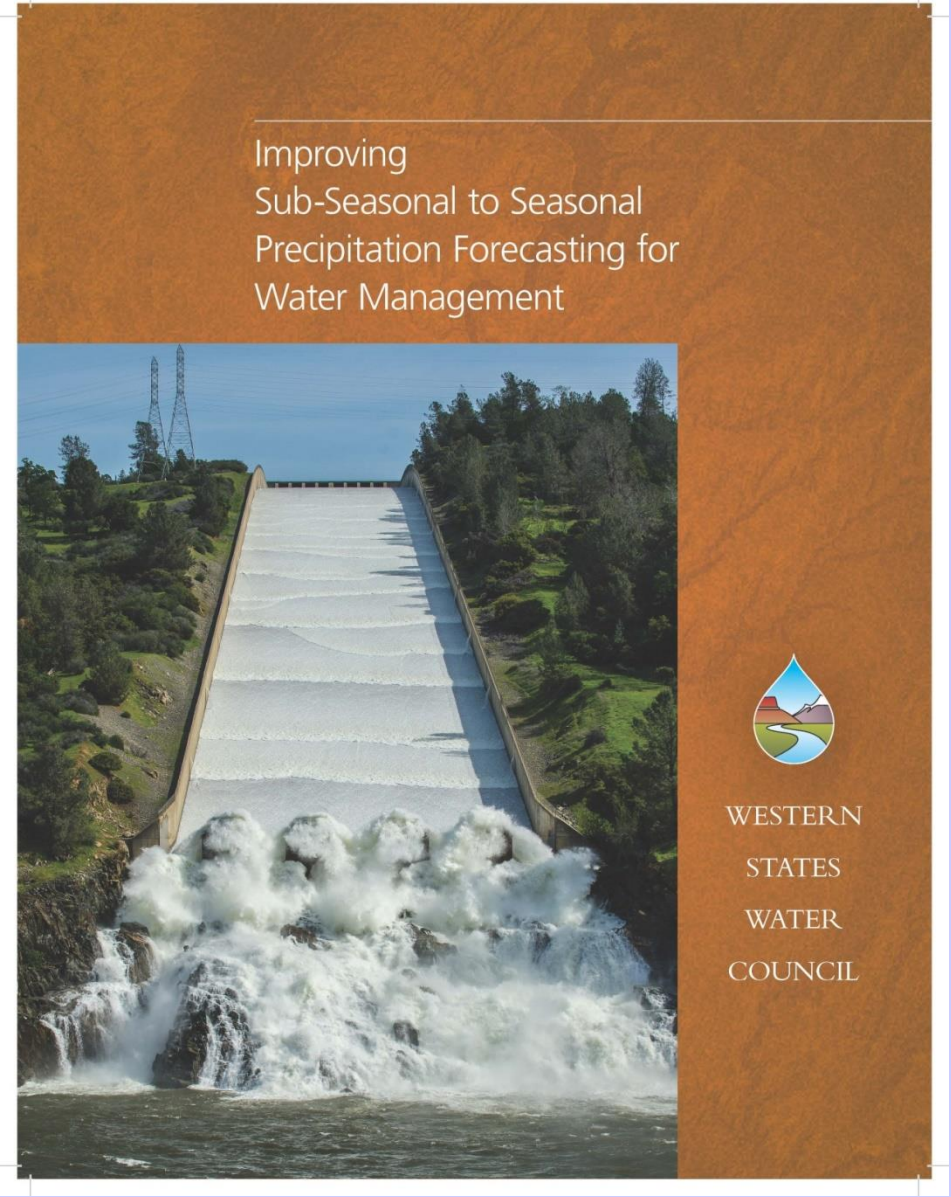


TROA & Improved S2S Forecasting – An Opportunity

Jeanine Jones , CDWR

Sub-seasonal to Seasonal (S2S) Precipitation Forecasting -- Background

- S2S forecasting refers to timespan beyond a 2-week weather forecast, going out weeks to months
- Skill of current operational National Weather Service outlooks is minimal, but skillful forecasts would be very useful for water management
- WSWC is working with S2S Precip Coalition to urge NOAA to put higher priority on improving forecasts

Truckee River Operating Agreement (TROA) Example for Application of S2S Forecasting

