

# Assessing Aquatic Habitat Connectivity and Low-flow Ecological Thresholds



Robert Holmes  
Instream Flow Coordinator  
California Department of Fish and Wildlife

CABW  
November 18-19, 2014  
Davis, CA



## Outcome

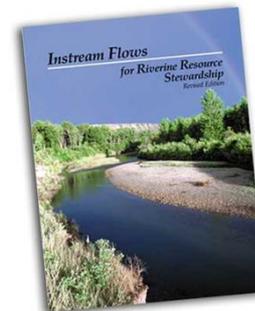
- General understanding of some of the methods available to assess aquatic habitat connectivity and low-flow ecological thresholds
  - Considerations when selecting such methods
  - Availability of CDFW Instream Flow Program QA/QC instream flow tools (standard operating procedures, guidance documents, FAQ sheets, checklists, .).
- 
- No single best method or flow (*think flow regimes*)



# What is Instream Flow & Why is it Important?

= *water flowing in a stream.*

- Most streams have some level of flow, but flow is no guarantee that all is well for organisms (including humans) that depend on the river's resources.
- Natural resource managers are faced with the complicated task of protecting and restoring public values to rivers while honoring existing uses.
- A good understanding of how instream flow levels and regimes relate to the many beneficial values and services of rivers (i.e., flood mitigation, waters supplies, biological productivity, recreation, ...) and the scale of alteration from the natural condition, is necessary for informed river management.



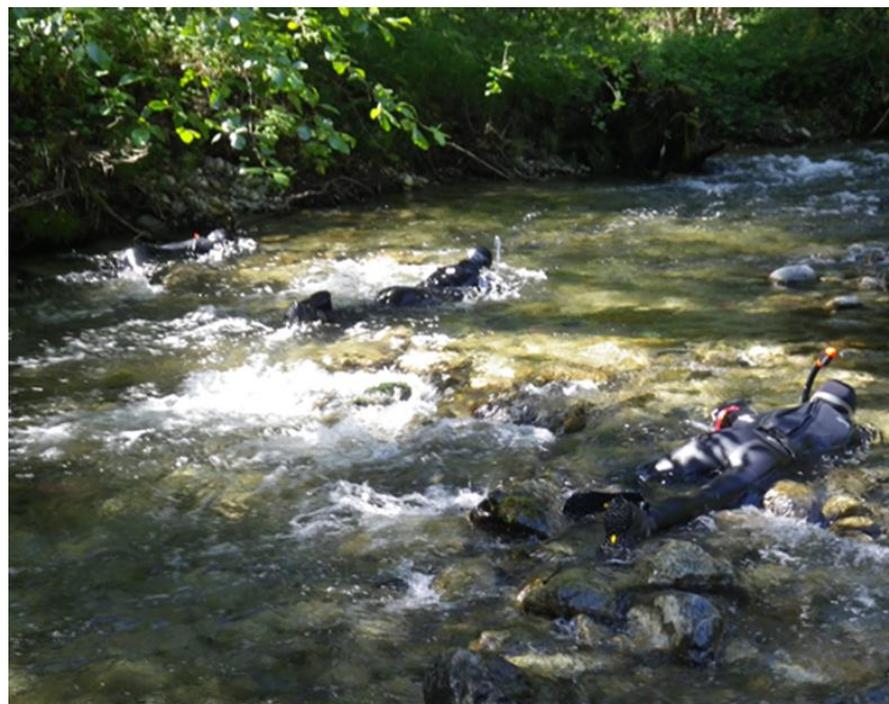
# Terminology

- *Instream Flows*: The amount of water in a stream to adequately provide for instream uses within the stream channel (i.e., aquatic organisms and riverine processes).
- *Ecological Flows*: The flows and water levels in a water body to sustain the ecological function of the flora and fauna, and habitat processes within that water body and its margins.
- *Environmental Flows*: The flows to sustain freshwater ecosystems and the human livelihoods and well-being that depend on these ecosystems.



