MODELING STRATEGIES FOR A GROUNDWATER DOMINATED HEADWATER SYSTEM

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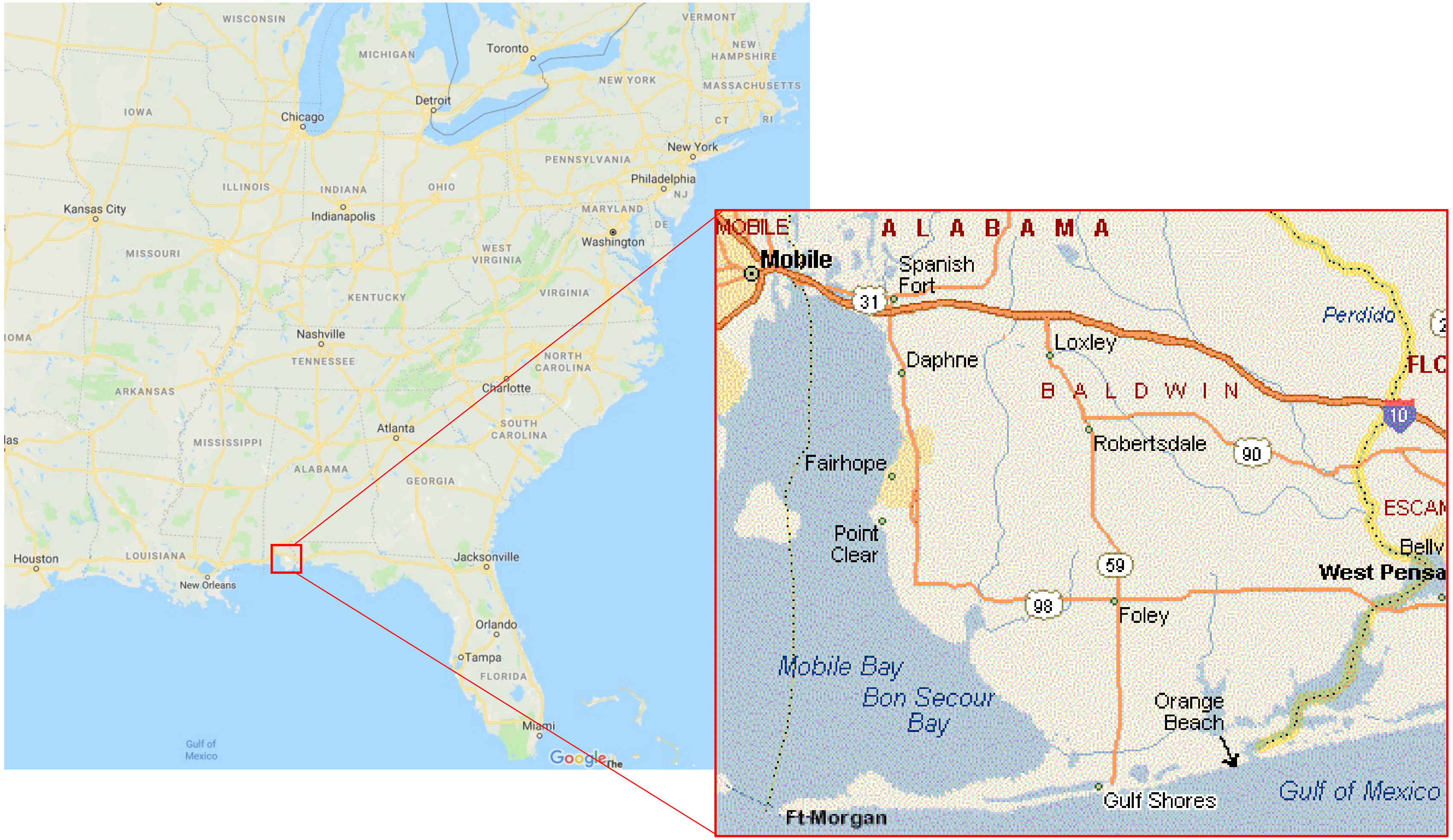
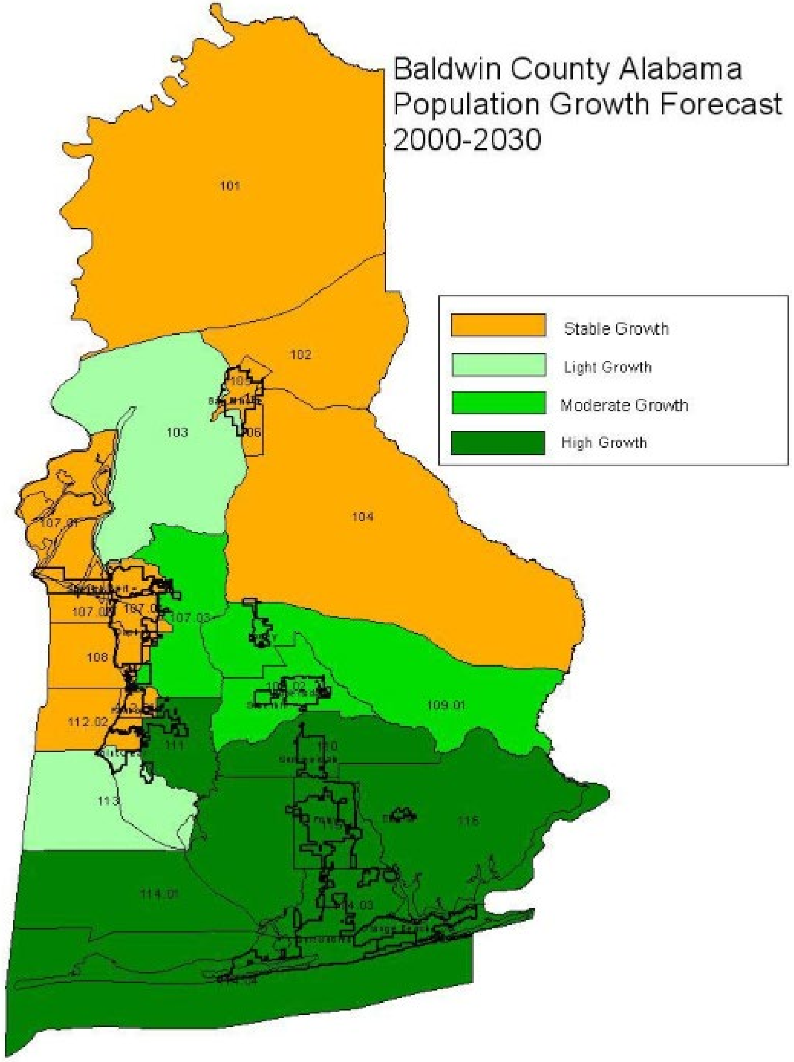
Baldwin County, AL

- 30% population growth between 2000 and 2010
- Increased concerns about regional and coastal water quality and quantity

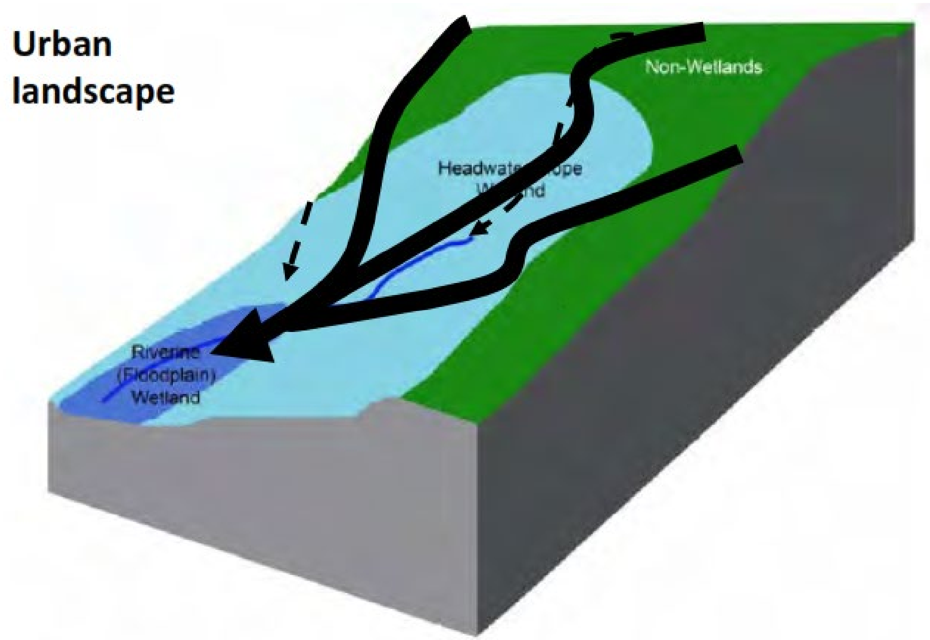




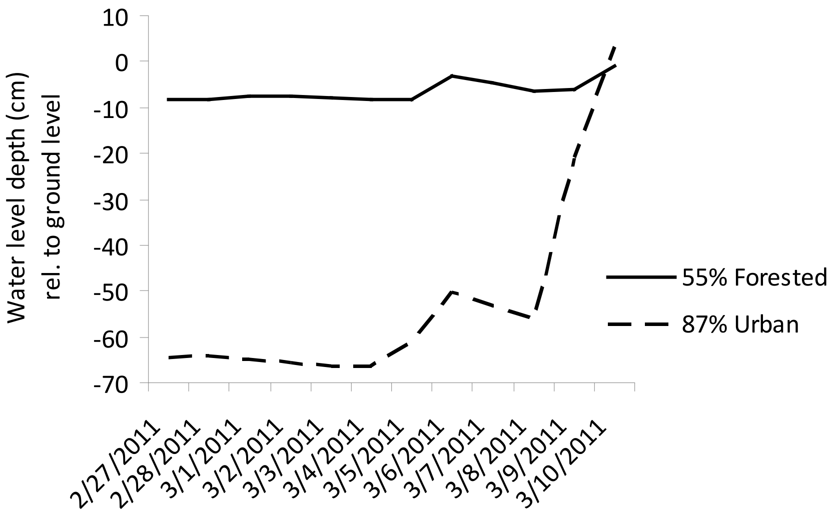
© Coastal Alabama river basin management plan

