

Sub-Task 3.4: Technical Review of the Redwood Creek PRMS Hydrologic Model

Appendix A: Hydrology Performance

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REDWOOD C NR BLUE LAKE, CA
Station ID: 11481500
10/01/2010 - 09/30/2022

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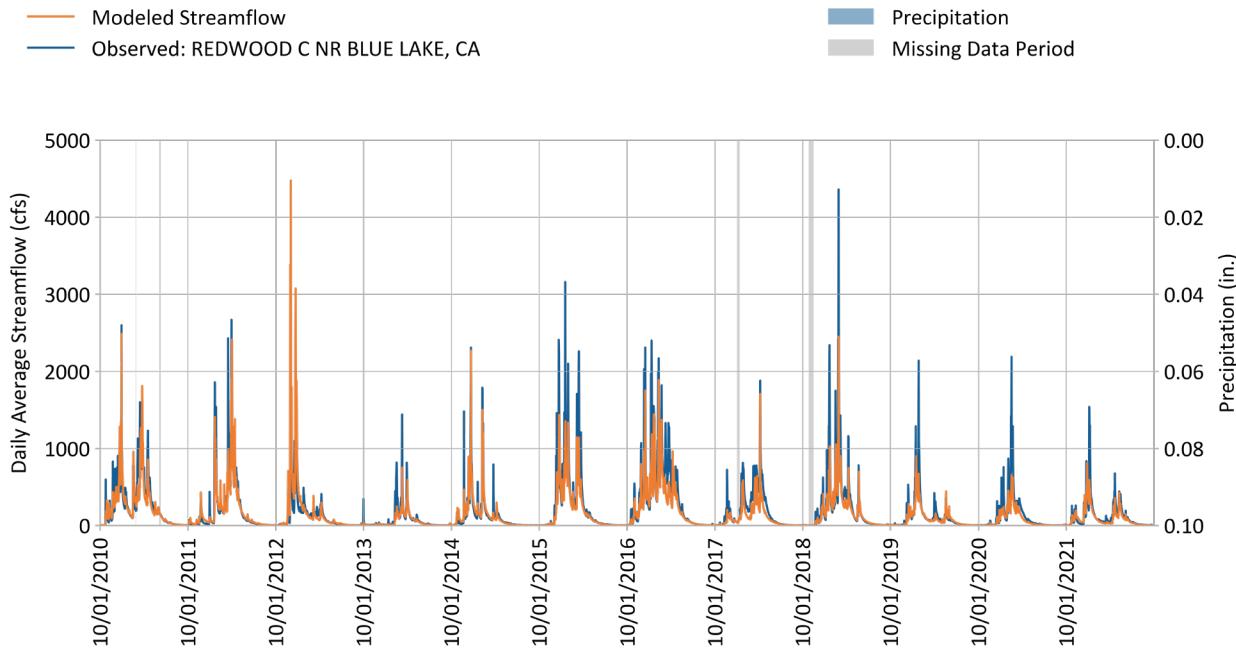


Figure 1. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: Simulated vs. daily observed streamflow.

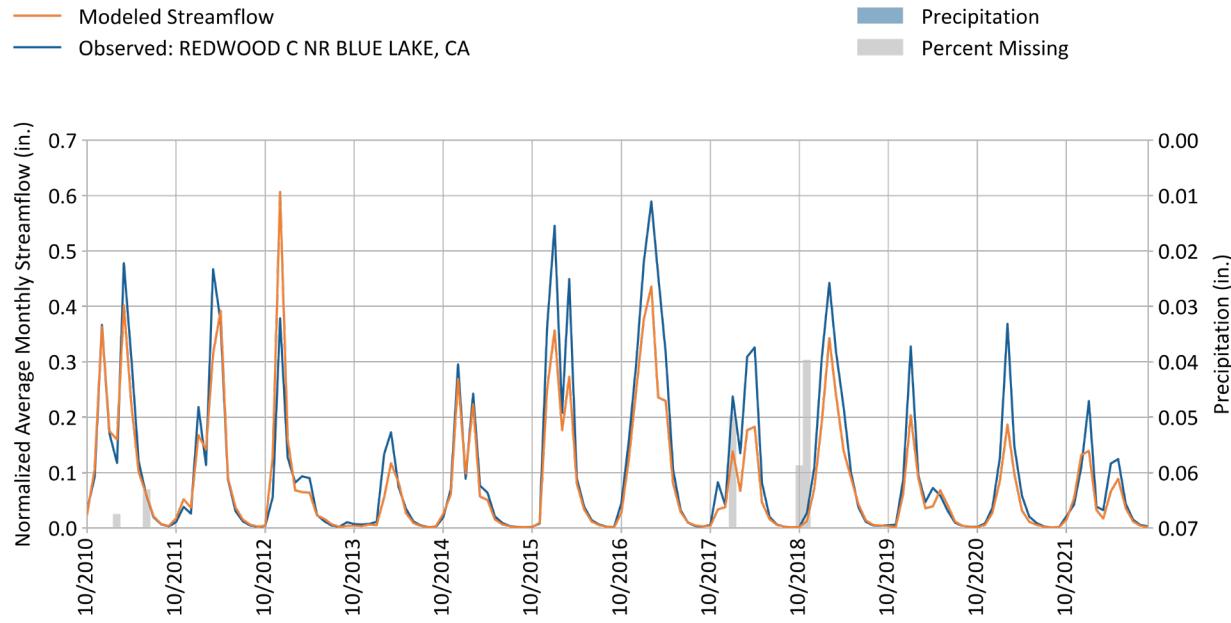


Figure 2. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: Simulated vs. observed normalized monthly streamflow.

