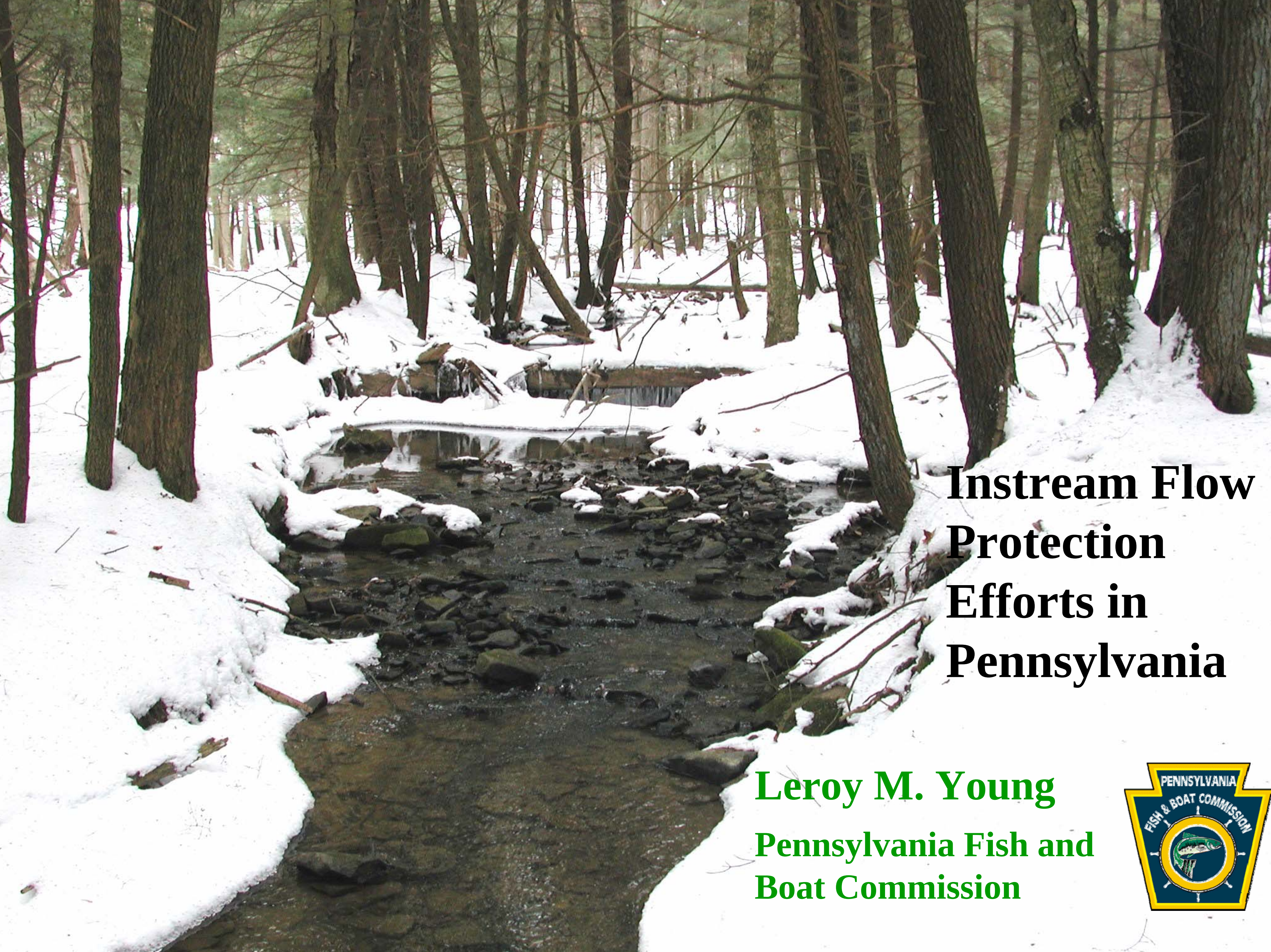

Instream Flow Protection Efforts in Pennsylvania

Leroy M. Young

Pennsylvania Fish and Boat Commission

Glossary

Instream use - any use of water that does not require a diversion or withdrawal from the original water course

Q - variable used to represent stream flow

Conservation release - release made from a dam to provide flow to downstream areas

Passby flow - flow rate below which a withdrawal is not allowed

Glossary

Common units of measurement for stream flow

cfs - cubic feet per second.

mgd – million gallons per day

gpm – gallons per minute

% ADF - % of the average daily flow (mean annual flow)

WUA - Weighted Usable Area. Unit of measurement for habitat in instream flow studies. Equal to the wetted area of a stream weighted by its suitability for fish and other aquatic organisms.

Surface Water Withdrawal Regulation in PA

- **PA Department of Environmental Protection**
- **Susquehanna River Basin Commission**
- **Delaware River Basin Commission**
- **PA Fish and Boat Commission**

Outline

- An evolution of questions
- An evolution of issues
- An evolution of methods

An evolution of questions

?

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?

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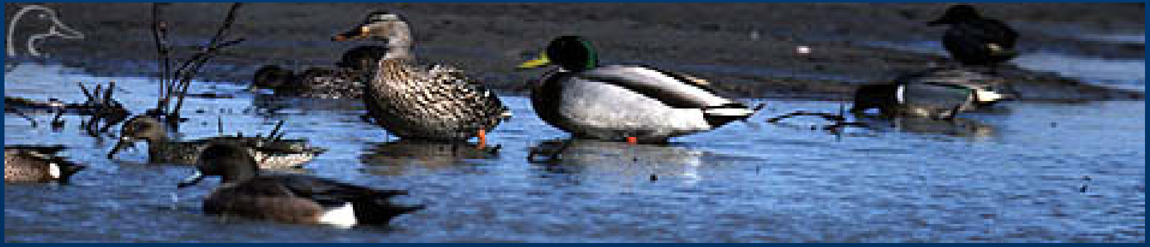
Q: Why protect instream flow?

A: Because out-of-stream uses . . .

. . . often conflict with instream needs



Q: What do you want, people or fish???

A: Many people *like* fish, and the waters they live in!!!

Q. How much water do the fish need??

A. A lot more than this, but . . . *how much* more??

A better question:
How much can natural stream flows be altered before aquatic ecosystems are significantly damaged??

An evolution of issues and methods

(At least 34 IF assessment tools are available)

1. Minimum instream flow needs

2. Incremental impacts of flow changes on fish and other organisms

3. Beyond fish to the entire aquatic ecosystem

Methods for Estimating Instream Flow Protection Amounts

Standard Setting Methods

- Q7-10
- Tennant

Incremental Method

- IFIM

An evolution of issues and methods

1. Minimum instream flow needs

2. Incremental impacts of flow changes on fish and other organisms

3. Beyond fish to the entire aquatic ecosystem

Minimum instream flow needs

Addressed using "Standard Setting Methods," e.g.,

- $Q_{7\text{-}10}$
- Wetted Perimet
- Tennant

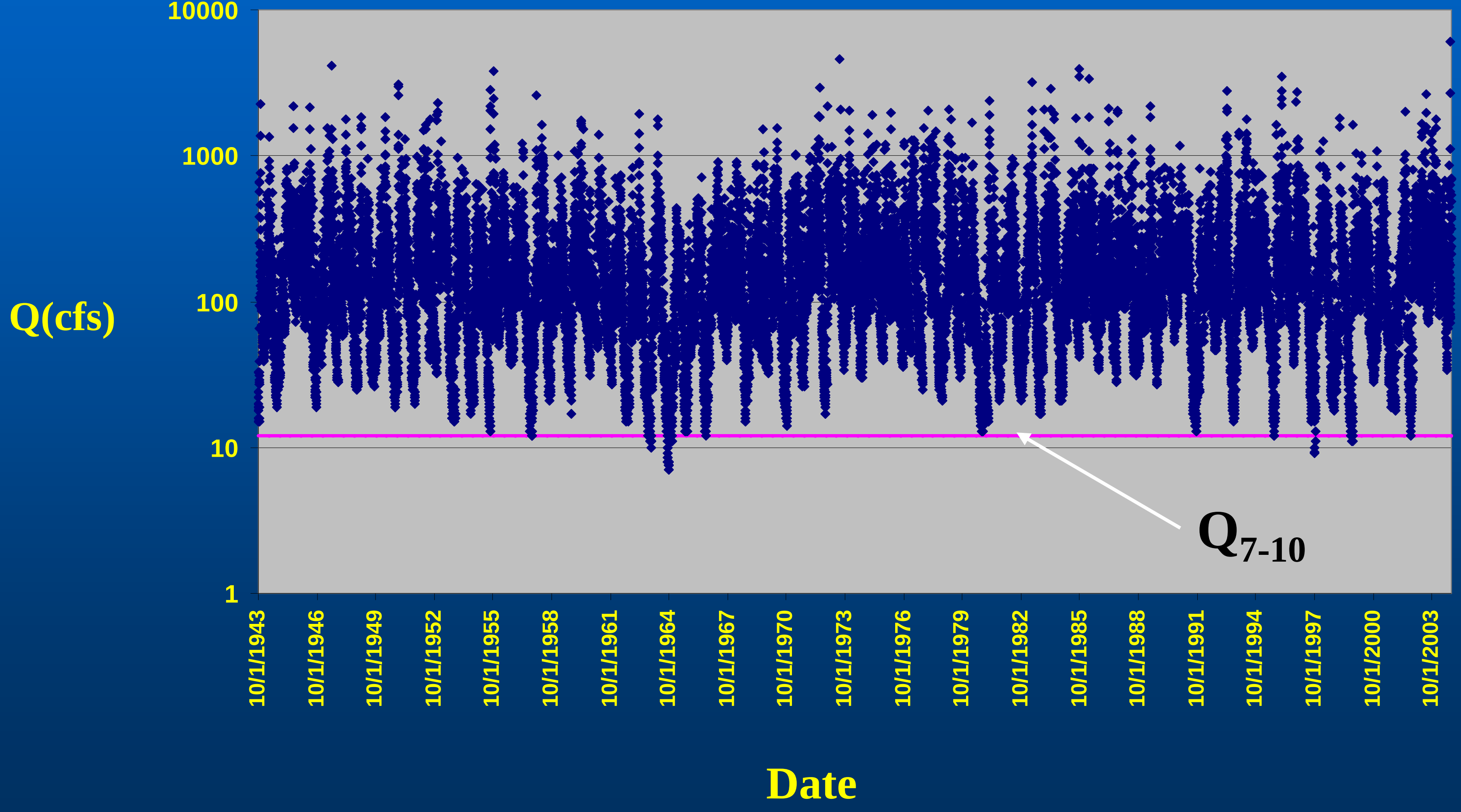
Q7-10 Method

- Drought flow which occurs for a period of seven consecutive days one time in 10 years
- Design standard for wastewater treatment plant discharges
- Normally exceeded about 99% of the time
- Equals about 6% of the Average Daily Flow (ADF) in PA

$Q_{7\text{-}10}$ (cont)

Until the early 1990's typically used by PA DEP, DRBC, and SRBC to determine passby requirements for instream intakes. A formula using $Q_{7\text{-}10}$ used to develop conservation release requirements for dams

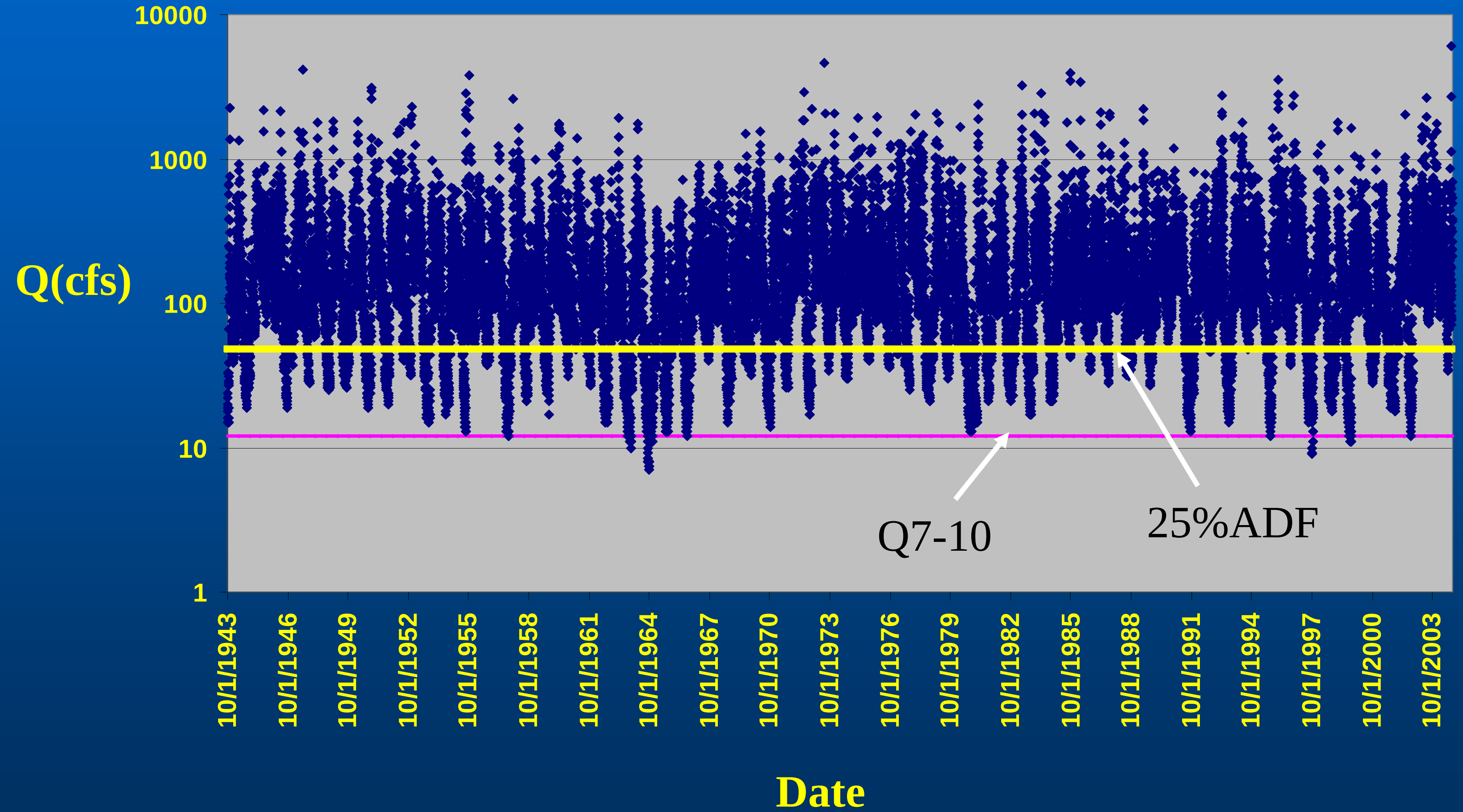
Lehigh River @ Stoddardtsville Flows (1943-2003)



Tennant Method

- Developed by Donald Tennant of the U.S. Fish and Wildlife Service
- Based on Tennant's observations that fish habitat declines rapidly at flows below 20-60% ADF
- Until the early 1990's used by PFBC for instream flow protection recommendations

Lehigh River @ Stoddardtsville Flows (1943-2003)