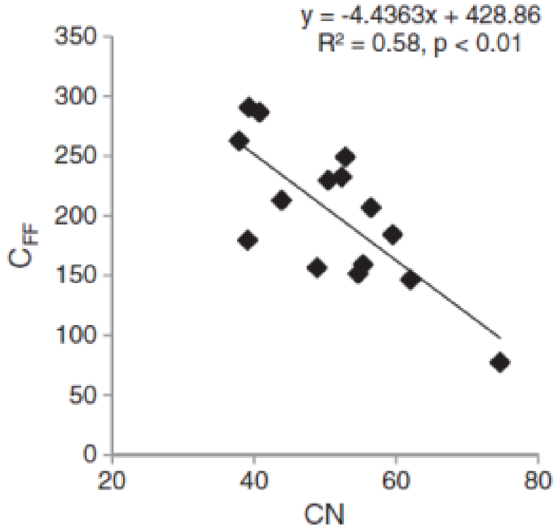
Wetland alterations

"Headwater streams are buried more extensively than are larger streams at all levels of urban development (low, residential, suburban, and urban)" – Elmore and Kaushal (2008)

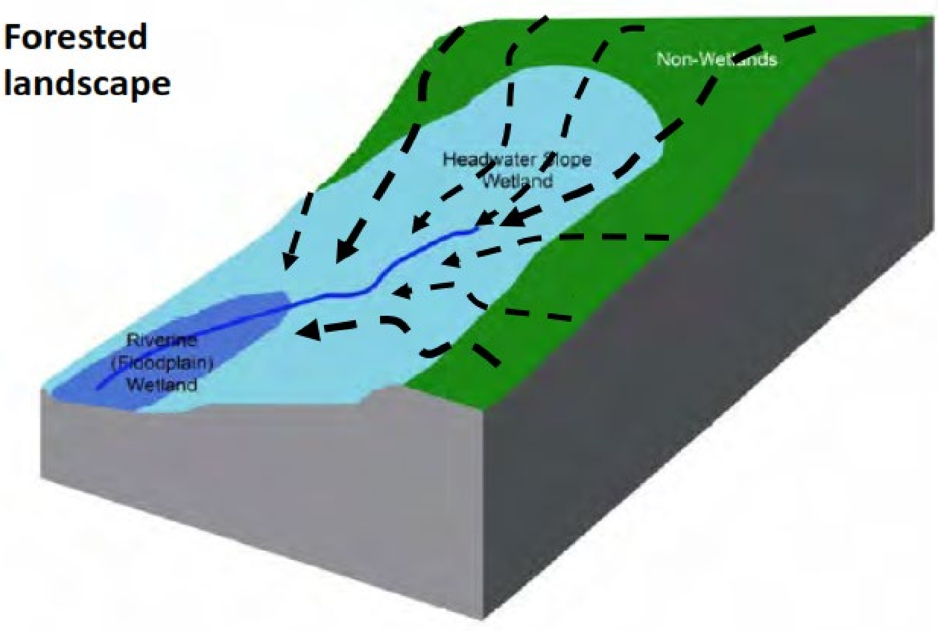


Watershed land use is an important driver of wetland function



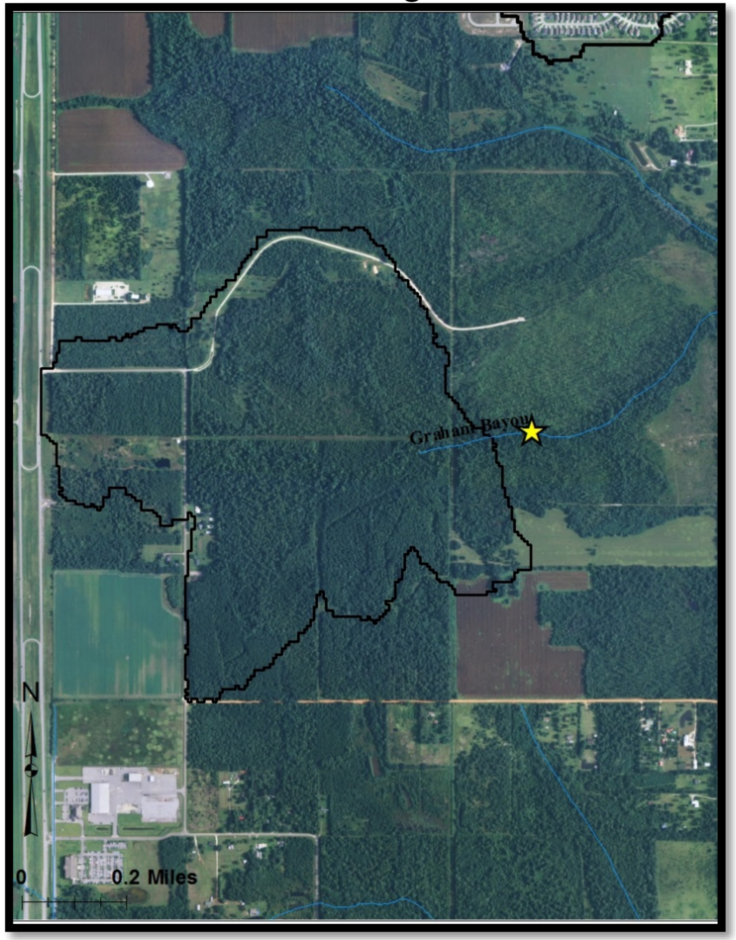


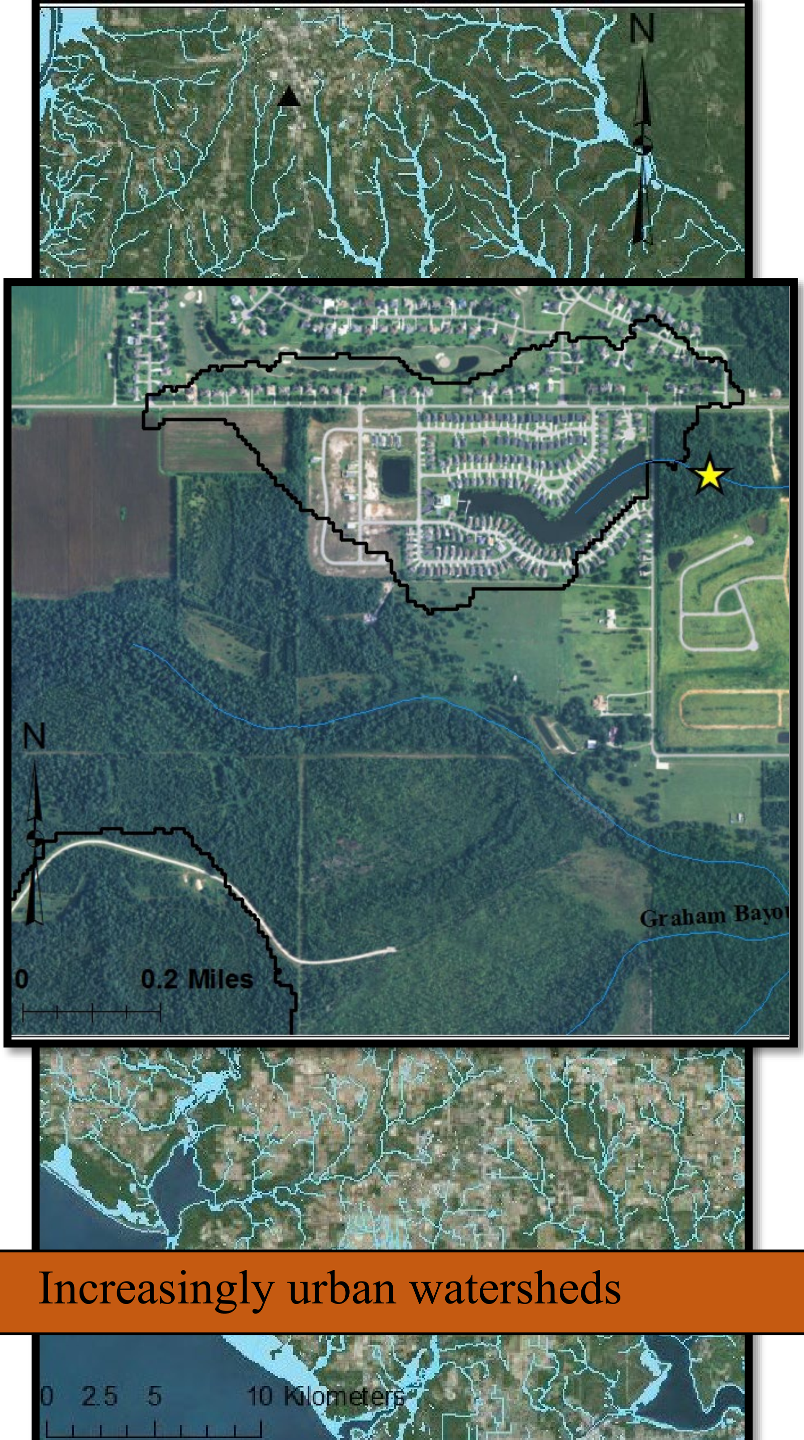
Headwater slope wetlands

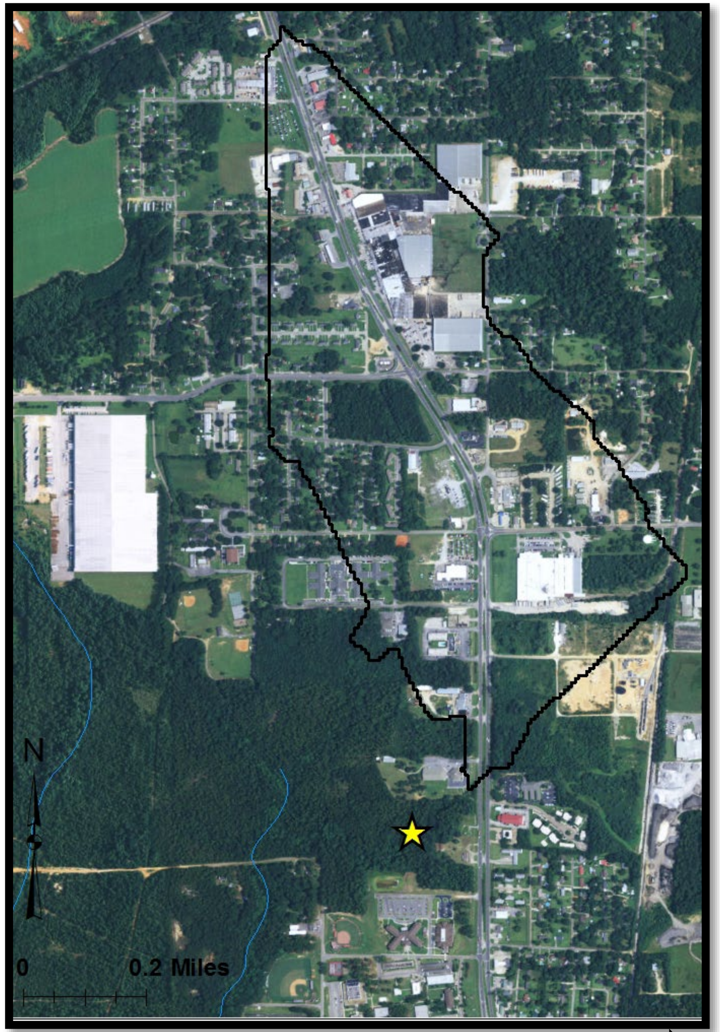


- Account for over two-thirds of the total stream length in a river
- Alterations can cause large scale impacts on ecological functions

