Adaptation of the AVGWLF Watershed Model for Use in Texas and Surrounding States: Phase 1

Submitted to:

Texas State Soil and Water Conservation Board
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Table of Contents

1.0 STUDY OVERVIEW

1.1 Introduction

Nonpoint source (NPS) pollution is considered a primary threat to the quality of waters in the United States. Section 319 of the Clean Water Act presents guidelines for the implementation of state NPS management programs; specifically, the guidance documents urge state NPS programs to implement a watershed approach. This entails the development of watershed-based plans that should identify sources of pollutants, describe management measures necessary to achieve pollutant (nitrogen, phosphorus, sediment) load reductions, and estimate these resulting pollutant load reductions.

Section 303(d) of the Clean Water Act and EPA guidance require states to identify waters that fail to meet (or are not expected to meet) water quality standards. Such waters are considered to be water quality-limited and require the development of Total Maximum Daily Loads (TMDLs). Methods for TMDL development and/or determining the extent of nonpoint source pollutant loads typically include long-term surface water monitoring and computer-based simulation modeling. As resources for monitoring have declined, reliance on computer modeling (for making necessary determinations) has increased.

The Environmental Protection Agency's Nonpoint Source Program Grants guidelines and the TMDL Regulations and Guidance both advocate a watershed approach to better address water quality problems. Both of these guidelines and regulations require the development of pollutant load reduction estimates to a watershed. Modeling has become an essential tool for evaluating the sources and controls of sediment and nutrient loading to surface waters. For the NPS program, however, there is concern over the reporting inconsistencies of load reduction estimates (LRE). Such inconsistencies may arise through the use of more than one model since different models have different purposes and levels of accuracy. In addition, there are huge variations in estimated pollutant load reductions being reported by different states. The states have therefore expressed a desire to use models that are neither too complicated nor oversimplified. It is widely believed that the use of a regional approach to develop LREs will help eliminate data reporting inconsistencies and give a better overall picture of the status of regional water quality. The states therefore recognize the tremendous benefits provided by a model that is regional in scope.

1.2 Background

Given the number and complexity of water quality problems facing the State of Texas and other states in EPA Region 6, a need exists for expanding the suite of tools currently available for evaluating water quality problems at the watershed level; including those associated with non-point sources of sediment and nutrients. As part of the effort described in this document, the Texas State Soil and Water Conservation Board (TSSWCB), in collaboration with the Penn State Institutes of Energy and the Environment (PSIEE), has undertaken the development of a "regionalized" version of **AVGWLF** for use in the states covered by EPA Region 6 (i.e., New Mexico, Texas, Oklahoma, Arkansas and Louisiana). The overall goal of this project is to provide states within this region with a technical tool that can be used to develop non-point source pollutant load reduction estimates and TMDLs at the watershed and regional scale.

1.3 AVGWLF Watershed Model Description

AVGWLF is a GIS-based watershed modeling system that was initially developed to facilitate the estimation of nutrient and sediment loads in watersheds in Pennsylvania. It has also been adapted for use elsewhere, including most recently New York and New England. The core watershed simulation model for this GIS-based application is the GWLF (Generalized Watershed Loading Function) model developed by Haith and Shoemaker (1987). The GWLF model provides the ability to simulate runoff, sediment, and nutrient (N and P) loadings from a watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model which uses daily time steps for weather data and water balance calculations. Monthly estimates are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values. The original GWLF model (called GWLF-E within **AVGWLF**) has been significantly enhanced to address better water-balancing as well as the estimation of such things as streambank erosion, nutrient contributions from farm animal populations, and pathogen loading from various sources.

AVGWLF is essentially a customized interface developed by Penn State for the ArcView 3.x GIS package that is used to parameterize input data for the GWLF-E model (see Evans et al., 2002). In utilizing this interface, the user is prompted to identify required GIS files and to provide other information related to “non-spatial” model parameters (e.g., beginning and end of the growing season, the months during which manure is spread on agricultural land, etc.). This information is subsequently used to automatically derive values for required model input parameters which are then written to the various input files needed to execute the GWLF-E model. Also accessed through the interface are Excel files that contain temperature and precipitation information used to create the necessary weather input file for a given watershed simulation. A Users Guide has previously been developed (and updated) that provides background information on the modeling approach and information on how to use **AVGWLF** (Evans et al., 2008).

This modeling tool was originally developed in Pennsylvania primarily as a result of that state’s interest in having a model that would not need to be calibrated prior to each use, but that could be used to estimate nutrient and sediment loadings in watersheds throughout the state with acceptable levels of accuracy, including those for which minimum amounts of water quality data were available. Subsequent use of **AVGWLF** in Pennsylvania has shown that the model provides reasonably good estimates for watersheds that exhibit a wide range of landscape characteristics (Evans et al., 2002). Based on 32 calibration and verification watersheds in the state, **AVGWLF** was successful in simulating nutrient load variations for monthly, seasonal, and yearly time periods. The success of **AVGWLF** applications in Pennsylvania and its applicability to a variety of water programs (e.g., NPS, TMDL, monitoring, etc.) has made it a desirable model for development and calibration in other regions of the country.

1.4 Study Objectives

For this study, TSSWCB collaborated with Penn State to calibrate and adapt the **AVGWLF** model for use in EPA Region 6, which includes the states of Texas, New Mexico, Oklahoma, Arkansas and Louisiana. It is anticipated that the adaptation of the **AVGWLF** model for this region will provide these states and their partners with an enhanced technical “tool kit” for use in the development of non-point source pollutant load reduction estimates and TMDLs.

This “regionalized” version of **AVGWLF** was calibrated and verified (tested) using representative watersheds throughout EPA Region 6. As a result of this calibration and verification, it is expected that this model will provide the states in this region with a tool to more consistently estimate load reductions and TMDLs (with some exceptions as described in later sections).

It is also hoped that the enhanced modeling tool will help the states to more efficiently implement the NPS and TMDL programs by building the capacity of all levels of government to develop effective, comprehensive programs for watershed protection and management. States will be able to make more informed decisions regarding such issues as choosing BMPs for specific areas, deciding on feasibility of centralized wastewater treatment, and determining the need for treatment upgrades. This capacity-building effort will also encourage the implementation of these programs on a regional scale.

2.0 METHODOLOGY

2.1 Study Site Selection

Given the limited budget for conducting the type of modeling effort undertaken as part of this project, it was proposed in the original scope of work that the software application be tested in a number of watersheds within three common eco-regions spanning Texas and other surrounding states in EPA Region 6 (i.e., the Southwest Tablelands, Central Great Plains, and South Central Plains areas as shown in Figure 1). In the initial review of available data, an assessment was made of all potential watersheds in the identified eco-regions in EPA Region 6 that met the following criteria: 1) watershed size was about 600 square miles in size or less, 2) continuous daily stream flow data were available for at least one 5 to 10-year period after 1995, 3) in-stream water quality data were available for this same period and location (i.e., the stream gages and water quality monitoring stations were in close proximity to each other), and 4) in terms of stream data, a sufficient number of samples were available for total N, total P and/or suspended sediment to derive reasonable observed load data sets. In evaluating potential watersheds, the primary sources of data reviewed included state agency, USGS, and EPA databases.

Within each of these eco-regions, it was initially proposed that **AVGWLF** be tested at eight (8) different sites in each eco-region for a total of 24 test sites across all 5 states. However, due to a general lack of suitable stream flow and/or water quality data (particularly in the drier, westernmost regions), the number of study sites was reduced to 22, with the final distribution of sites as follows: Southwest Tablelands (6), Central Great Plains (10), and South Central Plains (6) (see Figure 2 and Table 1). An attempt was made to select test watersheds that range in size from approximately 20 to 600 square miles. However, due to lack of available data, the watershed sizes of the watersheds selected range in size from about 50 to 1200 square miles in size. Additional site characteristics of each watershed are included in Table 2.

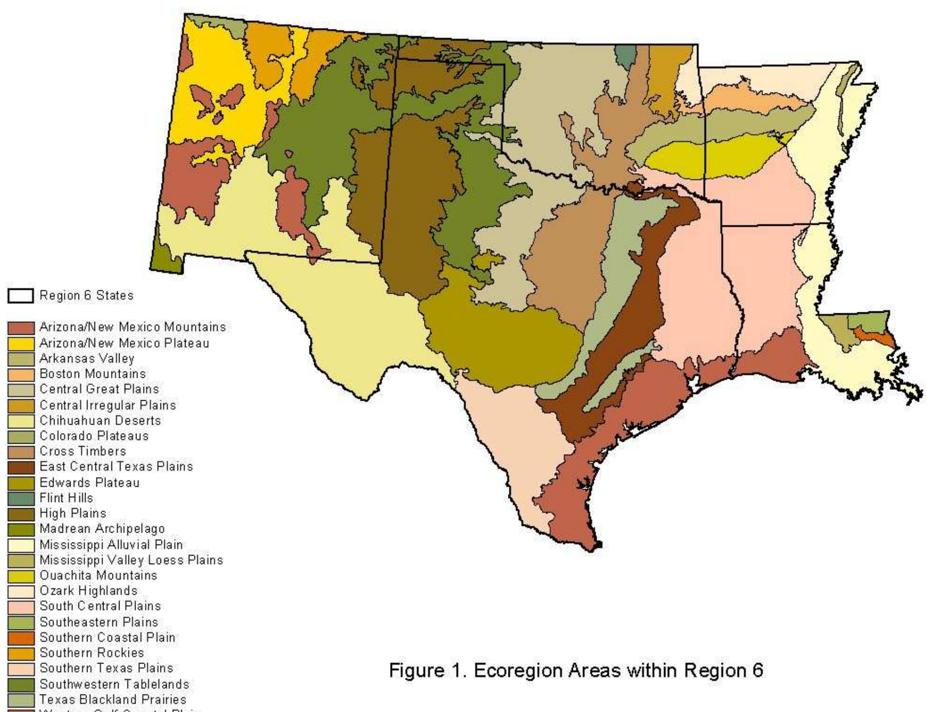

Figure 1. Ecoregion Areas within Region 6

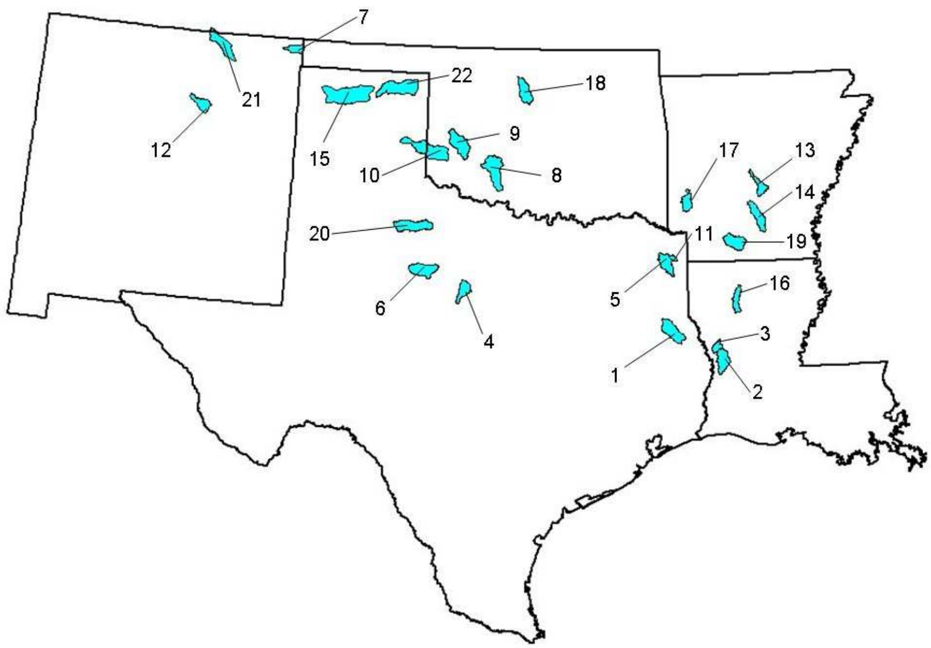

Figure 2. Location of watershed test sites.

Table 1. Selected watershed sites.

Map Id	WQ Station	USGS Gage	Watershed Name	Size (sq. mi.)	State
1	10636	8038000	Attoyac Bayou	496	TX
2	1166	8028100	Bayou Anacoco	384	LA
3	1160	8022500	Bayou Toro	138	LA
4	13640	8086290	Big Sandy Creek	289	TX
5	10245	7346045	Black Cypress	357	TX
6	11709	8084800	California Creek	472	TX
7	02CARRIZ002.7	7154500	Carrizozo Creek	195	NM
8	311300010020-01	7311000	East Cache Creek	690	OK
9	31150003-001AT	7304500	Elk Creek	552	OK
10	311800000010-01	7303500	Elm Fork/North Fork	841	TX/OK
11	10259	7346140	Frazier Creek	47	TX
12	13	8382000	Gallinas Creek	293	NM
13	OUA116	7363300	Hurricane Creek	197	AR
14	OUA28	7362550	Moro Creek	385	AR
15	10007	7233500	Palo Duro Creek	1180	TX
16	553	7352000	Saline Bayou	252	LA
17	RED21	7341200	Saline River	251	AR
18	620910030010-001AT	7160500	Skeleton Creek	396	OK
19	OUA27	7362110	Smackover Creek	407	AR
20	10185	7311800	South Fork Wichita R.	571	TX
21	11	7203525	Vermejo River	488	NM
22	10058	7233500	Wolf Creek	787	TX

Table 2. Summary of study site characteristics.

Watershed	Area (sq. mi.)	Percent Forested	Percent Agriculture[1]	Percent Developed	Percent Other[2]	Pt Source Influenced[3]	Steeply Sloping[4]	Precip. (cm/yr)	Runoff (cm/yr)[5]	R/P (%)[6]
Attoyac Bayou	496	43	16	1	40			131.75	41.11	31
Bayou Anacoco	384	60	2	4	34	X		143.01	51.50	36
Bayou Toro	138	70	4	1	25			132.50	47.01	35
Big Sandy Creek	289	61	5	<1	34			67.33	2.43	4
Black Cypress	357	68	16	3	13			118.77	30.63	26
California Creek	472	28	62	<1	10			53.24	1.93	4
Carrizozo Creek	195	36	0	0	64		X	41.95	0.25	<1
East Cache Creek	690	8	23	4	65	X		75.61	9.55	13
Elk Creek	552	25	51	1	23	X		77.05	8.62	11
Elm Fork/North Fork	841	59	9	<1	32			65.52	3.05	5
Frazier Creek	47	79	8	1	12			131.74	36.70	28
Gallinas Creek	293	48	<1	1	51	X	X	45.14	8.74	19
Hurricane Creek	197	70	8	5	17			116.90	37.34	32
Moro Creek	385	77	1	4	18			133.62	37.09	28
Palo Duro Creek	1180	5	58	1	36			41.15	0.03	<1
Saline Bayou	252	81	2	2	15			138.10	46.02	33
Saline River	251	79	10	1	10			125.40	40.21	32
Skeleton Creek	396	2	54	4	40			72.47	10.17	14
Smackover Creek	407	82	2	2	14			130.20	39.48	30
South Fork Wichita R.	571	89	2	<1	8			62.37	1.66	3
Vermejo River	488	69	<1	<1	31		X	32.61	2.77	8
Wolf Creek	787	12	30	<1	57			52.43	0.25	<1

[1] Includes both cropland and hay/pasture categories.
[2] Includes miscellaneous categories such as mined areas, open water, wetlands and open range/grass land. In the South Central Plains eco-region, these areas are primarily wetlands; in the other two regions they are primarily open range/grassland.
[3] In this case, defined as watersheds where point sources comprise at least 10% of the mean annual flow, or the total N or P loads.
[4] In this case, defined as having a mean watershed slope greater than 4%.
[5] Amount of mean annual precipitation that leaves watershed as stream flow.
[6] Percentage of mean annual precipitation that leaves watershed as stream flow.

2.2 Data Set Development

Within **AVGWLF**, both ArcView-compatible shape files and grids are manipulated for the purpose of estimating assorted model parameters. In order for parameter values to be estimated properly, it is imperative that each of the required grids and shape files be created and formatted correctly. The current version of **AVGWLF** (*Ver. 7.3*) is different from older versions in that many of the data sets used are now considered to be "optional" (see Section 2.B. of the newest **AVGWLF** users guide [Evans et al., 2008]). What this essentially means is that if optional layers are not specified by the user, then default values are assigned to the model parameters that would have been calculated utilizing the missing optional layers. Up to 13 shape files and 4 grid files can be used by **AVGWLF** for the purpose of deriving required GWLF-E model input data. Table 3 provides a listing and brief description of all of the required and optional GIS layers used. *(Note: It should be stressed that certain layers have been made "optional" solely for the purpose of making it easier for new users of AVGWLF to get "up and running" with the software. However, all data sets that are available should generally be loaded and used in order to insure that model results are based on the best available information).*

Table 3. Overview of GIS data layers used in **AVGWLF**.

File Names	Short Description	Required
Shape Files		
Weather stations	Weather station locations (points)	Y
Point Sources	Point source discharge locations (points)	N
Water Extraction	Water withdrawal locations (points)	N
Tile Drain	Locations of tile-drained areas (polygons)	N
Basins	Basin boundary used for modeling (polygons)	Y
Streams	Map of stream network (lines)	Y
Unpaved Roads	Map of unpaved roads (lines)	N
Roads	Road map (lines)	N
Counties	County boundaries - for USLE data (polygons)	N
Septic Systems	Septic system numbers and types (polygons)	N
Animal Density	Animal density (in AEUs per acre) (polygons)	N
Soils	Contains various soil-related data (polygons)	Y
Physiographic Provinces	Contains hydrologic parameter data (polygons)	N
Grid Files		
Land Use/Cover	Map of land use/cover (16 classes)	Y
Elevation	Elevation grid	Y
Groundwater-N	Background estimate of N in mg/l	N
Soil-P	Estimate of soil P in mg/kg (total or soil test P)	N

Specific format requirements for each dataset used by **AVGWLF** are provided in another document (format guide) that has recently been updated (Evans et al., 2008). The only other requirements for these datasets (i.e., shape files and grids) are that they must be compatible with ArcView 3.x software, and they must be in a metric projection in which the units are set to meters.

The latter requirement is due to the fact that various internal calculations are made based on the assumption that map units are in meters.

To support the creation of model input files via **AVGWLF** in each of the test sites shown in Figure 2, a number of GIS data sets were complied from various public sources. These data sets are representative of those that would typically be used for watershed modeling studies in which **AVGWLF** or a similar GIS-based watershed modeling application would be utilized. The primary data sets, along with their sources, are shown in Table 4. Also shown in this table are other data sets needed for either model input derivation or calibration purposes.

Table 4. Primary GIS data sets used for the project.

GIS/Other Data Sets	Source
DEM (70-meter)	NASA SRTM data (http://srtm.csi.cgiar.org)
Land Cover	USGS NLCD (http://landcover.usgs.gov/natllandcover.php)
Soil boundaries/characteristics	USDA STATSGO (http://soils.usda.gov/survey/geography/statsgo/)
Soil P estimate	Derived from STATSGO soil texture information
Groundwater N estimate	Derived from land cover and soils combination
Streams	State agency web sites
Study site boundaries	USGS HUC boundaries
Crop types/animal populations	USDA/National Agricultural Statistics Service
Stream flow	US Geological Survey (http://waterdata.usgs.gov/nwis/sw)
Water quality	USEPA/STORET and Texas Comm. On Environ. Quality

To facilitate their use within **AVGWLF** for this project, the GIS data sets obtained from various sources were re-projected into a common geographic coordinate system. Specifically, an Albers metric coordinate system utilized by many federal agencies for national data sets was used. The projection information for this system is as follows:

PROJCS: NAD_1927_Albers
GEOGCS: GCS_North_American_1927
DATUM: D_North_American_1927
SPHEROID: Clarke_1866
PRIMEM: Greenwich",0.0
UNIT: Degree, 0.0174532925199433
PROJECTION: Albers
PARAMETER: "False_Easting", 0.0
PARAMETER: "False_Northing", 0.0
PARAMETER: "Central_Meridian", -96.0
PARAMETER: "Standard_Parallel_1", 29.5
PARAMETER: "Standard_Parallel_2", 45.5
PARAMETER: "Latitude_Of_Origin", 23.0
UNIT: "Meter", 1.0

Descriptions of the shape files and grids compiled for use with **AVGWLF** as part of this project are provided in the following two sub-sections. These descriptions are organized on the basis of shape files versus grid files and required layers versus optional layers. A later sub-section (2.3) describes the daily weather data files associated with each weather station in the "weather" shape file. Many of the details on formats and usage of these files are not repeated below; rather, the reader is directed to the two key documents related to **AVGWLF** (the User Guide and the Format Guide) for additional information.

2.2.1 Shape Files

<u>Required Layers</u>

Basins

This particular file is used to represent the boundary of one or more basins (watersheds) in which modeling is to be performed. Typically, these features are digitized from USGS topographic maps or created "free-hand" using some type of base map or image. For the purposes of this project, ArcView-compatible boundary polygons were created for watersheds utilized for model testing purposes. For other areas within EPA Region 6, users will be required to prepare and identify watershed boundary files for use within **AVGWLF**. Instructions on how to prepare such files are given in the **AVGWLF** format guide (Evans and Corradini, 2008).

Streams

This layer is used to depict the stream segments for the watershed of interest. For the purposes of this project, stream network files (shapefiles) were downloaded from web sites maintained by state environmental agencies within the region and re-projected into the common geographic coordinate system discussed above. An example of stream data compiled for this study is shown in Figure 3.

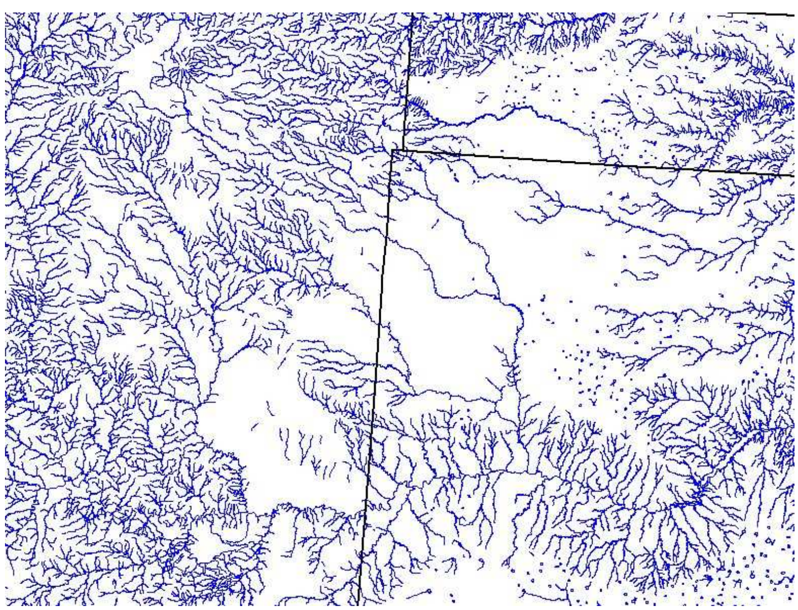

Figure 3. Stream features near the intersection of New Mexico, Texas and Oklahoma.

Weather Stations

This file identifies the locations of weather stations that can be used to create a "*weather.dat*" input file for GWLF-E. The data layer created for this study contains point features representing 42 weather stations (see the stations depicted as "clouds" in Figure 4), with each point having an associated Excel-formatted file containing daily temperature and precipitation data for the period generally from 1997 to 2006 (with a few exceptions as noted later).

Weather station locations (i.e., the points represented in the shape file) are oftentimes created by digitizing hard-copy maps or via "on-screen" digitizing using suitable base maps such as scanned USGS topographic maps or airphotos. For this project, locational (i.e., latitude/ longitude) information (as well as the historical weather data) for each weather station was obtained from a commercial database containing National Weather Service climate information (EarthInfo, 1996).

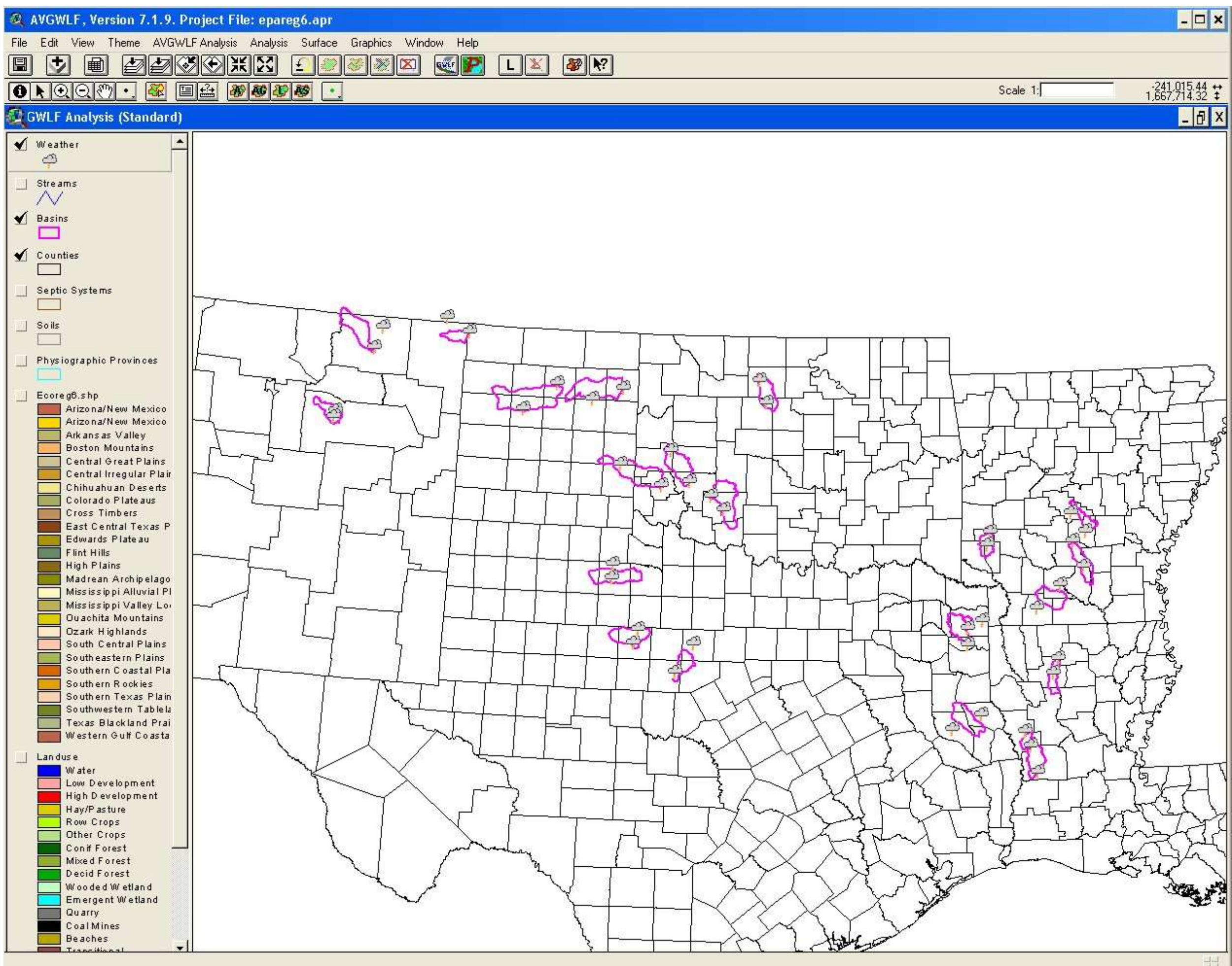

Figure 4. Example of weather stations (cloud icons) near watersheds within the region.

Soils

The soils layer is used to hold information pertaining to various soil-related properties. For this effort, generalized soil maps (STATSGO data sets) available from the U.S. Department of Agriculture (http://soils.usda.gov/survey/geography/) were acquired and seamed together for the entire region. The specific fields required by **AVGWLF** (which include "*MU_AWC*", "*MU_KF*", "*MUHSG_DOM*") were manually added using standard ArcView tools. Details pertaining to the format and usage of each of these fields can be found in the **AVGWLF** User Guide and Format Guide. An example of the soils layer for the region near the intersection of Oklahoma, Texas, Arkansas and Louisiana is depicted in Figure 5. In this figure, the different soil mapping units are color-coded on the basis of available water-holding capacity, with darker shades representing areas having greater capacity. (Note: The blue-colored features are lakes and reservoirs).

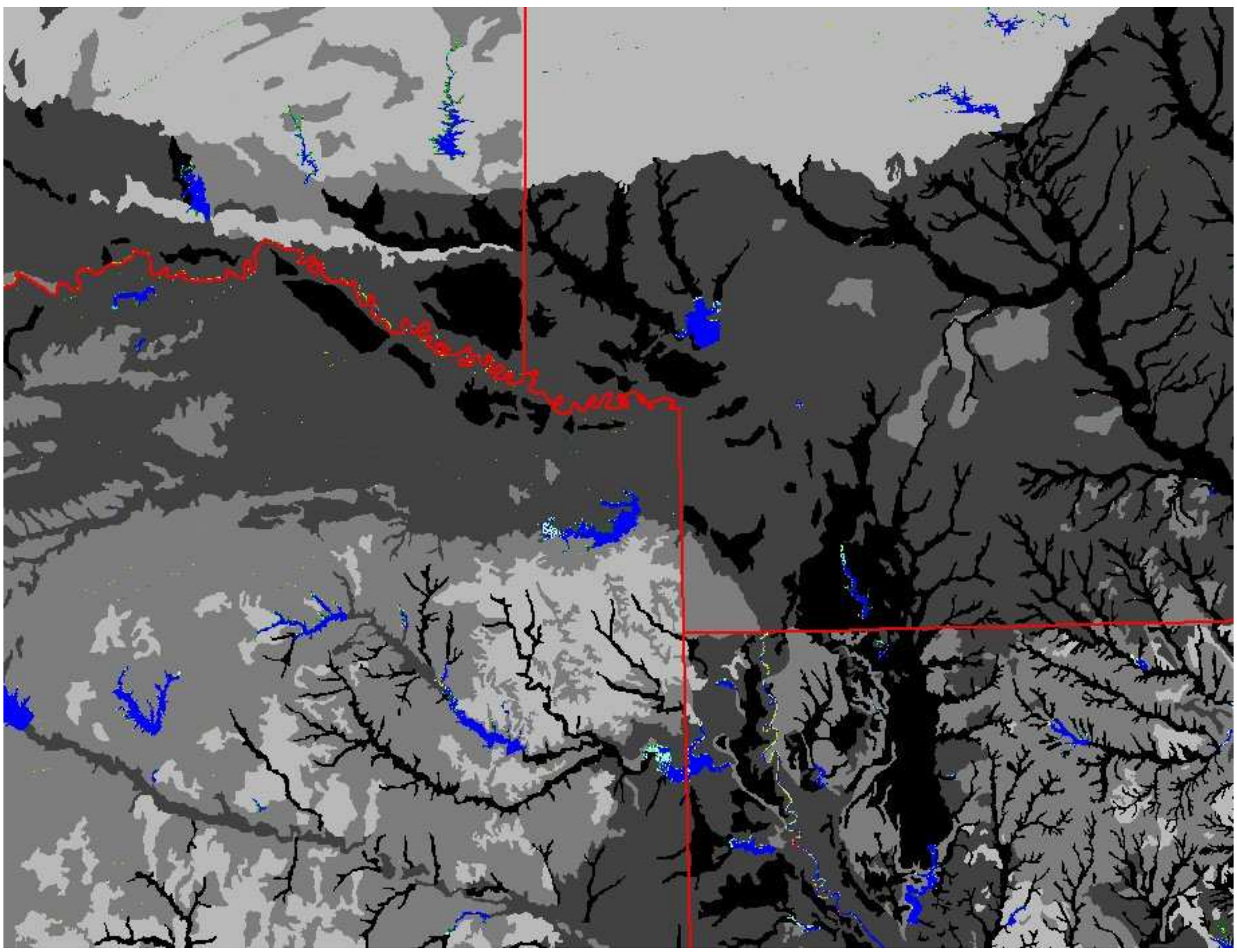

Figure 5. Example of a portion of the soil layer map.

Optional Layers

Point Sources

This file is used to identify the locations of point source discharges within the area of interest. ArcView "attribute" tables associated with these discharge points typically contain information on monthly nitrogen and phosphorus loads. For this project, the location of wastewater treatment plants in those watersheds where they existed was determined via the use of high-altitude aerial/satellite imagery (e.g., Google Maps). Nutrient loads were estimated by evaluating in-stream loads that existed during "dry weather" conditions over the course of the "observed" in-stream data record. These load estimates were subsequently entered directly into the appropriate input file for the GWLF-E model (in this case, the "nutrient.dat" file).

Water Extraction

This layer can be used to identify the locations of water withdrawal points within a given area. This file has an associated ArcView table with several required fields pertaining to the type of water withdrawal (i.e., surface or ground water), an estimate of the volume of water withdrawn on a monthly basis (in m^3/mo), and the period of withdrawal (i.e., May-September, November-March, April-October, or year-round). Similar to point locations described earlier (e.g., point sources and weather stations), these features are typically created by digitizing hard-copy maps or via "on-screen" digitizing using suitable base maps such as scanned USGS topographic maps or airphotos.

A common problem with this type of data is that, if available, estimates of water withdrawals at specific locations are typically based on permitted rather than actual water use volumes, which can result in severe over-estimations of water withdrawals. Water withdrawals can also vary dramatically from month-to-month, and are significantly affected by variations in precipitation in a given area. Due to the difficulties in obtaining usable data, this type of information was not considered in the current study.

Tile Drains

This GIS file can be used to indicate the areas within a watershed in which agricultural tile drainage is utilized. This file typically contains one or more polygon features that represent areas of agricultural land within which tile drainage is used to reduce soil water levels. Due to the difficulty of obtaining and/or creating such data, this type of information was not used in this study.

Unpaved Roads

This layer is used to depict the location of unpaved roads within the watershed of interest. In **AVGWLF**, such features are treated as "non-vegetated" surfaces in the sense that surface erosion is assumed to occur in these areas similar to other non-vegetated or poorly-vegetated surfaces such as disturbed areas and cultivated land. However, since no such data were available for this project, this particular layer was not constructed. If a user-specified layer is used, the USLE values of K and LS are estimated from soil data as with other source areas, and default values of 0.8 and 1.0 are used for the "C" and "P" factors, respectively.

Roads

This layer is only meant to serve as a “background” layer for the watershed of interest and was not compiled for the current study.

County Boundaries

This polygon layer is used to store information pertaining to the Universal Soil Loss equation used within the GWLF-E model. More specifically, this layer is used to hold parameter estimates for the “C” and “P” factors for different land cover types (e.g., hay/pasture, row crops, and wooded areas). In reality, this layer need not necessarily reflect county boundaries. In fact, it can be any polygon file that the user believes will adequately represent the variability in these factors within the area being simulated. Also, the values for these factors need not be different for each sub-area.

In practice, this layer is typically used to store representative estimates of the C and P values for a larger geographic area (e.g., a region or state). For example, within the version of **AVGWLF** used in Pennsylvania, the statewide representative values for C and P have been assigned as follows:

C_crop = 0.42 (primarily used for row crops)
C_past = 0.03 (primarily used for hay, pasture and some cover crops)
C_wood = 0.002 (used for wooded areas)
P1 = 0.52
P2 = 0.45
P3 = 0.52
P4 = 0.66
P5 = 0.74

In this instance, since little is known about the variability of these values within EPA Region 6, this layer was used to hold these same representative estimates for the entire region as well for use in the initial model runs. Then, in subsequent calibration work, these values were adjusted depending upon the predominant crop types found in different areas of the region. For this study, data on farm animal populations (see related discussion in a later section) and the extent of various crop types were obtained from USDA’s National Agricultural Statistics Service (see http://www.nass.usda.gov/) and incorporated into a national county boundary map that was subsequently re-projected to the common geographic coordinate described earlier.

Septic Systems

Within **AVGWLF**, a polygon layer is typically used to provide information on the number of people using on-lot waste disposal systems within any given area. Such information is usually obtained from federal census data or from local sources such as municipal and county planning departments. For the purposes of this project, estimates of the number of people on septic systems was derived from 2000 census data available at the county level from the U.S. Census Bureau (see http://www.census.gov/main/www/cen2000.html). The GWLF-E model can accept information on the populations served by different classes of septic systems such as properly operating systems (“normal systems”), malfunctioning systems that typically discharge waste material to the surface (“ponding systems”), malfunctioning systems that discharge waste to underlying water tables or groundwater without sufficient renovation (“short-circuiting systems”), and other situations where wastes are discharged to nearby water bodies with little or no treatment (e.g., direct pipe discharge from a holding tank). These latter types of systems are categorized as “direct discharges” by GWLF-E. Within **AVGWLF**, the populations served by any type of system are combined into only one category (“*SEW_SEPT*”). If the user so chooses, these populations may be re-distributed into the different categories using the editing function available within the GWLF-E model itself as described in the **AVGWLF** Users Manual (Evans et al., 2008).

Animal Density or Populations

With older versions of **AVGWLF**, information contained within an “animal density” layer can be used to coarsely estimate nutrient concentrations in runoff from pastures and manured areas in a watershed. When using this type of layer, animal density is expressed in terms of animal equivalent units (AEUs) per acre, where one AEU is equal to 1000 pounds of animal weight. This value normally ranges from 0 to about 1, but can be higher in areas with very large grazing animal populations. Of prime interest here is the representation of grazing animal populations such as dairy/beef cows, hogs, sheep, goats, horses, etc.

