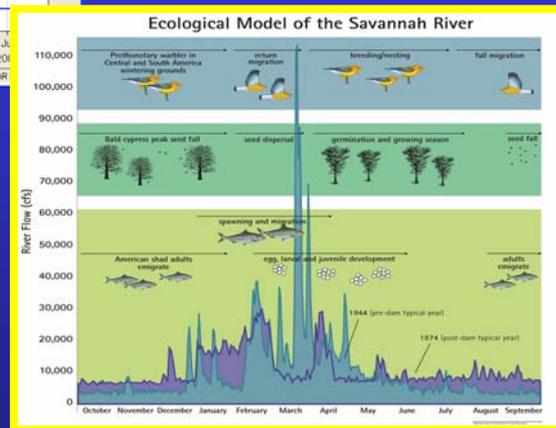
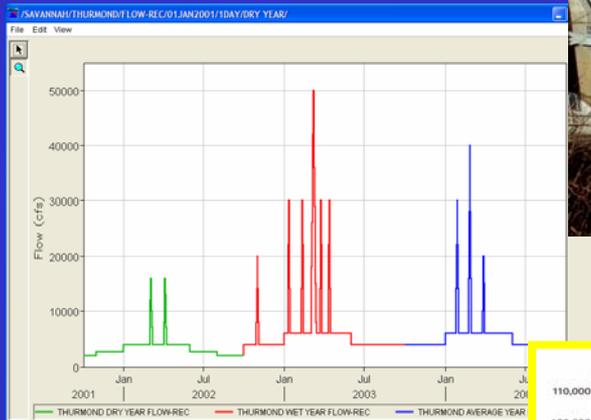


Tools to Assess Environmental Flows in Dam Operations



US Army Corps
of Engineers

John Hickey
Hydrologic Engineering Center



Andy Warner
Sustainable Waters Program

Sustainable Rivers Project (SRP)

...national collaboration between the U.S. Army Corps of Engineers and The Nature Conservancy to re-operate dams



US Army Corps
of Engineers



Sustainable Rivers Project (SRP)

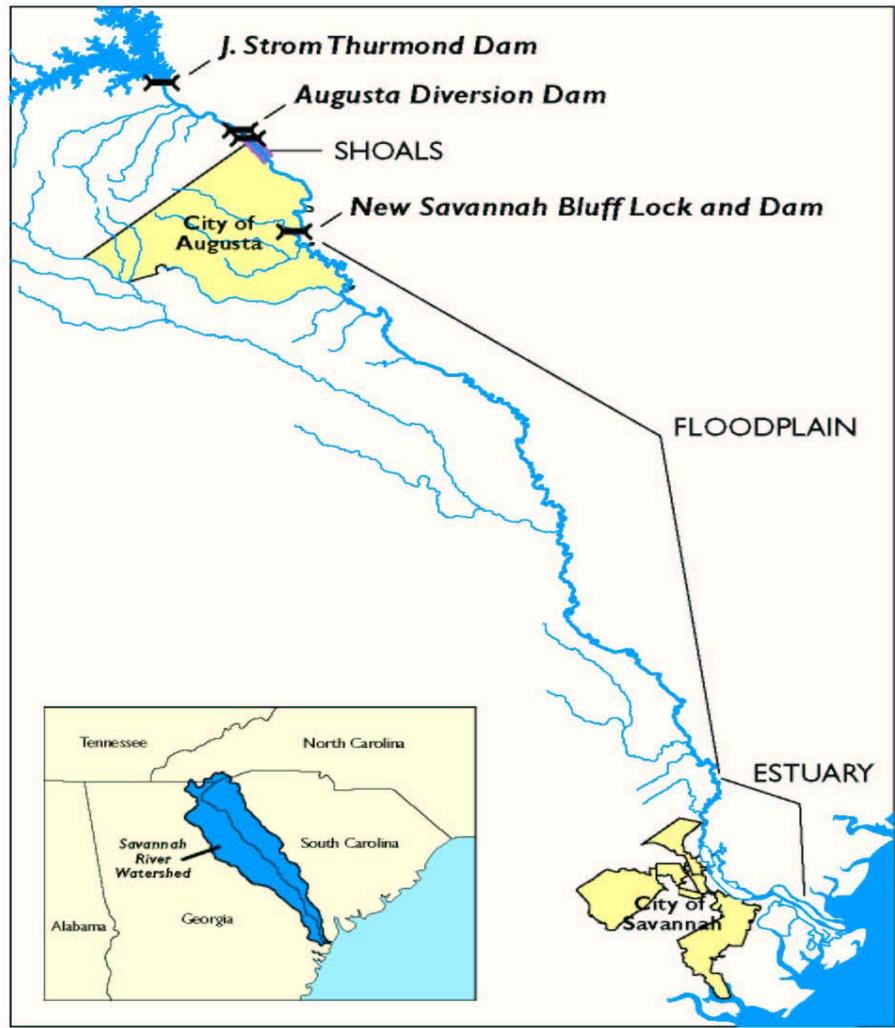
- **Collaboration on 9 River Systems**
- Joint Training Courses
- Interagency Personnel Agreement
- New Modeling Capabilities
- Joint Software Development

