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Water Abundance: Opportunities and Challenges in California

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Chairman Bentz and Members of the Subcommittee:

My name is Josh Weimer, and I am the Director of External Affairs for Turlock Irrigation District (TID) in California's San Joaquin Valley. TID was the first publicly-owned irrigation district in the state of California. Today it is one of only four in California that also provides electric retail energy directly to homes, farms, and businesses. Organized under the Wright Act, the District operates under the provisions of the California Water Code as a special district. TID is governed by a five-member, locally-elected Board of Directors.

TID delivers irrigation water through over 250 miles of a gravity-fed canal system that irrigates approximately 150,000 acres of farmland. In addition, TID owns and operates an integrated and diverse electric generation, transmission and distribution system that provides power to a population of 240,000 within a 662 square-mile area. TID is one of eight Balancing Authorities in California and operates independently within the Western United States power grid. A Balancing Authority performs a balancing function in which customers' usage and resources are matched on a moment-by-moment basis.

Thank you for the invitation to testify today on TID's industry-leading reservoir and watershed management activities. Our watershed, run-off, and hydrology are changing and we must adapt how we operate our system to account for these changes. New and improved infrastructure are part of the solution, but embracing new technology, technology that doesn't require any additional concrete, is the first low hanging fruit that TID has focused on. Maximizing the District's current storage and diversion facilities and our unique ability to operate the system ourselves versus having state or federal parameters, allow us to adapt to the challenges facing California water supplies.

Through private, state and federal partnerships, TID has been able to pioneer the use of innovative technologies through its Airborne Snow Observatory (ASO) program and ForecastInformed Reservoir Operations (FIRO) program, both of which support the enhancement of TID's water management operations. These tools are then inputted into its own in-house hydrologic model. TID's Hydrocomp Forecasting and Analysis Model (HFAM) is one of the only hourly and physically based models used for water operations in the state of California. The combination of results from these programs have proven accurate within a 2 percent margin. As discussed further below, using these technologies and data increases drought resilience, improves flood protection for our communities, and proved invaluable when operating the Don Pedro Dam and Powerhouse during the 2023 water year.

TID Background

TID has historic water rights dating back to the early 1870's and most of the water it supplies to its growers is diverted from the Tuolumne River. TID partnered with the neighboring Modesto Irrigation District (MID) ("the Districts"), and built La Grange Dam in 1893 to divert water out of the river and into the Districts' respective canals. The Districts joined forces again in the 1920s to build the first Don Pedro Dam. With a small storage capacity of 289,000 acre-feet, the dam held only enough water to accommodate growers' irrigation needs for a single growing season and generating carbon-free hydroelectric power for customers in the San Joaquin Valley of California. Don Pedro propelled TID to become a public power agency.

After numerous dry winters, the Districts decided to replace the original dam with a much larger one to store the water necessary to bridge multiple years of drought. The New Don Pedro Project was completed in 1971 and has storage capacity of 2,030,000 acre-feet, seven times larger than the original. TID is the majority-owner and operator of the Don Pedro Project, by virtue of the Districts' historic sharing agreement based on acreage served within each district, TID's share is 68.46%, while MID's share is 31.54%. The dam has many benefits that range from irrigation water storage, flood control, recreation, and environmental benefits, as well as power generation. The Don Pedro powerhouse has the capacity to provide a total of 203 MW of hydroelectric power.

Although TID operates Don Pedro as a water-first facility, the collaborative nature of TID's water and energy teams has provided the flexibility to maximize releases to generate hydropower and address the immediate needs of its customers' energy demands year-round. Don Pedro makes up approximately 20 percent of TID's energy portfolio, providing clean, carbon-free energy.

The Tuolumne River is TID and MID's primary source of water, replenished annually by the spring snowmelt in the 1,884 square-mile Tuolumne River watershed originating at Mt. Lyell in Yosemite National Park. Water for irrigation and hydroelectric power production is stored at the Don Pedro Reservoir about 50 miles east of Turlock in the Sierra Nevada foothills near the historic gold rush era town of La Grange. The average annual runoff is 1,893,042 acre-feet.