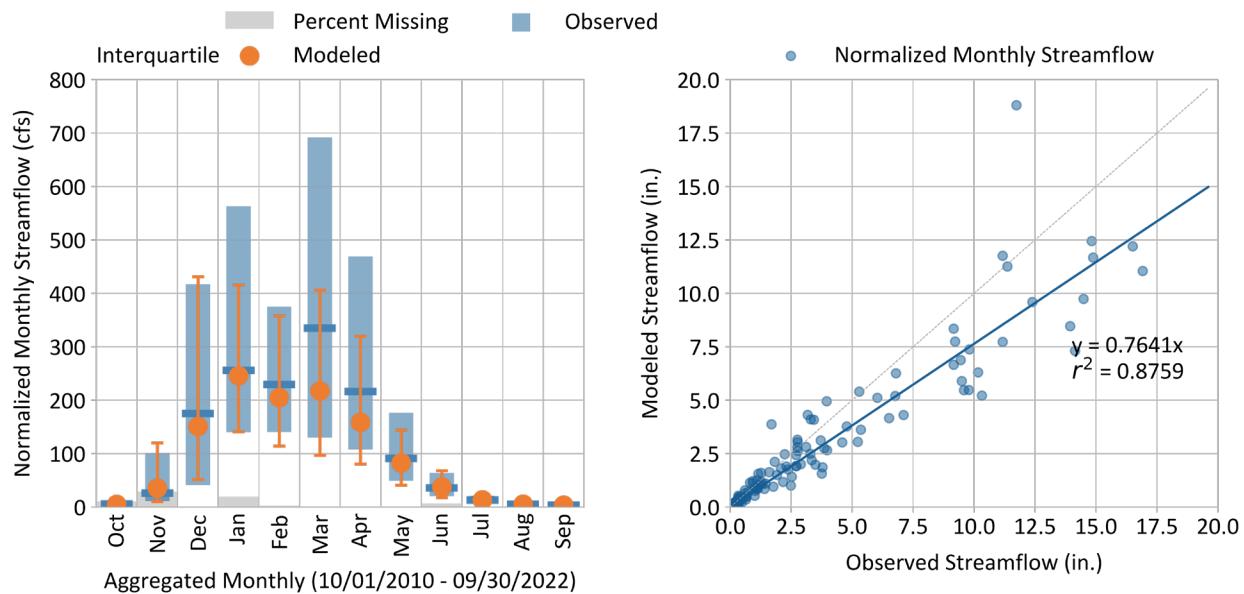


Figure 3. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: Simulated vs. observed normalized monthly streamflow.

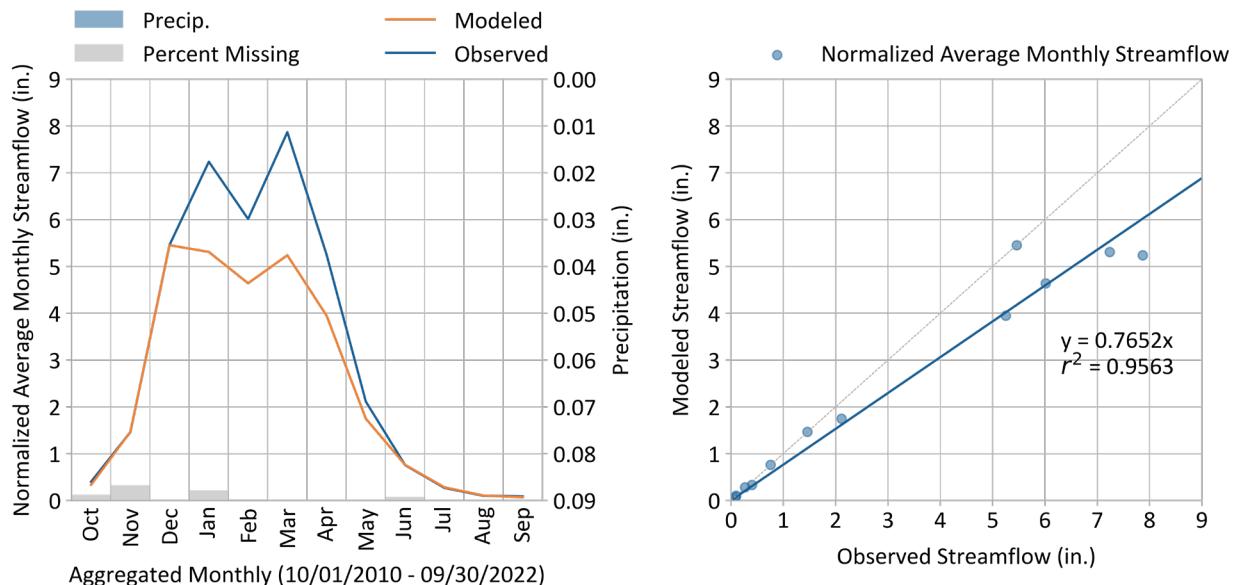


Figure 4. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: Average normalized monthly streamflow.

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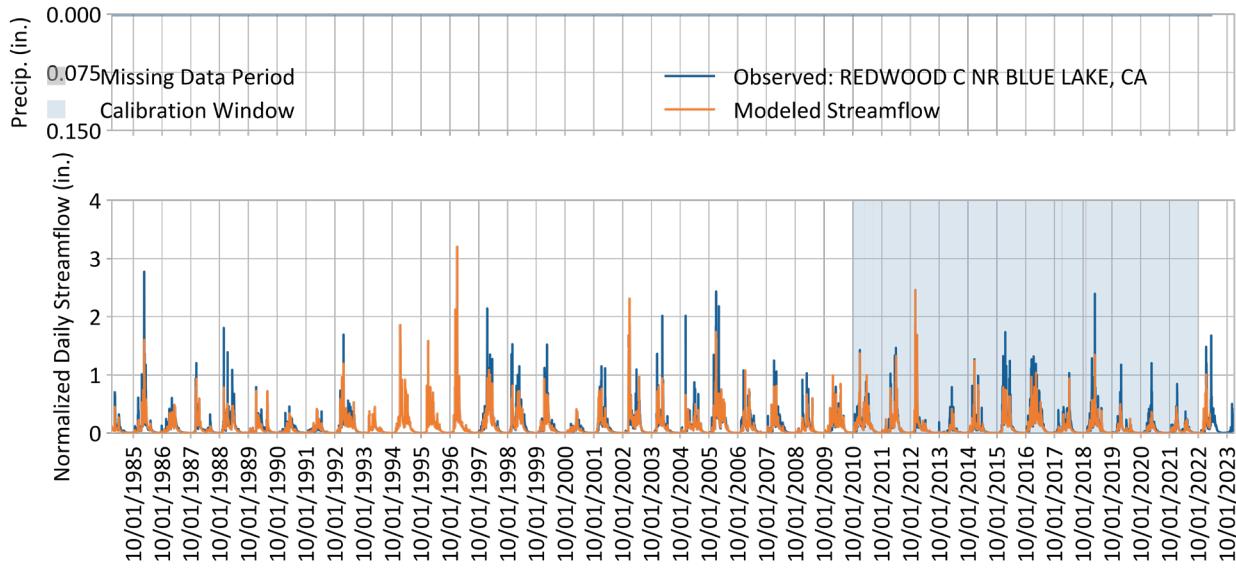


Figure 5. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: Simulated vs. observed normalized daily streamflow.