↙ *Hydrologic Engineering Center*

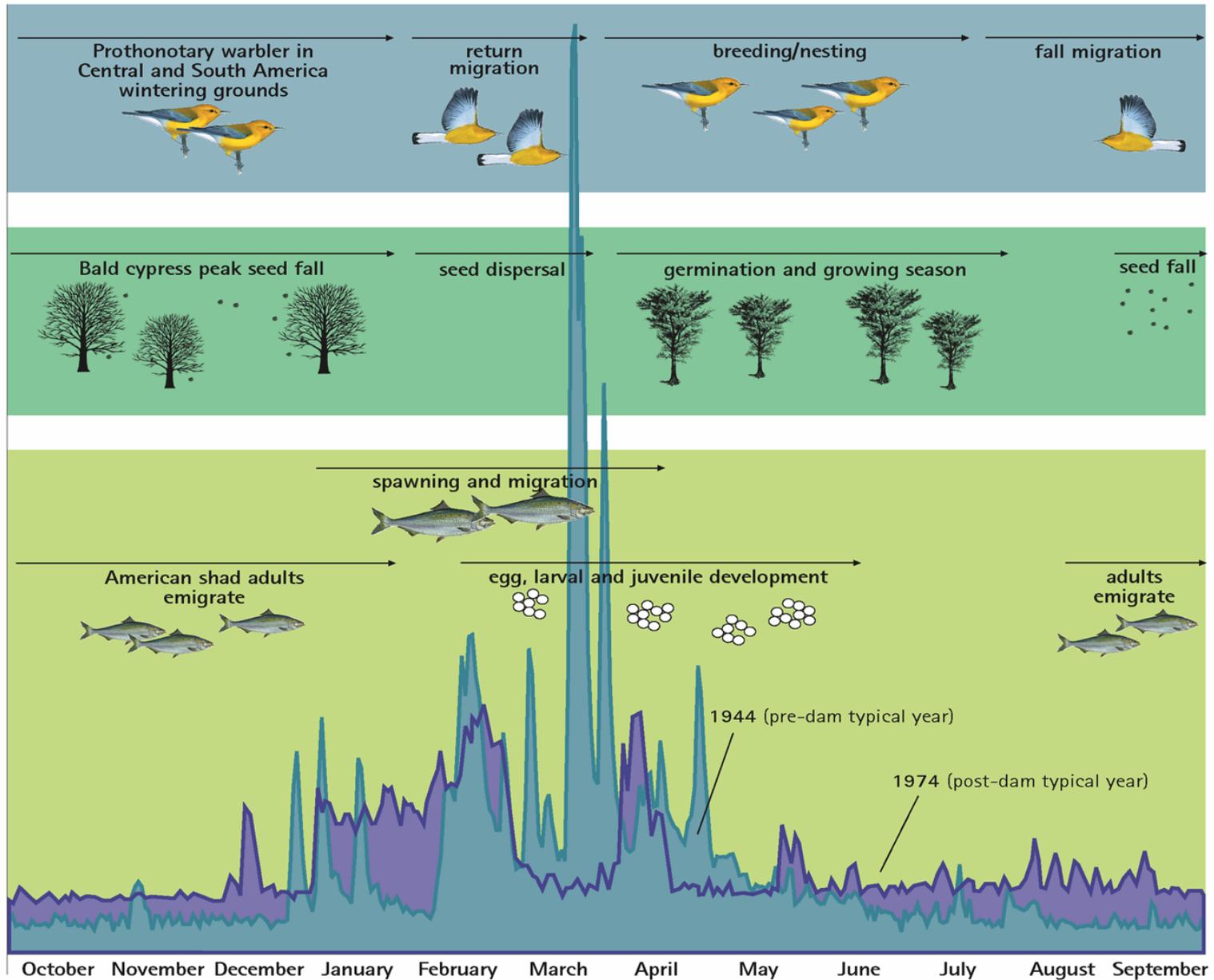


US Army Corps
of Engineers





Ecological Model of the Savannah River



Ecosystem Flow Recommendations

Savannah River, below Thurmond Dam (River-Floodplain)

