Urbanized Stream Source Ratio

October 20, 2015
Urban Stormwater Workgroup
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CENTER FOR WATERSHED PROTECTION

Chesapeake Bay Program
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Background

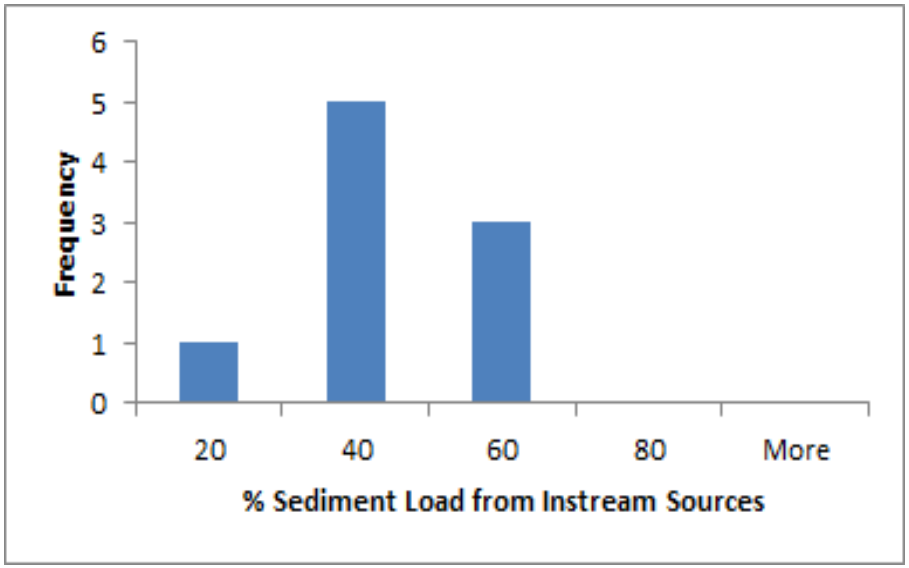
- Focus on small urban streams (0 to 3rd order)
- Watersheds below 60 square miles
- Improve alignment of source area load reductions with upland and in-stream BMPs in the Watershed Model

Previous Work

- Phase I – Literature Review (CWP, 2013 & 2014a)
- Phase II – MS4 Concentration Monitoring Data (CWP, 2014b)
- Phase III – Watershed Flow-Concentration Relations (CWP, 2015)

Previous Work

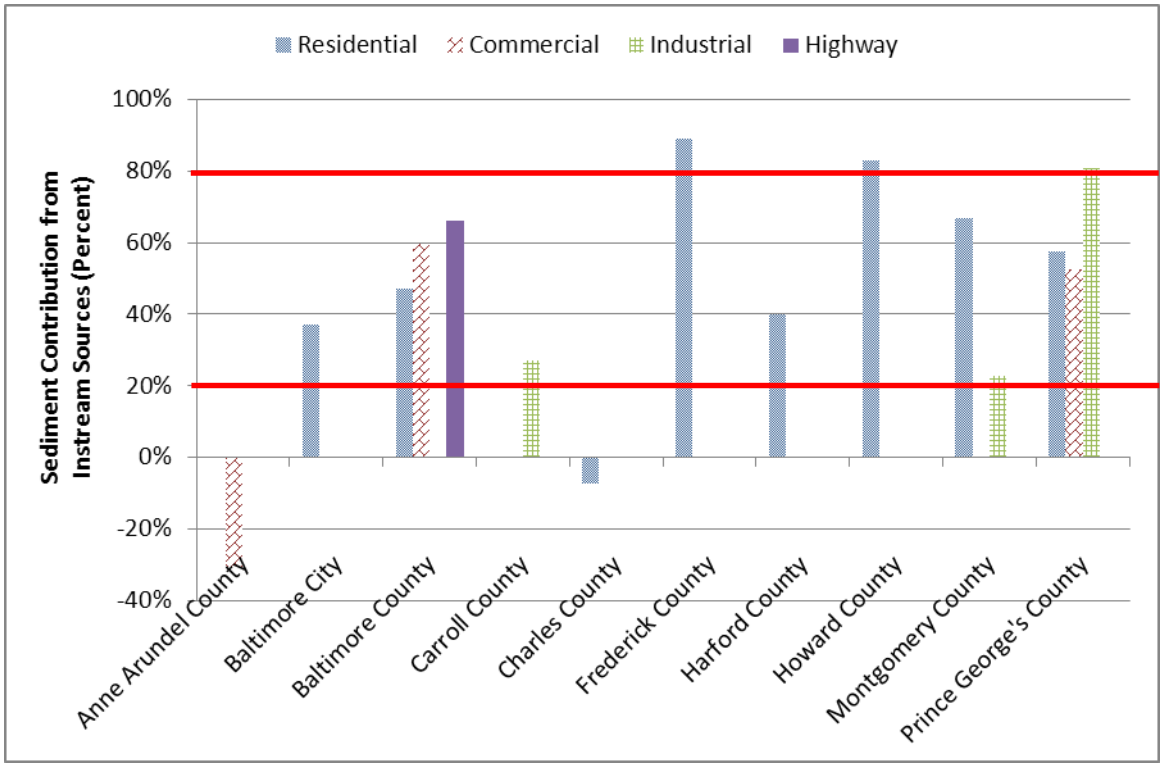
- Phase I – Literature Review (CWP, 2013)
  - 38 entries; 16 included % sediment from in-stream; 9 met size criteria (<60 sq. mi.)



Histogram of the percentage of sediment load from instream two outliers and modeling studies removed.

Previous Work

- Phase II – MS4 Concentration Monitoring Data (CWP, 2014)



Goals of Proposed Approach

- Focus on small urban streams (0 to 3rd order)
- Define a Stream Source Ratio (SSR) that quantifies the relative load attributed to in-stream sources (e.g. bed & bank erosion, resuspension)

$$SSR = \frac{Bed\ \&\ Bank\ Erosion}{Bed\ \&\ Bank\ Erosion + Upland} = \frac{E}{E + U}$$

From Smith and Wilcock (2015)
E = Lowland Bank Erosion
U = Upland Sediment Supply

General Approach

- Flow-Load relations for watershed as a whole
- Use CBWM hourly flow as proxy for monitored flow
- Mean upland sediment concentration used for upland load
  - County specific, from National Stromwater Quality Database, where available
- SSR estimated as a result
- Relate drainage area characteristics to SSR
- Initial predictive regression based on 9 watersheds
- Final predictive regression based on 6 watersheds

General Approach

WATERSHED NAME	DRAINAGE AREA (SQ. MI.)	IMPERVIOUS COVER (FRACTION)	FOREST COVER (FRACTION)	FRACTION HSG A/B	FRACTION HSG C/D	RIPARIAN LENGTH FRACTION OF STREAM	STORM DRAIN DENSITY (PER SQ. MI)	OUTFALL DENSITY (PER SQ. MI)	FRACTION BMP TREAT	SSR (ESTIMATED)
DIFFICULT RUN 1	5.59	0.184	0.392	0.590	0.370	0.340		4.8	0.240	0.917
DIFFICULT RUN 5	55.2	0.184	0.356	0.603	0.278	0.502		5.7	0.221	0.843
PAINT BRANCH	12.1	0.130	0.266	0.753	0.238	0.530		8.0		0.562
BREEWOOD	0.10	0.331	0.181	0.271	0.729	1.00	264.5	81.4	0.800	0.820
MOORES RUN @ RADECKE AVE	3.52	0.300	0.070	0.105	0.895	0.750				0.579
STONY RUN @ LINKWOOD	2.20	0.694	0.306	0.562	0.438	0.385				0.909
WEST BRANCH HERRING RUN @ IDLEWYLDE	2.13	0.277	0.116	0.551	0.449	0.405				0.319
SCOTT'S LEVEL - 01	3.42	0.246	0.029	0.359	0.641	0.767	364.5	39.5		0.314
POWDER MILL RUN	3.64	0.378	0.041	0.046	0.954	0.656	571.7			0.691

