Middle Potomac Watershed Assessment
Modeling Streamflows

Third of a six-part webinar series

June 16, 2011

The webinar will start momentarily.

Audio feed is by telephone

Toll-Free: (888) 296-1938

When prompted, enter Participant Code: 516128

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Middle Potomac Watershed Assessment
Modeling Streamflows

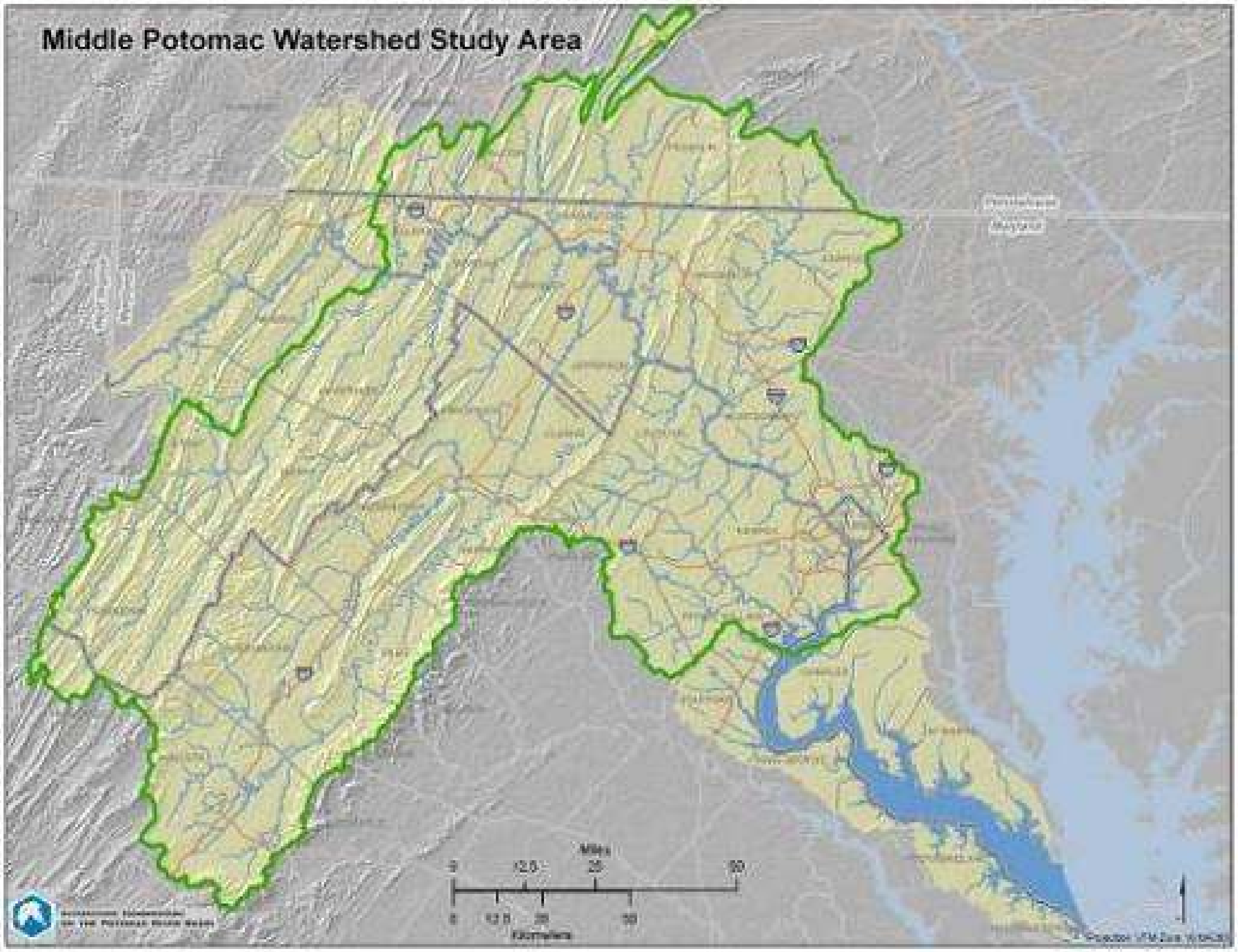
Speakers

Andrew Roach, U.S. Army Corps of Engineers, Baltimore District

Heidi Moltz, Senior Water Resources Scientist, Interstate Commission on the Potomac River Basin (ICPRB)

Project website: http://potomacriver.org/sustainableflows

Study Area


Middle Potomac Watershed Study Area
Miles
0
12.5
25
50
0
12.5
25
50
Kilometers

3

Objectives

1) Estimate current and future human water withdrawals and their impacts on flows.

2) Characterize flows needed to support healthy stream biotic communities.

3) Provide baseline information and analyses to support water use decision making.

Webinar Series

- Technical details on methodology for small streams
- Obtain feedback from stakeholders
- Prepare for concluding workshop: focus on management applications

Date	Webinar Topic
April 12	Technical overview of project
May 10	Current and future demands and impacts on flow
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→ Nov 29-Dec 1 Flow ecology response workshop at NCTC

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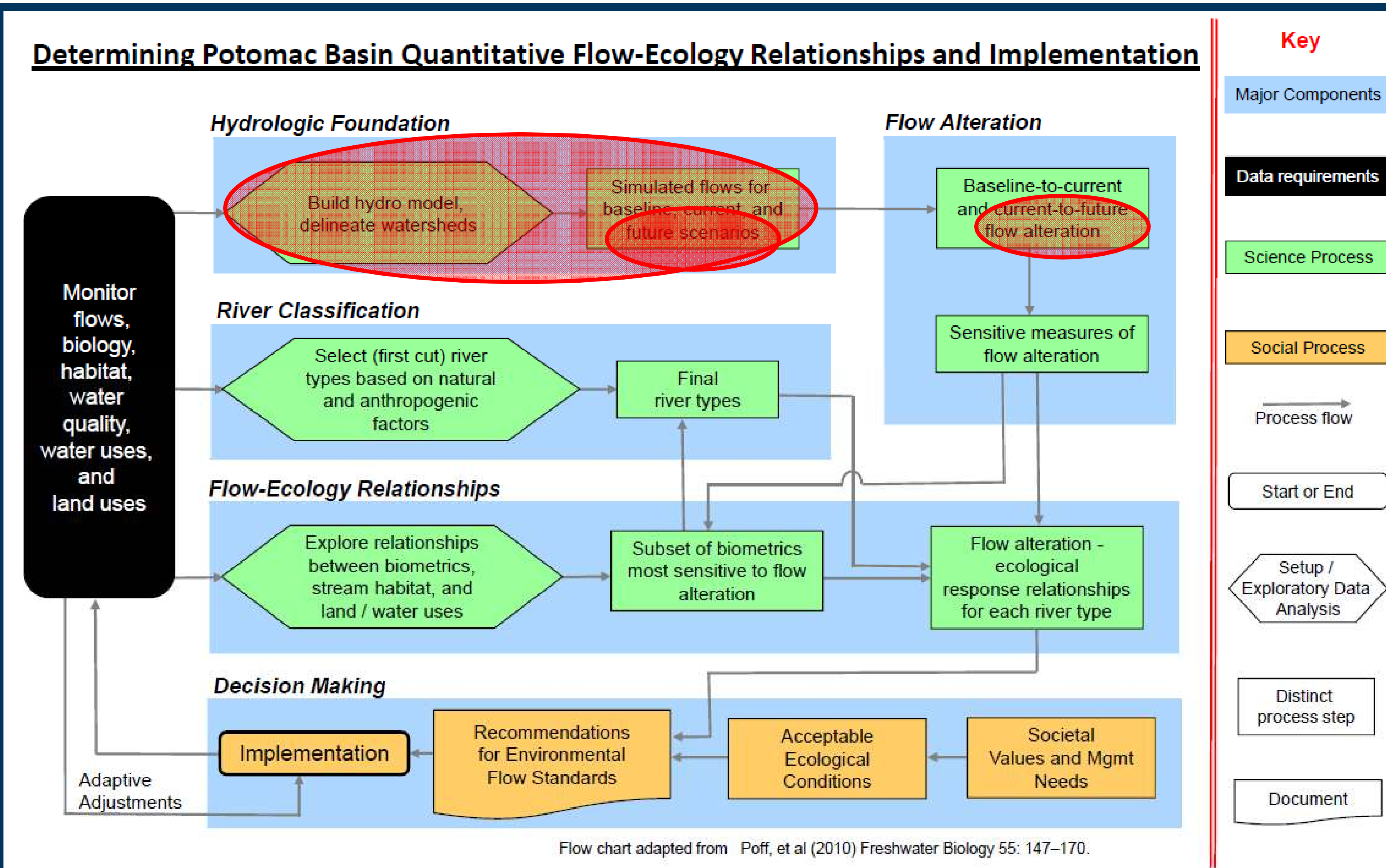
Hydrologic Foundation



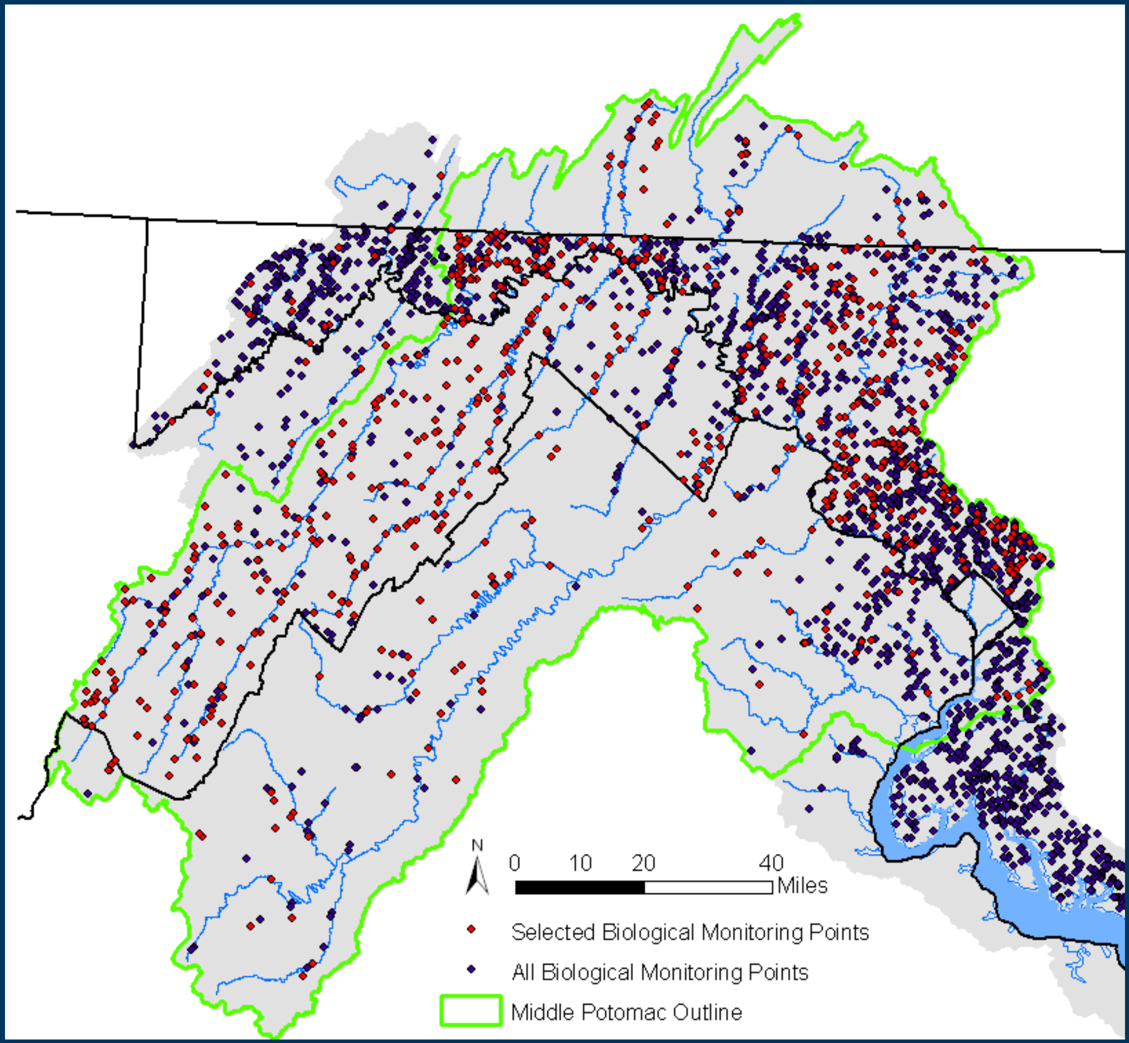
Modeling Streamflows Objective

Develop flow time series for select watersheds from which flow alteration will be estimated

Modeling Process

- Identify and delineate watersheds
- Select hydrologic simulation model
- Improve model components where possible
- Establish watersheds in model environment
- Calibrate model
- Develop scenarios
- Run model
- Evaluate output

Criteria for Selection of Biological Monitoring Points



Biological data obtained from local, state, and federal programs and assembled in the Chessie B-IBI database by the Chesapeake Bay Program.

- Best biologic sites across range of hydrologic alteration
- Range of watershed sizes
- Broad spatial distribution
- Within 200' of NHD streams

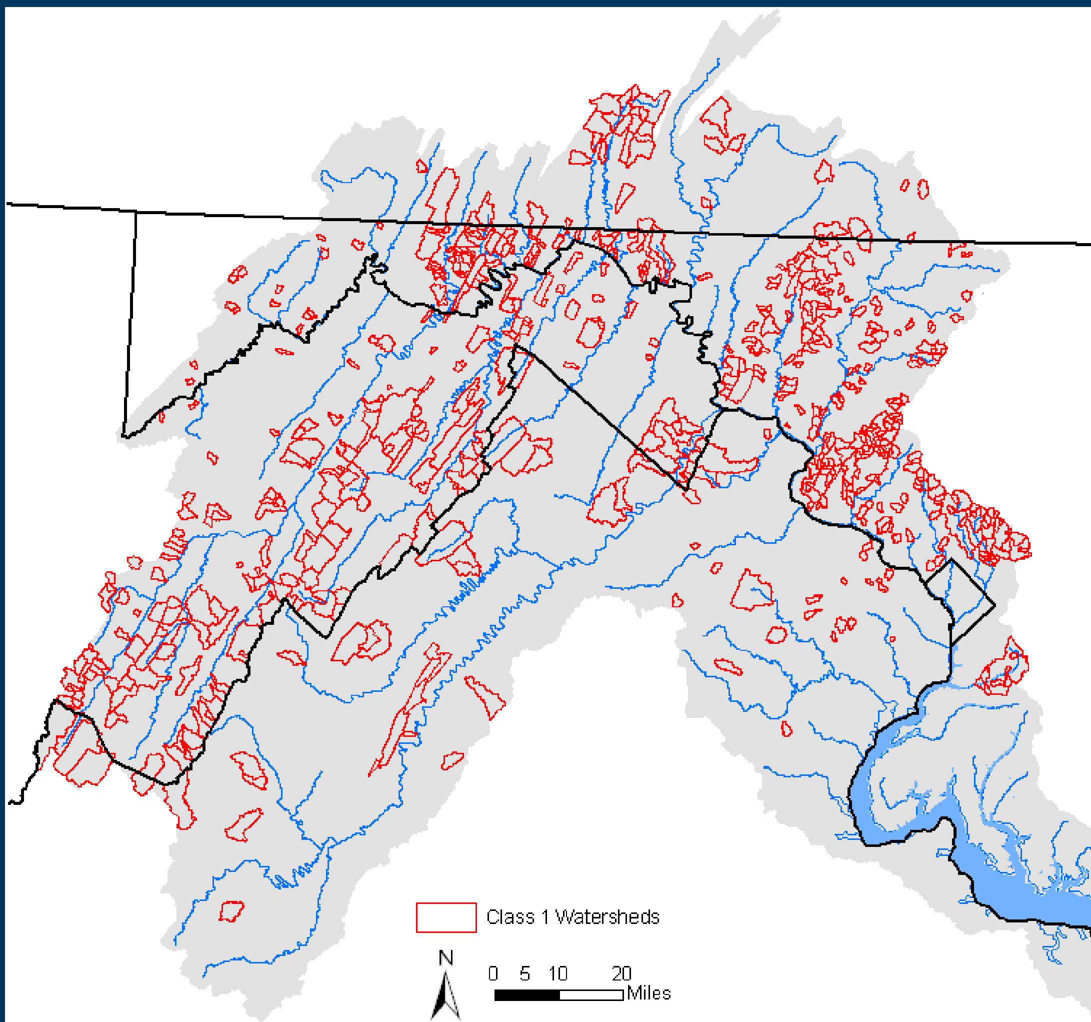
783 biological monitoring points selected