Floods

50,000-70,000 cfs; 2 weeks, avg every 2 yrs

- Maintain channel habitats
- Create floodplain topographic relief
- Provide fish access to the floodplain
 - control invasive species
- Maintain wetlands and fill oxbows and sloughs
- Enhance nutrient cycling & improve water clarity
 - Disperse tree seeds

High
Flow
Pulses

>30,000 cfs; 5 pulses, >2 days with 2 events of 2 week duration (March and early April)

20,000-40,000 cfs; 2-3 days, 1/month

- Provide predator-free habitat for birds
 - Disperse tree seeds
 - Transport fish larvae
- Flush woody debris from floodplain to channel
 - Floodplain access for fish
 - Fish passage past NSBLD

<13,000 cfs; 3 successive years, every 10-20 years

- Floodplain tree recruitment

8,000-12,000 cfs;

- Exchange water with oxbows

Low
Flows

>8,000 cfs

- Larval drift for pelagic spawners

<5,000 cfs

- Adequate floodplain drainage
- Create shallow water habitat for small-bodied fish

3,000 cfs; 3 successive years every 10-20 years

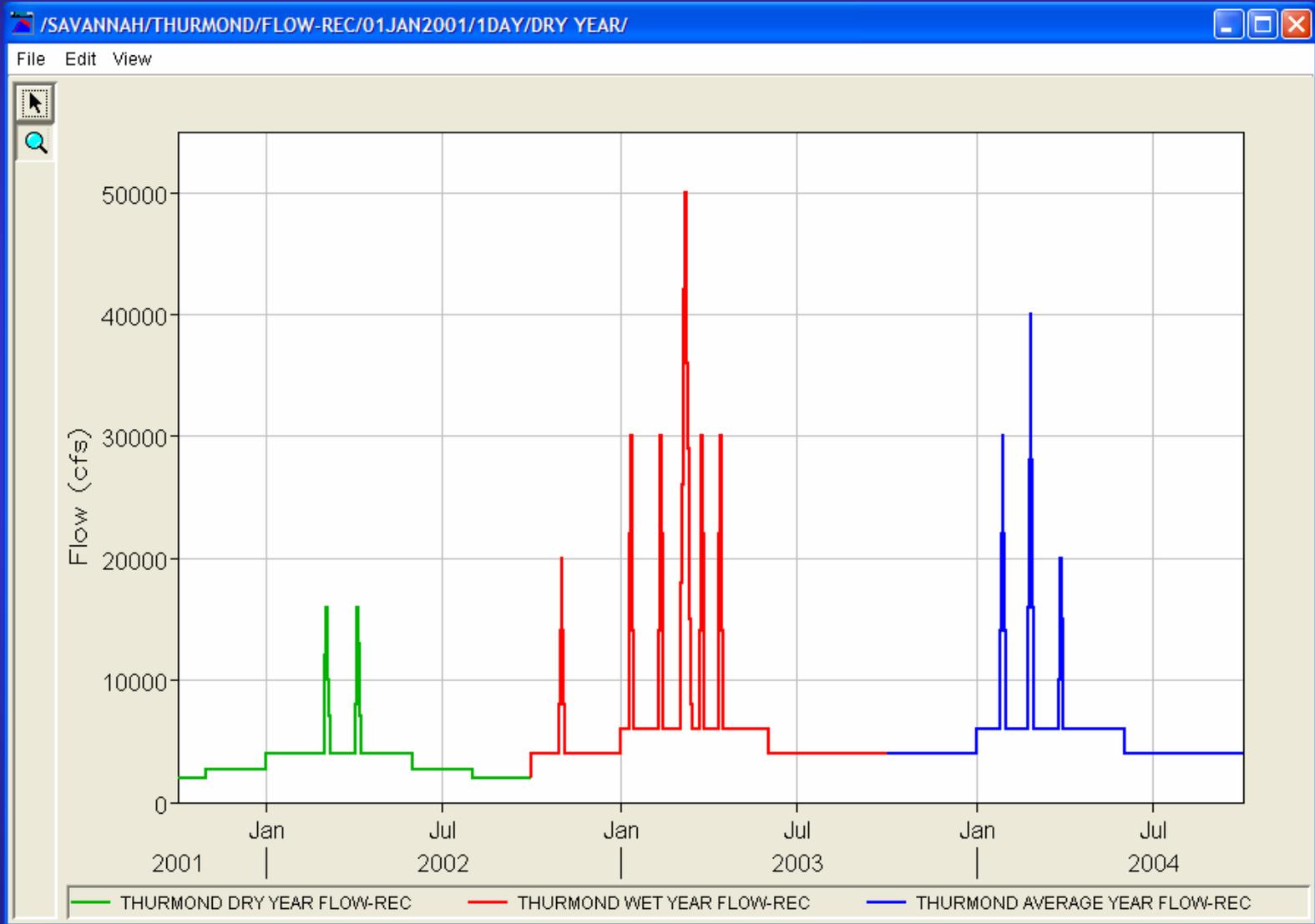
- Floodplain tree recruitment

Key

- Wet Year
- Avg Year
- Dry Year

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Savannah Flow Recommendations



Pulsinator

Scripting environmental flows



Real-time comparisons to natural flows & existing operations

Date (ddmmm)	Duration (Days)	Peak (cfs)	D.O.P. (Days)
01Mar	6	16000.0	1
01Apr	6	16000.0	1

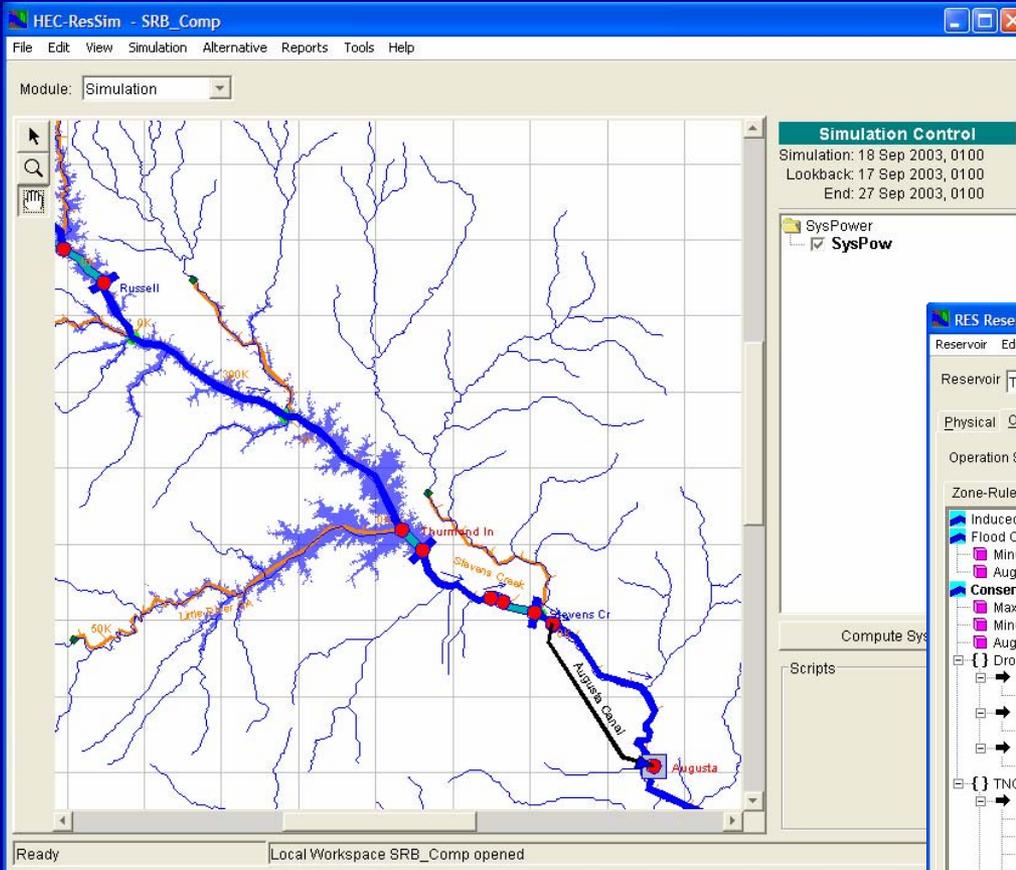
Date (ddmmm)	Flow (cfs)	Description
01Oct	2000.0	
01Nov	2700.0	
01Jan	4000.0	
01Jun	2700.0	
01Aug	2000.0	