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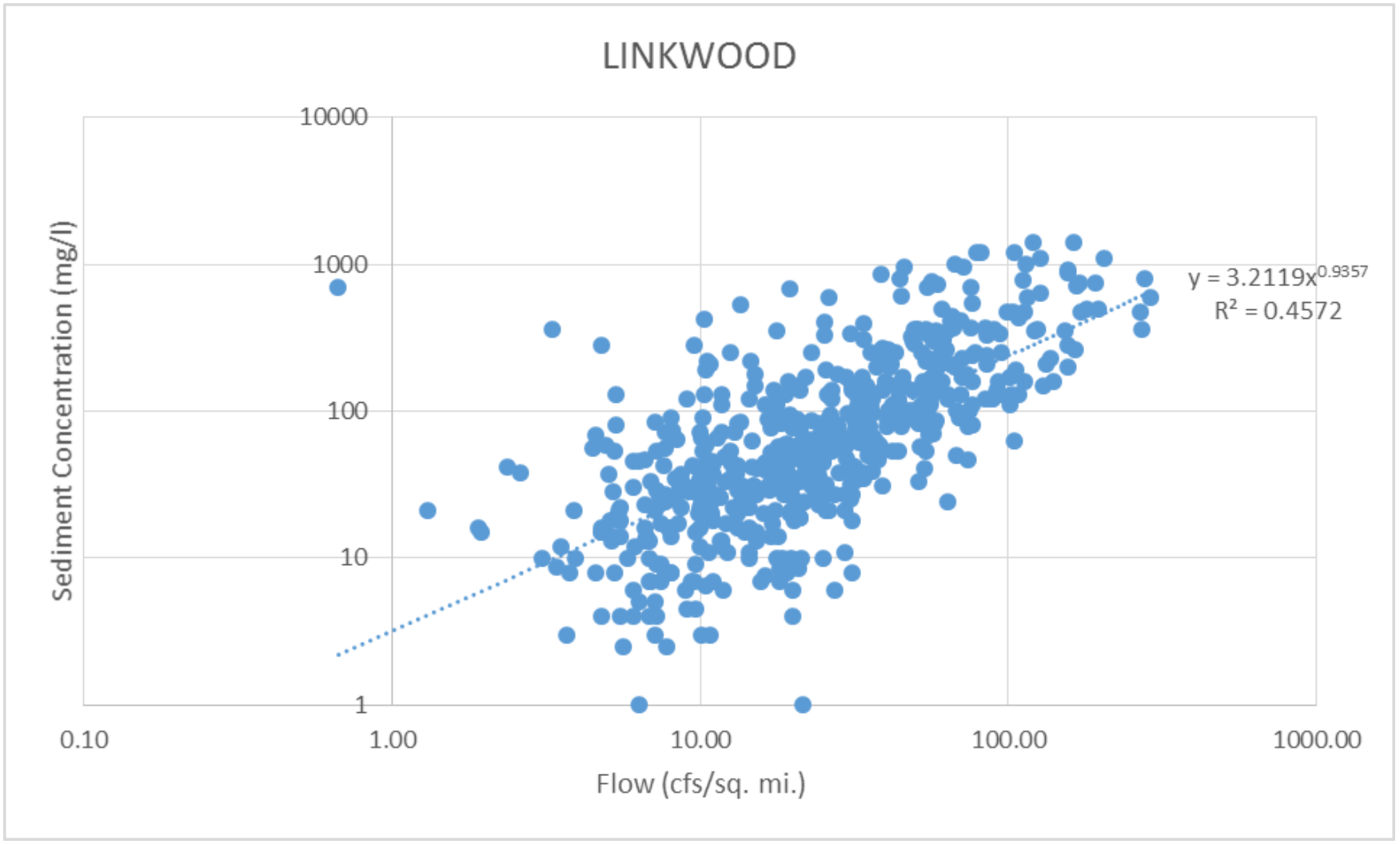
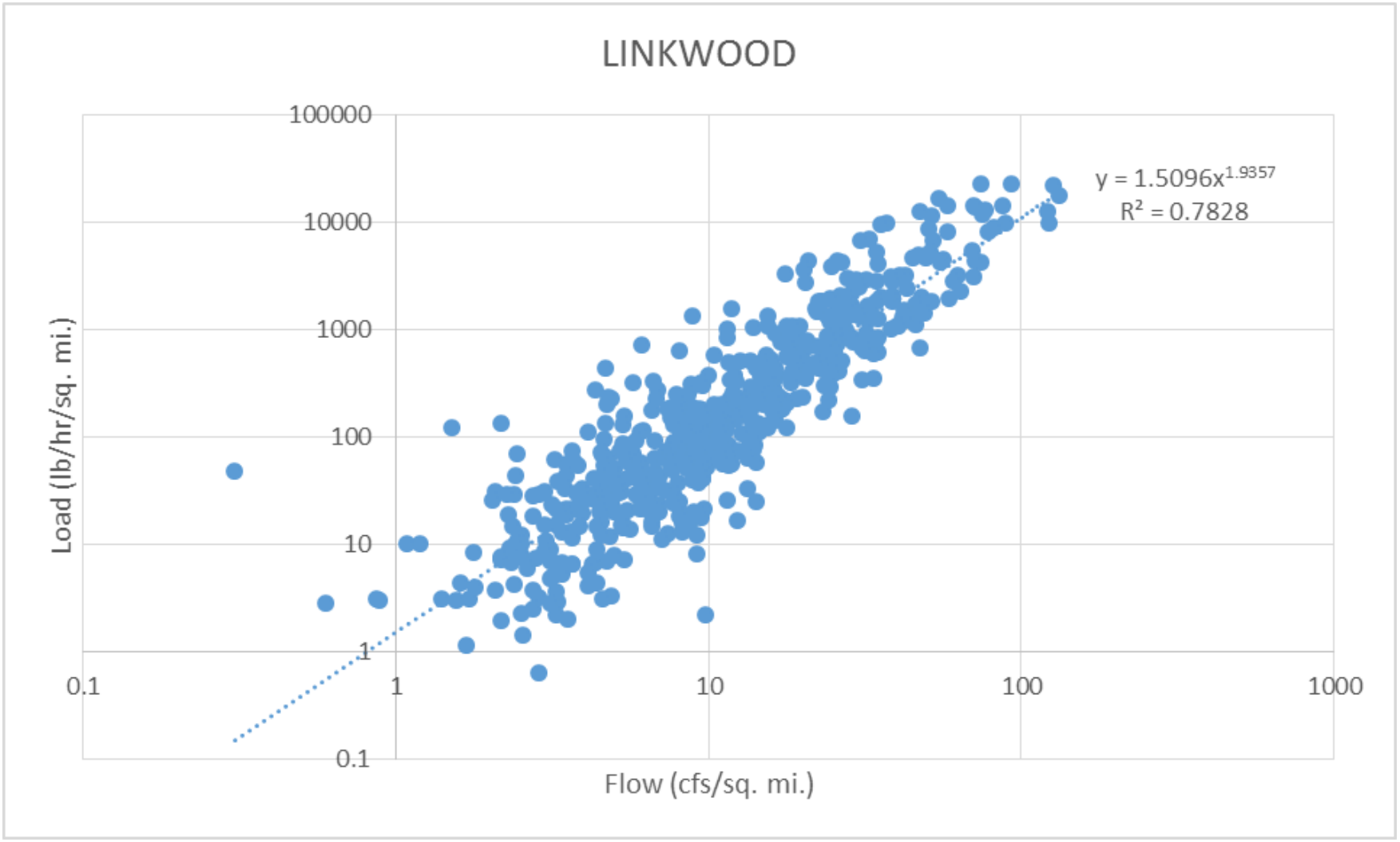
Flow-Concentration Relation