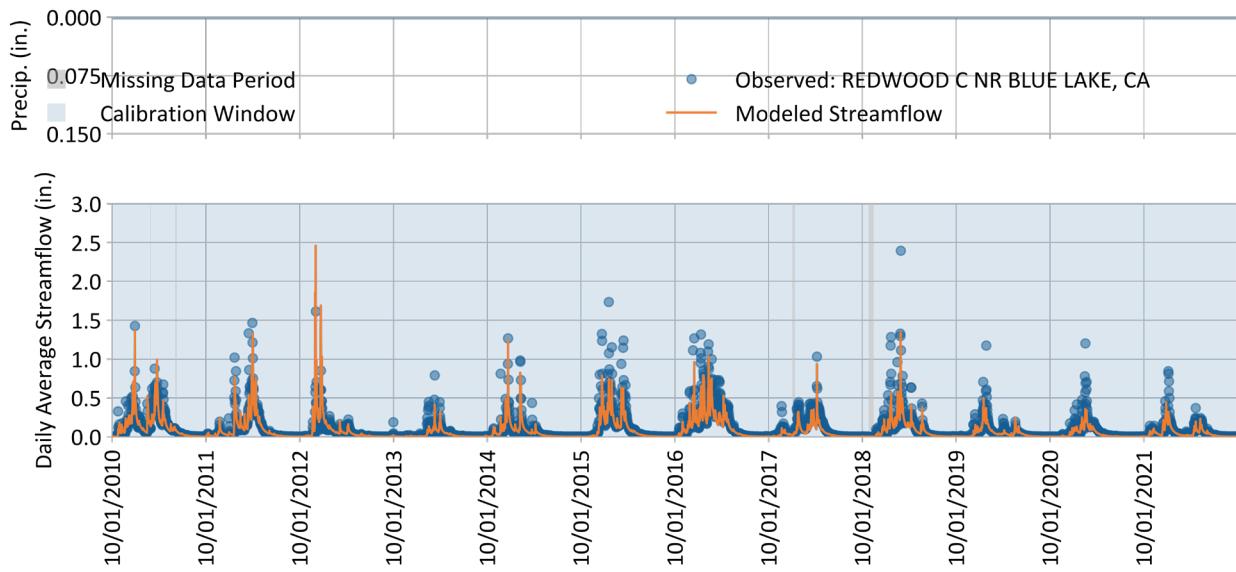


Figure 6. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: Simulated vs. observed normalized daily streamflow.

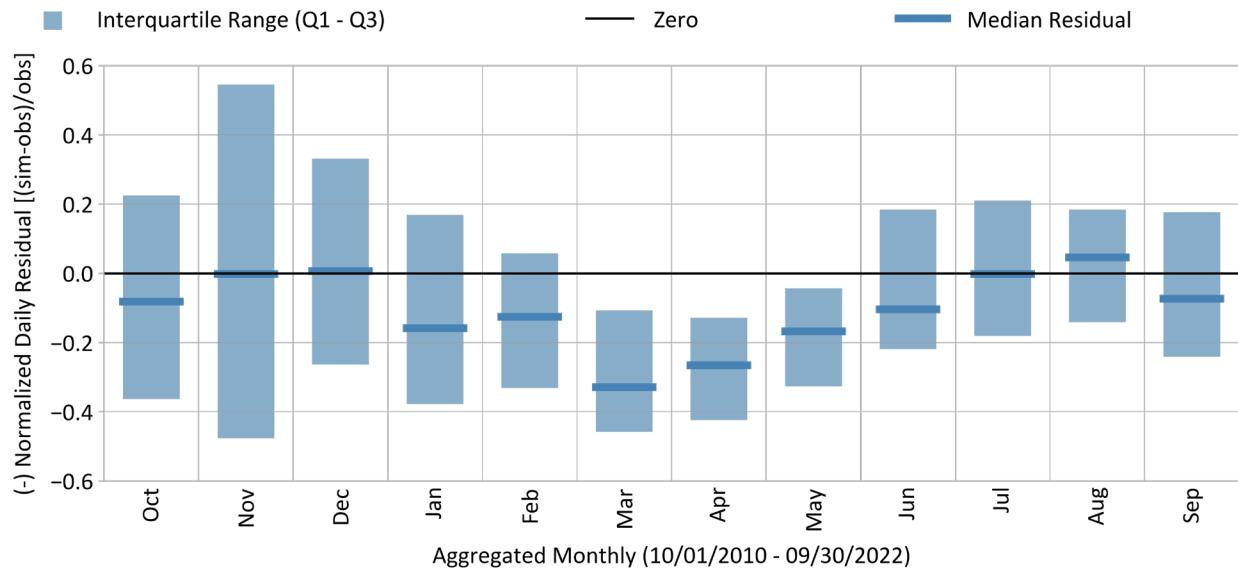


Figure 7. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: Standardized temporal residual boxplot.

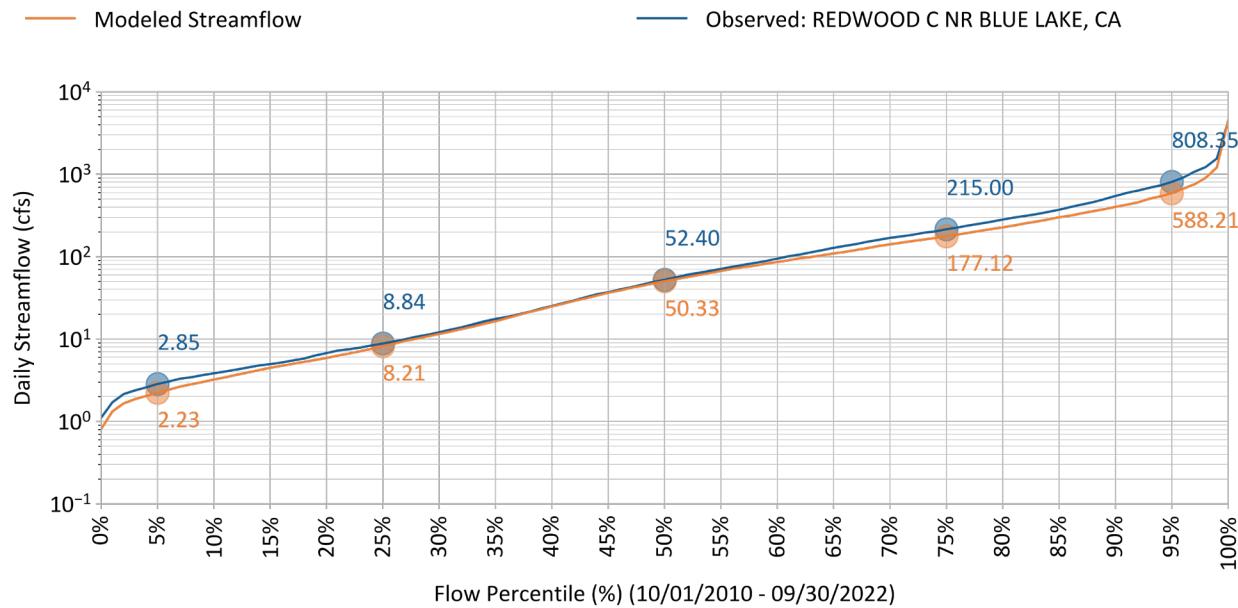


Figure 8. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: Simulated vs. observed streamflow duration curves.

