WaterFALL: **Water**shed **F**low and **ALL**ocation Model

July 13th, 2011

Michele Cutrofello & Bob Dykes

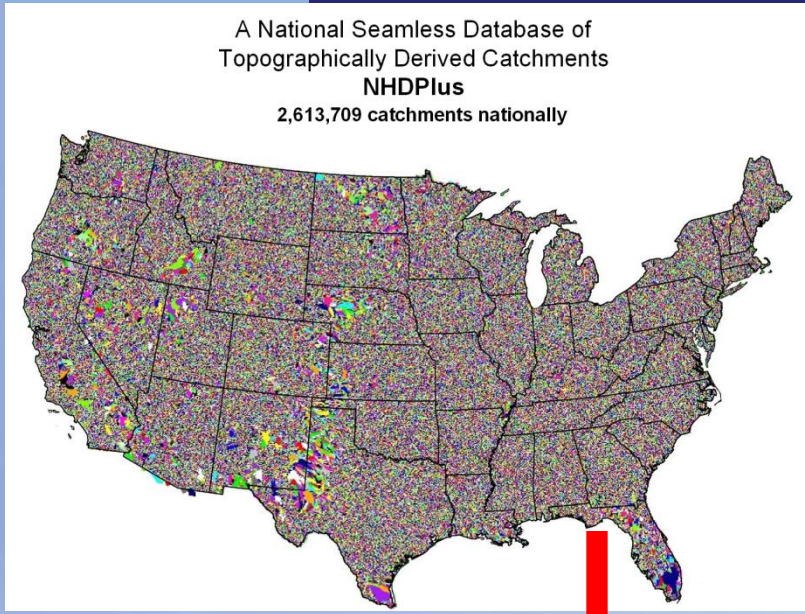
Development Team: Jay Rineer, Fekadu Moreda, Brandon Bergenroth, Aaron Parks, & Michael Norton

RTI International is a trade name of Research Triangle Institute.

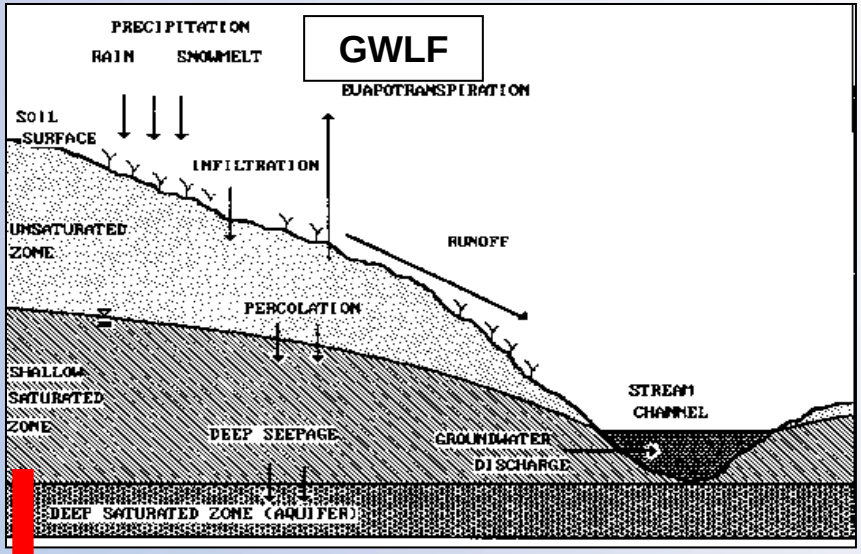
WaterFALL™ Design Objectives

1. Flexible hydrologic modeling platform to support multiple applications:
   - Water basin allocation planning and analysis
   - Climate change vulnerability/adaptation assessment
   - Ecological flow regime development
2. Provide “on demand” results
   - Facilitate “what if?” analysis
3. Scalable
4. Portable
5. Incorporate state-of-the-art information technology

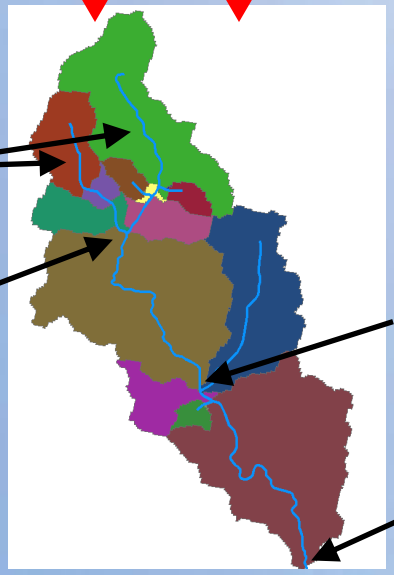
WaterFALL: Watershed Flow and ALLocation Model