Flow-Load Relation



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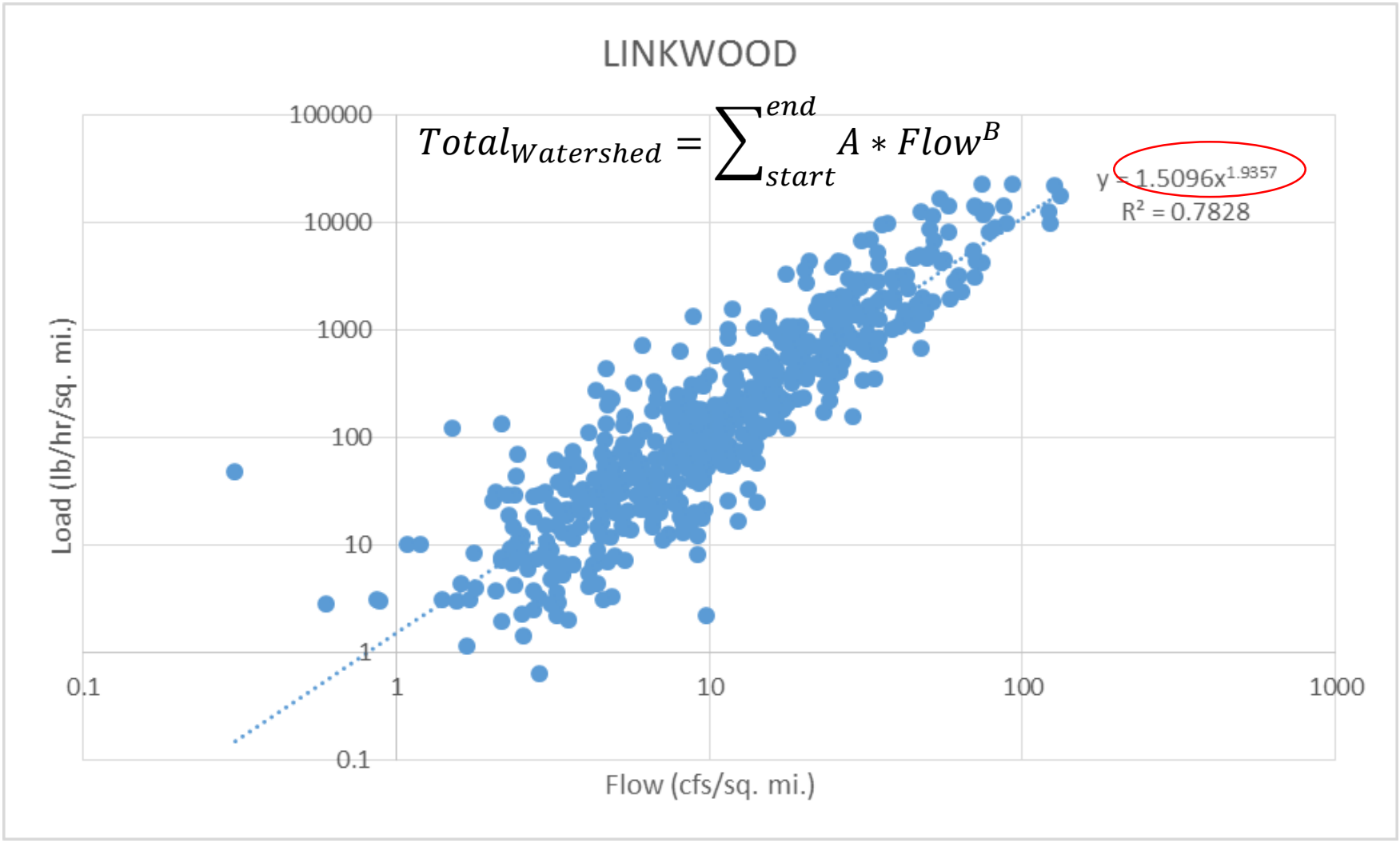
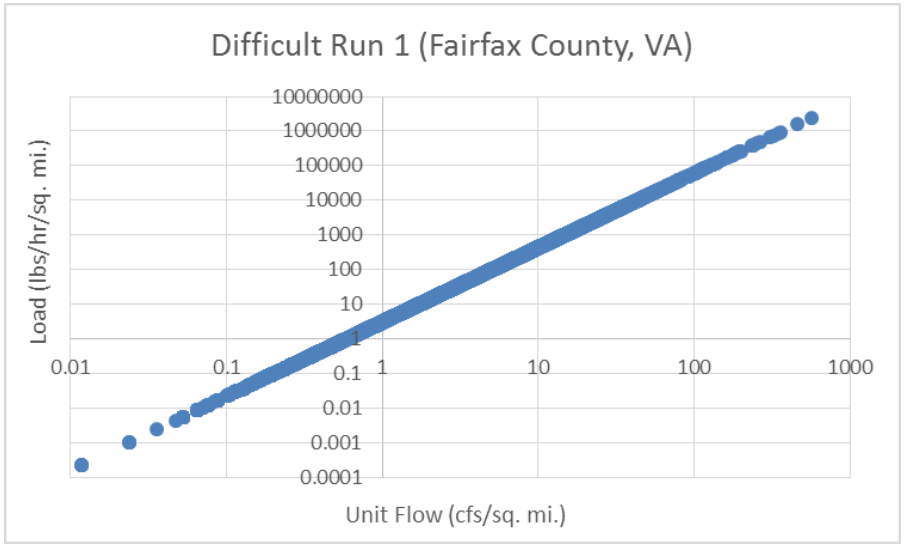
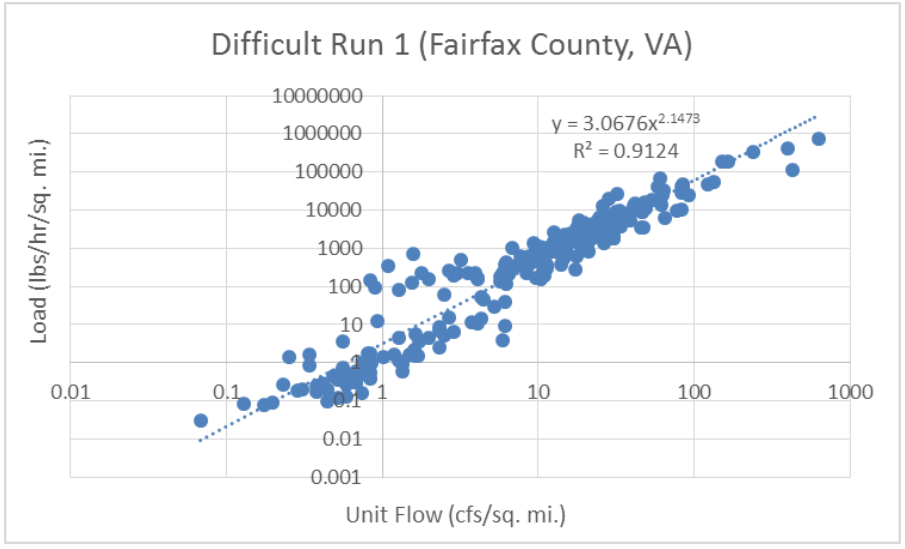


