California Environmental Flows Framework

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Prepared by:

California Environmental Flow Working Group, a committee of the California Water Quality Monitoring Council

Funded by:

State Water Resources Control Board, Division of Water Rights

November XX 2020

CEFF TECHNICAL TEAM

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- Sam Sandoval-Solis – University of California, Davis
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CA Environmental Flows Framework (CEFF)

Provides technical guidance for managers to efficiently develop scientifically defensible environmental flow recommendations following a functional flows approach.

Multi-step process to define:

- **Ecological flow criteria:** metrics that describe the range of flows that must be maintained within a stream and its margins to support the natural functions of healthy ecosystems
- **Environmental flow recommendations:** metrics that consider human uses and other management objectives along with ecological flow criteria

Guidance document now available: *ceff.ucdavis.edu*

Environmental Flow Methodologies

By 2002, Over 200 methods and broader frameworks existed to assess water requirements and support flow management (Tharme 2003)

DeSabla powerhouse
Butte Creek, CA

- **Hydrologic (flow)**
- **Hydraulic (flow + stage & velocity)**
- **Habitat-based (physical + biological)**
- **Holistic (entire ecosystem)**

So what's the Problem?

Flow-ecology relationships are:

- described for a limited set of flow metrics
- averaged over the flow record
- often single species focused
- static, not time variable
- not process-based
- don't account for shifting baselines

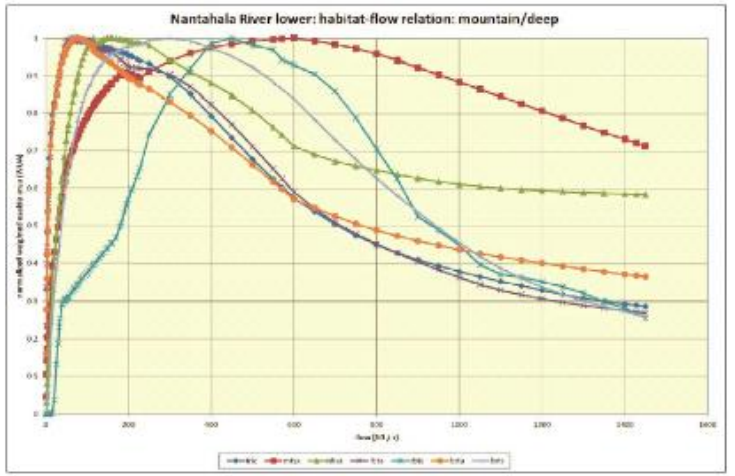
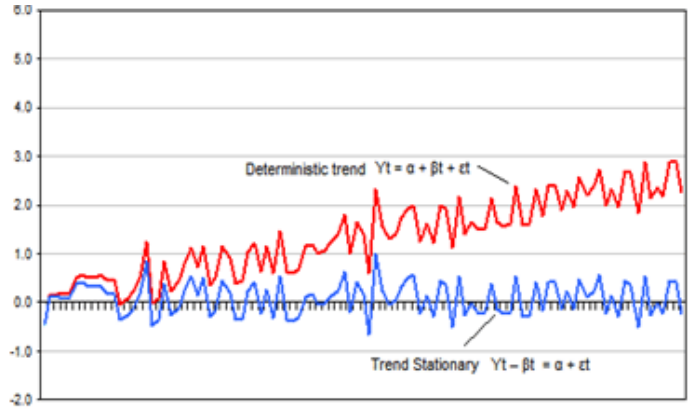


Figure 3. Example of WUA habitat-discharge relation (mountain-deep species/life stages) output from PHABSIM modeling.

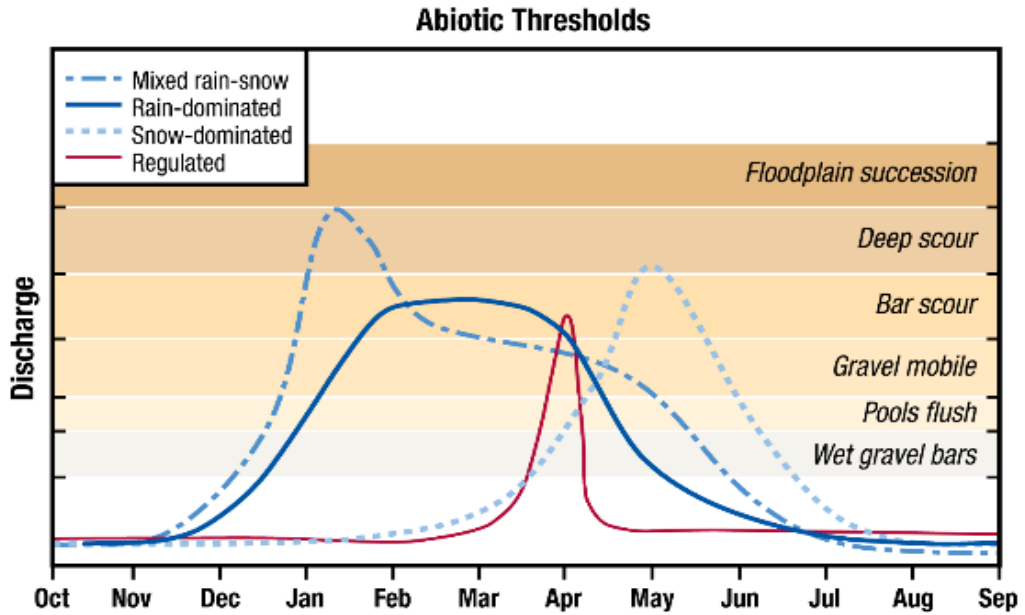


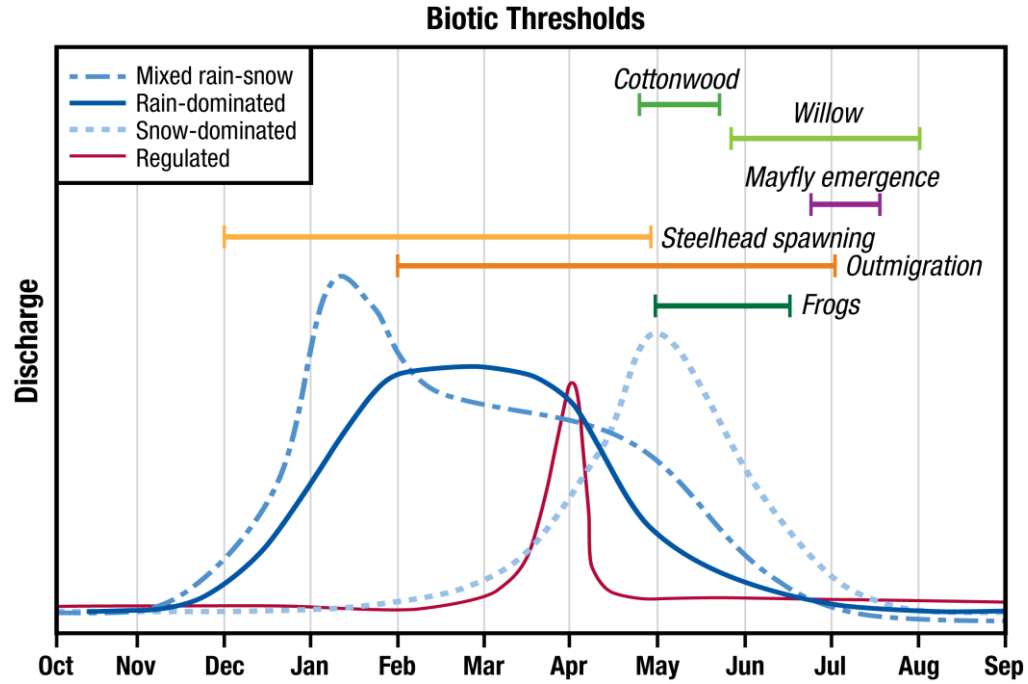
Functional Flows Approach

Environmental Flows - focus on hydrograph flow components that:

- Support natural disturbances
- Promote physical dynamics
- Drive ecosystem functions
- Support high biodiversity

