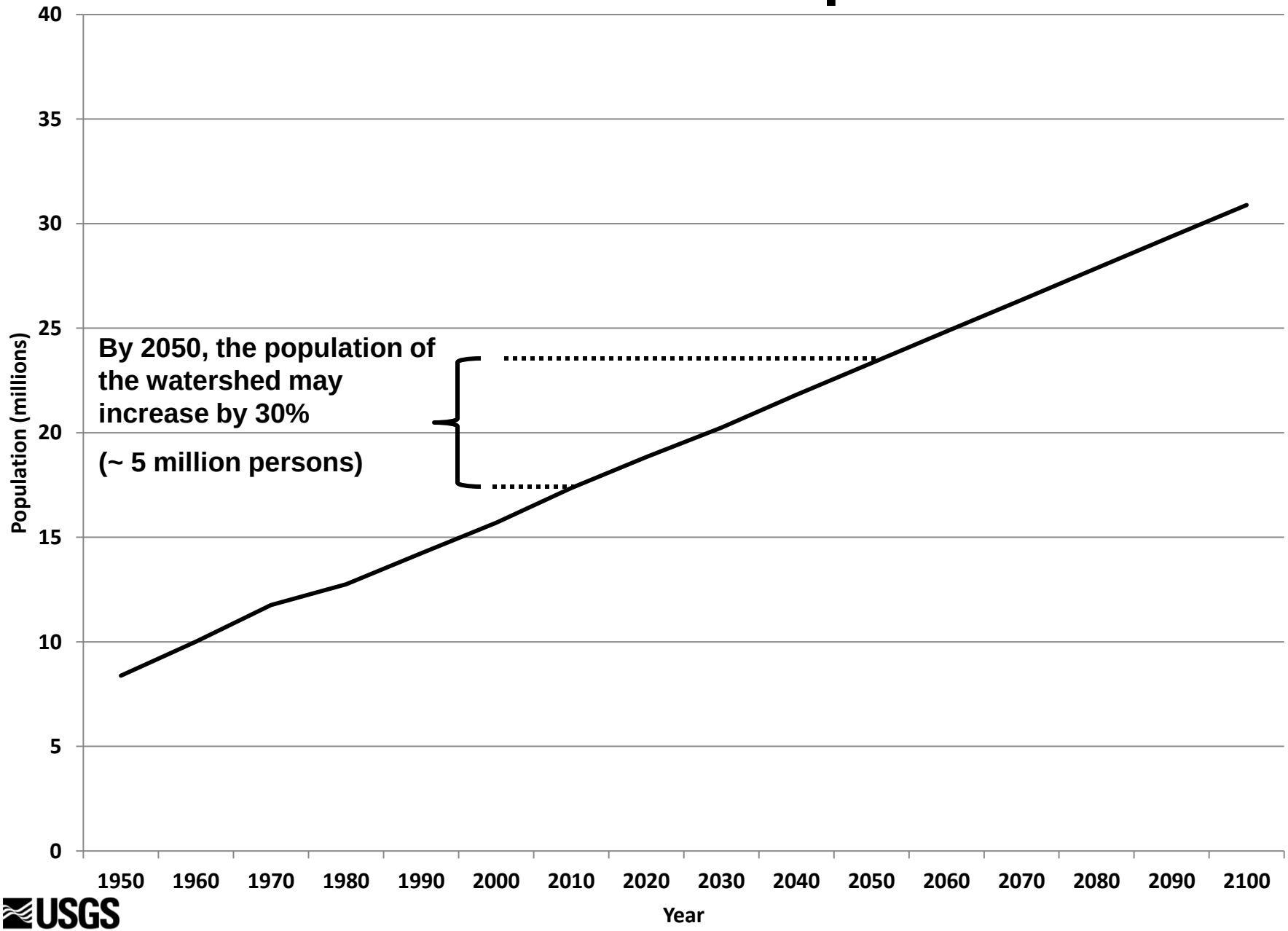
Chesapeake Bay Program
A Watershed Partnership

Interconnections Between Pervious and Impervious Areas in Urban Watersheds

Peter Claggett, Geographer
U.S. Geological Survey

Future Watershed Population



USGS

Estimating Impervious and Pervious Surface Area In the Chesapeake Bay Watershed

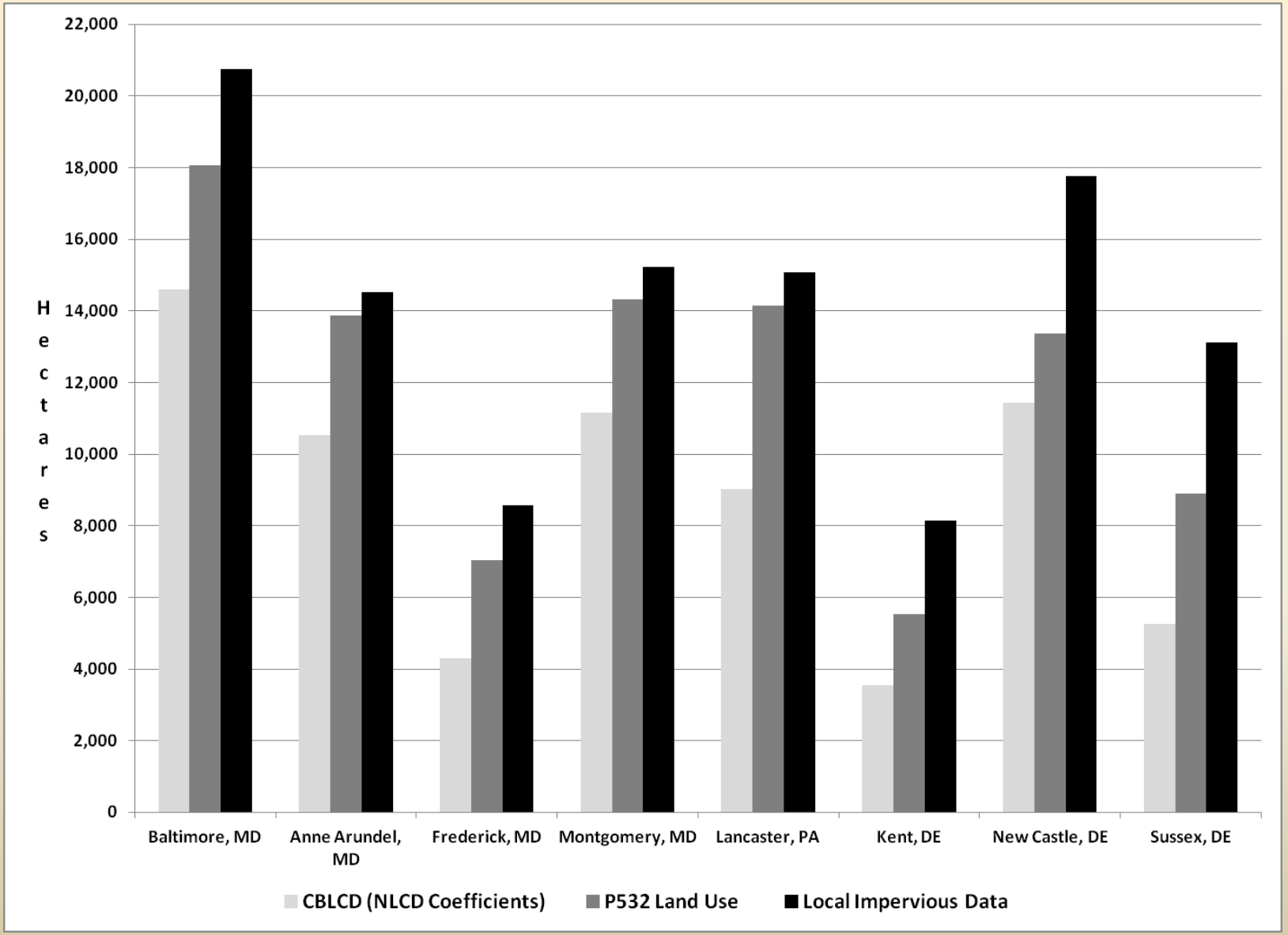
Model Version	Impervious Surface (circa 2001/02)	Pervious Surface (circa 2001/02)
CBLCD (land cover)	809,318	2,341,577
Phase 5.3.2 (land use)	1,269,030	3,398,732

Claggett, et al., 2013.

