Environmental Flow Science: Lessons Learned from Selected Environmental Flow Programs

NC Environmental Flow Science Advisory Board
November 15, 2011

Mary M. Davis, Ph.D.
Southern Instream Flow Network
“Hydrologic regimes are the master variables in aquatic ecosystems.” Poff et al. 1997
Southern Instream Flow Network

Purpose - To facilitate protective instream flow policies and practices in 15 southern states by providing science-based resources and opening lines of communication.

More information at: www.southeastaquatics.net/programs/sifn/
Presentation Overview

1. Review of science-based methods to determine IF needs

2. Methods used by select states to determine IF needs

3. IF resources for North Carolina
Science-based Methods to Determine Instream Flow Needs

• Instream Flow Incremental Method (IFIM)

• Ecologically Sustainable Water Management (ESWM)

• Ecological Limits of Hydrologic Alteration (ELOHA)
Instream Flow Incremental Method (IFIM)

Source: http://www.fort.usgs.gov/Products/Software/ifim/5phases.asp
IFIM Process: Site- and Project-specific Evaluations

Field Study

Habitat Modeling

Physical Modeling

Habitat vs. Flow for each organism

Hydrologic Modeling

- Time Series Analysis
- Flow Alternatives
- Recommendations

Requires time and $
IFIM Process:
Water management alternatives are the basis for a negotiated solution.
IFIM Essentials

- Well-established methodology developed in the 1980s and 1990s
- Applies (usually) species-specific models at site-specific level
- Based on *population responses to natural variation* in velocity, depth, cover, and area
- Negotiated instream flow solutions
Ecologically Sustainable Water Management (ESWM)

- Ecosystem Flow Requirements
- Human Needs
- Areas of Incompatibility
- Collaborative Dialogue
- Water Experiments
- Adaptive Management
Ecological Conceptual Model

Flow Components and Needs: Major Tributaries

Example: 01543500 Sinnemahoning Creek at Sinnemahoning, PA (685 sq mi)

Flow Component (Daily Exceedance Probability)
- High Flow Events ($Q_{10}$ to $Q_2$)
- Seasonal Flow ($Q_{25}$ to $Q_{50}$)
- Low Flow ($Q_{5}$ to $Q_{10}$)
- Minimum to $Q_{10}$

Spring
- Maintain channel morphology, island formation, and floodplain habitat

Summer
- Transport organic matter and fine sediment
- Promote vegetation growth
- Cue and direct immigration of juvenile American Eel
- Provide abundant food resources and nesting and feeding habitats for birds and mammals
- Support development and growth of all fishes, reptiles, and amphibians
- Maintain connectivity between habitats and refugia for resident and diadromous fishes
- Support mussel spawning, gychidilla release, and growth
- Promote macroinvertebrate growth
- Maintain water quality
- Maintain hyporheic habitat

Winter
- Maintain ice scour events and floodplain connectivity
- Support winter emergence of aquatic insects and maintain overwinter habitat for macroinvertebrates
- Cue diadromous fish emigration
- Maintain stable hibernation habitats for reptiles and amphibians, nesting habitats for mammals
- Maintain overwinter habitats for resident fish
- Support resident fish spawning

Fall
- Cue diadromous fish emigration
- Maintain stable hibernation habitats for reptiles and amphibians, nesting habitats for mammals

Source: Susquehanna River Commission 2011
Savannah River Ecosystem Flow Workshop Participants
**Ecosystem Flow Recommendations: Building Block Method**

**Augusta Shoals on the Savannah River**

<table>
<thead>
<tr>
<th>Ecosystem Flow Recommendations: Building Block Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Augusta Shoals on the Savannah River</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Floods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No flood flow recommendations provided for the Shoals</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High Flow Pulses</th>
<th>Low Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>20,000-40,000 cfs; 2-3 days, 1/month</td>
<td>&gt;5,000 cfs; Sturgeon spawning</td>
</tr>
<tr>
<td>20,000-40,000 cfs; 2-3 days, 1/month</td>
<td>6,000-10,000 cfs, with 6,000 cfs as baseflow</td>
</tr>
<tr>
<td>&gt;16,000 cfs; 1-2 days, 1-2 pulse</td>
<td>6,000-10,000 cfs, with 6,000 cfs as baseflow</td>
</tr>
<tr>
<td>• Herring passage over NSBLD</td>
<td>4,000-5,000 cfs; Sturgeon spawning</td>
</tr>
<tr>
<td>• Morone egg suspension</td>
<td>• Resident fish habitat</td>
</tr>
</tbody>
</table>