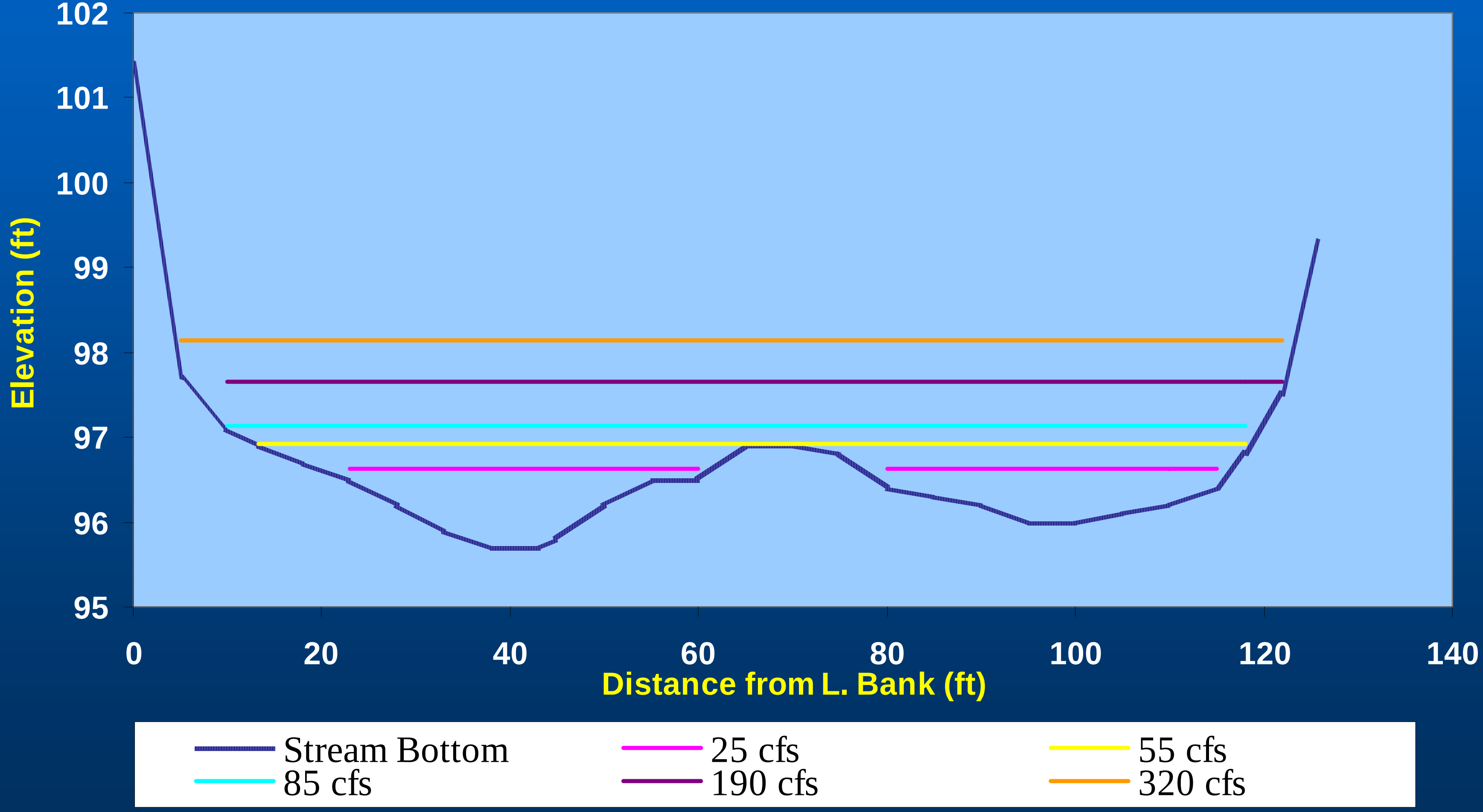


Wetted Perimeter Method

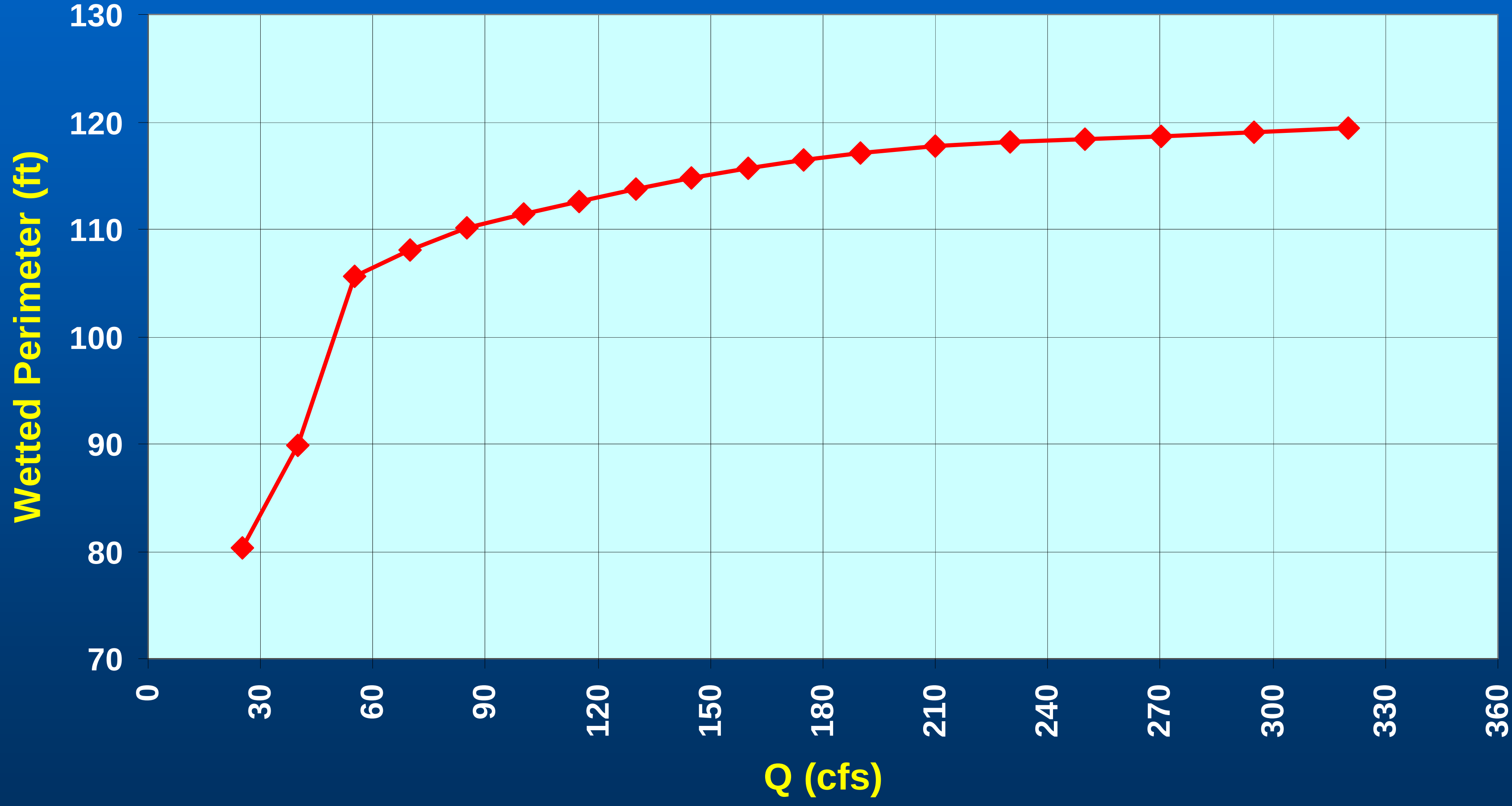
- Relates amount of stream bottom which remains covered with water (wetted perimeter) to flow

- Emphasis is placed on riffle areas which are critical habitats for aquatic invertebrates

Water Surface Elevations at Various Flows at Transect 5 (Riffle) - Tulpehocken Creek



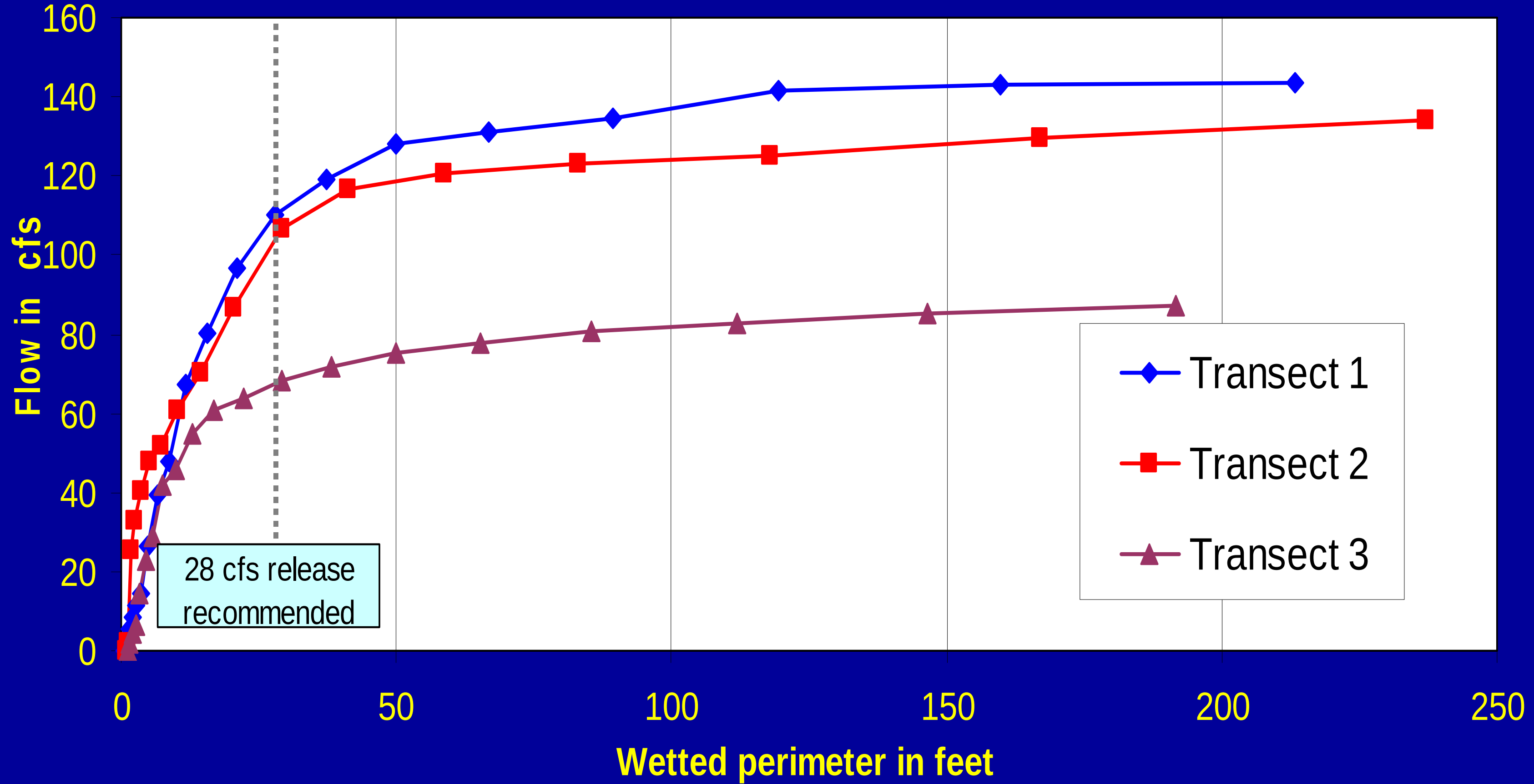
Wetted Perimeter vs Q at Transect 5
Tulpehocken Creek



Examples of Wetted Perimeter Use in PA

George B. Stevenson Dam and First Fork Sinnemahoning Creek – drawdown for dam repair - 1999

Discharge vs. wetted perimeter curve below George B. Stevenson Dam
First Fork Sinnemahoning Creek at flows < 250 cfs



Incremental Impacts

Instream Flow Incremental Methodology - IFIM

IFIM

- Determines effects of incremental changes in stream flow on:
  - Depth
  - Velocity
  - Substrate
  - Cover

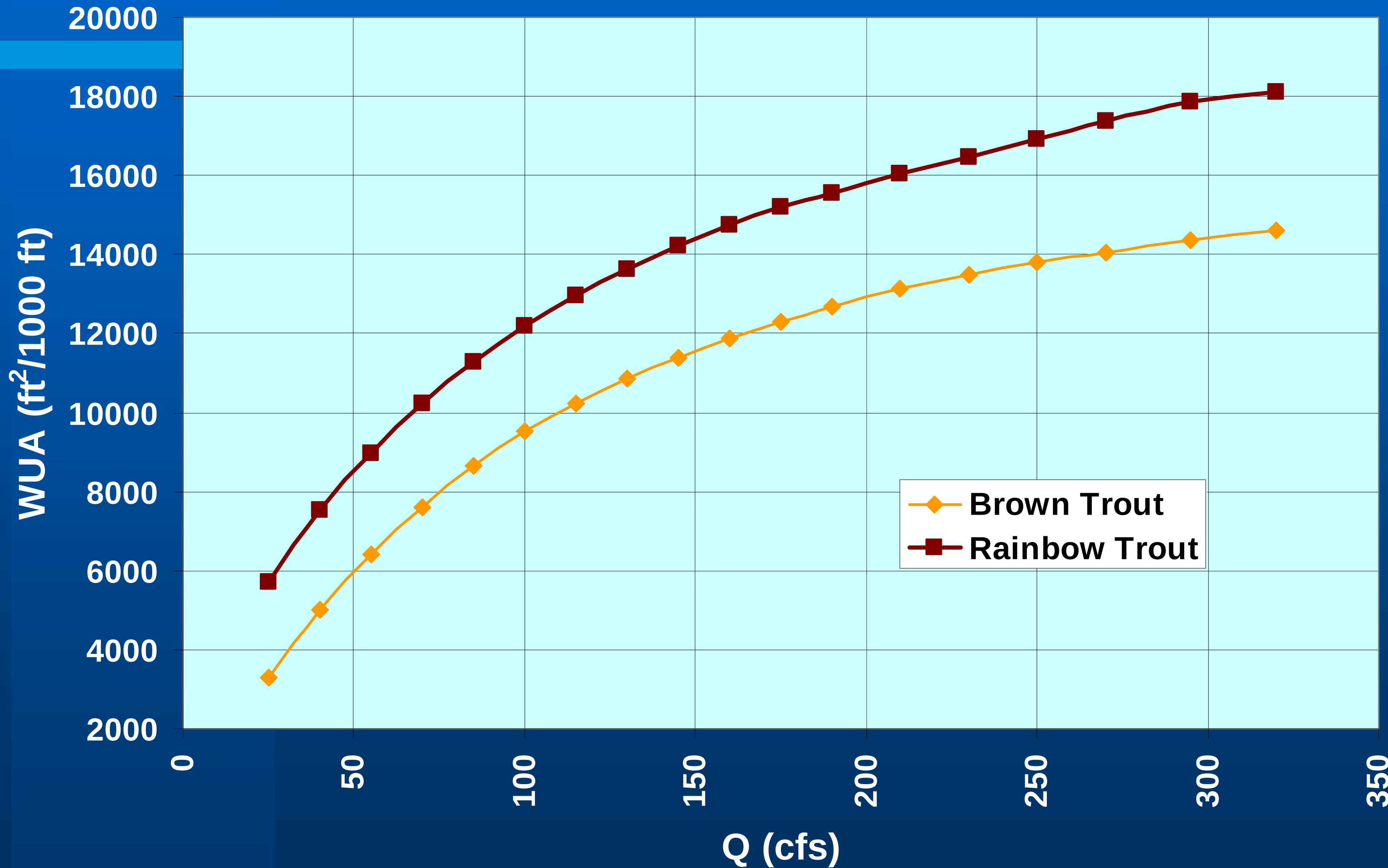
- Measures the effects of changes in these physical components of habitat on the suitability of these changes for various fish species

Examples of IFIM use in PA

- Blue Marsh Tailrace
- PA Instream Flow Model
- AES Ironwood
- Upper Delaware River

Blue Marsh Tailrace

WUA vs Q for Adult Trout, Tulpehocken Creek below Blue Marsh Dam



The Pennsylvania/Maryland Instream Flow Study

PA Dept. of Environmental Protection

PA Fish and Boat Commission

MD Department of Natural Resources

Susquehanna River Basin Commission

U.S. Army Corps of Engineers

U.S. Geological Survey

Chesapeake Bay Foundation

Regional application of IFIM involving studies on:

67 wild trout streams with drainage areas < 100 mi^2

OBJECTIVE

To develop a procedure for determining instream flow requirements that does not initially require a stream specific impact analysis. The instream flow requirement for a specific stream must be derivable from hydrologic records.