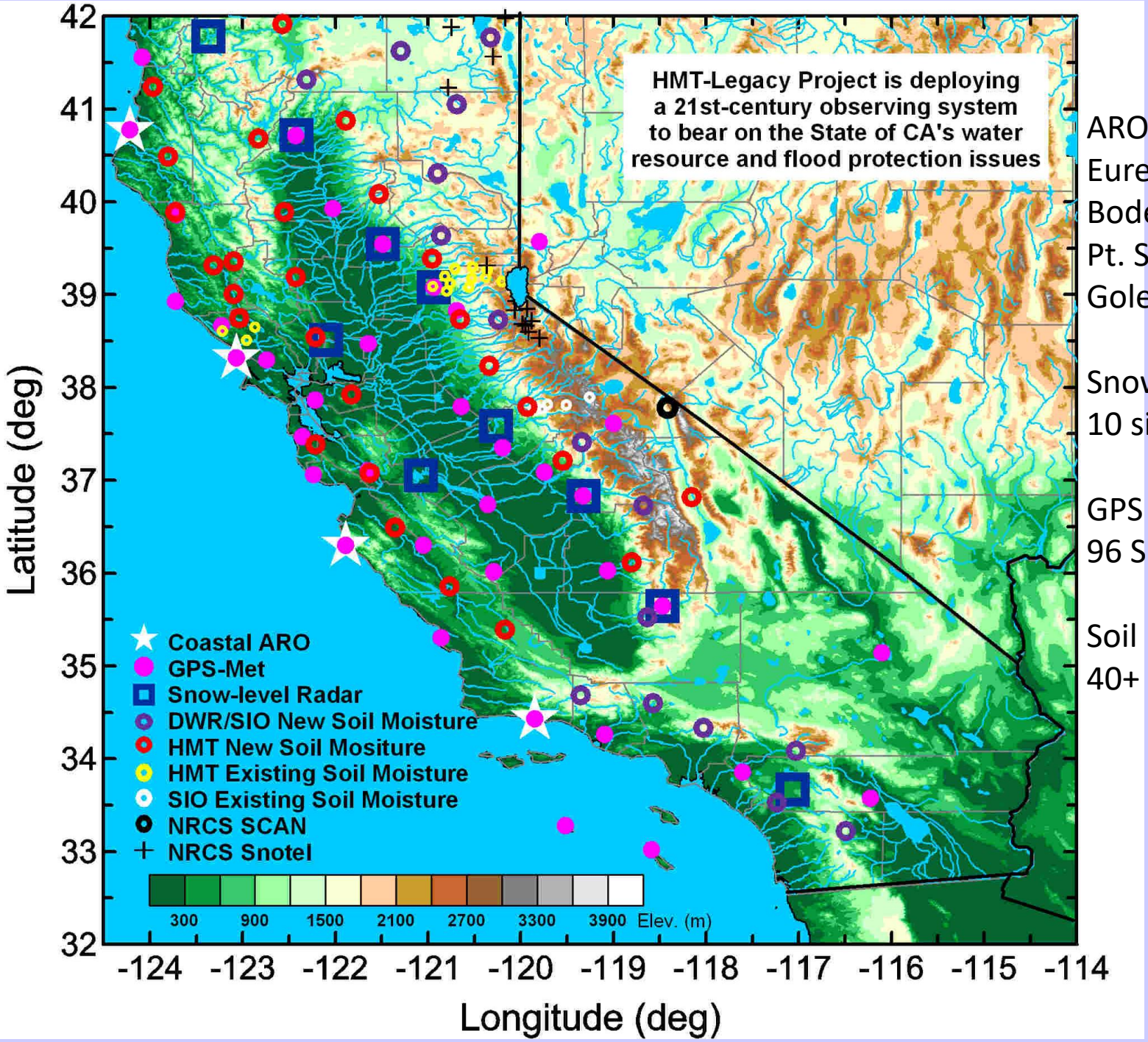
- Purpose of this talk is to reprise an excellent presentation from WSWC/CDWR workshop on S2S forecasting held in San Diego in May 2017, for the water rights people unable to attend that workshop
- Many of the following slides are from Shane Coors, Precision Water Resources Engineering, consultant to Truckee River Watermaster

About TROA

- Orr Ditch Decree, 1944
- Truckee – Carson – Pyramid Lake Water Rights Settlement Act of 1990
- TROA signed in 2008, to implement settlement act
- TROA implementation (finally) began in Dec 2015

Application of Improved Forecasting for TROA – California Perspective

- River operations benefits u/s in California for fishery flows and recreation
- TROA creates system of “credit water” in the upstream reservoirs in California, better forecasts translate to more efficient management of credit water
- Existing CDWR/NOAA 21st century observing system for extreme precip installed on west side of Sierra Nevada, those forecasting benefits can apply to east side of Sierra