**Key**

- Wet Year
- Avg Year
- Dry Year

**Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec**
---|---|---|---|---|---|---|---|---|---|---|---

- 20,000 cfs; 2-3 days, 1 pulse
- Sturgeon spawning

- 4,000-5,000 cfs; Sturgeon spawning

- >2,700,000 cfs

- >2,700 cfs

- >2,000 cfs

- >2,700 cfs

- • Protect spider lily from deer grazing
ESWM Essentials

• Developed in 1990s by The Nature Conservancy

• Applied at watershed level to improve flow regimes and restore ecological function

• Based on existing data and expert knowledge of ecological relationships with natural hydrologic regimes

• Integrates societal values with ecological needs
Ecological Limits of Hydrologic Alteration (ELOHA)

SCIENTIFIC PROCESS

Step 1. Hydrologic Foundation
- Baseline Hydrographs
- Flow Data and Modeling
- Developed Hydrographs

Step 2. River Classification (for each analysis node)
- Hydrologic Classification
- Geomorphic Sub-classification
- River Type

Step 3. Flow Alteration (for each analysis node)
- Analysis of Flow Alteration
- Measures of Flow Alteration

Step 4. Flow-Ecology Relationships
- Flow - Ecology Hypotheses for each river type
- Ecological Data for each analysis node

SOCIAL PROCESS

Implementation
- Environmental Flow Standards

Acceptable Ecological Conditions

Societal Values and Management Needs

Adaptive Adjustments

http://conserveonline.org/workspaces/eloha

(Poff et al. 2010)
Calculation of Flow Alteration

Output from The Nature Conservancy’s Indicators of Hydrologic Alteration (IHA) software
Flow-Ecology Relationships from Literature

Source: McManamay et al. 2011
Flow-Ecology Relationships from Existing Data

Source: Potomac River Commission Watershed Assessment 2011
Michigan’s Screening Tool for Ground-Water Withdrawals

Ecological Response to Flow Alteration

Proportion of initial fish population metric

Proportion of index flow removed

Characteristic species
Thriving species

Acceptable resource impact
Adverse resource impact
ELOHA Essentials

• Newly established method (Poff et al. 2010)

• Uses existing data to develop flow-ecology relationships for classes of rivers

• Based on ecological responses to flow alteration of natural hydrologic regime

• Integrates societal values with ecological values
Presumptive Flow Standard for Environmental Flow Protection

(Richter et al. 2011)
Presentation Overview

1. Review of science-based methods to determine IF needs

2. Methods used by selected programs to determine IF needs

3. IF resources for North Carolina
Approaches for Determining IF Standards

- **Minimum flow threshold**
  - 7Q10 (e.g., AL, LA, MS)
  - Modified Tennant (e.g., AR, GA, SC)

- **Statistically based standards**
  (e.g., FL St Johns WMD, Potomac River Commission)

- **Percent of flow approaches**
  (e.g., FL SW Florida and Suwannee River WMDs, TN Presumptive WQ Standard)

Under development in SE: TX, NC, VA
IF Methods Used by Selected Programs

- Florida
- Michigan
- Potomac River Commission
- Texas, if time allows
FLORIDA - INSTREAM FLOW PROTECTION POLICY AND MANAGEMENT PROGRAMS

Slides courtesy of Marty Kelly, Director SWFWMD MFL Program
The *minimum flow* for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.

A MFL is set by the Water Management Districts for each of their priority streams, rivers, lakes, and aquifers.

MFLs are used in
- water management allocation planning,
- surface and groundwater withdrawal permit conditions, and
- recovery plans.
SWFWMD Instream Flow Program

- Building Block Method
- PHABSim-style methodology
- Percent of Flow Reduction Approach
- ‘Significant Harm’ threshold = 15% reduction in available habitat for most conservative target
Physical Habitat Simulation System
Used for Blocks 1 and 2

- Depth
- Velocity
- Substrate
Long-Term Inundation Analysis
Used for Blocks 2 and 3

Floodplain
Exposed Roots
Snags
Low Flow Threshold - Wetted Perimeter
Used for All Blocks
Low Flow Threshold - Fish Passage
Used for All Blocks
Flow Prescription