Source: http://www.horizon-systems.com/nhdplus/documentation.php



Source: GWLF User Manual Version, Haith et al., 1996



Headwater reaches – flows generated with GWLF

Reach receives inflow from upstream and flows generated with GWLF

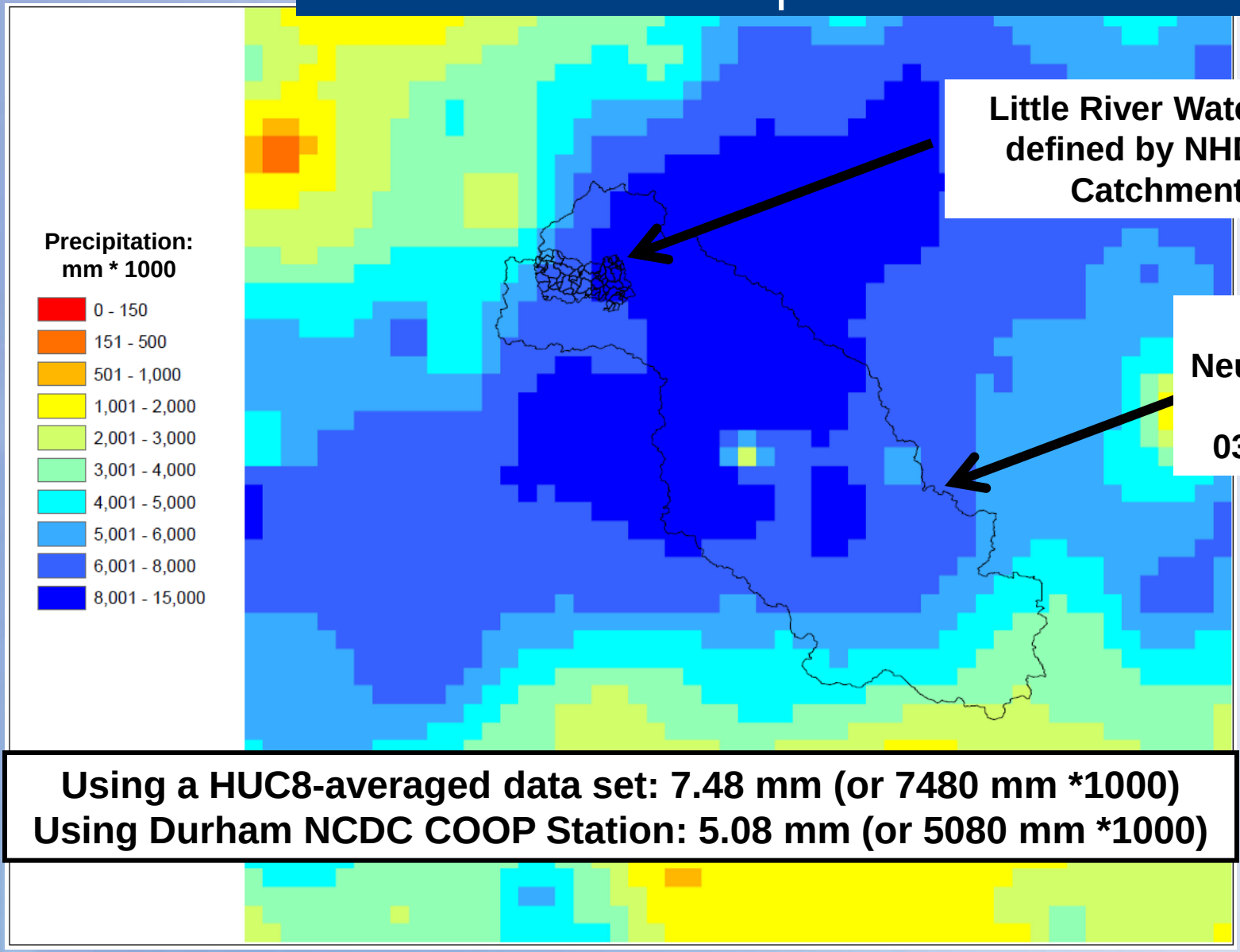
Outflow from catchment after inflow + GWLF flow subjected to routing method

Watershed outlet

Concepts of Model Framework

- Streamlined approach for model parameterization and application
- Data
  - NHDPlus catchment characteristics (1:100,000 scale)
  - SSURGO soils data
  - NLCD land use data
  - NCDC archive and PRISM-derived daily precipitation and temperature data
  - NOAA grid based hydrologic parameters (e.g., recession coefficients)
  - Generated Look Up Tables (LUT) for related data elements (e.g., Curve Number, ET cover factor, etc.)
- Model
  - GWLF basis
  - Enhancements to simplify data requirements and increase model applicability
- Routing
  - Application of an RTI-designed lag-routing method from one catchment to another allows individual GWLF application at each small catchment to link together to form a pseudo-distributed watershed model

4km-Gridded Precipitation on 11/11/02



Using a HUC8-averaged data set: 7.48 mm (or 7480 mm *1000)
Using Durham NCDC COOP Station: 5.08 mm (or 5080 mm *1000)

Video Demonstration of Web Interface

Sample Exported Results from WaterFALL™

Time_Series_Data.xls [Compatibility Mode] - Microsoft Excel

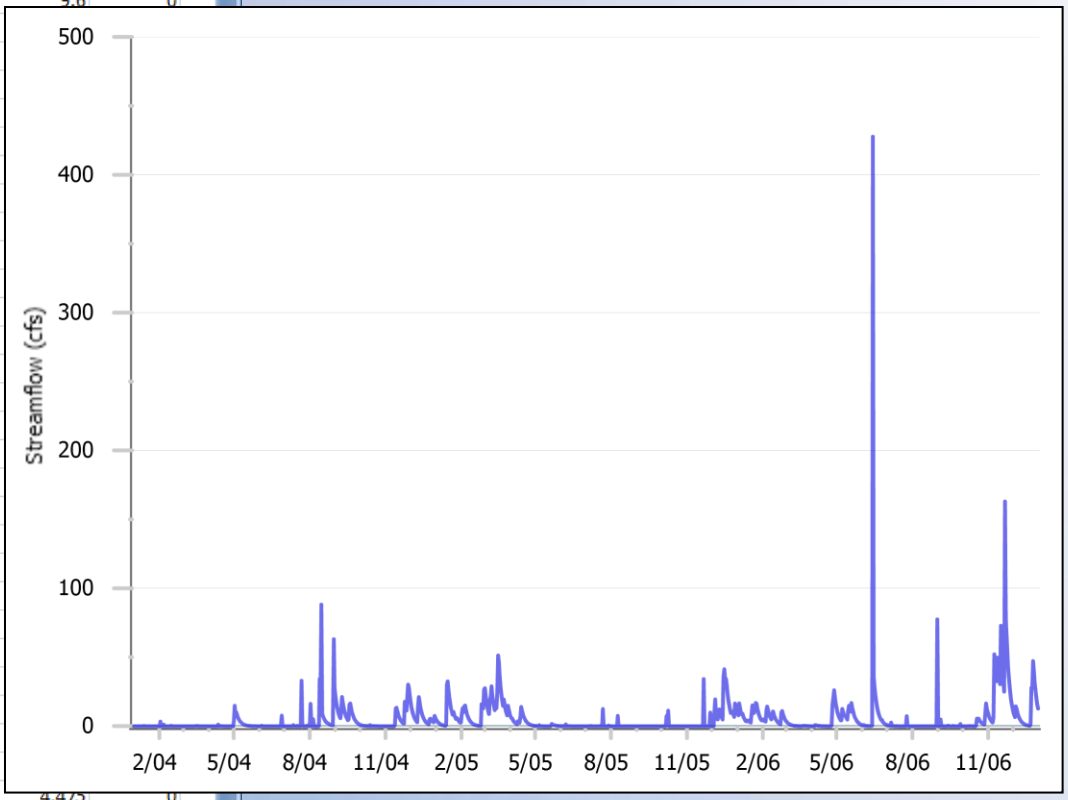
Home Insert Page Layout Formulas Data Review View

