OROVILLE DAM CITIZENS ADVISORY COMMISSION

Meeting 20
June 13, 2025

Hosted by the California Natural Resources Agency

CALIFORNIA NATURAL RESOURCES AGENCY

ITEM 1
WELCOME

ROLL CALL

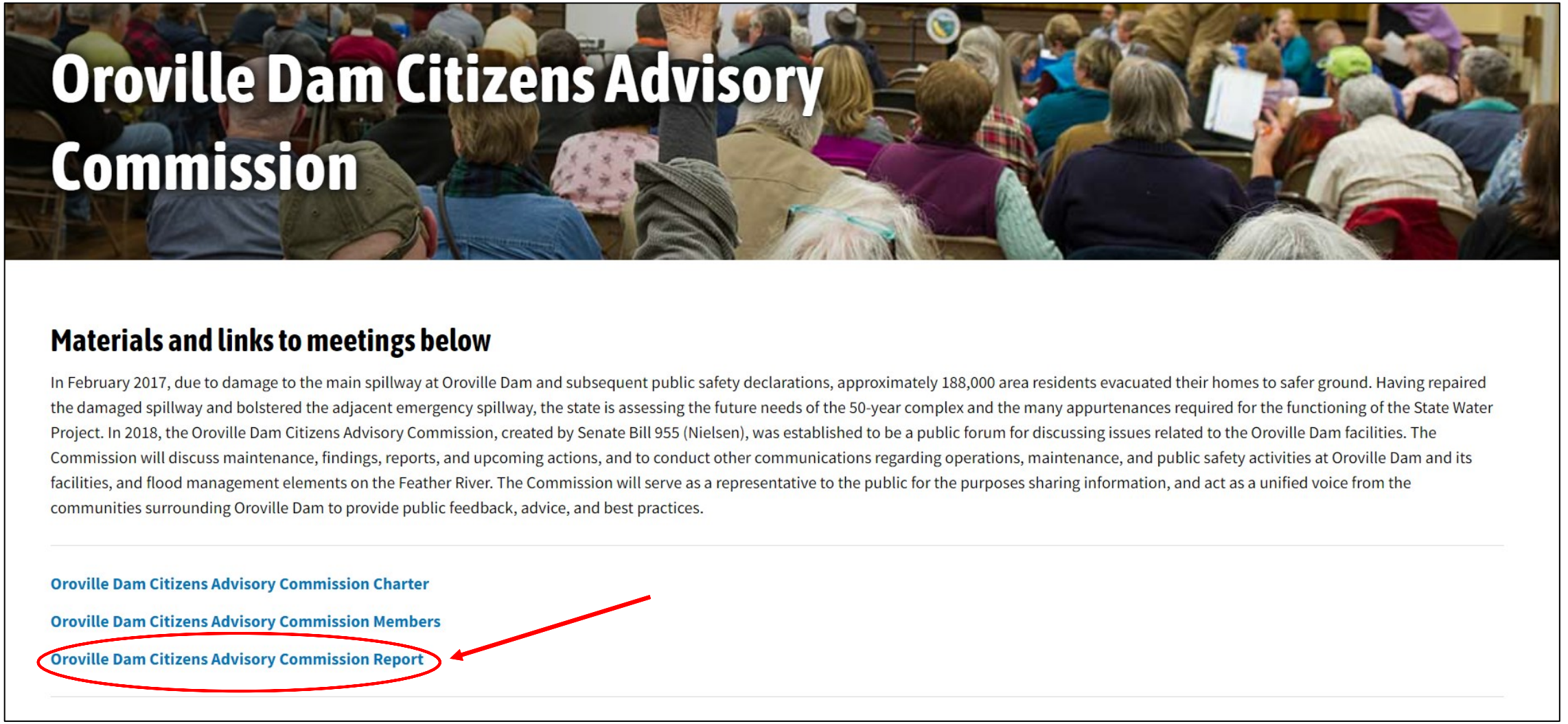
- Secretary of the California Natural Resources Agency
- California State Assembly
- California State Senate
- Director of the Department of Water Resources
- Director of the Office of Emergency Services
- Director of the Department of Parks and Recreation
- CHP Butte County Field Division Appointee
- City of Oroville Appointees
- County of Butte Appointees
- County of Sutter Appointees
- County of Yuba Appointees
- Butte County Sheriff Appointee
- Sutter County Sheriff Appointee
- Yuba County Sheriff Appointee

OPENING REMARKS CONTINUED

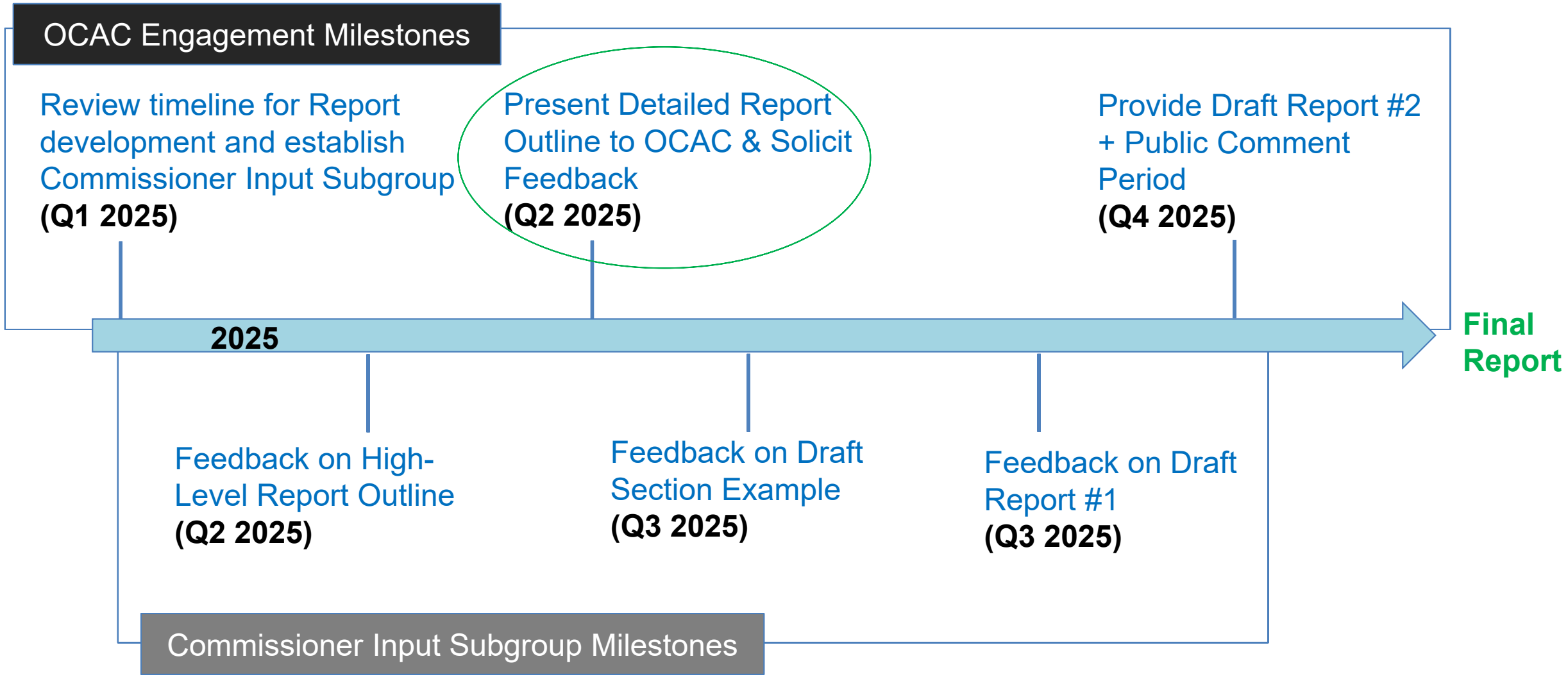
ITEM 2
LEGISLATIVE REPORT UPDATE

Commission Report

- Click “Oroville Dam Citizens Advisory Commission Report” on the main page to be taken to the Report landing page.



Commission Report 2 Development & Commissioner Input Timeline



Request of Commissioners

- Review outline after the meeting
- Provide any feedback on:
  - Report organization
  - Proposed content
  - OCAC accomplishments and/or lessons learned
- Send to Samantha Arthur at CNRA by Wed July 9.

Report and Content Mandated by SB 955

The commission must publish a report once every three years that provides the following:

1. An overview of ongoing maintenance and improvements made at the dam and its site.
2. A register of communications received from the department and other parties to the Commission.
3. Notice of upcoming plans made by the department for the dam and its site.
4. An overview of flood management projects on the Feather River affecting public safety and flood risk reduction.

Report Approach

- Cover the content mandated by SB 955
- Summarize the Commission's last three years of work
- Reflect on any progress and/or lessons learned by the Commission
- Produce a report that is a useful reference to members of the public and legislature

Report Outline – Key Sections

DRAFT CONSULTANT WORK PRODUCT

2025 Oroville Dam Citizens Advisory Commission
Legislative Report
High-Level Outline

Last Updated: May 2025

Cover Letter
Outline purpose/goals of commission, thanks to fellow commissioners and expert presenters, purpose of report and high-level progress to-date
- Consider Sec. Crowfoot, Assembly Member Gallagher to author as chair/vice chair

Executive Summary
Summary of key meeting topics.
List meetings between October 2022 and July 2025
List Senate Bill 955 requirements

For the purposes of this second triennial report, commission discussions are organized under several large themes that address the areas stipulated by SB 955 that the report must cover. The report is organized this way to provide readers with a logical framework to understand the Commission's work. These are:
- *Dam Safety Planning: Infrastructure*
- *Flood Management: Forecasting and Operations*
- *Flood/Emergency Preparedness and Coordination*

Table of Contents

Key Groups & Terms
Glossary of common technical and governance-related terminology used in report.

OCAC Speakers List
List of all speakers and affiliations 2022-2025

Introduction

Commission Background
Created through SB955 in response to Spillways Incident.

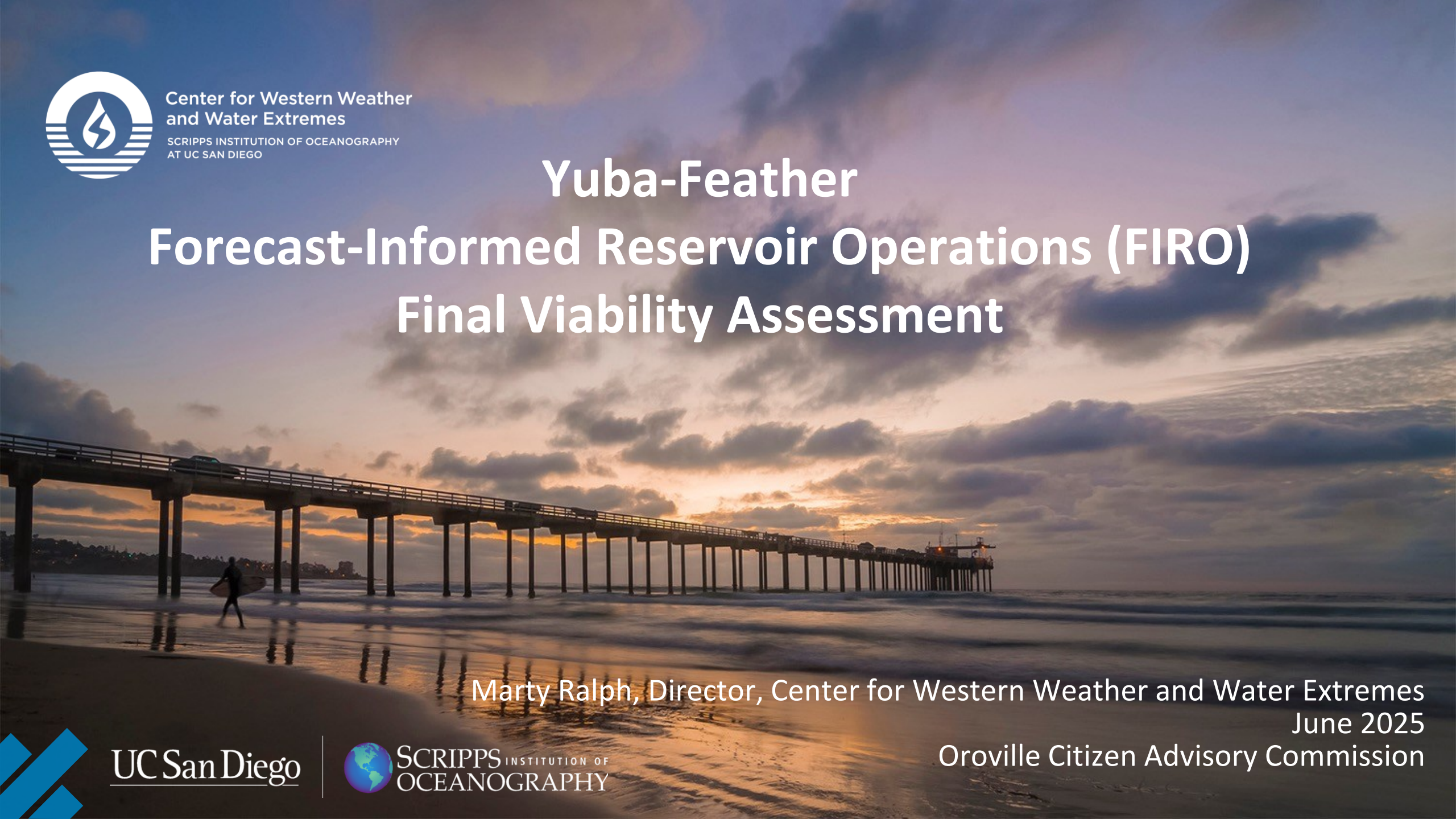
- Cover Letter
- Executive Summary
- Table of Contents
- Key Groups & Terms
- OCAC Speakers List 2023-2025
- Introduction
  - Commission Background
  - Commission Purpose & Scope
  - Commission Structure
  - Three Year Accomplishments
  - Report Structure
- Report Narrative
  - Dam Safety Planning: Infrastructure (SB955 #1&3)
  - Flood Management: Forecasting & Operations (SB955 #4)
  - Flood/Emergency Preparedness & Operations (SB955 #4)
- Conclusion
- Appendix: Register of Communications (SB955 #2)

Feedback from Commissioner Input Subgroup

- Clearly describe scope of the Commission
- Report out on progress in the form of actions taken
- Provide a simplified summary of topics before diving into the detail provided at meetings to orient the reader.
- Include pictures and maps to orient and engage the reader.
- For accomplishments, stress the improved (and unprecedented) communication between the State and parties throughout the Feather watershed.
- For improvements, consider ways to give the public more time to ask questions and engage at the meetings.

ITEM 3

THE YUBA-FEATHER FIRO FINAL VIABILITY ASSESSMENT



Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

Yuba-Feather Forecast-Informed Reservoir Operations (FIRO) Final Viability Assessment

Marty Ralph, Director, Center for Western Weather and Water Extremes

June 2025

Oroville Citizen Advisory Commission

UC San Diego | SCRIPPS INSTITUTION OF OCEANOGRAPHY

What is FIRO?

"FIRO is a reservoir-operations strategy that better informs decisions to retain or release water by integrating additional flexibility in operation policies and rules with enhanced monitoring and improved weather and water forecasts"

– American Meteorological Society (2020)

USACE FIRO Program:
Managed by Cary Talbot (ERDC)
Senior Scientist: F. M. Ralph (CW3E)

Center for Western Weather and Water Extremes

What is a FIRO Viability Assessment?