ARO Installs
Eureka – July 2015
Bodega Bay – Online
Pt. Sur – Nov 2015
Goleta – Aug 2015

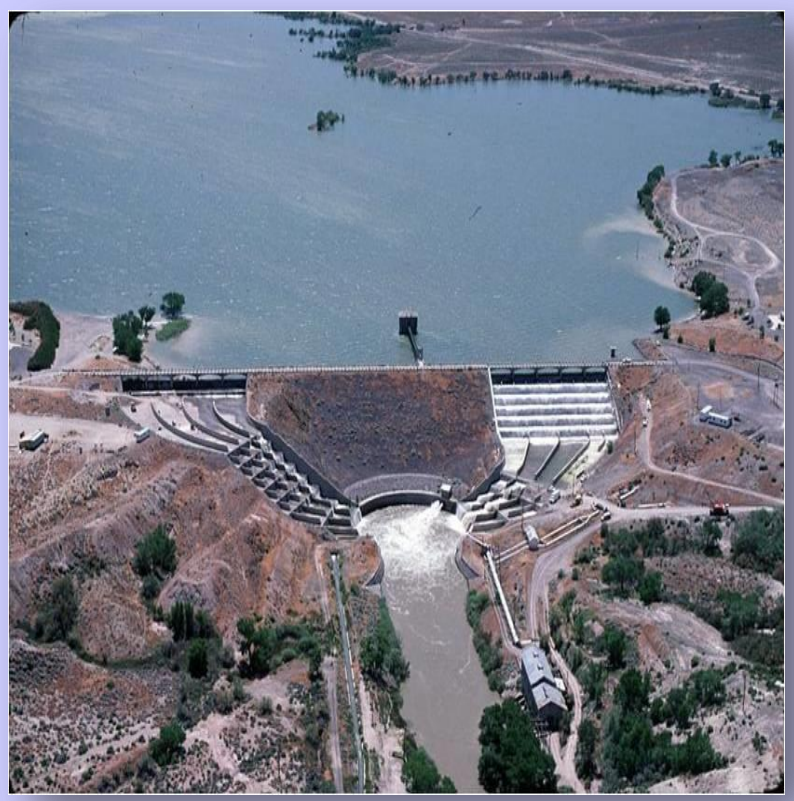
Snow Level Radar
10 sites installed

GPS Met
96 Sites Operational

Soil Moisture
40+ Sites

Impacts of Improved S2S Forecasts on Truckee - Carson Basin Operations

Western States Water Conference Workshop
May 19th, 2017



Shane Coors, PE
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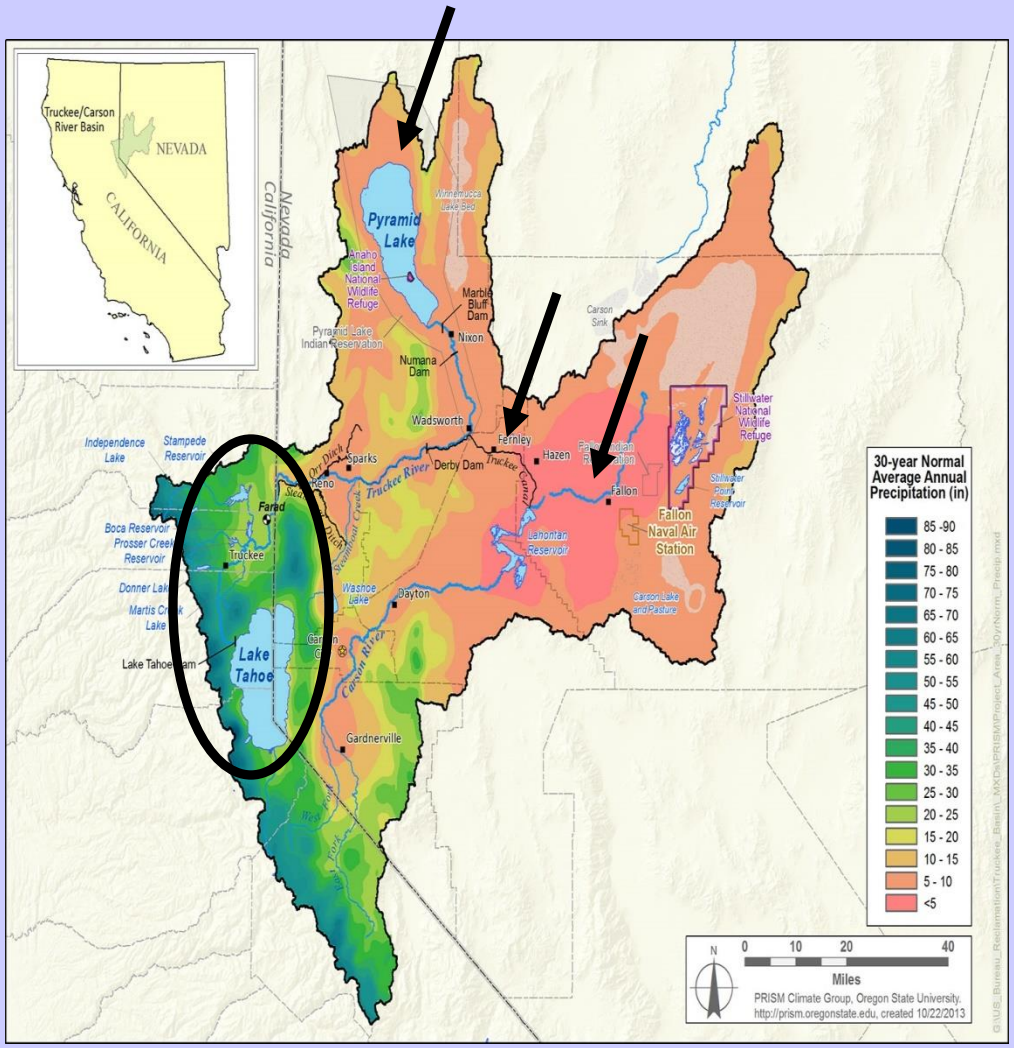
Truckee–Carson Basin Introduction

- Truckee River is ~100 miles long, flowing from Lake Tahoe to Pyramid Lake
