



# Prado Dam **FORECAST INFORMED RESERVOIR OPERATIONS FINAL VIABILITY ASSESSMENT**

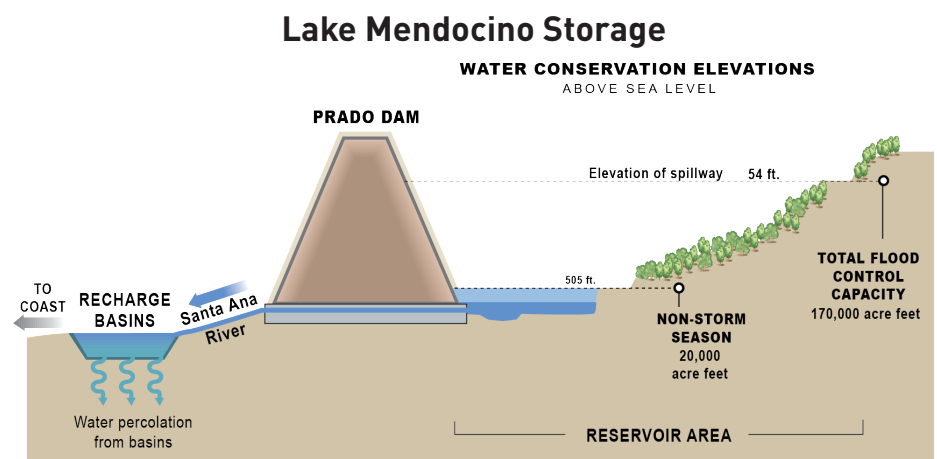
November 2023

## Executive Summary

### The Case for FIRO

Orange County Water District (OCWD) has been capturing and recharging stormwater from the Santa Ana River since 1936. Prado Dam, located about 10 miles upstream of OCWD’s recharge sites, was constructed by the U.S. Army Corps of Engineers (USACE) in 1941 for the primary purpose of flood risk management. USACE, which also operates the dam, has been collaborating with OCWD to temporarily impound water and release it from the dam to facilitate recharge of the OC groundwater basin, which is a key source of water to over 2.5 million people. To ensure reliability of Orange County’s water supply in light of changing weather and the increasing cost and unpredictability of imported water, OCWD initiated a partnership with USACE and the Center for Western Weather and Water Extremes (CW3E) at Scripps Institution of Oceanography (SIO), UC San Diego, to test Forecast Informed Reservoir Operations (FIRO) as a method to improve water supply reliability, while not impairing and possibly enhancing habitat and flood risk management. This Final Viability Assessment (FVA) presents results and recommendations for future FIRO operations. It builds on the 2021 Preliminary Viability Assessment (PVA), which demonstrated FIRO is viable at Prado Dam.

