An Analysis of the HSPF Model for Predicting In-stream Fecal Coliform Concentrations

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Introduction

Salado Creek in Bexar County, Texas is one of 65 streams listed as impaired water bodies in the Clean Water Act's 303(d) list for its high concentration of fecal coliform bacteria (TNRCC, 1998). The restoration of water quality of the impaired streams starts with acquiring knowledge about the system, including the amount and sources of pollutant loading and the sources that are to be controlled.

Since the HSPF model is suitable for modeling in-stream fecal coliform concentration and thus it is widely used for bacterial TMDL studies. Although the usefulness of water quality models as an aid in stream water quality restoration is unquestionable, in recent years US EPA started emphasizing the importance of incorporating the variability and uncertainty in modeling process (USEPA, 1997).

Objectives

1. To evaluate applicability of the HSPF model as a prediction tool for fecal coliform bacterial concentration
2. To determine the sensitivity of in-stream fecal coliform concentrations to changes in the model parameters
3. To determine the fraction of variance of in-stream fecal coliform concentrations due to the most sensitive parameters.
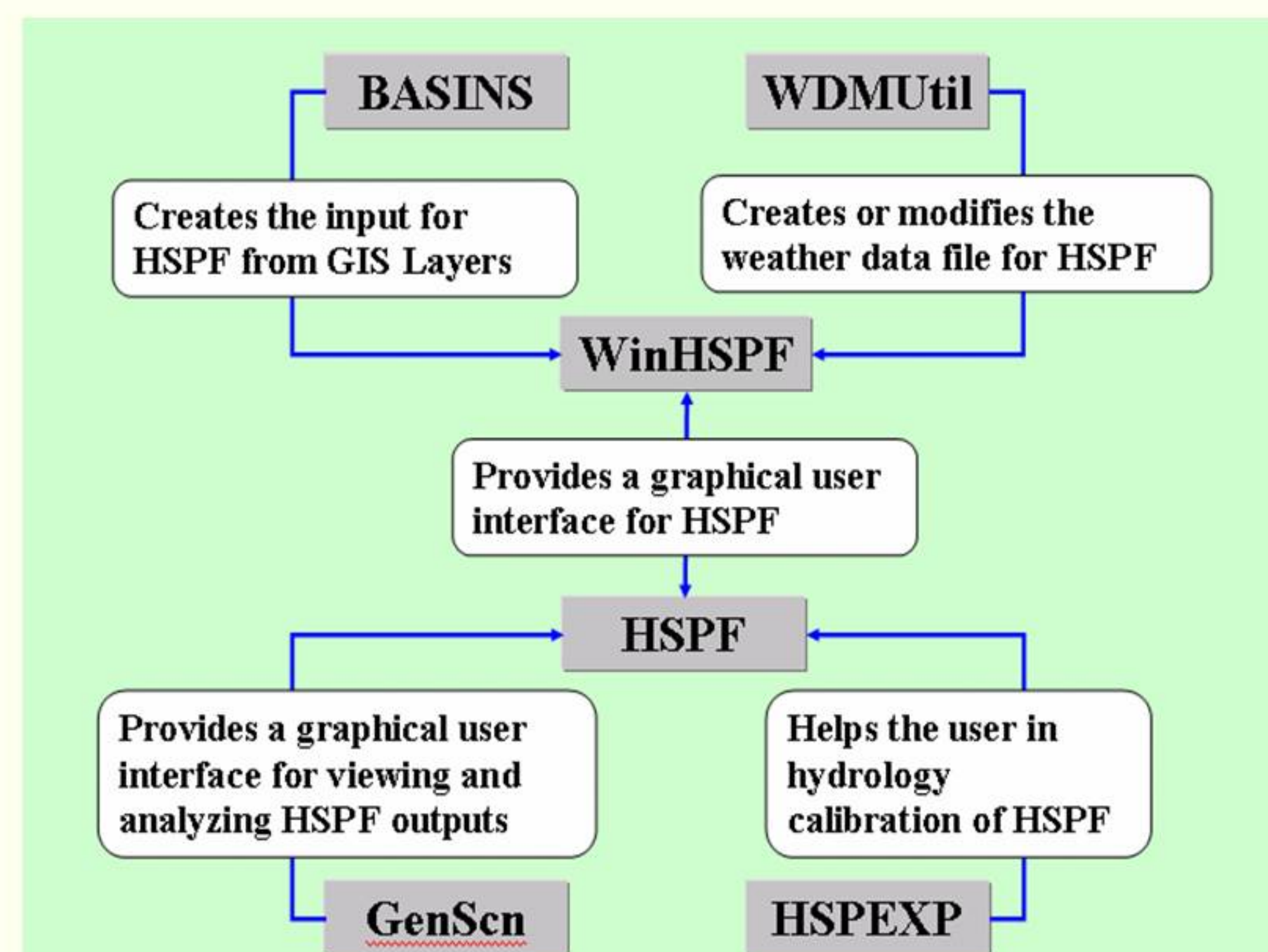
Methodology
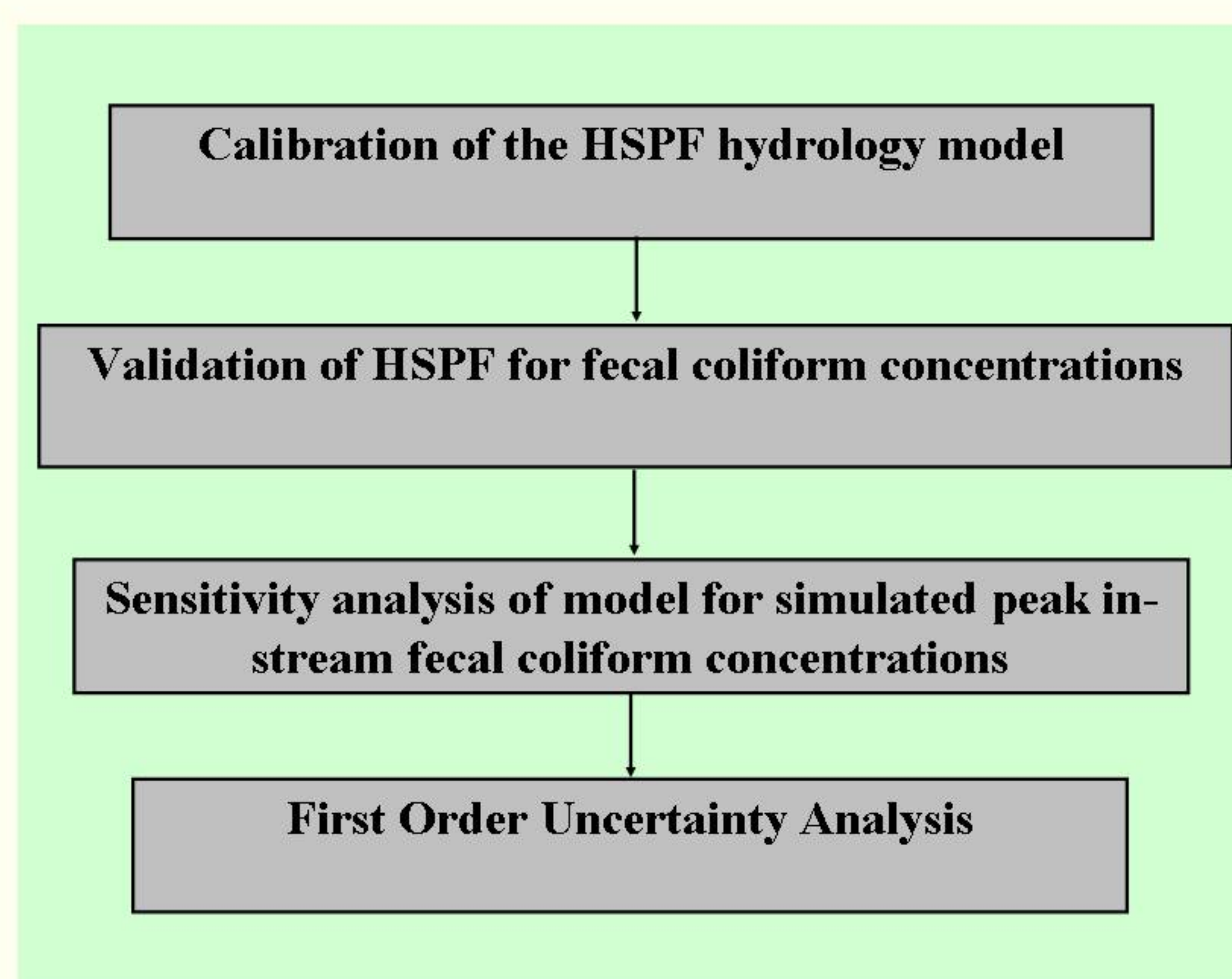
Methodology followed in present study