A1 runDate

	A	B	C	D	E	F	G	H	I
1	runDate	Inflow	Outflow	ReachVelocity	ReachDepth	Baseflow	Runoff	Temp	Precip
2	01/01/2004	1.058	1.342	0.242	0.131	0.284	0	7.828	0
3	01/02/2004	0.845	1.069	0.193	0.131	0.224	0	9.6	0
4	01/03/2004	0.675	0.852	0.154	0.131	0.177	0		
5	01/04/2004	0.539	0.679	0.164	0.098	0.14	0		
6	01/05/2004	0.43	0.541	0.131	0.098	0.111	0		
7	01/06/2004	0.344	0.432	0.105	0.098	0.088	0		
8	01/07/2004	0.275	0.344	0.126	0.066	0.069	0		
9	01/08/2004	0.219	0.274	0.101	0.066	0.055	0		
10	01/09/2004	0.175	0.219	0.08	0.066	0.043	0		
11	01/10/2004	0.14	0.175	0.064	0.066	0.034	0		
12	01/11/2004	0.112	0.139	0.051	0.066	0.027	0		
13	01/12/2004	0.09	0.111	0.082	0.033	0.021	0		
14	01/13/2004	0.408	0.473	0.124	0.098	0.017	0.048		
15	01/14/2004	0.329	0.584	0.151	0.066	0.255	0		
16	01/15/2004	0.262	0.463	0.12	0.066	0.202	0		
17	01/16/2004	0.208	0.368	0.096	0.066	0.159	0		
18	01/17/2004	0.166	0.292	0.076	0.066	0.126	0		
19	01/18/2004	5.021	6.48	0.411	0.361	1.459	0		
20	01/19/2004	5.839	7.586	0.478	0.361	1.747	0		
21	01/20/2004	4.655	6.036	0.42	0.328	1.381	0		
22	01/21/2004	3.711	4.804	0.373	0.295	1.092	0		
23	01/22/2004	2.959	3.823	0.335	0.262	0.864	0		
24	01/23/2004	2.36	3.043	0.306	0.23	0.683	0		
25	01/24/2004	1.882	2.422	0.285	0.197	0.54	0		
26	01/25/2004	1.501	1.929	0.274	0.164	0.427	0		
27	01/26/2004	10.926	13.935	0.609	0.525	3.009	0		
28	01/27/2004	8.711	11.09	0.557	0.459	2.38	0		
29	01/28/2004	6.945	8.827	0.479	0.427	1.882	0		
30	01/29/2004	5.538	7.026	0.454	0.361	1.488	0		
31	01/30/2004	4.418	5.595	0.399	0.328	1.177	0	4.475	0
32	01/31/2004	5.326	6.866	0.436	0.361	1.54	0	2.438	0
33	02/01/2004	4.247	5.465	0.383	0.328	1.218	0	-0.4	0.01
34	02/02/2004	6.278	7.656	0.47	0.394	0.963	0.415	0.734	1.112
35	02/03/2004	12.989	16.661	0.641	0.591	3.671	0	4.326	0.493
36	02/04/2004	14.487	18.641	0.676	0.623	4.154	0	4.146	0

