Center for Western Weather and Water Extremes

SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

Requirements and Options for FIRO Decision Support Tools: Progress and Challenges Ahead

Task 2 –Develop Evaluation Criteria for Extreme Events and Define Key Elements of Decision Support Tool

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Center for Western Weather and Water Extremes

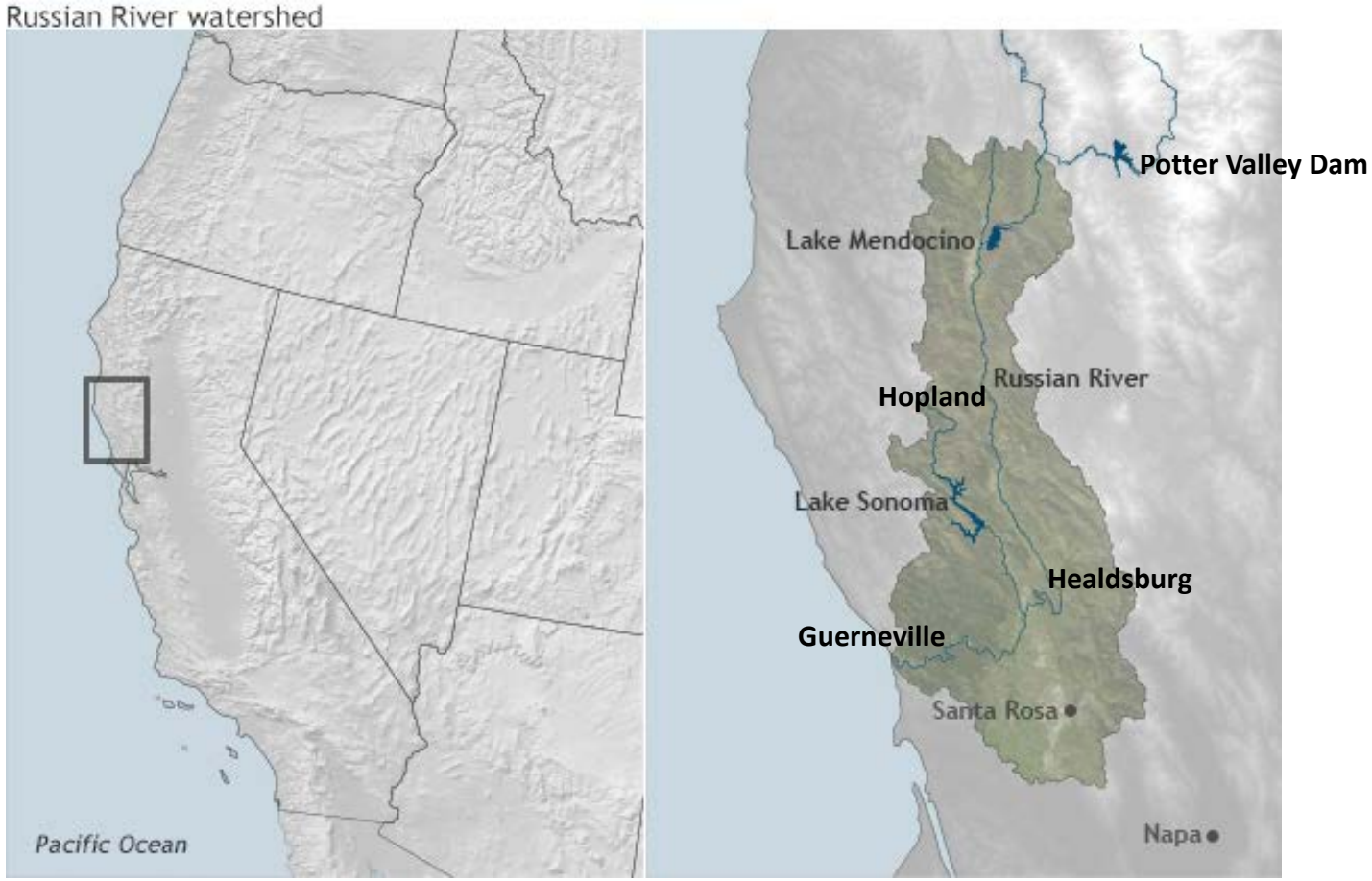
June 28, 2016

FIRO Workshop

Outline

- Review key elements of a decision support tool - FIRO Workplan 7.2
  - Only as they relate to forcing- meteorology/hydrology
- SCWA risk-based-release decision tool for Lake Mendocino
  - Example from 2016 using operational HEFS
  - Review Pros and Cons
- Proposed Folsom Reservoir FIRO plan
  - Review Pros and Cons
- Road Forward
  - Can we identify better forcing (QPF) for hydrologic model – FIRO Workplan 4.1-4.3

Russian River Watershed



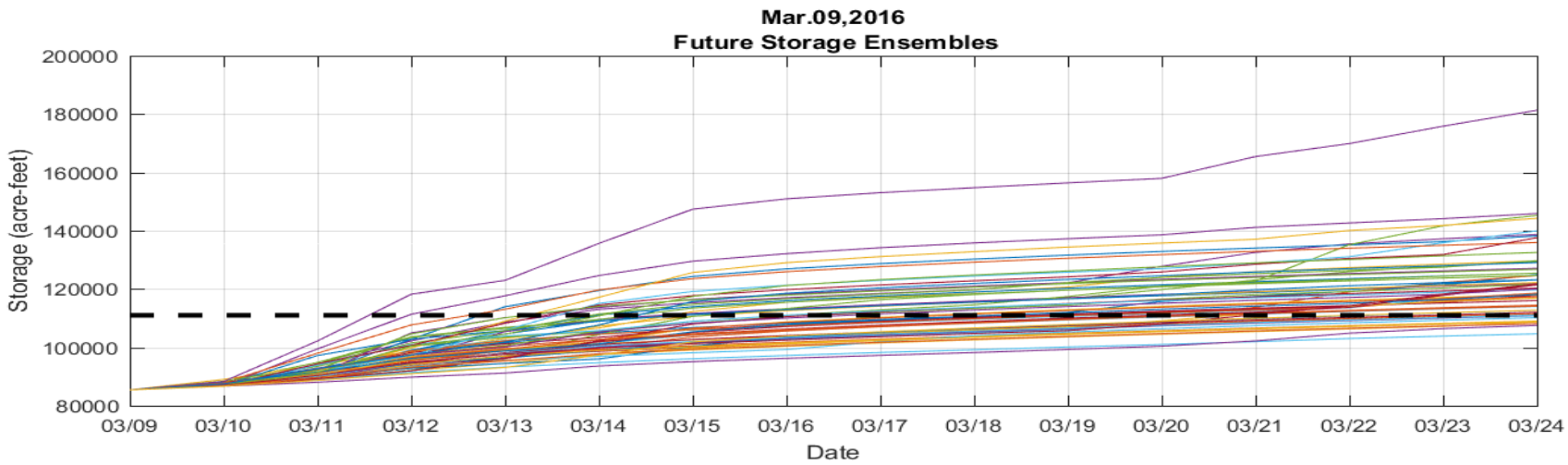
Desired Elements of Decision Support System* - *"Enhance quantitative knowledge of future water and weather conditions in the watershed and enable use of that enhanced knowledge in decision-making."*

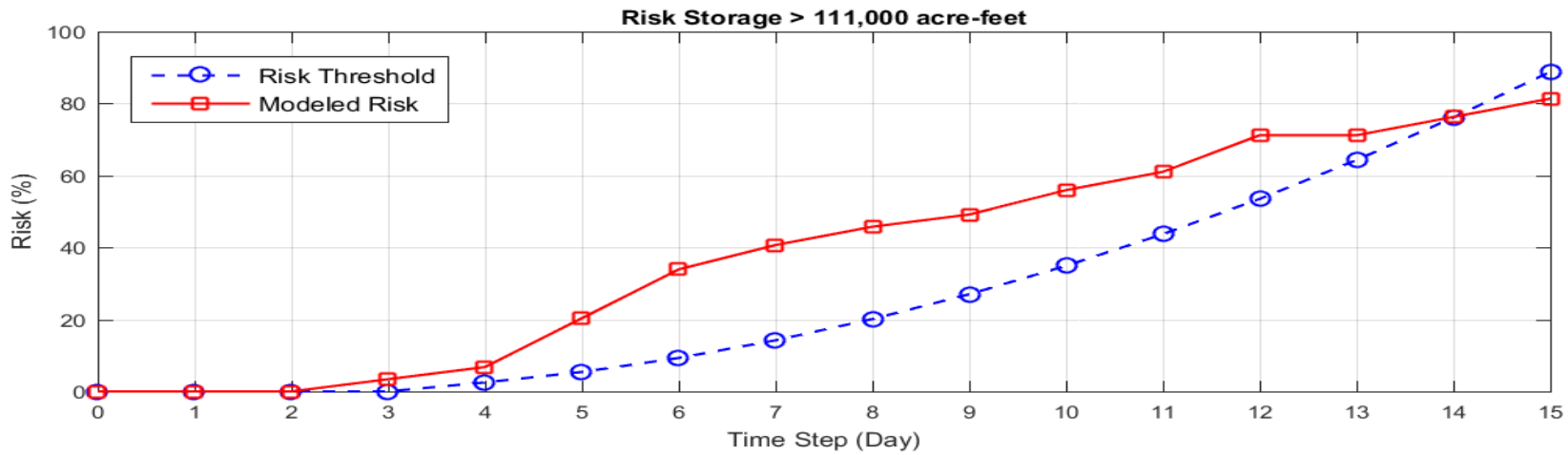
- Include all critical elements of the process
  - QPF/QPE + uncertainty
  - Hydrologic model + uncertainty
  - Upstream releases– Potter Valley Dam (and diversions)
  - Downstream flows and restrictions (Hopland flows – fish impacts)
    - Downstream forecast inflows – all sources plus uncertainty
- Risk Based
  - Understand the risk tolerance of decision maker
  - Understand release capacity of reservoir
  - Understand impacts downstream from large releases from COY – travel times
- Interactive
  - Allow running various scenarios by various decision makers
- Adaptive – scalable and flexible
  - Keep up with the state-of-the-science

*See Section 7.2.1 of FIRO Operations Plan for complete list of objectives and requirements of DSS