## Core Riverine Components

- Biology
- Connectivity
- Geomorphology
- Hydrology
- Water Quality



## Assessing Aquatic Habitat Connectivity

- Specify which of 4 dimensions you're using (lateral, vertical, longitudinal, time)
- Identify which elements are of interest (organisms, chemistry, bedload, energy)
- Specify time and duration when needed
- Need other tools to assess needs for other riverine elements and processes

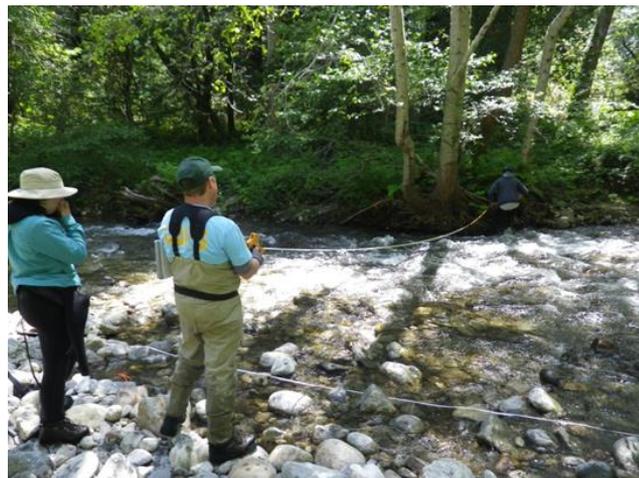


# Step One – Define Study Area, Reaches, and Habitat Types

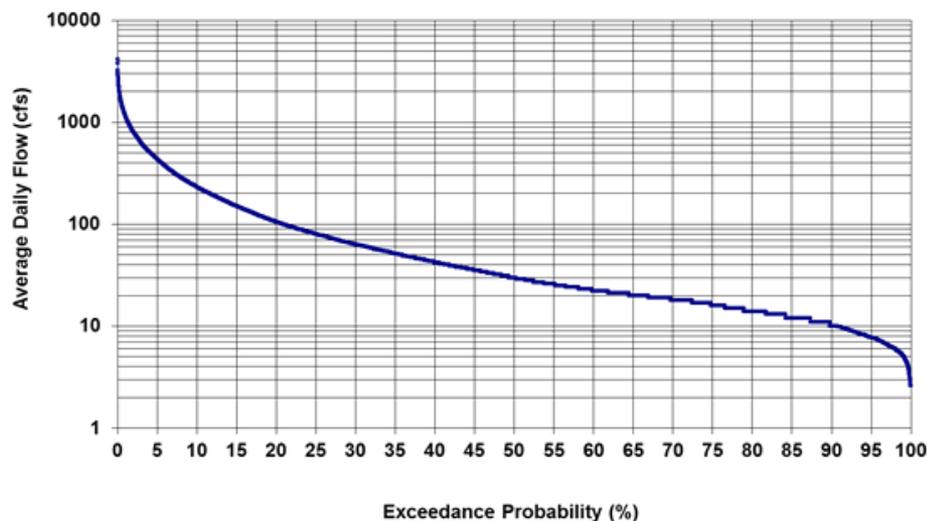
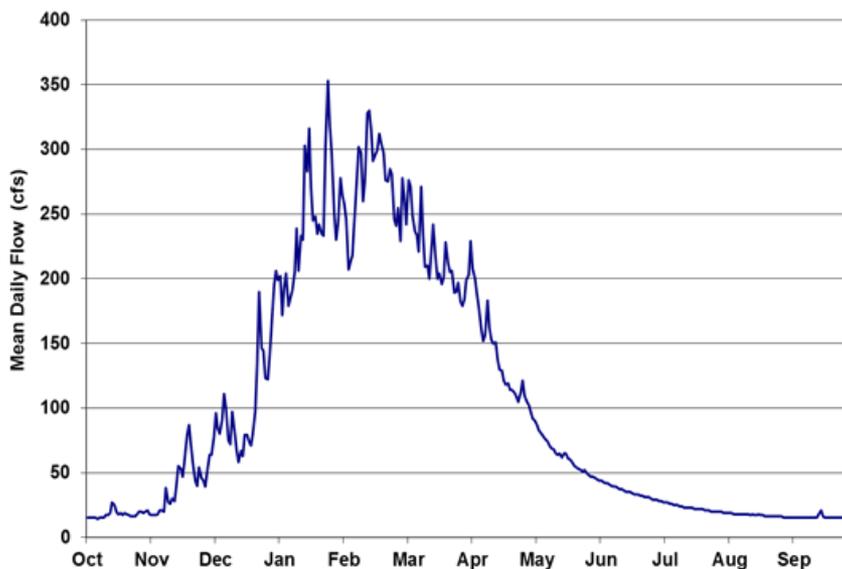
## Goal:

- Create inventory of habitat unit characteristics by type and distance within designated river reaches.
- Habitat inventory used as a basis for selecting study sites, and/or transects for hydraulic habitat analysis, and other studies.

