REGISTERED PROFESSIONAL ENGINEER
MICHAEL A. KONIECZKI
No. 74357
Exp. 6/30/2021
CIVIL
STATE OF CALIFORNIA

Memorandum

Date:	Thursday, July 02, 2020
Project:	Lake Mendocino Forecast-Informed Reservoir Operations (FIRO) Full Viability Assessment (FVA) Water Control Plan (WCP) Alternative Analysis
To:	Jay Jasperse, PE and Chris Delaney, PE
From:	Michael Konieczki, PE, D.WRE (CA Lic. # 74357); Ric McCallan, PE; Megan Lionberger, PE; and Melissa Larsen, PE
Subject:	WCP Alternative Analysis Results Metrics: Robustness Testing

Background

In 2014, Sonoma Water (SW) undertook a study to confirm the agency could manage Lake Mendocino storage more efficiently for authorized project purposes by integrating reservoir inflow forecasts explicitly in release schedule decision making. That study—which was referred to as the preliminary viability assessment (PVA)—confirmed SW could increase water supply benefit without adversely affecting the flood risk reduction capability if forecast-informed reservoir operation (FIRO) procedures were used. The U.S. Army Corps of Engineers (USACE), which is responsible for flood operation of Lake Mendocino, agreed with the finding and subsequently approved SW's request for a major deviation from the Lake Mendocino water control plan (WCP). This temporary deviation permitted SW greater flexibility in managing Lake Mendocino storage, pending additional investigation that would support incorporation of FIRO procedures in a formal revision of the WCP.

The PVA evaluated candidate FIRO strategies in a reconnaissance-level technical study, confirming viability of FIRO in concept. However, the PVA did not recommend a single specific strategy for integrating FIRO into a future WCP. That task is to be completed in a subsequent planning study—the Full Viability Assessment (FVA).

The objective of the FVA is to identify, through appropriate detailed technical analyses and other considerations, the best FIRO strategy for Lake Mendocino, along with the manner in which the strategy can be implemented in real-time operation by Sonoma Water (SW) and USACE, and enable the Water Control Plan (WCP) changes necessary to permit that change permanently. The FVA will also evaluate potential adaptive strategies that would allow operators to utilize new technology and improved forecast skill as it becomes available in the future.

The FVA is managed by the Lake Mendocino FIRO steering committee (SC), who identified technical studies consistent with USACE guidance needed for FIRO strategy analysis. The SC prepared a hydrologic engineering management plan (HEMP) that is "a technical outline of the hydrologic engineering studies necessary to formulate a solution to a water resources problem" (FIRO SC 2019). The objective of the HEMP is to identify and evaluate Lake Mendocino FIRO alternatives in a systematic, defendable, repeatable manner, providing information to the SC so it may identify the best FIRO strategy.

The SC defined in the HEMP the set of 16 Metrics listed in Table 1 to evaluate the WCP alternatives consistently. In addition, the SC defined in the HEMP the 5 WCP alternatives listed in Table 2 to be evaluated for the FVA.

Table 1. Summary of metrics identified in the HEMP

Metric	Metric Description
M1	Annual maximum flow frequency function at Hopland, Cloverdale, Healdsburg, and Guerneville
M2	Annual maximum pool elevation frequency function of Lake Mendocino
M3	Annual maximum pool elevation frequency function of Lake Sonoma
M4	Annual maximum Lake Mendocino total release frequency function
M5	Annual maximum Lake Sonoma total release function
M6	Annual maximum uncontrolled spill frequency function for Lake Mendocino
M7	Annual maximum uncontrolled spill frequency function for Lake Mendocino
M8	Expected annual inundation damage at critical Russian River locations
M9	Expected annual potential (statistical) loss of life due to floodplain inundation, critical Russian River locations
M10	Reliability of water supply delivery, as measured by annual exceedance frequency of Lake Mendocino May 10 reservoir storage levels
M11	The ability to meet instream flows to support threatened and endangered fish during the summer rearing season, as measured by the annual exceedance of the number of days June through September flows exceed 125 cfs
M12	The ability to meet instream flows to support fall spawning migration, as measured by the annual exceedance of the number of days October 15 to January 1 flows exceed 105 cfs
M13	Impacts to the Bushay Campground during the rec season (Memorial Day through Labor Day), as measured by the annual exceedance of the number of days that Lake Mendocino water-surface elevation exceeds 750 ft
M14	Impacts to power production of the CVD powerhouse
M15	Lake Mendocino bank protection, as measured by annual frequency of exceeding elevation 758.8 ft
M16	Impacts to hours of operation

