Sediment Simulation in Phase 6

Gary Shenk – USGS - Chesapeake Bay Program

4/19/17

Partnership Feedback on Modeling

- **Water Quality Goal Implementation Team**
  - Need more **transparent and easier** to understand decision-support tools to enable successful engagement of local partners

- **Scientific and Technical Advisory Committee**
  - Multiple Models
  - Phosphorus
  - Complex Reservoir Dynamics
  - Fine-scale processes

Keep it Simple!!

Include Everything!!!





Steady State Phase 6 Model Structure

Edge of Field

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Land Use Acres

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BMPs

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Land to Water

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Stream Delivery

*

River Delivery

Direct Loads

Phase 6

Keep It Simple

Include Everything

Edge of Field

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Land Use Acres

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BMPs

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Land to Water

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Stream Delivery

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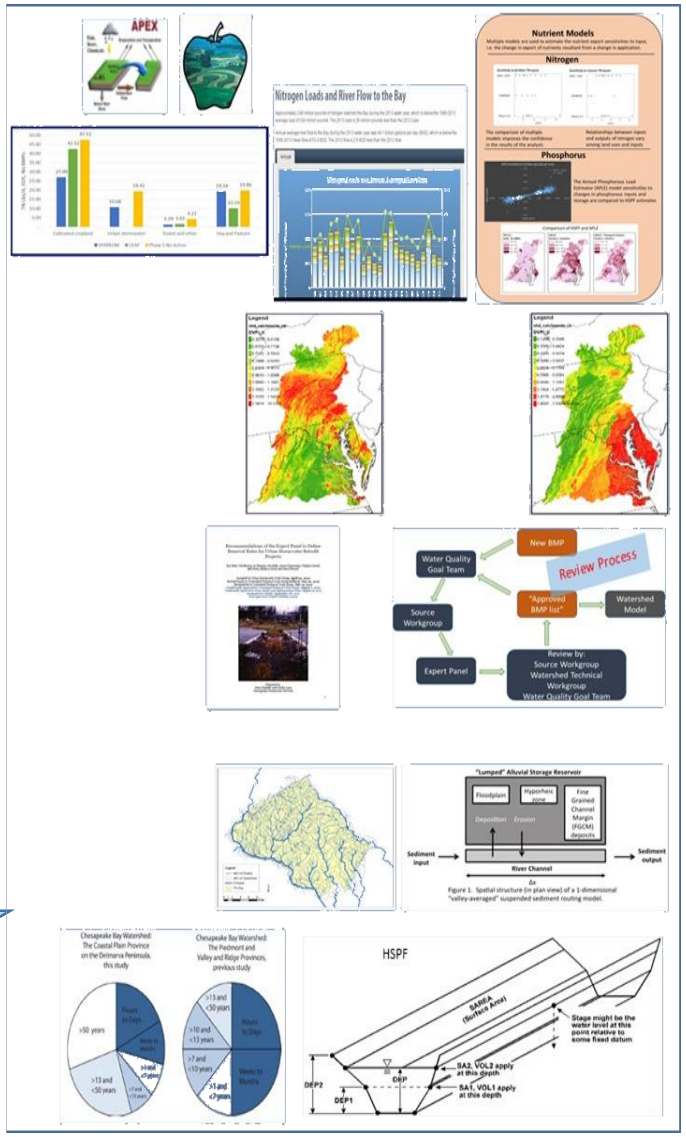
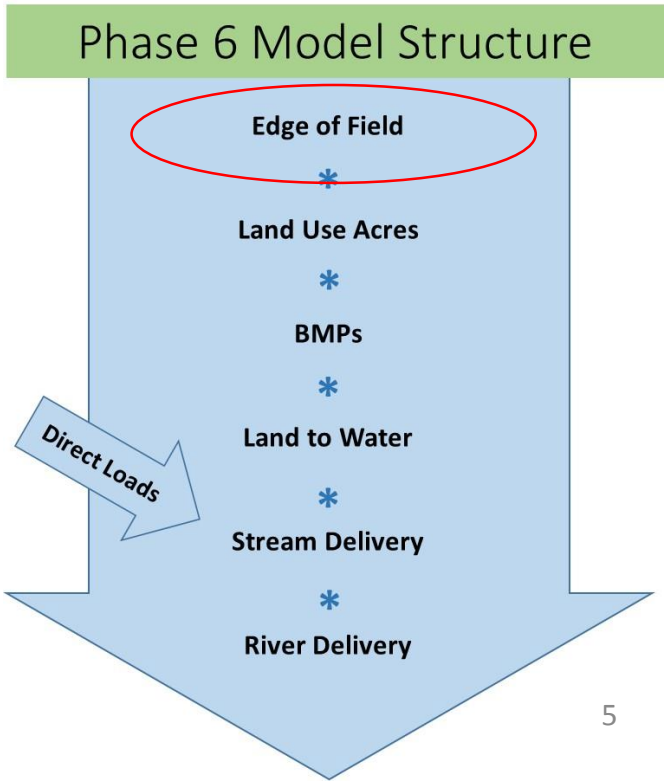
River Delivery

Direct Loads



RUSLE = Edge-of-Field Loads

- Evaluated at the 10m Pixel Level
- Summarized to LRseg and land use
  - Forest
  - Open Space
  - Crop
  - Pasture
  - Turfgrass
  - Tree Canopy over Turfgrass

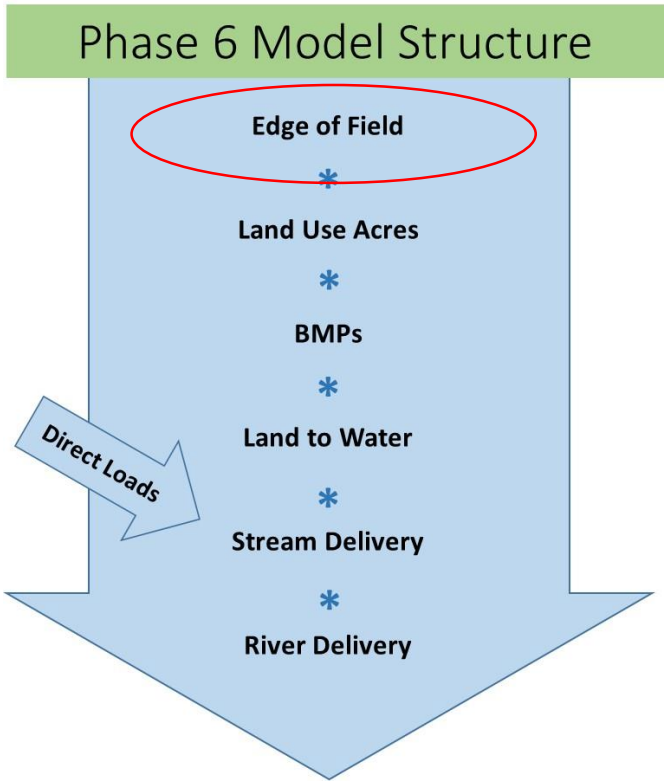


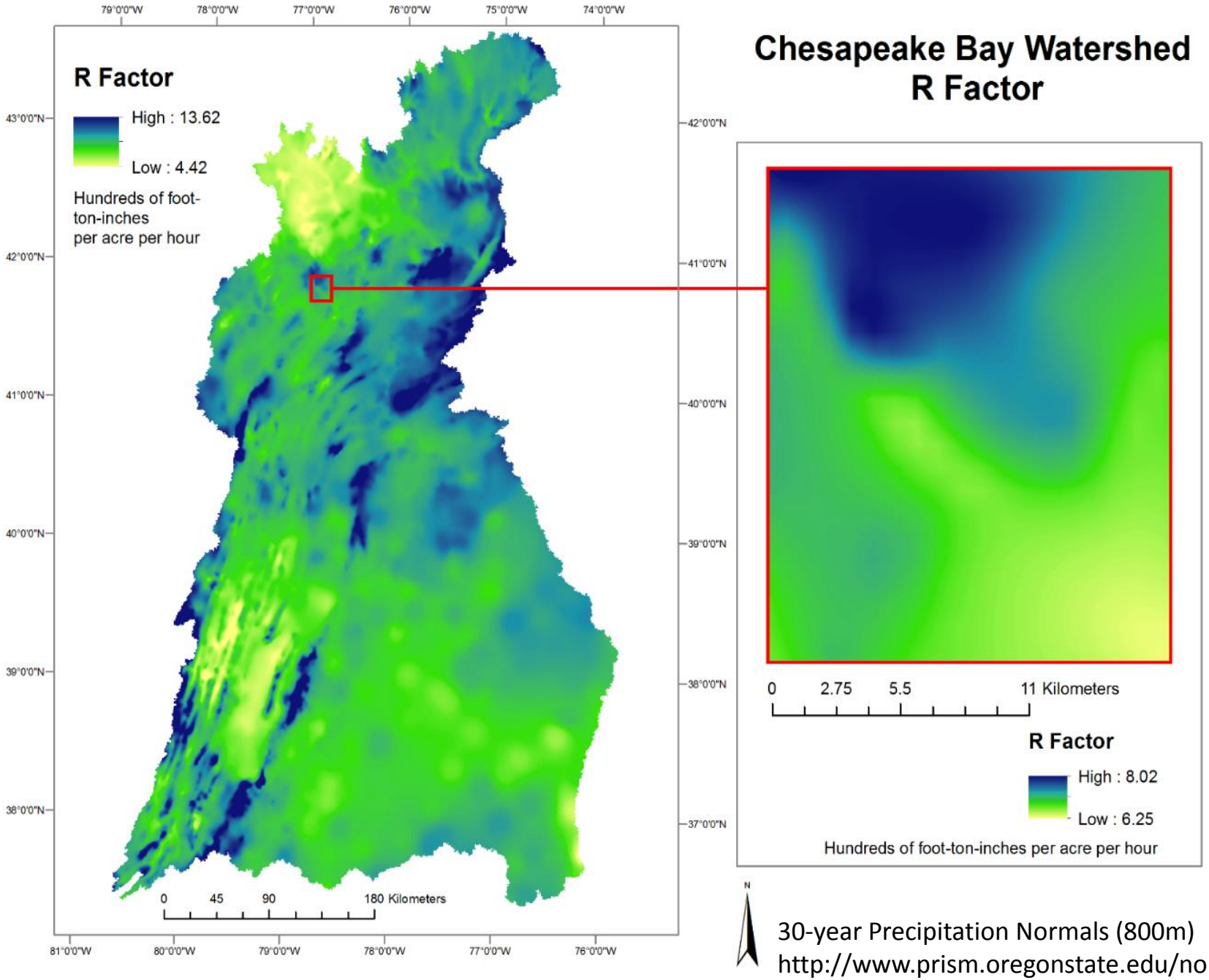
RUSLE => R * K * LS * C * P

- R = Runoff
- K = Erodibility
- LS = slope length

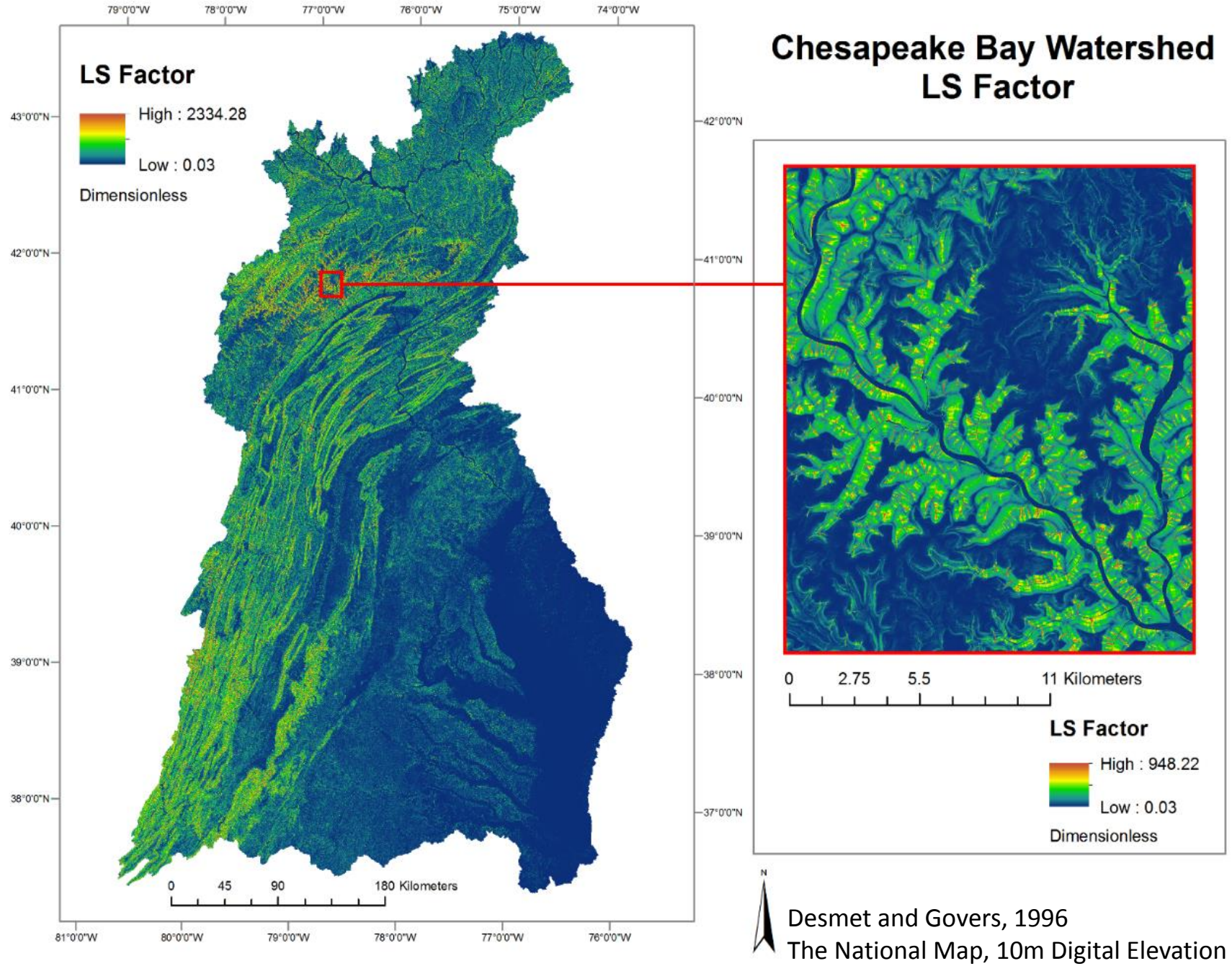
} Evaluated at 10 meter resolution

- C = Cover
  - By land use and Land-River segment
- P = Practice
  - = 1 since no action loads



