



Overlays to Hydrology-Based Environmental Flow Regimes

Science Advisory Committee

March 4, 2009

Austin, Texas

Overlays - Definition

- Application of analysis to validate or refine flow estimates derived from hydrologic analysis
 - Not limited to quantitative adjustments
 - Expected ecological response -> research priorities and indicators
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Overlays - Examples

- Literature Survey and Summary Report

 - Subsistence
 - *Water Quality Standards*
 - *Longitudinal Connectivity*
 - *Water Quality Models*

 - Base
 - *Analysis of Fish Assemblage*
 - *Hydraulic-Habitat Models*

 - High Flow Pulse
 - *Effective Discharge Estimate*
 - *Spawning/Migratory Cues*
 - *Riparian/Oxbow Connection Points*
 - *Sediment Transport Model*

 - Overbank
 - *Bankfull Discharge Estimate*
 - *High Flow Rating Curves*
 - *HEC-RAS Water Surface Model*
 - *GIS Analysis of Inundated Areas*
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Subsistence

Ecological Response

- *Maintain water quality criteria*
- *Providing life cycle cues*
- *Providing refugia habitat*

Overlays

- *Water Quality Standards*
- *Longitudinal Connectivity*

- *Water Quality Models*

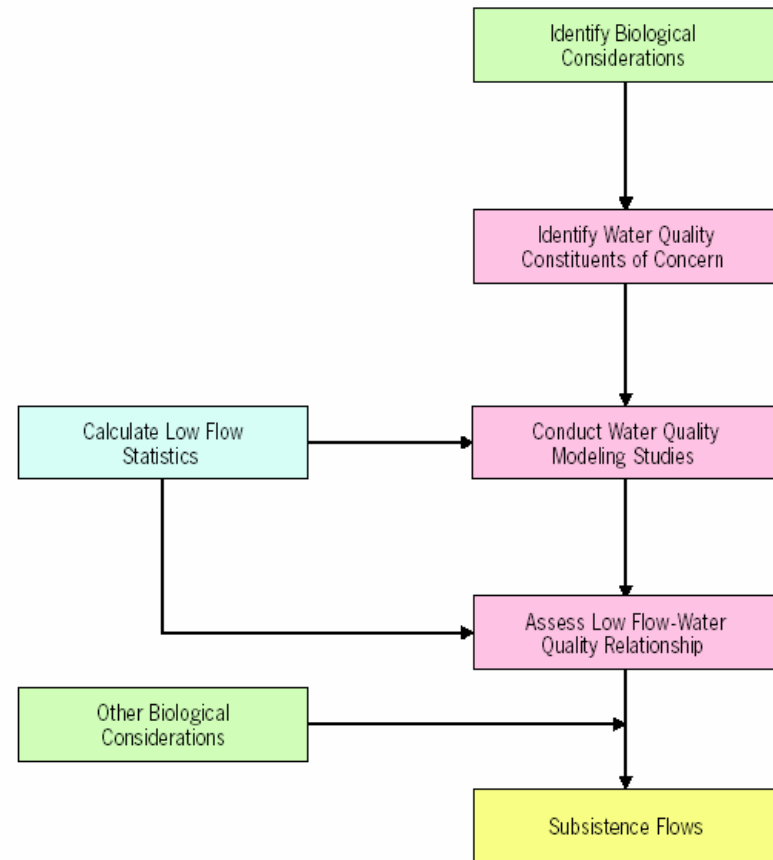
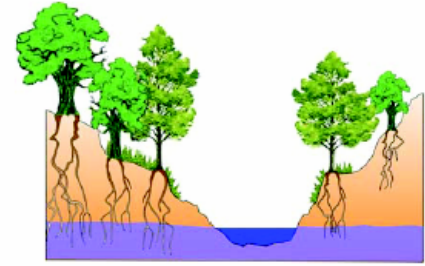
Subsistence Flows

Spatial scale:
River Reach

Temporal scale:
Hourly Flow, Varies from Month to Month

Primary discipline:

- Hydrology/Hydraulics
- Biology
- Geomorphology
- Water Quality



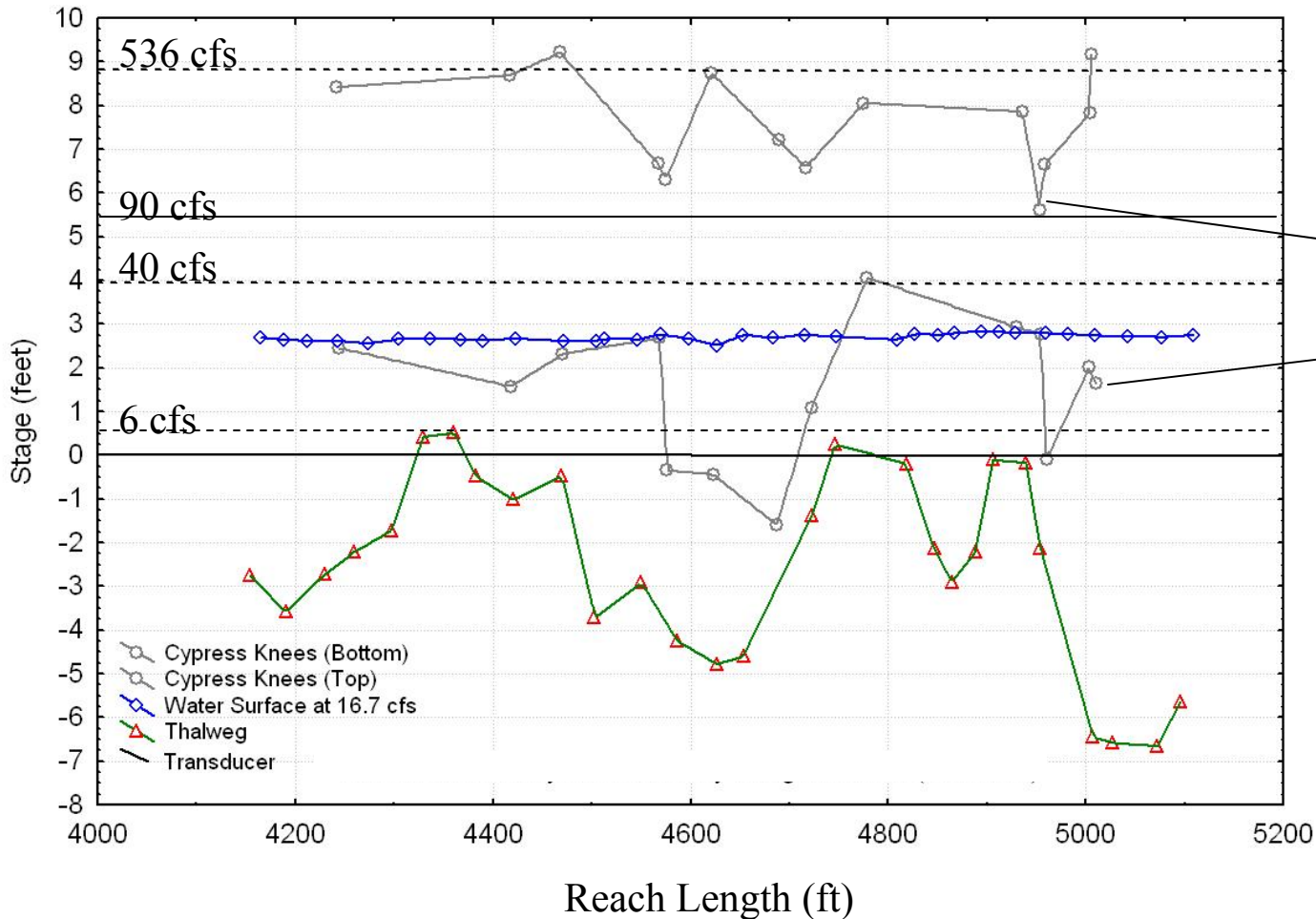
Watershed Protection Plan

- Identify water quality constituents of concern
 - pH, mercury (in fish tissue), elevated bacteria, depressed dissolved oxygen concentration (DO) and nuisance vegetation
 - Relationship to Flow Regime Components
 - *Subsistence* - Diurnal variation of DO
 - *Low Flow during Summer* - Change in temperature
 - *Pulses* - Flushing and refresh of pools or backwater areas
 - *Pulses* - Overbanking, interaction with maintenance flows; post-event influx of vegetation and organic matter
 - Potential water quality modeling tasks
 - *Subsistence flows* – Daily and/or diurnal DO kinetic analysis
 - *Base flows* - Evaluate summer (Jul-Aug) low flows against 8.4cfs 7Q2 for Big Cypress
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Longitudinal Connectivity