USGS

County-level Impervious Surface Estimates

Landsat (Phase 5.3.0), Modeled (Phase 5.3.2), and Local Data



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Claggett, et al., 2013.

TABLE 11. Contribution of Residences and Roads to Regional Impervious Surface and Turf Grass Area Estimates for 2006 in the Chesapeake Bay Watershed.

Claggett, et al., 2013.

	Zone Area	Impervious Surfaces		Turf Grass	
Source	(ha)	(ha)	(%)	(ha)	(%)
Urban zone	950,229	263,887	51.38	664,968	48.35
Suburban zone, residential lots	221,310	8,162	1.59	186,099	13.53
Suburban zone, roads		16,431	3.20	0	0.00
Rural zone, residential lots	15,295,590	90,779	17.68	524,353	38.12
Rural zone, roads		134,300	26.15	0	0.00
Total	16,467,129	513,559	100.00	1,375,420	100.00

For the Phase 6 Watershed Model:

Should all impervious and pervious surfaces be treated equal?

Is the per-unit area load contribution from hydrologically connected surfaces significantly different from disconnected and isolated surfaces?

If yes:

- How should connectivity be assessed?
- How should the differences in loads be estimated?
- How should the differences in loads be represented in HSPF?

If no:

- Does pattern matter?
- Is there a threshold response?
- What is the threshold?
- Is the threshold the same in all watersheds?

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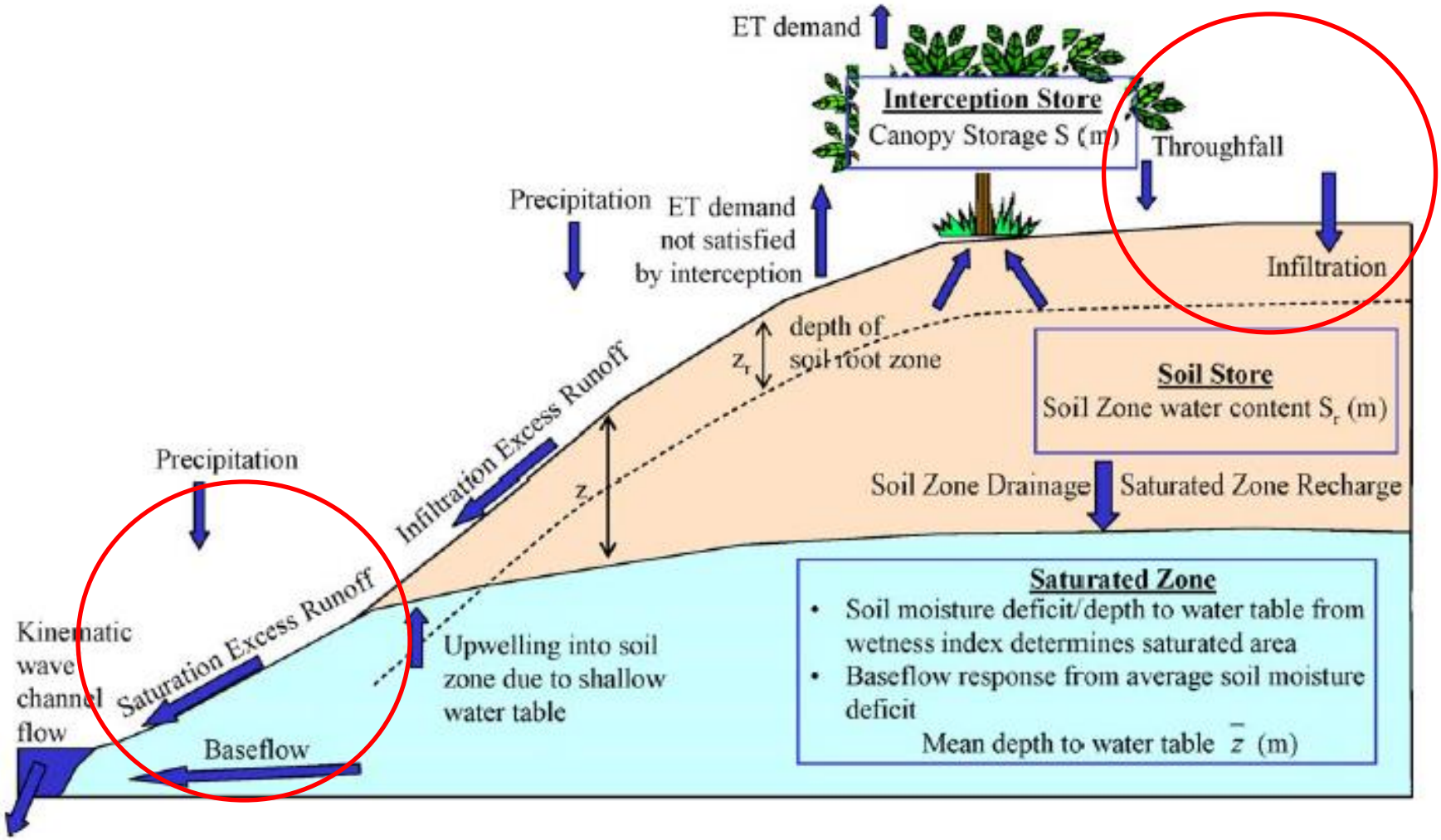
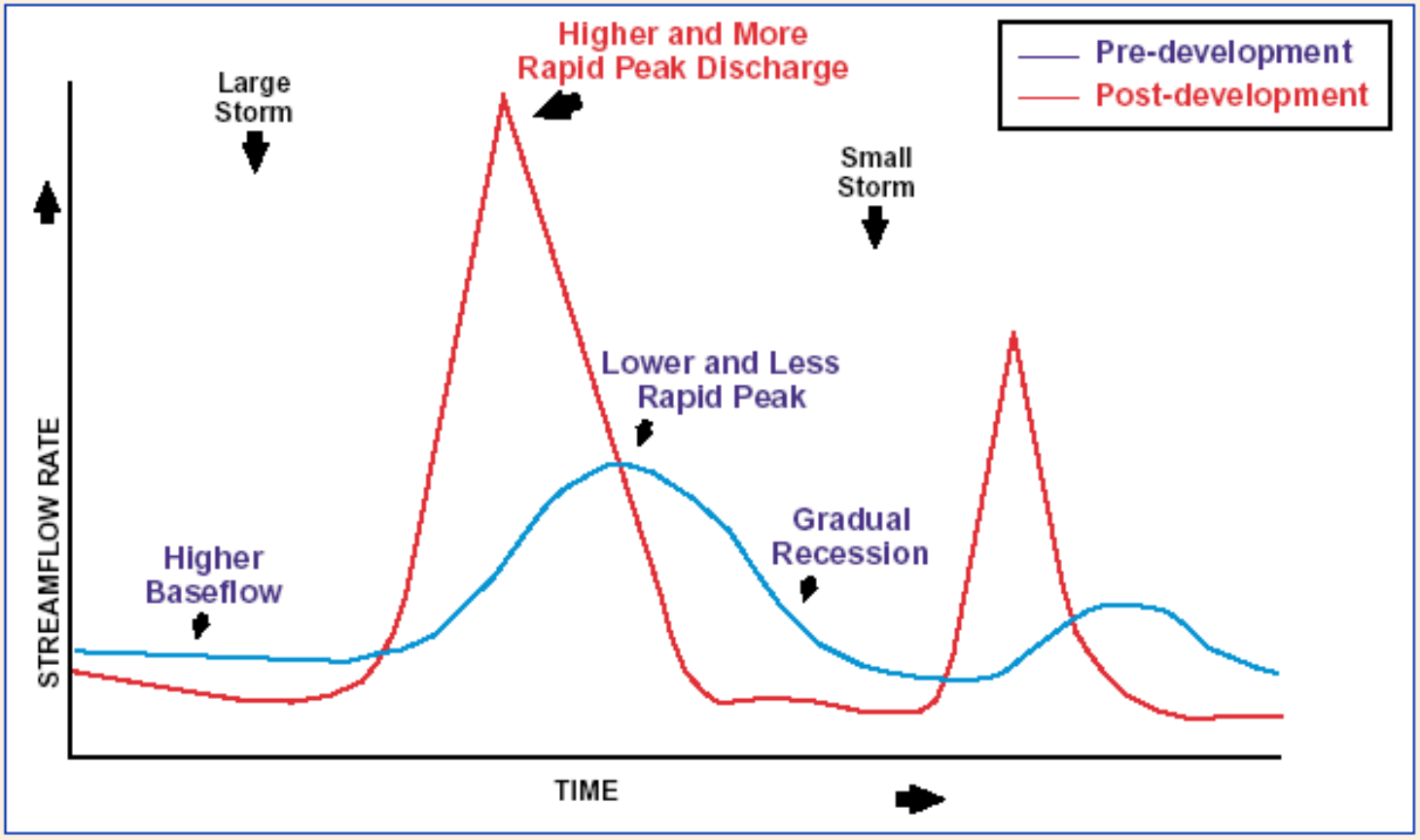


