Modeling Functional Flows

to support CEFF implementation

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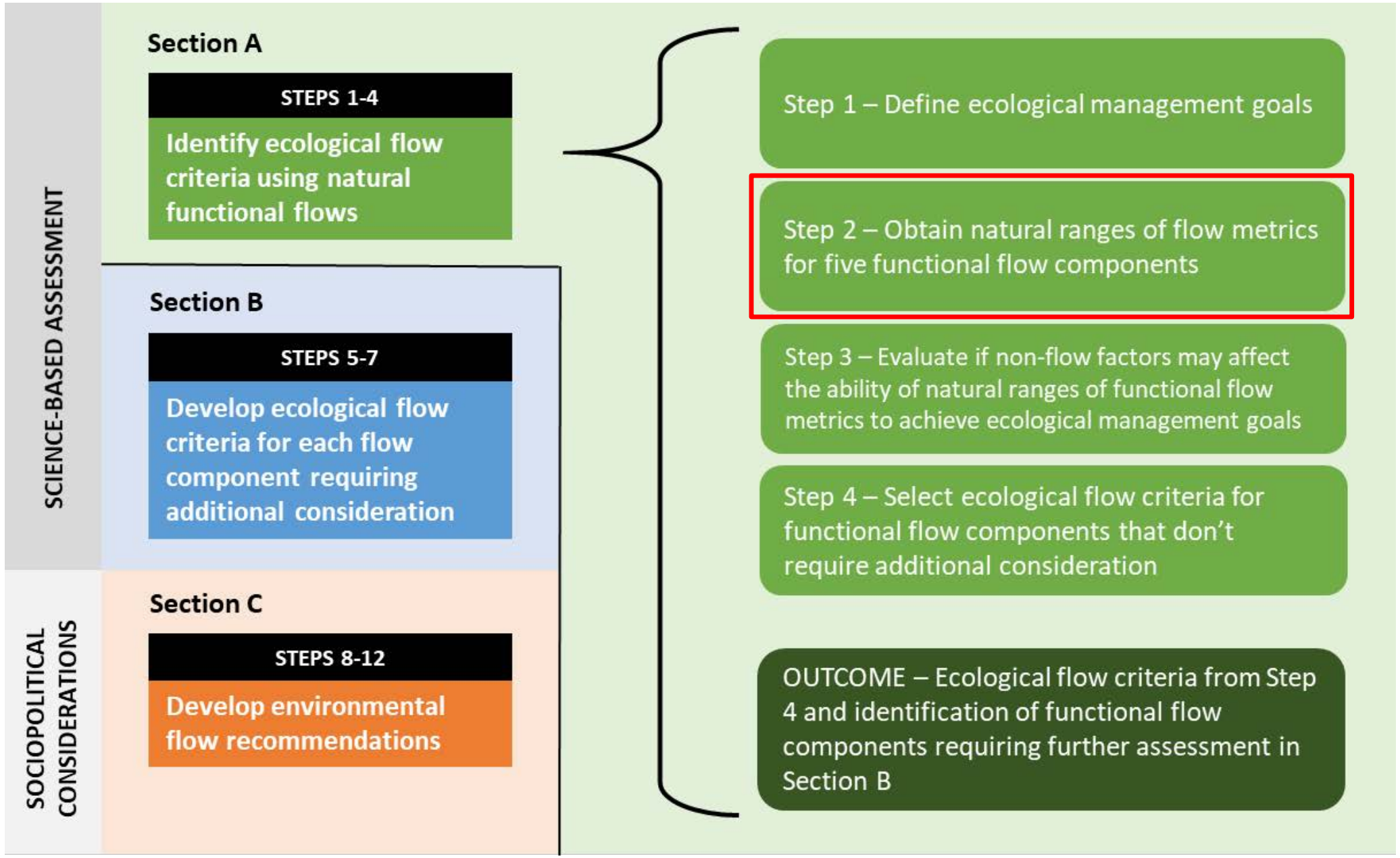
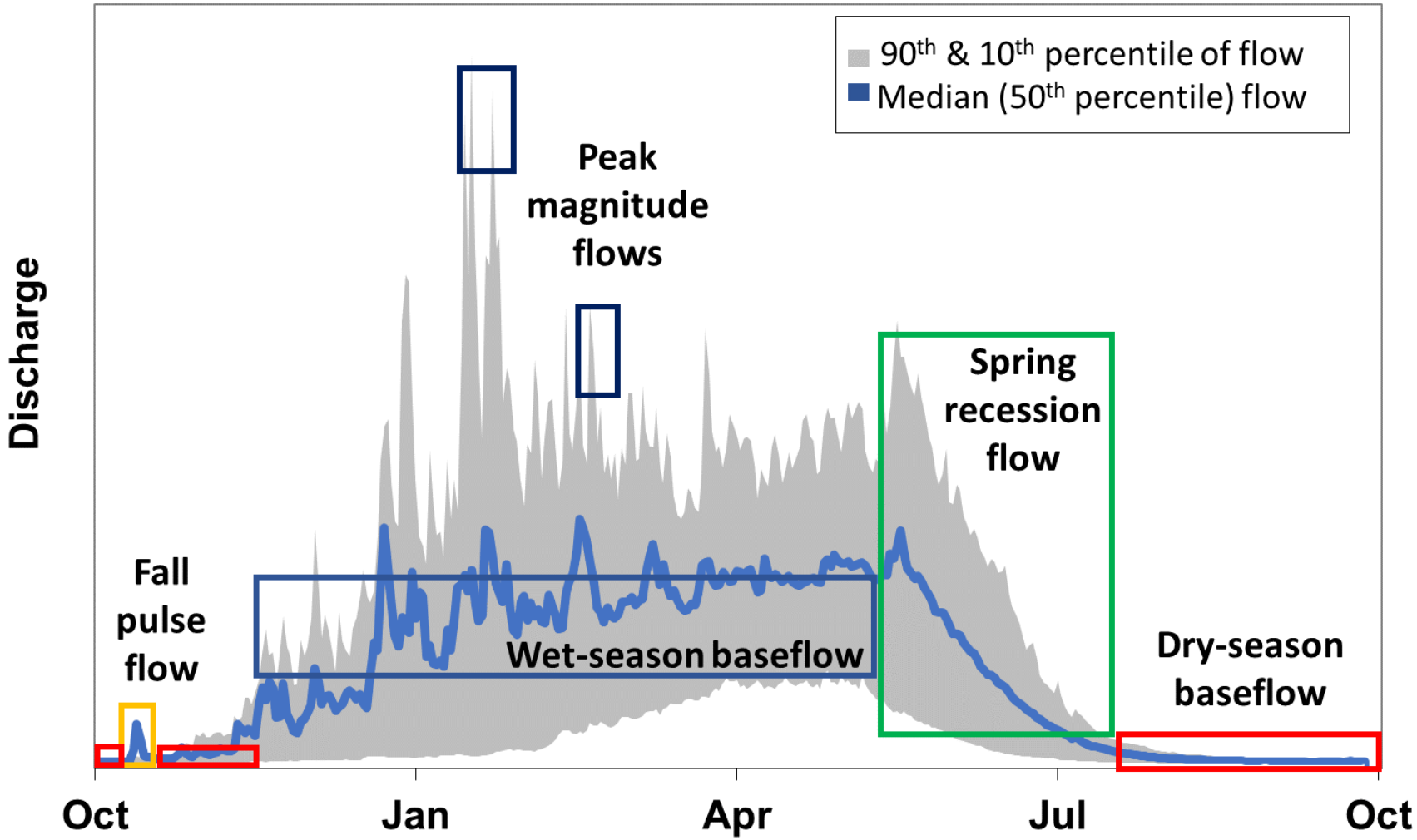
CABW Annual Conference
October 11, 2022