Habitat Unit #	Type	Length (ft)	Pool Depth (ft)	Lat.	Long.
1	GLD	197		36.97239	121 50.660
2	RUN	77		36.17201	121 40.652
3	LGR	38		36.17193	121 40.644
4	GLD	82		36.17067	121 40.635
5	POOL	96	4.5	36.17034	121 40.407



# Step Two – Develop Understanding of Natural Unimpaired Flow Conditions



*Important for identifying appropriate sampling times, and for use in calibrating hydraulic models.*



# Step Three - Consider Species/Lifestages

## Periodicities

South-central steelhead	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Adult Migration												
Spawning												
Egg Incubation												
Emergence/Fry												
Juvenile Rearing												
Smolt Emigration												



# Assessing Aquatic Habitat Connectivity

## Empirical Methods

- Critical Riffle Analysis can address connectivity at riffle sites

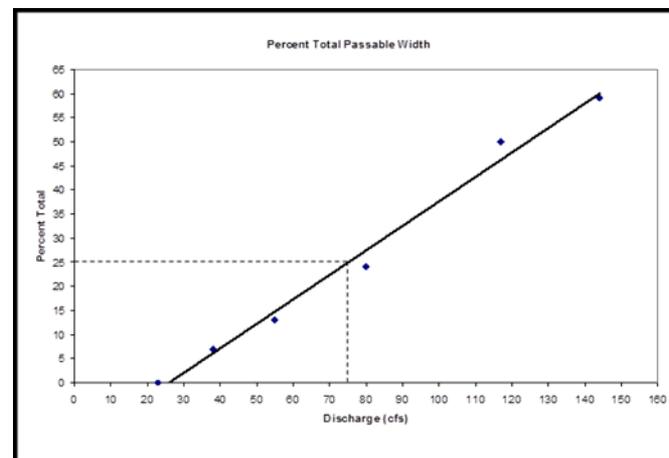
## Hydraulic Habitat Models

- Two dimensional (2D) models can address connectivity at the site or segment level



# Critical Riffle Analysis

*Critical riffles are those riffle habitats which may be particularly sensitive to changes in stream flow, and as such may prevent adult anadromous fish passage to and from spawning areas and/or may prevent movement of rearing juvenile salmonids (i.e., steelhead) between adequate summer rearing habitats.*



Species	Minimum Depth (ft)
Steelhead (adult)	0.7
Coho (adult)	0.6
Chinook (adult)	0.9
Salmonid (juvenile)	0.4



## Critical Riffle Analysis

- Empirical method (Thompson 1972) for assessing fish passage and habitat connectivity (depth and velocity)
  - Four to six sample events of range of flows
  - Transect follows shallowest course bank to bank
  - Depth criteria for adult steelhead from SWRCB
  - Two metrics (percent total and percent contiguous) meeting the criteria are plotted to identify flows
- 

### Considerations:

- *Can be used to identify protective (physical movement) flows – not minimum flows*
- Other factors also important to evaluate migratory success (length of riffle, availability of resting areas, condition of fish, temperature, ..)



