide the URL for accessing the data, contact information for the agency or organization responsible for the dataset, an explanation of why the data is useful for the visualization, and a description of the dataset that includes a list of parameters, units, sites, and other relevant metadata about the records included in the dataset.

ANCILLARY INFORMATION

In addition to data, Solvers may include ancillary information to aid users in understanding and interpretation of data. A list of **references** for ancillary information is included in the challenge materials.

Examples of ancillary information include:

- The Law of the River or other laws and policies
- Descriptive information about infrastructure and facilities
- Glossary of water management terms
- History of the Colorado River Basin
- Cultural information

SOLUTION REQUIREMENTS

To address the Challenge, solutions should address one or more relevant use case(s) of CRB data. Solutions may address one or more of the Example Use Cases described above, or may address other relevant use case(s) for CRB data proposed by the Solver. Solutions should include one or more of the following elements**:**

- Integrated visualization of multiple relevant CRB data types and/or ancillary information. This may include mashups of data from Reclamation and other sources, combination of multiple data types, and/or integration of data with ancillary information.
- User-customizable visualization of data and/or ancillary information. This may include user-driven selection of data parameters, time periods, or geographical range, or configuration of visualization layout or content to meet user needs and preferences.
- Interactive visualization of data and/or ancillary information. This may include zooming or panning around a visualization, drilling down into data, clicking through animations, inputting information, and/or responding to queries or requests from the visualization.

Examples of visualizations that the Seeker currently produces are provided in the challenge materials. These examples illustrate some of the relevant types of data and ancillary information that the Seeker desires to communicate with users. They may be used as starting points for visualization development by Solvers, but are not intended as examples of the types of visualizations that Solvers should submit.

JUDGING AND EVALUATION

Submissions will be evaluated by a judging panel composed of subject matter experts from Reclamation and Collaborating agencies. The judging panel will represent a broad range of relevant expertise, such as water operations and water accounting, technical communication and stakeholder outreach, data analysis and visualization, data publishing, software/web development, and related areas. The judging panel may also consult with technical experts outside of their expertise, as determined necessary, to evaluate specific submissions.

The judging panel will assess the merits of each solution against the following criteria:

- The degree to which they meet the above Solution Requirements
- How well each submission supports the use case(s) selected/proposed by the Solver.
- Ease of use
- Innovation and creativity

PRIZE PURSE

The Seeker has a **total cash prize purse of $60,000**. The Challenge cash prize awards will be contingent upon critical analysis and evaluation by the Seeker (Reclamation) and the judging panel appointed by the Seeker. The top submissions that meet or exceed the Solution Requirements will receive cash prize awards no less than $5,000 with a single cash prize award being as high as $20,000. No cash prizes are guaranteed unless they meet or exceed the Solution Requirements. Partial cash prizes will be considered for solutions that meet some, but not all, of the requirements. In addition, the Solvers with the top three submissions may be invited to present their visualizations for stakeholders online or at an in-person meeting. If the meeting is in-person, Reclamation will include an additional $1,500 for associated travel expenses if the winner agrees to present.

To receive an award, the Solvers will not have to transfer their exclusive IP rights to the Seeker. Instead, Solvers will grant to the Seeker a *non-exclusive license* to utilize their solutions. See the Challenge Specific Agreement for full details.

PROJECT DELIVERABLES:

Solvers are asked to submit a **data visualization** along with a **written description** of the how the visualization is intended to support improved understanding and interpretation of CRB data and improved analysis and decision making by Reclamation and/or non-Reclamation users. The solution may combine existing components, commercially available components, and/or novel Solver solutions. Ideas leveraged from other industries with similar problems are encouraged. Solvers may make up to 5 submissions for this Challenge. Each submission should be a distinctly different visualization with an accompanying written description and should be made as a separate submission using the same Project Room. Each submission will be evaluated separately and Solvers are eligible to receive multiple awards if they make multiple submissions.

Data Visualization:
Solvers must submit a data visualizations that addresses one or more potential use cases of CRB data. If the visualization is a website, web app, or video, the solver must upload and/or host the visualization on an external website and provide a link to the visualization in the accompanying written description. Similarly, if the visualization exceeds 25 MB, the solver must upload the visualization to an external website and provide a link to the visualization in the accompanying written description. Videos should be uploaded to a video hosting site as a private video. Online content should not be shared publicly until this Challenge is awarded.

Written Description:
Solvers must submit a written description of the visualization, not to exceed five pages. Written descriptions should describe key features of the visualization, including the datasets incorporated into the visualization, how the visualization integrates those datasets, and how the visualization allows users to interact with and explore those datasets. Written descriptions should also note the Example Use Case(s) or other use case(s) that the visualization addresses and summarize how data integration and interactive features of the visualization are intended to support analysis and decision making for the intended user. If the Solver's submission addresses a use case other than the three Example Use Cases described above, the written description must include a description of the selected use case, including the intended user and the purpose of the visualization. Lastly, written descriptions should describe any software used to create the visualization, including existing software tools or packages as well as any software developed for the visualization. Any software developed by the Solver that is necessary for the visualization must be included in the submission, including source code.

Additional details regarding submissions are listed below:

- Solvers may use proprietary software packages to develop visualizations. However, visualizations must not rely on proprietary software packages for users to display visualizations or to use interactive features.
- Source code for any software developed by the Solver that is necessary for the visualization may be appended to the written description and will not count towards the five page limit.
- The visualization and written description should not include any personal identifying information (name, username, company, address, phone, email, personal website, resume, *etc*.) or any information the Solvers may consider as their Intellectual Property they do not want to share.

Submissions to this Challenge must be received by 11:59 PM (US Eastern Time) on November 17, 2017.
Late submissions will not be considered.

Data Catalog Provided to Solvers

Solvers may use any relevant data that are either made available in this catalog or that are publicly available online from Federal, State, or local government agencies, peer reviewed scientific research, or other unbiased and reputable sources.

Three classes of data are included in this catalog:

(1) Datasets that are currently publicly available online in machine-readable formats.
For each Class 1 dataset, publicly available link(s) are provided. Class 1 datasets include datasets currently available through the CRB Web Reports website, the Reclamation Water Information System, or via other websites.

(2) Datasets that are currently publicly available online, but not in machine-readable formats.
For each Class 2 dataset, publicly available link(s) are provided. Class 2 datasets include datasets currently available in the form of static reports, graphics, or other non-machine-readable formats. The Seeker may make these Class 2 datasets publicly available online in machine-readable formats in the future. In some cases, machine-readable example files are provided in addition to the publicly available links to simplify use of these datasets by Solvers. The example files are provided for the sole purpose of participating in this InnoCentive Challenge; complete details regarding data use can be found in the Challenge Specific Agreement.