Appendix A: Hydrology Performance

Table 1. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: Relative mean error statistical metric for predicted vs observed volumes

		Observed vs Simulated Calibration Performance for Runoff Volumes (Simulated vs Observed Total Volume for Condition-Season across Simulation)		
Calibration Metrics (10/01/2010 - 09/30/2022)		Relative Mean Error (RME)		
		All Seasons	Wet Season	Dry Season
Total Annual Volume	-20.7%	-21.7%	-10.8%	
Highest 10% of Flows	-29.4%	-29.4%	-38.4%	
Lowest 50% of Flows	6.9%	24.3%	-3.1%	
Storm Volume	-33.4%	-34.0%	-19.6%	
Baseflow Volume	-14.6%	-15.3%	-9.2%	
Baseflow Recession Rate	1.6%	2.1%	1.2%	

Performance Metric	Hydrological Condition	Comparison Type	Performance Threshold for Hydrology Simulation				Reference
			Very Good	Good	Satisfactory	Unsatisfactory	
Relative Mean Error (RME)	Total Annual Volume	Compare Observed vs Simulated Total Volume across Simulation Period for Selected Season-Conditions	≤5%	5 - 10%	10 - 15%	>15%	Donigian et al. (1984), Lumb et al. (1984), and Donigian (2000)
	Seasonal Volume		≤10%	10 - 15%	15 - 25%	>25%	
	Highest 10% of Flows		≤10%	10 - 15%	15 - 25%	>25%	
	Lowest 50% of Flows		≤10%	10 - 15%	15 - 25%	>25%	
	Annual Storm Volume		≤10%	10 - 15%	15 - 25%	>25%	
	Seasonal Storm Volume		≤15%	15 - 30%	30 - 50%	>50%	
	Baseflow Volume		≤10%	10 - 15%	15 - 25%	>25%	
	Baseflow Recession Rate		≤3%	3 - 5%	5 - 10%	>10%	

Table 2. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: Percent bias statistical metric for predicted vs observed volumes

		Observed vs Simulated Calibration Performance for Flow Rates (Simulated vs Observed Flow Rates for Condition-Season across Simulation)		
Calibration Metrics (10/01/2010 - 09/30/2022)		Percent Bias (PBIAS)		
		All Seasons	Wet Season	Dry Season
All Conditions	20.7%	21.7%	10.8%	
Highest 10% of Daily Flow Rates	29.4%	29.4%	38.4%	
Lowest 50% of Daily Flow Rates	-6.9%	-24.3%	3.1%	
Days Categorized as Storm Flow	28.5%	29.3%	12.4%	
Days Categorized as Baseflow	12.4%	12.7%	10.2%	

Performance Metric	Hydrological Condition	Comparison Type	Performance Threshold for Hydrology Simulation				Reference
			Very Good	Good	Satisfactory	Unsatisfactory	
Percent Bias (PBIAS)	All Conditions	Compare All Observed vs Simulated Daily Flow Rates that Occur During Selected Season-Conditions	<5%	5% - 10%	10% - 15%	>15%	Moriasi et al. (2015)
	Seasonal Flows						
	Highest 10% of Daily Flow Rates						
	Lowest 50% of Daily Flow Rates						
	Days Categorized as Storm Flow						
	Days Categorized as Baseflow						

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Table 3. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: R² statistical metric for predicted vs observed volumes

		Observed vs Simulated Calibration Performance for Flow Rates (Simulated vs Observed Flow Rates for Condition-Season across Simulation)		
Calibration Metrics (10/01/2010 - 09/30/2022)		R-Squared (R ²)		
		All Seasons	Wet Season	Dry Season
All Conditions	0.75	0.71	0.87	
Highest 10% of Daily Flow Rates	0.37	0.38	1.0	
Lowest 50% of Daily Flow Rates	0.64	0.53	0.87	
Days Categorized as Storm Flow	0.71	0.68	0.83	
Days Categorized as Baseflow	0.83	0.78	0.91	

Performance Metric	Hydrological Condition	Comparison Type	Performance Threshold for Hydrology Simulation				Reference
			Very Good	Good	Satisfactory	Unsatisfactory	
R-Squared (R ²)	All Conditions	Compare All Observed vs Simulated Daily Flow Rates that Occur During Selected Season-Conditions	>0.85	0.75 - 0.85	0.60 - 0.75	≤0.60	Moriasi et al. (2015)
	Seasonal Flows						
	Highest 10% of Daily Flow Rates						
	Lowest 50% of Daily Flow Rates		>0.75	0.60 - 0.75	0.50 - 0.60	≤0.50	
	Days Categorized as Storm Flow						
	Days Categorized as Baseflow						

Table 4. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: Nash-Sutcliffe efficiency statistical metric for predicted vs observed flow rates

		Observed vs Simulated Calibration Performance for Flow Rates (Simulated vs Observed Flow Rates for Condition-Season across Simulation)		
Calibration Metrics (10/01/2010 - 09/30/2022)		Nash-Sutcliffe Efficiency (E)		
		All Seasons	Wet Season	Dry Season
All Conditions	0.73	0.68	0.86	
Highest 10% of Daily Flow Rates	-0.11	-0.11	-101.0	
Lowest 50% of Daily Flow Rates	0.34	-0.6	0.87	
Days Categorized as Storm Flow	0.67	0.63	0.82	
Days Categorized as Baseflow	0.82	0.77	0.88	

Performance Metric	Hydrological Condition	Comparison Type	Performance Threshold for Hydrology Simulation				Reference
			Very Good	Good	Satisfactory	Unsatisfactory	
Nash-Sutcliffe Efficiency (E)	All Conditions	Compare All Observed vs Simulated Daily Flow Rates that Occur During Selected Season-Conditions	>0.80	0.70 - 0.80	0.50 - 0.70	≤0.50	Moriasi et al. (2015)
	Seasonal Flows						
	Highest 10% of Daily Flow Rates						
	Lowest 50% of Daily Flow Rates		>0.70	0.50 - 0.70	0.40 - 0.50	≤0.40	
	Days Categorized as Storm Flow						
	Days Categorized as Baseflow						

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Table 5. REDWOOD C NR BLUE LAKE, CA (11481500) - Hydrology calibration: Key statistic metric

Statistic	Observed cfs	Simulated cfs	% Difference
Average Flow	185.8235	146.6568	-21.08%
Minimum Flow	1.11	0.81	-27.03%
5th Percentile Flow	nan	2.23	nan%
10th Percentile Flow	nan	3.222	nan%
25th Percentile Flow	nan	8.205	nan%
Median Flow	nan	50.33	nan%
75th Percentile Flow	nan	177.125	nan%
90th Percentile Flow	nan	402.054	nan%
95th Percentile Flow	nan	588.213	nan%
Maximum Flow	4360.0	4477.29	2.69%

7Q10	All Simulation	1.497	1.0218	-31.74%
	January	15.0851	12.6696	-16.01%
	February	43.0054	31.9235	-25.77%
	March	57.4233	44.5039	-22.5%
	April	44.7941	28.4528	-36.48%
	May	23.5157	15.8993	-32.39%
	June	10.2012	7.6416	-25.09%
	July	3.1848	3.3468	5.09%
	August	1.7951	1.5158	-15.56%
	September	1.4369	1.0927	-23.95%
	October	1.9007	1.3196	-30.57%
	November	3.5662	1.1497	-67.76%
	December	5.8314	6.4919	11.33%

Separated Baseflow	Average	125.7276	106.9156	-14.96%
	25th Percentile	nan	6.89	nan%
	Median	nan	43.19	nan%
	75th Percentile	nan	144.18	nan%