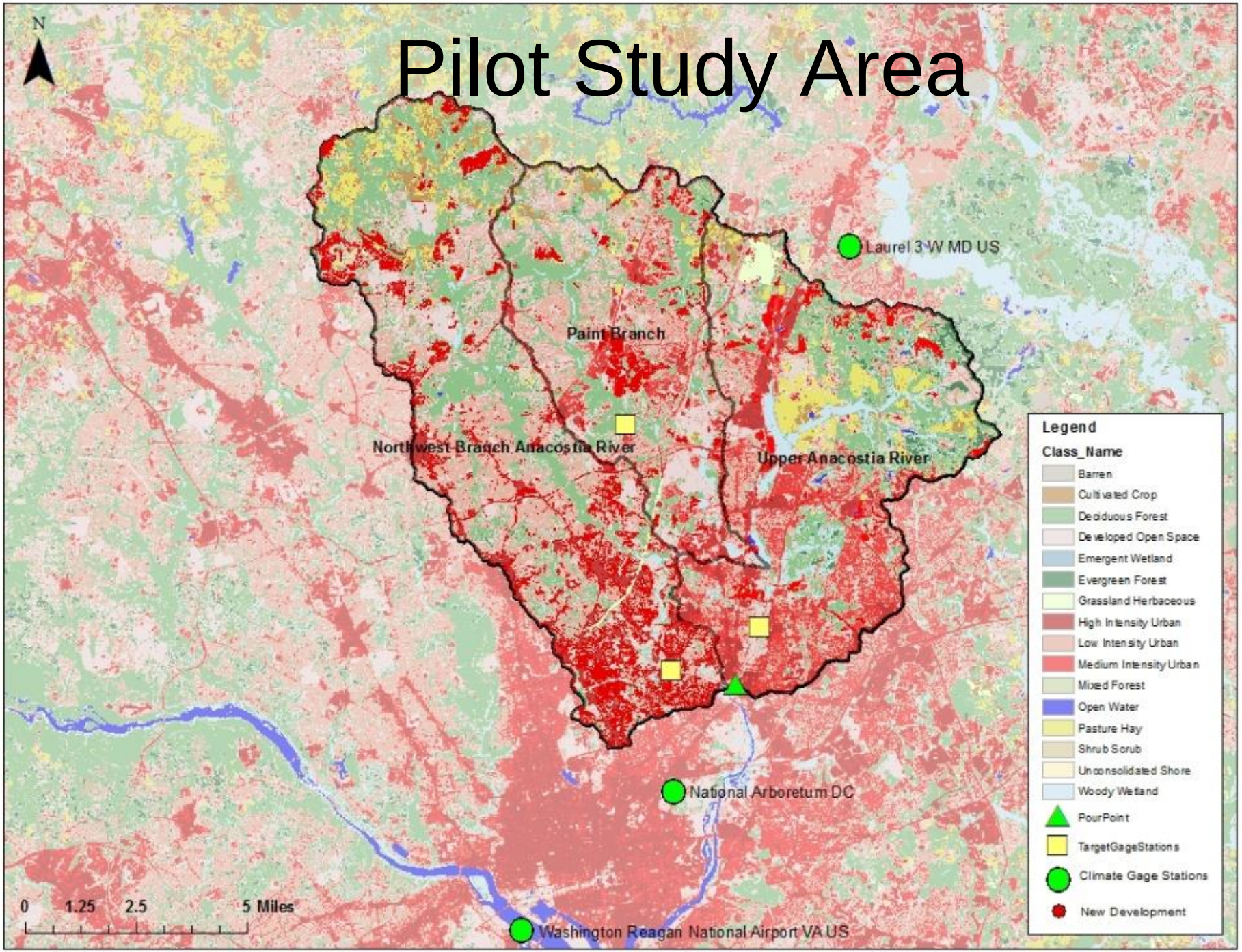
Fig. 1. Schematic of the physical processes represented by the TOPNET modeling system.

What are the impacts of development on flow?

