WaterSMART

Basin Study Program–Reservoir Operations Pilot Study

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Crooked River Pilot Study

Using water supply forecasting methods and climate change scenarios to evaluate reservoir operations.

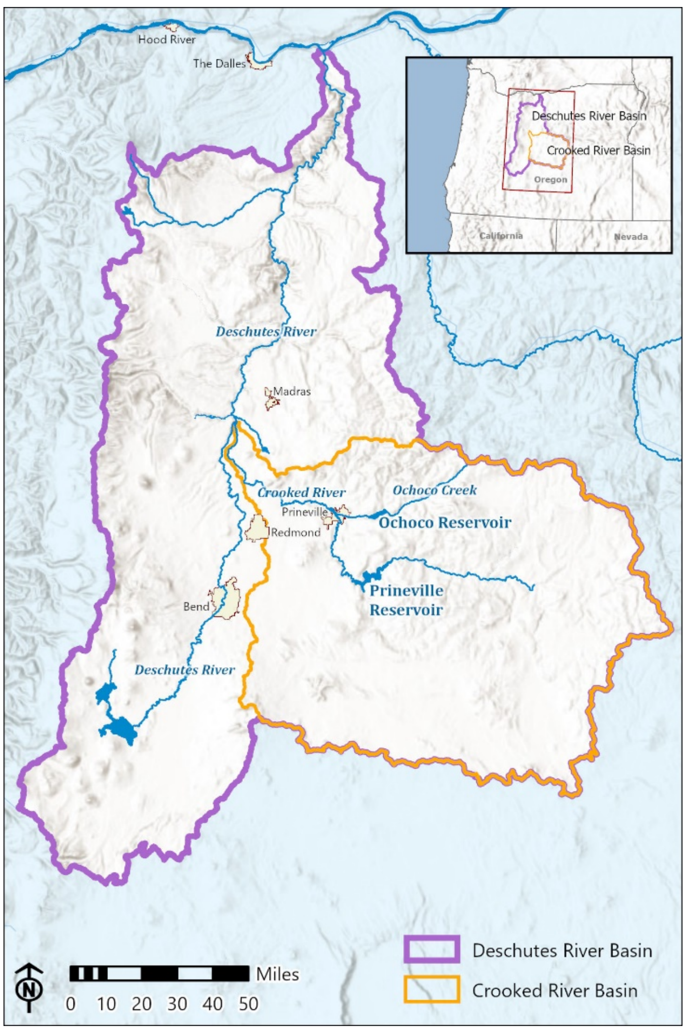

Figure 1. Crooked River Pilot Study location map showing Prineville Reservoir and Ochoco Reservoir watersheds outlined in orange.

Location

The Crooked River is a sub-basin of the Deschutes River basin, located in central Oregon, and drains into the Bureau of Reclamation's (Reclamation) Prineville and Ochoco Reservoirs (Figure 1). The Crooked River Pilot Study (Pilot Study) conducted by the Columbia-Pacific Northwest Regional Office, (CPN Region) is focused on operations at Prineville Dam, which impounds streamflow from the Crooked River and Bear Creek to fill Prineville Reservoir (active storage of 148,600 acre-feet). The dam provides flood control, water supply for irrigation and municipal and industrial (M&I) uses, fish and wildlife benefits, and recreational opportunities.

Overview

Prineville Reservoir is located in the rain-snow transitional zone, meaning that it receives a mix of rain and snow and the amount and timing of runoff is highly variable. Projections of future climate in the Crooked River Basin indicate that this transitional basin is at risk of increased winter flows with larger runoff events. This Pilot Study examined the existing operations at Prineville Reservoir using selected resource metrics (e.g., number of days above flood elevation) to determine how future climate scenarios may impact various project resource considerations.

Based on the analysis of future climate impacts, reservoir operating alternatives were developed to reduce the impacts of projected hydrologic variability on operational objectives.

Operating Scenarios to Manage Future Risk

Crooked River Reservoir operators rely on dynamic rule curves to guide reservoir refill from mid-February through April. Based on forecasted seasonal runoff volumes and projected reservoir fill dates, the rule curves identify the amount of reservoir storage space required to capture runoff and minimize downstream flood risks.