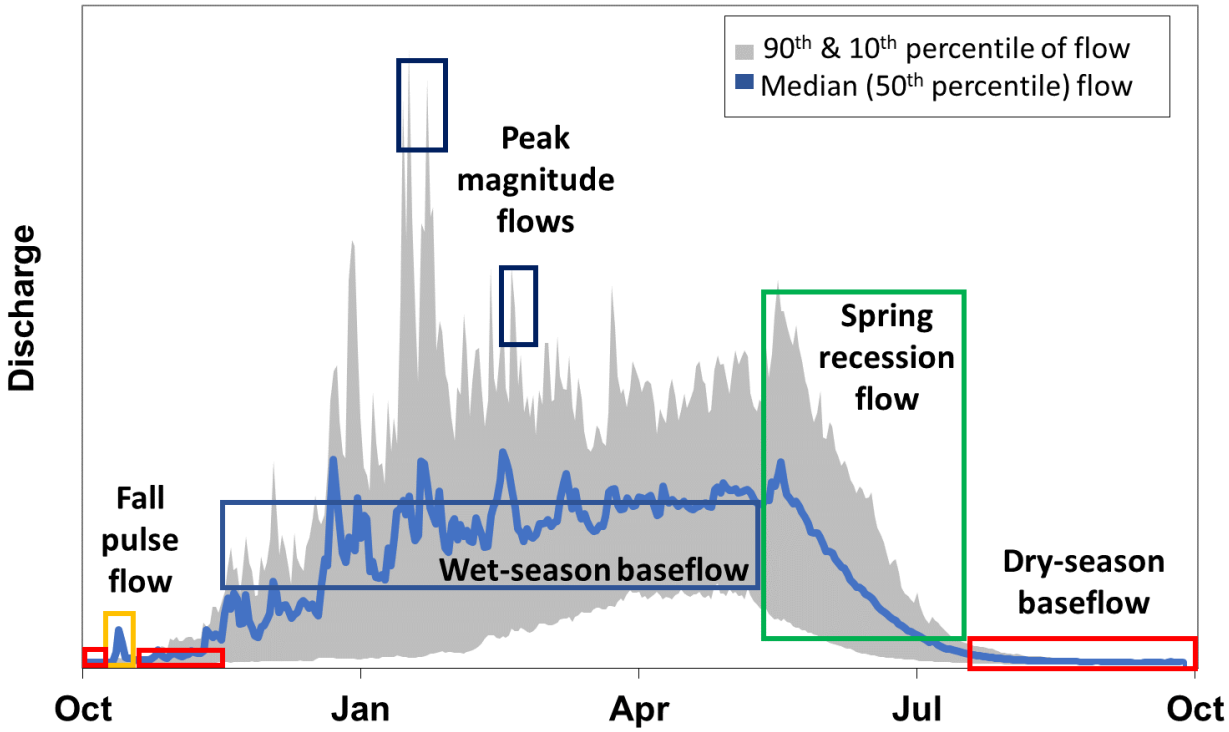

SCIENCE-BASED ASSESSMENT
SOCIOPOLITICAL CONSIDERATIONS
Section A
STEPS 1-4
Identify ecological flow criteria using natural functional flows
Section B
STEPS 5-7
Develop ecological flow criteria for each flow component requiring additional consideration
Section C
STEPS 8-12
Develop environmental flow recommendations
Step 1 – Define ecological management goals
Step 2 – Obtain natural ranges of flow metrics for five functional flow components
Step 3 – Evaluate if non-flow factors may affect the ability of natural ranges of functional flow metrics to achieve ecological management goals
Step 4 – Select ecological flow criteria for functional flow components that don't require additional consideration
OUTCOME – Ecological flow criteria from Step 4 and identification of functional flow components requiring further assessment in Section B