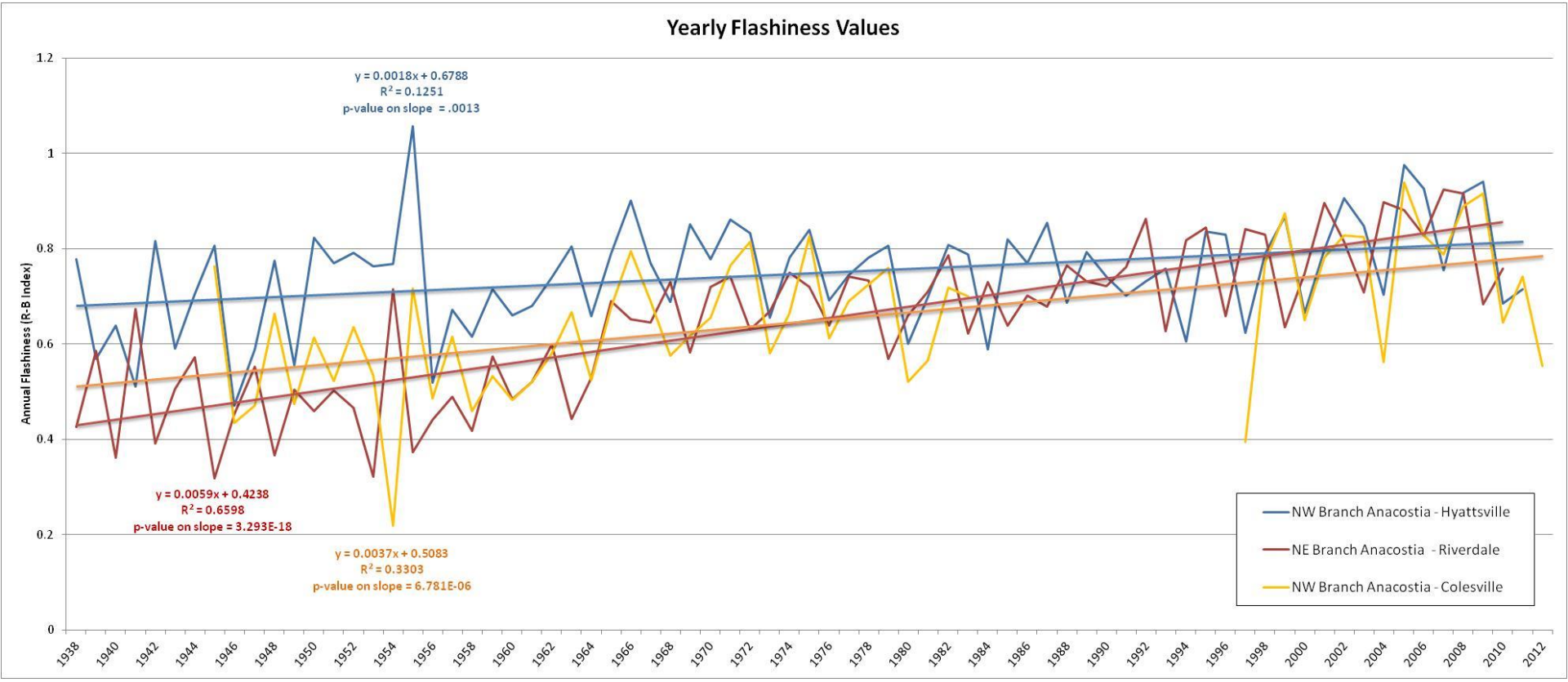


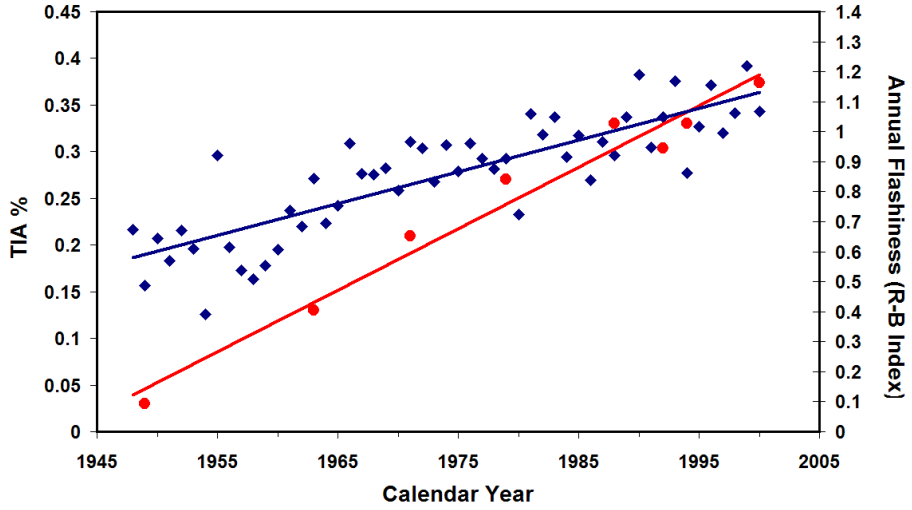
An altered hydrograph, typical of watersheds under the influence of impervious surface area.

K. Rice, USGS


Pilot Study Area
N
Laurel 3 W MD US
Paint Branch
Northwest Branch Anacostia River
Upper Anacostia River
National Arboretum DC
Washington Reagan National Airport VA US
0 1.25 2.5 5 Miles
Legend
Class_Name
Barren
Cultivated Crop
Deciduous Forest
Developed Open Space
Emergent Wetland
Evergreen Forest
Grassland Herbaceous
High Intensity Urban
Low Intensity Urban
Medium Intensity Urban
Mixed Forest
Open Water
Pasture Hay
Shrub Scrub
Unconsolidated Shore
Woody Wetland
PourPoint
TargetGageStations
Climate Gage Stations
New Development

Annual Changes in Flashiness 1938 – 2012
(Richards-Baker Index)

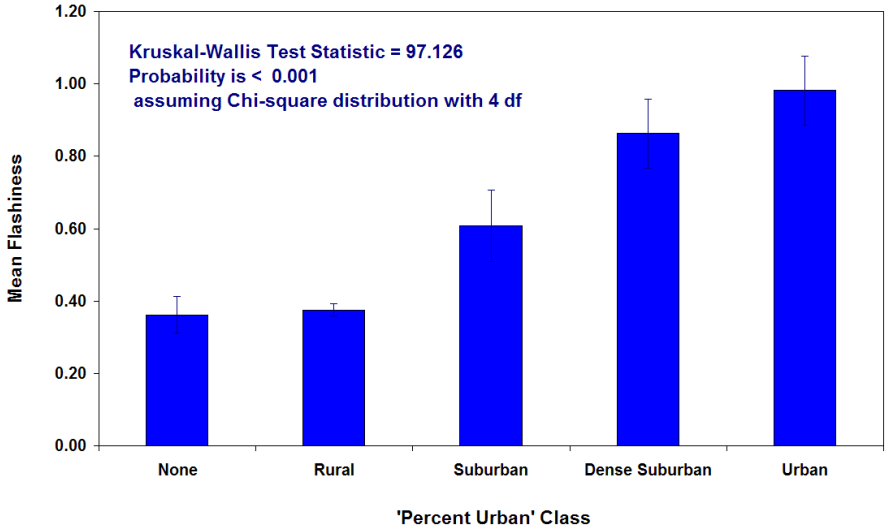




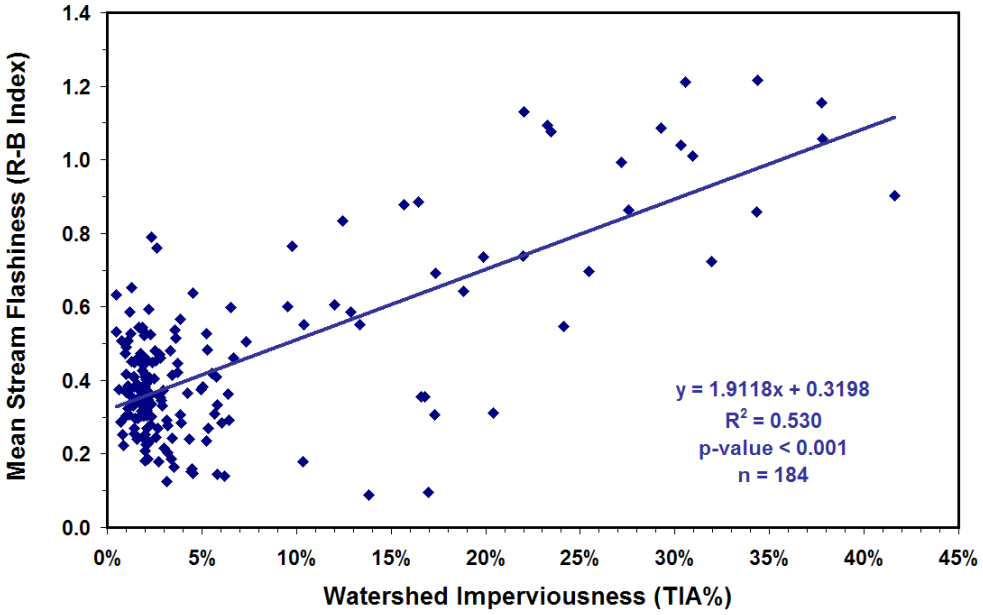
Upper Accotink: Flashiness and TIA% over time