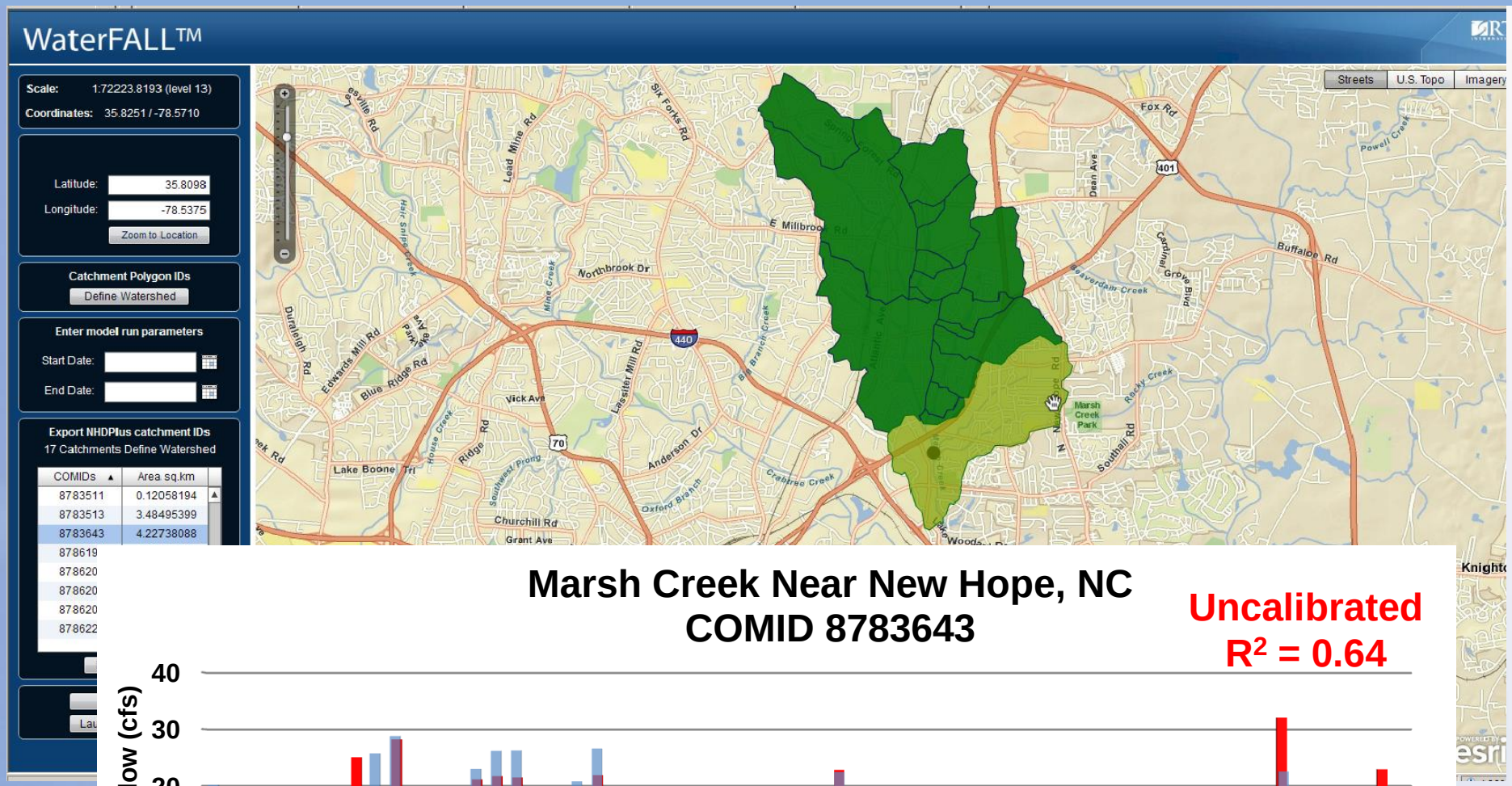
8783643

Ready 100%



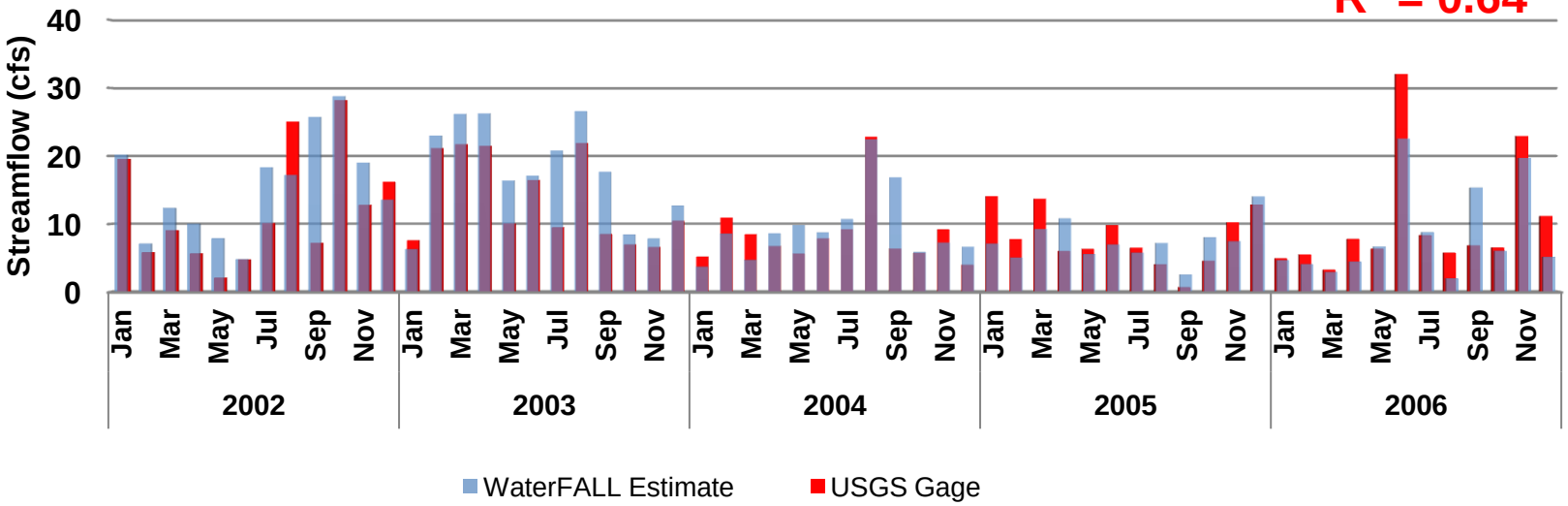
Calibration and Validation with Monitored Flows

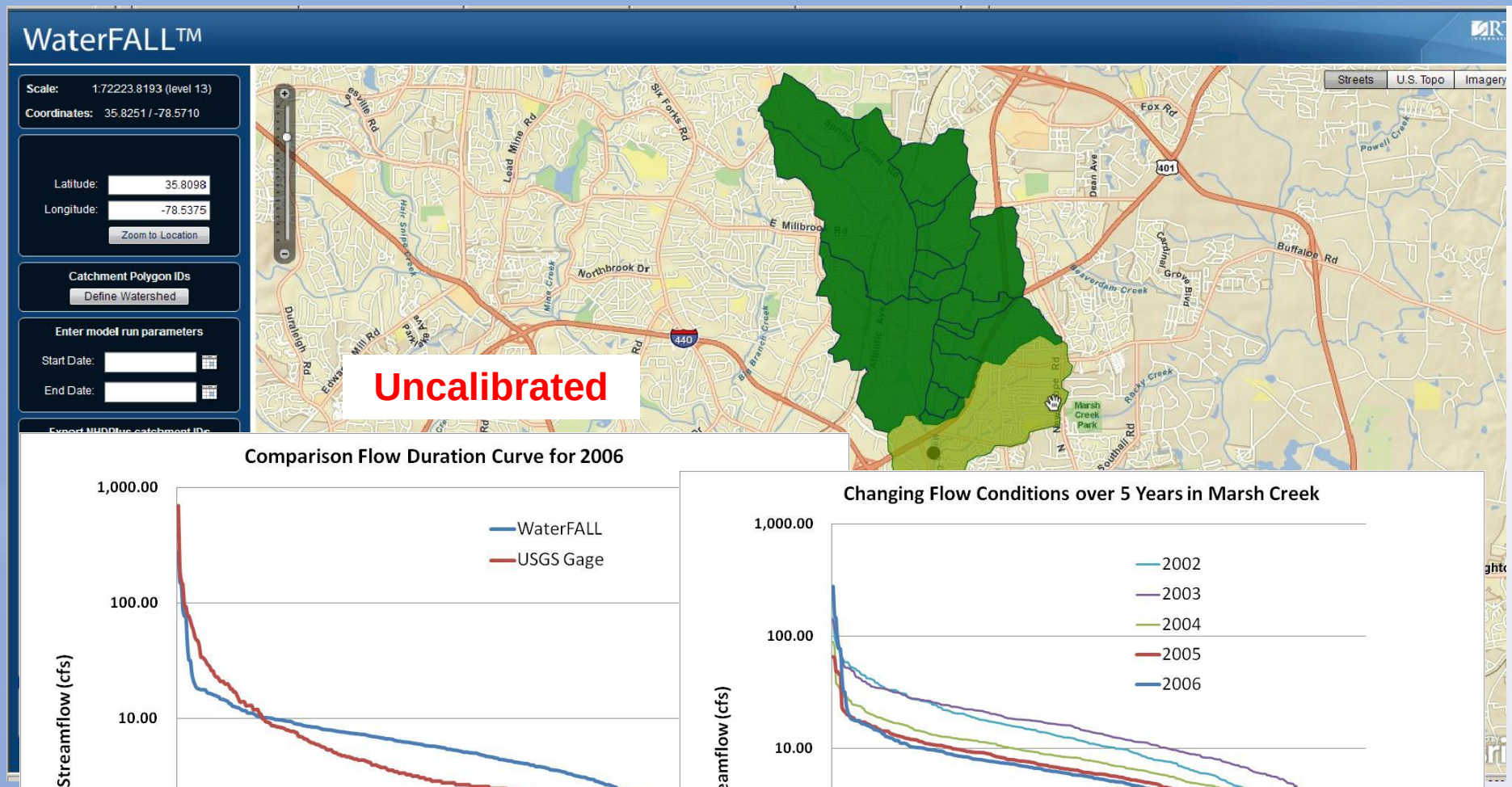
USGS Gage	Station Name	Latitude	Longitude	Area (mi²)
208732885	MARSH CREEK NEAR NEW HOPE, NC	35.817	-78.593	6.84
208524090	MOUNTAIN CREEK AT SR1617 NR BAHAMA, NC	36.150	-78.897	7.97
2084909	SEVENMILE CREEK NR EFLAND, NC	36.066	-79.144	14.10
2087580	SWIFT CREEK NEAR APEX, NC	35.719	-78.752	21.00
2087359	WALNUT CREEK AT SUNNYBROOK DRIVE NR RALEIGH, NC	35.758	-78.583	29.00
208758850	SWIFT CREEK NEAR MCCULLARS CROSSROADS, NC	35.694	-78.692	35.80
2086624	KNAP OF REEDS CREEK NEAR BUTNER, NC	36.128	-78.798	43.00
2085000	ENO RIVER AT HILLSBOROUGH, NC	36.071	-79.096	66.00
208726005	CRABTREE CR AT EBENEZER CHURCH RD NR RALEIGH, NC	35.845	-78.724	76.00
208521324	LITTLE RIVER AT SR1461 NEAR ORANGE FACTORY, NC	36.142	-78.919	78.20
2088000	MIDDLE CREEK NEAR CLAYTON, NC	35.571	-78.591	83.50
2087275	CRABTREE CREEK AT HWY 70 AT RALEIGH, NC	35.838	-78.674	97.60
208524975	LITTLE R BL LITTLE R TRIB AT FAIRNTOSH, NC	36.113	-78.860	98.90
2087324	CRABTREE CREEK AT US 1 AT RALEIGH, NC	35.811	-78.611	121.00
2085070	ENO RIVER NEAR DURHAM, NC	36.072	-78.908	141.00
2085500	FLAT RIVER AT BAHAMA, NC	36.183	-78.879	149.00
2086500	FLAT RIVER AT DAM NEAR BAHAMA, NC	36.149	-78.829	168.00
2088500	LITTLE RIVER NEAR PRINCETON, NC	35.511	-78.160	232.00
2087183	NEUSE RIVER NEAR FALLS, NC	35.940	-78.581	771.00
2087500	NEUSE RIVER NEAR CLAYTON, NC	35.647	-78.405	1150.00