Study areas







South — Increasingly urban watersheds — North

The general plan

SWAT
Watershed model

- Land use
- Climate
- Soils

Flow and nutrient time series

Calibrate with observed wetland data

WETQUAL
Wetland model

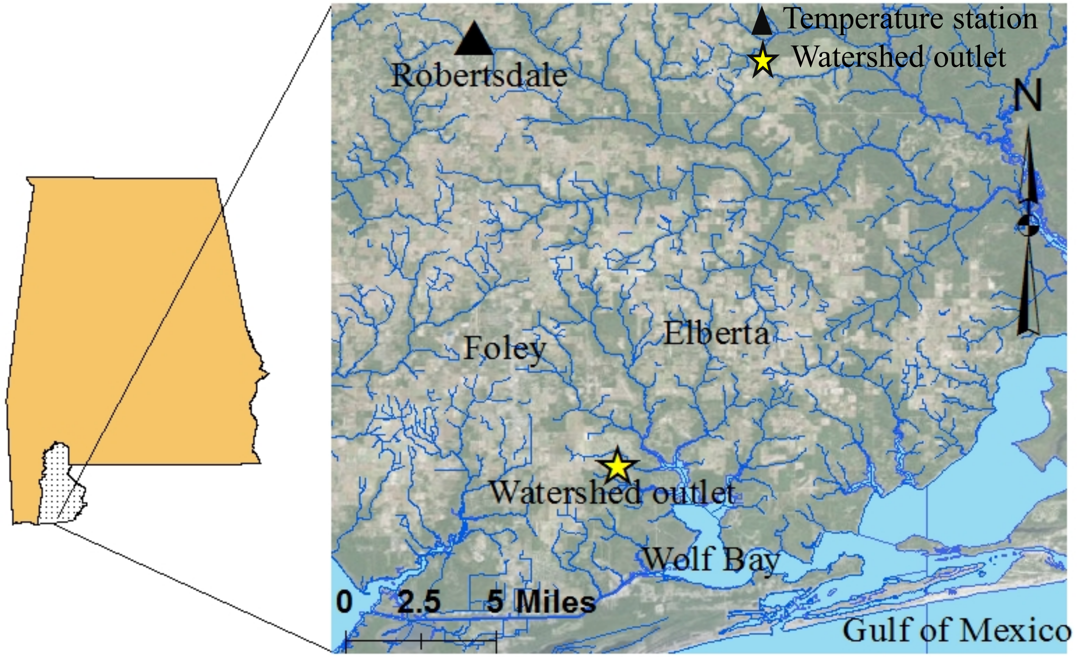
- Flow
- Nutrients
- Climate

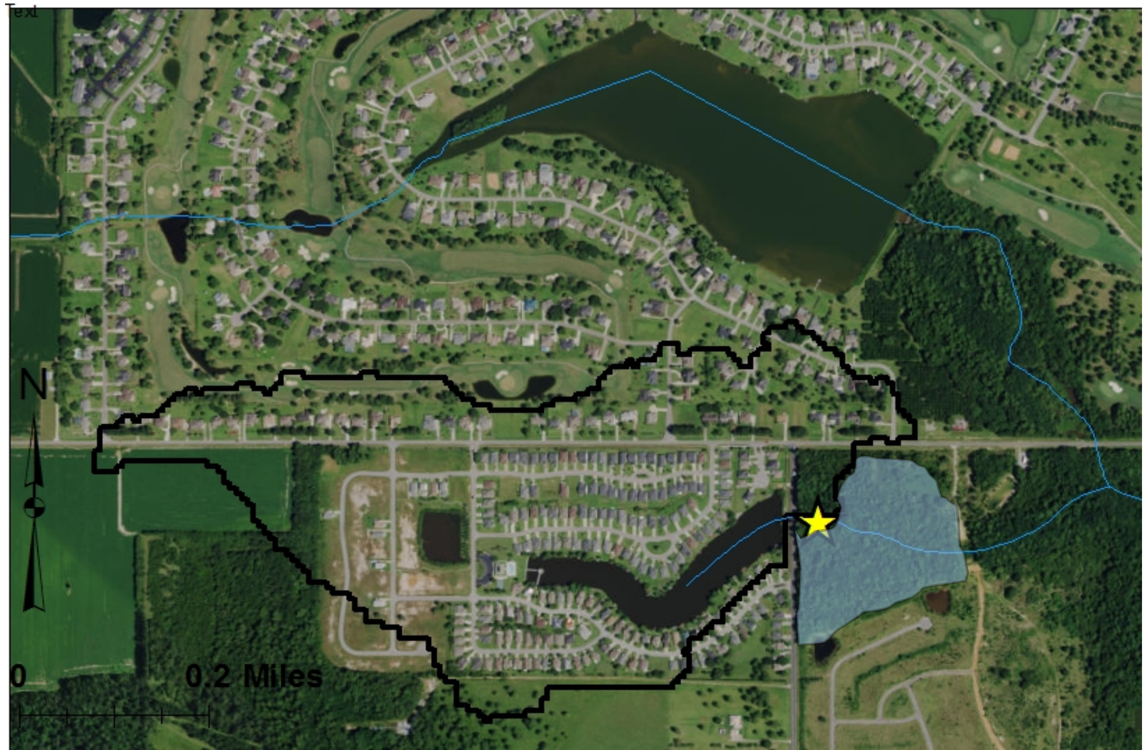
=

Improved water quality prediction

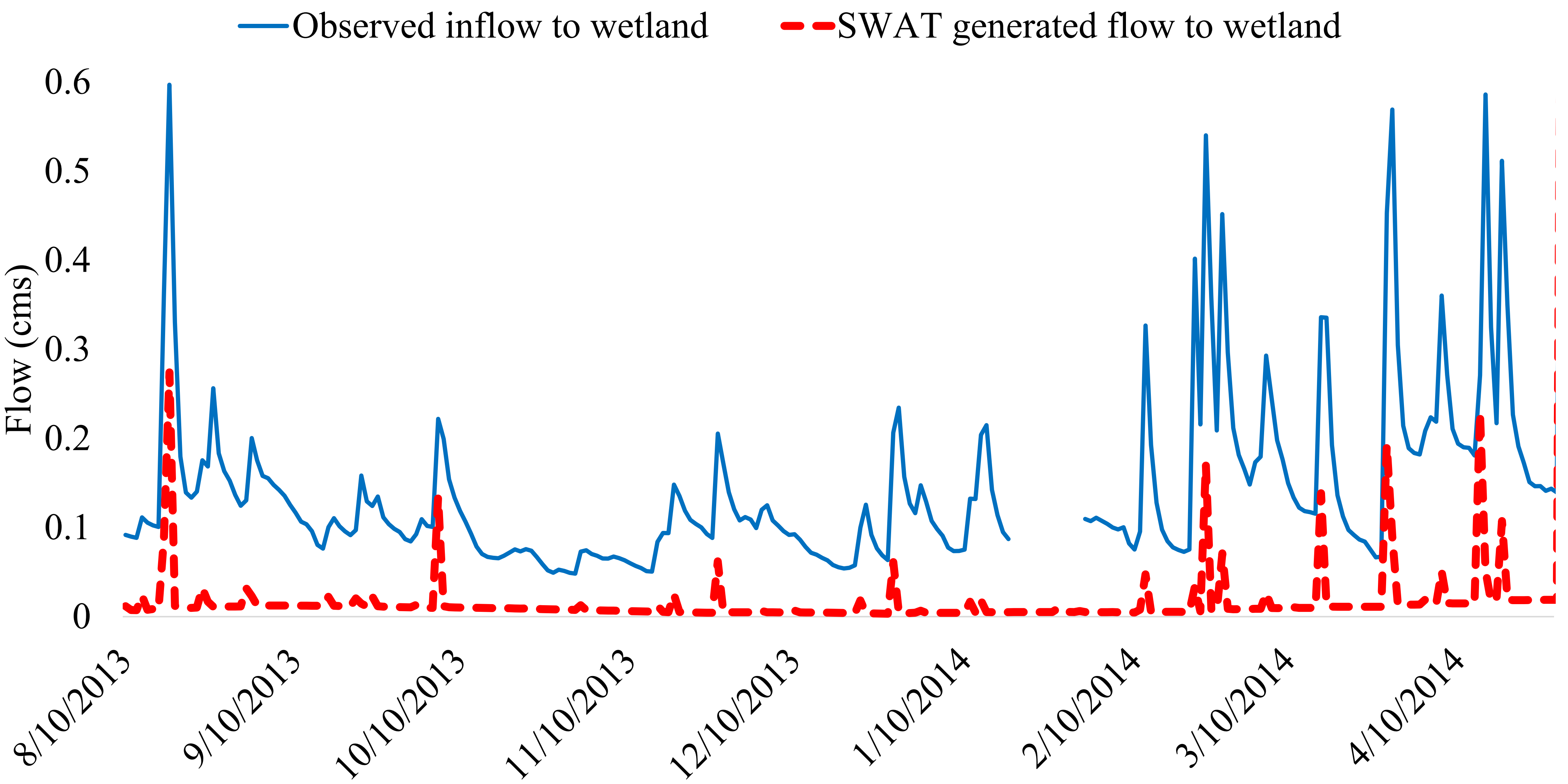
New Foley watershed

- Head watershed draining into headwater slope wetland (yellow star in map)
- Ungauged
- Stage data at discernible inflow from Aug 2013 – May 2014