CW3E

Risk Based Reservoir Release Decision Model 2016 Test Case



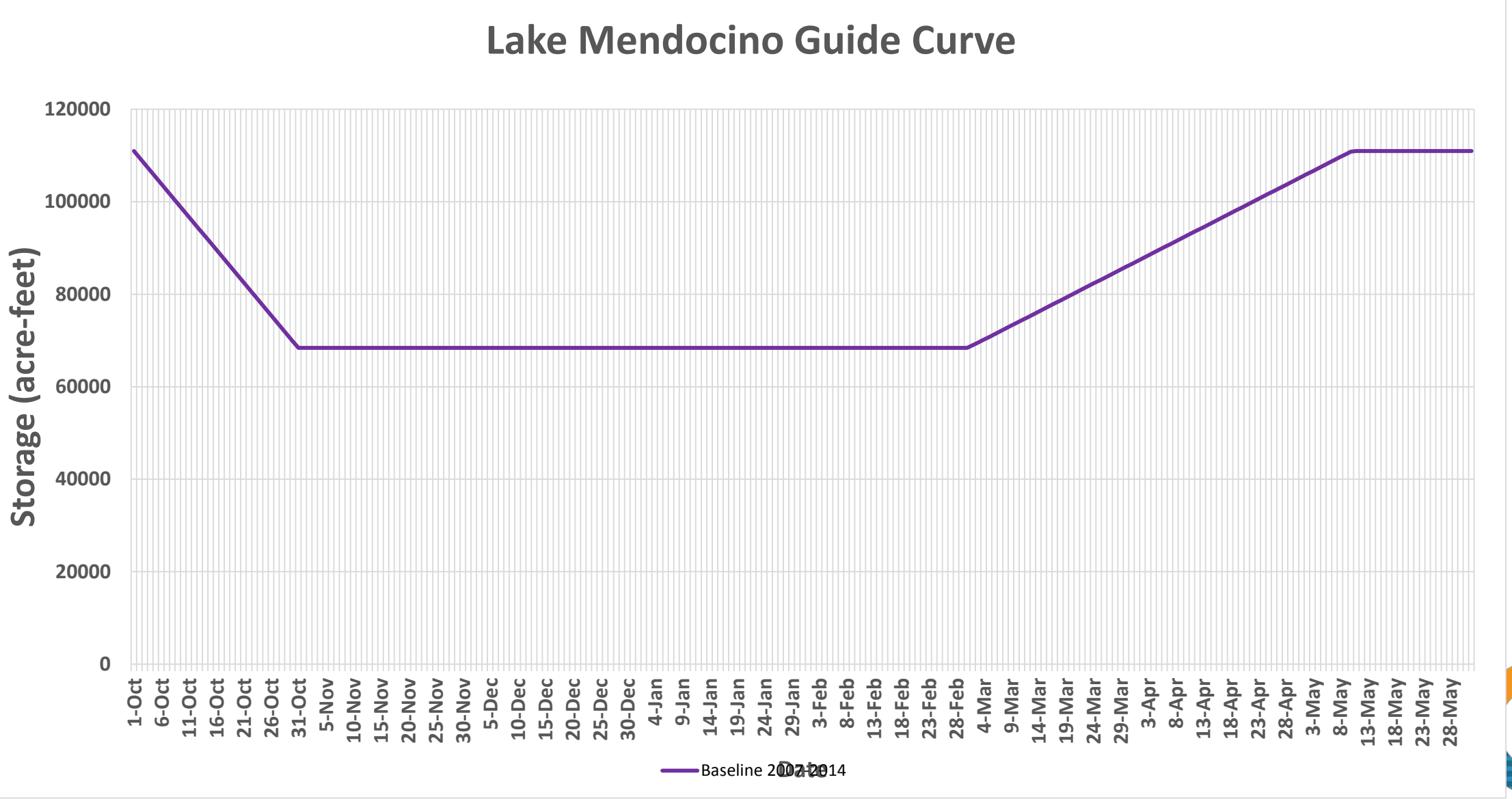


Chris Delaney

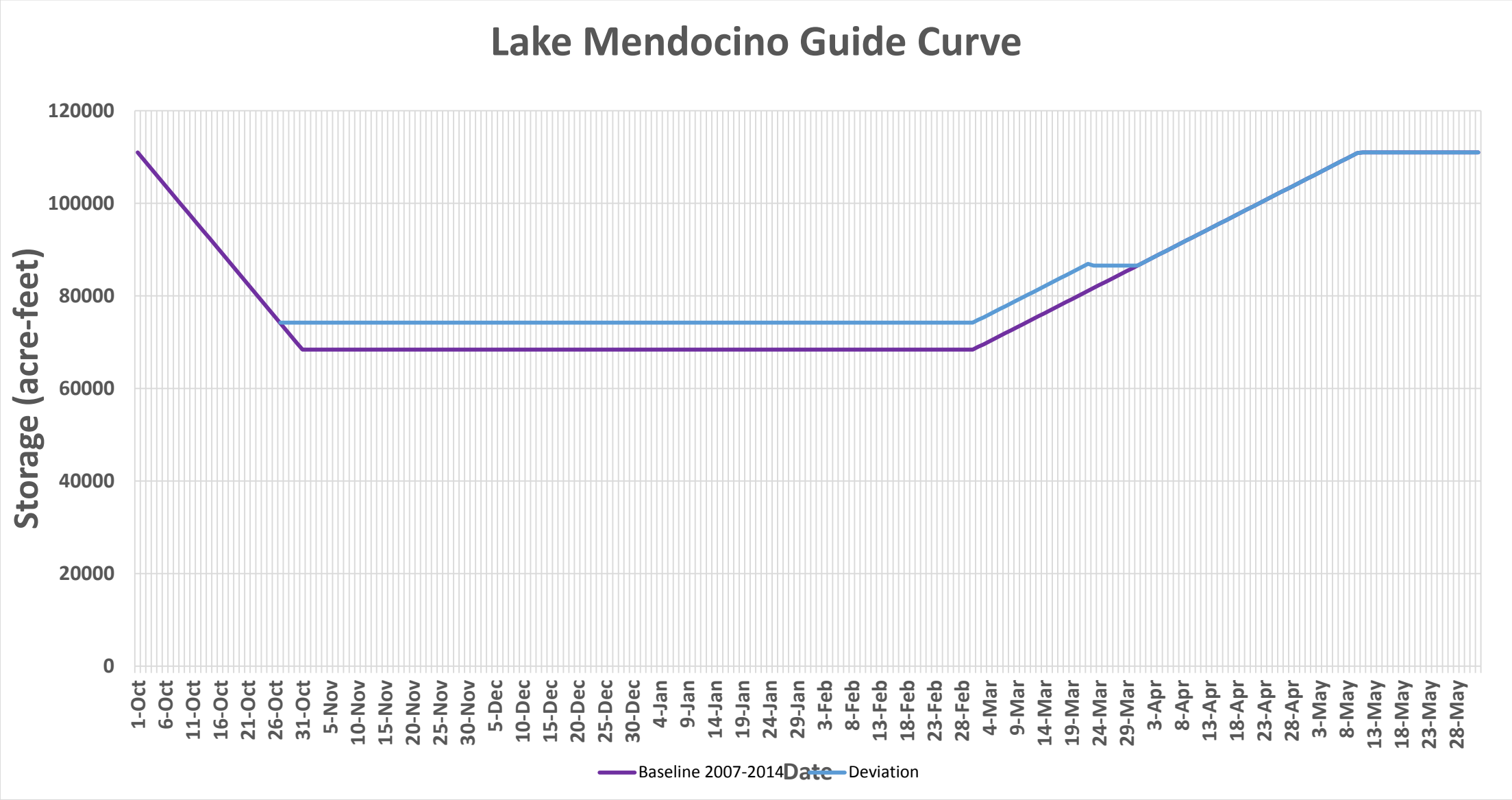
March 31, 2016

SONOMA COUNTY WATER AGENCY

Lake Mendocino Operations vs FIRO 2015-2016



Lake Mendocino Operations vs FIRO 2015-2016



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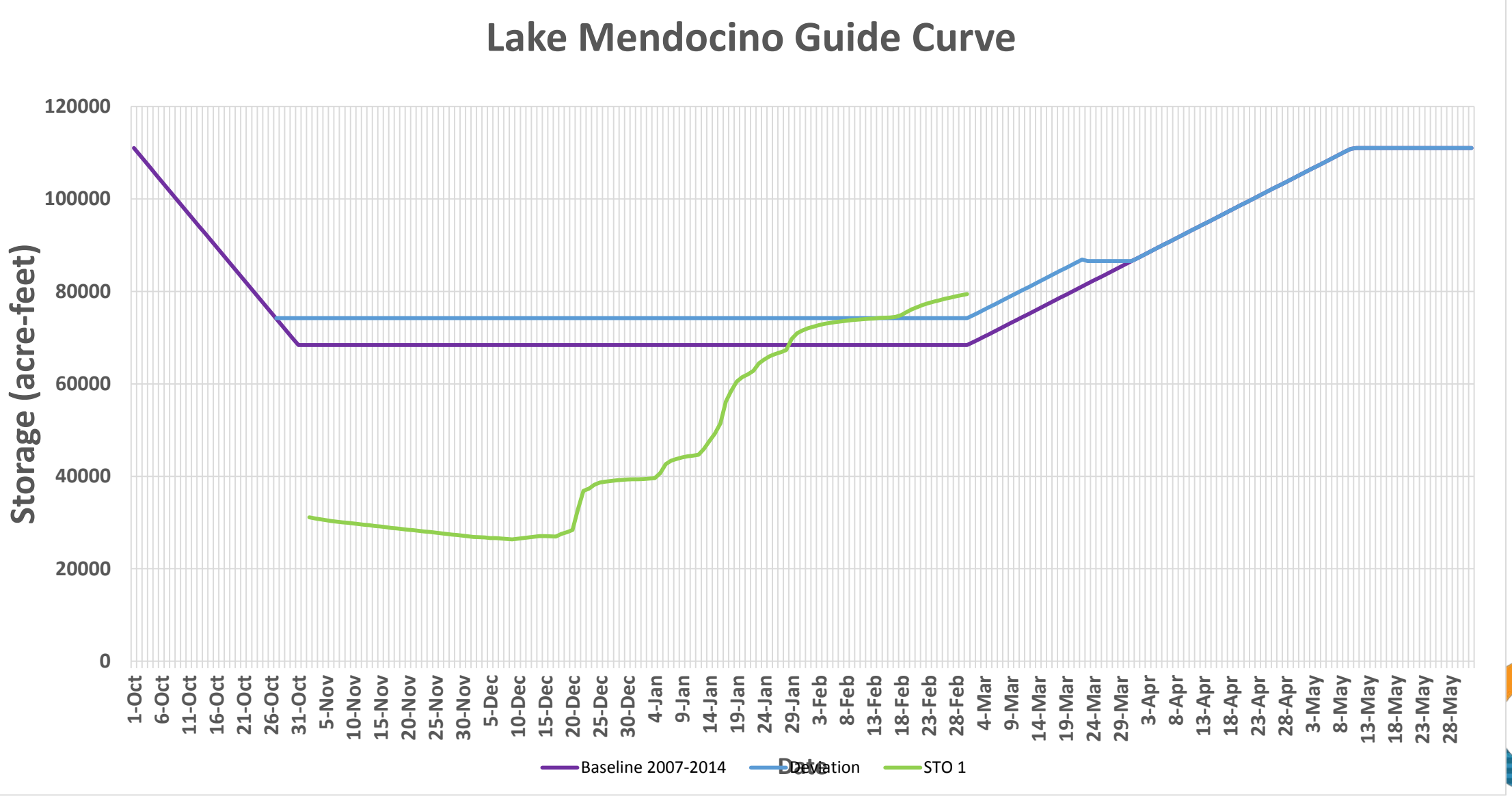
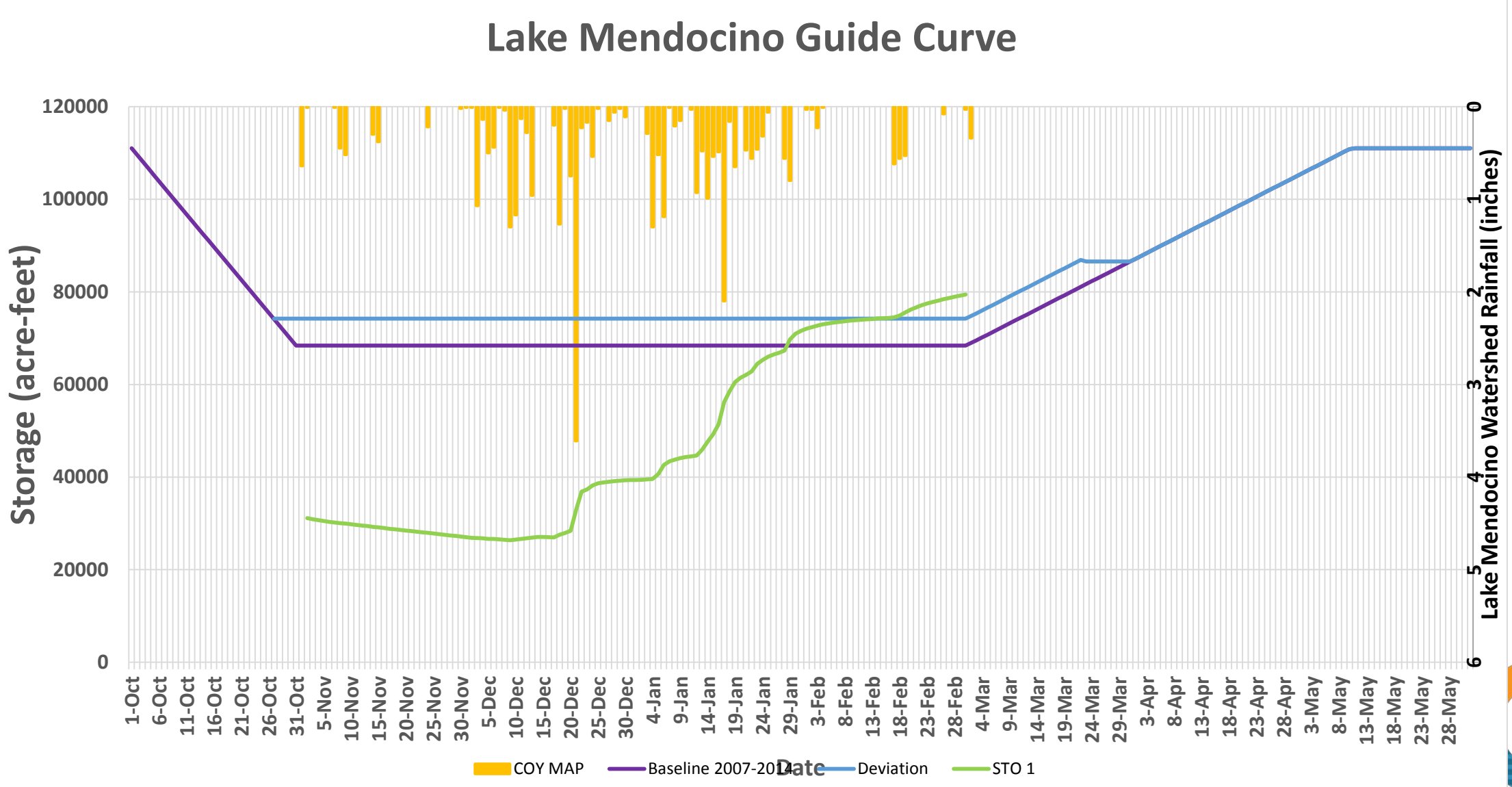
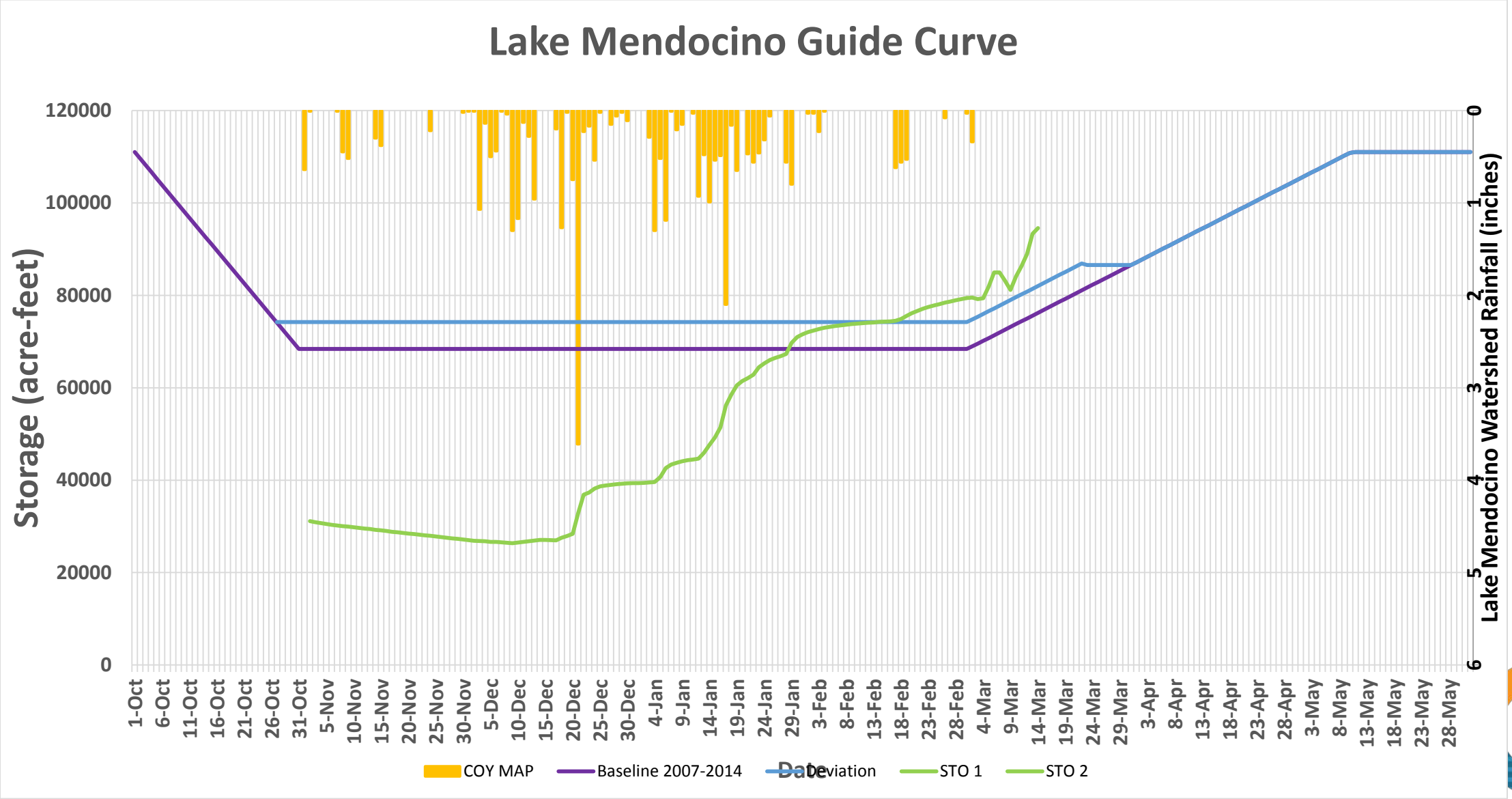


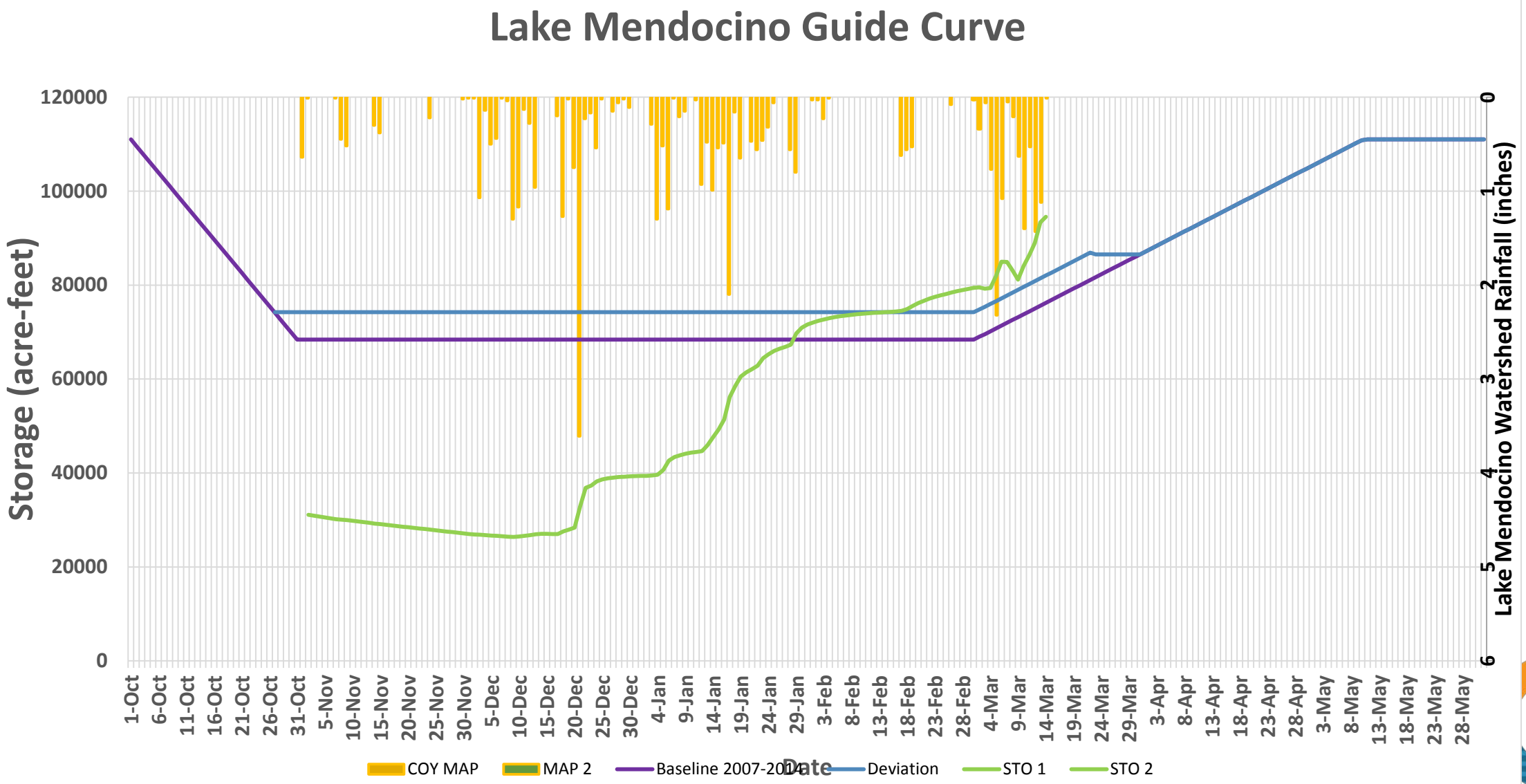
Lake Mendocino Operations vs FIRO 2015-2016