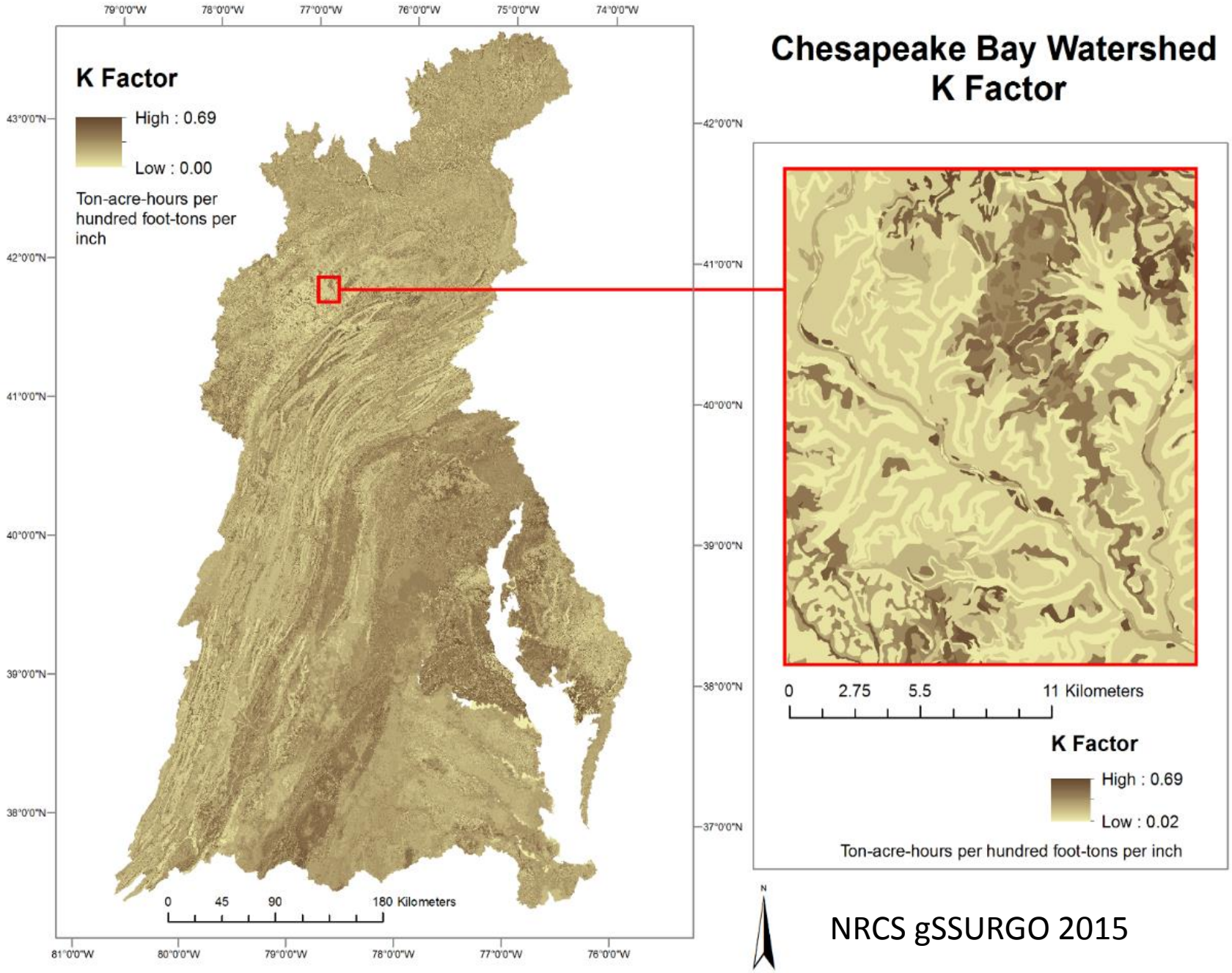


30-year Precipitation Normals (800m)
http://www.prism.oregonstate.edu/normals/



Desmet and Govers, 1996

The National Map, 10m Digital Elevation Model

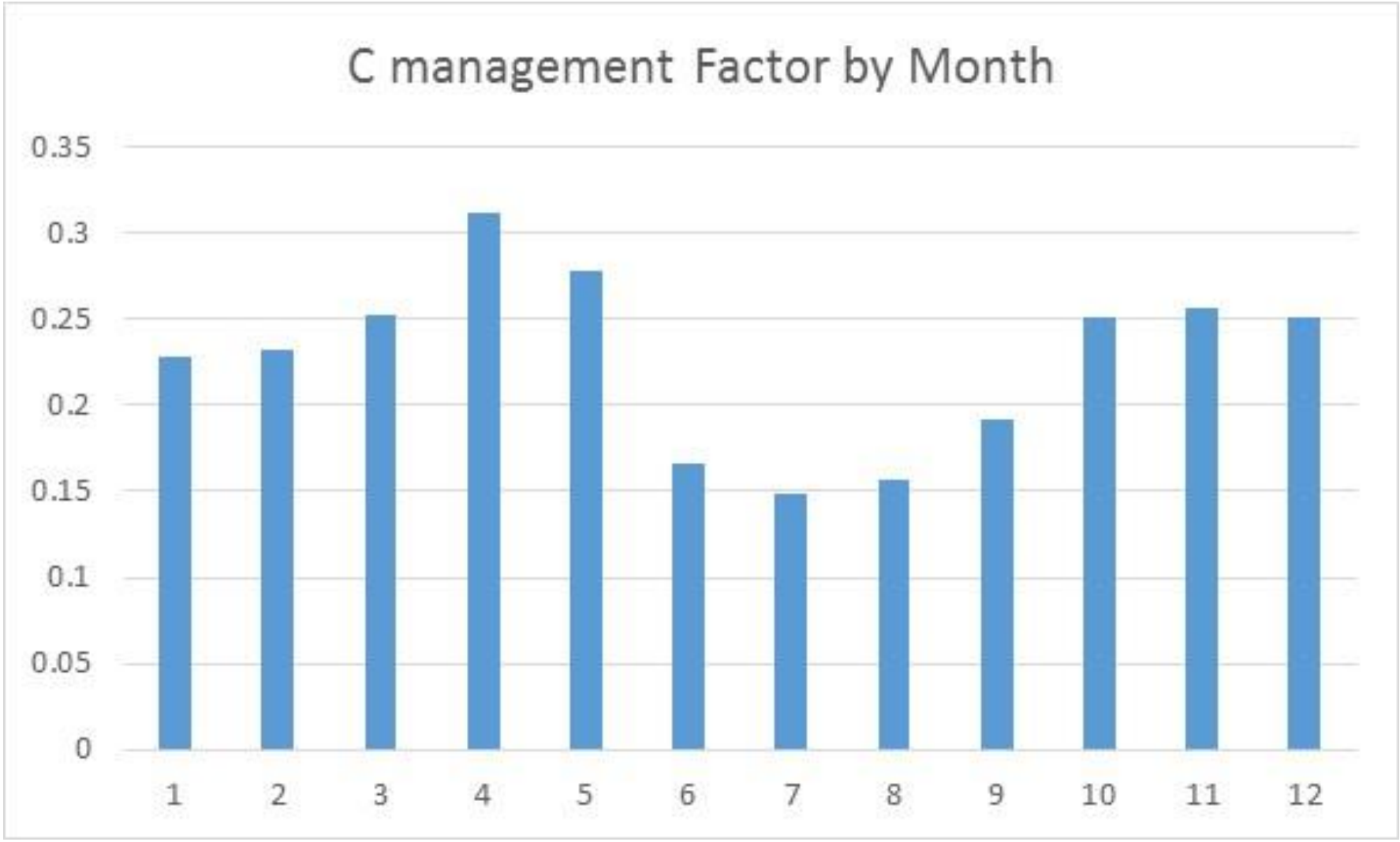

Chesapeake Bay Watershed
K Factor
K Factor
High : 0.69
Low : 0.00
Ton-acre-hours per hundred foot-tons per inch
79°0'0"W
78°0'0"W
77°0'0"W
76°0'0"W
75°0'0"W
74°0'0"W
43°0'0"N
42°0'0"N
41°0'0"N
40°0'0"N
39°0'0"N
38°0'0"N
37°0'0"N
81°0'0"W
80°0'0"W
79°0'0"W
78°0'0"W
77°0'0"W
76°0'0"W
0 45 90 180 Kilometers
0 2.75 5.5 11 Kilometers
K Factor
High : 0.69
Low : 0.02
Ton-acre-hours per hundred foot-tons per inch
N
NRCS gSSURGO 2015

C-Factor

- The C management Factor represents the effect of vegetative cover on erosion rates.
- Agricultural values were challenged during a STAC review and were revised using RUSLE2
- Literature values were used for non-agricultural lands.