- Seven upstream storage reservoirs that regulate ~70% of the basin water supply
- Majority of the water originates in California (Sierra Nevada Mountains)
- Majority of the water usage is in Nevada
- The river ends in a desert terminal lake, Pyramid Lake in the Great Basin
- Water is diverted from the Truckee Basin to the Carson basin via the Truckee Canal at Derby Dam
- The Newlands Project is served by the combined Truckee and Carson River in the lower Carson River basin



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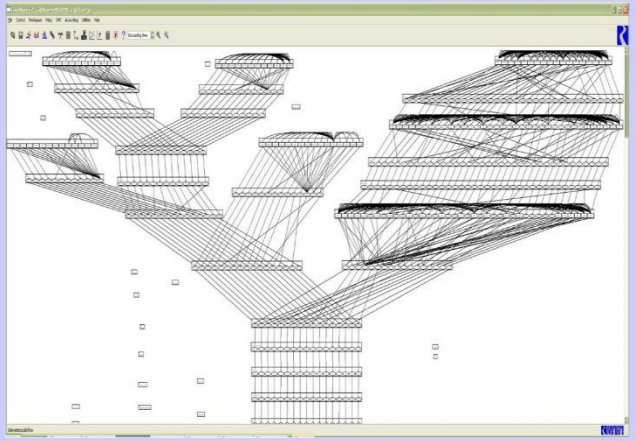
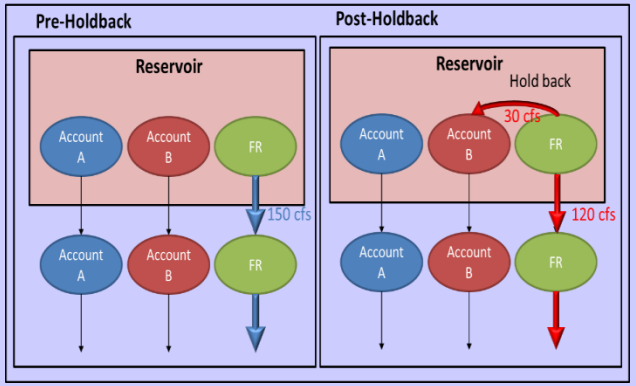
TROA Introduction