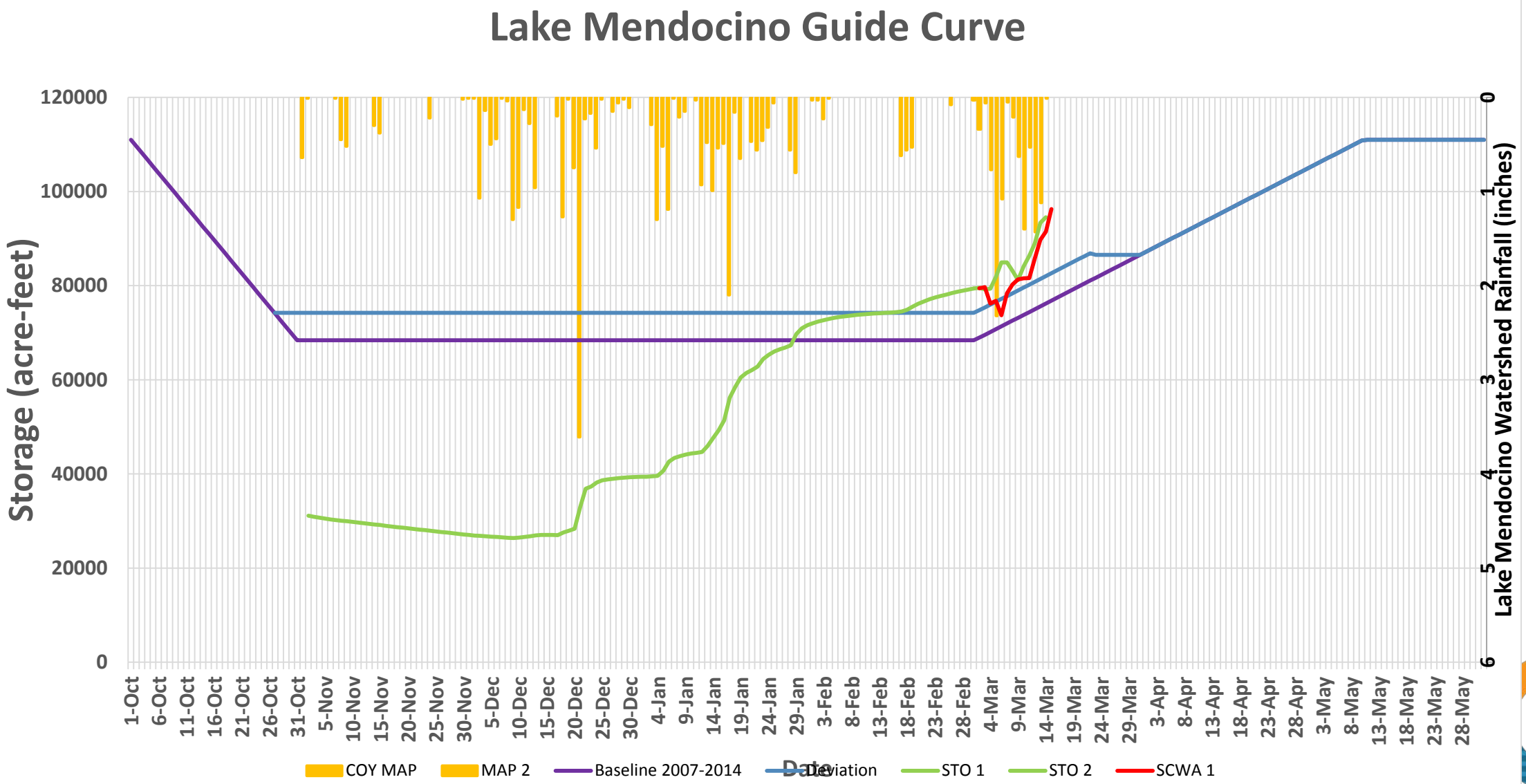
Lake Mendocino Operations vs FIRO 2015-2016



Lake Mendocino Operations vs FIRO 2015-2016



Lake Mendocino Operations vs FIRO 2015-2016



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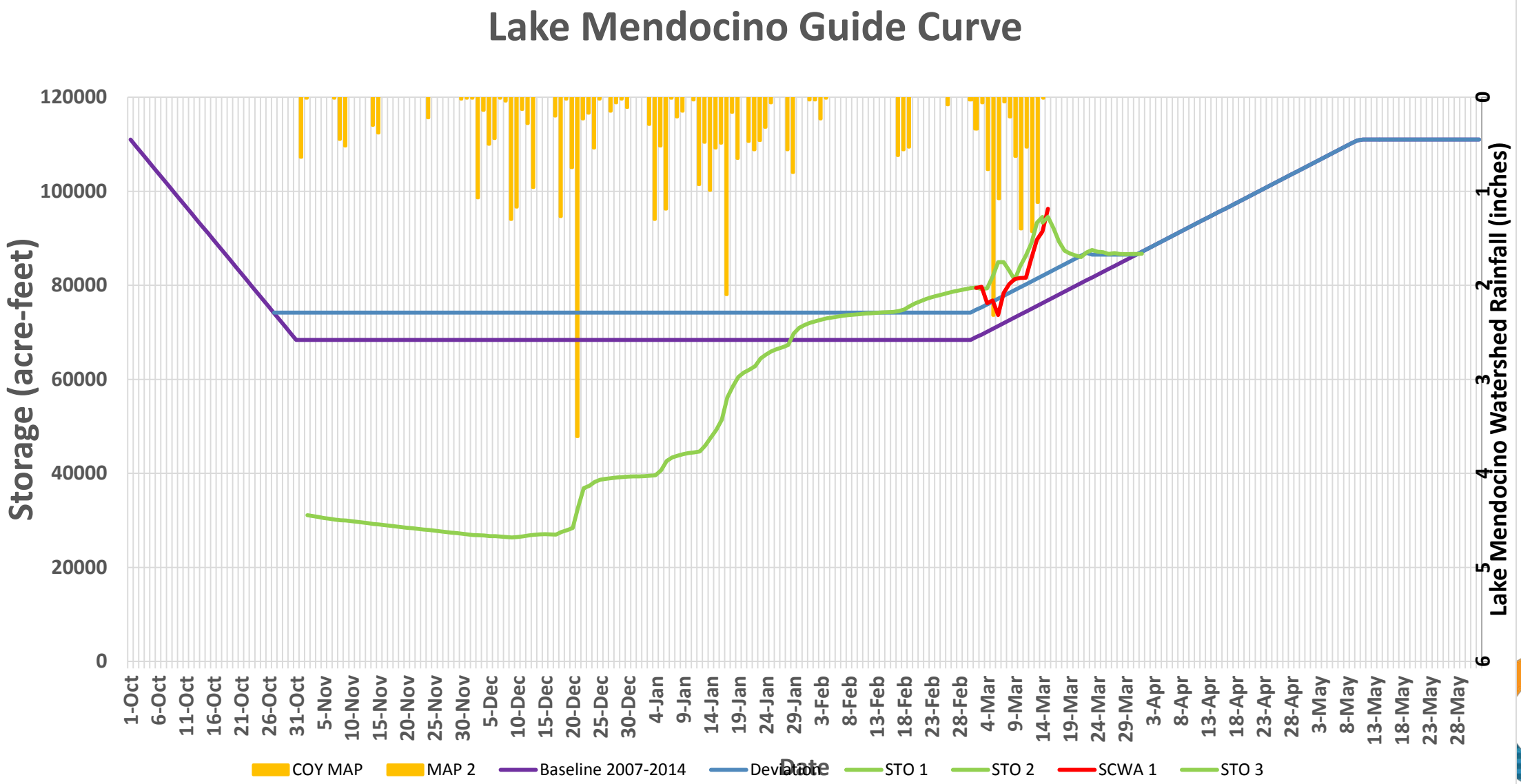

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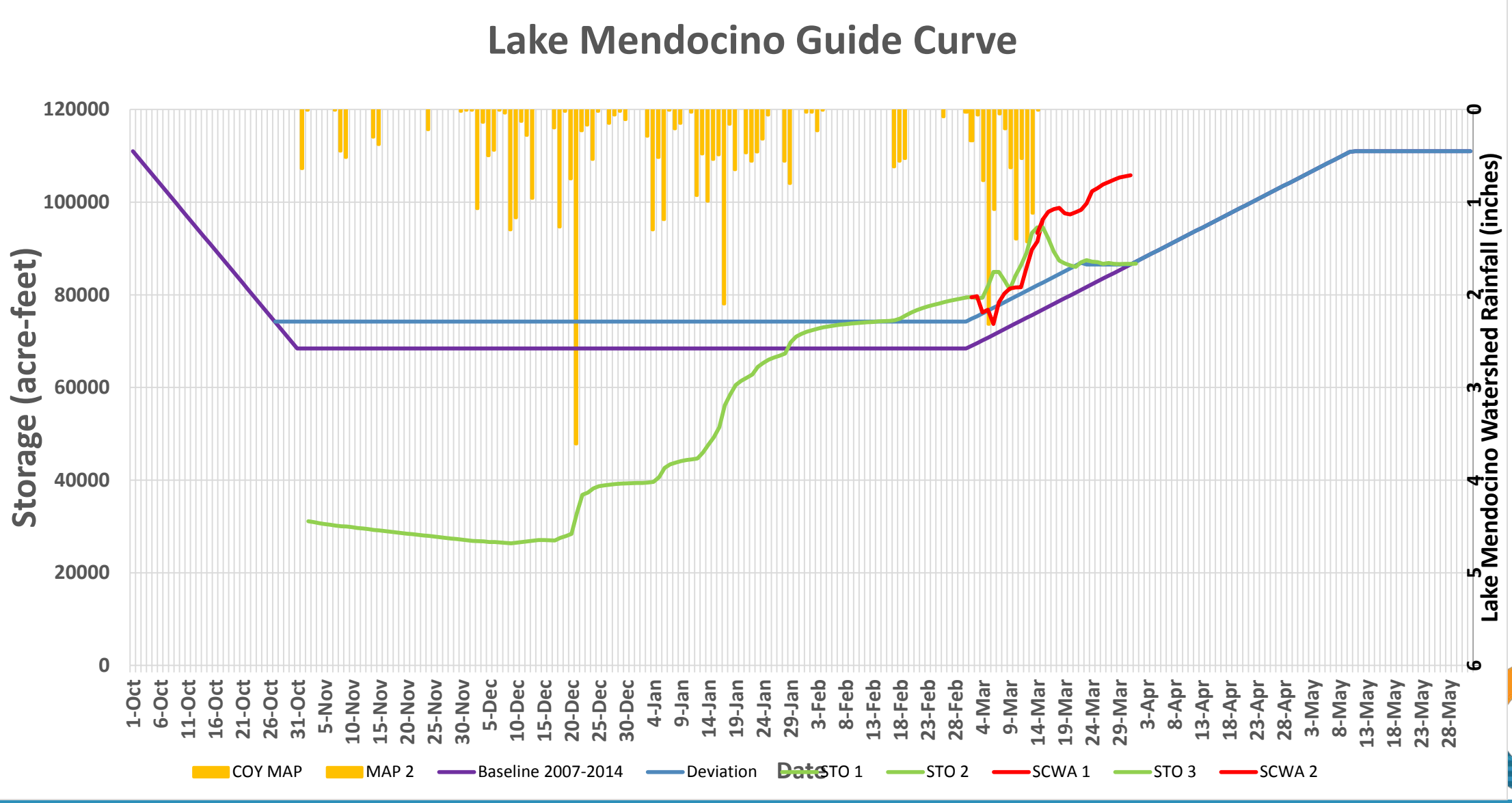

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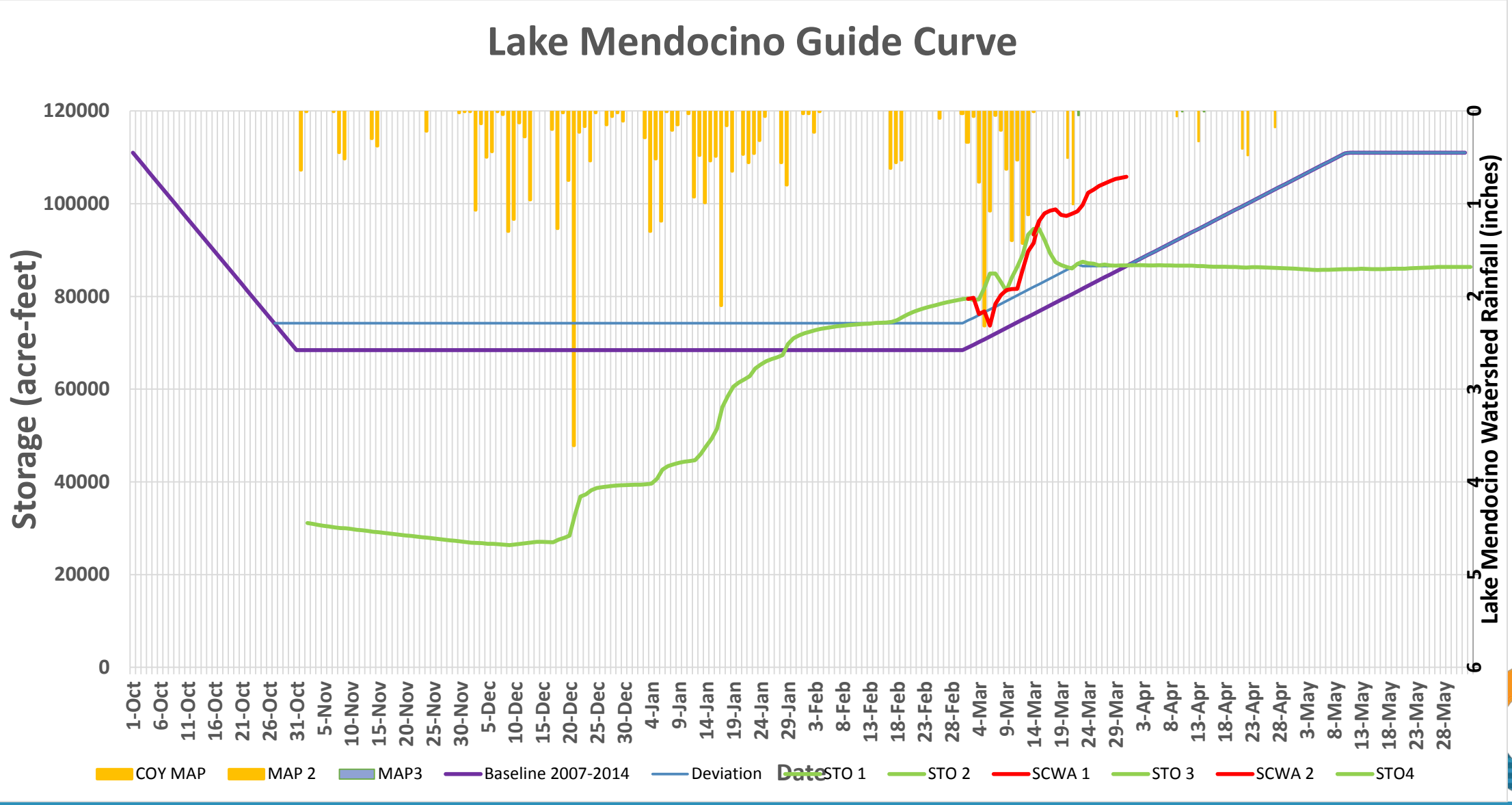

