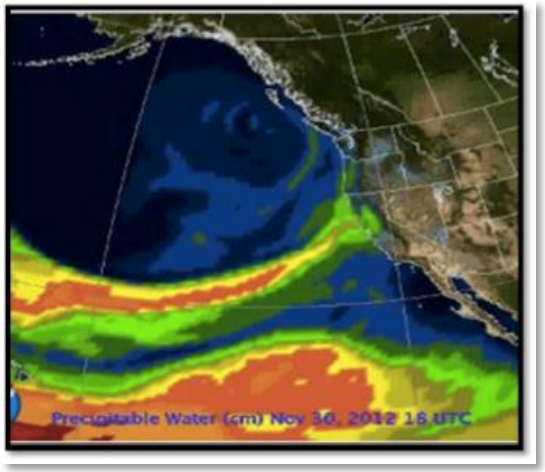
Forecast Informed Reservoir Operations – *An Opportunity to Improve the Resiliency of our Water Supply*



Western States Water Council
S2S Precipitation Forecasting
May 17, 2017
San Diego, California

Jay Jasperse, Chief Engineer
Sonoma County Water Agency

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Russian River Reservoirs

Dual Purpose Facilities

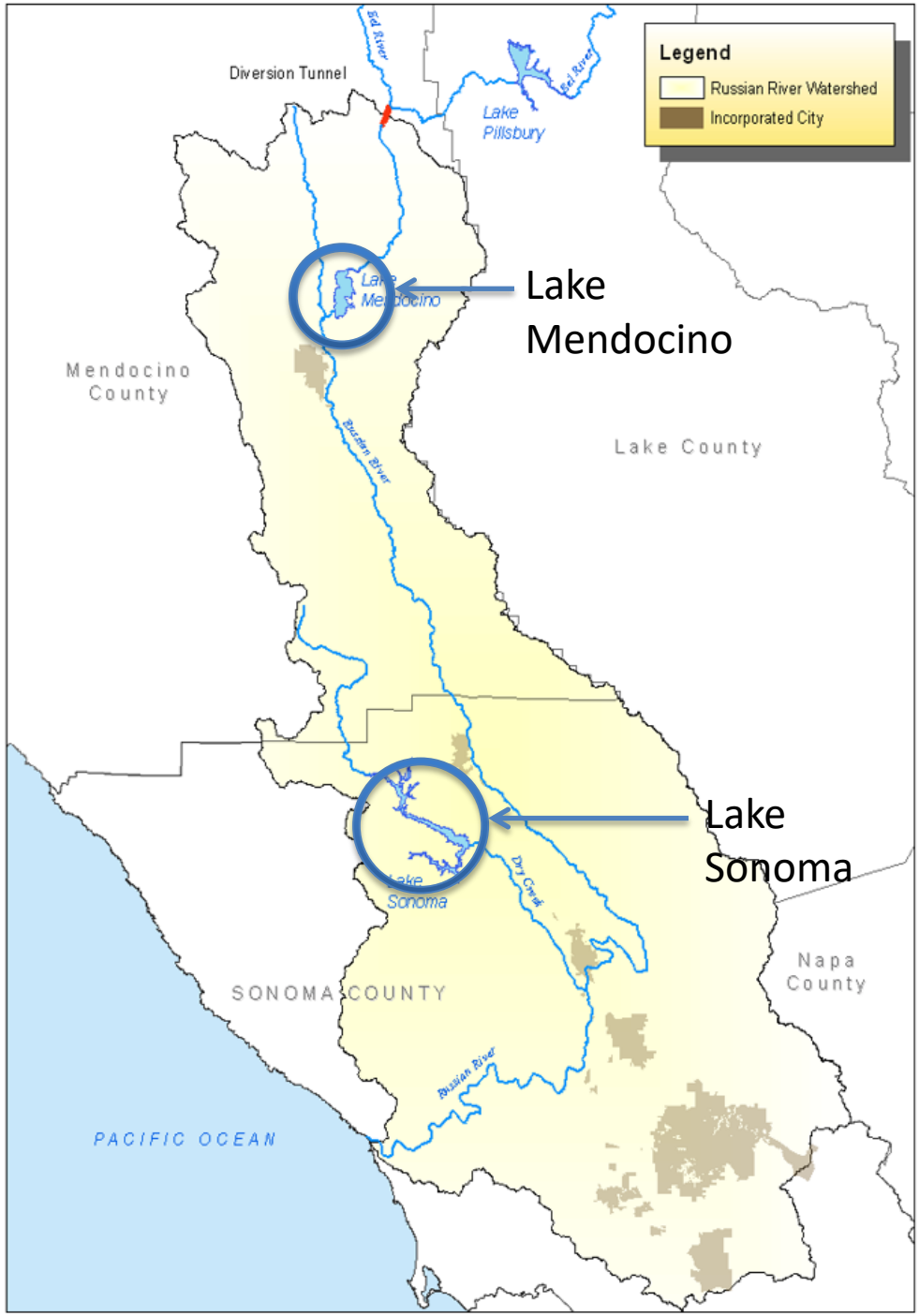
- Flood Protection (ACOE)
- Water Supply (SCWA)
- Operations Dictated by Storage Levels Relative to "Rule Curve"

Lake Sonoma (Warm Springs Dam)

Flood Control Pool:136,000 AF
Water Supply Pool: 245,000 AF

Lake Mendocino (Coyote Valley Dam)

Flood Control Pool: 48,100 AF
Water Supply Pool: 68,400 AF
(Nov. 1 – March 1)