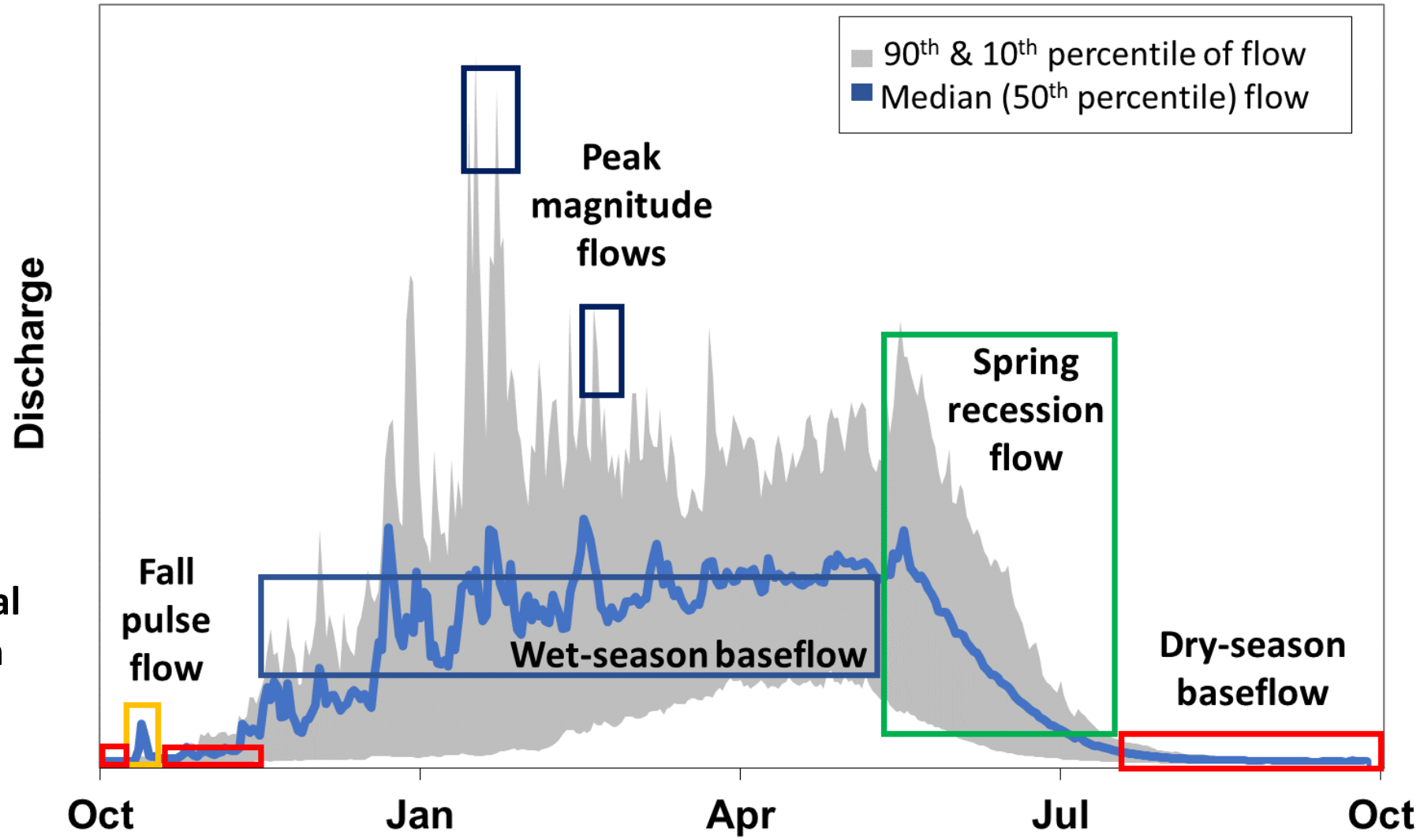
Consideration of geomorphic setting and channel-floodplain dynamics