- Origin – Public Law 101-618 - Under the 1990 Settlement Act, Secretary of the Interior is directed to negotiate an operating agreement for the Truckee River Reservoirs
- Purpose – To improve operational flexibility and efficiency of Truckee River reservoirs while satisfying water rights in conformance with existing decrees
- Signatory Parties
  - Secretary of the Interior (United States)
  - State of California
  - State of Nevada
  - Pyramid Lake Paiute Tribe
  - Truckee Meadows Water Authority
- Signed into law in 2008. Implementation began on December 1st, 2015
- The primary tool for implementation of the agreement is a RiverWare operations/accounting model run by the TROA Administrator/Federal Watermaster

TROA Characteristics

- TROA establishes mechanisms (credit water establishment, exchanges, etc.) by which stakeholders can utilize their water resources more flexibly and efficiently
- Stakeholders can propose and schedule mutually beneficial transactions (exchanges and trades) whereby diverse objectives can be achieved
  - Environmental benefits (enhanced instream flows, habitat maintenance)
  - Hydropower generation
  - Drought resiliency
  - Recreational flows and reservoir levels
- These transactions require much more precise and demanding water accounting and operation of the reservoirs
- Parties are less inclined to enter into these potentially beneficial, but voluntary transactions when outcomes are highly uncertain
- Hydrologic uncertainty is the greatest source of uncertainty in future conditions





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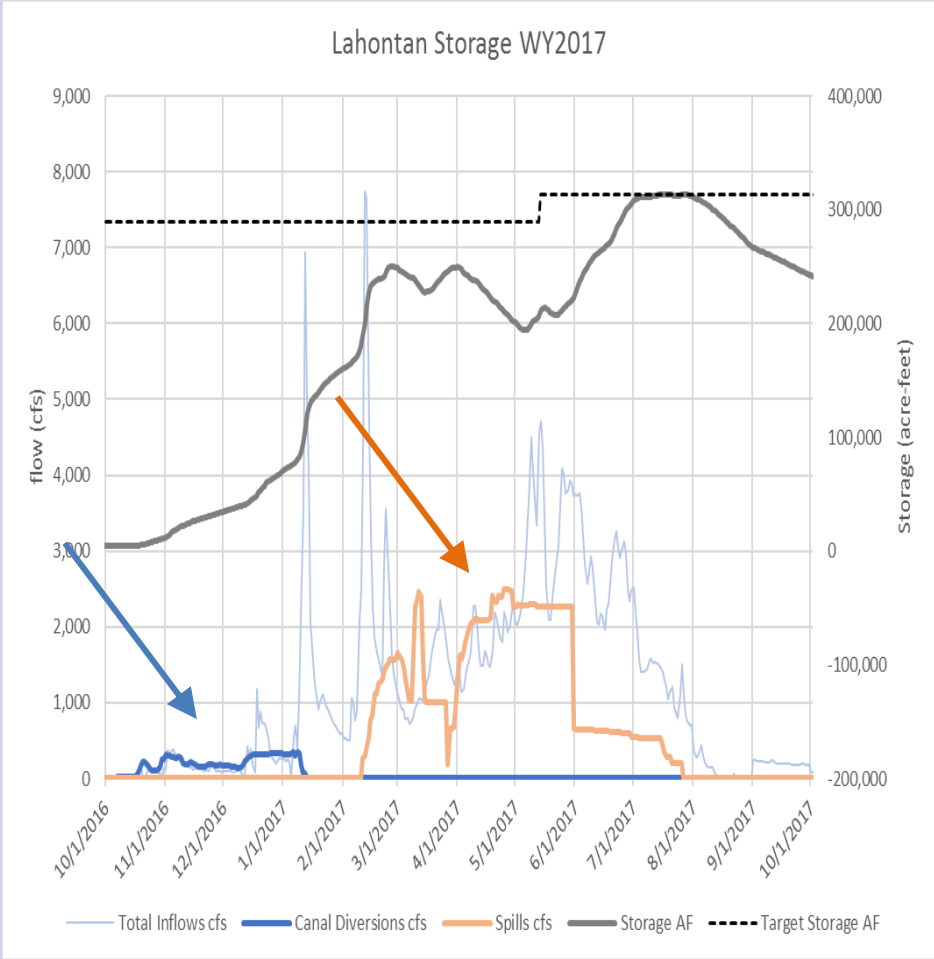
Lahontan-Truckee Canal Diversions

Example #1

- Lahontan reservoir stores inflow from the Carson River, supplemented by diversions from the Truckee River through the Truckee Canal
- In late 2016 per OCAP, 40 KAF was diverted through the Truckee Canal to Lahontan Reservoir because of very low storage
- Record inflows to Lahontan Reservoir from the Carson river occurred during early 2017
- Current projection is 440 KAF will be spilled this water year, requiring significant investments to facilitate this release.
- Had record high January and February inflows been foreseen in November, diversions could have been avoided, reducing the required spill.