Table 2. Candidate FIRO alternatives to be evaluated

ID	WCP Alternative	Description
1	Existing (Baseline) Conditions	This is the baseline condition (existing WCP operations) against which performance of all alternatives will be measured. It includes the seasonal rule curve and release selection rules from the 1986 USACE WCM and 2003 update to the flood control diagram (FCD).
2	Ensemble Forecast Operations (EFO)	Operates without a traditional rule curve and uses the 15-day ensemble streamflow forecasts to identify required flood releases.
3	Hybrid (Major Deviation #1)	A combination of the Baseline WCP and the EFO. This WCP was used for Major Deviation Operations in WY19 and WY20.
4	Modified Hybrid	Identical to Hybrid but with a “corner cutting” strategy that allows for greater storage to begin February 15th to aid with spring refill.
5	5-Day Deterministic Forecast	Defines alternative guide curves with 11,000 AF encroachment space and 10,000 draft space above and below the Baseline guide curve. Uses 5-day deterministic inflow (and Hopland) forecasts to choose the guide curve and make release decisions.

Task

The technical analysis team identified the need to complete additional robustness testing of the WCP alternatives using a long-duration event. The team identified an 18-day 2006 event pattern that was scaled so that the inflows to Lake Mendocino matched the p=0.005 (200-yr) and p=0.002 (500-yr) 18-day inflow volume quantiles. Scaling of the event and associated hindcasts were completed by the California Nevada River Forecast Center (CNRFC) and the 18-day inflow volume frequency quantiles were developed by USACE Hydrologic Engineering Center (HEC).

Operation of each Lake Mendocino WCP alternative was simulated using an HEC-ResSim model of the Russian River. We were tasked with processing and evaluating the HEC-ResSim model results as compared to the p=0.005 (200-yr) and p=0.002 (500-yr) quantiles of Metric 1 through Metric 7.

Action

To evaluate each WCP alternative, we:

1. Coordinated with SW and USACE Hydrologic Engineering Center (HEC) staff to develop procedures for computing each metric. These procedures are detailed in 2 technical memoranda titled *Proposed Procedure for Consequence Analysis* and *Procedures for computation of non-consequence metrics* provided on 4/24/2020.
2. Coordinated with SW and USACE Hydrologic Engineering Center (HEC) staff to obtain HEC-ResSim model results.
3. Evaluated the p=0.005 (200-yr) and p=0.002 (500-yr) robustness testing results of the 7 hydrologic metrics for each WCP alternative using the agreed procedures.

4. Compared, by metric, the robustness results of each WCP to p=0.005 (200-yr) and p=0.002 (500-yr) quantiles computed previously and documented out findings.

Study Area

Lake Mendocino, formed by the impoundment of the East Fork of the Russian River by the Coyote Valley Dam (CVD), is 3 miles east of the City of Ukiah, CA. Figure 1 shows its location. The 1,485-square mile Russian River watershed is a narrow valley between 2 adjacent northern coastal mountain ranges. The watershed is about 100 miles long and varies from 12 to 32 miles in width. Inflows to Lake Mendocino include runoff from an approximately 105-square mile drainage area and diversions from the Eel River to the East Fork of the Russian River above CVD through the Potter Valley Project. Some streamflows on the East Fork of the Russian River are diverted for irrigation purposes. Water from Lake Mendocino flows generally south down the East Fork Russian River until its confluence with the Russian River mainstem. Flow continues south near the towns of Hopland, Cloverdale, and Healdsburg. Just south of Healdsburg, Dry Creek flows into the Russian River from the west. The Russian River continues west past Guerneville to the Pacific Ocean.