Study approach:

- Wild trout waters with a drainage area < 100 mi^2
- Regional application of IFIM
- 67 streams; 97 stream segments

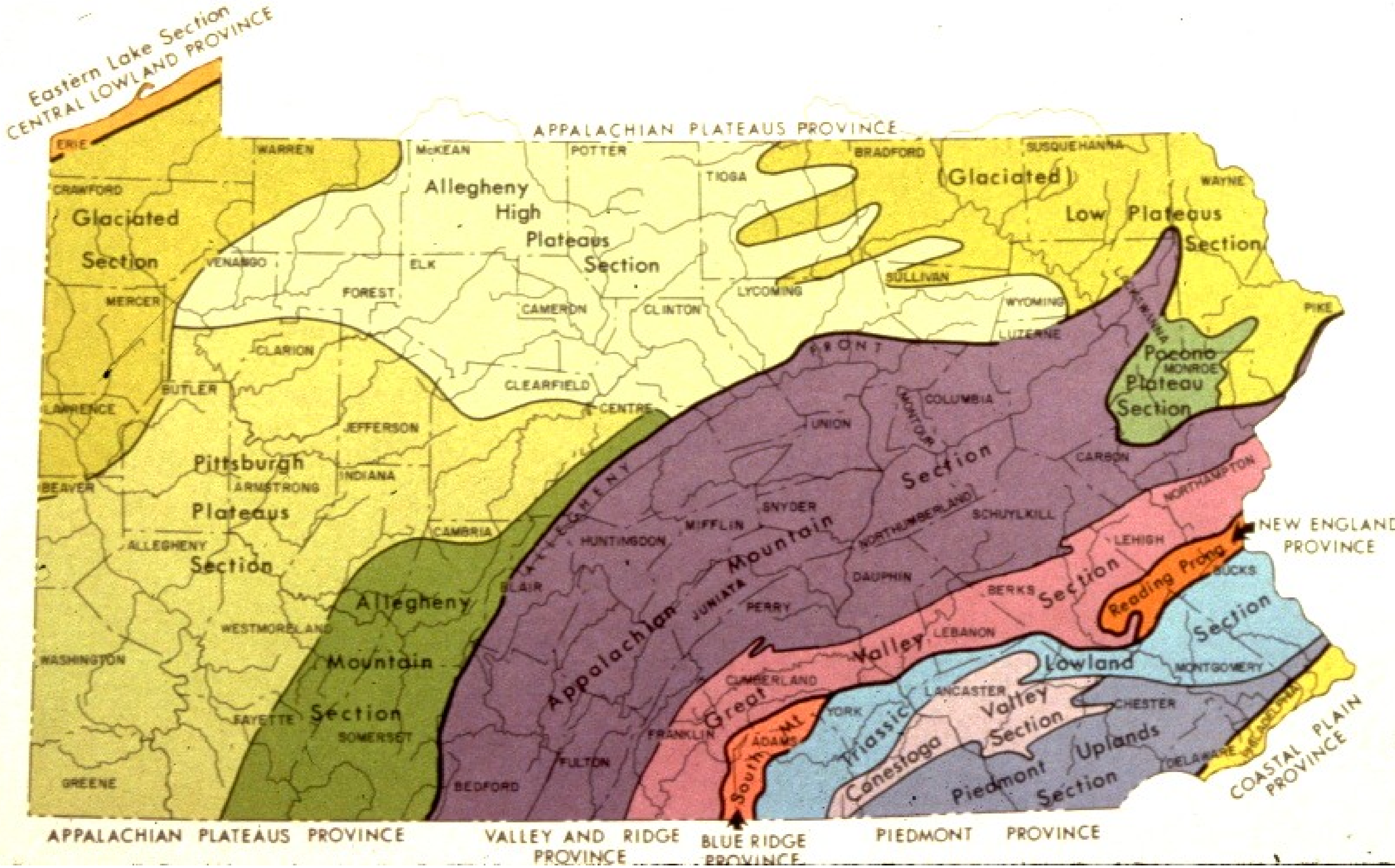
Select Study Sites

- **Stratify by Physiographic Region**
- **Stratify by stream length**
- **Randomly select streams and sites**
- **Sample size - 30 segments/Region**

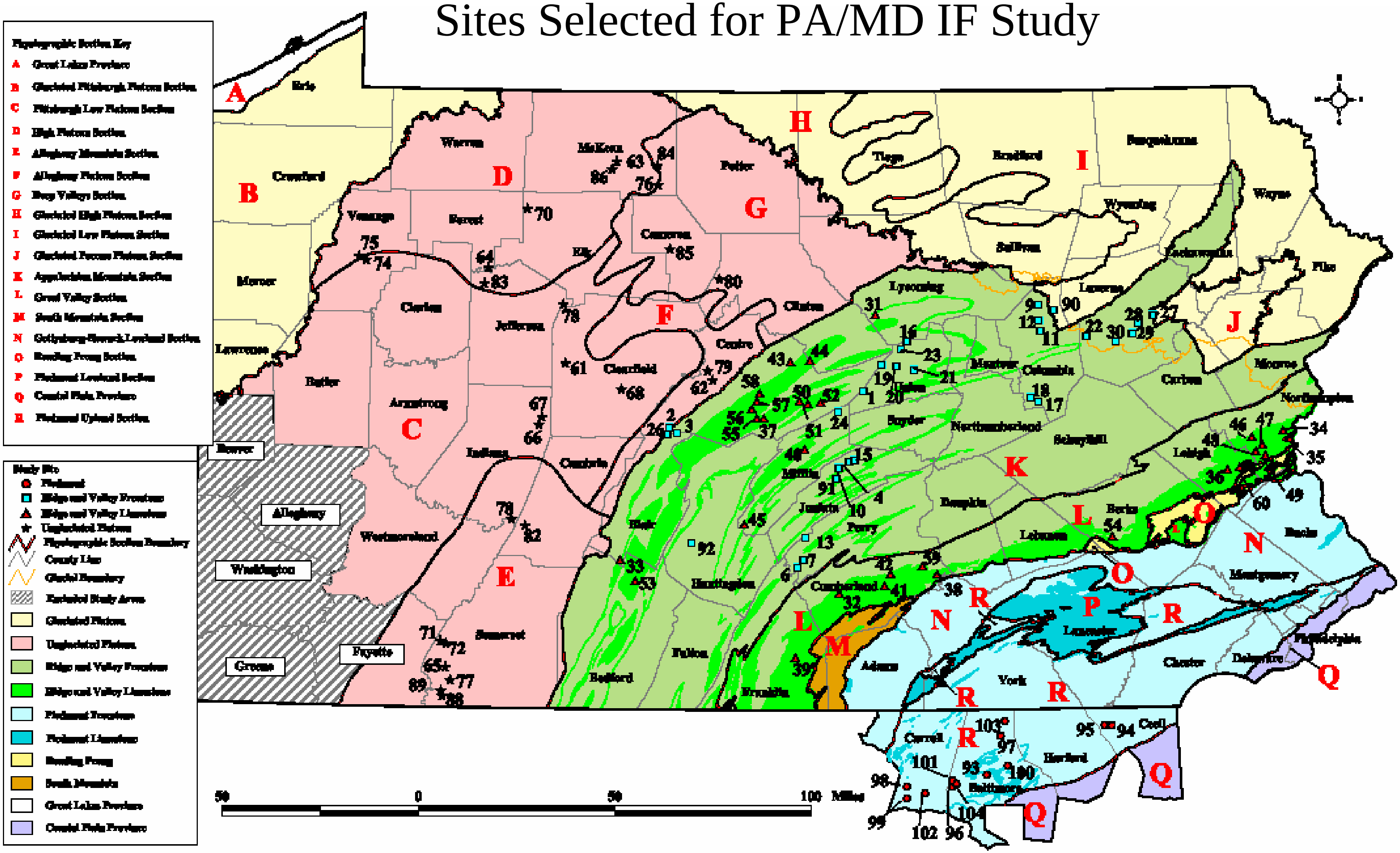
MAP 13

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, *State Geologist*

PHYSIOGRAPHIC PROVINCES OF PENNSYLVANIA



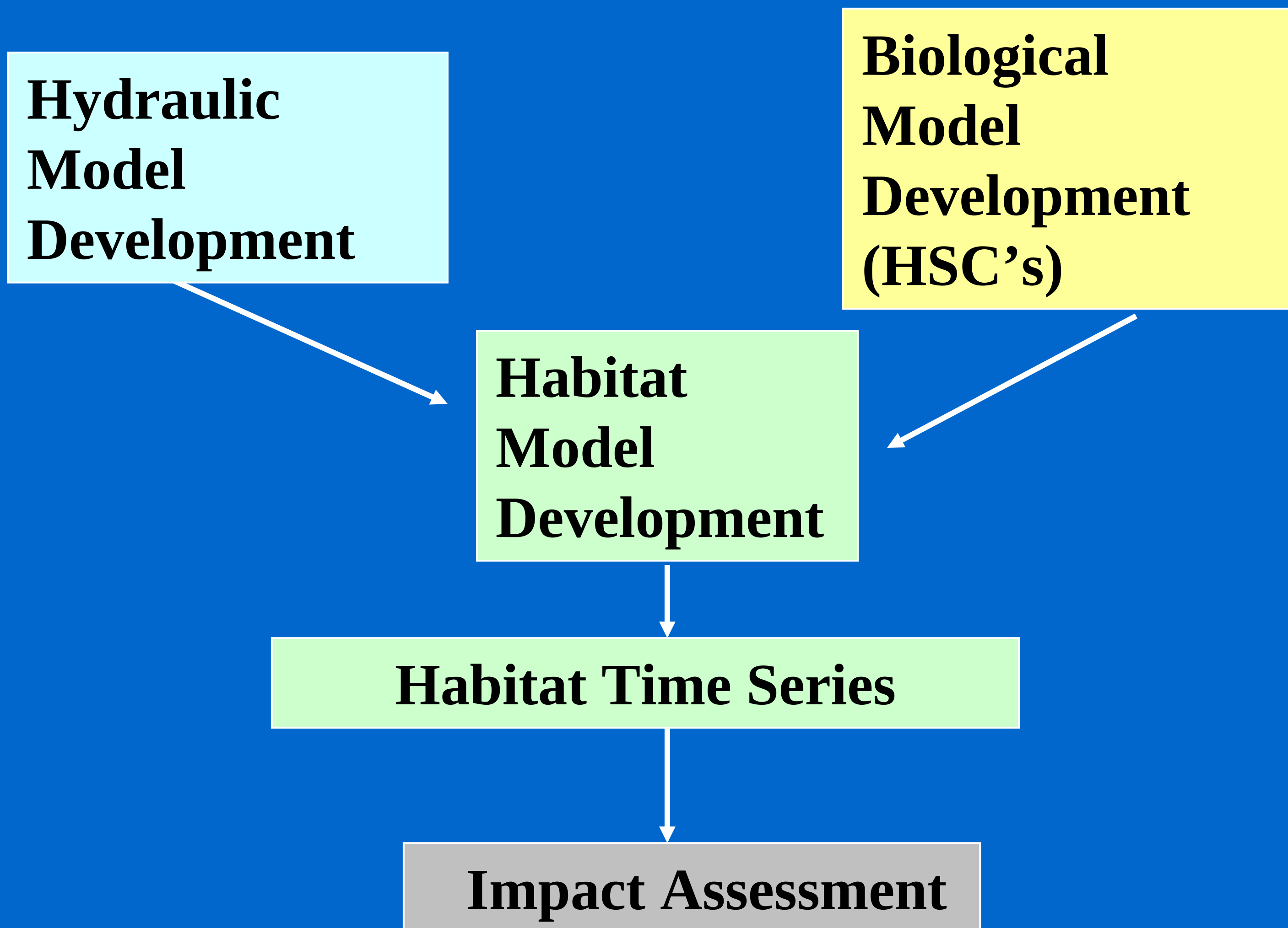
Sites Selected for PA/MD IF Study



Field Reconnaissance

- Verify trout reproduction
- Characterize mesohabitat
- Select one representative pool, riffle, and run/site