Percent of Flow and Seasonality of allowable cumulative withdrawals

LFT = 67 cfs
• Best Available Information
• Peer Review Process
# SWFWMD MFLs

## Range of Percent Allowable Withdrawals

*(Significant Harm Threshold < 15% habitat loss)*

<table>
<thead>
<tr>
<th>Block</th>
<th>Rivers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper Alafia</td>
</tr>
<tr>
<td></td>
<td>Hi</td>
</tr>
<tr>
<td><strong>1 (April 20-June 24)</strong></td>
<td>8</td>
</tr>
<tr>
<td><strong>2 (Oct 28 – Apr 19)</strong></td>
<td>8</td>
</tr>
<tr>
<td><strong>3 (Jun 25 – Oct 27)</strong></td>
<td>8</td>
</tr>
</tbody>
</table>

Source: [http://www.swfwmd.state.fl.us/projects/mfl/](http://www.swfwmd.state.fl.us/projects/mfl/)
SWFWMD MFL Essentials

• MFL set for each water body (i.e., no classification needed)

• Flow requirements based on most sensitive ecological response to flow alteration (i.e., fish, coarse woody debris, floodplains, organic soils, etc.)

• Estimate habitat loss based on cumulative depletion of the natural daily flow regime

• MFLs for medium size, coastal rivers show a small range of allowable depletions.
IF Methods Used by Programs

- Florida – using similar methods as NC; finding similar standards within river class
- **Michigan**
- Potomac River Commission
Environmental Flow Standards in Michigan

Slides courtesy of Paul Seelbach, USGS and Richard Bowman, TNC
Michigan River Classification Approach

Spatial framework
Well-established conceptual framework tested and implemented over past 15 years by TNC, USGS Regional Aquatic GAP, and a few states. Provides for multi-state coverage.

Reach attribution

MI fisheries classification

Coordination is good

Zoogeographic Region (WWF)

Ecological Drainage Unit (EDU)

Aquatic Ecological System (AES)

Ecological Segment

NHD+ Reach
Key landscape and riverine attributes for every reach came from existing map-level data and state-level models.

Examples: flow, temperature, slope, and elevation.
Spatial framework
Reach attribution
MI fisheries classification
Coordination is good

Summer temperature
Fish abundance

Cold fishes
Warm fishes

Cold transition
Warm transition

Cold transition
Warm transition
11 river classes based on flow and temperature

<table>
<thead>
<tr>
<th>Spatial framework</th>
<th>Reach attribution</th>
<th>MI fisheries classification</th>
<th>Coordination is good</th>
</tr>
</thead>
</table>

- **Cold**: Streams, Sm Rivers
- **Cold Trans**: Streams, Sm Rivers, Lg Rivers
- **Warm Trans**: Streams, Sm Rivers
- **Warm**: Sm Rivers, Lg Rivers
Simple. Familiar. Fish values.

Incredibly powerful in policy development. “Map that changed the world.” Map is central to state water law. Is in minds and language of policy leaders and users.

Is useful to many other river management programs. Can drill into database for more details.
Statewide habitat suitability info: flow and temperature

Rank scores per normal distribution; 60+ species
For representative sites per river type:
Considered initial “characteristic” species
Ran withdrawal simulations and followed scores

<table>
<thead>
<tr>
<th>Percent flow reduction</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>common shiner</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>white sucker</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>longnose dace</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>rainbow darter</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Variation in fish assemblage response curves for each of 15 representative sites within one river type. The mean response (dark line) was used in the water management program, and policy safeguards were used in recognition of the degree of variation.
Summaries of simulations create early warning and total impact curves (for assemblage).
Some replacement of sensitive species

Adverse Resource Impact
Curves and target zones per each ecological river type. Geographies of biological response and social values.
Michigan’s Screening Tool for Ground-Water Withdrawals

<table>
<thead>
<tr>
<th></th>
<th>Stream</th>
<th>Small River</th>
<th>Large River</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLD</td>
<td>A/B</td>
<td>14%</td>
<td>10.5%</td>
</tr>
<tr>
<td></td>
<td>B/C</td>
<td>14%</td>
<td>10.5%</td>
</tr>
<tr>
<td></td>
<td>ARI</td>
<td>20%</td>
<td>21%</td>
</tr>
<tr>
<td>TRANS</td>
<td>A/B</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>B/C</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>ARI</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>COOL</td>
<td>A/B</td>
<td>6%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>B/C</td>
<td>15%</td>
<td>19%</td>
</tr>
<tr>
<td></td>
<td>ARI</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>WARM</td>
<td>A/B</td>
<td>10%</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>B/C</td>
<td>18%</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>ARI</td>
<td>24%</td>
<td>17%</td>
</tr>
</tbody>
</table>