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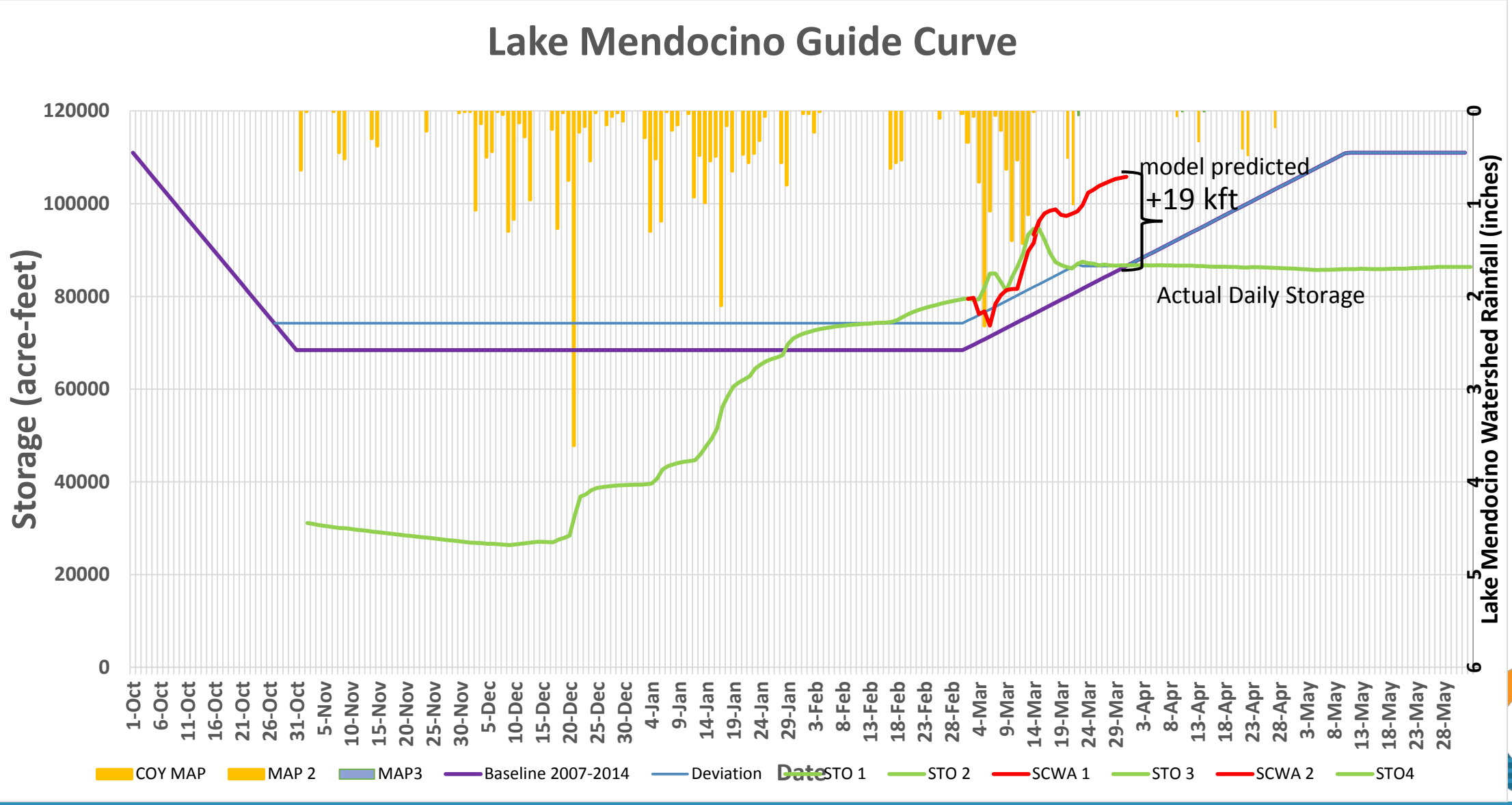
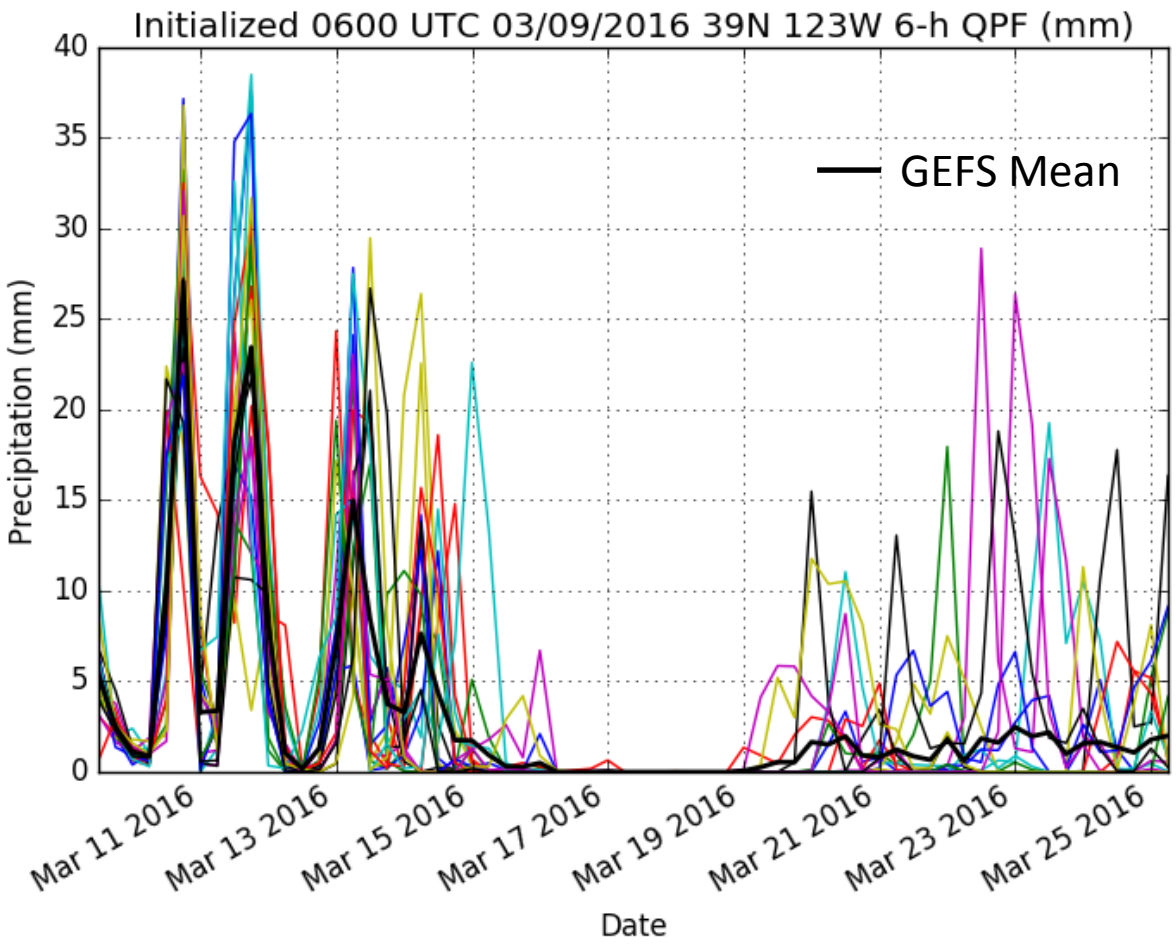


GEFS via Meteorological Ensemble Forecast Processor (MEFP)Ensemble Forcing for Risk Model

What is the skill of mean?

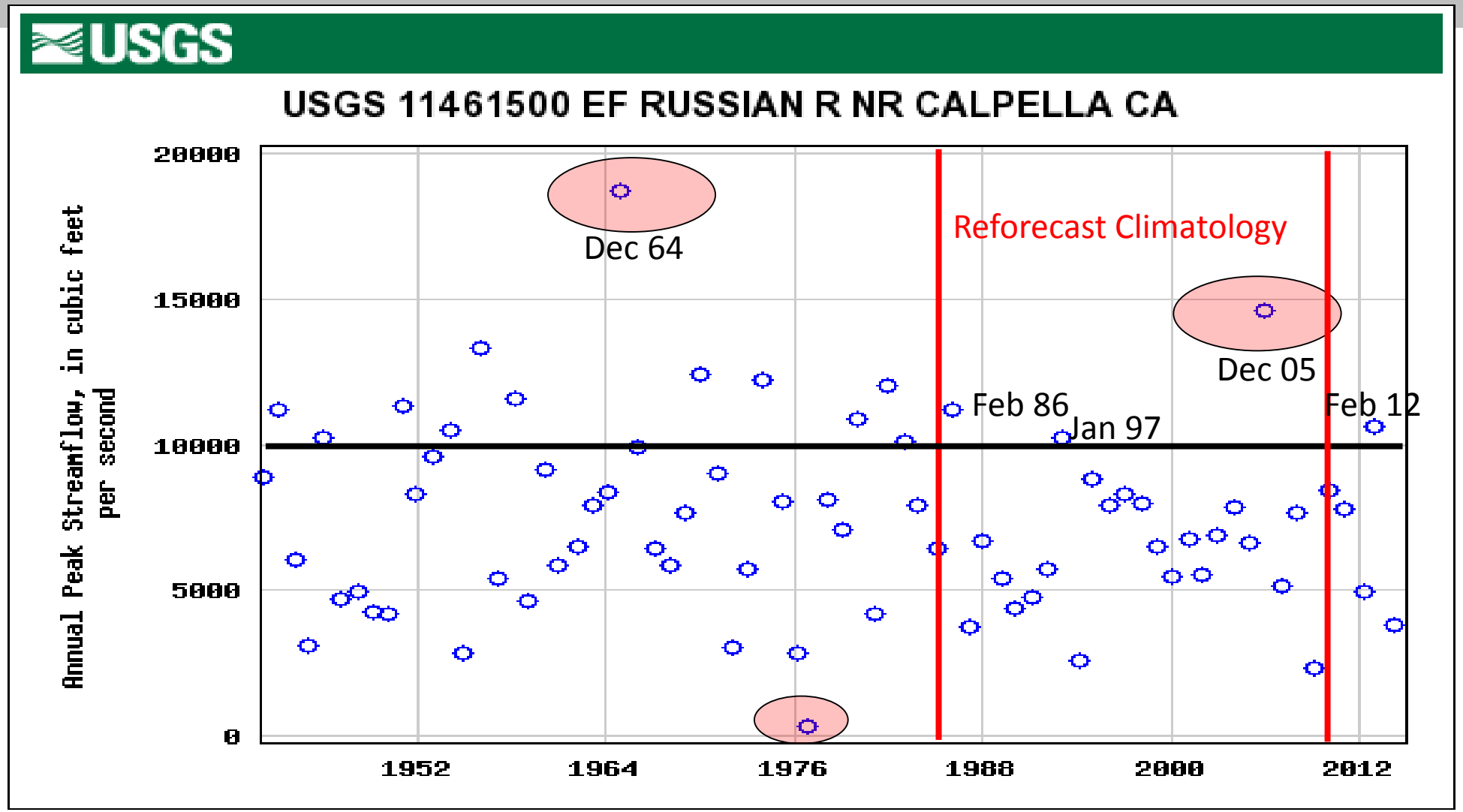


GEFS Mean drives COY 61 member Ensemble Inflows

Brown et al, 2014: Verification of temperature, precipitation, and streamflow forecasts from the NOAA/NWS Hydrologic Ensemble Forecast Service. 1. Experimental design and forcing verification. J.Hydrology, 514, 2869-2889.

CW3E

Historical Peak Inflows to Lake Mendocino



Benefits and Limitations of SCWA Risk Model

- Benefits
  - Utilizes existing Hydrologic Ensemble Forecast Service (HEFS) run by CNRFC
  - Accounts for uncertainty in meteorological forcing - MEFP -low bias and properly dispersed
  - Risk Based – can vary the risk tolerance based on assumed uncertainty in hydrologic forecasts and decision maker's aversion to risk –no spills!
  - Can be run in real-time utilizing existing software to provide guidance to USACE daily
  - Can utilize up to full storage capacity of Lake Mendocino maximizing water storage

Benefits and Limitations of SCWA Risk Model

- Limitations
    - Forcing based on 2012 version of GEFS ensemble mean- older version than currently running – uses only 21 member ensemble at coarser resolution than currently running
        - Only has 25 year climatology – 1986-2010 – few extremes – wet or dry
        - Limited Verification Available – CNRFC to review this summer
    - utilizes HAS (Hydrometeorological Analysis and Support) QPF for days 1-3 – only 15 year climatology – 2000-2014.
  - Requires NCEP to run older version of the GEFS daily for RFC use
  - Models have and will continue to improve as we increase resolution and develop mesoscale convective resolving ensembles.
  - New hydrologic model coming on-board through NWS Water Center – WRF-Hydro unknown capability – still needs accurate rainfall!!
- Is there other methods for FIRO decision support?

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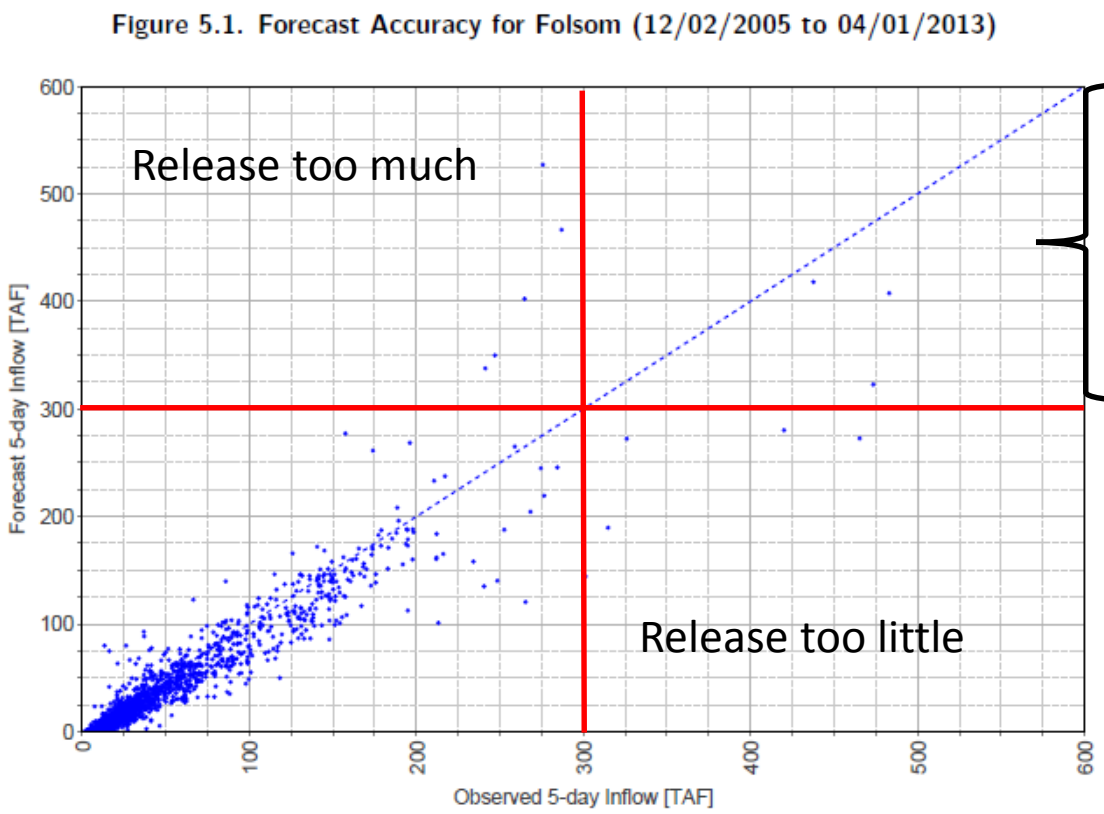
One "Proposed" Folsom Reservoir FIRO

- **Uses CNRFC Deterministic Day 1-2-3-5 day forecast inflows**
  - Demonstrated skill but deterministic
- Utilizes variable 200 TAF flood conservation pool based on forecast inflows
- example releases shown below