Components of IFIM



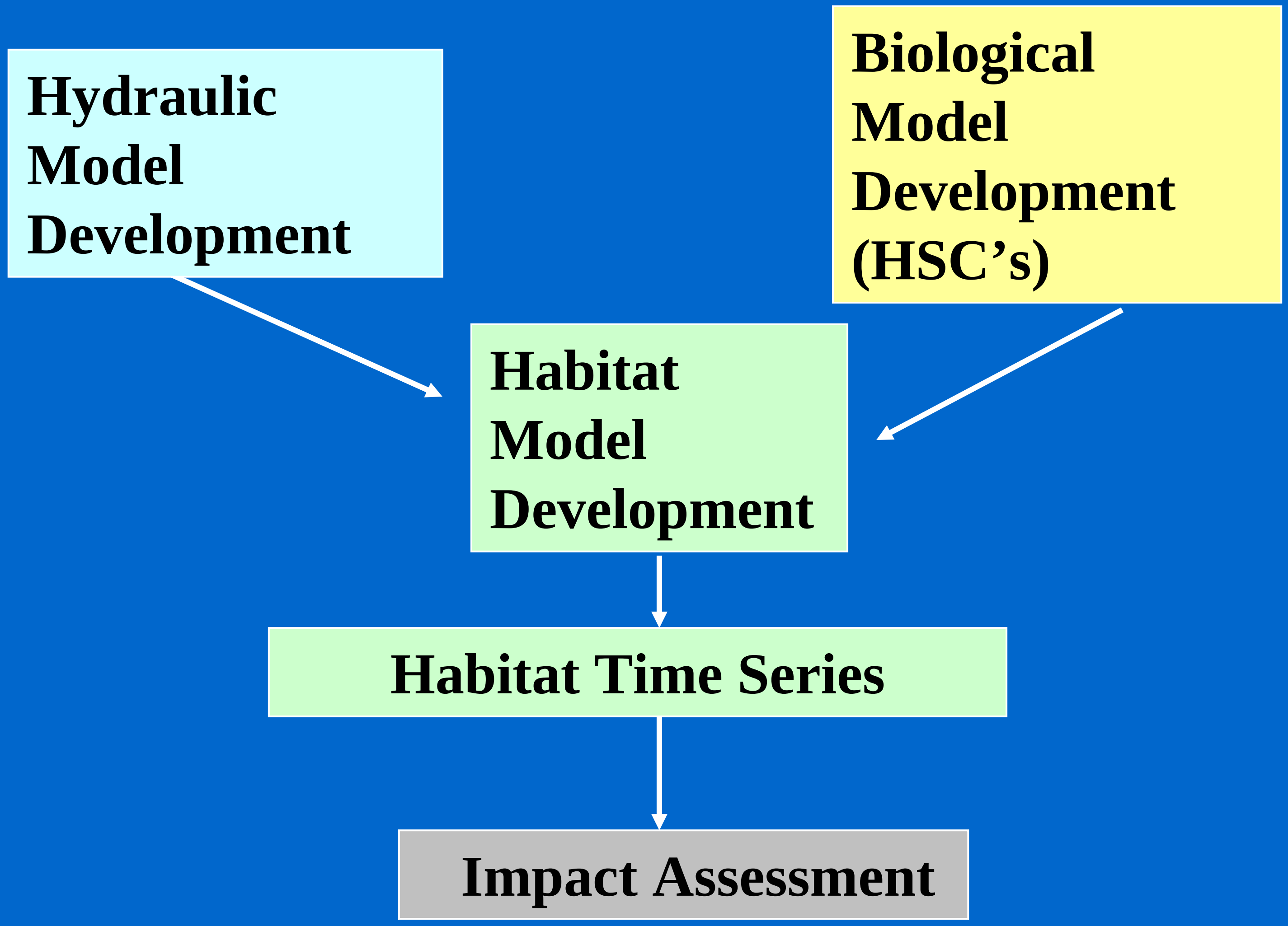
Collect Field Data

- **Depth, Velocity, Substrate, Cover**
- **Three flows/site**
- **Bracket range of median monthly Q's**

Develop Hydraulic Models for Each Study Site

- 254 transects calibrated
- 97 sites

Components of IFIM

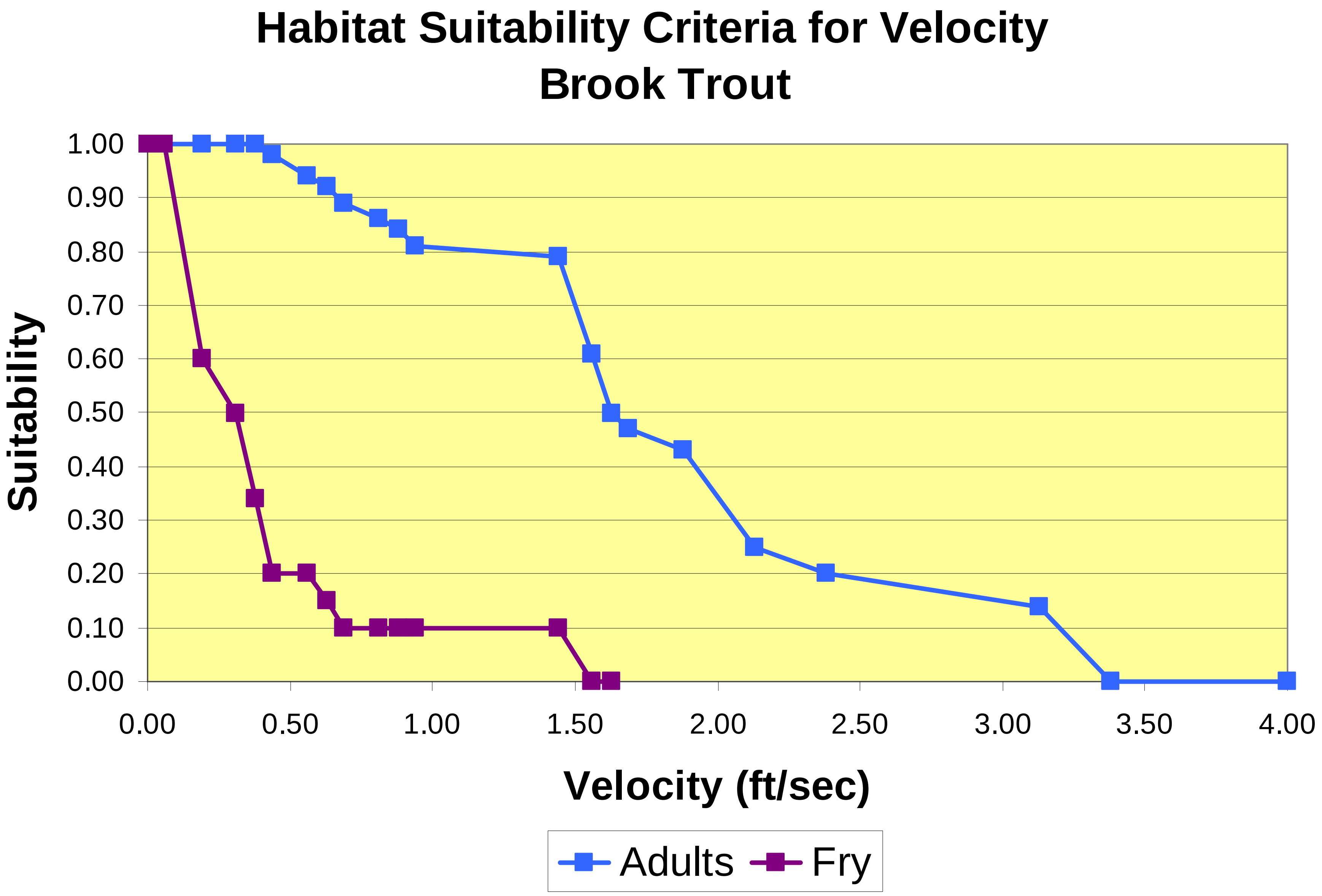


Habitat Suitability Curve Development

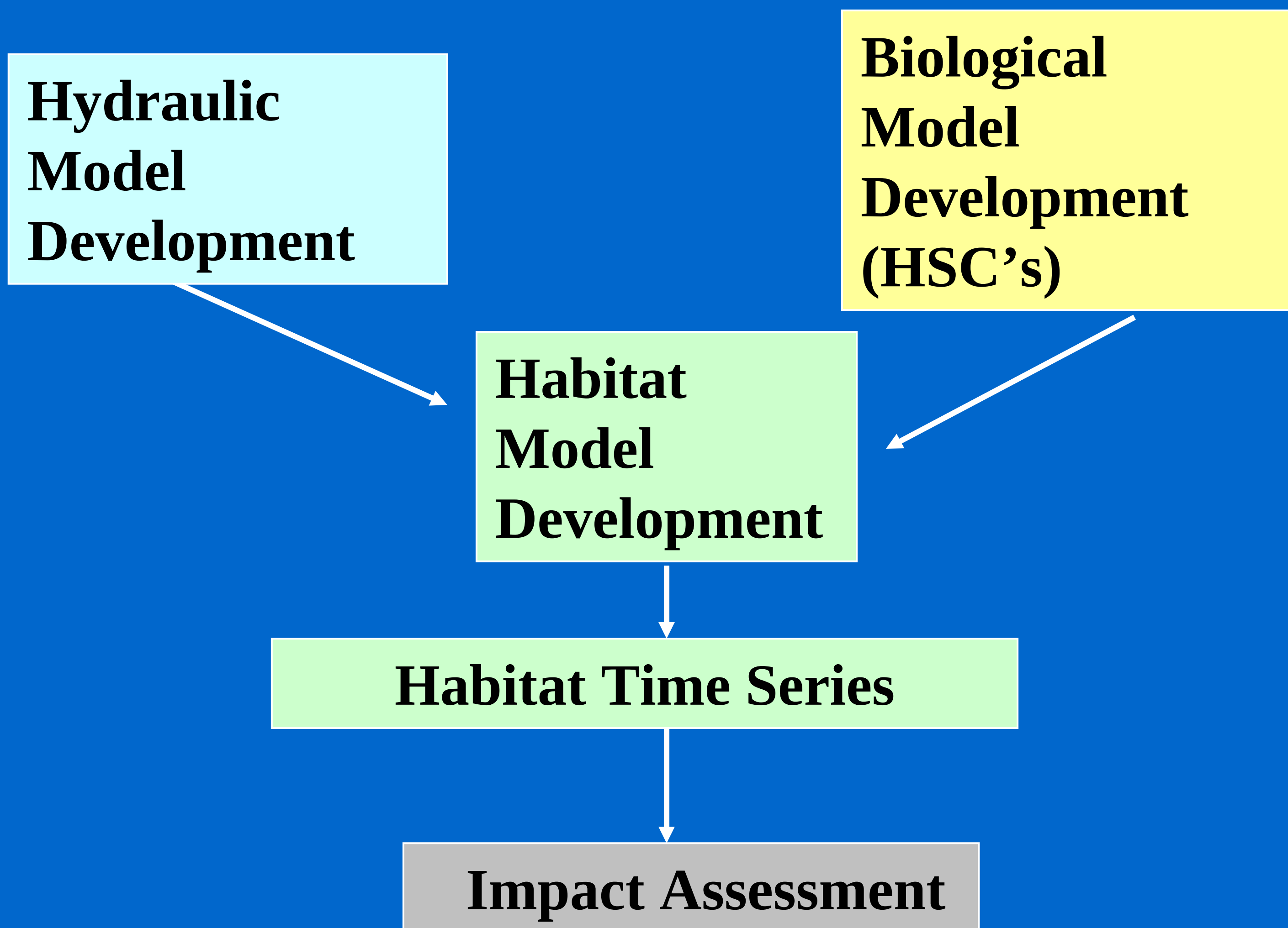
Study Site Selection

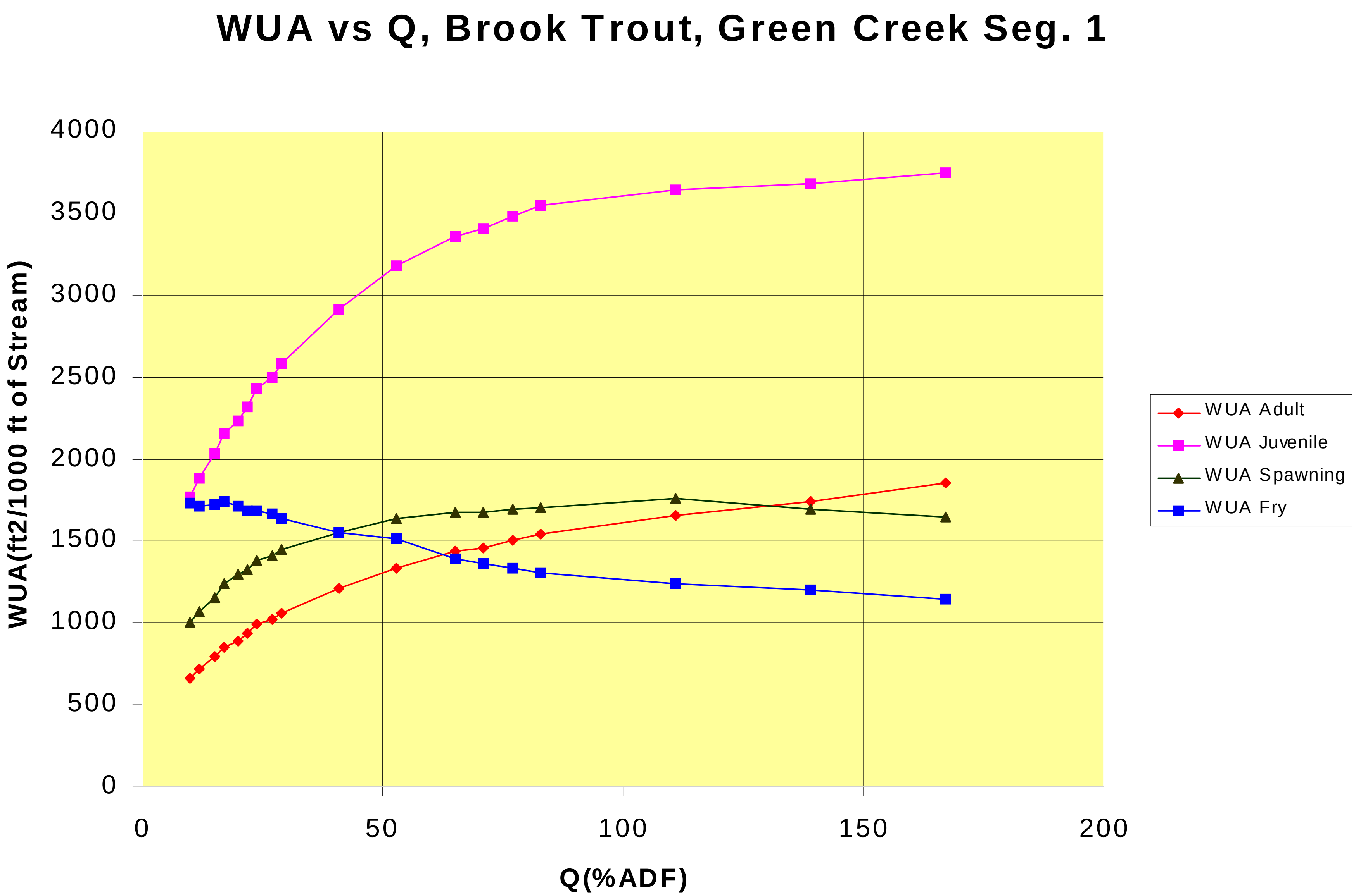
- **Two “Class A” wild brown trout streams (biomass> 40 kg/ha)**
- **Two “Class A” wild brook trout streams (biomass> 30 kg/ha)**