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Fish Water Operations

Example #2

- Pyramid Lake is home to one endangered fish species, the Cui-ui, and one threatened species, the Lahontan Cutthroat Trout
- 2015 was the 4th consecutive dry year in the Truckee System, and the driest April-July runoff volume on record
- Storage in Stampede reservoir, which is designated for the Pyramid Lake fishes, was retained in Fall of 2015 despite very low flows in the lower river
- If it had been known that 2016 would return to average, minimum flow targets could have been achieved, significantly reducing stress on the fish

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Uncertainty Propagation Technique

"The Problem"

- Water resources system models do a good job of accurately simulating physical processes and operational policy in a river system.
- There is uncertainty in model inputs such as demands, losses, return flows, and many others. But the largest source of uncertainty is the hydrologic forecast uncertainty, which is driven primarily by uncertainty in climate
- A "model run" assumes a single value for each of these quantities. It is almost certain, however, that the selected values are not accurate.
- Output from a model run gives no information about the level of uncertainty in its results.

Operation with Uncertainty Example

Lake Tahoe Releases - 2017

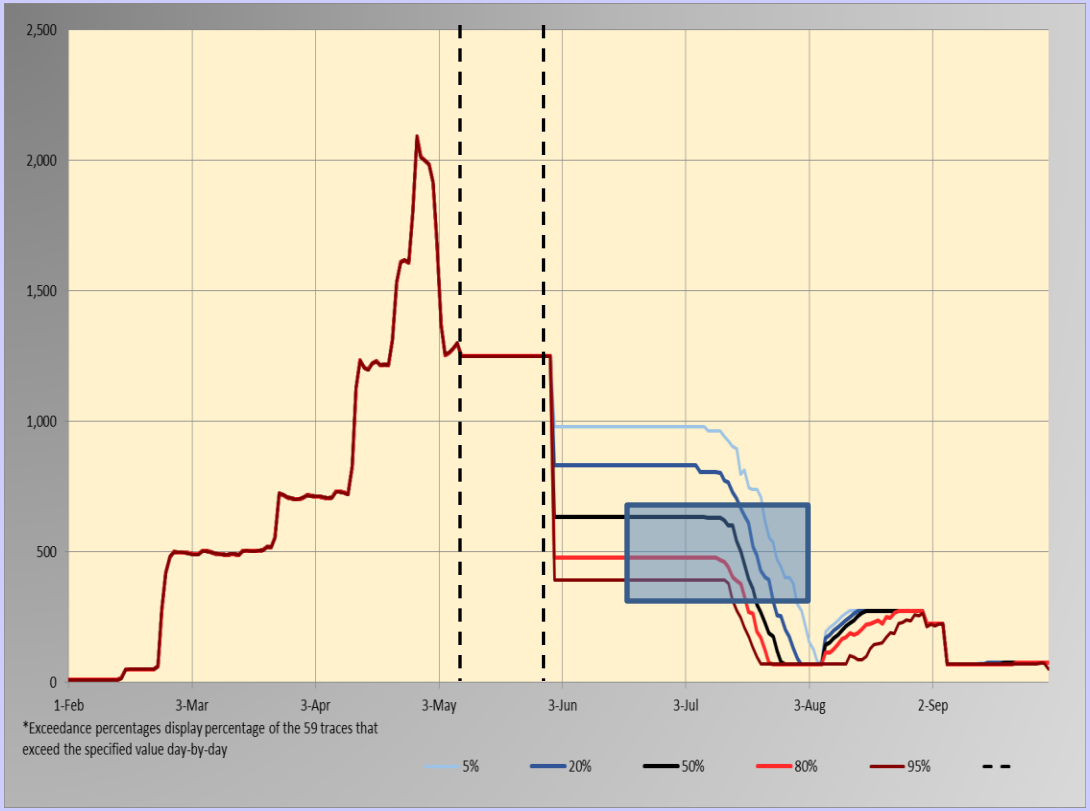
- 2017 has set the record for the most precip, deepest snowpack, and largest lake level rise to date in 116 years of record
- Federal Watermaster must spill to prevent the water surface elevation from exceeding its legal maximum (6229.1')
- For water supply purposes it is also critical that the lake be filled up to the maximum
- During runoff, daily inflows can be more than 15,000 cfs.
- Maximum release is 2600 cfs
- Level control releases must be initiated well in advance of the peak inflow
- High degree of uncertainty in future hydrology exists when critical release decisions are made