Functional Flow Components



Yarnell et al. 2020 *RRA*

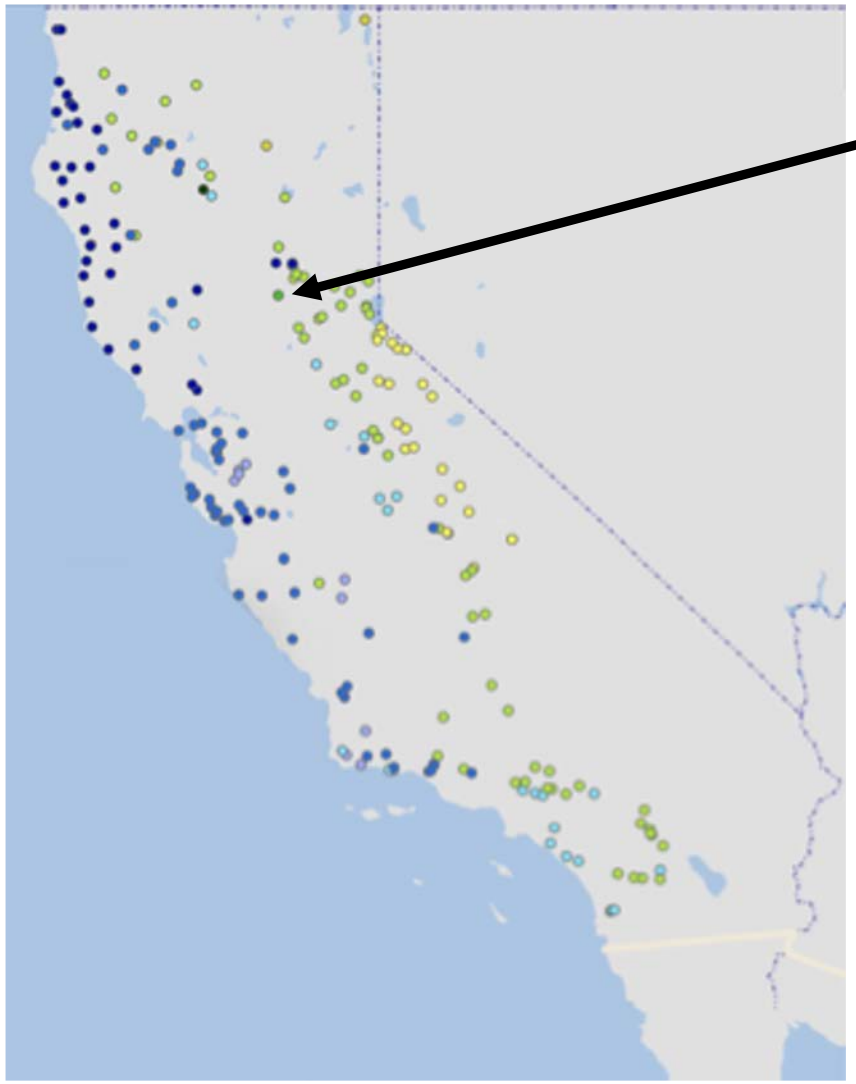
Functional Flow Metrics



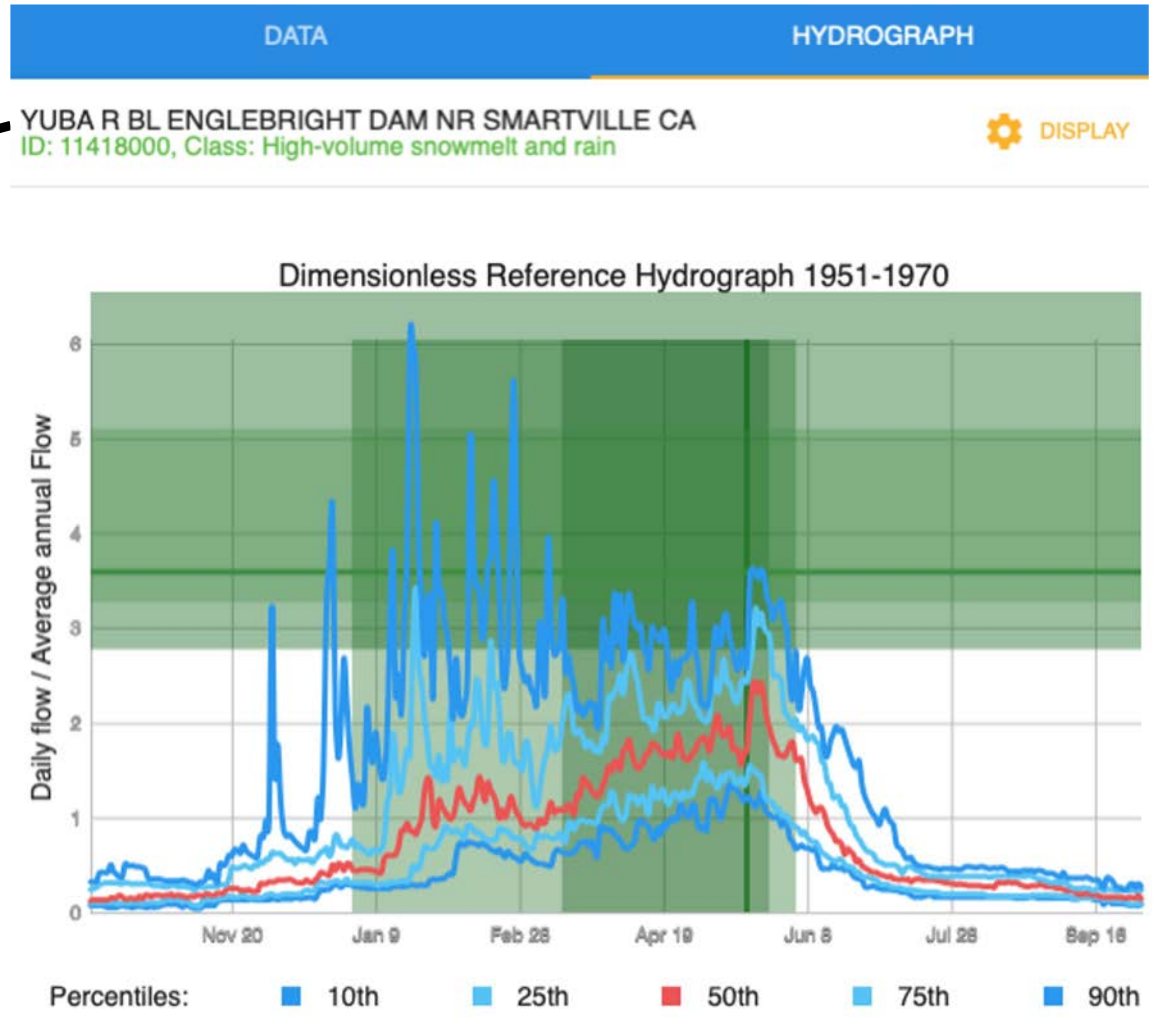
Metrics describe the magnitude, timing, duration, frequency, and rate-of-change of flow components