Develop HSC’s for Each Species and Life Stage

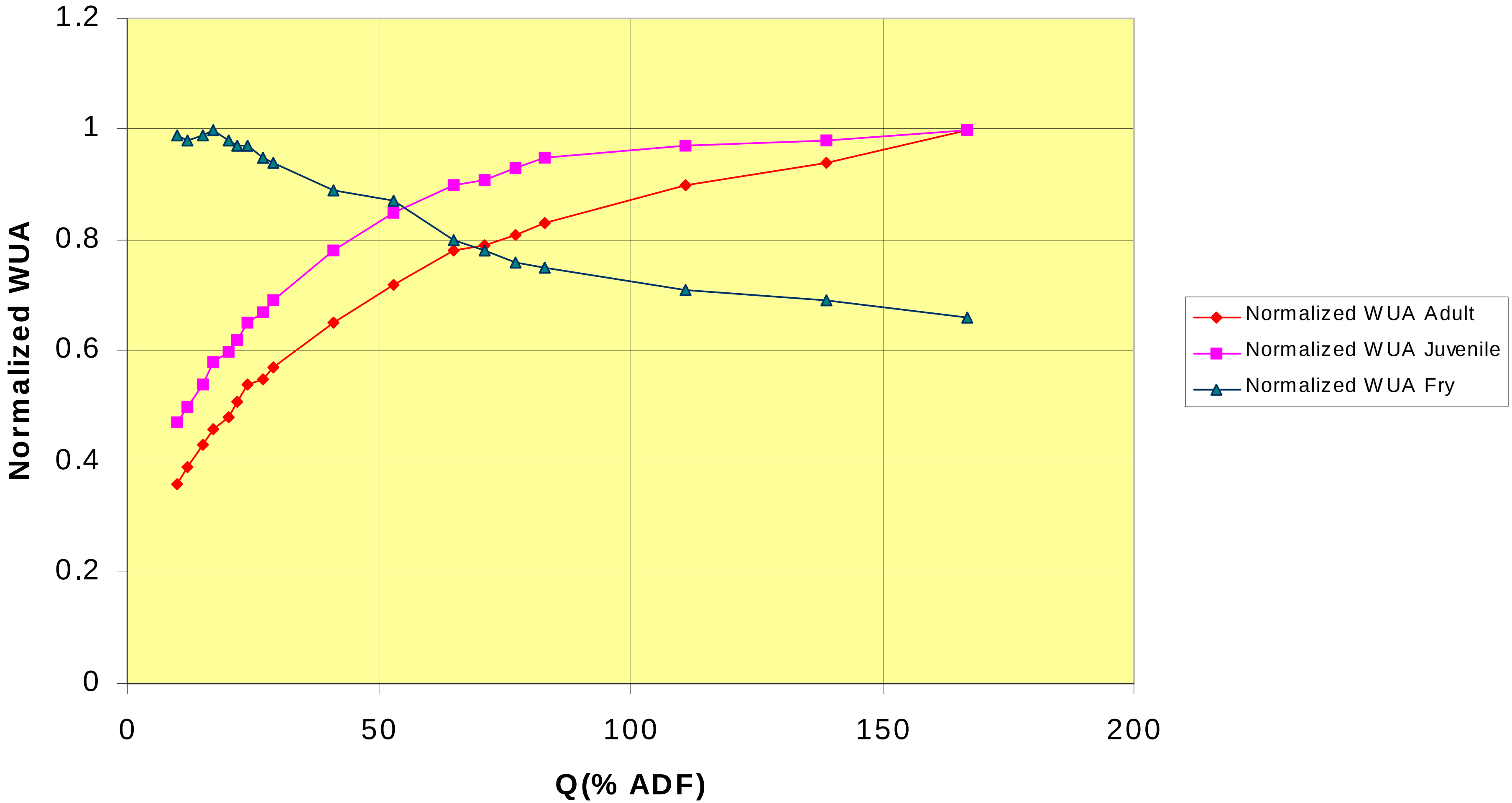

Habitat Suitability Criteria for Velocity
Brook Trout
Suitability
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Velocity (ft/sec)
Adults
Fry

Components of IFIM

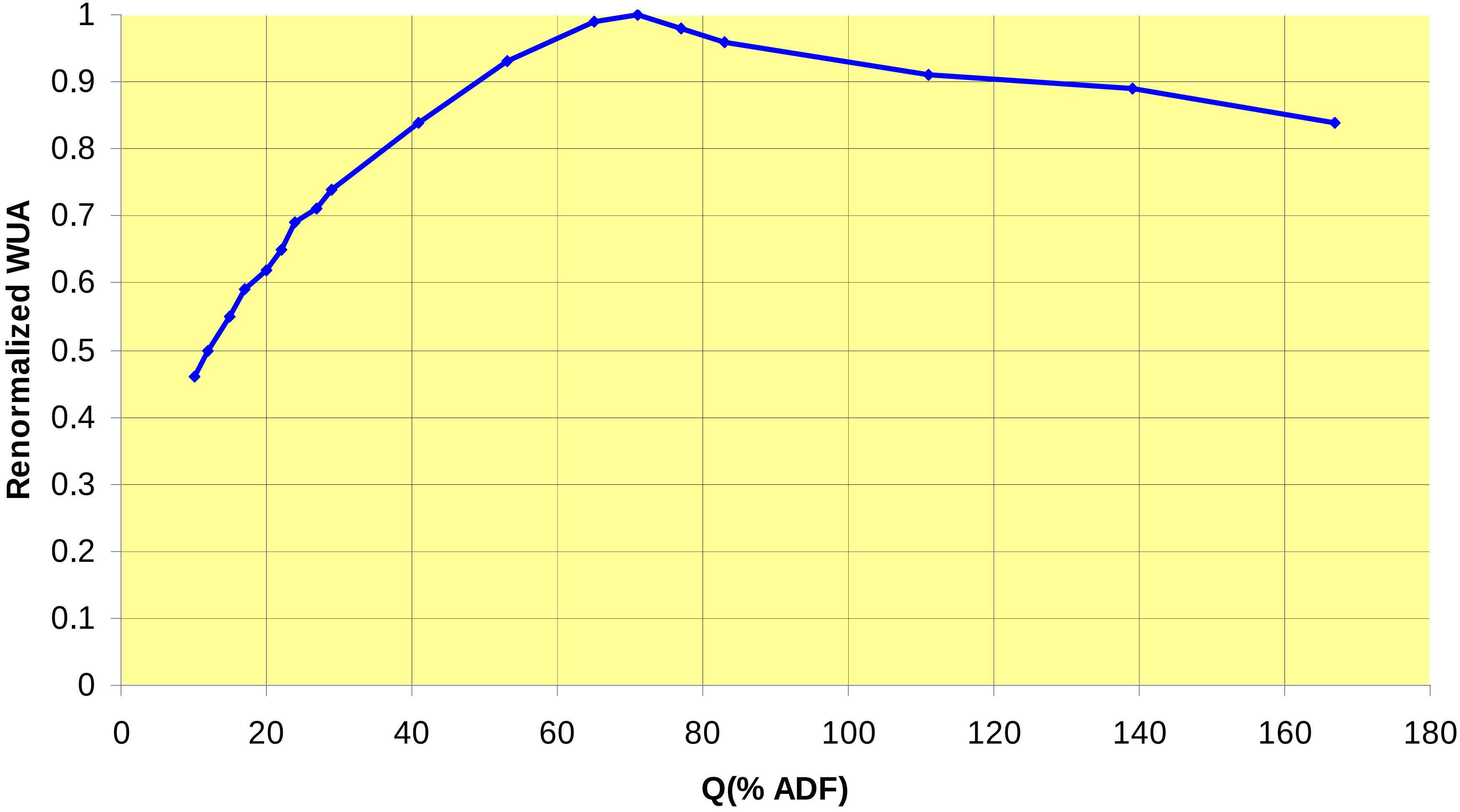



WUA vs Q, Brook Trout, Green Creek Seg. 1
WUA(ft2/1000 ft of Stream)
4000
3500
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
Q(%ADF)
WUA Adult
WUA Juvenile
WUA Spawning
WUA Fry

Normalized WUA vs Q, Brook Trout (Adults, Juveniles, and Fry), Green Creek Segment 1



Renormalized WUA vs Q for Brook Trout (Adults, Juveniles, and Fry) Green Creek Segment 1



Seasonal Components of Model

- **Fall/Winter (Adults, Juveniles, Spawning) = October, November, December, Jan, Feb**

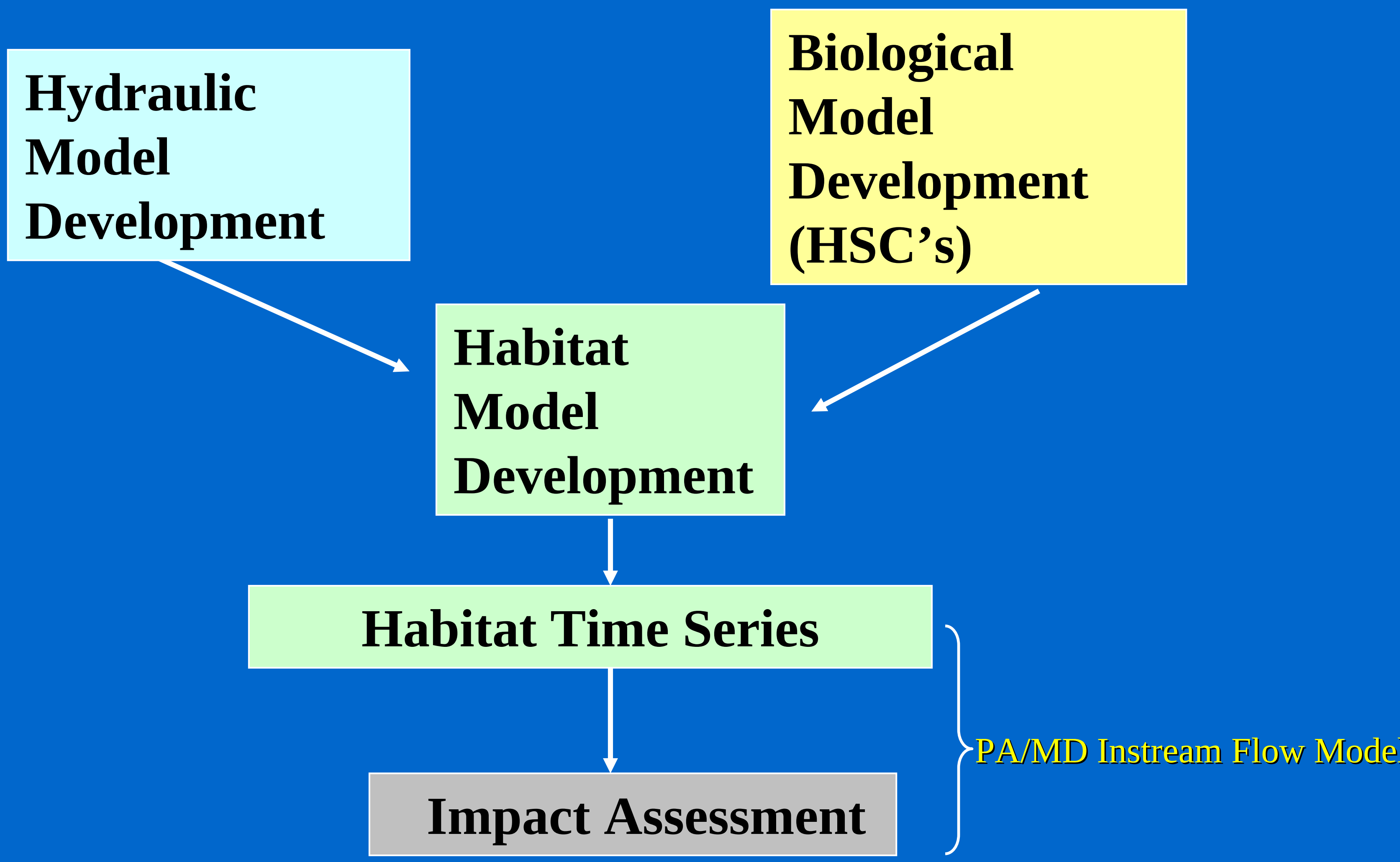
- **Spring (Adults, Juveniles, Fry)**

  = March, April, May, June

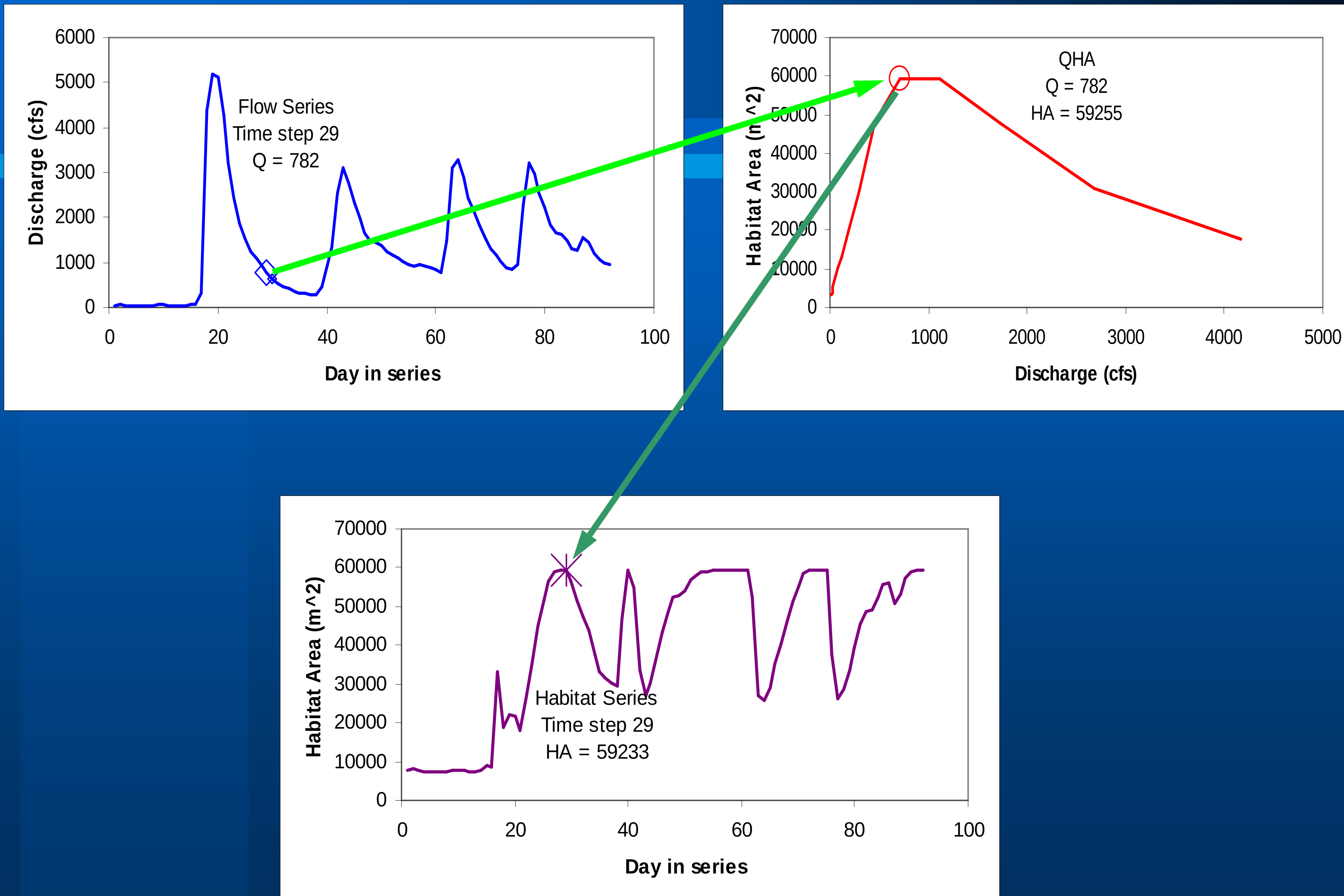
- **Summer (Adults, Juveniles)**

  = July, Aug, Sept

Components of IFIM



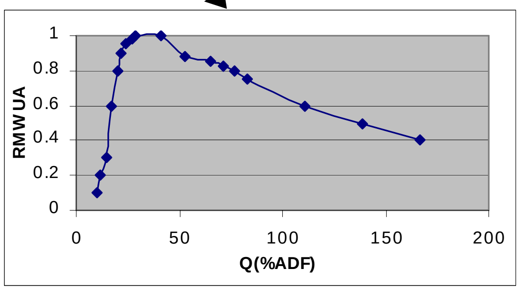
Habitat Time Series Generation

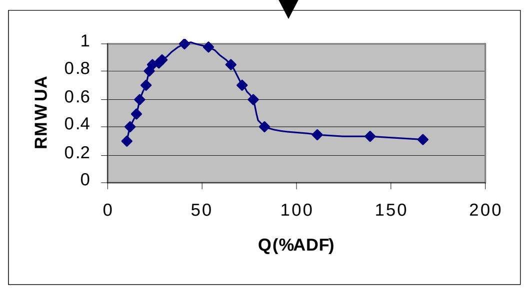


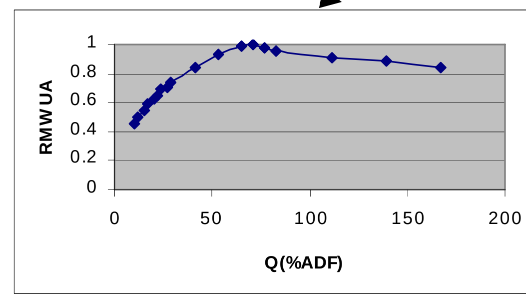
Overview of PA IF Model

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1980				158	70	24	16	26	18	14	40	84
1981	74	330	200	440	128	56	58	26	16	18	136	116
1982	98	500	380	90	122	36	16	36	20	20	38	184
1983	136	260	360	270	320	100	104	28	18	18	94	380
1984	220	290	192	450	280	102	34	24	44	32	38	280