Yarnell et al. 2010

Functional Flows in California

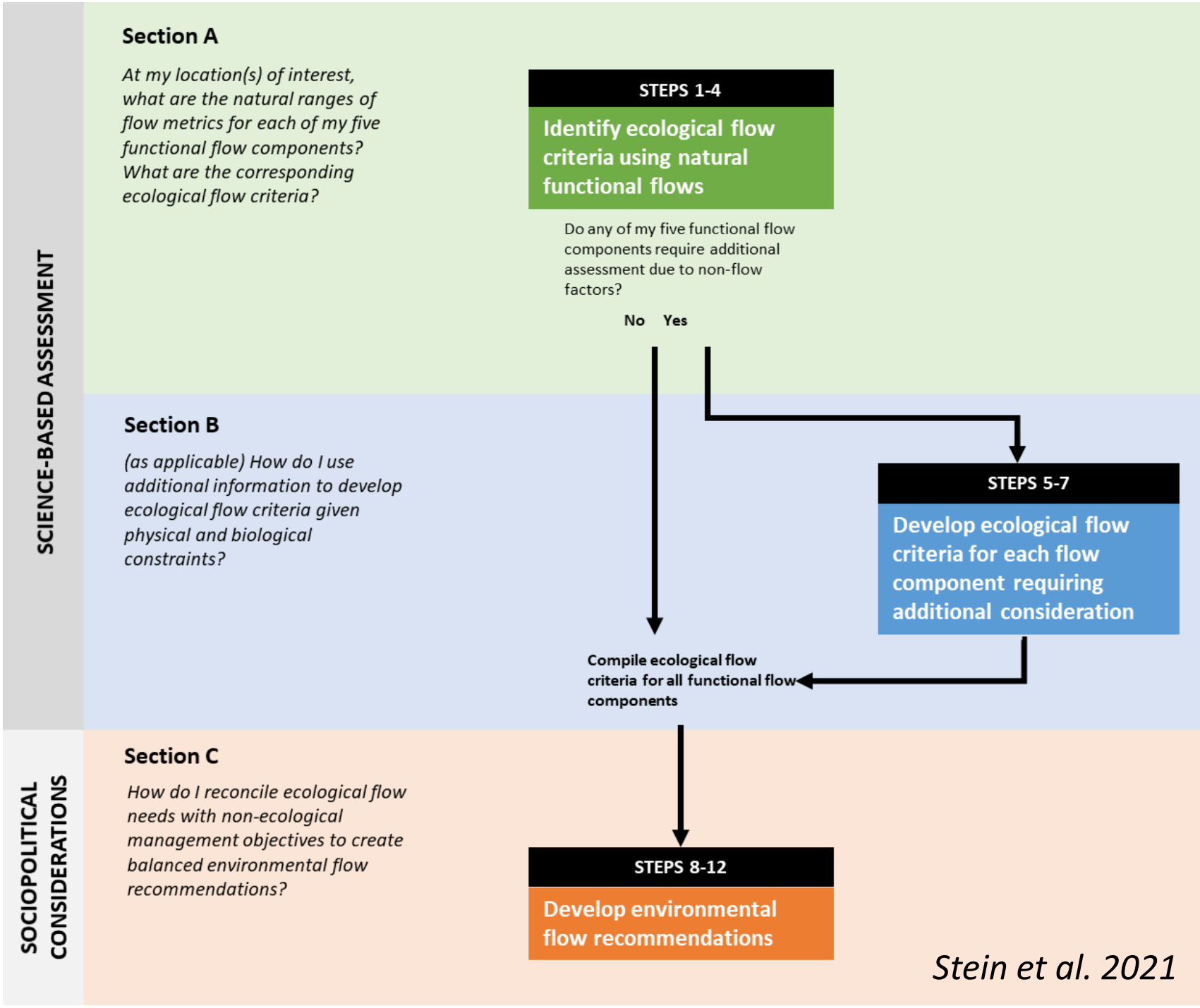


Metrics relate to general stream health based on *natural flow conditions*

Yarnell et al. 2020 RRA

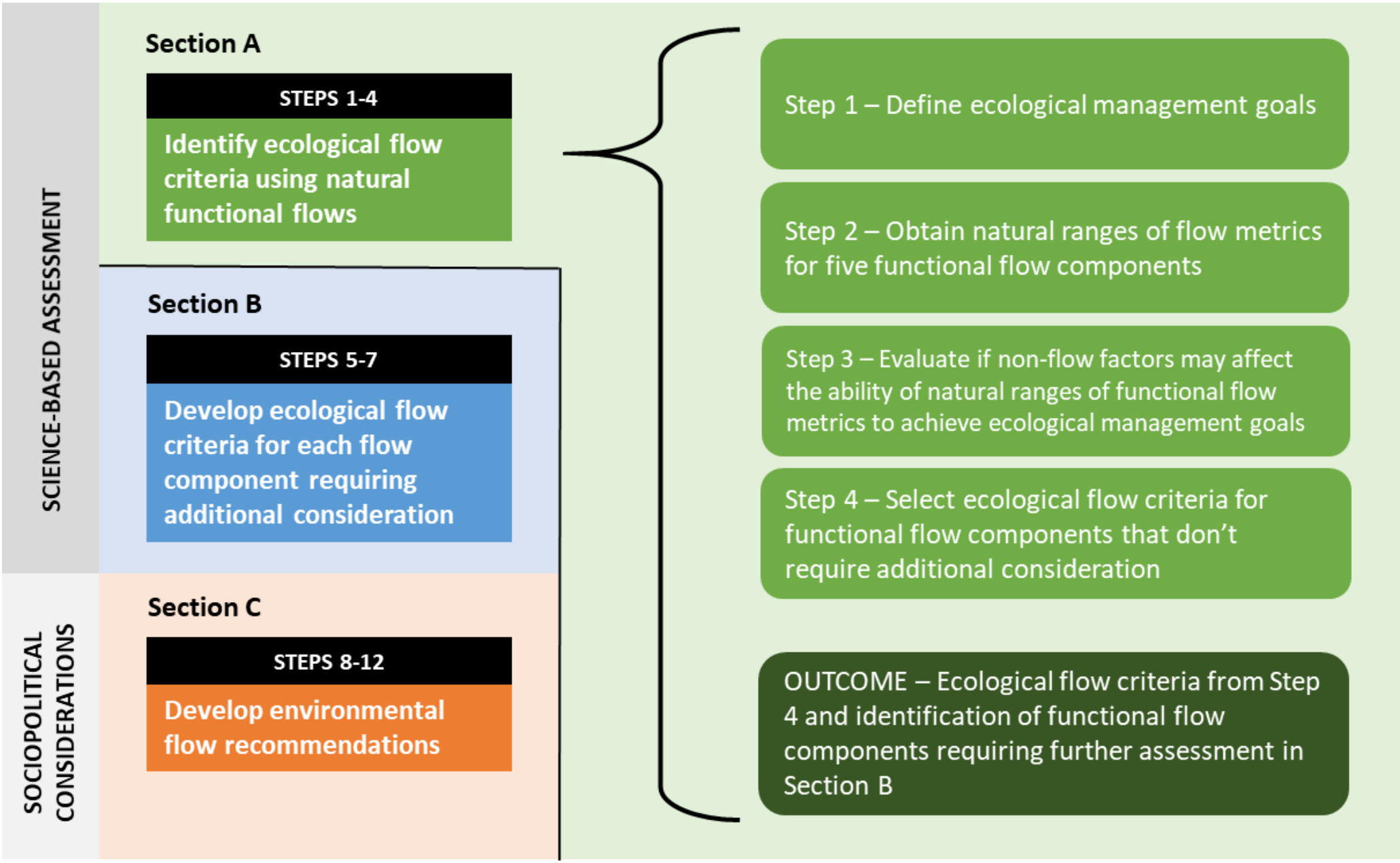
CEFF Steps Overview

ceff.ucdavis.edu

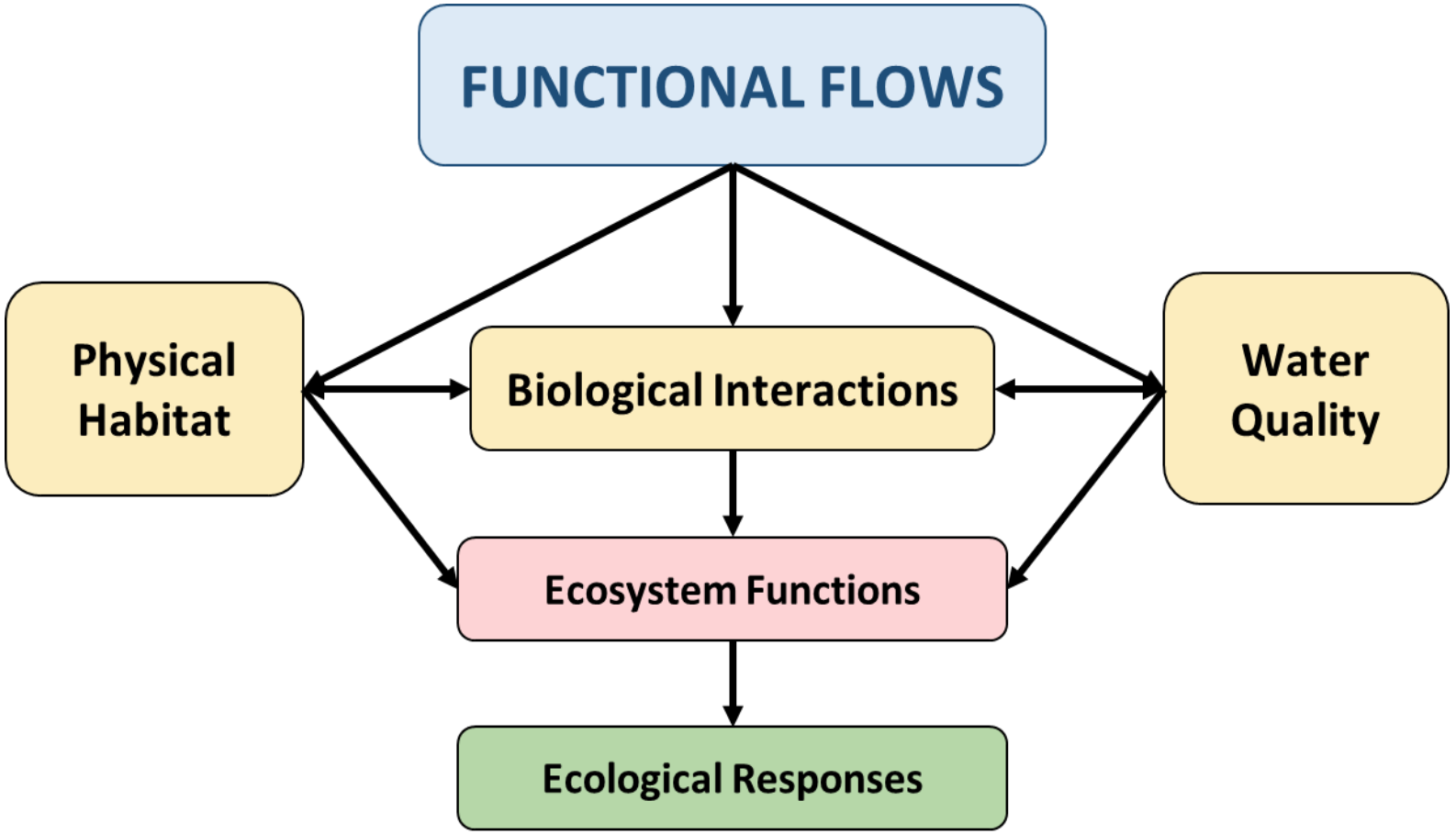


Stein et al. 2021

CEFF Section A



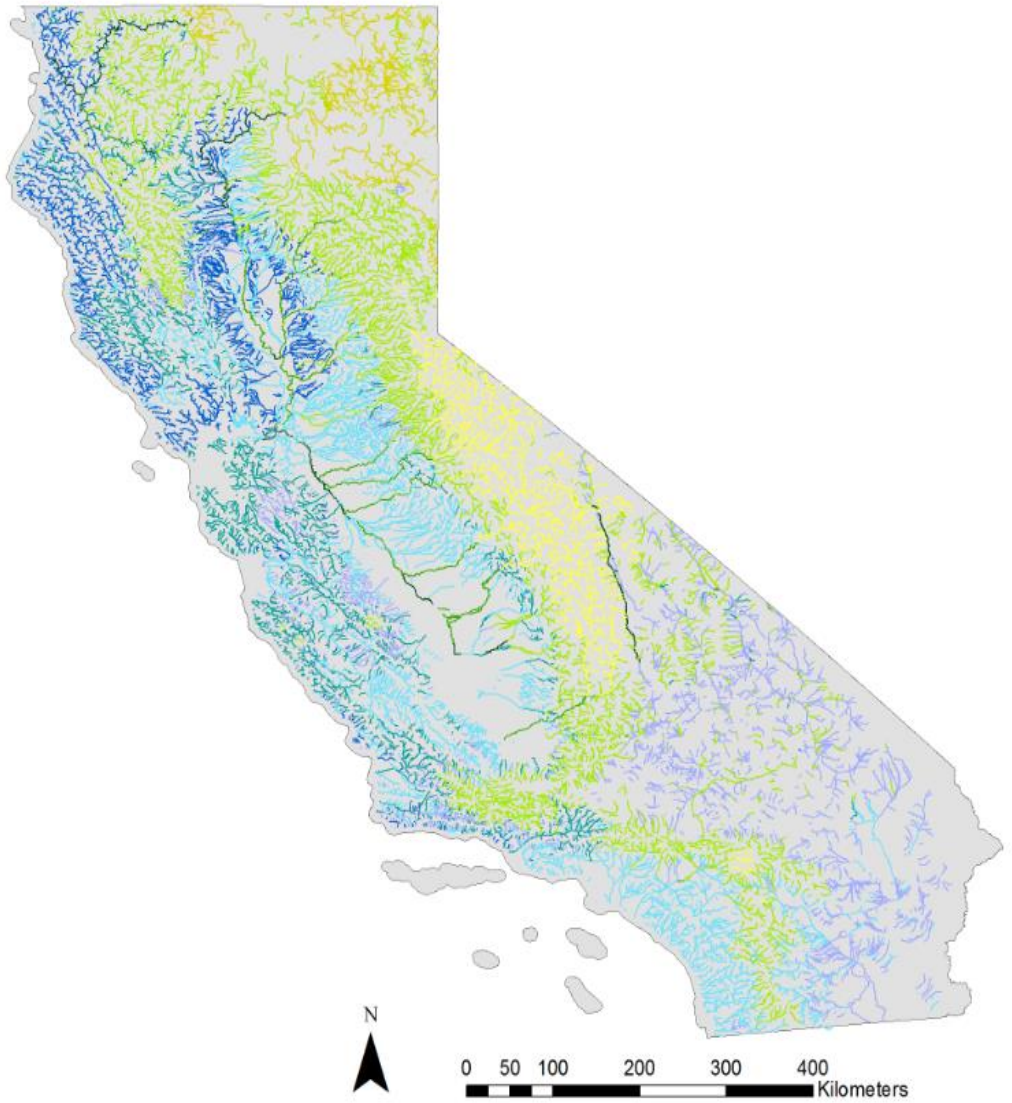
Using Natural Flows to Set Ecological Flow Criteria in Section A