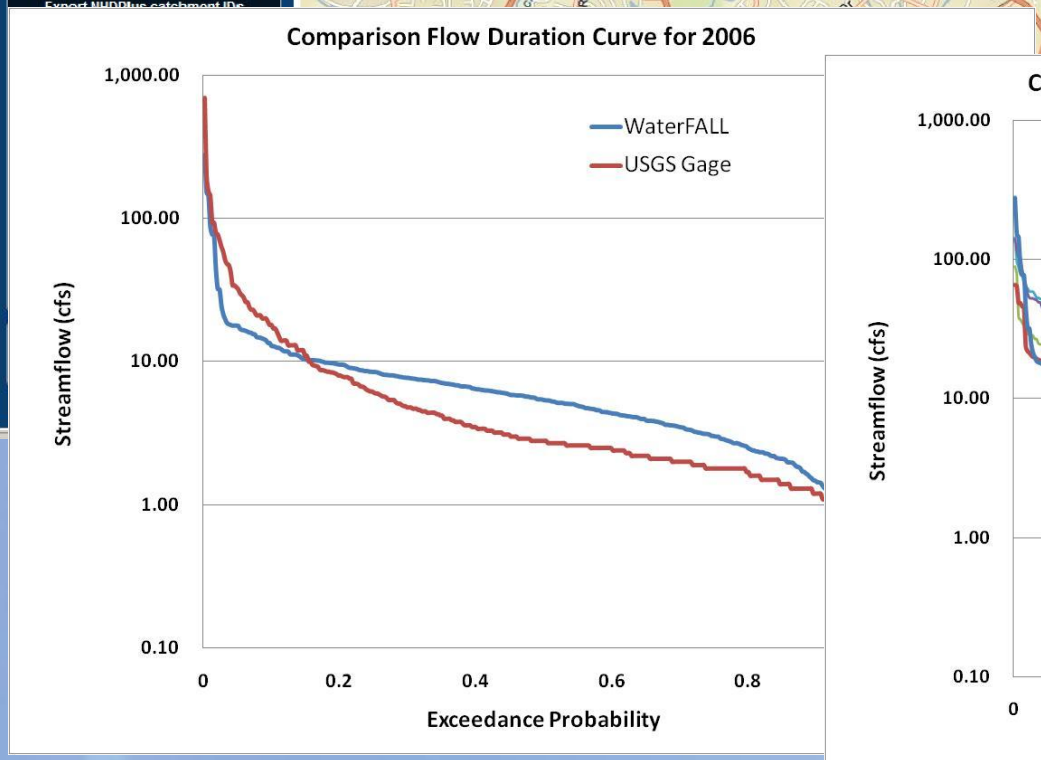


Marsh Creek Near New Hope, NC
COMID 8783643

Uncalibrated
$R^2 = 0.64$




WaterFALL™
Scale: 1:72223.8193 (level 13)
Coordinates: 35.8251 / -78.5710
Latitude: 35.8098
Longitude: -78.5375
Zoom to Location
Catchment Polygon IDs
Define Watershed
Enter model run parameters
Start Date:
End Date:
Streets
U.S. Topo
Imagery
Uncalibrated


Comparison Flow Duration Curve for 2006
WaterFALL
USGS Gage
Streamflow (cfs)
1,000.00
100.00
10.00
1.00
0.10
0
0.2
0.4
0.6
0.8
Exceedance Probability