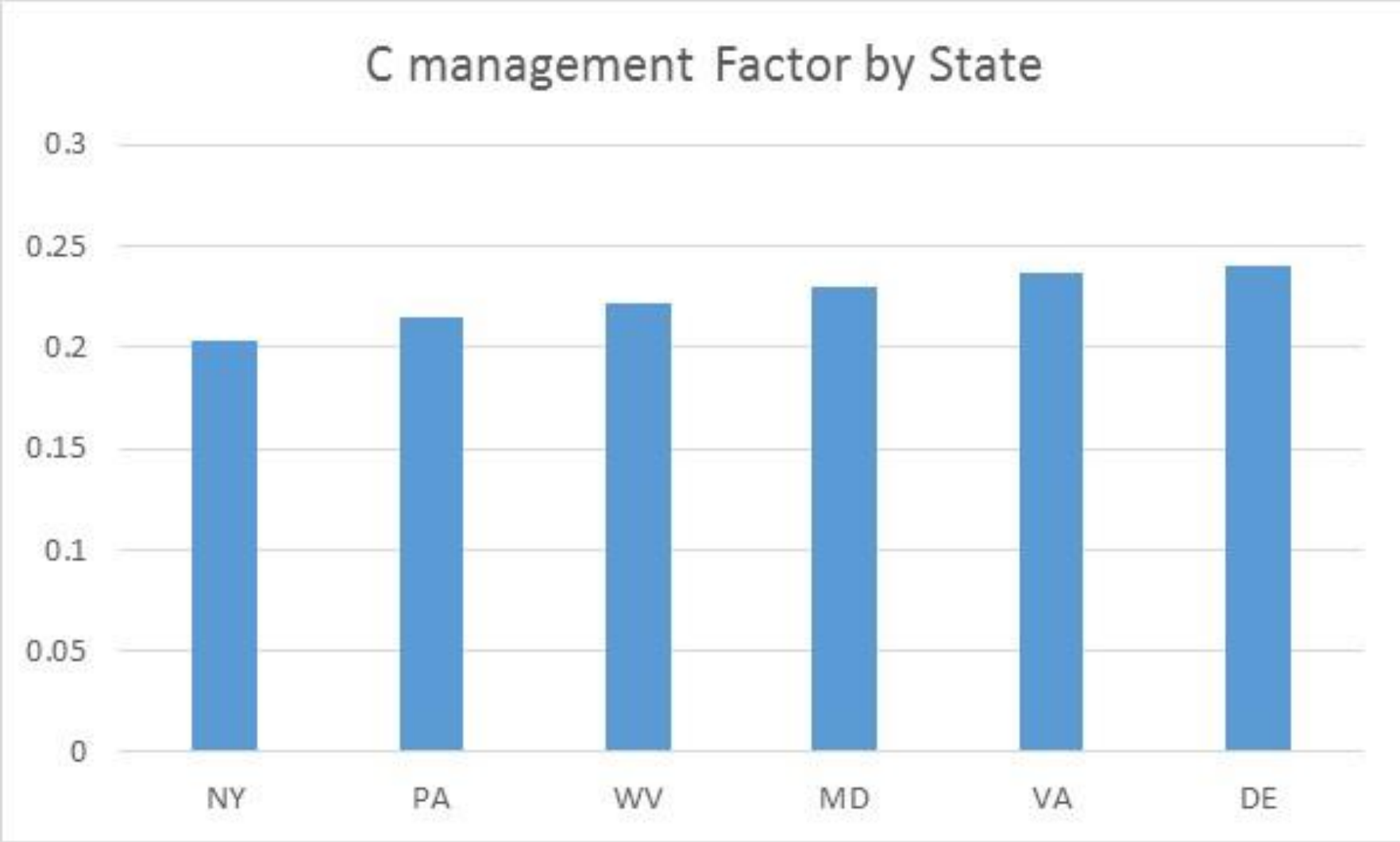
Simple average

Agricultural C-management factor



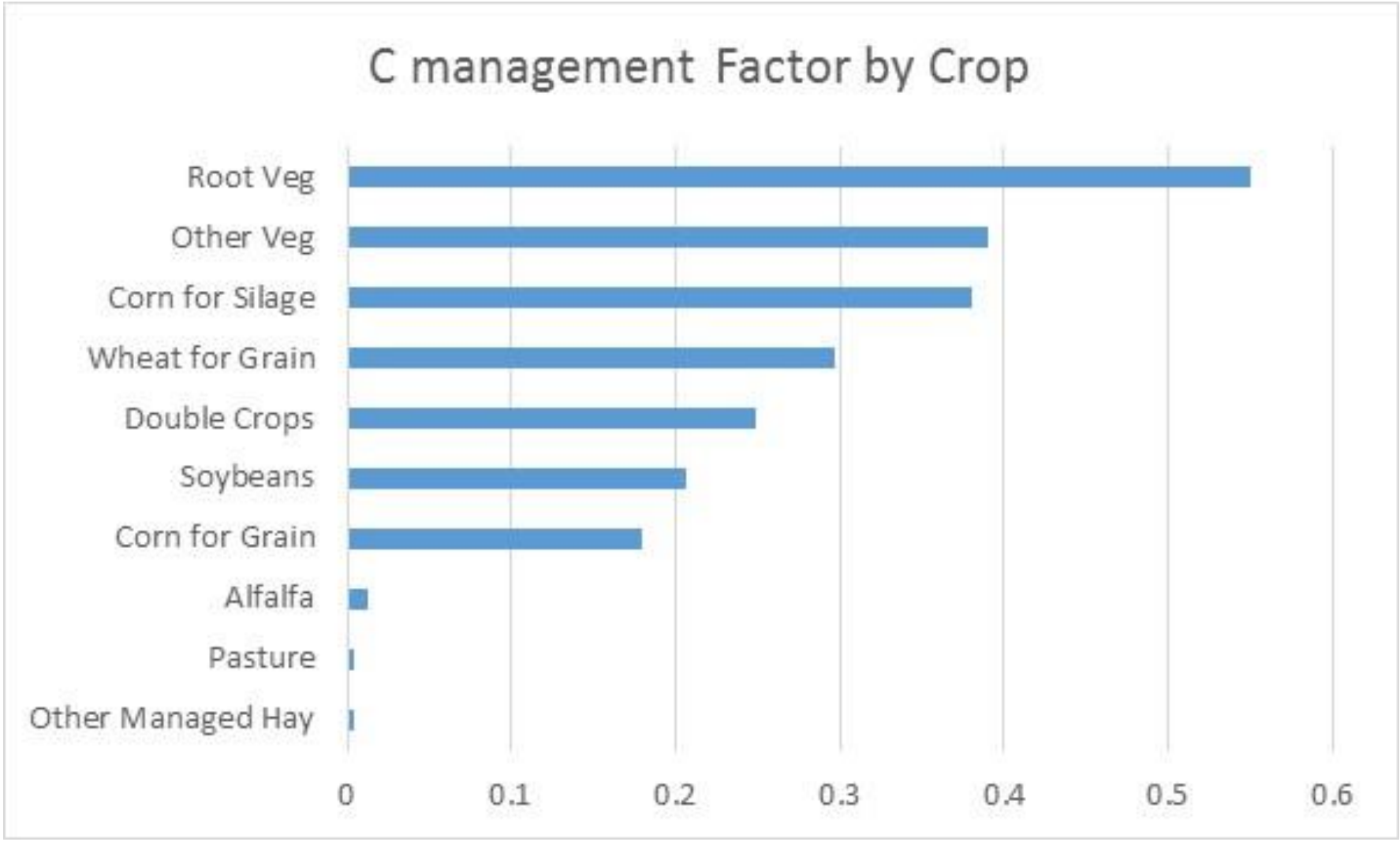
Simple average

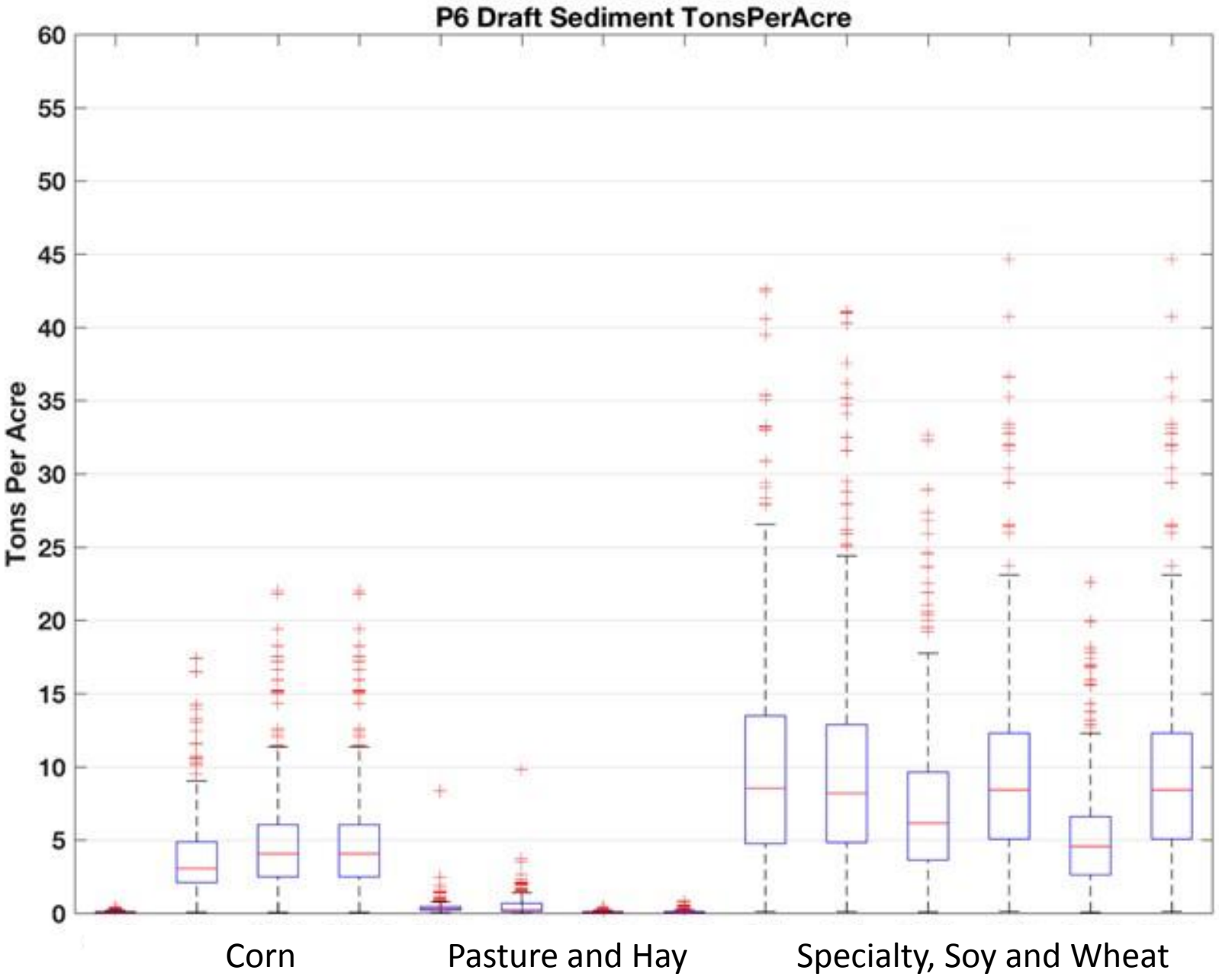
Agricultural C-management factor



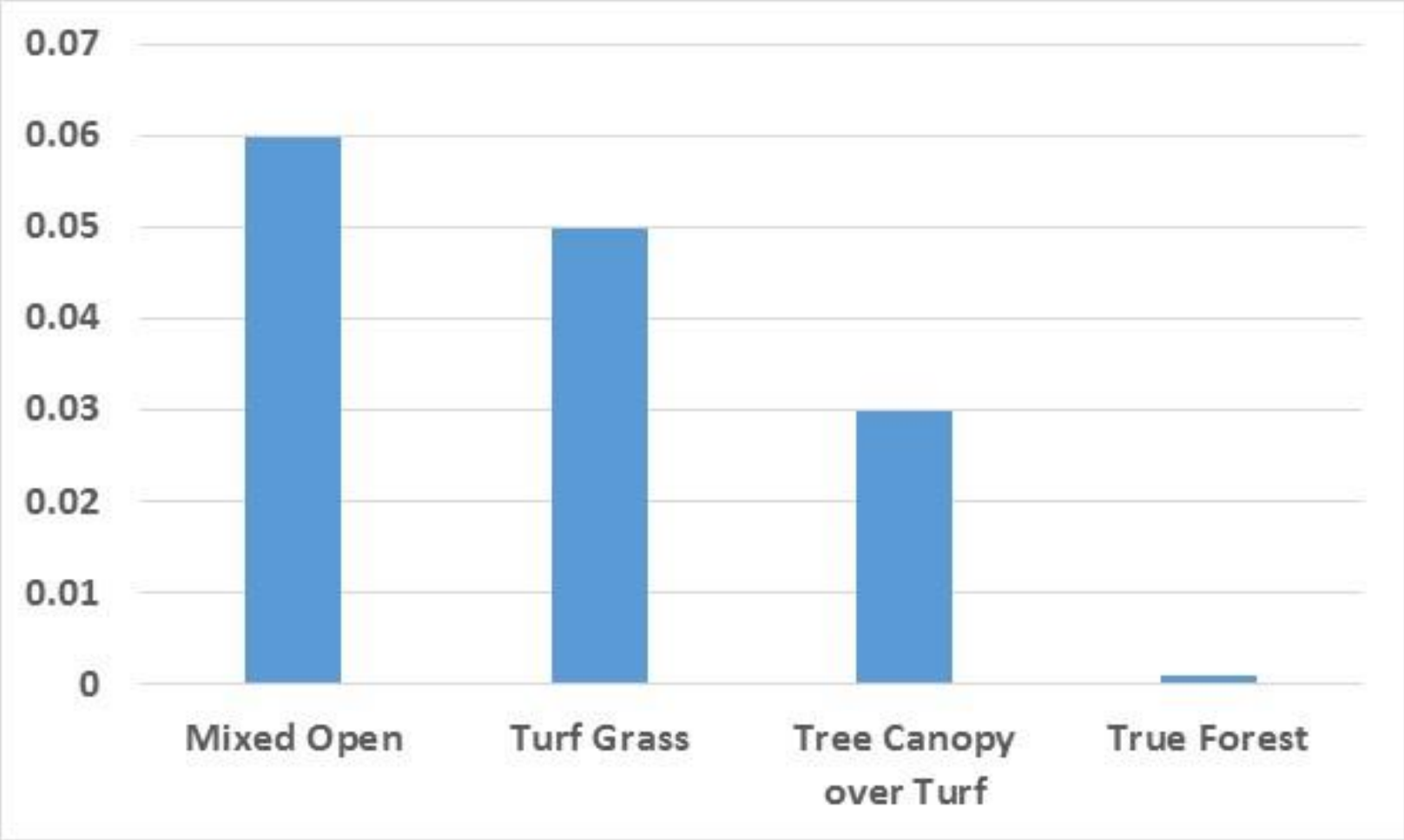
Simple average

Agricultural C-management factor




P6 Draft Sediment TonsPerAcre
Tons Per Acre
60
55
50
45
40
35
30
25
20
15
10
5
0
Corn
Pasture and Hay
Specialty, Soy and Wheat

Non-Agricultural C factors

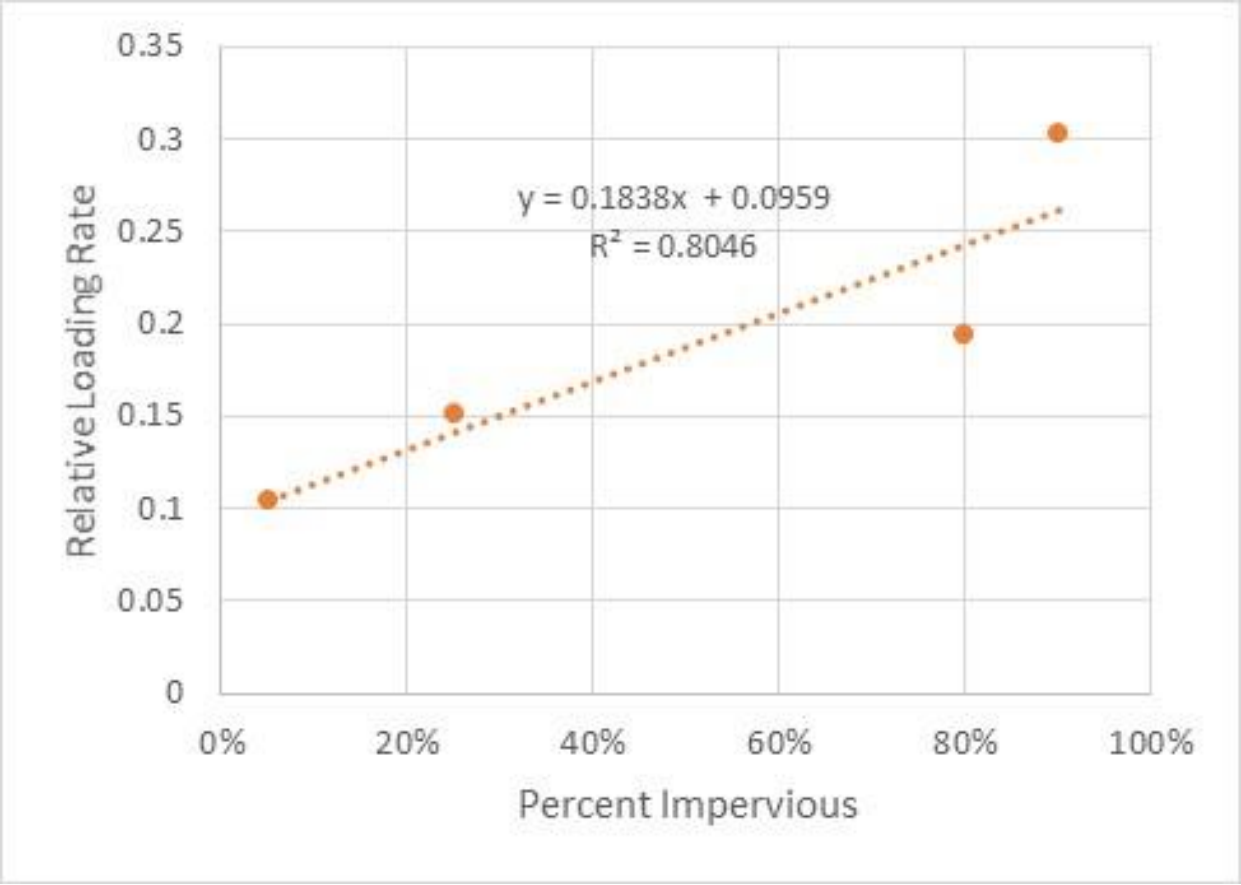


Construction

- Construction is set at 12 tons/acre/year as a global average by the Sediment and Erosion Control BMP Panel (Clark and others 2014).