Flow Component	Flow Characteristic
Fall pulse flow	Magnitude (cfs)
	Timing (date)
	Duration (days)
Wet-season base flow	Magnitude (cfs)
	Timing (date)
	Duration (days)
Wet-season peak flow	Magnitude (cfs)
	Duration (days)
	Frequency
Spring recession flow	Magnitude (cfs)
	Timing (date)
	Duration (days)
	Rate of change (%)
Dry-season base flow	Magnitude (cfs)
	Timing (date)
	Duration (days)

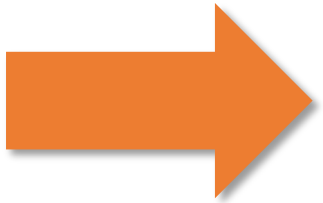
Functional Flow Calculator (eflows.ucdavis.edu)



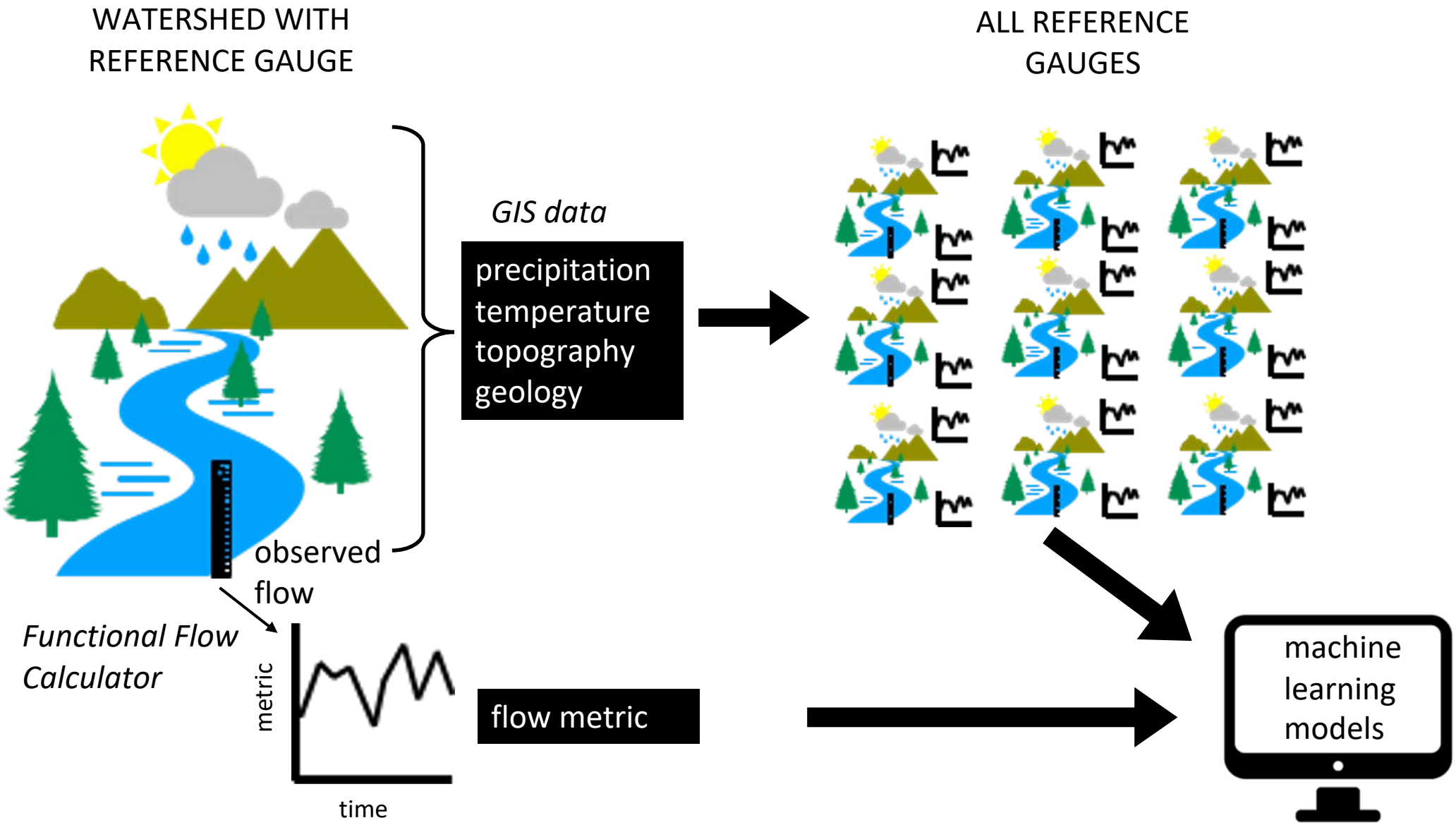
California Reference Gages (n = 223)