Time Series of Flow for Stream w/ Proposed Withdrawal



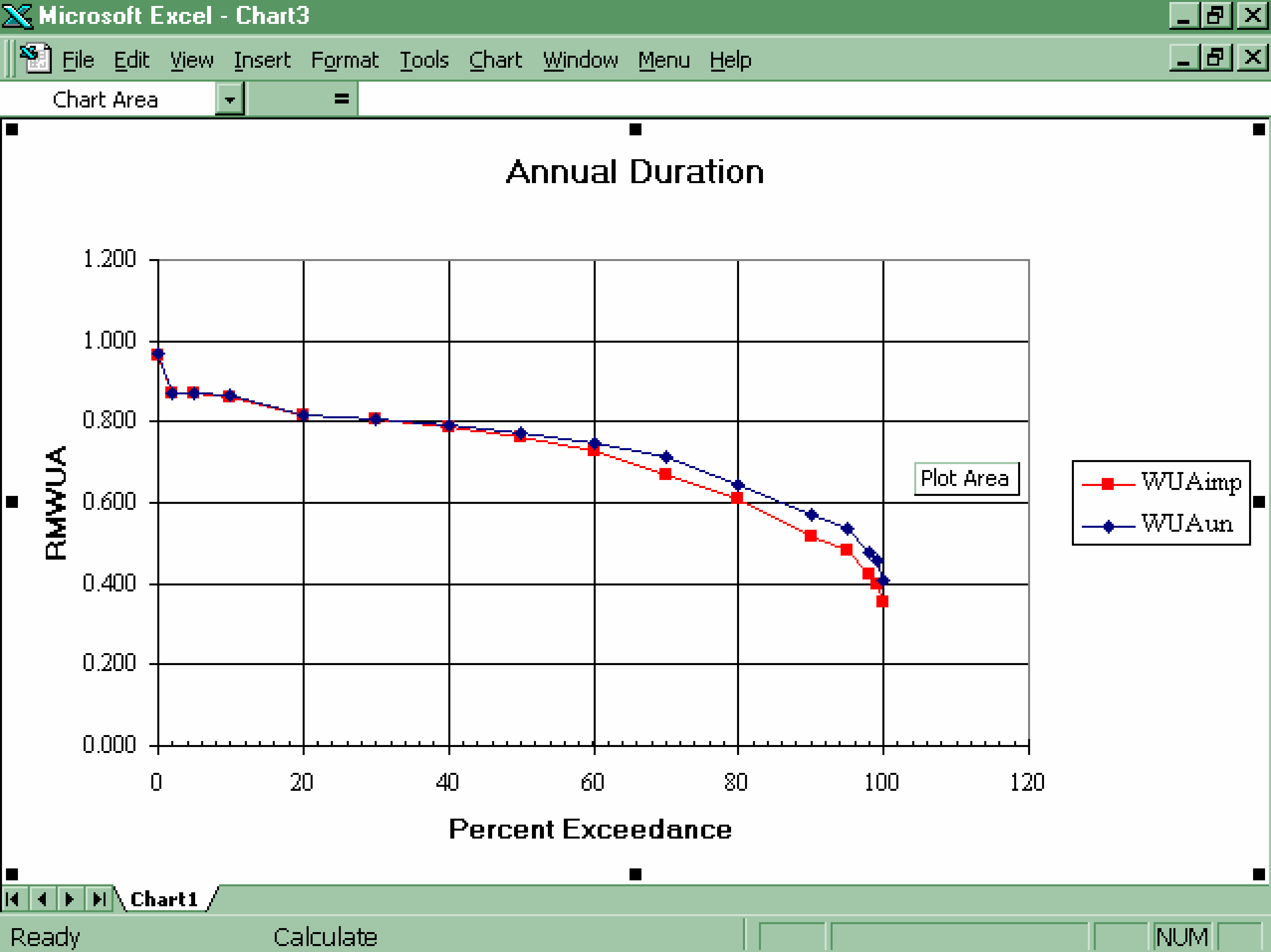


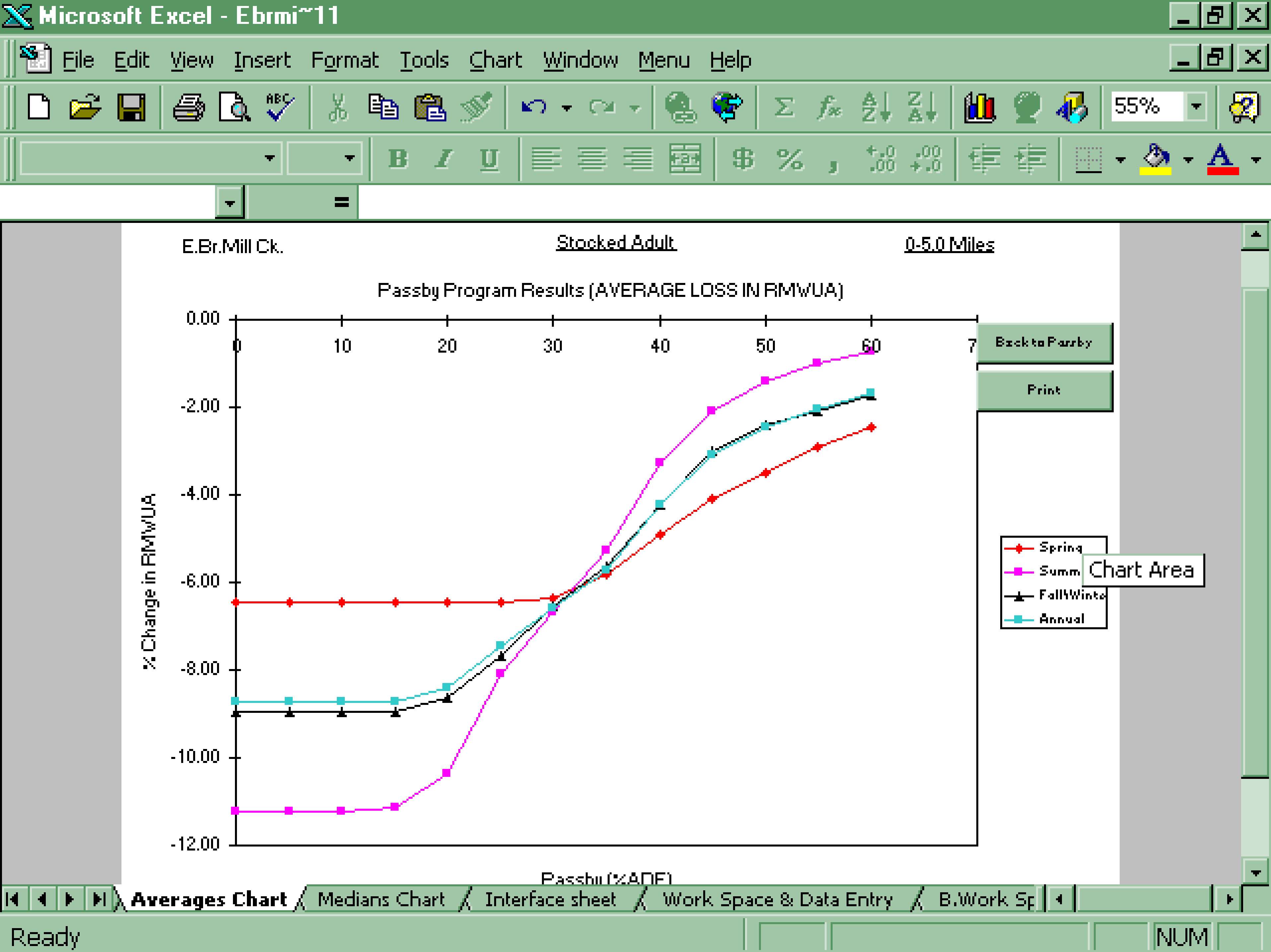


WUA vs Flow relationships for study streams

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1980				0.3	1	0.7	0.2	0.3	0.14	0.24	0.5	0.9
1981	0.7	0.25	1	0.4	0.98	0.45	0.8	0.4	0.14	0.15	0.9	0.9
1982	0.9	0.5	0.6	0.8	0.94	0.6	0.3	0.6	0.2	0.2	0.4	0.5
1983	0.9	0.6	0.7	0.3	0.2	0.98	0.98	0.4	0.3	0.1	0.8	0.5
1984	0.8	0.5	0.6	0.5	0.3	1	0.5	0.4	0.5	0.3	0.2	0.7

Time Series of Habitat for Stream w/ Proposed Withdrawal


Microsoft Excel - Chart3
File Edit View Insert Format Tools Chart Window Menu Help
Chart Area
=
Annual Duration
1.200
1.000
0.800
0.600
0.400
0.200
0.000
RMWUA
0
20
40
60
80
100
120
Percent Exceedance
Plot Area
WUAimp
WUAun
Chart1
Ready
Calculate
NUM


Microsoft Excel - Ebrmi~11
File Edit View Insert Format Tools Chart Window Menu Help
55%
E.Br.Mill Ck.
Stocked Adult
0-5.0 Miles
Passby Program Results (AVERAGE LOSS IN RMWUA)
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
0
10
20
30
40
50
60
% Change in RMWUA
Passby (%ADF)
Back to Passby
Print
Spring
Summ
Fall\Winte
Annual
Chart Area
Averages Chart
Medians Chart
Interface sheet
Work Space & Data Entry
B.Work Sp
Ready
NUM

A key question

Now that we know how much habitat is lost, how much loss is acceptable?

Assumptions

- Long term average annual habitat loss ≈ trout biomass loss
- Population loss of 5% is considered minimal or statistically non-detectable

Goal # 1

Maintain designated uses of the stream as defined in state water quality regulations

Designated uses

- Exceptional Value **– stream to be maintained and protected at existing quality**
- High Quality Cold Water Fishery **– No change in quality unless there is social and economic justification**
- Cold Water Fishery **– Maintenance and propagation of salmonids**

Goal # 2

Prevent changes in fisheries management class

Wild Trout Management Classes in PA

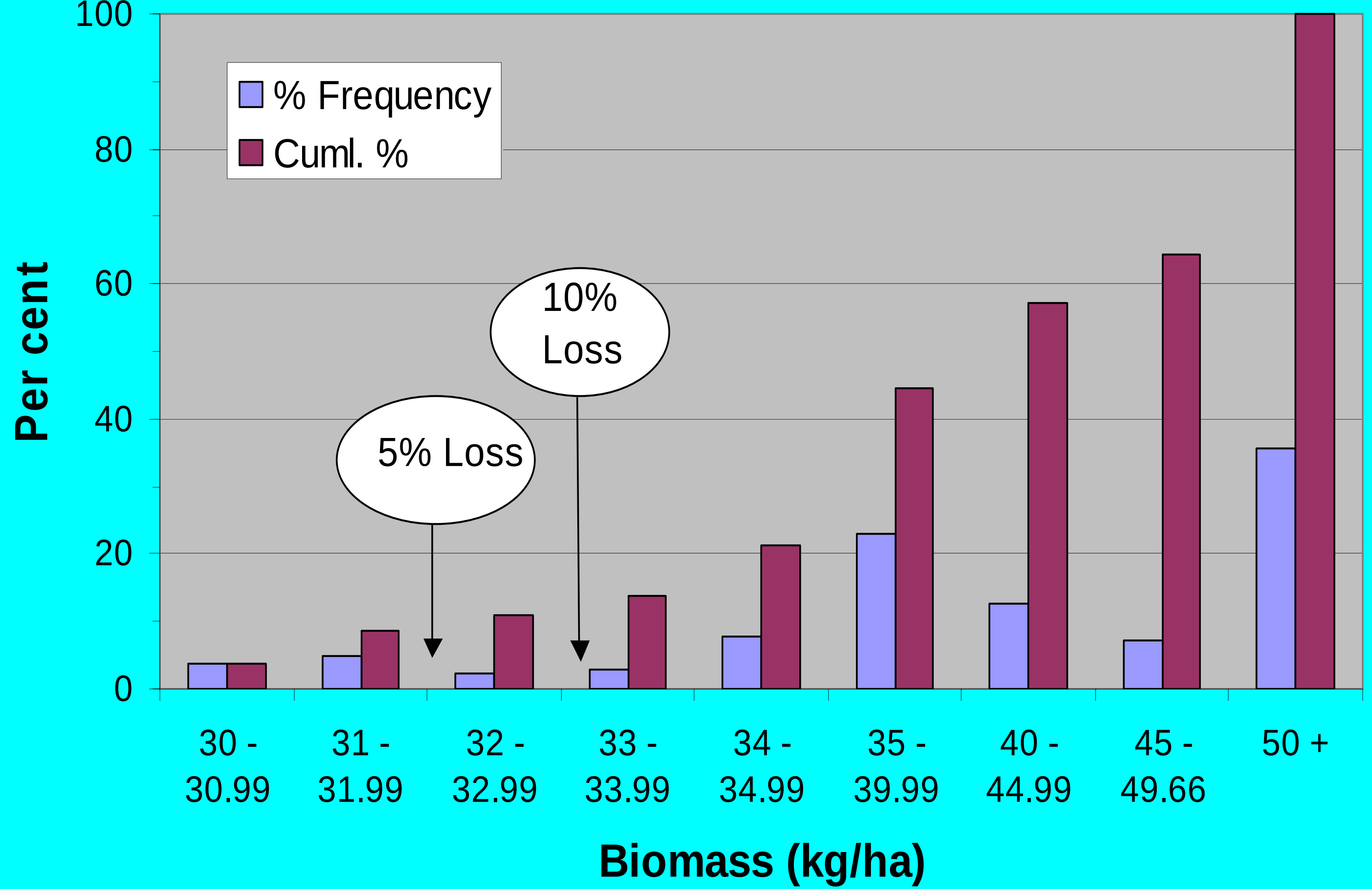
Class	Species	Biomass (kg/ha)
A	Brown Trout	≥ 40
A	Brook Trout	≥ 30
B	Brown Trout	20-39
B	Brook Trout	20-29
C	Combined	10-19
D	Combined	<10