TIA%

Annual Flashiness



Mean Flashiness by 'Percent Urban' Class



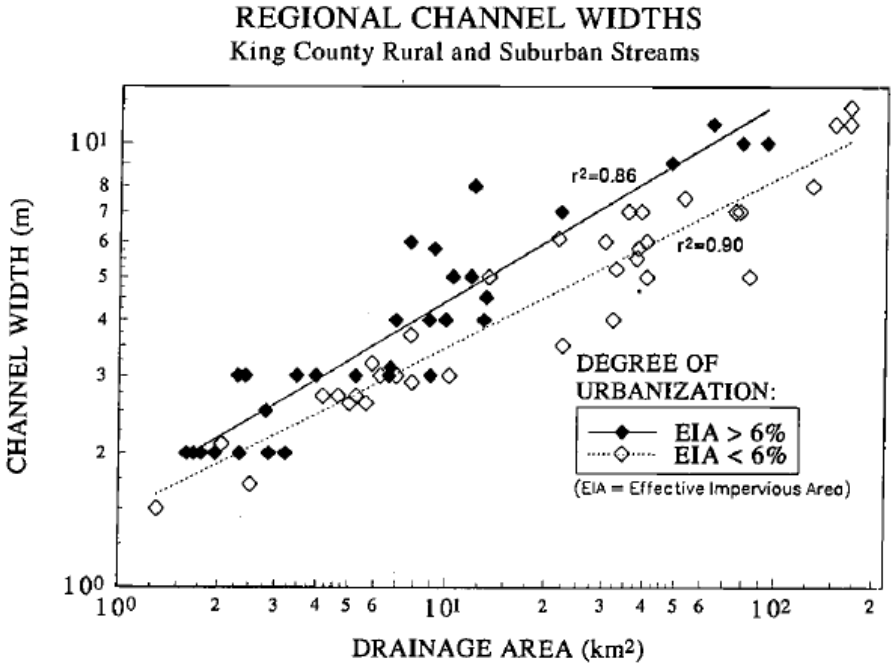
Mean Stream Flashiness vs. Watershed Imperviousness

Jarnagin 2007

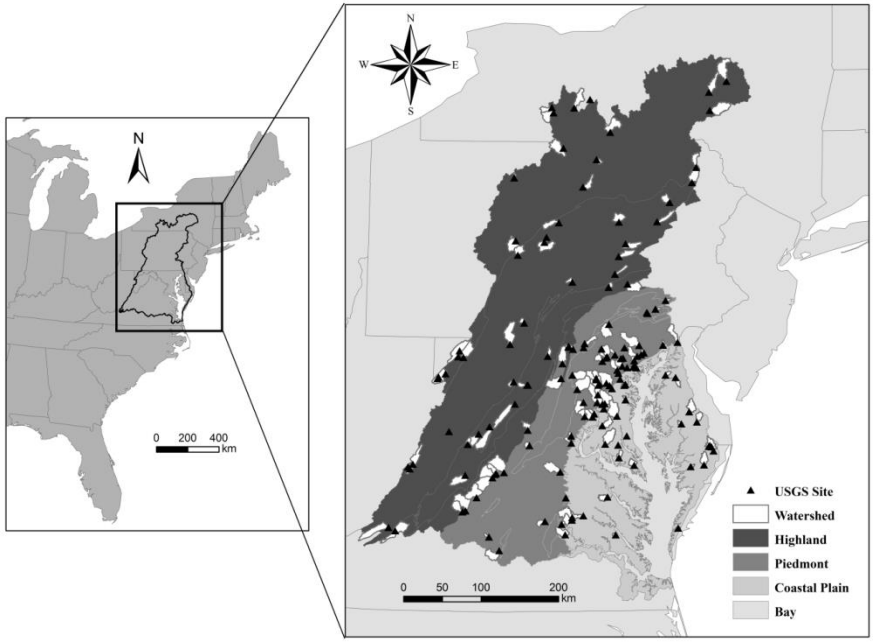
Percent change in Baseflow Contributions

Year	Urban Sewered	Urban Unsewered
1955	−2	−1
1956	5	3
1957	2	0
1958	−6	1
1959	−4	−2
1960	−21	−2
1961	−13	−2
1962	−19	−1
1963	−32	−2
1964	−36	−2
1965	−45	−1
1966	−78	−10
1967	−62	−7
1968	−72	−7
1969	−65	−8
1970	No record	−9

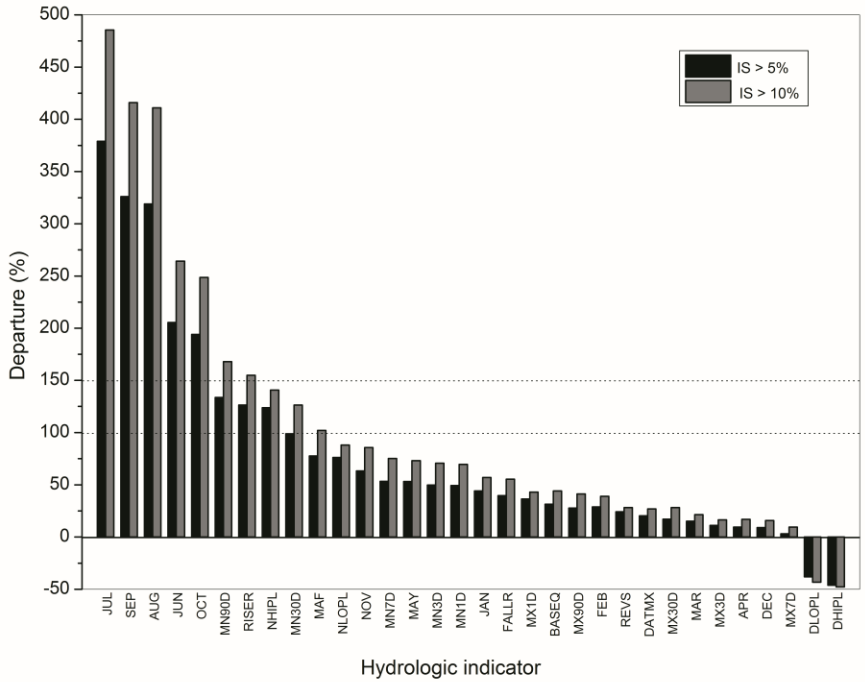
Shuster et al., 2005



Booth and Jackson, 1997



$$D\% = \frac{HI_u - HI_n}{HI_n} \times 100\%$$



Tian et al., submitted (used with permission from author)