Good agreement between surveyed channel features and the flow prescriptions chosen to maintain longitudinal **connectivity** from dry (6 - 90 cfs) through wet year (40 – 536 cfs)

Big Cypress Creek at Thomas Camp (BC03)
Maintain Biodiversity and Connectivity During a Wet Year



Cypress knees are important structure for aquatic biota

Base Flows

Ecological Response

- *Ensure adequate habitat conditions, including variability*

Overlays

- *Analysis of Fish Assemblage*
- *Hydraulic-Habitat Model*
 - *Stream Survey & Discharge Rating Curve*
 - *Habitat Suitability Criteria*

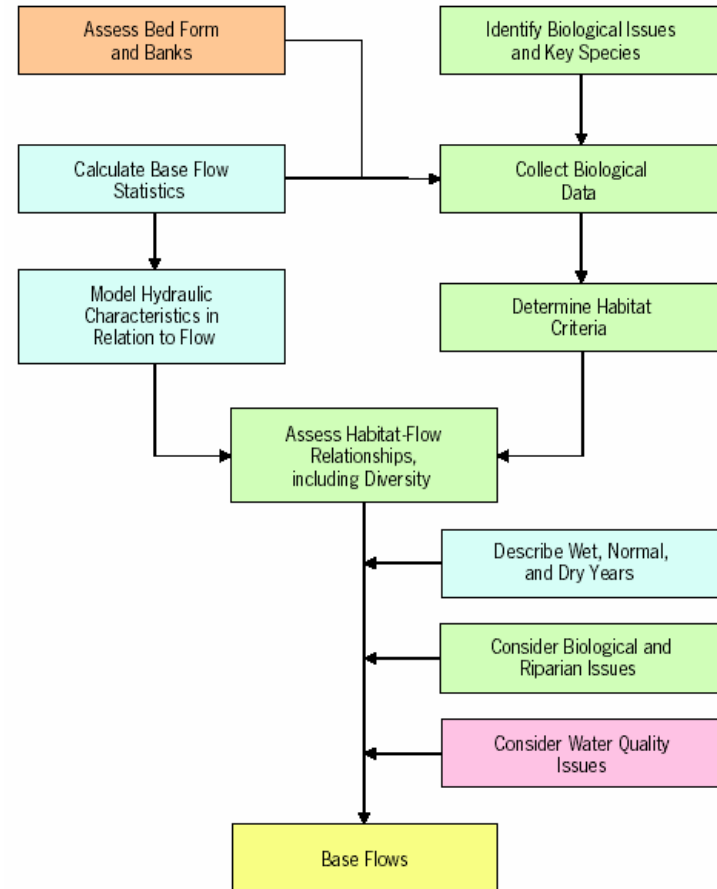
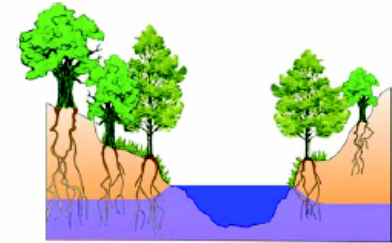
Base Flows

Spatial scale:
River Reach

Temporal scale:
Daily Flow Range, Varies from Month to Month

Primary discipline:

- Hydrology/Hydraulics
- Biology
- Geomorphology
- Water Quality



Analysis of Fish Assemblage – Literature Review

Life history summaries of select species representing various flow dependencies (i.e. dependent on flowing channel habitats, backwater habitats)

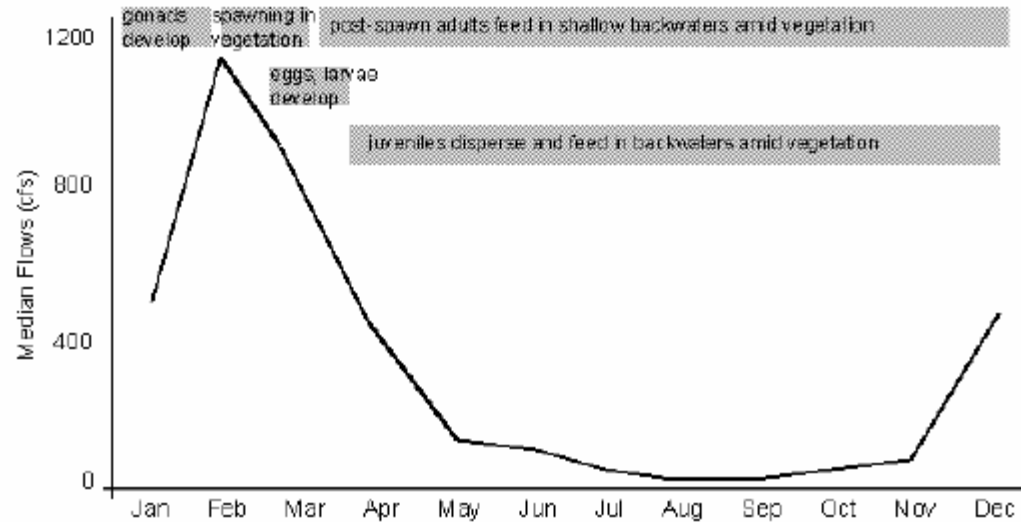


Figure 20. Chain pickerel (backwater-dependent species) life cycle in relation to seasonal flow (portrayed relative to pre-1967 median flows in Big Cypress Bayou).

“The ichthyofauna of the Cypress Bayou basin appears to have shifted from assemblages dominated by cyprinids, percids, and cyprinodontids in the 1950’s to assemblages dominated by centrachids, other cyprinids, clupeids, and atherinids in the 1980’s.”

Hoover et al. Fishes of the Cypress Bayou System in Northeast Texas and Northwest Louisiana. Unpublished manuscript 1989.

Analysis of Fish Assemblage – Museum Study

<u>Reproductive Guild</u>		<u>1953-1954</u>	<u>1995</u>	<u>2006</u>
Non guarders				
	Open Substratum			
	Pelagophils [†]	22.49	7.25	0.72
Guarders				
	Nest Spawners			
	Lithophils [∞]	7.38	42.58	56.15

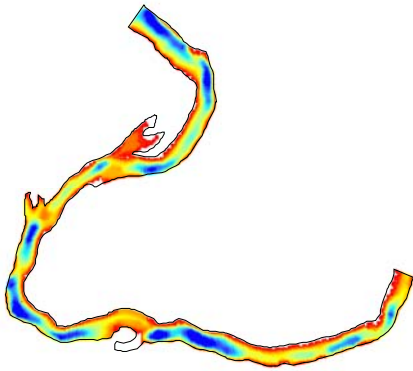
- Pelagophils[†]: Obligate riverine species, broadcast-spawn buoyant eggs within current
- Lithophils[∞]: Includes most Centrarchidae, spawn elliptical egg envelopes over rock or gravel nests

Historical Analysis of Fish Assemblage – Studies and Resources

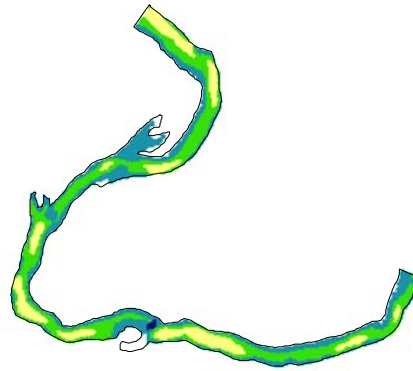
- Fishes of Texas - University of Texas at Austin, Texas Natural History Collections
 - Analysis of Existing Biological Data – Texas State University, Texas Instream Flow Program
 - Texas Freshwater Fishes -
<http://www.bio.txstate.edu/~tbonner/txfishes/index.htm>
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Hydraulic-Habitat Model