Allowable cumulative withdrawal (% median August)
Michigan Instream Flow Program

- River classification informed by fish assemblages
- *PHABSim*-style methodology
- *Percent of Flow Reduction Criteria*

![Graph showing Proportion of initial fish population metric vs. Proportion of median August flow removed for Characteristic and Thriving species. The graph indicates acceptable resource impact and adverse resource impact thresholds.]
IF Methods and Approaches Used by Advanced State Programs

- Florida – similar standards within river class
- Michigan – river classification informed by fish assemblages; similar standards within river class
- Potomac River Commission
Middle Potomac Watershed Assessment: Environmental Flows

- Follows ELOHA framework
- Multistate watershed
- www.potomacriver.org

Slides courtesy of Carlton Haywood, PRC
Ecological Limits of Hydrologic Alteration (ELOHA)

**SCIENTIFIC PROCESS**

**Step 1. Hydrologic Foundation**
- Baseline Hydrographs
- Flow Data and Modeling
- Developed Hydrographs

**Step 2. River Classification (for each analysis node)**
- Hydrologic Classification
- Geomorphic Sub-classification
- River Type

**Step 3. Flow Alteration (for each analysis node)**
- Analysis of Flow Alteration
- Measures of Flow Alteration

**Step 4. Flow-Ecology Relationships**
- Flow - Ecology Hypotheses for each river type
- Ecological Data for each analysis node

**SOCIAL PROCESS**

- Implementation
- Environmental Flow Standards
- Acceptable Ecological Conditions
- Societal Values and Management Needs

Adaptive Adjustments

http://conserveonline.org/workspaces/eloha

(Poff et al. 2010)
Hydrologic Data

- Simulated daily flow time series for a current conditions scenario and for a baseline scenario
  - Current conditions:
    - 2000 land use
    - 2005 withdrawals, discharges, and impoundment volume
    - 1984-2005 hydrology
  - Baseline:
    - Land use modified to 78% forest, 0.35% impervious surface, other land uses adjusted proportionally,
    - Discharges and withdrawals set to zero.
    - No impoundments
- Flows simulated for 747 watersheds
Hydrologic Metrics

- Broad suite of flow metrics are calculated for each flow time series
  - Plus additional metrics commonly used.
  - 256 metrics total

- Selection process to reduce number of metrics
  1. Metrics with high variation between baseline and current scenarios
  2. Metrics with high variation among watersheds
  3. High model efficiency: Medians and inter-quartile range of flow metric for Simulated flows versus for Observed flows are similar
  4. Select only one of highly correlated groups
  5. Represent different aspects of flow regime
  6. Explainable relationship with biota
Hydrologic Metrics

<table>
<thead>
<tr>
<th>Flow Range</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Frequency</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Mean high flow volume (MH21)</td>
<td>High Flow Duration (DH17)</td>
<td>High pulse count, High flow freq, Flood freq (FH9)</td>
<td>Skewness in annual max flow (MH19)</td>
</tr>
<tr>
<td>Mid</td>
<td>Median Q</td>
<td>Flood free season</td>
<td></td>
<td>Fall rate (RA3), Flashiness</td>
</tr>
<tr>
<td>Low</td>
<td>4b3, Seasonal Q85</td>
<td>Low pulse duration, Extreme low duration, Variability in low pulse duration (DL17)</td>
<td>Low pulse count, Extreme low freq.</td>
<td></td>
</tr>
</tbody>
</table>

*Seasonal flow metrics were evaluated but none of them met the initial screening criteria or were highly correlated with RA3. After further analysis some seasonal metrics may be included.*
Middle Potomac – Biological Data

1) Benthic macroinvertebrate data
   a) Only bio data set sufficiently rich for this basinwide, interstate, assessment
   b) Samples rarified to common basis and metrics calculated to family level for consistency