- The local load is a ratio of turfgrass

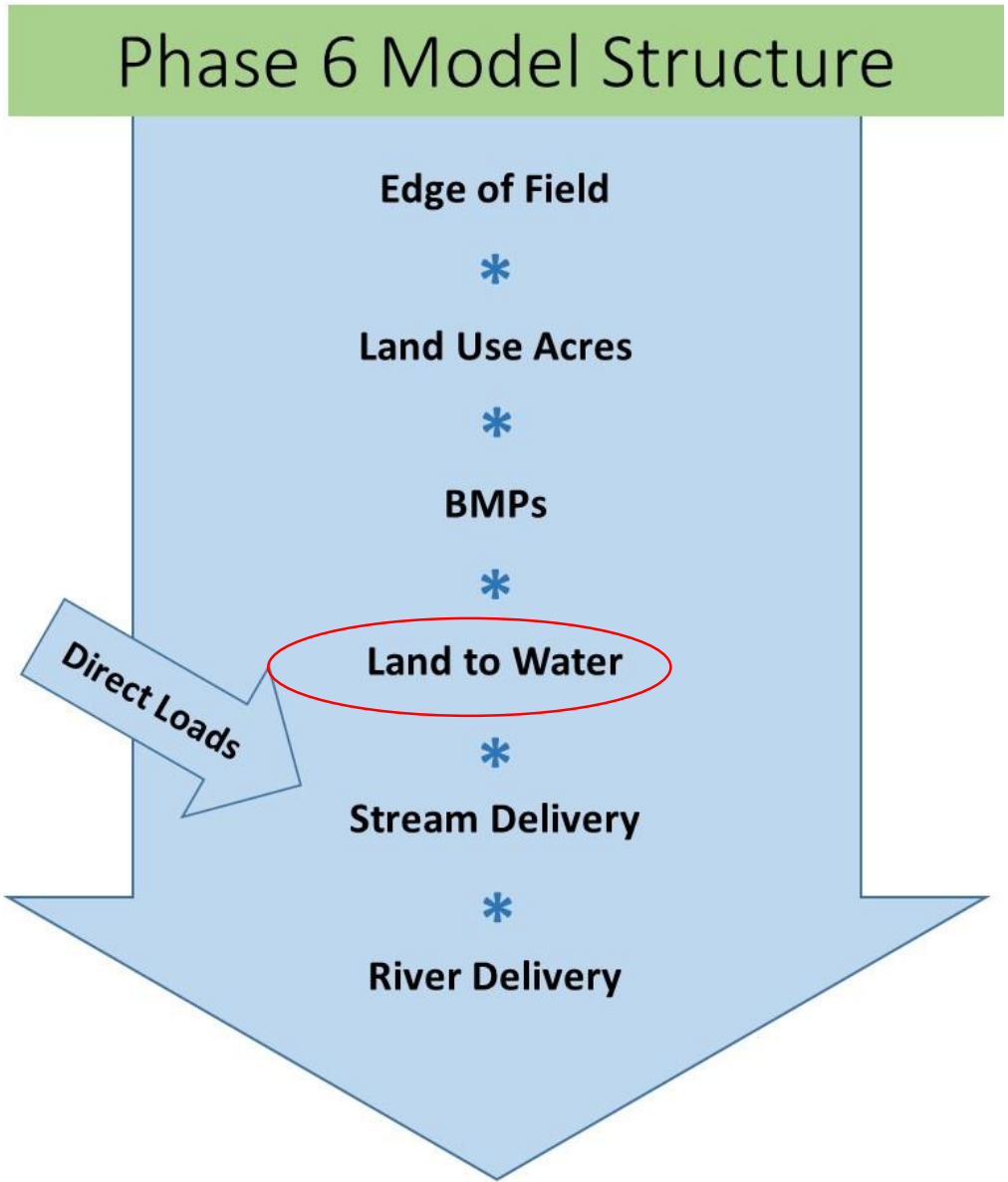
Impervious Load



Factor
1.0
3.0
3.0
3.0
1.0

- Impervious is 3x the sediment load **according to *outfall* data** in the NSQD

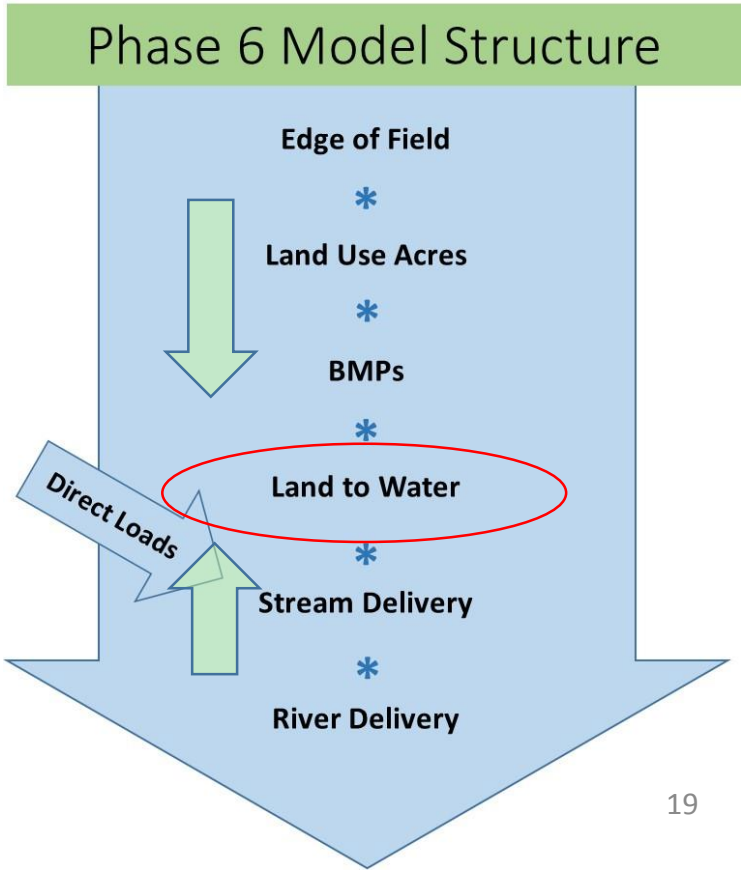
Sediment Delivery Ratio



Land to Water – calculate average

- [(EOF * acres * BMPs * L2W) + DL] * SD* RD = RIM Load

- L2W = 0.48



Sediment Delivery to Small Streams

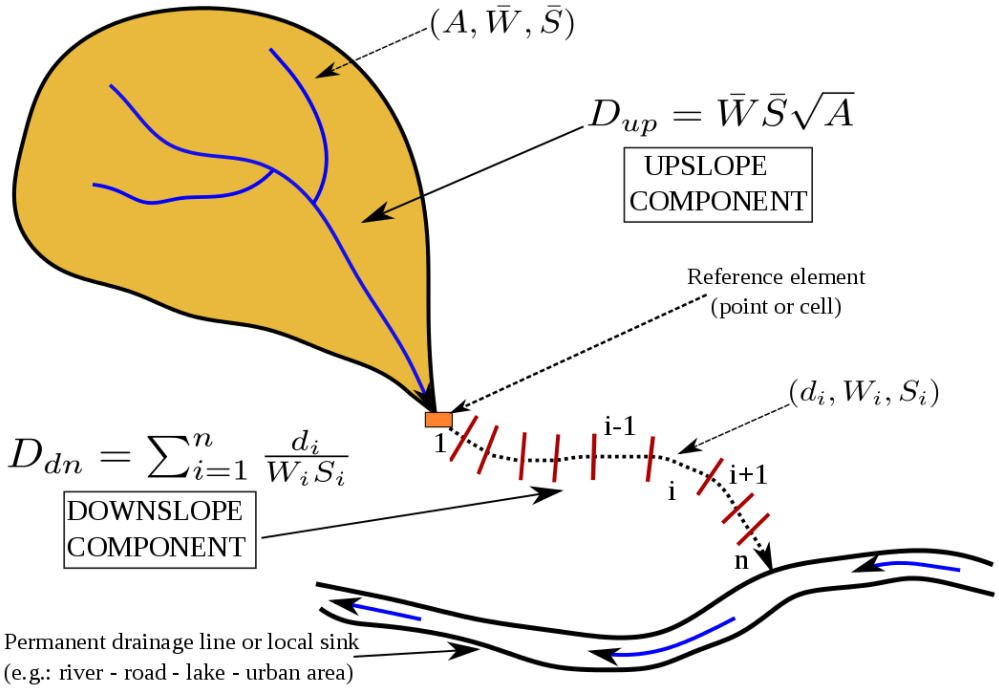
What is a small stream?

Synthetic stream network derived from 10m-DEM using a 60-acre minimum drainage area (meant to approximate 1:24,000 scale NHD network).

Phase 5.3.2 approach:

SDF = 0.417762 × Drainage Area $^{-0.134958}$ – 0.127097

Phase 6 approach:



Guidelines on the Sediment Connectivity

ArcGis 10.1 and 10.2 Toolbox

Release: 1.1

Marco Cavalli, Stefano Crema, Lorenzo Marchi

CNR-IRPI Padova (PP4)

June 2014

Sediment Delivery to Small Streams

$$IC = \log_{10}\left(\frac{D_{up}}{D_{dn}}\right)$$

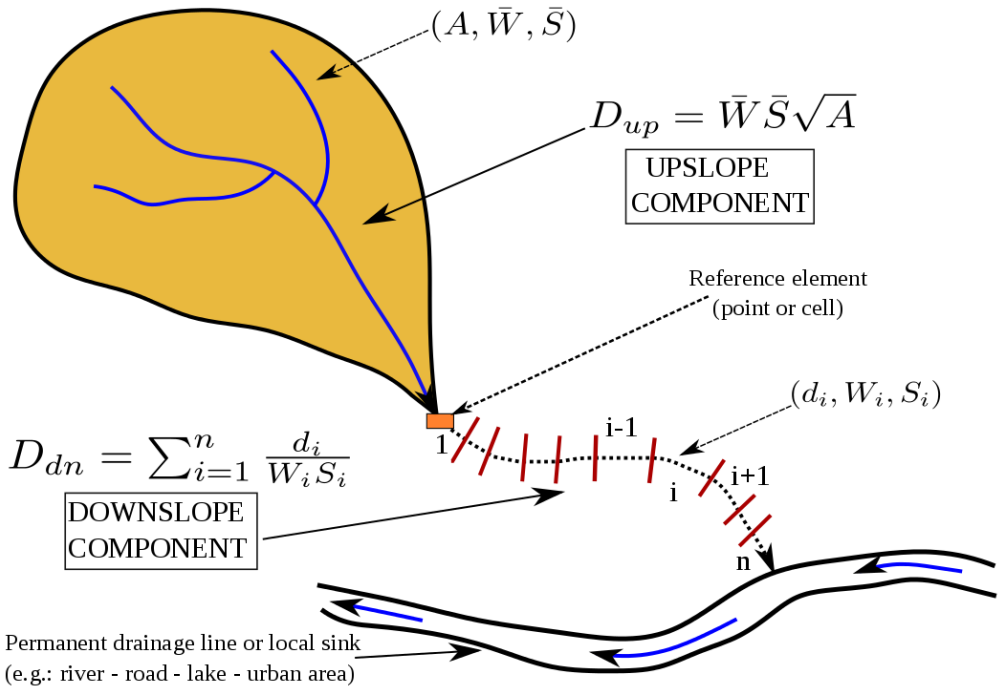
IC = Index of Connectivity

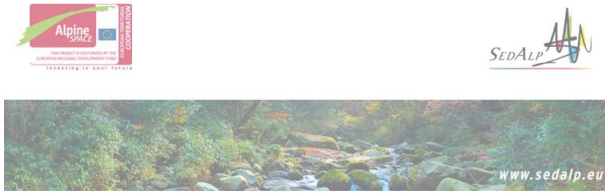
$$D_{dn} = \sum_i \frac{d_i}{W_i S_i}$$

Path length

Relative surface roughness

Slope gradient





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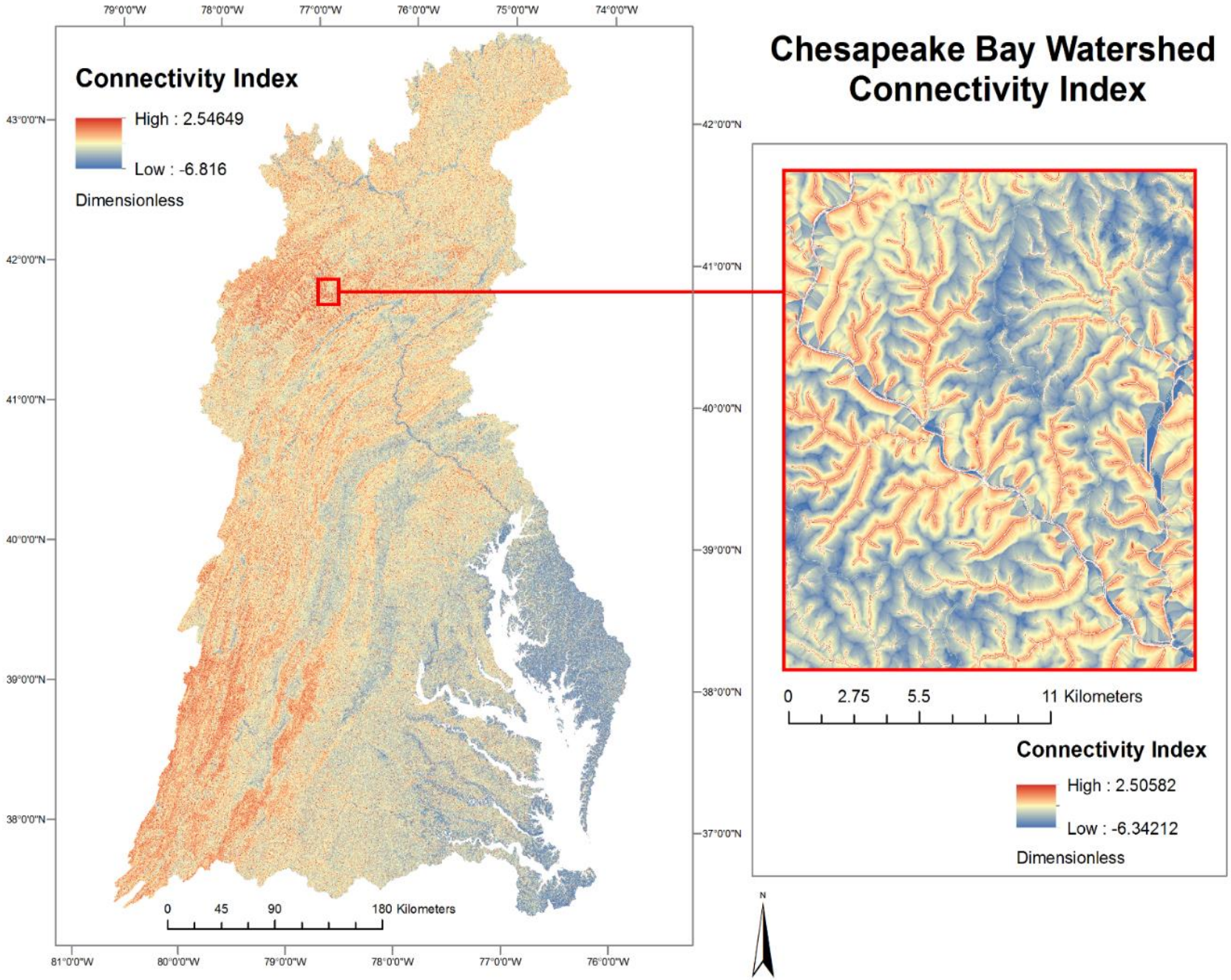
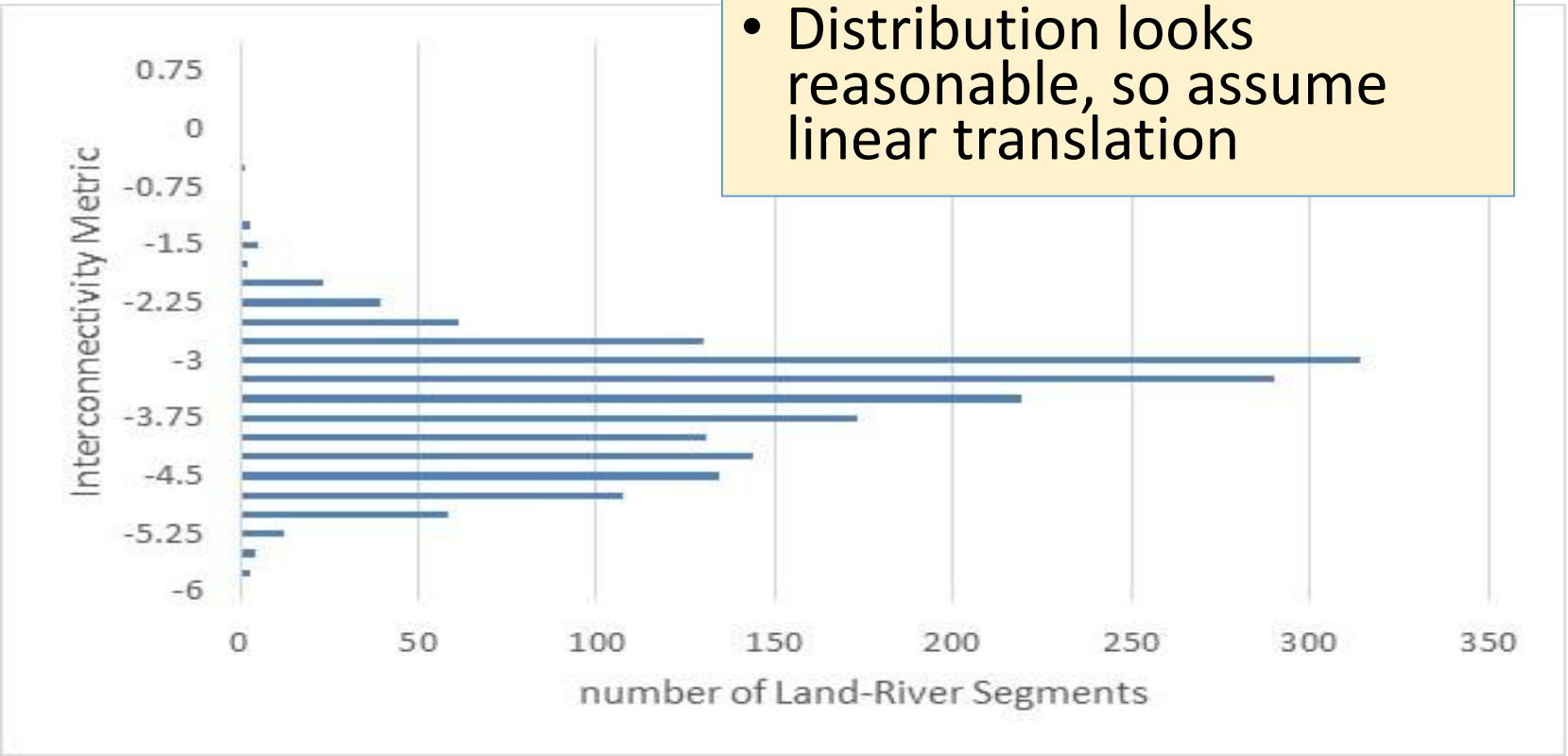