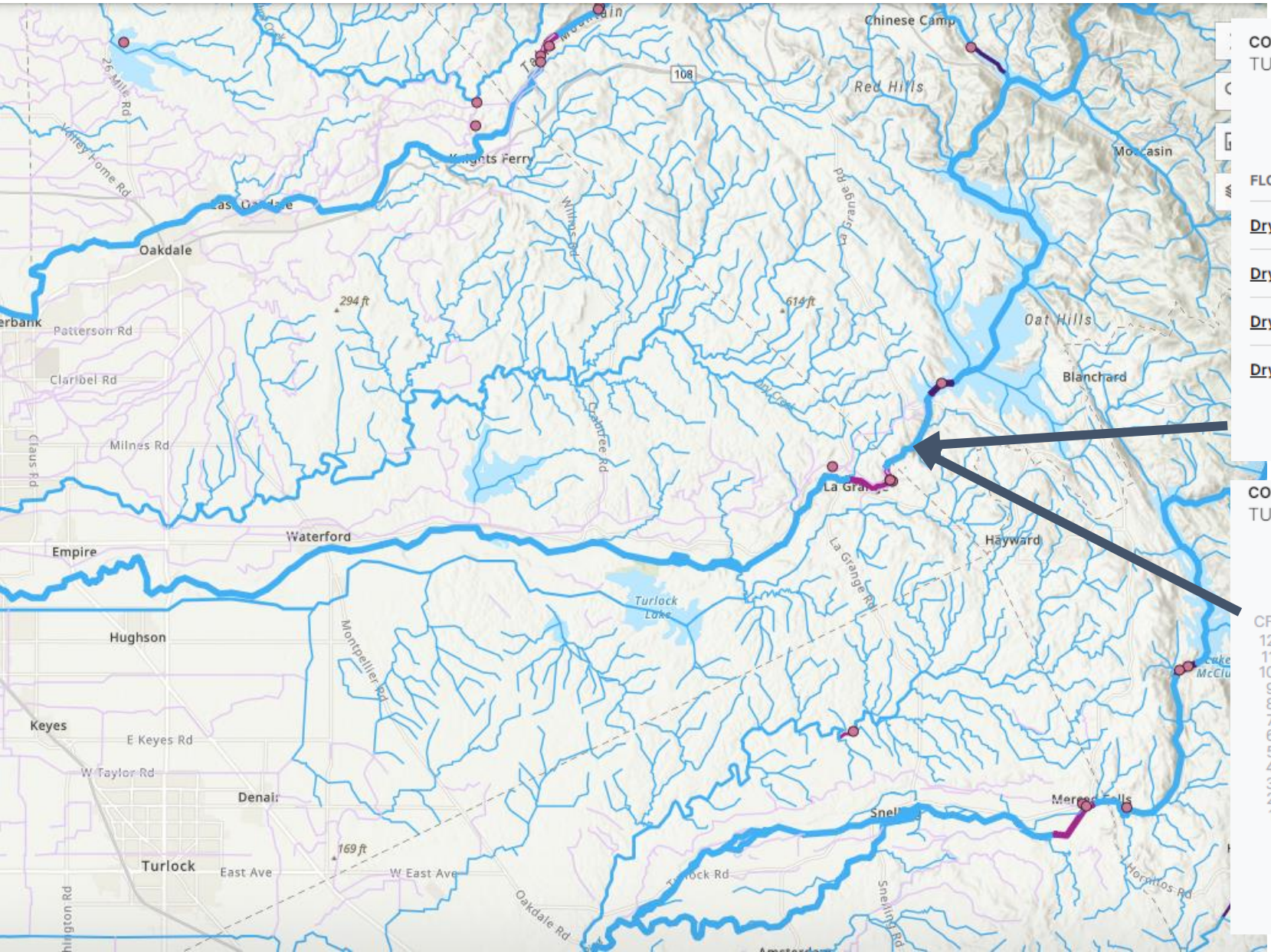
Modeled Natural Functional Flows

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

Grantham et al. 2022 FES



Natural Flows Web Tool: rivers.codefornature.org



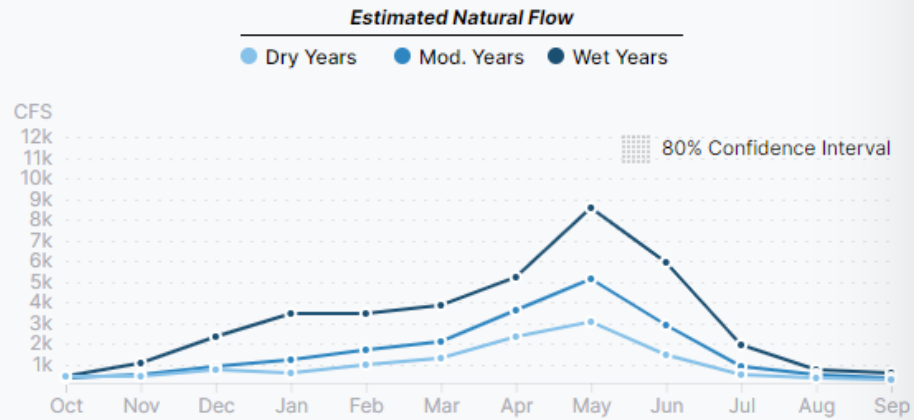
COMID: 17080381
TUOLUMNE RIVER

Flow Component	Year Type	Recurrence Interval
Dry-season base flow	All Years	2-year

FLOW METRIC	10th pctl	50th pctl	90th pctl	Observed Med.
Dry-season baseflow	189 CFS	526 CFS	862 CFS	-
Dry-season high baseflow	383 CFS	901 CFS	1,690 CFS	-
Dry-season start	Jul. 10	Jul. 29	Aug. 29	-
Dry-season duration	108 DAYS	160 DAYS	215 DAYS	-