# Department of Fish and Wildlife Water Branch Instream Flow Program



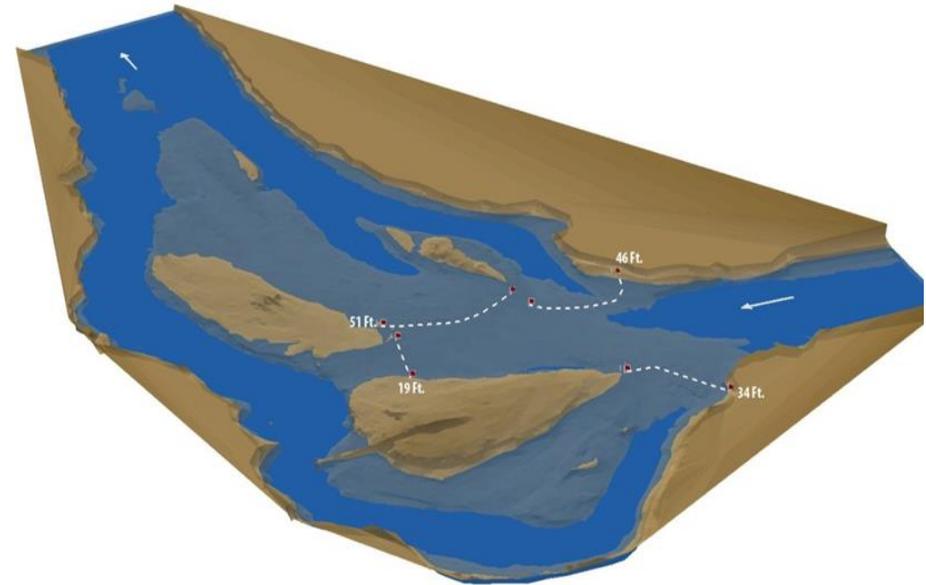


## 2D Hydraulic Habitat Models

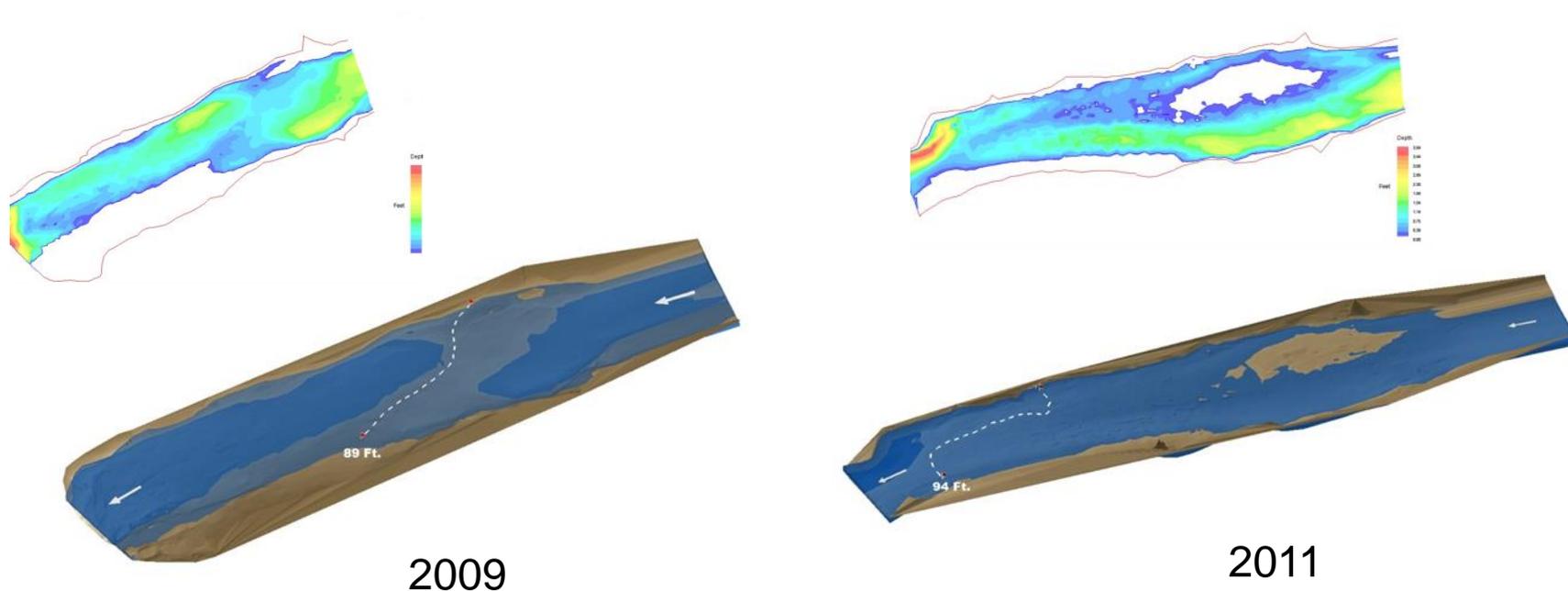
- Total Station and prism used to survey bed topography and physical features
- Establish vertical benchmarks and tying vertical benchmarks together
- Measuring stage of zero flow
- Collecting water surface elevations at range of flows