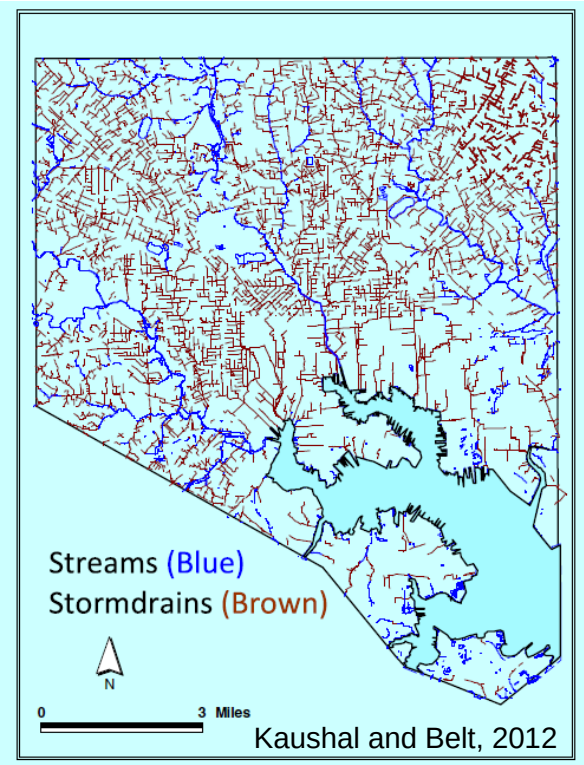
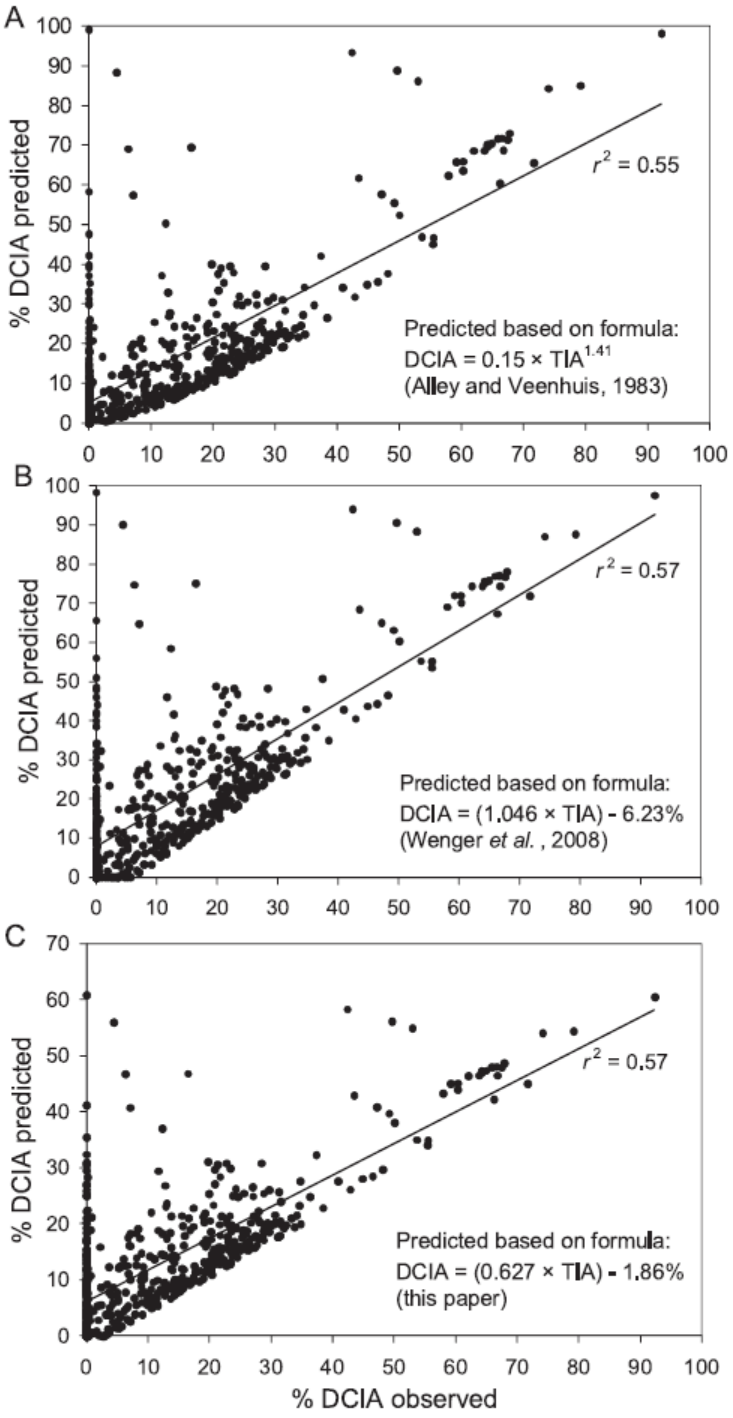
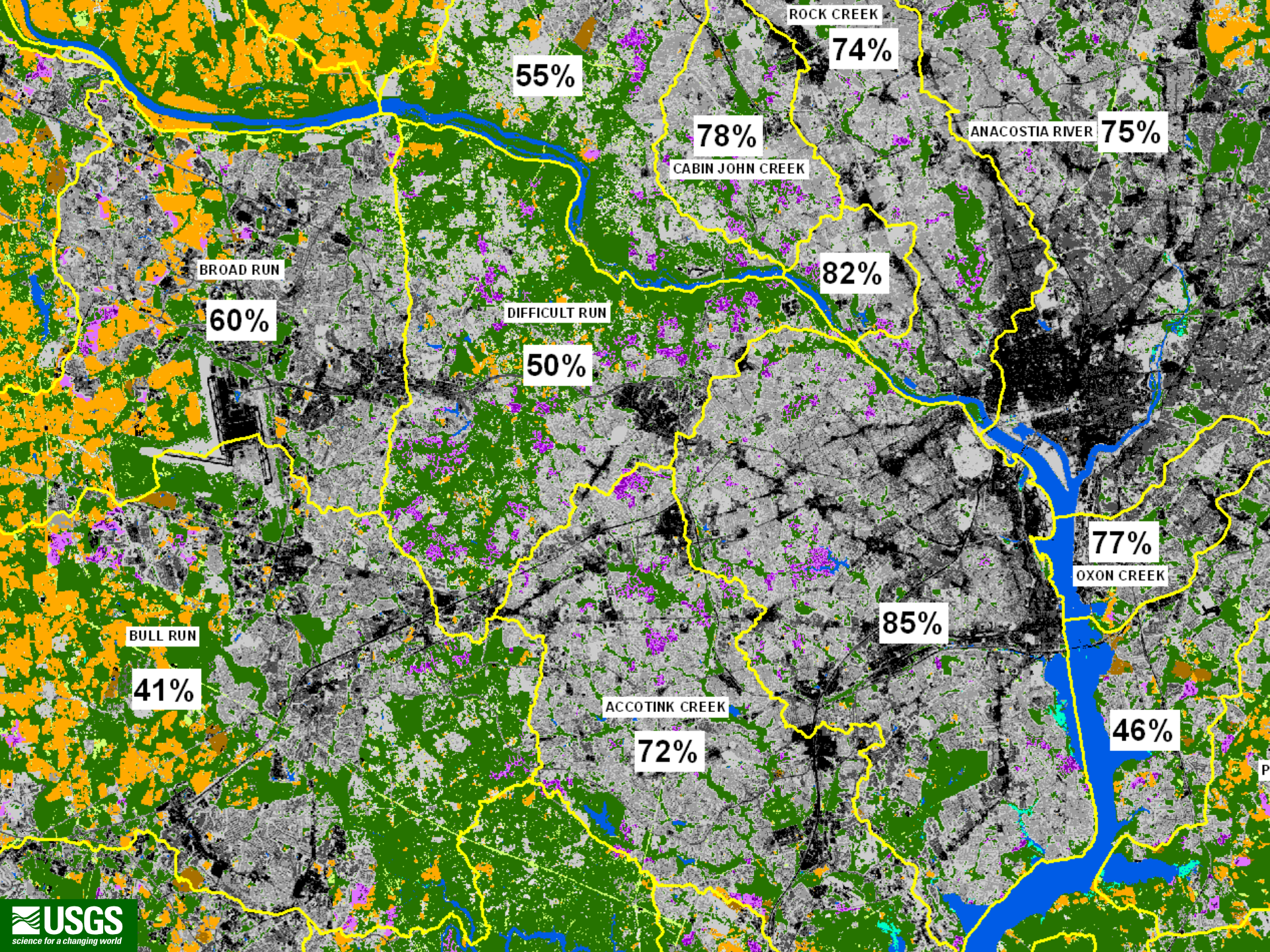


