How much water does a river need?

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via Webinar

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Instream Flow Components

- Overbank Flow
- High Flow Pulses
- Base Flow
- Subsistence Flow

Discharge (cfs)
Simple Conceptual Model

Natural Flow Regime

- Subsistence Flows
  - Conserve biological function
    - Adequate water quality tolerances met
    - Key habitat thresholds maintained

- Base Flows
  - Conserve biological / habitat diversity and suitable water quality
    - Habitat for flow dependent species
    - Bank storage/moisture
    - Suitable temperatures / dissolved oxygen

- High Flow Pulses
  - Life history / geomorphic processes
    - Fish spawning cues
    - Maintain channel
    - Sediment/nutrient transport

- Overbank Flows
  - Floodplain maintenance
    - Moisture and nutrients to floodplain
    - Riparian recruitment
Instream Flow Methods
Paradigm Shift in Instream Flow Recommendations

- 1950s-70s development of first instream flow methods yielding single minimum flow

- Growing recognition of role of natural flow regimes: magnitude, duration, frequency, timing, rate of change

- Recent shift to consideration of entire flow regime: subsistence, base, high flow pulses, overbank
Methods Evolution

1950s to 60s – Water quality
1970s – Hydrologic statistics
1980s – Quantitative biology models
1990s – Ecosystem processes
2000s – Holistic methods
Hydrology Methods

• Indicators of Hydrologic Alteration (IHA)
• Range of Variability Approach (RVA)
• Flow duration curves (Q_{95})
• Presumptive standard (e.g. 10% of flow can be diverted)
• HEFR (Texas)
Hydrology Model Considerations

- Long history of use (for some) - acceptance
- Good for describing hydrology (planning)
- Need long-term gage data
- Low to moderate effort
- Assumes a relationship with biology
- May have different relationships with biology on different streams
- Need other tools to assess needs for other riverine elements or specific needs
Biology

- Single Transect Methods
- Tennant Method (and variations)
- Physical Habitat Simulation (PHABSIM)
- MesoHABitat SIMulator (MesoHABSIM)
- Two Dimensional Models (River 2-D)
Single Transect Methods
Single Transect Methods (Wetted Perimeter)
Single Transect Methods

• 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
### Tennant Method (1976)

<table>
<thead>
<tr>
<th>Narrative Description of Flow</th>
<th>April to September</th>
<th>October to March</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flushing or maximum flow</td>
<td>200% from 48 to 72 hours</td>
<td></td>
</tr>
<tr>
<td>Optimum range of flow</td>
<td>60-100%</td>
<td>60-100%</td>
</tr>
<tr>
<td>Outstanding habitat</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>Excellent habitat</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td>Good habitat</td>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>Fair or degrading habitat</td>
<td>30%</td>
<td>10%</td>
</tr>
<tr>
<td>Poor or minimum habitat</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Severe degradation</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
</tr>
</tbody>
</table>
Tennant Method (1976)

- Can set threshold flows or regimes
- Need long-term gage data
- Limited ability to identify trade-offs
- Majority of challenges have been successfully defended
- Need other tools to assess needs for other riverine elements
QUICK TX DETOUR
Formed Basis of “Lyons’ Method” 1979

1. Flow percentages from Tennant or Montana Method (Tennant 1976)


3. Adjusted Tennant’s “seasons”

4. Flows “validated” on two sites downstream of Guadalupe River
Lyons’ Method
Percentage of Monthly Median

Oct – Feb
40%

Mar – Sept
60%
Instream Flow Recommendations using Lyons Method and 7Q2 flows

Lyons Method
- 121 cfs for Mar-Jun
- 59 cfs for Jul-Feb

Lyons Method + 7Q2
- 121 cfs for Mar-Jun
- 77 cfs for Jul-Feb
Physical Habitat Simulation (PHABSIM)

A. Site-specific microhabitat data

B. Habitat suitability criteria

C. Seasonal relationship between discharge and microhabitat for each life stage

Courtesy Rick Anderson, CDOW
2-Dimensional Physical Habitat Models

Courtesy Rick Anderson, CDOW
High-tech field equipment
RTK-GPS & ADP/sonar

Courtesy Rick Anderson, CDOW
2-D modeling simulates river hydraulics for a flow range

Shallow

Deep

Fast

Slow

600 cfs

Courtesy Rick Anderson, ODOW
1. Delineate meso habitat and determine surface area
2. Determine hydraulic variables (depth and velocity)
3. Rate the habitats suitability, based on species abundance

Courtesy Rick Anderson, CDOW
Habitat Suitability

Predicted Bluhead Biomass (Kg/m²)

- 0: Unusable
- 22: Unsuitable
- 83: Marginal
- 174: Optimal

Courtesy Rick Anderson, CDOW
Geomorphology

• Channel maintenance in gravel-bed streams
• Flushing flow
  – empirical
  – office-based
• Geomorphic classifications (Rosgen)
• HEC-6 and HEC-RAS
Geomorphology Model Considerations

- Usually have broad confidence intervals
- Address long-term physical habitat (not tied to one species)
- Need to specify timing, duration, ramping
- Need other tools to assess needs for other riverine elements
Water Quality

- Stream System Temperature (SSTEMP)
- Stream Network Temperature (SNTEMP)
- QUAL2E (and K)
- 7Q10
Water Quality

• Addressed long before water quantity
• Don’t address intra- or inter-annually variable flows or processes
• Don’t directly identify trade-offs with biology
• Need other tools to assess needs for other riverine elements and processes
Water quality models typically relate to minimum flows...
Connectivity Methods

- Habitat/hydraulic models can address longitudinal connectivity (e.g. min. depth for passage)
- Some groundwater models address vertical connectivity
- Estuary methods
  - Salinity-based inflow method
- Floodplain inundation assessments
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
Holistic Methodologies

- Downstream Response to Imposed Flow Transformation (DRIFT)
- Ecological Limits of Hydrologic Alteration (ELOHA)
- Bayesian Decision Models
- Demonstration Flow Assessment (DFA)
Ecological Limits of Hydrologic Alteration (ELOHA)

- Links hydrological alteration (IHA) with ecology
  - Requires good hydrological data
  - Requires information about ecological processes
Ecological Limits of Hydrologic Alteration (ELOHA)
Demonstration Flow Assessment
Empirical Methods
Adaptive management is a process

1. Establish Objectives
2. Implement Management
3. Monitor Effectiveness
4. Evaluate Results
5. Revise Management
Adaptive management requires:

• Long-term commitment of all parties to a common (defined) goal,

• A clear definition of what success looks like (dynamic vs. static; habitat vs. population)

• Extensive monitoring before and after implementation of a flow prescription

• Ability and resources (formal commitment, water & money) to implement new strategies when information shows the need.
There is no best method

Long-term persistence of organisms comes from long-term persistence of habitat and habitat processes
Natural Flow Regimes

Sound Ecological Environment

- **Subsistence Flows**
  - Conserve biological function
    - Adequate water quality tolerances met
    - Key habitat thresholds maintained

- **Base Flows**
  - Conserve biological / habitat diversity and suitable water quality
    - Habitat for flow dependent species
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Floodplain maintenance
- Moisture and nutrients to floodplain
- Riparian recruitment

Conserve biological function
- Adequate water quality tolerances met
- Key habitat thresholds maintained
People value clean, flowing water.
The land and water . . . and people are intimately connected.

“When you pull on one string in nature, you find it is connected to everything else”

John Muir
Healthy Ecosystems Benefit Humans
Instream Flow

- Science
- Institutional Capacity
- Laws & Policies
- Public Involvement