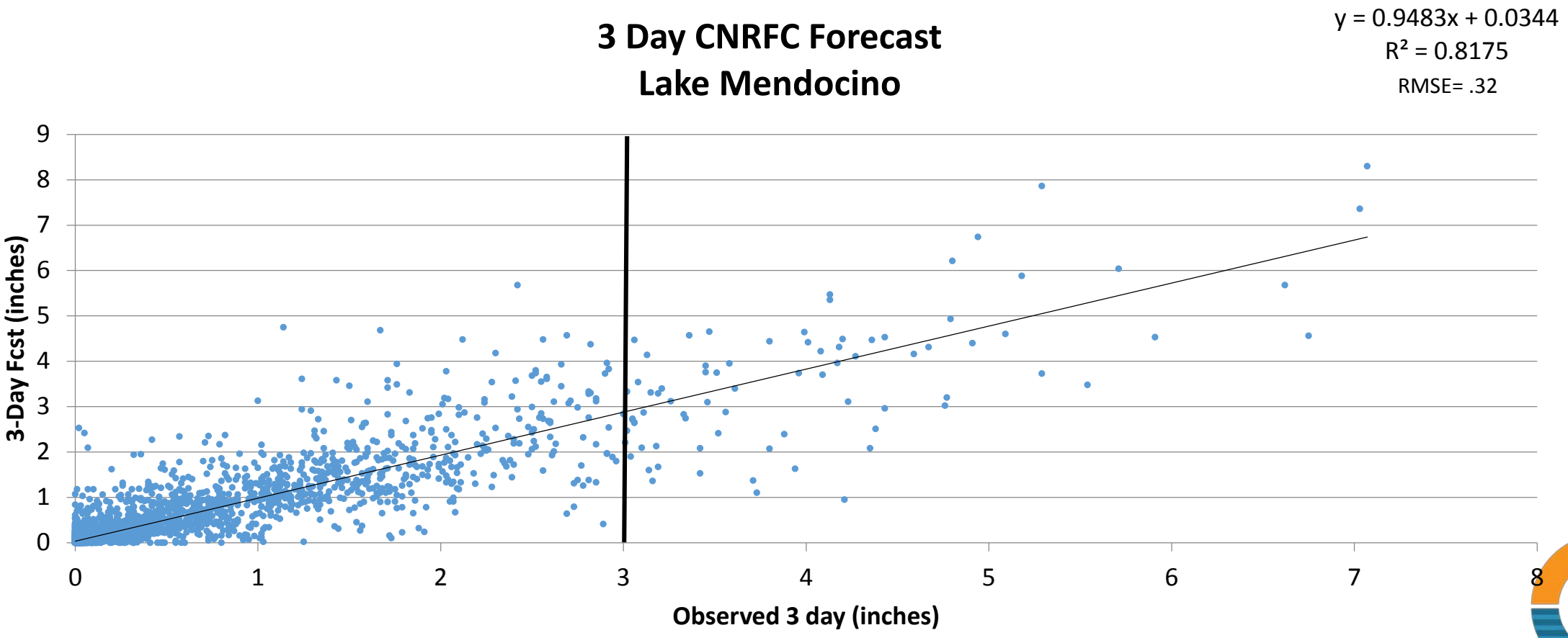


Inflow Forecast Volume	Release
120-hr volume < 300 TAF	Min: 8kcfs Max: inflow
120-hr volume > 300 TAF	25 kcfs
72-hr volume > 300 TAF	50 kcfs
48- hr volume > 300 TAF	80 kcfs
24-hr volume > 300 TAF and inflows >= 115 kcfs	115 kcfs

Courtesy MBK Engineers Technical Report to CA DWR

CW3E

3 Day CNRFC Total QPF vs Observations 2000-2016



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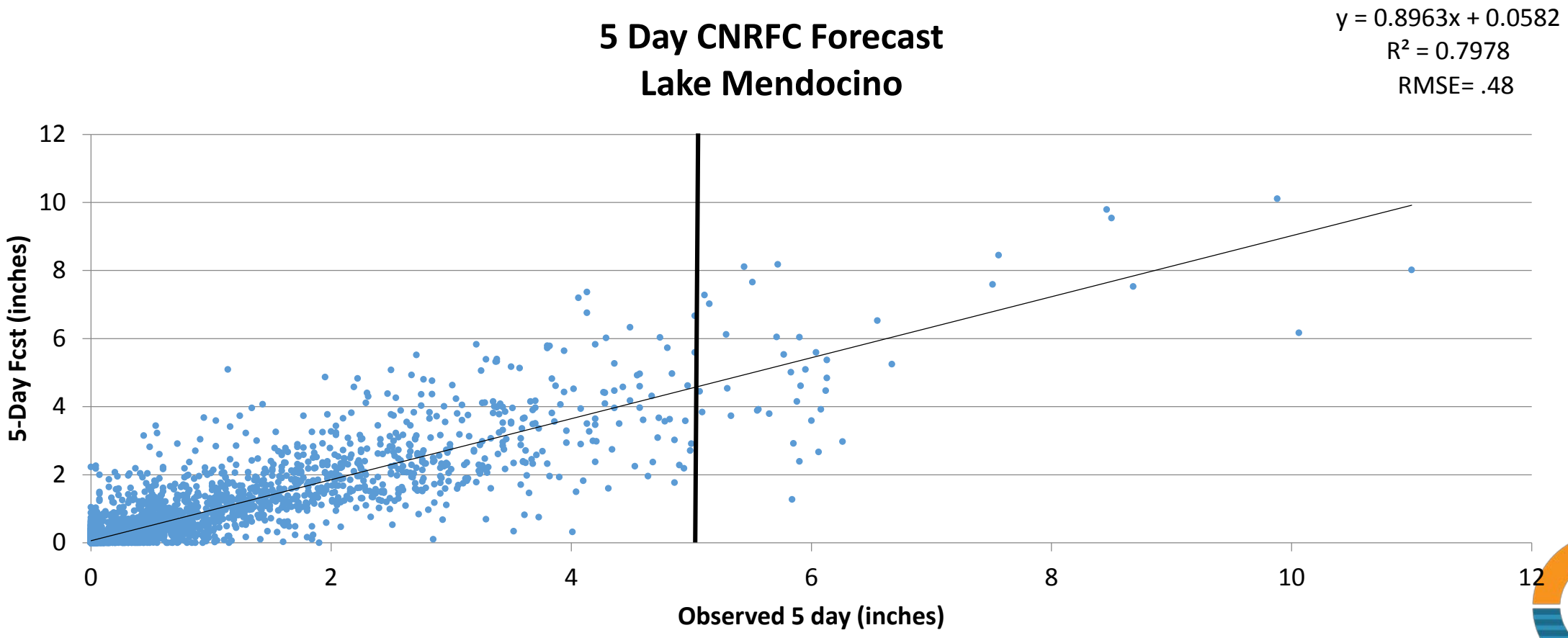
5-Day CNRFC Forecast vs Observed 2000-2016



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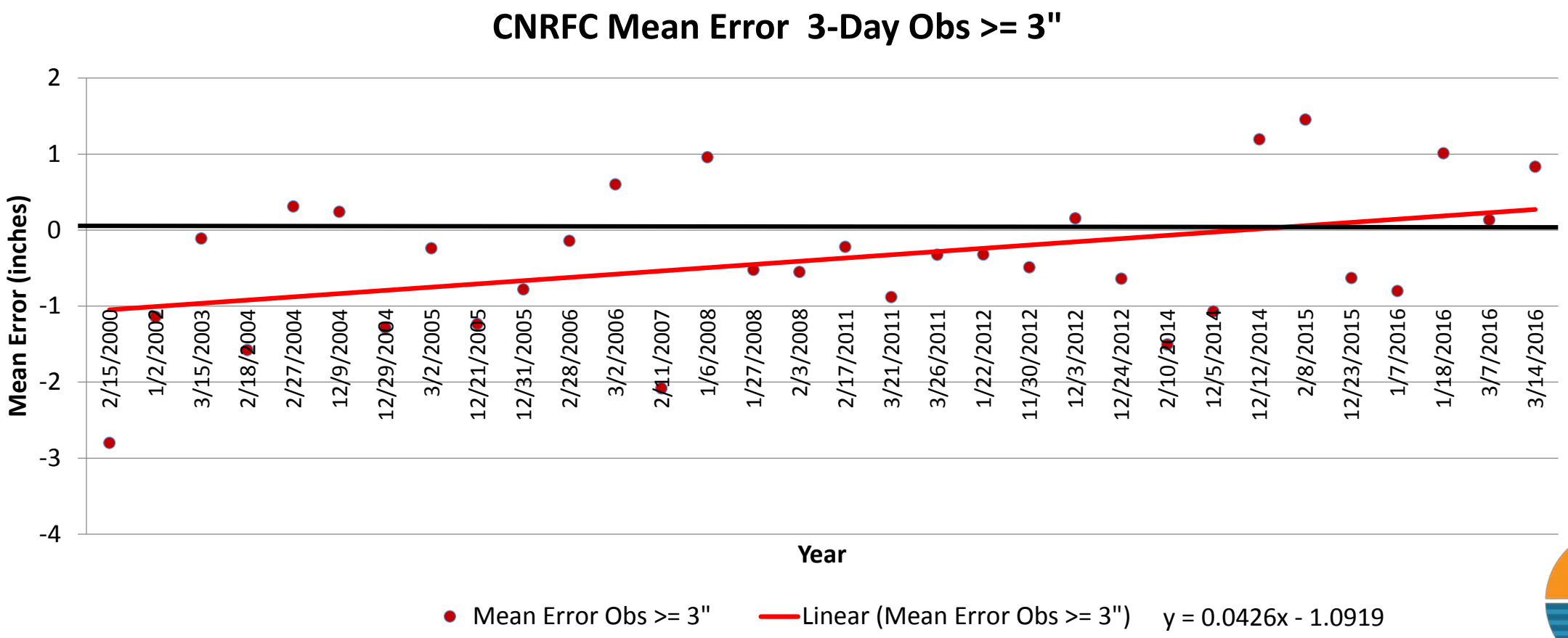
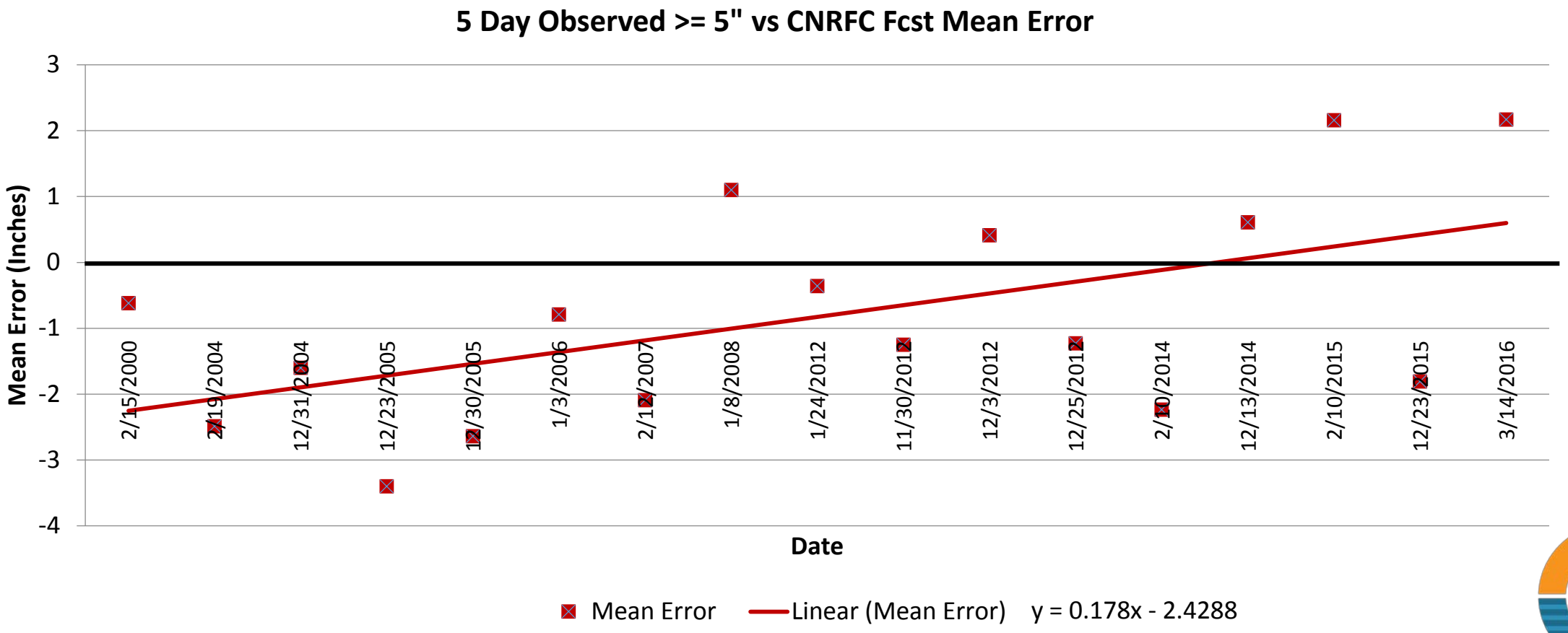
Trends in 3-Day Forecast Mean Error (Bias)



Trends in 5-Day Forecast Mean Error (Bias)



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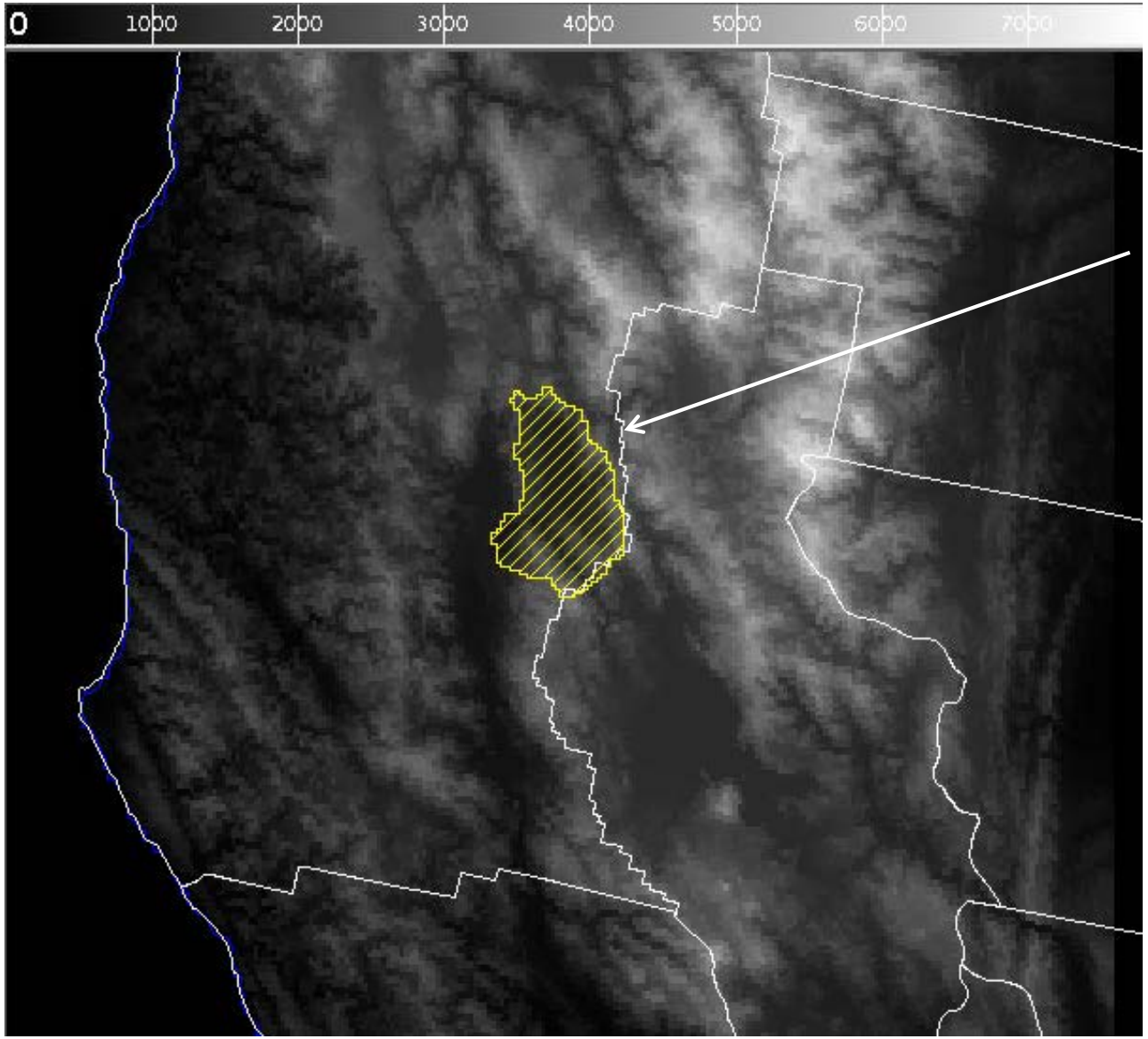
Road Forward

- Evaluate different QPF forcing inputs for COY Watershed – for MEFP?
  - HRRRX Day 1
  - CNRFC deterministic Day 1-5 forecasts
  - WestWrf
  - Newly implemented GFS20
  - Model blend (consensus forecast) – shown to be the best to date from 2 –year analysis
- Challenges
  - Any changes to HEFS requires long climatology to calibrate and validate forecast inflows
    - expensive
    - several years to implement
  - Once developed will be frozen
- More deterministic approach like Folsom??
  - As we develop high resolution convective resolving ensembles QPF should improve and should improve days 1-5 inflow forecasts
  - Stays current with technology
  - National Water Model –??