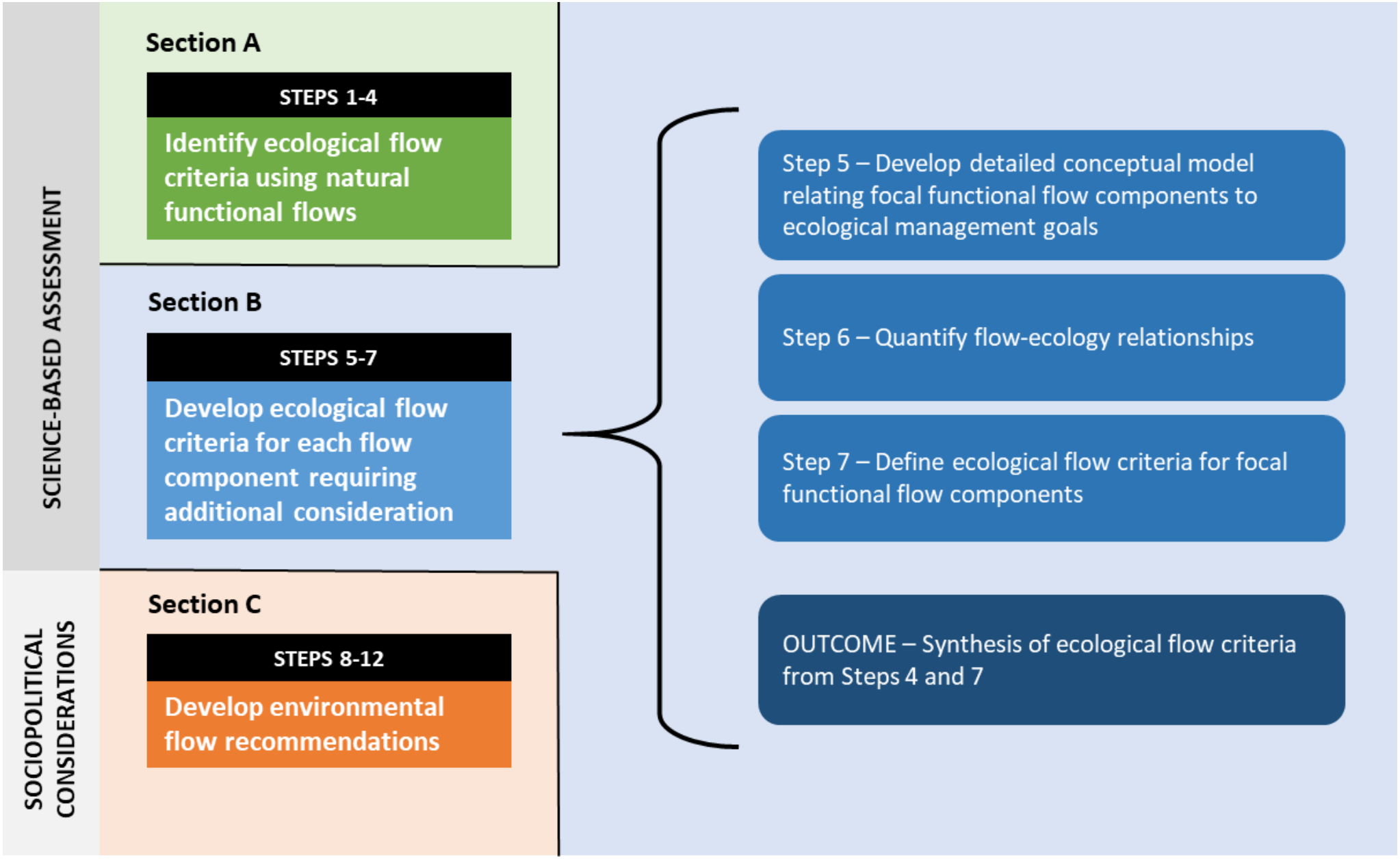
Functional Flow Metrics

COMID: 17080381
TUOLUMNE RIVER

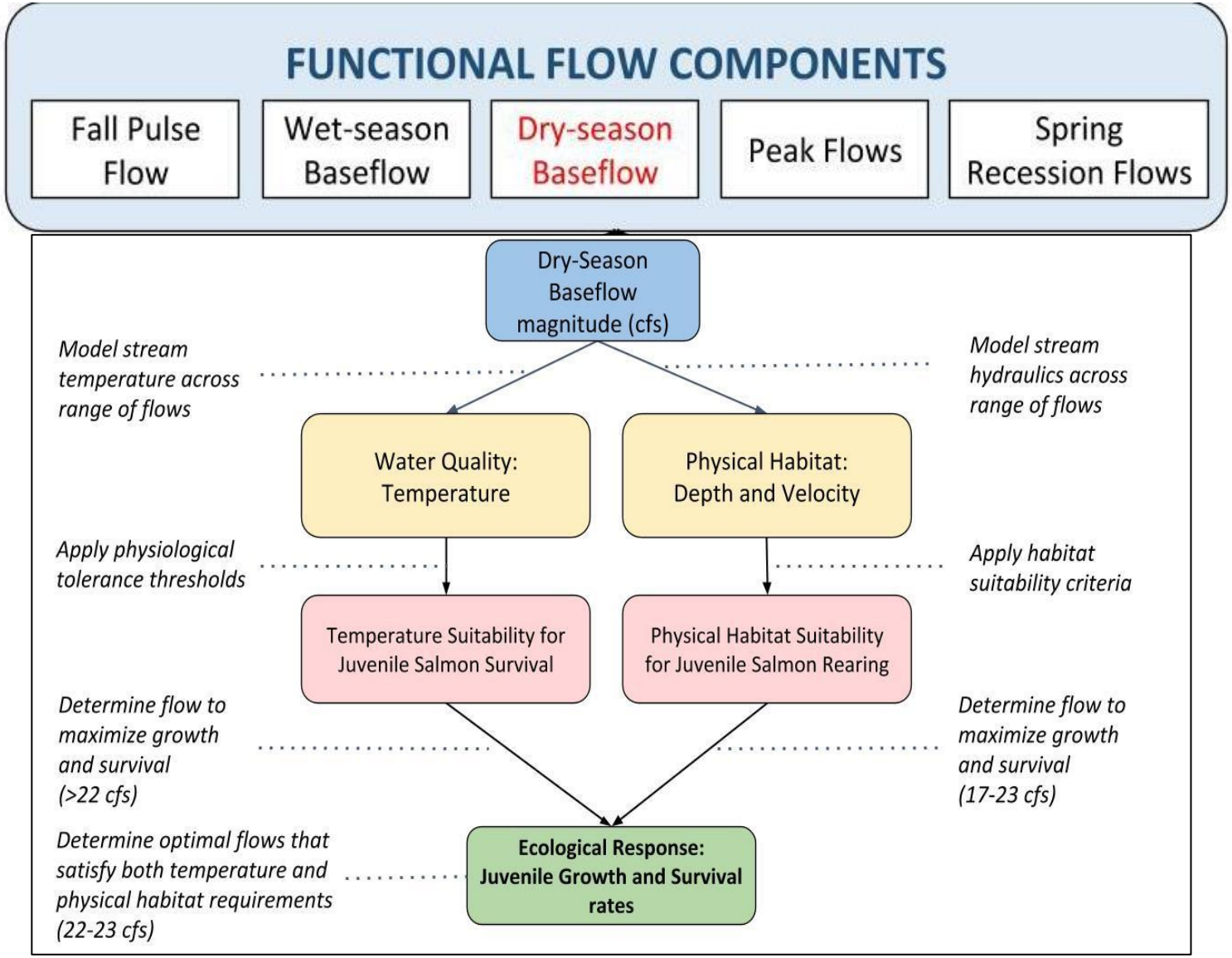


Line Hydrograph

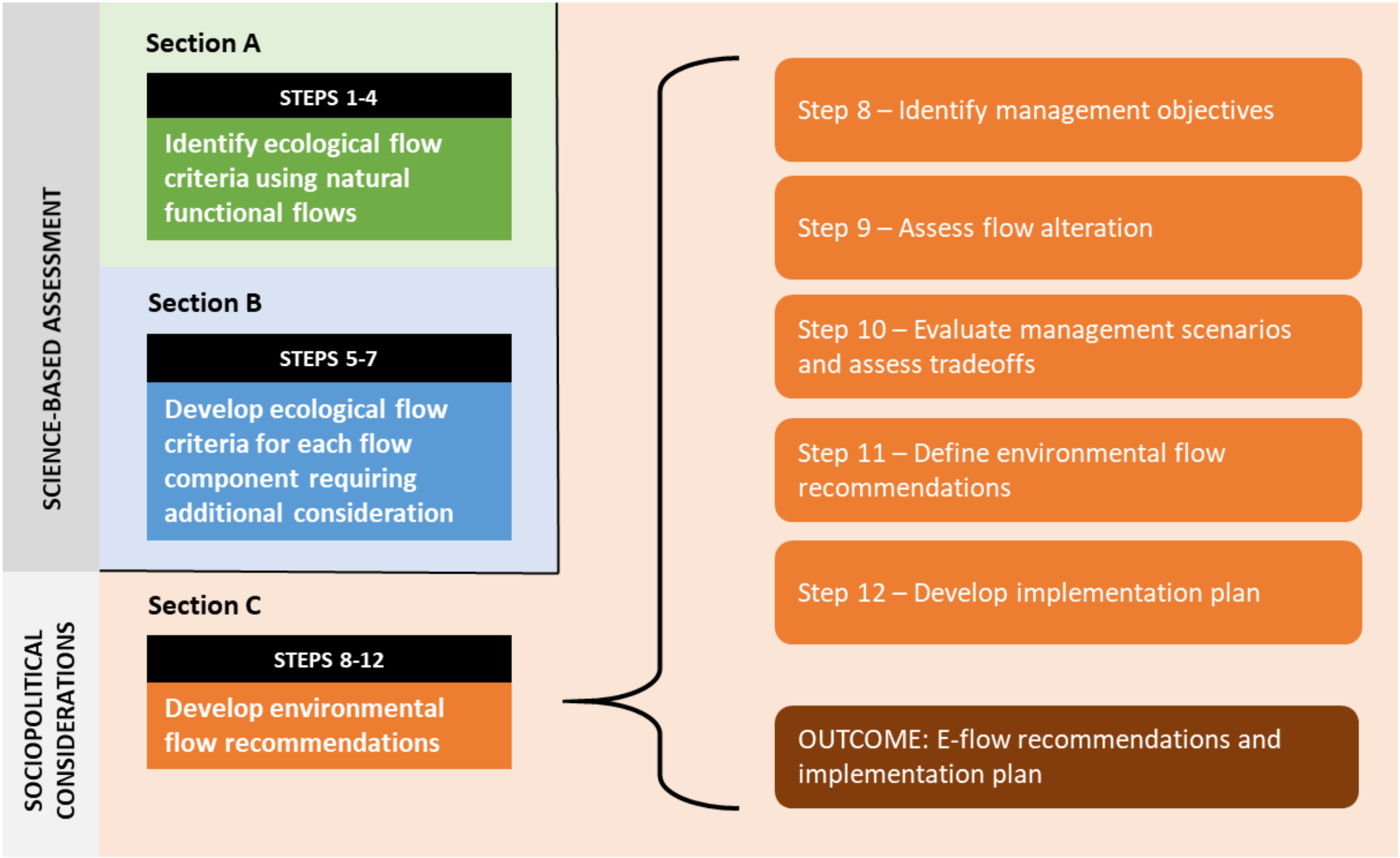
CEFF Section B



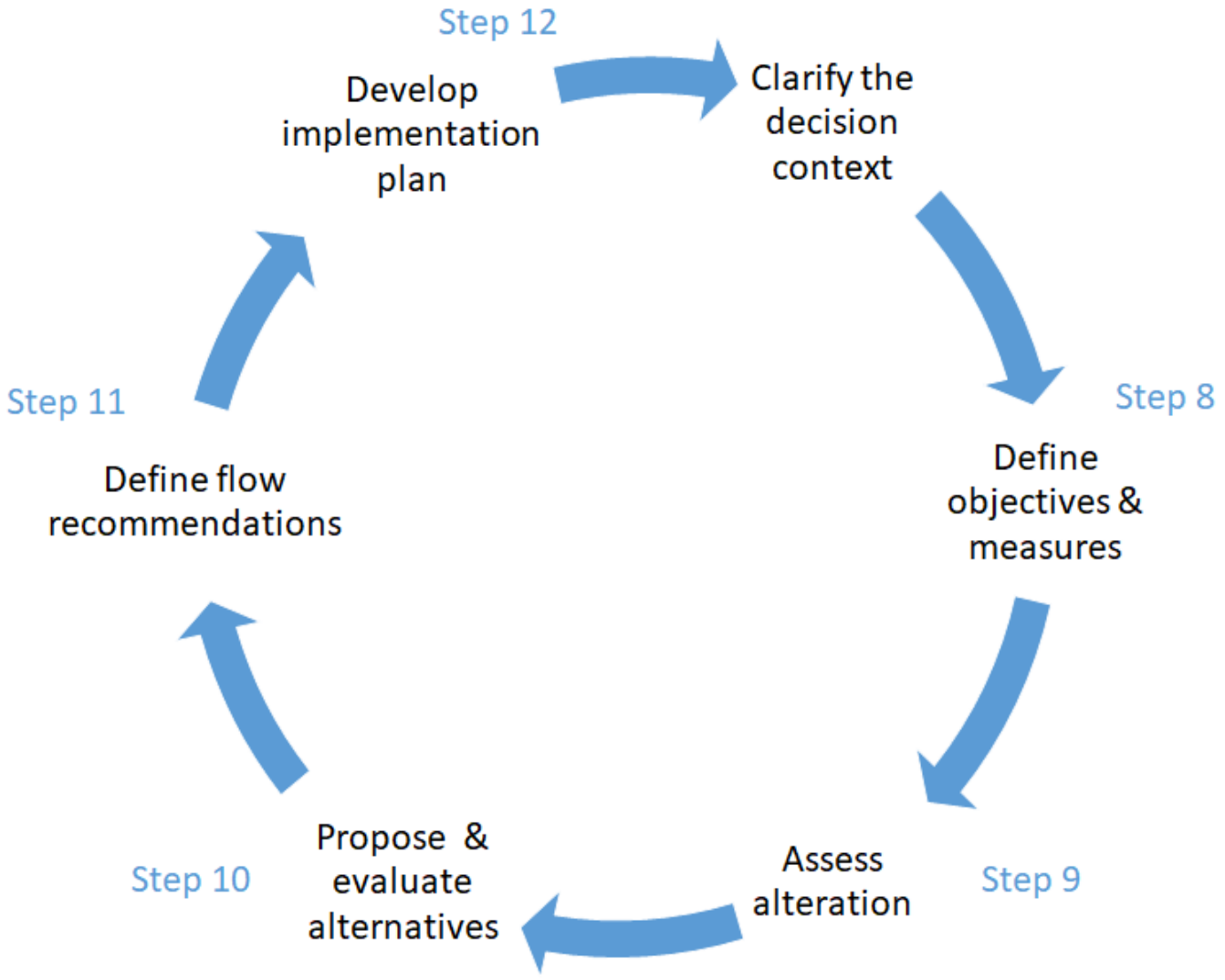
Section B: Investigating Specific Flow-Ecology Relationships



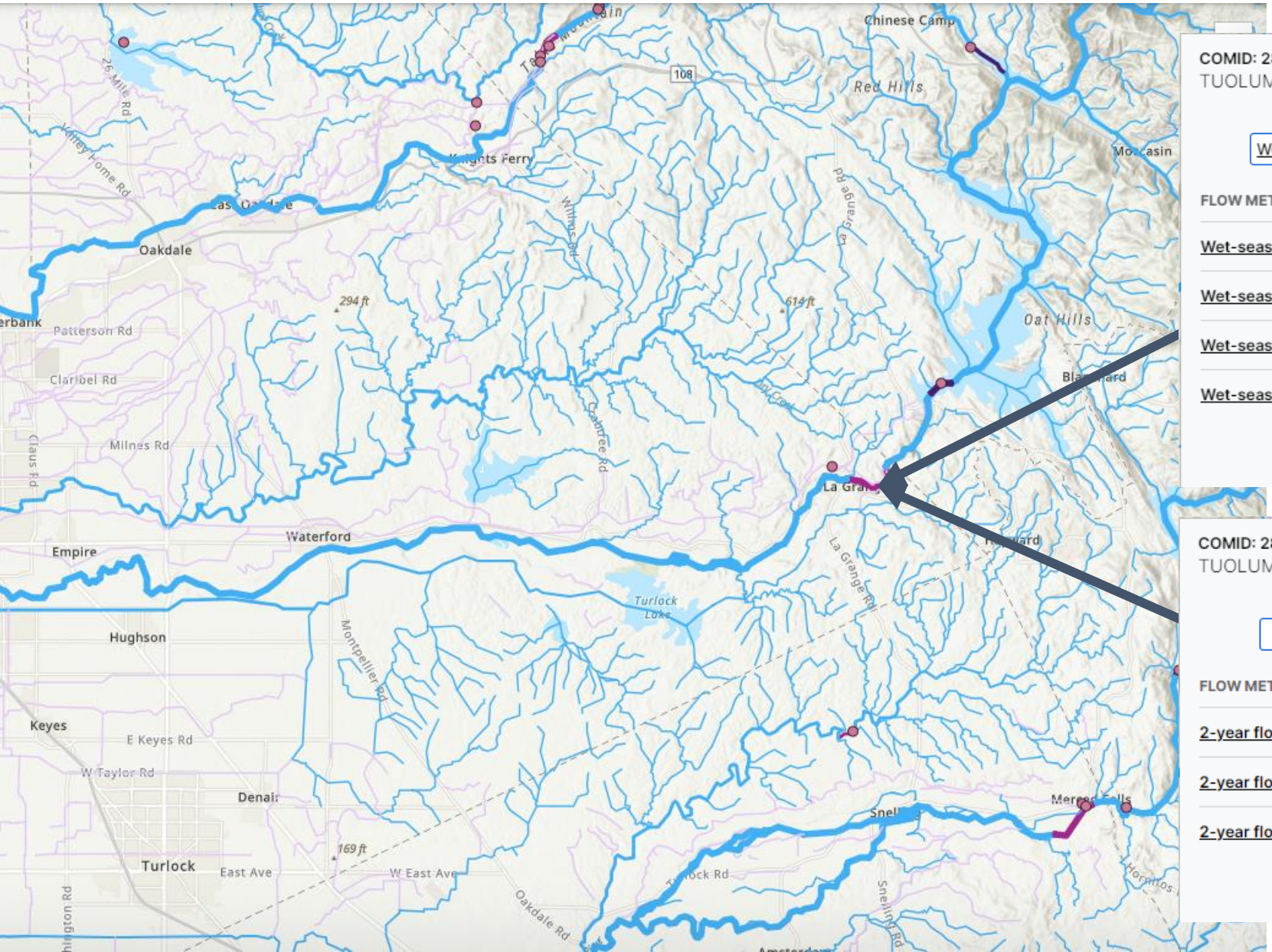
CEFF Section C



Section C
Develop Environmental Flow Recommendations



Section C: Alteration analysis - Tuolumne



COMID: 2823750
TUOLUMNE RIVER

Flow Component	Year Type	Recurrence Interval
Wet-season base flow	All Years	2-year

FLOW METRIC	10th pctl	50th pctl	90th pctl	Observed Med.
Wet-season baseflow	652 CFS	1,100 CFS	1,760 CFS	226 CFS
Wet-season median baseflow	1,810 CFS	3,130 CFS	5,110 CFS	1,290 CFS
Wet-season start	Nov. 17	Jan. 2	Feb. 14	Jan. 18*
Wet-season duration	71.4 DAYS	127 DAYS	185 DAYS	80.5* DAYS