Reality Check

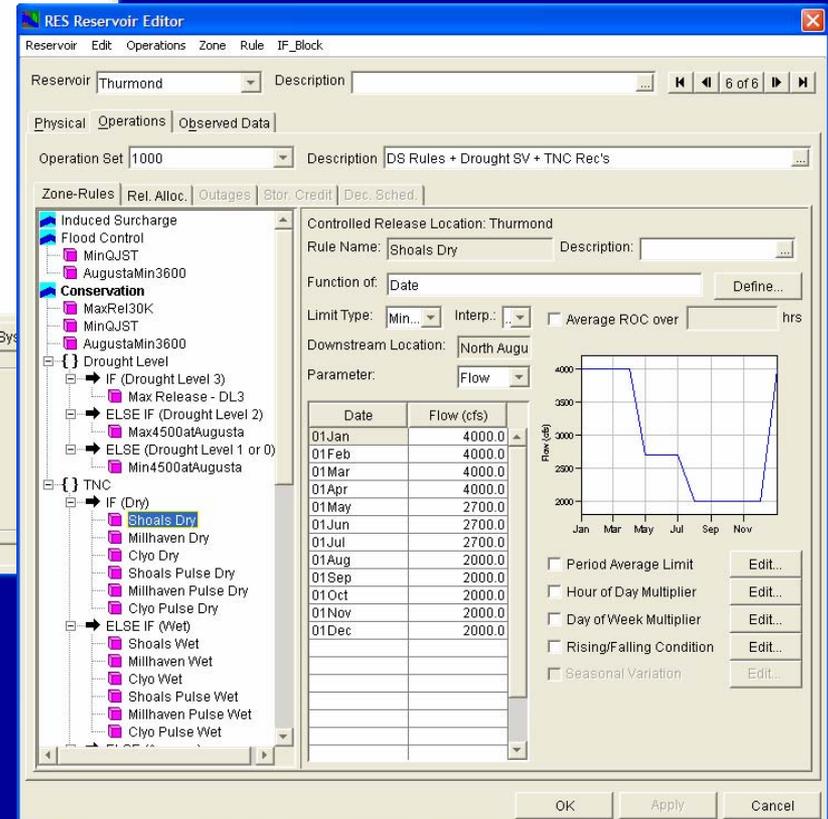
Access to other data



HEC-ResSim



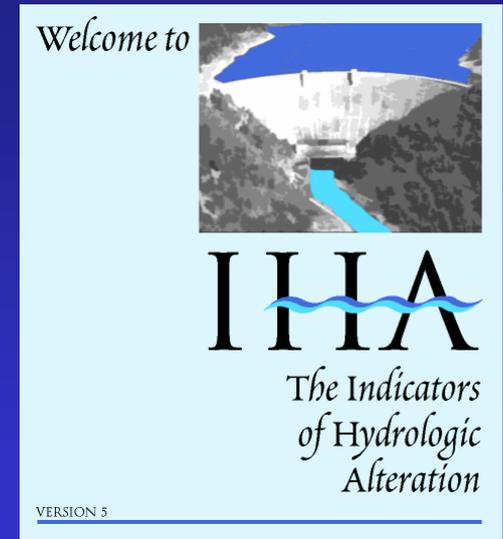
Reservoir Evaluation System – Reservoir modeling to analyze water management alternatives



Advanced Features used by Savannah District – System Hydropower; State Variables; If, Then, Else Logic...

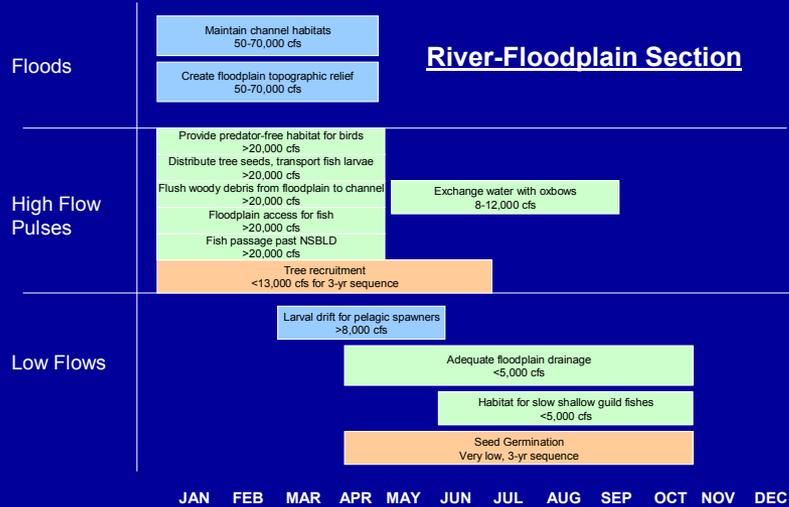
Indicators of Hydrologic Alteration (IHA)