2) Collected in years 2000 – 2008

3) 1,313 samples at 869 locations for 747 watersheds
## Biotic Metrics

<table>
<thead>
<tr>
<th>Candidate Biometric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diversity</strong></td>
<td></td>
</tr>
<tr>
<td>Family-Level Taxa Richness</td>
<td>Number of taxonomic families</td>
</tr>
<tr>
<td>Shannnon-Wiener Index</td>
<td>A common measure of taxonomic diversity</td>
</tr>
<tr>
<td><strong>Taxonomic Composition</strong></td>
<td></td>
</tr>
<tr>
<td>%EPT</td>
<td>% of individuals belonging to Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)</td>
</tr>
<tr>
<td>EPT Taxa</td>
<td>Number of EPT families</td>
</tr>
<tr>
<td>Gold’s Index</td>
<td>1 minus % of gastropods (snails), oligochaetes (worms), and Diptera (true flies) individuals; also indicates pollution.</td>
</tr>
<tr>
<td>%Chironomidae</td>
<td>% of individuals belonging to Chironomidae family of Diptera</td>
</tr>
<tr>
<td>Ephemeroptera Taxa</td>
<td>Number of Ephemeroptera families</td>
</tr>
</tbody>
</table>
Classification

Some biological metrics appear not to need classification.

Family-Level Taxa Richness

Watershed Size | Season | "Bioregion"

- 1st, 2nd, 3rd, 4th, 5th, 6th+
- Spring, Summer, Fall, Winter
- Coastal Plain, Piedmont, Ridges, Valleys
Classification

...while others may need classification

<table>
<thead>
<tr>
<th>%Shredders</th>
<th>%Net Caddisfly</th>
<th>%Chironomidae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watershed Size</td>
<td>Season</td>
<td>“Bioregion”</td>
</tr>
</tbody>
</table>

![Box plots showing data distribution for %Shredders, %Net Caddisfly, and %Chironomidae across different categories: Watershed Size, Season, and “Bioregion”.

The box plots illustrate variability and central tendency for each category, with clear visual differentiation between categories.]
Flow-Ecology Relationships
Flow-Ecology Relationships

High Flow Frequency vs BIBI

Watershed
- Woodlands & Impoundments
- Land Uses
- Climate
- Geomorphology

Population Controls
- Population
- Competition
- Disease
- Introductions
- Edaphics

Biological Community Health
- Water Quality
- Physical Habitat

Flow Regime

Stream Habitat

Flow Alteration

BIBI Values
Flow-Ecology Relationships

High Flow Frequency vs BIBI

Macrcinvertebrate community status deteriorates with increasing frequency of high flow events.
Flow-Ecology Relationships

- **Mean daily fall rate (RAI) vs BIBI**
- **Median annual flow vs BIBI**
- **Flood Free Season vs BIBI**
- **Mean of Jul-Oct monthly Q85 flow vs BIBI**
IF Methods and Approaches Used by Advanced State Programs

- Florida – similar standards within river class
- Michigan – river classification informed by fish assemblages; similar standards within river class
- Potomac River Commission – demonstrated ecological impairment due to flow alteration in addition to other sources of stress
Presentation Overview

1. Review of science-based methods to determine IF needs

2. Methods used by select states to determine IF needs

3. IF resources for North Carolina and the SE region
Southern Instream Flow Network

Purpose - To facilitate protective instream flow policies and practices in 15 southern states by providing science-based resources and opening lines of communication.

More information at: www.southeastaquatics.net/programs/sifn/
Southern Instream Flow Research Agenda

www.southeastaquatics.net/programs/sifn

- **Problem:** The limited focus on research and funding for instream flows has resulted in a lack of science to support protective instream flow standards.

- **Objective:** to highlight research needs and coordinate sources of funding and research to address these needs.

- **Goal:** to ensure that instream flow research is focused on the needs of water resource managers for scientifically credible and protective state instream flow standards and practices.
Southern Instream Flow Research Agenda
Priority Research Topics

1. Develop a regional river classification system

2. Identify commonalities in ecosystem responses to flow alterations

3. Compile regional aquatic ecology data sets

4. Develop hypotheses for regional ecological responses to flow alteration

5. Perform field studies to test ecological responses to altered flow regimes
Integration of Instream Research Agenda Products To Develop Flow-Ecology Relationships

- Ecological Condition Assessment
- Ecological Metric
- Hypothetical Flow-Ecology Relationships
- Aquatic Conservation Priority Areas
- Sources of Flow Alteration
- Quantify Flow Alteration
- Hydrologic Models
- River Classification
- Research Priorities and Validation

Flow-Ecology Relationships

Ecological Condition

Hydrologic Alteration
SE River Classification

• Utilizing existing classifications

• Hierarchical scales
  for geomorphology, hydrology, and biota

• Principals:
  John Faustini, USFWS and Chris Konrad, USGS
Preliminary SE Flow-Ecology Relationships