Chesapeake Bay Watershed
Connectivity Index
Connectivity Index
High : 2.54649
Low : -6.816
Dimensionless
79°0'0"W
78°0'0"W
77°0'0"W
76°0'0"W
75°0'0"W
74°0'0"W
43°0'0"N
42°0'0"N
41°0'0"N
40°0'0"N
39°0'0"N
38°0'0"N
37°0'0"N
81°0'0"W
80°0'0"W
0 45 90 180 Kilometers
0 2.75 5.5 11 Kilometers
Connectivity Index
High : 2.50582
Low : -6.34212
Dimensionless
N

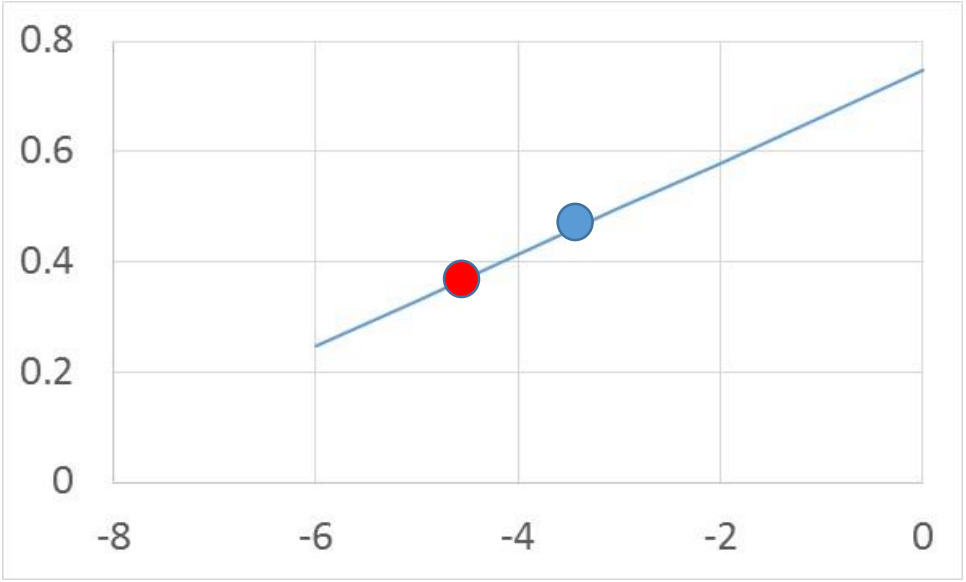
Sediment Delivery Ratio

- Need to convert to scale of 0 to 1 with an average of 0.48
- Distribution looks reasonable, so assume linear translation



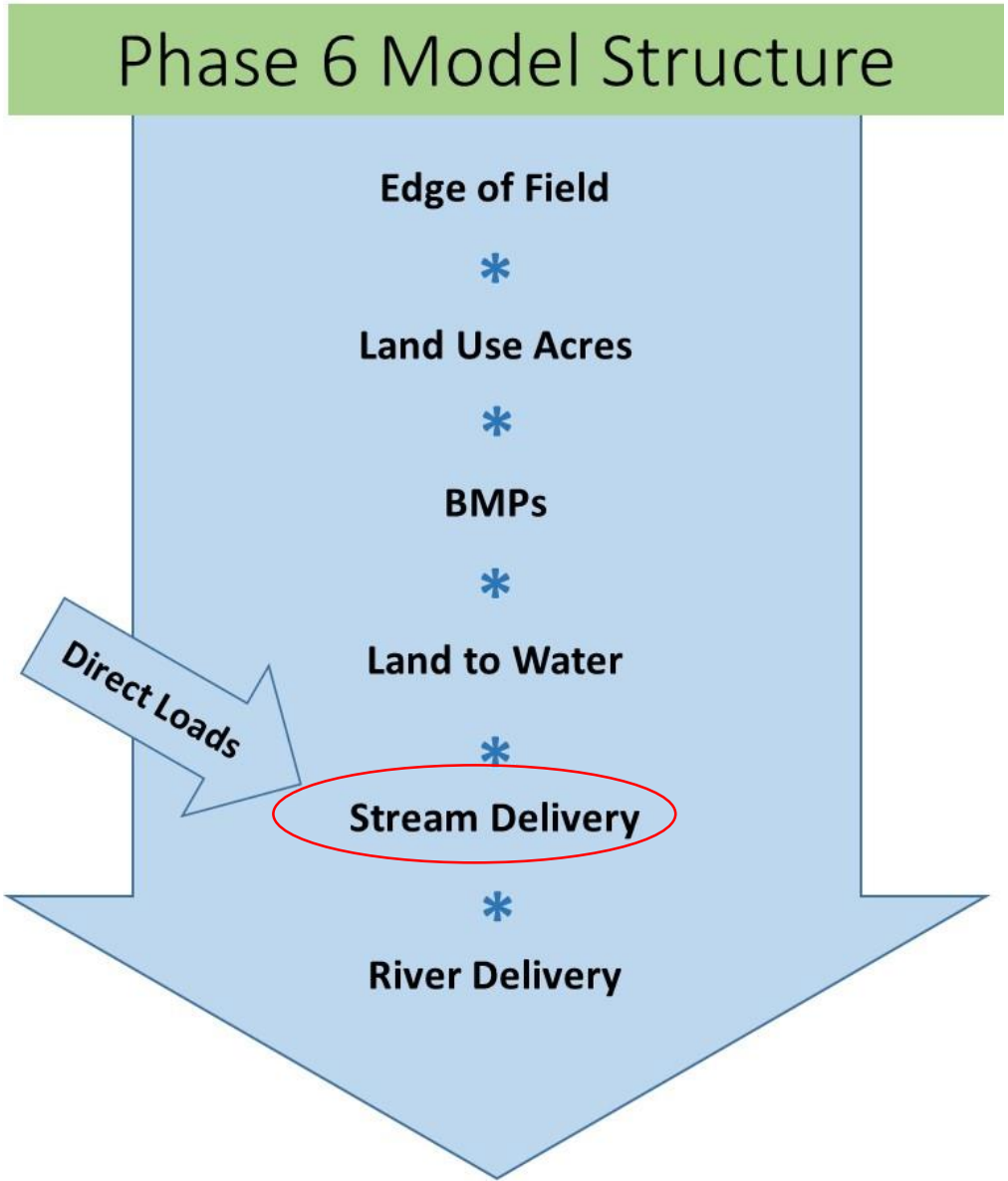
Interconnectivity Metric

- Center point at averages: (-3.2, 0.48)
- Second point at 1 Standard Deviation
  - SD of SDR from CEAP in the Upper Miss was 0.08 (8-digit HUC)
  - SD of P5.3.2 was 0.10
  - Choose 0.10
  - Establish second point at (-4.4, 0.38)

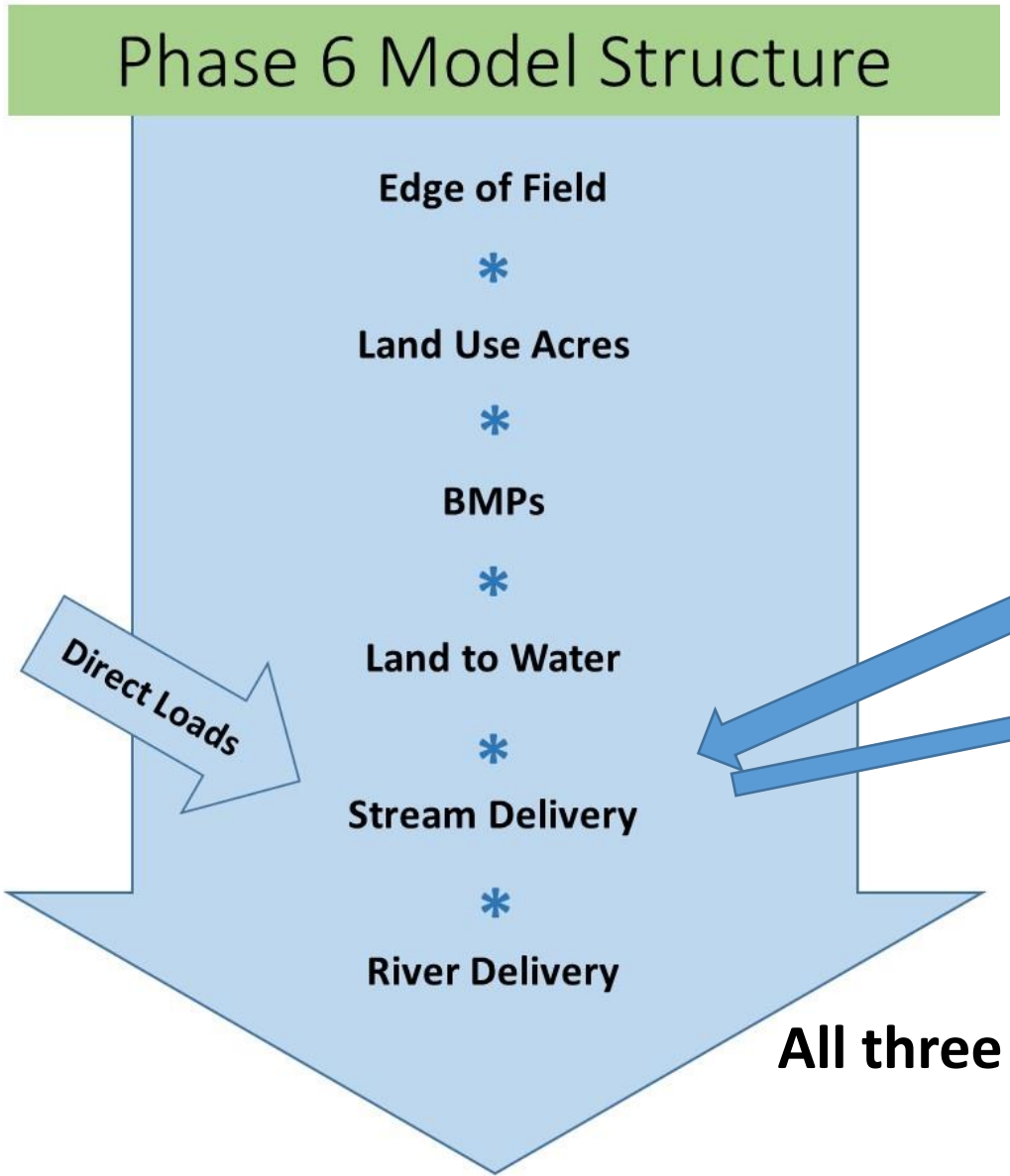


SDR = 0.083 * IC + .747

Stream Sediment Effects



Stream Sediment Effects – 2 methods



Absolute Load change
2 load sources
Streambank (+) STR
Floodplain (-) STF

Simple Factor - STR

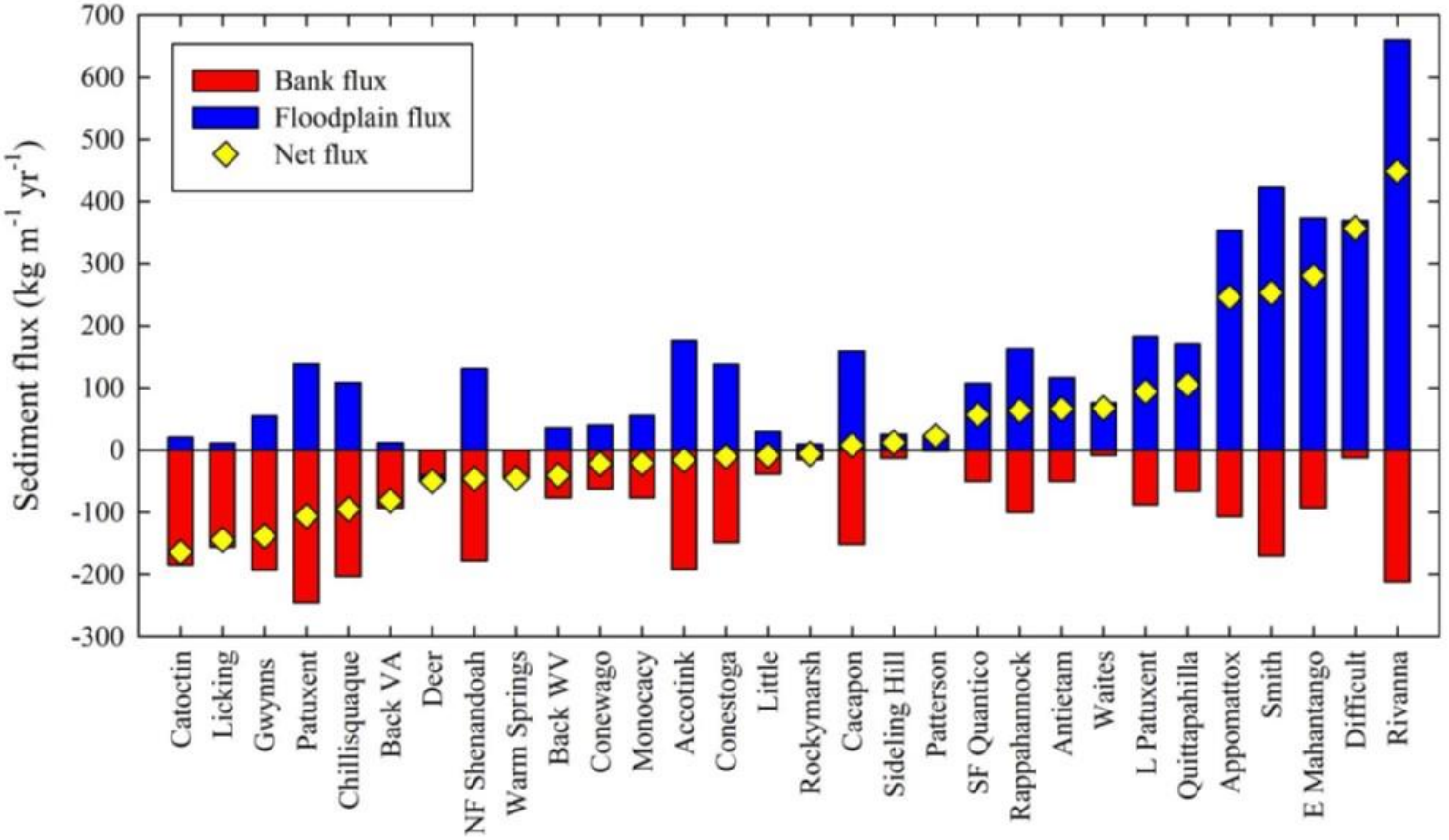
All three can exist in the same segment

Methods for Stream Estimation

- Chesapeake Floodplain Network
- Stream Source Ratio
- USGS Sparrow Regression Model

Chesapeake Floodplain Network – Ag and Natural

Greg Noe and others



- No net change
- Spatial variability generalized

Stream Delivery – Developed

- Center for Watershed Protection Work

$$\text{Stream Source Ratio} = \frac{\text{Stream Load}}{\text{Total Watershed Load}}$$