To evaluate long-term impacts to reservoir operations under future hydrology, the study team investigated how well the current dynamic rule curves would perform in a range of future climate scenarios for three future planning horizons—the 2040s (2030-2059), 2060s (2050-2079), and 2080s (2070-2099). The scenarios encompass a range of future warming and projected future precipitation—LWD (less warming and drier), LWW (less warming and wetter), median, MWD (more warming and drier), and MWW (more warming and wetter). The team used corresponding future hydrology under these scenarios as inputs to a RiverWare-based reservoir operations planning model for the Crooked River and Ochoco Creek watershed (Pilot Model), while keeping operational requirements the same, to illustrate how resource metrics might be different under possible future hydrologic conditions.

The study team found the existing rule curve preformed well and was resilient for almost all of the climate change scenarios across all time horizons with regards to providing flood control. The 2080s LWW scenario was the only scenario resulting in reservoir discharges above the existing maximum flood control discharge target of 3,000 cfs (resulting in an elevation in the river at which flooding occurs), Figure 2. The 2080 LWW scenario resulted in an additional 22 days of flows above the flood control discharge target and increased potential for water stored above the spillway elevation (surcharge) compared to the current condition. Results also indicated the need for deeper and longer-duration reservoir drawdown and larger reservoir discharges for flood protection. In addition, the study identified the need for improved forecasting methodology to better predict seasonal runoff in the transitional zone.

Climate change conditions—increased runoff and releases for flood control—were also found to increase the number of days with total dissolved gas (TDG) levels in excess of 120 percent, which would negatively impact fish health. High TDG levels can cause gas bubbles to develop in the blood and tissue of fish, causing trauma or death.

Table 1. Number of days above various discharge values, including the days above the maximum flood control discharge target (3,000 cfs), under a range of future temperature and precipitation scenarios for the 2080s time horizon.

Model Run	# of Days Discharge (cfs) is greater than				
	1,000	1,500	2,000	2,500	3,000[1]
Current Condition	726	391	253	139	4
Future climate Scenario	**# Days Different from Current Condition**				
2080s LWD	156	3	-4	16	-4
2080s LWW	499	302	114	109	22
2080s MWD	43	-3	-58	-29	-4
2080s MWW	572	336	142	125	1
2080s Median	289	144	13	27	-4

[1] Existing maximum flood control discharge target.

Based on the model results, the study team focused efforts on the 2080s LWW scenario to investigate how a rule curve might be modified to account for a changing hydrologic condition outside of what the original rule curve was designed for. Two new dynamic rule curves were developed, including: 1) A rule curve that could meet flood protection requirements under the wetter 2080s climate change scenario, and 2) a dynamic rule curve for managing TDG concentrations downstream. A dry-year alternative operation was also developed to improve reservoir refill in years with less than average runoff conditions and capturing almost 10,000 acre-feet more storage, compared to the current operation.

Primary Benefits

As the effects of climate change manifest in real-time, reservoir operators need to understand potential adaptations that will allow them to continue to operate safely. Lessons learned from this study could help future planning in basins that experience increased flooding or drought due to a changing climate.

This study provides a successful example of a new modeling approach that incorporates revised reservoir refill rule curves into operations modeling, helping reservoir operations adjust to changes in climate or hydrologic variability. It demonstrates how reservoir managers can measure the impacts to the resources that basin stakeholders value most. This information can then be used as guidance for developing new operational rules, as needed, to meet future conditions and demands.

> The Crooked River Pilot Study provides a great example of incorporating future uncertainly into long-term operations. For real-time operators, dealing with uncertainly is an ongoing challenge and any information about what a reasonable "bookend" of possible operations might look only helps us to optimize reservoir operations for our stakeholders.
>
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Additional Information

Useful Links

Site Specific Pilots
https://www.usbr.gov/watersmart/pilots/

Pilot Study Final Report Press Release
https://www.usbr.gov/watersmart/pilots

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