Model Description

Study was conducted using tools available in EPA's BASINS system framework as shown below

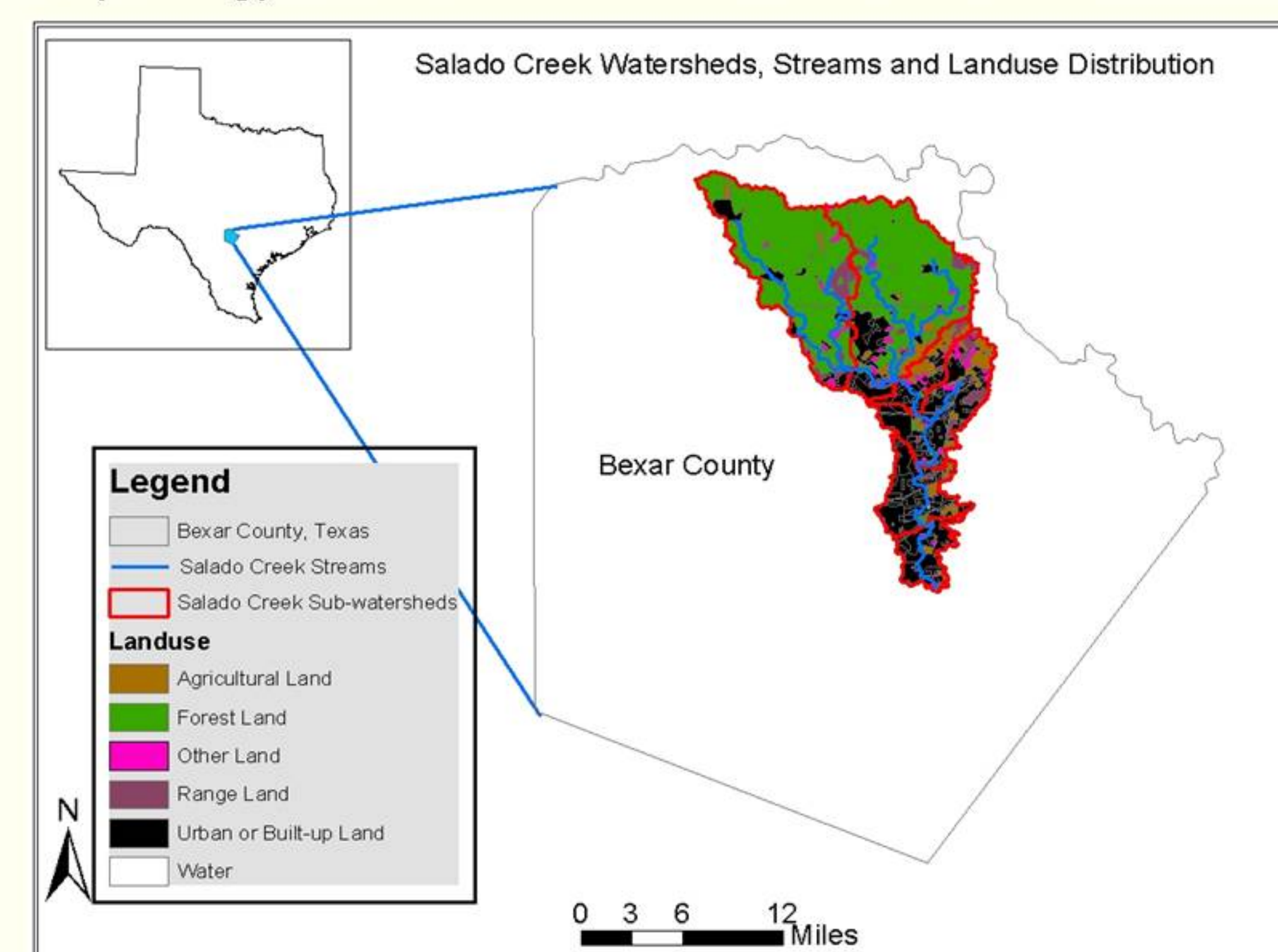**Computer programs employed in the study**