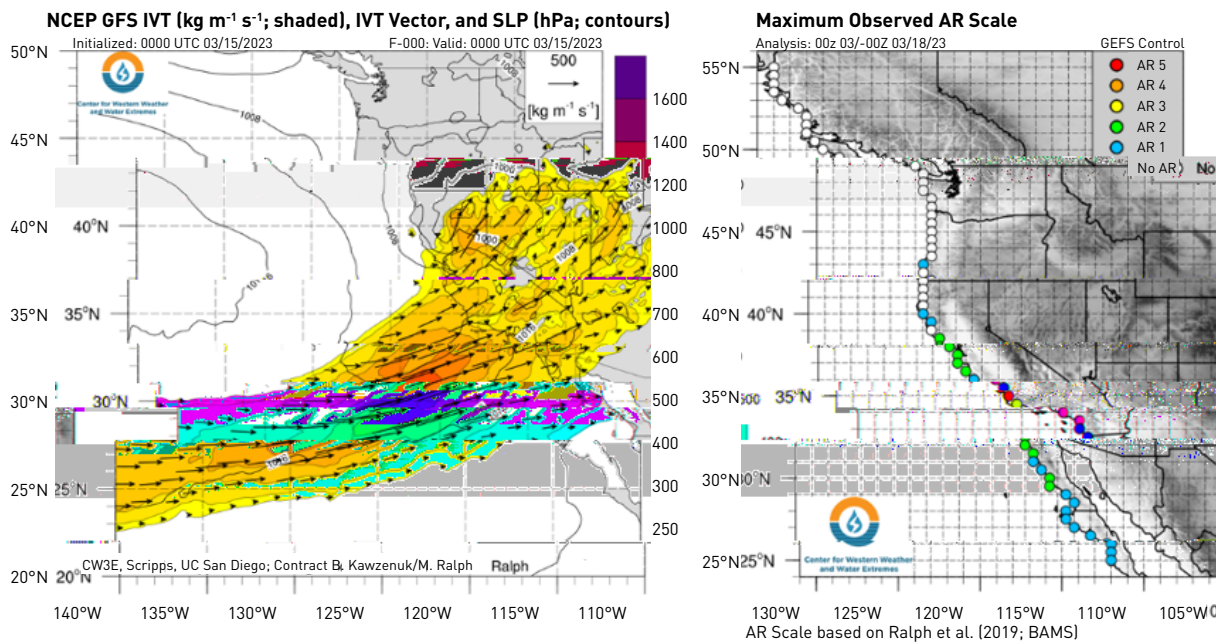
The current conservation pool, which stores a maximum of 20,000 acre feet, at elevation 505’, is where water is temporarily stored and can be used for recharge (Figure 1-1). In April 2021, the Prado Dam Interim Water Control Manual (IWCM) was modified, to allow the water conservation pool to rise to elevation 505’ year-round.



**Figure 1-1.** Schematic of Prado Dam water conservation elevation for stormwater capture (credit: OCWD).

# Atmospheric Rivers and FIRO

Atmospheric rivers (ARs) are the major determinant of flooding and a lack of ARs leads to drought conditions in California. ARs are responsible for more than half of all beneficial precipitation and over 90 percent of flood damages in California. Long, narrow bands of concentrated moisture, ARs stretch thousands of miles across the Pacific Ocean, carrying up to 20 times as much water as the Mississippi River. When ARs make landfall, they can release a staggering amount of rain and snow, as was demonstrated during a particularly active AR season from October 2022-April 2023, when 16 ARs dumped a maximum of nearly 74 inches, and an average of 29 inches of precipitation in the Santa Ana watershed. (Figure 1-2 shows a landfalling AR that took aim on the watershed in mid-March.) For this reason, improved AR forecasts are essential to implement FIRO.



**Figure 1-2.** (Left) A landfalling AR on 15 March 2023, one of several that contributed to >140% of normal precipitation for the Los Angeles basin as of this date. (Right) Estimated impact of the AR as measured on the AR scale, on 11 March 2023.

## What is FIRO?

FIRO is a flexible water management strategy that uses data from watershed monitoring and modern weather and hydrologic forecasting to help water managers selectively retain or release water from reservoirs in a manner that reflects current and forecasted conditions. FIRO uses emerging science and technology to optimize limited resources and adapt to changing climate conditions. Scientific research on the intensity, duration, and location of ARs is central to FIRO.

To guide the FIRO effort at Prado Dam, OCWD and CW3E co-chair a Steering Committee, with members from USACE, the U.S. Fish and Wildlife Service, the California Nevada River Forecast Center, the California Department of Water Resources, and Orange County Public Works. Using the collaborative Steering Committee process, FIRO has proven viable on Lake Mendocino in Northern California and is currently being assessed at Lake Sonoma (Russian River Watershed), at New Bullards Bar Reservoir and Lake Oroville in the Yuba and Feather River watersheds, at Seven Oaks Dam in the upper Santa Ana Watershed, and at Howard Hanson Dam on the Green River in Washington.

# Results and Recommendations

To evaluate FIRO, the Steering Committee established operational constraints, boundary conditions, and tested variables such as spillway elevations (with and without a planned spillway raise), and maximum release schedules for buffer pool elevations up to 520'. Five water management alternatives, with five buffer pool elevations combined for a total of 26 scenarios (including baseline), were modeled using 1990-2019 hindcasts and extreme events scaled to 100-, 200-, and 500-year 3-day Prado Dam inflow volumes. Results were compared against 12 metrics.