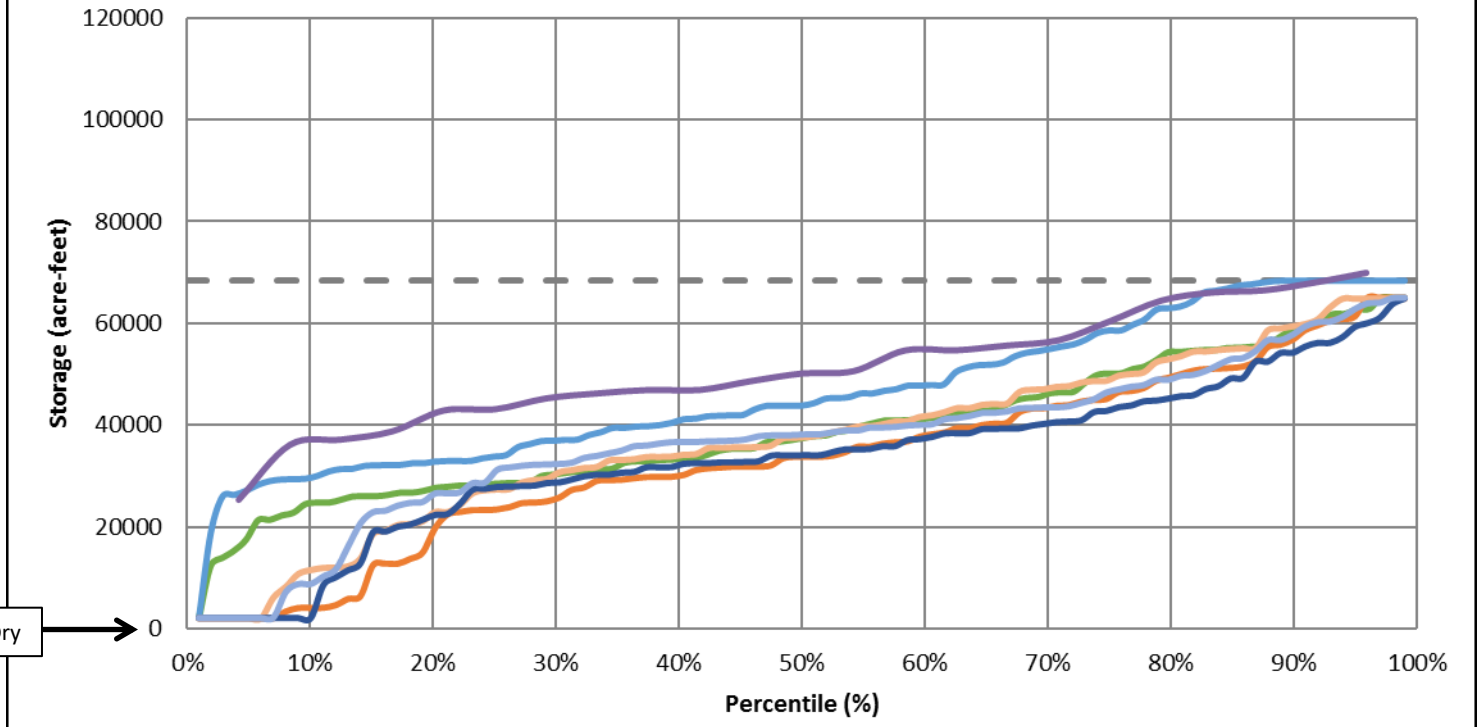


The Issue: Lake Mendocino's Water Supply Is Not Reliable

Some Reasons For Low Water Supply Reliability:

- Reduced inflow (56%) from the Eel River (via Potter Valley Project) results in an overall decrease of ~45% of total inflow
- Highly variable precipitation patterns
  - Almost 50% rainfall from atmospheric rivers
- Future growth & climate change will likely further reduce reliability

Lake Mendocino Minimum Annual Storage Distribution



Reservoir is Dry →

- Scenario #1: Modeled Data (1910 - 2013) with Current Operations of PVP, 2015 Projected Demands, and Modeled Historical Climate
- Scenario #4: Modeled Data (1910 - 2013) with Current Operations of PVP, 2045 Projected High Demands, and Modeled Historical Climate
- Scenario #5: Modeled Data (2001 - 2099) with Current Operations of PVP, 2045 Projected Low Demands, and Modeled Dry Climate
- Scenario #6: Modeled Data (2001 - 2099) with Current Operations of PVP, 2045 Projected High Demands, and Modeled Dry Climate
- Scenario #7: Modeled Data (2001 - 2099) with Current Operations of PVP, 2045 Projected Low Demands, and Modeled Wet Climate
- Scenario #8: Modeled Data (2001 - 2099) with Current Operations of PVP, 2045 Projected High Demands, and Modeled Wet Climate
- Observed Historical Data (1984 – 2006)

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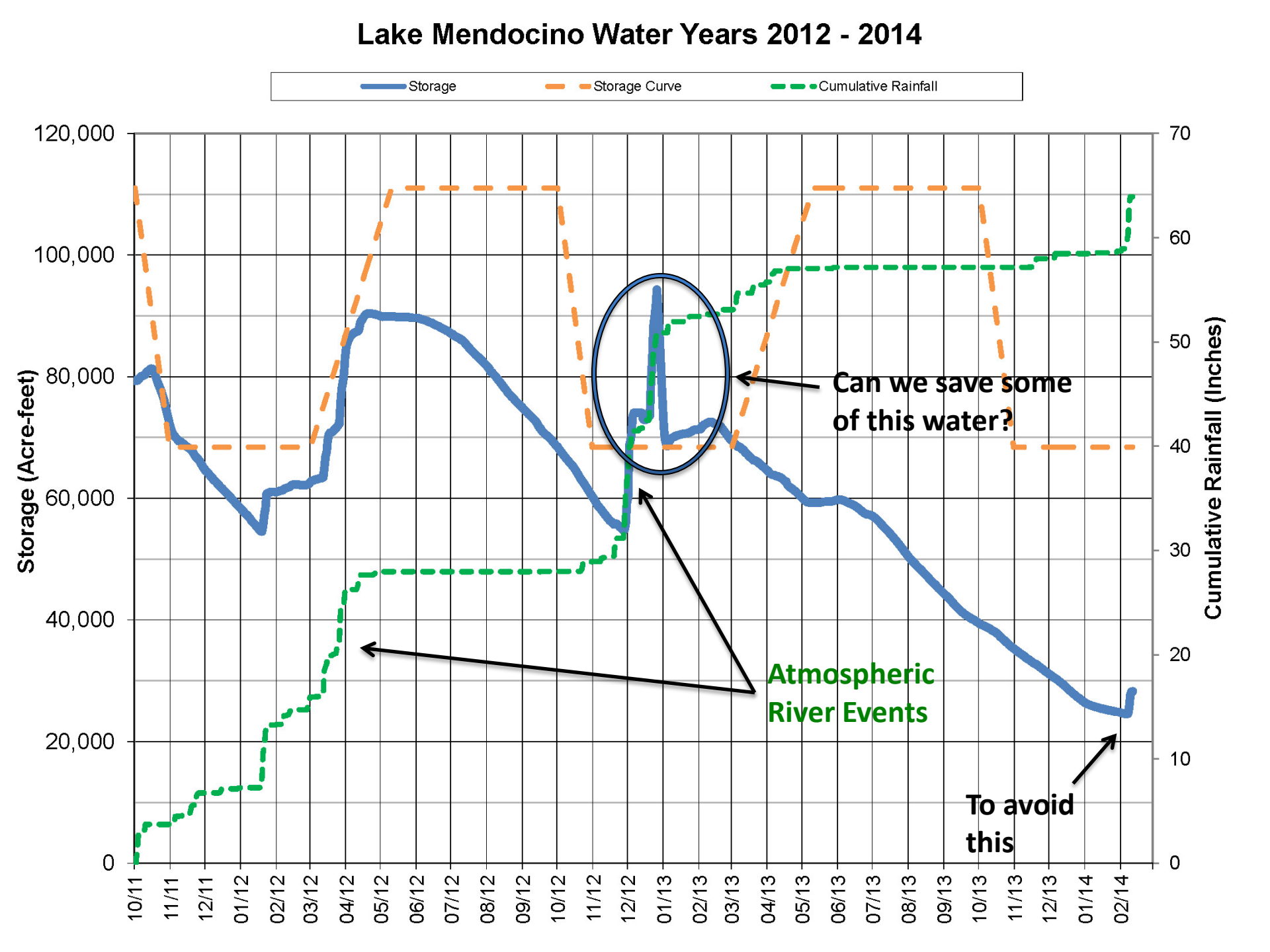
Lake Mendocino Water Years 2012 - 2014
Storage
Storage Curve
Cumulative Rainfall
Storage (Acre-feet)
Cumulative Rainfall (Inches)
120,000
100,000
80,000
60,000
40,000
20,000
0
70
60
50
40
30
20
10
0
10/11
11/11
12/11
01/12
02/12
03/12
04/12
05/12
06/12
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10/13
11/13
12/13
01/14
02/14
Can we save some of this water?
Atmospheric River Events
To avoid this