Study Area

Lies within San Antonio River Basin, Bexar County, Texas

Hydrologic Unit Code Boundary: 12100301

Watershed Area: 123,155 acres

Hydrology Calibration Location: USGS 08178800

**Sub-watersheds, streams and the landuse distribution of the study area**

Results

Hydrology Calibration - steps

1. Adjust precipitation, evapotranspiration, and loss to deep groundwater for an overall water mass balance
2. Adjust the high-flow/low-flow distribution by modifying percolation rates, groundwater recharges, and re-emergence of water to streams
3. Match peak storm volumes
4. Fit the seasonal distribution of flows

Long Term Calibration

Long term hydrology calibration was carried for a period from January 1, 1970 to December 31, 1993.
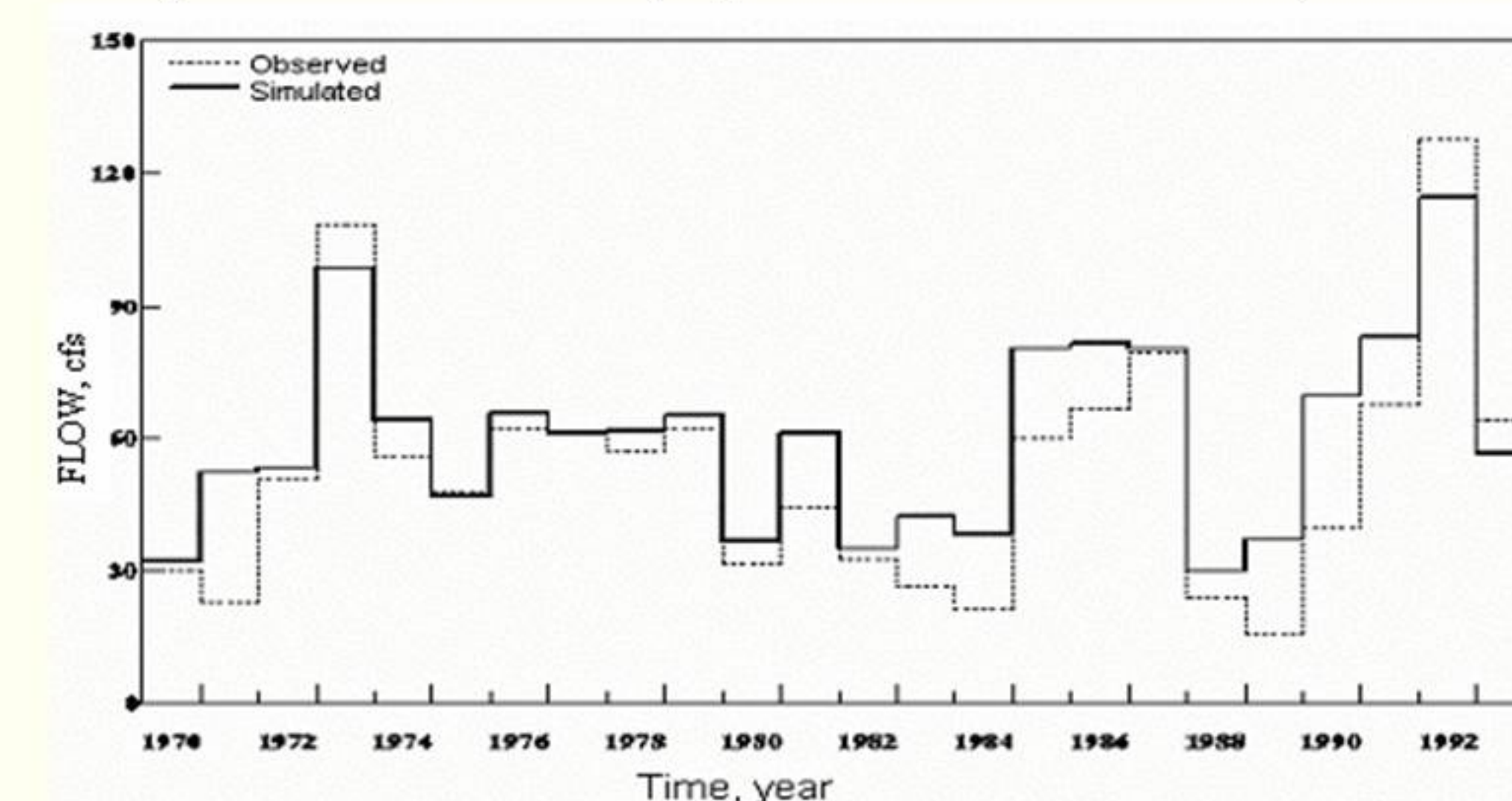
**Yearly mean streamflow at the outlet of Salado Creek**