SSR = 1.4085 * (fraction Impervious)

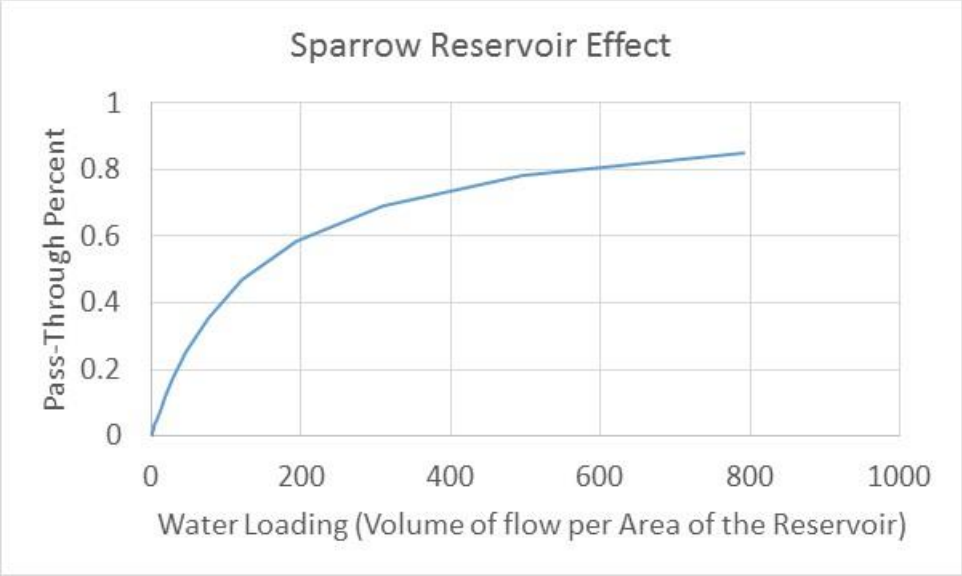
+ 0.5341 * (fraction CD soils)

- 0.2828

Averages about 0.5 for developed areas

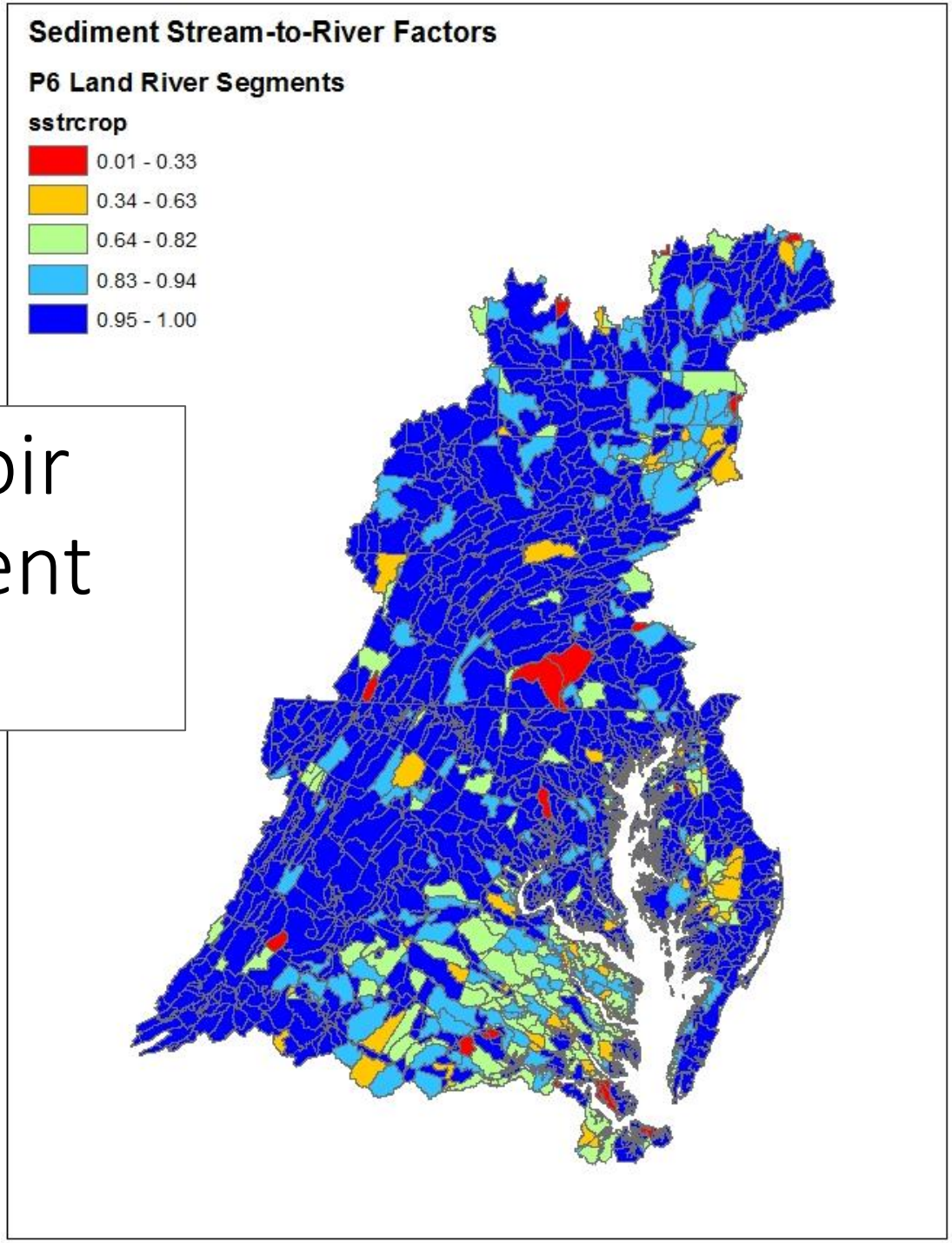
Sediment Sparrow

- Rivers are not a significant sediment sink except
  - Coastal Plain rivers larger than 120 cfs
  - Reservoirs



Brakebill, Ator, and Schwarz, 2010

Sparrow Reservoir Effect on Sediment from crop



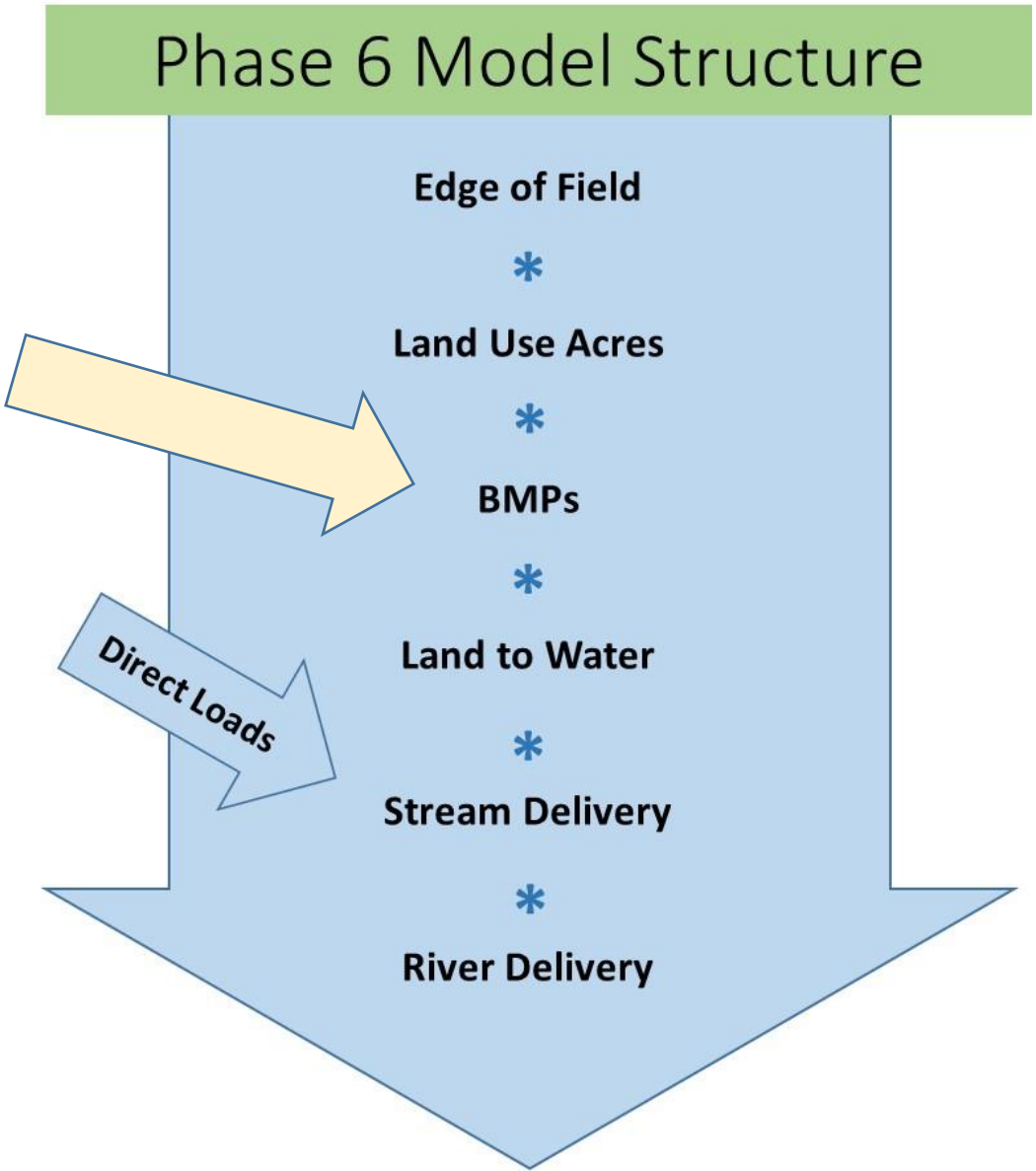
Stream Effects

- Streams in developed areas contribute roughly half of the sediment from those areas
- Streams in non-developed areas do not gain or lose sediment
- Reservoirs are sinks for sediment.

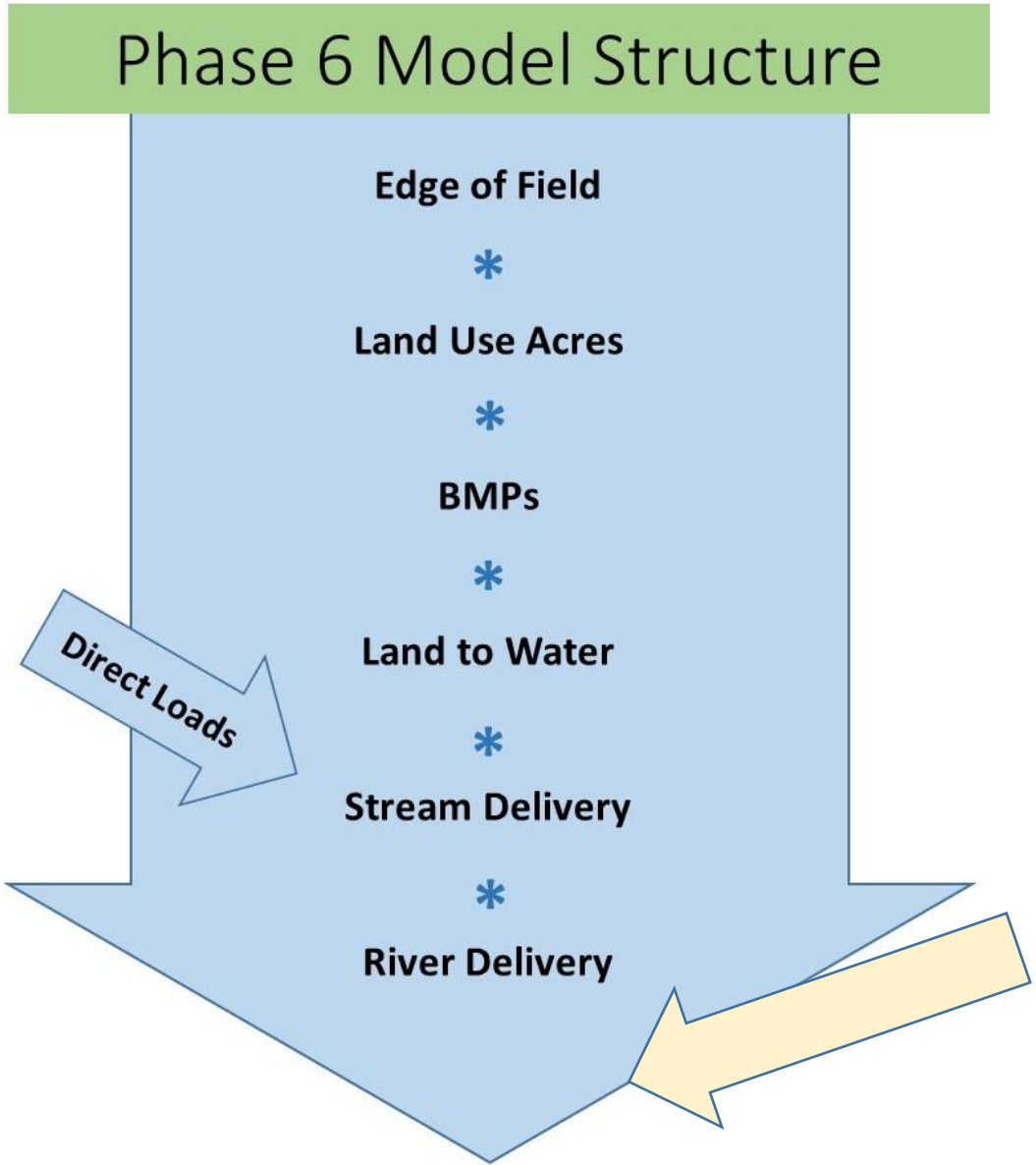
Stream Effects

- Streams in developed areas contribute roughly half of the sediment from those areas
  - STB loads in developed areas
- Streams in non-developed areas do not gain or lose sediment on average
  - Test STB and STF predictions from Chesapeake Floodplain Network
- Reservoirs are sinks for sediment.
  - Apply sparrow factors.