(3) Datasets that are not currently publicly available online in any format.
For each Class 3 dataset, example data files are provided in the challenge materials. The Seeker or other partners in the CRB may make Class 3 datasets publicly available online in machine-readable formats in the future.

Class 3 datasets are provided as sample data for the sole purpose of participating in this InnoCentive Challenge. Class 3 datasets are provisional and subject to revision. Subsequent review based on field inspections, measurements, or other verification procedures may result in significant revisions to the data. Final data shown in reports or publications may differ significantly from sample data. Complete details regarding data use can be found in the Challenge Specific Agreement.

Short Description	Data Class	Web Reports URL	RWIS URL	Other URL for Machine Readable Data, web service, or API	Other URL for Non Machine Readable Data	Example File	Comments/ Notes / Descriptive Info
Daily model data for Hoover Dam, Davis Dam, and Parker Dam release and elevation projections	1	Web Reports Main Page; Dataset "Daily projections for Lower Colorado mainstream dams"; Select from list of available record sets https://www.usbr.gov/lc/region/g4000/riverops/webreports/	N/A	Lower Colorado River Operations Schedule for current week and next two weeks(html): https://www.usbr.gov/lc/region/g4000/hourly/rivops.html	Lake Mead Elevation projections(PDF): http://www.usbr.gov/lc/region/g4000/hourly/MeadReport.pdf Hoover Operations graphs(PDF): http://www.usbr.gov/lc/region/g4000/hoover.pdf Davis Operations graphs(PDF): http://www.usbr.gov/lc/region/g4000/davis.pdf Parker Operations graphs(PDF): http://www.usbr.gov/lc/region/g4000/parker.pdf	N/A	Daily projections for end-of-day reservoir elevation and average daily release from Davis and Parker dams for up to 30 days in the future. Projections are updated daily.
Hourly model data for Davis Dam and Parker Dam release and energy projections	1	Web Reports Main Page; Select Dataset "Hourly projected releases at Davis Dam and Parker Dam"; Select from list of available record sets https://www.usbr.gov/lc/region/g4000/riverops/webreports/	N/A	N/A	Water Release Schedules: http://www.usbr.gov/lc/region/g4000/hourly/DavisParkerSchedules.pdf	N/A	Hourly projections for average release and total energy generation at Davis and Parker Dams for 3 days. Projections are updated daily.
The 24-Month Study Report - Monthly model data for UC and LC operations (Reclamation's official projection of future operations of the CRB reservoir system)	1	Web Reports Main Page; Dataset "Operation Plan for the Colorado River System Reservoirs"; Select from list of available record sets https://www.usbr.gov/lc/region/g4000/riverops/webreports/	N/A	N/A	24-month Study Report access (PDF): http://www.usbr.gov/uc/water/crsp/studies/index.html Current 24-Month Study Report (PDF): http://www.usbr.gov/lc/region/g4000/24mo.pdf Query Page for 24-Month Study Reports (PDF): http://www.usbr.gov/lc/region/g4000/24mo/index.html	N/A	The 24-Month Study Report describes Reclamation's most likely future operations of the CRB reservoir system. Reclamation receives CRB reservoir unregulated inflow forecasts from the CBRFC which are then extended to 24-32 months per the inflow matrix (see data set #39). Reclamation uses these extended inflow scenarios in the 24-Month Study Model by routing them through the modeled CRB reservoir system. Reclamation applies all environmental and resource management policies for each reservoir to project future reservoir release conditions over a 24-32 month future time horizon. The 24-Month Study Model provides a consolidated outlook of the CRB reservoir and river conditions over this future time horizon. The 24-Month Study Model and Report are updated monthly.
YAO Reservoir Data	2	N/A	N/A	HTML: https://www.usbr.gov/lc/region/g4000/hourly/hourly.html	N/A	N/A	Reservoir elevation, storage, and release data for Imperial Dam, Senator Wash, and Brock Reservoir, facilities operated by the Lower Colorado Region, Yuma Area Office (YAO).

Short Description	Data Class	Web Reports URL	RWIS URL	Other URL for Machine Readable Data, web service, or API	Other URL for Non Machine Readable Data	Example File	Comments/ Notes / Descriptive Info
YAO River Gage Data	1	Web Reports Main Page; Dataset "Yuma Area Office River Gages (Martinez Lake, Picacho)" ; Select from list of available record sets https://www.usbr.gov/lc/region/g4000/riverops/webreports/	N/A	HTML: https://www.usbr.gov/lc/region/g4000/hourly/hourly.html	N/A	N/A	River gage data for sites on the lower Colorado River operated by the YAO, including Martinez Lake and Picacho
UC Reservoir Data	1	Web Reports Main Page; Dataset "Upper Colorado Region Reservoir Gages"; Select from list of available record sets https://www.usbr.gov/lc/region/g4000/riverops/webreports/	https://water.usbr.gov/query.php	https://www.usbr.gov/rsvrWater/HistoricalApp.html	N/A	N/A	These datasets are the basic parameters Reclamation collects and maintains for all reservoirs in the Upper Colorado Basin (i.e. above and including Lake Powell). Datasets are either measured through gaging systems or computed from other measured data parameters. For several smaller reservoirs evaporation is assumed to be insignificant and is therefore omitted. The UC Historical Data Application, while menu driven, can be used to create URLs which can be saved and modified for automated data retrievals.
LC River Gages	1	Web Reports Main Page; Dataset "Lower Colorado River Stream Flow Data"; Select from list of available record sets https://www.usbr.gov/lc/region/g4000/riverops/webreports/	https://water.usbr.gov/query.php	N/A	Final Data reports (PDF): https://www.usbr.gov/lc/region/g4000/PubStreamFlow/index.html	N/A	Observed river gage data along the lower Colorado River. Web Reports contains provisional data. Final data for river stage and flow can be found in the linked PDF reports.
LC Reservoir Data	1	Web Reports Main Page; Dataset "Lower Colorado River Reservoir Data"; Select from list of available record sets https://www.usbr.gov/lc/region/g4000/riverops/webreports/	https://water.usbr.gov/query.php	N/A	Final Data reports (PDF): http://www.usbr.gov/lc/region/g4000/riverdata/index.html	N/A	Observed reservoir data for mainstream reservoirs. Provisional real-time data is available through Web Reports. Final approved data is available in PDF from Lower Colorado River Historical Stream Flow Reports page.
UC Reservoir Inflow	1	Web Reports Main Page; Dataset "Upper Colorado Region Reservoir Gages"; Select from list of available record sets https://www.usbr.gov/lc/region/g4000/riverops/webreports/	https://water.usbr.gov/query.php	https://www.usbr.gov/rsvrWater/HistoricalApp.html	N/A	N/A	Calculated inflow for major UC reservoirs (Fontenelle, Flaming Gorge, Blue Mesa, Morrow Point, Crystal, and Lake Powell) - includes unregulated and regulated inflow. The UC Historical Data Application can be used to create a URL which can be saved and modified. Once a site is selected the URL can be modified to get other datasets.
Flow arriving at Imperial Dam	3	N/A	N/A	N/A	See "Example Datasets.xlsx"	N/A	Data on inflows arriving at Imperial Dam in the Lower Colorado River. Example is a PDF screenshot of a dashboard currently only accessible within the Reclamation network.