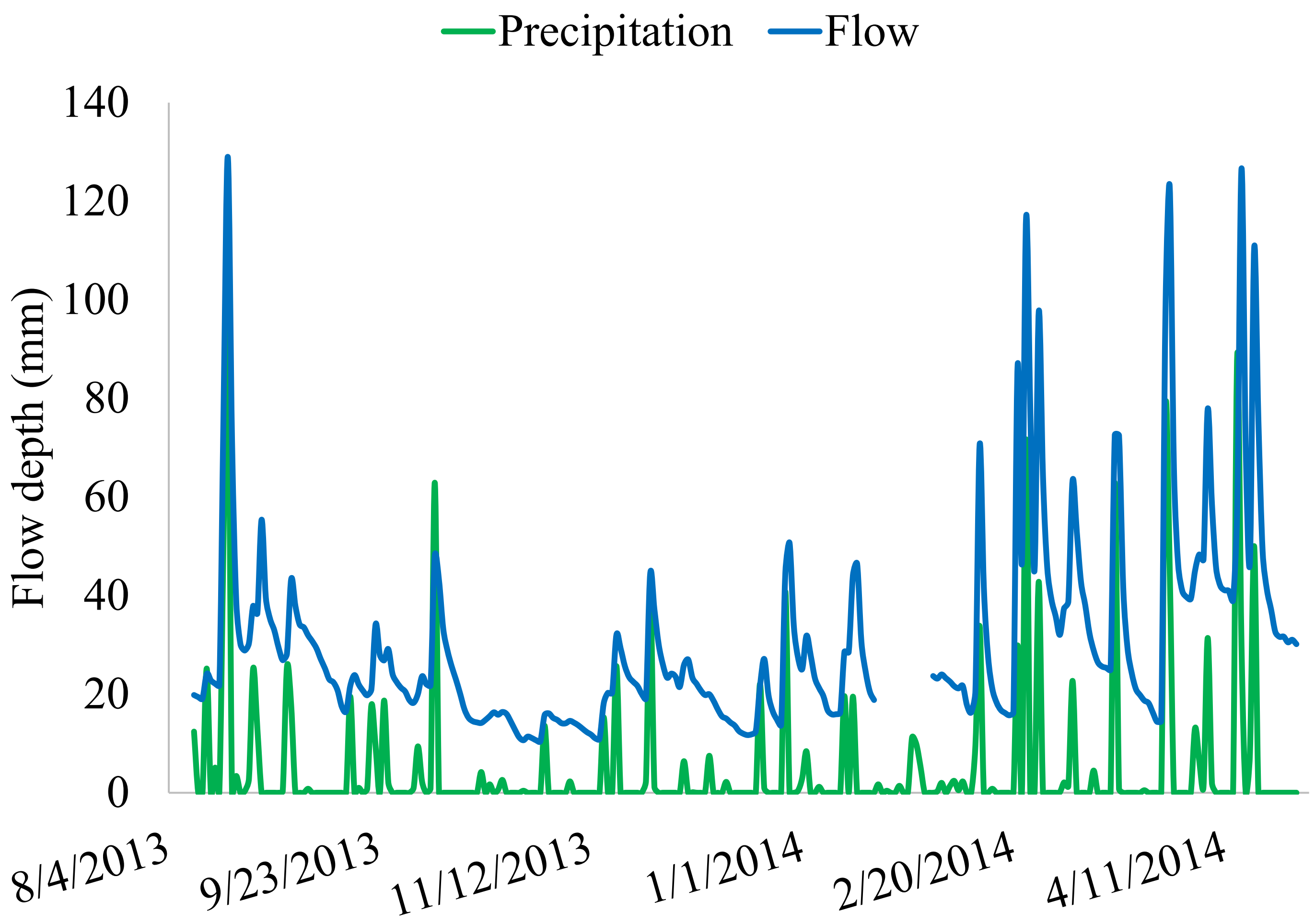




Observed data



On inspection…



Watershed size = 0.49 sq.km
Precipitation = **1723** mm
Total flow = **6599** mm

Where was all this extra water coming from?

The problem

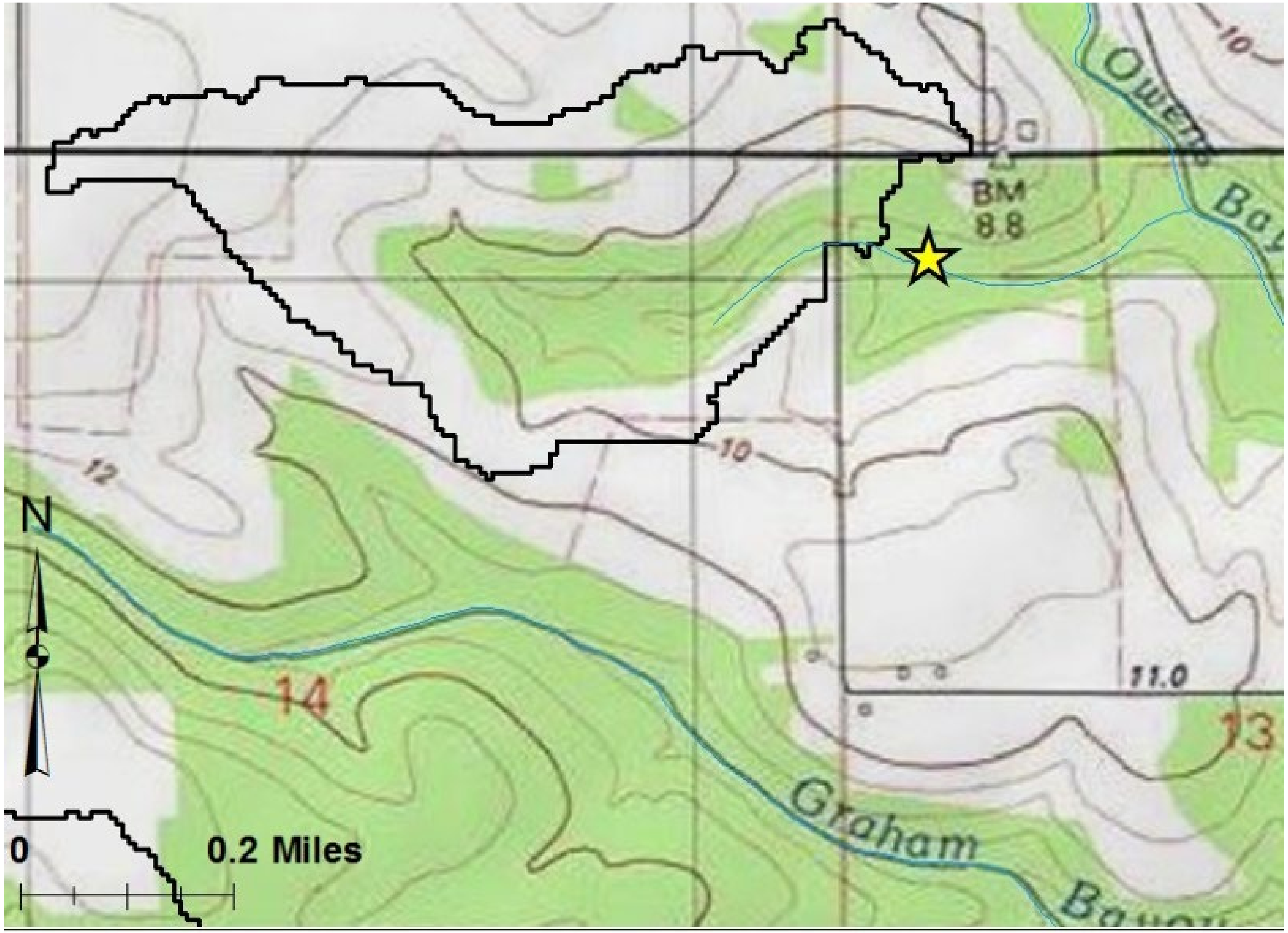
- Observed flows exceeded precipitation inputs
- However from repeated field visits, observed flow data is correct
- The $$$ question -
  - Where is all this extra baseflow coming from?
  - Does the watershed (0.47 km^2) have a very large ground watershed which SWAT fails to account for?