The Challenge…



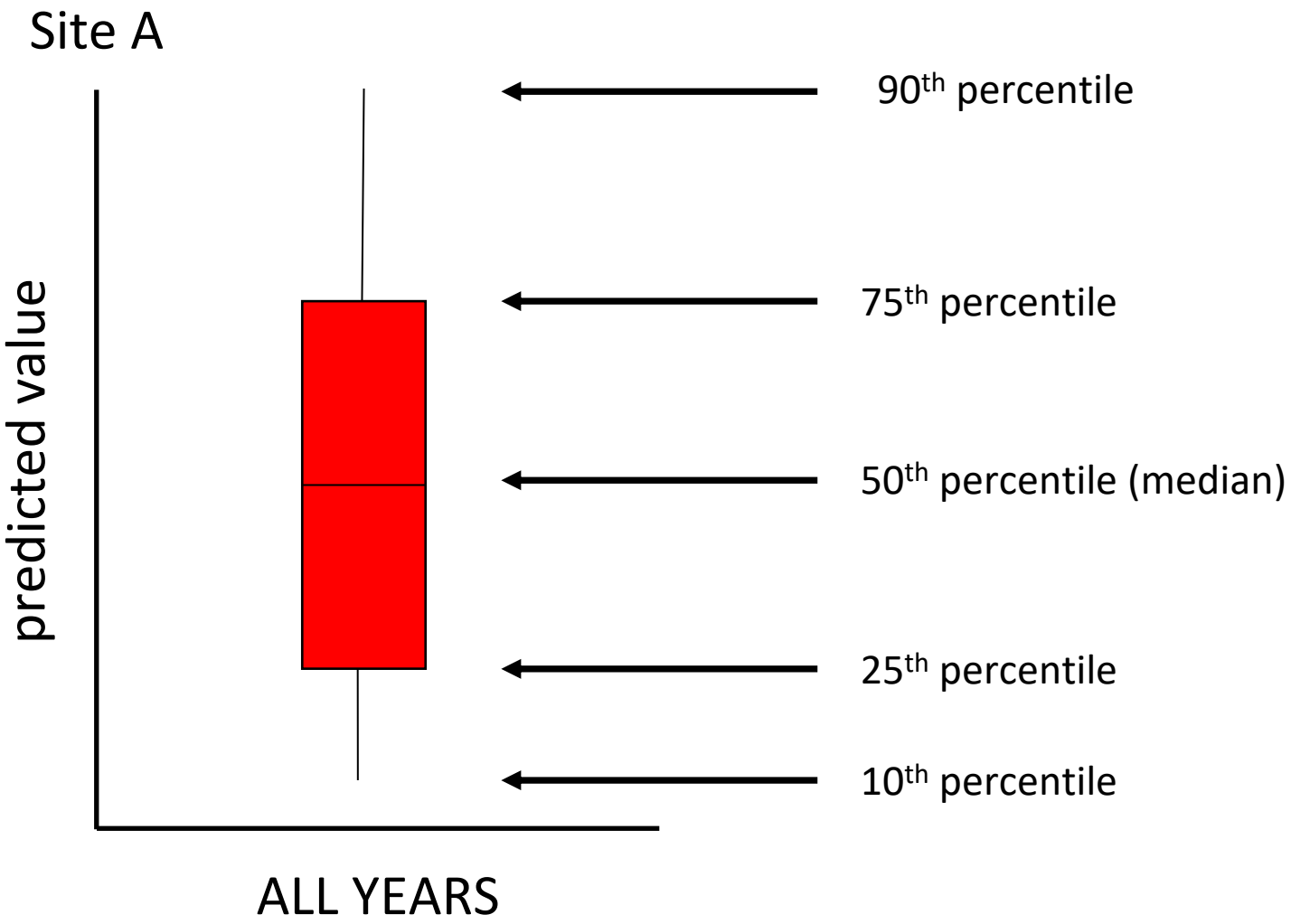
Functional Flow Metric Modeling Approach



Functional Flow Metrics

Flow Component	Flow Characteristic	Flow metrics
Fall pulse flow	Magnitude (cfs)	Peak magnitude of pulse flow
	Timing (date)	Timing of fall pulse flow
	Duration (days)	Duration of pulse flow
Wet-season base flow	Magnitude (cfs)	Magnitude of baseflow (50^{th} and 90^{th} percentile of daily flow)
	Timing (date)	Wet season start timing
	Duration (days)	Wet season duration
Wet-season peak flow	Magnitude (cfs)	Magnitude of peak flow (2-, 5- and 10-year recurrence interval)
	Duration (days)	Duration of 2-, 5-, and 10-year recurrence interval peak flow
	Frequency	Number of days of 2-, 5-, and 10-year peak flow within year
Spring recession flow	Magnitude (cfs)	Peak magnitude of spring flow
	Timing (date)	Spring recession timing
	Duration (days)	Spring recession duration
	Rate of change (%)	Spring recession rate-of-change
Dry-season base flow	Magnitude (cfs)	Magnitude of baseflow (10^{th} and 50^{th} percentile of daily flow)
	Timing (date)	Dry season timing
	Duration (days)	Dry season duration