- IHA: statistical software for analyzing flow regimes
- **Potential DSS-IHA link**
...to allow immediate assessment of management options



HEC-EFM

Hydrology-Ecology Links



Ecosystem Functions Model (EFM) – Analyze alternative flows (ResSim) from an ecosystem perspective

Savannah.efm - HEC-EFM

File Edit Help

Relationship name: Base - Habitat for Shad and Striped Bass

Description: Base - Habitat for Shad and Striped Bass
Pulse - Habitat for Shad and Striped Bass
Base - Spring Sturgeon Spawning
Base - Shoals Spider Lilly
Pulse - Shoals Spider Lilly
Base - Habitat for Resident Fish and Outmigrants
Base - Fall Sturgeon Spawn
Pulse - Fall Sturgeon Spawn

Options

- Write computation arrays
- Hypothesis tracking - increased flow will
 - Curve eco-health
- Confidence tracking: ★☆☆☆☆

Index A B C D E

Statistical queries

- Season
 - From: 01/01 (m/d)
 - To: 05/31 (m/d)
- Duration of 30 days
 - Sustained high Average high
 - Sustained low Average low
- Rate of change: Stage Flow
 - feet per [] days
 - Rising Falling Absolute

Time series specifications

- 50 % exceedance (of time)
 - Flow frequency Flow duration
 - [] to [] Water year range
 - Individual water year
 - Relationship-defined water year

Geographical queries

- Velocity
 - From [] to [] ft/sec
- Depth
 - From [] to [] ft

Map layers

- HEC-RAS and GeoRAS information:
 - Inundated area shapefile: []
 - Depth grid coverage: []
 - Velocity grid coverage: []
 - Shear stress file: []
- Other map layers: []

Map Intercept

Properties Relationships Tables

Completed Recalc

HEC-EFM: Results

Savannah.efm - HEC-EFM

File Edit Help

Evaluated at: 03/31/2004 13:01

Summary

Relationship	Conf.	Unimpaired		Chg.	Gaged		Chg.	Prescription	
		Stage, ft	Flow, cfs		Stage, ft	Flow, cfs		Stage, ft	Flow, cfs
Base - Habitat for Shad and Striped Bass	n/a	2.9	4,556	Pos	3.8	5,572	Neg	1.8	4,067
Pulse - Habitat for Shad and Striped Bass	n/a	33.4	130,469	Neg	21.6	34,974	Neg	23.2	50,000
Base - Spring Sturgeon Spawning	n/a	2.4	4,496	Pos	3.9	5,580	Pos	4.4	6,000
Base - Shoals Spider Lilly	n/a	5.3	6,811	Neg	3.5	5,314	Neg	.1	2,700
Pulse - Shoals Spider Lilly	n/a	24.4	70,488	Pos	19.6	27,779	Pos	4.4	6,000
Base - Habitat for Resident Fish and Outmigrants	n/a	14.0	16,533	Neg	7.6	9,008	Neg	.9	3,350
Base - Fall Sturgeon Spawn	n/a	.0	711	Pos	1.4	3,768	Pos	1.7	4,000
Pulse - Fall Sturgeon Spawn	n/a	19.2	34,324	Neg	7.3	10,252	Neg	1.3	3,675
Base - Floodplain Seedling Establishment	n/a	10.7	12,308	Pos	4.8	6,387	Pos	.1	2,700
Flood - Geomorphic Effects	n/a	34.1	133,395	n/a	21.8	36,269	n/a	23.2	50,000
Pulse - Freshening Pulse	n/a	18.7	40,775	n/a	19.4	28,440	n/a	12.5	16,286