A FIRO Viability Assessment is a research process that evaluates whether the skill of streamflow forecasts in a region, including the storms and extreme precipitation that creates floods there, can be used effectively at a specific reservoir or set of reservoirs, to achieve desired outcomes for flood risk management, water availability enhancement or environmental goals.

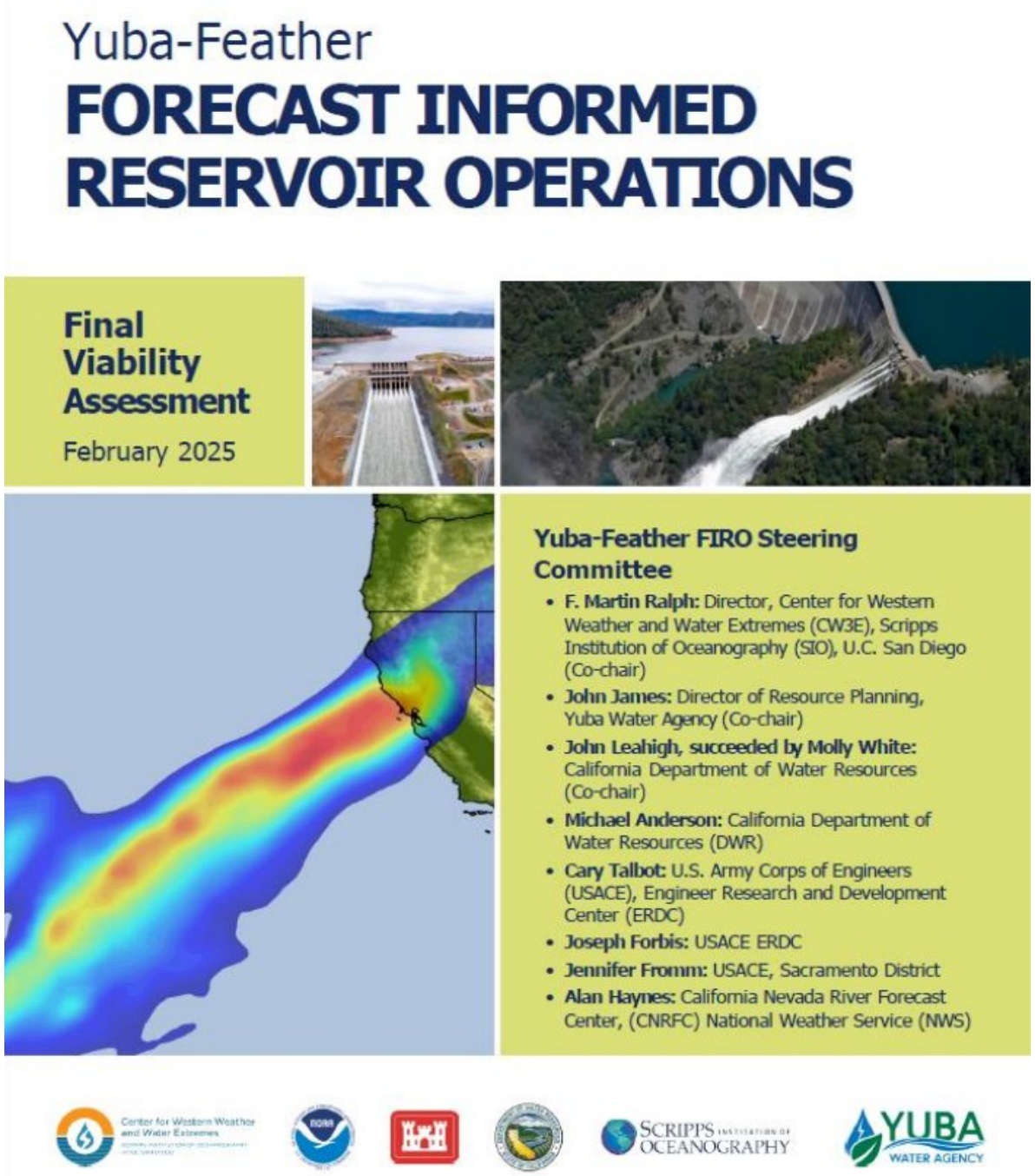
Yuba-Feather FIRO Steering Committee

Center for Western Weather and Water Extremes

What is a FIRO “Final Viability Assessment” (FVA)?

An FVA presents the conclusion regarding whether forecast skill is adequate for use of FIRO at a dam, including:

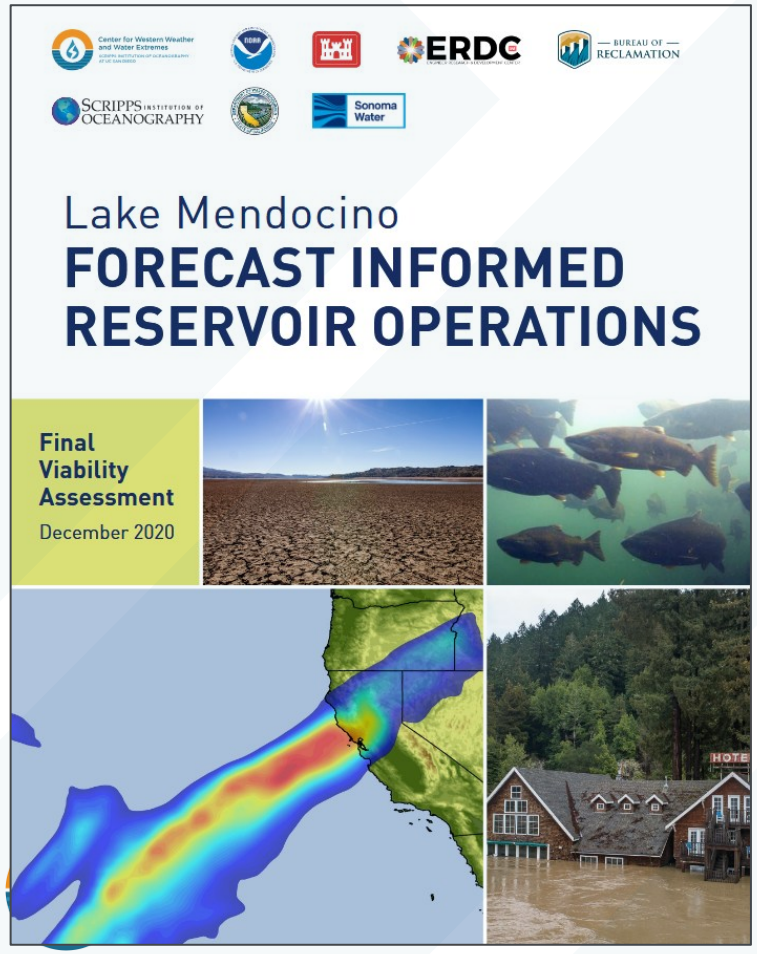
- impacts of flood risk management, water availability, and other goals,
- specific recommendations about how FIRO could be potentially implemented at the dam(s), and
- description of the analysis methods and technical results.



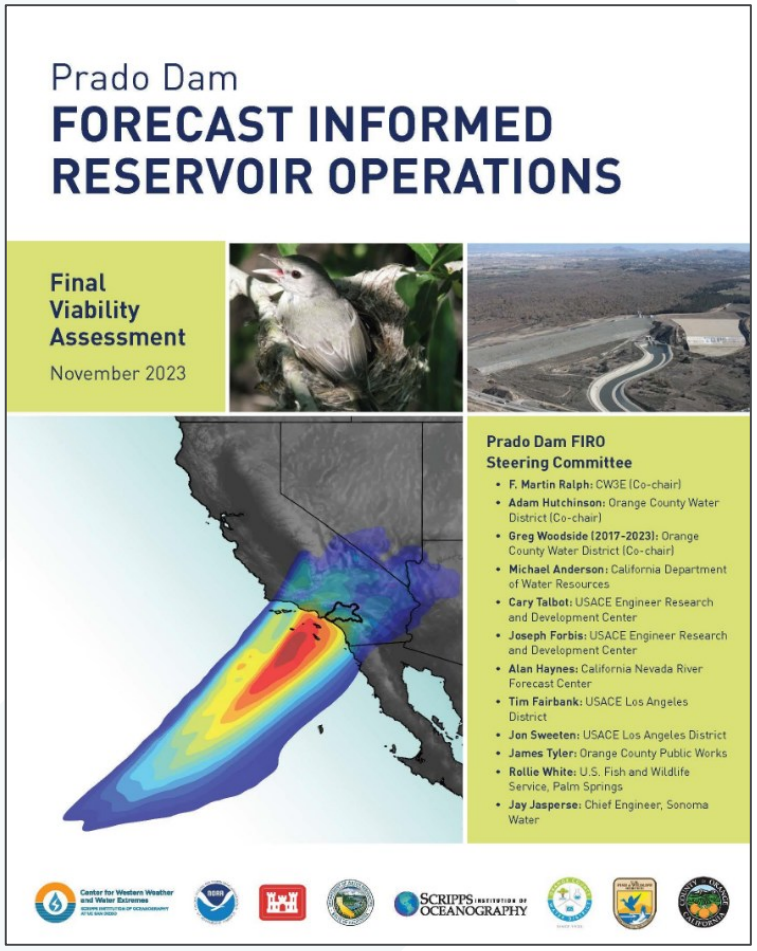
Center for Western Weather and Water Extremes

The FIRO Program Has Completed 3 FVAs as of June 2025

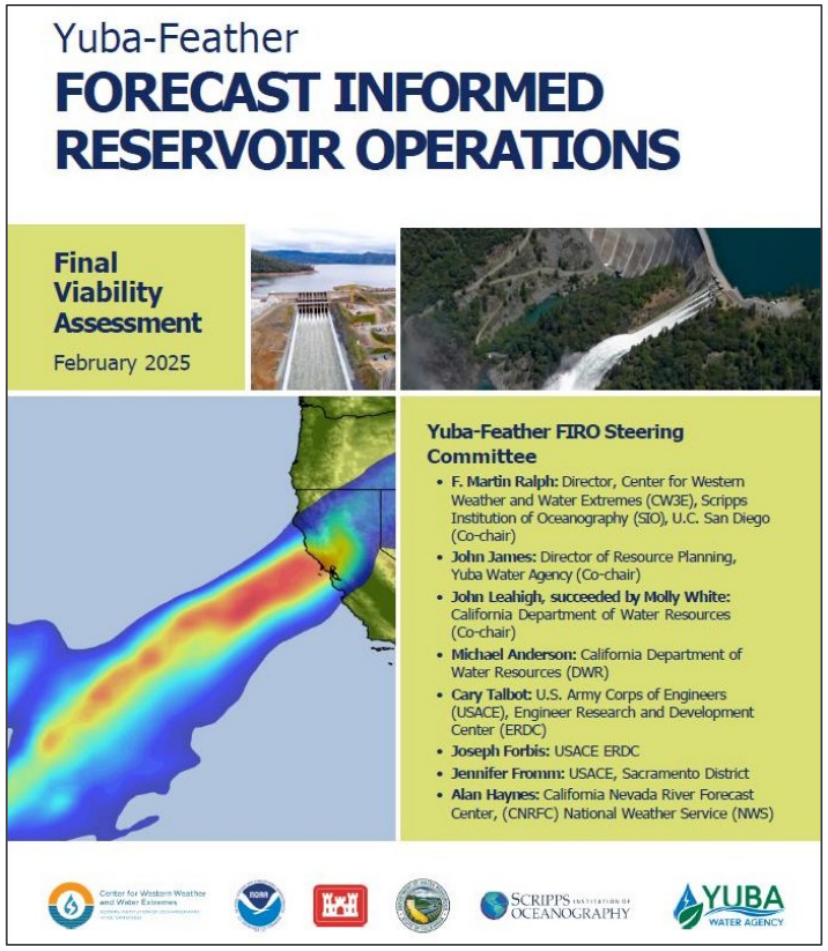
Lake Mendocino
Russian River
2020



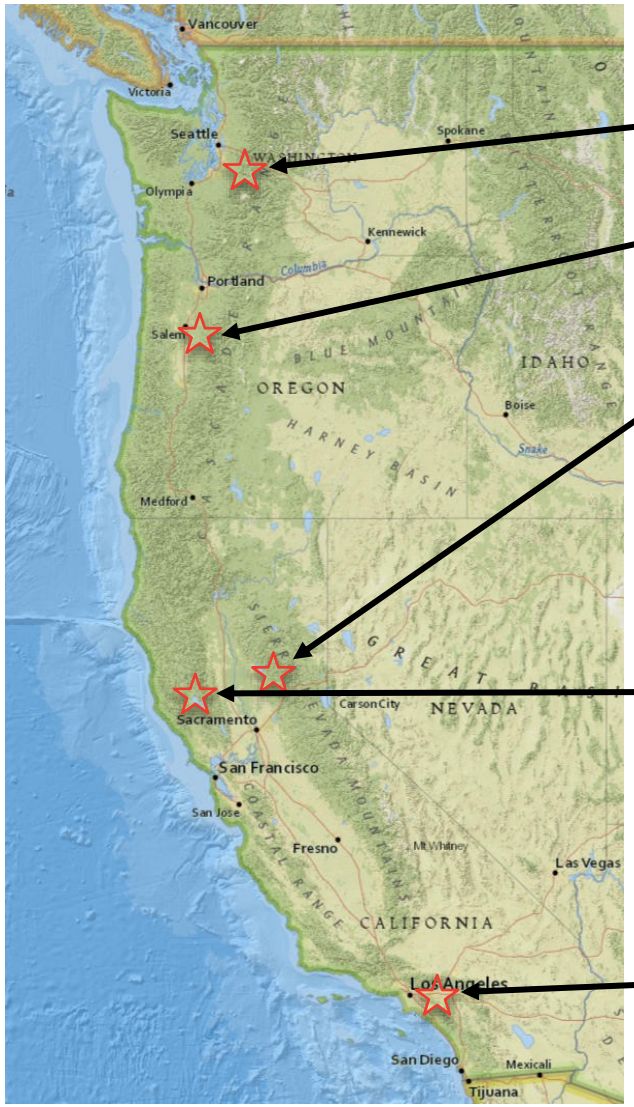
Prado Dam
Santa Ana River
2023



Lake Oroville & New Bullards Bar
Feather and yuba Rivers
2025



Current FIRO Pilot Project Locations



Howard Hanson Dam
Green River, Seattle District USACE
Willamette Valley (14 Dams)
Willamette River, Portland District USACE

New Bullards Bar Dam
Yuba River, Yuba Water Agency
Oroville Dam
Feather River, CA Dept. of Water Resources
Sacramento District, USACE