Short Description	Data Class	Web Reports URL	RWIS URL	Other URL for Machine Readable Data, web service, or API	Other URL for Non Machine Readable Data	Example File	Comments/ Notes / Descriptive Info
Drought monitor	2	N/A	N/A	N/A	Graphical view of current drought conditions: https://www.drought.gov/drought/data-maps-tools/current-conditions NIDIS Drought Data Page: https://www.drought.gov/drought/search/data	N/A	Graphical view of current drought conditions in the Colorado River Basin, provided by the National Integrated Drought Information System (NIDIS)
Observed Temperature and Precipitation	2	N/A	N/A	Raw data tables: http://www.cpc.noaa.gov/products/analysis_monitoring/cdus/prcp_temp_tables/	N/A	N/A	Observed Temperature and Precipitation data provided by the Climate Prediction Center (CPC)
Weather forecast data	1	N/A	N/A	N/A	Select forecast points from NWS website: https://www.weather.gov/wrh/	N/A	Suggested forecast points, provided by the national Weather Service (NWS): Upper Basin - Fontenelle, Flaming Gorge, Upper Colorado Mainstem, Aspinal, Navajo, Powell near Glen Canyon Dam Lower Basin - Mead near Hoover Dam, Mohave, Havasu, Imperial Dam, Imperial Valley
Colorado Basin River Forecast Center (CBRFC) ESP Forecast Traces for the Colorado River Mid-Term Operations Model.	1	N/A	N/A	http://www.cbrfc.noaa.gov/outgoing/32month/	N/A	N/A	This link is maintained by the CBRFC at this link and updated monthly. Old traces are not saved online. Reclamation receives 35 unregulated inflow scenarios each month that have equal probabilities of occurrence based on potential future weather and climate conditions. These 35 unregulated inflow scenarios make up the hydrological universe for Reclamation's Colorado River Mid-Term Operational Model (MTOM). The MTOM model provides 35 equally probable potential operational conditions for the CRB reservoir system looking into the future. From this data Reclamation can provide the probabilities of specific conditions occurring over a 5-year future period. These forecasts and MTOM data is updated monthly.

Short Description	Data Class	Web Reports URL	RWIS URL	Other URL for Machine Readable Data, web service, or API	Other URL for Non Machine Readable Data	Example File	Comments/ Notes / Descriptive Info
CBRFC Official Water Supply Forecasts	1	N/A	N/A	Water Supply Official Forecast List: https://www.cbrfc.noaa.gov/rmap/wsup/rlist_wsup.csv	N/A	N/A	The CBRFC official water supply forecasts are volumes of unregulated inflow forecasted to flow into the mainstem CRB reservoirs during the period from April 1st to July 31st. This period is referred to as the water supply season. We receive official forecasts beginning January (at the beginning of the month) and these updated each month through July. Official forecasts issued at the beginning of each month are updated mid-month. Reclamation only uses the official forecasts in it modeling runs for the 24-Month Study.
Short term spatial precipitation and temperature forecasts	2	N/A	N/A	QPF Data: https://www.cbrfc.noaa.gov/rmap/grid/gfe/qpf/	5-day forecasts for temperature and precipitation: https://www.cbrfc.noaa.gov/rmap/grid/index.php	N/A	5-day quantitative forecasts for precipitation and temperature in the Colorado River Basin. Provided by the CBRFC
Seasonal snowpack Observed snow and SWE from NRCS SNOTEL sites	2	N/A	N/A	Query Interface to access CSV data: http://wcc.sc.egov.usda.gov/nwcc/rgrpt?report=swe_hist	N/A	N/A	The Natural Resources Conservation Service (NRCS) maintains a network of snow measurement stations throughout the West. These stations provide real time snowpack conditions at 100s of locations where snowpack accumulates during the winter months. This data is a primary indicator for future potential inflow conditions into CRB reservoirs during the runoff season.
UC 24-Month Study Inflow Matrix	3	N/A	N/A	N/A	N/A	See “Example Datasets.xlsx”	This matrix describes how Reclamation interfaces forecasts provided by the CBRFC, with statistical unregulated inflow data to create 24-32 month inflow scenarios which are modeled in the 24-Month Study
UC Mainstem Reservoir Unregulated Inflow Statistics	3	N/A	N/A	N/A	N/A	See Pearson Stats Example Files folder	Reclamation does not publish these but do provide them as excel spreadsheets upon request. These spreadsheets represent the official inflow or unregulated inflow statistics for the major Upper Colorado River reservoirs. They are based on 30 water years of data from 1981 through 2010. Every 10 years these are updated so that the most recent 3 completed decades are used in the generation of the statistics. For example after water year 2020 is complete Reclamation will recompute our statistics based on the period from 1991 through 2020. This is one way in which Reclamation adopts changing climate conditions because only the most recent 3 decades are used in the statistics that are used in our hydrological outlooks. The term unregulated inflow is based on the observed inflow adjusted for upstream change in reservoir storage and upstream evaporation. This unregulated inflow is what would flow into the reservoir if upstream reservoirs did not exist. We only account for major upstream reservoirs.