Flow Range Overlap





SSR Estimation

- Flow-load relation used to estimate total watershed load
- Event Mean Concentration for county from NSQD represents upland
  - $Outfall(upland) = EMC_{Storm} * Flow_{Total}$

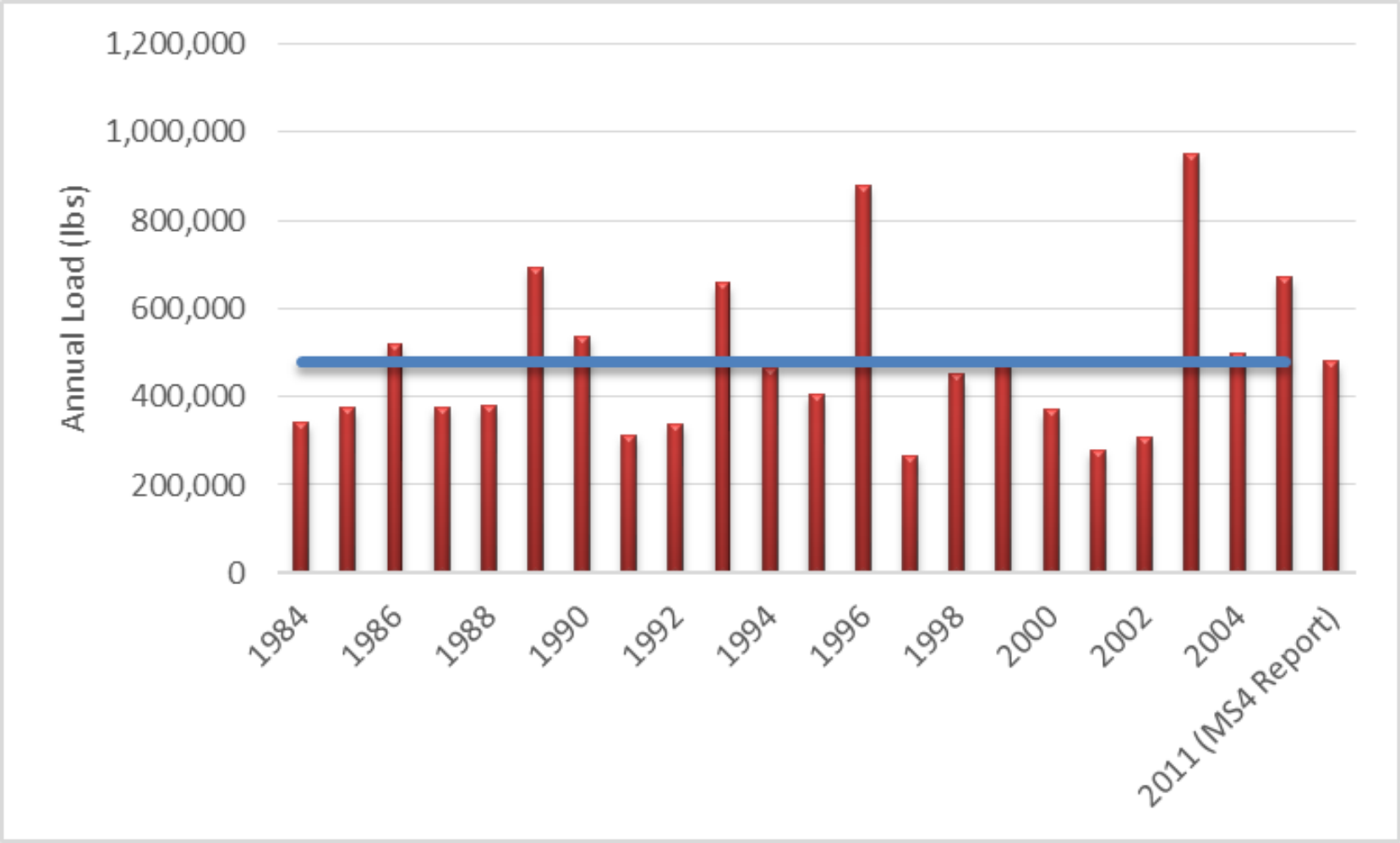
Linkwood		
Fraction Impervious	0.694	
OUTFALLS		
TSS Storm EMC		
	Mean	
	mg/L	
	40	
Surface Flow (in/ac/hr)	Baseflow & Interflow (in/ac/hr)	
560.7	124.3	
	Mean Load (lbs/ac)	
	6,208.6	
Annual Loads		
	Mean (lbs/ac/year)	
	295.6	
Total annual load	416,273	lbs

Average Annual Load (lbs)	4,561,082	lbs/yr
Upland Load	416,273	lbs/yr
Corridor Load	4,144,809	lbs/yr
SSR	0.9087	

Watershed	**Upland TSS EMC (mg/l)**
Difficult Run 1	49.82
Difficult Run 5	49.82
Paint Branch	58.00
Breewood	58.00
Moores Run @ Radecke Ave	44.04
Stony Run @ Linkwood	40.00
West Branch Herring Run @ Idlewylde	40.00
Scott's Level - 01	32.41
Powder Mill Run	40.00
Average	**49.86**