Separated Stormflow	Average	60.0058	39.7412	-33.77%
	25th Percentile	nan	0.42	nan%
	Median	nan	3.51	nan%
	75th Percentile	nan	20.645	nan%

REDWOOD C A ORICK CA
Station ID: 11482500
10/01/1985 - 09/30/2022

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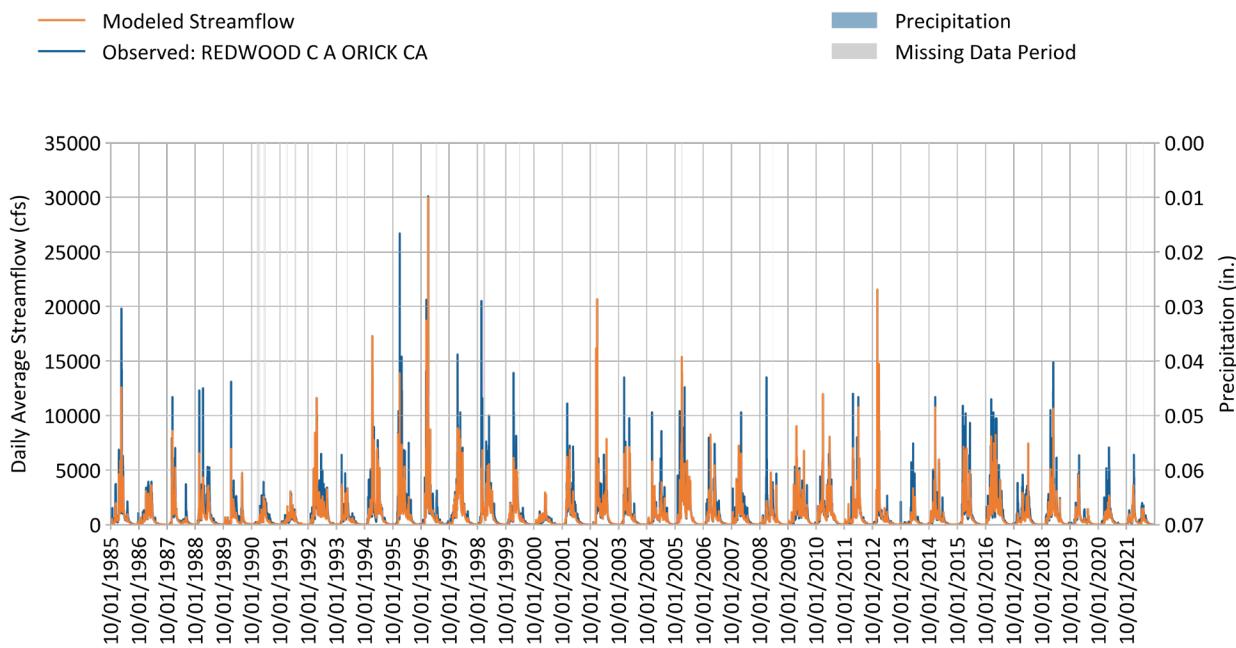


Figure 9. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: Simulated vs. daily observed streamflow.

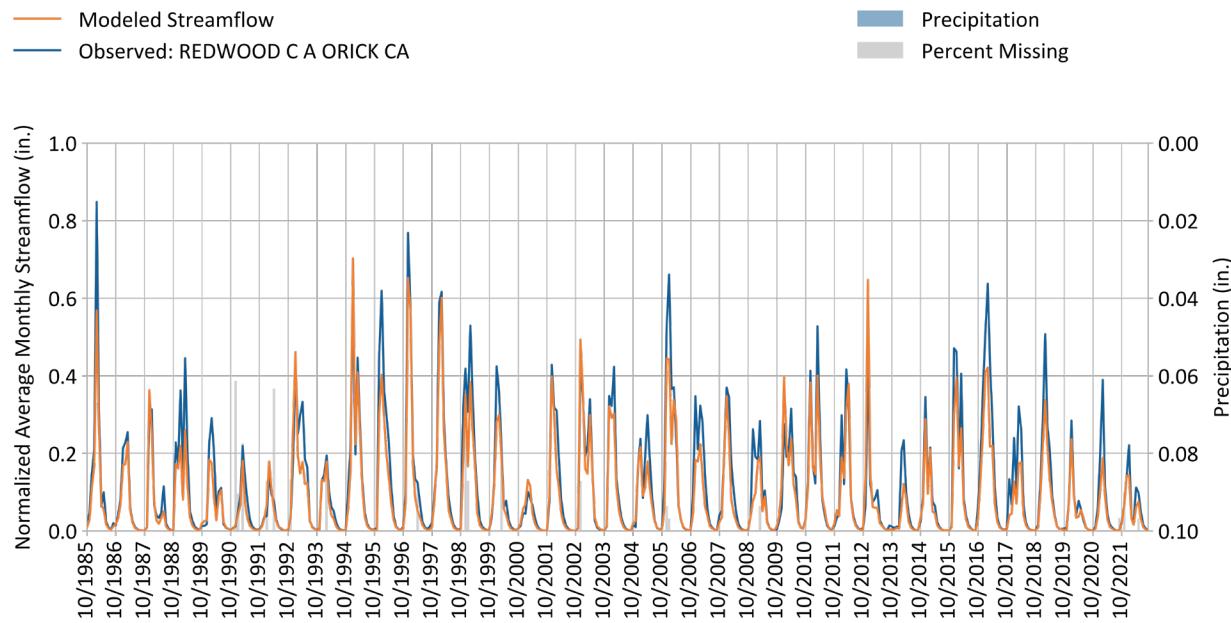


Figure 10. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: Simulated vs. observed normalized monthly streamflow.