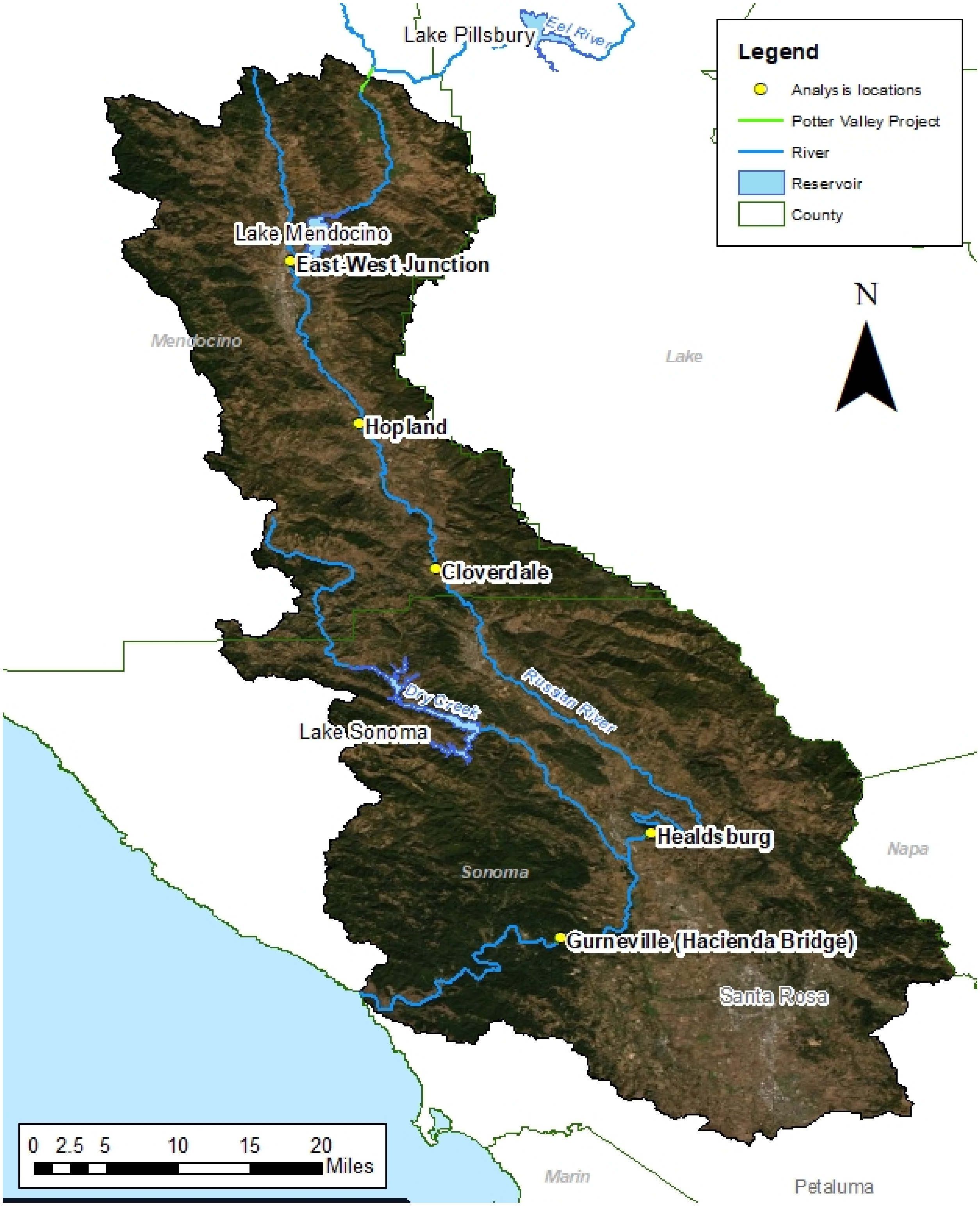

Figure 1. Map of Russian River watershed, including Lake Mendocino

Findings

According to the HEMP, the efficacy of WCP alternatives must be evaluated using a set of measurable statistics that assess each alternative objectively. The SC defined in the HEMP a set of 16 Metrics as listed in Table 1 above. The following sections of this memo summarize the modeling results in terms of the first 7 of these metrics and compare the performance of WCP alternatives to that of the existing (baseline) conditions, and to the p=0.005 (200-yr) and p=0.002 (500-yr) quantiles computed previously.

Annual Maximum Flow-Frequency Functions (Metric 1)

M1 is calculated by post-processing HEC-ResSim output to determine the annual maximum flow for each water year in the period of record (POR) of 1/1/1985 through 9/30/2017 (water year [WY] 1985 to WY 2017), and the scaled 200-year and 500-year design floods (1986, 1995, 1997, and 2006). Table 3 through Table 8 show the previously computed p=0.005 (200-yr) and p=0.002 (500-yr) annual exceedance probability (AEP) quantiles and robustness testing results at Hopland, Cloverdale, Healdsburg, and Guerneville.