*The FVA shows that FIRO strategies can be successfully used to enhance the opportunities for recharge by OCWD, and the Steering Committee recommends that a buffer pool of 510 or perhaps 512 feet be explored during the interim operations period prior to Prado Dam WCM Update #2.*

## Prado Dam FIRO Steering Committee

**F. Martin Ralph:** CW3E (Co-chair)

**Adam Hutchinson:** Orange County Water District (Co-chair)

**Greg Woodside (2017-2023):** Orange County Water District (Co-chair)

**Michael Anderson:** California Department of Water Resources

**Cary Talbot:** USACE Engineer Research and Development Center

**Joseph Forbis:** USACE Engineer Research and Development Center

**Alan Haynes:** California Nevada River Forecast Center

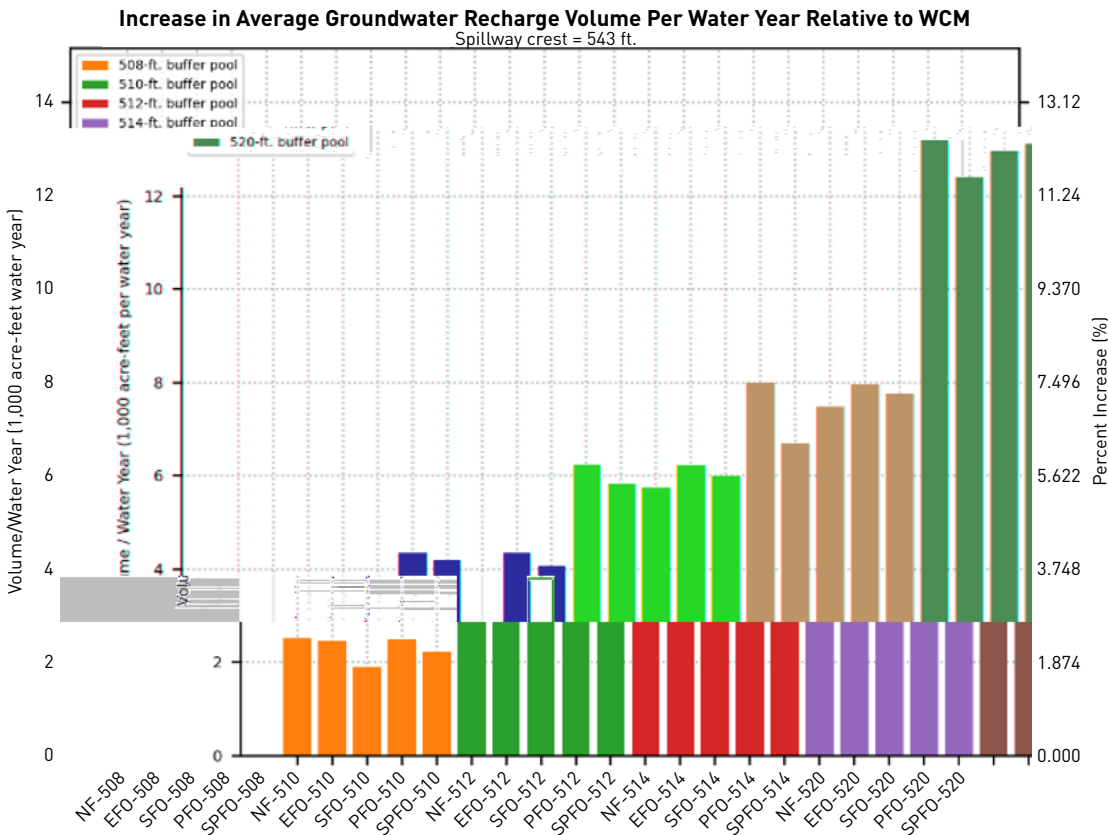
**Tim Fairbank:** USACE Los Angeles District

**Jon Sweeten:** USACE Los Angeles District

**James Tyler:** Orange County Public Works

**Rollie White:** U.S. Fish and Wildlife Service, Palm Springs

**Jay Jasperse:** Chief Engineer, Sonoma Water



**Figure 1-3.** Recharge benefits associated with the alternatives assessed at buffer pools up to 520' compared to the existing (baseline) WCM, based on the 1990-2019 simulation without the spillway raise.