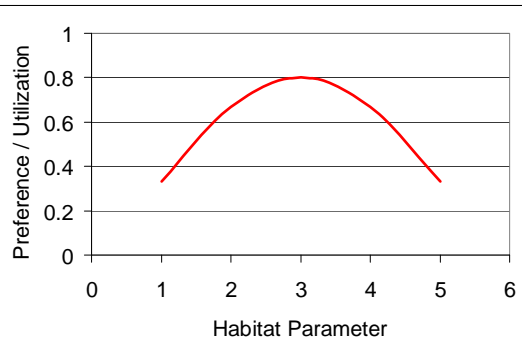
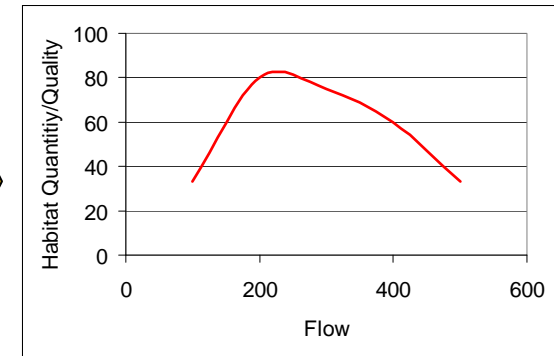
Hydraulic Model



Habitat Area

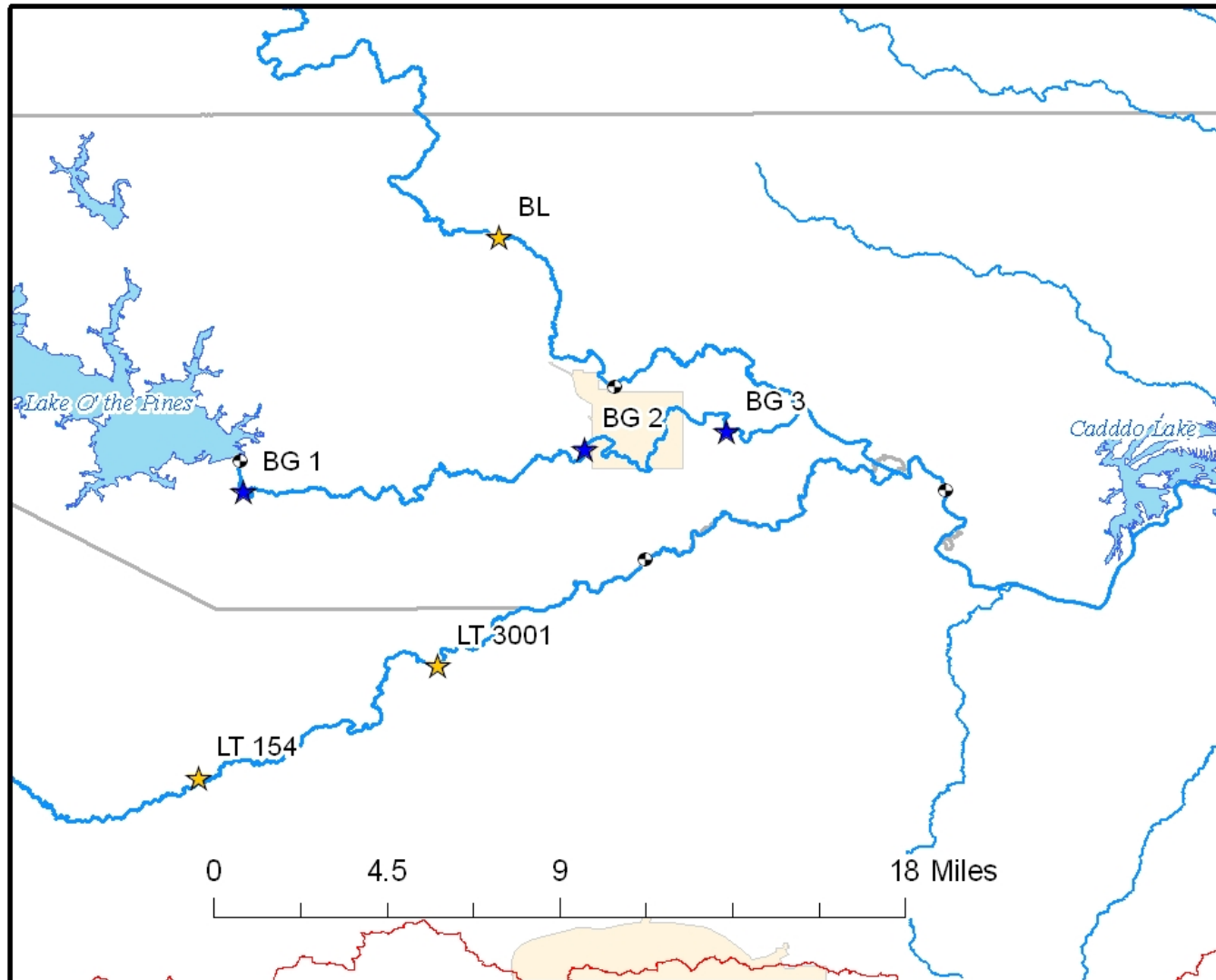


Flow vs. Habitat

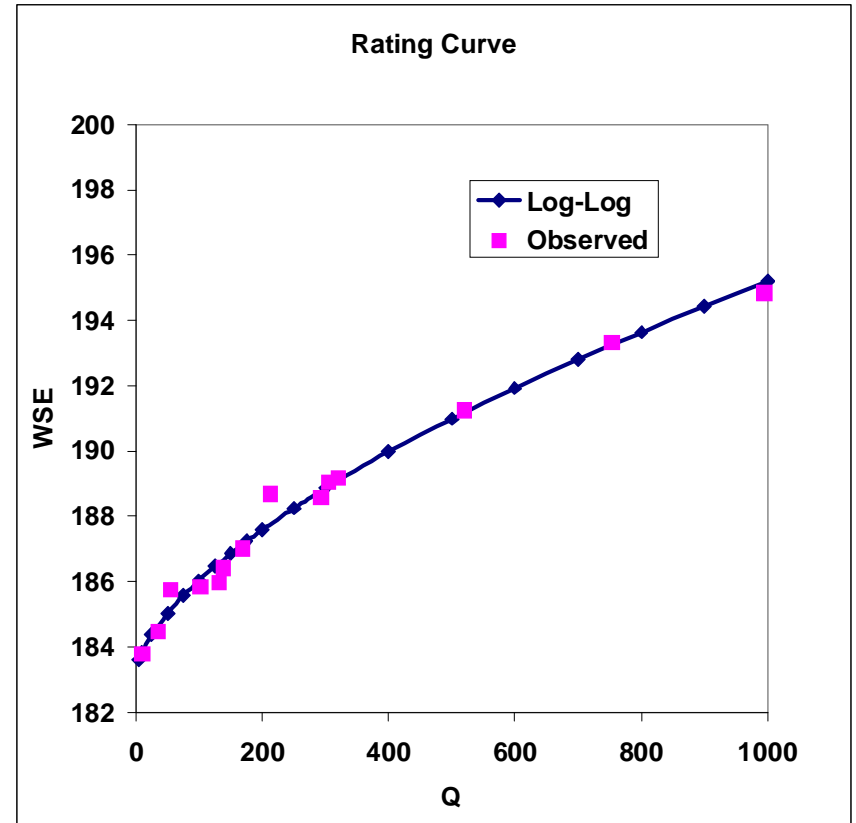
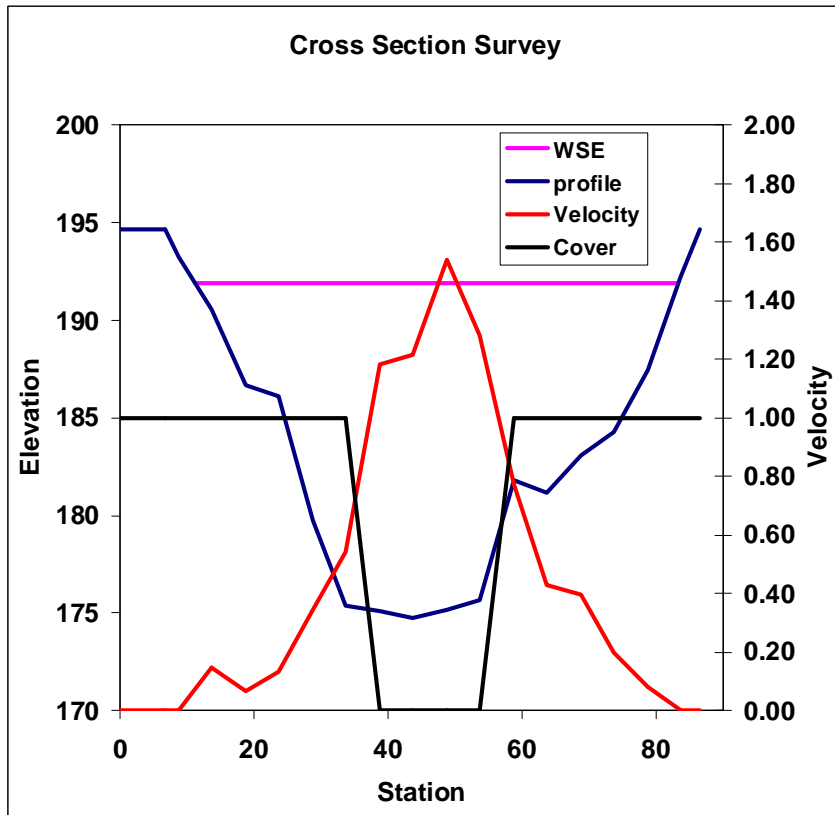


