

May 2022 Colorado River Mid-Term Modeling System: Ensemble Streamflow Prediction Mode (CRMMS-ESP)

Key Modeling Assumptions:

- Version
 - Model file and ruleset saved in RiverWare version 8.4.4
 - NOTE: RiverWare version 8.4.4 or higher is required to run the May 2022 CRMMS due to implementation of new RiverWare Accounting functionality
 - Model file CRMMS_V2.0.202205_ESP.mdl
 - Ruleset file CRMMS_V2.0.rls
- Model initialization
 - Observed April 30, 2022 initial conditions for all modeled reservoirs
 - Model run duration of May 2022 through September 2027
 - May 2022 Most Probable final unregulated inflow forecasts dated May 4, 2022 loaded into model
- Unregulated inflow forecast ensemble
 - All inflow traces are provided by the Colorado Basin River Forecast Center and dated May 4, 2022 (or May 17, 2022 for Navajo modified unregulated inflow).
 - The Ensemble Inflow workbook includes the 30 ESP traces plus the official May 2022 Most Probable inflow scenario used in the May 2022 24-Month Study.
 - For the Most Probable inflow scenario, the inflows from the third year are repeated for the fourth, fifth, and sixth years to provide a model run duration.
 - The output is viewable in the CRMMS_EnsembleOutput workbook, which provides visualizations for the first two years of the model run for the 24-Month Study's official forecast scenario.
- Lower Basin water demand schedules
 - 2022: Water use schedules are based on the May 2022 Most Probable 24-Month Study, but may be varied based on the Lower Basin hydrology for each trace.
 - 2023-2024: Water use schedules are based on those used in the May 2022 Most Probable 24-Month Study, but may be varied based on the Lower Basin hydrology, projected water supply conditions, or the Sacramento River Water Year Classification (SRWYC) for each trace.
 - 2025-2027: Water use schedules repeat the 2023 default monthly schedules in the out-years except for Southern Nevada Water Authority and the California water users affected by the Colorado River Water Delivery Agreement. Schedules may be revised based on Lower Basin hydrology, projected water supply conditions, or the SRWYC for each trace.
- Modeled Policy
 - The model assumes the same operations as the 2007 Interim Guidelines, the Drought Response Operations Agreement (DROA), the 2019 Drought

Contingency Plans (DCP), and the International Boundary Water Commission Minute 323 to the 1944 Treaty with Mexico including the Binational Water Scarcity Contingency Plan through water year (WY) 2027.

- The model includes the 2022 DROA Plan to release a total of 500 kaf from Flaming Gorge from May 2022 through April 2023.
- The model includes the Glen Canyon Dam operational adjustment, which reduces releases from Glen Canyon Dam by 480,000 acre-feet in WY 2022 resulting in a WY 2022 release of 7.0 maf.
 - Recognizing that operational decisions for 2023 and beyond have not been made, projections of all future year operating tiers/conditions utilize the concept of “operational neutrality”, which means that the reduction of releases from Glen Canyon Dam in WY 2022 will not affect future operating determinations and will be accounted for “as if” this volume of water had been delivered to Lake Mead in WY 2022.
 - Again, recognizing that operational decisions for 2023 and beyond have not been made, for all traces that project Glen Canyon Dam to operate in a balancing condition in a future water year, releases are simulated in a manner that attempts to preserve the benefits to Glen Canyon Dam facilities and operations.
- Changes to modeling system files since the April 2022 CRMMS-ESP release
 - In the Havasu reservoir object, changed the Parker Dam power method from the Peak and Base method to the LCR Power method.
 - In the LCR method, energy is computed based on outflow and operating head, and uses an efficiency coefficient which varies based on the monthly timestep. Analysis of projected versus actual energy indicates that this method produces better projections than the Peak and Base method because Parker Dam is frequently not operated as a peaking power plant.
 - Added the new Flaming Gorge bathymetry data to the elevation-volume and elevation-area tables in the Flaming Gorge reservoir object.
 - Implemented RiverWare Accounting functionality (data and rules) to track DROA releases, recovery, and storage in Upper Basin reservoirs. This is predominantly done when the model is in 24-Month Study mode.
 - Incorporated the approved 2022 DROA Plan actions into model data and rules for CRMMS-ESP runs (i.e., ensemble mode):
 - Added data slots and rules so that approved DROA releases from Flaming Gorge (as well as Blue Mesa or Navajo, should a future such operation be approved) are added to the variable Flaming Gorge release computed by the rule logic as appropriate for each hydrologic inflow scenario. This takes place through a new rule “Add DROA Release for ESP”.
 - In 2021, in contrast, Flaming Gorge and Blue Mesa outflows with approved DROA releases were set to input as entered in the Most Probable 24-Month Study, which did not allow for hydrologic variability in that water year.

- The incremental volume added to (or subtracted from) each monthly time step can be found in the following slots:
`FlamingGorgeData.AdditionalReleaseDueToDROA_ESP`,
`NavajoData.AdditionalReleaseDueToDROA_ESP`, and
`BlueMesaData.AdditionalReleaseDueToDROA_ESP`
 - These slots are populated by a new initialization rule: “Set Additional DROA Releases from ESP from 24 Month Study”.
- Incorporated the approved Glen Canyon Dam operational adjustment into model data and rules:
 - Added data slots for “effective,” or “tier determination” elevations for Lakes Powell and Mead.
 - *MeadData.EffectiveEOCYPoolElev* represents the end-of-calendar-year physical elevation plus 480 kaf added to the storage volume.
 - *PowellData.EffectiveEOCYPoolElevWith823Rel* represents the end-of-calendar-year elevation where Lake Powell releases the traditional 8.23 maf release pattern for tier determination purposes, after 480 kaf are subtracted from the physical storage volume.
 - Rule logic was added to use the slots above to set Lake Powell’s release tier and Lake Mead’s operating condition and DCP level.
 - Rules and functions are used in the following policy sets: Powell, PowellafterLBDV, and Mead and Lower Basin Condition Determination (e.g., function `GetProjectedPoolElevation`).
 - Added effective pool elevation slots to rdf and excel output DMIs.
 - Added data slots to track water stored in Lake Powell which would otherwise have been released downstream into Lake Mead.
 - *PowellData.LBAnnualWaterInPowell* represents the volume by which Lake Powell’s annual outflow was reduced in a given water year
 - *PowellData.LBBankInPowell* represents the cumulative volume by which Lake Powell’s outflow was reduced over the model run. Rule logic was added so this volume will not be released during the computation of balancing releases. Balancing in all years of the model run will be to the “effective” end-of-water-year storage (i.e., end-of-WY storage plus or minus the 480 kaf).