FVA Complete

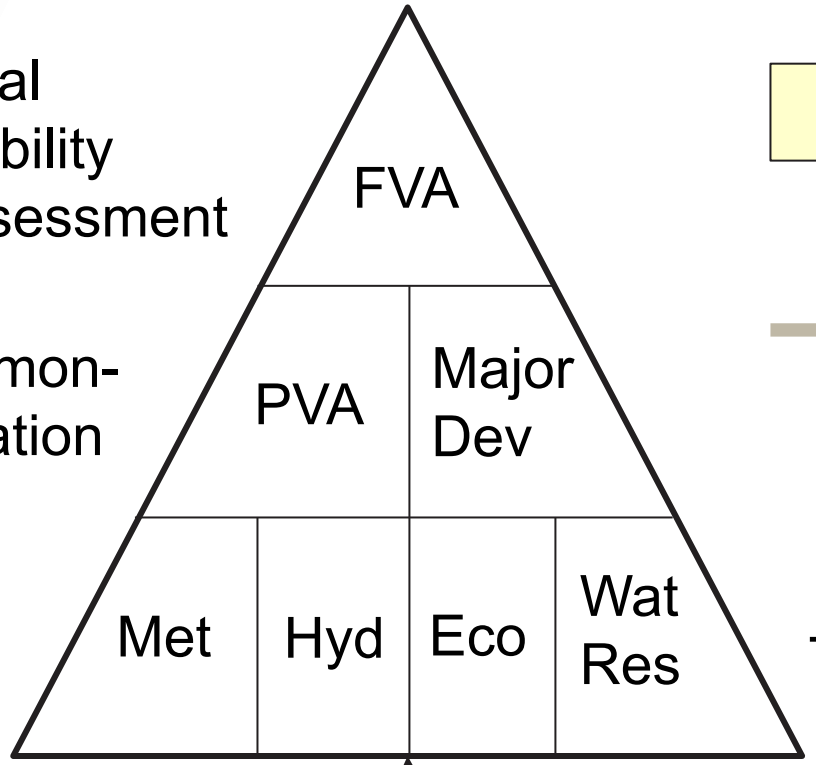
Lake Mendocino
Lake Sonoma
Russian River, San Francisco District USACE

FVA Complete

Prado Dam
Seven Oaks Dam
Santa Ana River, Los Angeles District USACE,
San Bernardino County Flood Control District

FVA Complete

FIRO and Water Control Manual Updates



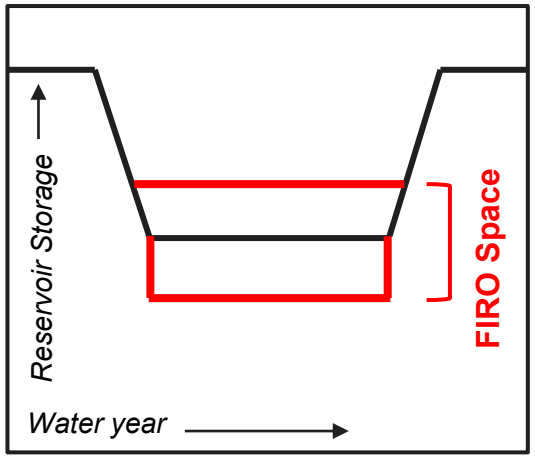
Interim

Multi-year "Deviation"

WCM Studies

Additional Technical Studies for WCM Update Process
Study 1
Study 2
etc…

WCM Update



It is important to note that FIRO is a Research And Operations Partnership (RAOP)

The “FIRO FVA” and “WCM Update” Are Separate Processes

- While this FIRO viability assessment was conducted in parallel with the Water Control Manual updates, the viability assessment is a separate process.
- The FIRO FVA (a research pilot project) explored a range of FIRO options, is not a decisional document, and is overseen by an inter-agency steering committee.
- During the WCM update process, the USACE identifies preferred alternatives and analyzes a full range of impacts and benefits.
- The WCM update is under the sole auspices of USACE; it can be informed by the FVA but is not bound by the FVA.
- It is also important to note that the FVA only analyzed scaled extreme events, the WCM update will include a more robust period-of-record analysis.

Yuba Water Agency's Proposed Atmospheric River Control (ARC) Spillway

- To maximize the benefits of FIRO and better leverage improved forecasts, Yuba Water is designing the secondary ARC spillway to allow for greater forecast-informed pre-releases at lower reservoir elevations at NBB.

- Using FIRO with the planned spillway will enable up to an additional 117,000 acre-feet of reservoir space to reduce water surface elevations and pressure on levees during high flow events, significantly reducing flood risk for Yuba County and other communities near the lower Yuba and Feather rivers.

Image Courtesy of Yuba Water Agency

Water Control Manual Updates Underway for FIRO Watersheds

Lake Mendocino
Russian River
2020

Deviation Status: Major Deviation since Oct 2019

WCM Update: Nearing Completion

Prado Dam
Santa Ana River
2023

Deviation Status: Minor Deviation since March 2025

WCM Update: Process Began in 2024

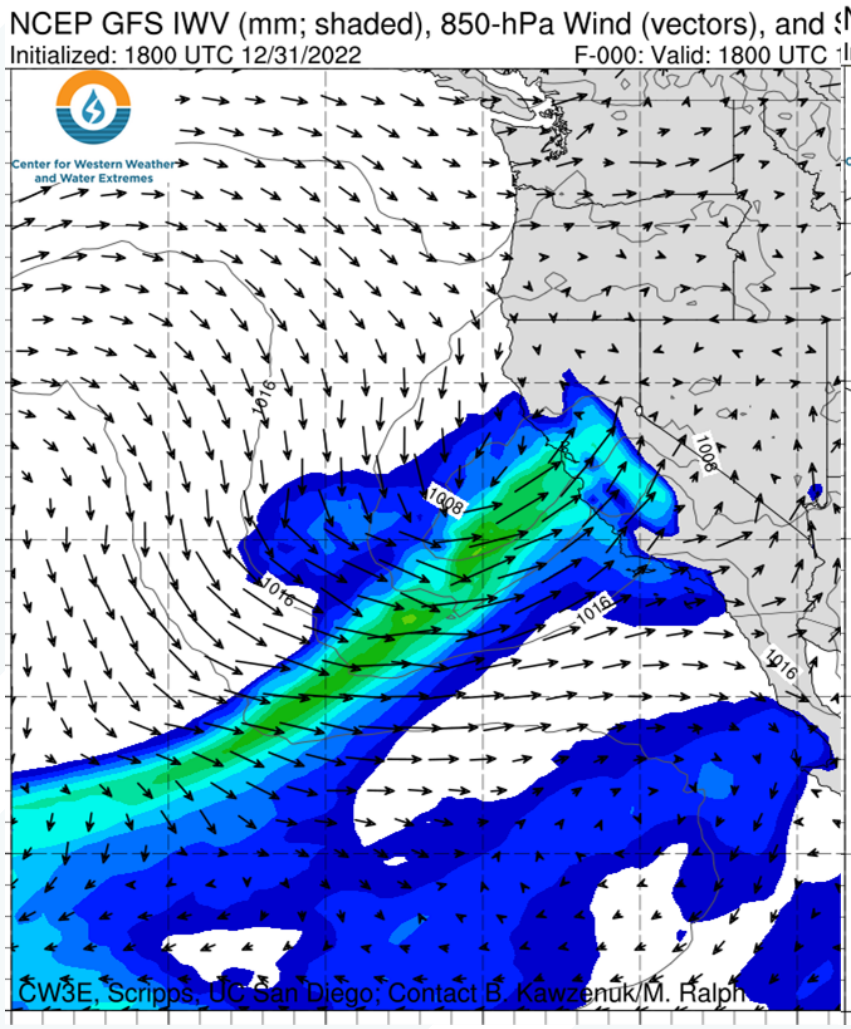
Lake Oroville & New Bullards Bar
Feather and yuba Rivers
2025

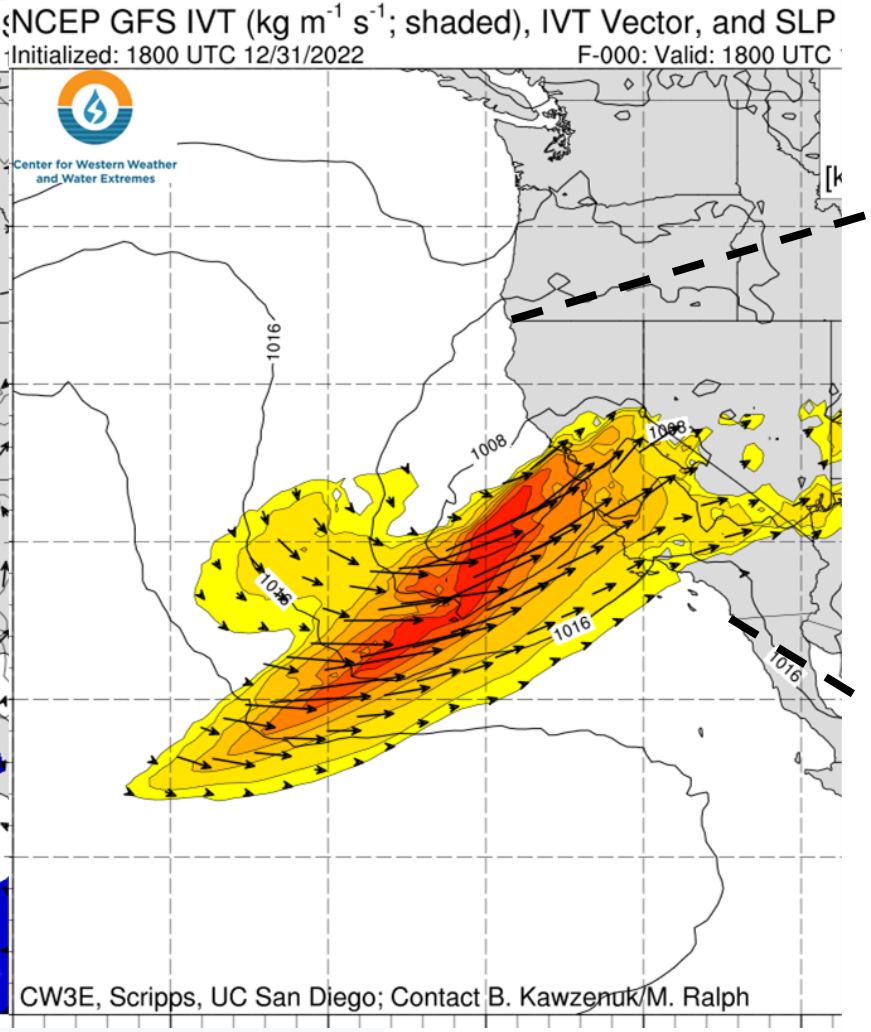
Deviation Status: TBD

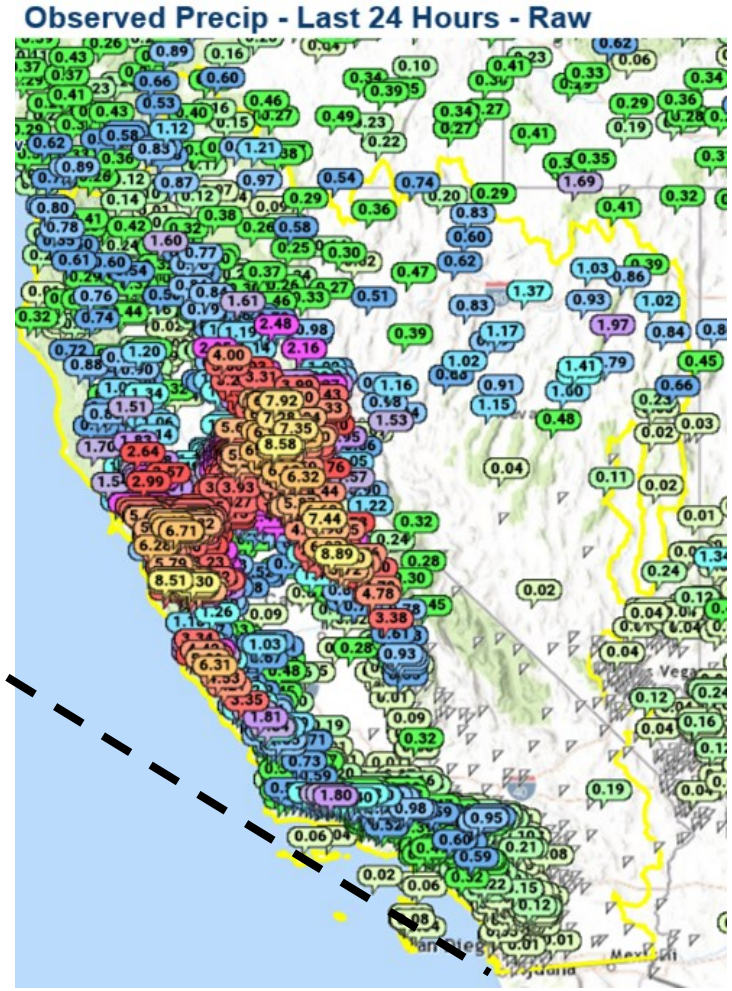
WCM Update: Consider FIRO FVA recommendations

Research Found That "Atmospheric River" Type Storms Are Key Here: They produce essentially all the flooding, and about 50% of annual rain