With more recent versions of **AVGWLF** (Ver. 6.0 and higher), such as used in this study, data on animal populations can be used to more directly simulate loads from these sources from a variety of different pathways (see related discussion in Section 3 of the **AVGWLF** Users Guide [Evans et al., 2008]). For the purposes of this project, county-level data on animal populations were obtained from the National Agricultural Statistics Service (http://www.nass.usda.gov/census/) for subsequent entry in the “animal data” form used by **AVGWLF**. Figure 6 depicts county-level data on cattle populations derived from this particular data set, with darker colors indicating larger populations.

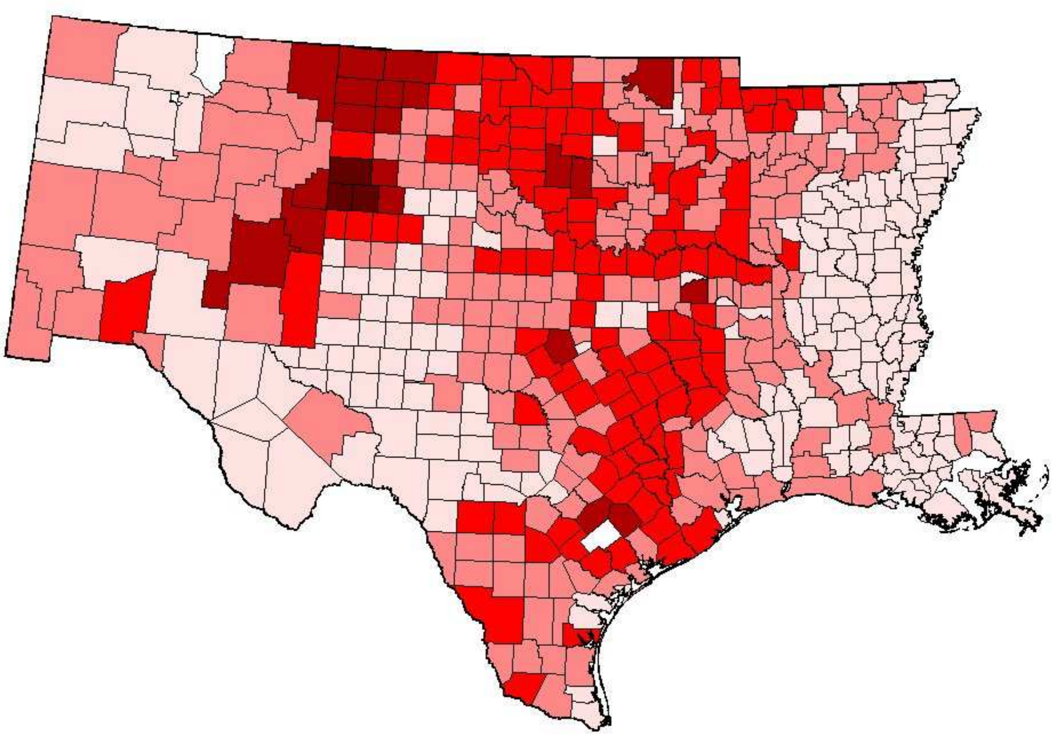

Figure 6. Color-coded animal layer based on cattle populations by county.

Physiographic Province

This particular layer is essentially a "place-holder" layer for data pertaining to rainfall intensity during warm and cool seasons. As explained in the **AVGWLF** Users Guide (Evans et al., 2008), "rainfall erosivity coefficients" are used within the GWLF-E model to estimate the rainfall intensity factor used in the USLE algorithm, and vary with season and geographic location. A generalized table of values for different rainfall erosivity zones around the U.S. is given in Table B-14 of the original GWLF User's Manual (Haith et al., 1992). Generalized erosivity zones for parts of the U.S. are illustrated in Figure B-1 of this same document as well. For this study, erosivity values were assigned to different ecological zones as defined on a national eco-region map currently being used by the USEPA (see http://www.epa.gov/wed/pages/ecoregions/level_iii.htm). The portion of this national map covering EPA Region 6 was shown previously in Figure 1. In this case, specific erosivity values were assigned to each of the pertinent regions using the above-referenced information contained in the GWLF User's manual.

Another parameter estimate that is stored by the physiographic province layer is the groundwater recession coefficient. Although only one representative statewide value (0.1) is used in the Pennsylvania version of **AVGWLF**, this layer can be used to reflect the variability in groundwater recession rates across large regions should it be necessary. Based on the calibration results discussed in a later section, this single representative value was changed to three different values for each of the eco-regions used in this study.

2.2.2 Grid Files

<u>Required Layers</u>

Land Use/Cover

The land use/cover layer is one of the most critical layers used within **AVGWLF** since pollutant loads emanating from a watershed are largely dictated by land surface conditions. Within **AVGWLF**, a standard grid file compatible with ESRI software is used to estimate values for a number of GWLF-E model parameters. There are no special fields required, but the grid cell values for this particular layer must correspond to a specific land use/cover coding scheme in order for various processes and calculations to be handled correctly. This coding scheme is given in Table 5. When recoding existing GIS layers to reflect this scheme, emphasis is placed on land "cover" versus land "use" since this layer is primarily used to estimate model parameters related to runoff, surface erosion and infiltration, which are directly related to vegetative cover.

For the current study, 2001-vintage National Land Cover Dataset (NLCD) data developed by the U.S. Geological Survey (see http://landcover.usgs.gov/) for each of the states in EPA Region 6 were used. These data sets were "re-projected" into the common regional coordinate system and then seamed together to produce one single layer. In using this data, some re-coding was necessary to re-produce the grid cell values given in Table 5. An example of a portion of this layer in Texas is shown in Figure 7.

Table 5. Grid cell values for land use/cover layer.

Category	Cell Value
Water	1
Low-Density Development	2
High-Density Development	3
Hay/Pasture	4
Row Crops	5 or 6
Coniferous Forest	7
Mixed Forest	8
Deciduous	9
Woody Wetland	10
Emergent Wetland	11
Quarries	12
Coal Mines	13
Beaches	14
Transitional	15
Turfgrass/Golf Course	16

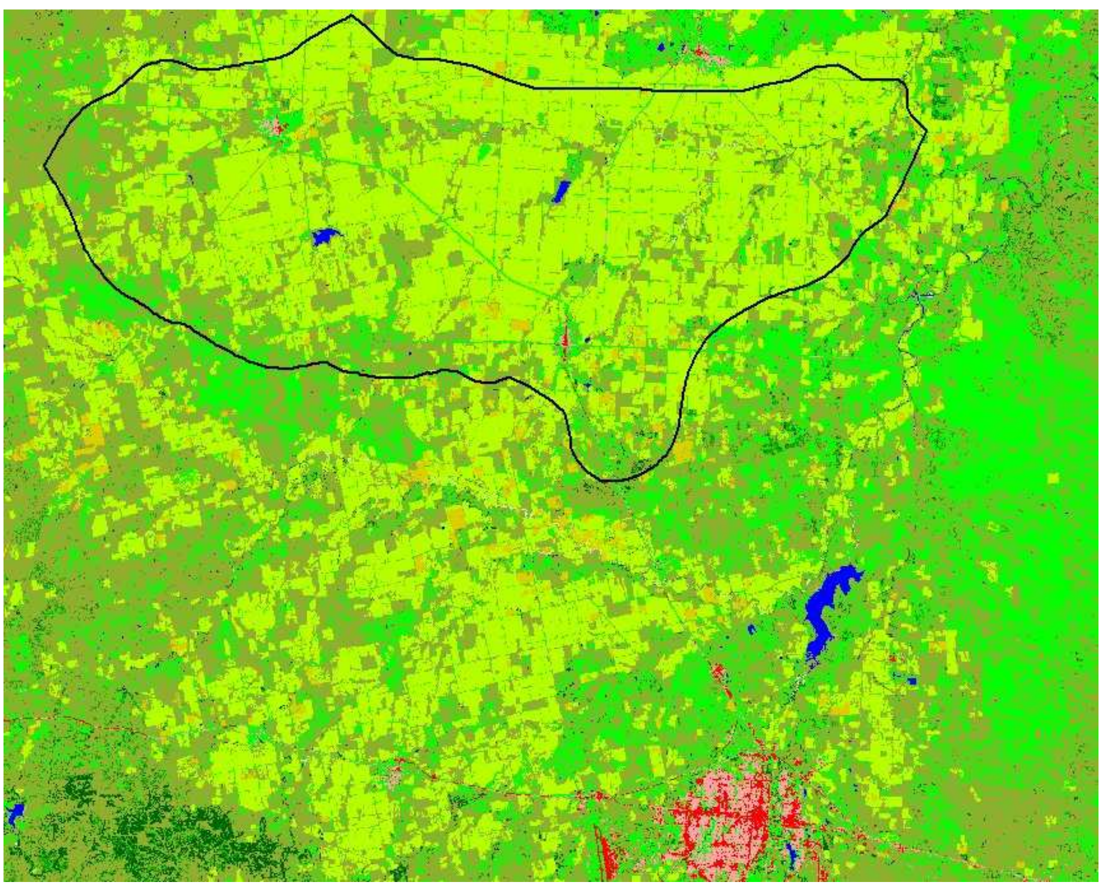

Figure 7. Land use/cover in and around the California Creek watershed in Texas.

Surface Elevation (Topography)

This particular grid layer is used to calculate land slope-related data for use within **AVGWLF**. There are no fields specifically required by **AVGWLF**. However, the grid must be in a metric projection, and the grid cell values (i.e., elevation values) must be in meters. In Pennsylvania, good model results have been obtained using 100-meter DEM (digital elevation model) data for watersheds greater than about 10 square miles in size. However, higher- resolution data sets may also be used. One potential drawback to using higher resolution data is increased processing time. Another is that processing errors can result with high resolution data over large geographic areas due to insufficient allowances by ArcView for internal “swap space” (essentially, insufficient internal memory).

For this study, digital elevation data sets created by NASA as part of it’s Shuttle Radar Topography Mission were used (see http://srtm.csi.cgiar.org/Index.asp). At the equator, the resolution of this data is ostensibly 90 meters, but varies as one moves from the equator. For the EPA Region 6 area, the data resolution is on average about 71 meters. Figure 8 shows a portion of this data centered on south-central Oklahoma.

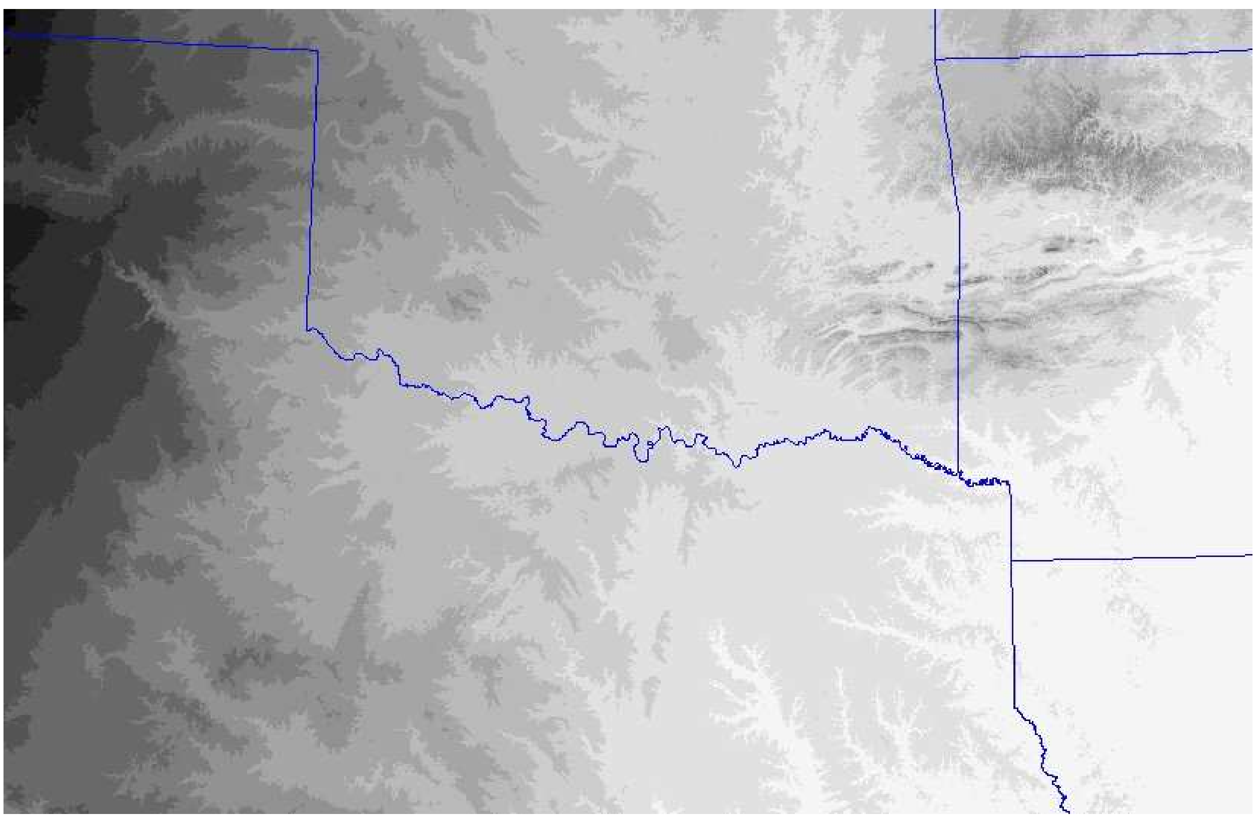

Figure 8. DEM data for portion of EPA Region 6.

Optional Layers

Groundwater Nitrogen

To estimate nitrogen loads to streams, the GWLF-E model requires an estimate of the background concentration of nitrogen in groundwater (or more correctly, shallow subsurface water). The initial estimate of this concentration (in mg/l) is made based on the groundwater nitrogen grid, which is subsequently adjusted using an internal regression formula. The initial concentration estimates (i.e., grid cell values) are typically based on spatial relationships between surficial conditions (surface geology/soils) and land use/cover. For example, intensively-fertilized areas (e.g., cropland in corn) underlain by highly porous material (e.g., fractured limestone or sandy soils) oftentimes exhibit sub-surface water concentrations of 10 mg/l or higher. It is these and other similar relationships that are used to derive this grid for a given area. An example of a portion of the grid developed for EPA Region 6 is shown in Figure 9. In this figure, a "stop light" color-coding scheme is used in which the colors range from dark green (1 mg/l) to red (12 mg/l). The initial nitrogen concentration values used in creating the grid for different conditions are shown in Table 6

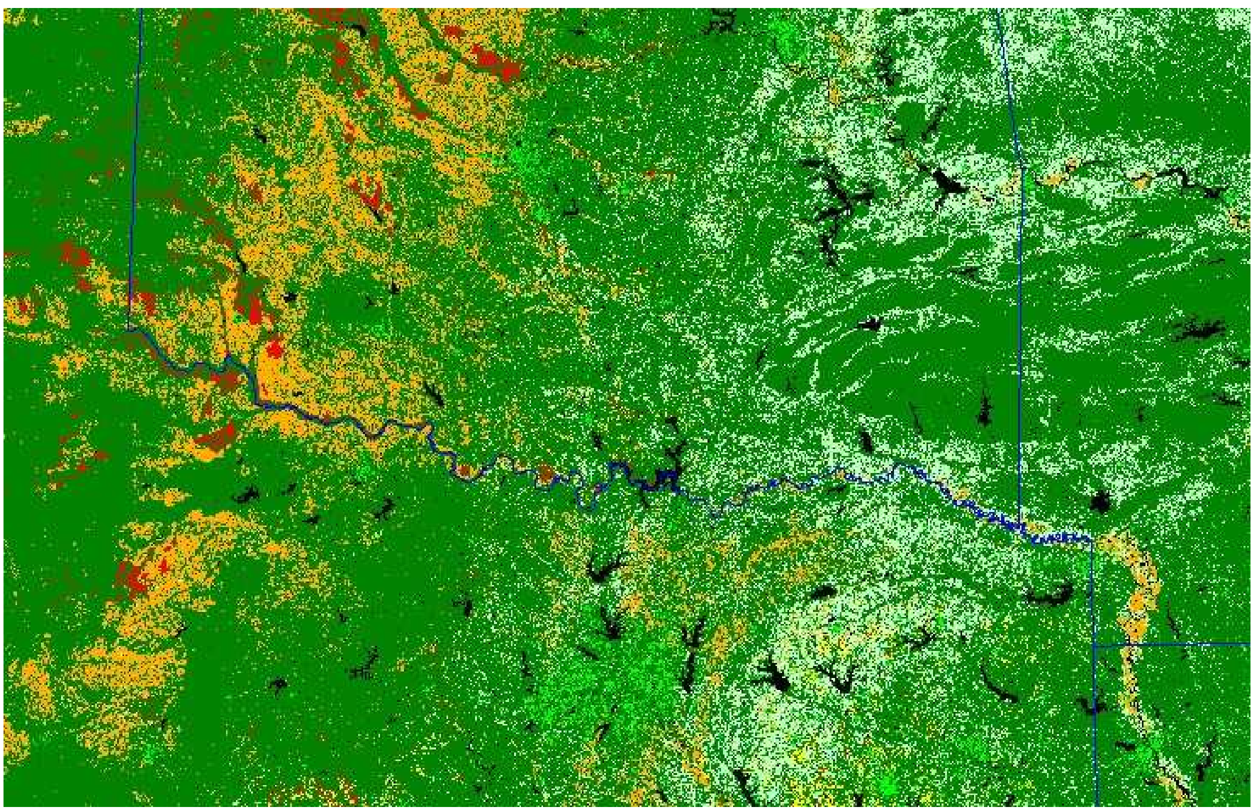

Figure 9. Example of groundwater nitrogen grid.

Table 6. Coding scheme for groundwater N estimates (mg/l).

Land cover type	Highly porous	Less porous
Wooded areas	1	1
Low-intensity developed	4	3
High-intensity developed	3	2
Hay/pasture	7	5
Row crops	12	9
Turfgrass/golf courses	5	3
Other	2	2

Soil Phosphorus

As described in the **AVGWLF** Users Guide (Evans et al., 2008), the cell values within the soil phosphorus grid can depict either “soil test P” or “total P”. The former is an estimate of available soil P as measured by a standard lab test such as the Bray, Olsen or Mehlich tests. The latter is an estimate of the concentration of total P in the soil (both organic and inorganic, and dissolved and particulate). One approach to creating a “total P” grid is to re-code an existing soil type map using empirical relationships between soil texture and phosphorus concentration (in mg/kg) based on soil sampling. For this project, information resulting from regional studies on the relationship between soil texture and land cover type (agriculture or non-agriculture) in Canada (MacLean, 1971; Bates, 1990; and Rousseau, 1988) was used to create the soil P grid for EPA Region 6 (see Table 7). Figure 10 illustrates a portion of this grid centered on southern Oklahoma and northern Texas. In this figure, darker colors indicate higher soil P values.

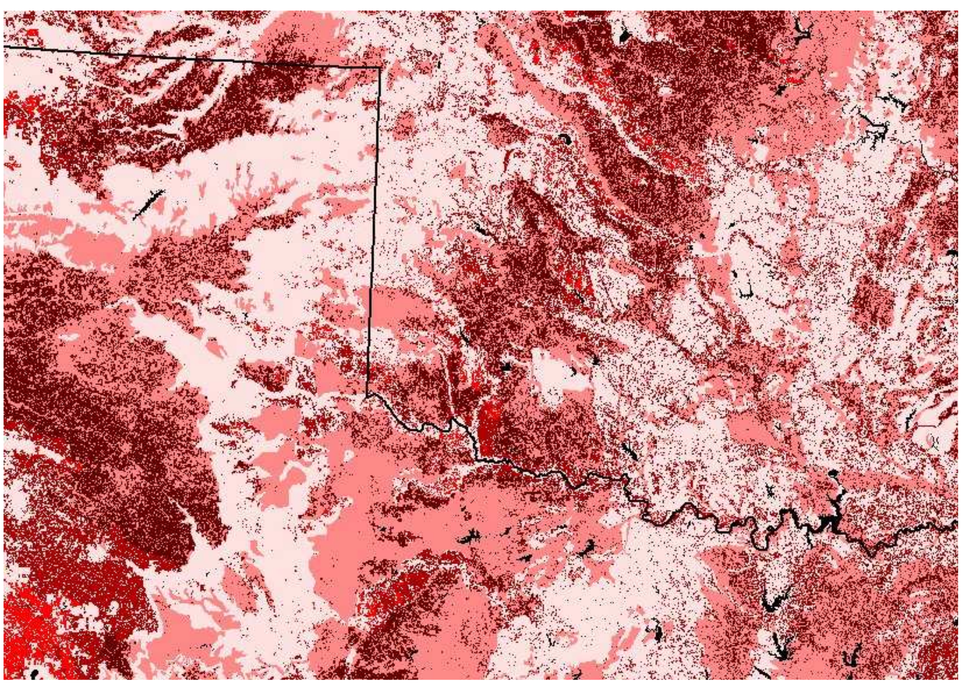

Figure 10. Total soil P grid for portions of Texas and Oklahoma.

Table 7. Recoding scheme used to create grid reflecting total soil P (in mg/kg) based on soil texture and land cover type.

Soil Texture	Land cover	Cell (soil P) value
Silt loam	Ag	780
Silt loam	Non-Ag	332
Loam	Ag	720
Loam	Non-Ag	288
Organic	Ag	1000
Organic	Non-Ag	600
Sandy loam	Ag	660
Sandy loam	Non-Ag	244
Loamy sand	Ag	600
Loamy sand	Non-Ag	200
Sand	Ag	580
Sand	Non-Ag	180
Clay	Ag	900
Clay	Non-Ag	420
Silty clay	Ag	840
Silty clay	Non-Ag	376
Silty clay loam	Ag	840
Silty clay loam	Non-Ag	376
Silt	Ag	780
Silt	Non-Ag	332
Clay loam	Ag	870
Clay loam	Non-Ag	400

2.3 Weather Files

The weather input file (*weather.dat*) used by the GWLF-E model consists of daily temperature and precipitation values typically obtained from climate station records compiled by the National Weather Service. In the file, a line is required to specify the number of days in each month, and subsequent lines are used to record the average daily temperature (in degrees C) and total precipitation (in centimeters). A portion of an example *weather.dat* file is shown in Figure 11.

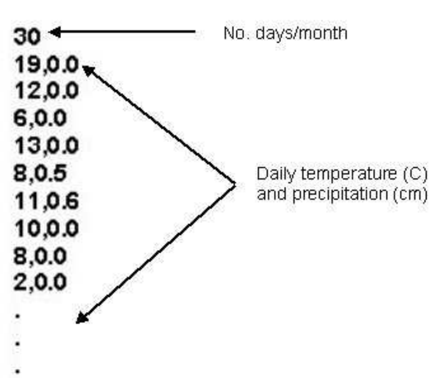

Figure 11. Portion of a sample ”weather.dat” file.

Within **AVGWLF**, *weather.dat* files are automatically created using daily climate data contained in Excel database files. These Excel files are connected to a weather station shape file via the use of a unique station ID number. In constructing the *weather.dat* file for a given watershed, **AVGWLF** uses daily data from nearby weather stations. If one or more stations are contained within the watershed polygon, the mean daily values for temperature and precipitation are used. If no stations are within the polygon, the daily mean values of the two stations nearest to the center of the polygon are used.

It is the “STA_ID” field contained in the attribute table of the weather station shape file that is used to connect a specific point location to its respective Excel database file. This connection is made by using a unique STA_ID number in the name of the Excel weather file in a specific manner. For example, a weather station with a STA_ID number of “612356” would be associated with an Excel file via use of the name “sta612356.csv”. (Note that this “comma separated variable” file type is the text version of an Excel file created via use of the “*Save As*” function in Excel).

For this study, 42 separate Excel-formatted weather files were created for each of the corresponding weather stations (see related discussion on weather station shape file creation in Section 2.2.2). In some cases, the same station is used to supply weather information for more than one watershed. The necessary information on temperature and precipitation was drawn from a commercial database product of weather data obtained from the National Weather Service (EarthInfo, 1996).

2.4 GWLF-E Model Execution and Output

As mentioned previously, the **AVGWLF** interface is primarily used to create input files for the GWLF-E model. It is not the intent of this report to provide instructions on how to use the model. Rather, the user is directed to review the appropriate sections in the **AVGWLF** Users Manual for such information. For introductory purposes, however, brief descriptions are provided in Appendix A of the various types of input and output files associated with GWLF-E, as well as an overview of the input parameters and model results.

3.0 MODEL TESTING, CALIBRATION AND VERIFICATION

3.1 Overview

As described earlier, **AVGWLF** is a GIS-based modeling tool that was initially developed by researchers at Penn State University to support TMDL and similar watershed assessments in the state of Pennsylvania. This tool essentially provides a link between ArcView GIS software and an enhanced version of the GWLF (Generalized Watershed Loading Function) model originally developed at Cornell University in the late 1980s (Haith and Shoemaker, 1987). The utility of this modeling tool has since been appreciably improved via testing and calibration to the point where it is being used extensively by government and research personnel in Pennsylvania and elsewhere (Evans et al., 2002; Evans and Hristov, 2004; Evans, 2005; Evans, 2006; Markel et al., 2006; Evans, 2008; and Strobl et al., 2009). The primary objective of this current study was to evaluate whether this modeling tool could have similar utility in selected areas of Texas and other states included in EPA Region 6.

For this study, **AVGWLF** was tested and evaluated via completion of a series of successive modeling steps. In the first step, the **AVGWLF** tool as it currently exists (i.e., the "Pennsylvania" version) was used to simulate stream flows as well as nutrient and sediment loads for the twenty-two test watersheds located throughout EPA Region 6 (see section 2.1). In this case, no attempt was made to adjust any model input parameters prior to running the GWLF-E model. In other words, the input files that were automatically created by **AVGWLF** using the various data sets described in section 2.2 and default model algorithms were used without making any changes to **AVGWLF**-derived input parameters (see section 3.4 for a more complete description of this step). The simulated results were then compared against observed flow and load data sets created with historical in-stream flow and water quality data (see section 3.2). For the second step (i.e., model calibration), numerous adjustments were iteratively made to various input files for the purpose of achieving the "best fit" between simulated and observed results for each individual watershed. For the third step, using the calibration results as a guide, changes were made to selected "parameter estimation" algorithms incorporated into **AVGWLF** for the purpose of achieving optimal GWLF-E output results across all twenty-two test watersheds. In this instance, separate "improved" versions were developed for each of the three test eco-regions. These "regionalized" versions of **AVGWLF** were then re-run on all watersheds, and the resulting input files were directly executed within GWLF-E without further adjustment. The intent here was to see if model results could be improved upon in comparison to those achieved during the initial model runs (i.e., those obtained in the first step). It was anticipated that the model results for most watersheds might not be as good as those obtained during the calibration runs, but that the model results overall would be better than those obtained during the initial model runs with the "Pennsylvania" version of **AVGWLF**.

For each modeling step, statistical evaluations of the accuracy of simulated flow and load predictions were made. To assess the correlation, or "goodness-of-fit", between observed and predicted values, two different statistical measures were utilized: 1) the Pearson product-moment correlation coefficient, and 2) the Nash-Sutcliffe coefficient. The Pearson coefficient is calculated as:

$$R^2 = \left(\frac{\sum (y - y_m)(x - x_m)}{\sqrt{\sum (y - y_m)^2 \sum (x - x_m)^2}} \right)^2$$

where x_m is the mean of the observed (x) values, and y is the model-simulated value. The R^2 value is a measure of the degree of linear association between two variables, and represents the amount of variability that is explained by another variable (in this case, the model-simulated values). Depending on the strength of the linear relationship, the R^2 can vary from 0 to 1, with 1 indicating a perfect fit between observed and predicted values.

The Nash-Sutcliffe coefficient is calculated as:

$$1-\frac{\sum(y-x)^2}{\sum(x-x_m)^2}$$

where x_m is the mean of the observed data, and y is the model-simulated value. Like the R^2 measure described above, it is another indicator of "goodness of fit", and is one that has been recommended by the American Society of Civil Engineers (ASCE, 1993) for use in hydrologic studies. With this coefficient, values equal to 1 indicate a perfect fit between observed and predicted data, and values equal to 0 indicate that the model is predicting no better than using the average of the observed data. Therefore, any positive value above 0 suggests that the model has some utility, with higher values indicating better model performance. In practice, these coefficients tend to be lower than R^2 for the same sets of data being evaluated. (Note that with this statistic, values can only go as high as 1 in the positive direction, but are essentially unlimited in the negative direction, which can cause confusion for those familiar with the standard R^2 measure).

3.2 Compilation of Observed Flows and Loads

As described previously in section 2.0, the watershed study sites were selected based on the availability of relatively long-term flow and water quality data. For each watershed, historical stream flow and water quality data were typically compiled for the 10-year period from January 1997 to December 2006. (Due to a lack of available stream flow and/or water quality sample data, this time period was slightly different in a few instances as noted in later sections). The stream flow data were obtained directly from the on-line water resource database maintained by the U.S. Geological Survey (http://waterdata.usgs.gov/nwis/sw). One exception to this approach is the Attoyac River watershed in Texas. In this case, historical water quality data were available, but USGS stream flow data were not. For this site, daily stream flow data simulated via the use of the SWAT watershed model was provided by the Texas State Soil and Water Conservation Board. For all watersheds, water quality sample data were obtained either from the cognizant state agency (e.g., the Texas Commission on Environmental Quality [see http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/swqm_data.html]), or via USEPA's national water quality data web portal (STORET) (see http://www.epa.gov/storet/dw_home.html). Depending on availability at any given site, these data sets included in-stream concentrations of nitrogen, phosphorus and/or sediment based on periodic sampling. As discussed in a later section, data availability varied widely, and nitrogen, phosphorus and sediment were not routinely available for all sites.

To derive observed nutrient and sediment loads for each watershed, the FLUX program developed by Walker (1999) was used. FLUX is an interactive software package designed for use in estimating nutrient, sediment and other water quality loadings based on stream sample data over a given time period. Data requirements include in-stream sample concentrations, corresponding flow measurements, and a complete flow record (i.e., mean daily flows) for the period of interest. Using various calculation techniques, FLUX helps the user to develop flow/concentration relationships which, in turn, are used to estimate total mass discharge and associated error statistics based on use of the daily flow record. The FLUX program was developed for the U.S. Army Corps of Engineers to assist them in water quality studies conducted throughout the country.

3.3 Initial Model Runs

Once the required **AVGWLF**-formatted GIS and weather files and observed flow and load data sets were developed as described in section 2.0, **AVGWLF** was run on each of the twenty-two test watersheds shown in Figure 2 and Tables 1 and 2. As described previously, the primary purpose of **AVGWLF** is to estimate various input parameters for the GWLF-E model using an assortment of user-provided GIS data layers. Upon running **AVGWLF**, values for these input parameters are written to various input files (primarily the *transport.dat*, *nutrient.dat* and *weather.dat* files). For these initial runs, no adjustments were made to any parameter values that were automatically estimated by **AVGWLF** prior to executing the GWLF-E model. In some case, however, some parameter estimates could not be automatically derived due to missing GIS or other data. In this study, for example, a "point source" layer with corresponding wastewater treatment plant discharges was not available. To account for these sources, estimates of combined discharges within a given watershed were derived by evaluating observed flows and loads during "dry weather" periods. Water volumes related to dam/reservoir releases were estimated using the same approach. Additionally, watershed-level animal populations needed for the "*animal.dat*" file were estimated using the county-level "animal population" data described in section 2.2.1 and shown in Figure 6 (see section 3.A of the **AVGWLF** Users Manual for a discussion on how this particular input file is created and/or edited). These estimated values were also carried forward to the calibration and verification runs discussed in later sections.

Upon completing the initial model runs for each watershed, evaluations of model accuracy were made using the statistical measures described above. Although most calculations within the GWLF-E model are made using daily climate input, simulated flows and loads are reported on a monthly basis. Consequently, statistical analyses were done by comparing monthly simulated results against observed monthly data. The model prediction results for the initial runs are summarized by eco-region in Table 9. (Note that due to the non-normal distribution of possible values, median values are reported for the Nash-Sutcliffe measure, whereas means are given for the normally-distributed R^2 results). Example comparisons between observed and predicted results for one watershed (Elm Fork/North Fork River) are shown in Figures 12 through 15. For comparison purposes, mean annual flows and loading rates for each watershed were also computed, and these results are summarized in Table 10.

3.4 GWLF-E Model Calibration Runs

During this second step, adjustments were made to various GWLF-E model input parameters for the purpose of obtaining a "best fit" between the observed and simulated results for each individual watershed. Such adjustments were made based upon an evaluation of historical in-stream data and in consideration of adjustments and model input parameters reported on by others working with similar models and landscape conditions.

With respect to stream flow, adjustments were made that increased or decreased the amount of the estimated evapotranspiration and/or groundwater recession rate values. These adjustments primarily affected total flow volumes, as well as the relative amounts and timing of peak and base flows. With respect to nutrient loads, changes were made to the estimates for sub-surface nitrogen

Table 9. Summary statistics for initial model runs.

Watershed	Eco-Region	Flow (NS)[1]	TSS (NS)[1]	TN (NS)[1]	TP (NS)[1]	Flow (R^2)[1]	TSS (R^2)[1]	TN (R^2)[1]	TP (R^2)[1]
Attoyac Bayou	SCP	-1.41	-0.67	-2.20	0.40	0.69	0.69	0.71	0.64
Bayou Anacoco	SCP	0.75	---	0.85	0.69	0.90	---	0.85	0.76
Bayou Toro	SCP	0.84	---	0.74	0.78	0.91	---	0.91	0.85
Black Cypress Creek	SCP	0.65	0.65	---	0.55	0.85	0.70	---	0.56
Frazier Creek	SCP	0.78	-0.04	0.00	0.63	0.88	0.66	0.88	0.73
Hurricane Creek	SCP	0.89	-1.01	0.79	0.49	0.91	0.79	0.90	0.74
Moro Creek	SCP	0.90	-5.62	0.42	0.24	0.93	0.84	0.92	0.83
Saline Bayou	SCP	0.71	---	0.88	0.67	0.92	---	0.91	0.74
Saline River	SCP	0.68	0.66	0.52	0.58	0.85	0.70	0.84	0.63
Smackover Creek	SCP	0.68	0.05	0.69	0.62	0.89	0.81	0.89	0.74
Median/Mean[2]		*0.73*	*-0.04*	*0.69*	*0.60*	*0.87*	*0.74*	*0.87*	*0.72*
Big Sandy Creek	GCP	-12.14	0.44	-16.60	---	0.56	0.49	0.75	---
California Creek	GCP	0.30	0.78	---	0.86	0.57	0.78	---	0.91
East Cache Creek	GCP	-7.75	0.13	-3.94	0.31	0.38	0.30	0.39	0.48
Elk Creek	GCP	-2.25	---	-6.06	-3.56	0.76	---	0.69	0.88
Elm Fork/North Fork River	GCP	-40.42	-3.63	-16.05	0.27	0.54	0.53	0.60	0.56
Skeleton Creek	GCP	-1.94	---	-0.85	-2.17	0.52	---	0.47	0.77
Median/Mean[2]		*-5.00*	*0.29*	*-6.06*	*0.27*	*0.56*	*0.53*	*0.58*	*0.72*
Carrizozo Creek	SWT	-1368.72	-15.41	-295.60	-11.83	0.38	0.36	0.43	0.69
Gallinas Creek	SWT	-1.71	0.49	0.60	0.29	0.58	0.53	0.61	0.53
Palo Duro Creek	SWT	-237.70	-108922.11	---	-4368.63	0.00	0.28	---	0.15
South Fork Wichita River	SWT	-56.16	0.31	0.52	0.31	0.28	0.34	0.53	0.43
Vermejo River	SWT	-1.47	-11.20	-0.18	-0.49	0.70	0.56	0.70	0.73
Wolf Creek	SWT	-2913.27	-17271.78	-14305.30	-352.48	0.51	0.26	0.50	0.35
Median/Mean[2]		*-146.93*	*-13.31*	*-0.18*	*-6.16*	*0.41*	*0.39*	*0.55*	*0.48*

[1] Flow = stream flow, TSS = total suspended sediment, TN = total nitrogen, TP = total phosphorus, and NS = Nash-Sutcliffe coefficient.
[2] Median value is given for NS results and mean value is given for R^2 results.