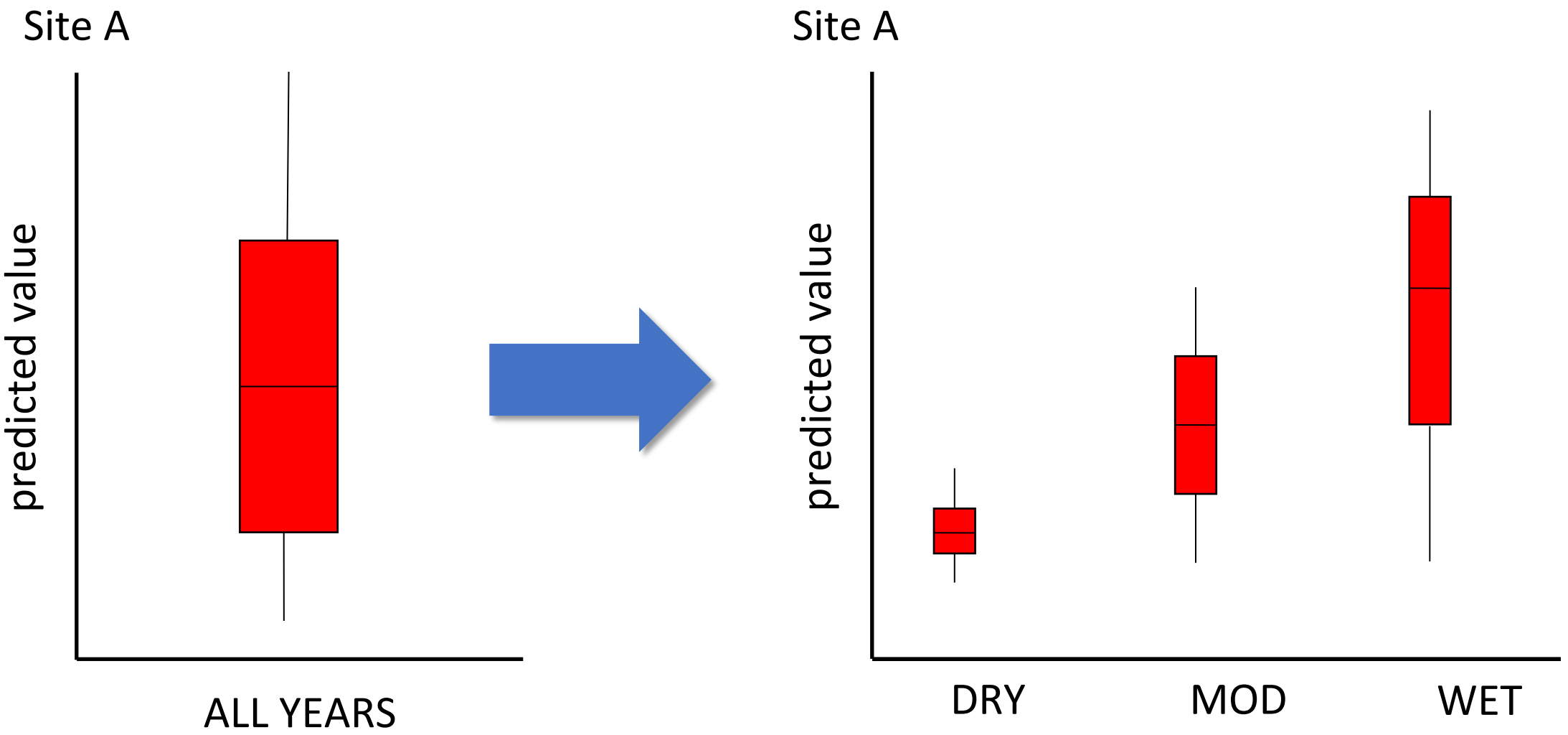
Functional Flow Metric Model Predictions



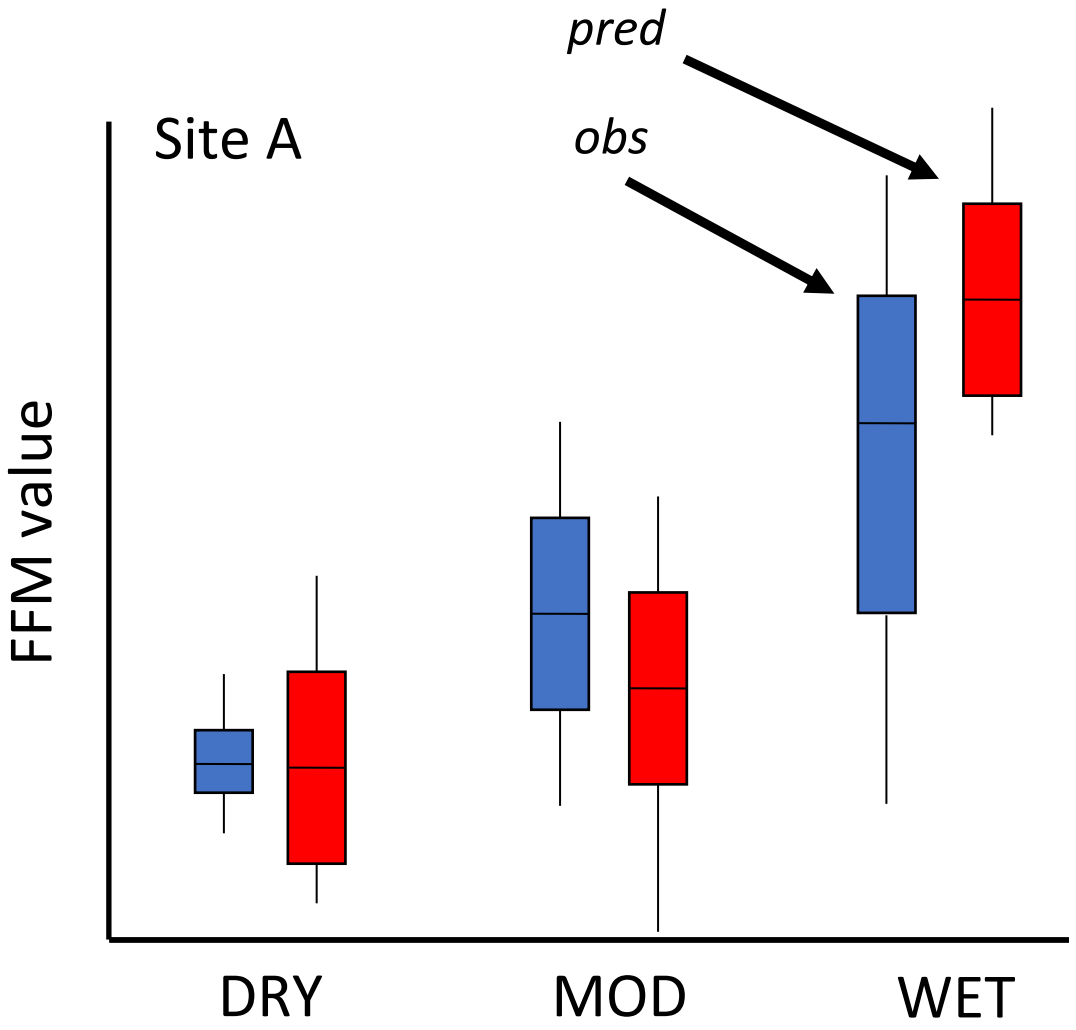
Aggregate annual model predictions to estimate:

expected natural range of flow conditions at a site (over a "long term" period)

Functional Flow Metric Model Predictions



Functional Flow Metric Model Evaluation



1. Screen out sites with limited number of observed values (< 15-20 years)
2. Plot range of predicted values with range of observed values
3. Evaluate differences in between predicted and observed values, by several criteria
   - Percent observations within predicted range
   - Observed divided by predicted median value
   - Correlation coefficient (r^2)
   - Nash-Sutcliffe Efficiency (NSE)
   - Percent bias

Composite Measure of Model Performance

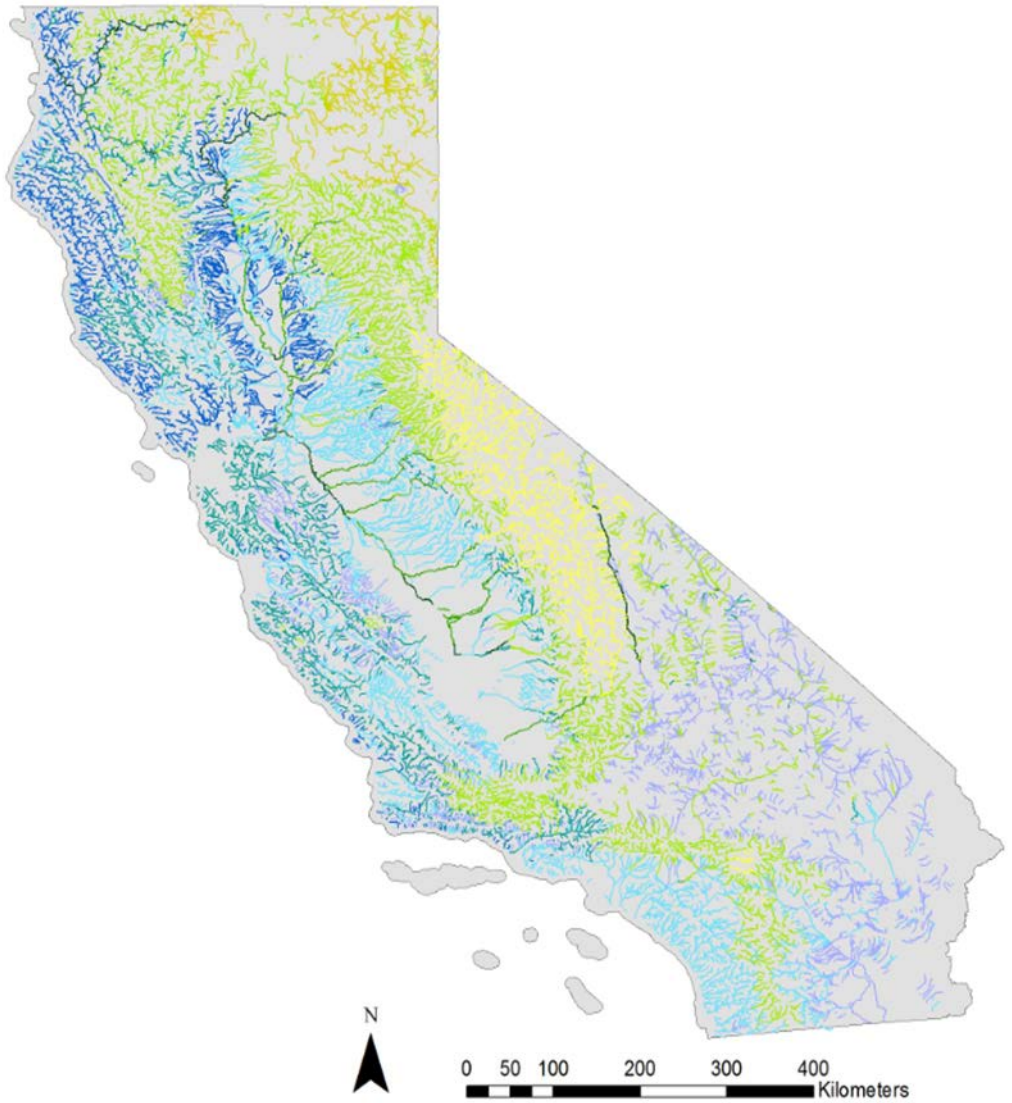
- Scale all performance criteria from 0-1 and calculate average

Excellent	> 0.9
Very Good	0.81 – 0.90
Good	0.65 – 0.81
Fair	0.50 – 0.64
Poor	<0.5