Anthropogenic Flow Alterations

Source: McManamay et al. 2011
Compile regional aquatic ecology data sets

Multistate Aquatic Resources Information System

www.marisdata.org

Integrating State Data into the National Fish Habitat Assessment

MARIS States (2010)
SARP Flow Alteration Assessment

Approach – Qualitatively assess sources, spatial distribution, and relative magnitude of hydrologic alteration from water consumption, impervious cover, and dams.
In conclusion:

Generally, instream flow science is progressing and is resulting in more protective policies and management practices.

From the case studies:

- River classification works well where there is a clear relationship with biota.
- ‘Flow-ecology’ relationships help guide selection of hydrologic and biotic metrics
- Demonstrated ecological impairment due to flow alteration provides a strong basis for instream flow criteria.

If we had more time:

- Scientific certainty should be balanced with policy development.
- Presumptive standards may provide a protective option until more studies can be completed.
Environmental Flows Allocation Process in Texas

Slides Courtesy of
Kevin Mayes
Director, EF Program
## Texas EF Program

- *Flow Regime* – Integration of Ecological Flow Components
- *IFIM-style methodology*
- *Statistically-based approach for recommendations*
- *Sound ecological management target*

### Overbank Flows

<table>
<thead>
<tr>
<th>Flow Type</th>
<th>Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overbank</td>
<td>4,000-10,000 cfs for 2-3 days</td>
<td>Once every 3-5 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Channel Maintenance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Riparian Connectivity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seed dispersal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Floodplain habitat</td>
</tr>
</tbody>
</table>

### High Flow Pulses

<table>
<thead>
<tr>
<th>Flow Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Flow Pulses</td>
<td>300-450 cfs</td>
</tr>
<tr>
<td></td>
<td>maintain biodiversity and longitudinal connectivity</td>
</tr>
</tbody>
</table>

### Base Flows

<table>
<thead>
<tr>
<th>Flow Type</th>
<th>Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec</td>
</tr>
</tbody>
</table>

### Subsistence Flows

<table>
<thead>
<tr>
<th>Flow Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsistence</td>
<td>35 - 55 cfs</td>
</tr>
<tr>
<td></td>
<td>Maintain water quality (35 cfs) and key habitats in May (55 cfs)</td>
</tr>
</tbody>
</table>
Texas Instream Flow Studies: Technical Overview

- Clear definitions and process
- Well-defined stakeholder/public involvement process
- Integration framework ties flow components and disciplines
- Approved by National Research Council
Texas Environmental Flow Program
Priority Study River Segments
TIFP Process

Stakeholder Input → Reconnaissance and Information Evaluation
Stakeholder Input → Goal Development Consistent with Sound Ecological Environment
Stakeholder Input → Study Design
Stakeholder Input → Multidisciplinary Data Collection and Evaluation
Stakeholder Input → Data Integration to Generate Flow Conditions
Stakeholder Input → Draft Study Report
Stakeholder Input → Final Study Report

Peer Review

Next Steps: Implementation, Monitoring, and Adaptive Management

SB2 ends

Post SB2
Instream Flow Components
(National Research Council 2005)

- Overbank Flow
- High Flow Pulses
- Base Flow
- Subsistence Flow
Primary Disciplines

- Hydrology & Hydraulics
- Physical Processes (Geomorphology)
- Biology
- Water Quality

Connectivity
Key Species and/or Habitat Diversity
Hydrology-Based Environmental Flow Regime (HEFR) Basics

- Uses hydrologic data
- Computations are rapid
- Populates a flow regime matrix

1. Select Flow Gage
2. Select Period of Record
3. Separate (parse) Hydrograph into Flow Components
4. Generate Statistical Summaries in Excel

Produced for the Senate Bill 3 Environmental Flows Allocation Process
Mesohabitat for Rainwater Ranch at Q=1000cfs

- Boundary
- Mesohabitat
  - Deep Pool
  - Medium Pool
  - Shallow Pool
  - Run
  - Slow Riffle
  - Fast Riffle
  - No Data
Base Flows