Necessity Has Driven Innovation

Over the course of TID's 137-year history, one principle has remained at the forefront, necessity drives innovation. Our community certainly understood this in 1887 when a vote of the people brought irrigation to the valley, and numerous times over the following decades when the District decided to build its own water system and take our communities' destiny into our own hands. Unprecedented metrological events 25 years ago were one of those key moments that set TID on a course of trailblazing reservoir management.

The massive flooding events across Northern California in early 1997 caught all reservoirs operators off guard. At the time, the technology and forecasting didn't exist to operate a river system. Rather, operators were reactionary and passive to what the inflow gages showed after the fact. The Tuolumne River channel below Don Pedro is very narrow and only able to pass 10,000 cfs without flooding in Modesto. The unique hydrology surrounding the 1997 events led to the opening of the control spillway gates for the first time since construction was completed in 1971. In flow into Don Pedro peaked at over 140,088 cfs with an hourly peak over 180,000cfs which caused the elevation to rise so quickly that water ended going over the uncontrolled spillway.

These types of experiences were common during 1997, but what was uncommon was the response and action taken following the flooding. TID decided at that time that a lack of forecasting, situational intelligence, and specific Tuolumne River watershed modeling must be addressed to ensure safety and stewardship of the Tuolumne River and our downstream communities.

In 1998, TID knew what information was needed, and set out to find the experts to create a Tuolumne-specific model to inform reservoir operations. Almost 10 years prior, a TID employee took a two-week hydrology class taught by experts at Stanford University. During that time, he was introduced to Dr. Norm Crawford who had been researching hydrological simulation programing since he developed the Stanford Watershed Model in the 1960s. TID budgeted $200,000 in 1998, and sought out Dr. Crawford to develop a Tuolumne-specific model. As with all models, the initial development cost is only one portion of the overall investment. Annual development and calibration is what takes these tools from interesting models, to useful operational products, over the course of 25 years the average annual budget has been approximately $50,000.

HFAM

HFAM is a hydrologic simulation program that determines watershed conditions and reservoir inflow based on current and forecasted meteorology. The Tuolumne HFAM model runs hourly from a 93-year meteorological database and represents the watershed using 827 land segments, 133 stream channels, 8 irrigation canals and 13 lakes and reservoirs, incorporating physical factors (soil and vegetation types) and then bringing in inputs (precipitation, temperature, wind, solar radiation) which is all used to output information on soil moisture, snowpack and runoff within the watershed. This advanced model offers a 16-day forecast to make informed decisions

for flood control and water supply during dry years. Results have proven accurate within a 2 percent margin.

HFAM evolved from research at Stanford University in the 1960s (Stanford Watershed Model), and development continued in the 70s and 80s (Hydrological Simulation Program – FORTRAN) and to the present supported by numerous organizations and state and federal agencies.

HFAM includes Systematic Operation Analysis for Reservoirs (SOAR), reservoir operations code that maximizes the value of Don Pedro by balancing the competing use of the reservoir for flood control and for irrigation and hydropower water supply. SOAR can be used to analyze operations under current conditions or to assess impacts of climate change or the benefits of additional storage options such as additional reservoir storage, managed groundwater aquifer recharge, or connections with other reservoirs.

ASO

In 2012, TID has partnered with the NASA JPL and the United States Department of Agriculture (USDA) to bring snow survey measurement, runoff forecasting, and reservoir operations into the 21st century with the Airborne Snow Observatory (ASO) program.

ASO provides a precise measurement of depth and water content for every square meter of snow in the Tuolumne River watershed, and when combined with conventional snow surveys, provides a near-perfect picture of snow water content. The ASO technology measures snow depth and water content using an airplane-mounted light detection and ranging (LiDAR) technology instrument and an imaging spectrometer. The aircraft flies over and scans mountain basins to completely and accurately measure snowpack across the entire watershed.