Table 3. Annual maximum regulated flow frequency at Hopland

Annual Exceedance Probability	1/AEP	Results Description	Maximum Regulated Flow (cfs)				
			Baseline	EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	43,129	42,886	43,091	43,091	43,014
		Robustness test	36,989	37,865	35,744	35,743	37,099
0.002	500	Quantile	53,302	51,967	50,498	50,498	50,473
		Robustness test	45,708	43,029	39,525	39,515	46,073

Table 4. Difference in annual maximum regulated flow frequency at Hopland

Annual Exceedance Probability	1/AEP	Results Description	Difference in Annual Maximum Regulated Flow Quantile (cfs) and [%]			
			EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	-243 [-1%]	-38 [0%]	-38 [0%]	-115 [0%]
		Robustness test	876 [2%]	-1,245 [-3%]	-1,246 [-3%]	110 [0%]
0.002	500	Quantile	-1,335 [-3%]	-2,804 [-5%]	-2,804 [-5%]	-2,829 [-5%]
		Robustness test	-2,679 [-6%]	-6,183 [-14%]	-6,193 [-14%]	365 [1%]

Table 5. Annual maximum regulated flow frequency at Healdsburg

Annual Exceedance Probability	1/AEP	Results Description	Maximum Regulated Flow (cfs)				
			Baseline	EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	109,736	109,581	109,885	109,902	109,745
		Robustness test	93,060	92,332	92,158	92,157	93,095
0.002	500	Quantile	127,529	127,222	127,099	127,099	127,159
		Robustness test	103,773	101,799	101,156	101,154	103,976

Table 6. Difference in annual maximum regulated flow frequency at Healdsburg

Annual Exceedance Probability	1/AEP	Results Description	Difference in Annual Maximum Regulated Flow Quantile (cfs) and [%]			
			EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	-155 [0%]	149 [0%]	166 [0%]	9 [0%]
		Robustness test	-728 [-1%]	-902 [-1%]	-903 [-1%]	35 [0%]
0.002	500	Quantile	-307 [0%]	-430 [0%]	-430 [0%]	-370 [0%]
		Robustness test	-1,974 [-2%]	-2,617 [-3%]	-2,619 [-3%]	203 [0%]

Table 7. Annual maximum regulated flow frequency at Guerneville (Hacienda Bridge)

Annual Exceedance Probability	1/AEP	Results Description	Maximum Regulated Flow (cfs)				
			Baseline	EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	152,464	152,218	152,503	152,524	152,354
		Robustness test	119,486	118,946	118,518	118,517	119,525
0.002	500	Quantile	179,745	179,248	179,063	179,061	179,162
		Robustness test	136,370	134,255	133,335	133,331	136,522

Table 8. Difference in annual maximum regulated flow frequency at Guerneville (Hacienda Bridge)

Annual Exceedance Probability	1/AEP	Results Description	Difference in Annual Maximum Regulated Flow Quantile (cfs) and [%]			
			EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	-246 [0%]	39 [0%]	60 [0%]	-110 [0%]
		Robustness test	-540 [0%]	-968 [-1%]	-969 [-1%]	39 [0%]
0.002	500	Quantile	-497 [0%]	-682 [0%]	-684 [0%]	-583 [0%]
		Robustness test	-2,115 [-2%]	-3,035 [-2%]	-3,039 [-2%]	152 [0%]

Lake Mendocino Annual Maximum Frequency Functions (Metrics 2, 4, and 6)

M2, M4, and M6 describe the maximum pool elevation, maximum total release, and uncontrolled spill frequency functions at Lake Mendocino. Table 9 through Table 16 summarize p=0.005 (200-yr) and p=0.002 (500-yr) annual exceedance probability (AEP) quantiles and robustness testing results of these functions.

Table 9. Annual maximum pool elevation in Lake Mendocino

Annual Exceedance Probability	1/AEP	Results Description	Maximum Pool Elevation (ft)				
			Baseline	EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	768.13	766.77	763.15	763.10	766.13
		Robustness test	771.02	771.59	767.72	767.72	771.10
0.002	500	Quantile	770.68	769.51	766.47	766.43	769.71
		Robustness test	772.49	772.17	770.46	770.44	772.53

Table 10. Difference in annual maximum pool elevation in Lake Mendocino

Annual Exceedance Probability	1/AEP	Results Description	Difference in Annual Pool Elevation Frequency Quantile (ft)			
			EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	-1 [-1%]	-5 [-4%]	-5 [-4%]	-2 [-2%]
		Robustness test	1 [1%]	-3 [-2%]	-3 [-2%]	0 [0%]
0.002	500	Quantile	-1 [-1%]	-4 [-3%]	-4 [-3%]	-1 [-1%]
		Robustness test	0 [0%]	-2 [-2%]	-2 [-2%]	0 [0%]

