A Methodology for Adaptive Water Management

Forecast-Informed Reservoir Operations (FIRO)

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Motivation

Drivers for FIRO

• The drought in California. Doing more with less.
• The need for the ability to have increased water management efficiencies with no loss in flood safety
• The need for climate change/variability adaptation methodologies
• The need to facilitate an answer to the “Forecast Act” before the U.S. Congress
FIRO Methodology: Providing an Iterative Means to Manage Climate Variability to Optimize Water Supplies

Step 1: Seasonal water supply forecasting (1 month to 10 years)

Step 2: Development of a Precipitation/Runoff Index

Step 3: Integrate the improved knowledge of the watershed into near-term hydro-meteorological forecasting for operational decisions.

Step 4: Integration of this improved knowledge into a more proactive water management plan.
Step 1: Seasonal Guidance for Reservoir Operations

Hydro-climate indices (i.e. El Nino/La Nina, Pacific Decadal Oscillations, the Blob) are used to make water year projections for a given basin.

Methodology:

• Develop correlations between historic HCI data (ONI/MEI) and eventual hydrologic outcomes

• Identify significant correlations between ENSO/PDO values and potential runoff
Step 1: Proof of Concept

The Flathead Lake BIA Drought Management Plan

- USACE/BIA Study
- Utilizes HCI guidance to prepare for the water year
- 10-year study – side-by-side USACE – HCI guidance
- >73% success rate for water year decisions in January.
Step 2: Precipitation/Runoff Index Development

- A database for hydro-meteorological information for both current and future conditions
- Can accept current input and any additional input that can be provided by future remote sensing infrastructure
- Increased knowledge of the watershed enhances existing forecast methodologies
Step 2: Proof of Concept

Improving Streamflow Forecasts in the Upper Rio Grande – CWCB, NSSL, NASA, JPL, NCAR, NRCS

- Airbourne LIDAR for snowpack analysis
- Improved SNODAS information network
- Portable weather radar (MRMS system, NSSL)
- Use of WRF-Hydro to project future flows
- Current/Advanced Remote Sensing for hydrologic guidance

Conejos Water Conservancy District - $237,000
Step 3: Integrating Forecast Data for Operational Use

- Determining the best use of an improved data set for model initialization and hydrologic forecasting.
- Old model/New data or New model/New data?
- Can be the extension and application of the HMT study findings (FIRO project in Sonoma County)
- The CNRFC, DWR and HEC have an interest in providing/assisting this integration.
Step 3: Proof of Concept

Improving Streamflow Forecasts in the Upper Rio Grande – CWCB, NSSL, NASA, JPL, NCAR, NRCS

• Difference between 25% error (previous years) and 4% error (during study) = $18M.
• Cost-to-benefit of 1 to 15.
• Program could be provided to the entire State of Colorado for $10M.
Step 4: Implementation

Envisioned as a collaborative effort to integrate FIRO methodologies into operational decision making with consideration for:

- Flood safety
- Water rights
- Minimum instream flows and temperature
- Hydropower production
- Water Supply (water utilities)
FIRO will provide a holistic approach for creating a more resilient water supply for California.
Each of the components of a complete FIRO program have been done successfully and are currently employed, sometimes ad hoc, in many locations in California and elsewhere.

The concept has been proven and will work in California. It needs to be deployed and vetted, so that it can eventually be expanded to the entire system.
What About This Water Year?
El Niño - Winter of 2015-2016

Quantifying El Niño:

Hydro-climate indices are used to quantify the shift of global energy and the strength of a given El Niño event. These are called the Oceanic El Niño Index (ONI) and the Multi-variate El Niño Southern Oscillation Index (MEI). They are a monthly dimensionless measure of sea surface and sub-surface temperatures, air pressure, wind, and cloud cover.

These monthly index values vary on a scale from -4 to +4.

Below -0.5 = La Niña
Above 0.5 = El Niño
Between -0.5 and 0.5 = Neutral
El Niño - Winter of 2015-2016

Where are we at today?

The current outlook calls for a Oct/Nov/Dec ONI of 2.2, but a Nov/Dec/Jan ONI of 2.5! The highest value in the entire period of record (1950-2015) for a three month period.

That is one very strong El Niño.
So, How Does This Year Compare to Other Strong El Niño Winters?

1982-1983
NOAA/NCDC Climate Division Precipitation Anomalies (in)
Nov to Mar 1982–83
Versus 1950–2007 Longterm Average

1997-1998
NOAA/NCDC Climate Division Precipitation Anomalies (in)
Nov to Mar 1997–98
Versus 1950–2007 Longterm Average
What Kind of Confidence Do You Have in this Forecast?

Of the 5 strongest El Niños in the 65 year period of record, 4 out of 5 have produced at least 140% of normal winter precipitation for the region.

An 80% chance for a 6 month forecast is almost as good as it gets.
All El Niños are Not the Same

The “blob” of above normal SSTs off the coast during this very strong El Niño has the potential to further modify weather systems as they approach the coast.
Questions?
FBRO Schematic

Database observed precipitation (P), snowpack (S), streamflow (Q), and reservoir inflow/outflow (RIO) at critical points and times (at least a 30 year period of record)

Examine methodologies and techniques to forecast critical event producing meteorological conditions

Examine meteorological scenarios with modified storage rules in CALSIM and flood models (baseline/historic scenarios)

The California Data Exchange Center, USACE, USGS, DWR, NRCS, USBR, NASA, JPL, NCAR, Local agencies, etc.

Compare values of P/S/Q/RIO to existing rule operational rule curves

Analyze meteorological conditions that produce the average and critical rainfall events

Hydro-meteorological Test (HMT) bed, MM5, RUC, GFS, WRF Hydro, Advanced QPF/QPE modeling, River Forecast Center output, Doppler Radar, Dual Pole Doppler Radar, etc.

Short-range FBO

Long-range FBO

Seasonal FBO

Long-range FBO = > 15-days (primarily done w/ statistical analysis of climate modes)
Short-range FBO = < 15-days (primarily done w/wx forecast models)
Seasonal FBO = > 60-days (primarily based on hydro-climate indices (ENSO, PDO, etc.)