The Relationship of Management Class to Designated Use

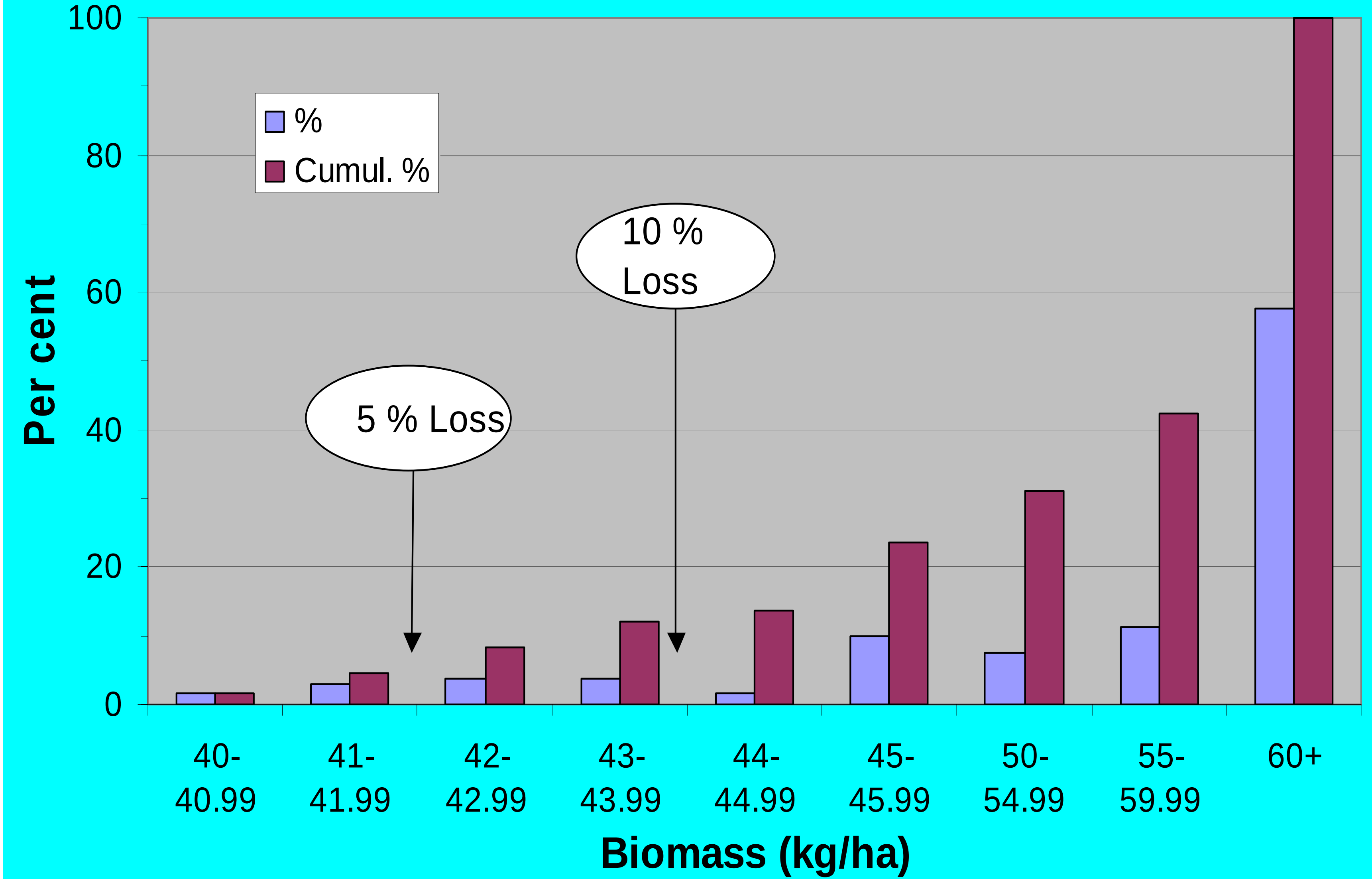
- **Class A Trout Fisheries – Generally designated as EV or HQ-CWF**
- **Class B & C Trout Fisheries – Generally designated as CWF**
- **Class D Trout Fisheries – Generally designated as CWF or TSF**

Criteria Development

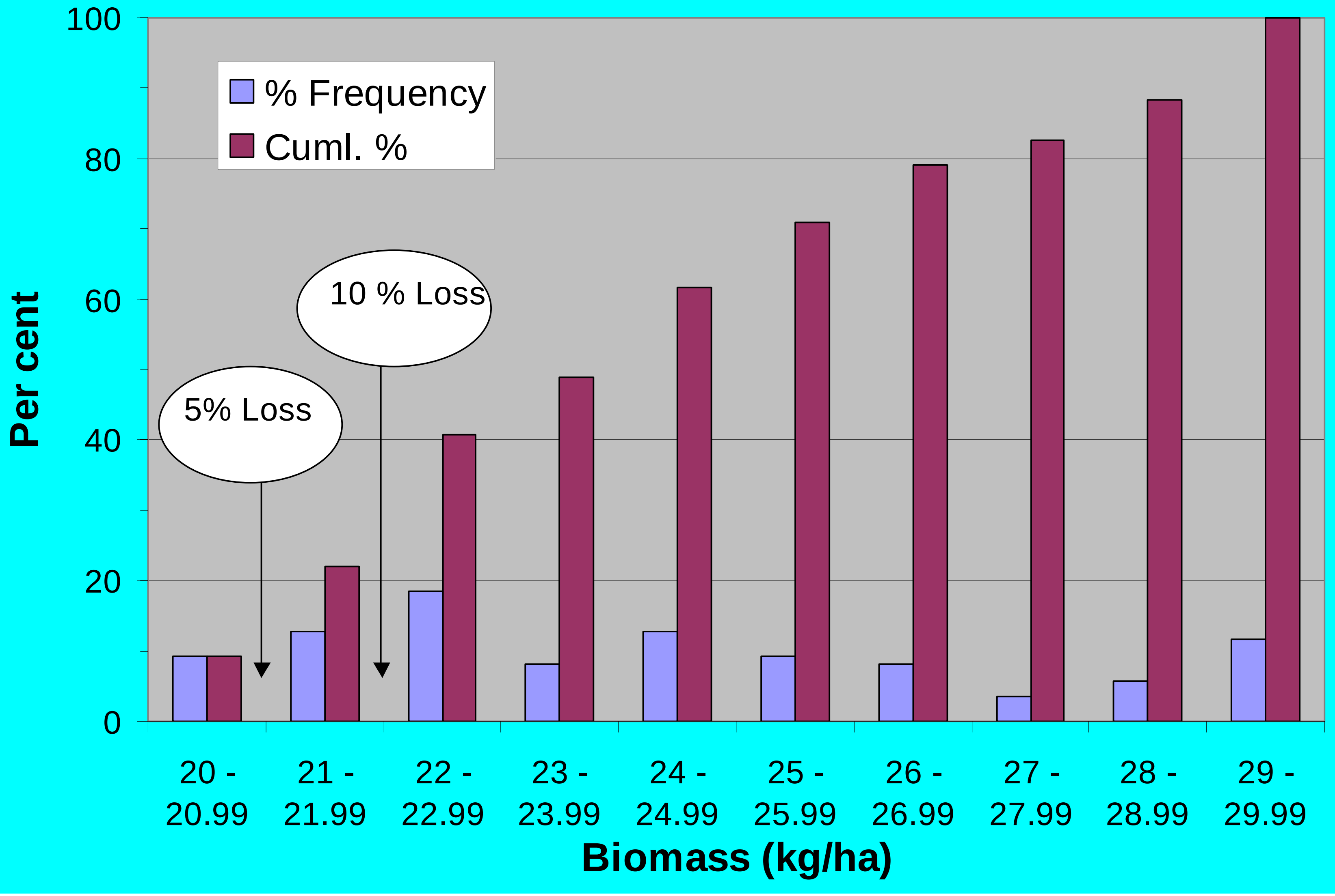
Frequency distribution of biomass for Class A wild brook trout streams in Pennsylvania



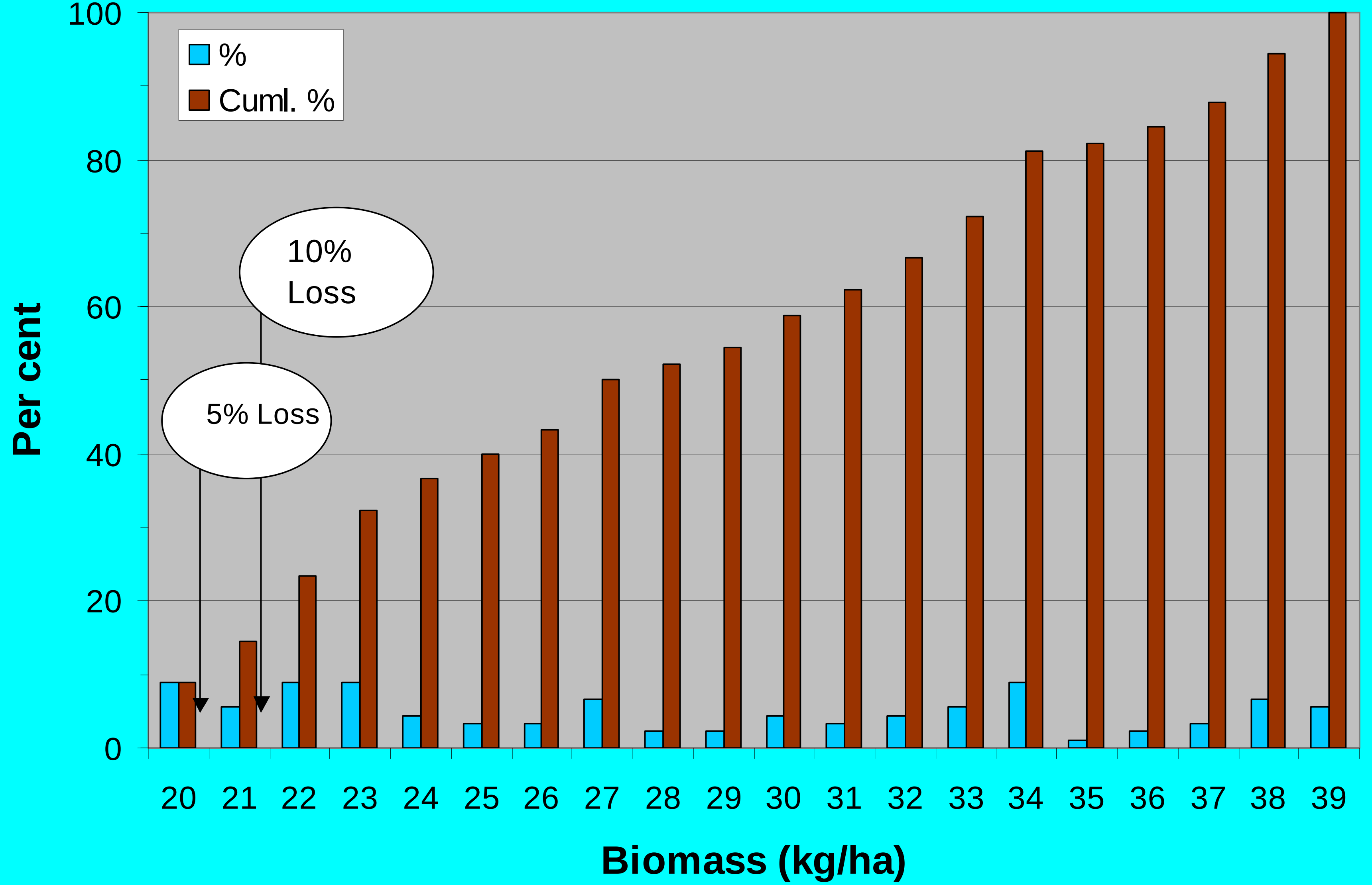
Frequency distribution of biomass for Class A wild brown trout waters in Pennsylvania



Frequency distribution for Class B wild brook trout waters in Pennsylvania



Frequency distribution of biomass for Class B wild brown trout waters in Pennsylvania



Criteria for DEP Draft Guidance and SRBC Policy

- **EV, HQ, and Class A – 5% mean annual habitat loss**
- **HQ with SEJ – 7.5%**
- **Class B – 10%**
- **Class C or D – 15%**

Groundwater Withdrawal Regulation in Pennsylvania

- **Pennsylvania DEP**
- **SRBC**
- **DRBC**
- **PFBC**

The Oley Decision (Oct 24, 1996)

Oley Twp. et al. v Commonwealth of Pennsylvania, Department of Environmental Protection and Wissahickon Spring Water, Inc. Permittee


'87 3 10

Prior to the appeal:

- DEP interpreted their responsibilities in Public Water Supply permit review for wells as limited to verification that water quality was safe for domestic use.
- No consideration given to interrelationship of well pumping to surface water quantity.

As a result of the appeal:

Environmental Hearing Board ruled that DEP must consider whether well construction & operation will violate the PA Clean Streams Law which effectuates the federal Clean Water Act requirement that the beneficial uses of water resources must be preserved. 1994 US Supreme Court decision (*PUD No. 1 of Jefferson County v. Washington Dept. of Ecology, 114 S. Ct. 1900 (1994*)) recognized that the antidegradation policy of CWA applies to not only <u>water quality</u> but also <u>water quantity.</u>

Also:

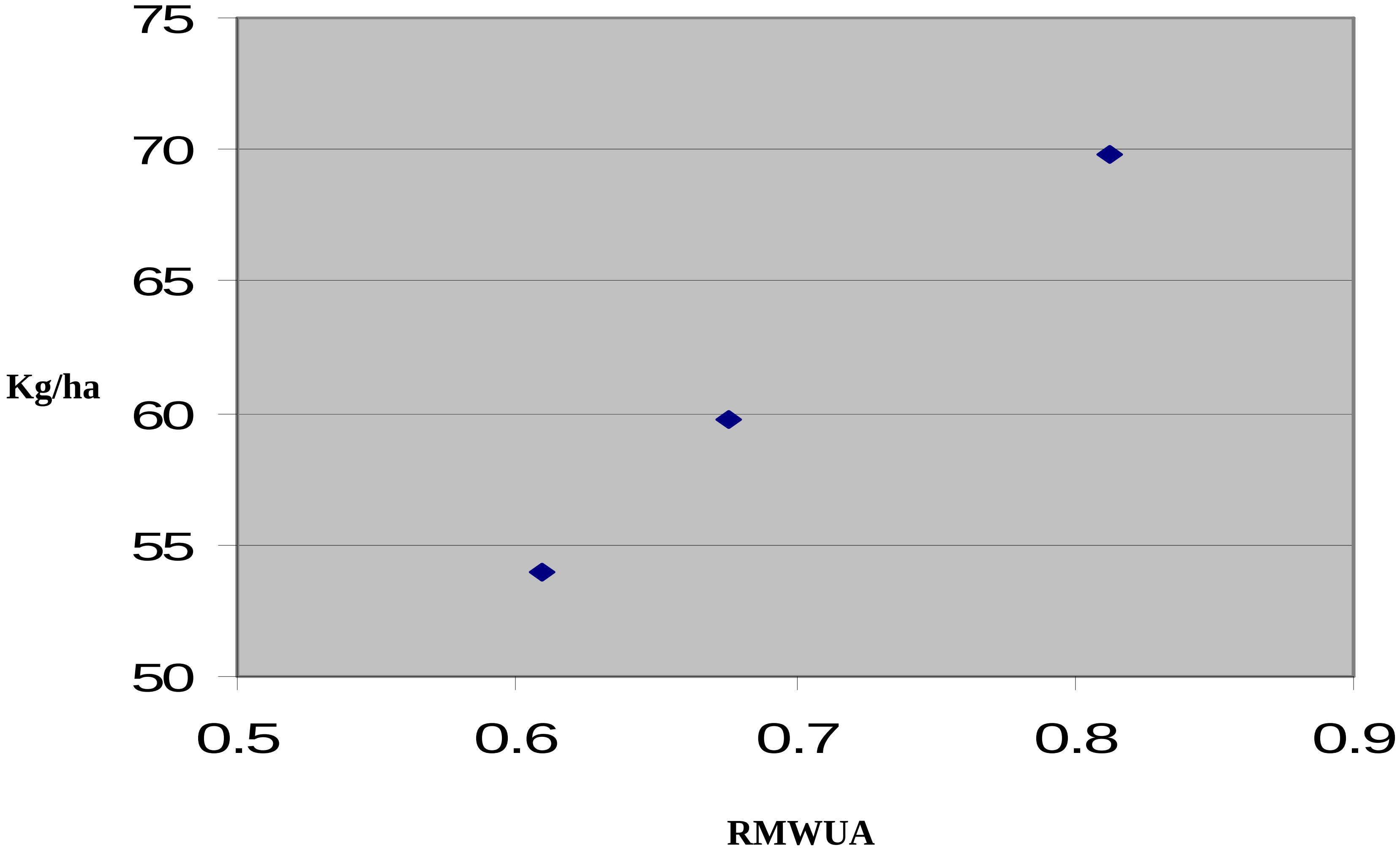
Section 611 of Clean Streams Law makes it unlawful to cause <u>pollution</u>. The definition of <u>pollution</u> in the Clean Streams Law includes ". . . contamination by alteration of the <u>physical</u>, chemical,or biological properties of such waters . . ."