## 2D Hydraulic Habitat Models



## 2D Hydraulic Habitat Models



*2D modeling simulates river hydraulics for a range of flows and can be used to evaluate flow and habitat relationships for various species and lifestages, including passage and habitat connectivity*



## General Model Considerations

- Different models available
- Focus on survival or habitat suitability
- Flow / habitat relationship may differ in different streams or stream segments
- Some address trade-offs
- Need other tools to assess needs for other riverine elements



# Assessing Low-Flow Ecological Thresholds

- A low-flow “cut-off” is recognized as an important component of an overall instream flow regime prescription.
- The low-flow threshold can be applied to conserve fisheries, and widely recognized that having such a threshold can preserve ecosystem structure and function in riverine ecosystems that support fisheries (DFO, 2013).

## Methods:

### Hydrological Methods

- Tennant
- Presumptive Standard (Richter et al. 2011)

### Single Transect Methods

- Wetted Perimeter



# Tennant Method

Narrative Description of Flow	April to September	October to March
Flushing or maximum flow	200% from 48 to 72 hours	
Optimum range of flow	60-100%	60-100%
Outstanding habitat	60%	40%
Excellent habitat	50%	30%
Good habitat	40%	20%
Fair or degrading habitat	30%	10%
Poor or minimum habitat	10%	10%
Severe degradation	<10%	<10%

*Many people think of Tennant as an office based, single-flow setting tool. The fact is that Tennant never intended this method to be used that way. Rather, any flow set using the technique should be validated in the field and the tool should be used to establish a range of flows.*



## Tennant Method

- Can set threshold flows or regimes
- Need long-term gage data
- Limited ability to identify trade-offs
- Majority of challenges have been successfully defended (widely accepted method)
- Need other tools to assess needs for other riverine elements

*A key consideration with a hydrology method is that if hydrologic patterns have been altered, the flows derived may be artificially lower.*