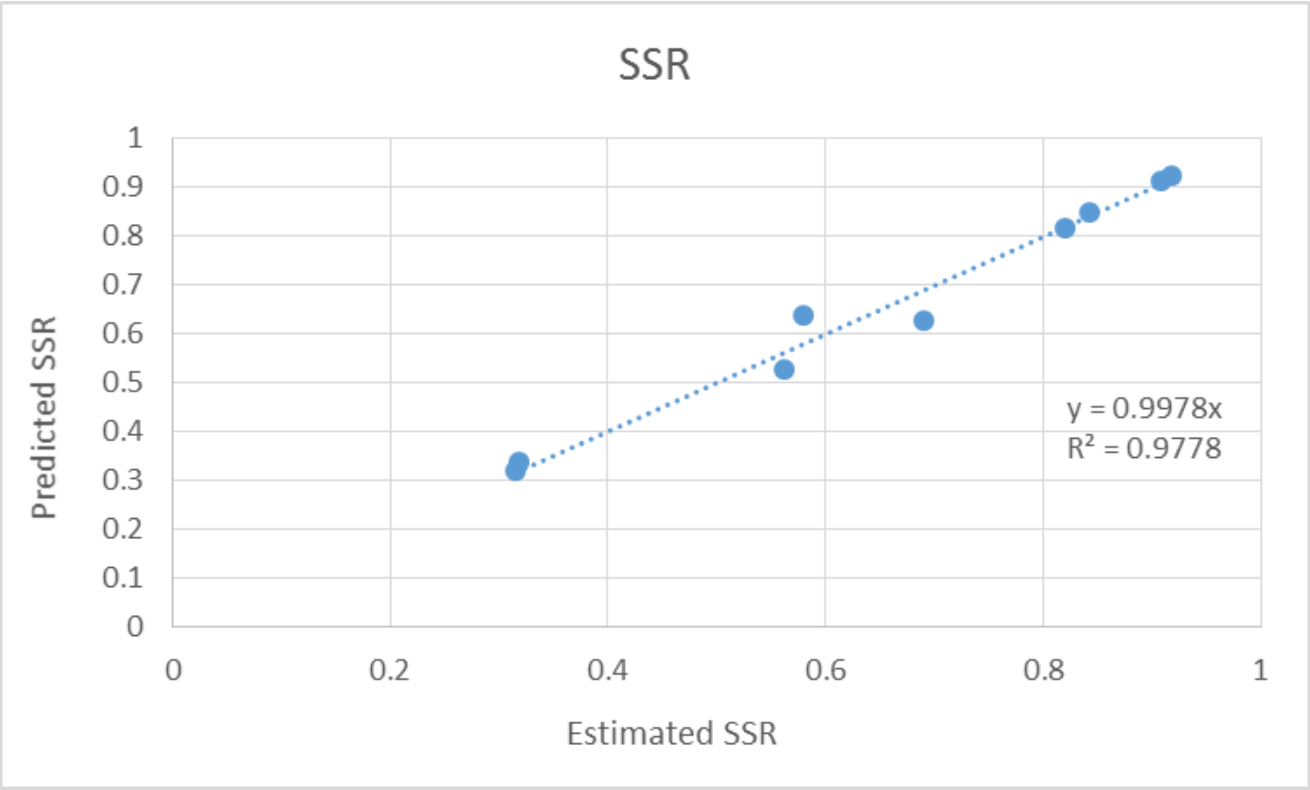
Scott's Level

MS4 Report for 2011 = 480,183 lbs
Annual Average (flow-load) = 480,195 lbs



Initial Predictive Regression

- $SSR = 0.001364 * Drainage\ Area\ (sq\ mi.) + 0.282962 * Impervious\ Cover\ (fraction) + 2.456579 * Forest\ Cover\ (fraction) + 0.807264 * Fraction\ HSG\ CD + 0.128841 * Riparian\ Length(fraction\ of\ stream) - 0.441092$



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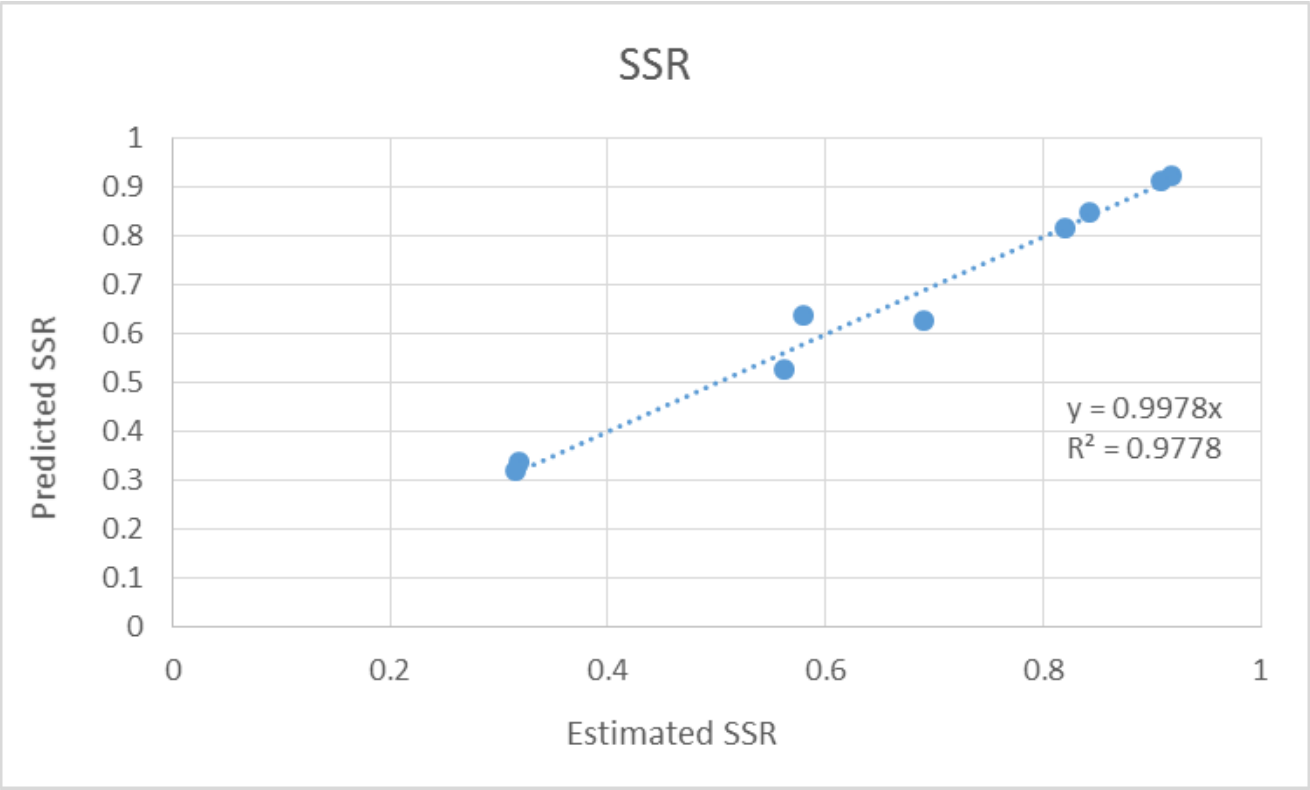
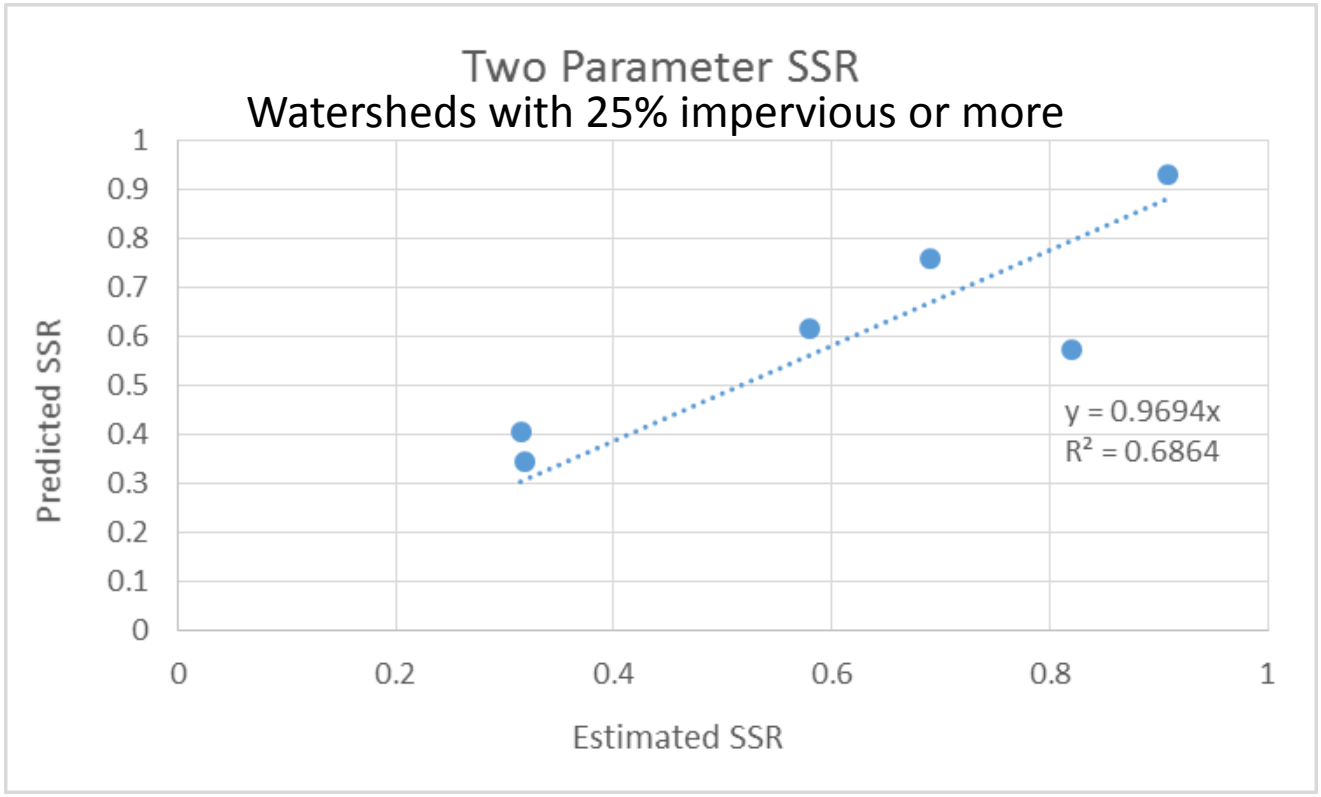