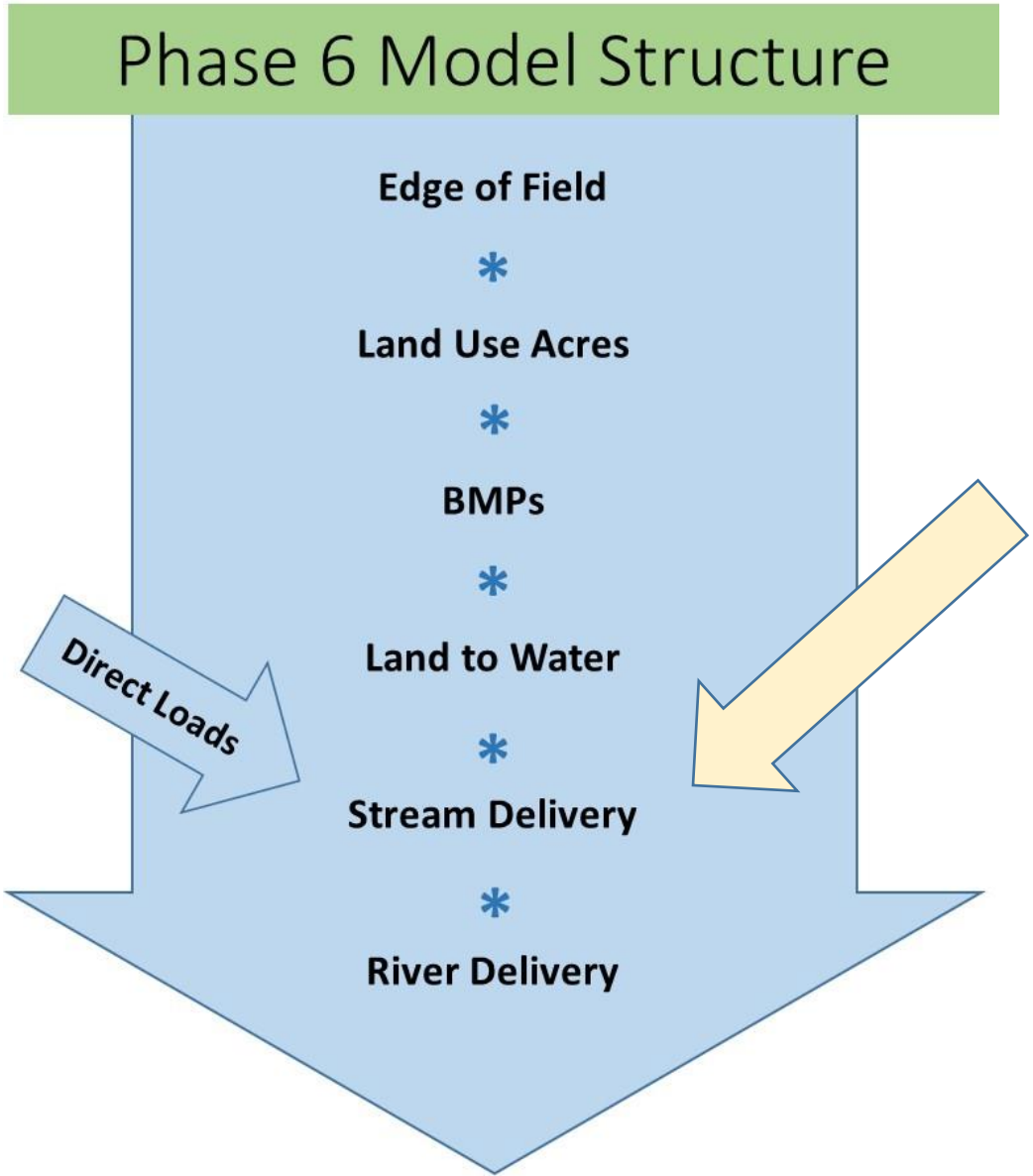
Most Sediment BMPs



Tidal Shoreline Restoration BMP



Stream Restoration BMP

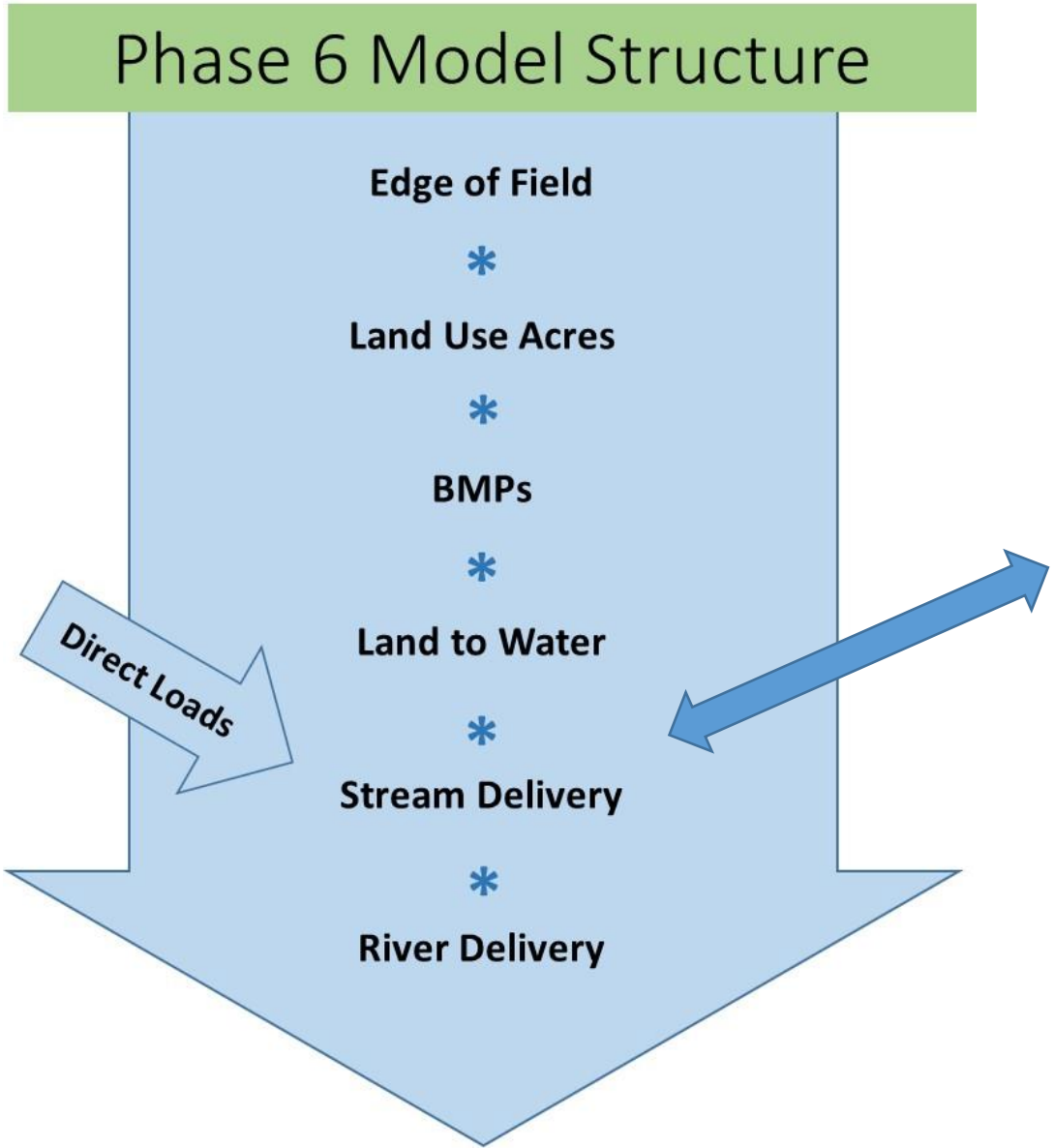


Guidance from the Stream Restoration BMP panel

The WTWG approved this BMP for use only along first, second and third order streams.

The panel recommended accounting for [small stream] sediment attenuation just as the Watershed Model does