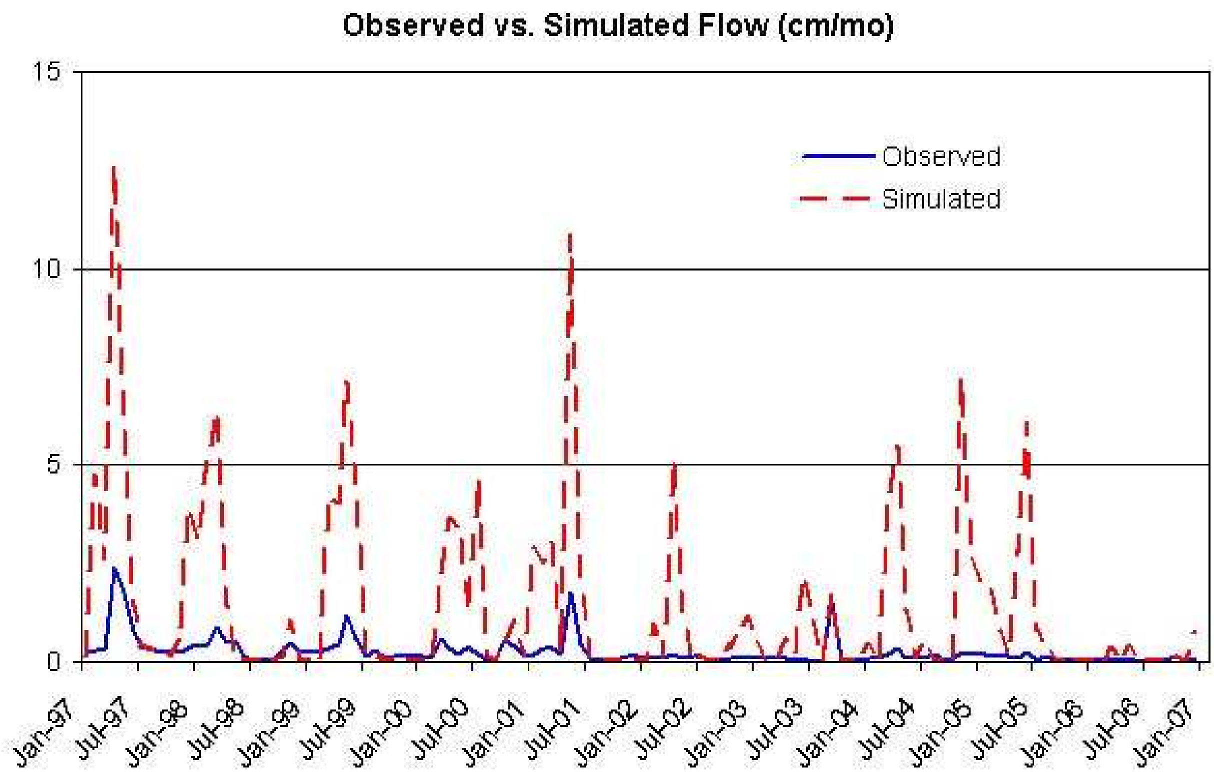

Figure 12. Initial simulated flow results for Elm Fork/North Fork River watershed.

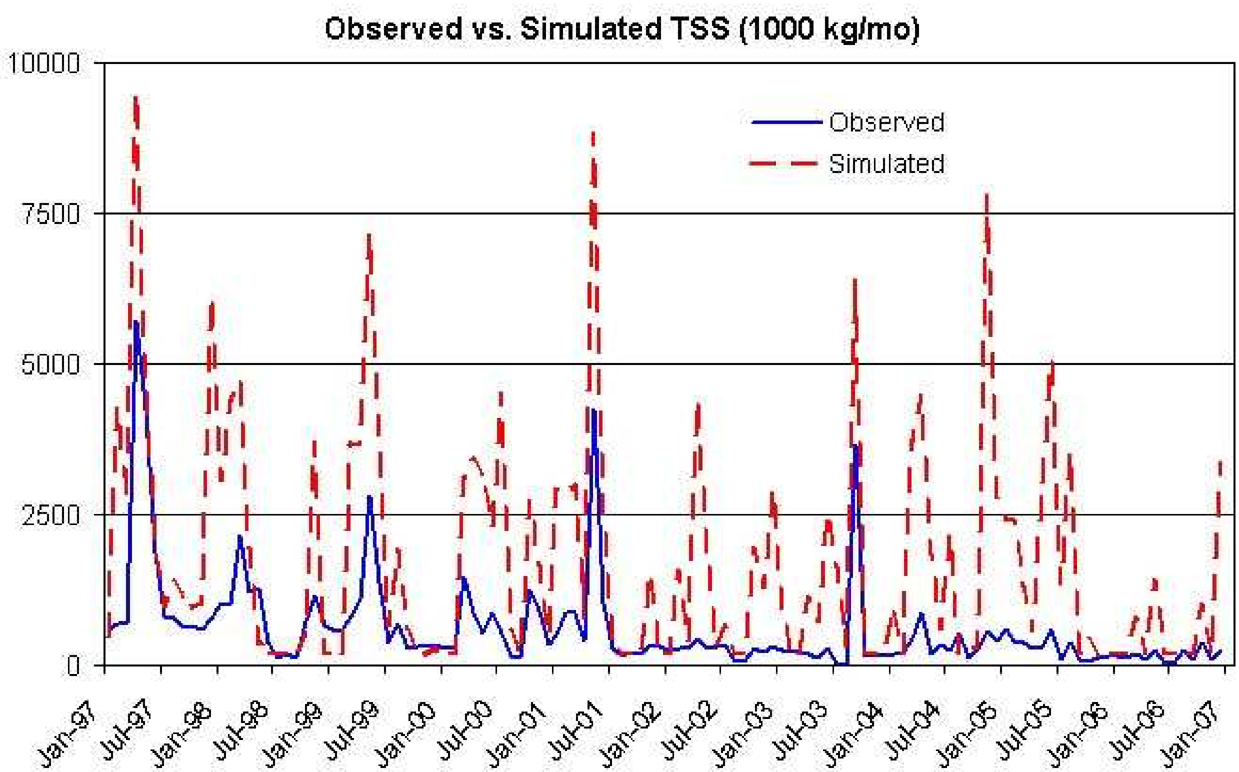

Figure 13. Initial simulated TSS results for Elm Fork/North Fork River watershed.

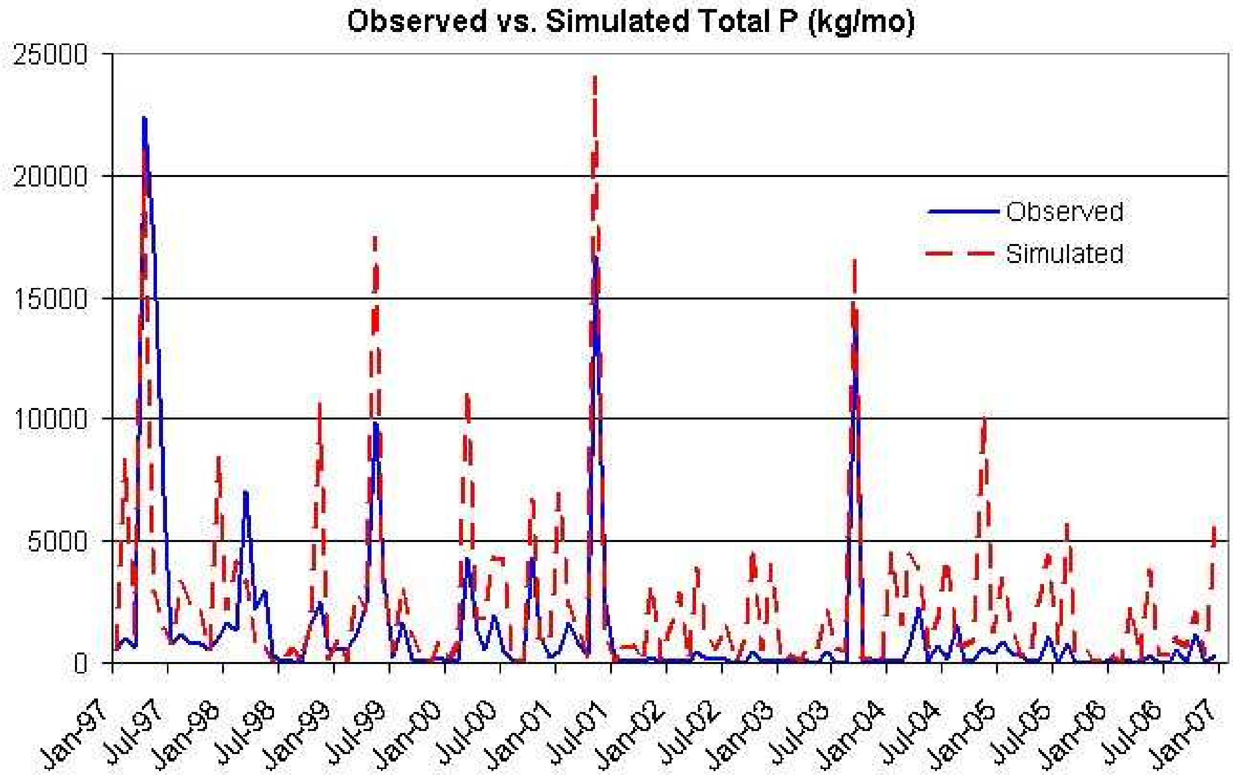

Figure 14. Initial simulated total P results for Elm Fork/North Fork River watershed.

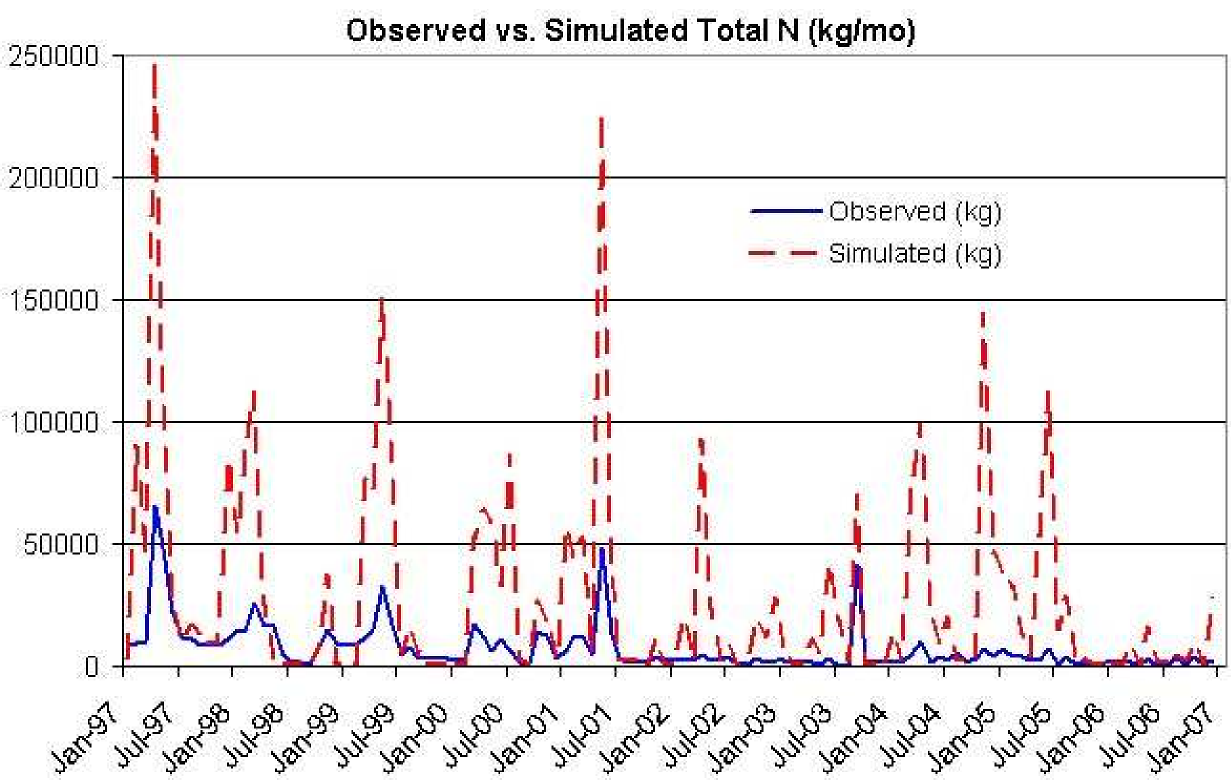

Figure 15. Initial simulated total P results for Elm Fork/North Fork River watershed.

Table 10. Summary of mean annual flows and loads for initial model runs.

Watershed	Eco-Region	Precip. (cm/yr)	Observed Flow[1]	Observed TSS[2]	Observed TN[2]	Observed TP[2]	Simulated Flow[1]	Simulated TSS[2]	Simulated TN[2]	Simulated TP[2]
Attoyac Bayou	SCP	131.75	41.11	130.5	3.17	0.78	55.19	29.0	5.16	0.49
Bayou Anacoco	SCP	143.01	51.50	---	3.85	0.69	66.65	---	3.81	0.55
Bayou Toro	SCP	132.50	47.01	---	4.61	0.72	58.94	---	3.70	0.65
Black Cypress Creek	SCP	118.77	30.63	23.2	---	0.26	38.74	39.7	---	0.23
Frazier Creek	SCP	131.74	36.70	48.7	1.29	0.23	45.54	67.0	2.37	0.18
Hurricane Creek	SCP	116.90	37.34	26.0	2.45	0.26	42.80	71.0	1.93	0.17
Moro Creek	SCP	133.62	37.09	25.5	3.06	0.27	46.19	101.1	1.41	0.11
Saline Bayou	SCP	138.10	46.02	---	2.37	0.25	62.95	---	2.12	0.19
Saline River	SCP	125.40	40.21	98.1	5.43	0.44	54.93	114.8	3.28	0.40
Smackover Creek	SCP	130.20	39.48	35.7	2.82	0.24	56.25	69.1	1.95	0.19
Mean		*130.20*	*40.71*	*55.39*	*3.23*	*0.41*	*52.82*	*70.24*	*2.86*	*0.32*
Big Sandy Creek	GCP	67.33	2.43	30.7	0.11	---	16.31	50.6	0.81	---
California Creek	GCP	53.24	1.93	67.5	---	0.10	2.68	78.7	---	0.14
East Cache Creek	GCP	75.61	9.55	263.4	2.10	0.49	44.39	499.7	7.74	0.54
Elk Creek	GCP	77.05	8.62	---	2.10	0.23	23.29	---	7.83	0.53
Elm Fork/North Fork R.	GCP	65.52	3.05	33.6	0.40	0.07	16.52	95.4	1.55	0.14
Skeleton Creek	GCP	72.47	10.17	---	4.23	0.23	27.87	---	9.10	0.54
Mean		*68.54*	*5.96*	*98.8*	*1.79*	*0.22*	*21.84*	*181.1*	*5.41*	*0.38*
Carrizozo Creek	SWT	41.95	0.25	0.9	0.017	0.004	18.28	9.2	0.59	0.027
Gallinas Creek	SWT	45.14	8.74	89.0	1.00	0.17	19.76	87.8	1.02	0.09
Palo Duro Creek	SWT	41.15	0.03	0.1	0.007	0.001	0.48	66.8	0.45	0.065
South Fork Wichita R.	SWT	62.37	1.66	43.4	0.69	0.27	9.99	52.9	0.76	0.21
Vermejo River	SWT	32.61	2.77	1.6	0.109	0.004	6.11	9.2	0.19	0.007
Wolf Creek	SWT	52.43	0.25	0.3	0.021	0.003	18.31	64.2	3.65	0.081
Mean		*45.95*	*2.28*	*22.55*	*0.31*	*0.08*	*12.16*	*48.4*	*1.11*	*0.08*

[1] Reported in centimeters of mean annual water depth across the watershed
[2] Reported in units of kg/ha per year

and phosphorus concentrations, as well as to estimates of nutrient concentrations in surface water runoff from various land cover types. In regard to both sediment and nutrients, adjustments were made to the estimated value for the "C" factor in the USLE equation for selected land cover categories, as well as to the "sediment a" factor used to calculate sediment loss due to stream bank erosion. Finally, revisions were also made to the default retention coefficients used by GWLF-E for estimating sediment and nutrient retention in lakes and wetlands (see section 2.D of the AVGWLF Users Manual on details concerning this particular model function).

Table 11 summarizes the model input adjustments made for each of the test watersheds, and the model simulation results for the calibration runs are summarized by eco-region in Table 12. The observed vs. predicted data plots for the watershed shown for the initial run in Figures 12 through 15 (the Elm Fork/North Fork) were updated and are shown for comparison purposes in Figures 16 through 19. Similar to Table 10, the mean annual flows and loading rates for each watershed are summarized in Table 13. Screen captures of selected final input files and output plots for the model calibration runs are included in Appendix B.

3.5 Adjustments to AVGWLF

Based upon an evaluation of changes made to the input files during the GWLF-E model calibration runs, revisions were made to various routines within **AVGWLF** to modify the way in which selected model parameters were automatically being estimated. The **AVGWLF** software application was originally developed for use in Pennsylvania, and based on the calibration results of this study, it appeared that certain routines were calculating values for some model parameters that were either too high or too low. Consequently, it was necessary to make some modifications to these routines to better reflect differences in local conditions throughout EPA Region 6. In fact, based on the evaluation, it was determined that it would be best to create a separate version of **AVGWLF** for each of the three eco-regions tested in order to better reflect the wide disparity in climate and landscape conditions existing in each. Changes made to **AVGWLF** algorithms and default settings are summarized below.

<u>Evapotransporation</u>

Based on the initial model runs, it was determined that the version of **AVGWLF** currently used in Pennsylvania was not satisfactorily estimating the amount of evapotranspiration occurring on a mean annual basis throughout all of the watersheds in EPA Region 6, particularly in the drier, westernmost regions. As a result, stream flow was being over-estimated in each case. As shown by the results in Table 10, stream flow was over-estimated by about 30% for the South Central Plains region and by a factor of 4-5 times for the other two regions, which consequently had an adverse affect on predicted sediment and nutrient yields. To correct for this problem, it was necessary to increase the amount of simulated evapotransporation in order to decrease stream flow. In Table 11, the values shown in the "ET" column indicate the amount by which evapotranspiration had to be increased in order to correctly simulate stream flow. In this case, adjustment factors ranging from 1.50 to 4.25 indicate percent increases of 50 to 325%.

As also reflected in Table 10, the magnitude of change in this factor was not the same across all eco-regions. For the South Central Plains region, a code revision was made to include an adjustment factor that increased the amount of ET calculated automatically by **AVGWLF** by 50%. For the Great Central Plains and Southwestern Tablelands, this factor was set to increase evapotranspiration by 110% and 125% for the Southwestern Tablelands and Great Central Plains, respectively.

Table 11. Summary of adjustments made to GWLF-E input parameters to achieve calibration.

Calibration Watershed	ET	S Ret	N Ret	P Ret	Sed a	GWN	GWP	GWR	Crop C	H/P C	For C	Turf C	Turf N	Turf P	H/P N	Crop N
Attoyac Bayou	1.50	0.63	0.21	0.21	NC	+	+	0.01	0.10	0.03	0.100	0.04	0.70	0.29	0.70	1.84
Bayou Anacoco	1.50	(1)	0.12	0.20	(1)	+	+	0.10	0.15	0.03	0.200	0.04	0.75	0.29	(1)	(1)
Bayou Toro	1.45	(1)	0.09	0.28	(1)	+	+	0.10	0.20	0.03	0.200	0.04	0.75	0.29	(1)	(1)
Big Sandy Creek	3.25	0.84	0.12	0.29	NC	-	NC	0.10	0.20	0.06	0.030	0.06	0.65	0.29	0.65	1.60
Black Cypress Creek	1.65	0.86	(1)	0.33	NC	(1)	+	0.03	0.12	0.03	0.002	0.04	(1)	0.29	(1)	(1)
California Creek	1.20	0.45	(1)	0.29	NC	(1)	+	0.10	0.24	0.03	0.002	0.04	(1)	0.30	(1)	(1)
Carrizozo Creek	1.50	0.79	0.11	0.21	0.10	+	+	0.10	(1)	(1)	0.001	0.03	0.85	0.38	(1)	(1)
East Cache Creek	3.00	0.60	0.12	0.20	NC	+	+	0.07	0.20	0.06	0.004	0.06	0.85	0.29	0.75	1.84
Elk Creek	2.00	(2)	(2)	(2)	NC	-	+	0.08	0.10	(1)	0.002	0.04	1.00	0.20	(1)	2.00
Elm Fork / N. Fork R.	2.50	0.84	0.07	0.21	NC	+	+	0.03	0.13	(1)	0.002	0.04	0.85	0.33	(1)	1.95
Frazier Creek	1.65	0.63	0.15	0.33	1.47	-	+	0.03	0.12	0.03	0.015	0.04	0.75	0.29	0.75	1.84
Gallinas River	1.60	0.60	0.07	0.21	NC	+	+	0.08	0.15	0.03	0.002	0.04	1.00	0.38	(1)	(1)
Hurricane Creek	1.20	0.93	0.08	0.27	NC	-	+	0.10	(1)	0.03	0.050	0.04	(1)	(1)	0.75	(1)
Moro Creek	1.30	0.93	0.07	0.21	0.75	+	+	0.10	(1)	0.03	0.100	0.08	0.75	0.29	0.75	(1)
Palo Duro Creek	3.75	(2)	(2)	(2)	0.01	-	-	0.10	0.01	(1)	0.002	0.04	0.60	0.15	(1)	1.00
Saline Bayou	1.65	(1)	0.12	0.29	(1)	+	+	0.06	0.15	0.03	0.050	0.01	0.75	0.29	(1)	(1)
Saline River	1.45	0.86	0.07	0.33	0.60	+	+	0.05	0.15	0.03	0.020	0.04	0.85	0.29	(1)	(1)
Skeleton Creek	1.60	0.84	0.00	0.29	NC	+	-	0.10	0.10	0.03	0.002	0.04	1.00	0.20	1.00	2.00
Smackover Creek	1.60	0.89	0.08	0.33	0.80	+	+	0.05	0.15	0.03	0.050	0.04	0.85	0.29	0.85	1.84
S. Fork Wichita R.	1.50	(2)	(2)	(2)	NC	+	+	0.06	0.42	(1)	0.030	0.04	2.00	0.60	(1)	2.90
Vermejo River	2.00	0.96	0.10	0.26	0.66	+	+	0.04	0.15	0.03	0.002	0.08	0.85	0.29	2.90	2.90
Wolf Creek	4.25	0.96	0.15	0.35	0.10	-	+	0.08	0.01	(1)	0.002	0.04	0.30	0.10	(1)	0.30

Notes:
1) “ET” signifies an adjustment factor used to increase the amount of ET over that estimated initially by AVGWLF.
2) “S Ret”, “N Ret” and “P Ret” are retention coefficients that indicate percent removal of sediment and nutrients by wetlands, ponds and lakes. An entry of “(1)” indicates the absence of observed data, and “(2)” means that there were no intervening wetlands, ponds or lakes in the given watershed.
3) “Sed a” signifies the “sediment a” factor used by GWLF-E. The value shown indicates the amount by which the value estimated by AVGWLF had to be increased or decreased to achieve calibration. An entry of “NC” means that the value estimated by AVGWLF was not changed, and “(1)” indicates the absence of observed data.
4) “GWN” and “GWP” refer to groundwater N and groundwater P, respectively. Entries of “+” and “-“ indicate increases or decreases to the values automatically estimated by AVGWLF, “NC” indicates no change to the estimated value, and “(1)” indicates no observed N data.
5) “GWR” refers to the groundwater recession coefficient.
6) “Crop C’, H/P C”, “For C” and “Turf C” refer to the USLE “C” value for cropland, hay/pasture land, forest land, and turfgrass areas, respectively. An entry of “(1)” indicates that very little of that land cover type occurs in the given watershed.
7) “Turf N”, Turf P, “H/P N”, “H/P P”, and “Crop N” refer to typical N or P concentrations in surface water runoff (in mg/l) for turfgrass, hay/pasture or cropland areas. An entry of “(1)” indicates either a lack of observed data or a relative lack of this category of land in the watershed

Table 12. Summary statistics for GWLF-E model calibration runs.

Watershed	Eco-Region	Flow (NS)	TSS (NS)	TN (NS)	TP (NS)	Flow (R^2)	TSS (R^2)	TN (R^2)	TP (R^2)
Attoyac Bayou	SCP	0.85	0.24	0.80	0.80	0.88	0.44	0.86	0.81
Bayou Anacoco	SCP	0.87	---	0.83	0.74	0.88	---	0.83	0.84
Bayou Toro	SCP	0.92	---	0.83	0.82	0.92	---	0.89	0.87
Black Cypress Creek	SCP	0.84	0.78	---	0.80	0.89	0.82	---	0.81
Frazier Creek	SCP	0.76	0.60	0.92	0.81	0.80	0.67	0.92	0.82
Hurricane Creek	SCP	0.90	0.77	0.88	0.81	0.90	0.80	0.89	0.85
Moro Creek	SCP	0.94	0.74	0.78	0.77	0.94	0.81	0.79	0.79
Saline Bayou	SCP	0.88	---	0.87	0.82	0.90	---	0.88	0.84
Saline River	SCP	0.87	0.59	0.71	0.72	0.87	0.61	0.86	0.79
Smackover Creek	SCP	0.88	0.76	0.83	0.82	0.88	0.78	0.84	0.85
Median/Mean[2]		*0.88*	*0.74*	*0.83*	*0.81*	*0.89*	*0.70*	*0.86*	*0.83*
Big Sandy Creek	GCP	0.80	0.43	0.77	---	0.81	0.73	0.82	---
California Creek	GCP	0.81	0.70	---	0.90	0.81	0.79	---	0.93
East Cache Creek	GCP	0.87	0.48	0.87	0.45	0.90	0.73	0.88	0.60
Elk Creek	GCP	0.86	---	0.85	0.82	0.90	---	0.90	0.87
Elm Fork/North Fork River	GCP	0.63	0.65	0.76	0.46	0.81	0.65	0.76	0.53
Skeleton Creek	GCP	0.88	---	0.78	0.75	0.89	---	0.80	0.75
Median/Mean[2]		*0.84*	*0.57*	*0.78*	*0.75*	*0.85*	*0.73*	*0.83*	*0.74*
Carrizozo Creek	SWT	0.89	0.53	0.77	0.84	0.90	0.54	0.78	0.84
Gallinas Creek	SWT	0.74	0.39	0.67	0.46	0.75	0.70	0.74	0.77
Palo Duro Creek	SWT	0.83	-4.01	-1.77	-2.54	0.83	0.28	0.02	0.03
South Fork Wichita River	SWT	0.66	0.68	0.73	0.34	0.83	0.69	0.80	0.47
Vermejo River	SWT	0.89	0.73	0.89	0.86	0.91	0.83	0.91	0.88
Wolf Creek	SWT	-0.38	-2.34	-5.28	-5.24	0.35	0.08	0.28	0.25
Median/Mean[2]		*0.79*	*0.46*	*0.70*	*0.40*	*0.76*	*0.52*	*0.59*	*0.54*

[1] Flow = stream flow, TSS = total suspended sediment, TN = total nitrogen, TP = total phosphorus, and NS = Nash-Sutcliffe coefficient.
[2] Median value is given for NS results and mean value is given for R^2 results.

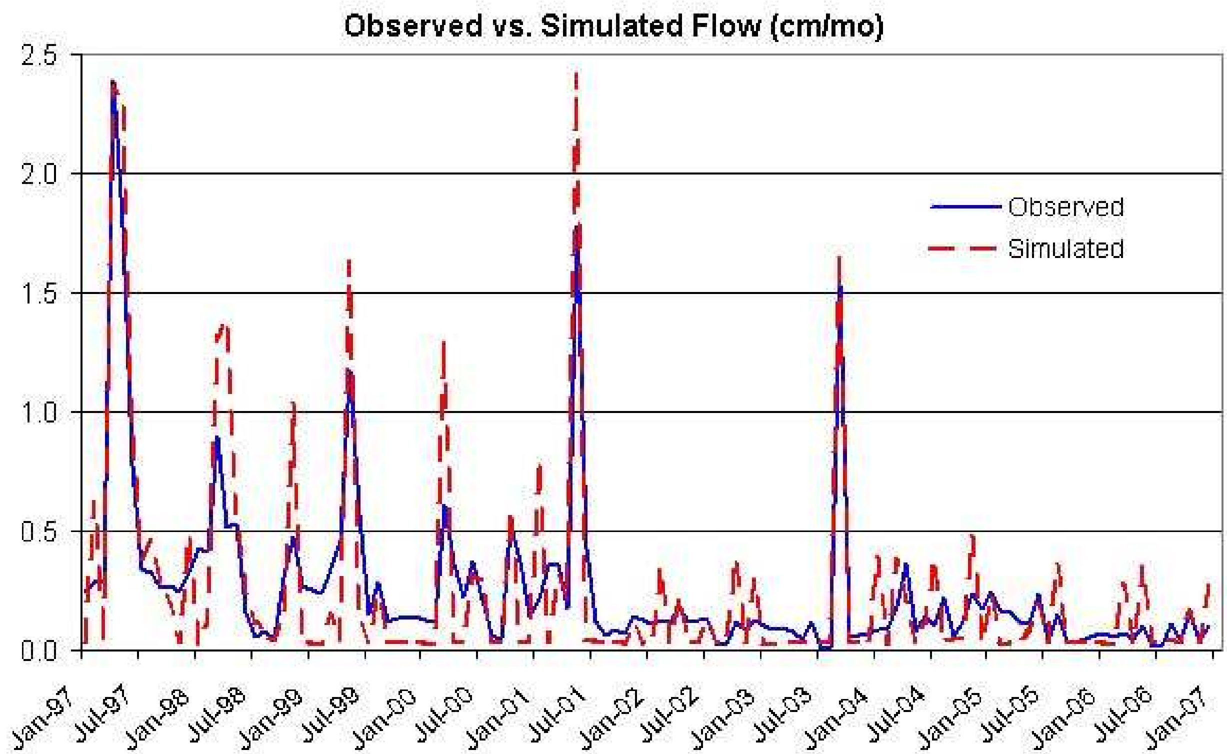

Figure 16. Calibrated flow results for Elm Fork/North Fork River watershed.

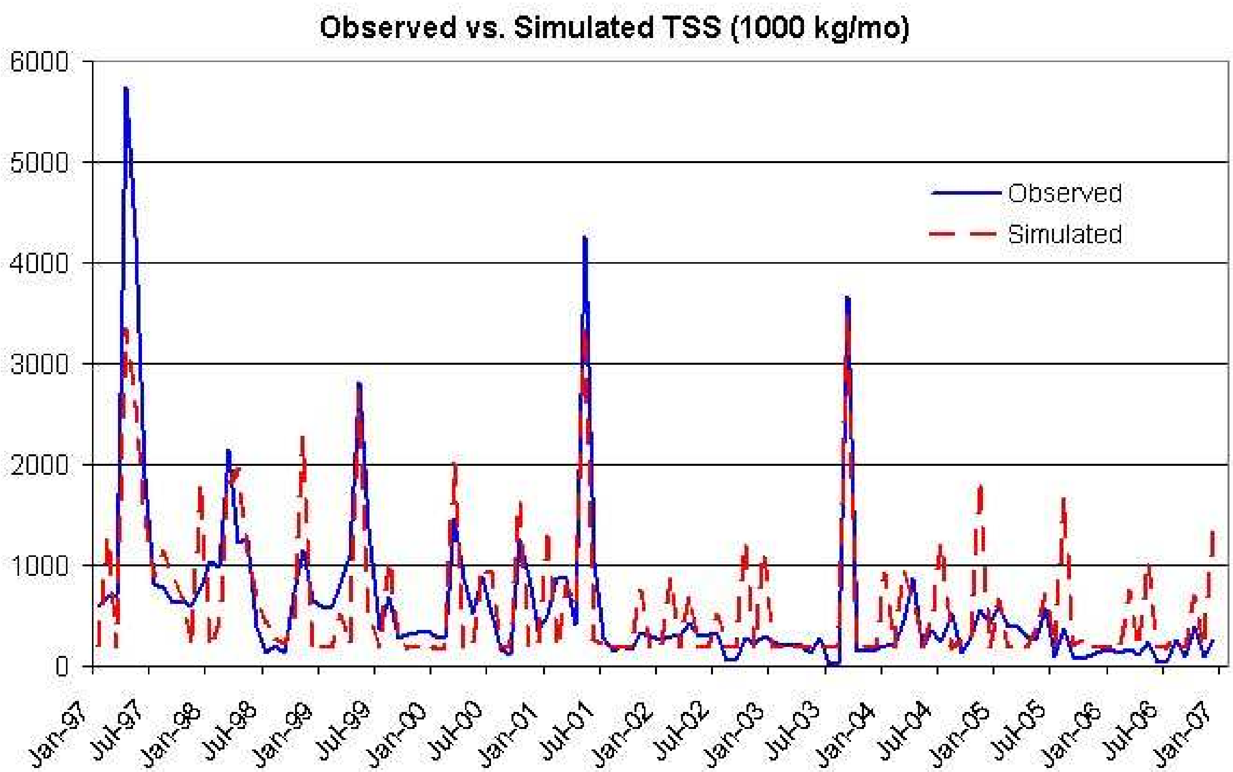

Figure 17. Calibrated TSS results for Elm Fork/North Fork River watershed.

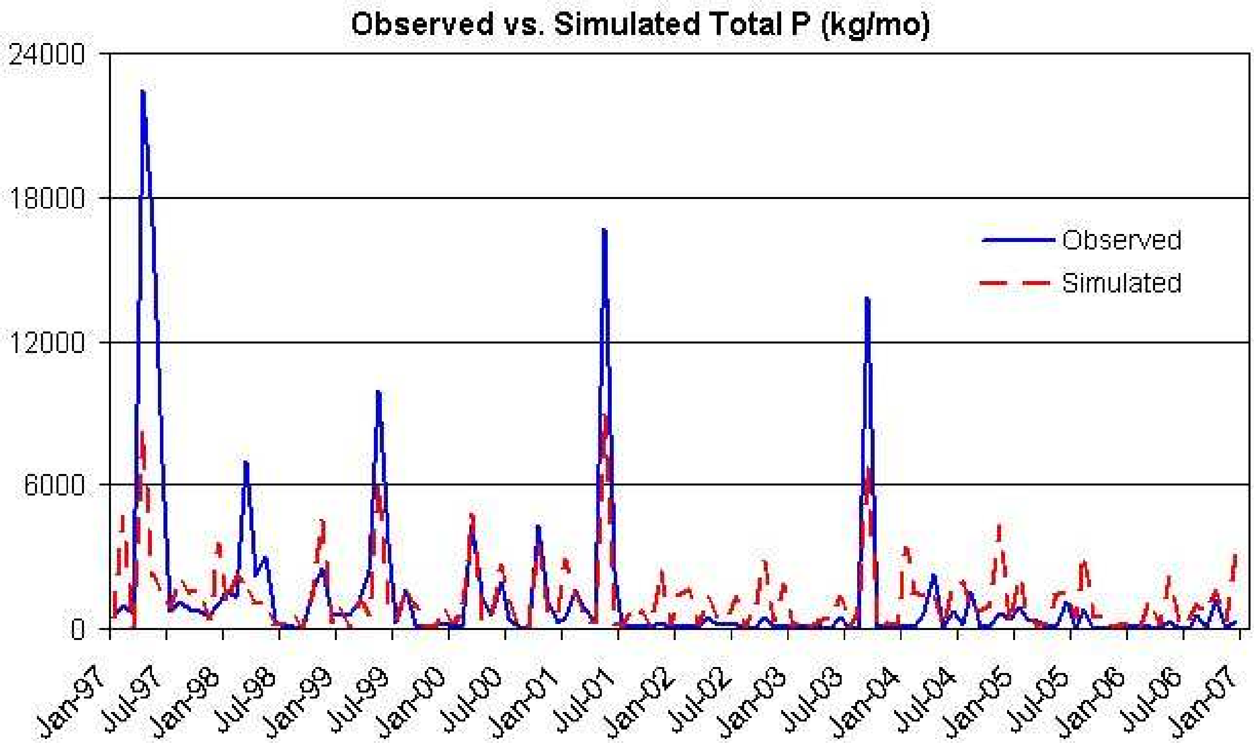

Figure 18. Calibrated total P results for Elm Fork/North Fork River watershed.

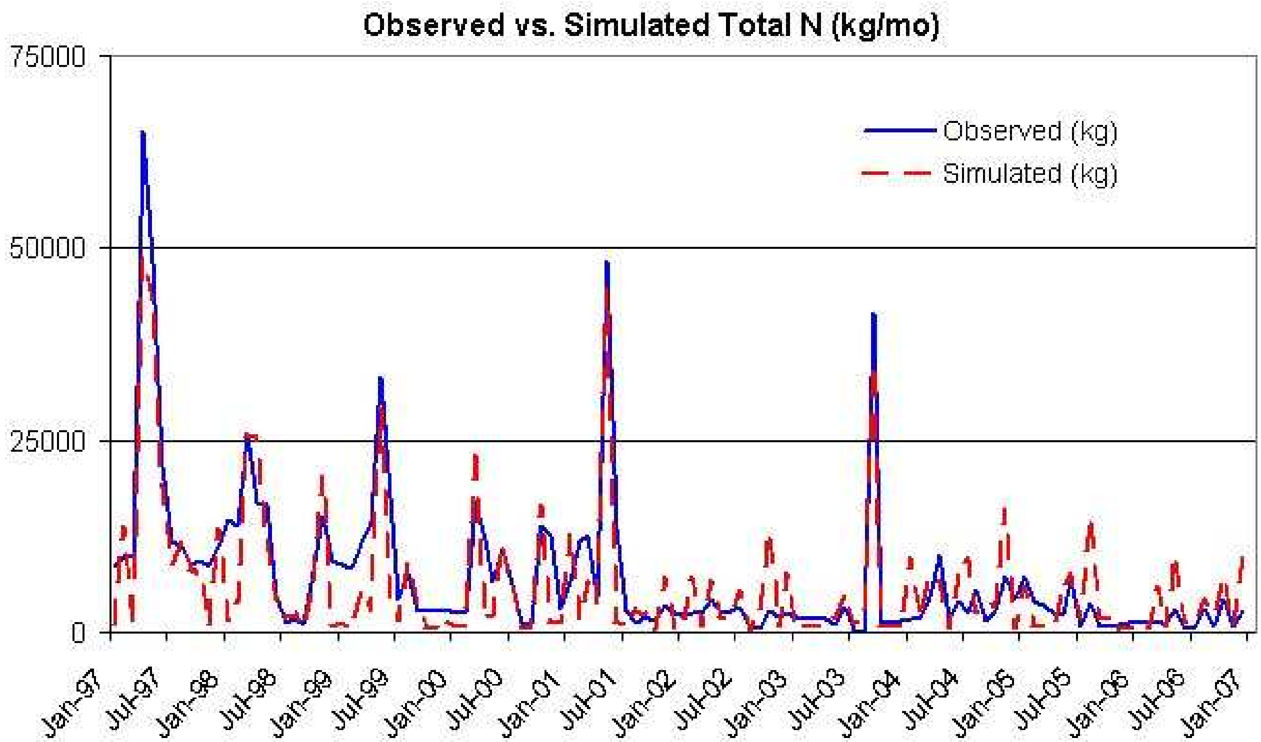

Figure 19. Calibrated total N results for Elm Fork/North Fork River watershed.