Watershed Delineation

Multi-watershed delineation tool, Utah State University

http://hydrology.usu.edu/mwdtool

Watersheds Draining to Biological Monitoring Points

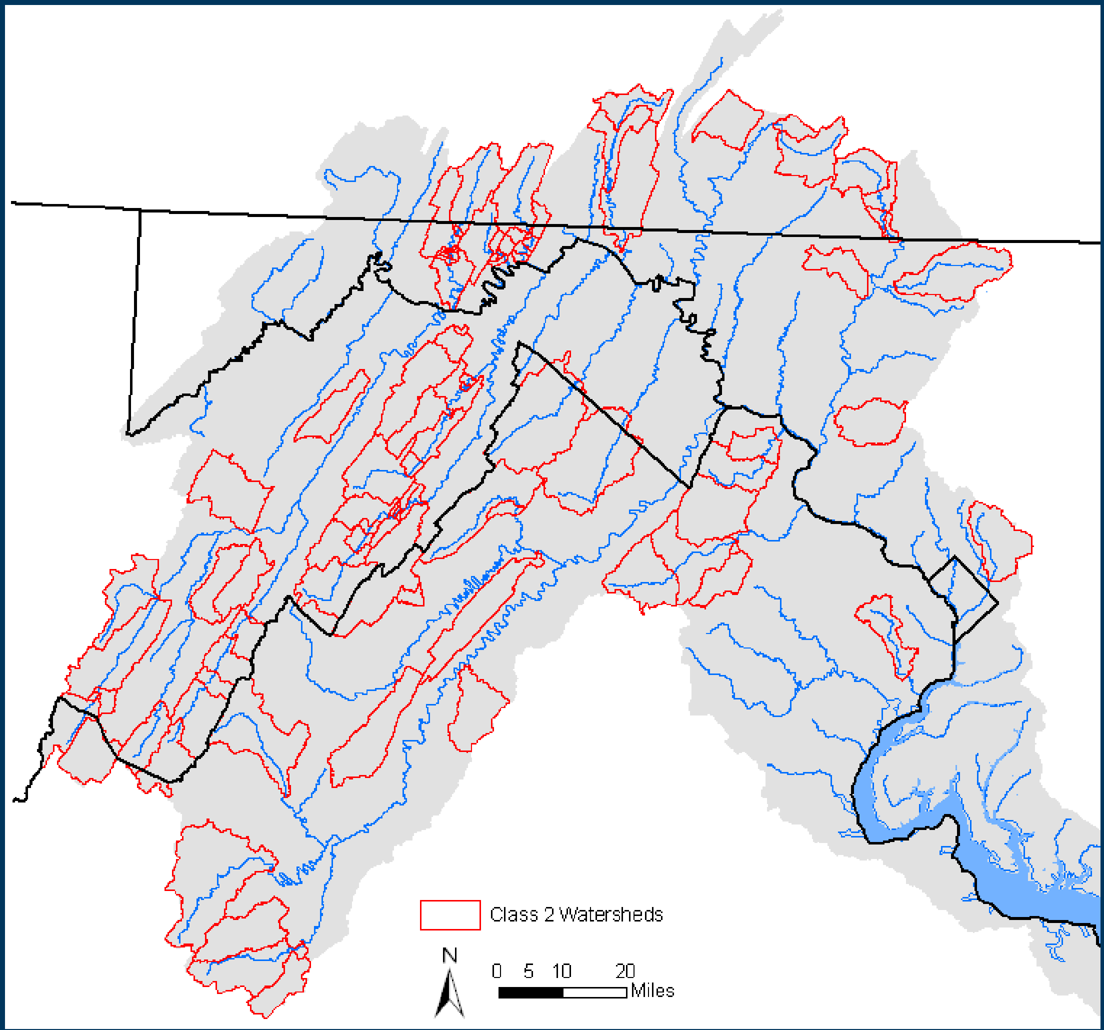


574 NEAFWA Headwater/Creek Watersheds

(< 38.6 sq. mi.)

NEAFWA = Northeast Association of Fish and Wildlife Agencies

Watersheds Draining to Biological Monitoring Points



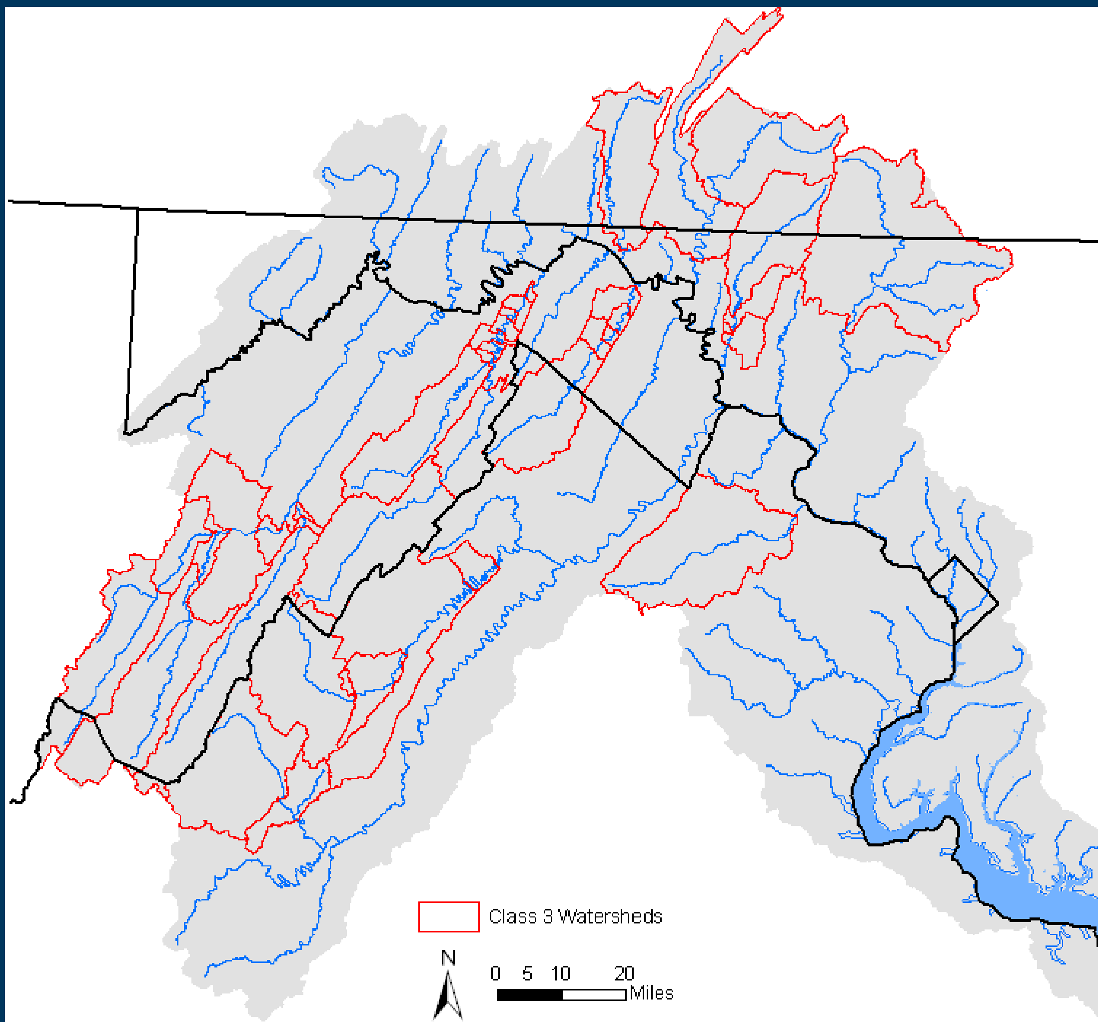
92 NEAFWA

Small River Watersheds

(38.6 - 200 sq. mi.)

NEAFWA = Northeast Association of Fish and Wildlife Agencies

Watersheds Draining to Biological Monitoring Points

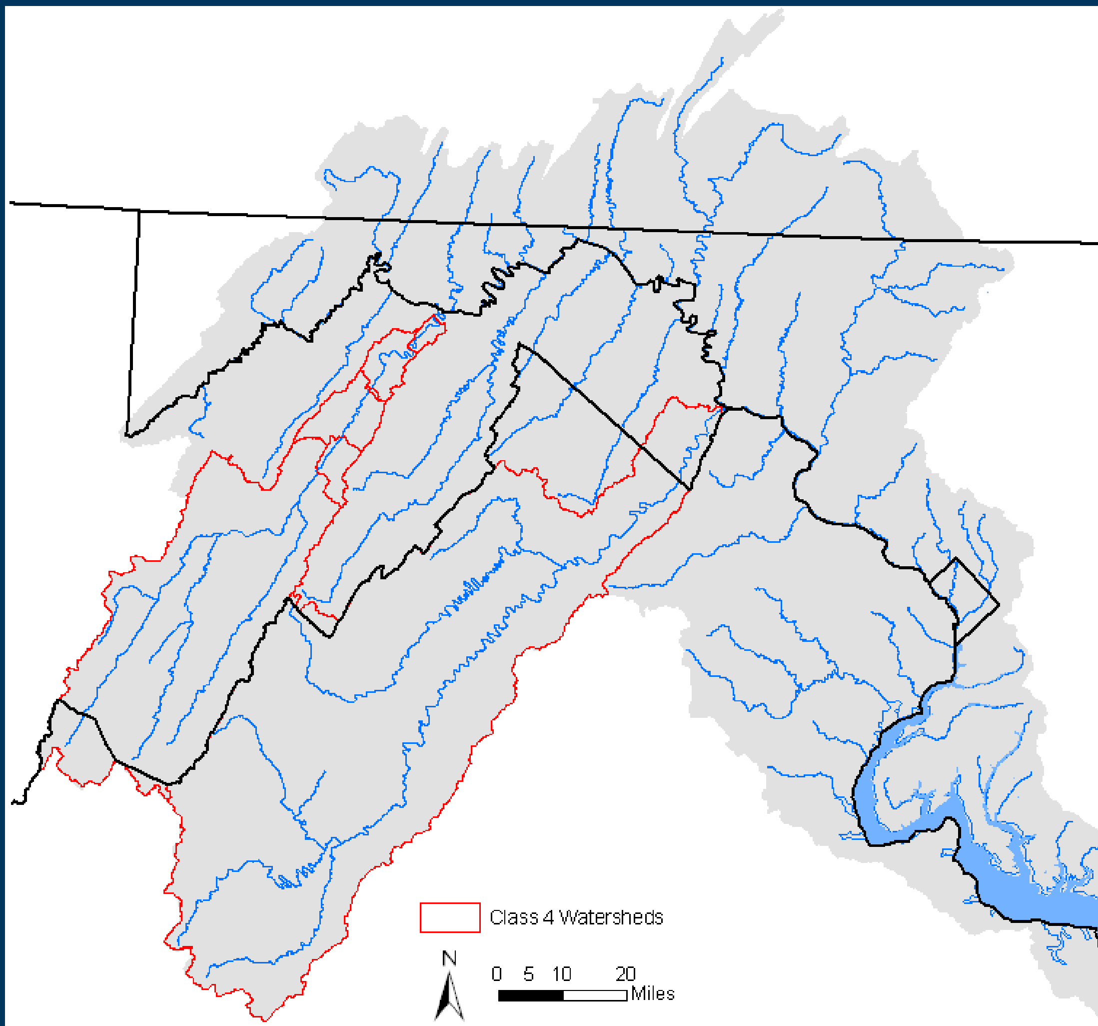


39 NEAFWA Medium River Watersheds

(200 - 1,000 sq. mi.)

NEAFWA = Northeast Association of Fish and Wildlife Agencies

Watersheds Draining to Biological Monitoring Points



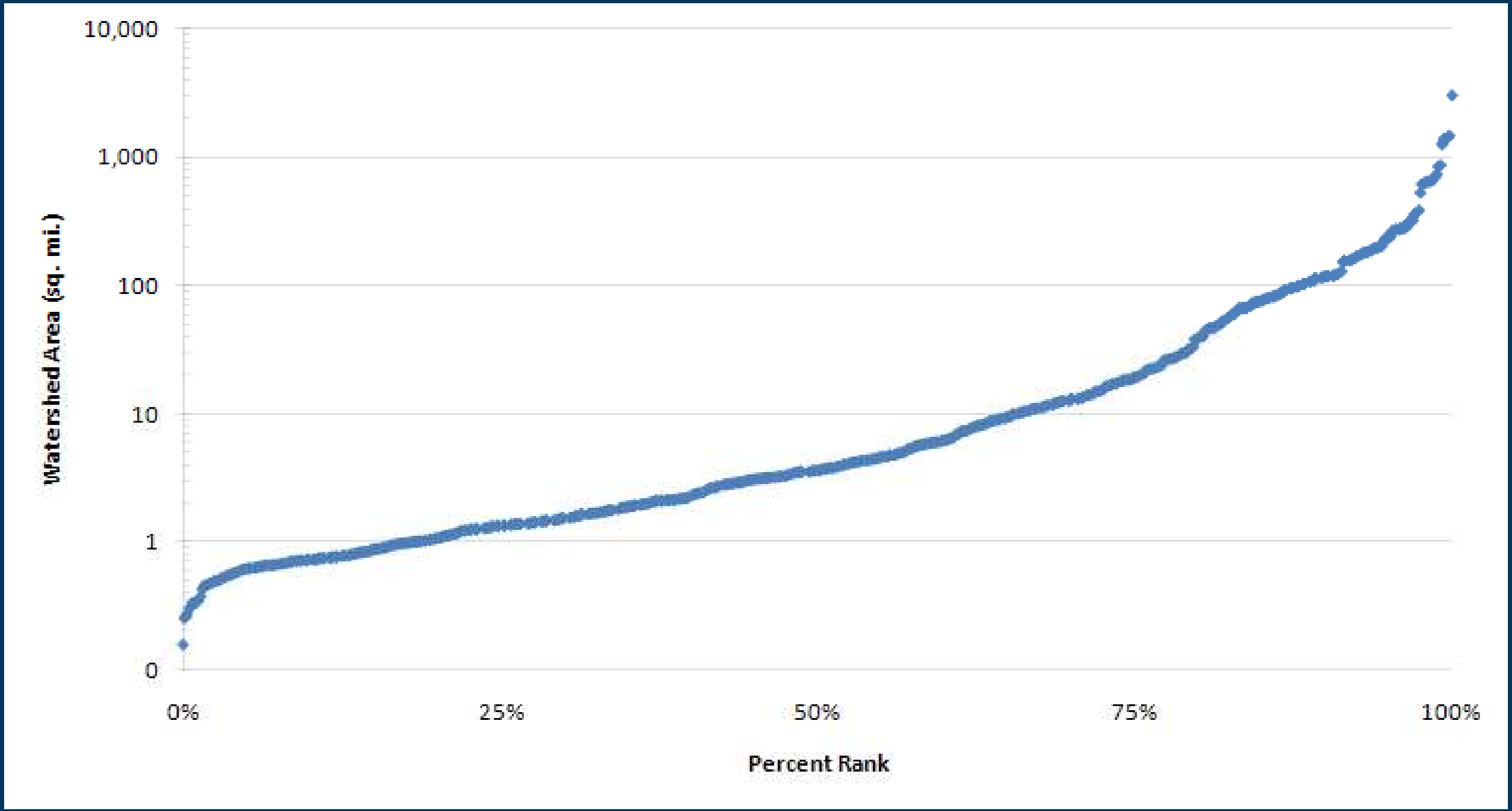
7 NEAFWA Large/Great River Watersheds

(>1,000 sq. mi.)