Lake Mendocino FIRO Demonstration Project – A Collaborative Effort

Broad coalition of federal, state, & regional agencies comprised of scientists & water managers

<u>Steering Committee:</u>

Federal: NOAA (OAR, NWS, NMFS), USGS, Army Corps of Engineers, & Bureau of Reclamation

State: California Department of Water Resources & Scripps Center for Western Weather & Water Extremes

Regional: Sonoma County Water Agency

Partnerships: NOAA Habitat Blueprint
Integrated Water Resource Sciences & Services

Possible Operational Improvements: Forecast Informed Operations

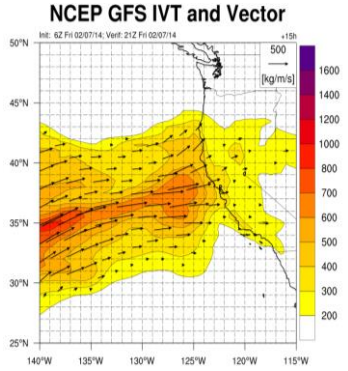
Incorporate current forecast skill into operations for periods when no storm events are predicted (near-term)

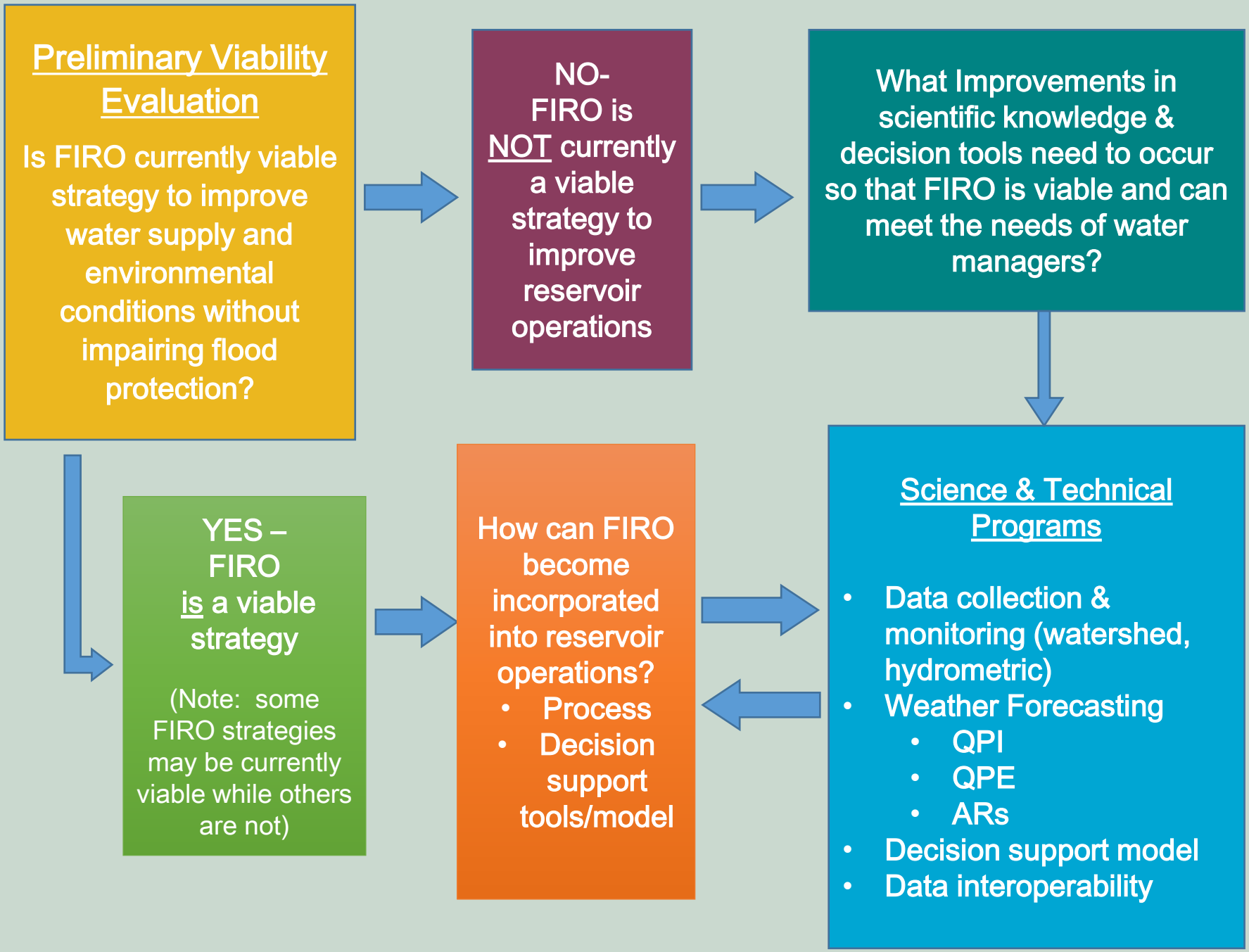
Reservoir operations consider watershed conditions (mid-term)

- SCWA/NOAA/USGS install soil moisture & rain gages above reservoirs
- Develop correlations between rainfall-soil moisture-reservoir inflow

Forecast skill for atmospheric river events (long-term)

- Predict landfall & intensity of storms
- CalWater-2 and other research




Preliminary Viability Evaluation
Is FIRO currently viable strategy to improve water supply and environmental conditions without impairing flood protection?
NO- FIRO is NOT currently a viable strategy to improve reservoir operations
What Improvements in scientific knowledge & decision tools need to occur so that FIRO is viable and can meet the needs of water managers?
YES – FIRO is a viable strategy
(Note: some FIRO strategies may be currently viable while others are not)
How can FIRO become incorporated into reservoir operations?
• Process
• Decision support tools/model
Science & Technical Programs
• Data collection & monitoring (watershed, hydrometric)
• Weather Forecasting
• QPI
• QPE
• ARs
• Decision support model
• Data interoperability