The New Years Day Landfalling Atmospheric River of January 2023



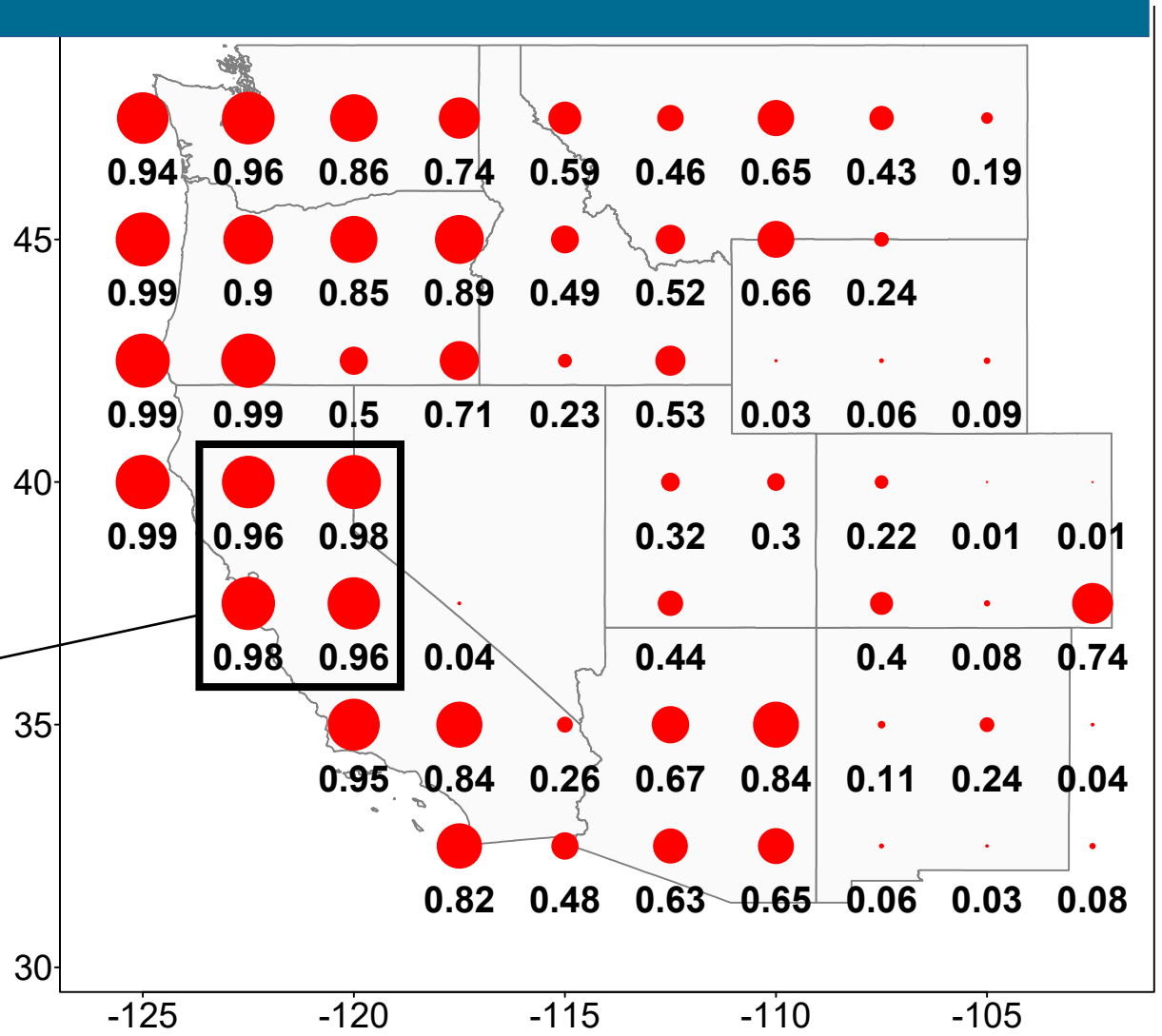




ARs Drive Losses

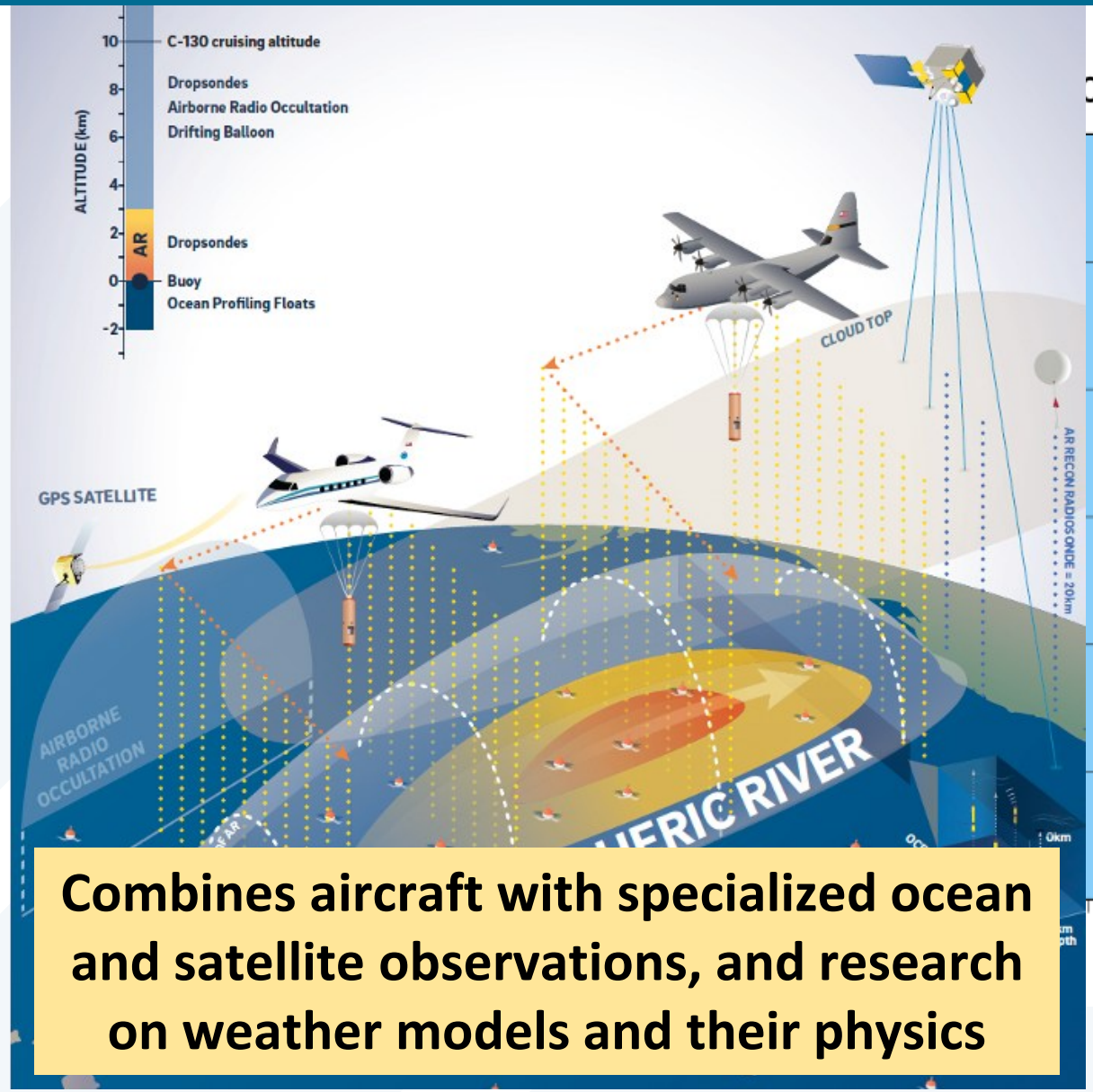
- 84% of insured losses in the 11 western states were caused by ARs
- Over 99% of insured losses were caused by ARs in the many of the most highly affected areas

- Nearly 100% of all flood damages over 40 years in the Feather-Yuba area were due to ARs storms

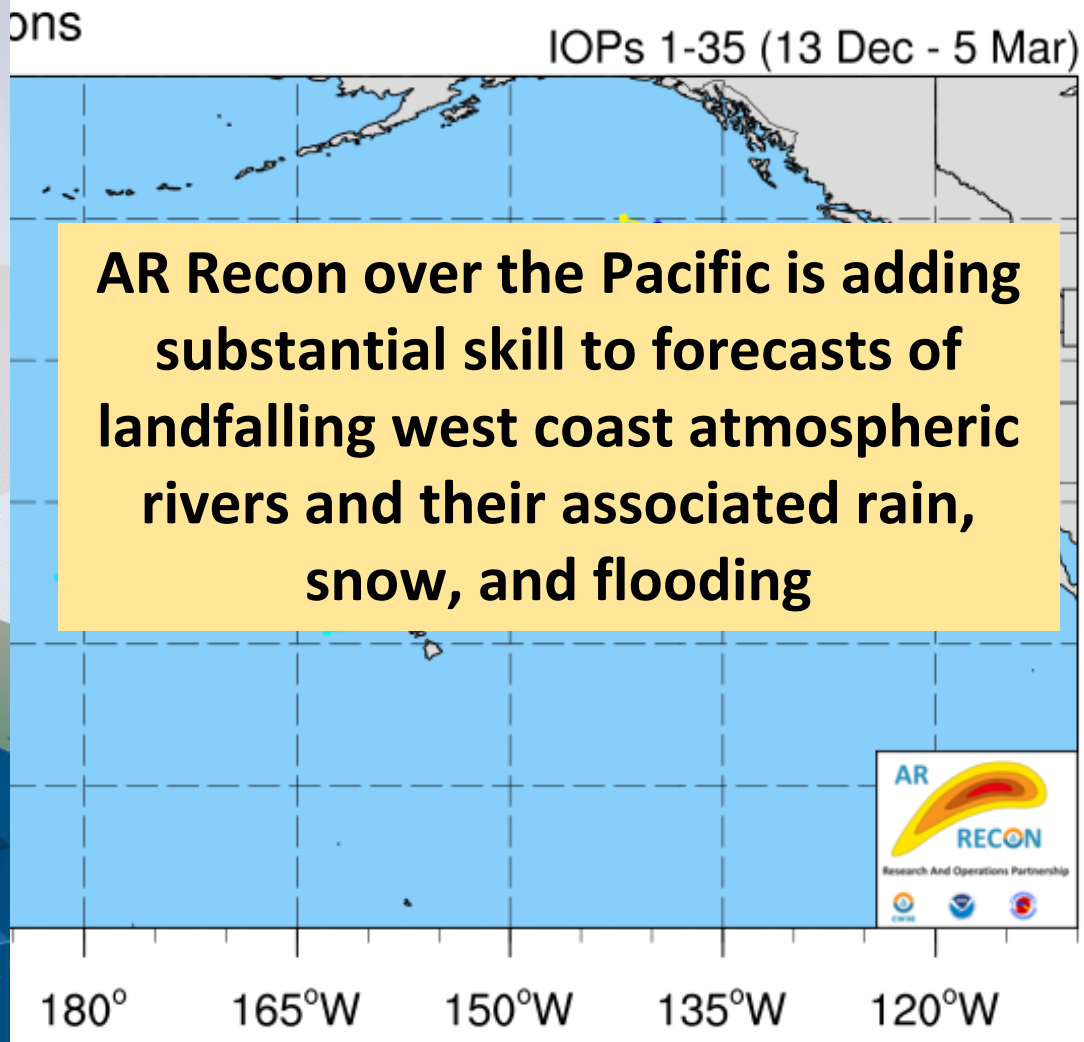


Corringham et al.2019, Science Advances

AR RECON WATER YEAR 2025 WITH NOAA, US AIR FORCE, NAVY, UCSD/SIO

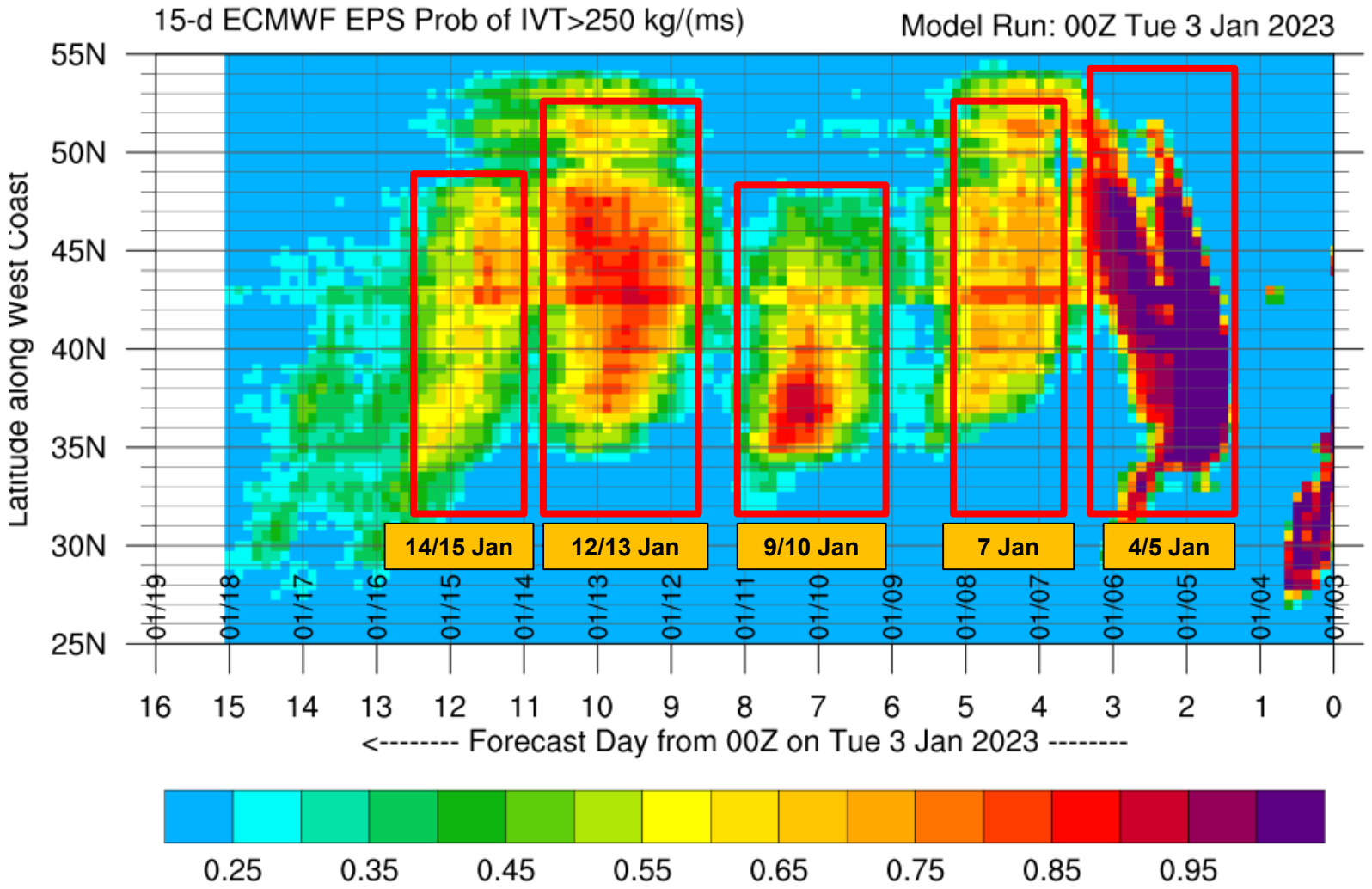


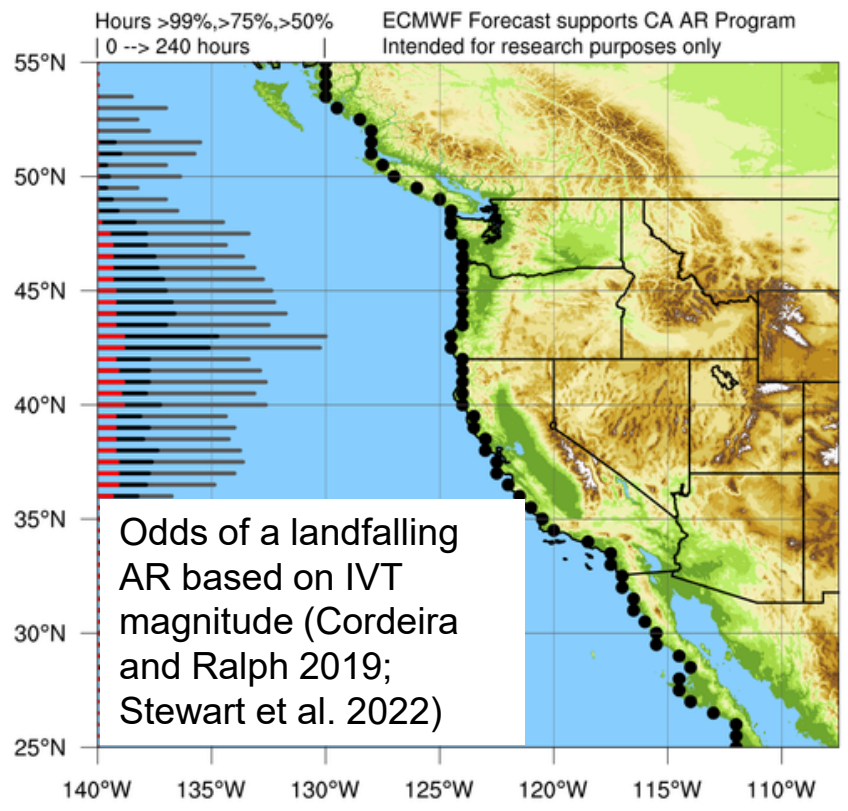
Combines aircraft with specialized ocean and satellite observations, and research on weather models and their physics



AR Recon over the Pacific is adding substantial skill to forecasts of landfalling west coast atmospheric rivers and their associated rain, snow, and flooding