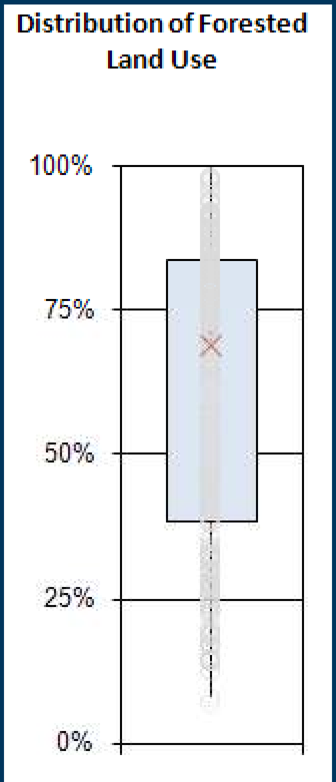
712 total watersheds

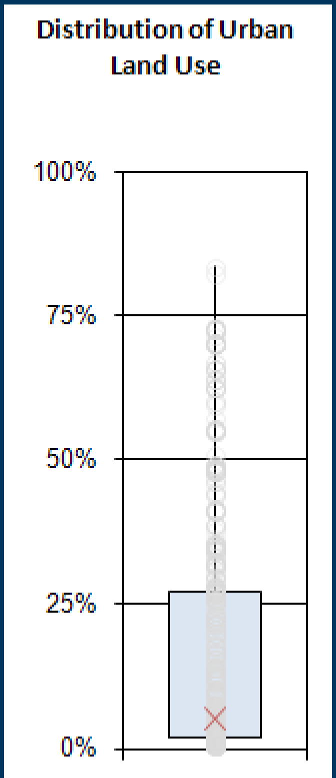
NEAFWA = Northeast Association of Fish and Wildlife Agencies

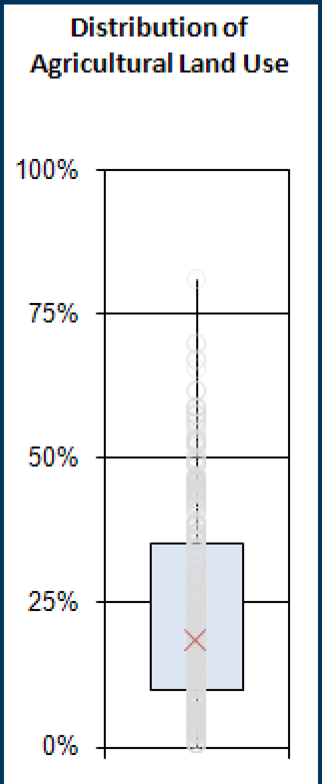
Distribution of Watershed Sizes



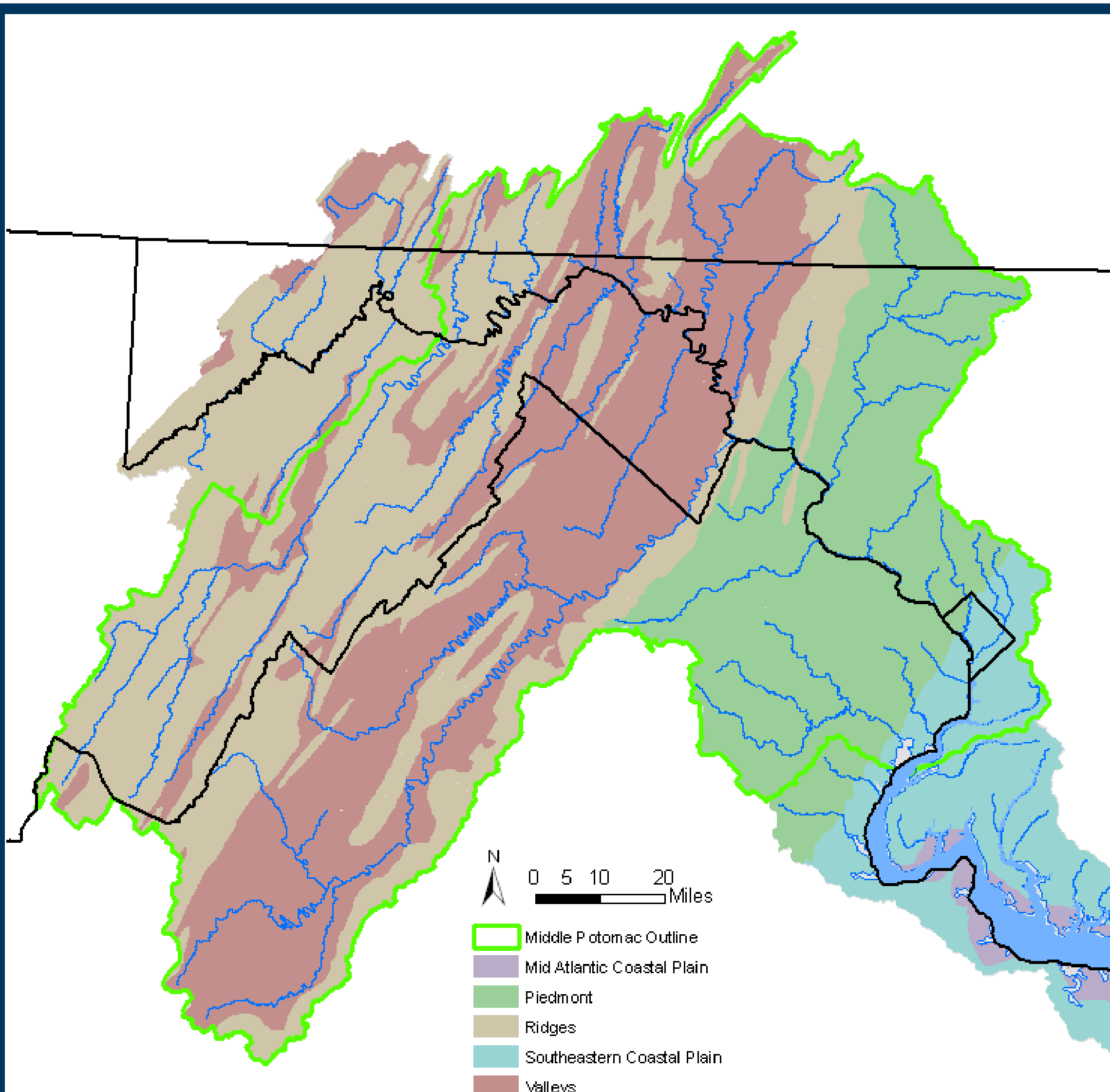
Watershed Land Cover Distribution





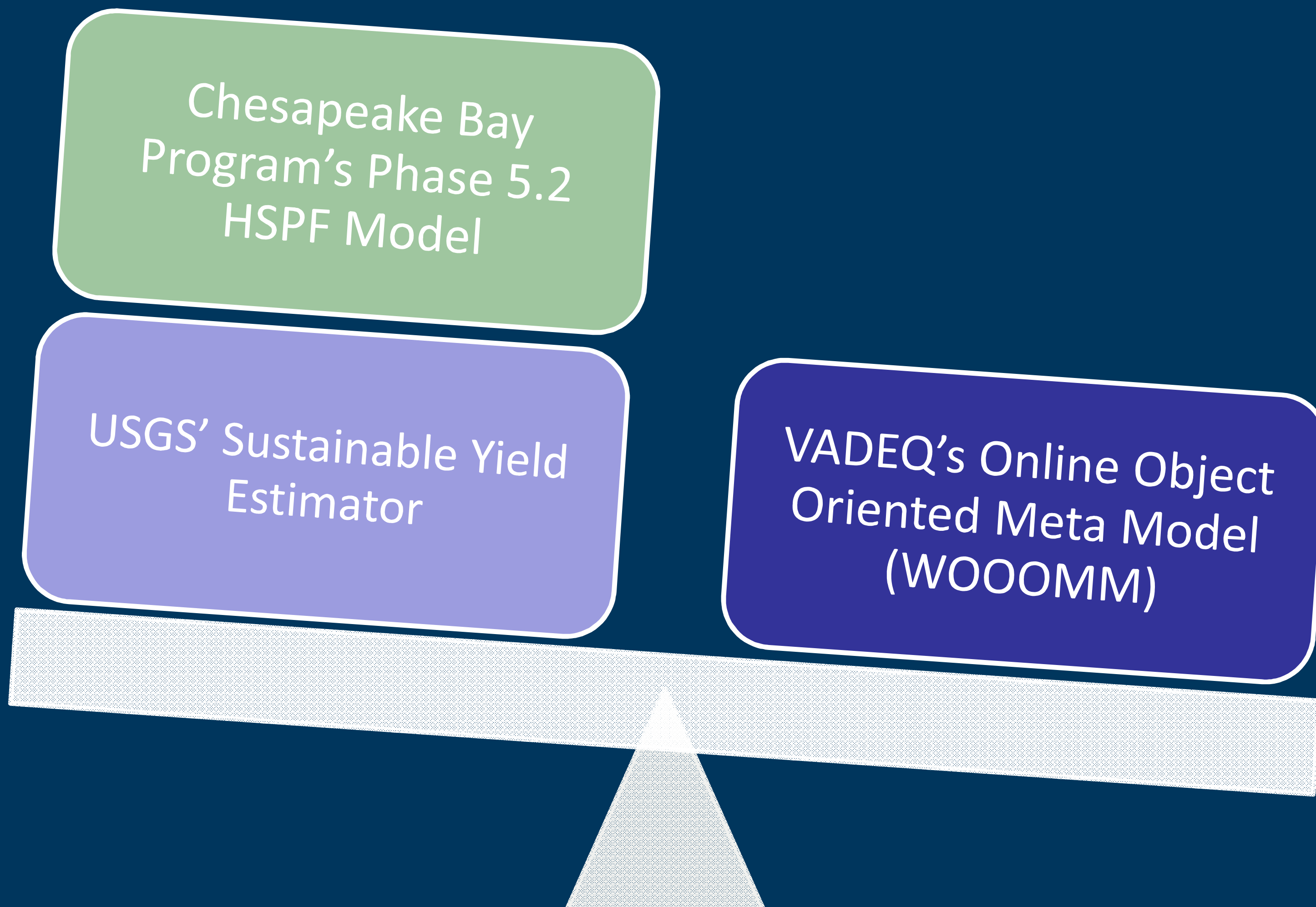


Watershed Bioregion Distribution



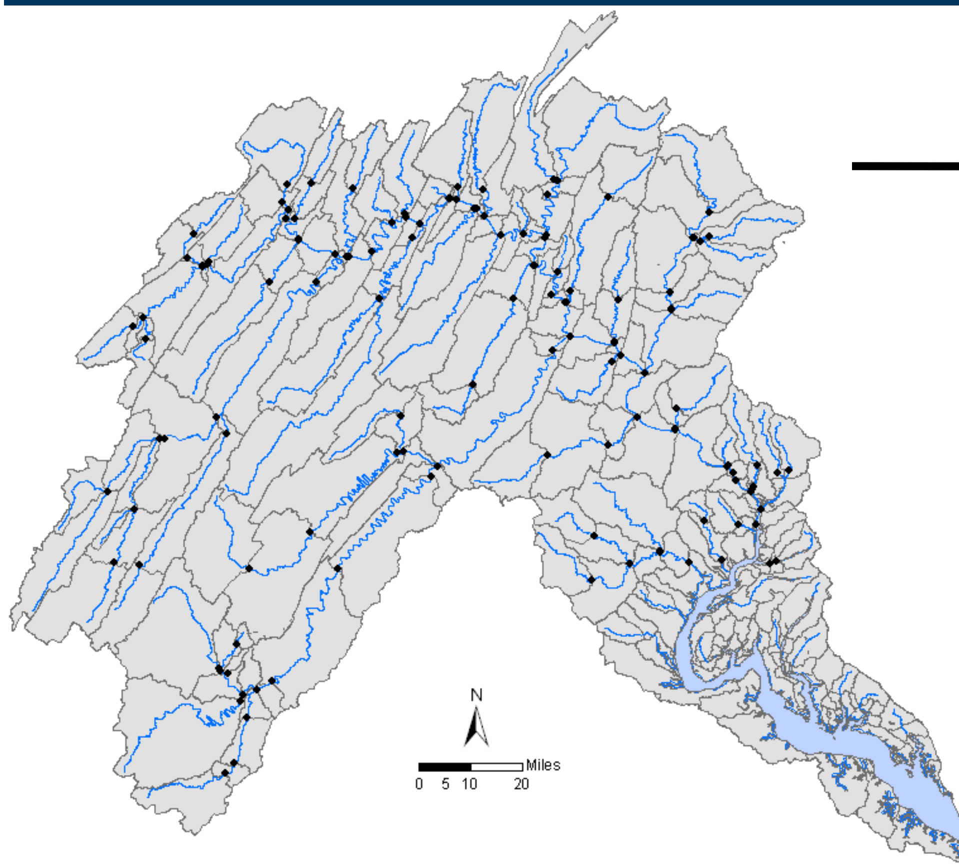
Number of Watersheds Chessie B-IBI Bioregions	
Coastal Plain	33
Ridges	254
Piedmont	217
Valleys	208