Table 13. Summary of mean annual flows and loads for model calibration runs.

Watershed	Eco-Region	Observed Flow[1]	Observed TSS[2]	Observed TN[2]	Observed TP[2]	Simulated Flow[1]	Simulated TSS[2]	Simulated TN[2]	Simulated TP[2]
Attoyac Bayou	SCP	41.11	130.5	3.17	0.78	42.74	92.2	3.59	0.72
Bayou Anacoco	SCP	51.50	---	3.85	0.69	52.34	---	3.87	0.60
Bayou Toro	SCP	47.01	---	4.61	0.72	47.36	---	4.46	0.74
Black Cypress Creek	SCP	30.63	23.2	---	0.26	34.48	23.7	---	0.29
Frazier Creek	SCP	36.70	48.7	1.29	0.23	40.29	36.8	1.36	0.25
Hurricane Creek	SCP	37.34	26.0	2.45	0.26	37.43	30.3	2.30	0.26
Moro Creek	SCP	37.09	25.5	3.06	0.27	38.17	34.7	2.72	0.25
Saline Bayou	SCP	46.02	---	2.37	0.25	48.15	---	2.20	0.28
Saline River	SCP	40.21	98.1	5.43	0.44	41.72	99.7	4.11	0.46
Smackover Creek	SCP	39.48	35.7	2.82	0.24	40.76	36.1	2.64	0.24
Mean		*40.71*	*55.39*	*3.23*	*0.41*	*42.34*	*50.50*	*3.03*	*0.41*
Big Sandy Creek	GCP	2.43	30.7	0.11	---	2.69	15.4	0.16	---
California Creek	GCP	1.93	67.5	---	0.10	1.84	58.2	---	0.09
East Cache Creek	GCP	9.55	263.4	2.10	0.49	10.09	210.1	2.03	0.33
Elk Creek	GCP	8.62	---	2.10	0.23	8.62	---	1.65	0.25
Elm Fork/North Fork River	GCP	3.05	33.6	0.40	0.07	3.04	34.4	0.34	0.07
Skeleton Creek	GCP	10.17	---	4.23	0.23	10.85	---	3.41	0.25
Mean		*5.96*	*98.8*	*1.79*	*0.22*	*6.19*	*79.53*	*1.52*	*0.20*
Carrizozo Creek	SWT	0.25	0.9	0.017	0.004	0.23	1.1	0.02	0.004
Gallinas Creek	SWT	8.74	89.0	1.00	0.17	8.65	56.8	0.84	0.11
Palo Duro Creek	SWT	0.03	0.1	0.007	0.001	0.03	0.51	0.009	0.002
South Fork Wichita River	SWT	1.66	43.4	0.69	0.27	1.67	47.1	0.63	0.21
Vermejo River	SWT	2.77	1.6	0.109	0.004	2.49	1.9	0.096	0.004
Wolf Creek	SWT	0.25	0.3	0.021	0.003	0.38	0.6	0.05	0.007
Mean		*2.28*	*22.55*	*0.31*	*0.08*	*2.24*	*18.00*	*0.27*	*0.06*

[1] Reported in centimeters of mean annual water depth across the watershed
[2] Reported in units of kg/ha per year

Groundwater Recession (Lag Time)

In the Pennsylvania version of **AVGWLF**, the value for the groundwater recession rate is automatically set at 0.10. During the model calibration step, this value was found to vary from 0.01 to 0.10 across all watersheds (see the "GWR" column in Table 11). Similar to evapotranspiration, there were trends in this value associated with the different eco-regions that could be used to make different adjustments in each of the three regional versions of **AVGWLF**. Consequently, these values were set at 0.06, 0.08 and 0.07 for the South Central Plains, Great Central Plains, and Southwestern Tablelands, respectively. In each case, these changes had the affect of "flattening out" the peaks in stream flow in each region relative to the initial model runs.

Groundwater Nitrogen and Phosphorus

During the calibration process, it was noted that **AVGWLF**-derived estimates of groundwater (i.e., sub-surface) nitrogen and phosphorus concentration appeared to be generally too low when evaluated against observed in-stream concentrations during low-flow periods. To correct for this, adjustments were made in the three regional versions of **AVGWLF** to increase estimates of these model input values.

Streambank Erosion

Within **AVGWLF**, the simulation of streambank erosion is primarily affected by the "sediment a" factor (see section 6.A of the AVGWLF Users Manual). Based on the results of the calibration step (see column "Sed a" in Table 11), the algorithm used in **AVGWLF** to estimate this factor was changed to decrease predicted streambank erosion by 5% for the South Central Plains and Southwestern Tablelands regional versions. The corresponding algorithm in the Central Great Plains version was left unchanged.

USLE "C" Factors

As described in section 6.A of the AVGWLF Users Manual, the USLE soil loss equation is used within the GWLF-E model to calculate soil erosion from upland areas (i.e., outside of stream channels). The "C" factors associated with this equation are automatically assigned within **AVGWLF** based on land use/cover type. As a result of the calibration process, it was noted that these values needed to be adjusted in order to better represent varying landscape conditions and activities in the three eco-regions.

In Pennsylvania, for example, the "C" factor for cropland is automatically given a value of "0.42" to reflect the extensive cultivation of corn in agricultural areas of the state. After the initial runs, it was determined that this value needed to be adjusted to reflect the different crops grown in EPA Region 6 (see the "Crop C" column in Table 11). In this region, the most prevalent crop is wheat, with a mix of lesser quantities of corn, cotton, soybeans and sorghum. In Table 11, watersheds with lower "Crop C" values tended to have greater amounts of wheat, whereas areas with higher values tended to have relatively greater percentages of the other crops. For the regionalized versions of **AVGWLF**, the "Crop C" values were set at 0.15 for the South Central Plains region, at 0.17 for the Great Central Plains region, and at 0.18 for the Southwestern Tablelands region.

With respect to forested land, these areas are automatically given a value of 0.002 by **AVGWLF** in Pennsylvania to reflect the relatively small amount of soil erosion that occurs in these areas. In many areas of EPA Region 6, this value is reasonable where timber cutting is not widespread. However, in many areas of EPA Region 6 where this activity is quite common, it was necessary to increase this value to represent the comparatively greater amounts of soil erosion from this source. For the South Central Plains, where this type of activity is quite extensive, this value was set at 0.08. For the other two regions, this value was set at 0.007. This latter value is greater than the value of 0.002 mentioned above to reflect the "thinner" tree cover occurring in this region in comparison to similar areas in Pennsylvania.

Another category for which it was necessary to adjust the "C" value is "Turf_Grass". In Pennsylvania, this category is primarily used to represent golf courses and similar areas of managed turfgrass. For the current study, this category was used to represent the relatively large expanses of naturally-occurring herbaceous grasslands which essentially do not exist in Pennsylvania and many other states in the eastern part of the country. To accommodate this change, several of the default model parameter values previously used for this category had to be adjusted. In this instance, the "C" values were set at 0.04 for the South Central Plains and Southwestern Tablelands regions, and at 0.05 for the Great Central Plains region.

Dissolved Nutrient Loads in Runoff

Within the GWLF-E model, dissolved nitrogen and phosphorus loads in surface water runoff are calculated via the use of estimated "event mean concentration" values for each land use/cover category. To reflect differences between the northeast part of the country and those states included in EPA Region 6, changes in the default settings for several key cover types (i.e., cropland, hay/pasture land, and turfgrass) were made. These changes (shown in Table 14) were made using event mean concentration values suggested in the literature (e.g., Harmel et al., 2006) as initial estimates and subsequent adjustments made during the calibration process. (Note that in the case of dissolved P for hay/pasture land for the Southwestern Tablelands, the existing default value of 2.9 was not changed since very little land of this type was found in the watersheds evaluated in this region).

Table 14. Adjusted values for dissolved nutrient concentration estimates (in mg/l).

Eco-Region	Turfgrass N	Turfgrass P	Hay/Pasture N	Cropland N
South Central Plains	0.77	0.29	0.76	1.84
Great Central Plains	0.86	0.28	0.80	1.91
Southwestern Tablelands	1.00	0.35	2.90	2.00

In the Pennsylvania version of **AVGWLF**, the dissolved P estimate for turfgrass is calculated automatically based on the area-weighted value of soil P for the watershed (see related discussion in section 2.2.2 of this document). For this study, however, the pertinent algorithm in this case was changed to re-set this value as 0.29, 0.28 and 0.35 for the South Central Plains, Great Central Plains, and Southwestern Tablelands, respectively

Lake/Wetland Retention

As described in section 2.D of the AVGWLF users manual (Evans et al., 2008), the enhanced version of the GWLF model used in this study (GWLF-E), includes a relatively simple empirical routine for estimating the retention of sediment and nutrients by "in-stream" lakes, ponds and wetlands. This routine is used to reduce nutrient and sediment loads generated within a watershed utilizing editable reduction coefficients and a user-specified estimate of the extent of land area "drained" by such features. For the Pennsylvania version of **AVGWLF**, reduction coefficients of 0.84, 0.12 and 0.29 are used for sediment, nitrogen and phosphorus retention, respectively. (Note that these values are very similar to those found in the literature for studies describing the use of detention ponds and wetlands as "best management practices" for controlling polluted runoff in urban and rural areas). Based on the calibration work completed as part of this study, these coefficients were changed slightly as shown in Table 15.

Table 15. Adjusted values for dissolved nutrient concentration estimates (in mg/l).

Eco-Region	Sediment	Nitrogen	Phosphorus
South Central Plains	0.82	0.11	0.29
Great Central Plains	0.71	0.09	0.26
Southwestern Tablelands	0.83	0.11	0.25

3.6 Model Verification Runs

Subsequent to making the "region-specific" modifications to **AVGWLF** as described in the previous section, additional model runs were made on all of the test watersheds. In this case, however, the three "regionalized" versions of **AVGWLF** were used instead of the Pennsylvania version. Also, as with the initial runs, no additional changes were made to the GWLF-E model input files automatically generated by the new versions of **AVGWLF** other than adding the same animal population and point source data as used in the two previous model runs where needed.

The new simulation results are summarized by eco-region in Table 16, and the corresponding mean annual flows and loading rates are provided in Table 17. Updates of the plots for the Elm Fork/North Fork River watershed are given in Figures 20 through 23.

Table 16. Summary statistics for model verification runs.

Watershed	Eco-Region	Flow (NS)	TSS (NS)	TN (NS)	TP (NS)	Flow (R^2)	TSS (R^2)	TN (R^2)	TP (R^2)
Attoyac Bayou	SCP	0.09	-0.40	-0.90	0.61	0.75	0.57	0.73	0.73
Bayou Anacoco	SCP	0.87	---	0.76	0.56	0.87	---	0.82	0.83
Bayou Toro	SCP	0.91	---	0.68	0.71	0.91	---	0.87	0.85
Black Cypress Creek	SCP	0.71	0.00	---	0.66	0.90	0.62	---	0.80
Frazier Creek	SCP	0.69	0.41	-2.41	0.65	0.83	0.54	0.84	0.81
Hurricane Creek	SCP	0.85	-1.75	0.79	0.73	0.86	0.78	0.85	0.83
Moro Creek	SCP	0.90	-6.74	0.43	0.50	0.91	0.82	0.86	0.80
Saline Bayou	SCP	0.87	---	0.87	0.80	0.90	---	0.87	0.84
Saline River	SCP	0.86	-0.65	0.56	0.70	0.86	0.29	0.82	0.72
Smackover Creek	SCP	0.88	-0.65	0.74	0.84	0.90	0.76	0.88	0.85
Median/Mean[2]		*0.87*	*-0.65*	*0.68*	*0.68*	*0.87*	*0.63*	*0.84*	*0.81*
Big Sandy Creek	GCP	-0.26	0.45	-2.21	---	0.60	0.62	0.56	---
California Creek	GCP	0.90	0.51	---	0.86	0.93	0.79	---	0.93
East Cache Creek	GCP	-0.51	0.46	0.57	0.33	0.71	0.56	0.70	0.65
Elk Creek	GCP	0.88	---	0.86	0.69	0.91	---	0.88	0.86
Elm Fork/North Fork River	GCP	-0.39	0.53	0.46	0.41	0.72	0.66	0.68	0.65
Skeleton Creek	GCP	0.82	---	0.46	0.55	0.88	---	0.84	0.70
Median/Mean[2]		*0.28*	*0.49*	*0.46*	*0.55*	*0.79*	*0.66*	*0.73*	*0.76*
Carrizozo Creek	SWT	-31.88	-0.64	-13.88	-1.66	0.08	0.40	0.18	0.34
Gallinas Creek	SWT	0.51	0.22	0.27	0.10	0.70	0.57	0.70	0.63
Palo Duro Creek	SWT	0.83	-19125.73	-163.59	-811.54	0.83	0.29	0.13	0.14
South Fork Wichita River	SWT	-0.52	0.48	0.44	0.24	0.53	0.67	0.65	0.34
Vermejo River	SWT	0.79	0.71	0.75	-3.56	0.85	0.86	0.86	0.86
Wolf Creek	SWT	-404.63	-1712.81	-1465.09	-245.01	0.48	0.28	0.50	0.55
Median/Mean[2]		*-0.52*	*0.22*	*0.27*	*-1.66*	*0.53*	*0.56*	*0.58*	*0.54*

[1] Flow = stream flow, TSS = total suspended sediment, TN = total nitrogen, TP = total phosphorus, and NS = Nash-Sutcliffe coefficient.
[2] Median value is given for NS results and mean value is given for R^2 results.

Table 17. Summary of mean annual flows and loads for model verification runs.

Watershed	Eco-Region	Observed Flow[1]	Observed TSS[2]	Observed TN[2]	Observed TP[2]	Simulated Flow[1]	Simulated TSS[2]	Simulated TN[2]	Simulated TP[2]
Attoyac Bayou	SCP	41.11	130.5	3.17	0.78	42.79	38.6	4.52	0.58
Bayou Anacoco	SCP	51.50	---	3.85	0.72	52.37	---	3.33	0.48
Bayou Toro	SCP	47.01	---	4.61	0.39	46.45	---	3.61	0.63
Black Cypress Creek	SCP	30.63	23.2	---	0.26	36.98	38.0	---	0.35
Frazier Creek	SCP	36.70	48.7	1.29	0.23	43.46	26.4	3.16	0.33
Hurricane Creek	SCP	37.34	26.0	2.45	0.26	32.23	74.4	1.98	0.23
Moro Creek	SCP	37.09	25.5	3.06	0.27	34.86	104.3	1.44	0.16
Saline Bayou	SCP	46.02	---	2.37	0.25	50.74	---	2.46	0.29
Saline River	SCP	40.21	98.1	5.43	0.44	40.42	159.9	3.41	0.51
Smackover Creek	SCP	39.48	35.7	2.82	0.24	43.16	78.3	2.09	0.27
Mean		*40.71*	*55.39*	*3.23*	*0.41*	*42.35*	*74.27*	*2.89*	*0.38*
Big Sandy Creek	GCP	2.43	30.7	0.11	---	4.36	19.2	0.30	---
California Creek	GCP	1.93	67.5	---	0.10	1.32	36.0	---	0.08
East Cache Creek	GCP	9.55	263.4	2.10	0.49	20.99	292.6	3.10	0.24
Elk Creek	GCP	8.62	---	2.10	0.23	8.07	---	1.81	0.27
Elm Fork/North Fork River	GCP	3.05	33.6	0.40	0.07	3.57	41.4	0.33	0.04
Skeleton Creek	GCP	10.17	---	4.23	0.23	7.75	---	2.00	0.30
Mean		*5.96*	*98.8*	*1.79*	*0.22*	*7.68*	*97.30*	*1.51*	*0.19*
Carrizozo Creek	SWT	0.25	0.9	0.017	0.004	0.78	2.2	0.062	0.008
Gallinas Creek	SWT	8.74	89.0	1.00	0.17	4.67	43.4	0.538	0.069
Palo Duro Creek	SWT	0.03	0.1	0.007	0.001	0.03	27.1	0.092	0.027
South Fork Wichita River	SWT	1.66	43.4	0.69	0.27	2.21	25.5	0.49	0.19
Vermejo River	SWT	2.77	1.6	0.109	0.004	1.87	2.8	0.077	0.006
Wolf Creek	SWT	0.25	0.3	0.021	0.003	3.22	15.4	0.602	0.047
Mean		*2.28*	*22.55*	*0.31*	*0.08*	*2.13*	*19.40*	*0.31*	*0.06*

[1] Reported in centimeters of mean annual water depth across the watershed
[2] Reported in units of kg/ha per year

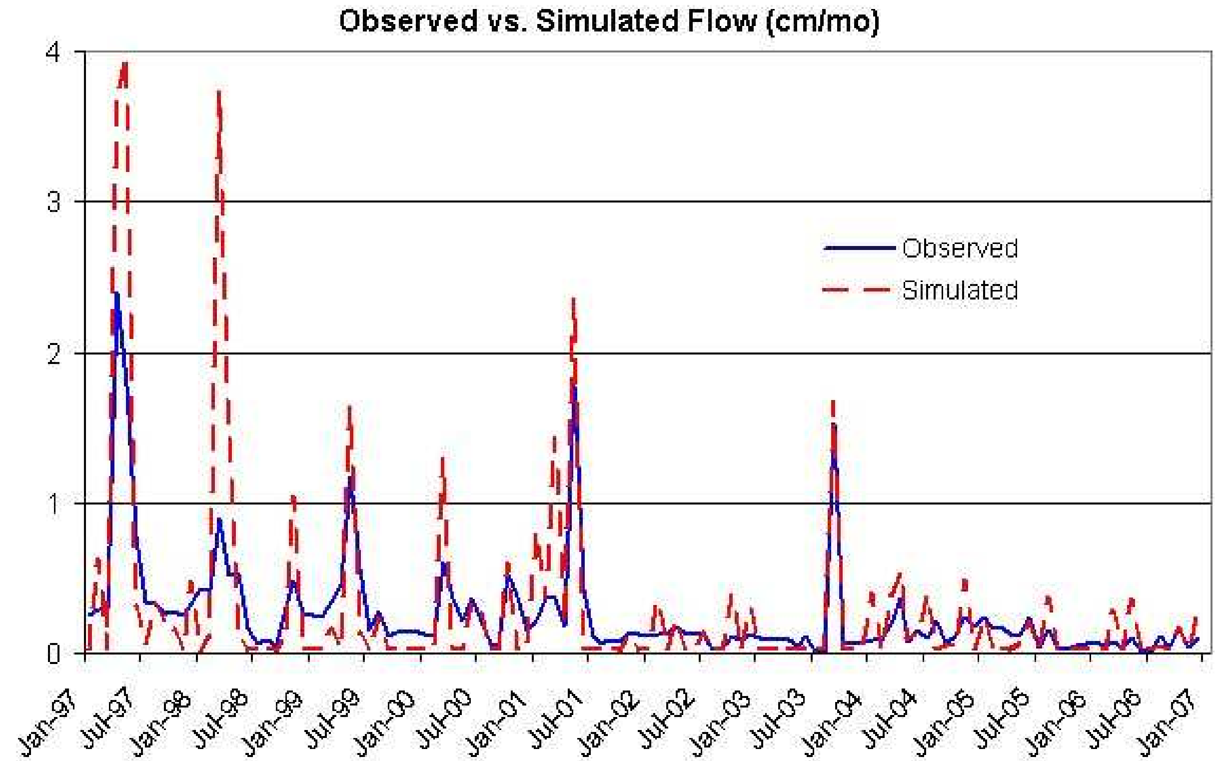

Figure 20. Calibrated flow results for Elm Fork/North Fork River watershed.

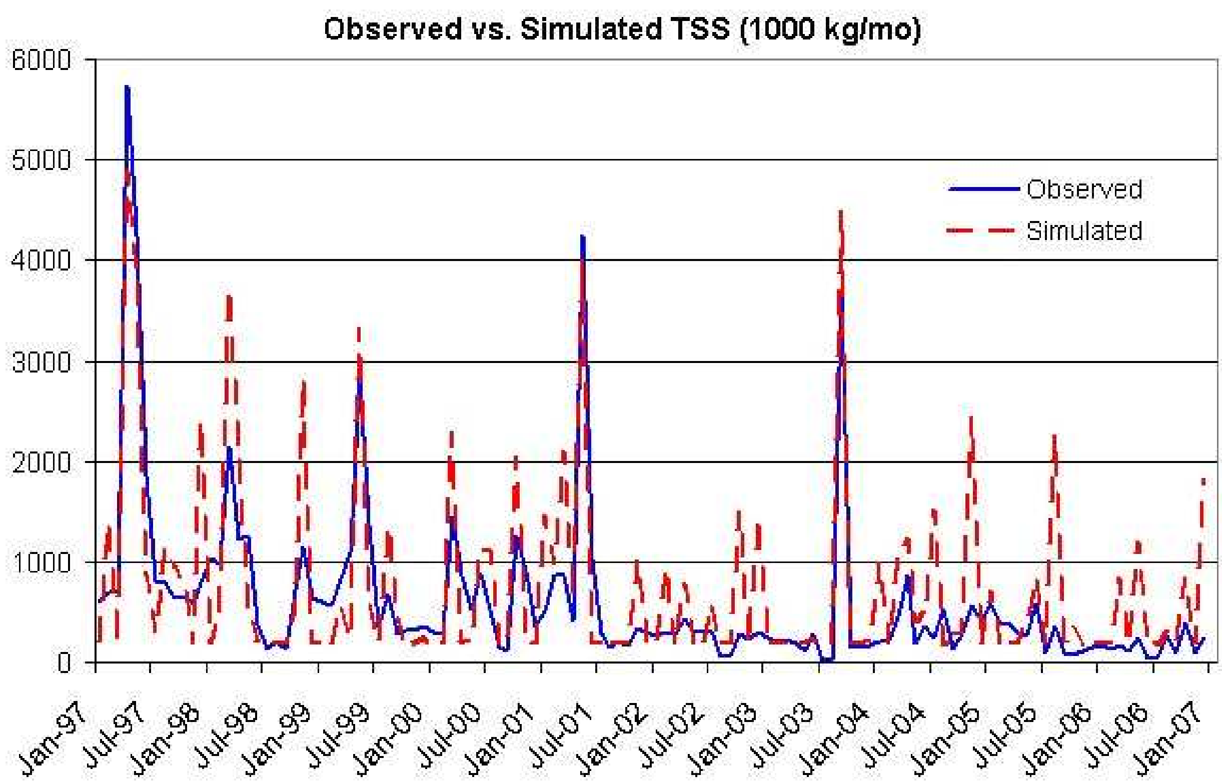

Figure 21. Calibrated TSS results for Elm Fork/North Fork River watershed.

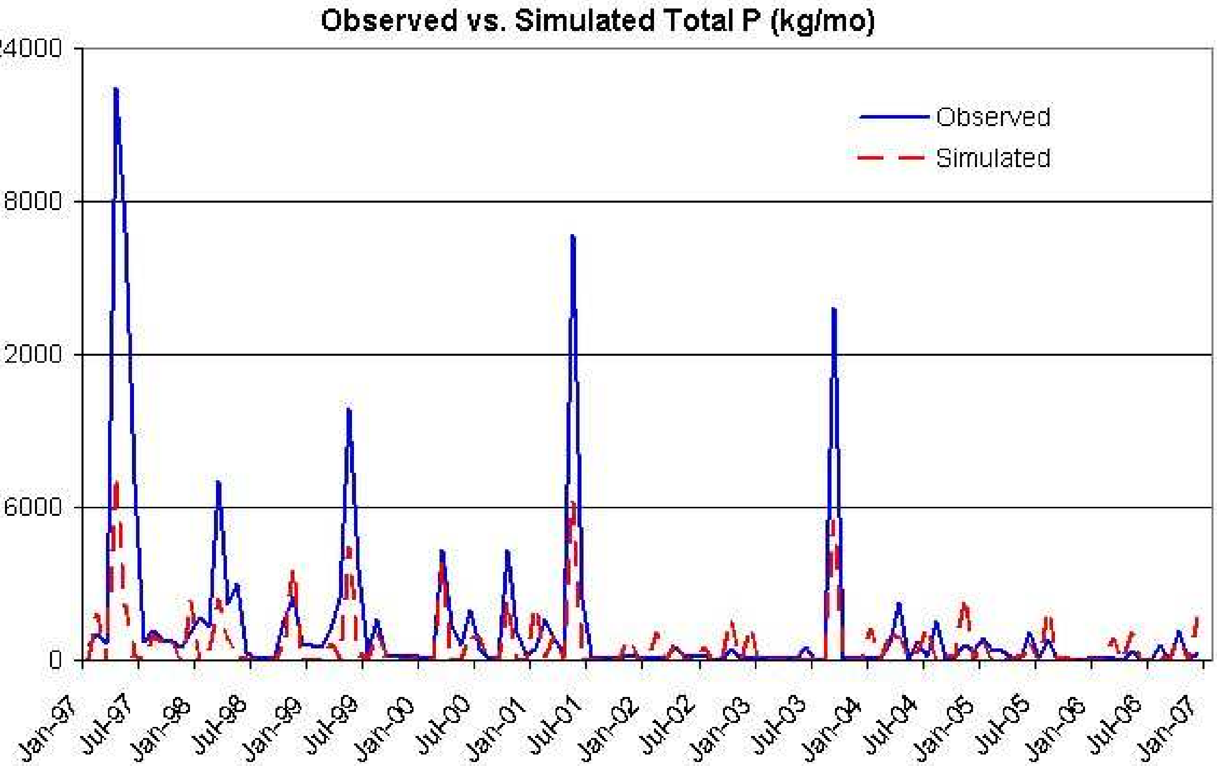

Figure 22. Calibrated total P results for Elm Fork/North Fork River watershed.

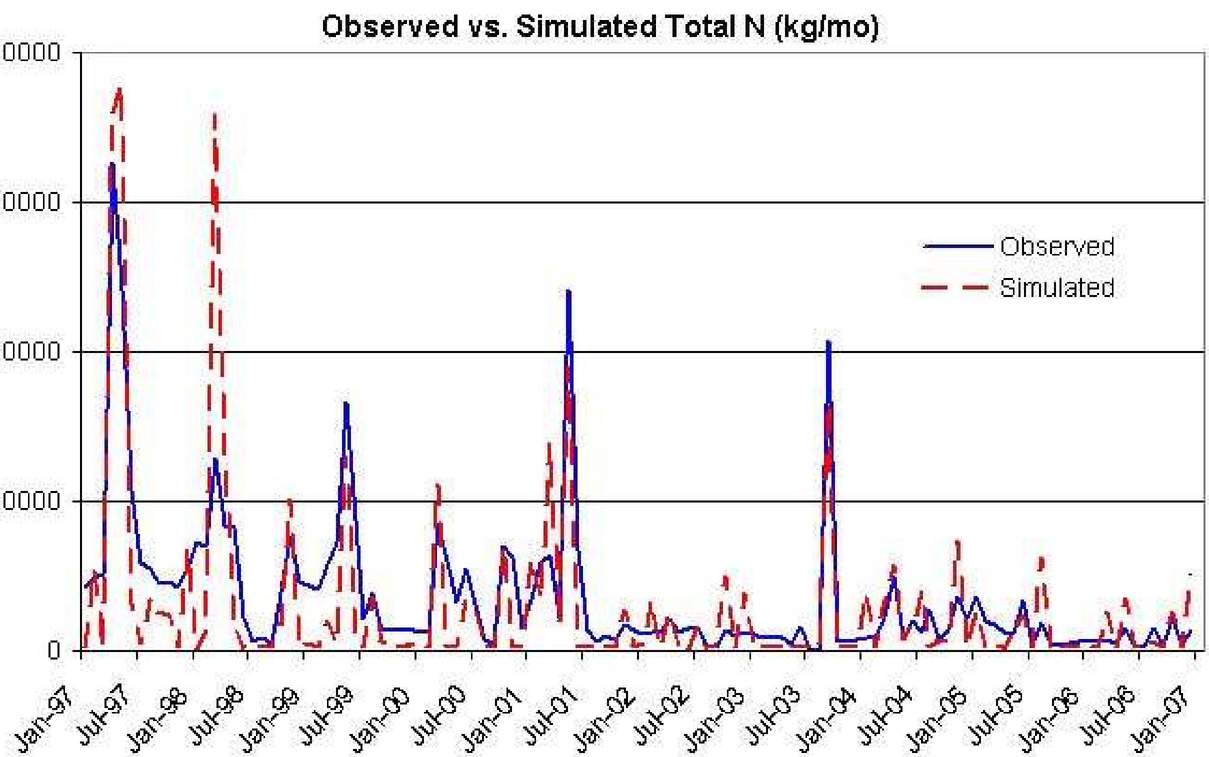

Figure 23. Calibrated total N results for Elm Fork/North Fork River watershed.

4.0 DISCUSSION OF RESULTS

For this study, GWLF-E model runs were completed in twenty-two test watersheds distributed across EPA Region 6. These runs were done in three different steps. In the first step, the Pennsylvania version of **AVGWLF** was used to create the model input files for each watershed. Then, GWLF-E was run on each of the watersheds without making any adjustments to **AVGWLF**-derived input data (with the exception of adding the point source and animal data as discussed in section 3.3). In the second step, numerous adjustments were iteratively made to various GWLF-E input files for the purpose of achieving the "best fit" between simulated and observed results for each individual watershed. For the last step, using the calibration results as a guide, three separate "improved" versions of **AVGWLF** were developed for each of the three test eco-regions. These "regionalized" versions were then re-run on all watersheds, and the resulting input files were directly executed within GWLF-E without further adjustment.

The three eco-regions evaluated in the study vary widely in terms of their climate and landscape characteristics which greatly affect the flows and loads generated by watersheds in each area. As can be seen from Table 10, the mean annual precipitation in the South Central Plains, the Great Central Plains, and the Southwestern Tablelands is about 130, 69, and 46 cm/yr, respectively. In the South Central Plains, about 30% of the mean annual total is delivered as stream flow. In the other two areas, however, only about 5-10% of the total ends up as stream flow. By comparison, in Pennsylvania, New York and New England (where **AVGWLF** has been tested extensively), stream flow is typically about 30-40% of mean annual precipitation, which ranges from about 100 to 150 cm/yr (Evans et al., 2002; Evans, 2007).

With regard to nitrogen, the test watersheds exhibited mean annual loads (based on the observed data) ranging from about 0.02 to 4.61 kg/ha (see Table 10). Observed phosphorus loading rates ranged from almost 0 to 0.78 kg/ha, and ranged from about 1 to 263 kg/ha for sediment. In all cases, higher loading rates are usually associated with areas of increased precipitation, more extensive agriculture, higher animal densities, and/or larger point source discharges. By comparison, states in the northeastern part of the U.S. typically have nitrogen loading rates ranging from about 1 to 20 kg/ha, phosphorus rates from about 0.1 to 1 kg/ha, and sediment rates from about 20 to 1500 kg/ha (Evans et al., 2002; Evans, 2007). The higher rates evidenced in the northeast (particularly at the upper end of the range) are most likely related to the greater prevalence of row crop cultivation in agricultural areas, greater topographic relief and degree of urbanization, and higher rates of atmospheric deposition in this region.

During the model calibration runs, adjustments were made to various input parameters for the purpose of obtaining a "best fit" between the observed and simulated data. One of the challenges in a calibration exercise such as this is to optimize the results across all model outputs (in this case, stream flows, as well as sediment, nitrogen and phosphorus loads). As with any watershed model like GWLF-E, it is possible to focus on a single output measure (e.g., sediment or nitrogen) in order to improve the fit between observed and simulated loads. Isolating on one model output, however, can sometimes lead to less acceptable results for other measures. Consequently, it is oftentimes difficult to achieve very high correlations (e.g., N-S values above 0.80) across all model outputs. Given this limitation, it was felt that reasonably good results were obtained for the calibration runs. In model calibration, initial emphasis is usually placed on getting the hydrology correct. Therefore, adjustments to flow-related model parameters are usually finalized prior to making adjustments to parameters specific to sediment and nutrient production. In practice, as evidenced by the values in Table 12, this typically results in better statistical fits between stream flows than the other model outputs.

Summary statistics for each eco-region for all three model runs are given in Table 18. From the results shown in this table, it can be seen that a fair degree of success was achieved in calibrating the GWLF-E model in that the average (mean or median) values for the initial model runs were generally improved upon in each region during the calibration step. From this table, as well as from Tables 9 and 12, it can also be seen that the level of success varied from watershed to watershed and from region to region. Note that it appears as if model accuracy for TSS and TN decreased slightly for the South Central Plains during the calibration process. This, however, is misleading in that the N-S coefficients were much lower for the initial model runs in comparison with the calibration runs. This latter measure is a better indicator of model accuracy than the typical R^2 measure in that it accounts for the fact that two separate data sets can be highly correlated, but not correspond very well on a "one-to-one" basis.

Overall, the GWLF-E model, when calibrated, performed better in the South Central Plains eco-region than in the other two regions. This should not be surprising since the original GWLF model (as well as the enhanced version) were developed and tested more extensively under conditions more similar to the former region. Even with the initial **AVGWLF** runs, the results (with the possible exception of TSS) were fairly good. From the initial model runs, it was evident that the "Pennsylvania" version of **AVGWLF** was not adequately simulating evapotranspiration in the much drier, westernmost regions. Once the GWLF-E model was calibrated for each watershed, however, there was a significant increase in accuracy over the initial model runs even for these areas. Model results for both the initial and calibration runs, though, are still better for the South Central Plains eco-region in comparison to the other two.

As indicated earlier, a primary focus of this study was to see if "regionalized" versions of **AVGWLF** could be developed that provided reasonable estimates of flows and loads in the absence of model calibration. Consequently, new versions in which algorithm adjustments were made based on the calibration results were developed, and these versions were subsequently re-run on all of the test watersheds to see if the results might approach those achieved using calibrated models. Again, the intent here was to use **AVGWLF** to create model input files , and then to run GWLF-E without making any adjustments as was done during the calibration step. The results for this step were shown previously in Tables 16 and 17, and the average results by eco-region are compared with those obtained during the initial and calibration runs in Table 18.

For the South Central Plains eco-region, the results from the model verification runs are sometimes similar to those from the initial models runs, and at other times similar to those from the calibration runs. Overall, there is not a huge difference between all three runs in that the results are fairly good in all three cases. It is the opinion of this author, however, that the "regionalized" versions of **AVGWLF** are probably better than the Pennsylvania version used for the initial runs because of the higher median N-S value for simulated flow obtained when using the former. This opinion is based on the belief that since the flow results are more accurate, the causes for the resulting sediment and nutrient loads will likely be more accurate as well for any given watershed.

For example, in Tables 9 and 10 it appears as if the nitrogen and phosphorus loads were initially simulated with reasonably high degrees of accuracy (median N-S values of 0.69 and 0.60, and R^2 values of 0.87 and 0.72, respectively). These values are misleading, however, because the loads simulated in this eco-region from upland source areas (e.g., cropland, hay/pasture, forest, etc.) due to surface water runoff and erosion were, in fact, being overestimated due to the overestimation of surface water runoff (by an average factor of about 30%) which, in turn, was caused by underestimation of evapotranspiration in these areas. During the calibration step, it was noted that once runoff and stream flow were decreased by correctly accounting for increased rates of

Table 18. Average statistical results by eco-region for each AVGWLF model run.

	Simulated Flow[1]	Simulated TSS[1]	Simulated TN[1]	Simulated TP[1]	Simulated Flow[2]	Simulated TSS[2]	Simulated TN[2]	Simulated TP[2]
South Central Plains								
Initial Model Runs	0.73	-0.04	0.69	0.60	0.87	0.74	0.87	0.72
Model Calibration Runs	0.88	0.74	0.83	0.81	0.89	0.70	0.86	0.83
Model Verification Runs	0.87	-0.65	0.68	0.68	0.87	0.63	0.84	0.81
Great Central Plains								
Initial Model Runs	-5.00	0.29	-6.06	0.27	0.56	0.53	0.58	0.72
Model Calibration Runs	0.84	0.57	0.78	0.75	0.85	0.73	0.83	0.74
Model Verification Runs	0.28	0.49	0.46	0.55	0.79	0.66	0.73	0.76
Southwestern Tablelands								
Initial Model Runs	-146.93	-13.31	-0.18	-6.16	0.41	0.39	0.55	0.48
Model Calibration Runs	0.79	0.46	0.70	0.40	0.76	0.52	0.59	0.54
Model Verification Runs	-0.52	0.22	0.27	-1.66	0.53	0.56	0.58	0.54

[1] Nash-Sutcliffe coefficient (median value for all watersheds)
[2] Pearson correlation (R^2) coefficient (mean value for all watersheds)

evapotranspiration, these nutrient loads also decreased. It was only through proper accounting of the animal populations and timbering activities in this eco-region that a correct estimation of nutrient production could be achieved. In this region, such sources can be important in terms of their contributions of sediment and nutrient loads at the watershed level. Consequently, when modeling watershed loads, it is important to apportion the loads from various sources as accurately as possible since this type of information is critical when trying to evaluate potential mitigation activities that might be implemented in the future to reduce such loads.