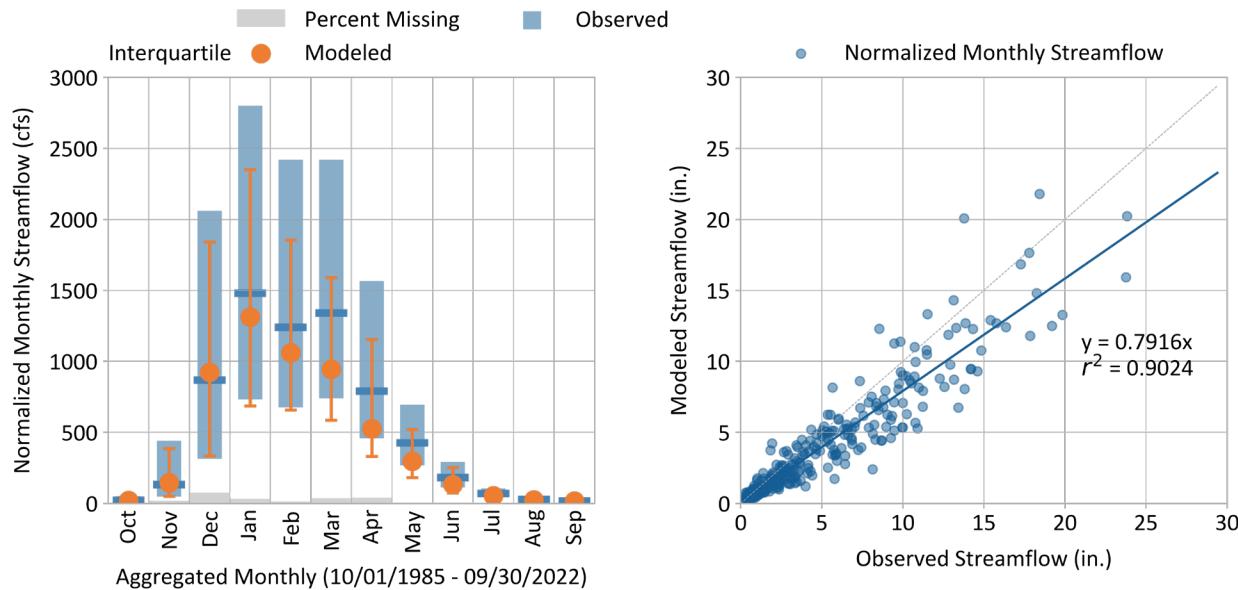


Figure 11. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: Simulated vs. observed normalized monthly streamflow.

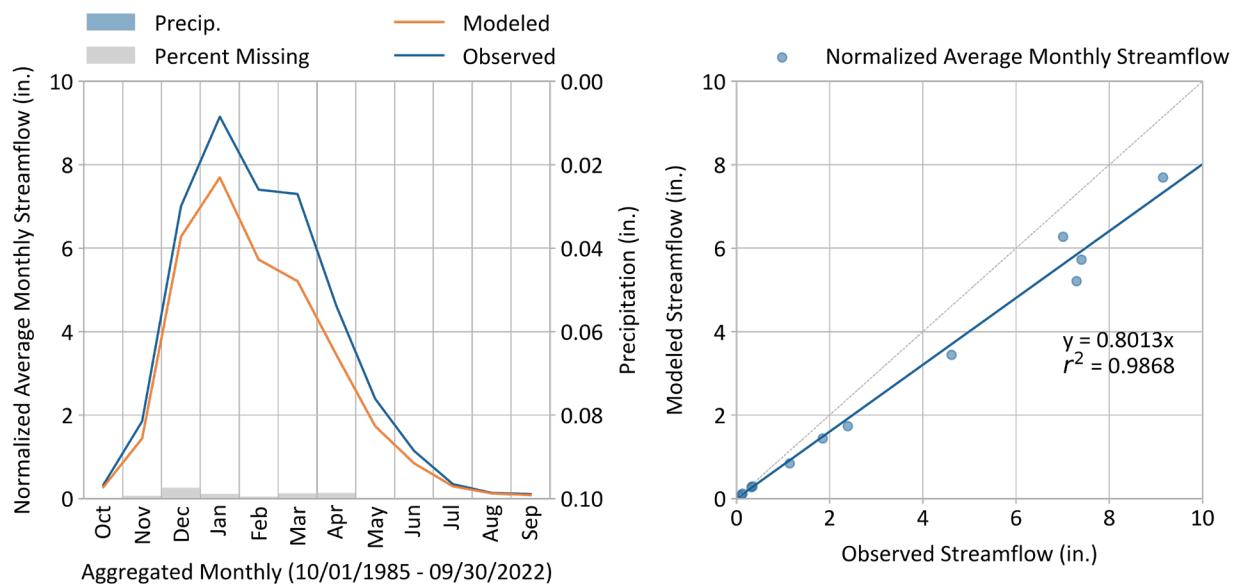


Figure 12. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: Average normalized monthly streamflow.

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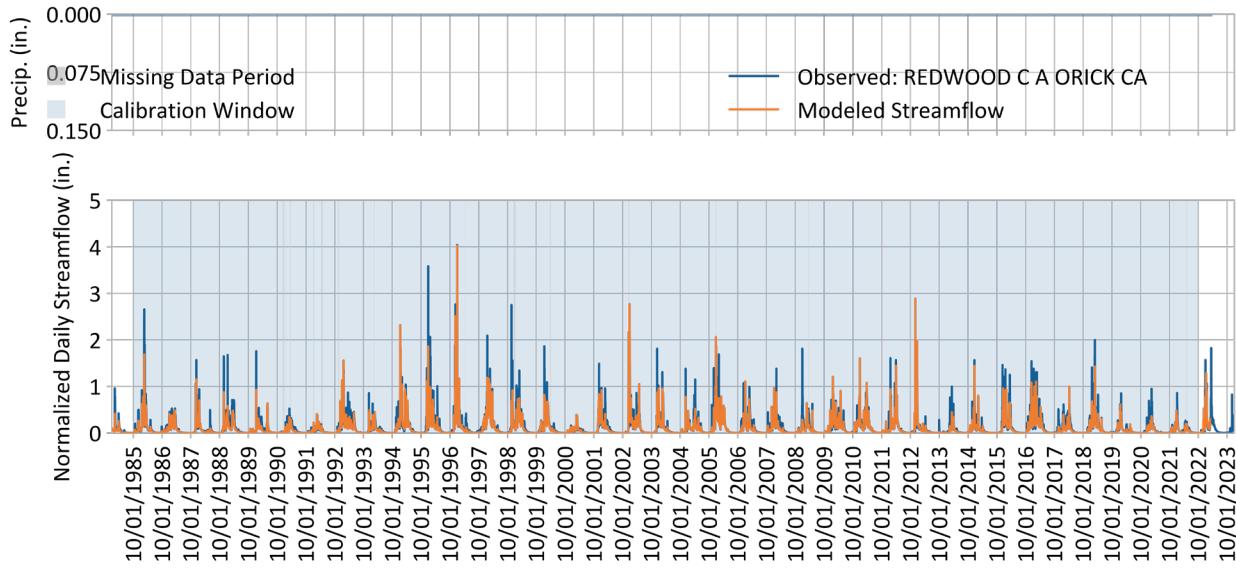


Figure 13. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: Simulated vs. observed normalized daily streamflow.