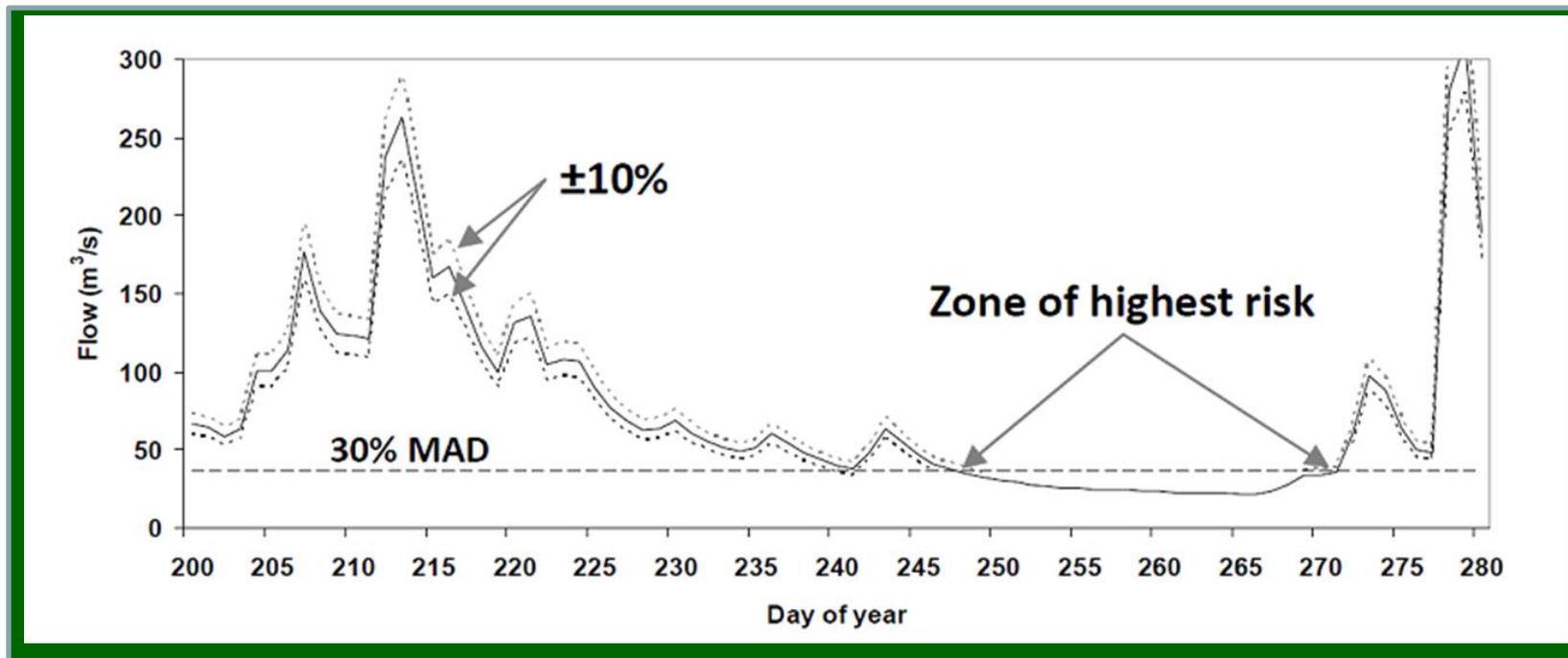
## Assessing Connectivity Flow Needs

- Richter et al. (2011) recommends using a presumptive standard approach to prevent aquatic ecosystem degradation.
  - *daily flow alterations of no more than 10%-20%*
  - *30% of the MAD for low-flow threshold (requires detailed studies)*



# Presumptive Standard Approach

*Depiction of Zone of Highest Risk (Instantaneous Discharges < 30% MAD)*



Source:



Fisheries and Oceans Canada  
Pêches et Océans Canada  
Science Sciences

National Capital Region

Canadian Science Advisory Secretariat  
Science Advisory Report 2013/017

**FRAMEWORK FOR ASSESSING THE ECOLOGICAL FLOW  
REQUIREMENTS TO SUPPORT FISHERIES IN CANADA**



## Single Transect Methods (Wetted Perimeter)

- Low to moderate effort
- Long history of use
- Only useful for setting threshold flows
- Limited ability to identify trade-offs
- Doesn't address flow variability needs
- Need other tools to assess needs for other riverine elements



# Wetted Perimeter Methodology

Goal:

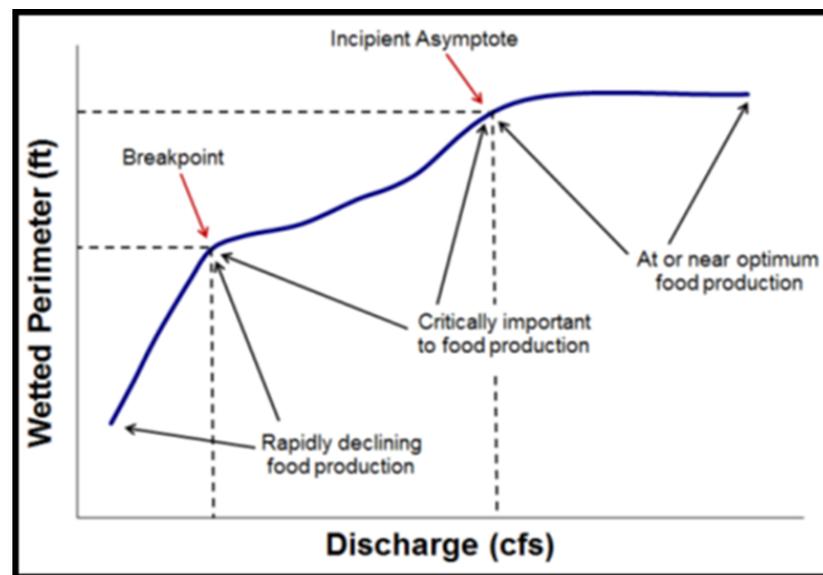
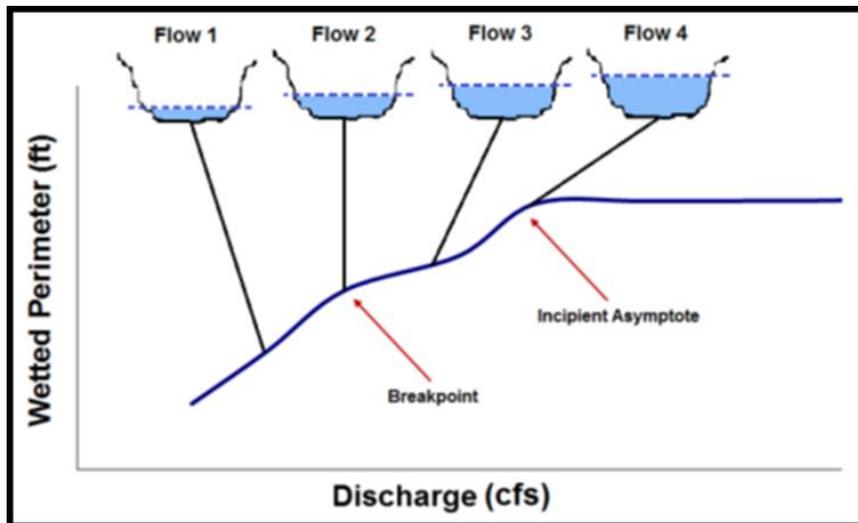
Identify low-flow ecological threshold for ecology/fishery using site-specific data and manning's equation