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CBRFC forecast data - daily ESP results	1	N/A	N/A	List of Daily ESP Forecasts: https://www.cbrfc.noaa.gov/rmap/wsup/esplist.php	N/A	N/A	Ensemble Streamflow Prediction (ESP) is a hydrologic modeling system used by the CBRFC. To project future river flow and reservoir inflow conditions. The modeling system applies 30 equally possible future climatological conditions to current hydrological conditions to produce 30 equally possible river flow or reservoir inflow conditions at specific forecast points within the CRB. The CBRFC uses this modeling system to produce a variety of statistical forecast products to describe future hydrologic conditions at specific forecast points within the CRB. For many of these forecast points, CBRFC has set up online data portals that are updated daily indicating how ESP results are changing through time as actual weather conditions occur. ESP updates are useful for tracking and predicting how future inflow forecasts for CBR reservoir may change.
Natural flow data	1	N/A	N/A	Currently Used Natural Flow and Salt Dataset Access (Excel): https://www.usbr.gov/lc/region/g4000/NaturalFlow/current.html	N/A	N/A	Natural flow at a specific location is defined as what would flow past that location if there was no human influence on the hydrologic system. For a specific location, natural flow is the observed flow adjusted for all upstream change in storage in man-made reservoirs, all upstream reservoir evaporation in man-made reservoirs and all upstream human based consumptive use and loss of water. While observed flows are collected in real time, and reservoir storage and evaporation are easily retrieved, human based consumptive use and loss is very difficult to measure. Often times, it takes several years to collect the data required to estimate human based consumptive use and loss. For this reason, natural flow datasets lag by 3-5 years behind the current year.
Operational water use schedules in the 24-Month Study	2	N/A	N/A	N/A	Current 24-month Study Report (PDF) (SNWA, MWD, CAP, and Mexico): https://www.usbr.gov/lc/region/g4000/24mo.pdf	N/A	Monthly operational diversion schedules for select water users in the lower basin that are included in the 24-Month Study report. SNWA water use schedules (“SNWP Use”) are on page 11 of the report and MWD, CAP, and Mexico water use schedules (“MWD Diversion”, “CAP Diversion”, and “Flow to Mexico”, respectively) are on page 13.
Forecasted Lower Basin water use	2	N/A	N/A	N/A	Current Forecast of End of Year Consumptive Use for Lower Basin (PDF): http://www.usbr.gov/lc/region/g4000/hourly/forecast.pdf	See “Example Datasets.xlsx”	Forecasted water use in the Lower Colorado Basin. Forecasts are updated every business day and posted to the web as a pdf. The example file provides the data for the first 6 charts for days throughout the year that the forecast was run. The first column is the date the forecast was run. The next columns are daily forecasted end of year consumptive use values in Acre-Feet for their respective charts in the PDF 2016 report.

Short Description	Data Class	Web Reports URL	RWIS URL	Other URL for Machine Readable Data, web service, or API	Other URL for Non Machine Readable Data	Example File	Comments/ Notes / Descriptive Info
Lower Basin real-time diversion and return flow gages	2	N/A	N/A	N/A	https://www.usbr.gov/lc/region/g4000/riverdata/index.html https://www.usbr.gov/lc/region/g4000/riverops/RiverOpsMap.html	N/A	N/A
Decree Accounting-Div/Return/CU data (final report)	1	Web Reports Main Page; Dataset "Colorado River Accounting and Water Use Data for Arizona, California, and Nevada"; Select from list of available record sets https://www.usbr.gov/lc/region/g4000/riverops/webreports/	N/A	N/A	Main Page for Accessing Decree Accounting Reports. Select Report Year from list of Water Accounting Reports (PDF); Scroll to section V(B) Records of Diversions, Return Flows, and Consumptive Use: https://www.usbr.gov/lc/region/g4000/wtracct.html	N/A	Lower Basin Water Accounting Data; includes diversions, return flows, and consumptive use. Currently, 2003 -present is available. Additional years as far back as 1993 may soon become available.
Decree - Intentionally Created Surplus (ICS)	1	Web Reports Main Page; Dataset "Colorado River Accounting Data for Intentionally Created Surplus for Arizona, California, and Nevada"; Select from list of available record sets https://www.usbr.gov/lc/region/g4000/riverops/webreports/	N/A	N/A	Main Page for Accessing Decree Accounting Reports. Select Report Year from list of Water Accounting Reports (PDF); Scroll to section on Intentionally Created Surplus: https://www.usbr.gov/lc/region/g4000/wtracct.html	N/A	Intentionally Created Surplus (ICS) yearly balances for Lower Basin states and individual water users as recorded in the Water Accounting Reports.
Decree - ICMA / deferred water	2	N/A	N/A	N/A	Data found in Water Accounting Reports starting in 2011 (Article V(D) of report) : https://www.usbr.gov/lc/region/g4000/wtracct.html	See "Example Datasets.xlsx"	Intentionally Created Mexican Allocation (ICMA) and other water deferred by Mexico and stored in Lake Mead. Example data is yearly balances as recorded in the Water Accounting Reports.
Decree - IOPP Total payback and remaining balances	2	N/A	N/A	N/A	Main Page for Accessing Decree Accounting Reports. Select Report Year from list of Water Accounting Reports (PDF); Scroll to section on Inadvertent Overruns and Paybacks within the States of Arizona, California, and Nevada: https://www.usbr.gov/lc/region/g4000/wtracct.html	N/A	Inadvertent Overruns and Paybacks for Lower Basin water users - yearly balances as recorded in the Water Accounting Reports

Short Description	Data Class	Web Reports URL	RWIS URL	Other URL for Machine Readable Data, web service, or API	Other URL for Non Machine Readable Data	Example File	Comments/ Notes / Descriptive Info
Estimates of Evapotranspiration and Evaporation Along the Lower Colorado River – acreage and water use	2	N/A	N/A	N/A	Main Page for Accessing Decree Accounting Reports. Select Report Year from list of Water Accounting Reports (PDF); Scroll to section on Evapotranspiration and Evaporation Reports (formerly, LCRAS Reports): https://www.usbr.gov/lc/region/g4000/wtracct.html	https://www.usbr.gov/lc/region/g4000/4200Rpts/LCRASRpt/2011/2011ETandAcreageSummaries.xlsx	The "Estimates of Evapotranspiration and Evaporation Along the Lower Colorado River" report provides estimates of annual agricultural, riparian vegetation, and open water acreages and water uses along the lower Colorado River from Hoover Dam to the Southerly International Boundary with Mexico. Reclamation has reported this data since 1995, in reports previously called the “Lower Colorado River Accounting System (LCRAS) Evapotranspiration and Evaporation Calculation. Beginning with the 2009 report, Reclamation reformatted the report to provide a more user-friendly product.
Colorado River Consumptive Use and Loss reports	2	N/A	N/A	N/A	Colorado River System Consumptive Uses and Losses Reports (PDF) http://www.usbr.gov/uc/library/envdocs/reports/crs/crsul.html	N/A	These reports reflect the Department of the Interior's best estimate of actual consumptive uses and losses for each year within the Colorado River Basin. The reliability of the estimates is affected by the availability of data and the current capabilities of data evaluation. The reports include a breakdown of the beneficial consumptive use by major types of use, by major tributary streams, and, where possible, by individual States.
USGS-Remote Sensing derived Consumptive Use (SSEBop) - Field or Regional scale ET ranges	1	N/A	N/A	Actual ET Data (NetCDF): https://cida.usgs.gov/thredds/ncss/ssebopeta/monthly/dataset.html	SSEBop Dataset Description (PDF): https://earlywarning.usgs.gov/docs/SSEBopETreadme.pdf	N/A	N/A
ET stations - California and AZ	1	N/A	N/A	AZMET Data (Arizona): https://cals.arizona.edu/azmet/az-data.htm LC River mainstem sites: Mohave, Mohave 2, Parker, Parker 2, Yuma Gila, Yuma Valley, Yuma South, and Yuma Mesa CIMIS Data (California): http://wwwcimis.water.ca.gov/ LC River mainstem sites: Blythe NE, Ripley, and Palo Verde II	N/A	N/A	N/A