Objectives

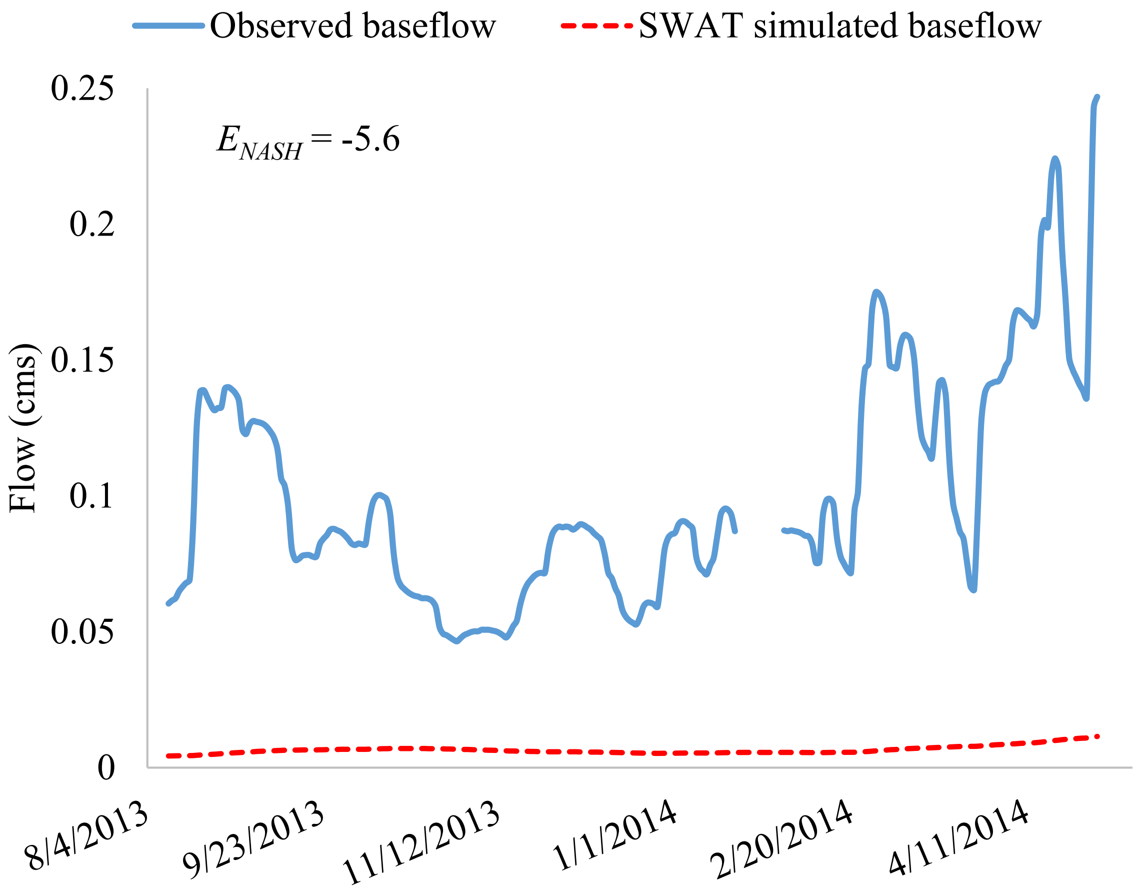
- Can flows be modeled in SWAT relatively simply without having to resort to complex groundwater models?

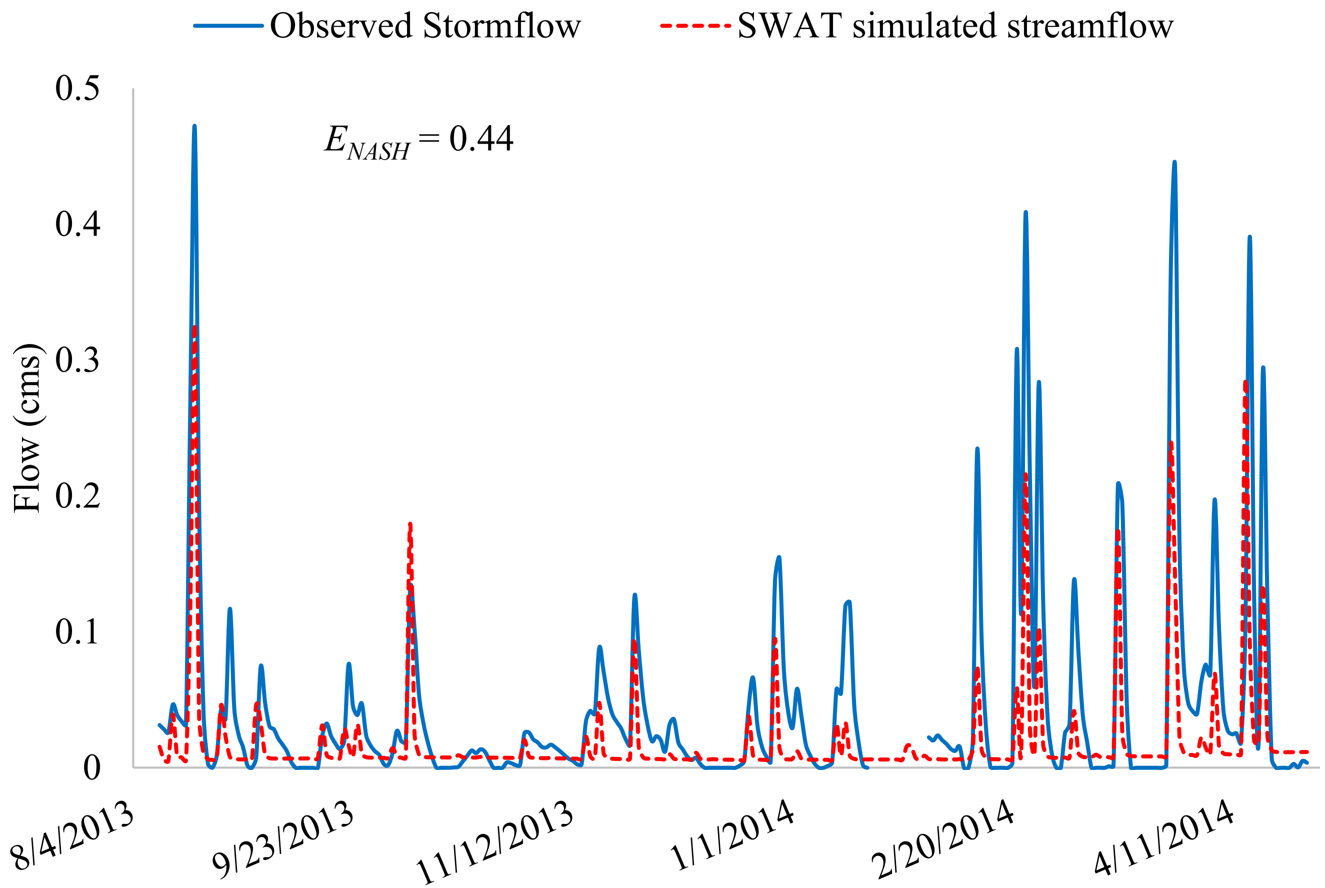
- Provide useful approaches using SWAT model to predict flows in small watersheds with extensive ground watersheds

Topo map



Taking a closer look..