$$Q = 1.486/n AR^{2/3}S^{1/2} \text{ or } n = 1.486/Q AR^{2/3}S^{1/2}$$

- Stratified random transect selection process at riffles
- Fixed cross-channel transects
- Three sets of survey data at various flows (Water Surface Elevations, Water Depths, Water Velocities, Substrate Composition, Stream Width)



# Wetted Perimeter: Upper and Lower Breakpoints



Dr. Rob Titus (CDFW) coined term "incipient asymptote"



## Overall Considerations

- Every situation is different so each has a unique solution
  - Must consider natural water availability and water year/month types (wet, normal, dry)
  - All methods require training
  - Habitat connectivity and low-flow threshold flows not always available under unimpaired flow conditions
- 
- Good approach is to assess flow needs using a suite of methods to address specific endpoints at specific times of the year



## How Does One Determine How Much Water a River Needs?

- There is usually not just one flow level that a river needs to stay healthy.
- Using hydrology, biology, connectivity, geomorphology, and water quality to identify flow regimes for fish and wildlife.
- Inter- and intra-annual flow prescriptions are needed to preserve the ecological health of a river.
- Think flow regimes!



## Acknowledgments: The QA Research Group at Moss Landing Marine Laboratories

Six staff members specializing in the Quality Assurance associated with all areas of environmental science

- ✓ bioassessment
- ✓ physical habitat
- ✓ algae
- ✓ field measurements
- ✓ toxicity testing
- ✓ statistical analysis
- ✓ project design
- ✓ instream flow
- ✓ data assessment
- ✓ database structures
- ✓ aquatic ecology
- ✓ chemistry including ultra-trace, speciation, and emerging contaminants





## Protecting Rivers and Lakes in the Face of Uncertainty

Third International Workshop on Instream Flows

Portland, Oregon – April 28-30, 2015

*Problem-solving workshop focused on approaches and strategies that have effectively resolved uncertainty. Special emphasis placed on integrating new and traditional instream flow methods.*



## For more information contact:

Robert Holmes  
CDFW Instream Flow Coordinator  
Instream Flow Council Western Region Director  
Water Branch  
830 S Street  
Sacramento, CA 95811  
916 324-0838

[Robert.Holmes@wildlife.ca.gov](mailto:Robert.Holmes@wildlife.ca.gov)

DFG Instream Flow Program information at:  
[http://www.dfg.ca.gov/water/instream\\_flow.html](http://www.dfg.ca.gov/water/instream_flow.html)

Instream Flow Council  
<http://www.instreamflowcouncil.org/>



**INSTREAM FLOW COUNCIL**  
*Protecting, Maintaining, and  
Restoring Aquatic Ecosystems*