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ET stations - DRI	1	N/A	N/A	WRCC (western states including AZ and CA): http://raws.dri.edu/azF.html LC River mainstem sites: Havasu AZ, Rice Valley CA, Ahakahv Preserve AZ, Cibola AZ, Squaw Lake CA, and Fort Yuma CA	Overview of Western Regional Climate Center (WRCC): http://wrcc.dri.edu/	N/A	N/A
Surface Water Salinity reports	3	N/A	N/A	N/A	N/A	See “Example Datasets.xlsx”	Data on surface water salinity in the lower Colorado River
Groundwater Basemaps	2	N/A	N/A	N/A	Yuma Area Water Management System Groundwater Basemaps page: https://www.usbr.gov/lc/yuma/programs/YAWMS/GROUNDWATER_maps.cfm	N/A	GIS data (shapefiles) and groundwater data in the lower Colorado River basin near Yuma, AZ
SRP reservoir data	2	N/A	N/A	N/A	http://data.hydrometdataservice.info/dwr/	N/A	Data provided and maintained by the Salt River Project in Arizona.

U.S. Army Corps of Engineers (USACE) reservoir data for Alamo (Bill Williams River) and Painted Rock (lower Gila River)	1	N/A	N/A	Bill Williams/Alamo: http://natasha.spl.usace.army.mil/cgi-bin/cgiwrap/zinger/slLatestBasin.cgi?billwill+elev Gila River/Painted Rock: http://natasha.spl.usace.army.mil/cgi-bin/cgiwrap/zinger/slLatestBasin.cgi?gila+elev Dam data for Alamo: http://natasha.spl.usace.army.mil/cgi-bin/cgiwrap/zinger/slProjReport.cgi?almoData.in Dam data for Gila: http://natasha.spl.usace.army.mil/cgi-bin/cgiwrap/zinger/slProjReport.cgi?ptrkData.in Alamo stage and flow data (sample is 30 days): http://natasha.spl.usace.army.mil/cgi-bin/cgiwrap/zinger/slBasin2Hgl.py?dataType=Stage&locn=Alamo+DS-Bill+Williams+R+%28GOES%29&days=30&req=Text Gila River Stage and Flow data (sample is 30 days): http://natasha.spl.usace.army.mil/cgi-bin/cgiwrap/zinger/slBasin2Hgl.py?dataType=Stage&locn=Painted+Rock+DS-Gila+R+%28GOES%29&days=30&req=Text USGS Stream Gage Data Upstream of Alamo: https://waterdata.usgs.gov/az/nwis/uv/?site_no=09424900&PARAmeter_cd=00065,00060	N/A	N/A	Reservoir elevation, storage, and release data for Alamo Dam and Painted Rock Dam, flood control facilities operated by the U.S. Army Corps of Engineers. Releases from these facilities provide inflow into the Colorado River system via lower basin tributaries.

Short Description	Data Class	Web Reports URL	RWIS URL	Other URL for Machine Readable Data, web service, or API	Other URL for Non Machine Readable Data	Example File	Comments/ Notes / Descriptive Info
				USGS Stream Gage Data Downstream of Alamo: https://waterdata.usgs.gov/az/nwis/uv/?site_no=09426000&PARAmeter_cd=00065,00060 USGS Stream Gage Data Downstream of Painted Rock: https://waterdata.usgs.gov/az/nwis/uv/?site_no=09519800&PARAmeter_cd=00065,00060			
IBWC River Gage Data	1	N/A	N/A	Historical NIB data: https://www.ibwc.gov/wad/DDQNIBCO.HTM Historical SIB data: https://www.ibwc.gov/wad/DDQSIBCO.HTM All Colorado River sites: http://www.ibwc.state.gov/Water_Data/histflo2.htm https://www.ibwc.gov/Water_Data/rtdata.htm	N/A	N/A	Historical and real-time data for Northerly International Boundary (NIB) and Southerly International Boundary (SIB), provided by the International Boundary and Water Commission (IBWC). Historical data from 1950 through about 2010 is available online for several sites including NIB and SIB.

Short Description	Data Class	Web Reports URL	RWIS URL	Other URL for Machine Readable Data, web service, or API	Other URL for Non Machine Readable Data	Example File	Comments/ Notes / Descriptive Info
USGS NWIS Gages	1	N/A	N/A	Upper Colorado Region NWIS Gages https://waterdata.usgs.gov/nwis/current?huc2_cd=14&index_pmcode_STATION_NM=1&index_pmcode_DATETIME=2&format=station_list&group_key=huc_cd&sort_key_2=site_no&html_table_group_key=NONE&rdb_compression=file&list_of_search_criteria=huc2_cd%2Crealtime_parameter_selection Lower Colorado Region NWIS Gages https://waterdata.usgs.gov/nwis/current?huc2_cd=15&index_pmcode_STATION_NM=1&index_pmcode_DATETIME=2&format=station_list&group_key=huc_cd&sort_key_2=site_no&html_table_group_key=NONE&rdb_compression=file&list_of_search_criteria=huc2_cd%2Crealtime_parameter_selection	USGS NWIS Page https://waterdata.usgs.gov/nwis	N/A	Data provided via the USGS National Water Information System
USGS Lake Mead evaporation dataset	3	N/A	N/A	N/A	Data (Excel): https://www.sciencebase.gov/catalog/item/55f6fba8e4b0477df11bff2b Report (PDF): http://pubs.usgs.gov/sir/2013/5229/	N/A	Report and data from Phase 1 of a U.S. Geological Survey (USGS) study on Lake Mead evaporation.
Gridded Climate Data	1	N/A	N/A	Gridded Climate Datasets Access Page: https://www.esrl.noaa.gov/psd/data/gridded/	N/A	N/A	A variety of geographic datasets pertaining to climate variables of interest. Data sets provided by the Earth Systems Research Laboratory.
PRISM Datasets	2	N/A	N/A	PRISM Data Main Page: http://www.prism.oregonstate.edu/	N/A	N/A	Climate observations which incorporate a variety of modeling techniques and are available at multiple spatial/temporal resolutions, covering the period from 1895 to the present**.**