Close Calibration

HSPF model hydrology was further calibrated for a close match of daily flows for a period from January 1, 1991 to December 31, 1993.

Observed and Simulated Flows at the outlet of Salado Creek Watershed
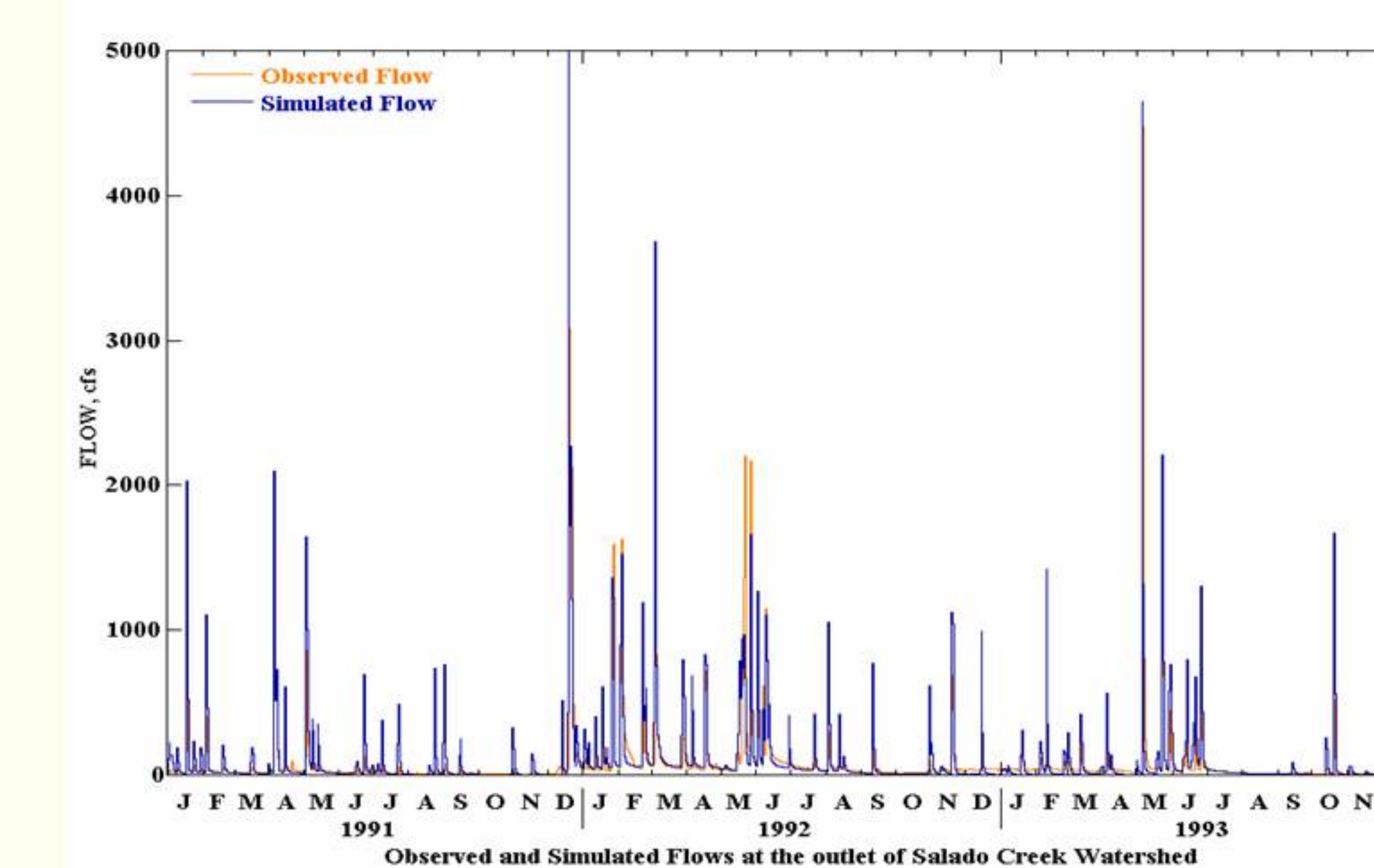
Model Validation for Bacteria