Result

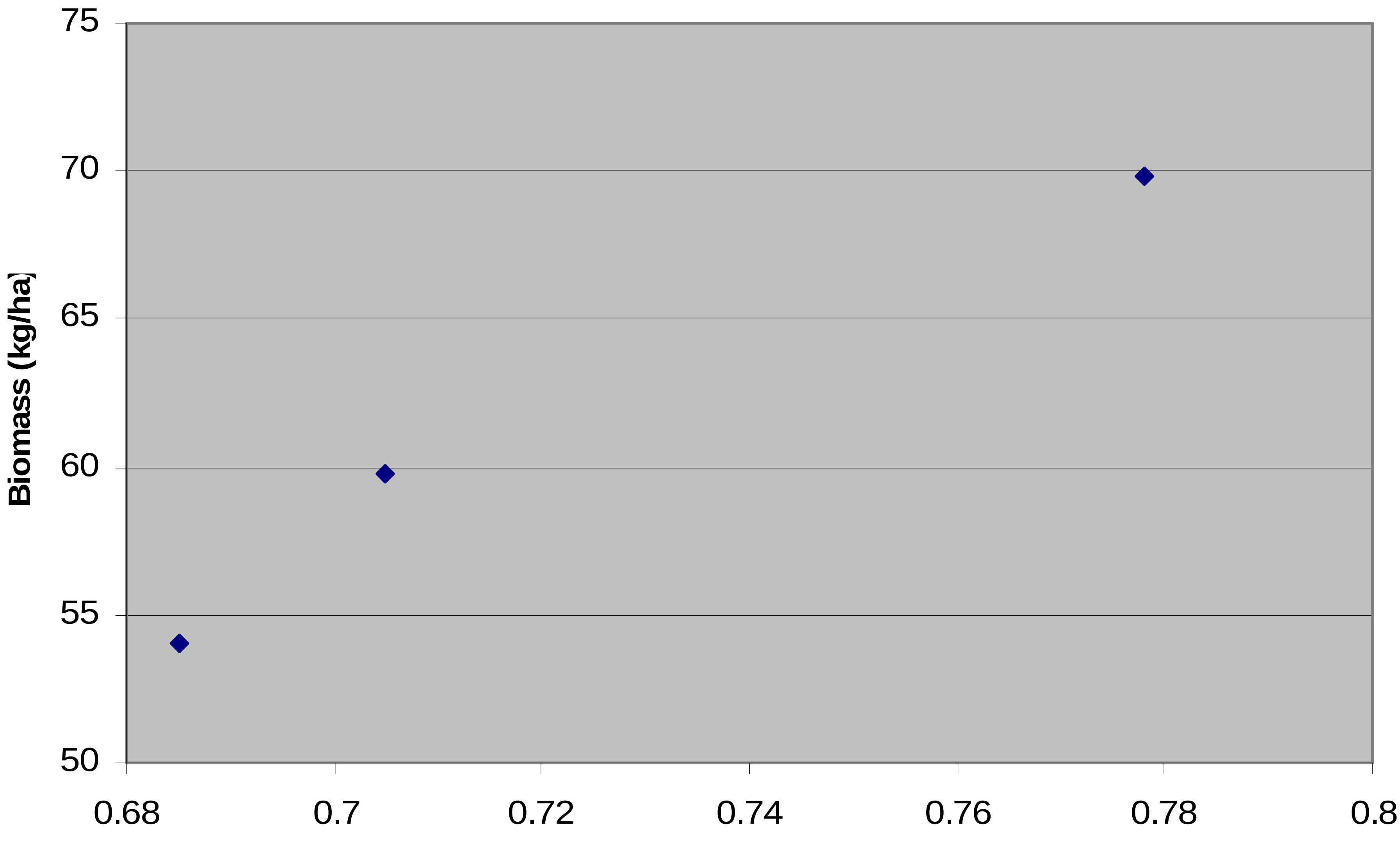
- DEP must now evaluate effects of well operation and pumping on surface waters
- SRBC and DRBC also evaluate these impacts for wells in the Susquehanna & Delaware River Basins

Pennsylvania Environmental Defense Fund and Pennsylvania Fish and Boat Commission v. Commonwealth of Pennsylvania, Department of Environmental Protection and Houtzdale Municipal Authority, Permitee (December 1997)

Same Fall -Winter RMWUA vs Adult Biomass (Trim Root Run)



Mean Annual RMWUA vs Total Brook Trout Biomass from Trim Root Run 2000-2004



“Recent” happenings

AES Ironwood Project, Lebanon County

- **Natural gas-fired power plant**
- **Water Supply – Tulpehocken and Quittapahilla Creek**
- **Habitat impacts – < 5%**
- **More stable flows in Tulpehocken Creek**
- **Voluntary mitigation – $27,000/year**

Bottled Water

- Perrier/Nestle – headwaters of Ontelaunnee Creek, Lehigh County
- IFIM study/biological study comparison to PA IF model results

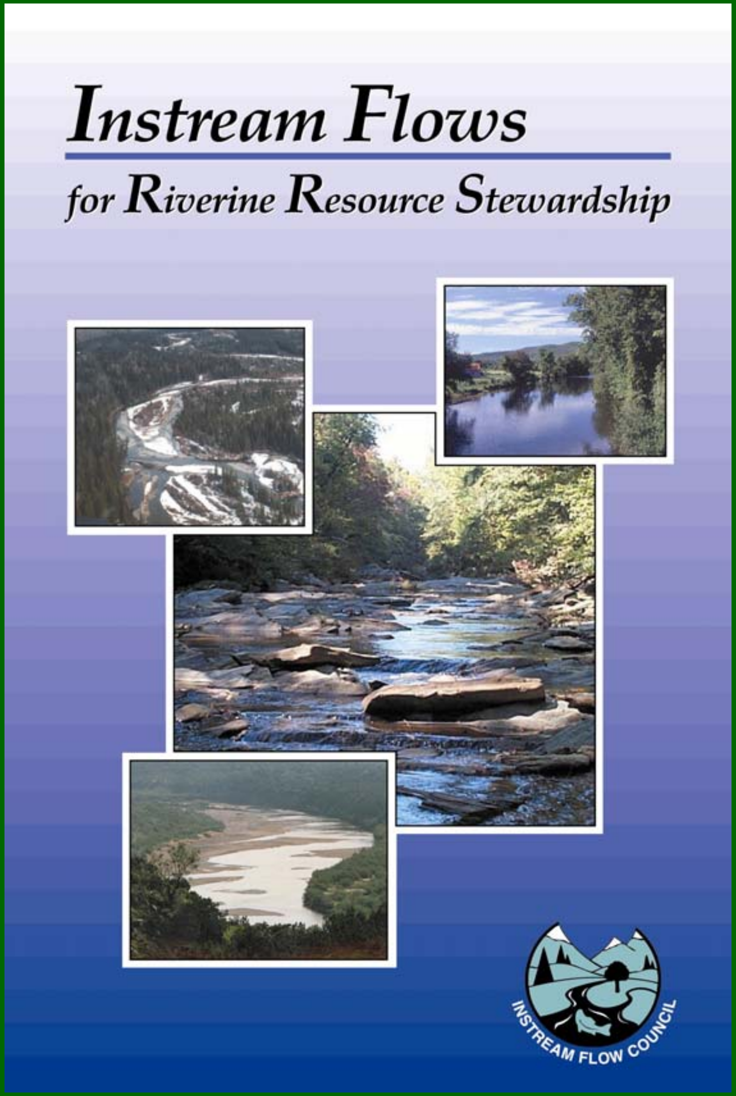
PA-American Osceola Well Field

- **Production wells on Trout Run & Minnie Run, Centre County**
- **Intensive study of well pumping impacts on springs, wetlands, stream flow, & shallow groundwater system**
- **Passby flows made a condition of pumping based on study results**

New statewide IF study planning

- Based on indices of hydrological alteration
- Similar to methods developed in NJ by USFWS and USGS

www.instreamflowcouncil.org



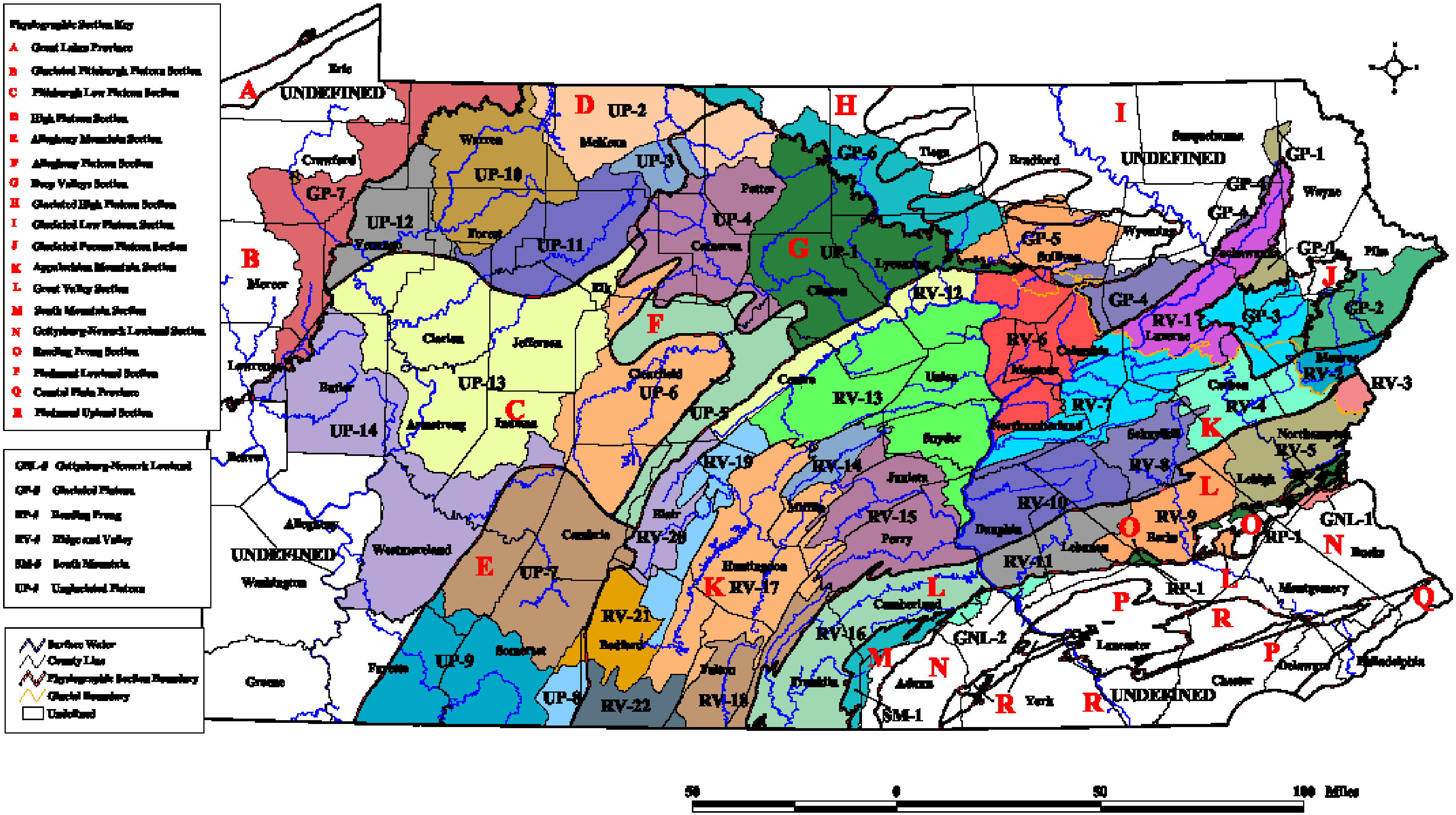


Plate 2. Pennsylvania-Maryland Instream Flow Study: Hydrologic Regions

Stream Variation

Stream A

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Mean
1999													a
2000													b
2001													c
2002													d
Mean	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	X

Stream B

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Mean
1999													a
2000													b
2001													c
2002													d
Mean	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	X

Yearly average = (Stream A Mean(a,b,c,d) + Stream B Mean(a,b,c,d))/2

Monthly average = (Stream A Mean(J,F,M,…D) + Stream B Mean(J,F,M,…D))/2

Yearly Variation

	Jan	Feb	Mar		Dec	Mean
1999	Mean (Streams A,B,C,etc)	Mean (Streams A,B,C,etc)				a
2000						b
2001						c
2002						d
Mean	Jan	Feb	Mar		Dec	X

Yearly average = average (a,b,c,d)

Problem set

1. Develop a median monthly flow dataset for USGS gage Lehigh River at Stoddartsville (Bald Eagle Ck at Tyrone)
2. Synthesize a dataset from this same gage but for a site with a drainage area of 5 sq. miles
3. Estimate the passby flow for a withdrawal of 1 mgd from this gage that yields an average annual habitat loss of 5%, 10% and 15% using the preliminary analysis model (you will need to ask me certain questions to do this)
4. Estimate the passby flow for a withdrawal of 0.5 mgd from this gage that yields an average annual habitat loss of 5%, 10% and 15% using the detailed analysis model
5. At a 5% habitat loss, how frequently will the entire withdrawal be available on an annual basis using median flow data.
6. Use the median monthly flow data from question 2. Assume this is daily data. Determine what the habitat loss is from one year to the next if ½ the flow is taken each day