Habitat Suitability

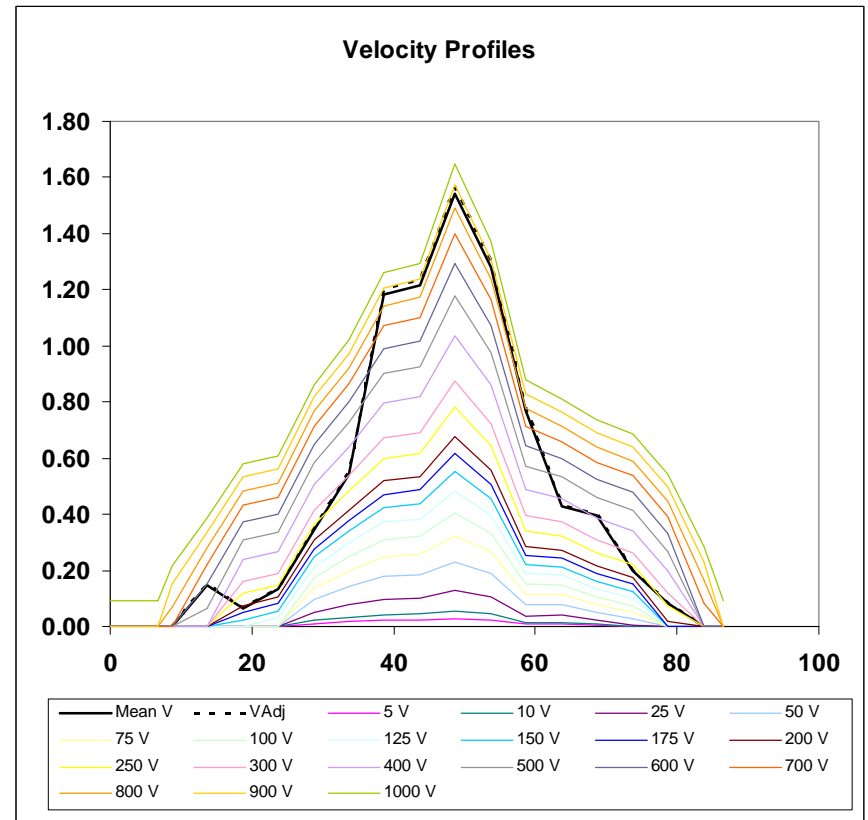
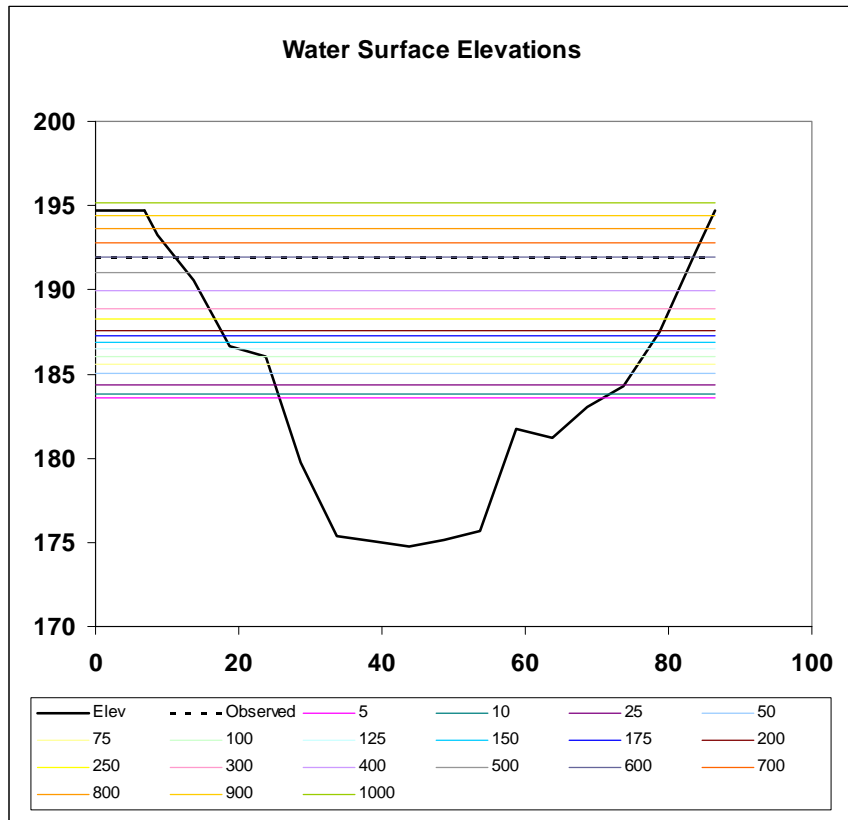
Existing Data