How far in advance can we predict landfalling ARs? 5 to 7 days





Odds of a landfalling AR based on IVT magnitude (Cordeira and Ralph 2019; Stewart et al. 2022)

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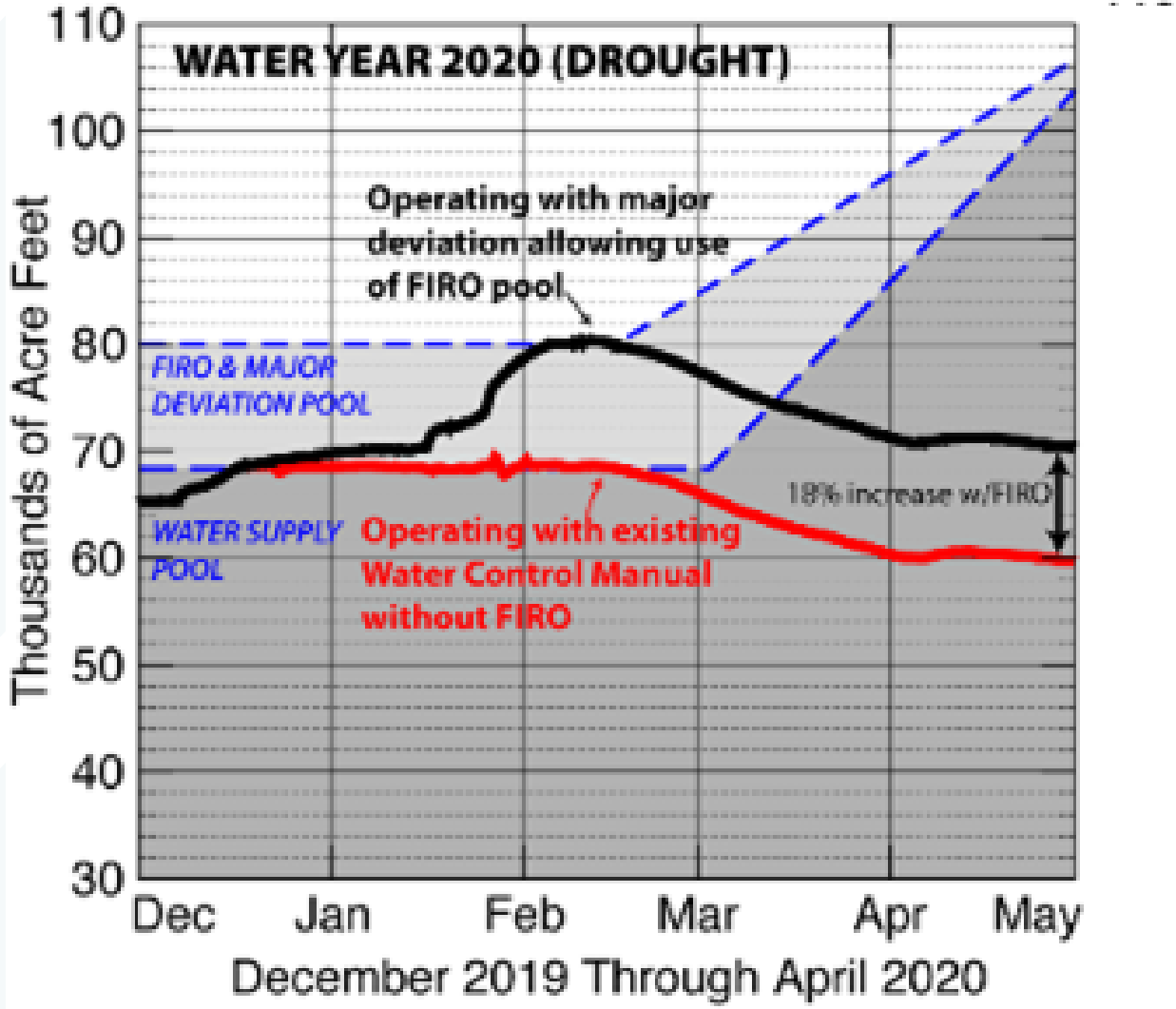
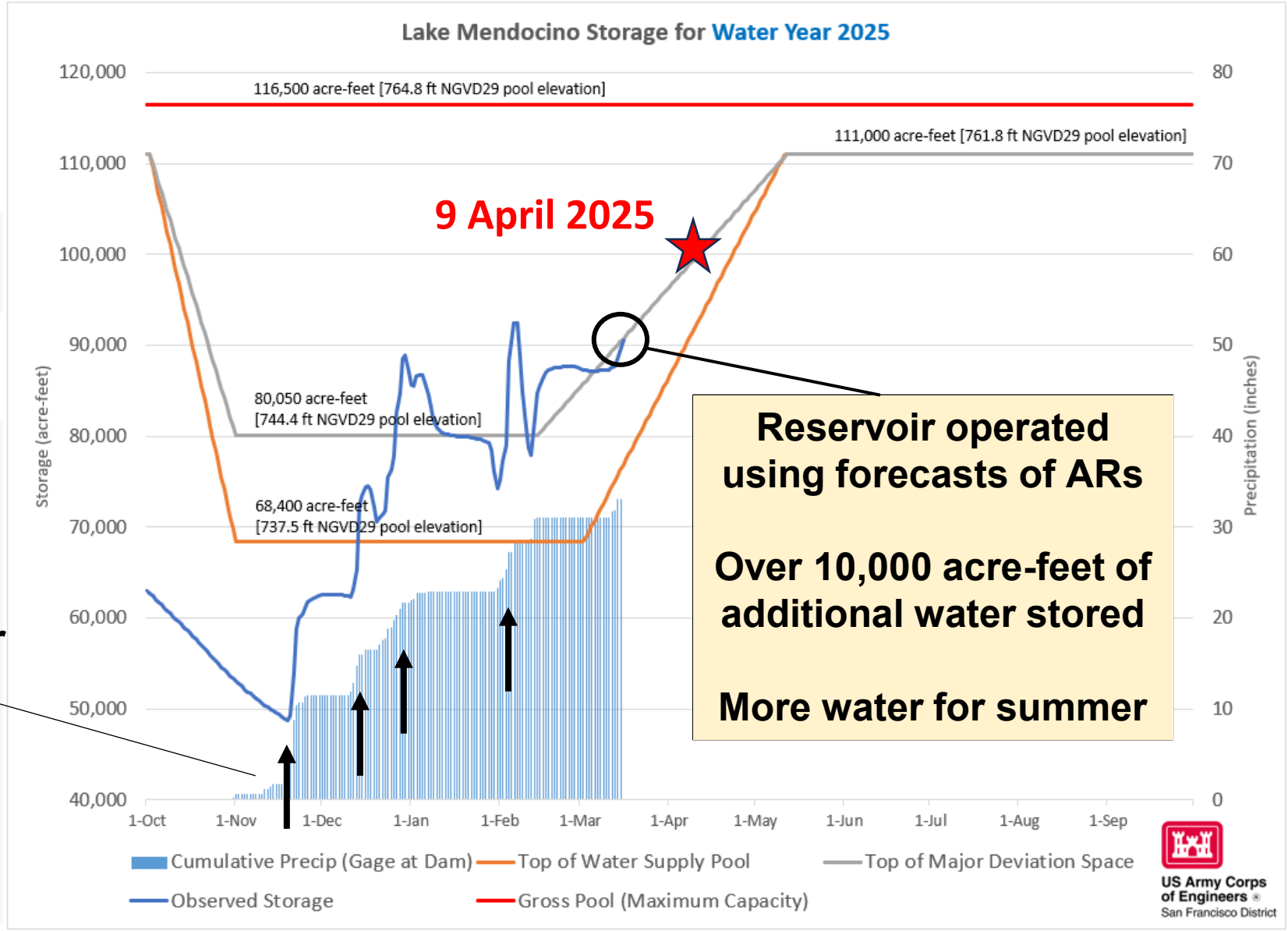
At Lake Mendocino FIRO is demonstrating use of AR Forecasts to support reservoir operations in both drought and flood years



Center for Western Weather and Water Extremes

LAKE MENDOCINO FIRO OPERATIONS WATER YEAR 2025



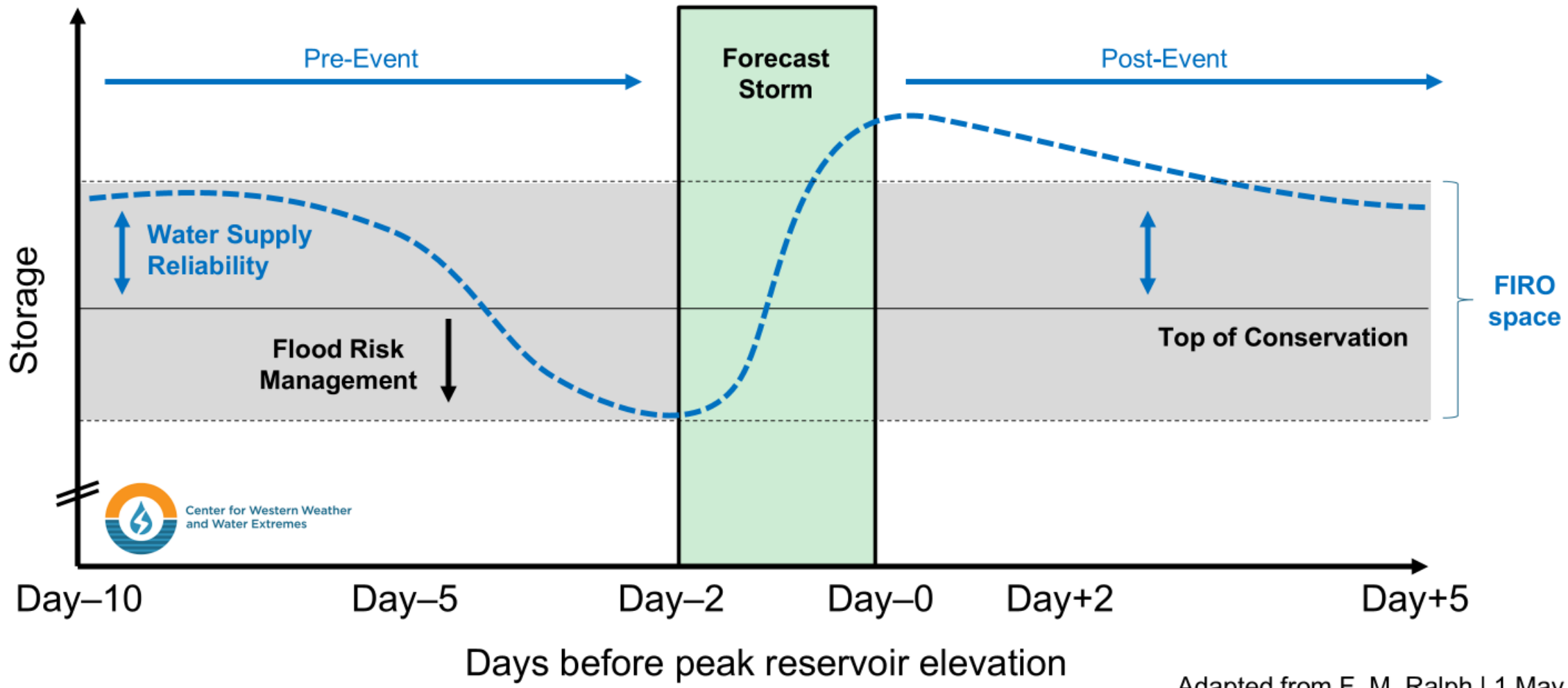
Atmospheric River storms

Reservoir operated using forecasts of ARs

Over 10,000 acre-feet of additional water stored

More water for summer

Research and Operations Applications: FIRO

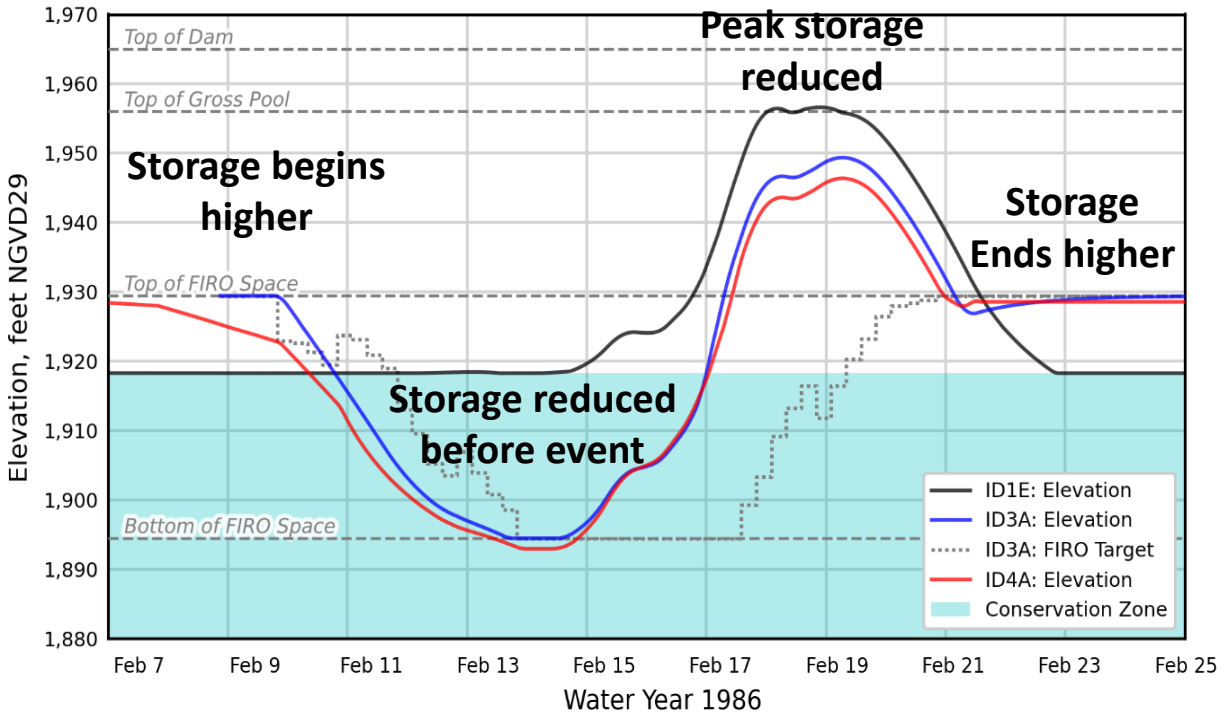


Adapted from F. M. Ralph | 1 May 2024

FIRO is viable for Yuba-Feather (Oroville and NBB)

116% Scaling of the 1986 Flood Event – New Bullards Bar example

Reservoir Elevation



Impact on flow releases

Increased release before event (pre-release)