CW3E

QPF verification using NWS GFE Software



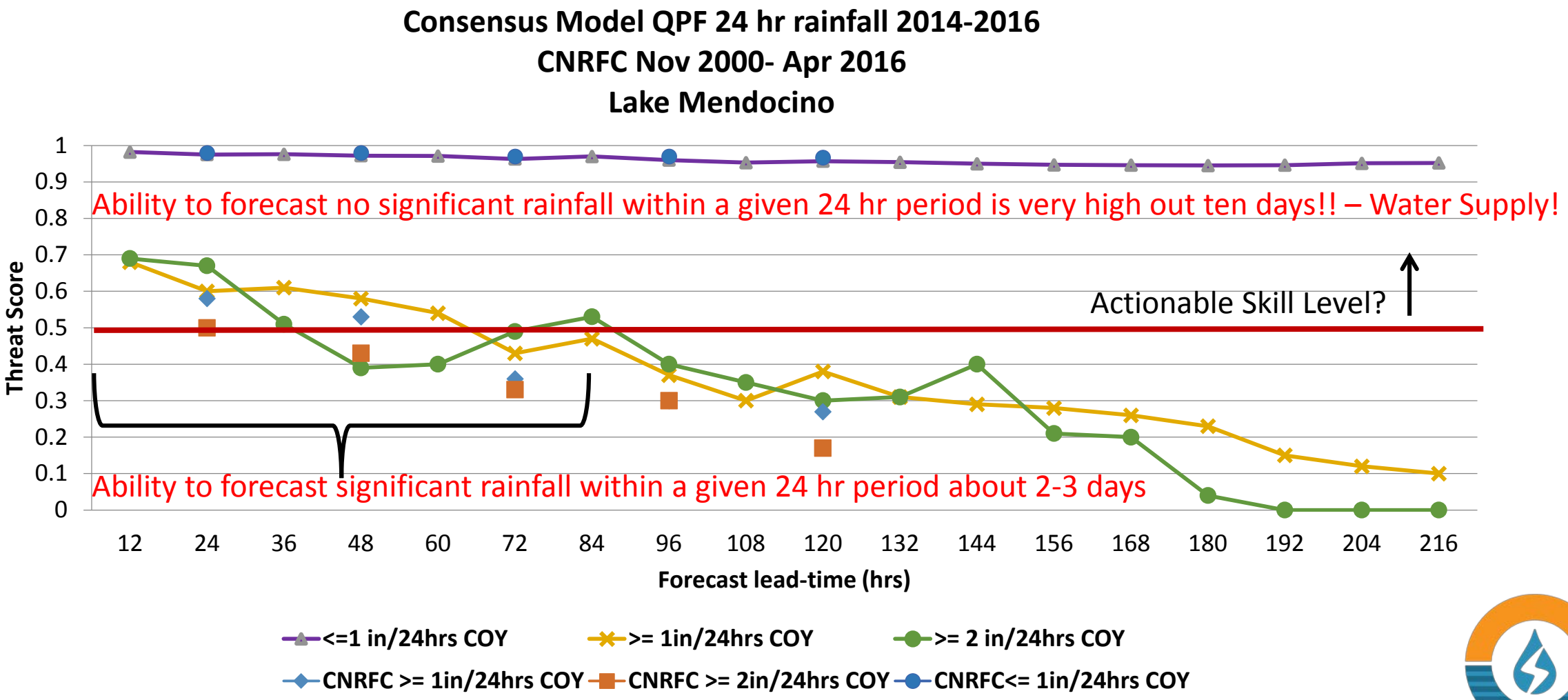
Lake Mendocino Watershed

Derive the Mean Areal Precipitation (MAP)for each model available for days 1-5

Compare to fcst and obs MAP provided by CNRFC

Compare to AR landfall strength

24-hr QPF Verification – Impact on Decision Support



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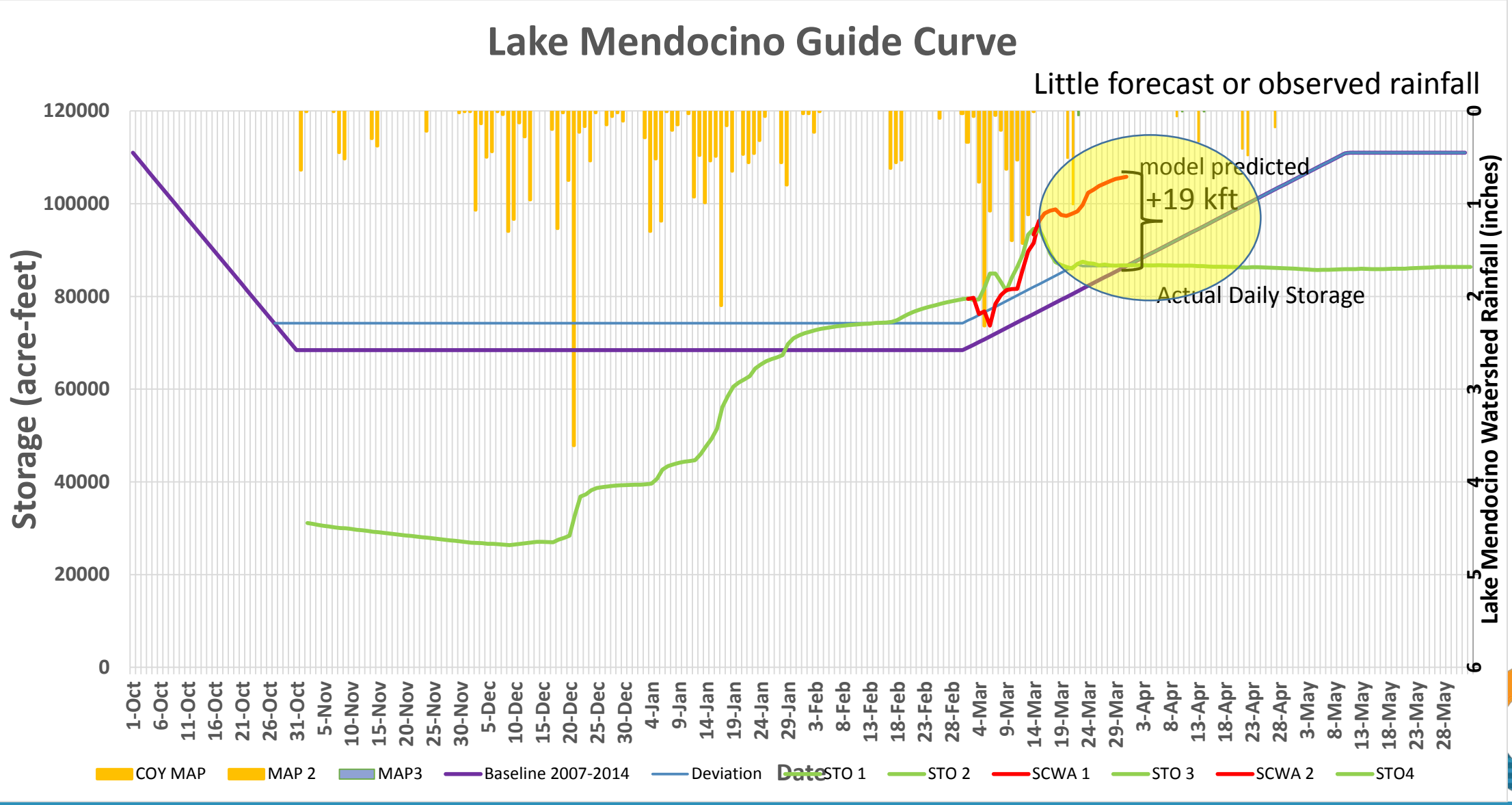
Quote Directly From FIRO Workplan (pg 32)

- “The confident prediction of “very little rain” over the next seven days during the rainy season may prove to be as or more valuable than the prediction of high flows during an AR event in the management scheme for Lake Mendocino. An analysis of archived forecasts as well as hindcasts will be necessary to evaluate this hypothesis.”
- Results from CNRFC QPF and inflow forecasts verification suggest this hypothesis may be correct.

Lake Mendocino Operations vs FIRO 2015-2016

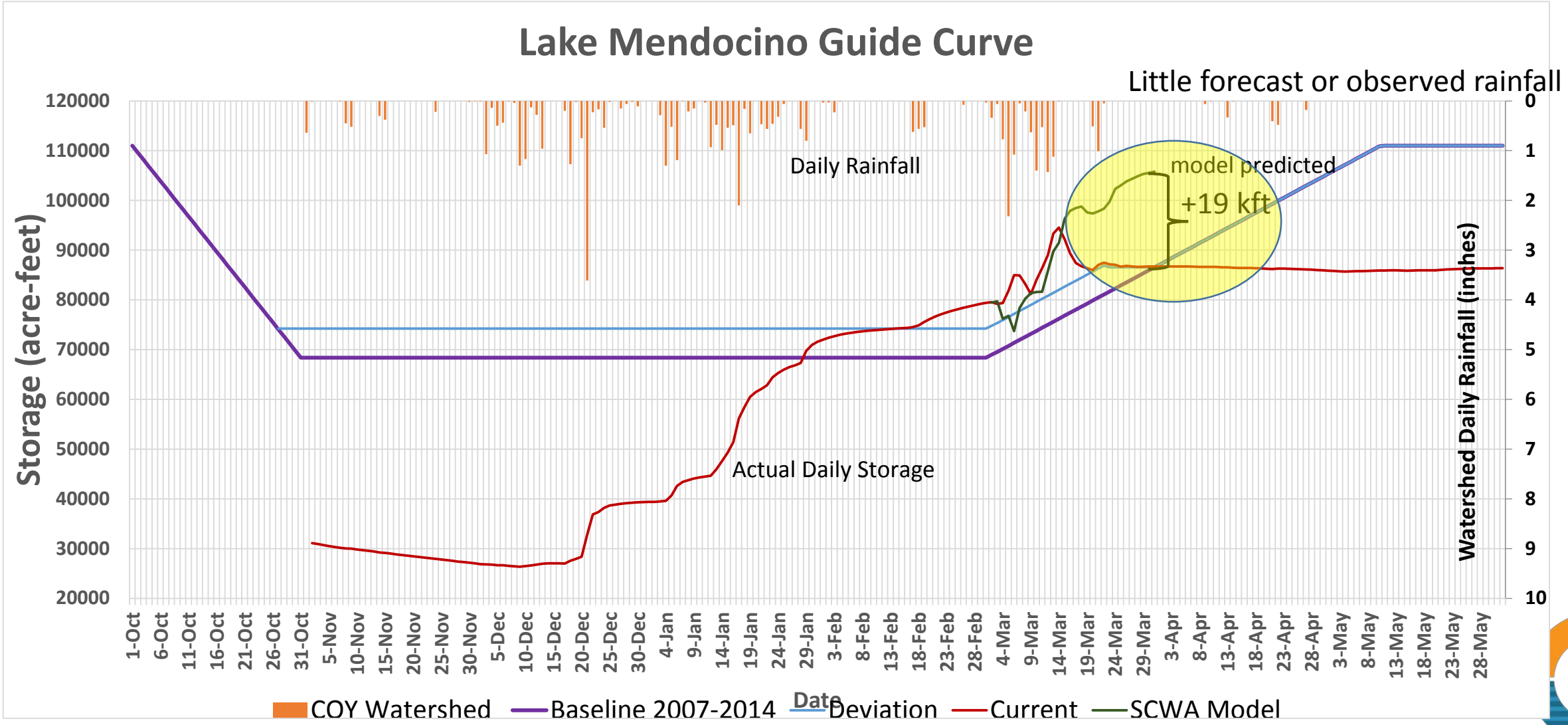


FIRO Workshop

Thank You

david.reynolds@noaa.gov

Lake Mendocino Operations vs FIRO 2015-2016



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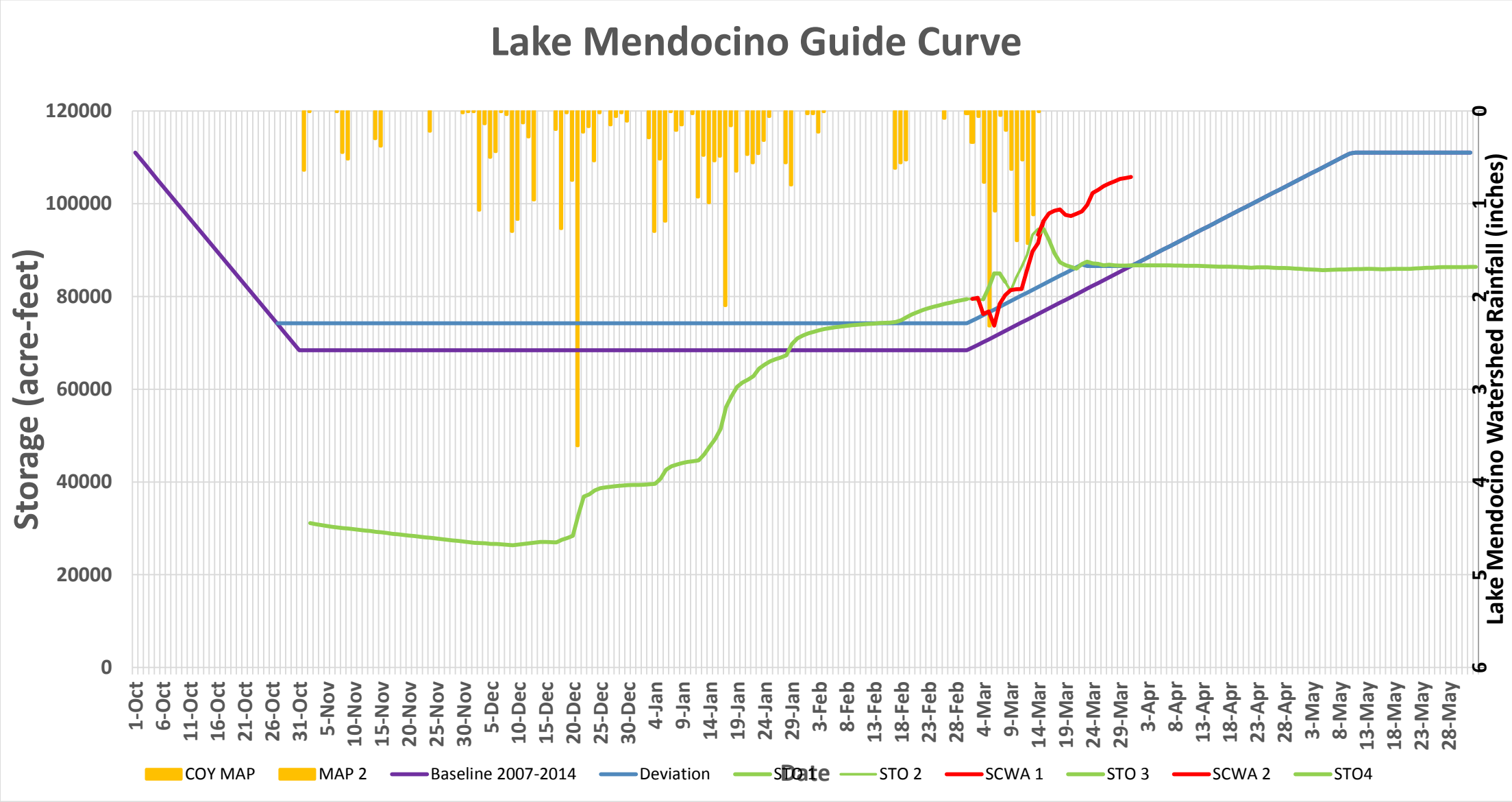