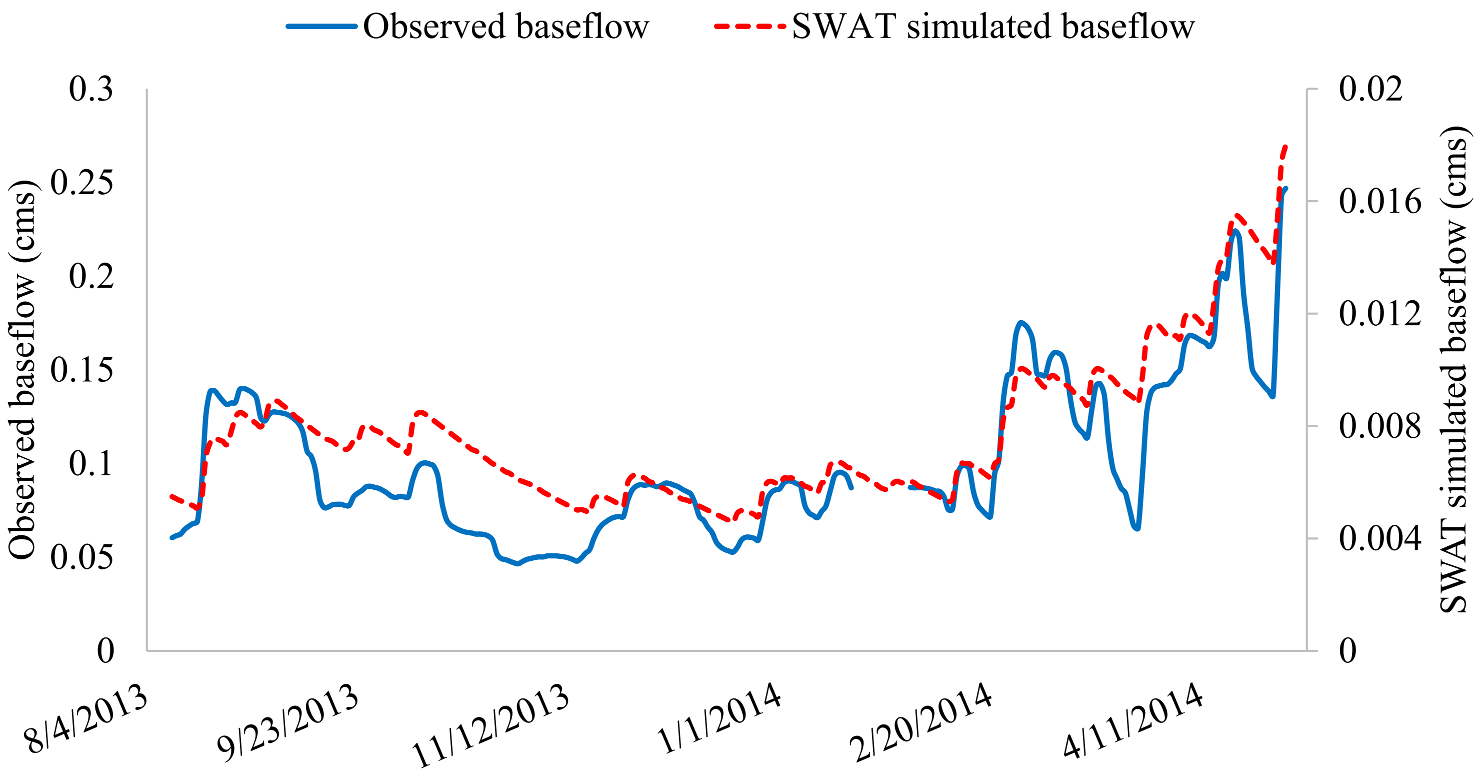


Approach 1

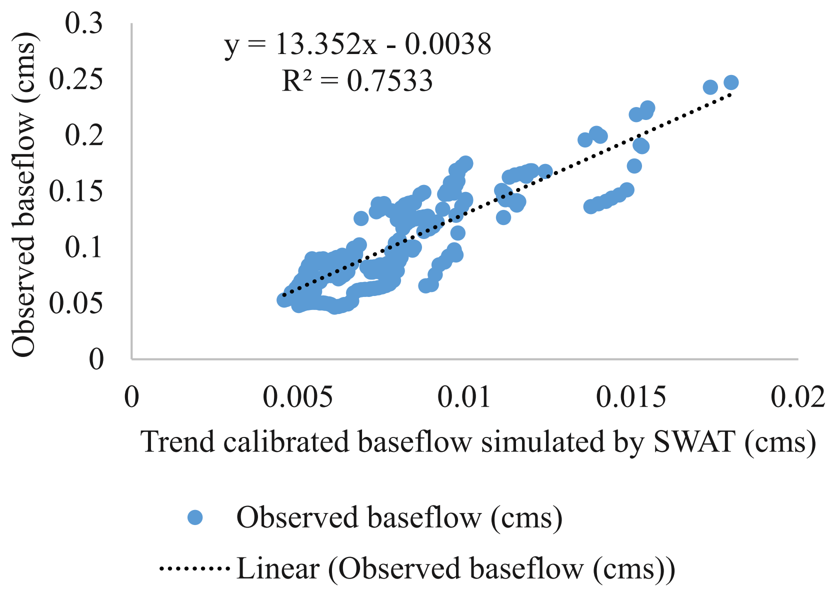
From the data,

$$\text{SWAT streamflow} + \underbrace{[a + (b * \text{SWAT baseflow})]}_{\text{Linear regression}} \cong \text{Observed streamflow}$$

Calibrating baseflow trend

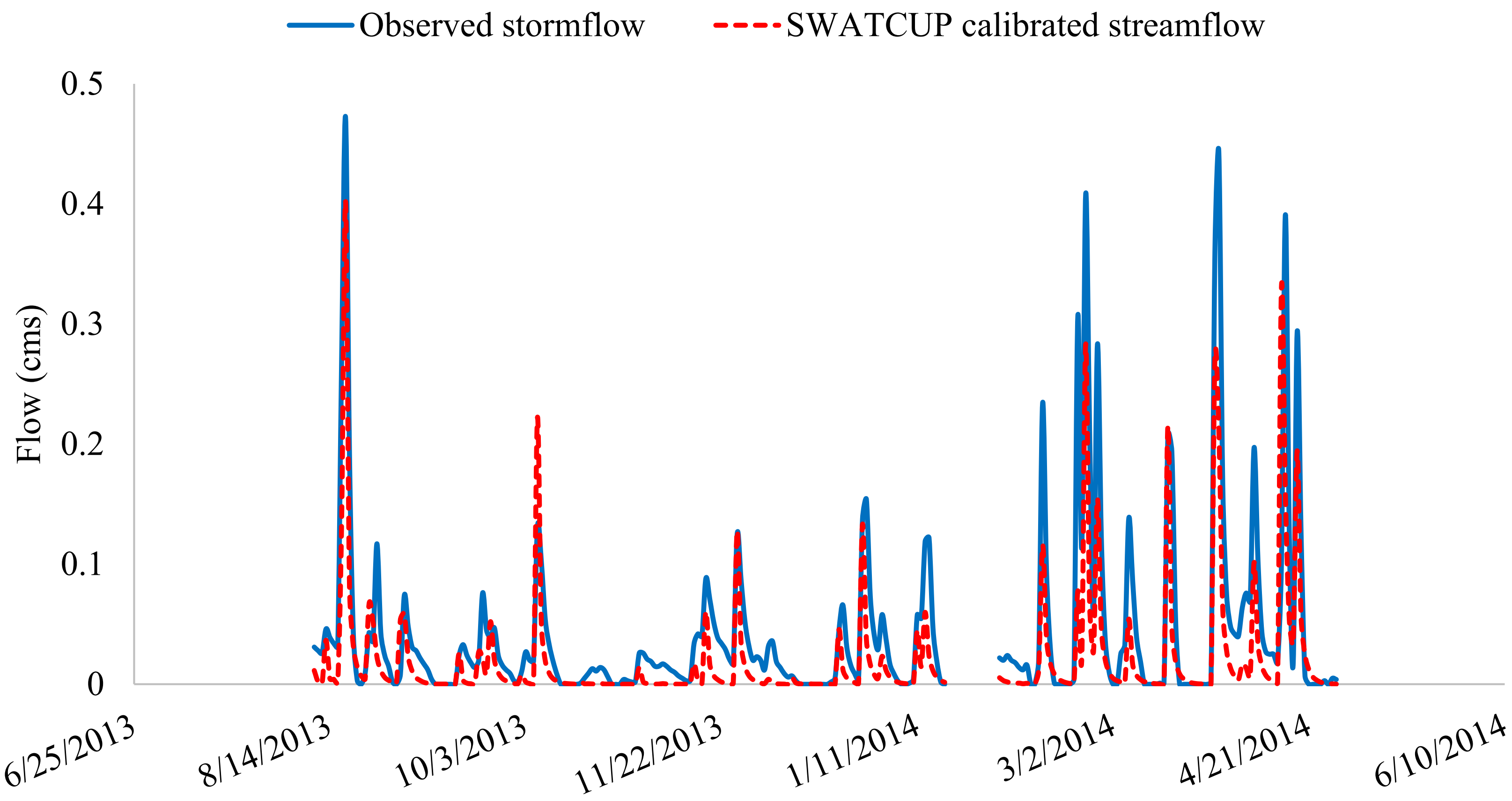


Important SWAT parameters:
GWDELAY = 1 day
RCHRGE_DP = 0



Observed baseflow = 13.352 * Simulated baseflow – 0.0038 (R^2 = 0.75)