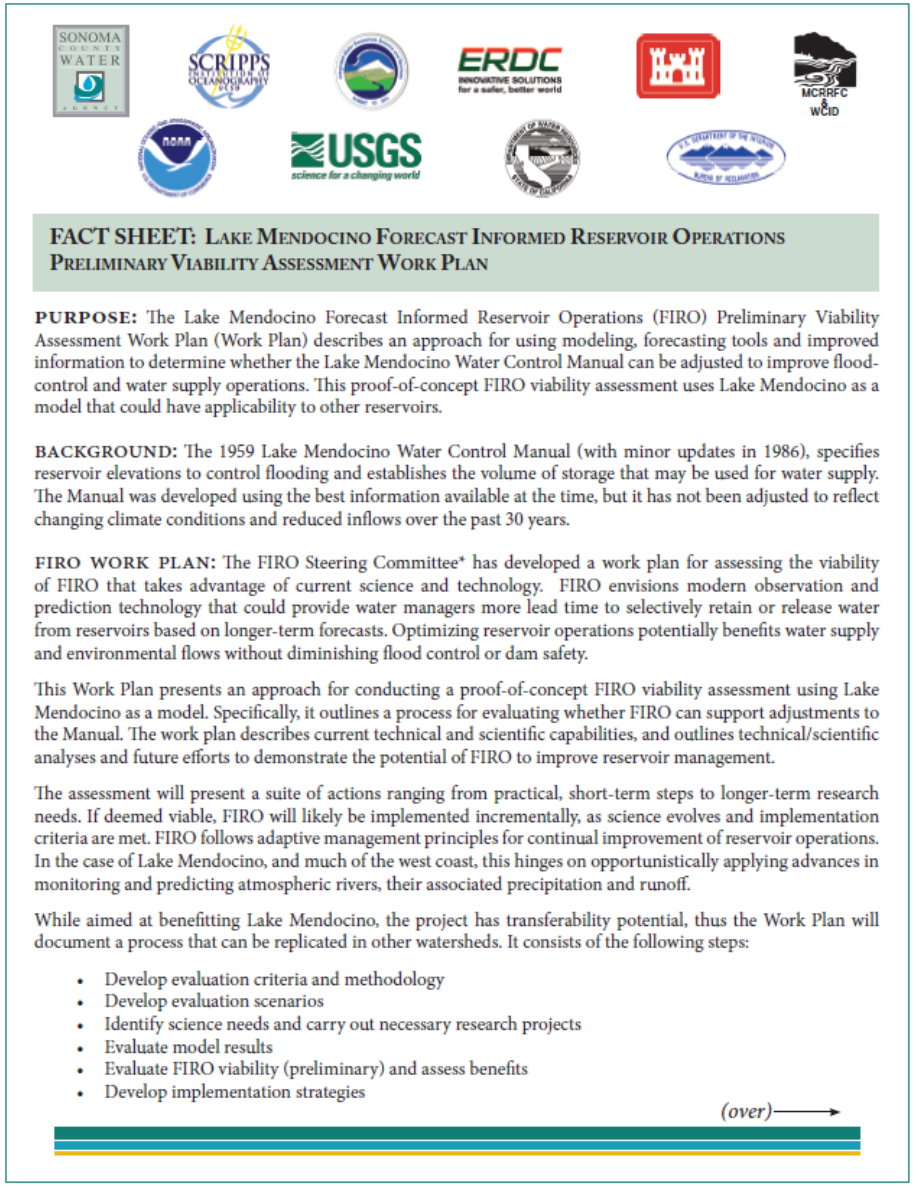
Demonstration Project Status

Steering Committee
- Monthly calls
- Quarterly meetings

Annual Workshops
- Three workshops to date

Completed Work Plan Summer 2015

Workgroups
- Preliminary Viability Assessment (Summer 2017)
- Interim Operations
- Decision Support Tool Development
- Science
- Outreach



FACT SHEET: LAKE MENDOCINO FORECAST INFORMED RESERVOIR OPERATIONS PRELIMINARY VIABILITY ASSESSMENT WORK PLAN

PURPOSE: The Lake Mendocino Forecast Informed Reservoir Operations (FIRO) Preliminary Viability Assessment Work Plan (Work Plan) describes an approach for using modeling, forecasting tools and improved information to determine whether the Lake Mendocino Water Control Manual can be adjusted to improve flood-control and water supply operations. This proof-of-concept FIRO viability assessment uses Lake Mendocino as a model that could have applicability to other reservoirs.

BACKGROUND: The 1959 Lake Mendocino Water Control Manual (with minor updates in 1986), specifies reservoir elevations to control flooding and establishes the volume of storage that may be used for water supply. The Manual was developed using the best information available at the time, but it has not been adjusted to reflect changing climate conditions and reduced inflows over the past 30 years.

FIRO WORK PLAN: The FIRO Steering Committee* has developed a work plan for assessing the viability of FIRO that takes advantage of current science and technology. FIRO envisions modern observation and prediction technology that could provide water managers more lead time to selectively retain or release water from reservoirs based on longer-term forecasts. Optimizing reservoir operations potentially benefits water supply and environmental flows without diminishing flood control or dam safety.

This Work Plan presents an approach for conducting a proof-of-concept FIRO viability assessment using Lake Mendocino as a model. Specifically, it outlines a process for evaluating whether FIRO can support adjustments to the Manual. The work plan describes current technical and scientific capabilities, and outlines technical/scientific analyses and future efforts to demonstrate the potential of FIRO to improve reservoir management.

The assessment will present a suite of actions ranging from practical, short-term steps to longer-term research needs. If deemed viable, FIRO will likely be implemented incrementally, as science evolves and implementation criteria are met. FIRO follows adaptive management principles for continual improvement of reservoir operations. In the case of Lake Mendocino, and much of the west coast, this hinges on opportunistically applying advances in monitoring and predicting atmospheric rivers, their associated precipitation and runoff.