Table 11. Annual maximum storage in Lake Mendocino

Annual Exceedance Probability	1/AEP	Results Description	Maximum Storage (ac-ft)				
			Baseline	EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	122,661	120,128	113,439	113,343	118,937
		Robustness test	128,125	129,209	121,896	121,893	128,280
0.002	500	Quantile	127,482	125,269	119,556	119,491	125,643
		Robustness test	130,946	130,321	127,065	127,035	131,024

Table 12. Difference in annual maximum storage in Lake Mendocino

Annual Exceedance Probability	1/AEP	Results Description	Difference in Annual Storage Frequency Quantile (ac-ft) and [%]			
			EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	-2,533 [-2%]	-9,222 [-8%]	-9,318 [-8%]	-3,724 [-3%]
		Robustness test	1,084 [1%]	-6,229 [-5%]	-6,232 [-5%]	155 [0%]
0.002	500	Quantile	-2,213 [-2%]	-7,927 [-6%]	-7,992 [-6%]	-1,840 [-1%]
		Robustness test	-625 [0%]	-3,880 [-3%]	-3,910 [-3%]	78 [0%]

Table 13. Annual maximum total release in Lake Mendocino

Annual Exceedance Probability	1/AEP	Results Description	Maximum Total Release (cfs)				
			Baseline	EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	7,626	6,056	5,873	5,873	6,304
		Robustness test	7,131	10,197	6,275	6,275	7,316
0.002	500	Quantile	12,460	9,261	8,888	8,888	9,030
		Robustness test	14,673	13,210	6,275	6,275	15,518

Table 14. Difference in annual maximum total release in Lake Mendocino

Annual Exceedance Probability	1/AEP	Results Description	Difference in Annual Total Release Frequency Quantile (cfs) and [%]			
			EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	-1,570 [-21%]	-1,753 [-23%]	-1,753 [-23%]	-1,322 [-17%]
		Robustness test	3,066 [43%]	-856 [-12%]	-856 [-12%]	185 [3%]
0.002	500	Quantile	-3,199 [-26%]	-3,572 [-29%]	-3,572 [-29%]	-3,430 [-28%]
		Robustness test	-1,463 [-10%]	-8,398 [-57%]	-8,398 [-57%]	845 [6%]

Table 15. Annual maximum uncontrolled spill in Lake Mendocino

Annual Exceedance Probability	1/AEP	Results Description	Uncontrolled Spill (cfs)				
			Baseline	EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	4,402	1,781	971	946	1,822
		Robustness test	6,231	7,597	1,993	1,992	6,416
0.002	500	Quantile	7,342	5,260	3,278	3,231	5,168
		Robustness test	9,573	8,910	5,332	5,308	9,618

Table 16. Difference in annual uncontrolled spill frequency in Lake Mendocino

Annual Exceedance Probability	1/AEP	Results Description	Difference in Annual Uncontrolled Spill Frequency Quantile (cfs) and [%]			
			EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	-2,621 [-60%]	-3,431 [-78%]	-3,456 [-79%]	-2,580 [-59%]
		Robustness test	1,366 [22%]	-4,238 [-68%]	-4,239 [-68%]	185 [3%]
0.002	500	Quantile	-2,082 [-28%]	-4,064 [-55%]	-4,111 [-56%]	-2,174 [-30%]
		Robustness test	-663 [-7%]	-4,241 [-44%]	-4,265 [-45%]	45 [0%]

Lake Sonoma Annual Maximum Flow Frequency Functions (Metrics 3, 5, and 7)

M3, M5, and M7 describe the maximum pool elevation, maximum total release, and uncontrolled spill frequency functions at Lake Sonoma. Table 17 through Table 24 summarize p=0.005 (200-yr) and p=0.002 (500-yr) annual exceedance probability (AEP) quantiles and robustness testing results of these functions.

Table 17. Annual maximum pool elevation in Lake Sonoma

Annual Exceedance Probability	1/AEP	Results Description	Maximum Pool Elevation (ft)				
			Baseline	EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	491.84	492.80	493.69	493.69	491.81
		Robustness test	482.42	482.46	485.65	485.65	481.79
0.002	500	Quantile	493.10	493.71	494.32	494.47	493.10
		Robustness test	485.53	486.67	491.43	491.43	485.53

Table 18. Difference in annual maximum pool elevation in Lake Sonoma

Annual Exceedance Probability	1/AEP	Results Description	Difference in Annual Pool Elevation Frequency Quantile (ft) and [%]			
			EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	1 [0%]	2 [1%]	2 [1%]	0 [0%]
		Robustness test	0 [0%]	3 [1%]	3 [1%]	-1 [0%]
0.002	500	Quantile	1 [0%]	1 [0%]	1 [0%]	0 [0%]
		Robustness test	1 [0%]	6 [2%]	6 [2%]	0 [0%]