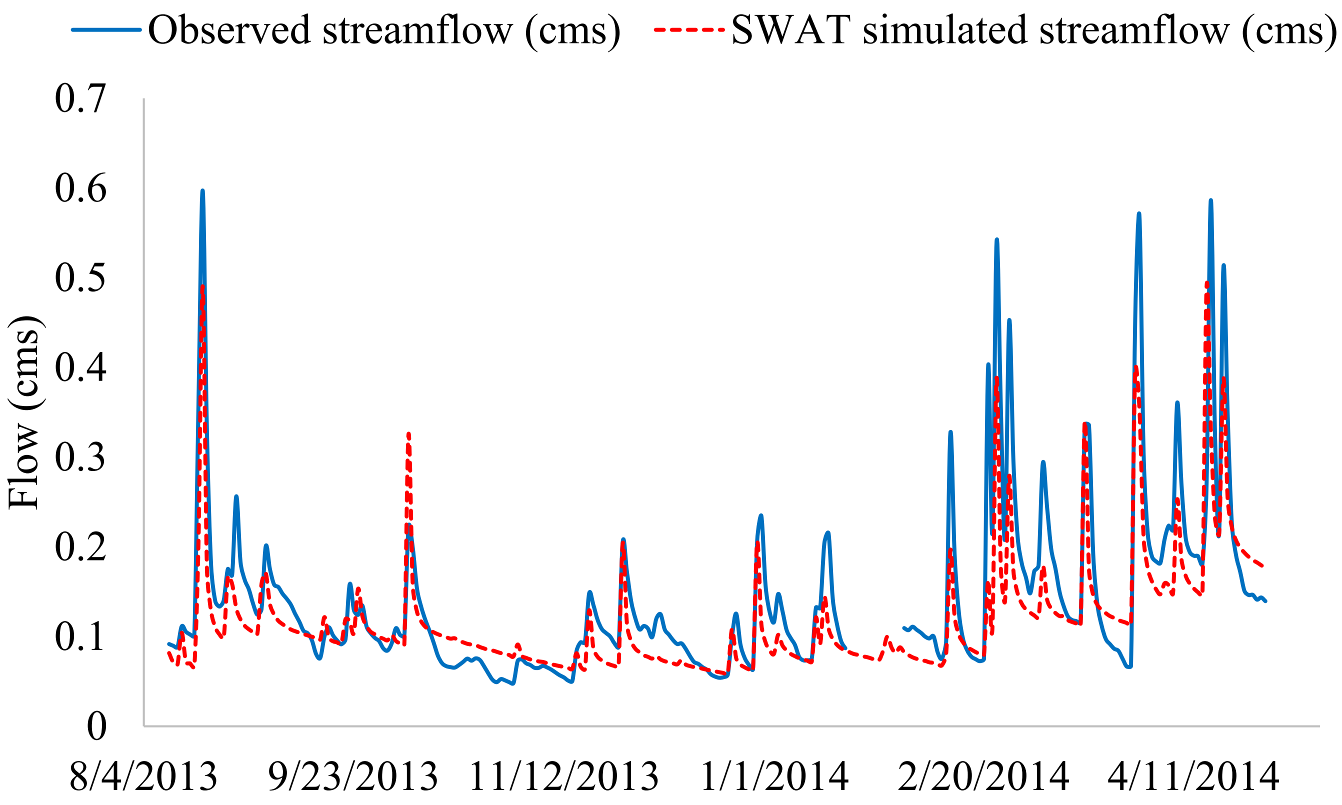
Calibrating stormflow

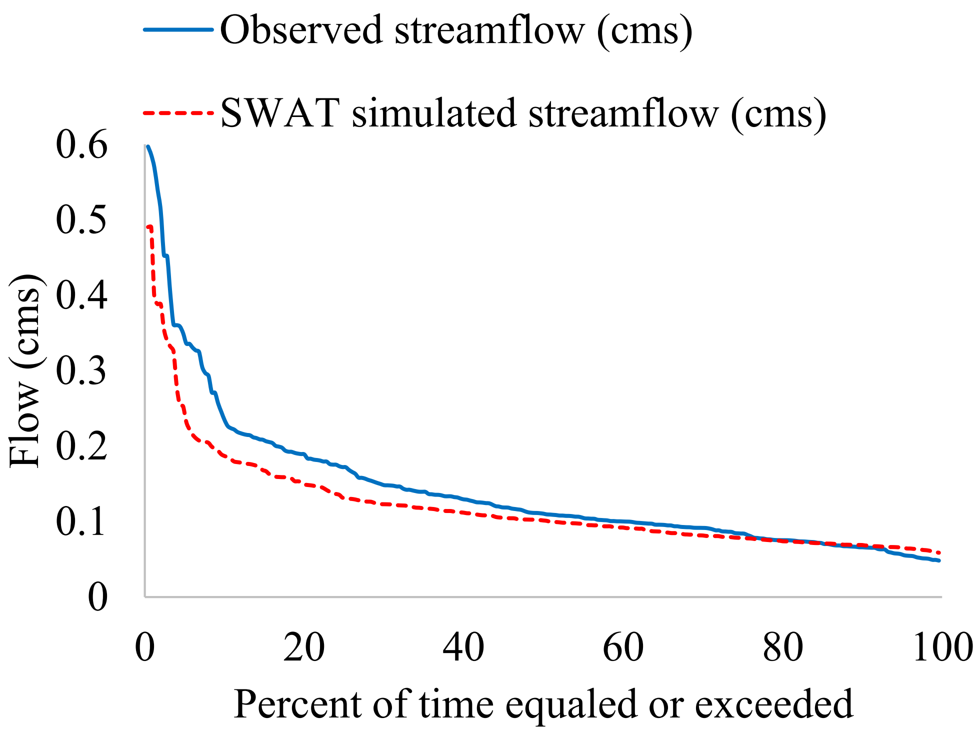


Parameter_Name	Fitted_Value
1: r__CN2.mgt	0.015
2: v__ALPHA_BF.gw	0.690
3: v__GW_DELAY.gw	0.362
4: v__GWQMN.gw	21.741
5: v__GW_REVAP.gw	0.199
6: v__ESCO.hru	0.842
7: v__CH_N2.rte	0.224
8: v__CH_K2.rte	32.122
9: v__ALPHA_BNK.rte	0.884
10: r__SOL_AWC(..).sol	-0.151
11: r__SOL_K(..).sol	0.014
12: r__SOL_BD(..).sol	-0.809
13: v__RCHRG_DP.gw	0.006

($R^2 = 0.71$, $E_{\text{NASH}} = 0.62$)

Calibrated baseflow + calibrated stormflow



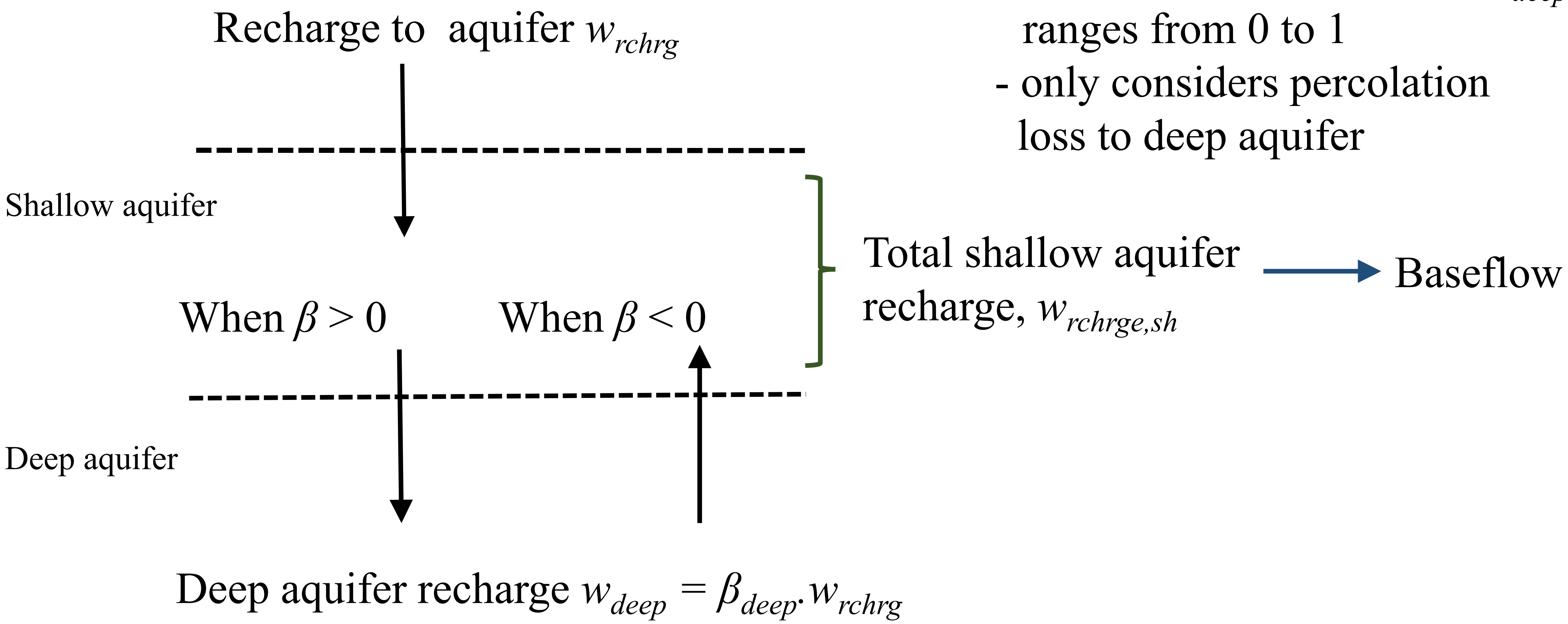


Predicted flow = 13.352 * trend calibrated baseflow – 0.0038 + calibrated stormflow