With respect to the Central Great Plains eco-region, it can be seen from Table 18 (and Tables 12 and 13) that the calibration runs produced the best results by far. This is understandable since the Pennsylvania version of **AVGWLF** significantly underestimated evapotranspiration as described in the previous section. Therefore, it is not surprising that the modified version of **AVGWLF** resulted in a more dramatic improvement between the initial and verification runs since a much-improved ET estimation routine was included in this version. When compared with the South Central Plains, the calibration results are slightly poorer as reflected by the generally lower N-S and R^2 values. As alluded to earlier, this may well be due to a reduced capacity for the GWLF-E model to simulate processes in climates that are very much drier than those like the region in which the original model was developed (i.e., northeastern U.S.).

Similar to the Great Central Plains, calibrated model runs for the Southwestern Tablelands region resulted in fairly dramatics improvements over those for the initial model runs (see Tables 18, 12, and 13). This, again, was due primarily to the improved simulation of evapotranspiration (and therefore, runoff and stream flow) in each watershed. However, the calibration run results were less accurate overall than those for the Great Central Plains; and the results from the verification runs were the least accurate of the three regions.

As expected, in most cases across all three eco-regions the monthly Nash-Sutcliffe coefficients were somewhat lower in comparison to the R^2 values due to the nature of this particular statistic. As described earlier, this statistic is used to iteratively compare simulated values against the mean of the observed values, and values above zero indicate that the model predictions are better than just using the mean of the observed data. In other words, any value above zero would indicate that the model has some utility beyond using the mean of historical data in estimating the flows or loads for any particular time period. As with R^2 values, higher Nash-Sutcliffe values reflect higher degrees of correlation than lower ones. When considering the inherent difficulty in achieving optimal results across all measures as discussed above (along with the potential sources of error as discussed in a later section), the results for the calibration runs in each region are believed to be quite good (especially in the South Central Plains and Central Great Plains regions). The results for the verification runs were also quite good for the South Central Plains regions, with the results for the Central Great Plains region being slightly poorer, but still reasonable. The results for the Southwestern Tablelands, particularly in the case of the initial and verification runs, were the most problematic of the three eco-regions.

In most cases across all eco-regions, the sediment load predictions were less satisfactory than those for the other outputs, and this is not entirely unexpected given that this constituent is usually more difficult to simulate than nitrogen or phosphorus. Improvements in sediment prediction could most likely have been achieved by isolating on this particular output during the calibration process; but this would have resulted in poorer performance in estimating the nutrient loads for many of the watersheds. Phosphorus predictions were generally also less accurate than those for nitrogen. This is not unusual given that a significant portion of the phosphorus load for a given watershed is highly related to sediment transport processes. Nitrogen, on the other hand, is often linearly correlated to flow, which typically results in accurate predictions of nitrogen loads if stream flows are being accurately simulated.

For this study, model accuracy was primarily based on statistical evaluations of correspondence between observed and simulated flows and loads in individual watersheds on a monthly time frame. Another way of evaluating the utility of **AVGWLF** is to assess predictions of mean annual flows and loads against those that might occur throughout EPA Region 6. In other words, can **AVGWLF** (in particular, the regionalized versions) be used to predict mean annual flows and loads with a reasonably high degree of accuracy when compared against other watersheds in the region? Shown in Figures 24 through 27 are the “pooled” results of observed and simulated mean annual flows and loads from the verification runs for all twenty-two test watersheds. What these plots show, among other things, is that a reasonable degree of separation can be achieved in correctly identifying watersheds with relatively higher flows and loads versus those with lower flows and loads. In general, mean annual flows and phosphorus loads appear to be better simulated than mean annual sediment and nitrogen loads.

As with any model, the results obtained with **AVGWLF** are directly related to the quality of the input data. If the quality of the input data sets is poor, then any simulation based on them can be expected to be poor as well. (An exception to this general statement is when serendipitous combinations of input data occur to produce a “good” prediction, which can happen more often than might be expected). Generally speaking, data quality is usually related to “inherent” data accuracy (how accurately are local conditions reported or represented) and the “appropriateness” of the data used. In the first instance, data may be missing or incorrectly reported (e.g., incorrectly located point source data, incorrectly labeled soils data, old land use data, data of insufficient spatial resolution, etc.). In the second instance, data may be spatially correct and of high quality, but may be “inappropriate” because they do not accurately reflect local conditions. An example of this latter case would be weather data used from a climate station that may be too far away from a given area to adequately represent daily weather conditions within that area. Both of these data quality problems existed to some degree during the course of this study that may have affected the accuracy of the simulations performed using **AVGWLF**. Although it was not within the scope of this particular study to evaluate the effects that data quality might have on modeling results within the region, some observations related to this issue are offered below.

1) With respect to weather data, an attempt was made to compile data for as many weather stations as possible. Ideally, these stations should be located within, or very near to, the boundaries of each watershed in order to accurately reflect local conditions. Due to data availability, however, it was not always possible to achieve this level of coverage. Consequently, it is possible that simulations performed for some watersheds in which at least one or both of the stations were outside the watershed (e.g., Vermejo River, Carrizozo Creek, Big Sandy Creek, Attoyac Bayou, Smackover Creek and Frazier Creek) may have been adversely affected by the use of weather data drawn from stations located some distance from them. Based on previous experience, this author has noticed that problems related to station distance are typically more acute during summer months when isolated, relatively intense storms occurring near the stations are not evident in areas only a few miles away (or during the reverse situation). Such problems typically result in the over- or under-prediction of sediment and phosphorus loads during these times of the year.

2) In developing the necessary data sets to drive **AVGWLF**, an attempt was made to compile the best available map data at a spatial resolution that would support the types of calculations made to derive estimates for various model input parameters. For the most part, it

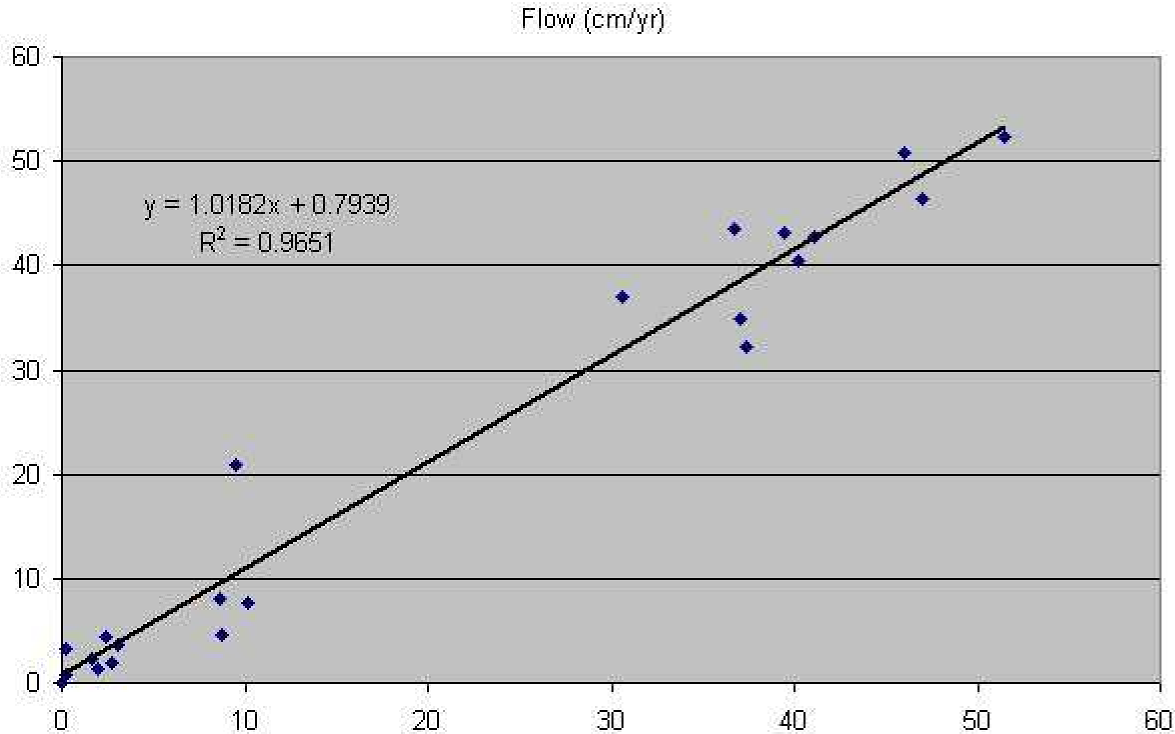

Figure 24. Simulated vs. observed mean annual flows for all watersheds.

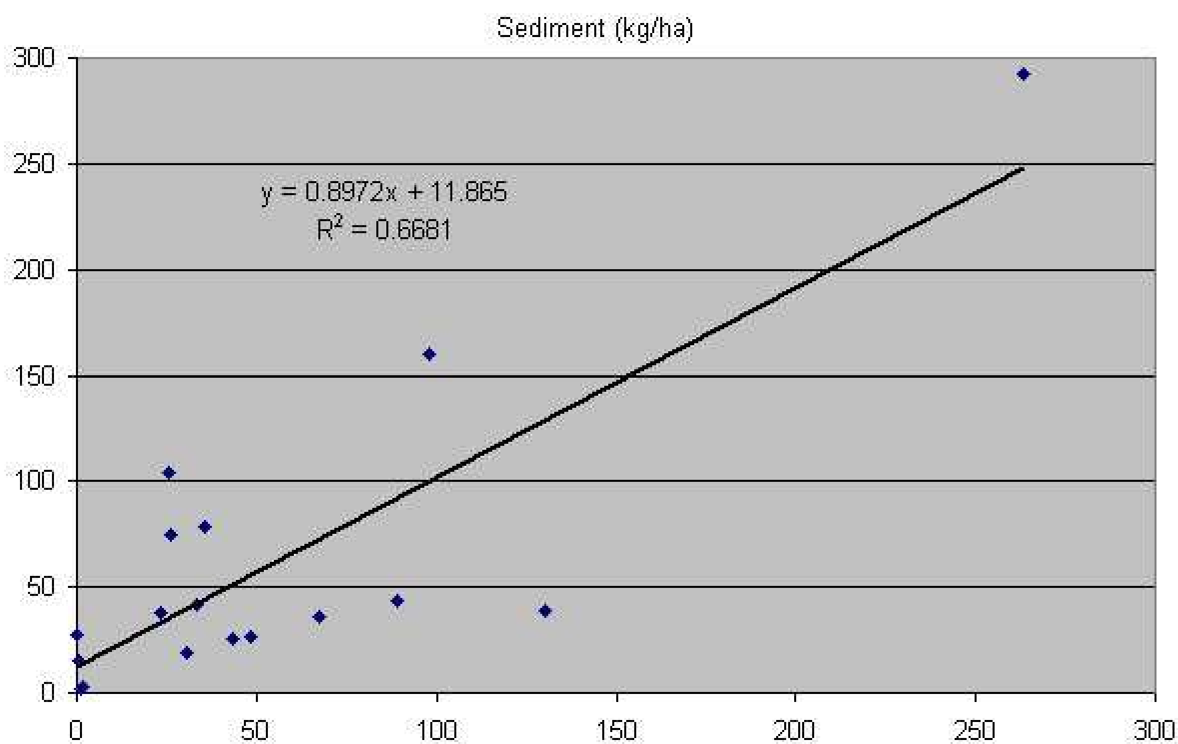

Figure 25. Simulated vs. observed mean annual sediment loads for all watersheds.

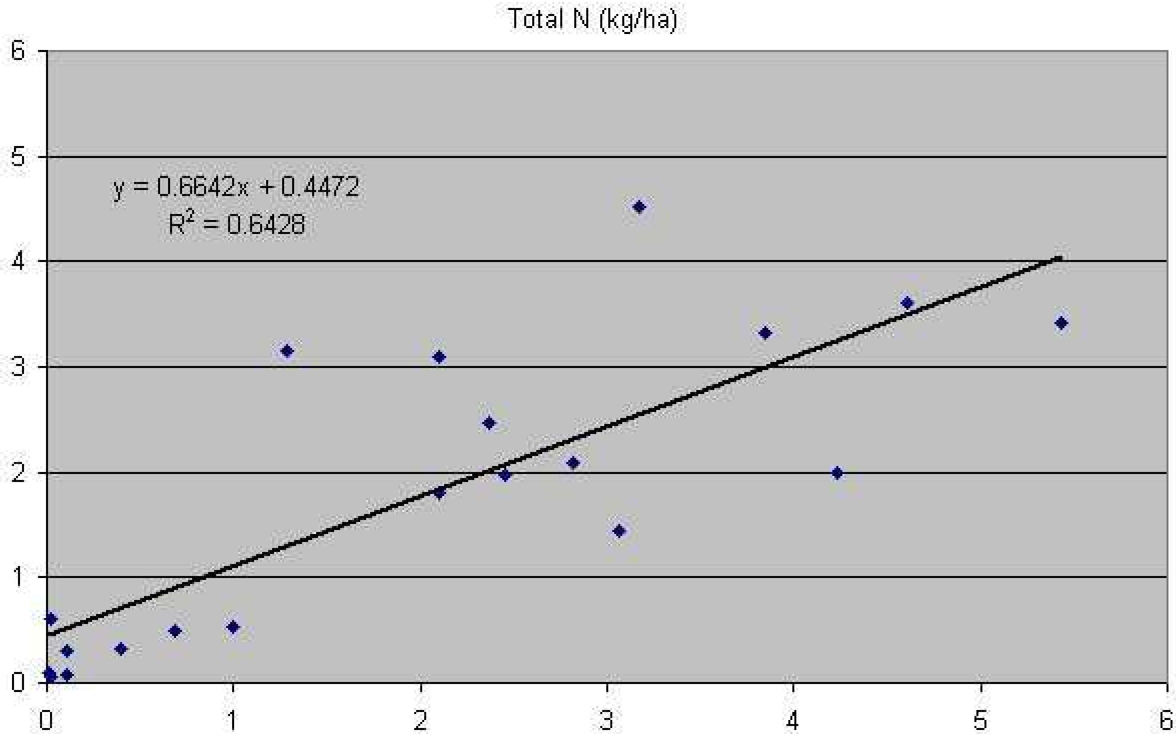

Figure 26. Simulated vs. observed mean annual nitrogen loads for all watersheds.

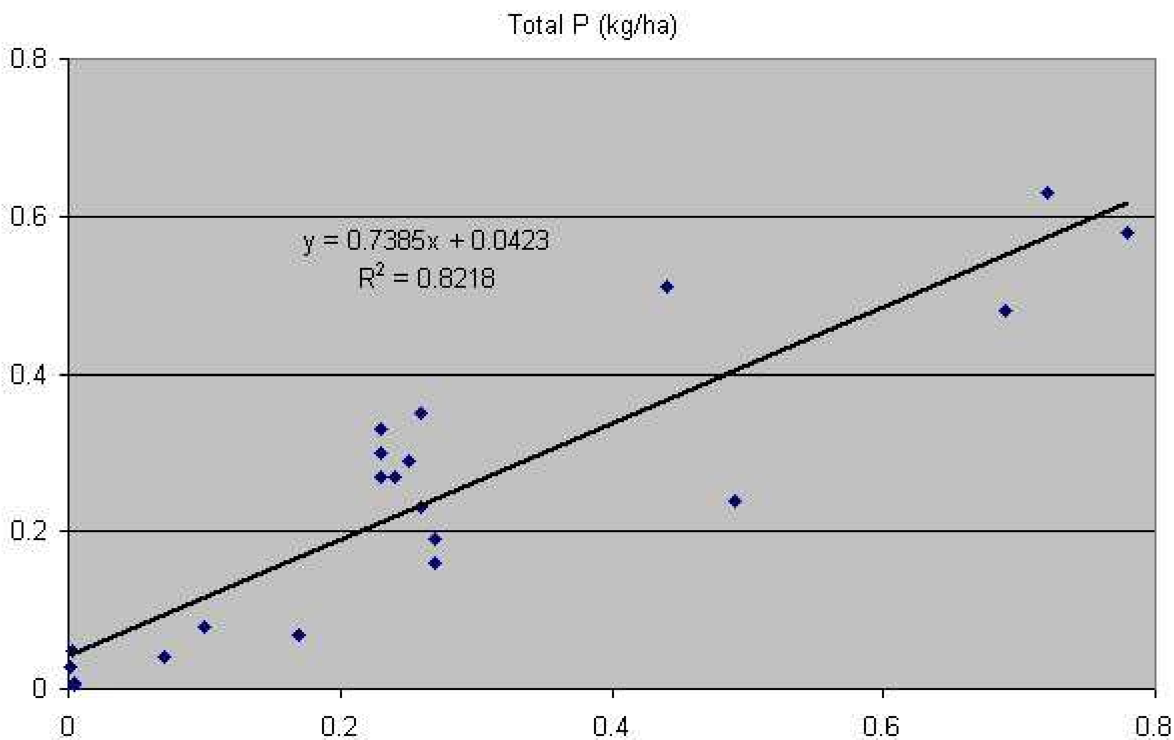

Figure 27. Simulated vs. observed mean annual phosphorus loads for all watersheds.

is believed that the resolution of most of the data sets used were reasonable given the complexity of the GWLF-E model and the scale at which watershed simulations were made. One possible exception is the animal population data. In other geographic regions where **AVGWLF** has been used, this type of information has typically been compiled for polygon areas similar in size to zip code, census tract or municipal boundaries. In this case, however, due to data constraints, this data layer was constructed using federal (i.e., USDA) data available only at the county boundary level. This spatial resolution may not be sufficiently precise to estimate nutrient loads in small watersheds with very intensive grazing operations.

3) In most of the watersheds used as test sites in this study, point source discharges generally contributed very little in terms of overall flows and loads. In cases where significant point sources did exist (e.g., East Cache Creek and Gallinas Creek), it was relatively easy to estimate such loads using observed stream flows and nutrient loads during "precipitation-free" periods. However, if **AVGWLF** is anticipated for future use as a watershed modeling tool in EPA Region 6, it is advised that a point source layer be constructed in order to better represent these sources in the region, particularly in the instances where in-stream monitoring data may not be available.

4) The **AVGWLF** modeling package allows for the consideration of surface and ground water withdrawals in simulating watershed hydrology. Depending upon the amount of water extracted within a given area, such withdrawals may have a noticeable effect on local stream flows. No attempt was made to collect this type of information for the watersheds used in this study since this type of information is generally very difficult to obtain. Therefore, the potential influence of such withdrawals was not considered in the simulations conducted.

5) Within **AVGWLF**, there are routines for transporting sediment and nutrient loads via three primary pathways: 1) overland flow, 2) subsurface flow, and 3) tile drain flow. The first two pathways apply to any type of landscape, while the last one only applies to agricultural areas. As explained in section 2.2.1, the tile drain layer is an optional one. If one is supplied, then different loading coefficients are used than when flow is routed via the other pathways; if not, then flows and loads are only transported via the other two pathways. It is not known to what extent tile drains are used in EPA Region 6; consequently, it is difficult to determine what affect the lack of data pertaining to their use had in various watersheds.

6) Not all watershed simulation models produce output in the same format. The type and format of the output from a given model necessarily has a direct effect on the manner in which subsequent calibration work is performed. Many water quality models, for example, produce estimates of flow and constituent concentrations over relatively short time frames that can be directly compared against available in-stream flow and concentration data. Other models like GWLF-E, on the other hand, produce estimates of flow and loads that are accumulated over longer time periods. In the case of GWLF-E, load estimates (rather than concentrations) are calculated daily and then reported on a monthly basis for each year of the simulation period. For calibration purposes, this requires that simulated loads be compared against "observed" loads compiled for the same time period. Since continuous load estimates based on daily observations are rare given the high cost of in-stream sampling, such loads are normally "estimated" using another procedure. Such procedures are typically based on the assumption that fluctuations in concentration or load are primarily dependent on varying flow conditions and do not typically consider the effects of rainfall intensity (Yochum, 2000), which can have a significant influence on observed loads (particularly for sediment and phosphorus) in a watershed. In this project, the FLUX program developed by the U.S. Army Corps of Engineers was used to develop statistical relationships between constituent concentration and stream flow

(see related discussion in section 3.2). Since daily estimates of load are essentially based on limited stream flow and concentration data, this procedure is subject to error, and it is possible that "observed" loads for any month may be slightly higher or lower than "actual" loads, thereby further complicating comparisons between simulated and "observed" data.

8) Another possible source of error is related to the selection of watershed sites in the Southwestern Tablelands eco-region. As described previously, an attempt was made to identify test watersheds in each region that had corresponding in-stream flow and water quality measurements. Unfortunately, due to a general lack of such data, finding suitable sites was a problem for this region. As shown in Figure 28, only one of the test watersheds (South Fork of the Wichita River) was wholly contained within this eco-region. Parts of the other watersheds (which were sometimes quite large parts as in the case of the Palo Duro and Vermejo River sites) covered three other eco-regions in addition to the Southwestern Tablelands (i.e., the Great Central Plains, Southern Rockies, and High Plains). This situation most likely complicated efforts to develop "regionalized" routines in **AVGWLF** based on underlying assumptions of landscape homogeneity for this particular region.

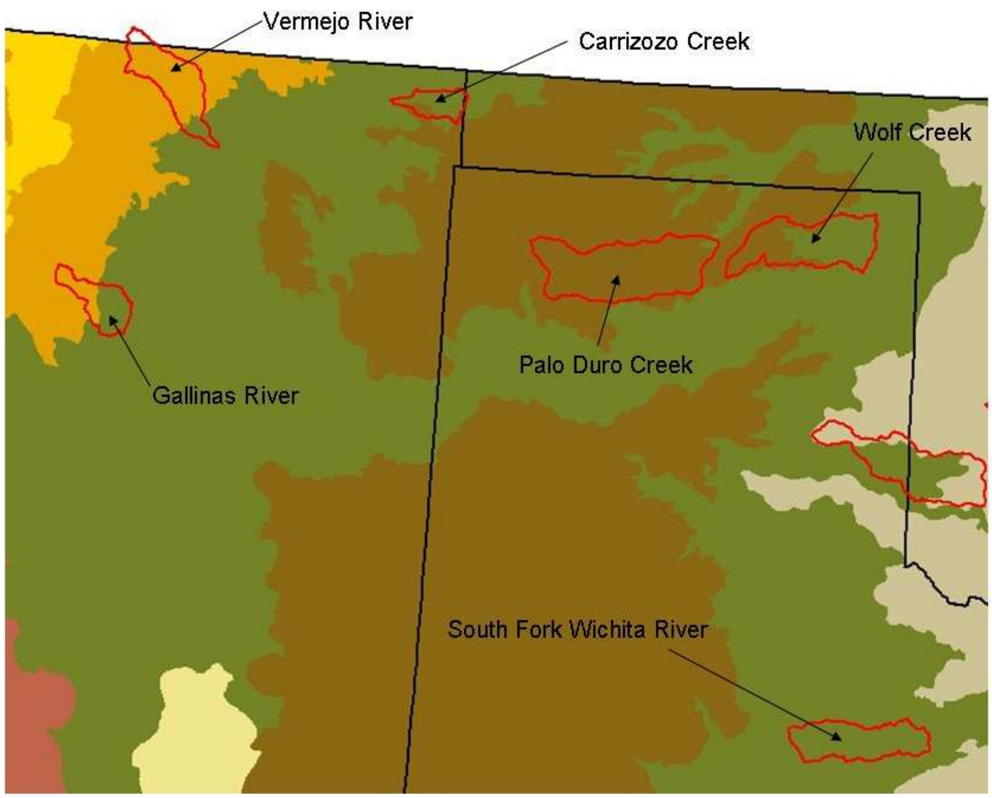

Figure 28. Locations of watersheds in the Southwestern Tablelands.

9) A last potential source of error has to do with the flow data for the Attoyac Bayou. In this instance, there were no in-stream flow measurements available at the water quality station used to represent the watershed outlet. Rather, flow data simulated at this location by another model (SWAT) was used as the "observed" flow data, as well as to derive observed sediment and nutrient load estimates utilizing the FLUX program. Given that these flow measurements were not "actual" measurements, it is likely that the results for this particular watershed were negatively affected to some degree.

5.0 SUMMARY AND CONCLUDING REMARKS

Two primary objectives of this study were to: 1) evaluate the utility of using the **AVGWLF** watershed modeling tool in selected areas of EPA Region 6, and 2) develop and evaluate region-specific versions of **AVGWLF** that could potentially be used to provide estimates of sediment, nitrogen and phosphorus loads in these areas with sufficient accuracy to support TMDL and similar watershed assessments. As part of the study, numerous regional data sets were developed to support modeling activities. Revisions were made to the version of **AVGWLF** used previously in Pennsylvania, and model testing was done in 22 different watersheds. Based on the testing, it was determined that **AVGWLF**, when calibrated, can simulate sediment and nutrient loads at a reasonably high level of accuracy. Generally speaking, un-calibrated model runs using the regionally-adapted version of the software provide less reliable estimates of these loads. The verification run results for two of the eco-regions (the South Central Plains and the Central Great Plains) suggest that the "region-specific" versions of **AVGWLF** may be good enough to estimate flows and loads in these areas without calibration for most watershed modeling purposes. However, the results for the Southwestern Tablelands regions indicate that **AVGWLF**, if run un-calibrated, may not adequately simulate hydrology and pollutant transport processes with sufficient accuracy in very dry areas of EPA Region 6.

Several sources of potential model error were identified and described. Many of these potential sources are not necessarily specific to the model used in this study, but are typical of many modeling approaches (e.g., problems with weather data, lack of available map data, etc.). With respect to data, substantial effort could be expended verifying the accuracy of various data layers or compiling them at more precise spatial scales. Based upon the results obtained in this study, it appears that the data sets generally available via most state and federal sources are adequate for deriving model input data. Two data sets that might warrant additional effort in developing include those associated with point source data and animal populations. For this study, it was relatively easy to estimate the former for the few instances where this type of information was needed due to the use of historical in-stream flow and water quality data. However, this would be problematic in areas where these data do not exist. With regard to the animal data, for this study county-level population data from USDA were used to estimate watershed-level numbers. However, it is likely that these estimates would be more accurate if the original data were re-compiled at a more detailed spatial scale (e.g., at the zip code or municipal level).

If consideration is given to using **AVGWLF** in other eco-regions (particularly in the absence of calibration data), it is likely that unsatisfactory results will be achieved in the drier, westernmost portions of EPA Region 6 (i.e., the panhandle of Oklahoma, west Texas, and probably most of New Mexico). In the easternmost areas, however, regionalized versions of **AVGWLF** would likely yield results similar to those obtained for the South Central Plains and Central Great Plains areas, with the possible exception of coastal areas where water table fluctuations are significant and tidal influences may be strong. Due to the rather generalized way in which the GWLF-E model simulates shallow subsurface flow, predictions of sediment and nutrient loads in such areas may be less reliable.

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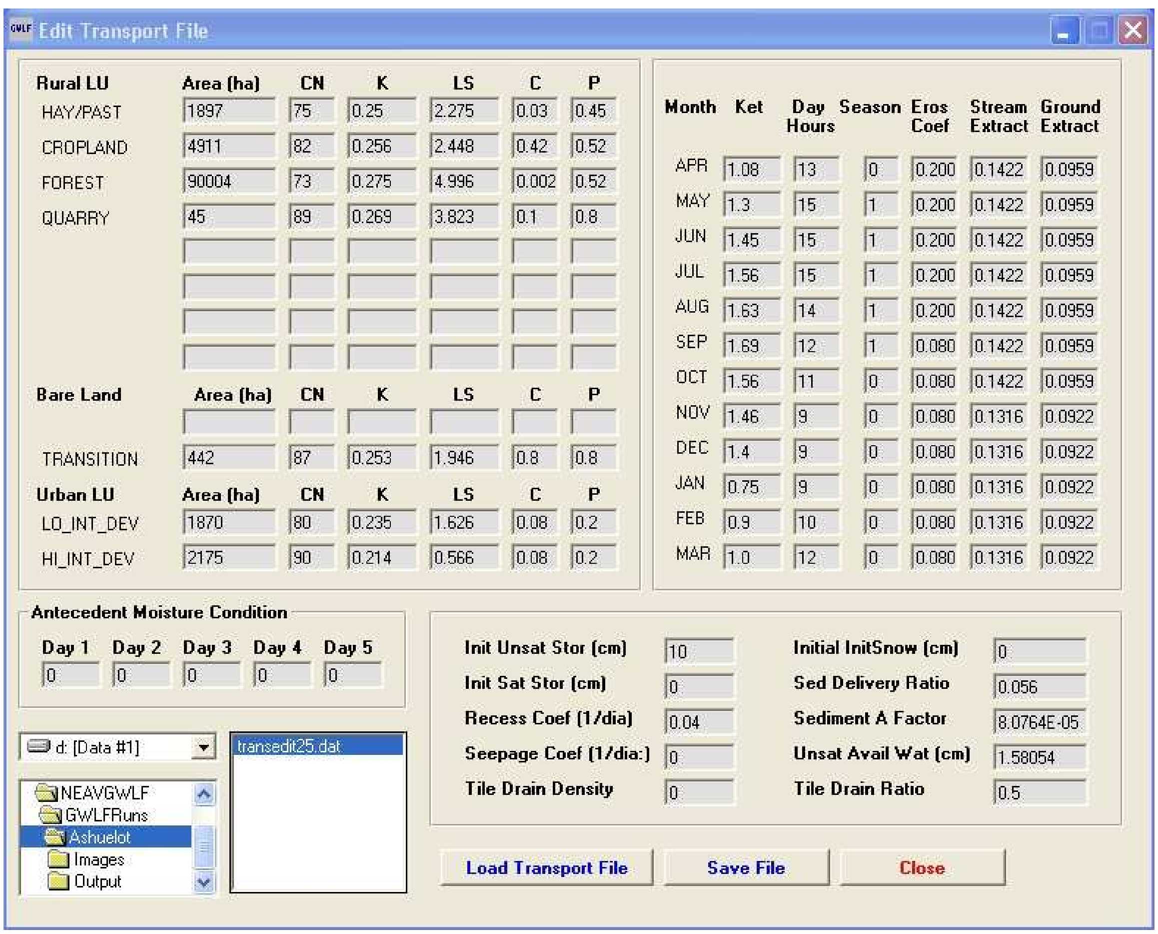
APPENDIX A

Overview of GWLF-E Model Input/Output Files

Specific options for selecting, viewing and editing input and output files for GWLF-E are described in considerable detail in sections D and E of the AVGWLF Users Manual that is provided with the application software (and is accessible via the "Help" function in AVGWLF). The intent of this particular section is to provide some details regarding labels and units used in each type of file.

As described earlier in this document and in the User Manual, the AVGWLF interface is used to create input files for the GWLF-E model. The three basic files created include a "transport.dat" file, a "nutrient.dat" file, and a "weather.dat" file. These files are automatically placed in the folder specified by the user when using AVGWLF (see section C of the AVGWLF User Manual). The parameter values for each file have specific units that correspond to the way in which they are used in the GWLF model, and both the "transport.dat" and "nutrient.dat" files can be viewed and edited by the user. Examples of input data for these latter files created as a result of executing AVGWLF for a particular watershed are shown in Figures A1 and A2. (Note that Excel-formatted (*.csv) versions of these input files are also created by AVGWLF. However, only the "text" (*.dat) versions of these files are opened by the GWLF-E executable). Another more complicated input file (not shown here) is the "animal.dat" file, which is used to animal site-specific data on animal populations and types.



Edit Transport File

Rural LU	Area (ha)	CN	K	LS	C	P
HAY/PAST	1897	75	0.25	2.275	0.03	0.45
CROPLAND	4911	82	0.256	2.448	0.42	0.52
FOREST	90004	73	0.275	4.996	0.002	0.52
QUARRY	45	89	0.269	3.823	0.1	0.8
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
TRANSITION	442	87	0.253	1.946	0.8	0.8
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
LO_INT_DEV	1870	80	0.235	1.626	0.08	0.2
HI_INT_DEV	2175	90	0.214	0.566	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
APR	1.08	13	0	0.200	0.1422	0.0959
MAY	1.3	15	1	0.200	0.1422	0.0959
JUN	1.45	15	1	0.200	0.1422	0.0959
JUL	1.56	15	1	0.200	0.1422	0.0959
AUG	1.63	14	1	0.200	0.1422	0.0959
SEP	1.69	12	1	0.080	0.1422	0.0959
OCT	1.56	11	0	0.080	0.1422	0.0959
NOV	1.46	9	0	0.080	0.1316	0.0922
DEC	1.4	9	0	0.080	0.1316	0.0922
JAN	0.75	9	0	0.080	0.1316	0.0922
FEB	0.9	10	0	0.080	0.1316	0.0922
MAR	1.0	12	0	0.080	0.1316	0.0922

Antecedent Moisture Condition

Day 1	Day 2	Day 3	Day 4	Day 5
0	0	0	0	0

Init Unsat Stor (cm)	10	Initial InitSnow (cm)	0
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.056
Recess Coef (1/dia)	0.04	Sediment A Factor	8.0764E-05
Seepage Coef (1/dia:)	0	Unsat Avail Wat (cm)	1.58054
Tile Drain Density	0	Tile Drain Ratio	0.5

d: [Data #1]
NEAVGWLF
GWLFRuns
Ashuelot
Images
Output
transedit25.dat

Load Transport File | Save File | Close

Figure A1. Example "transport.dat" file as viewed with the GWLF-E program.

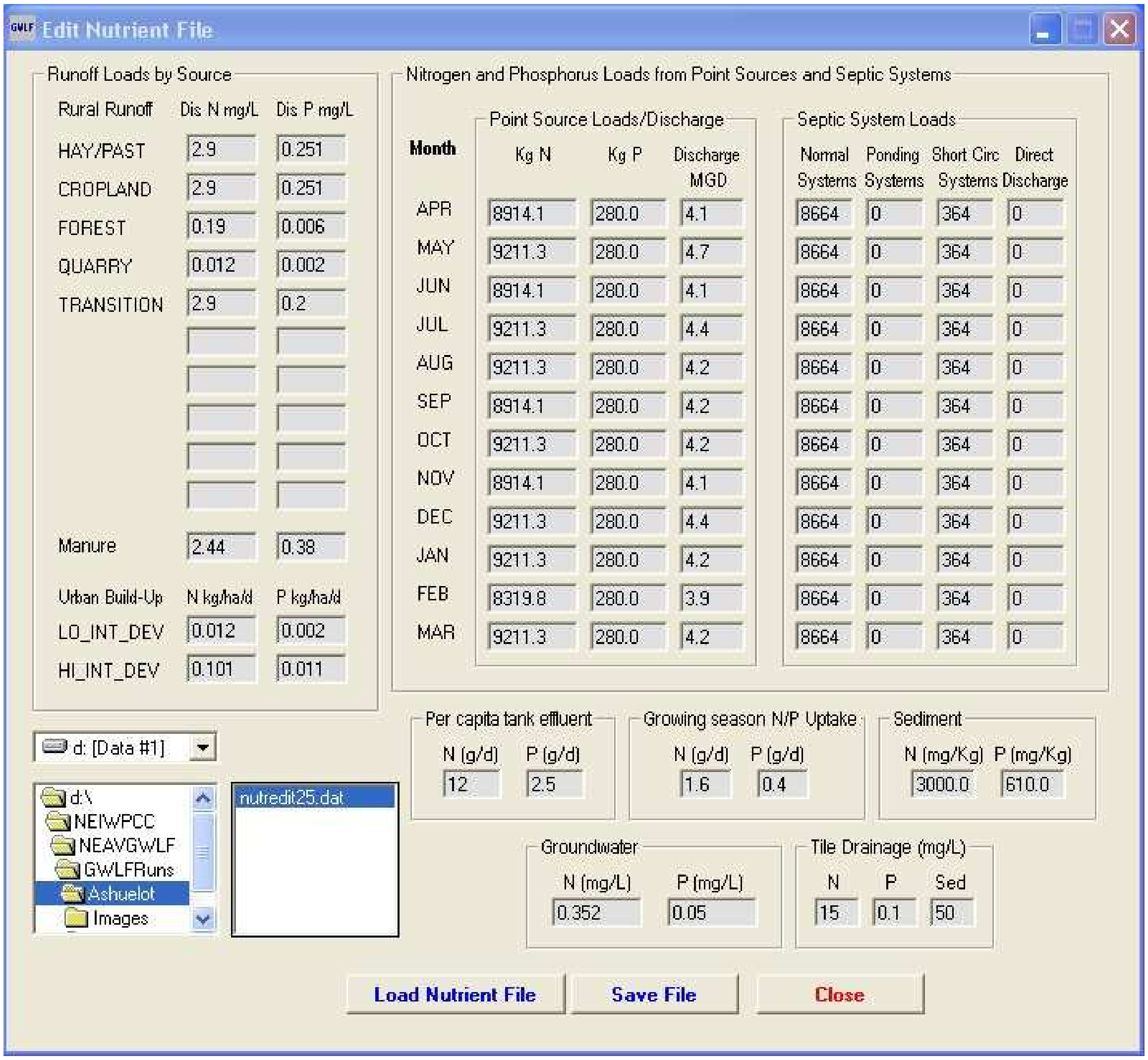


Figure A2. Example “nutrient.dat” file as viewed with the GWLF-E program.