California pioneered snow surveys in 1929 with a water supply forecasting program that relied on measurements of snow in select locations to estimate spring and summer runoff into reservoirs across the state. Conventional snow survey methods, although still valuable, have not been revisited until recently with NASA's ASO program. They rely heavily on professional judgment and extrapolation with a large margin of error because they use a minimal number of locations to estimate snowpack over tens of thousands of square-miles of watershed.

Having the ASO data that has been proven within 97 percent accurate enables TID to better manage operations, including the use of hydro generation at Don Pedro Power Plant, and benefits water supply, flood control, and environmental impacts.

The Tuolumne River Watershed is over 1,800 square-miles, but there are currently only 17 points of measurement in the entire watershed – equating to one site for every 88 miles. The points consist of remote measurement sites and snow pillows that measure the weight of snowpack and transfer that into a water equivalency.

Highly precise and accurate data from the ASO program can allow for better informed decisions with managing precious water supply. This data allows for earlier and larger groundwater recharge deliveries in wet years, avoid losses from overly conservative forecasts in dry years,

more balance among competing demands at reservoirs during the refill season, and earlier and more confident decisions for allocation and managing environmental flows.

Scripps

Owning and operating its own water system has allowed TID water operators to proactively seek out new practices that it believes will benefit its customers and has given it more flexibility to test and refine its water operations. Years ago, TID's Chief Hydrologist discovered the great work that the Center for Western Weather and Water Extremes, Scripps Institution of Oceanography at UC San Diego was doing on atmospheric river research and started to incorporate that technology into TID's water operations.

Now known as the Forecast Informed Reservoir Operations (FIRO), this technology observes atmospheric rivers using a variety of methods including satellites, ocean tracking buoys and by using an aircraft to fly directly into an oncoming storm before landfall. Data turns into models which yield real-time data made available online, and reservoir operators throughout the West have the ability to use the data to inform their operations. Using this data has proven invaluable to TID operations, which has improved public safety, and provides tremendous value to our customers.

TID has become a founding member of Scripps' Water Affiliates Group and is excited to enhance its relationship with Scripps and continue using the latest technology to inform our water operations.

Results of Multi-decade Investments in Technology

Regardless of the water year type, drought or flood, TID continues to see the daily benefits of the investments made over the past 25 years.

In 2017, the wettest year on record for TID, ASO began providing images of every square-meter of the watershed. The Department of Water Resources (DWR) and California Nevada River Forecast Center (CNRFC) increased their snowpack runoff forecasts, which caused TID to increase the Tuolumne River to near-maximum channel capacity to accommodate the runoff. However, once TID received the ASO data, which showed less runoff than anticipated, we had the confidence to decrease releases from Don Pedro Reservoir.

The following year, in 2018, data allowed TID to get a deviation from the U.S. Army Corps of Engineers that saved approximately 150,000 acre-feet of water. The deviation allowed TID to encroach into the flood control space in Don Pedro and forgo vacating the water which the District would have historically been required to do to prepare for unexpected flooding. With the investment in modeling and real-time data collection, TID was able to show that the District knew exactly how much snow was in the watershed and that there was no precipitation coming in the 16 day forecast that would threaten public safety.

Importantly, the positive results of TID's advanced water operations has also served to prove the cost effectiveness of investments in technology and data, increased the confidence to use model outputs to make consequential decisions on reservoir operations, and drive planning for infrastructure development needed for the future.

2023 Advanced Reservoir Operations

The 2023 Water Year ended up as the third wettest year on record with 4,020,029 acre-feet of runoff, however it did not start off that way. At the end of December, the District was preparing for a 4th year of drought, but that changed over the course of one day. We went from drought planning to flood planning within the course of 24 hours. These are the realities of how water managers must be constantly ready for any conditions and they must possess the necessary tools and resources to be confident to take early action.

Coming off the third driest three-years on record, Don Pedro Reservoir was half full, with roughly 1 million acre-feet of storage space available. Most water operators in that situation decided to fill their reservoirs and then deal with any potential issues later. TID took a different approach.