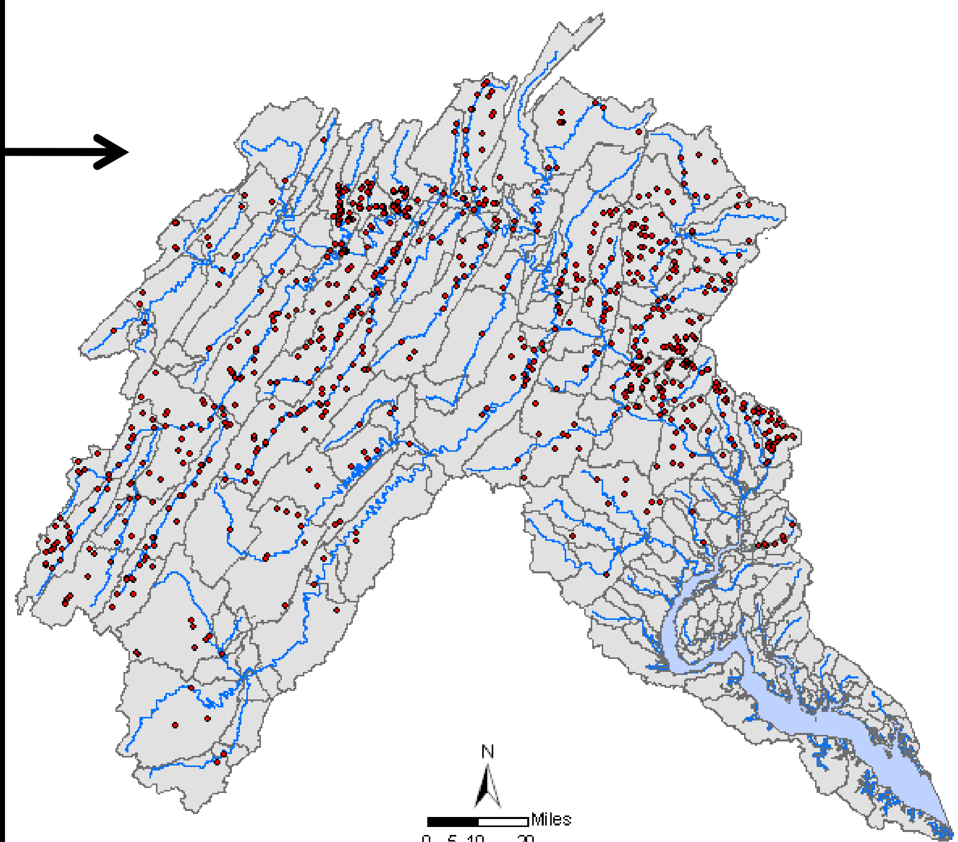
Model Selection



WOOOMM Benefits

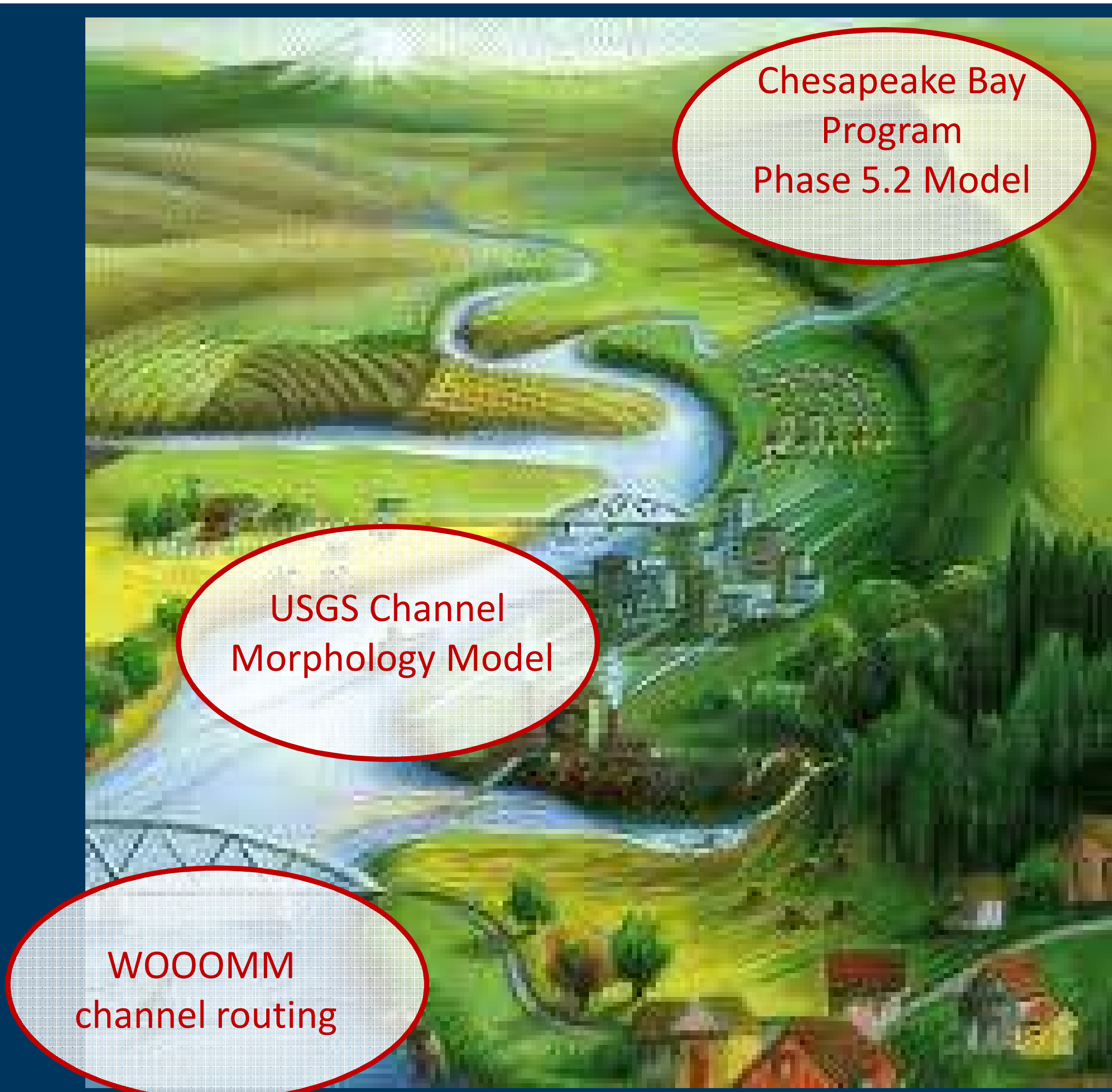
CBP model output locations | WOOOMM output locations





WOOOMM: Online Object Oriented Meta-Model

WOOOMM Components



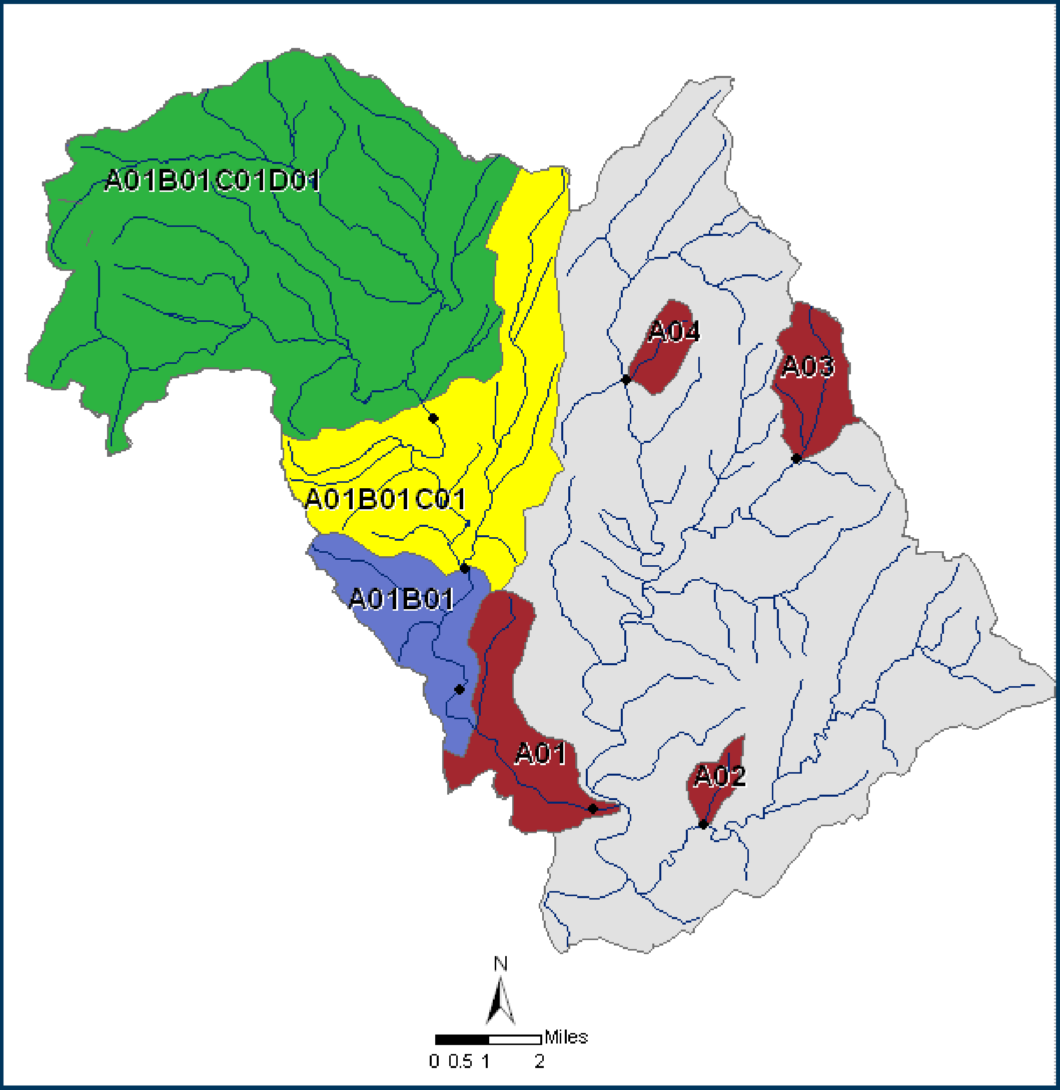
Watershed illustration
by Jane MacQueen

WOOOMM Data Inputs

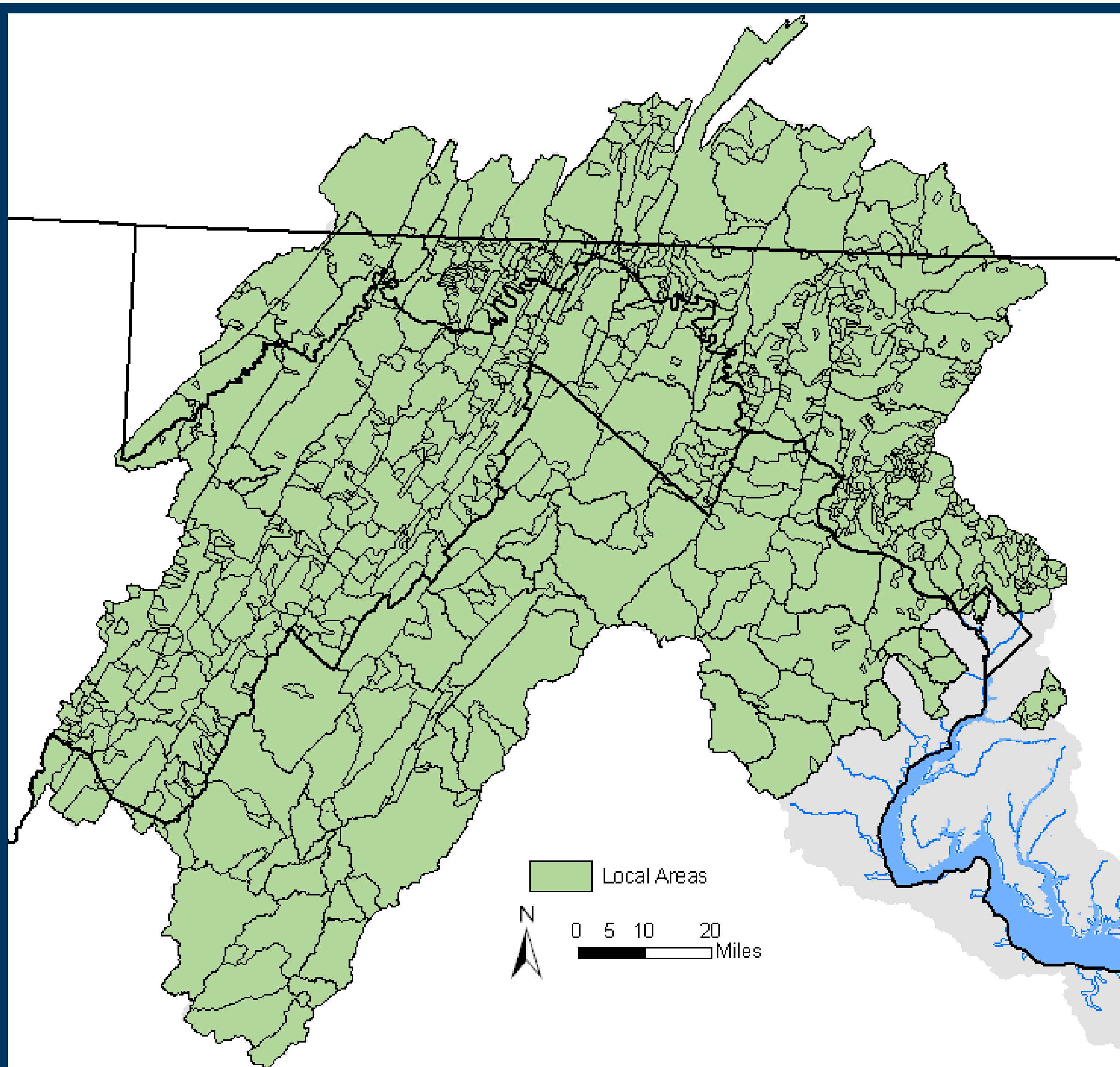
Model Inputs

- Watershed inputs
  - Unique ID
  - Watershed routing
  - CBP outputs
- Channel routing/morphology
  - Dominant physiographic province
  - Channel slope
  - Channel length
- Physical characteristics
  - Meteorology
  - Area
- Anthropogenic activities
  - Withdrawals
  - Discharges
  - Impoundments
  - Land use