Short Description	Data Class	Web Reports URL	RWIS URL	Other URL for Machine Readable Data, web service, or API	Other URL for Non Machine Readable Data	Example File	Comments/ Notes / Descriptive Info
Landsat remote sensing data	1	N/A	N/A	Landsat data main page: https://landsat.usgs.gov/ Climate Engine Main Page; Select Type = Remote Sensing and select Landsat dataset of interest: http://clim-engine.appspot.com/	N/A	N/A	Land surface temperature, vegetation, snow, water Also available via Google Earth Engine (Cloud)
MODIS remote sensing data	1	N/A	N/A	MODIS Main Page: https://modis.gsfc.nasa.gov/ Climate Engine Main Page; Select Type = Remote Sensing and select MODIS dataset of interest: http://clim-engine.appspot.com/	N/A	N/A	Land surface temperature, vegetation, snow, water Also available via Google Earth Engine (Cloud)
UI METDATA/gridMET (Surface meteorological dataset based on PRISM and NLDAS-2)	1	N/A	N/A	University of Idaho Gridded Surface Meteorological Data Main Page: http://climate.nkn.uidaho.edu/METDATA/ Climate Engine Main Page; Select Type = Climate and select UI METDATA/gridMET dataset: http://clim-engine.appspot.com/	N/A	N/A	Temperature, precipitation, relative humidity, specific humidity, solar radiation, potential ET, near surface wind velocity Also available via Google Earth Engine (Cloud)
CHIRPS (Climate Hazards Group InfraRed Precipitation with Station) data	1	N/A	N/A	Climate Hazards Group InfraRed Precipitation with Station data Main Page: http://chg.geog.ucsb.edu/data/chirps/ Climate Engine Main Page; Select Type = Climate and select CHIRPS Precipitation dataset: http://clim-engine.appspot.com/	N/A	N/A	Precipitation Also available via Google Earth Engine (Cloud)

Ancillary Information Reference Materials provided to Solvers

Reference Name	Reference URL	Reference Description
The Law of the River	https://www.usbr.gov/lc/region/g1000/lawofrvr.html https://www.usbr.gov/lc/region/g4000/wtracct.html	Website with short descriptions of components of the Law of the River and links to further PDFs of the documents
2007 Interim Guidelines	https://www.usbr.gov/lc/region/programs/strategies.html	Website that contains detailed information about the interim guidelines governing Lake Powell and Lake Mead annual operations
Water Delivery Contracts and Entitlements	https://www.usbr.gov/lc/region/g4000/contracts/entitlements.html	Website that contains information about Lower Colorado Region water delivery contracts and entitlements.
Colorado River Storage Project (CRSP)	https://www.usbr.gov/uc/rm/crsp/index.html https://www.usbr.gov/uc/rm/crsp/aspinall/index.html https://www.usbr.gov/uc/rm/crsp/navajo/index.html https://www.usbr.gov/uc/rm/crsp/fg/index.html https://www.usbr.gov/uc/rm/crsp/gc/index.html	Website that contains information about the CRSP reservoirs in the Upper Colorado Region, with additional links to specific information about CRSP projects
UC Region Adaptive Management Program	https://www.usbr.gov/uc/rm/amp/index.html	Information about Adaptive Management in the Upper Colorado Region, particularly Glen Canyon Dam
LC Region Multi-	http://www.lcrmsc	Information about the Lower Colorado Region

Reference Name	Reference URL	Reference Description
Species Conservation Program	p.gov/	Multi-Species Conservation Program
Lake Mead and Lake Mohave Recreation Conditions	https://www.nps.gov/lake/learn/news/lakeconditions.htm	Website maintained by the National Park Service with information relevant to recreation at Lake Mead and Lake Mohave
Lake Mead/Hoover Dam FAQ	https://www.usbr.gov/lc/hooverdam/faqs/faqs.html	Website containing information about Lake Mead and Hoover Dam
Visiting Hoover Dam	https://www.usbr.gov/lc/hooverdam/index.html	Website containing information pertaining to recreation and education at Hoover Dam
Davis Dam and Parker Dam	https://www.usbr.gov/lc/hooverdam/davisdam.html https://www.usbr.gov/lc/hooverdam/parkerdam.html	Websites containing information about facilities on the lower Colorado River, Davis Dam and Parker Dam
Yuma Area Office historical milestones	https://www.usbr.gov/lc/yuma/about_us/yao_history.html	Timeline of significant events in the Lower Basin, Yuma Area Office service area
Bureau of Reclamation Lower Colorado Region Southern California Area Office	https://www.usbr.gov/lc/socal/	Main Page for Southern California Area Office
System Conservation Pilot Program	http://www.ucrcommission.com/RepDoc/SCPPDocuments/SCPP_15_18.pdf https://www.usbr.gov/lc/region/programs/PilotSysConsProg/pilotsystem.html	The System Conservation Pilot Program provides funding for testing a wide range of measures to conserve Colorado River water in Lake Powell or Lake Mead as Colorado River System water for the benefit of all users to help offset declining reservoir elevations. The program is funded by Reclamation and water agencies in the Upper and Lower Basins. Reclamation's Lower Colorado Region is the implementing agency for the Pilot Program in the Lower Basin, while the Upper

Reference Name	Reference URL	Reference Description
		Colorado River Commission is the implementing agency in the Upper Basin.
Bureau of Reclamation Lower Colorado Region Phoenix Area Office	https://www.usbr.gov/lc/phoenix/	Main page for Phoenix Area Office
Western Colorado Area Office	https://www.usbr.gov/uc/wcao/index.html	Main page for the Western Colorado Area Office- this office is involved with numerous water projects within the Colorado River Basin
Provo Area Office	https://www.usbr.gov/uc/provo/index.html	Main page for the Provo Area Office - this office is primarily involved with Colorado River operations through the Central Utah Project which exports water from the Colorado River Basin into the Great Basin.
Albuquerque Area Office	https://www.usbr.gov/uc/albuq/index.html	Main page for the Albuquerque Area Office - this office is primarily involved with Colorado River operations through the San Juan-Chama Project which exports water from the Colorado River Basin into the Rio Grande River Basin
Eastern Colorado Area Office	https://www.usbr.gov/gp/ecao/index.html	Main page for the Eastern Colorado Area Office - this office is primarily involved with Colorado River operations through various projects which export water from the Colorado River Basin to the Front Range of the Rocky Mountains.