Final – Simplified Predictive Regression

- $SSR = 1.4085 * Impervious\ Cover\ (fraction) + 0.5341 * Fraction\ HSG\ CD - 0.2828$



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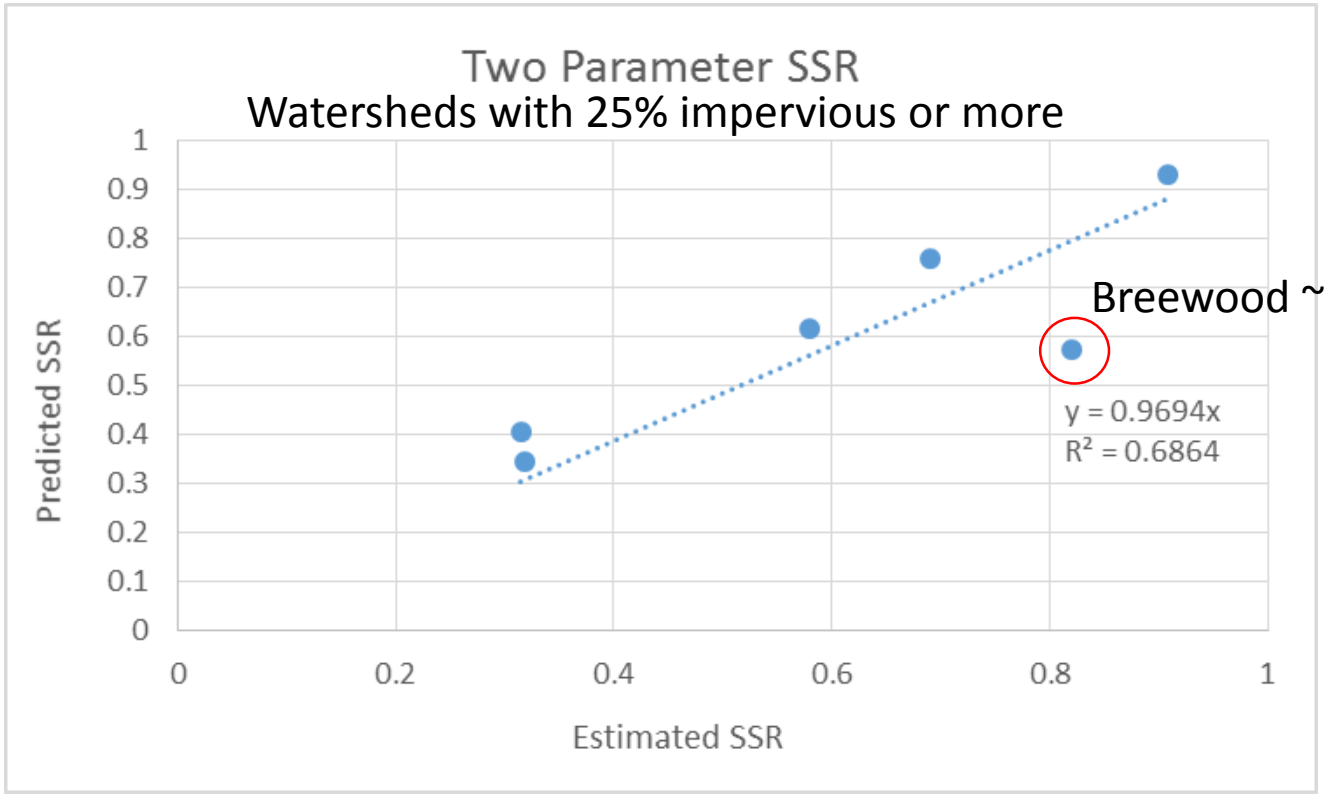