Cross Section Surveys & Rating Curves

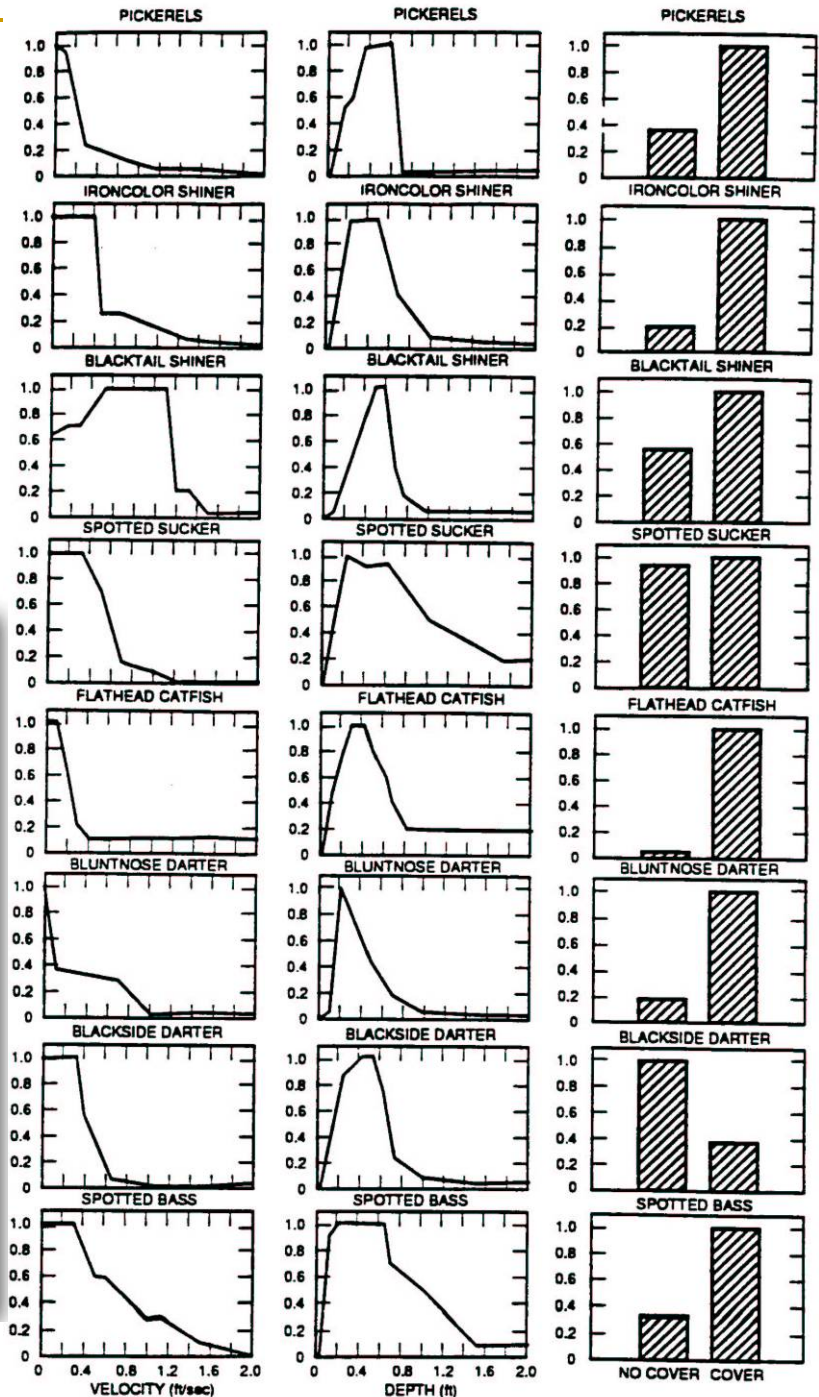
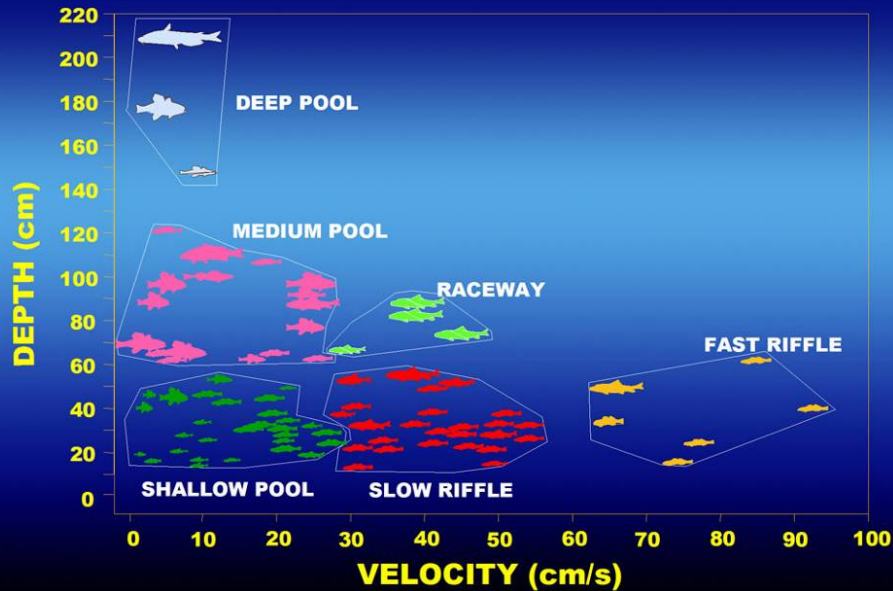


Modeled Depth and Velocity

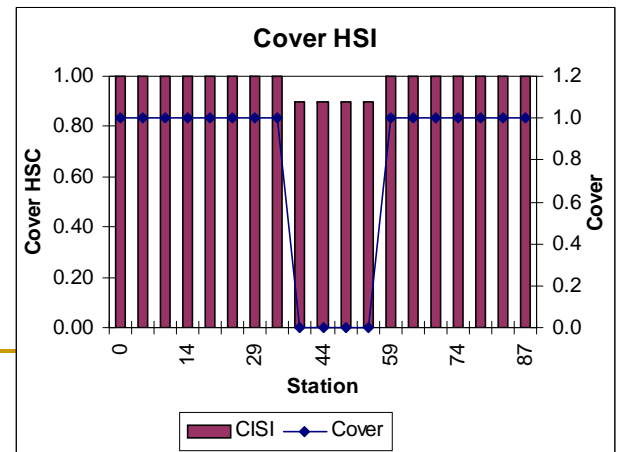
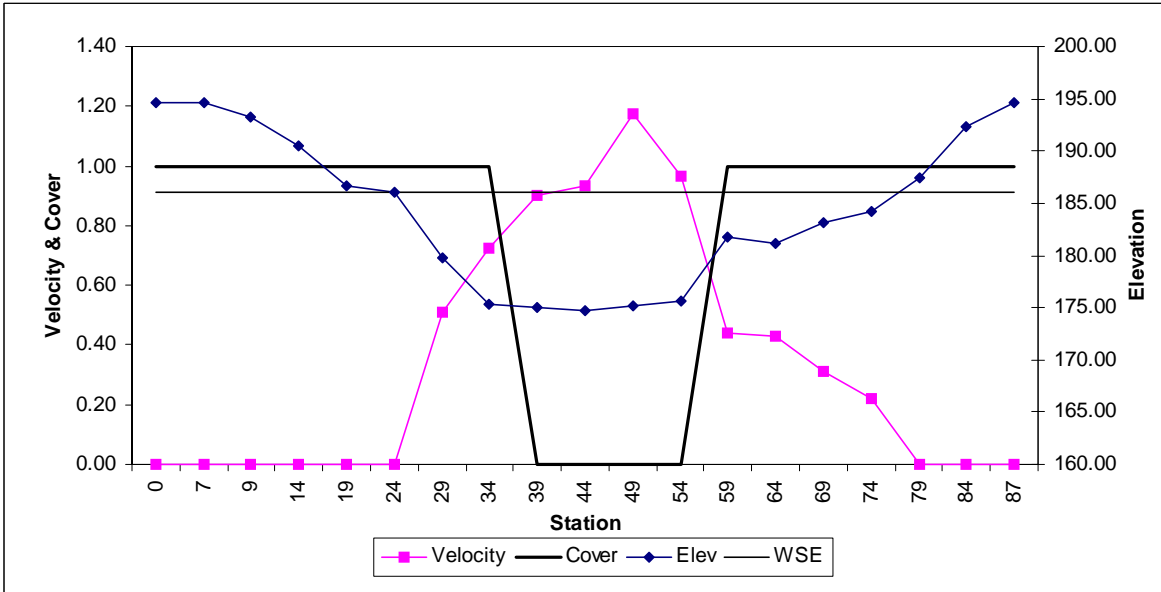
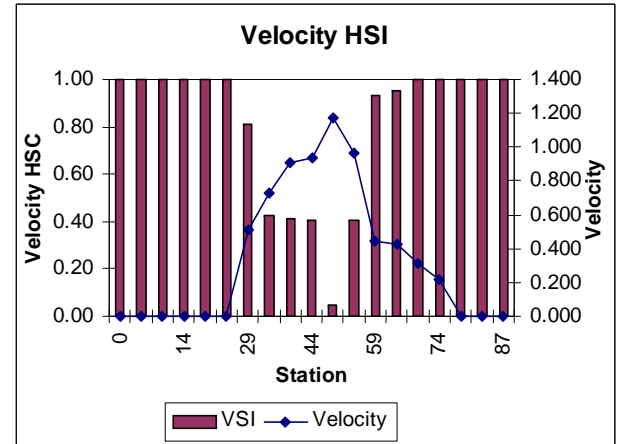
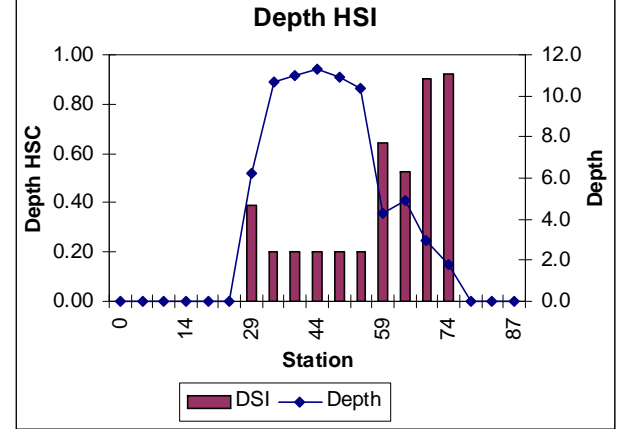
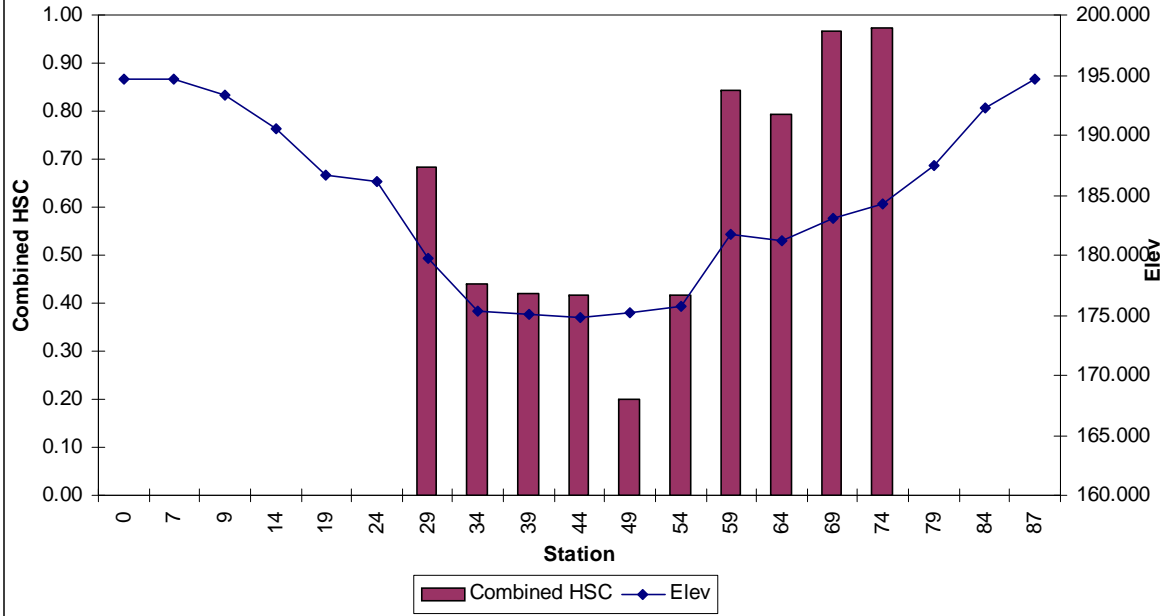