Descriptions of the units used for input files and their meanings are described in detail in the original GWLF manual, the AVGWLF User Manual, and the AVGWLF Format Guide, all of which are provided with the software (which are located in the “Help” folder under the “AVGWLF” directory). However, to aid the first-time user of AVGWLF, brief descriptions of the various input parameters shown in Figures A1 and A2 are provided in Tables A1 and A2, respectively. In some cases, the units are too complicated to properly address in a brief description. In these instances, the user is referred to an appropriate location in a specific document.

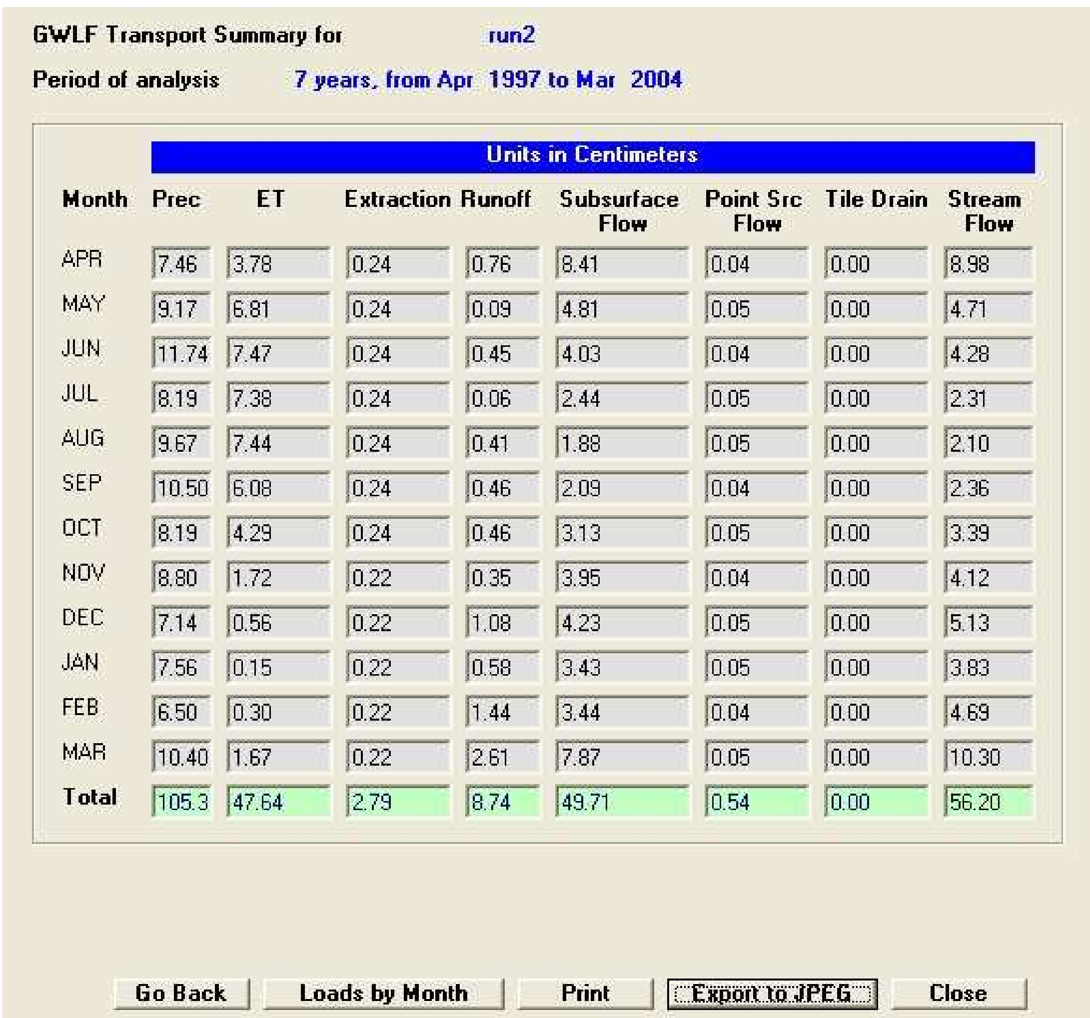
Table A1. Summary descriptions of transport file input parameters

Label/Parameter	Units	Comments	Reference
Rural LU		Indicates Rural Land Uses	
Bare Land		Non-vegetated land use categories	
Urban LU		Urban Land Uses	
Area (ha)	Hectares		
CN		Curve Number (range of 0-100)	See pp. 15-17 of GWLF Users Manual
K		Inherent soil erodibility (range of 0-1)	See pp. 30-32 of GWLF Users Manual
LS		Slope length factor	See pp. 30-31 of GWLF Users Manual
C	Fraction	Cover factor (range of 0-1)	See pp. 30-35 of GWLF Users Manual
P	Fraction	Crop practice factor (range of 0-1)	See pp. 30-35 of GWLF Users Manual
Ket		Potential evapo-transpiration coefficient	See pp. 20-21 of GWLF Users Manual
Day Hours	Hours	Hours of daylight by month	
Season		Growing season (0 = no, 1 = yes)	
Eros Coef		Erosivity coefficient (range of 0-1)	See pp. 31 and 36 of GWLF Users Manual
Stream Extract	cm	Indicates amount of surface water extracted in units of water depth (cm) across the watershed.	See p. 16 of AVGWLF Users Manual
Ground Extract	cm	Indicates amount of ground water extracted in units of water depth (cm) across the watershed.	See p. 16 of AVGWLF Users Manual
Antecedent Moisture Condition			See pp. 15-17 of GWLF Users Manual
Init Unsat Stor (cm)	cm	Initial unsaturated storage in units of water depth across the watershed.	See pp. 20-21 of GWLF Users Manual
Init Sat Stor (cm)	cm	Initial unsaturated storage in units of water depth across the watershed.	See pp. 20-21 of GWLF Users Manual
Recess coeff (day^{-1})	day^{-1}	Fraction relating subsurface flow to steamflow	See pp. 30 of GWLF Users Manual
Seepage Coef (day^{-1})	day^{-1}	Fraction relating to seepage to an aquifer	See pp. 30 of GWLF Users Manual
Tile Drain Density	Fraction	Percent of watershed drained (range from 0-1)	See p. 17 of AVGWLF Manual
Initial Snow (cm)	cm	Initial snow depth in cm of water depth	See p. 15 of GWLF Users Manual
Sed Delivery Ratio	Fraction	Fraction of eroded sediment delivered to outlet	See pp. 30-32 of GWLF Users Manual
Sediment A Factor		Related to streambank erosion	See pp. 15-16 of AVGWLF Users Manual
Unsat Avail Wat (cm)	Cm	Available water-holding capacity of soil in units of water depth across the watershed.	See p. 14 of AVGWLF Users Manual
Tile Drain Ratio	Fraction	Relates to fraction of surface and subsurface flow diverted to tile drain flow.	See pp. 16-17 of AVGWLF Users Manual

Table A2. Summary descriptions of nutrient file input parameters.

Label/Parameter	Units	Comments	Reference
Rural Runoff (Dis N or Dis P)	mg/l	Estimate of dissolved N or P in surface runoff from rural land categories.	See p. 18 of AVGWLF Users Manual
Manure	mg/l	Estimate of additional dissolved N or P in surface runoff from agricultural land.	See p. 18 of AVGWLF Users Manual
Urban Build-Up	kg/ha/day	Accumulation of N and P on urban land surfaces in kg per day.	See pp. 18-19 of GWLF Users Manual
Point Source Loads (N and P)	kg/mo	Estimate of total N and P loads from point sources.	
Point Source Discharge	MGD	Estimate of total point source flows in MGD (million gallons per day).	
Septic System Loads	persons	Estimate of people using different types of septic systems.	See pp. 21-22 of GWLF Users Manual
Per capita tank effluent (N / P)	g/d	Estimate of per capita loads in grams/day.	See pp. 21-22 of GWLF Users Manual
Growing season N/P uptake	g/d	Estimate of per capita septic system load taken up by plants during the growing season.	See pp. 21-22 of GWLF Users Manual
Sediment (N and P)	mg/kg	Estimate of N and P in soil eroded from upland sources (mg/kg is same as ppm).	See pp. 22-23 of AVGWLF Users Manual
Groundwater (N and P)	mg/l	Estimate of average N and P concentrations in groundwater in the watershed.	See pp. 19-21 of AVGWLF Users Manual
Tile Drainage	mg/l	Estimates of typical concentrations of sediment, N and P in tile drains in cultivated areas.	See pp. 16-17 of AVGWLF Users Manual

Using AVGWLF, model output can be viewed in two basic formats: average and yearly (annual). After a GWLF-E model run, output results in both formats are automatically stored in two separate files: a "summary.dat" file and a "results.dat" file (in this case, these names correspond to those used by the original GWLF DOS-version model). The former contains mean monthly and annual values for hydrology, sediment and nutrient estimates for the simulation period. In contrast, the latter contains monthly values for every year of the simulation period. These files are "text" files called "name-sum.dat" and "name-res.dat", and can be found in the "output" folder created automatically by AVGWLF in the same folder where the input files are located. Excel "text" (i.e., *.csv) versions of these same output files are also created automatically by AVGWLF and placed in the same "output" folder as the other output files. Examples of model results viewed using the GWLF-E executable program are shown in Figures A3-A5. Summary descriptions of the output shown in these figures are also provided in Tables A3-A5.



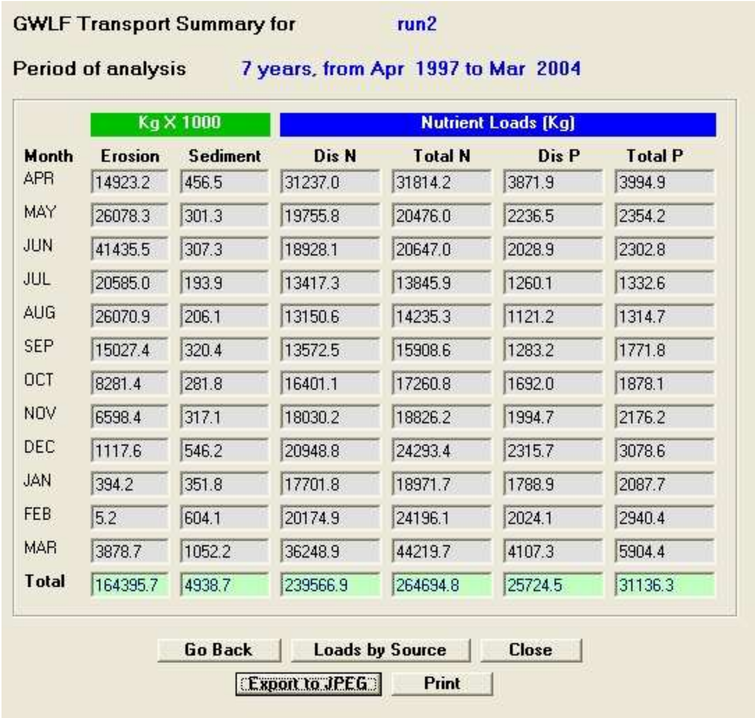
GWLF Transport Summary for run2

Period of analysis 7 years, from Apr 1997 to Mar 2004

Units in Centimeters

Month	Prec	ET	Extraction	Runoff	Subsurface Flow	Point Src Flow	Tile Drain	Stream Flow
APR	7.46	3.78	0.24	0.76	8.41	0.04	0.00	8.98
MAY	9.17	6.81	0.24	0.09	4.81	0.05	0.00	4.71
JUN	11.74	7.47	0.24	0.45	4.03	0.04	0.00	4.28
JUL	8.19	7.38	0.24	0.06	2.44	0.05	0.00	2.31
AUG	9.67	7.44	0.24	0.41	1.88	0.05	0.00	2.10
SEP	10.50	6.08	0.24	0.46	2.09	0.04	0.00	2.36
OCT	8.19	4.29	0.24	0.46	3.13	0.05	0.00	3.39
NOV	8.80	1.72	0.22	0.35	3.95	0.04	0.00	4.12
DEC	7.14	0.56	0.22	1.08	4.23	0.05	0.00	5.13
JAN	7.56	0.15	0.22	0.58	3.43	0.05	0.00	3.83
FEB	6.50	0.30	0.22	1.44	3.44	0.04	0.00	4.69
MAR	10.40	1.67	0.22	2.61	7.87	0.05	0.00	10.30
Total	105.3	47.64	2.79	8.74	49.71	0.54	0.00	56.20

Figure A3. Example of "average" hydrology output.



GWLF Transport Summary for run2

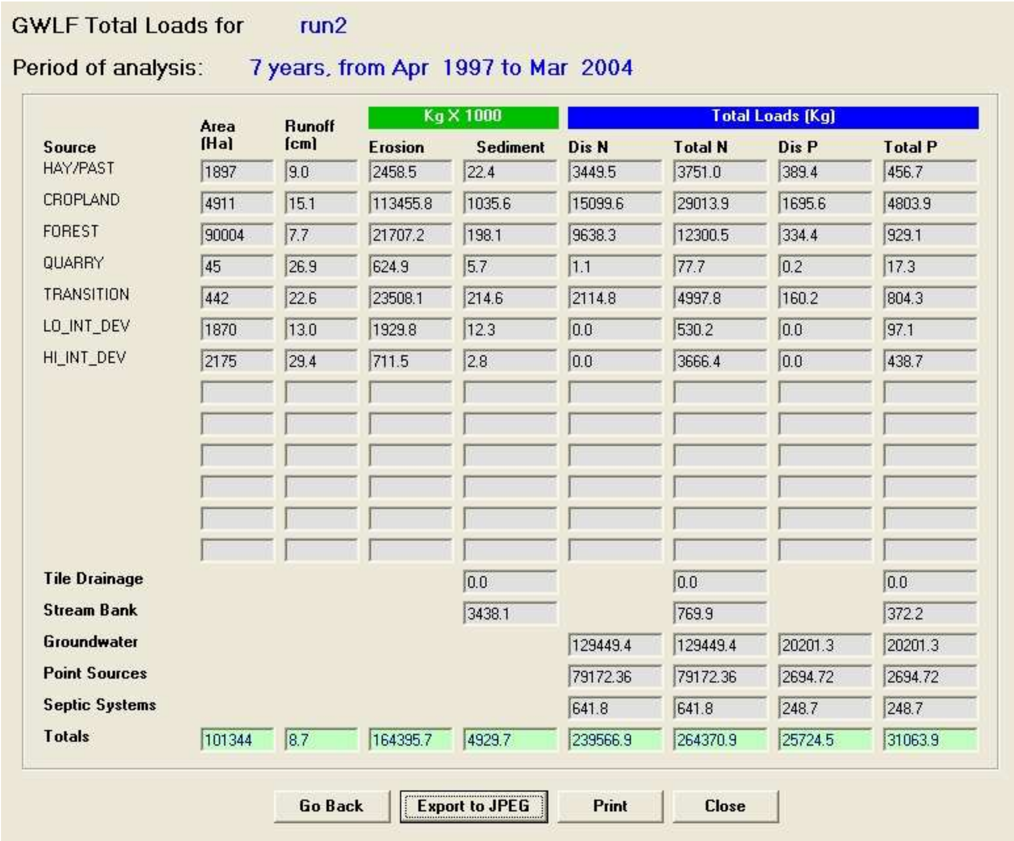
Period of analysis 7 years, from Apr 1997 to Mar 2004

Month	Kg X 1000		Nutrient Loads (Kg)			
	Erosion	Sediment	Dis N	Total N	Dis P	Total P
APR	14923.2	456.5	31237.0	31814.2	3871.9	3994.9
MAY	26078.3	301.3	19755.8	20476.0	2236.5	2354.2
JUN	41435.5	307.3	18928.1	20647.0	2028.9	2302.8
JUL	20585.0	193.9	13417.3	13845.9	1260.1	1332.6
AUG	26070.9	206.1	13150.6	14235.3	1121.2	1314.7
SEP	15027.4	320.4	13572.5	15908.6	1283.2	1771.8
OCT	8281.4	281.8	16401.1	17260.8	1692.0	1878.1
NOV	6598.4	317.1	18030.2	18826.2	1994.7	2176.2
DEC	1117.6	546.2	20948.8	24293.4	2315.7	3078.6
JAN	394.2	351.8	17701.8	18971.7	1788.9	2087.7
FEB	5.2	604.1	20174.9	24196.1	2024.1	2940.4
MAR	3878.7	1052.2	36248.9	44219.7	4107.3	5904.4
Total	164395.7	4938.7	239566.9	264694.8	25724.5	31136.3

Go Back | Loads by Source | Close

Export to JPEG | Print

Figure A4. Example of average monthly output.



GWLF Total Loads for run2

Period of analysis: 7 years, from Apr 1997 to Mar 2004

Source	Area (Ha)	Runoff (cm)	Kg X 1000		Total Loads (Kg)			
			Erosion	Sediment	Dis N	Total N	Dis P	Total P
HAY/PAST	1897	9.0	2458.5	22.4	3449.5	3751.0	389.4	456.7
CROPLAND	4911	15.1	113455.8	1035.6	15099.6	29013.9	1695.6	4803.9
FOREST	90004	7.7	21707.2	198.1	9638.3	12300.5	334.4	929.1
QUARRY	45	26.9	624.9	5.7	1.1	77.7	0.2	17.3
TRANSITION	442	22.6	23508.1	214.6	2114.8	4997.8	160.2	804.3
LO_INT_DEV	1870	13.0	1929.8	12.3	0.0	530.2	0.0	97.1
HI_INT_DEV	2175	29.4	711.5	2.8	0.0	3666.4	0.0	438.7
Tile Drainage				0.0		0.0		0.0
Stream Bank				3438.1		769.9		372.2
Groundwater					129449.4	129449.4	20201.3	20201.3
Point Sources					79172.36	79172.36	2694.72	2694.72
Septic Systems					641.8	641.8	248.7	248.7
Totals	101344	8.7	164395.7	4929.7	239566.9	264370.9	25724.5	31063.9

Go Back | Export to JPEG | Print | Close

Figure A5. Example of average output by source.

Table A3. Summary of hydrology output by month.

Column	Units[1]	Comments
Prec	cm	Precipitation based on data from weather input file.
ET	cm	Evapotranspiration
Extraction	cm	Water extraction (wthdrawals) from surface or ground water sources.
Runoff	cm	Overland surface runoff.
Subsurface Flow	cm	
Point Src Flow	cm	Effluent flows from point source dischargers.
Tile Drain	cm	
Stream Flow	cm	Sum of runoff, subsurface, point source and tile drain flows.

[1] All units are in cm of water depth across the watershed

Table A4. Summary of average loads by month.

Column	Units[1]	Comments
Erosion	kg x 1000	Estimate of average monthly eroded sediment in metric tons (before deposition)
Sediment	kg x 1000	Estimate of average monthly eroded sediment delivered to watershed in metric tons outlet after deposition.
Dis N	kg	Estimate of dissolved N.
Total N	kg	Estimate of total N.
Dis P	kg	Estimate of dissolved P.
Total P	kg	Estimate of total P.

Table A5. Summary of average loads by source.

Column	Units[1]	Comments
Area (ha)	ha	Total area of each land/use category within the watershed.
Runoff (cm)	cm	Runoff in water depth (cm) for each source area.
Erosion	kg x 1000	Estimate of average monthly eroded sediment in metric tons (before deposition).
Sediment	kg x 1000	Estimate of average monthly eroded sediment delivered to watershed in metric tons outlet after deposition.
Dis N	kg	Estimate of dissolved N.
Total N	kg	Estimate of total N.
Dis P	kg	Estimate of dissolved P.
Total P	kg	Estimate of total P.

APPENDIX B

Screen Captures of Selected Input Files and Output Plots for Model Calibration Runs

Attoyac Bayou (TX)

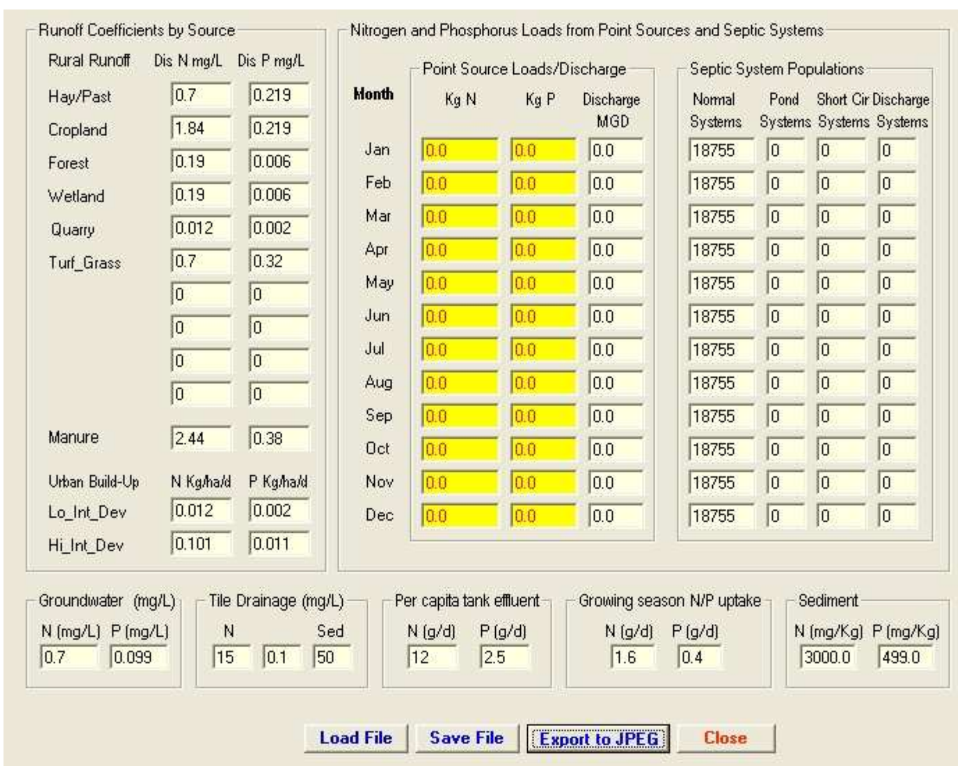
Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	21043	75	0.264	0.348	0.03	0.45
Cropland	118	82	0.309	0.264	0.1	0.45
Forest	55618	60	0.249	0.565	0.1	0.45
Wetland	34498	80	0.256	0.348	0.01	0.1
Quarry	145	85	0.208	0.394	0.1	0.1
Turf_Grass	14728	58	0.251	0.463	0.04	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	1385	80	0.248	0.457	0.08	0.2
Hi_Int_Dev	114	93	0.275	0.381	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	1.11	10	0	0.11	0	0
Feb	1.2	10.8	0	0.2	0	0
Mar	1.37	11.8	1	0.2	0	0
Apr	1.47	12.9	1	0.2	0	0
May	1.53	13.8	1	0.2	0	0
Jun	1.58	14.2	1	0.2	0	0
Jul	1.59	14	1	0.2	0	0
Aug	1.61	13.2	1	0.2	0	0
Sep	1.61	12.2	1	0.2	0	0
Oct	1.61	11.1	1	0.2	0	0
Nov	1.62	10.2	1	0.11	0	0
Dec	1.49	9.8	0	0.11	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.01
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.053	Seepage Coefficient	0
Unsat Avail Wat (cm)	12.1416	Tile Drain Ratio	0.5	Sediment A Factor	1.9585E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	0.7	0.219
Cropland	1.84	0.219
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	0.7	0.32
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

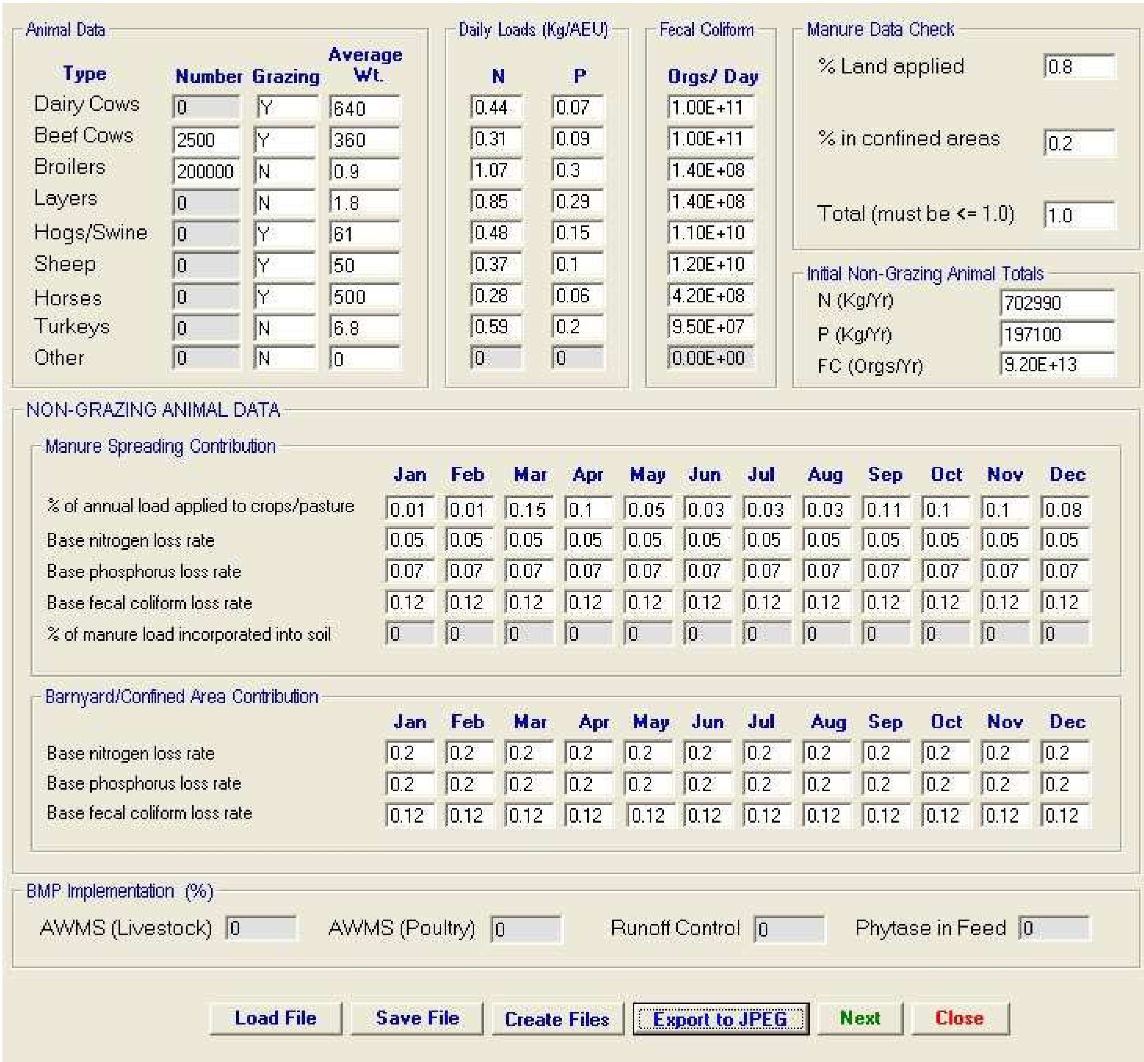
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	18755	0	0	0
Feb	0.0	0.0	0.0	18755	0	0	0
Mar	0.0	0.0	0.0	18755	0	0	0
Apr	0.0	0.0	0.0	18755	0	0	0
May	0.0	0.0	0.0	18755	0	0	0
Jun	0.0	0.0	0.0	18755	0	0	0
Jul	0.0	0.0	0.0	18755	0	0	0
Aug	0.0	0.0	0.0	18755	0	0	0
Sep	0.0	0.0	0.0	18755	0	0	0
Oct	0.0	0.0	0.0	18755	0	0	0
Nov	0.0	0.0	0.0	18755	0	0	0
Dec	0.0	0.0	0.0	18755	0	0	0

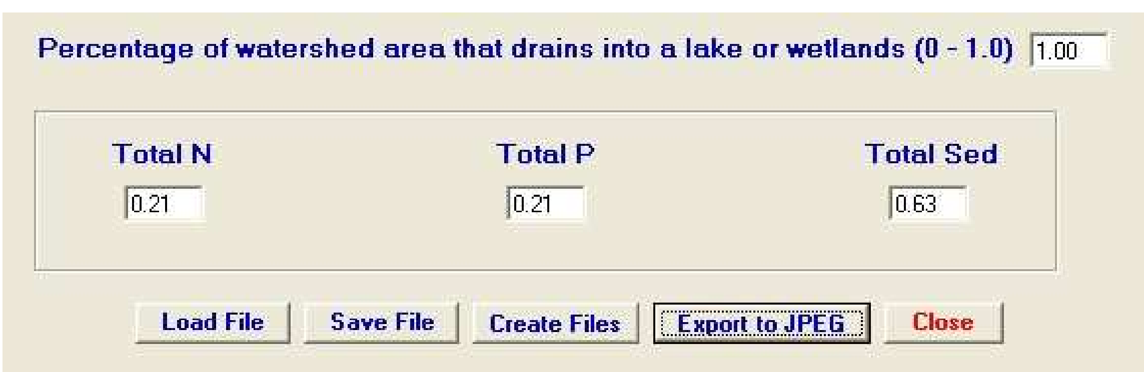
Groundwater (mg/L): N (mg/L)	P (mg/L)	Tile Drainage (mg/L): N	P	Sed	Per capita tank effluent: N (g/d)	P (g/d)	Growing season N/P uptake: N (g/d)	P (g/d)	Sediment: N (mg/Kg)	P (mg/Kg)
0.7	0.099	15	0.1	50	12	2.5	1.6	0.4	3000.0	499.0

Load File | Save File | Export to JPEG | Close

Nutrient file

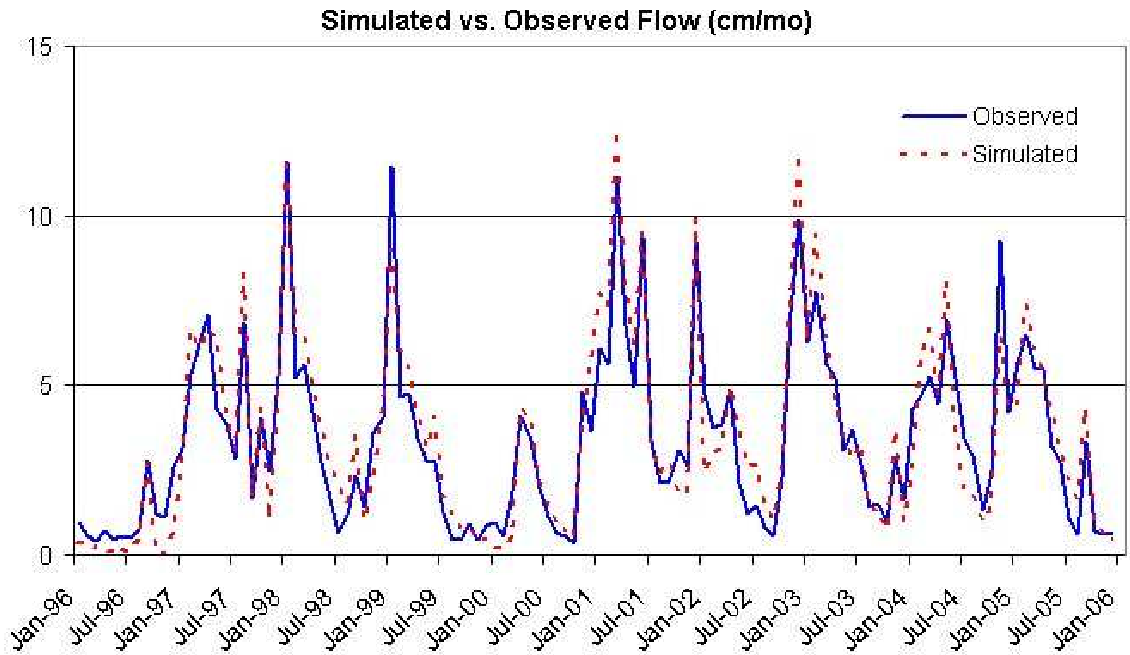


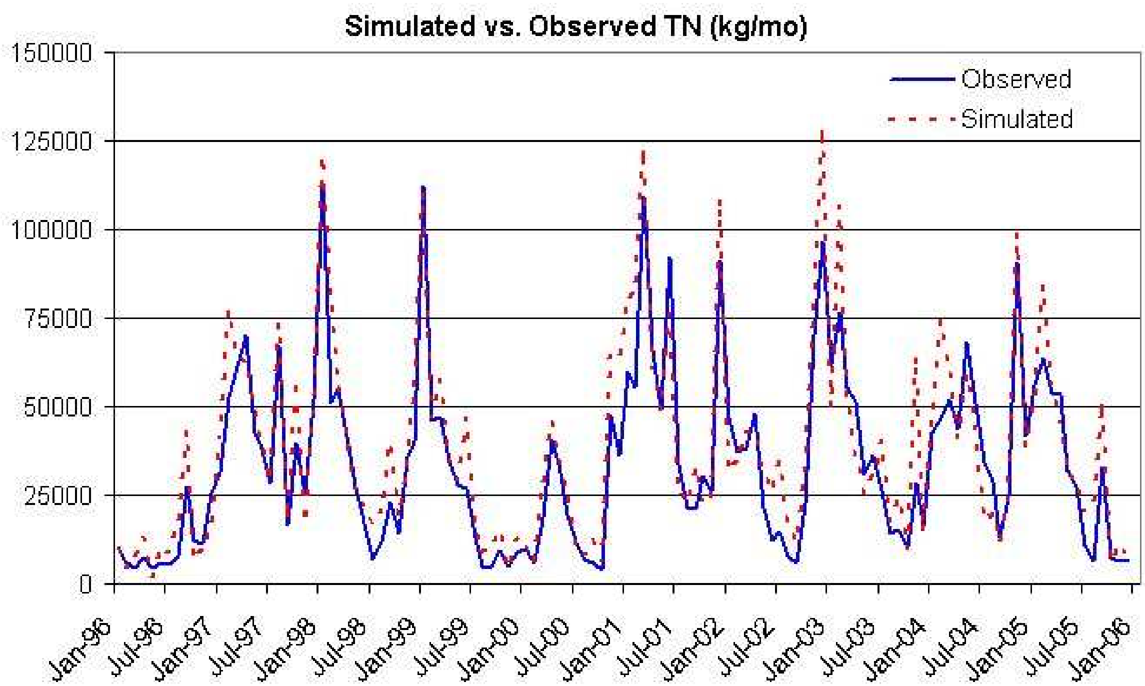
Animal file

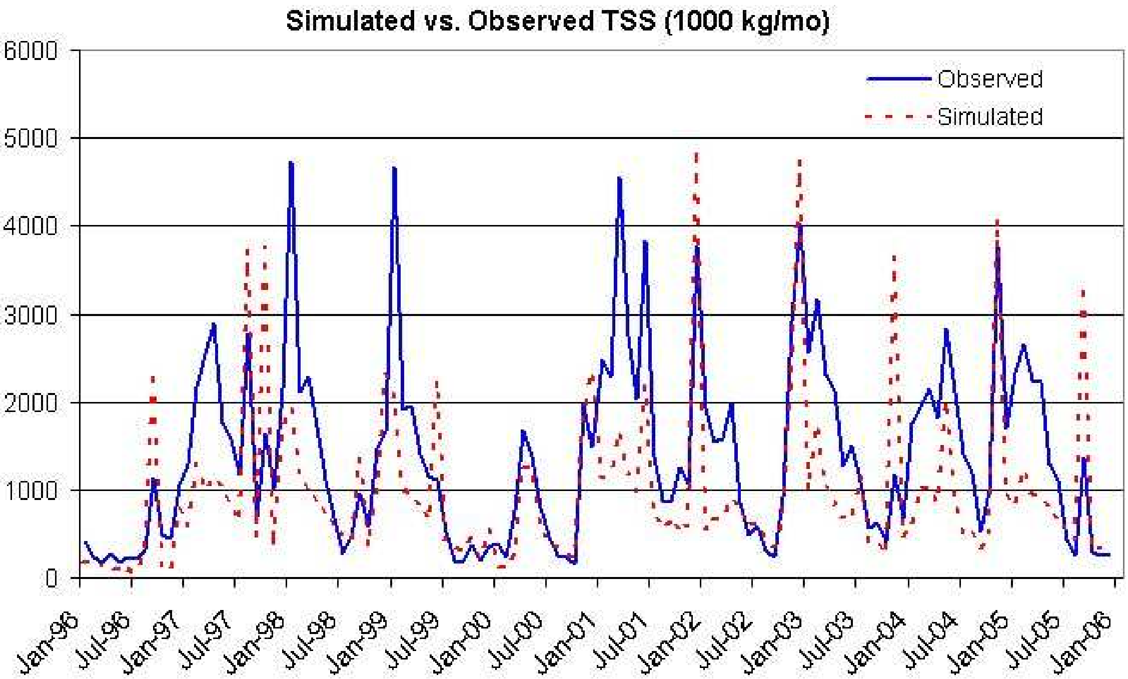


Retention file

Attoyac Bayou (TX)