Table 19. Annual maximum storage in Lake Sonoma

Annual Exceedance Probability	1/AEP	Results Description	Maximum Storage (ac-ft)				
			Baseline	EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	369,538	372,909	376,027	376,027	369,416
		Robustness test	337,650	337,772	348,356	348,356	335,593
0.002	500	Quantile	373,963	376,098	378,275	378,799	373,945
		Robustness test	347,975	351,791	368,119	368,119	347,958

Table 20. Difference in annual maximum storage in Lake Sonoma

Annual Exceedance Probability	1/AEP	Results Description	Difference in Annual Storage Frequency Quantile (ac-ft) and [%]			
			EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	3,371 [1%]	6,489 [2%]	6,489 [2%]	-122 [0%]
		Robustness test	122 [0%]	10,706 [3%]	1,0706 [3%]	-2,057 [-1%]
0.002	500	Quantile	2,135 [1%]	4,312 [1%]	4,836 [1%]	-18 [0%]
		Robustness test	3,816 [1%]	20,144 [6%]	20,144 [6%]	-17 [0%]

Table 21. Annual maximum total release in Lake Sonoma

Annual Exceedance Probability	1/AEP	Results Description	Maximum Total Release (cfs)				
			Baseline	EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	6,015	6,015	6,015	6,015	6,015
		Robustness test	6,000	6,000	6,000	6,000	6,000
0.002	500	Quantile	6,015	6,015	6,015	6,015	6,015
		Robustness test	6,000	6,000	6,000	6,000	6,000

Table 22. Difference in annual maximum total release in Lake Sonoma

Annual Exceedance Probability	1/AEP	Results Description	Difference in Annual Total Release Frequency Quantile (cfs) and [%]			
			EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	0 [0%]	0 [0%]	0 [0%]	0 [0%]
		Robustness test	0 [0%]	0 [0%]	0 [0%]	0 [0%]
0.002	500	Quantile	0 [0%]	0 [0%]	0 [0%]	0 [0%]
		Robustness test	0 [0%]	0 [0%]	0 [0%]	0 [0%]

Table 23. Annual maximum uncontrolled spill in Lake Sonoma

Annual Exceedance Probability	1/AEP	Results Description	Uncontrolled Spill (cfs)				
			Baseline	EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	1,251	1,277	1,263	1,263	1,285
		Robustness test	0	0	0	0	0
0.002	500	Quantile	1,335	1,360	1,339	1,339	1,345
		Robustness test	0	0	0	0	0

Table 24. Difference in annual uncontrolled spill frequency in Lake Sonoma

Annual Exceedance Probability	1/AEP	Results Description	Difference in Annual Uncontrolled Spill Frequency Quantile (cfs) and [%]			
			EFO	Hybrid	Modified Hybrid	5-Day Deterministic Forecast
0.005	200	Quantile	26 [2%]	12 [1%]	12 [1%]	34 [3%]
		Robustness test	0 [0%]	0 [0%]	0 [0%]	0 [0%]
0.002	500	Quantile	25 [2%]	4 [0%]	4 [0%]	10 [1%]
		Robustness test	0 [0%]	0 [0%]	0 [0%]	0 [0%]

Summary of Findings

In general, we found that routings of the extended 2006 p=0.005 (200-yr) and p=0.002 (500-yr) events had similar, or slightly improved results compared to quantiles computed previously. Figure 2 and Figure 3 show the pool elevation, reservoir release, and Hopland flow hydrograph for the extended 2006 p=0.005 (200-yr) and p=0.002 (500-yr) events. Specifically, we found:

- The p=0.005 (200-yr) and p=0.002 (500-yr) flows at Hopland, Healdsburg, and Guerneville (Hacienda Bridge) were reduced or the same (within 1% of the difference when compared to baseline). The exception here is the p=0.005 (200-yr) EFO routing, which had a slight 2% increase from baseline because of increases uncontrolled spills from Lake Mendocino.
- The p=0.005 (200-yr) and p=0.002 (500-yr) Lake Mendocino pool elevation, total release, and uncontrolled spills preformed worse than the quantiles computed previously. The Hybrid and Modified Hybrid routing still showed reductions when compared to baseline; however, the EFO and 5-Day Deterministic Forecast routings showed 22% and 3% increases in uncontrolled spills for the p=0.005 (200-yr) routings.
- There were no impacts to the operations at Lake Sonoma.