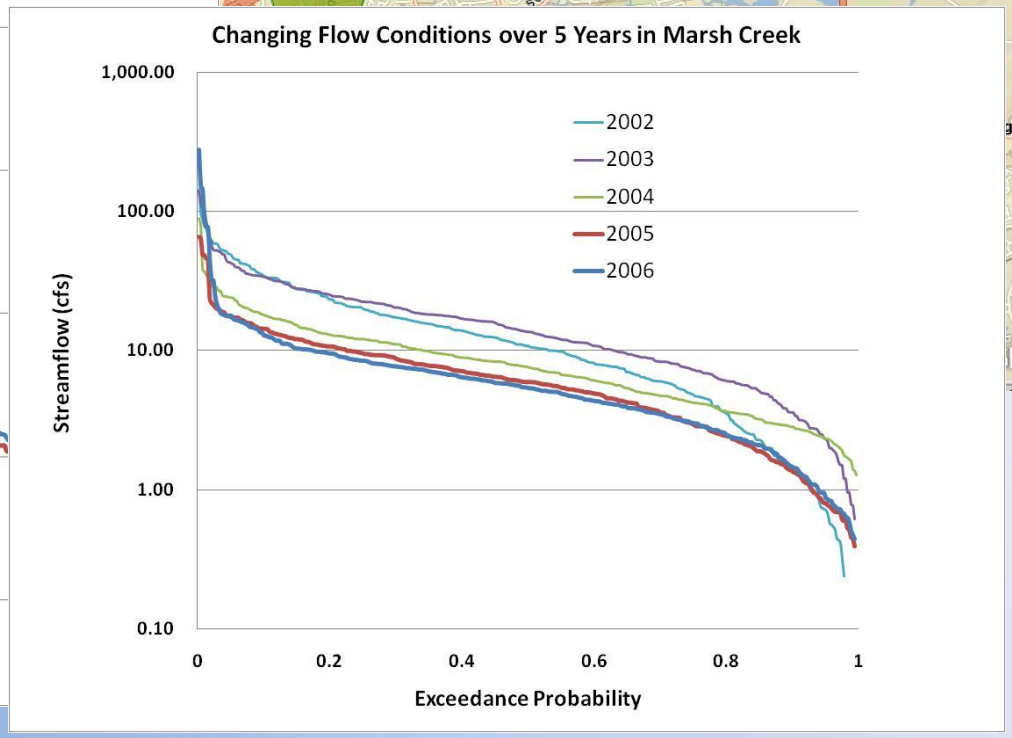

Changing Flow Conditions over 5 Years in Marsh Creek
2002
2003
2004
2005
2006
Streamflow (cfs)
1,000.00
100.00
10.00
1.00
0.10
0
0.2
0.4
0.6
0.8
1
Exceedance Probability

Table 1. GWLF parameters that are related to flow generation

Calibration Parameters

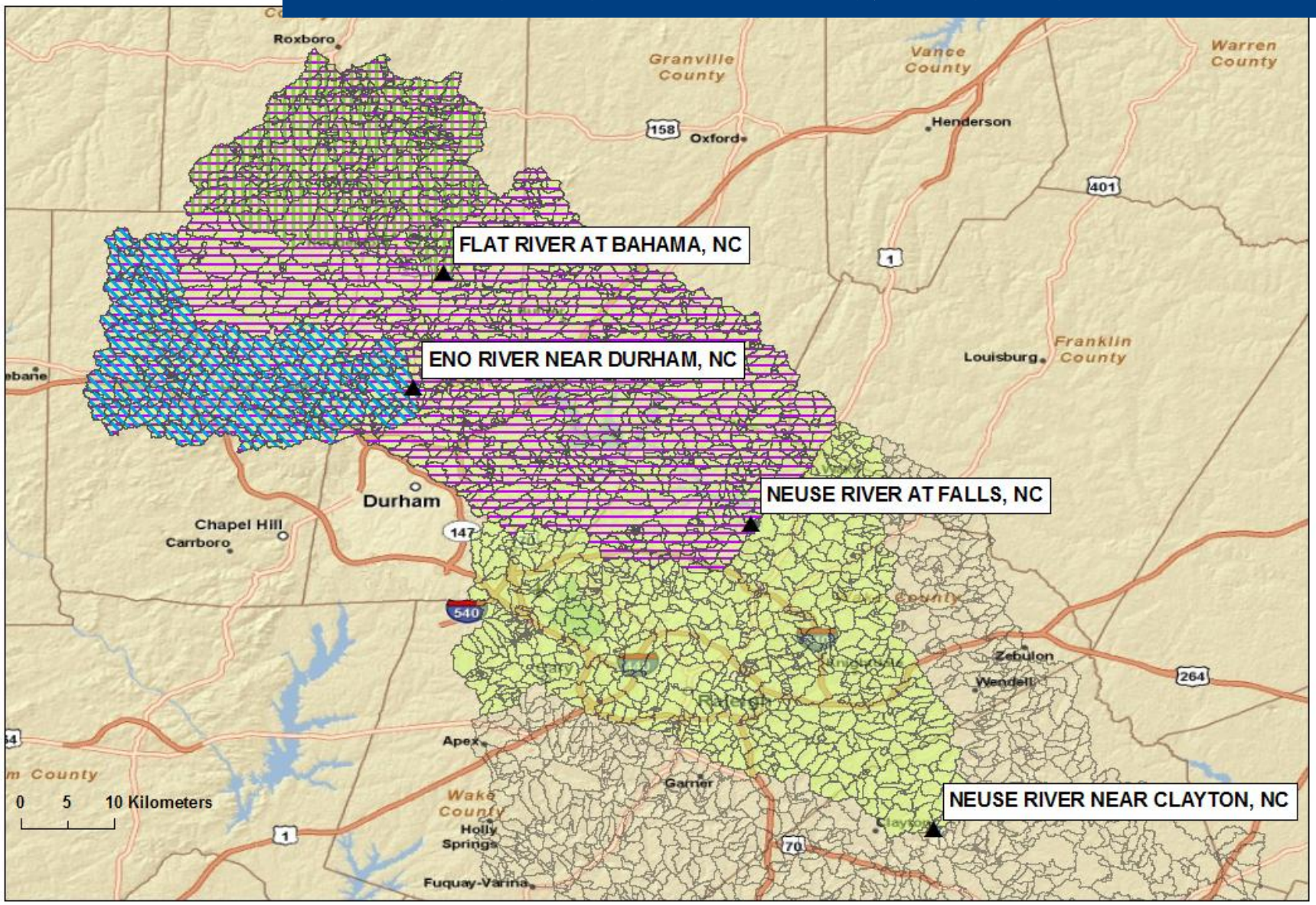
Parameters	Description	Source & Estimation Method	Calibration Method
Available Soil water Capacity	This parameter triggers the start of percolation	Estimated by National Weather Service compilation of parameters for Sacramento Soil Moisture Accounting Model; Based on SSURGO and NLCD data	CURRENT: Manual adjustment of NWS values over study region using multiplication factors. FUTURE: Automated calibration of individual catchment values or regional values using software (PEST).
Recession Coefficient	Base flow coefficient controls the rate of ground water flow from the saturated storage		
Seepage Coefficient	Seepage parameter controls the rate of seepage to the deep storage.	Best professional judgment estimate	