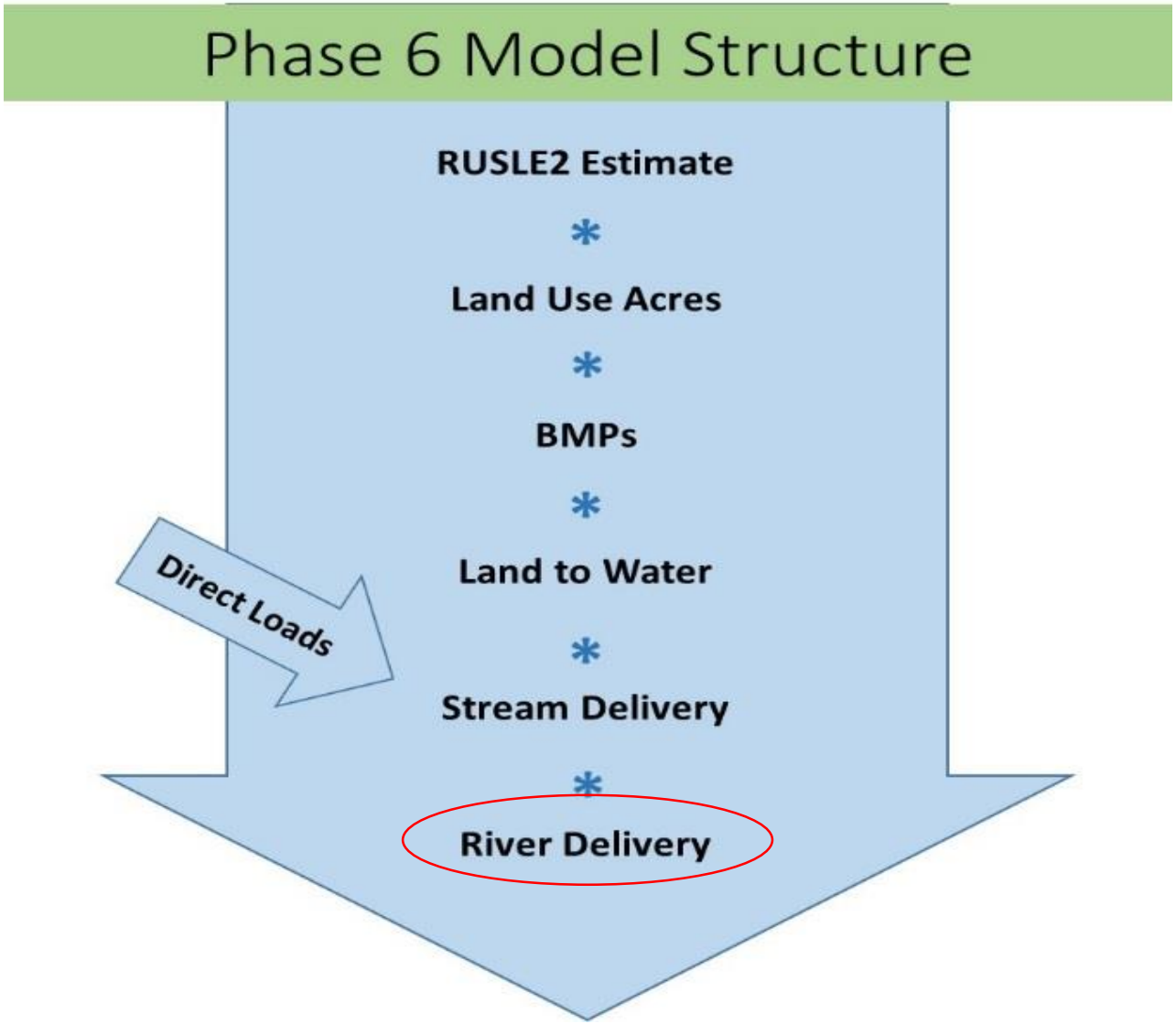
Stream Restoration BMP



Reduction in Streambank (STR) loading source. Can become negative

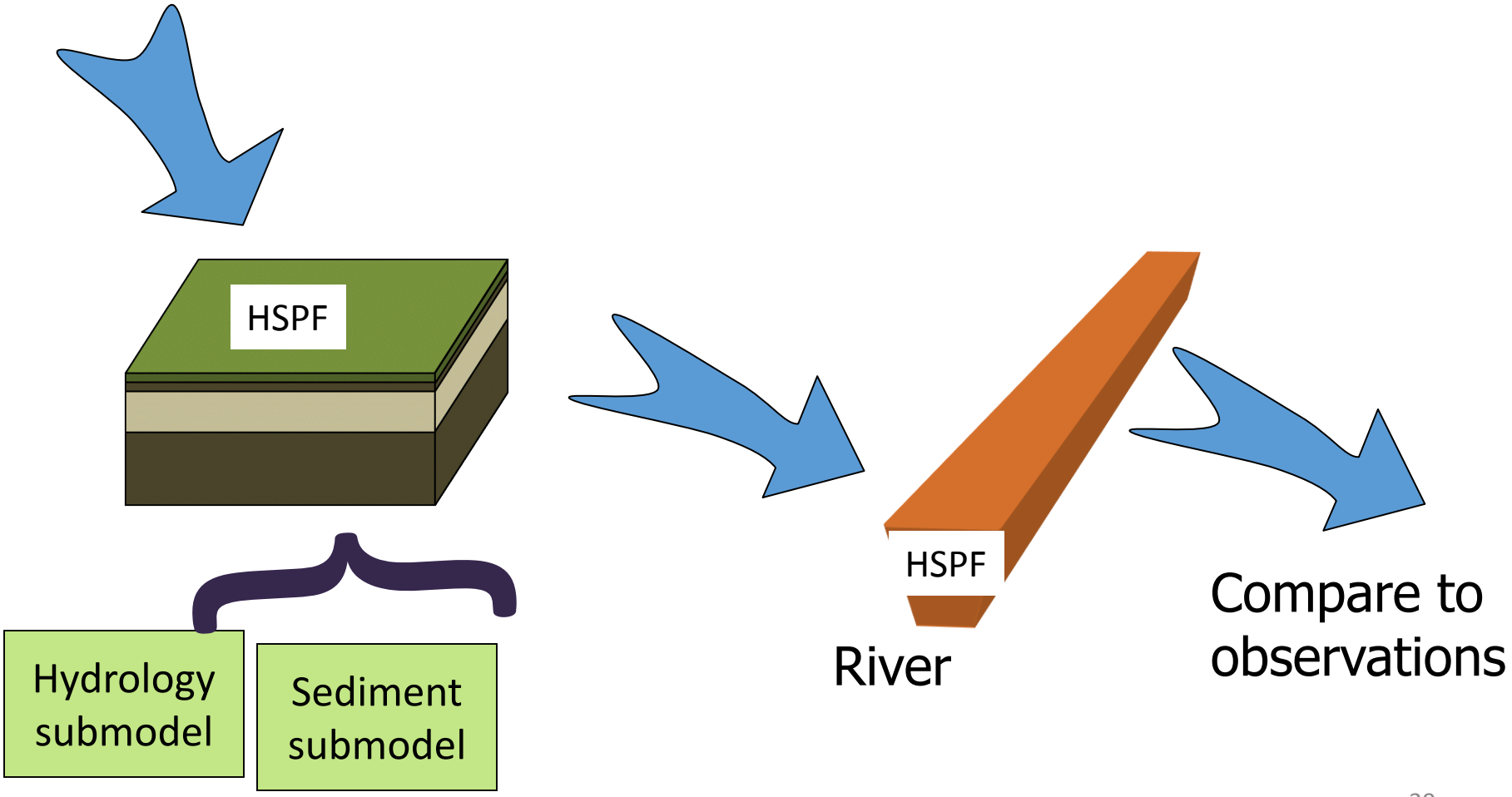
Multiplied by stream to river factor

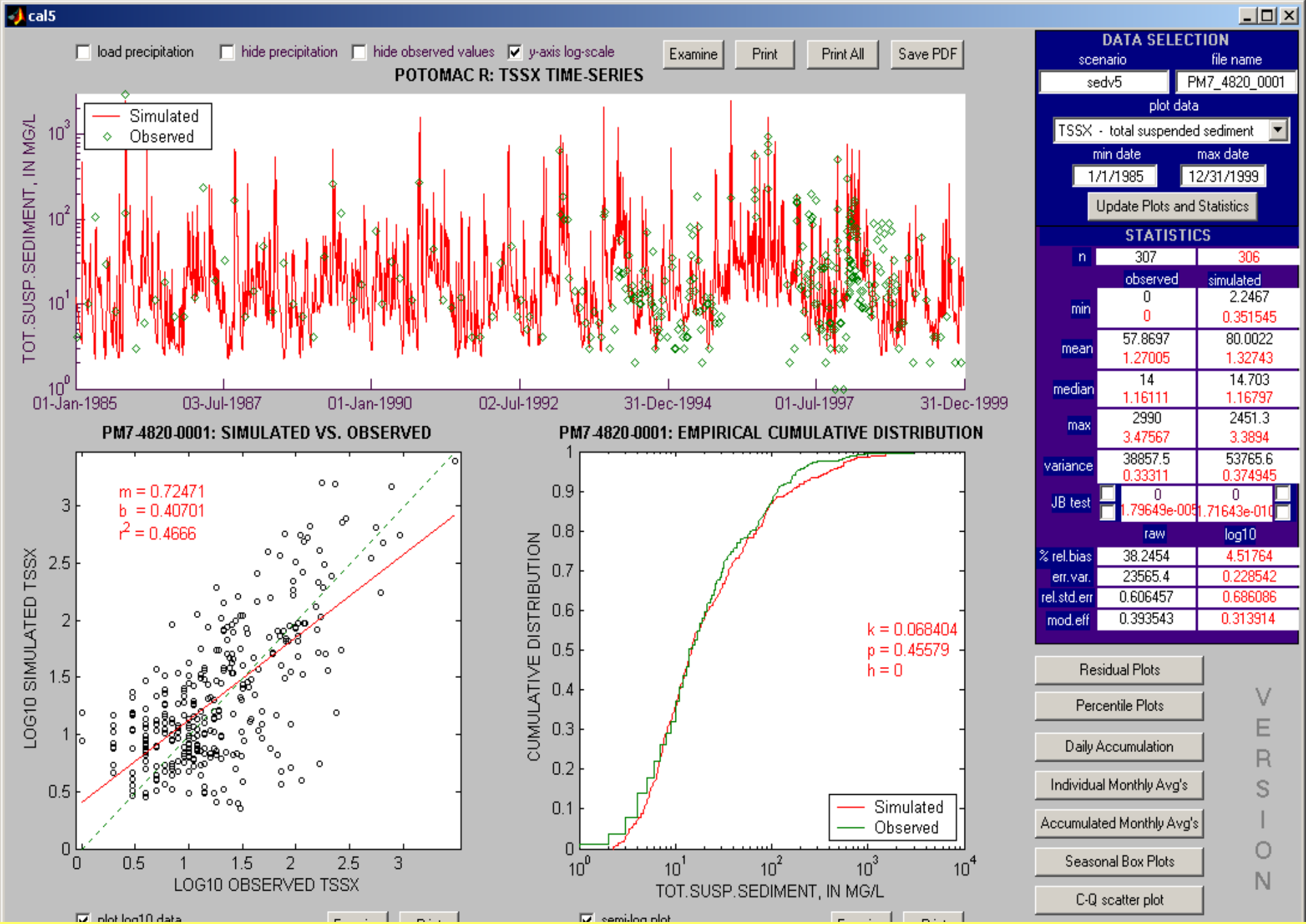
Sediment Delivery Ratio



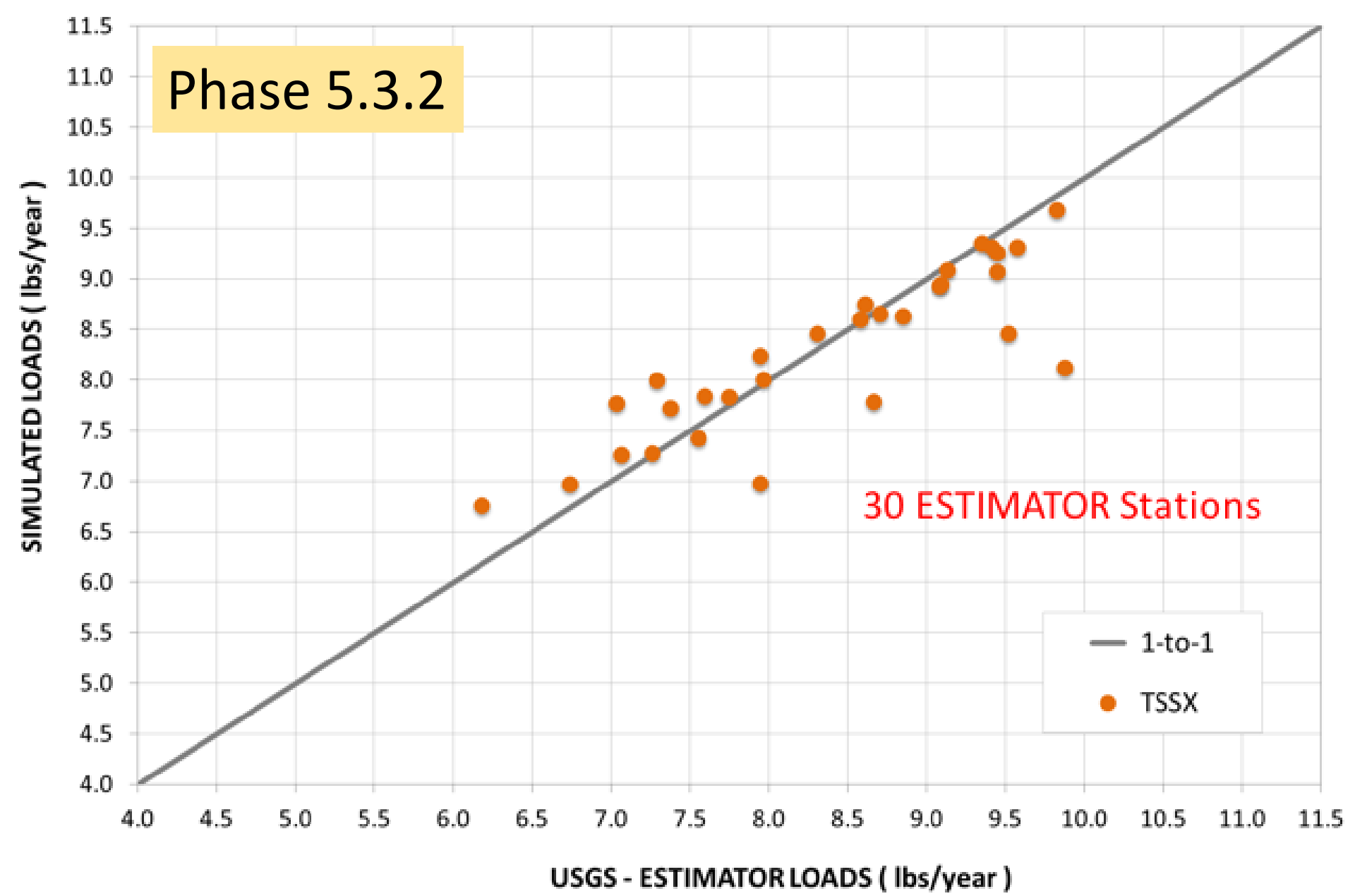
River Delivery Calibrated in the HSPF model

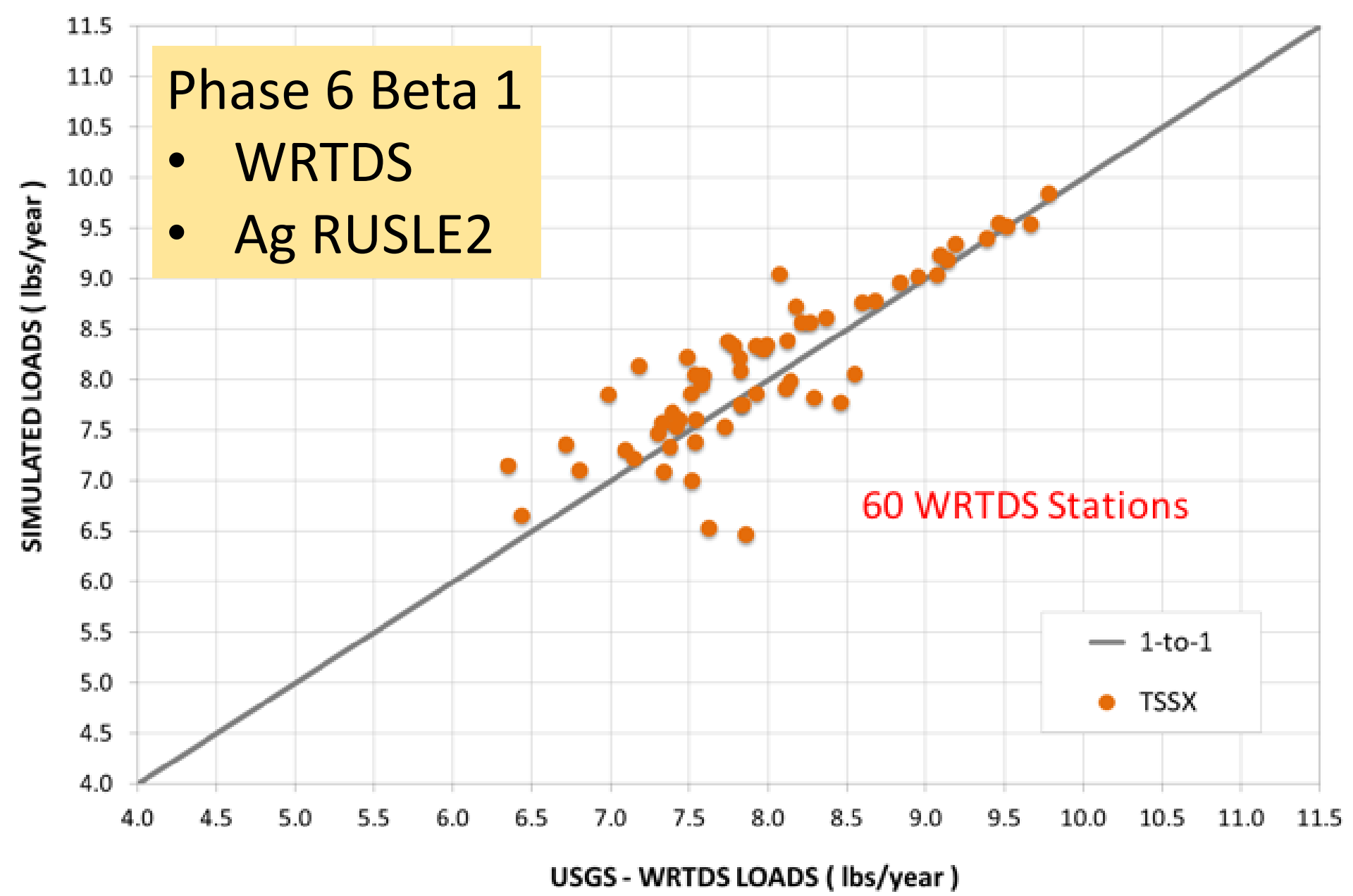
Precipitation

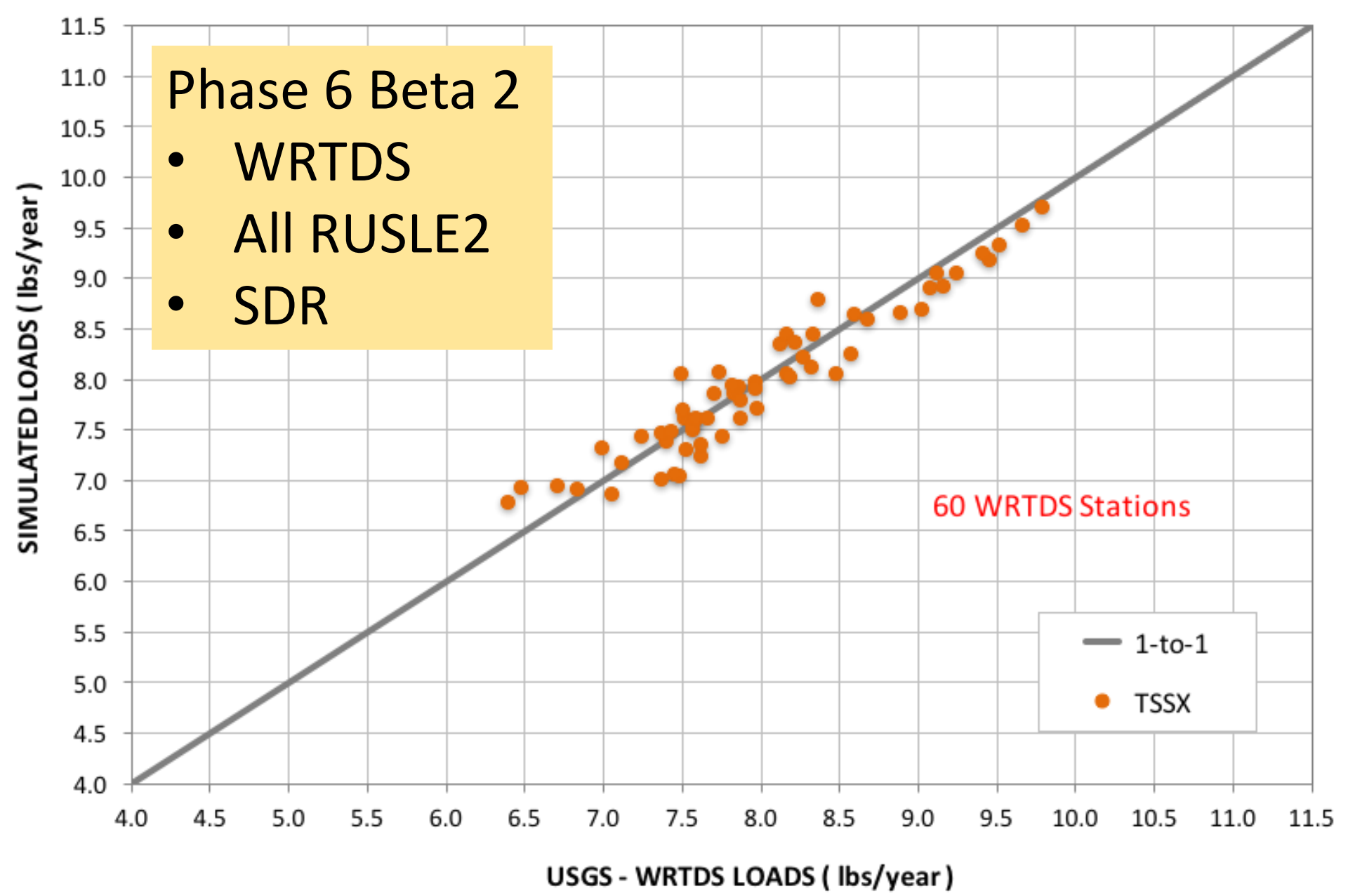




Potomac Fall Line


Phase 5.3.2
SIMULATED LOADS (lbs/year)
USGS - ESTIMATOR LOADS (lbs/year)
30 ESTIMATOR Stations
1-to-1
TSSX
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5


Phase 6 Beta 1
• WRTDS
• Ag RUSLE2
60 WRTDS Stations
1-to-1
TSSX
SIMULATED LOADS (lbs/year)
USGS - WRTDS LOADS (lbs/year)
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0 10.5 11.0 11.5


Phase 6 Beta 2
• WRTDS
• All RUSLE2
• SDR
60 WRTDS Stations
1-to-1
TSSX
SIMULATED LOADS (lbs/year)
USGS - WRTDS LOADS (lbs/year)
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0 10.5 11.0 11.5





Questions?

Edge of Field

*

Land Use Acres

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BMPs

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Land to Water

Direct Loads

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Stream Delivery

*

River Delivery

Phase 6