List of Reports and Visualizations Currently Produced by Reclamation Provided to Solvers

Report or Visualization Name	URL (if applicable)	Report or Visualization Description
Sample JS for using Web Reports outputs	Page: https://usbr.github.io/crbTools/ Code: https://github.com/usbr/usbr.github.io/tree/master/crbTools	Sample resources and code snippets for querying and using the JSON outputs produced by the CRB Tools Web Reports system. Produced as a static HTML file with JS code to read JSON uses D3, leaflet, & DyGraphs.
Teacup Diagram	https://www.usbr.gov/lc/region/g4000/TeacupDiagram.html	Image updated daily with data from the previous day. Produced by custom C# program.
Gages by geographic location website	https://www.usbr.gov/lc/region/g4000/riverops/RiverOpsMap.html	System of web pages (data tables and charts) updated hourly with real time provisional data. Produced by custom C# program and uses DyGraphs.
Hourly data quality matrix	https://www.usbr.gov/lc/region/g4000/riverops/HourlyDataQualityMatrix/index.html	Web page updated hourly with real-time data quality. Produced as a static HTML file with JS code to read a text file; uses D3.
Observed reservoir data and most recent projections	https://www.usbr.gov/lc/region/g4000/riverops/AutomatedMeadSample.html https://www.usbr.gov/lc/region/g4000/riverops/AutomatedParkerSample.html https://www.usbr.gov/lc/region/g4000/riverops/AutomatedDavisSample.html	Web page updated hourly with observed data and most recent modeled projections. Produced as a static HTML file with JS code to read a text file; uses DyGraphs.
System Status Presentation	Presentation included in PDF	PowerPoint presentation sent out weekly by BCOO water ops staff describing the status of basin conditions
Weekly Water Supply Report	https://www.usbr.gov/lc/region/g4000/weekly.pdf	Web report in PDF format updated weekly by BCOO water ops staff describing the basin status including reservoir conditions and projected water supply and demand
YAO OMO Dashboard	Screenshot included in PDF	Internal dashboard used by Yuma Area Office staff

Appendix G – Prize Competition Judging Rubric

Criteria	Measure	Score				Measure Weight	Criteria Weight
		0	1	2	3		
1. Integrated visualization of multiple relevant CRB data types and/or ancillary information (supporting contextual information).	1a. Number of datasets and ancillary information in the visualization	One dataset and no ancillary information	One dataset and one piece of ancillary information	Two datasets or One dataset with two or more pieces of ancillary information	Three or more datasets or Two or more datasets with two or more pieces of ancillary information	.5	2.0
	1b. Level of sophistication of integration, including distinctiveness of data sources and datasets integrated in the visualization	No integration	Simple integration (e.g. the solution integrates datasets from the same source or integrates very similar datasets).	Moderate integration (e.g. the solution integrates datasets from the same or similar sources or integrates somewhat similar datasets).	Complex integration (e.g. the solution integrates datasets from multiple data sources and/or integrates very distinct types of data.)	1.5	

Criteria	Measure	Score				Measure Weight	Criteria Weight
		0	1	2	3		
2. User-customizable visualization of data and/or ancillary information (supporting contextual information).	2a. Number of user-driven selections or configuration settings (e.g. selection of data parameters, time periods, or geographical range or configuration of visualization layout or content to meet user needs and preferences.)	No user-driven selection or configuration	One user-driven selection or configuration option	Two user-driven selection or configuration options	Three or more user-driven selection or configuration options	0.33	1.0
	2b. Level of sophistication of user driven selection or configuration settings (e.g. selection of data parameters, time periods, or geographical range or configuration of visualization layout or content to meet user needs and preferences.)	No user-driven selection or configuration	Simple user-driven selection or configuration options	Moderate user-driven selection or configuration	Complex user-driven selection or configuration	0.67	
3. Interactive visualization of data and/or ancillary information	3a. Number of interactive capabilities and/or types of interactions (e.g. zooming or panning around the visualization, clicking through animations, inputting information, and/or responding to queries or requests from the visualization.)	No interactive capabilities	One interactive capability	Two interactive capabilities	Three or more interactive capabilities	0.33	1.0

Criteria	Measure	Score				Measure Weight	Criteria Weight
		0	1	2	3		
	3b. Level of sophistication of interactive capabilities (e.g. zooming or panning around the visualization, clicking through animations, inputting information, and/or responding to queries or requests from the visualization.)	No interactive capabilities	Simple interactive capabilities	Moderate interactive capabilities	Complex and sophisticated interactive capabilities	0.67	
4. Support for Use Case	4a. Level of support for the use case(s) selected, including conveying a story or message, if applicable	No support for the use case(s) selected.	Basic or limited support for the use case(s) selected.	Adequate support for the use case(s) selected.	Extensive and complex support for the use case(s) selected.	2.0	2.0
5. Ease of use	5a. Ease of use and navigability, e.g. How quickly can the user investigate information? How easy is it for the user to move among the various pages, or layers of the data visualization solution? Can the user find additional related non-data information intuitively?	Confusing, difficult to use, or not intuitive to the user without instructions.	Usable without instructions, but some aspects may be confusing, difficult to navigate, or not intuitive.	Easy to use and intuitive to the user.	Very easy to use and completely intuitive to the user.	2.0	2.0

Criteria	Measure	Score				Measure Weight	Criteria Weight
		0	1	2	3		
6. Innovation and Creativity	6a. Originality and overall innovation of the visualization solution.	No innovation, originality, or creativity.	Limited amount of innovation, originality, or creativity (e.g. includes one innovative or creative aspect).	Moderate amount of innovation, originality, or creativity (e.g. includes two innovative or creative aspects or has multiple differences from existing visualizations).	Extensive amount of innovation, originality, or creativity (e.g. includes three or more innovative or creative aspects or is unlike any other solutions or existing visualizations).	2.0	2.0
		Other Judging Considerations					
Innovative Nugget Submissions that include an innovative idea, concept, or design may be awarded a special Innovative Nugget prize.		**Y/N =** The submission does/does not include an innovative idea, concept, or design that we should explore or expand upon. If yes, describe: _____					

Appendix H – Prize Competition Results

Solutions Recommended for Full Awards

S009
Solution S009 consists of an interactive map and data display with a wide variety of information about Colorado River Basin reservoirs. The judging panel felt that this solution addresses many of the types of questions received by Reclamation's Public Affairs offices. The panel also appreciated the solution's attempt to characterize conditions around the reservoirs, although the execution of the data aggregation would need further work. This solution was far superior to the other submissions. The responsiveness, interactions, and overall look and feel were very impressive. The solution was the most comprehensive with respect to the number of datasets utilized and display of actual data, not just mock-ups. It was one of the better-looking, modern and clean submissions. However, although the solution was very well constructed, it was not particularly innovative. The solution has potential to be further developed with additional information, including forecast data.
OUTCOME: Award of $15,750