Lower peak release

Faster reductions of high releases

FIRO Space

90,000 Acre-feet at New Bullards Bar

170,000 Acre-feet at Oroville

Combined: 260,000 Acre feet

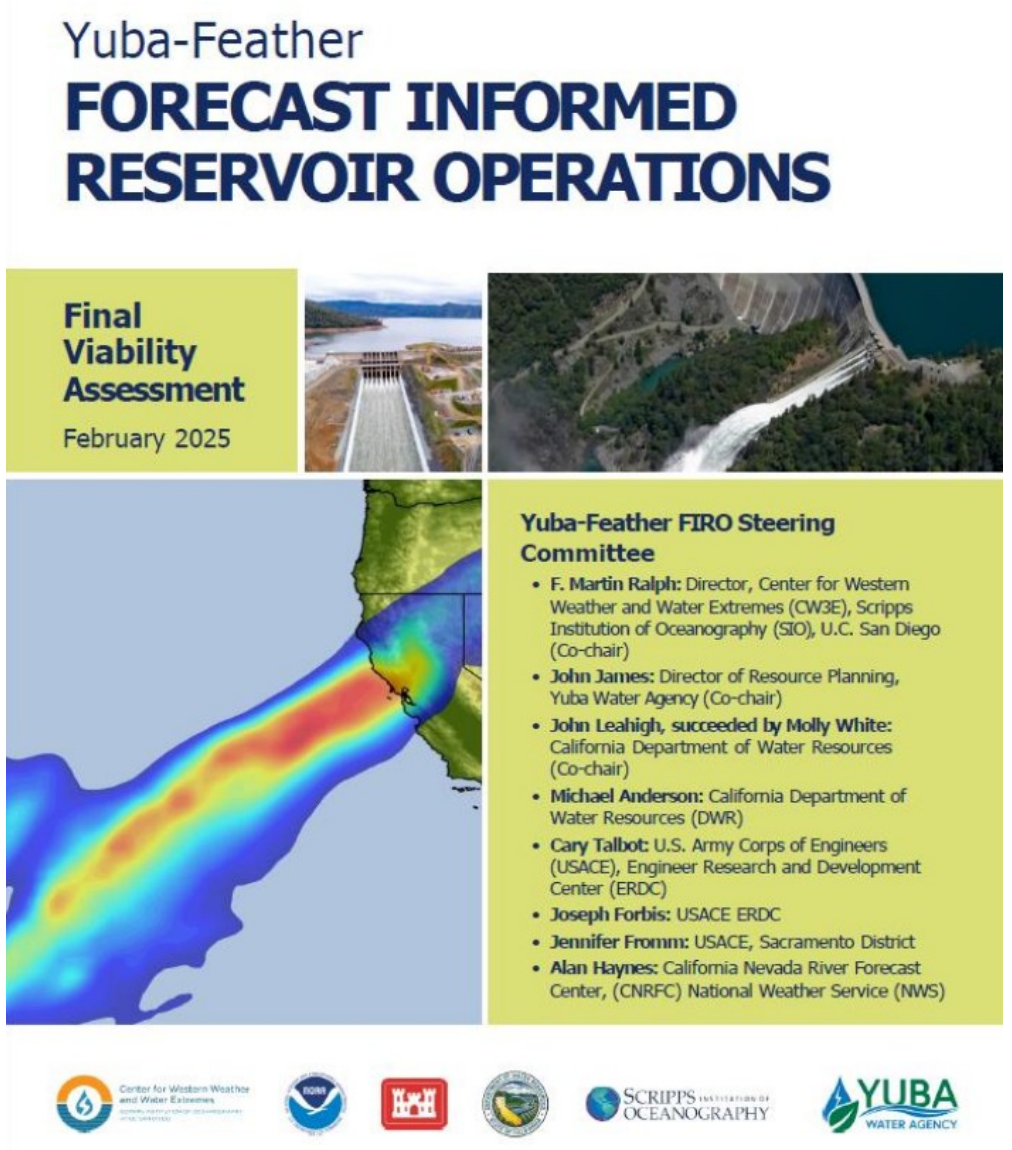
Key FVA Results

FIRO is viable at Oroville and New Bullards Bar.

FIRO strategy reductions in downstream flood flows and peak reservoir elevation across all scale factors are attributable to (1) use of forecasts, (2) FIRO space that extends into the water conservation pool, and (3) the planned ARC Spillway.

It is recommended that forecasts be incorporated into the WCM updates.

For the scenarios tested, FIRO with the ARC spillway enhances flood risk mitigation capacity by roughly 260,000 acre-feet.



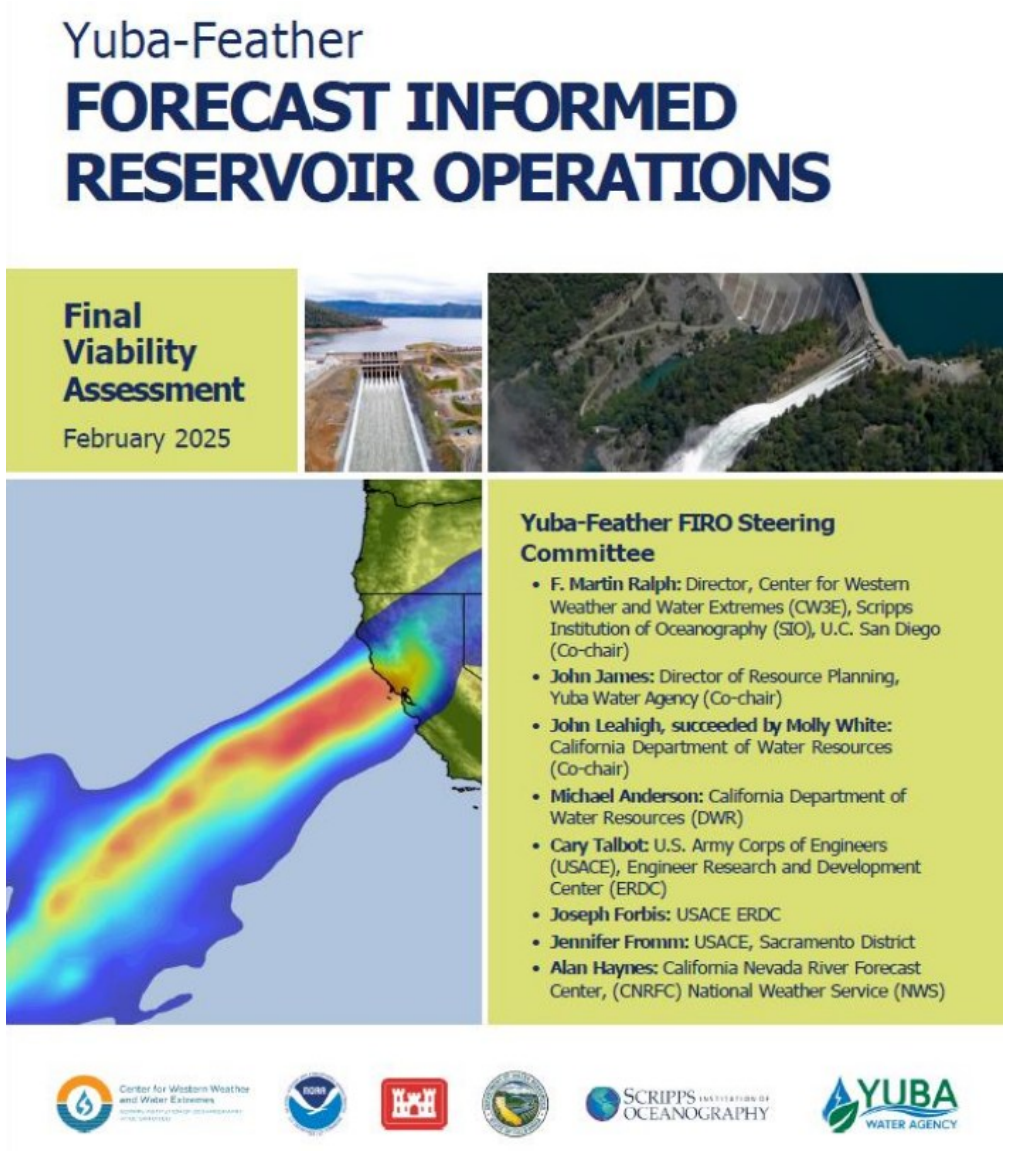
Key FVA Results

Heavy precipitation in the watershed is driven by atmospheric rivers.

Landfalling ARs are predicted with lead times of about 5 to 7 days.

24-hour total volume flows are skillful out to 6 days lead time.

Post-event storages were consistently higher than pre-FIRO storages; there could be a water supply benefit, pending a full analysis in the WCM updates.



Scientific American (2022)
by F. Martin Ralph

METEOROLOGY

FORECASTING ATMOSPHERIC RIVERS

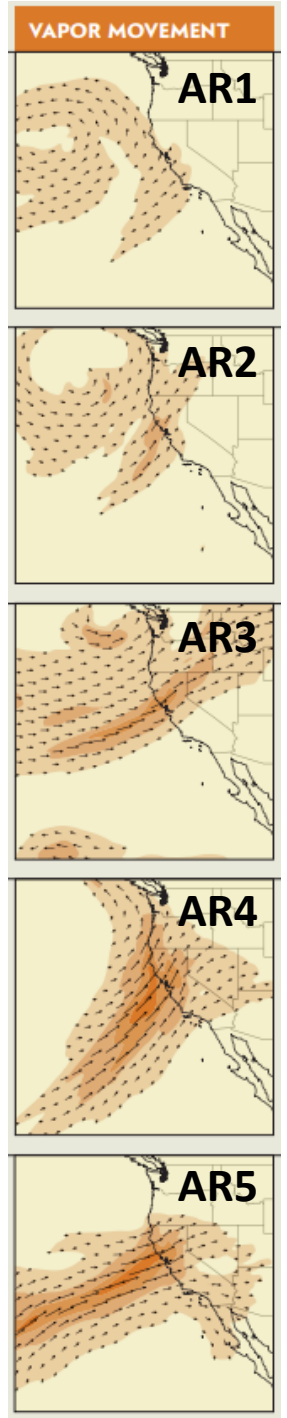
Knowing when torrents of rain will strike can save property and lives

By F. Martin Ralph

Illustration by Mark Ross

THANK YOU

Contact: mralph@ucsd.edu
Website: CW3E.ucsd.edu



AR Scale(examples)

ITEM 4

CNRFC RIVER AND RESERVOIR INFLOW FORECASTING

CALIFORNIA DEPARTMENT OF WATER RESOURCES

California-Nevada River Forecast Center (CNRFC) River and Reservoir Inflow Forecasting

OCAC presentation, June 13, 2025

Bibek Joshi, P.E.

Joint State-Federal Partnership

Federal

- National Oceanic and Atmospheric Administration
  - National Weather Service
    - California Nevada River Forecast Center

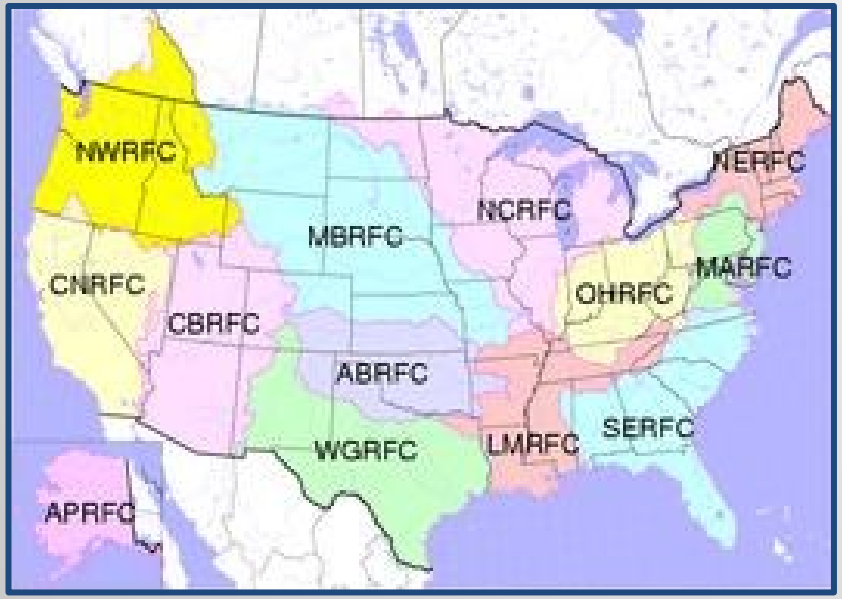
State

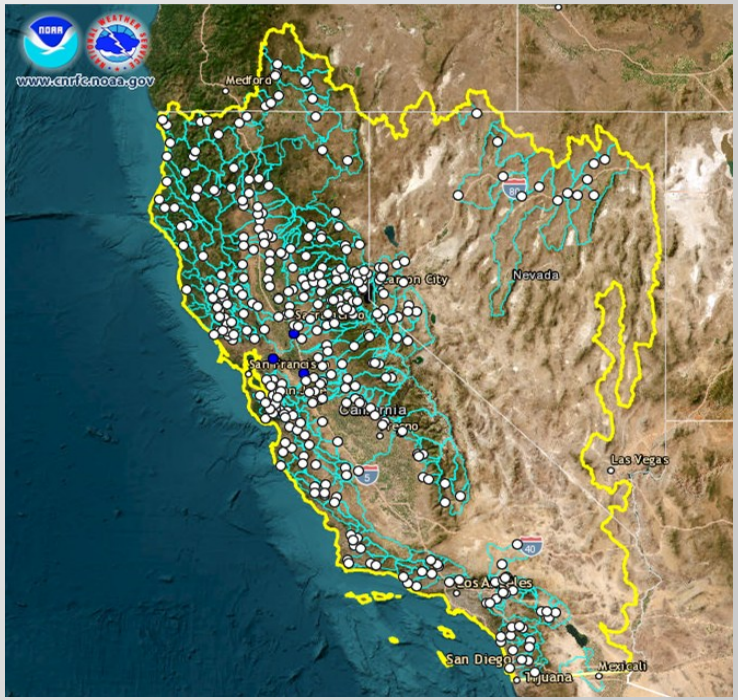
- CA Natural Resources Agency
  - Department of Water Resources (DWR)
    - Division of Flood Operations

CNRFC Domain

- 1 of 13 RFCs
- CNRFC covers most of CA & NV, and portion of lower Oregon
- Provide short range flood forecasting services
- Provide long range water supply forecasting services

245,000 sq. miles
350 Basins modeled
102 Forecast Points
173 'Other' Forecast Points
102 Reservoir Inflows





CALIFORNIA DEPARTMENT OF
WATER RESOURCES

CNRFC Forecast Schedule

Winter (Wet) Operations

- Two Forecasts/day (9am & 3pm)
- Weekends : only 9am forecast

Summer (Dry) Operations

- One Forecast/day (9am each day)

Flood Operations

- **4 Forecasts/day (9am, 3pm, 9pm, 3am)**

CNRFC Modeling

Observed Data

- 1200+ rain gages
- 600+ air temperature sensors
- 500+ river gages
- 120+ reservoir stage and releases
- Freezing level

Weather Forecast Inputs

- Precipitation
- Temperature
- Freezing Levels

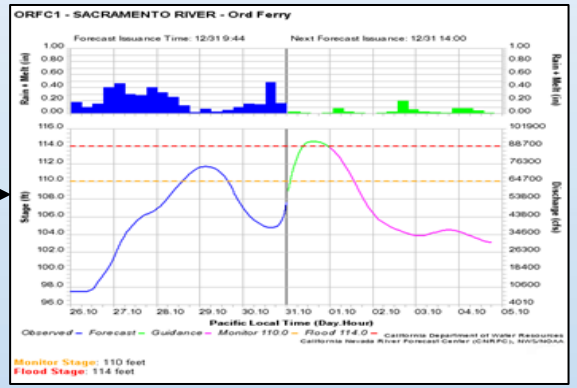
Input

Hydrologic Models

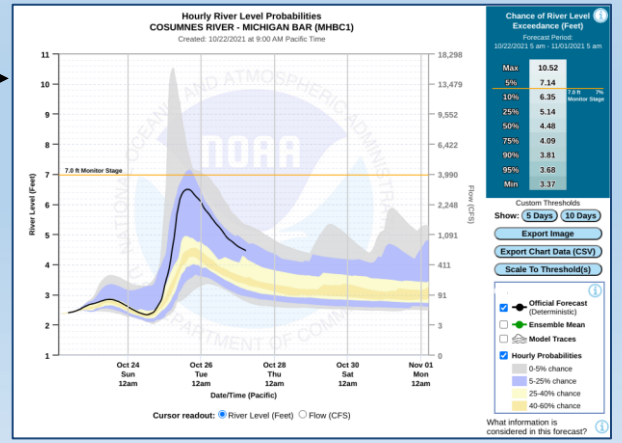
- Snow-17 (snow pack)
- SAC-SMA (soil moisture)
  - Rain-Snow Elevation
  - Routing
  - Reservoir Modeling