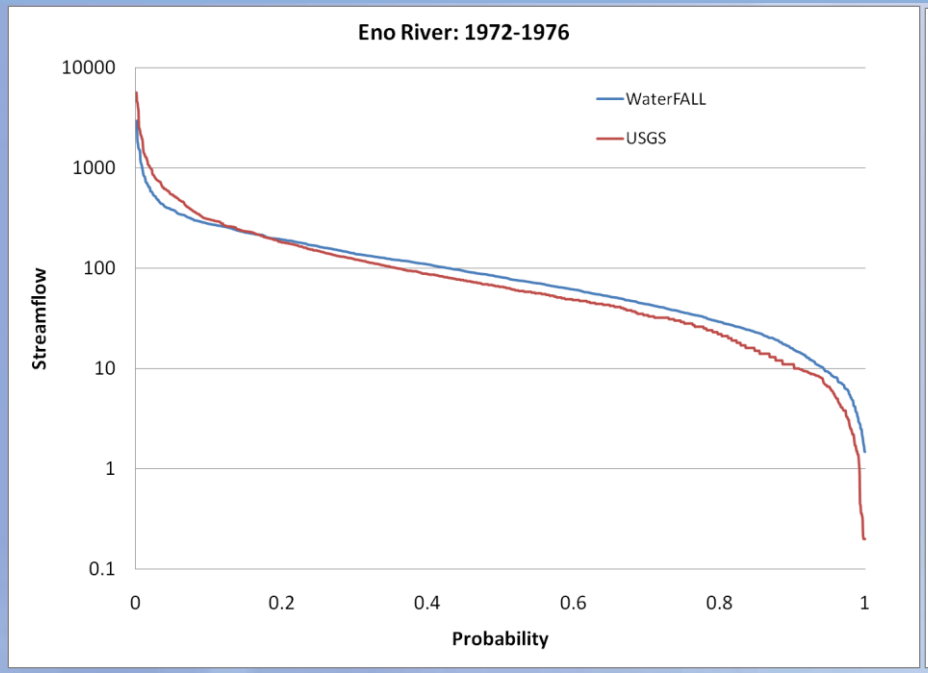
Neuse River Calibration

Outlet COMID (# catchments)	USGS Gage	Station Name	Regulations of flows	Lat	Long	Drainage Area (mi^2)
8786017 (2438)	02087500	Neuse River near Clayton, NC	Regulated by Falls Reservoir	35.647	-78.405	1150
8782653 (1594)	02087183	Neuse River Near Falls, NC	Flow is regulated by Falls Dam	35.940	-78.581	771
8778363 (355)	02085500	Flat River at Bahama, NC	Minor regulation at low flow	36.183	-78.879	149
8778383 (213)	02085070	Eno River near Durham, NC	Some regulation during periods of low flow caused by mill 600 ft upstream	36.072	-78.908	141

- Calibration at 4 gages within larger Neuse Watershed
- Used pre-regulated period of 1972-1976 (before Falls Lake began filling in Upper Neuse)