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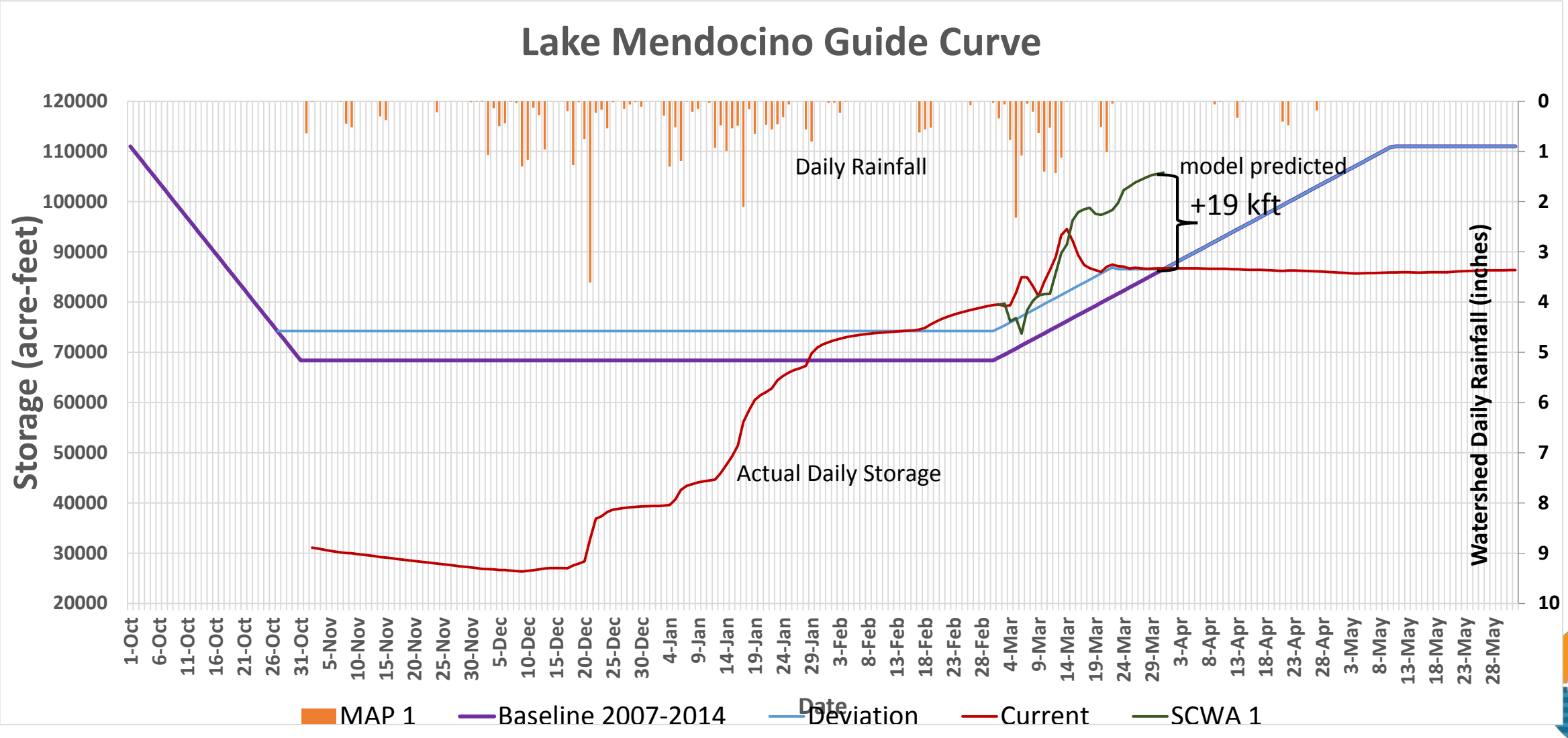
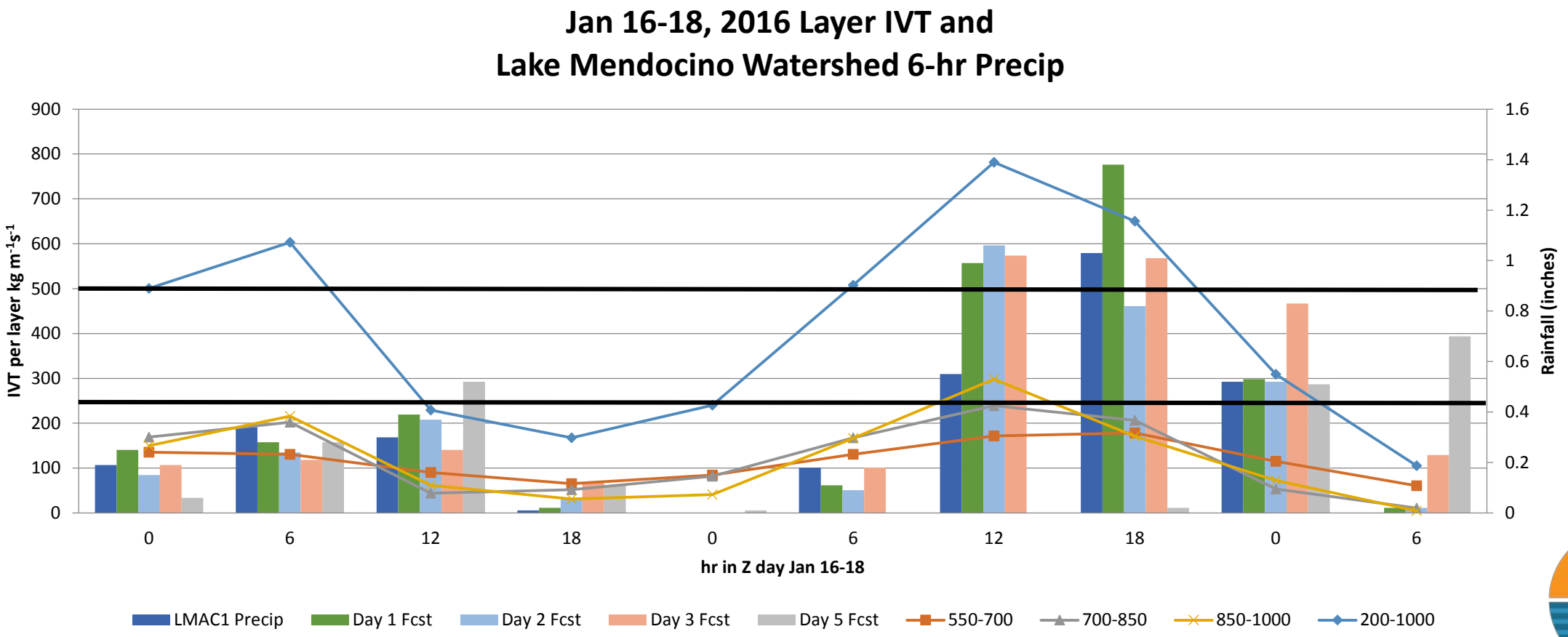
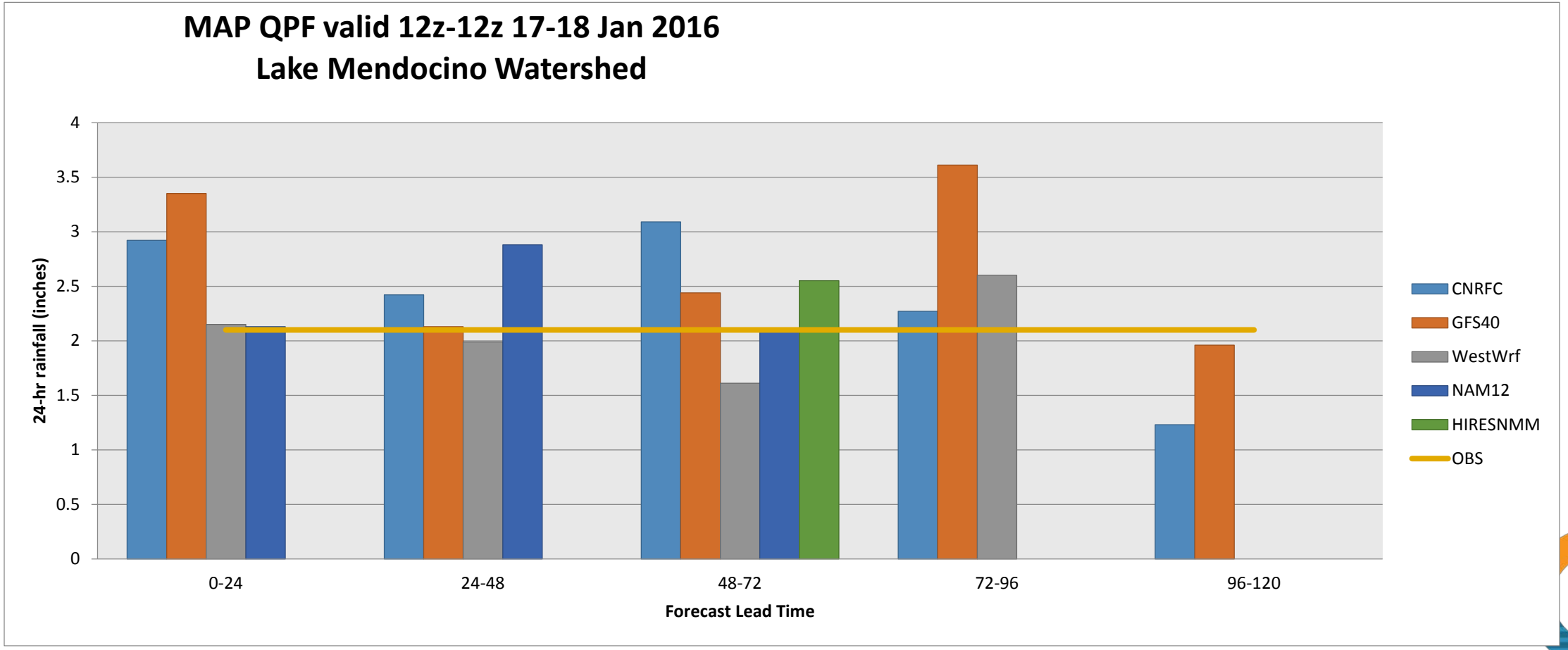


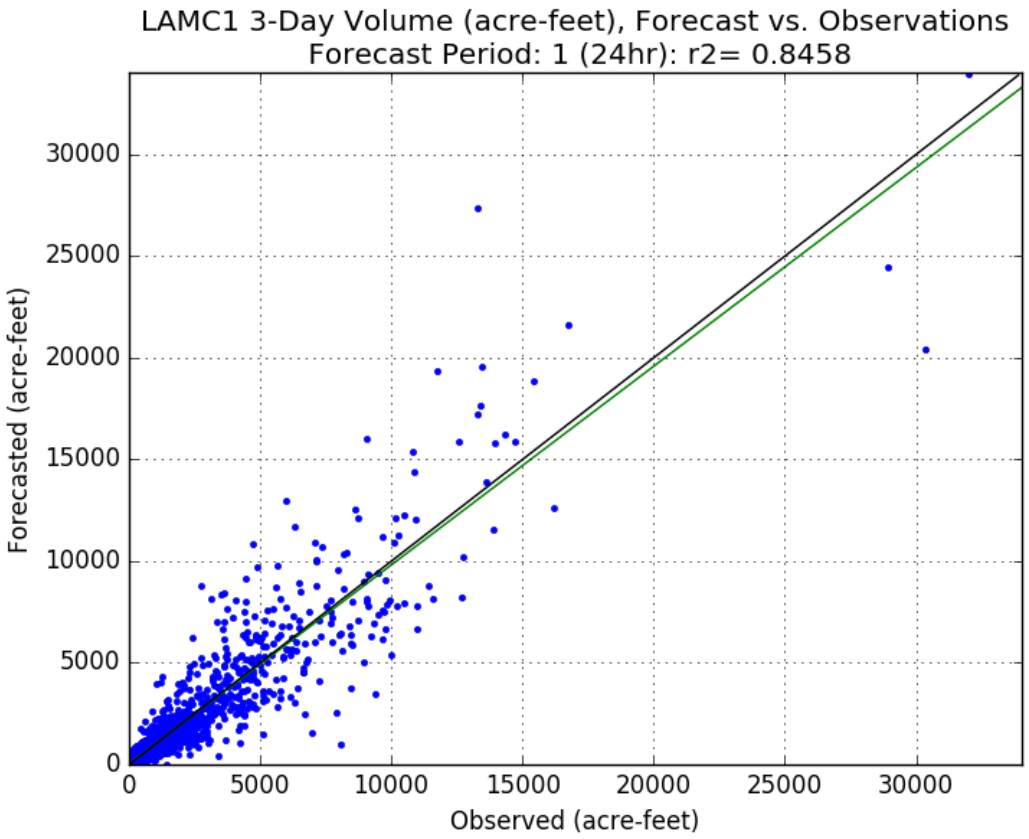
Jan 16-18, 2015 Layer IVT and 6-hr CNRFC Fcst and Obs MAPs

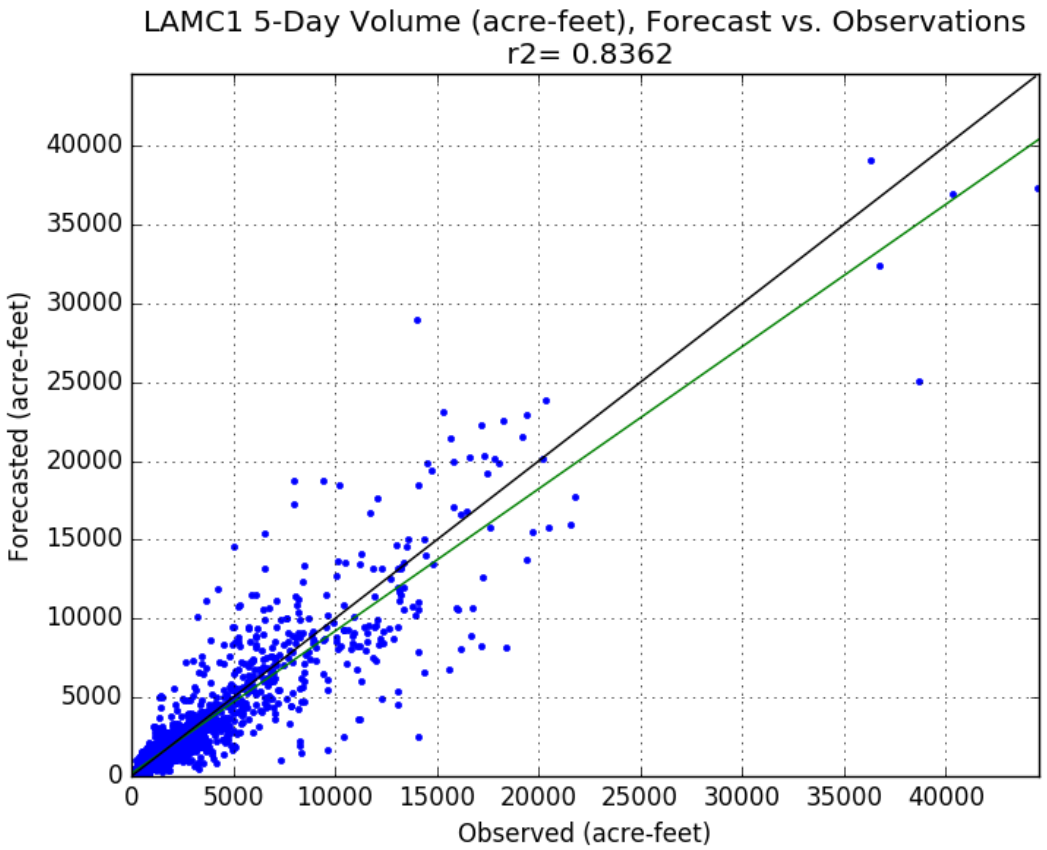


Jan 17-18, 2016 MAP QPF Verification



Regression Curve Inflow Forecasts Coyote Reservoir (2005-2015)