Simulated vs. Observed TSS (1000 kg/mo)
6000
5000
4000
3000
2000
1000
0
Observed
Simulated
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
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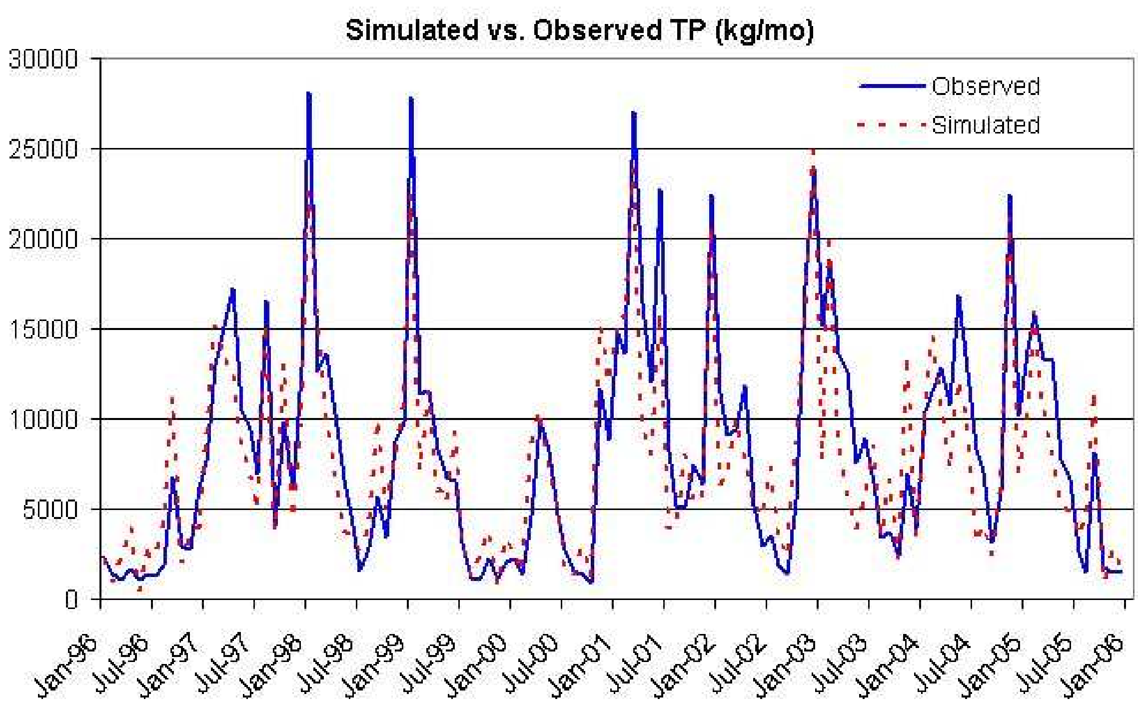
Jan-05
Jul-05
Jan-06


Simulated vs. Observed TP (kg/mo)
30000
25000
20000
15000
10000
5000
0
Observed
Simulated
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06

Bayou Anacoco (LA)

Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	2134	81	0.272	0.269	0.03	0.45
Cropland	20	85	0.302	0.27	0.15	0.45
Forest	59367	80	0.276	0.274	0.2	0.45
Wetland	15402	90	0.306	0.238	0.01	0.1
Quarry	293	91	0.264	0.322	0.1	0.1
Turf_Grass	15888	78	0.273	0.285	0.04	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	3083	84	0.278	0.279	0.08	0.2
Hi_Int_Dev	594	94	0.279	0.278	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.92	10.1	0	0.11	0	0
Feb	0.99	10.8	0	0.2	0	0
Mar	1.17	11.8	1	0.2	0	0
Apr	1.28	12.9	1	0.2	0	0
May	1.34	13.7	1	0.2	0	0
Jun	1.38	14.1	1	0.2	0	0
Jul	1.4	13.9	1	0.2	0	0
Aug	1.41	13.2	1	0.2	0	0
Sep	1.41	12.2	1	0.2	0	0
Oct	1.43	11.1	1	0.2	0	0
Nov	1.43	10.3	1	0.11	0	0
Dec	1.29	9.9	0	0.11	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.058	Seepage Coefficient	0
Unsat Avail Wat (cm)	15.1812	Tile Drain Ratio	0.5	Sediment A Factor	3.3423E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file

Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	2.9	0.19
Cropland	2.9	0.19
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	0.75	0.29
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

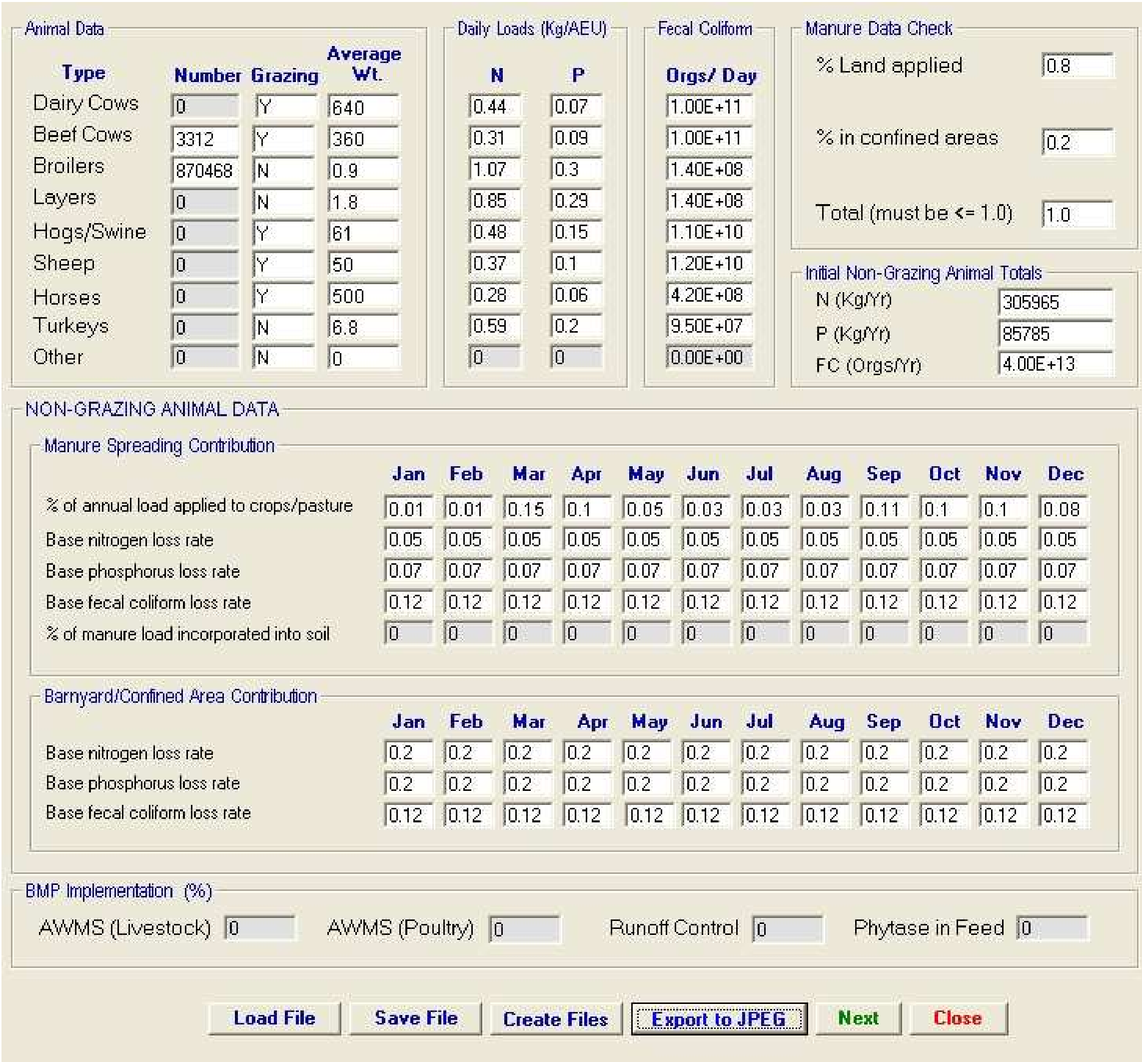
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	4000.0	200.0	4.0	17209	0	0	0
Feb	4000.0	200.0	4.0	17209	0	0	0
Mar	4000.0	200.0	4.0	17209	0	0	0
Apr	4000.0	200.0	4.0	17209	0	0	0
May	4000.0	200.0	4.0	17209	0	0	0
Jun	4000.0	200.0	4.0	17209	0	0	0
Jul	4000.0	200.0	4.0	17209	0	0	0
Aug	4000.0	200.0	4.0	17209	0	0	0
Sep	4000.0	200.0	4.0	17209	0	0	0
Oct	4000.0	200.0	4.0	17209	0	0	0
Nov	4000.0	200.0	4.0	17209	0	0	0
Dec	4000.0	200.0	4.0	17209	0	0	0

Groundwater (mg/L): N (mg/L)	P (mg/L)	Tile Drainage (mg/L): N		Sed	Per capita tank effluent: N (g/d)	P (g/d)	Growing season N/P uptake: N (g/d)	P (g/d)	Sediment: N (mg/Kg)	P (mg/Kg)
0.68	0.08	15	0.1	50	12	2.5	1.6	0.4	3000.0	394.0

Load File | Save File | Export to JPEG | Close

Nutrient file



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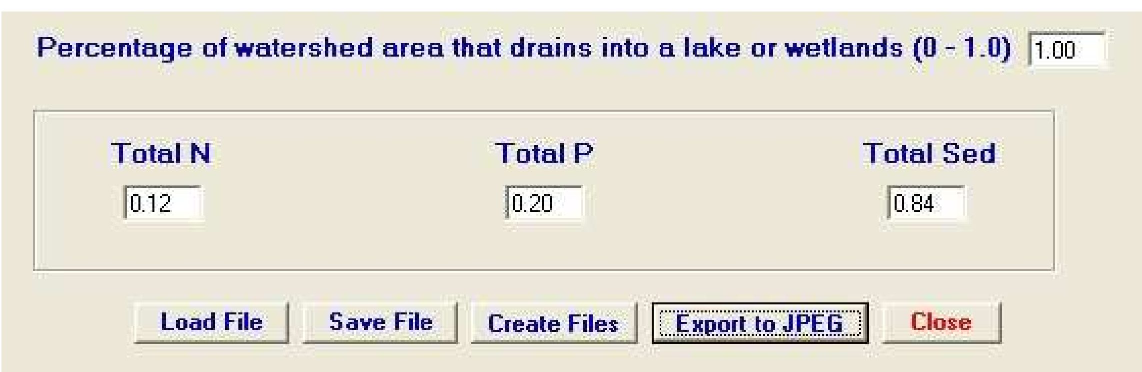
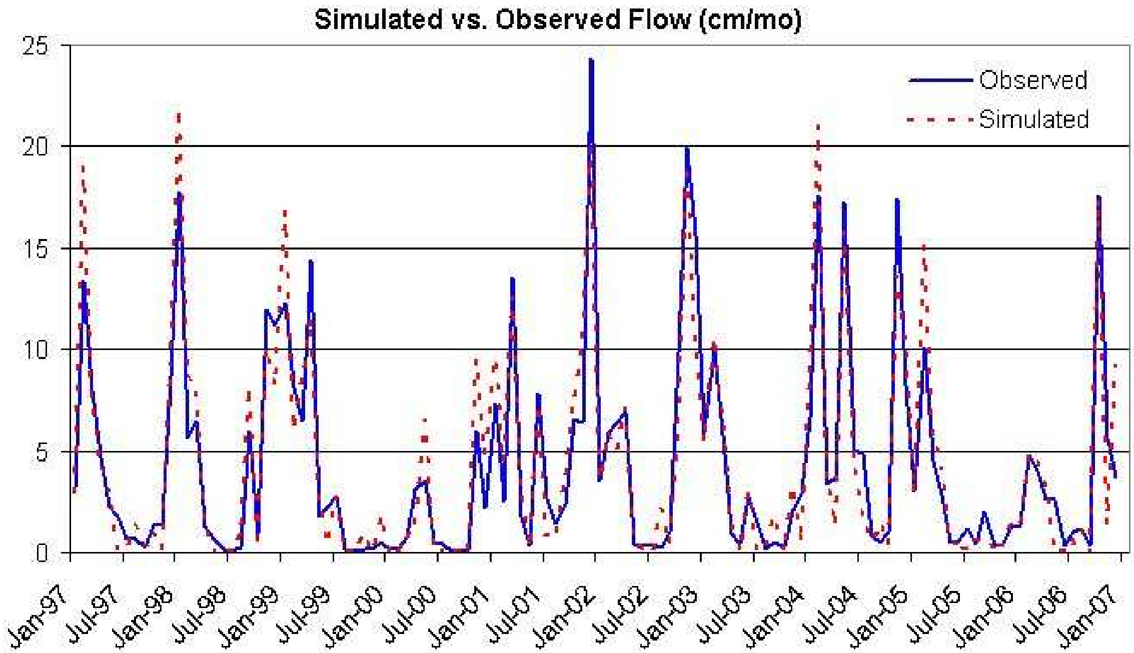
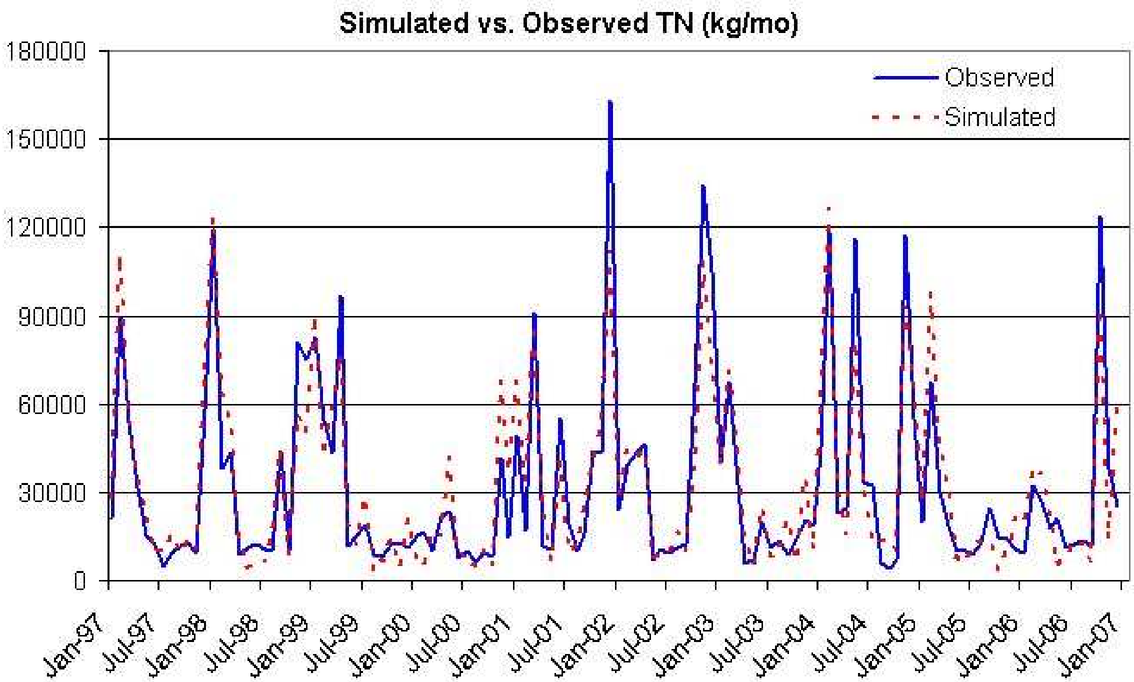


Retention file

Bayou Annacoco (LA)





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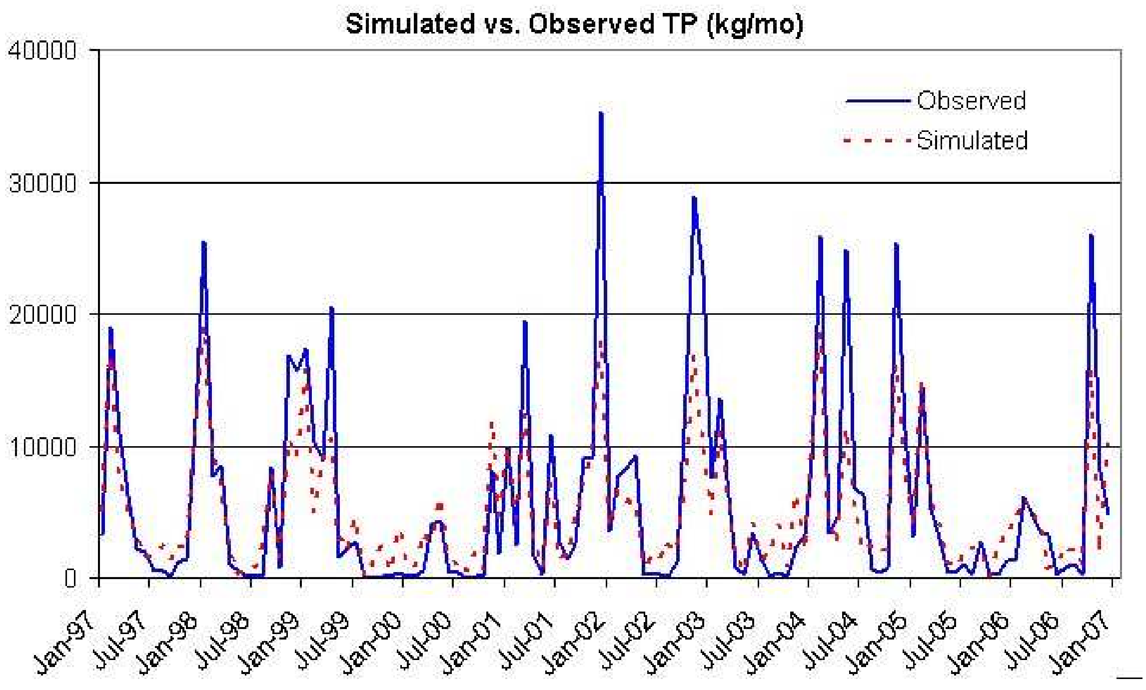


Simulated vs. Observed TP (kg/mo)
40000
30000
20000
10000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

Bayou Toro (LA)

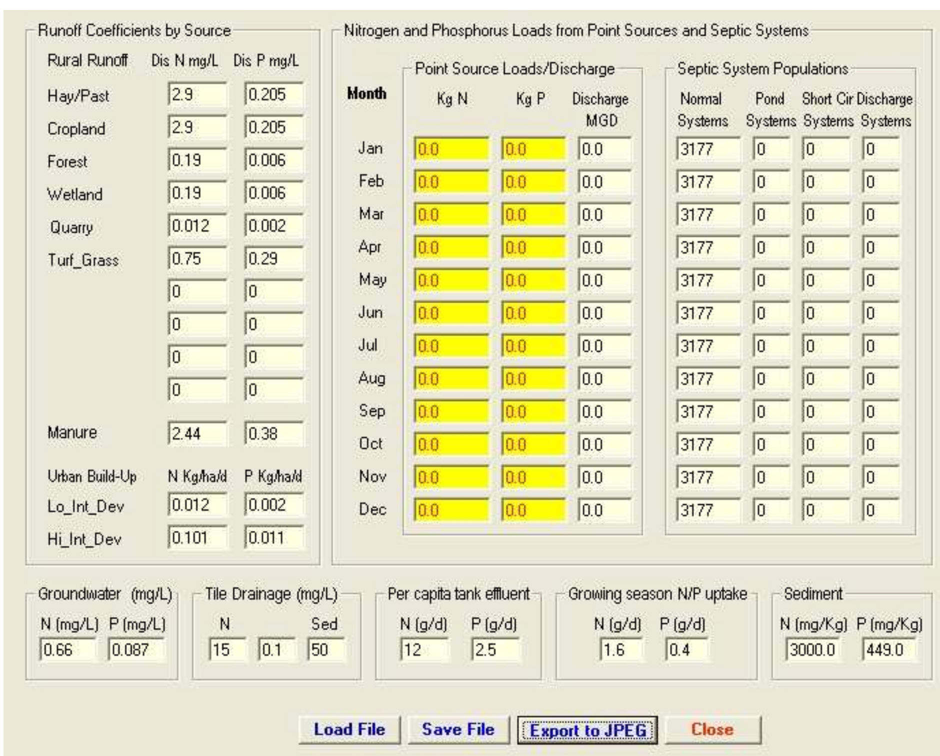
Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	1438	81	0.322	0.332	0.03	0.45
Cropland	9	85	0.23	0.229	0.2	0.45
Forest	24940	80	0.315	0.33	0.2	0.45
Wetland	4766	90	0.336	0.249	0.01	0.1
Quarry	36	91	0.305	0.398	0.1	0.1
Turf_Grass	3918	78	0.316	0.402	0.04	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	342	84	0.319	0.316	0.08	0.2
Hi_Int_Dev	50	93	0.315	0.252	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.9	10.1	0	0.11	0	0
Feb	0.97	10.8	0	0.2	0	0
Mar	1.17	11.8	1	0.2	0	0
Apr	1.29	12.9	1	0.2	0	0
May	1.36	13.7	1	0.2	0	0
Jun	1.39	14.1	1	0.2	0	0
Jul	1.42	13.9	1	0.2	0	0
Aug	1.44	13.2	1	0.2	0	0
Sep	1.44	12.2	1	0.2	0	0
Oct	1.45	11.1	1	0.2	0	0
Nov	1.45	10.3	1	0.11	0	0
Dec	1.29	9.9	0	0.11	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.078	Seepage Coefficient	0
Unsat Avail Wat (cm)	15.6419	Tile Drain Ratio	0.5	Sediment A Factor	2.3329E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	2.9	0.205
Cropland	2.9	0.205
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	0.75	0.29
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

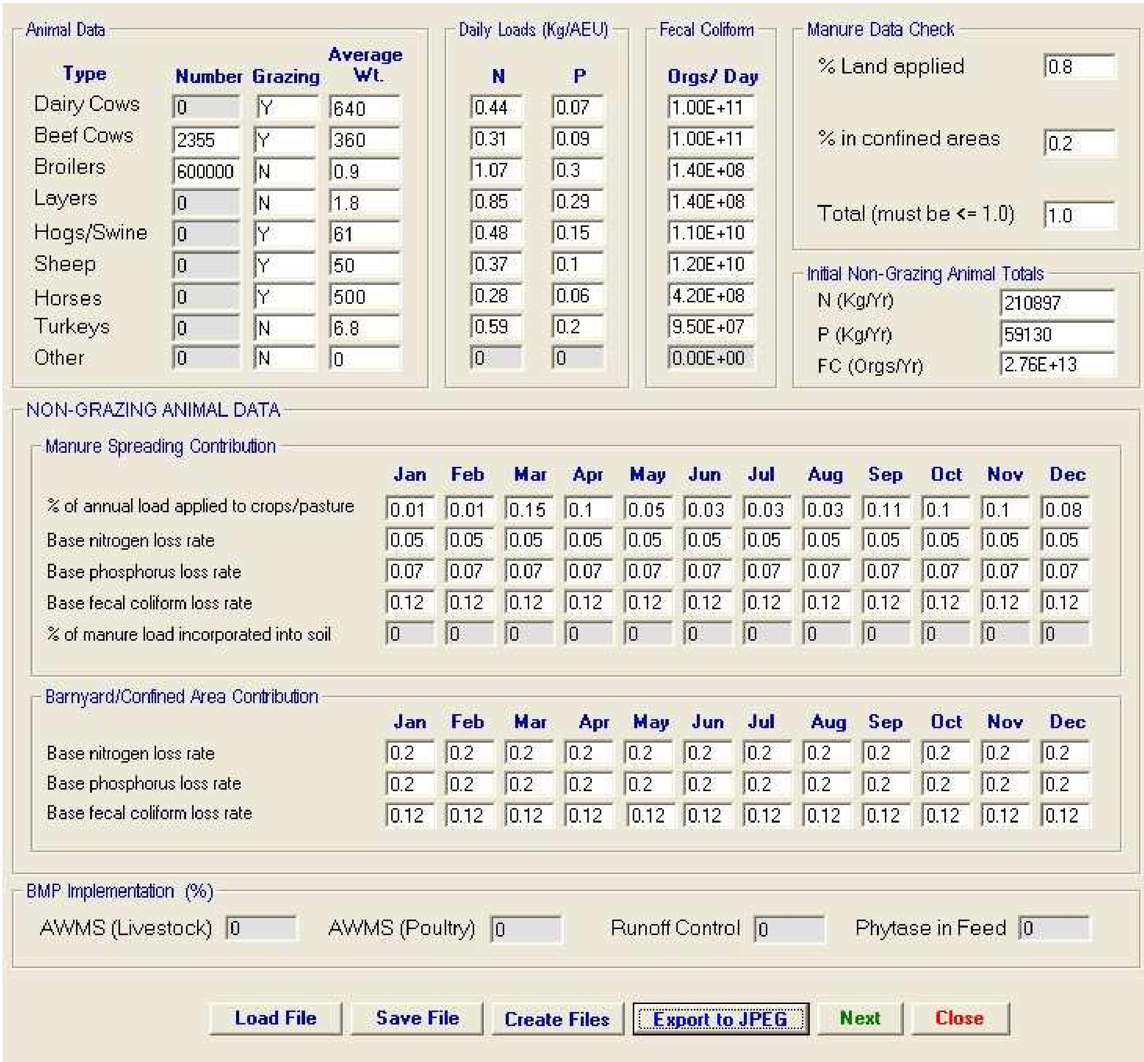
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	3177	0	0	0
Feb	0.0	0.0	0.0	3177	0	0	0
Mar	0.0	0.0	0.0	3177	0	0	0
Apr	0.0	0.0	0.0	3177	0	0	0
May	0.0	0.0	0.0	3177	0	0	0
Jun	0.0	0.0	0.0	3177	0	0	0
Jul	0.0	0.0	0.0	3177	0	0	0
Aug	0.0	0.0	0.0	3177	0	0	0
Sep	0.0	0.0	0.0	3177	0	0	0
Oct	0.0	0.0	0.0	3177	0	0	0
Nov	0.0	0.0	0.0	3177	0	0	0
Dec	0.0	0.0	0.0	3177	0	0	0

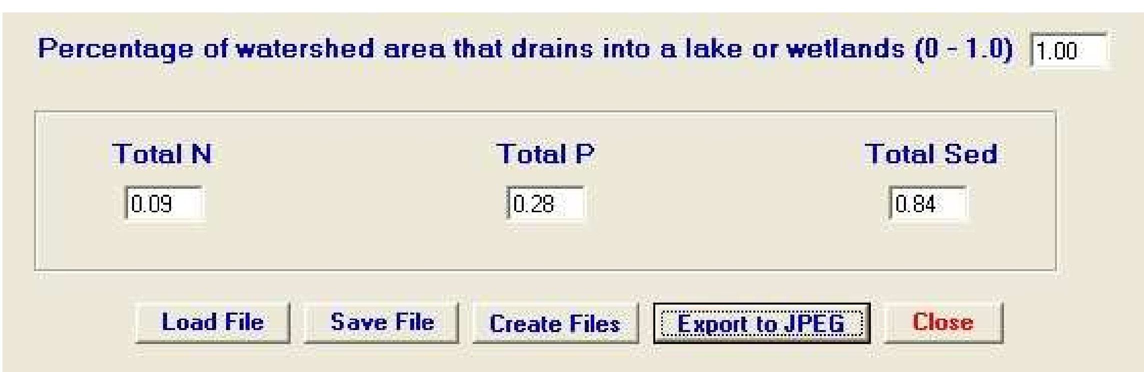
Groundwater (mg/L): N (mg/L)	P (mg/L)	Tile Drainage (mg/L): N		Sed	Per capita tank effluent: N (g/d)	P (g/d)	Growing season N/P uptake: N (g/d)	P (g/d)	Sediment: N (mg/Kg)	P (mg/Kg)
0.66	0.087	15	0.1	50	12	2.5	1.6	0.4	3000.0	449.0

Load File | Save File | Export to JPEG | Close

Nutrient file

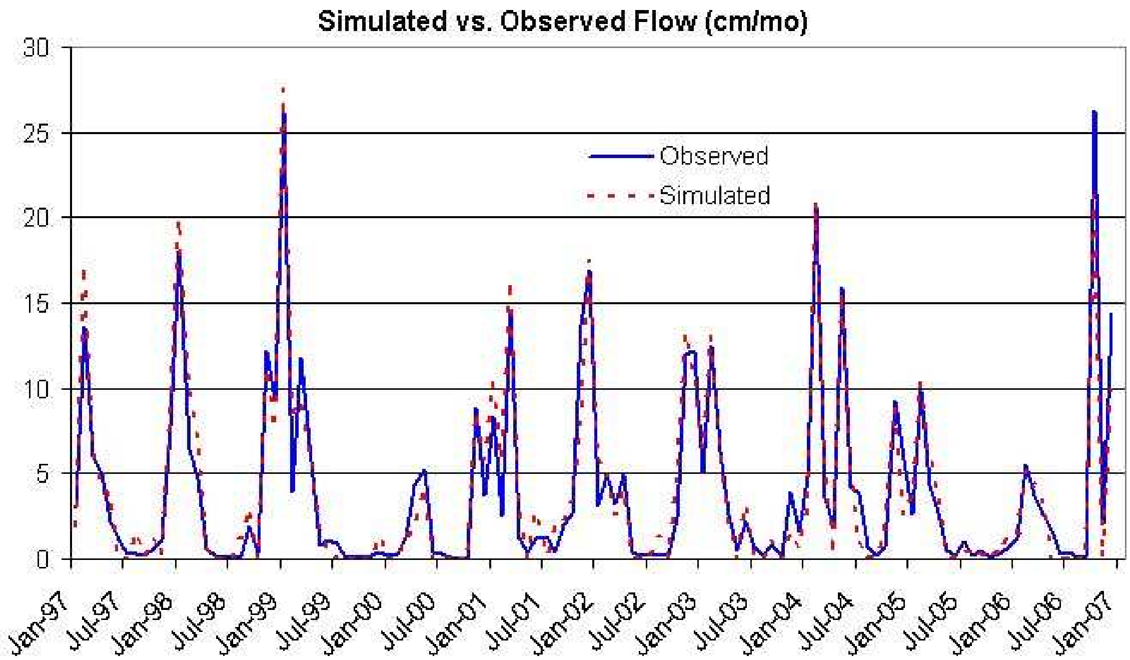


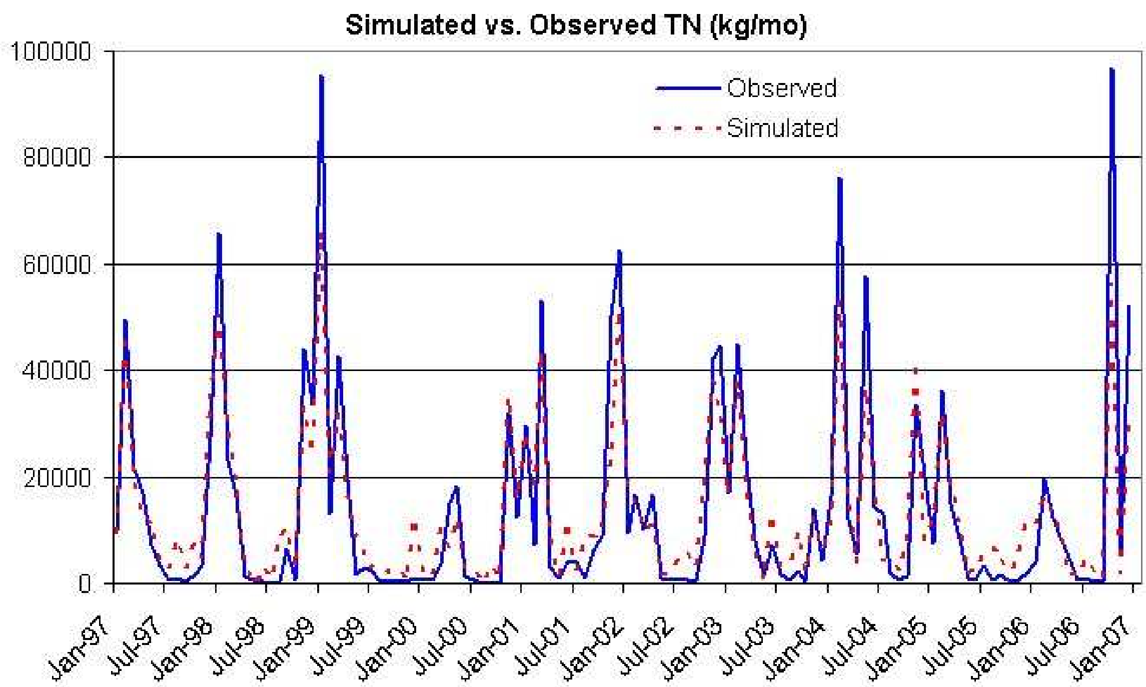
Animal file



Retention file

Bayou Toro (LA)





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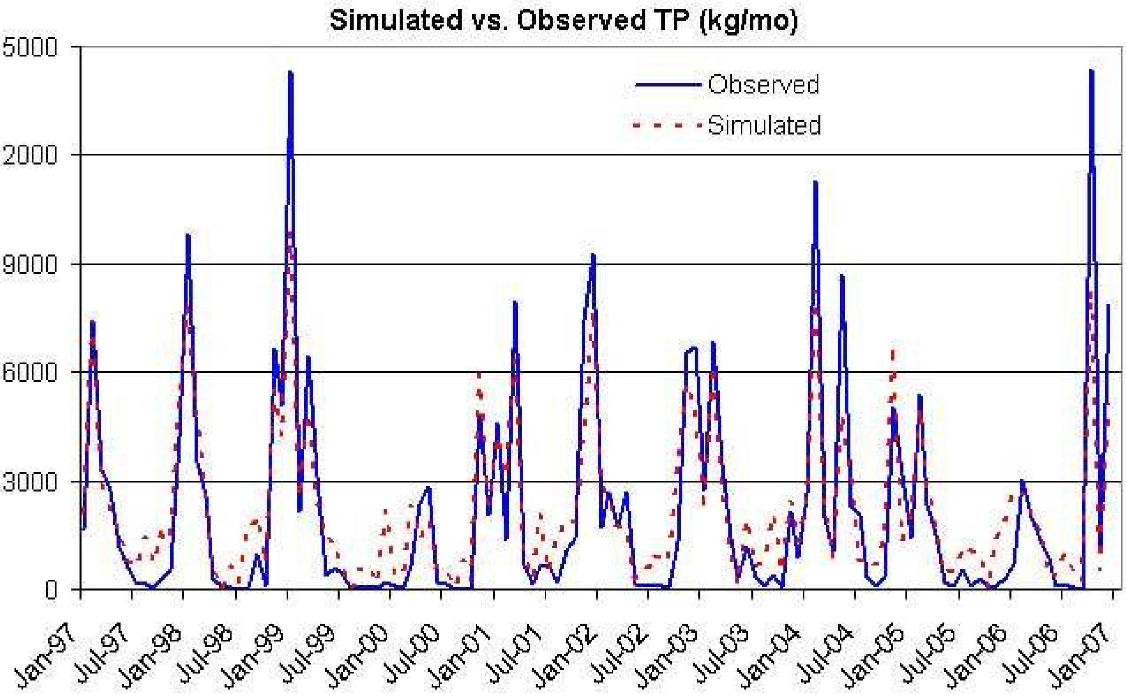


Simulated vs. Observed TP (kg/mo)
15000
12000
9000
6000
3000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

Big Sandy Creek (TX)

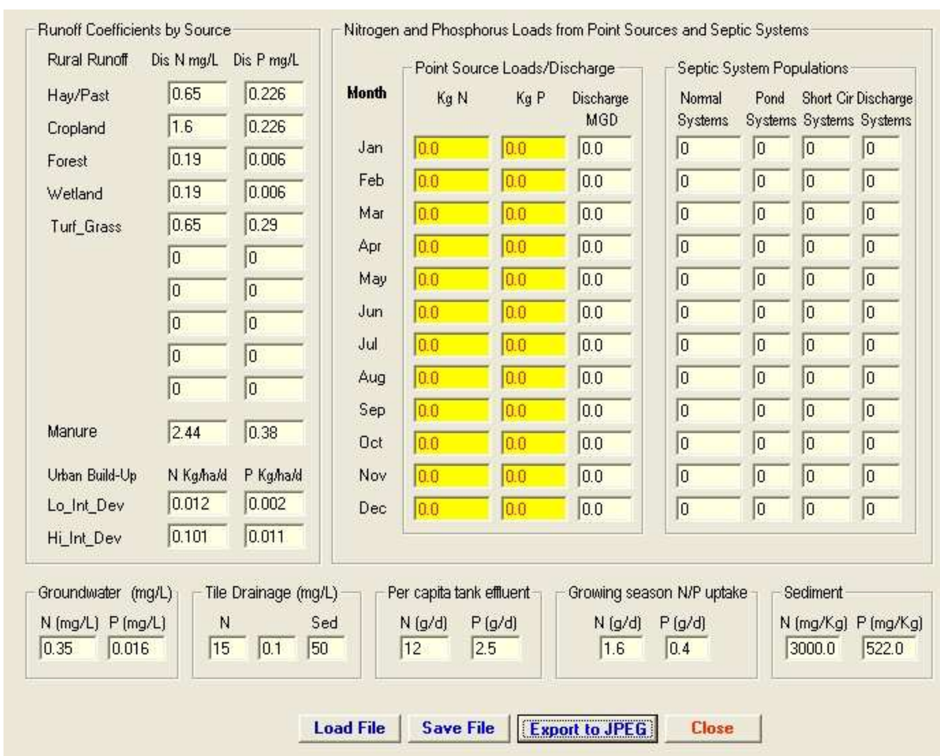
Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	860	75	0.296	0.268	0.06	0.45
Cropland	2642	85	0.306	0.256	0.2	0.45
Forest	45808	73	0.3	0.299	0.03	0.45
Wetland	113	87	0.289	0.22	0.01	0.1
Turf_Grass	24905	71	0.31	0.258	0.06	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	137	83	0.304	0.264	0.08	0.2
Hi_Int_Dev	55	93	0.305	0.25	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	1.27	10	0	0.024	0	0
Feb	1.37	10.8	0	0.024	0	0
Mar	1.43	11.8	0	0.024	0	0
Apr	1.82	12.9	1	0.037	0	0
May	2.02	13.8	1	0.037	0	0
Jun	2.15	14.2	1	0.037	0	0
Jul	2.21	14	1	0.037	0	0
Aug	2.28	13.2	1	0.037	0	0
Sep	2.31	12.2	1	0.037	0	0
Oct	2.31	11.1	1	0.024	0	0
Nov	1.98	10.2	0	0.024	0	0
Dec	1.79	9.8	0	0.024	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.063	Seepage Coefficient	0
Unsat Avail Wat (cm)	11.3179	Tile Drain Ratio	0.5	Sediment A Factor	1.7895E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	0.65	0.226
Cropland	1.6	0.226
Forest	0.19	0.006
Wetland	0.19	0.006
Turf_Grass	0.65	0.29
	0	0
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