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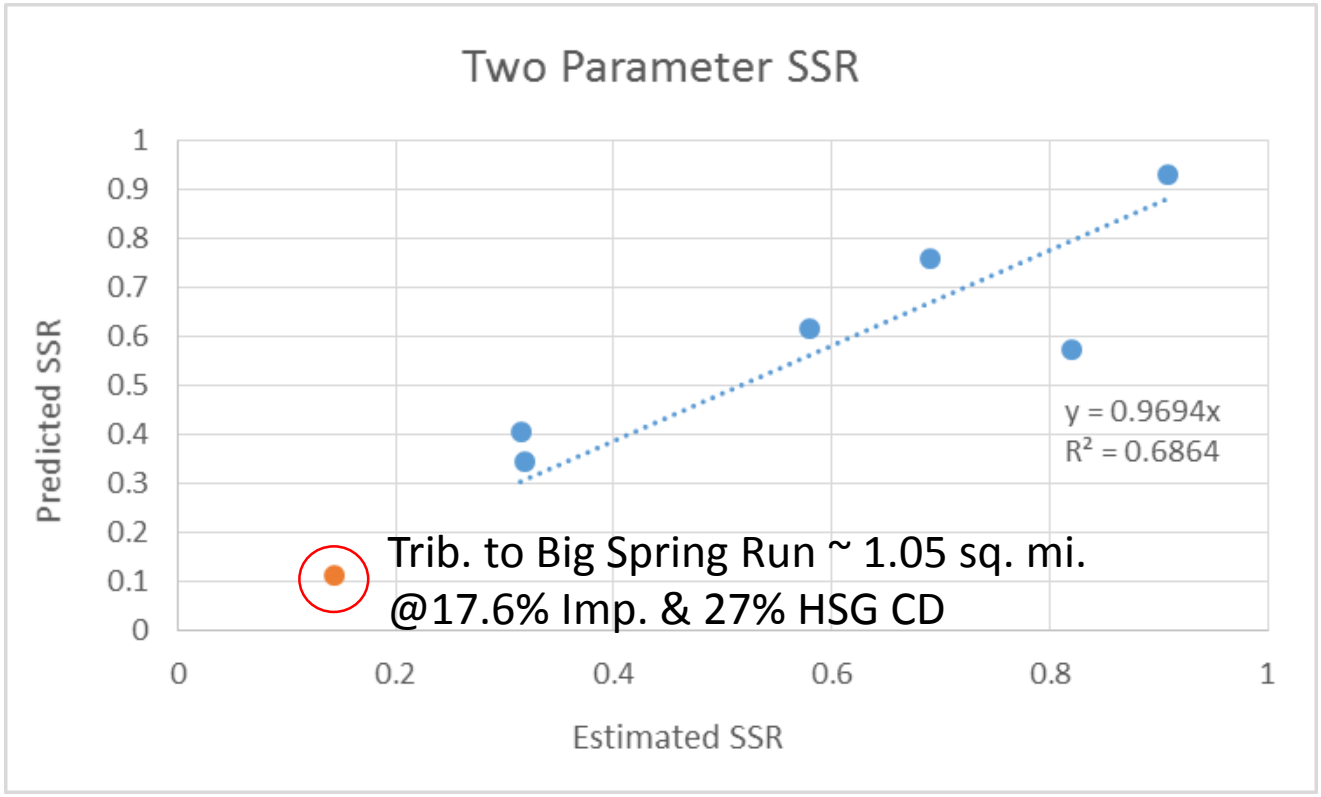
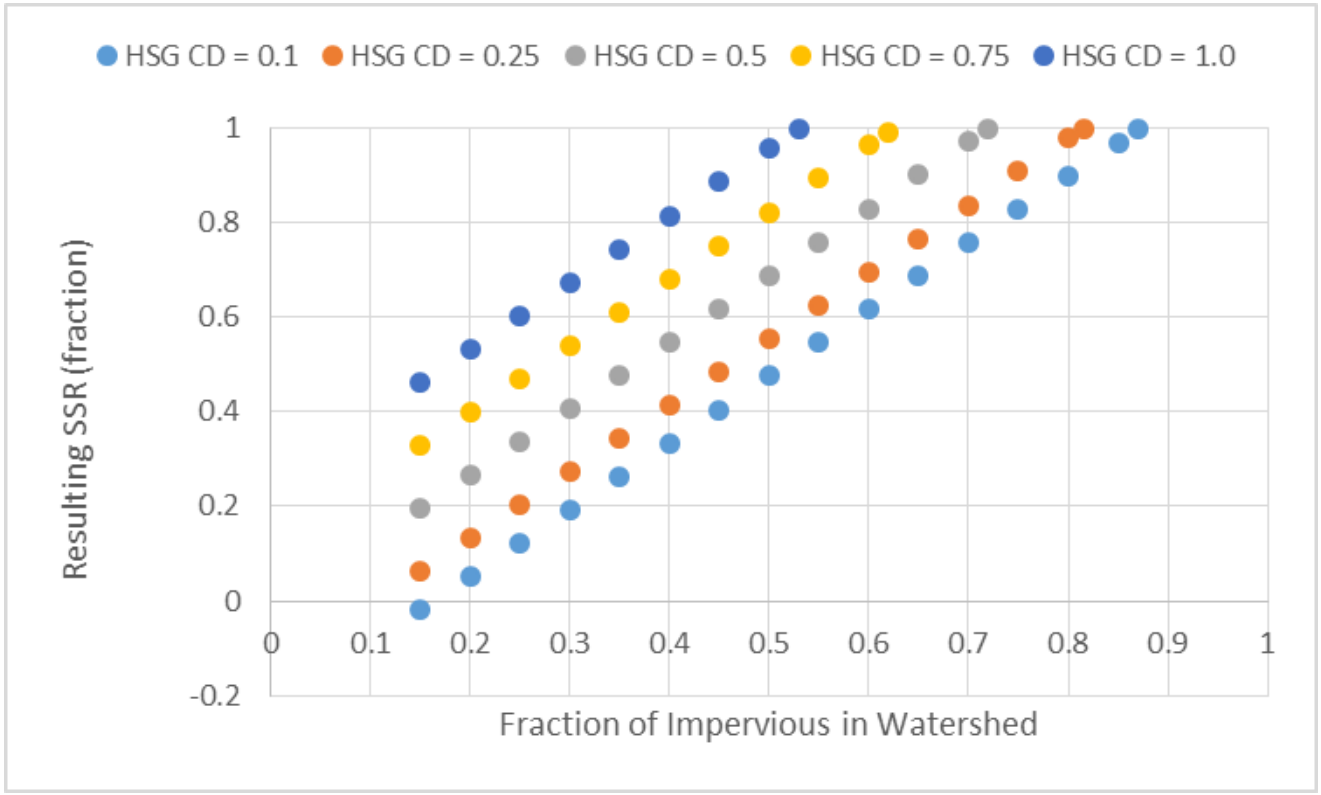


Predicted SSR for Small Urban Streams

- General envelope of potential SSR results



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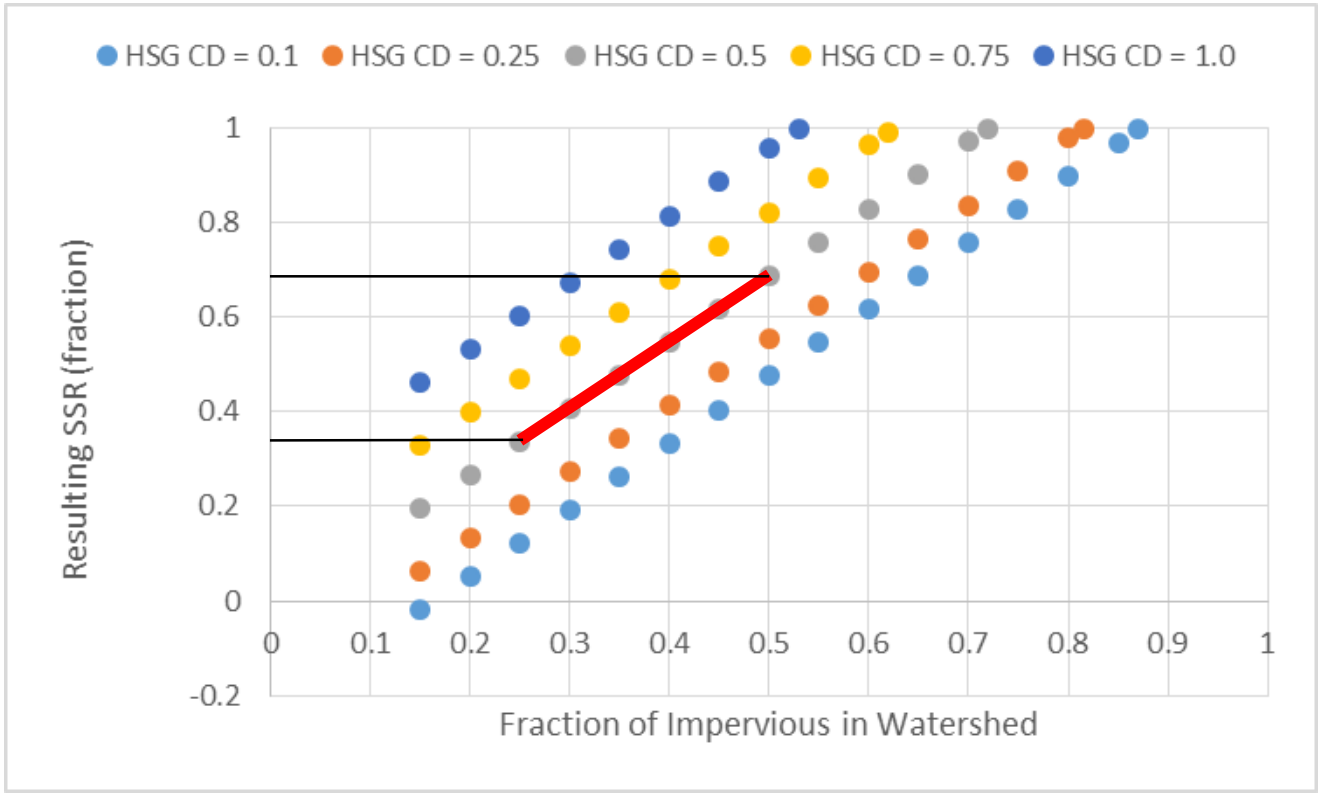
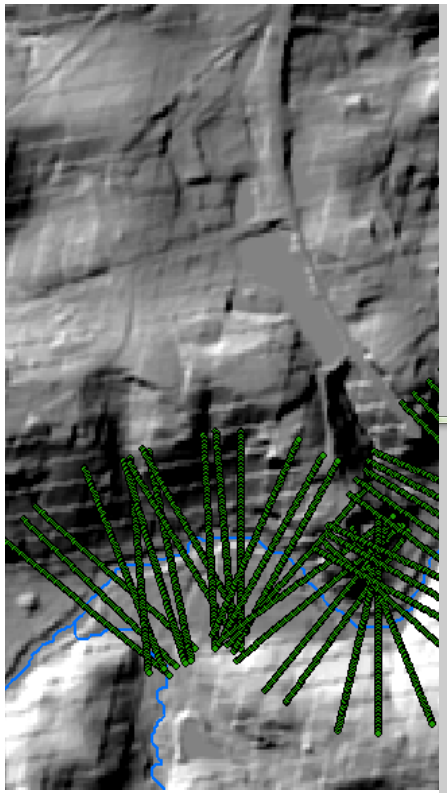