Output

Deterministic Forecast "Most-likely outcome"

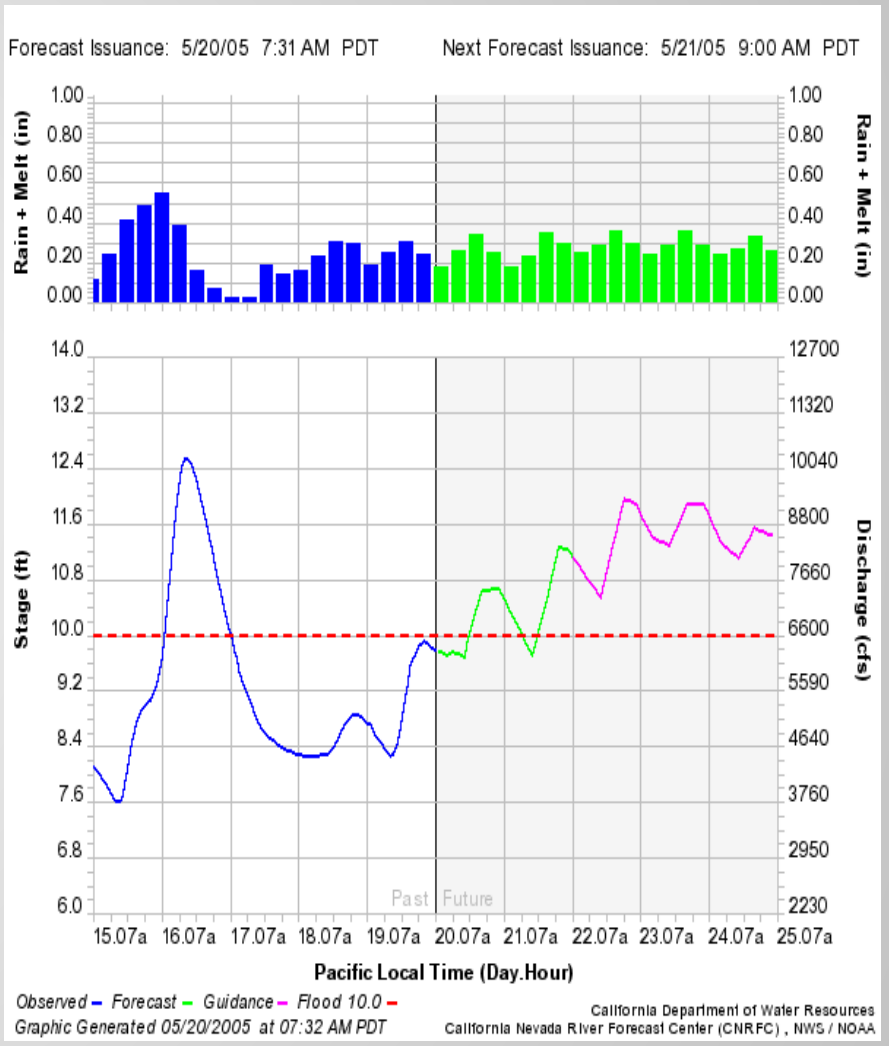


Ensemble Forecast Probabilistic



Deterministic Forecasts

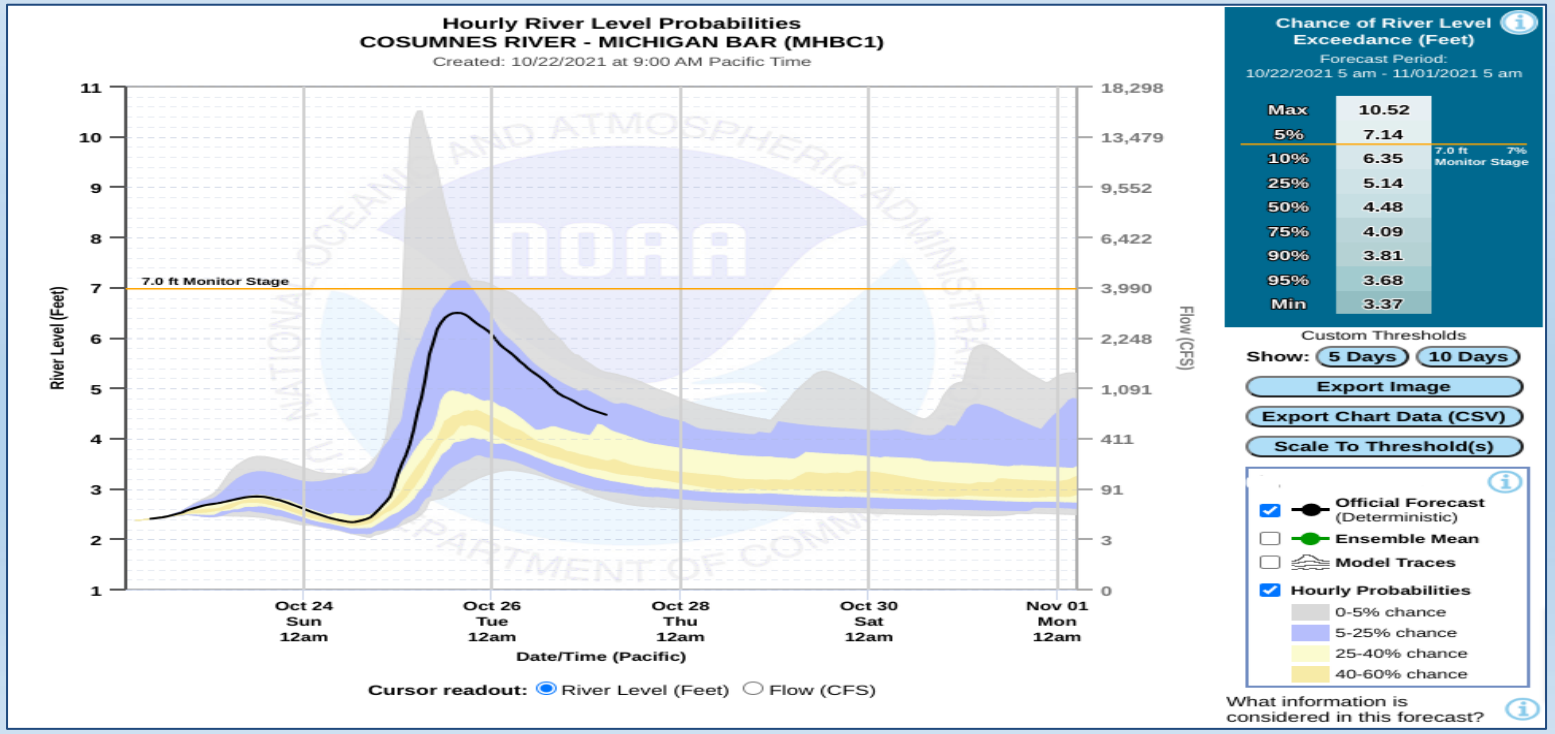
- A single, best-estimate prediction
- It answers what is the most likely outcome
- Based on one weather forecast, one model run and one set of initial conditions
  - Cosumnes River at Michigan Bar is forecast to peak at 12.1 feet on December 31 at 9 pm
  - The 5-day total inflow to Lake Oroville is forecast to be around 412 thousand acre-feet



CALIFORNIA DEPARTMENT OF WATER RESOURCES

Ensemble Forecasts

- What are the possible outcomes, and how likely are they?
- Capture a range of possible outcomes based on varying meteorological inputs
- 44 model runs instead of 1
- Represents uncertainty and supports risk-informed decision making
  - Example: In the next 5 days, there is a 95% chance that the Cosumnes River at Michigan Bar will exceed 7.0 feet, a 50% chance it will exceed 12.0 feet, and a 5% chance it will exceed 18.0 feet.

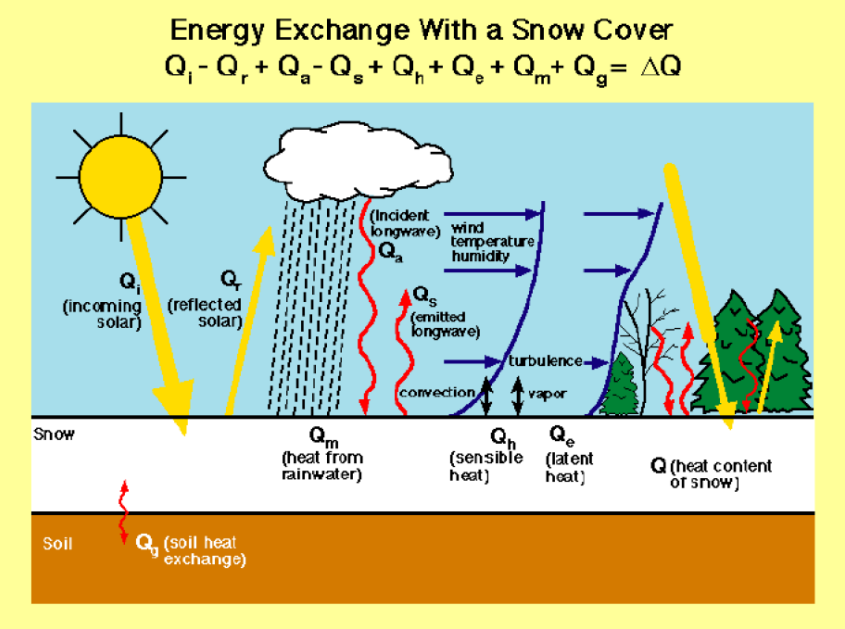


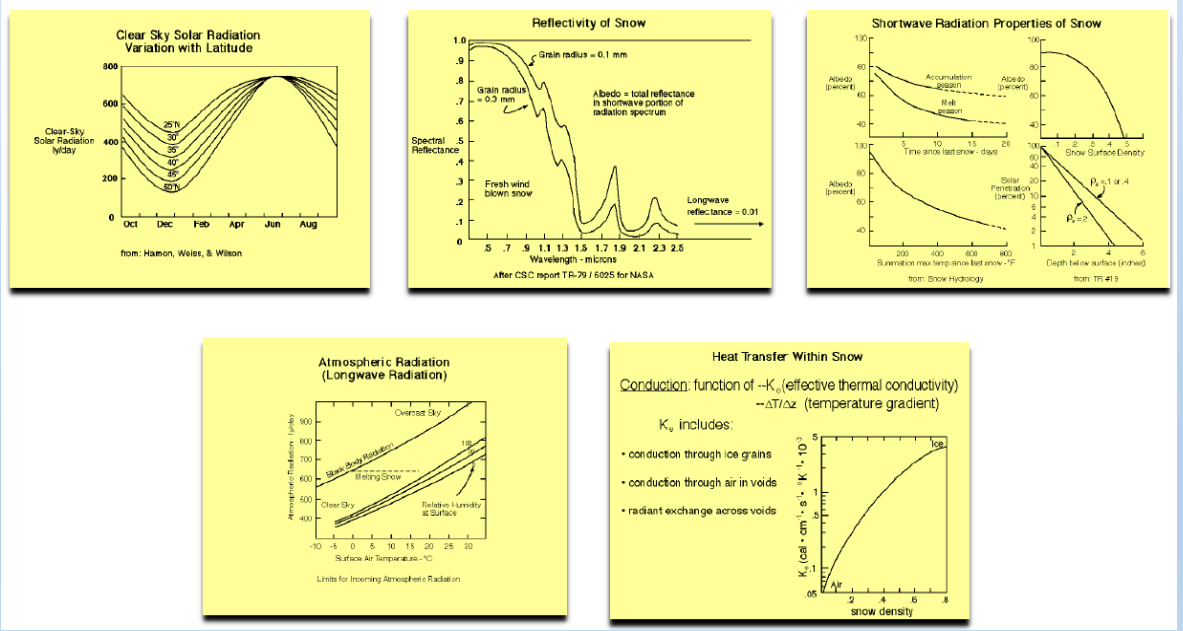
Snowmelt Methodology

- Snowmelt modeling (SNOW-17)
- Rain-on-snow event

SNOW-17 – A Conceptual Model

- Most of the important physical processes that take place within a snow cover are included, but in a simplified form.
- SNOW-17 is an index model using air temperatures as the sole index to determine energy exchange across the snow-air interface.
- The only other input variable needed to run the model is precipitation.





SNOW-17 Model – Operations

- Input Variables
  - Air Temperature
    - 10 days of max/min point forecasts
  - Precipitation
    - Six days of QPF
  - Freezing Level
    - Specifies rain/snow elevation
- Output
  - Rain + Melt
  - Simulated Water Equivalent
  - Simulated Area Extent of Snow Cover
  - Simulated Snow Depth

SNOW-17 Model – Operations

- The only inputs to SNOW-17 are temperature, precipitation, and freezing level
- Many physical processes are simplified with seasonal assumptions
- SNOW-17 has two modes:
  - Temperature indexed melt runoff
  - Rain-on-snow runoff
- Forecasters can make modifications (MODs) to SWE, the areal extent of the snow cover, and the melt factor
- The most common MODs use is the Melt Factor Correction (MFC) to better match observed melt in the spring
- Forecasters periodically (generally monthly) “true-up” the simulated SWE with observations using the historical relationship between snow course (point) observations and simulated SWE for each basin.