Index Values

Unimpaired Gaged Prescription

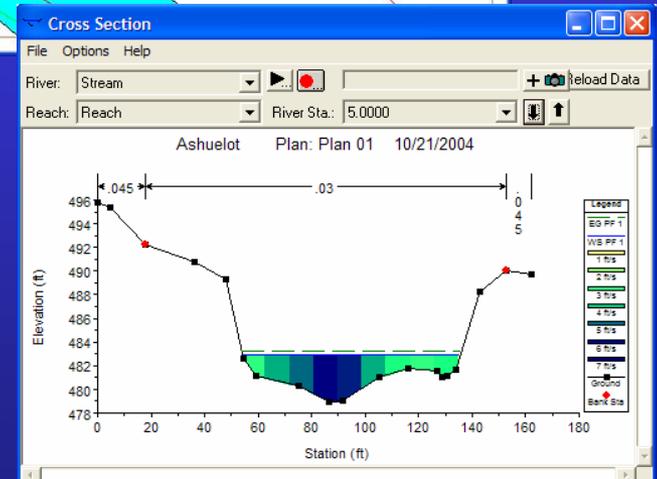
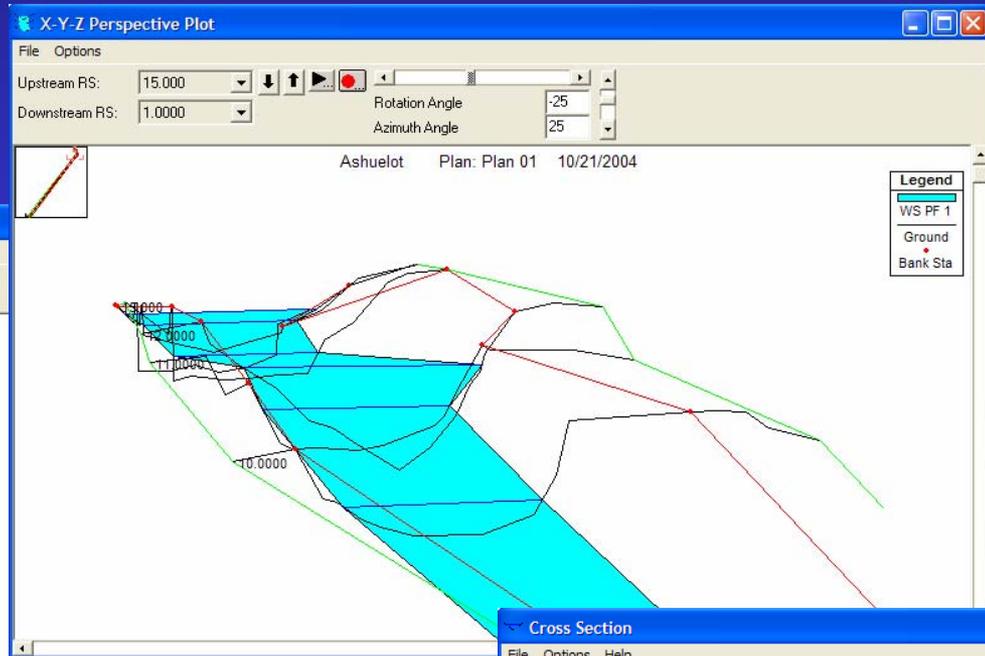
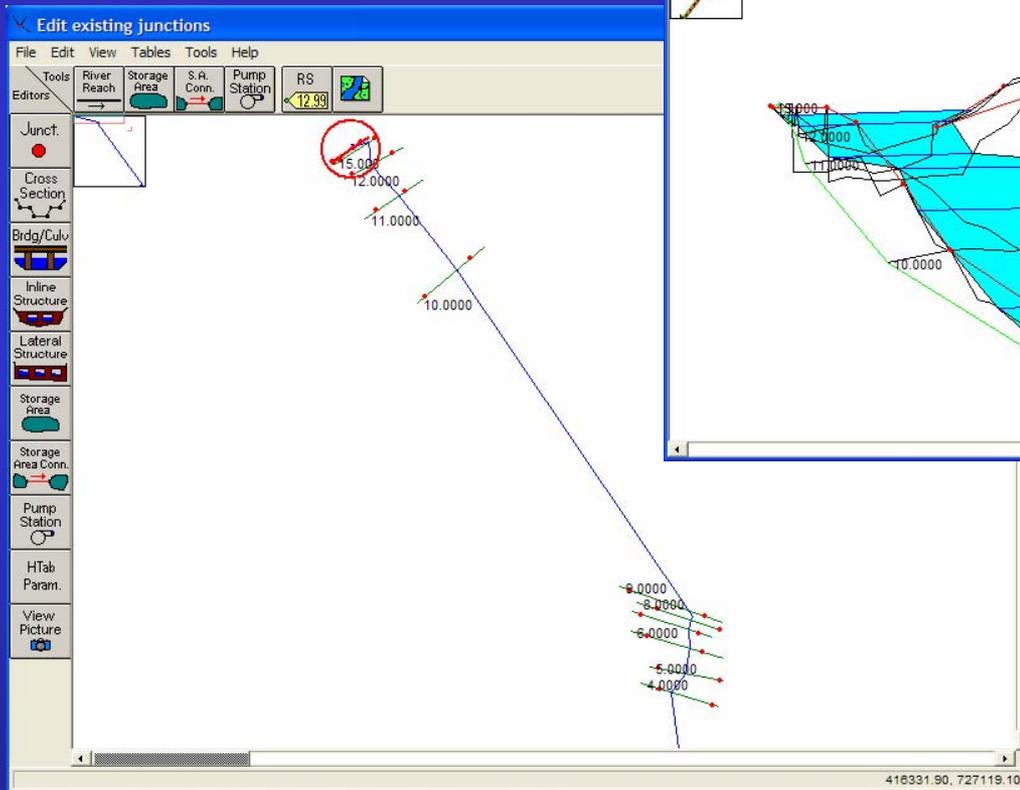
Notes:

Properties Relationships **Tables**

Completed Recalc

HEC-RAS

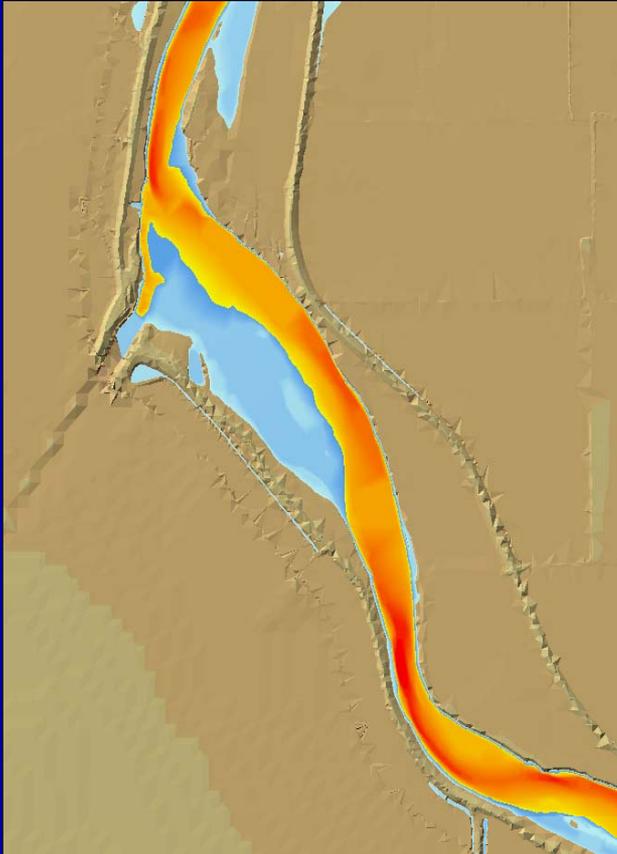
River Analysis System –
River hydraulics, steady
or unsteady state



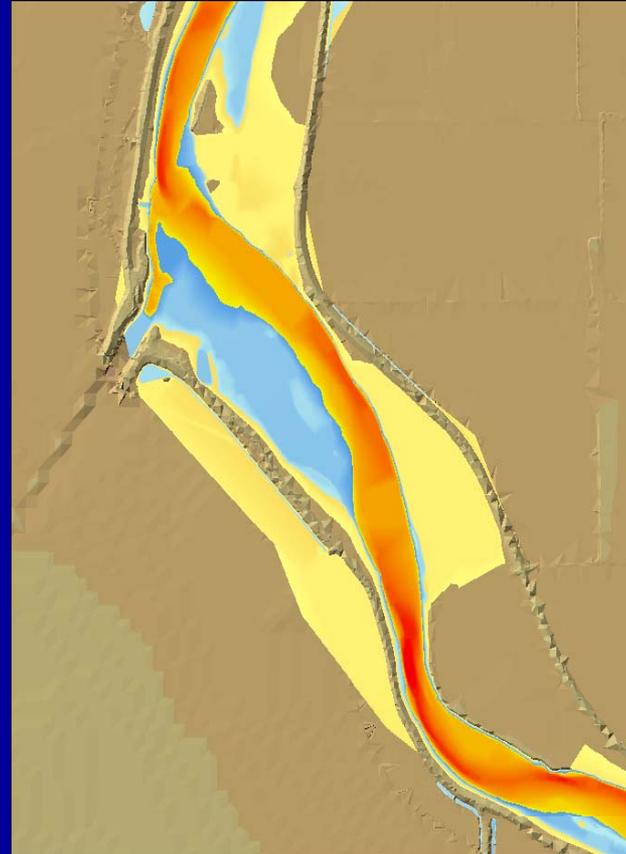
EFM-RAS

Floodplain Spawning

Without Project



With Project



Tools for Assessing Environmental Flows in Dam Operations

- Institutional relationships:
 - coordination and collaboration on multiple projects
 - joint training
 - formal staff exchanges (IPA)

... are fostering the improvement of existing tools and the development of new ones



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The common definition of a problem leads to the common development of a solution



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