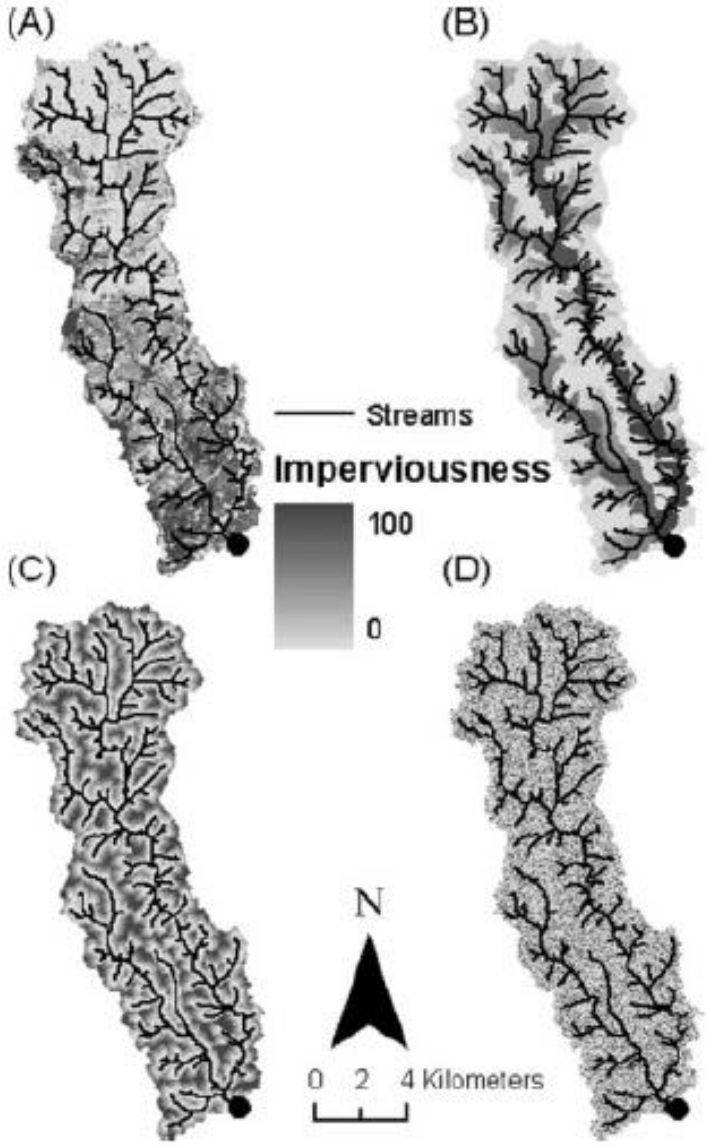
TABLE 4. Total and Directly Connected Impervious Area Categorized by Impervious Surface Type.

	TIA		DCIA		
Surface Type	**(m^2)**	**(%)**	**(m^2)**	**(%)**	**% Connected**
Building	66,168	27.6	44,364	32.9	67.0
Driveway	58,918	24.6	23,525	17.4	39.9
Street	54,432	22.7	48,551	36.0	89.2
Parking area	29,473	12.3	18,144	13.5	61.6
Sidewalk	13,097	5.5	3	0.0	0.0
Concrete	6,963	2.9	211	0.2	3.0
Wooden deck	4,984	2.1	0	0.0	0.0
Pool	2,363	1.0	0	0.0	0.0
Shed	882	0.4	12	0.0	1.3
Other	2,047	0.1	4	0.0	6.7

Parcel scale analysis by Roy and Shuster, 2009

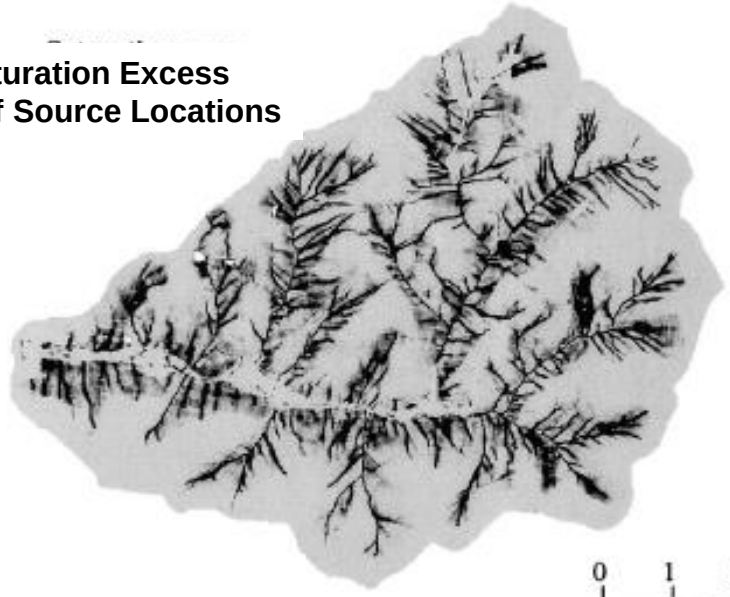



ROCK CREEK
74%
55%
78%
ANACOSTIA RIVER
75%
CABIN JOHN CREEK
BROAD RUN
82%
60%
DIFFICULT RUN
50%
77%
OXON CREEK
85%
BULL RUN
41%
ACCOTINK CREEK
72%
46%
USGS
science for a changing world