The HSPF model was tested to determine how well the model can represent the dynamics of in-stream fecal coliform.
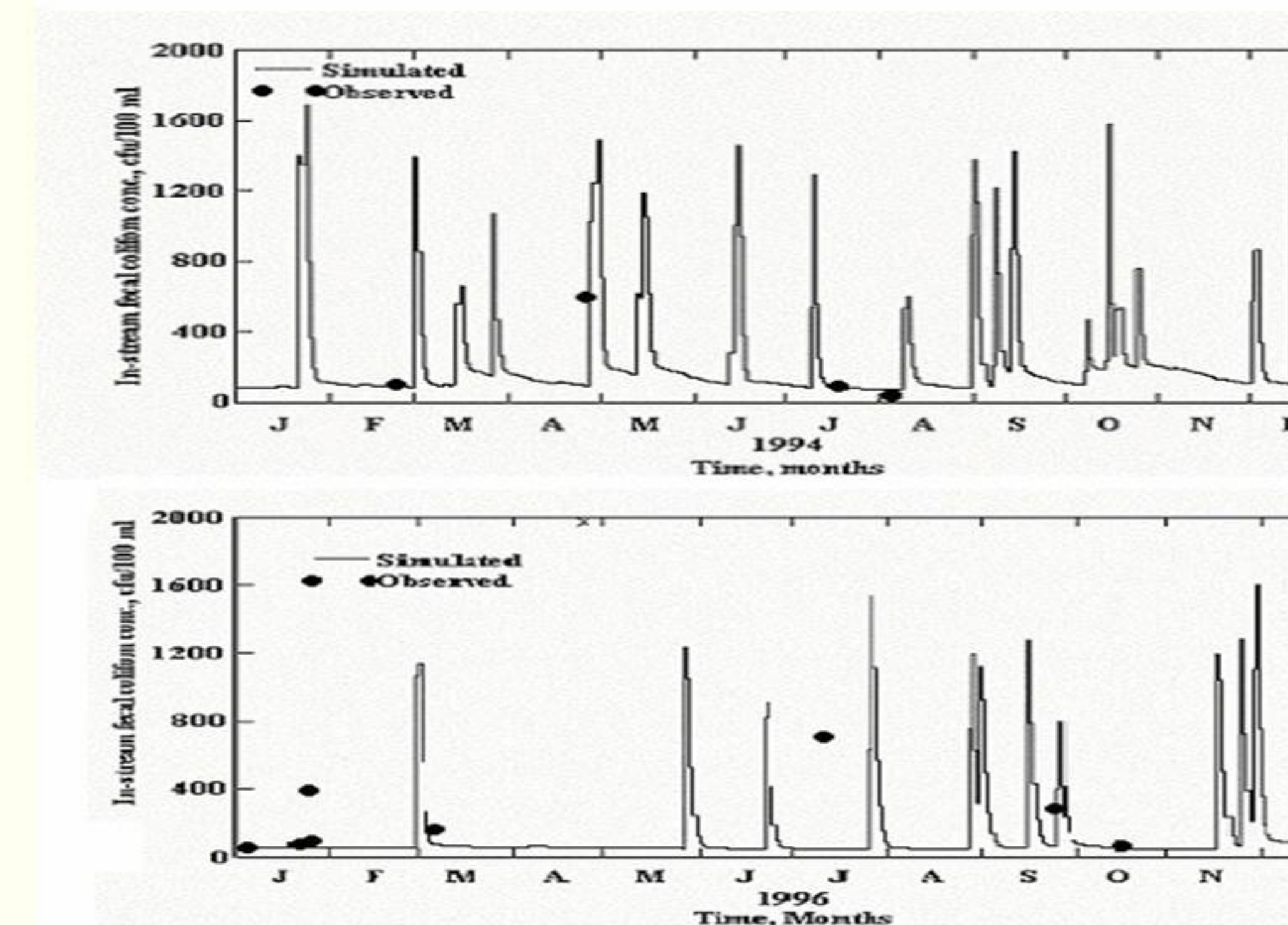
Fecal Coliform concentration at the outlet of Salado Creek