The FVA recommendations will be considered by the USACE as it updates the Prado Dam Water Control Plan (WCP), a key component of the WCM, which governs operation of Prado Dam. Figure 1-4 shows the timeline for two planned WCM updates.

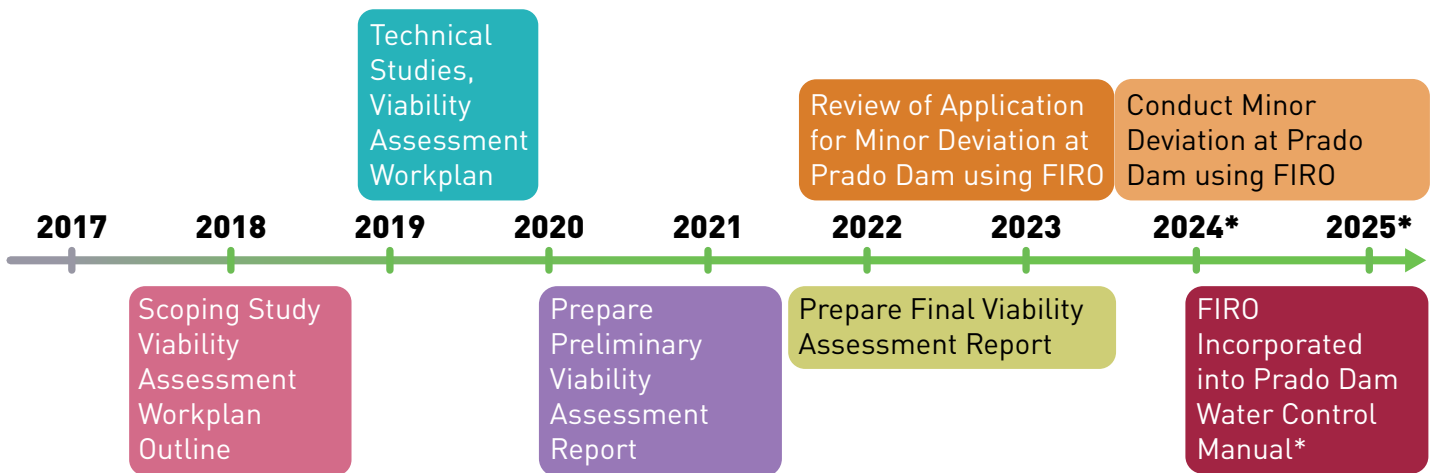
## Key Findings

On average, forecast-informed reservoir strategies from elevation 510' to 512' are estimated to yield 4,000 to 6,000 ac-ft per year of additional groundwater recharge over existing operations. Increasing the maximum elevation to 520' results in an additional average recharge of 12,000 ac-ft per year more than existing operations..

Over the range of the hindcast period and for scaled events, FIRO strategies do not impact flood risk management outcomes associated with reservoir spill and high releases for all buffer pools tested up to 520.'

The selection of the buffer pool can impact the frequency of inundation at elevations 514' and 520,' but all FIRO strategies at all buffer pools perform better than the baseline WCM when considering the frequency of exceeding 520.'

There are no identifiable environmental impacts associated with FIRO alternatives; in fact, there are some indications of positive impacts at higher water levels. Additional monitoring is needed to adjust water levels as needed during FIRO operations.



End dates for Minor Deviation and Water Control Manual Update not shown

\*Timeline dependent on hydrology and completion of the Santa Ana River Mainstem Project

**Figure 1-4. Prado Dam Timeline**

Note: Two WCM updates are planned for Prado Dam. WCM update #1 addresses the increased maximum discharge capacity of the Prado Dam outlet. WCM update #2 will include a formal consideration of FIRO. During the Interim Operations period (prior to WCM update #2), work will continue to refine the FIRO approach and evaluate a planned 508' Minor Deviation.