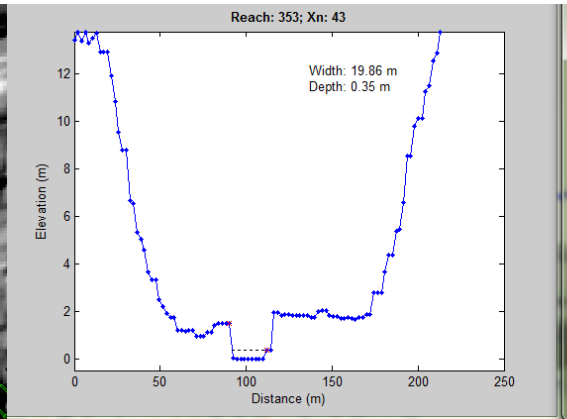
Phase 6 Implementation

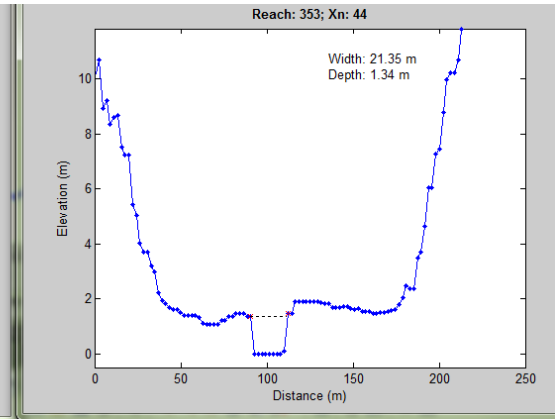
- RUSLE based on work by USGS and Tetra-Tech represents upland load
  - Impervious cover would contribute no sediment
  - Apply the predicted SSR and “back-calculate” sediment from stream
- Sediment EMCs
  - Upland loads calculated on-the-fly with modeled flow
    - Tetra Tech NSQD and Literature EMC (140.44 mg/l)
    - CWP Maryland MS4 analysis EMC (92.21 mg/l)
    - NSQD Bay States average (CWP, 2014) EMC (72.77 mg/l)
  - Apply the predicted SSR and “back-calculate” sediment from the stream
- Phase 5.3.2 total load (fallback)
  - SSR to parse load into upland and stream

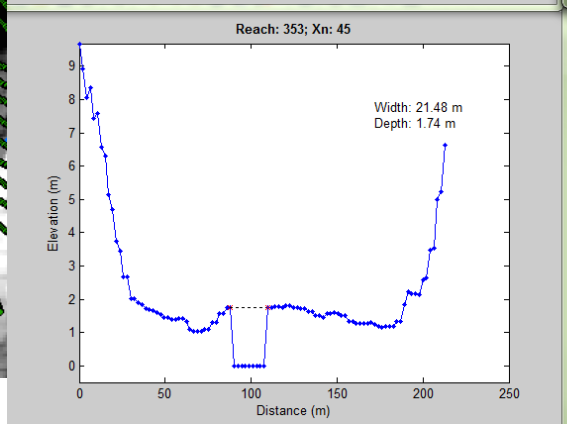
Rural Streams (<15% Imp.) - USGS

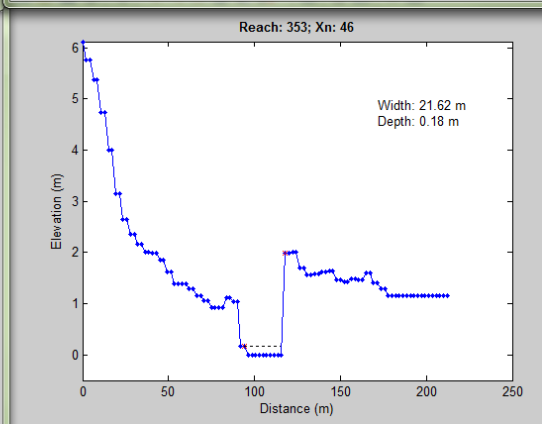
- Spatial analysis estimating Stream Parameters
- Sediment balance based on USGS monitoring data











Questions?

- References

  - Center for Watershed Protection. 2013. Technical Memorandum: Sediment Stream Loading Literature Review in Support of Objective 1 of the Sediment Reduction and Stream Corridor Restoration Analysis, Evaluation and Implementation Support to the Chesapeake Bay Program Partnership.
  - Center for Watershed Protection. 2014a. Technical Memorandum: Stream Sediment Studies in Support of Objective 1 of the Sediment Reduction and Stream Corridor Restoration Analysis, Evaluation and Implementation Support to the Chesapeake Bay Program Partnership.
  - Center for Watershed Protection. 2014b. Technical Memorandum: Analysis of Stream Sediment Monitoring in Support of Objective 1 of the Sediment Reduction and Stream Corridor Restoration Analysis, Evaluation and Implementation Support to the Chesapeake Bay Program Partnership.
  - Center for Watershed Protection. 2015. Technical Memorandum: Analysis of Stream Sediment Monitoring to create a watershed characteristic regression in Support of Objective 1 of the Sediment Reduction and Stream Corridor Restoration Analysis, Evaluation and Implementation Support to the Chesapeake Bay Program Partnership.