Functional Flow Metrics

COMID: 2823750
TUOLUMNE RIVER

Flow Component	Year Type	Recurrence Interval
Peak flow	All Years	2-year

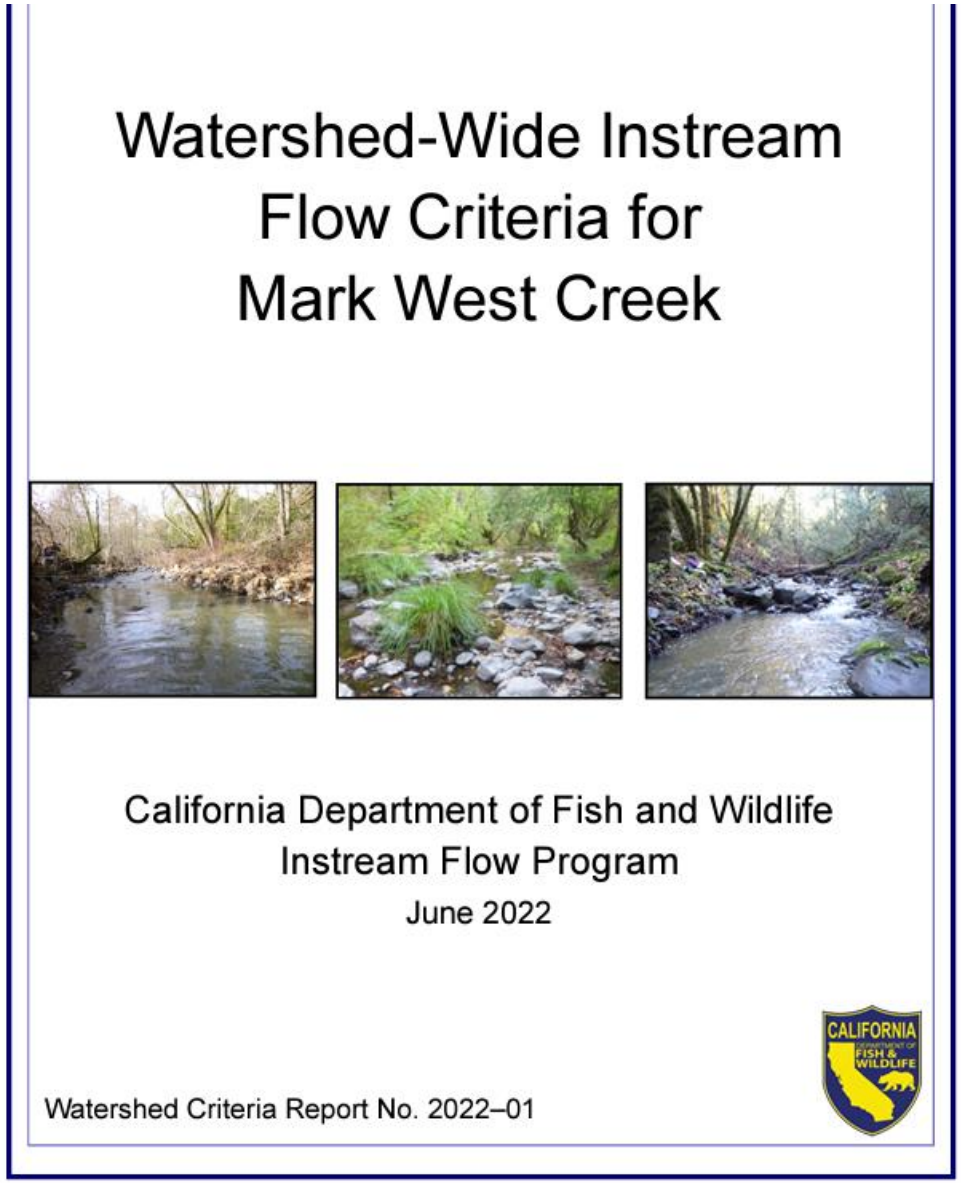
FLOW METRIC	10th pctl	50th pctl	90th pctl	Observed Med.
2-year flood magnitude	9,380 CFS	17.2 KCFS	24.4 KCFS	2,980 CFS
2-year flood duration	2 DAYS	5 DAYS	19 DAYS	88.5 DAYS
2-year flood frequency	1 OCCUR.	2 OCCUR.	4 OCCUR.	2.5 OCCUR.

Functional Flow Metrics

Outcomes of CEFF

- Ecological flow criteria for areas of interest
  - Required by multiple regulatory processes (FERC, SGMA, ESA, WQcerts, etc)
- Environmental flow recommendations (via stakeholder process)
- Recommended mitigation measures (via stakeholder process)
- Implementation, monitoring and adaptive management plan
- Online tools:
  - natural flows database/web tool (rivers.codefornature.org)
  - functional flow calculator in python (eflows.ucdavis.edu)
  - information repository (ceff.ucdavis.edu)