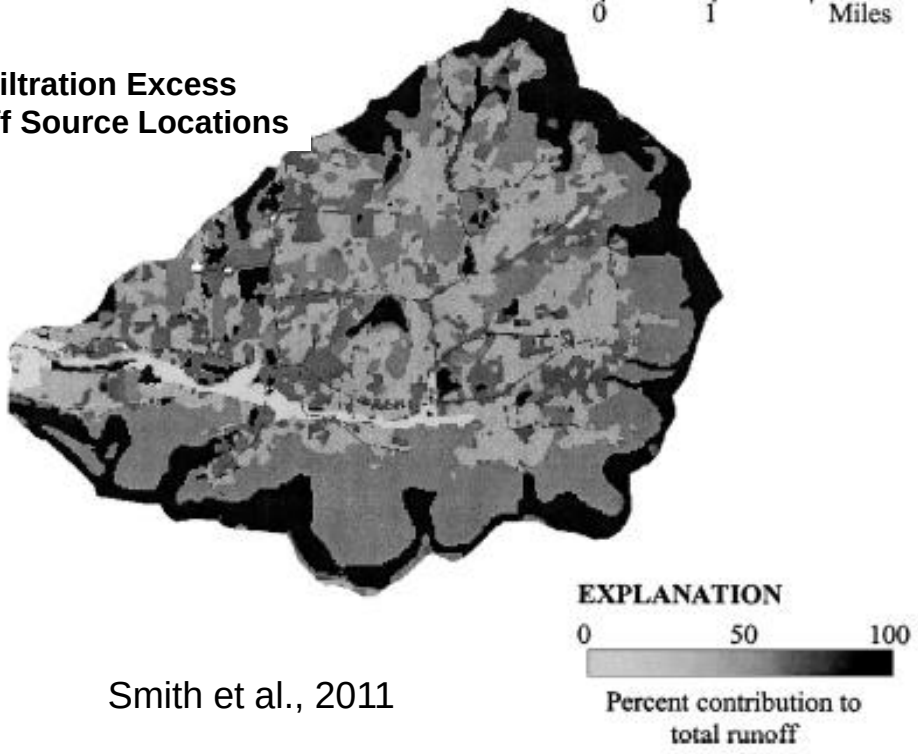


Mejia and Moglen, 2010

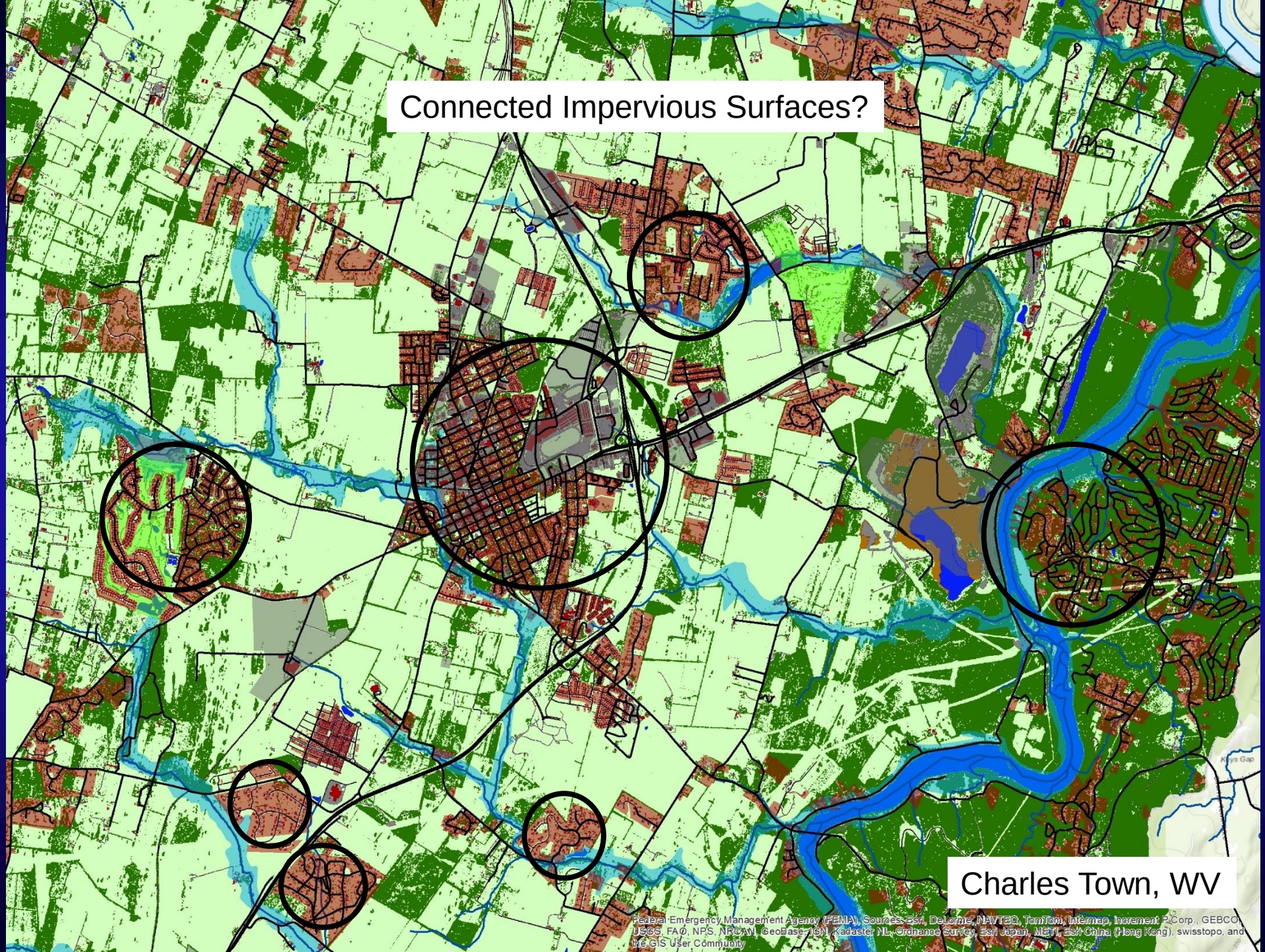
Saturation Excess Runoff Source Locations

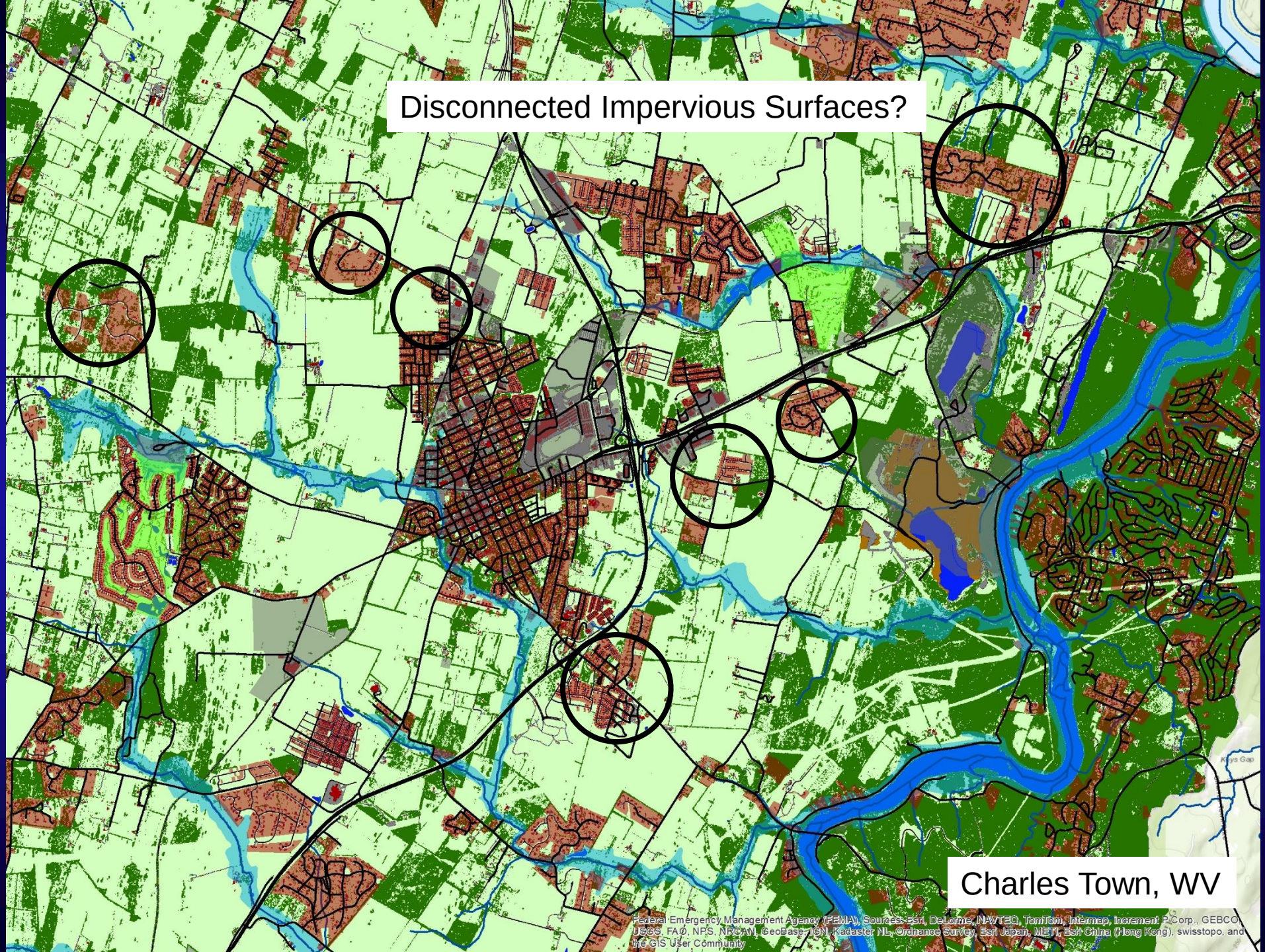


Infiltration Excess Runoff Source Locations



Smith et al., 2011


Connected Impervious Surfaces?
Charles Town, WV
Federal Emergency Management Agency (FEMA), Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community


Disconnected Impervious Surfaces?
Charles Town, WV
Federal Emergency Management Agency (FEMA), Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

Accommodating connectivity in Phase 6

1. Develop an urban runoff load adjustment factor per modeling segment based on a measure of connectivity and/or a measure of stream flow alteration.

2. Integrate the effects of connectivity, floodplains, riparian forests, stream order, dry weather illicit discharges, sewage overflows, and exfiltration into a stream corridor “land use”.

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Peter Claggett, Geographer
U.S. Geological Survey

pclaggett@usgs.gov
pclagget@chesapeakebay.net