While aimed at benefitting Lake Mendocino, the project has transferability potential, thus the Work Plan will document a process that can be replicated in other watersheds. It consists of the following steps:

- Develop evaluation criteria and methodology
- Develop evaluation scenarios
- Identify science needs and carry out necessary research projects
- Evaluate model results
- Evaluate FIRO viability (preliminary) and assess benefits
- Develop implementation strategies

(over)

2017 Virtual FIRO Test Trial

Actual Operations - In compliance with rule curve

Virtual Ensemble Forecast Operations

- No Rule Curve
- Operations by FIRO based on 60-member ensemble forecasts of reservoir inflows from CNRFC (NWS)

Virtual Hybrid Operations

- Combination of Rule Curve & FIRO
- Zone or band of storage which is operated by FIRO using ensemble forecasts are used to inform operations
- When storage outside of FIRO zone/band, operations by rule curve

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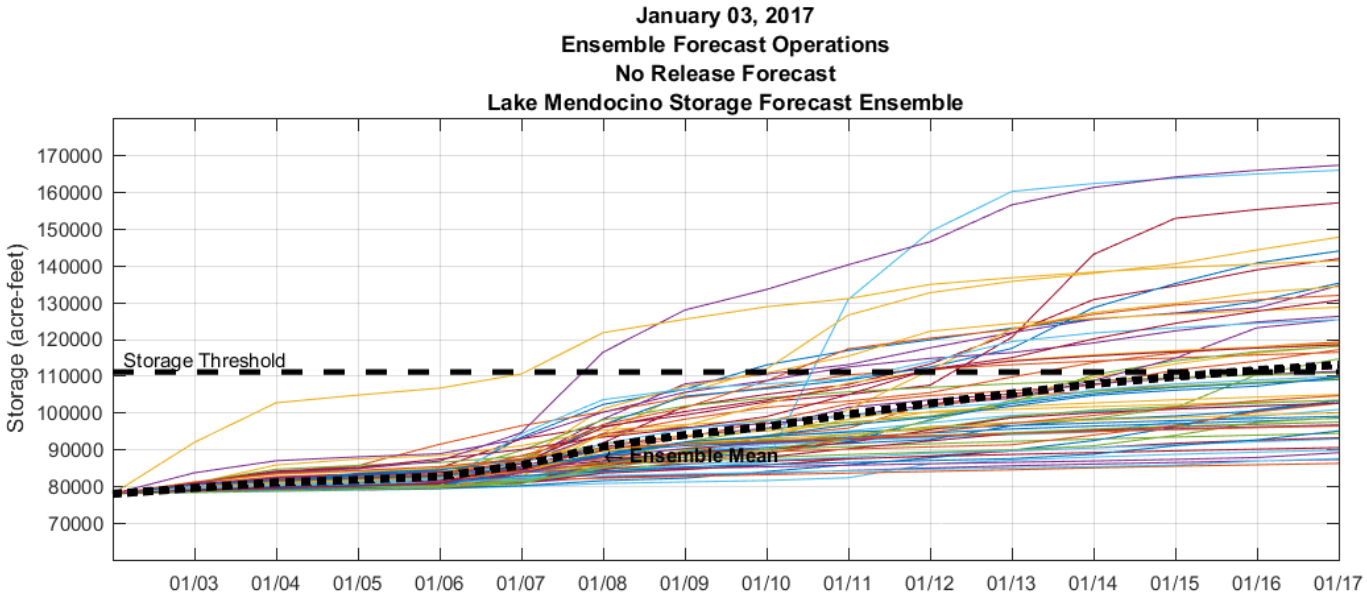
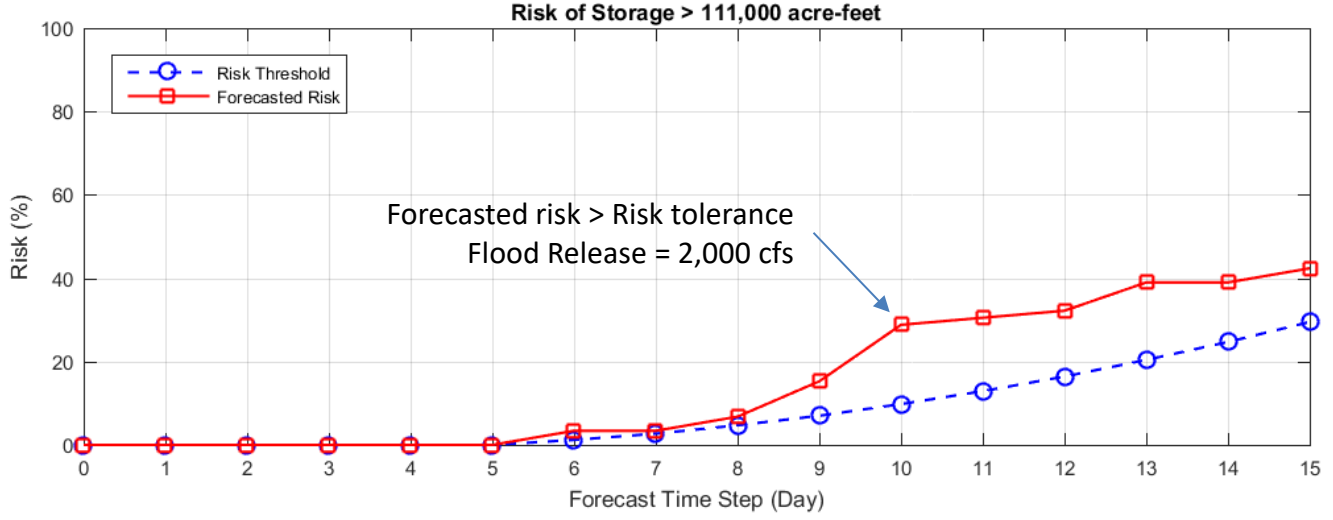
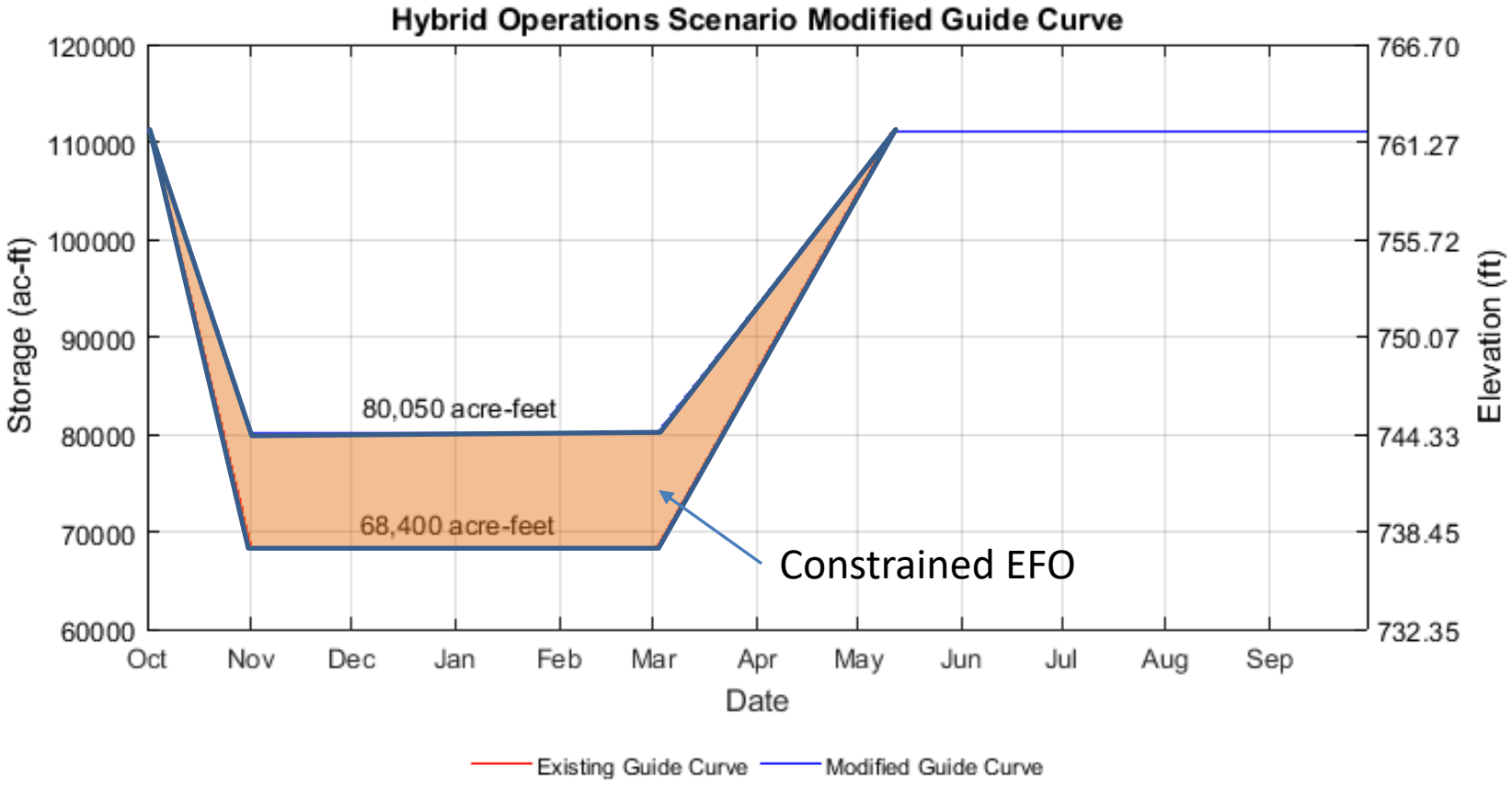
Ensemble Forecast Scenario