Assess Bedform and Banks

Calculate Base Flow Statistics

Model Hydraulic Characteristics in Relation to Flow

Assess Habitat-Flow Relationships, including Diversity

Describe Wet, Normal, and Dry Years

Identify Biological Issues and Key Species

Collect Biological Data

Determine Habitat Criteria

Assess Habitat-Flow Relationships, including Diversity

Consider Biological and Riparian Issues

Consider Water Quality Issues

Base Flows

Primary Discipline
- Hydrology/Hydraulics
- Biology
- Geomorphology
- Water Quality
High Flow Pulses

Assess Active Channel Processes

Develop Sediment Budgets

Assess Channel Adjusting Flow Behavior

Describe Significant Habitat Conditions

Consider Biological Issues

Calculate High Flow Statistics

Consider Water Quality Issues

High Flow Pulses

Primary Discipline
- Hydrology/Hydraulics
- Biology
- Geomorphology
- Water Quality
Overbank Flows

- Calculate Flood Frequency Statistics
- Model Extent of Flood Events
- Assess Overbank Flow Behavior
- Conduct Riparian Studies
- Estimate Riparian Requirements
- Overbank Flows

Primary Discipline:
- Hydrology/Hydraulics
- Biology
- Geomorphology
- Water Quality
Integration to Generate a Flow Regime
Integration of Flow Components

<table>
<thead>
<tr>
<th>Overbank Flows</th>
<th>4,000-10,000 cfs for 2-3 days</th>
<th>700-1500 cfs for 2-3 days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Once every 3-5 years</td>
<td>2-3 X per year every year</td>
</tr>
<tr>
<td></td>
<td>Channel Maintenance</td>
<td>Sediment transport</td>
</tr>
<tr>
<td></td>
<td>Riparian Connectivity</td>
<td>Lateral connectivity</td>
</tr>
<tr>
<td></td>
<td>Fish spawning</td>
<td></td>
</tr>
<tr>
<td>Subsistence Flows</td>
<td>35 - 55 cfs</td>
<td>100-150 cfs</td>
</tr>
<tr>
<td></td>
<td>Maintain water quality (35 cfs)</td>
<td>Fish habitat</td>
</tr>
<tr>
<td></td>
<td>and key habitats in May (55 cfs)</td>
<td></td>
</tr>
</tbody>
</table>

High Flow Pulses

<table>
<thead>
<tr>
<th>Base Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-150 cfs Fish habitat</td>
</tr>
<tr>
<td>150-300 cfs Spring spawning</td>
</tr>
<tr>
<td>40-50 cfs Fish habitat</td>
</tr>
<tr>
<td>90-100 cfs Fish habitat</td>
</tr>
</tbody>
</table>

300-450 cfs maintain biodiversity and longitudinal connectivity

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Status of Texas Environmental Flow Process

**Texas Environmental Flows Process** (Stakeholder process under SB3)
Stakeholder environmental flow recommendations (instream flows and freshwater inflows to bays and estuaries):
1. Sabine-Neches-Sabine Lake
2. Trinity-San Jacinto-Galveston Bay
3. Colorado and Lavaca Rivers and Matagorda and Lavaca Bays Basin and Bay
4. Guadalupe, San Antonio, Mission, and Aransas Rivers
5. Mission, Copano, Aransas, and San Antonio Bays Basin and Bay

Analyses and draft reports in prep:
• Rio Grande, Rio Grande Estuary, and Lower Laguna Madre
• Brazos River and Associated Bay and Estuary System
• Nueces River and Corpus Christi and Baffin Bays.

**Texas Instream Flow Program** (Environmental studies under SB2)
Interim report:
1. Lower San Antonio River

Multidisciplinary studies underway in:
• lower San Antonio River
• middle and lower Brazos River
• lower Sabine River
• Parts 3 and 4 – this is the most important part. Take care to focus on the science as much as possible, and if talking about the approach a state settled on, point out changes that were made based on other factors (economics, politics etc.)

• With regards to the science and what other states are doing, here are some questions:
  – Are they classifying/sorting streams? How?
  – How are they coming up with ecological response relationships? What metrics are they evaluating? If working with biological databases, how are they isolating flow effects from water quality effects and effects downstream of big dams not related to flow?
  – How are they evaluating degree of hydrologic alteration against which biological data is being contrasted? What metrics for flow alteration?
Develop testable ideas about flow-ecology relations

- many possible ecological responses
- multiple plausible hydrologic drivers

Freeman and Marcinek 2006

**Figure 5.** Richness estimates for fluvial specialist (A) and habitat generalist (B) fishes plotted in relation to withdrawal index at intake and reservoir sites, data for all years.