Operation with Uncertainty Example

Lake Tahoe Releases - 2017

- Release schedule set on May 8th : Release 1,250 cfs until June 1st
- RiverWare Model run 59 times holding this schedule until June 1st , then operating each trace individually to achieve perfect fill
- Resulting range in flows post-June 1st is the current range of uncertainty in future operations given the current range of uncertainty in inflows
- Traces are counted to generate exceedance bands of the output ensemble
- The 1,250 cfs was chosen after multiple ensemble runs as the optimal release based on the range of post-June 1 flows
- Release schedule was designed by taking into account the entire spread of future conditions
  - Guaranteed step down
  - Low end is above minimum
  - Maximize chances for rafting

Lake Tahoe Outflow (cfs)



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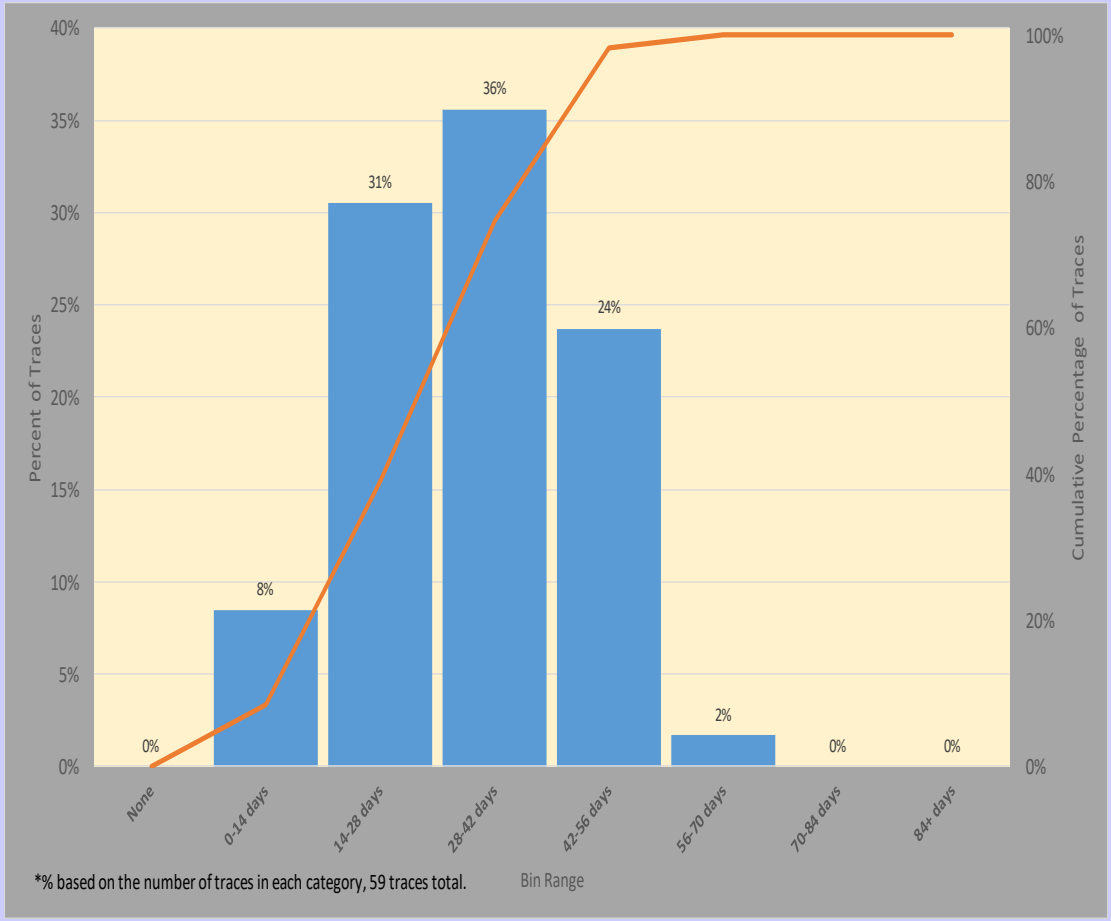
Operation with Uncertainty Example

Lake Tahoe Releases - 2017

So…will there be rafting in 2017? What is the right answer?