S014
Solution S014 consists of an ArcGIS Online web map showing river, reservoir, and stream gage data, plus popups for more information. The sample provided a basic and appealing map and informational buttons with mockups of innovative and creative visualizations. The mockups provided an appealing and interesting variety of visualizations. The solution has significant potential to include more interaction with the user and expansion to other datasets.
OUTCOME: Award of $10,750

S018
Solution S018 consisted of an interactive map for the western United States displaying data from RWIS. The solvers leveraged the current RWIS data service and re-created the database on the public cloud, which was an innovative approach. The judging panel appreciated the data-rich popup displays and the simple and easy to use main menu. This solution has a standard interactive map for accessing data, but has significant potential for adding more data and integrating into a larger visualization. It would require more development to customize for the intended use.
OUTCOME: Award of $7,750

S020
Solution S020 consisted of a ShinyApps site with a vertical scrolling layout with multiple components, including water users in the Lower Colorado River Basin. The submission provided a number of useful interactive features, including the ability to scale water users by consumptive use and historical data. The solution met the minimum solution requirements, and contained good ideas, but would need further development to clarify data interpretation. The solution had a good simple visual representation of the data and the graphics were interactive and intuitive.
OUTCOME: Award of $7,750

S008
Solution S008 consisted of an interactive map allowing exploration of water supply in the Lower Colorado River Basin. It provided a useful and innovative way of visualizing the Law of the River. The visualization would need significant development to clarify and correct the interpretation of the data and Law of the River, but it has potential for educating and increasing understanding of stakeholders. The submission has potential for inclusion in a larger visualization, and could be expanded to include additional data, such as the order of priority of water use. The solution met the minimum requirements, but would need work to implement.
OUTCOME: Award of $5,250

S021
Solution S021 consisted of a Tableau dashboard focused on fishing. It provided an easy to use, intuitive, and attractive website that could effectively support recreational fishing users. The submission has the potential to be a good starting point for further development and integration into a visualization tool with a broader scope. The solution meets the minimum solution requirements, but has some data issues, particularly with the aggregation of county data and the inclusion of California counties.
OUTCOME: Award of $5,250

Submissions Recommended for "Innovative Nugget" Awards

S012
Solution S012 consisted of a group of interactive maps that allow the user to explore the stream network of the NHDPlus. It was selected for an "innovative nugget" award based on the potential for further development of the concept. The dashboard provided an interactive interface, but only used one data source and did not provide adequate support for CRB data use cases. The solution did not meet all of the solution requirements and missed the mark of the prize competition, but has lots of potential for educational use. Public Affairs is very interested in utilizing this dashboard concept in a visitor center or other educational situations.
OUTCOME: $2,500

S013
Solution S013 consisted of a data dashboard tailored to fishing or white water rafting. It was selected for an "innovative nugget" award for its clean and focused method of displaying recent trends relevant for recreational activities. The judging panel found the solution to be somewhat limited in scope, and noted that it did not convey whether the conditions were appropriate for the selected activity, so it is up to the user to know. Although it provided user-customizable selection, it did not provide interactive capabilities.
OUTCOME: $2,500

S023
Solution S023 consisted of an animated visualization of hourly streamflow at multiple locations. It was selected for an "innovative nugget" award for the pulsating graphs to visualize time lags in flows and relative magnitude of flow changes. It was a novel approach to visualization of hourly

streamflow data, and appeared to be well suited as an add-on module to a larger visualization rather than a standalone visualization solution.
OUTCOME: $2,500

Submissions Not Recommended for Award

S004
Solution 004 consisted of a series of graphs based on Visualizing Water, a graphical illustration of water use developed by TRUTHStudio and The Nature Conservancy. The submission did not present an innovative visualization with interactive features and therefore did not meet the minimum solution requirements and judging criteria detailed in the prize competition posting. This solution did not warrant further discussion.
OUTCOME: No award

S005
Solution 005 consisted of three example visualizations developed for other purposes. It was written in the form of a statement of qualifications and did not provide a visualization solution for the Colorado River Basin Since no solution was provided, it did not warrant further discussion.
OUTCOME: No award

S006
Solution 006 consisted of a proposal for developing an interactive visualization consisting of a main map and widgets. The solution utilized a tracking algorithm for customization, but there was concern that it would be difficult to implement in Reclamation's environment. The rest of the submission was vague and not well developed, and the judging panel felt that logging in should not be considered a novel idea. The solution did not warrant further discussion.
OUTCOME: No award

S007
Solution 007 consisted of a method for making short-term streamflow predictions. The submission did not address the majority of solution requirements and judging criteria detailed in the prize competition posting. The solution did not warrant further discussion.
OUTCOME: No award

S010
Solution 010 consisted of a static image of 3D bar graphs and a discussion of "The Natural Flow Regime." The submission did not address the majority of the solution requirements and judging criteria detailed in the prize competition posting. The solution did not warrant further discussion.
OUTCOME: No award

S011
Solution 011 consisted of a Tableau map showing streamflow and weather conditions. It was similar to existing websites and other submissions, and did not offer innovative visualization ideas. . The solution was simplistic and did not warrant further discussion.
OUTCOME: No award

S015
Solution 015 consisted of a Tableau dashboard with a map and graphs. It consisted of typical mapping and water data visualization features, and was very basic. The solution seemed to be similar to many other data sites that are already available and did not warrant further discussion.
OUTCOME: No award

S016
Solution 016 consisted of a description of an Amazon Alexa interface for retrieving Colorado River Basin data. This solution did not meet the solution requirements detailed in the prize competition posting because of its lack of visualization. The solution also did not support CRB data use cases. The solution did not warrant further discussion.
OUTCOME: No award

S017
Solution 017 consisted of a map with data layers. The submission description was vague, but described standard mapping features and typical methods for displaying water data, without explaining how the visualization would support a use case or provide innovative, interactive, and user-driven features. The solution did not warrant further discussion.
OUTCOME: No award

S022
Solution 022 consisted of a 3D dashboard for use with virtual reality. It provided interactive capability for existing web pages, but did not directly use or integrate any datasets. The solution did not warrant further discussion.
OUTCOME: No award

S024
Solution 024 consisted of an animated visualization of hourly projected reservoir releases and energy. It was very similar to Solution 23, but lacked the ability to see time lags and trends. Due to the similarities to Solution 023, the “innovative nugget’ was awarded to only one of these solutions.
OUTCOME: No award