General Modeling Information

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Colorado River System 5-Year Projected Future Conditions

Overview

Two models, the Colorado River Simulation System (CRSS) and the Mid-term Operations Probabilistic Model (MTOM), are utilized in developing probabilistic projections of future Colorado River system conditions over the timeframe of two years to several decades. Both CRSS and MTOM are comprehensive models of the Colorado River system implemented in the commercial river modeling software developed by the University of Colorado called RiverWare™, and are updated and maintained continually by Reclamation's Upper and Lower Colorado Regions.

CRSS is a long-term planning model typically used to project river and reservoir conditions over a period of decades into the future, while MTOM is a risk-based operational model for mid-term operations within a one to two year planning window. Both models simulate the operation of the major reservoirs on the Colorado River and provide information regarding the projected future state of the system on a monthly basis. Output variables include the amount of water in storage, reservoir elevations, releases from the dams, the amount of water flowing at various points throughout the system, and diversions to and return flows from water users throughout the system. These simulations utilize a mass balance (or water budget) calculation, which accounts for water entering the system, stored in the system, and leaving the system. Both models contain modeling "rule sets", which control the operation of the Colorado River mainstream reservoirs, including Lake Powell and Lake Mead. These rule sets describe how water is released and delivered under various hydrologic conditions with an aim to reflect actual operations.

CRSS representation of Hoover Dam to Davis Dam

A key difference between CRSS and MTOM are inputs regarding future hydrology. Both models simulate a range of hydrologic futures to account for future hydrologic uncertainty. Because CRSS is a long-term model, capable of projecting decades into the future, hydrologic inputs are derived from methods designed to represent future uncertainty in hydrologic variability and long-term change. MTOM is used to project operations over the next one to two years and utilizes streamflow forecasts provided by the National Weather Service Colorado Basin River Forecasting Center (CBRFC) to account for mid-term hydrologic uncertainty.

Coupling results from CRSS and MTOM provides a set of projections that utilizes the current CBRFC forecast for the near-term, and accounts for wide range of plausible future inflows for the mid- to long-term.

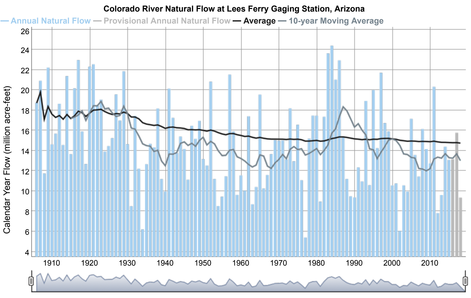
Future Hydrology

Although there are several sources of uncertainty in CRSS/MTOM output (for example, representation and parameterization of physical process such as reservoir evaporation and future water use for entities throughout the Colorado River Basin) projections of future conditions (for example, future Lake Mead and Lake Powell elevations) are most sensitive to future hydrology. Observations over the period of historical record (1906 through present) show that inflow into the system has been highly variable from year to year and over decades thus significant uncertainty exists in projecting future system inflows. Both models account for uncertainty in future inflows by conducting multiple simulations that reflect a range of plausible inflow scenarios. The results from these simulations are expressed in probabilistic terms, and are used to quantify the probability of occurrences of particular events (for example, higher or lower reservoir elevations).

Colorado River Natural Flows

The Colorado River natural flow dataset is the observed flow corrected for the effects of upstream reservoirs and depletions. It represents the flow that would have occurred at a location had depletions and reservoir regulation not been present upstream of that location.

The historical Colorado River natural flow at the Lees Ferry gaging station in Arizona is shown in the graph below.

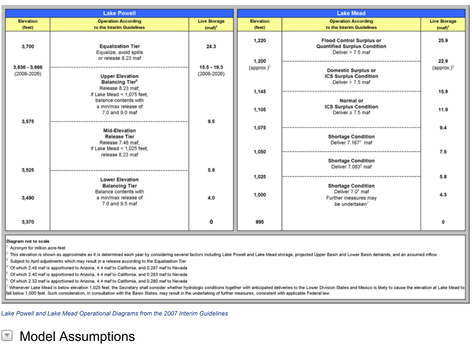


There are several methods for projecting possible future inflow sequences. Because CRSS is a long-term model, capable of projecting decades into the future, hydrologic inputs are derived from methods designed to represent future uncertainty in hydrologic variability and long-term change. These methods include resampling the historical record (either from the measured record or a derived record using a "proxy" such as tree-ring data), deriving future inflow data by preserving key statistics of this historical record while adding a random component, and using physically-based models to simulate runoff based on general circulation model projections of temperature and precipitation. The Colorado River Basin Water Supply and Demand Study assessed future streamflow projections derived from each one of these methods and then compared projections of the Colorado River system under each.

MTOM is used to project operations over the next one to two years and utilizes streamflow forecasts provided by the CBRFC to account for near- to mid-term hydrologic uncertainty.

Lake Mead and Lake Powell Coordinated Operations

The modeled operations are consistent with the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and Lake Mead. The coordinated operational diagram below outlines the coordinated reservoir operations of both reservoirs at different pool elevations.



Lake Powell and Lake Mead Operational Diagrams from the 2007 Interim Guidelines

Model Assumptions

Key model assumptions and differences between the two models used by Reclamation to develop probabilistic projections of future Colorado River system conditions are highlighted in the table below.

Table 1: Key Model Assumptions

	MTOM	CRSS
Primary Use	Risk-based operational planning and analysis during mid-term time period	Long-term planning studies, operational criteria development, and risk analysis
Simulation Start Date	Current month of current calendar year	January of next calendar year
Reservoir Initial Conditions	Based on observed reservoir elevations from the last day of the previous month	Actual or projected December 31 conditions of the previous or current year. Projected conditions are based on either MTOM or the 24-Month Study.
Lake Powell and Lake Mead Operations	Operations are consistent with the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and Lake Mead.	
Upper Basin Inflows	Ensemble of 35 unregulated inflow forecasts based on observed temperature and precipitation from 1981-2015, provided by the Colorado Basin River Forecast Center.	Several method available to generate future natural flows. These include resampling natural flow record (1906-2014) or tree-ring record, or deriving streamflow from general circulation model simulations.
Lower Basin Inflows	35 possibilities based on the 35-year (1981-2015) historical record	Several method available to generate future natural flows. These include resampling the historical natural flow record (1906-2015) or tree-ring record, or deriving streamflow from general circulation model simulations.
Upper Basin Water Demand	Estimated and incorporated in the unregulated inflow forecasts provided by the CBRFC	Developed in coordination with the Upper Colorado River Commission
Lower Basin Water Demand	Developed in coordination with the Lower Basin States and Mexico	

For additional information or questions, please contact us via email at: ColoradoRiverModeling@usbr.gov.

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