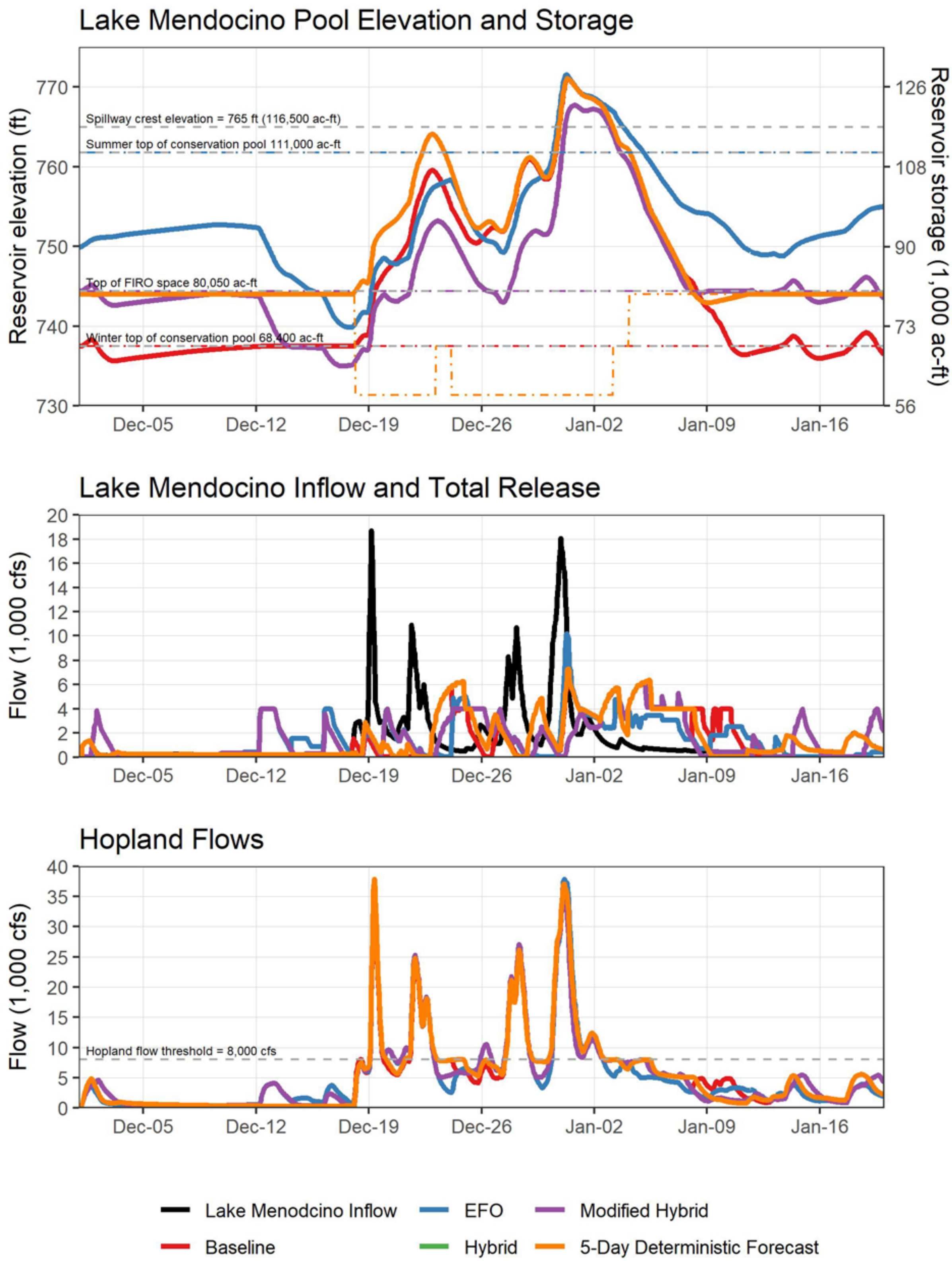

Figure 2. Routing results for the extended 2006 event pattern p=0.005 (200-yr) scaling. Hybrid and Modified Hybrid results are nearly identical. Thin dashed lines indicate TOC or top of FIRO space for associated WCP alternative.