- It's not "No"
- It's not "Yes"
- It is definitely "Maybe"
- Probability distribution that characterizes the uncertainty in future operational condition is the most correct and complete answer
- Decreased uncertainty in future precipitation will propagate through the model to decrease uncertainty in operational conditions and facilitate better answers

Number of days between July and Labor day of 200 cfs to 5



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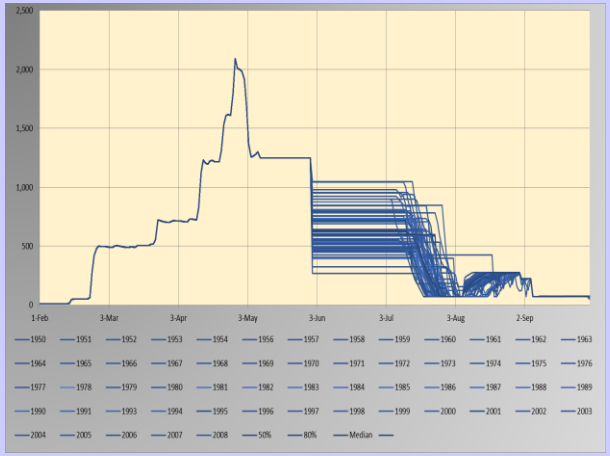
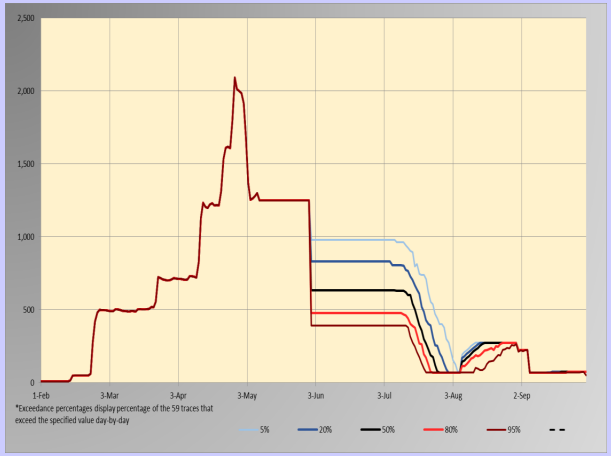
Taking a Look Ahead

How might better S2S predictability translate to reduced uncertainty in future operational conditions?

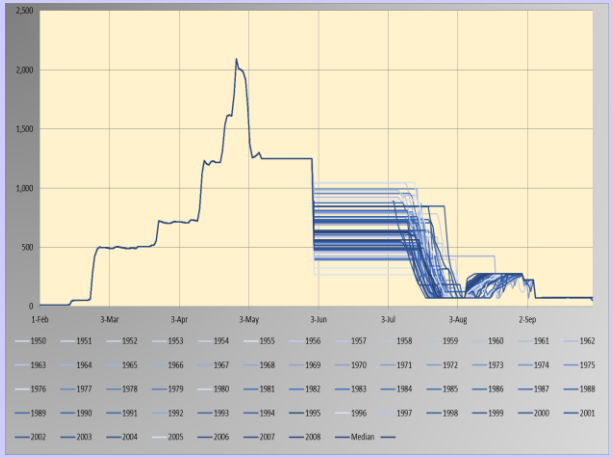
Un-weighted traces



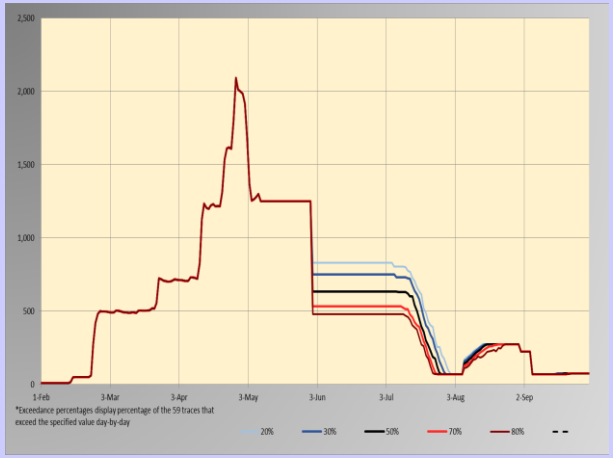
Σ traces



Weighted traces



Σ traces * weight



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Summary & Conclusions

- Modern water management is all about operating more efficiently
- We can negotiate the best agreements, but they can't be effectuated without the proper tools
- There's big potential benefit in improving S2S forecasting
- The federal government needs to place a higher priority on improving its operational outlook products and on supporting the needed research