Sensitivity Analysis

Varying input parameters ±10% from the mean value the HSPF model was analyzed to determine which parameters, when changed, caused the greatest change in the peak in-stream concentrations of fecal coliform at the outlet of the Salado Creek.

Table 1. Sensitivity of peak in-stream fecal coliform concentrations (PFC) to HSPF input parameters for the Salado Creek Watershed.

Group of Activity in HSPF model	Parameter	Absolute sensitivity, S	Relative sensitivity, Sr
PERLND:QUAL-INPUT	SQOLIM	4.84E-08	0.99
RCHRES:GQ-GENDECAY	THFST	3.23E+05	0.79
PERLND:QUAL-INPUT	WSQOP	-2.53E+05	-0.97
RCHRES:GQ-VALUES	TWAT	-2170	-0.30
RCHRES:GQ-GENDECAY	FSTDEC	-2.13E+05	-0.20

First Order Analysis

The five parameters that the maximum value of in-stream fecal coliform concentrations at the outlet of the Salado Creek showed the most sensitivity to were used in a First Order Approximation. The First Order Approximation was used to determine which of these sensitive parameters contributed the most to the variance of in-stream fecal coliform concentration.

Results of First Order Analysis

Parameter	Mean	Variance	Sensitivity S	$S^2 \times$ Var	Fraction of Model Variance	% of variance
SQOLIM	2.47E+7 1Mfc/ac	7.44 E+27	4.84E+08	1.74E+13	9.99E-01	99.91
THFST	1.025 (/day)	0.00188	3.23E+05	1.96E+08	1.13E-05	0.00
FSTDEC	0.55	0.0675	-2.53E+05	1.20E+10	6.89E-04	0.07
TWAT	71.00 (F)	75.08	-2.13E+05	3.05E+09	1.75E-04	0.02
WSQOP	1.25 (in/hr)	0.1875	-2.17E+03	3.52E+08	2.02E-05	0.00

Conclusions

The specific findings from the study include:

1. The parameters that peak in-stream fecal coliform concentrations are most sensitive to are those that represent the maximum storage of fecal coliform bacteria over the pervious land segment (SQOLIM), and surface runoff that removes 90 percent of quality constituent from pervious land segment (WSQOP) of PERLND section (corresponding to pervious land segment) of HSPF model.
2. Other parameters in-stream fecal coliform concentration predictions are sensitive to are stream water temperature (TWAT), first-order decay rate of quality constituent (FSTDEC) and temperature correction coefficient for the first order decay rate (THFST) of RCHRES section.
3. Though the model is highly sensitive to the parameters listed above, results of the First Order Analysis showed that a major portion of the model output variance is caused by the variation in the parameter representing the maximum storage of fecal coliform bacteria over the pervious land segment.