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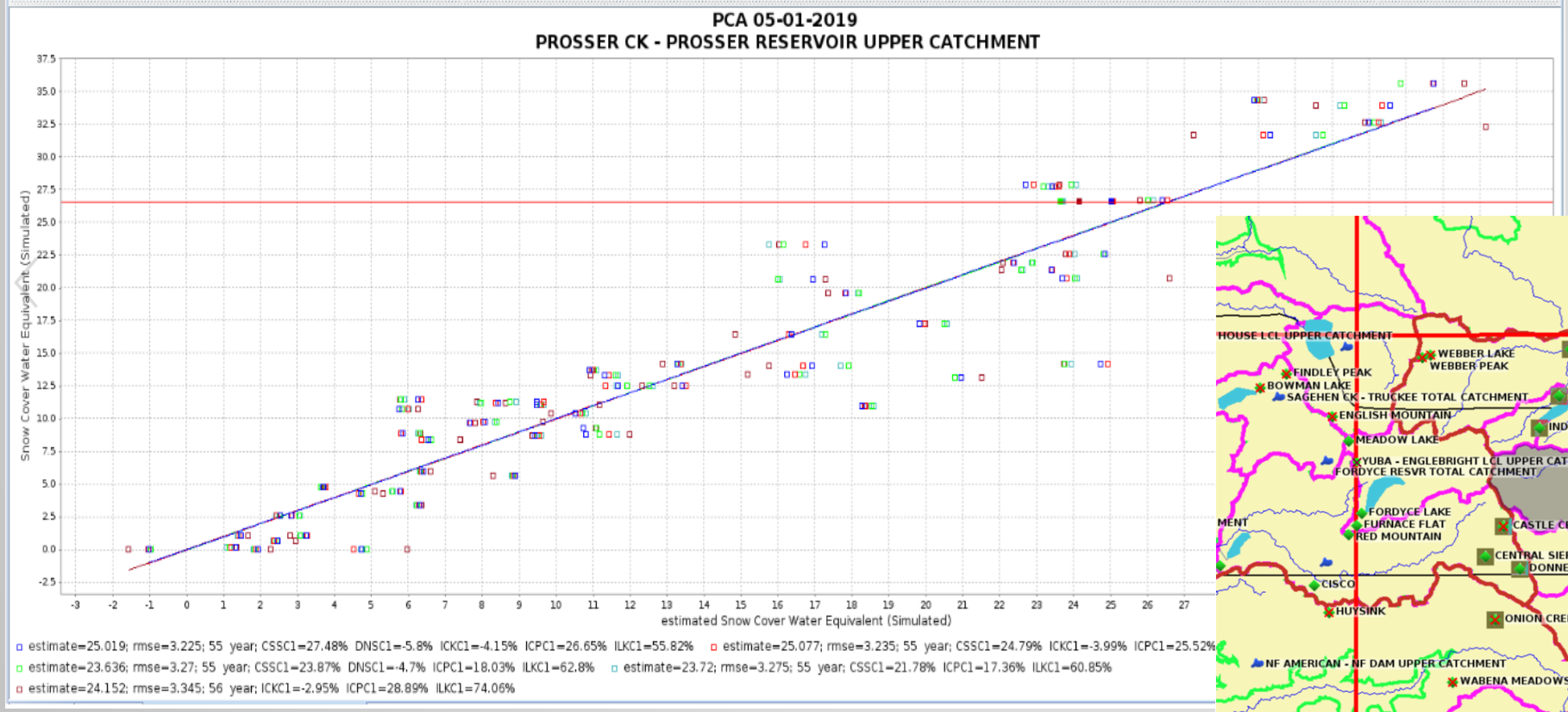
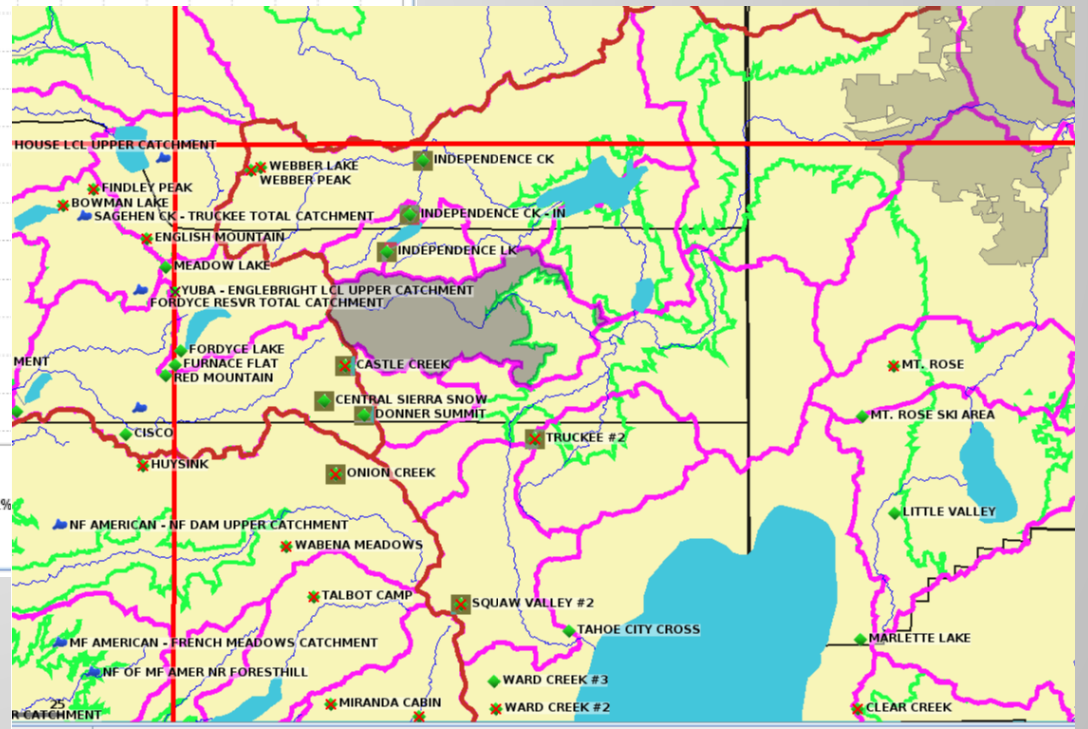
Snow update

	rank	simulated	estimated	rmse	period of record	equation	max	min	mean	method
	1	26.59	25.02	3.225	1961 - 1982 1984 - 2013 2016 - 2...	Y = 0.167*CSSC1 - 0.031*DNSC1 - 0.355*ICKC1 + 0.412*ICPC1 + 0.23*ILKC1 -2.372	35.66	0	13.34	REGRESSION
	2	26.59	25.08	3.235	1961 - 1982 1984 - 2013 2016 - 2...	Y = 0.15*CSSC1 - 0.342*ICKC1 + 0.395*ICPC1 + 0.221*ILKC1 -2.348	35.66	0	13.34	REGRESSION
	3	26.59	23.64	3.27	1961 - 1982 1984 - 2013 2016 - 2...	Y = 0.14*CSSC1 - 0.024*DNSC1 + 0.27*ICPC1 + 0.25*ILKC1 -2.858	35.66	0	13.34	REGRESSION
	4	26.59	23.72	3.275	1961 - 1982 1984 - 2013 2016 - 2...	Y = 0.128*CSSC1 + 0.26*ICPC1 + 0.243*ILKC1 -2.825	35.66	0	13.34	REGRESSION
	5	26.59	24.15	3.345	1961 - 2013 2016 - 2018	Y = 0.256*ICKC1 + 0.454*ICPC1 + 0.309*ILKC1 -3.633	35.66	0	13.68	REGRESSION

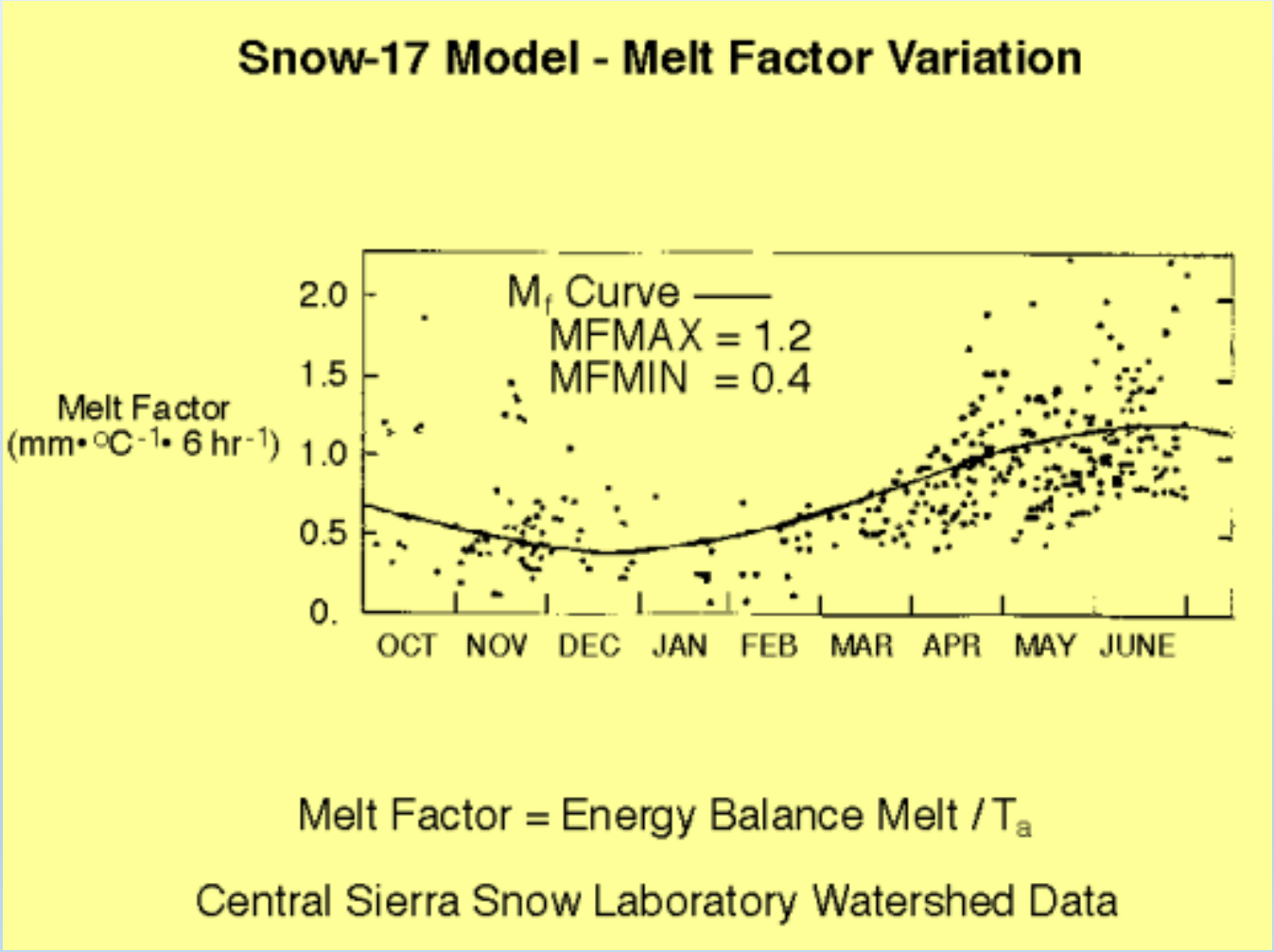




Energy Exchange at the Snow-Air Interface
SNOW-17 Energy Balance Modalities

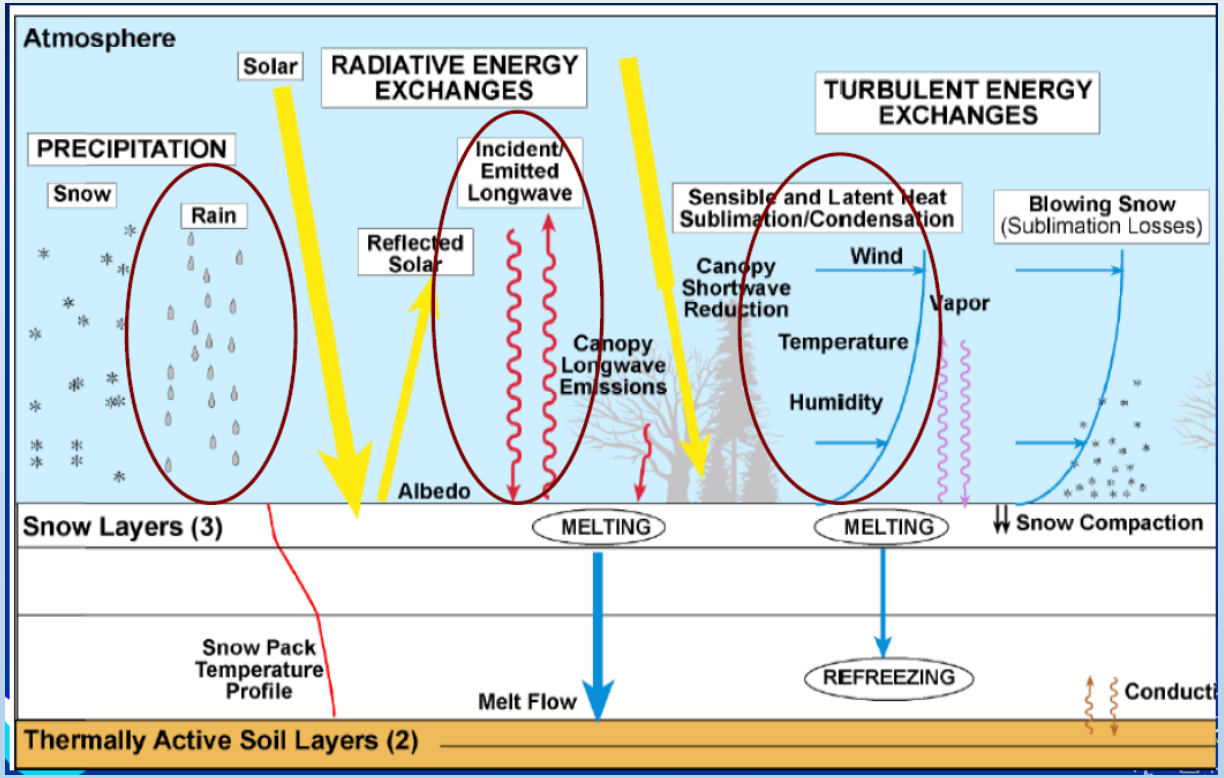
- Rain-on-Snow Mode
  - When sufficient rain occurs, the model uses energy balance to compute surface melt by making several assumptions about the meteorological conditions (overcast, high RH, rain assumes the ambient air temperature)
  - SNOW-17 goes into Rain-On-Snow mode whenever the amount of rain during a givern precipitation data time interval is greater than 1.5 mm per six hours.
- Non-Rain Melt Mode
  - When precipitation is < 1.5 mm/6 hours, SNOW-17 uses a melt factor to estimate the amount of surface snowmelt.
  - SNOW-17 uses a seasonal melt factor variation based on energy balance computations and empirical data from the Central Sierra Snow Lab.
- Rain-on-Snow
  - Melt = Rain Melt + Turbulent Transfer + Longwave exchange
- Non-Rain Melt
  - Melt = Surface Melt (Melt Factor) + Rain Melt

SNOW-17 Model – Melt Factor Variation



Snowmelt Due to Rain-on-Snow

- Rain-on-Snow is a complex phenomena.
- Many variables need to be considered (Temperature, humidity, wind speed, snowpack conditions, forests,…)
- The strongest component is usually turbulent transfer.
- All components together may reach 25% (or more) snowmelt-to-rain ratios in very warm events, especially at lower elevations.
- When snowpack is deep and still cold, little additional snowmelt occurs during rain-on-snow events.



Summary

- Flood forecasting products includes deterministic (best estimate) and ensemble (range of estimates) hydrographs
- SAC-SMA and SNOW-17 models include important physical processes in simplified forms
- Forecasters use field observations to inform the hydrologic models
- Rain-on-snow is a complex process and is included in the stream runoff computation. It can add 25% (or more) snowmelt-to-rain ratio in warm events

MEETING 21 AGENDA

PROPOSED TOPICS

1. Annual budget and project prioritization update
2. Dam Safety Update

FEEDBACK DUE DATES

- CNRA will circulate proposed Action Item Tracker updates and proposed Meeting 20 Agenda by **June 20**
- Commissioner feedback **July 11**

ITEM 5
PUBLIC COMMENT

The Oroville Dam Citizens Advisory Commission will now take public comment.

We appreciate your input.

ITEM 6
ADJOURN

Commission Meeting #21

October 2025