Due to the snowpack measurements and the Scripps information, we were able to run over 100 simulations in HFAM that showed that months later there would be more water than we would be able to store. The decision was then made to start making pre-flood releases in early January with over 800,000 acre-feet of storage space available. Don Pedro has 340,000 acre-feet of flood control space, but we have started to operate the reservoir utilizing the entire storage capacity for flood control.

By starting excess releases in January, the Tuolumne was able to vacate water while river levels in the San Joaquin were low. Other water operators were holding on to all of the water, desperate to recover from 3 years of drought.

Over the course of the water year, even with a 10,000 cfs limit in the river, TID was able to pass over 2 million acre-feet of water through Don Pedro. The District held maximum channel releases for over 70 consecutive days. This is even more impressive when you know that the Tuolumne River has an uncontrolled creek, Dry Creek, which feeds into the main stem in the city of Modesto. Water released from Don Pedro takes 20 hours to arrive at the confluence of Dry Creek, this requires TID hydrologists to not only take into consideration the elevation of Don Pedro and inflows into the reservoir, but they must factor in local precipitation and adjust releases a day prior to that water arriving in Modesto where flood stage is measured.

At the same time, our Power team was facing historical hikes in natural gas prices, which would undoubtedly impact the cost to provide power to our electric customers. The early releases allowed us to not just evacuate water in a consistent manner to provide room for flood control, but to also maximize the use of that water as free fuel for hydro-generation. The hydropower generated created over $20 million offset of gas purchases.

Without TID's historic investment in modeling and the incorporation of technology and data in partnership with private, state and federal entities, it would have been very difficult for the TID Board to make such a consequential decision to release water before runoff was behind Don Pedro Dam.

Next Phase Investments

While the advancements TID has made in the last 25 years has been more significant than any watershed in the state, the District continues to lean into cutting-edge research and technology.

The District entered into a discussion with Cornell and DWR on a Climate Generator. This research was to develop a base line indication of the magnitude of climate change that one could expect. We already know that the hydrology is changing, the wet years are getting wetter more often and the dry years are getting drier for longer periods of time. So the question is what hydrology should we be planning to and this research is considered vital for our sensitivity analysis for planning and operations purposes.

Key Takeaway and Opportunities for Federal Action

TID's experience developing and implementing science and technology into its reservoir and watershed operations has paid dividends as discussed above, and there are opportunities to replicate this approach in other Basins in California and across the West. Several important lessons based on TID's program that are worth highlighting as other entities considering this approach include:

1. Infrastructure is still a critical backbone of water management. For TID, it is the combination of our models and use of day along with Don Pedro reservoir, our extensive distribution system, and other critical infrastructure that allow for these successes managing through droughts and floods. Technology will only take water management so far without robust infrastructure, and in fact, our knowledge of the watershed helps drive infrastructure decisions.
2. Making meaningful strides to be more precise in reservoir and watershed management requires a long-term dedication to investment and incremental improvement. TID's water management program did not happen overnight and it is important for decision makers to take an approach that gives these types of programs the time needed to test and work properly.

TID stands ready to work with other reservoir managers in California – whether federal, state, or other entities – to provide lessons learned and key findings from our experience. There are also opportunities for the federal government to improve and facilitate these types of actions. Increasing funding to help with ASO flights through the Bureau of Reclamation and other agencies, continued support for further improvements to FIRO, and greater certainty that federal regulators will incorporate modeling and studies into decision making – whether it be flood control regulation or other areas – would help advance efforts to maximize the benefits of

existing reservoirs. Additionally, the Tuolumne River watershed is largely public land and ensuring proper management and wildfire risk reduction is increasingly important to mitigate impacts to reservoir and watershed management.

Conclusion

Thank you for the opportunity to testify in front of the committee and share TID's history and our commitment to watershed and reservoir management. TID takes our commitment to water supply, recreation, public safety and stewardship seriously.

The 2023 example is profound, but those results are a byproduct of 25 years' worth of investments. TID strongly encourages all organization and agencies that have responsibilities for reservoir and watershed management to lean into the lowest-hanging fruit to enhance water supply reliability.