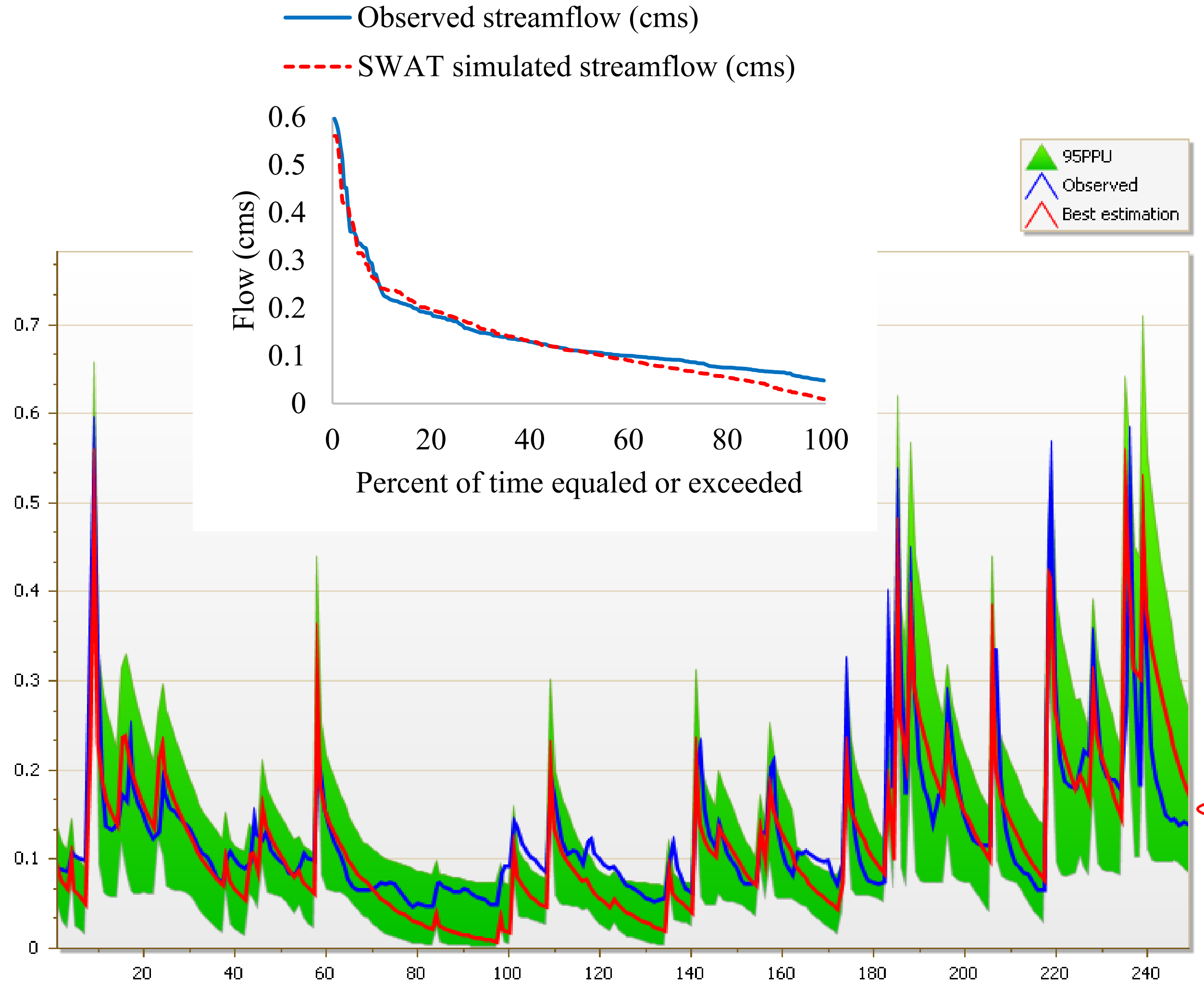
(R^2 = 0.74, E_{NASH} = 0.67)

Approach 2

- In SWAT, RCHRGE_DP (β_{deep}) ranges from 0 to 1
  - only considers percolation loss to deep aquifer



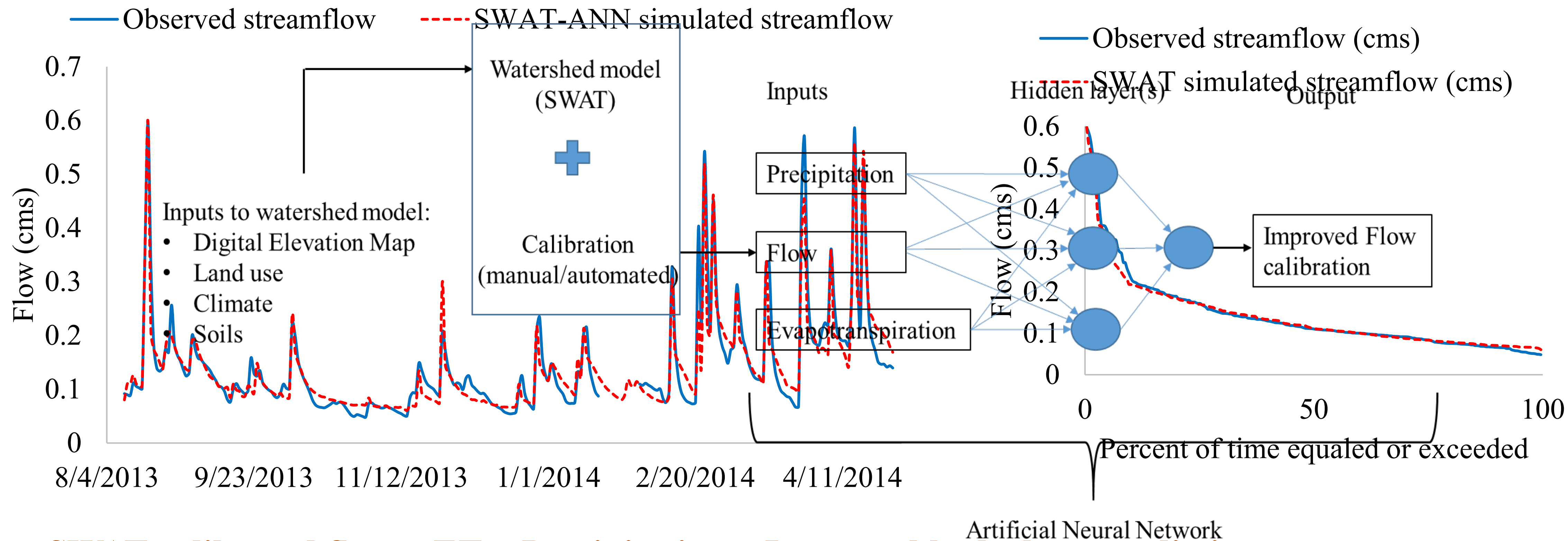
Calibrate with negative RCHRGE_DP



Parameter_Name	Fitted_Value	Min_value	Max_value
1: r__CN2.mgt	0.285	0.126	0.421
2: v__ALPHA_BF.gw	0.082	0.001	0.173
3: v__GW_DELAY.gw	0.563	0.001	3.104
4: v__GWQMN.gw	41.312	25.939	43.589
5: v__GW_REVAP.gw	0.094	0.026	0.101
6: v__ESCO.hru	0.952	0.916	0.985
7: v__CH_N2.rte	0.144	0.125	0.254
8: v__CH_K2.rte	131.781	85.332	142.185
9: v__ALPHA_BNK.rte	0.386	0.232	0.740
10: r__SOL_AWC(..).sol	-0.435	-0.441	-0.068
11: r__SOL_K(..).sol	0.241	-0.098	0.442
12: r__SOL_BD(..).sol	0.029	-0.217	0.134
13: v__RCHRG_DP.gw	-15.293	-19.559	-13.066

(P-factor = 0.84, R-factor = 1.04, R^2 = 0.78, E_{NASH} = 0.75

SWAT+ANN for improved calibration



SWAT calibrated flow + ET + Precipitation = Improved hydrology prediction

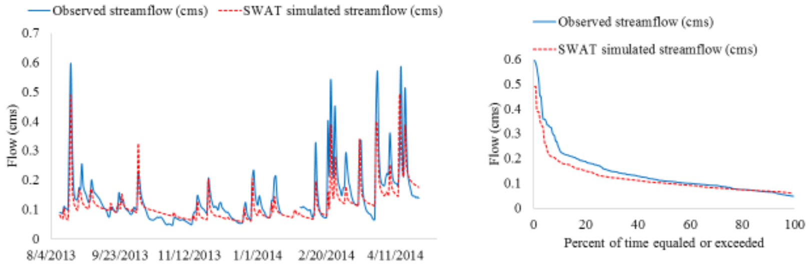
1 hidden layer, 8 nodes, log-sigmoid transfer function

$E_{\mathrm{NASH}} = 0.89$

Results and conclusions

- Evaluated approaches for SWAT application in groundwater dominant watersheds
- Useful SWAT parameter tweak to model high groundwater systems without having to resort to complex groundwater models
- SWAT+ANN is a very useful tool for superior hydrology calibration

Calibrated baseflow + calibrated stormflow



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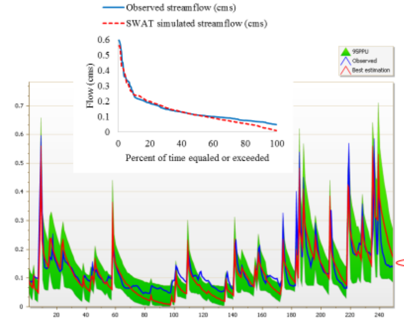

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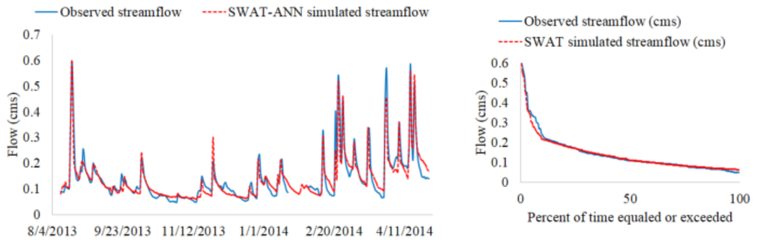

SWAT calibrated flow + ET + Precipitation = Improved hydrology prediction
1 hidden layer, 8 nodes, log-sigmoid transfer function
$E_{NASH} = 0.89$

QUESTIONS ?

- CENTER FOR -
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- AT THE -
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