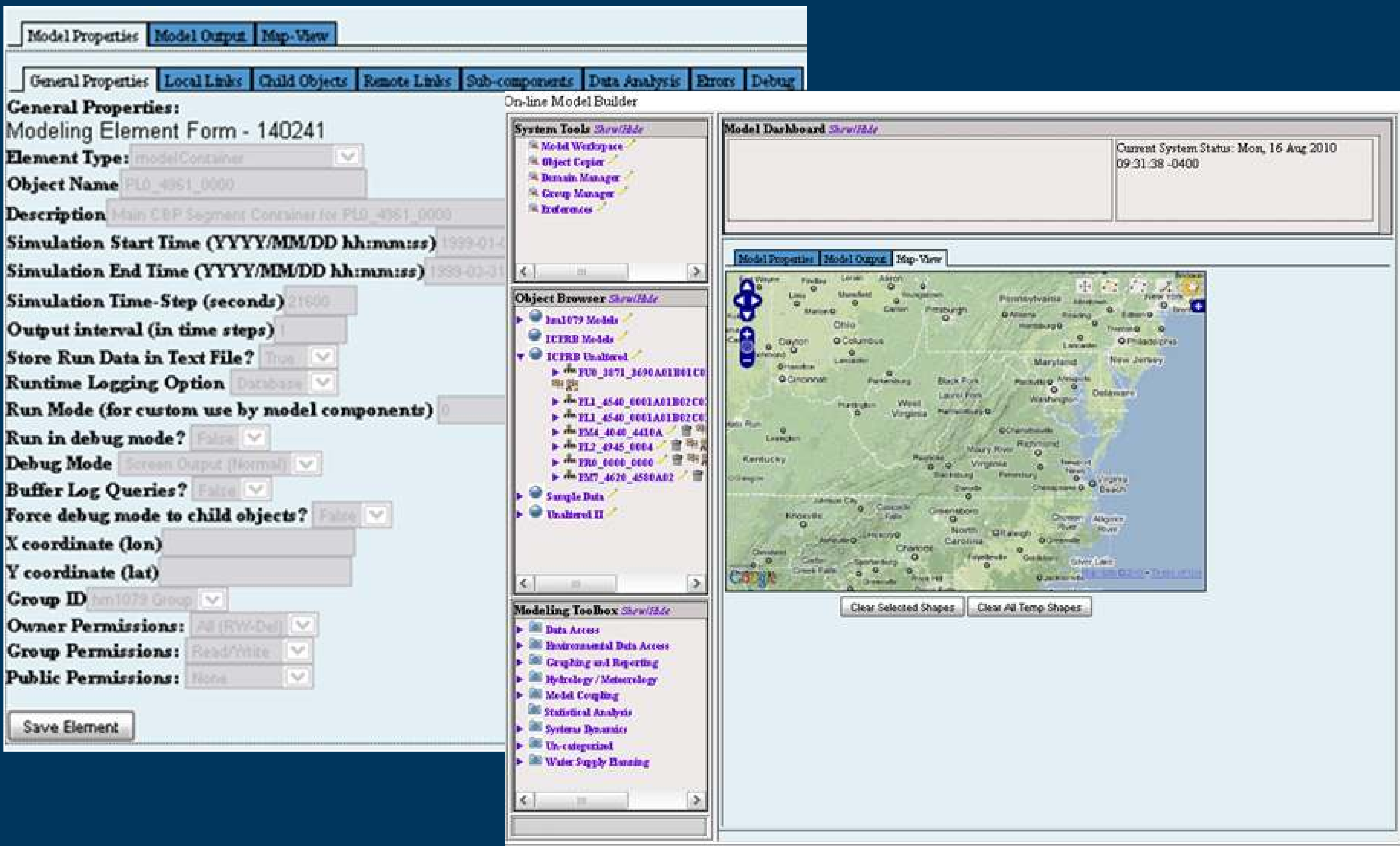
Nested Watershed Simulation, WOOOMM



WOOOMM Simulation Areas



WOOOMM, A Look Inside



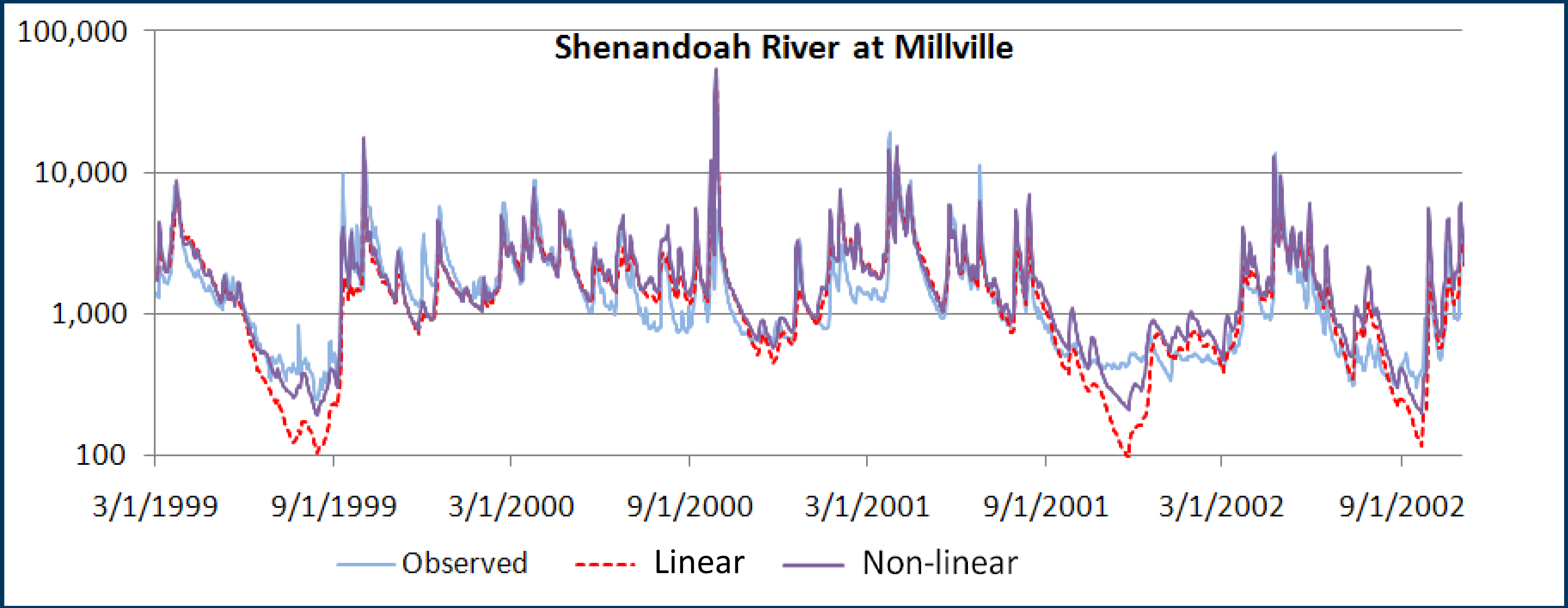
CBP Model Enhancements

Chesapeake Bay Program (CBP) Phase 5.2 model enhancements

- Non-linear groundwater recession
- Re-segmentation at "significant" impoundments
  - CBP model includes 4 impoundments in the Potomac Basin – Jennings Randolph, Savage Reservoir, Stony River Dam, and T. Nelson Elliot

Non-linear Groundwater Recession

- Linear, one-parameter, groundwater recession models tend to under-simulate low flows
- CBP Phase 5.2 was enhanced with a non-linear groundwater algorithm
- Results show modest low flow improvements
- This update is expected to be included in the CBP Phase 5.32 model



Model Re-segmentation Criteria

1. Significant
   - >10% mean annual flow
   - Hydroelectric

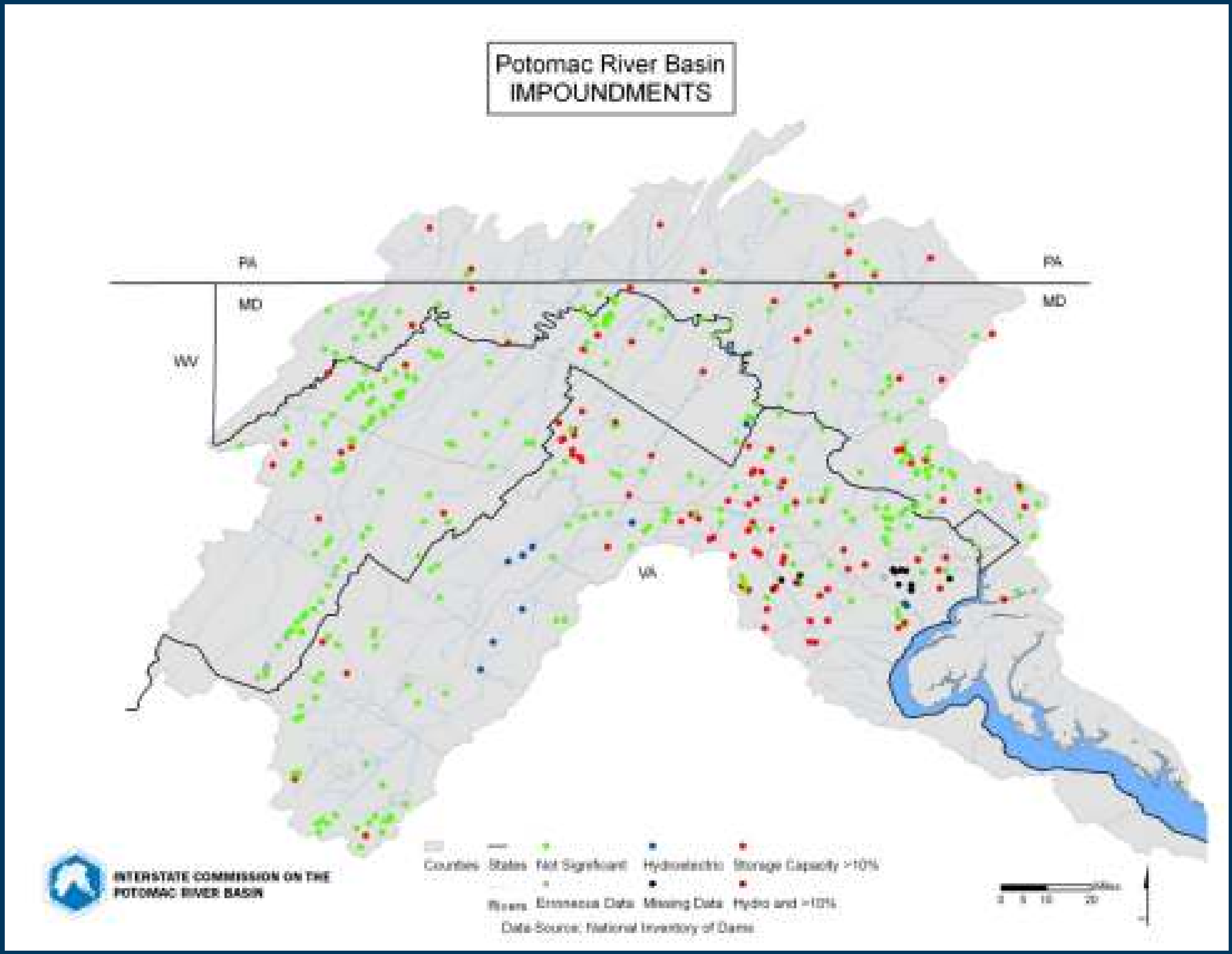
   +

2. Biological monitoring points upstream and downstream

   =

12 impoundments

22 new segments

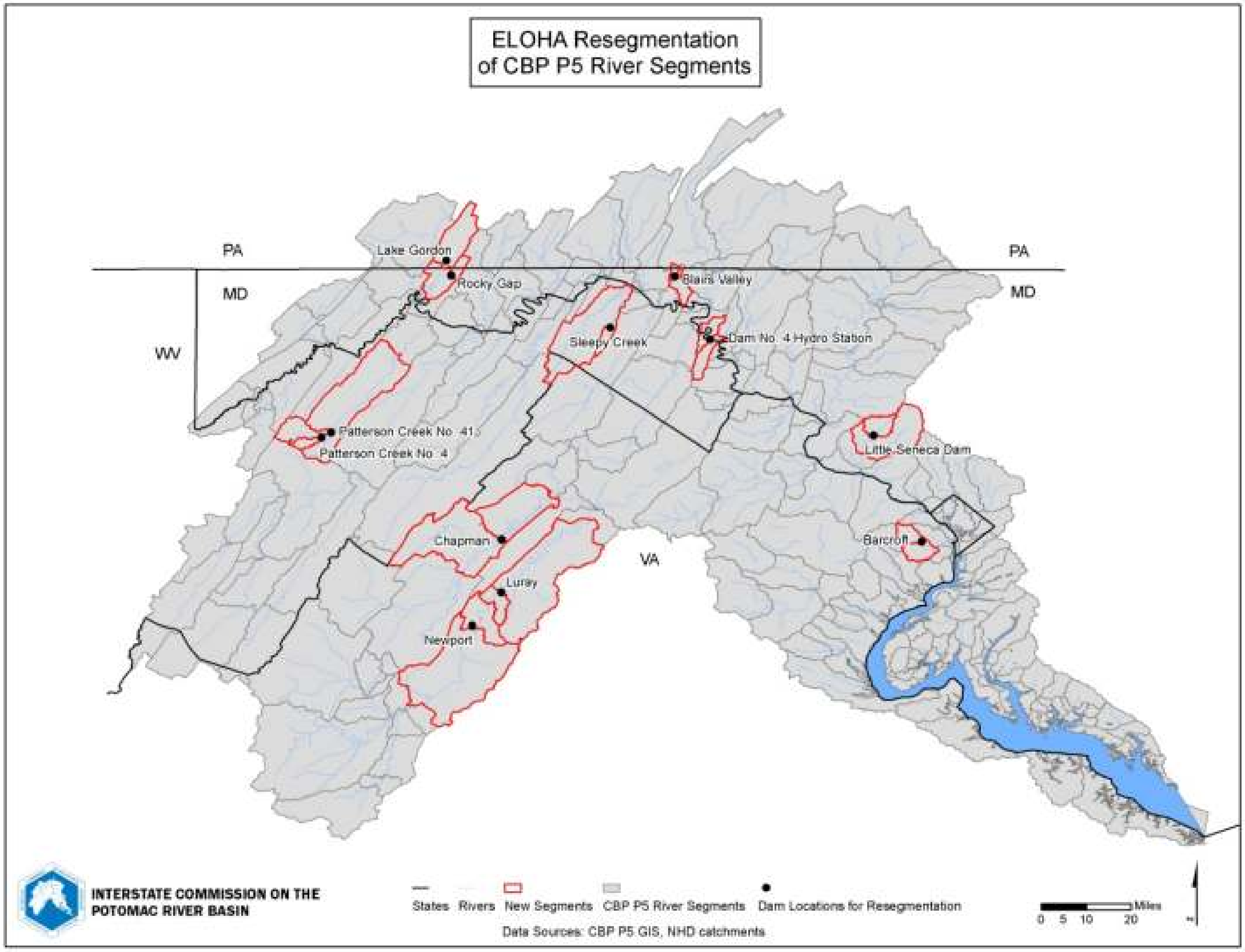


Selected Impoundments for Model Re-segmentation

Dam Name	Primary Purpose	County	State	Normal Storage (acre-feet)
Little Seneca	Recreation	Montgomery	MD	13050
Blairs Valley	Recreation	Washington	MD	486
Rocky Gap	Recreation	Allegany	MD	5381
Barcroft	Recreation	Fairfax	VA	2500
Newport	Hydro	Page	VA	1090
Luray	Hydro	Page	VA	880
Sleepy Creek	Recreation	Berkeley	WV	2460
Patterson Creek No. 4	Flood /Storm Water Mgmt	Grant	WV	1989
Patterson Creek No. 41	Flood /Storm Water Mgmt	Grant	WV	5480
Dam No. 4 Hydro Station	Hydro	Berkeley	WV	6460
Lake Chapman	Hydro	Shenandoah	VA	300
Lake Gordon	Water Supply	Bedford	PA	3633

Impoundment information as reported in the National Inventory of Dams

Model Re-segmentation Locations



Model Calibration and Evaluation

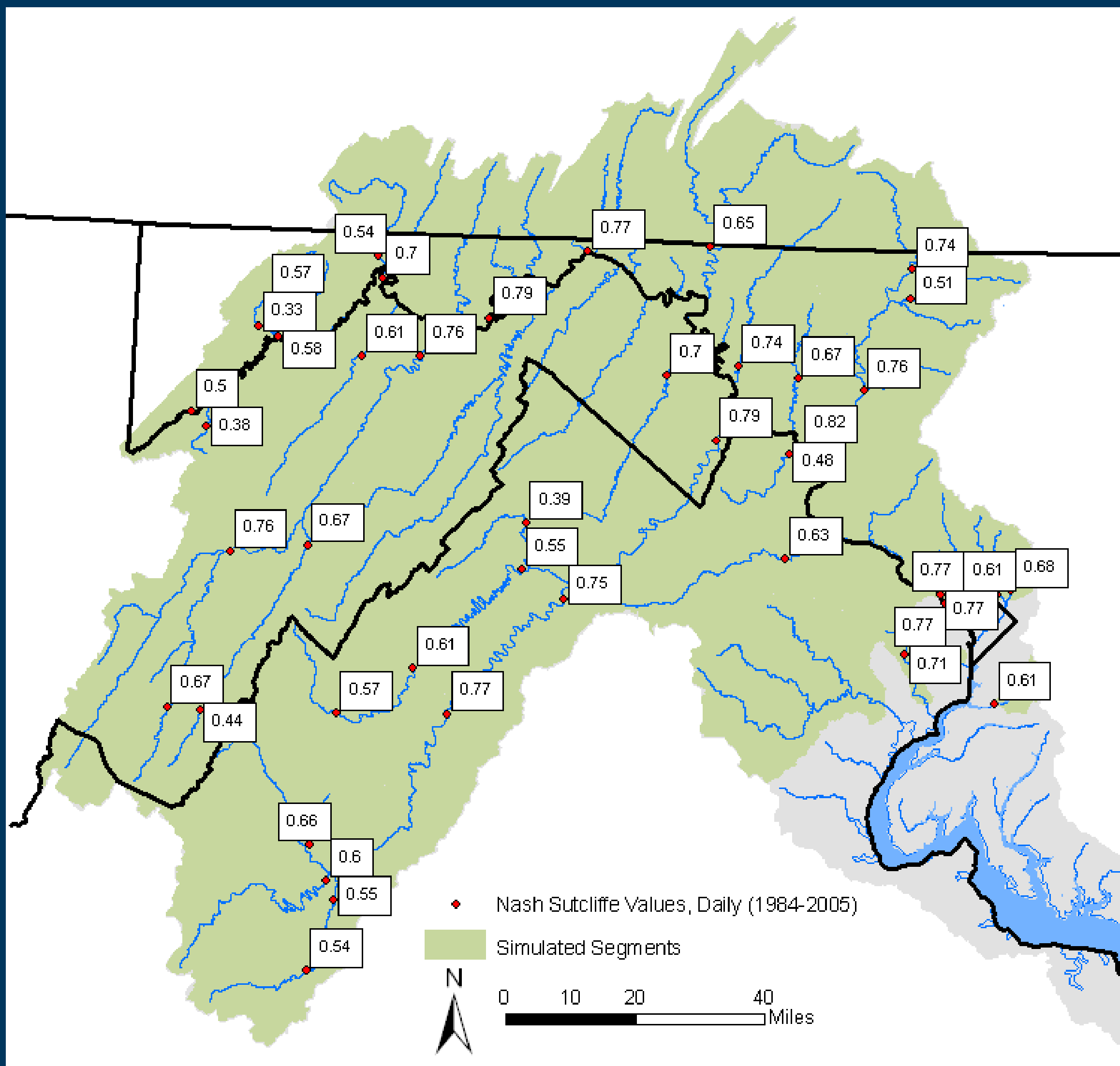
CBP HSPF auto-calibration routine

"iterative procedure which links adjustments in parameter values to the statistics comparing observed and simulated flows at [~46] calibration stations [USGS gages]"