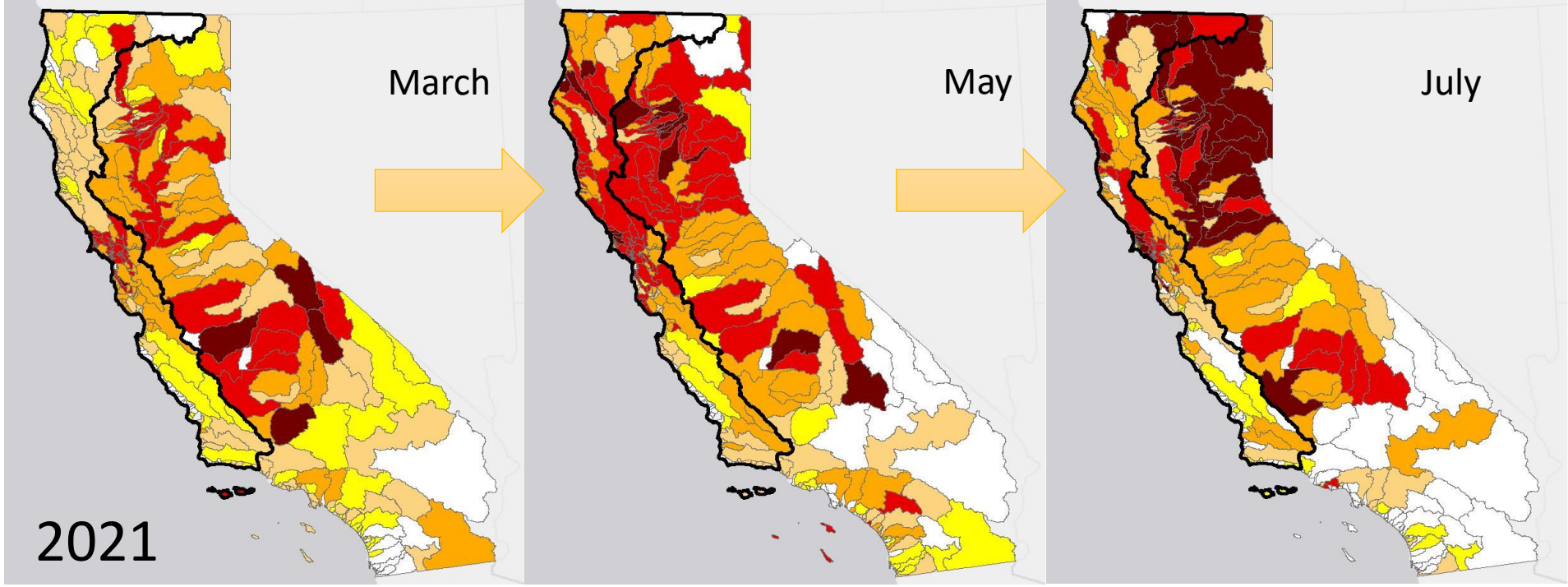
Applications

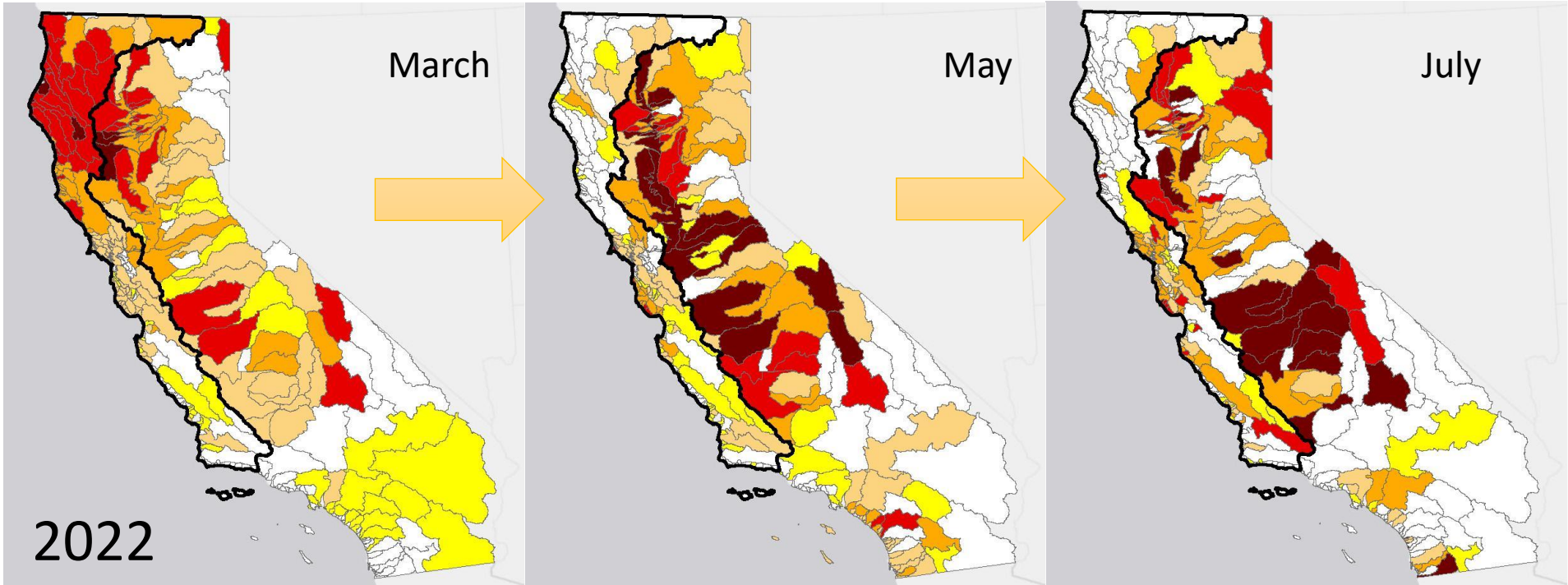


Metric	Wet Years	Moderate Years	Dry Years
Fall pulse flow magnitude (cfs)	226 (39–1,450)	159 (35–1,090)	135 (31–697)
Fall pulse flow duration (total days per year, when present)	4 (2–9)*	4 (2–9)*	4 (2–9)*
Fall pulse flow start timing	Oct 24 (Oct 7–Nov 16)	Oct 27 (Oct 7–Nov 20)	Nov 1 (Oct 8–Nov 25)
Wet-season baseflow magnitude (cfs)	144 (58–314)	87 (28–199)	43 (13–118)
Median wet-season flow magnitude (cfs)	550 (270–1,050)	320 (174–650)	164 (46–460)
Wet-season duration (days)	126 (78–163)	105 (63–153)	92 (50–157)
Wet-season start timing	Dec 3 (Nov 14–Dec 15)	Dec 2 (Nov 15–Dec 26)	Dec 13 (Nov 7–Jan 22)
2-year peak flow magnitude (cfs)	7,840 (2,680–14,400)	7,840 (2,680–14,400)	7,840 (2,680–14,400)
2-year peak flow duration (total days per year, when present)	3 (1–16)*	3 (1–16)*	3 (1–16)*
2-year peak flow frequency (events per year, when present)	2 (1–5)*	2 (1–5)*	2 (1–5)*
5-year peak flow magnitude (cfs)	10,600 (4,970–23,000)	10,600 (4,970–23,000)	10,600 (4,970–23,000)
5-year peak flow duration (total days per year, when present)	1 (1–5)*	1 (1–5)*	1 (1–5)*
5-year peak flow frequency (events per year, when present)	1 (1–3)*	1 (1–3)*	1 (1–3)*
Spring recession flow magnitude (cfs)	2,460 (731–9,510)	1,820 (499–6,430)	1,300 (249–5,080)
Spring recession flow duration (days)	42 (25–105)	45 (24–114)	49 (23–124)
Spring recession flow start timing	Apr 10 (Mar 8–May 4)	Mar 27 (Mar 5–Apr 17)	Mar 28 (Mar 4–May 3)
Spring recession flow rate of change (%)	7 (4–17)*	7 (4–17)*	7 (4–17)*
Dry-season baseflow magnitude (cfs)	15 (4–40)	11 (1–25)	5 (<1–16)
Dry-season duration (days)	203 (149–252)	197 (135–262)	203 (135–264)
Dry-season start timing	May 25 (Apr 23–Jun 27)	May 26 (Apr 13–Jul 10)	May 26 (Apr 12–Jul 29)

* indicates a metric with inferred ranges that was not modeled by water year type

Drought Flows Monitor



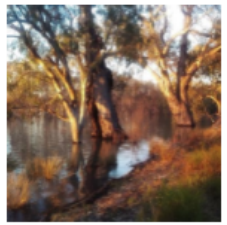


Interactive dashboard:
https://public.tableau.com/app/profile/kklausmeyer/viz/DroughtFlows/Dashboard1
Source data:
https://rivers.codefornature.org/#/home

Drought category (percentile)

- Exceptional drought (lowest estimate)
- Extreme drought (2-5th)
- Severe drought (6-10th)
- Moderate drought (11-20th)
- Abnormally dry (21-30th)
- Normal / wet (31-100th)
- SWRCB Regions 1-3

Special Issue Journal – Frontiers in Freshwater Science



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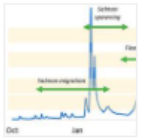

The California Environmental Flows Framework: Meeting the Challenges of Developing a Large-Scale Environmental Flows Program

Eric D. Stein , Julie Zimmerman , Sarah M. Yarnell , Bronwen Stanford, Belize Lane , Kristine T. Taniguchi-Quan , Alyssa Obester , Theodore E. Grantham , Robert A. Lusardi and Samuel Sandoval-Solis

Original Research Environmental flow programs aim to protect aquatic habitats and species while recognizing competing water demands. Often this is done at the local or watershed level because it is relatively easier to address technical and implementation challenges ...

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Daniel Chilton , David P. Hamilton , Ivan Nagelkerken , Perran Cook , Matthew R. Hipsey , Robert Reid , Marcus Sheaves , Nathan J. Waltham and Justin Brookes

Review Estuaries host unique biodiversity and deliver a range of ecosystem services at the interface between catchment and the ocean. They are also among the most degraded ecosystems on Earth. Freshwater flow regimes drive ecological processes contributing ...

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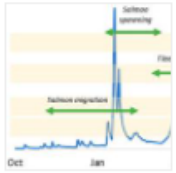
- Highlights CEFF in the context of international efforts



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Original Research Environmental flow programs aim to protect aquatic habitats and species while recognizing competing water demands. Often this is done at the local or watershed level because it is relatively easier to address technical and implementation challenges ...

Application of flow ecology analysis to inform prioritization for stream restoration and management actions

Katie Irving , Kristine Taniguchi-Quan , Amanda Aprahamian , Cindy Rivers, Grant Sharp , Raphael D Mazor , Susanna Theroux , Ryan Peek and Eric D. Stein

Original Research A key challenge in managing flow alteration is determining the severity and pattern of alteration associated with the degradation of biological communities. Understanding these patterns helps managers prioritize locations for restoration and flow ...

Functional Flows in Groundwater-Influenced Streams: Application of the California Environmental Flows Framework to Determine Ecological Flow Needs

Sarah M. Yarnell , Ann Willis , Alyssa Obester , Ryan A. Peek , Robert A. Lusardi, Julie Zimmerman , Theodore E. Grantham and Eric D. Stein

Original Research Environmental flows, or the practice of allocating water in river systems for ecological purposes, is a leading strategy for conserving aquatic species and improving river health. However, consideration of surface-groundwater connectivity is seldom ...

Developing ecological flow needs in a highly altered region: Application of California Environmental Flows Framework in southern California, USA

Kristine T. Taniguchi-Quan , Katie Irving , Eric D. Stein , Aaron Poresky , Richard A. Wildman, Jr., Amanda Aprahamian , Cindy Rivers, Grant Sharp , Sarah Yarnell and Jamie Feldman

Original Research Flow alteration is a pervasive issue across highly urbanized watersheds that can impact the physical and biological condition of streams. In highly altered systems, flows may support novel ecosystems that may not have been found under natural ...

Identifying Functional Flow Linkages Between Stream Alteration and Biological Stream Condition Indices Across California

Ryan Peek , Katie Irving , Sarah M. Yarnell , Rob Lusardi, Eric D. Stein and Raphael Mazor

Original Research Large state or regional environmental flow programs, such as the one based on the California Environmental Flows Framework, rely on broadly applicable relationships between flow and ecology to inform management decisions. California, despite having ...

Modeling Functional Flows in California's Rivers

Theodore Grantham , Daren M. Carlisle , Jeanette Howard , Belize Lane , Robert Lusardi, Alyssa Obester , Samuel Sandoval-Solis, Bronwen Stanford, Eric D. Stein , Kristine T. Taniguchi-Quan , Sarah M. Yarnell and Julie K. H. Zimmerman

Original Research Environmental flows are critical to the recovery and conservation of freshwater ecosystems worldwide. However, estimating the flows needed to sustain ecosystem health across large, diverse landscapes is challenging. To advance protections of ...