Habitat Suitability Criteria

MEAN HABITAT USE

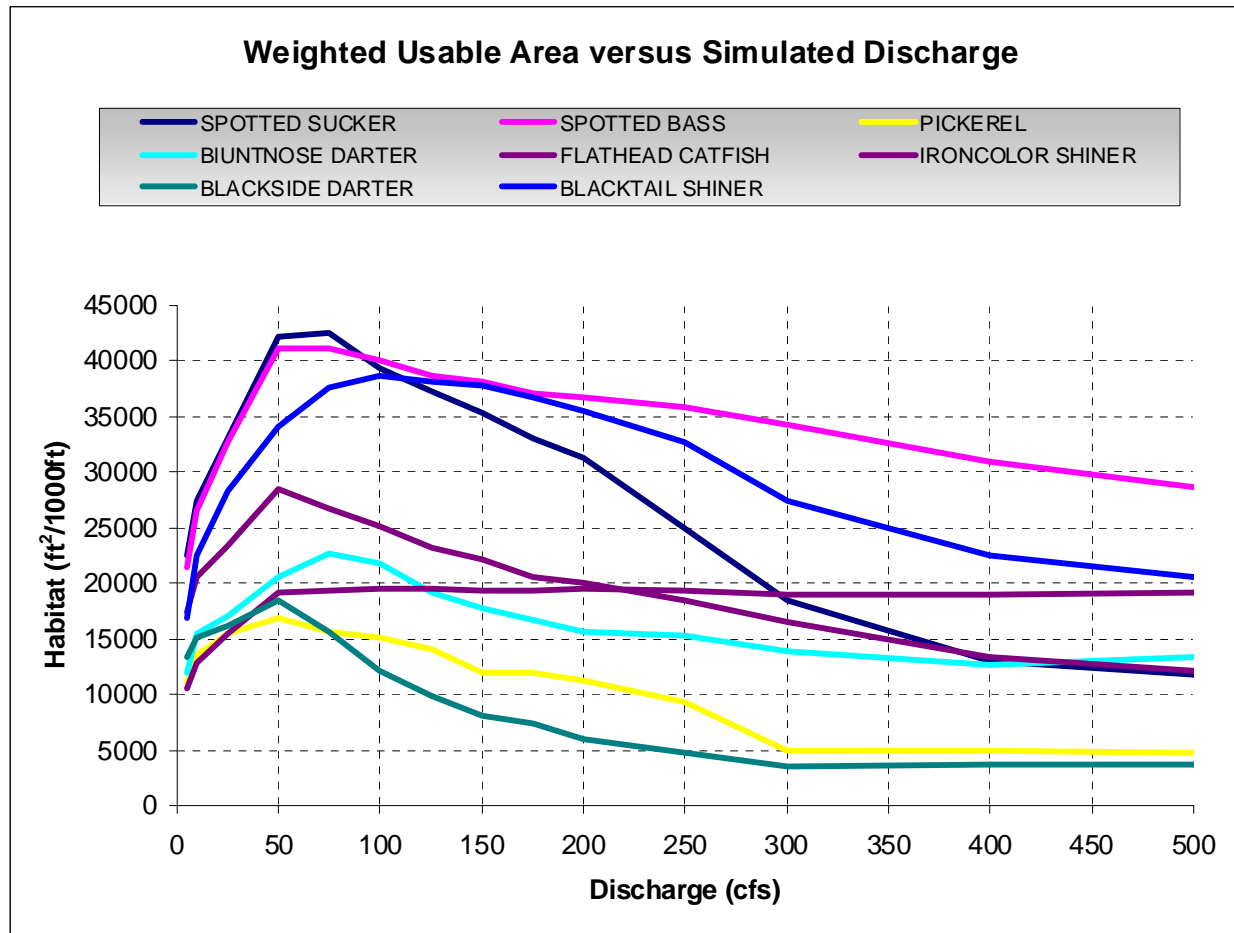


Big Cypress at 1 Mile DS LOP
Q = 100 cfs
Species = SPOTTED SUCKER_ADULT



Ecological Response Curves

Flow vs. WUA



Refinement/Validation of Initial Building Block Recommendations

- Does anything jump out as a concern
 - Period of Record - pre vs. post impact
 - Effect of other overlays
 - Assemblage trends analysis
 - Hydrologic conditions (Three?)
 - All months or by seasons
 - Spatial differences
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High Flow Pulses

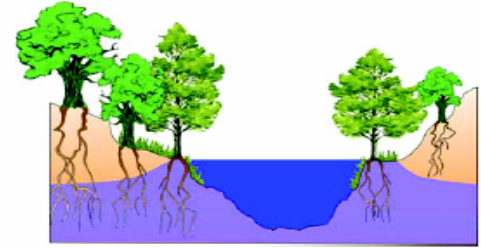
High Flow Pulses

Spatial scale:
River Segment

Temporal scale:
Multiple High Flow, Pulses Throughout the Year

Primary discipline:

- Hydrology/Hydraulics
- Biology
- Geomorphology
- Water Quality



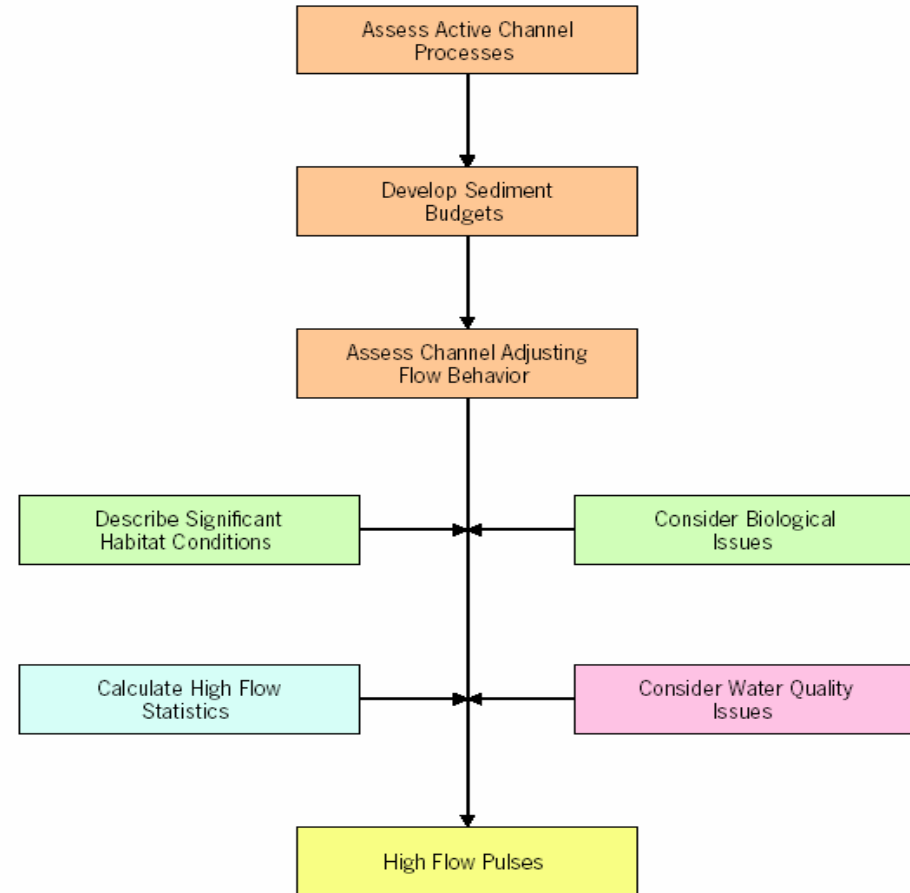
Ecological Responses

- *Maintain important physical habitat features*
- *Longitudinal connectivity*

Overlays

- *Effective Discharge Estimate*
- *Spawning/Migratory Cues*
- *Riparian/Oxbow Connection Points*

- *Sediment Transport Models*



Overbank

Ecological Responses

- *Maintain riparian areas*
- *Provide lateral connectivity between the river channel and active floodplain*

Overlays

- *Bankfull Discharge Estimate*
- *High Flow Rating Curves*
- *HEC-RAS Water Surface Model*
- *GIS Analysis of Inundated Areas*

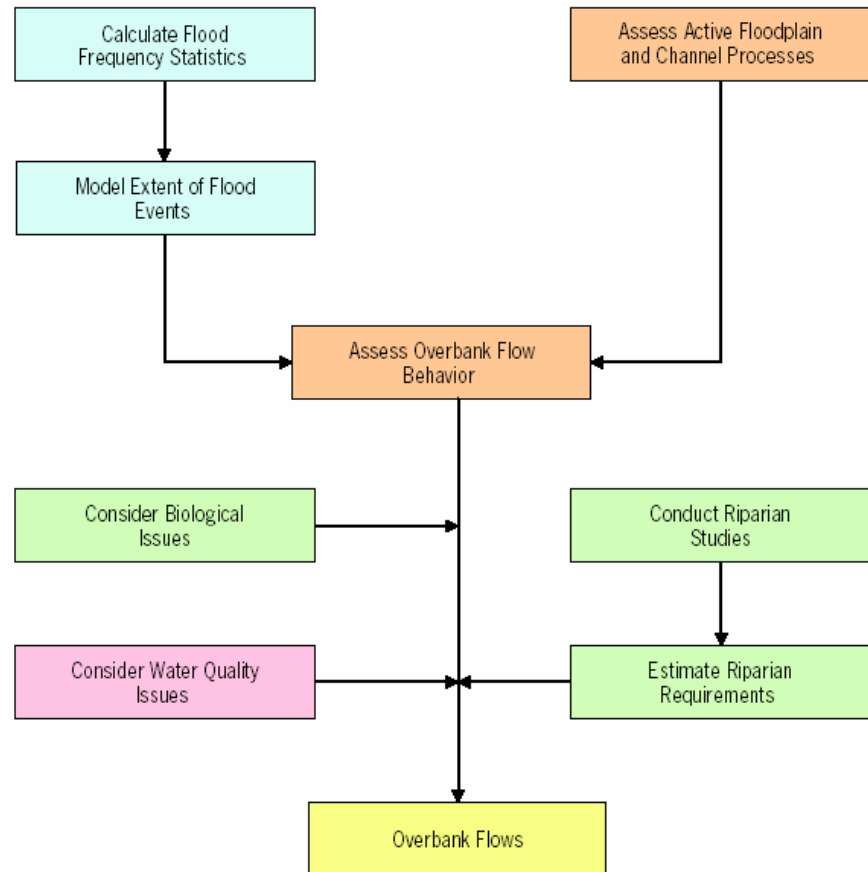
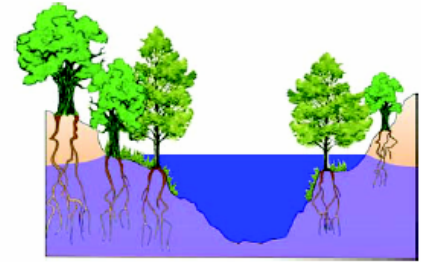
Overbank Flows

Spatial scale:
River Segment

Temporal scale:
Extreme Flow Events, Occur Less Than Once per Year

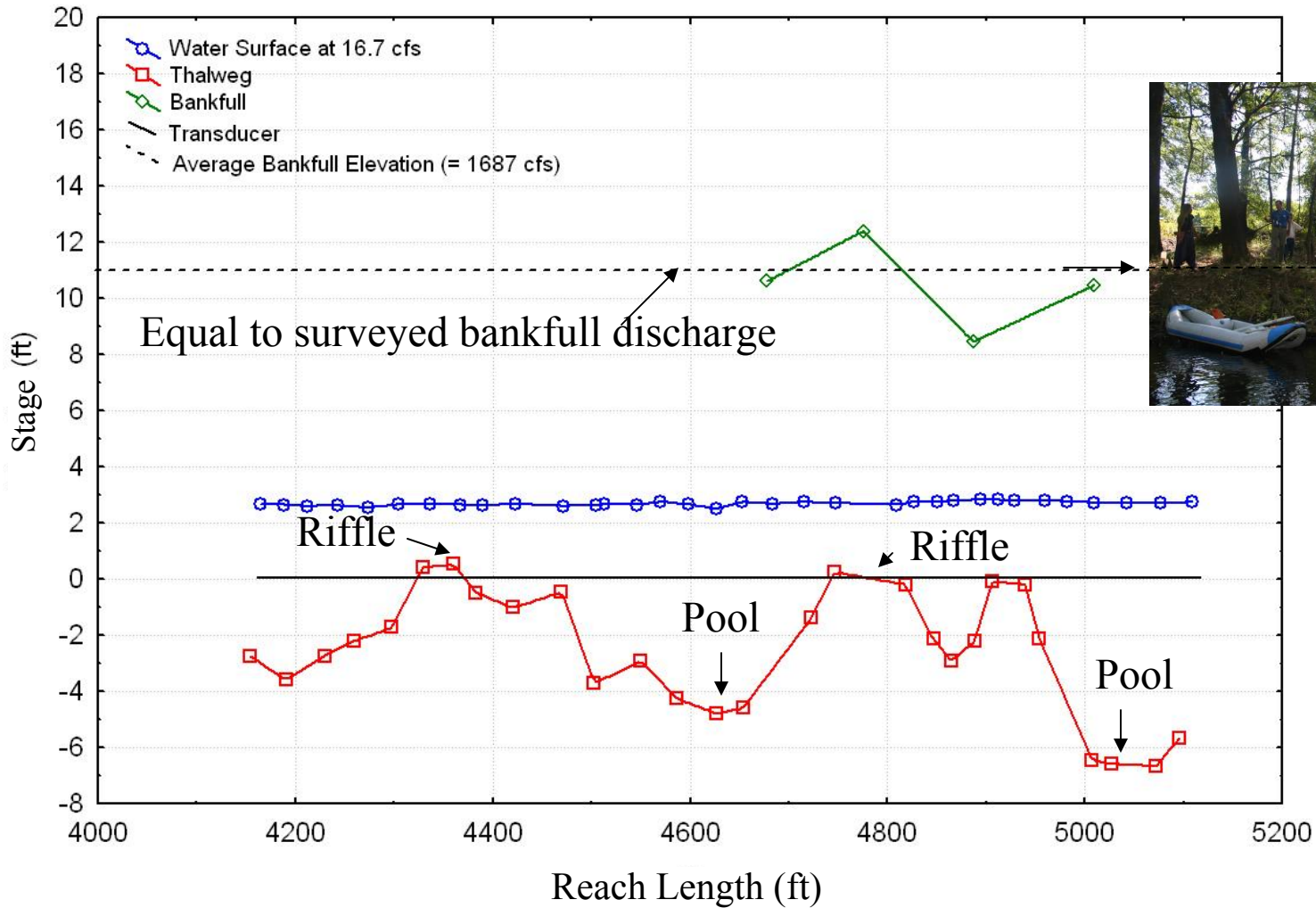
Primary discipline:

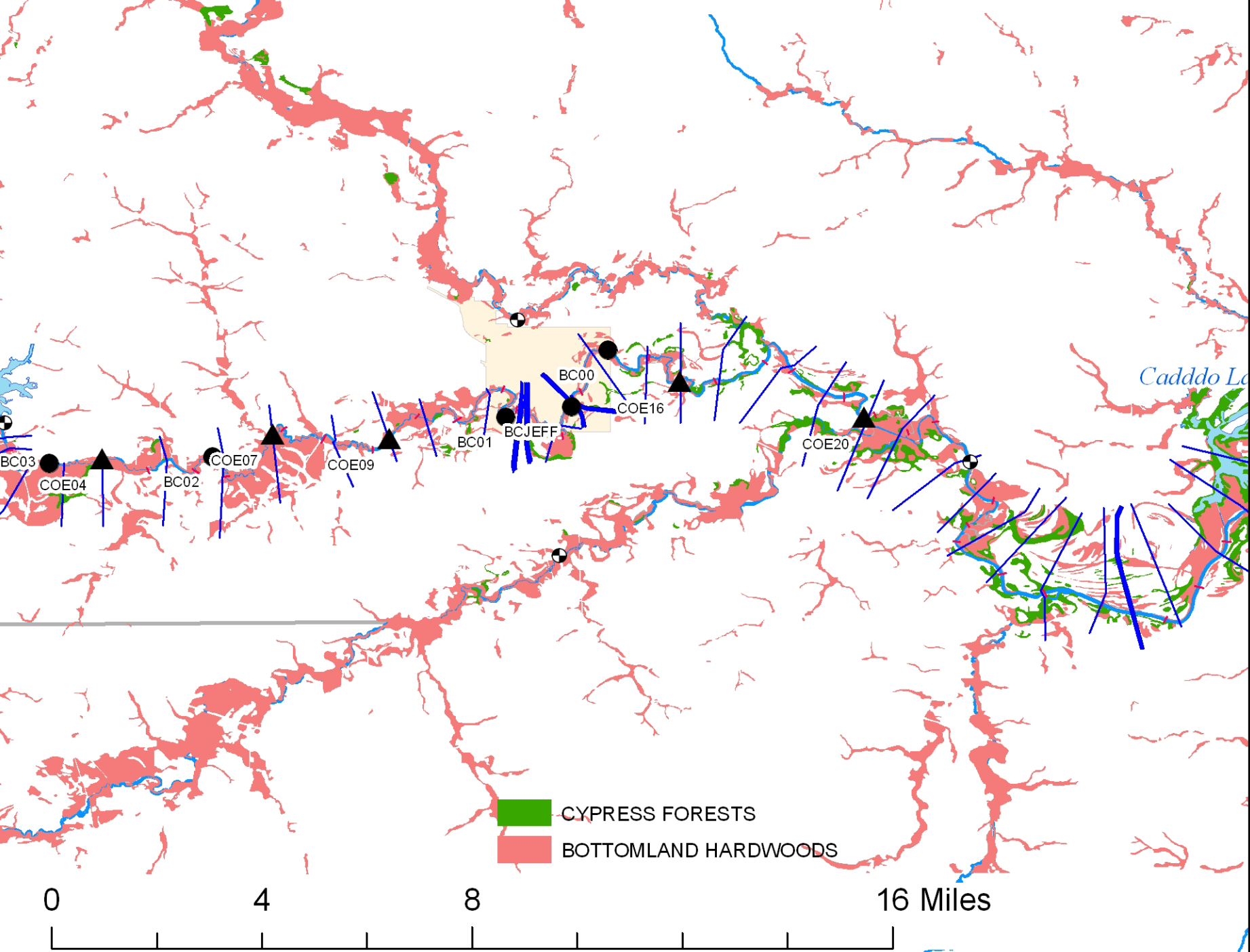
- Hydrology/Hydraulics
- Biology
- Geomorphology
- Water Quality



Bankfull discharge ($\bar{X} = 1687$ cfs) in upstream reach is much less than the 2 to 3-year recurrence discharge of 6,000 cfs that was prescribed

Big Cypress Creek at Thomas Camp (BC03)
Estimated Bankfull Discharge





Comparison to NWS Flood Stage

NWS Flood Stages	Stage	Discharge	Flows Project - Building Blocks
	27.3	20,000	Preliminary Large Flood estimate - approximate 10 year recurrence
	24.1	10,000	Preliminary Small Flood estimate - approximate 3 year recurrence
Major Flood Stage:	22	6,046	
	22.0	6,000	Preliminary bankfull estimate - approximate 2 year recurrence
Moderate Flood Stage:	21	4,681	
Flood Stage:	20	3,580	
Action Stage:	20	3,580	
	19.4	3,000	Flow that connects to oxbows and other off-channel wetlands upstream of Jefferson
	18.7	2,500	Approximate mean bankfull over study reach
	17.4	1,687	Approximate mean bankfull in upper reach

Instream Flow Building Blocks

Big Cypress Creek – Hydrology based only

Floods

<u>20,000 cfs for 2-3 days</u> Every 10 years PeakFQ(10) = 23,300
<u>6,000-10,000 cfs for 2-3 days</u> Every 3-5 years PeakFQ(2-3) = 6,485 - 9,956

High Flow Pulses

<u>6,000 cfs for 2-3 days</u> Every 2 years PeakFQ(2) = 6,485
<u>1,500 cfs for 11 days</u> 7X a year every year

Low Flows

396	500	536	445	264	140	70	41	32	49	94	275
268	347	390	330	150	79	35	12	12	26	56	117
116	195	218	198	114	49	13	6	6	6	26	61

Key

- Wet Year
- Avg Year
- Dry Year

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

Instream Flow Building Blocks

Big Cypress Creek

Floods

<p><u>20,000 cfs for 2-3 days</u> Every 10 years *For channel migration</p>
<p><u>3,000-10,000 cfs for 2-3 days</u> Every 3-5 years *Maintain aquatic habitat in floodplain * Riparian seed dispersal * Inhibition of upland vegetation for both creek & lake *Seed dispersal * Vegetation removal</p>

3000 = flow that connects to oxbows and other off-channel wetlands upstream of Jefferson.

High Flow Pulses

<p><u>2,500 cfs for 2-3 days</u> Every 2 years * For channel maintenance * Oxbow connectivity</p>

2,500 = about mean bankfull over the reach studied.

<p><u>1,500 cfs for 2-3 days</u> 3-5X a year every year * 1 occurring in March for Paddlefish * Sediment transport •Waterfowl habitat flushing (Includes December)</p>

2-3 days = peak period for high-flow and floods.

Low Flows

Maintain biodiversity and connectivity (backwater & oxbows)											
396	500	536	445	264	140	70	41	40	49	94	275
Pre-dam median	Benthic drift & dispersal, fish spawning					Fish habitat			Pre-dam median		
268	347	390	330	150	79	35	40	40	40	90	117
Fish habitat		Spawning habitat				Maintain aquatic diversity			Fish habitat		
90	90	218	198	114	49	13	8.4	8.4	40	90	90

Key

- Wet Year
- Avg Year
- Dry Year

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