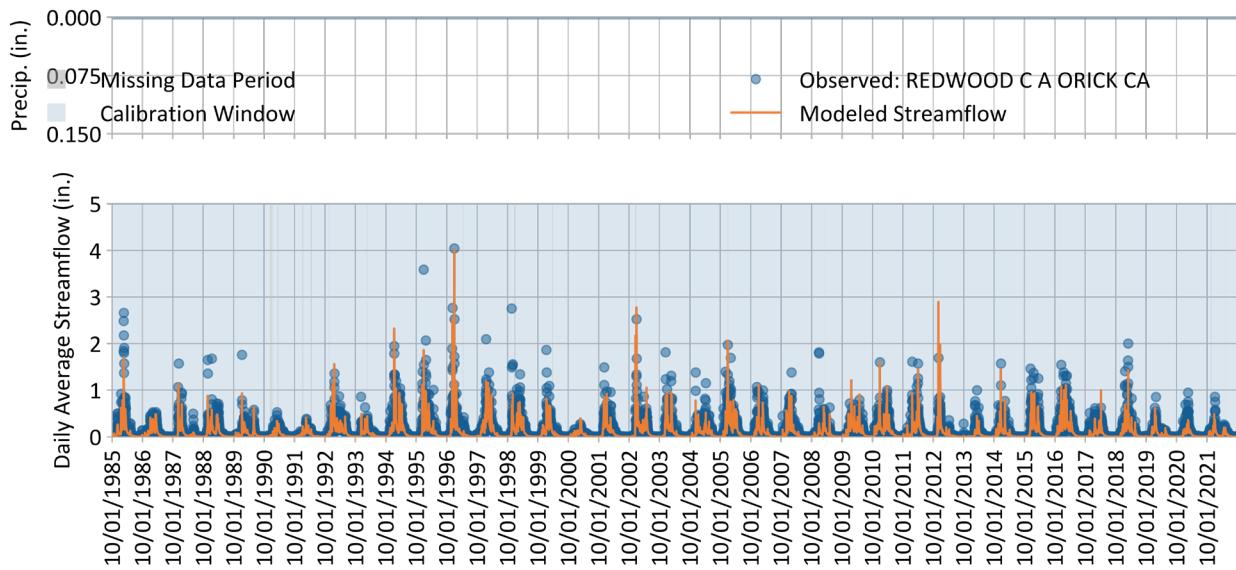


Figure 14. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: Simulated vs. observed normalized daily streamflow.

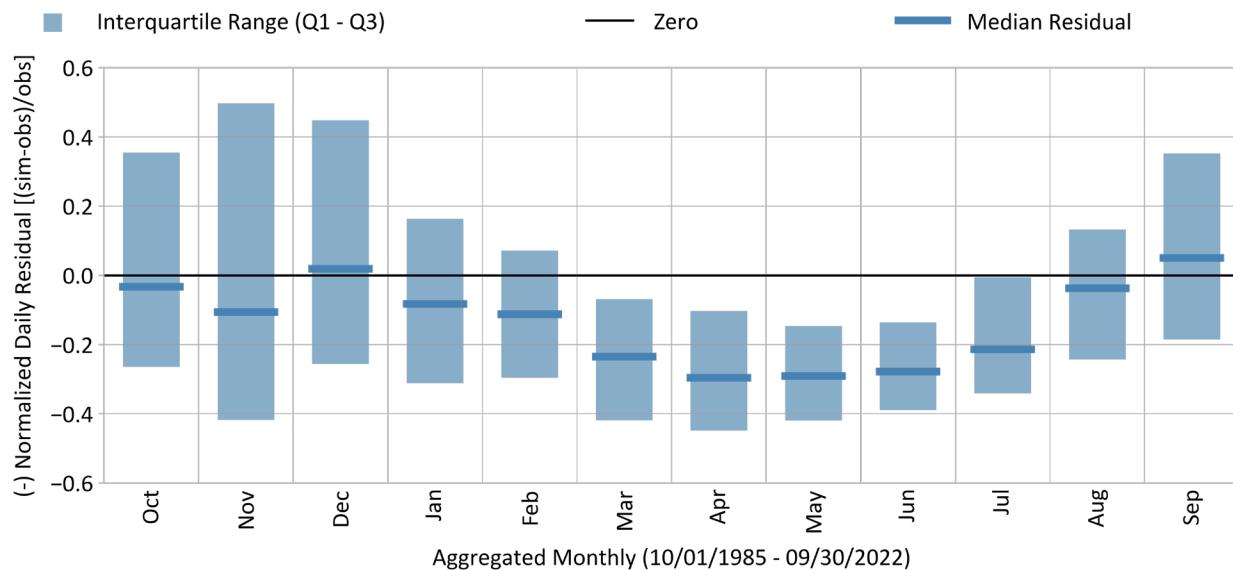


Figure 15. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: Standardized temporal residual boxplot.

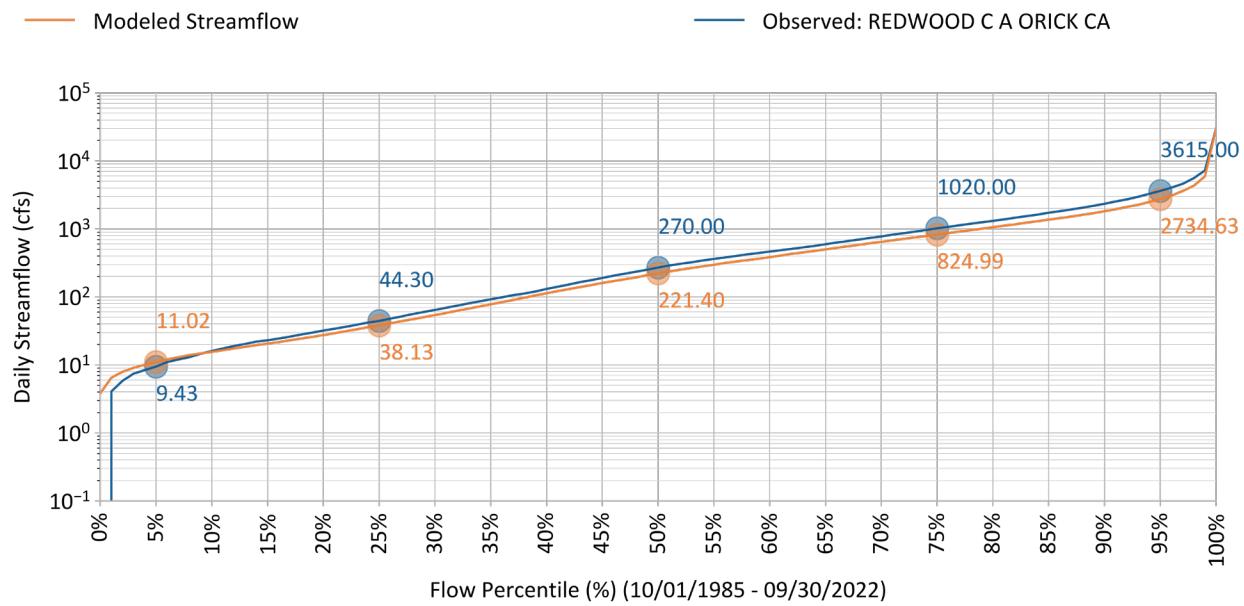


Figure 16. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: Simulated vs. observed streamflow duration curves.