Multi-basin Calibration & Results




Eno River: 1972-1976
WaterFALL
USGS
Streamflow
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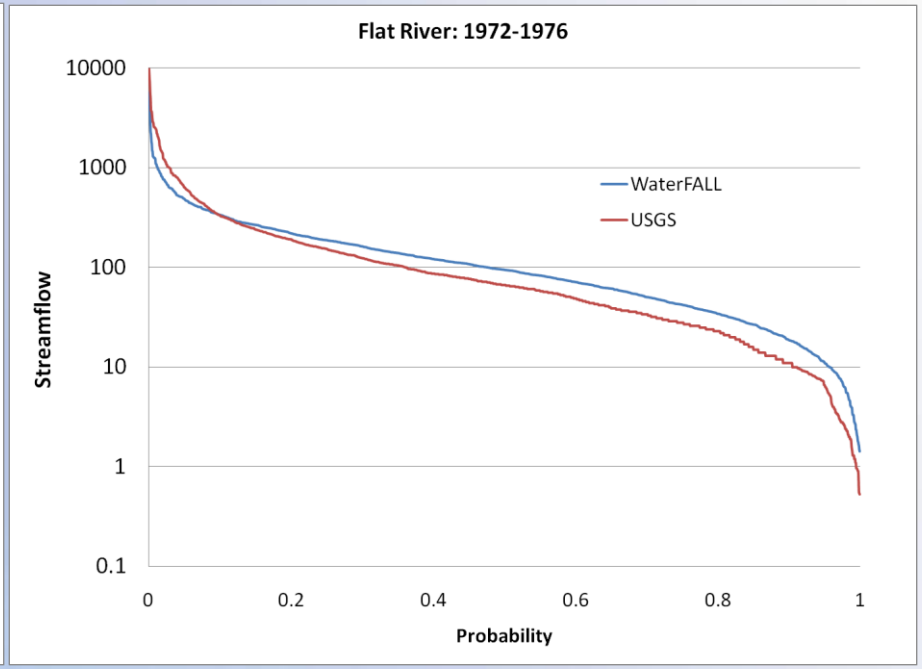
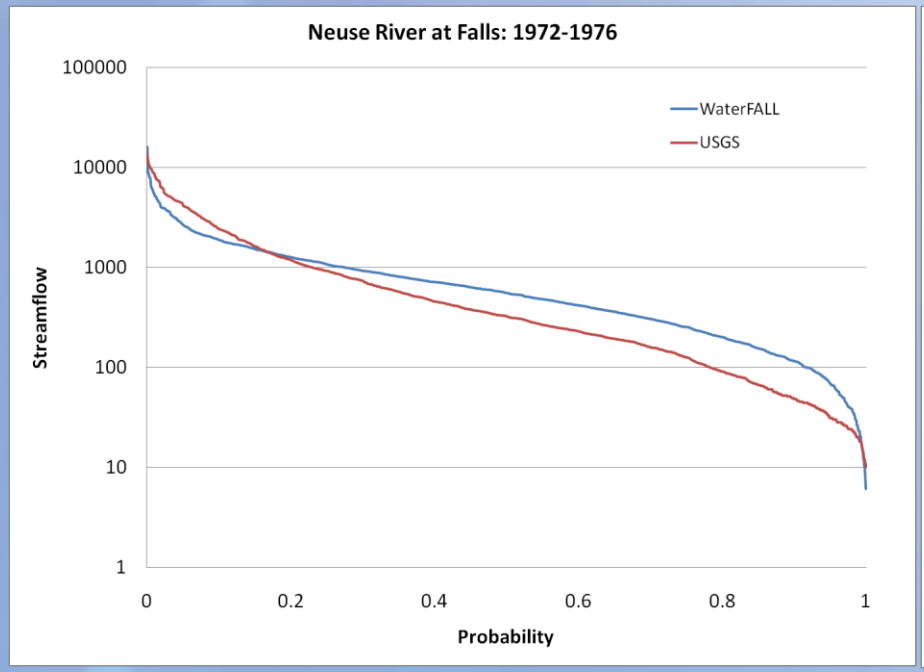
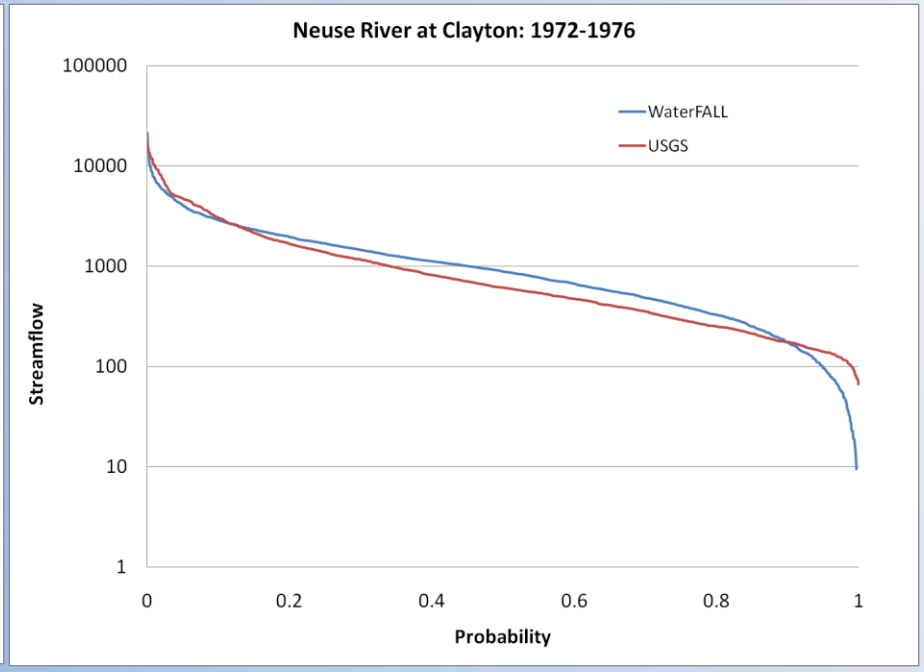
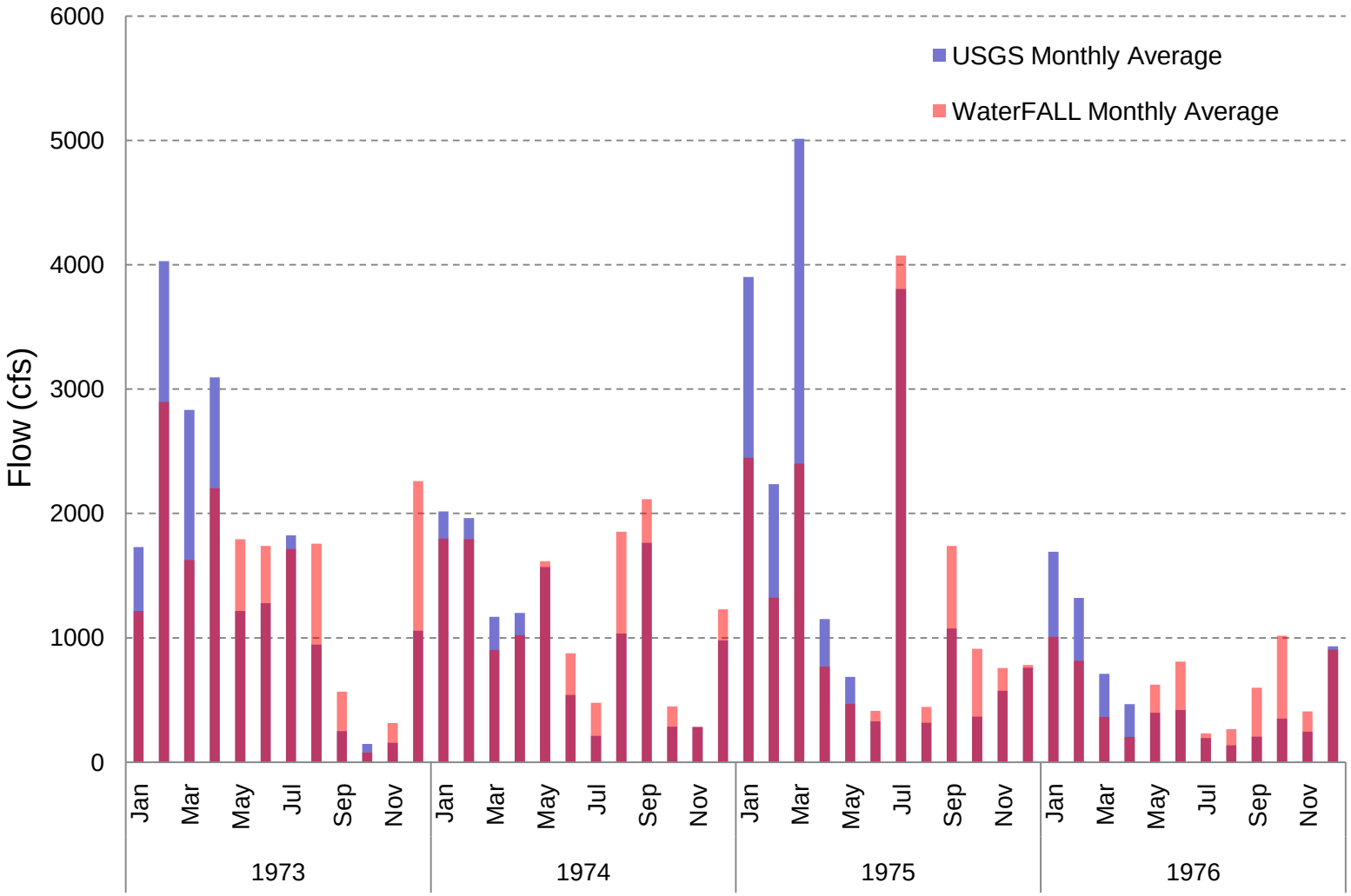
1000
100
10
1
0.1
0
0.2
0.4
0.6
0.8
1
Probability


Flat River: 1972-1976
WaterFALL
USGS
Streamflow
10000
1000
100
10
1
0.1
0
0.2
0.4
0.6
0.8
1
Probability


Neuse River at Falls: 1972-1976
WaterFALL
USGS
Streamflow
100000
10000
1000
100
10
1
0
0.2
0.4
0.6
0.8
1
Probability


Neuse River at Clayton: 1972-1976
WaterFALL
USGS
Streamflow
100000
10000
1000
100
10
1
0
0.2
0.4
0.6
0.8
1
Probability

Calibration Results for Neuse River at Clayton, NC



Overall Simulation Volume Error: 5%
Nash-Sutcliffe (daily flows): 0.53

Next Up On Our Agenda….

- Speed it Up! *(Technology transfer in progress)*
- Land Use Change *(Planned, awaiting implementation)*
- Climate Change *(Planned, awaiting implementation)*
- Human Withdrawals and Returns *(Planning and data gathering)*
- Automated Calibration *(Scoping Stage)*
- Reservoirs and Hydrologic Controls *(Scoping Stage)*

More Information

Michele Cutrofello

WaterFALL™ Team Lead

919.990.8458

mcutrofello@rti.org

Robert (Bob) Dykes

Manager, Watershed and Ecosystem Management Center

919.541.8705

rdykes@rti.org