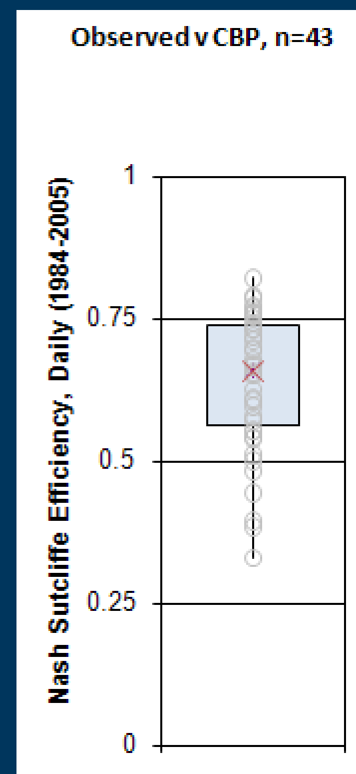
Hydrology calibration parameters (from CBP documentation)

Parameter	**Description**
LAND_EVAP	PET adjustment (similar to pan evaporation coefficient)
INFILT	Base infiltration rate
LZSN	Lower zone soil moisture storage index
AGWR	Baseflow recession coefficient
INTFW	Ratio of interflow to surface runoff
IRC	Interflow recession coefficient
AGWTP	Evapotranspiration from groundwater storage

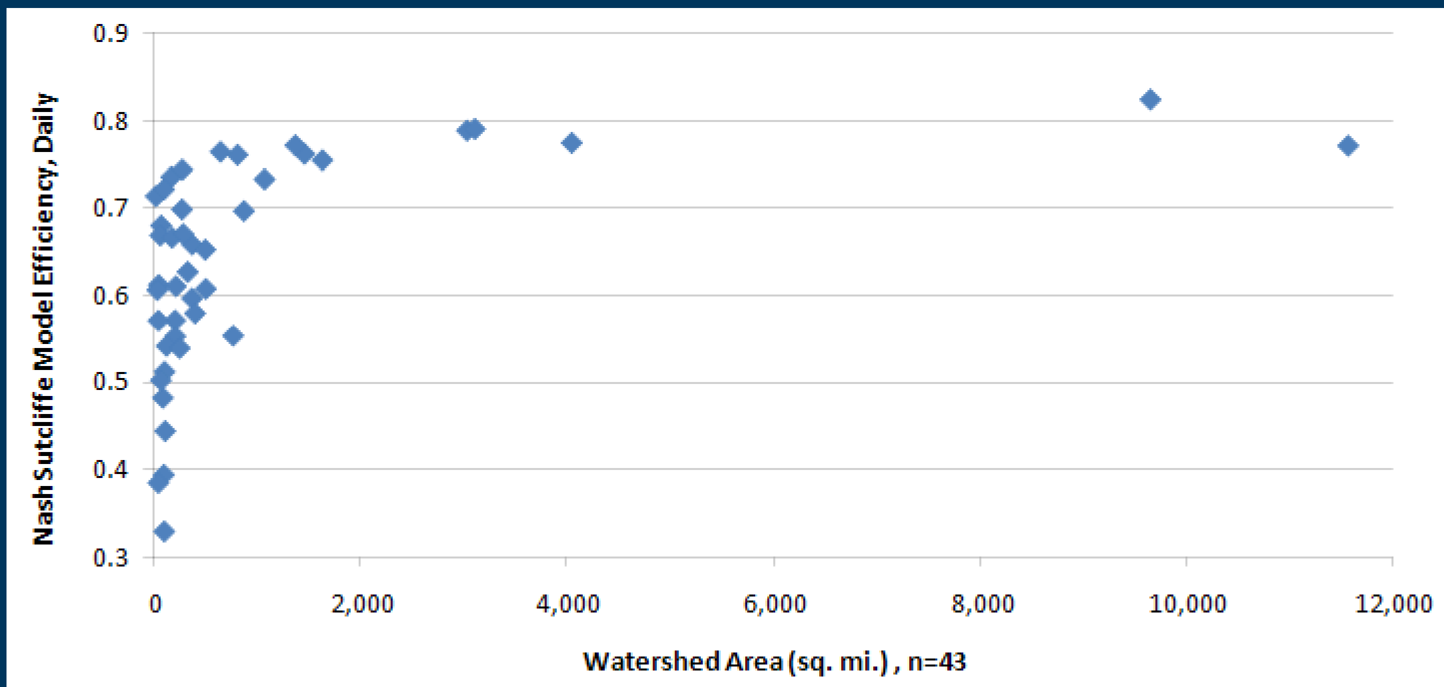
Nash Sutcliffe CBP Model Efficiency, Daily Flows



$$E = 1 - \frac{\sum_{i=1}^{n} (O_i - P_i)^2}{\sum_{i=1}^{n} (O_i - \bar{O})^2}$$

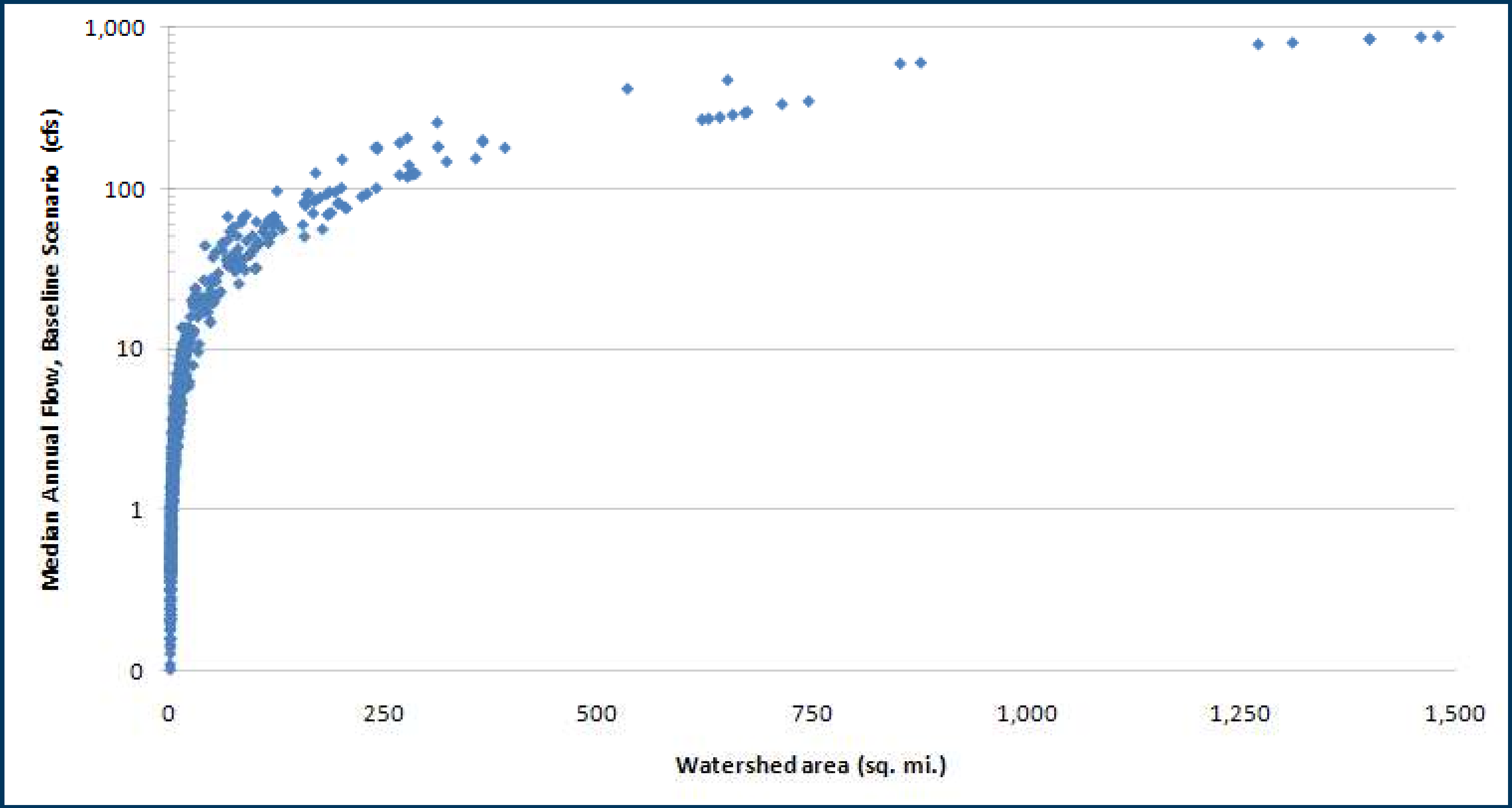


CBP Model Efficiency, Daily Flows



WOOOMM Results Screening

screened watersheds for “reasonable” flow:area ratio



Model Scenarios

Current

Baseline

Future (through 2030)

- Domestic and Public Supply 1 (DP1)
- Domestic and Public Supply 2 (DP2)
- Power
- Hot and Dry
- Climate Change

(details on future scenarios presented at May 10th webinar - http://potomacriver.org/sustainableflows/)

Model Scenarios

	Land Use	Withdrawal	Discharge	Impound	Temperature	Precipitation
Baseline	>78% forest, <0.35% impervious cover	0	0	0	CBP (84-05)	CBP (84-05)
Current	2000 RESAC converted to P5 land use categories	ICPRB 2005	CBP point source database, 2005	16	CBP (84-05)	CBP (84-05)
DP 1	CBP 5.1 future projections	per capita increase 0%	withdrawal - CU	16	CBP (84-05)	CBP (84-05)
DP 2	CBP 5.1 future projections	per capita increase 1.82%	withdrawal - CU	16	CBP (84-05)	CBP (84-05)
Power	CBP 5.1 future projections	Projected and additional power plant and retrofits	withdrawal - CU	16	CBP (84-05)	CBP (84-05)
Hot and Dry	CBP 5.1 future projections	DP2 base with increases in DP, PO, and irrigation	withdrawal - CU	16	10.8% increase (1930 drought)	Decrease (1930 drought v “normal” year)
Climate Change	CBP 5.1 future projections	per capita increase 4.38%	withdrawal - CU	16	0.4C increase by 2030	CBP (84-05)

DP = domestic and public supply
CU = consumptive use
CBP = Chesapeake Bay Program

Withdrawals and Discharges

Current scenario:

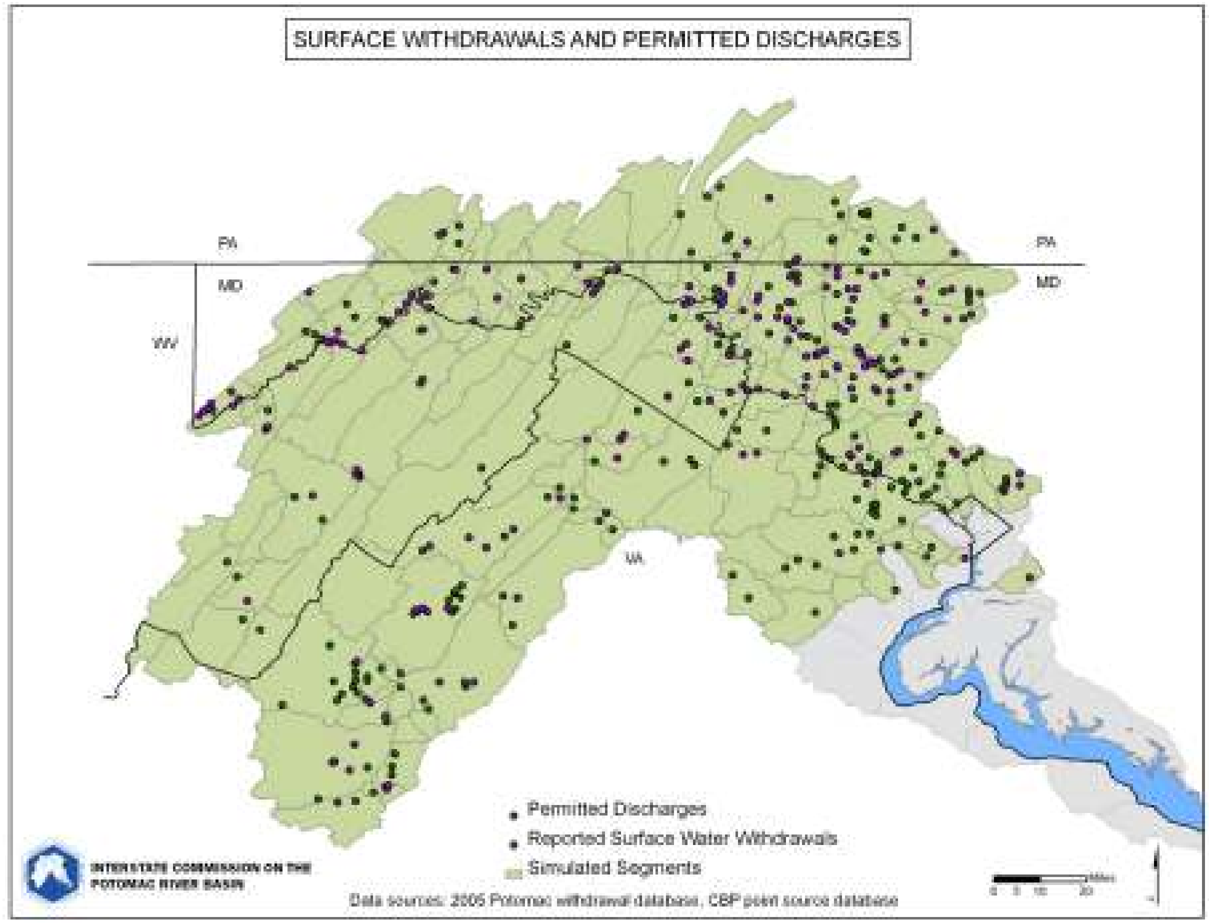
- 2005 reported surface water withdrawals, permitted point source discharges

Baseline scenario:

- No withdrawals, no discharges

Future scenario:

- No new withdrawals or discharges, projected changes in use



Simulated by latitude and longitude, rather than CBP WDM format

Land Uses

Current scenario:

- Spatially explicit 2000 RESAC land uses converted to P5.2 land use categories

Baseline scenario:

- >=78% forest
- <=0.35% impervious cover

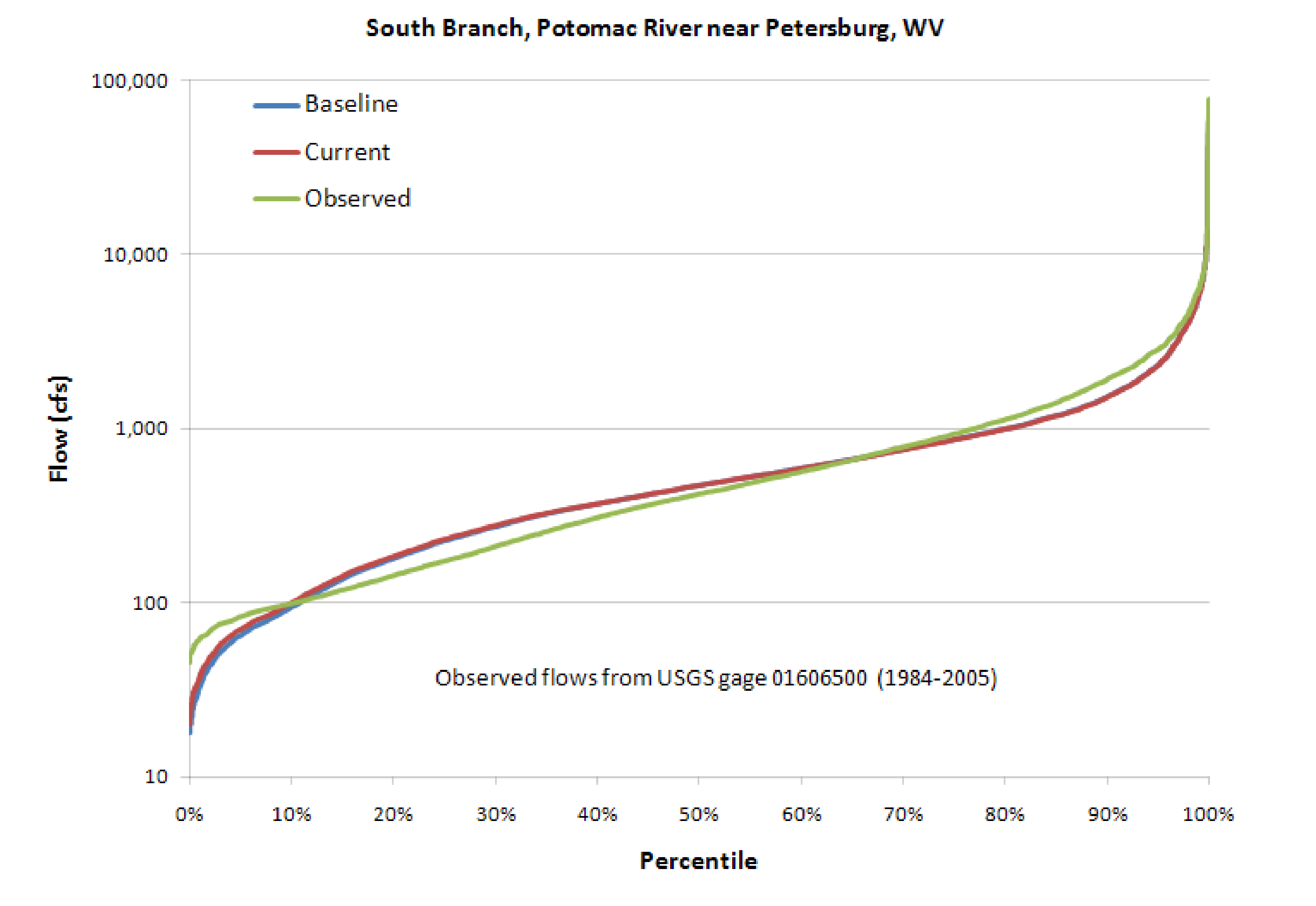
Future scenario:

- CBP projected land uses

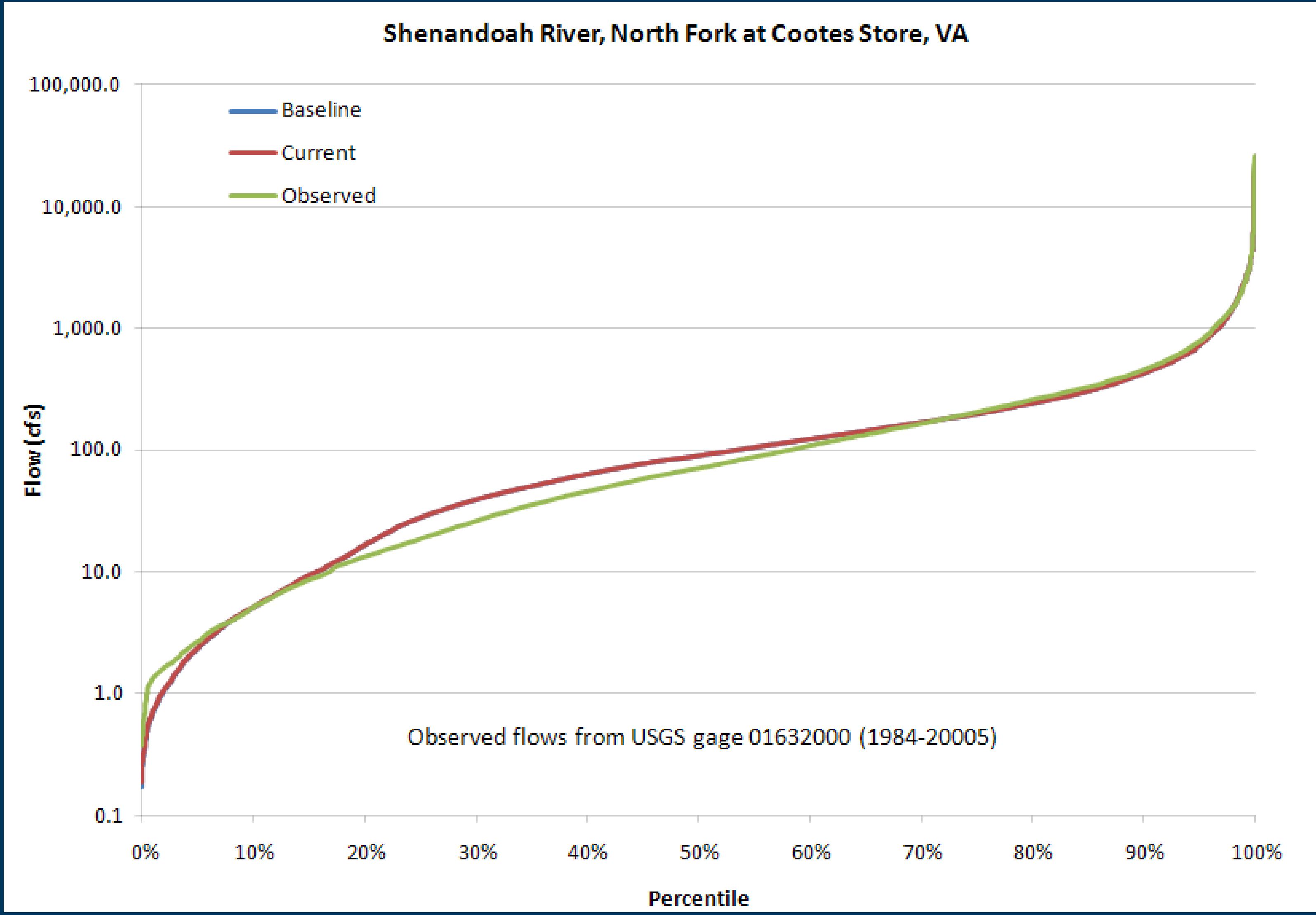
RESAC land uses
Open Water
Low Intensity, Developed
Medium Intensity Developed
High Intensity, Developed
Transportation
Urban/Residential Deciduous Tree
Urban/Residential Evergreen Tree
Urban/Residential Mixed Tree
Urban/Residential/Recreational Grass
Extractive
Barren
Deciduous Forest
Evergreen Forest
Mixed (Deciduoud-Evergreen) Forest
Pasture/Hay
Croplands
Natural Grass
Deciduous Wooded Wetland
Evergreen Wooded Wetland
Emergent (Sedge-Herb)Wetland)
Mixed Wetland

Phase 5.2 Description
Water
High Intensity Impervious Urban
Low Intensity Impervious Urban
High Intensity Pervious Urban
Low Intensity Pervious Urban
Forest
Harvested Forest
Extractive
Bare-construction
Animal Feeding Operations
Alfalfa
High Till Crop without manure
High Till Crop with manure
Hay without nutrients
Hay with nutrients
Low Till Crop with Manure
Alfalfa with Nutrient Management
High Till Crop with Manure and Nutrient Mgmt
High Till Crop with Nutrient Mgmt
Hay with nutrients and Nutrient Mgmt
Low Till Crop with manure and Nutrient Mgmt
Pasture with Nutrient Mgmt
Pasture
Trampled Pasture
Nursery

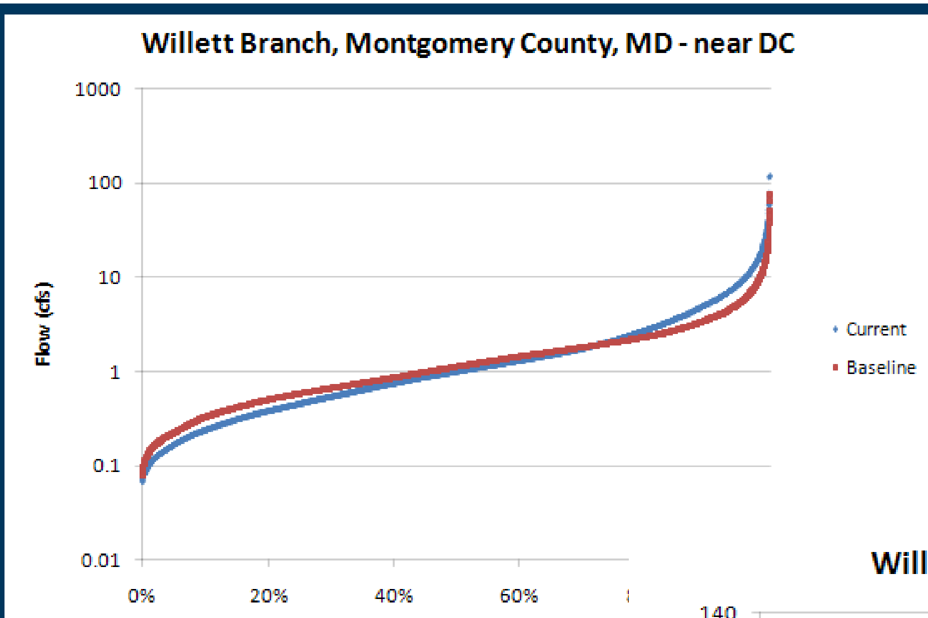
Select Preliminary Results
Reference Watershed



Select Preliminary Results
Reference Watershed

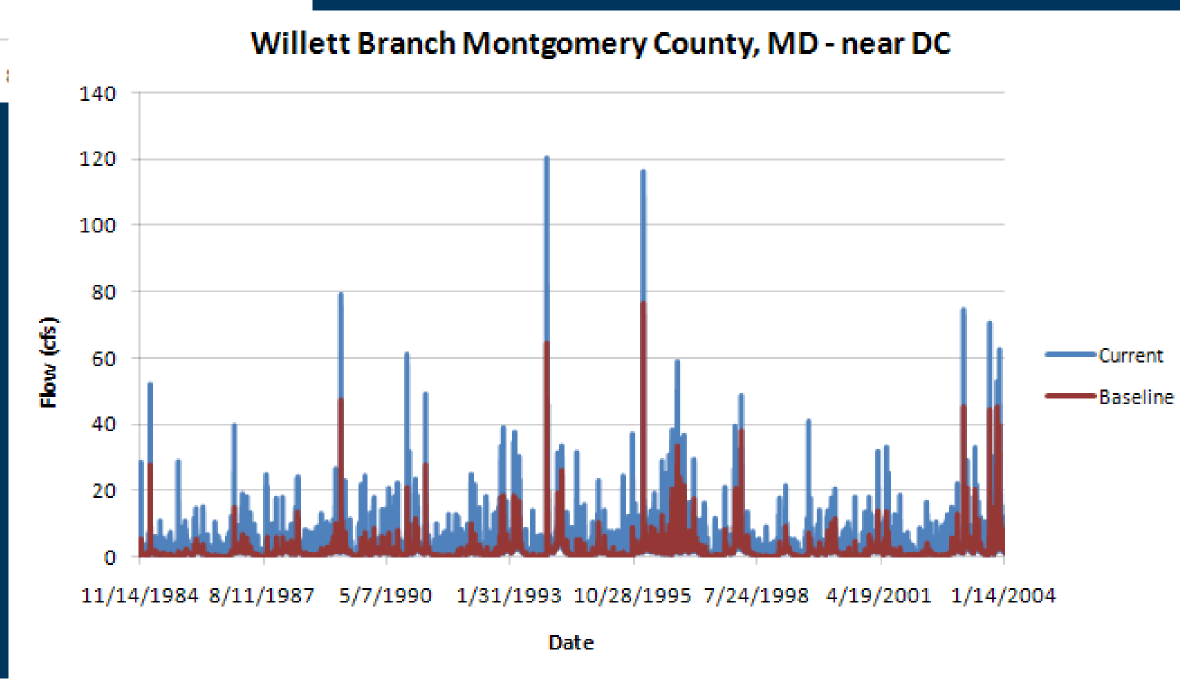


Select Preliminary Results
Urban Watershed

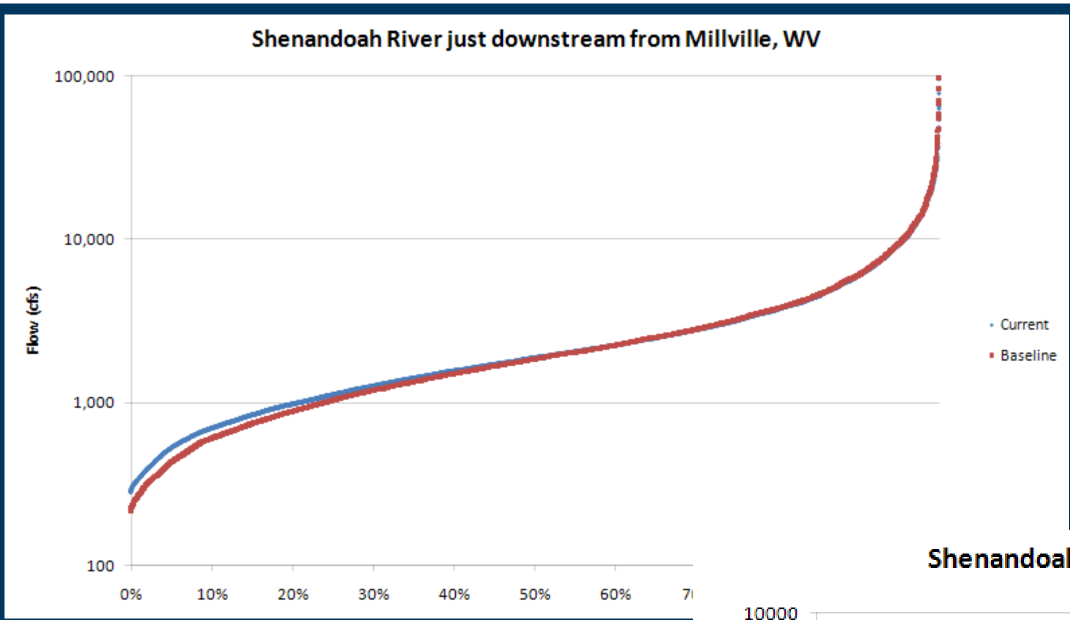


Current scenario conditions:

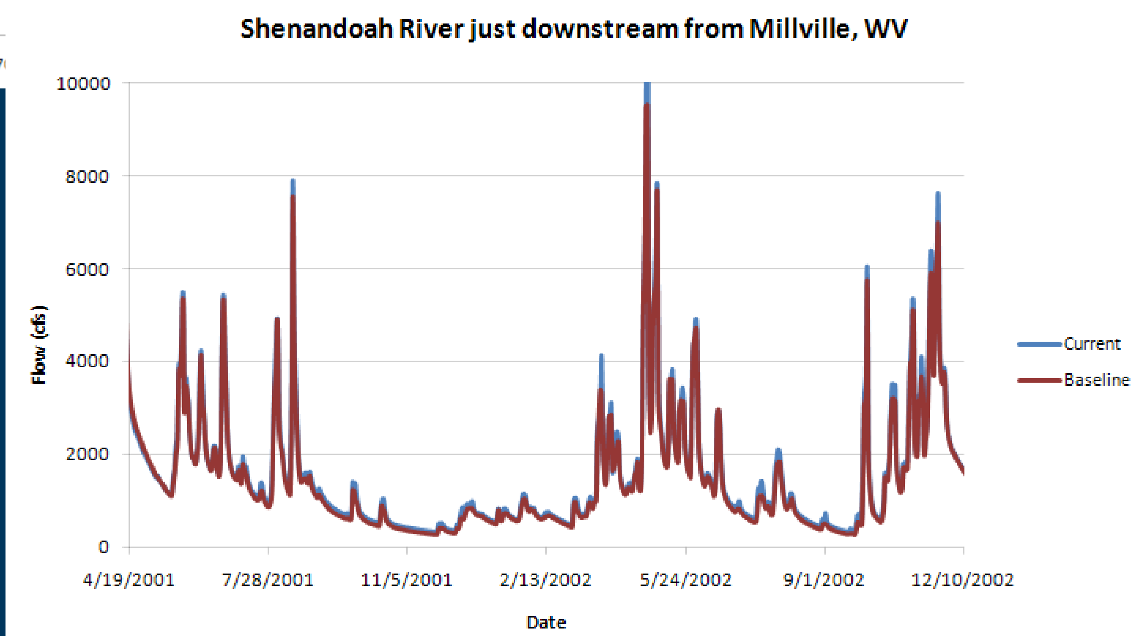
- 2 sq. mi.
- 8% forest
- 0.2% agriculture
- 84% urban
- 20% impervious



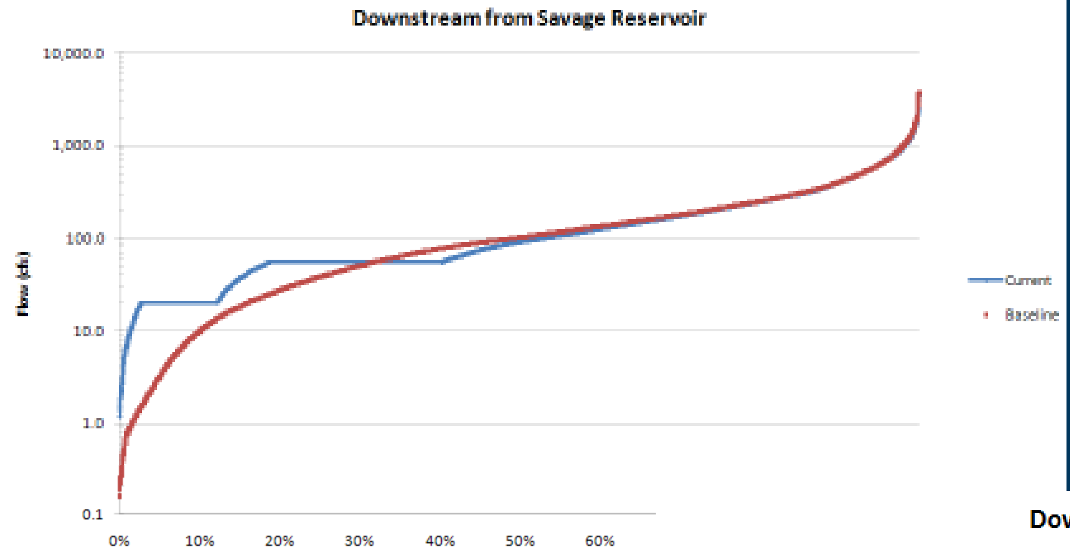
Select Preliminary Results
Large Watershed



Current scenario conditions:
- 3,050 sq. mi.
- 56% forest
- 36% agriculture
- 9% urban
- 0.86% impervious

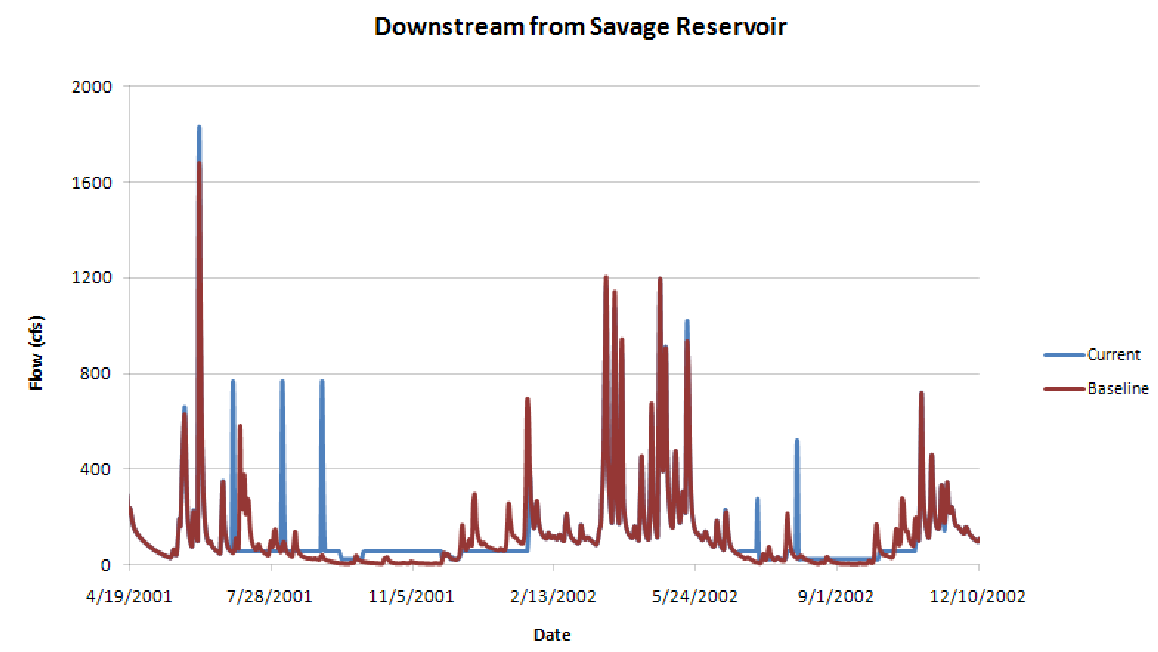


Select Preliminary Results
Impounded Watershed

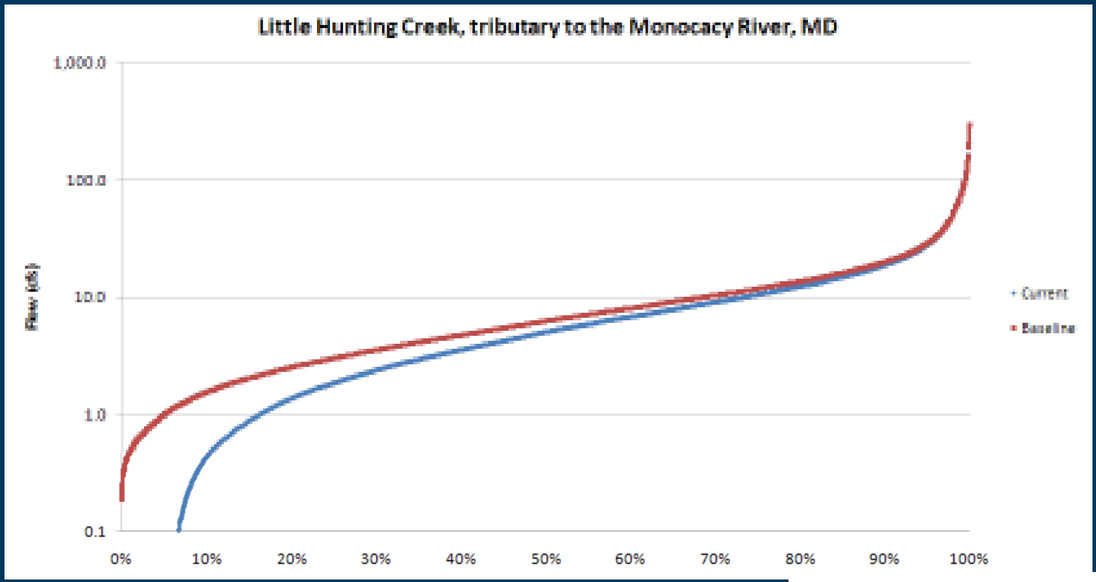


Current scenario conditions:

- 105 sq. mi.
- 88% forest
- 2.5% urban
- 8.5 % agriculture

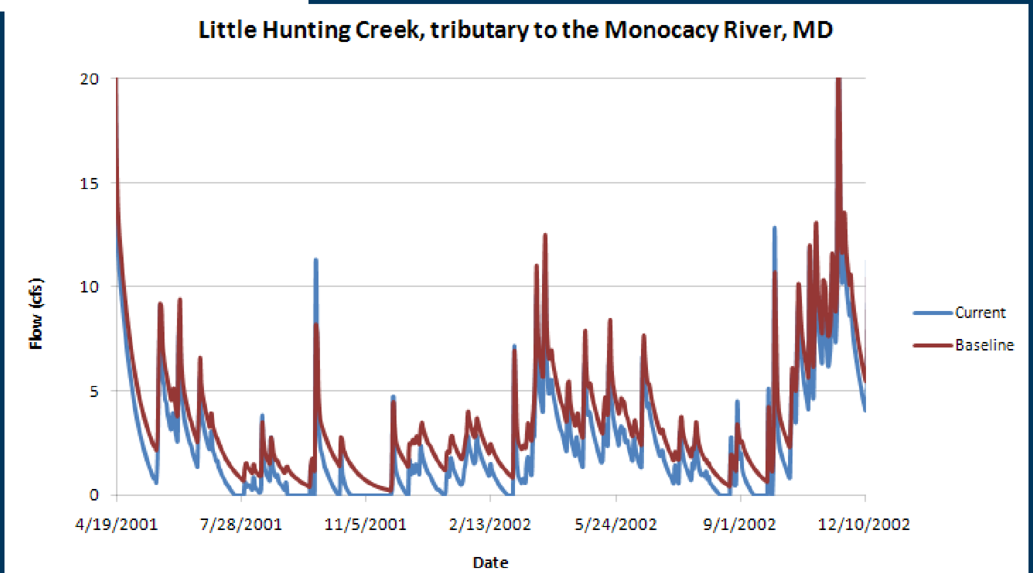


Select Preliminary Results
Surface Water Withdrawals



Current scenario conditions:

- 9 sq. mi.
- 76% forest
- 14% agriculture
- 11% urban
- 1% impervious
- 764 MGY surface withdrawal



Limitations

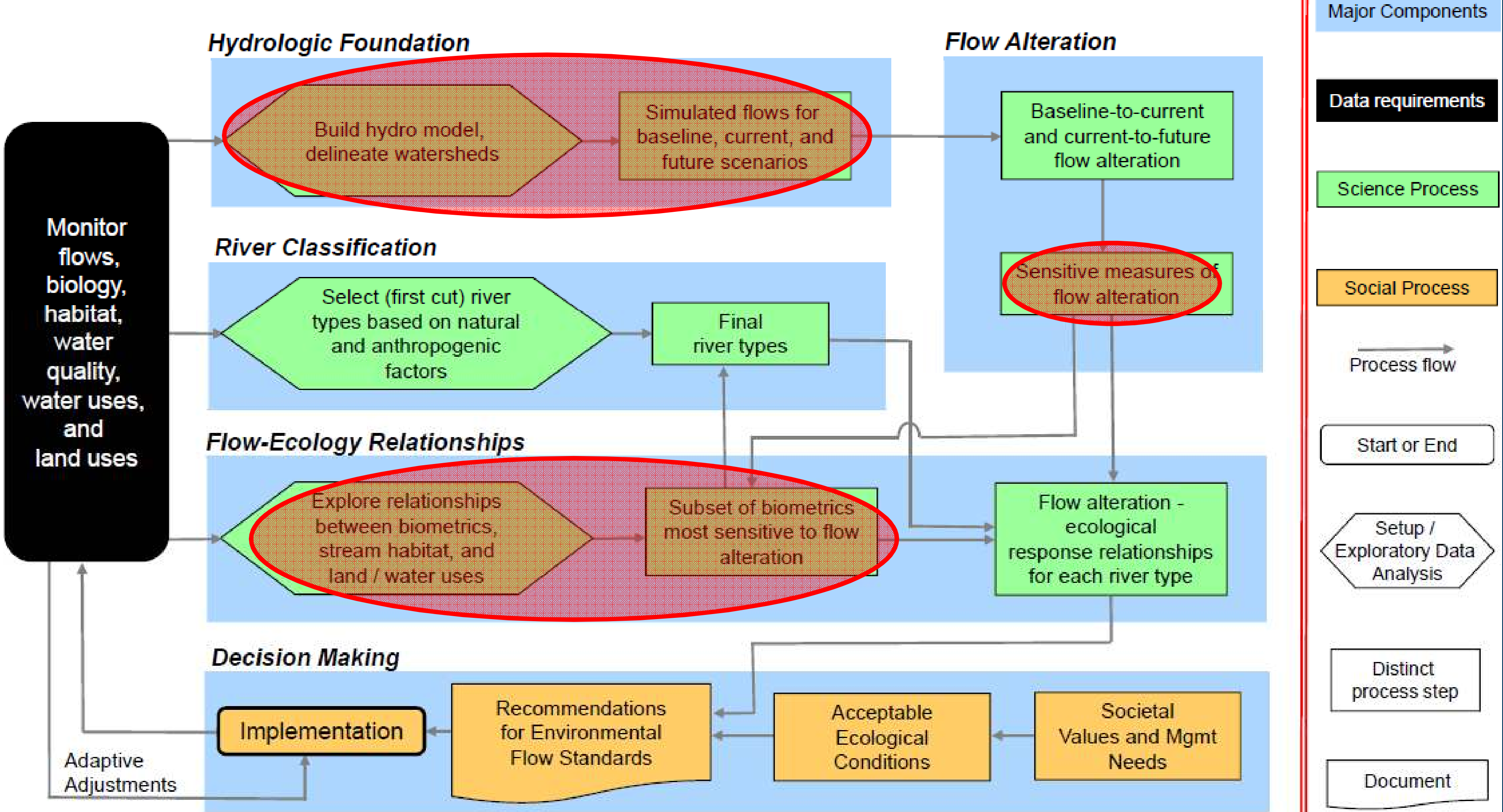
- Extreme (high and low) flows
- Sub-daily flows
- Potential error sources
  - May differ between watersheds
  - Scale of watersheds (very large to very small)
  - Geology, slope, etc.
- Calibration locations primarily on larger watersheds
- Resolution of model inputs compared to watershed sizes
  - (ex. precipitation)

But…

- Purpose is to evaluate relative difference in flows between scenarios (% alteration) – not to obtain absolute flow values

Next Steps

Determining Potomac Basin Quantitative Flow-Ecology Relationships and Implementation



Flow chart adapted from Poff, et al (2010) Freshwater Biology 55: 147–170.

Webinar Series

- Technical details on methodology for small streams
- Obtain feedback from stakeholders
- Prepare for concluding workshop: focus on management applications

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Sept 8	Quantitative flow-ecology relationships Part 2: ELOHA curves, uncertainty, and interpretation
Oct 27	From science to management applications

→ Nov 29-Dec 1 Flow ecology response workshop at NCTC

Conclusion

Questions? Comments?

Heidi Moltz, Ph.D.
hmoltz@icprb.org
301.274.8116

http://potomacriver.org/sustainableflows/

Discussion

- Raise your hand by clicking on the button on the webinar menu.
- Please remain muted until the conference organizer calls on you.
- Once called upon, un-mute your phone by selecting *7.
- Afterward, please mute your phone again by selecting *6.