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Table 6. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: Relative mean error statistical metric for predicted vs observed volumes

		Observed vs Simulated Calibration Performance for Runoff Volumes (Simulated vs Observed Total Volume for Condition-Season across Simulation)		
Calibration Metrics (10/01/1985 - 09/30/2022)		Relative Mean Error (RME)		
		All Seasons	Wet Season	Dry Season
Total Annual Volume	-20.7%	-20.2%	-25.2%	
Highest 10% of Flows	-26.4%	-26.4%	-25.6%	
Lowest 50% of Flows	-6.8%	16.3%	-19.1%	
Storm Volume	-29.8%	-29.3%	-38.6%	
Baseflow Volume	-14.7%	-13.7%	-21.3%	
Baseflow Recession Rate	1.6%	1.9%	1.4%	

Performance Metric	Hydrological Condition	Comparison Type	Performance Threshold for Hydrology Simulation				Reference
			Very Good	Good	Satisfactory	Unsatisfactory	
Relative Mean Error (RME)	Total Annual Volume	Compare Observed vs Simulated Total Volume across Simulation Period for Selected Season-Conditions	≤5%	5 - 10%	10 - 15%	>15%	Donigian et al. (1984), Lumb et al. (1984), and Donigian (2000)
	Seasonal Volume		≤10%	10 - 15%	15 - 25%	>25%	
	Highest 10% of Flows		≤10%	10 - 15%	15 - 25%	>25%	
	Lowest 50% of Flows		≤10%	10 - 15%	15 - 25%	>25%	
	Annual Storm Volume		≤10%	10 - 15%	15 - 25%	>25%	
	Seasonal Storm Volume		≤15%	15 - 30%	30 - 50%	>50%	
	Baseflow Volume		≤10%	10 - 15%	15 - 25%	>25%	
	Baseflow Recession Rate		≤3%	3 - 5%	5 - 10%	>10%	

Table 7. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: Percent bias statistical metric for predicted vs observed volumes

		Observed vs Simulated Calibration Performance for Flow Rates (Simulated vs Observed Flow Rates for Condition-Season across Simulation)		
Calibration Metrics (10/01/1985 - 09/30/2022)		Percent Bias (PBIAS)		
		All Seasons	Wet Season	Dry Season
All Conditions	20.7%	20.2%	25.2%	
Highest 10% of Daily Flow Rates	26.4%	26.4%	25.6%	
Lowest 50% of Daily Flow Rates	6.8%	-16.3%	19.1%	
Days Categorized as Storm Flow	23.0%	22.5%	30.9%	
Days Categorized as Baseflow	17.5%	16.6%	22.4%	

Performance Metric	Hydrological Condition	Comparison Type	Performance Threshold for Hydrology Simulation				Reference
			Very Good	Good	Satisfactory	Unsatisfactory	
Percent Bias (PBIAS)	All Conditions	Compare All Observed vs Simulated Daily Flow Rates that Occur During Selected Season-Conditions	<5%	5% - 10%	10% - 15%	>15%	Moriasi et al. (2015)
	Seasonal Flows						
	Highest 10% of Daily Flow Rates						
	Lowest 50% of Daily Flow Rates						
	Days Categorized as Storm Flow						
	Days Categorized as Baseflow						

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Table 8. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: R² statistical metric for predicted vs observed volumes

		Observed vs Simulated Calibration Performance for Flow Rates (Simulated vs Observed Flow Rates for Condition-Season across Simulation)		
Calibration Metrics (10/01/1985 - 09/30/2022)		R-Squared (R ²)		
		All Seasons	Wet Season	Dry Season
All Conditions	0.8	0.77	0.86	
Highest 10% of Daily Flow Rates	0.54	0.54	0.16	
Lowest 50% of Daily Flow Rates	0.64	0.57	0.84	
Days Categorized as Storm Flow	0.76	0.74	0.8	
Days Categorized as Baseflow	0.86	0.82	0.92	

Performance Metric	Hydrological Condition	Comparison Type	Performance Threshold for Hydrology Simulation				Reference
			Very Good	Good	Satisfactory	Unsatisfactory	
R-Squared (R ²)	All Conditions	Compare All Observed vs Simulated Daily Flow Rates that Occur During Selected Season-Conditions	>0.85	0.75 - 0.85	0.60 - 0.75	≤0.60	Moriasi et al. (2015)
	Seasonal Flows						
	Highest 10% of Daily Flow Rates						
	Lowest 50% of Daily Flow Rates						
	Days Categorized as Storm Flow						
	Days Categorized as Baseflow						

Table 9. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: Nash-Sutcliffe efficiency statistical metric for predicted vs observed flow rates

		Observed vs Simulated Calibration Performance for Flow Rates (Simulated vs Observed Flow Rates for Condition-Season across Simulation)		
Calibration Metrics (10/01/1985 - 09/30/2022)		Nash-Sutcliffe Efficiency (E)		
		All Seasons	Wet Season	Dry Season
All Conditions	0.78	0.74	0.81	
Highest 10% of Daily Flow Rates	0.31	0.31	-3.22	
Lowest 50% of Daily Flow Rates	0.55	0.14	0.79	
Days Categorized as Storm Flow	0.74	0.72	0.75	
Days Categorized as Baseflow	0.83	0.79	0.87	

Performance Metric	Hydrological Condition	Comparison Type	Performance Threshold for Hydrology Simulation				Reference
			Very Good	Good	Satisfactory	Unsatisfactory	
Nash-Sutcliffe Efficiency (E)	All Conditions	Compare All Observed vs Simulated Daily Flow Rates that Occur During Selected Season-Conditions	>0.80	0.70 - 0.80	0.50 - 0.70	≤0.50	Moriasi et al. (2015)
	Seasonal Flows						
	Highest 10% of Daily Flow Rates						
	Lowest 50% of Daily Flow Rates						
	Days Categorized as Storm Flow						
	Days Categorized as Baseflow						

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Table 10. REDWOOD C A ORICK CA (11482500) - Hydrology calibration: Key statistic metric

Statistic	Observed cfs	Simulated cfs	% Difference
Average Flow	856.808	684.8586	-20.07%
Minimum Flow	0.0	3.81	N/A
5th Percentile Flow	nan	11.02	nan%
10th Percentile Flow	nan	15.549	nan%
25th Percentile Flow	nan	38.1275	nan%
Median Flow	nan	221.405	nan%
75th Percentile Flow	nan	824.99	nan%
90th Percentile Flow	nan	1817.14	nan%
95th Percentile Flow	nan	2734.6255	nan%
Maximum Flow	30100.0	29966.68	-0.44%

7Q10	All Simulation	3.2781	5.7763	76.21%
	January	156.6918	168.213	7.35%
	February	264.8686	265.0916	0.08%
	March	297.5421	244.999	-17.66%
	April	224.3228	136.6267	-39.09%
	May	130.2821	79.9248	-38.65%
	June	53.8688	35.5757	-33.96%
	July	19.573	17.3755	-11.23%
	August	7.8988	9.3216	18.01%
	September	3.7712	6.7991	80.29%
	October	4.5502	5.7419	26.19%
	November	11.5399	10.225	-11.39%
	December	52.6042	60.464	14.94%

Separated Baseflow	Average	518.5655	443.0054	-14.57%
	25th Percentile	nan	31.57	nan%
	Median	nan	179.34	nan%
	75th Percentile	nan	632.68	nan%

Separated Stormflow	Average	339.7267	241.8531	-28.81%
	25th Percentile	nan	2.71	nan%
	Median	nan	21.32	nan%
	75th Percentile	nan	131.635	nan%