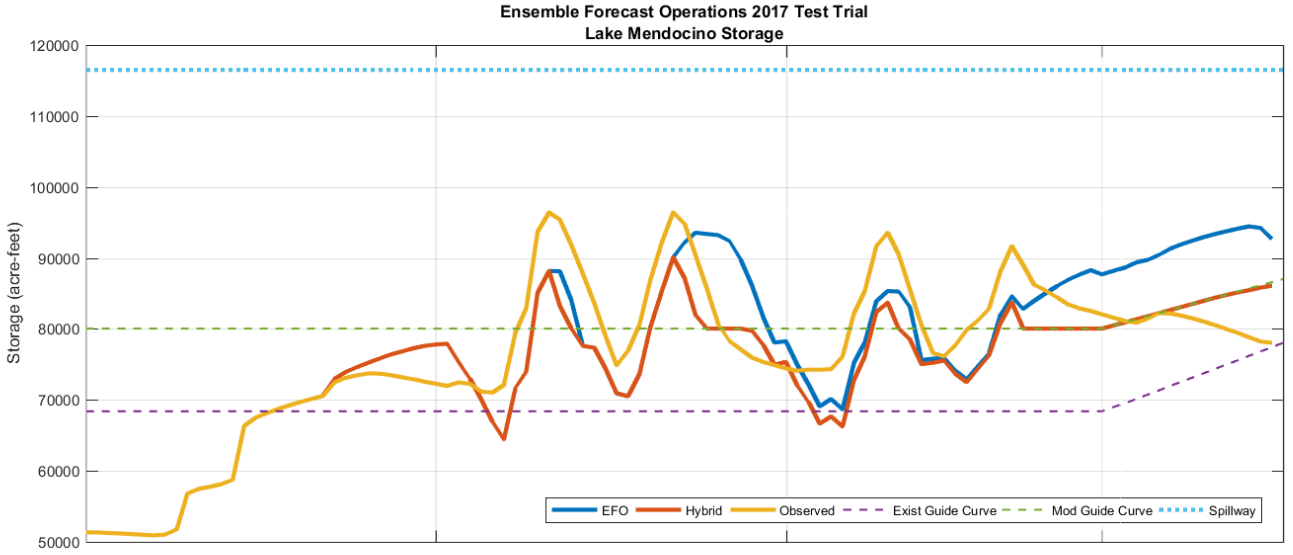


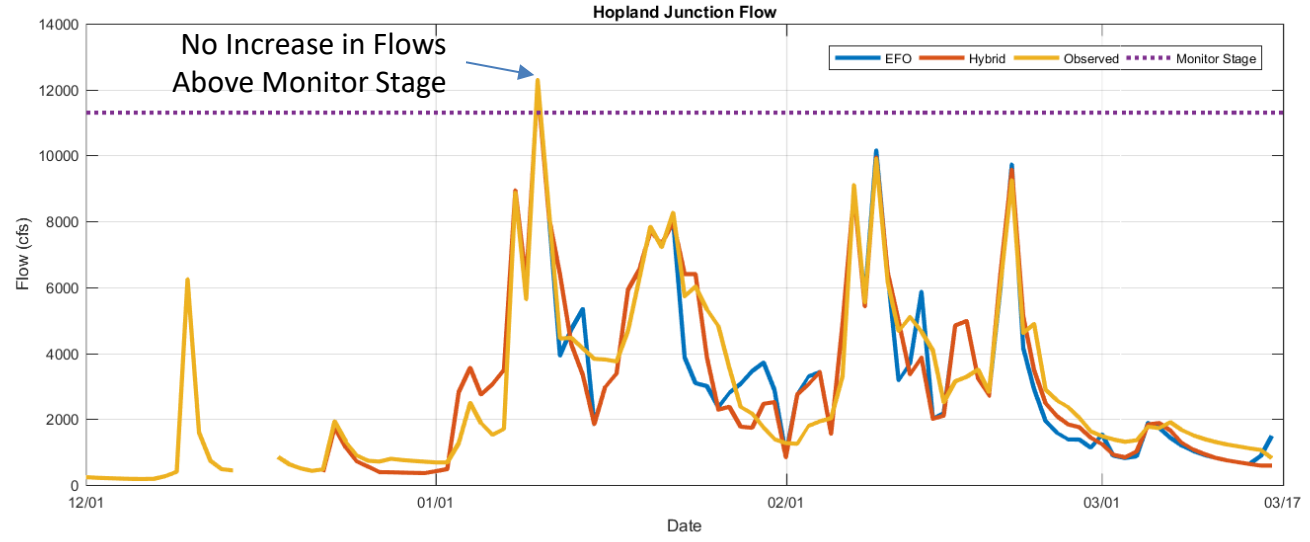


Virtual Hybrid Operations Scenario



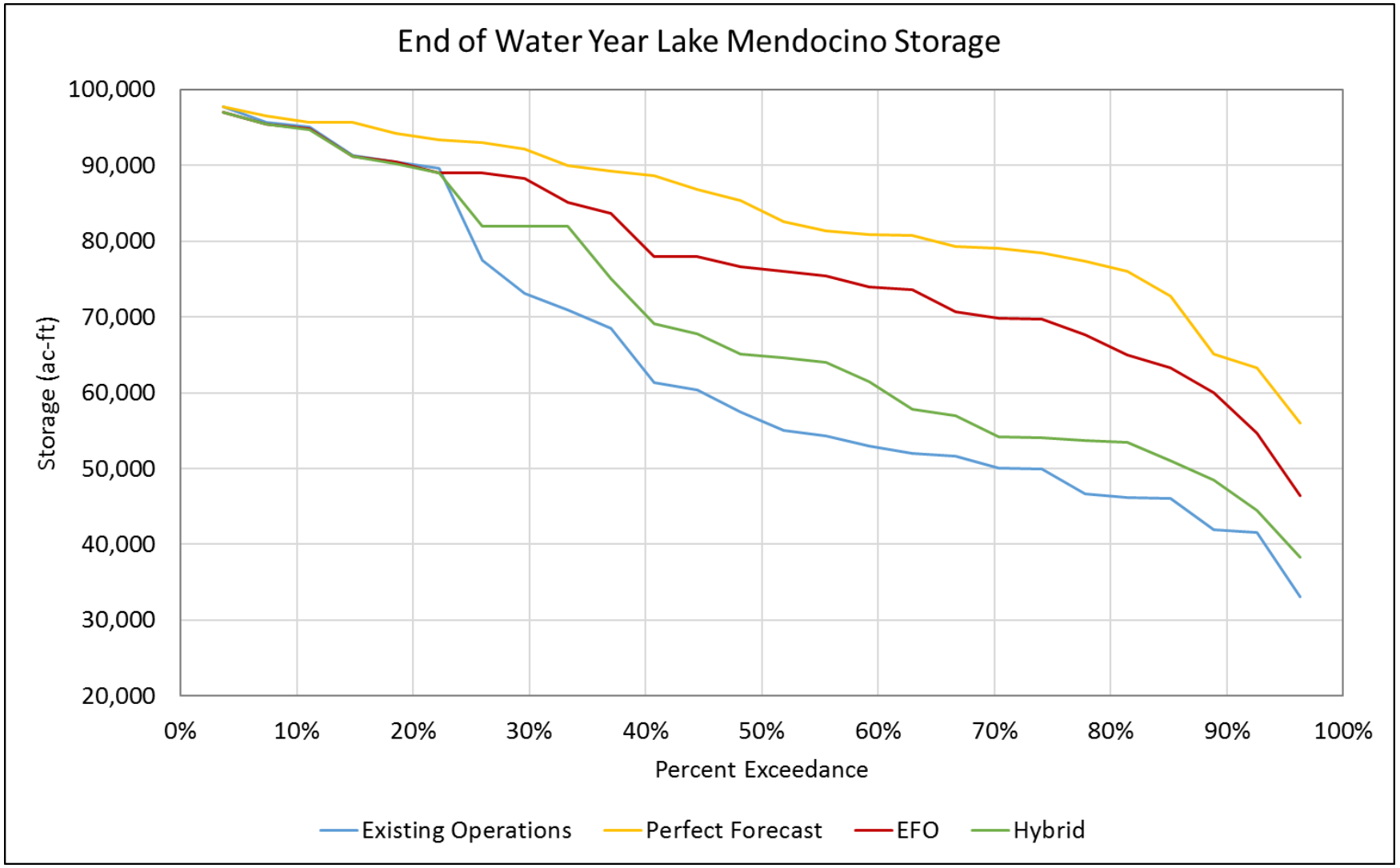
2017 FIRO Virtual Test Trial



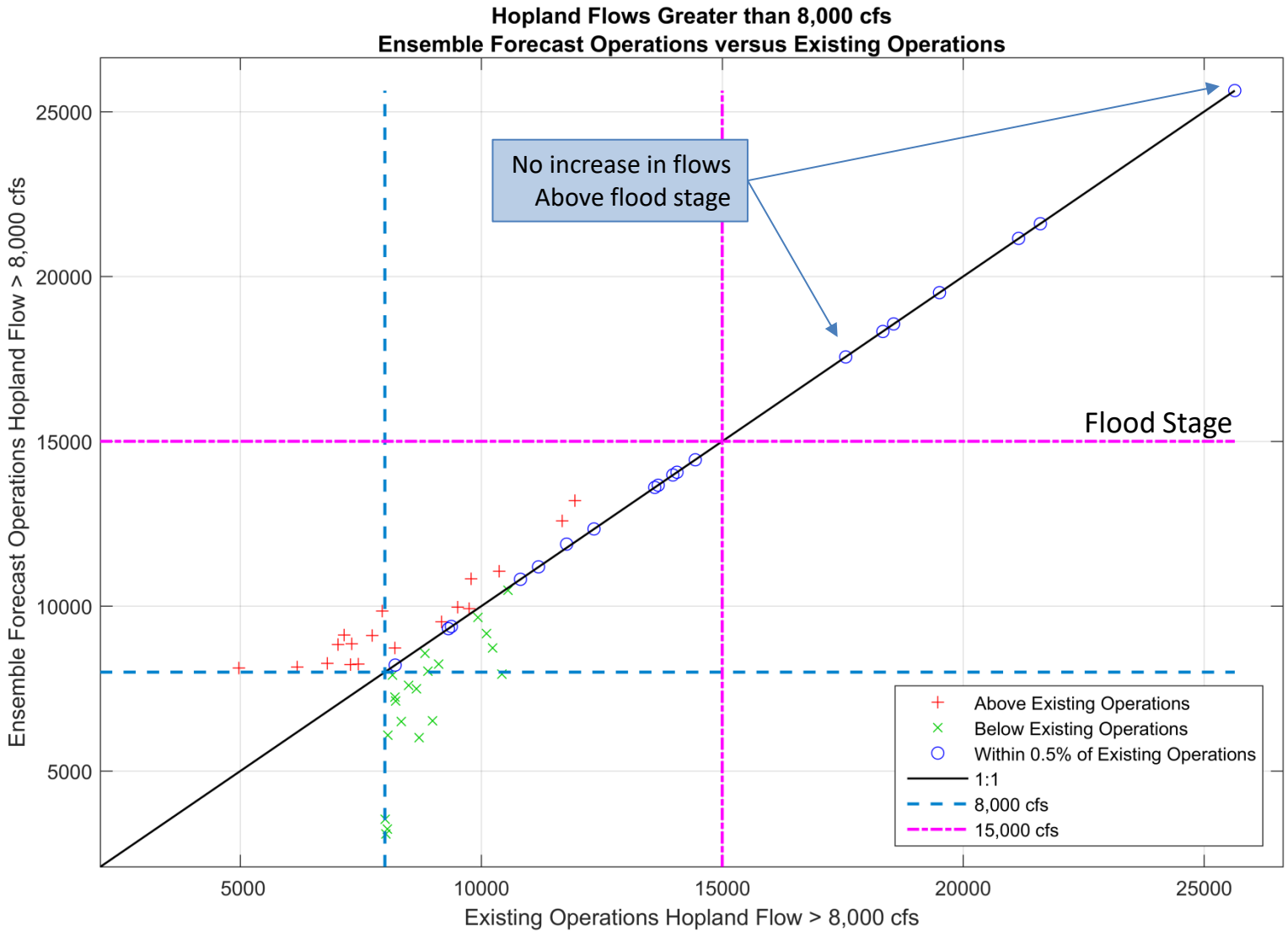


FIRO Improves Water Storage

Preliminary Modeling Results 1985-2010

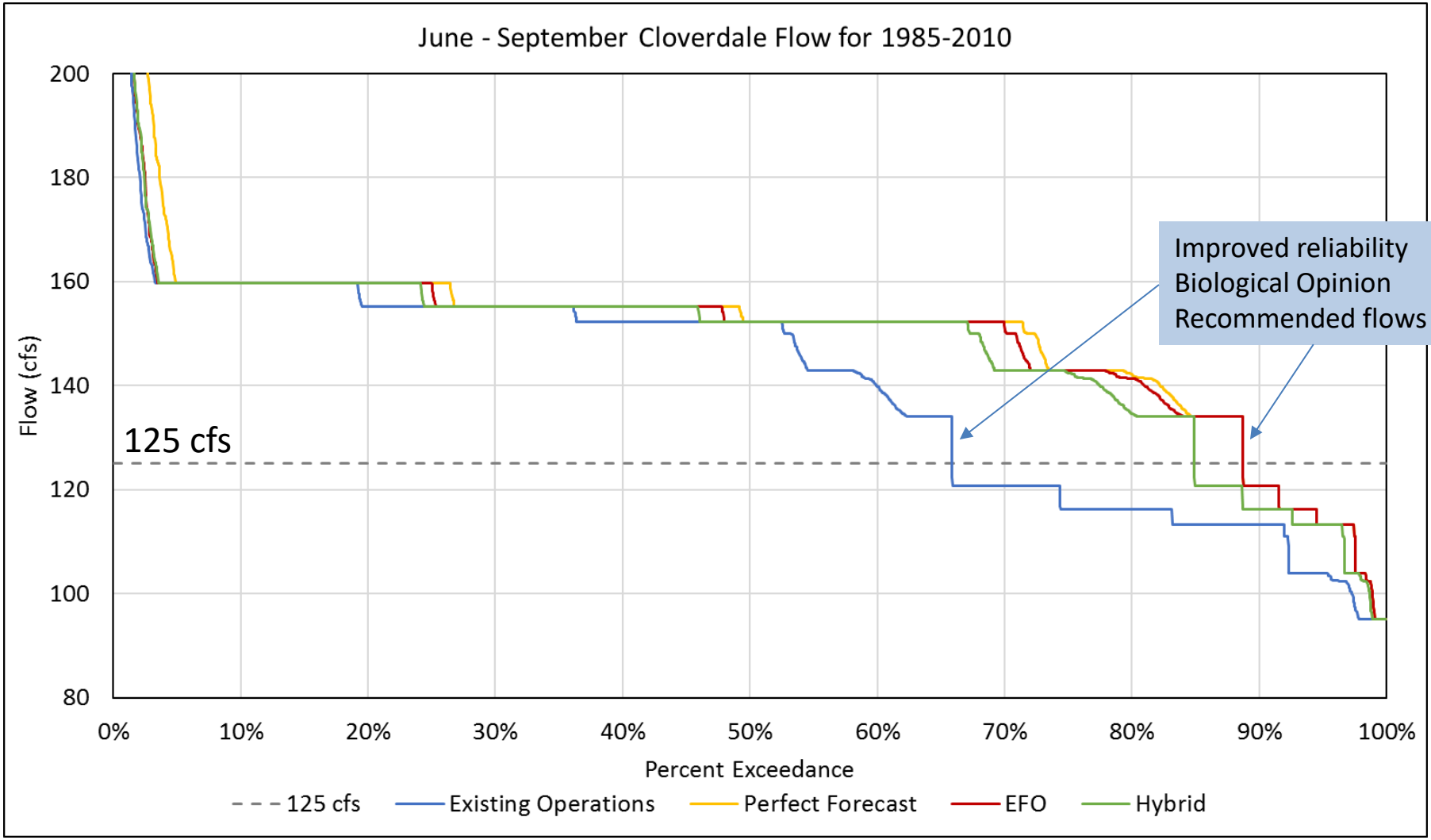


Model Simulation Results
Hopland Flows > 8,000 cfs



FIRO Improves In-Stream Flows June -September

Cloverdale Flows - Preliminary Modeling Results



Next Steps

- Utilize USACE deviation process for Water Control Plans to implement “test” FIRO operations for next 2-3 years
- Learn from each experience to modify subsequent deviation request & improve decision support tools
- Develop Viability Assessment to support Water Control Plan change for Lake Mendocino

Summary

- **Water management operations must respond to highly variable weather (precipitation) conditions**
  - Decreasing snowpack means precipitation forecasting is increasingly important (e.g., Atmospheric rivers)
- **Many reservoirs operated using rules several decades old & based on limited hydrological data**
- **Increasing requirements & stresses imposed on reservoir operations (e.g., water supply, flood management, environmental, & recreation)**
- **FIRO shows promise for improved reservoir water supply & in-stream flows**

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Summary

- **Must ensure flood management won't be compromised**
  - FIRO shows potential for improved flood management
- **FIRO has potential to build resiliency & defer/avoid expensive capital projects**
- **Lake Mendocino demonstration project employs technical/scientific innovation utilizing collaborative multi-agency partnership**
- **Incremental implementation (version 1, version 2, etc.) with continual improvements as technical & scientific advances are incorporated**