Flow Component	Flow Characteristic	Performance
Fall pulse flow	Magnitude (cfs)	Very Good
	Timing (date)	Good
	Duration (days)	Good
Wet-season base flow	Magnitude (cfs) – 10th percentile	Excellent
	Magnitude (cfs) – 50th percentile	Very Good
	Timing (date)	Very Good
	Duration (days)	Very Good
Peak flow	Magnitude (cfs) – 2, 5, 10-yr rec. int.	Excellent
	Duration (days) – 2, 5, 10-yr rec. int.	Very Good
	Frequency – 2, 5, 10-yr rec. int.	Good
Spring recession flow	Magnitude (cfs)	Very Good
	Timing (date)	Very Good
	Duration (days)	Very Good
	Rate of change (%)	Very Good
Dry-season base flow	Magnitude (cfs) – 50th percentile	Excellent
	Magnitude (cfs) – 90th percentile	Excellent
	Timing (date)	Very Good
	Duration (days)	Very Good

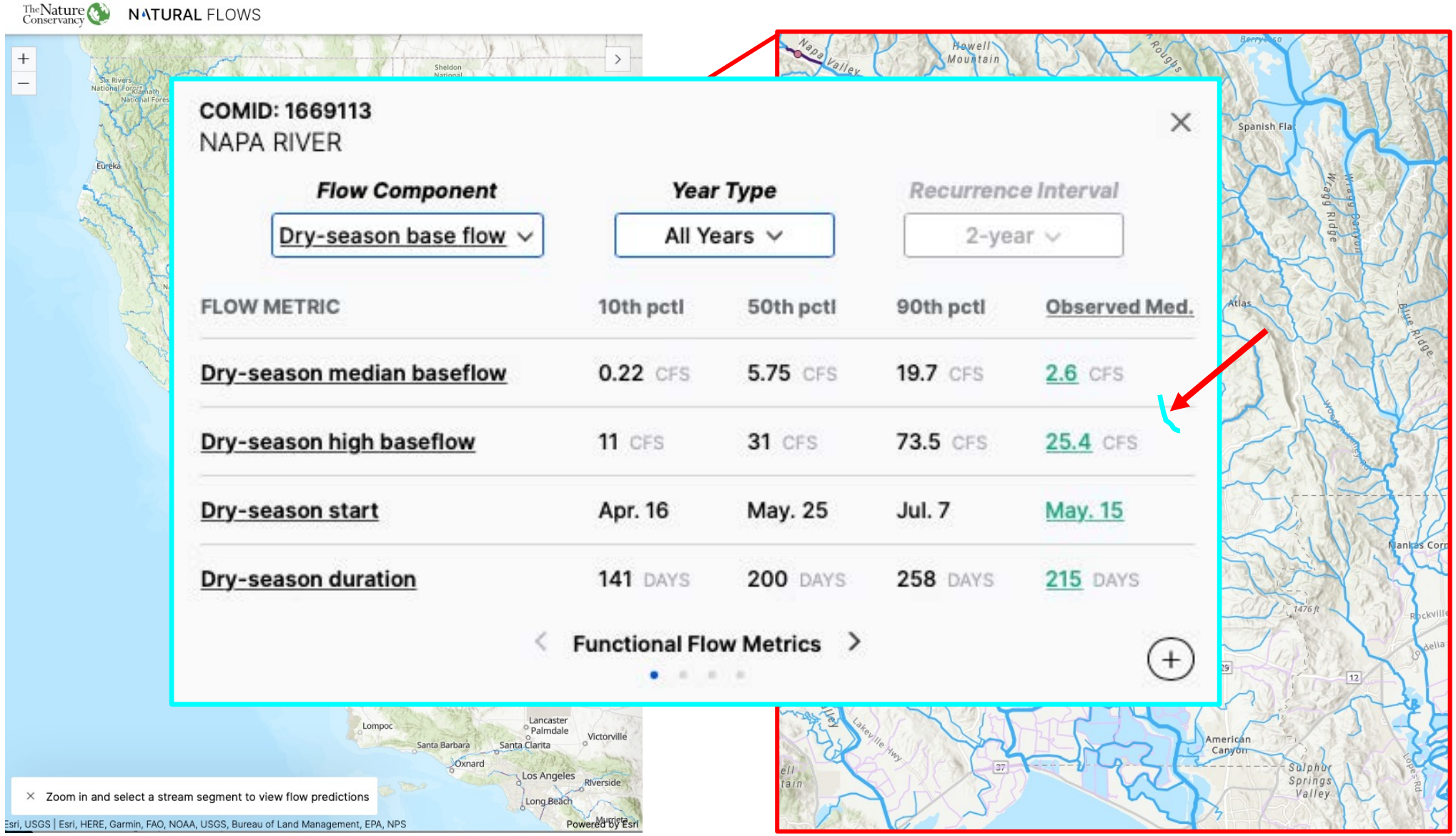
Modeled natural functional flows

- Predictions of natural functional flow metric ranges at every stream in the state
- Hydrologic models predictions used for 16 metrics and observed, reference-gage data used for 8 metrics
- Ranges reported by water-year type for most metrics



Natural Flows Database

rivers.codefornature.org



See 2022 publication for details (open-access)

frontiers in Environmental Science

ORIGINAL RESEARCH
published: 11 March 2022
doi: 10.3389/fenvs.2022.787473

Check for updates

Modeling Functional Flows in California's Rivers

Theodore E. Grantham[1,2], Daren M. Carlisle[3], Jeanette Howard[4], Belize Lane[5], Robert Lusardi[6,7], Alyssa Obester[8], Samuel Sandoval-Solis[2,9], Bronwen Stanford[8], Eric D. Stein[10], Kristine T. Taniguchi-Quan[10], Sarah M. Yarnell[6] and Julie K. H. Zimmerman[4]*

Summary

- We can predict most functional flow metrics with ”good” accuracy
- Functional flow metric predictions have been generated for all streams in the state
- Functional flow predictions have been embedded in **California Environmental Flows Framework** to guide development of environmental flow recommendations
- Site-specific assessments will help to identify strengths and weaknesses in approach and guide future efforts to improve models

Acknowledgements

CEFF Technical Team and Participants in the E-Flows Workgroup

Daren Carlisle (USGS)

Funding from State Water Board