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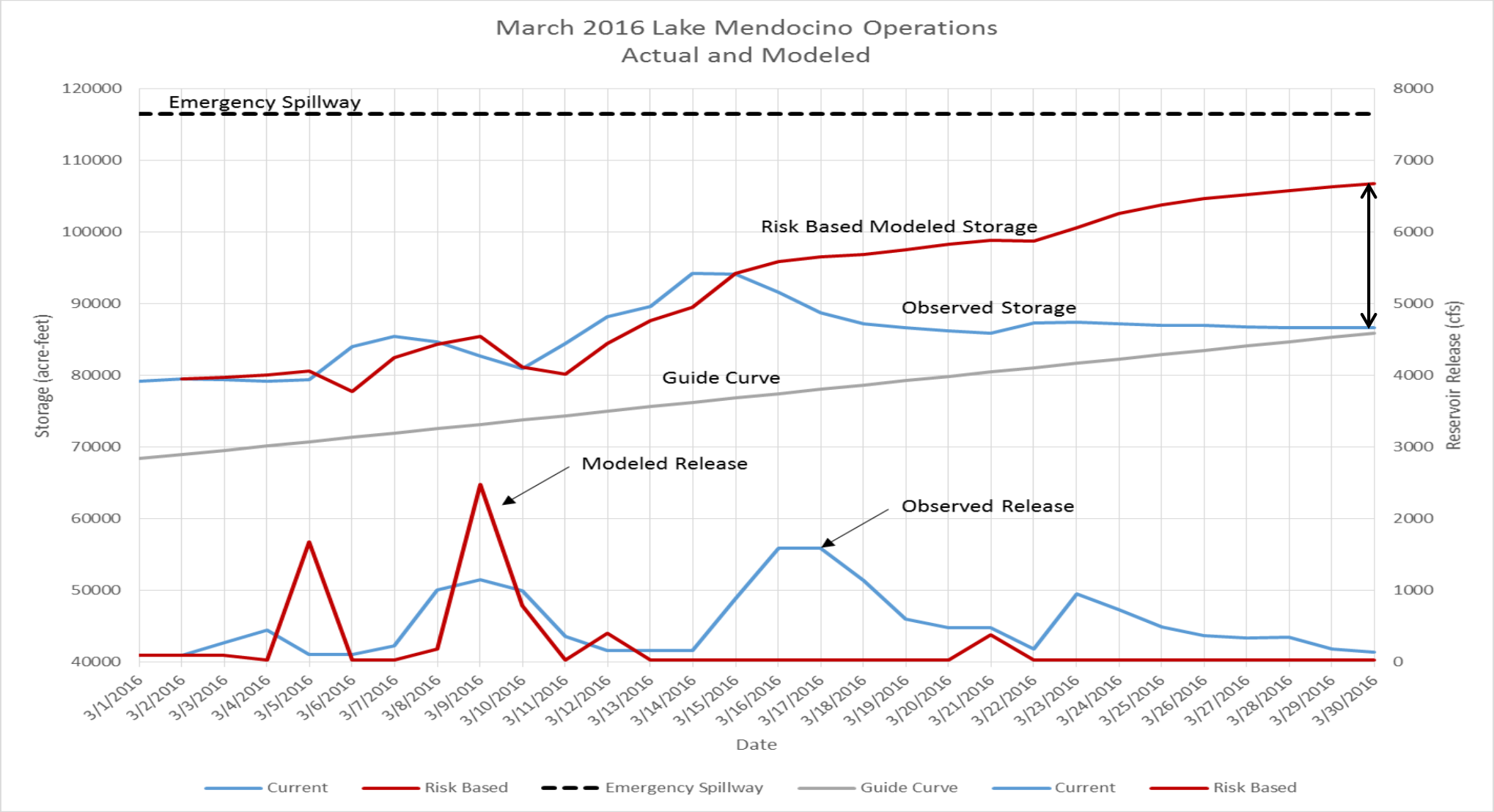
March 2016 Observed LM Operations & Modeled Risk Based Operations



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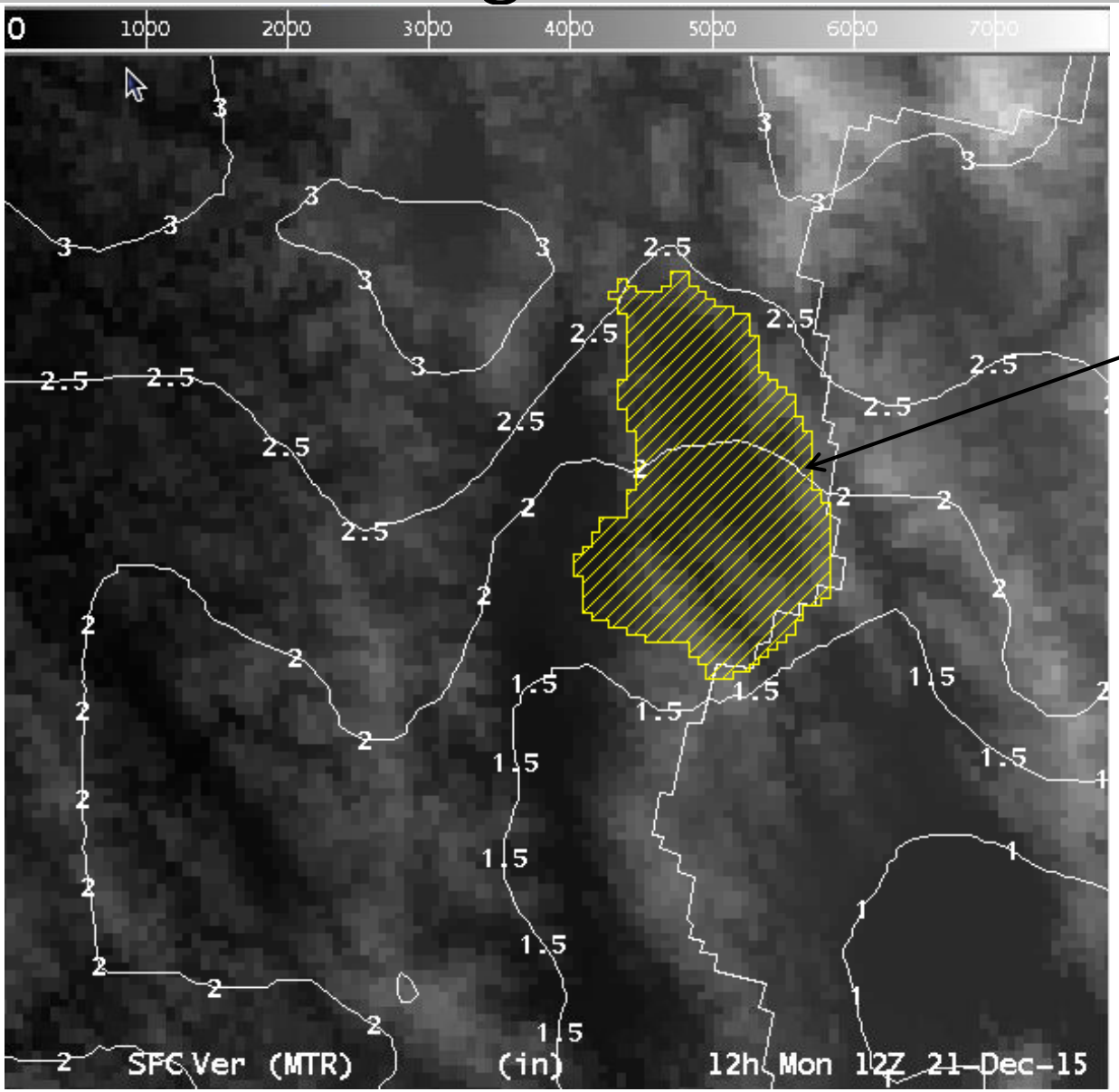
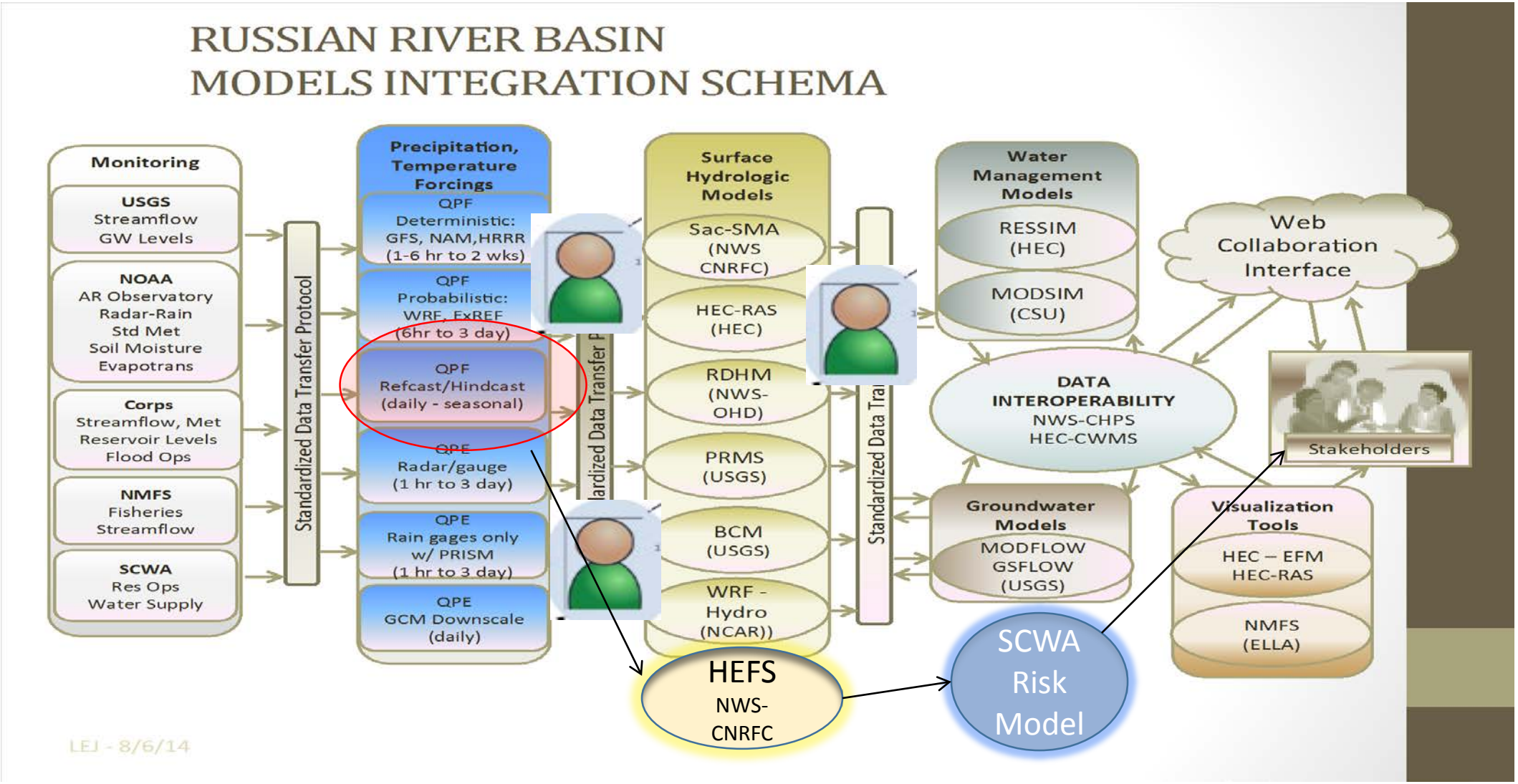
QPF verification using NWS GFE Software

12-00Z 21 Dec 2015
RFC QPE



Lake Mendocino Watershed

Modeling to Decision Support – Technology is Advancing Rapidly



From Dr. Lynn Johnson CIRA

CW3E

Road Forward- Forecast Guidance Available

Model	Description
Nam12	12 km North American Model to 84 hrs
GFS40	Global Forecast System 40 Km resolution Global Model to 10 days downscaled using model upslope wind/ moisture
SREF	Short Range Ensemble Forecast 40 km to 84 hrs run at 03-09-15-21Z.
ECMWF	High Resolution ECMWF 93 km to 10 days– downscaled using model upslope wind/ moisture
HIRESWarw	5 km high resolution western ARW core model run at 12Z and 00Z daily to 48 hrs
HIRESWnmm	5 km high resolution western NMM core model run at 12Z and 00Z daily to 48 hrs
WestWrf	3 km California nest run at 12 and 00Z daily to ten days
HRRR and HRRX with Time Averaged Ensembles (last 4 runs)	3 km out to 13 (HRRR) or 24 hrs (HRRRX)
HPCQPF	Weather Prediction Center gridded forecast guidance 5 km – to 84 hrs
MOSGuide	Gridded MOS guidance at 5 km
NDFD	NWS National Digital Forecast Database at 2.5 km
RFCQPF	4 km to 84 hrs from 12Z only
CONSALL	Gridded average of all numerical and statistical guidance excluding WestWrf and manual forecasts

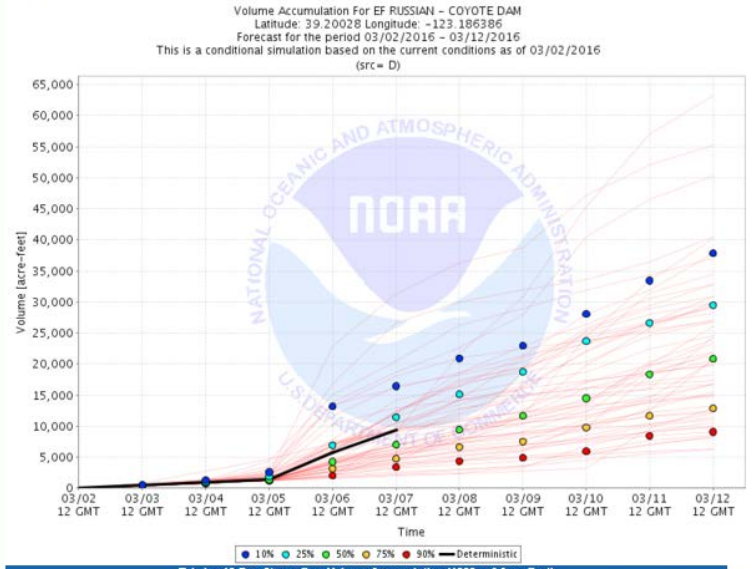
Ensemble inflows COY
May 2 2016

EAST FORK RUSSIAN RIVER - LAKE MENDOCINO (LAMC1)

Latitude: 39.20° N Longitude: 123.19° W Elevation: 670 Feet
Location: Mendocino County in California River Group: Russian Napa

Issuance Time: Mar 02 2016 at 8:40 AM PST

10-Day Accumulated Volume Plot



Tabular 10-Day Streamflow Volume Accumulation (1000s of Acre-Feet)

Probability	Mar 03	Mar 04	Mar 05	Mar 06	Mar 07	Mar 08	Mar 09	Mar 10	Mar 11	Mar 12
10% (Max)	0.5	1.3	2.6	13.2	16.4	20.9	22.9	28.1	33.4	37.8
25%	0.5	1.0	1.9	6.9	11.4	15.2	18.8	23.7	26.6	29.5
50% (Most Prob)	0.4	0.9	1.4	4.2	7.0	9.4	11.7	14.5	18.3	20.8
75%	0.4	0.8	1.3	3.1	4.8	6.6	7.5	9.8	11.7	12.8
90% (Min)	0.4	0.8	1.2	2.1	3.4	4.4	4.9	5.9	8.4	9.1