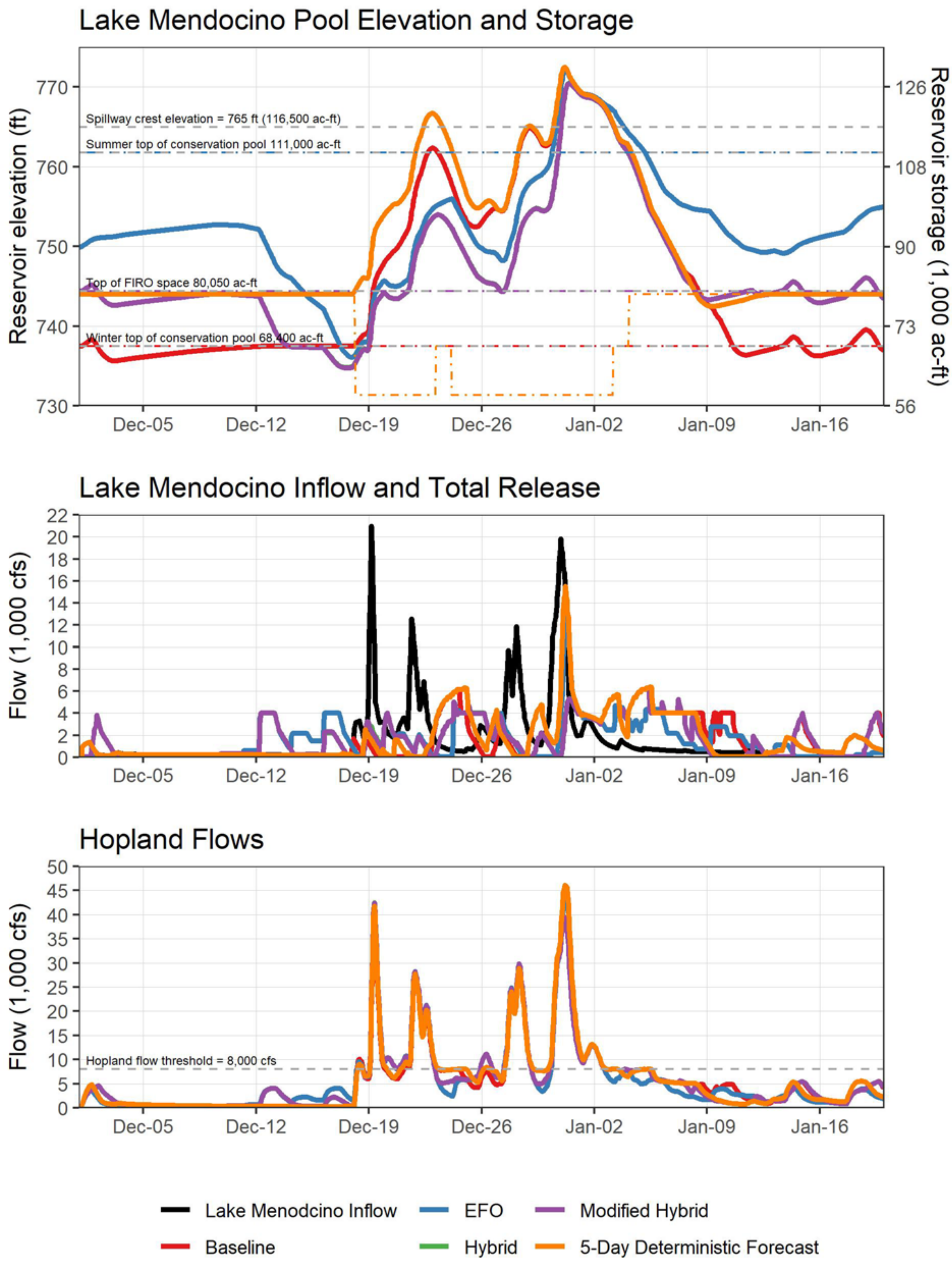

Figure 3. Routing results for the extended 2006 event pattern p=0.002 (500-yr) scaling. Hybrid and Modified Hybrid results are nearly identical. Thin dashed lines indicate TOC or top of FIRO space for associated WCP alternative.

References

United States Army Corps of Engineers (USACE 2013) HEC-ResSim Reservoir System Simulation User's Manual Version 3.1, May 2013.

United States Army Corps of Engineers (USACE 2016b) HEC-RAS River Analysis System User's Manual Version 5.0, February 2016.

FIRO Steering Committee (2019) Hydrologic engineering management plan (HEMP) for Lake Mendocino Forecast-informed Reservoir Operation (FIRO) evaluation of water control plan alternatives within the Full Viability Assessment (FVA) Version 3.0, August 1,2019

FIRO Steering Committee (2017) Preliminary viability of Lake Mendocino forecast informed reservoir operations. June 25, 2017.