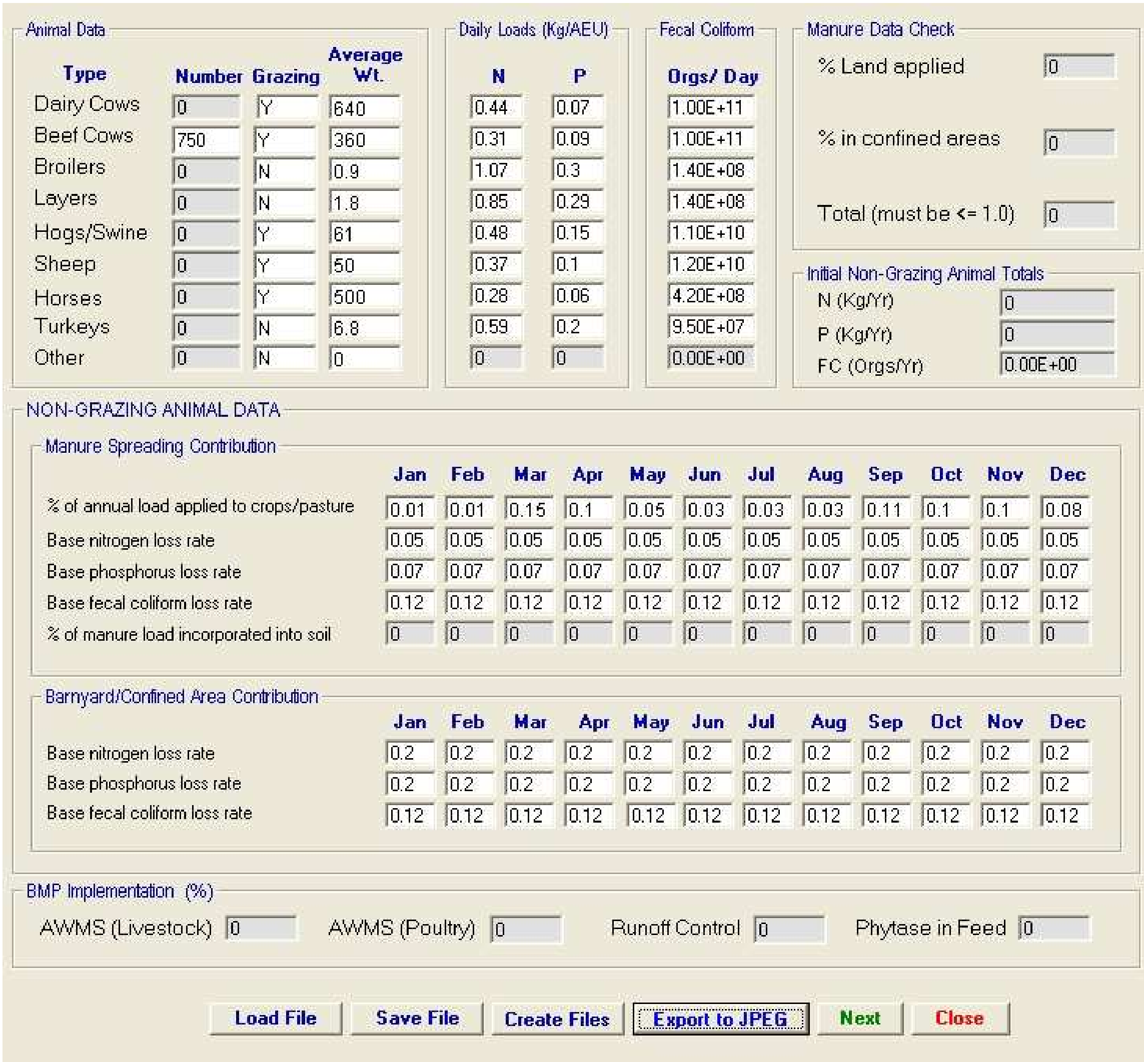
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge			Septic System Populations			
	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	0	0	0	0
Feb	0.0	0.0	0.0	0	0	0	0
Mar	0.0	0.0	0.0	0	0	0	0
Apr	0.0	0.0	0.0	0	0	0	0
May	0.0	0.0	0.0	0	0	0	0
Jun	0.0	0.0	0.0	0	0	0	0
Jul	0.0	0.0	0.0	0	0	0	0
Aug	0.0	0.0	0.0	0	0	0	0
Sep	0.0	0.0	0.0	0	0	0	0
Oct	0.0	0.0	0.0	0	0	0	0
Nov	0.0	0.0	0.0	0	0	0	0
Dec	0.0	0.0	0.0	0	0	0	0

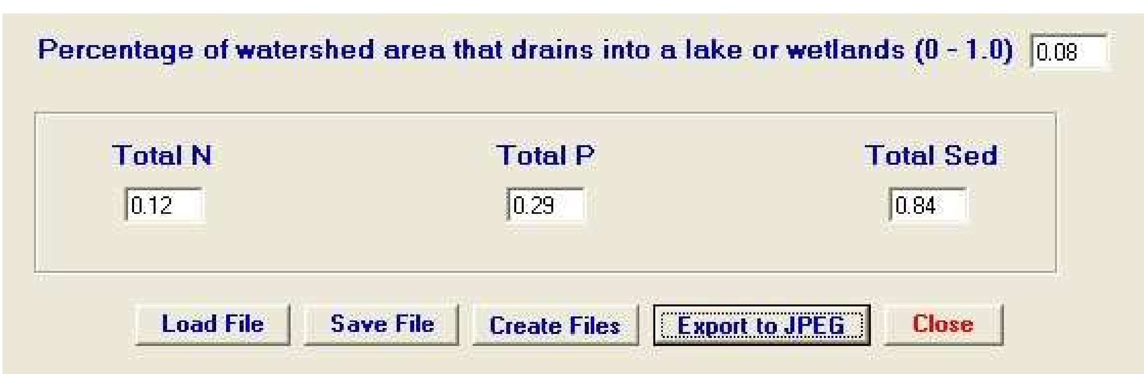
Groundwater (mg/L)		Tile Drainage (mg/L)			Per capita tank effluent		Growing season N/P uptake		Sediment	
N (mg/L)	P (mg/L)	N		Sed	N (g/d)	P (g/d)	N (g/d)	P (g/d)	N (mg/Kg)	P (mg/Kg)
0.35	0.016	15	0.1	50	12	2.5	1.6	0.4	3000.0	522.0

Load File | Save File | Export to JPEG | Close

Nutrient file

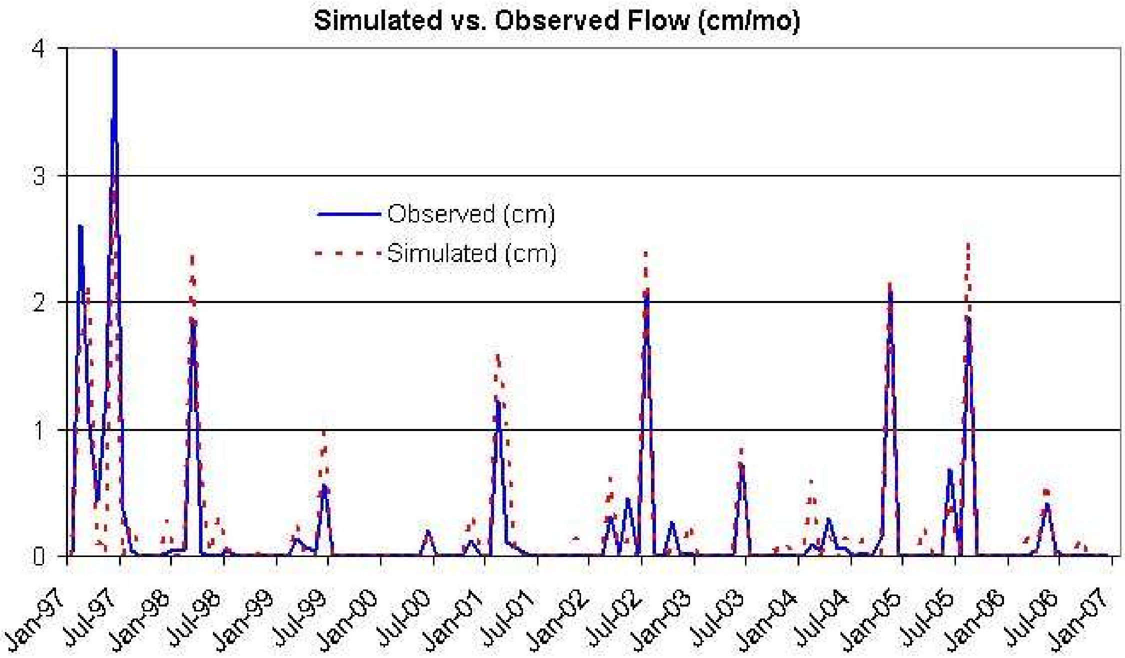


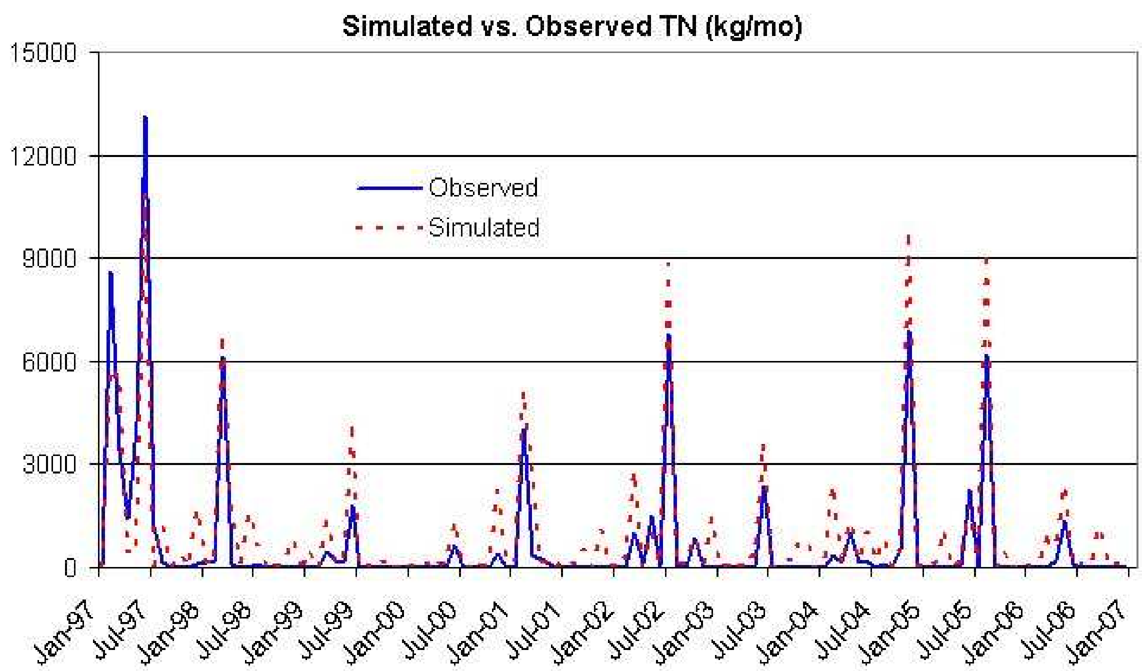
Animal file

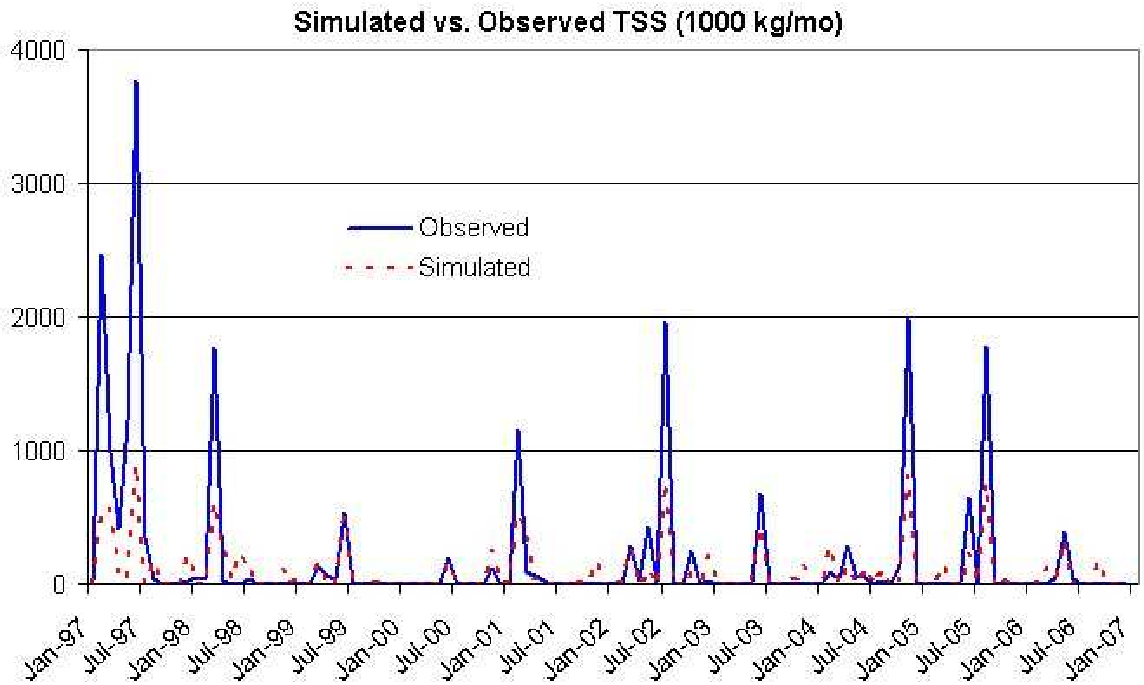


Retention file

Big Sandy Creek (TX)



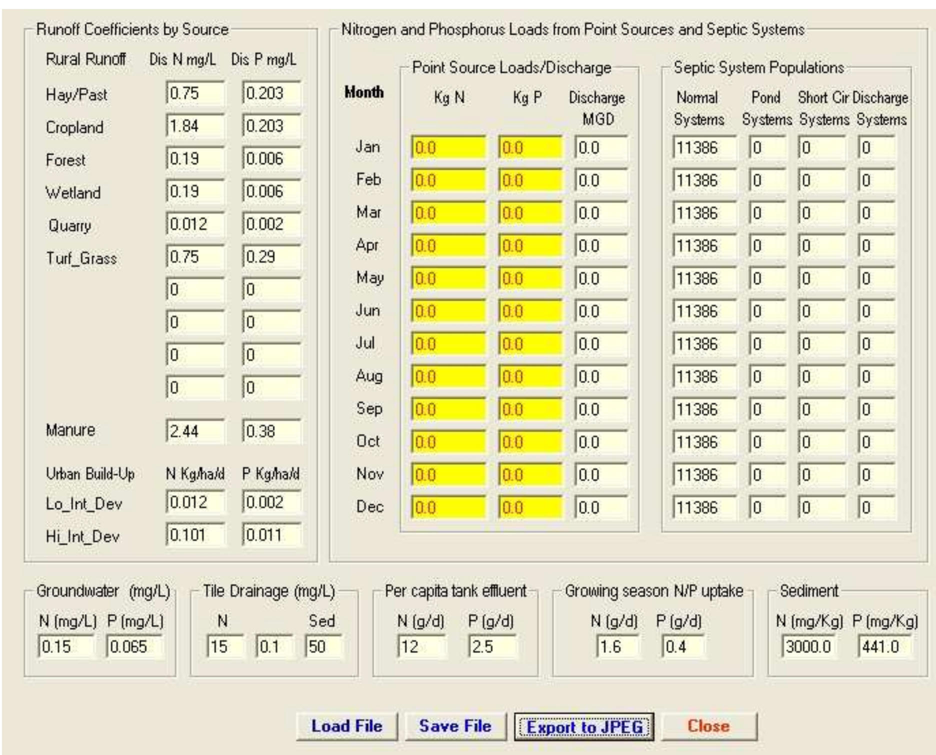



Simulated vs. Observed TSS (1000 kg/mo)
4000
3000
2000
1000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

No TP Data

Black Cypress Creek (TX)

Transport file



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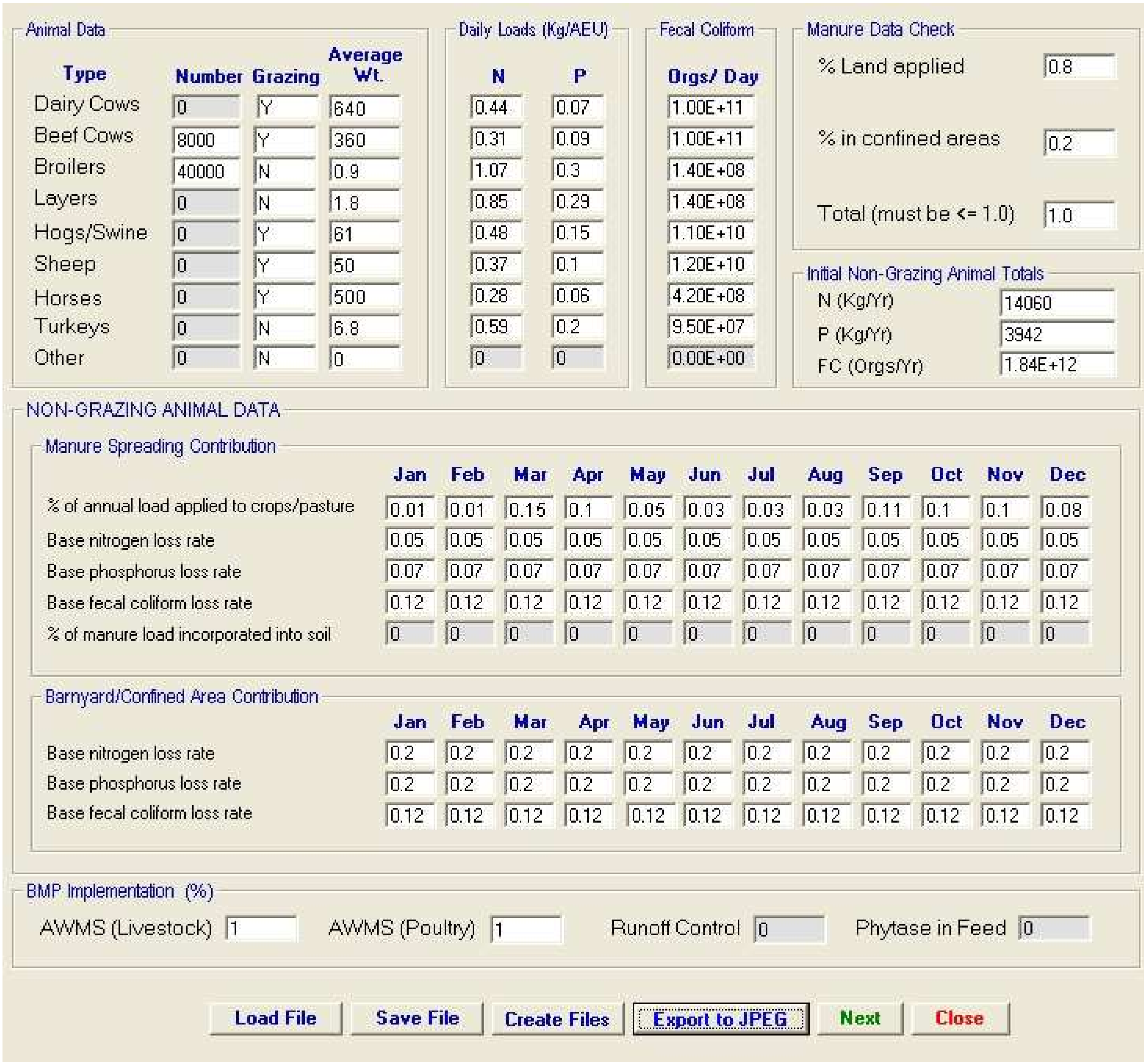

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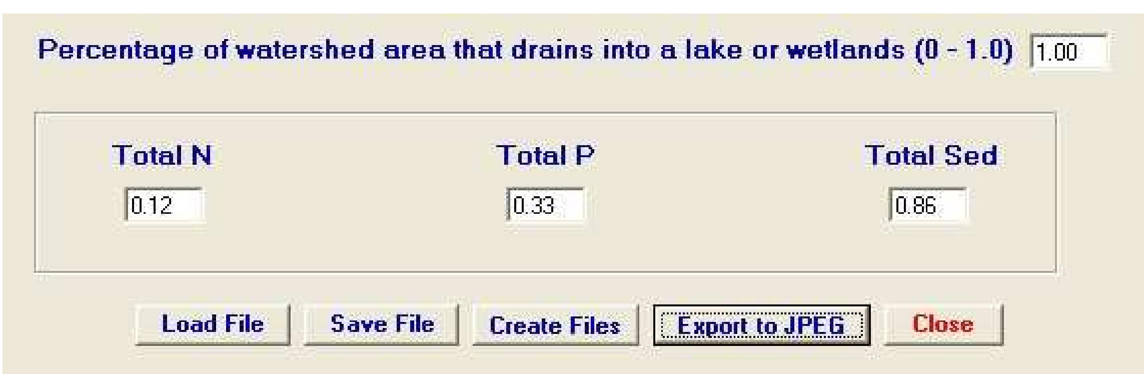
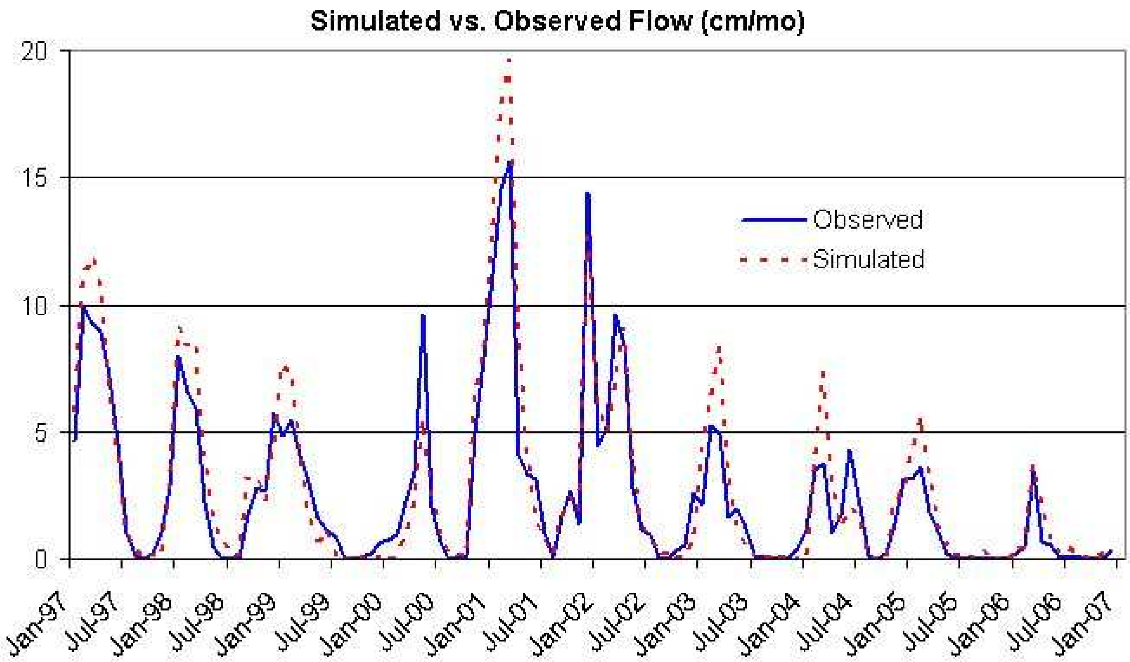


Retention file

Black Cypress Creek (TX)



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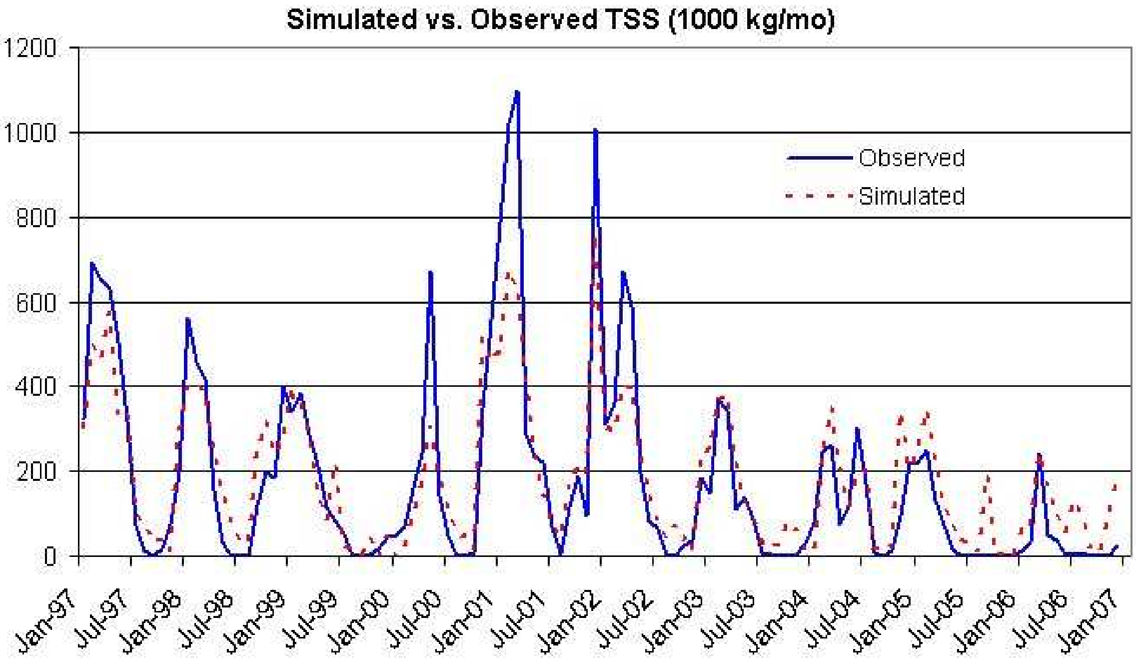
Simulated vs. Observed TSS (1000 kg/mo)
1200
1000
800
600
400
200
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
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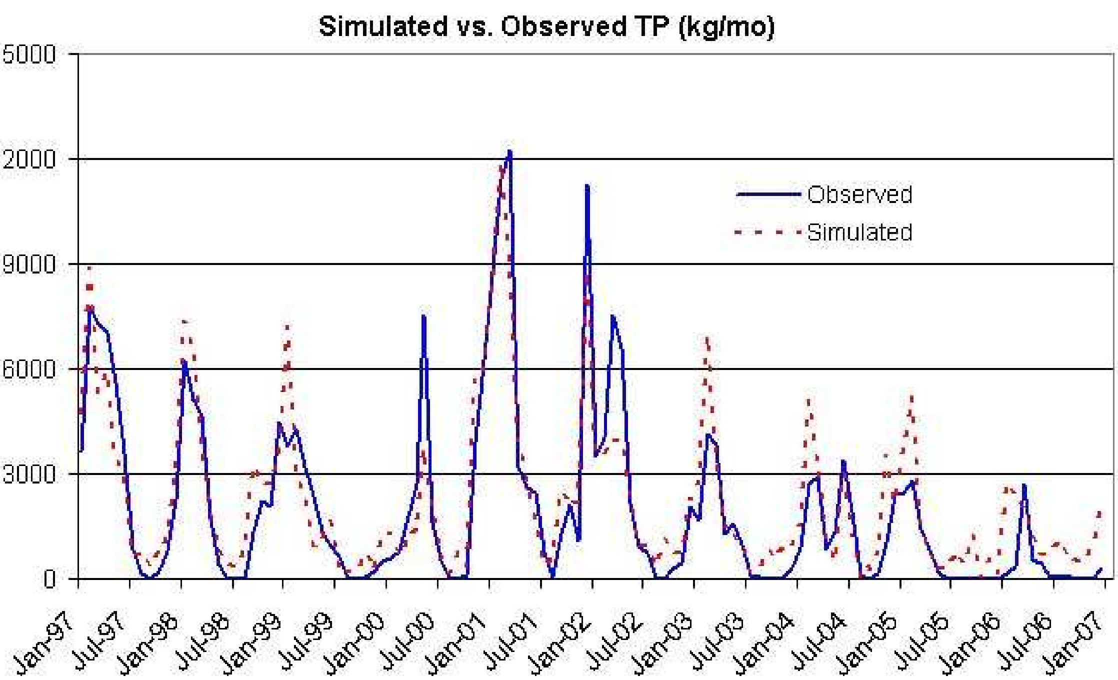
Jan-06
Jul-06
Jan-07


Simulated vs. Observed TP (kg/mo)
15000
12000
9000
6000
3000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

California Creek (TX)

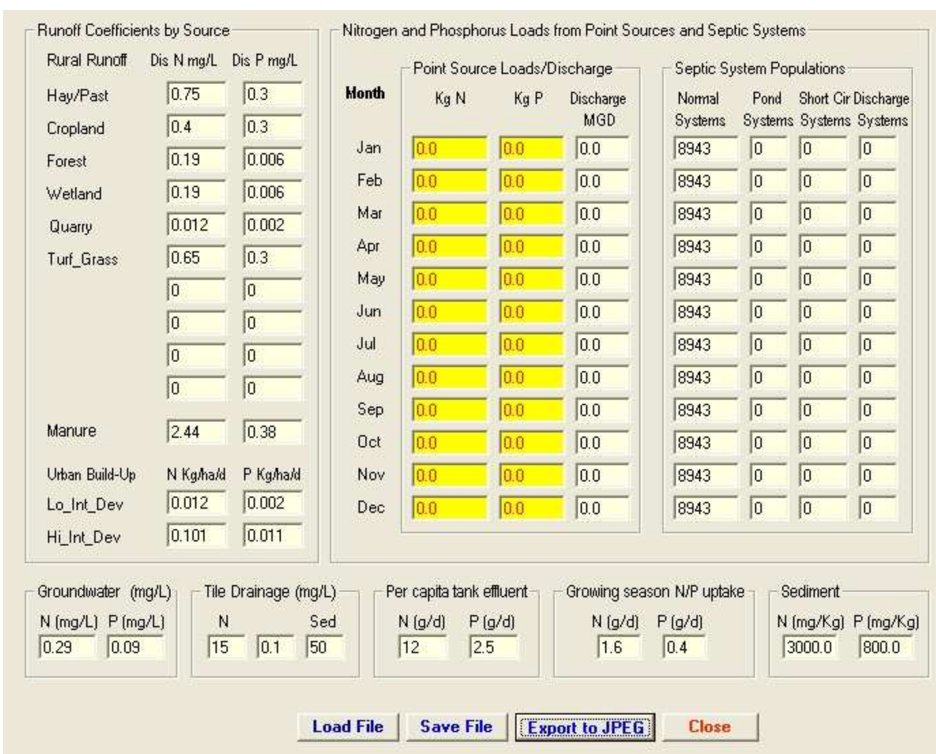
Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	1700	63	0.269	0.247	0.03	0.52
Cropland	74221	82	0.291	0.265	0.24	0.52
Forest	33665	60	0.279	0.354	0.002	0.52
Wetland	115	87	0.296	0.135	0.01	0.1
Quarry	12	89	0.314	0.292	0.1	0.1
Turf_Grass	11673	71	0.276	0.423	0.04	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	341	83	0.294	0.285	0.08	0.2
Hi_Int_Dev	130	93	0.286	0.523	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.47	10	0	0.2	0	0
Feb	0.52	10.8	0	0.2	0	0
Mar	0.53	11.8	0	0.2	0	0
Apr	0.8	12.9	1	0.3	0	0
May	0.97	13.8	1	0.3	0	0
Jun	1.06	14.2	1	0.3	0	0
Jul	1.12	14	1	0.3	0	0
Aug	1.15	13.2	1	0.3	0	0
Sep	1.16	12.2	1	0.3	0	0
Oct	1.18	11.1	1	0.2	0	0
Nov	0.92	10.2	0	0.2	0	0
Dec	0.77	9.8	0	0.2	0	0

Init Unsat Stor (cm)	10	**Initial Snow (cm)**	0	**Recess Coefficient**	0.1
Init Sat Stor (cm)	0	**Sed Delivery Ratio**	0.054	**Seepage Coefficient**	0
Unsat Avail Wat (cm)	14.7746	**Tile Drain Ratio**	0.5	**Sediment A Factor**	1.7820E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	0.75	0.3
Cropland	0.4	0.3
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	0.65	0.3
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

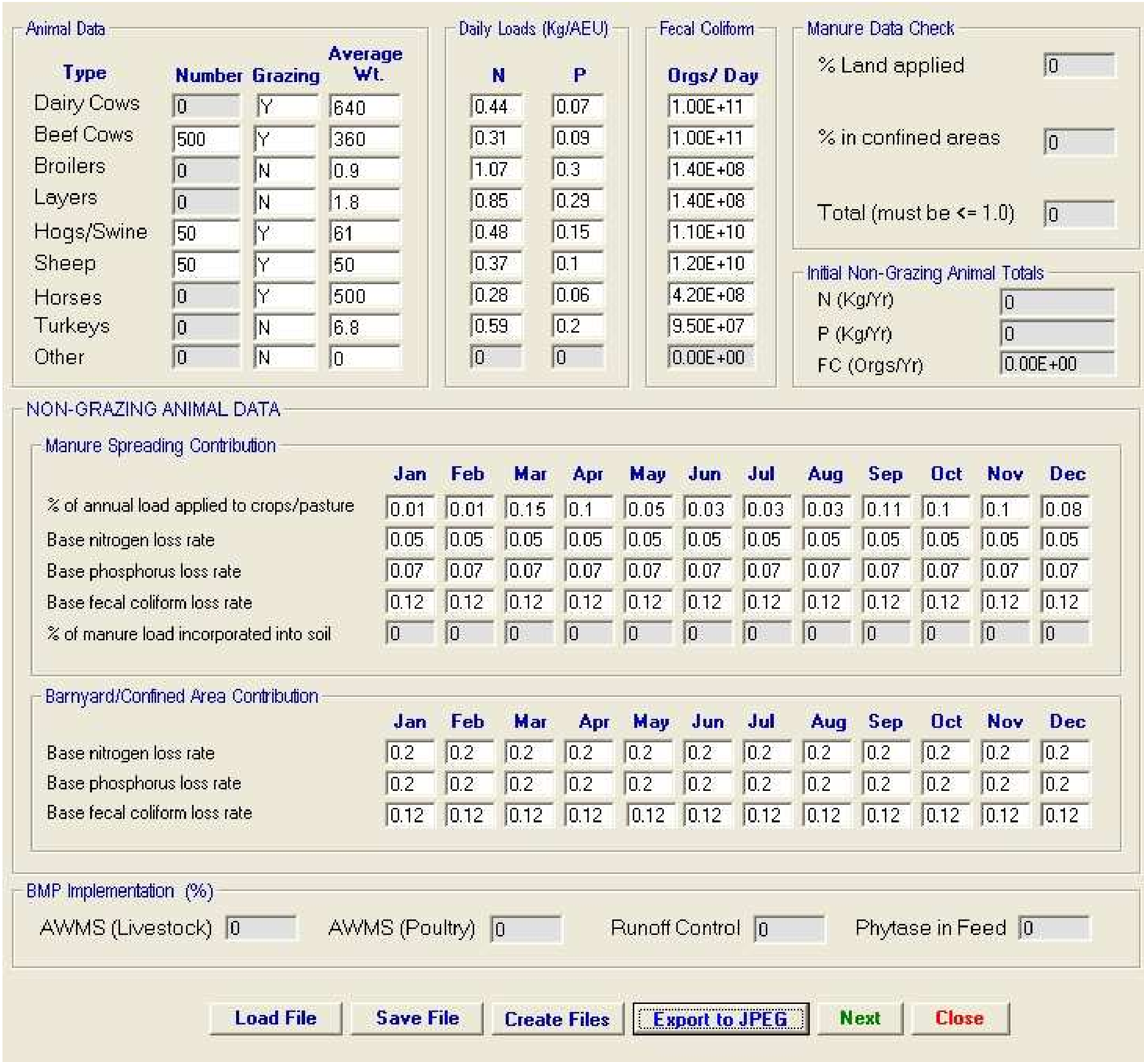
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge			Septic System Populations			
	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	8943	0	0	0
Feb	0.0	0.0	0.0	8943	0	0	0
Mar	0.0	0.0	0.0	8943	0	0	0
Apr	0.0	0.0	0.0	8943	0	0	0
May	0.0	0.0	0.0	8943	0	0	0
Jun	0.0	0.0	0.0	8943	0	0	0
Jul	0.0	0.0	0.0	8943	0	0	0
Aug	0.0	0.0	0.0	8943	0	0	0
Sep	0.0	0.0	0.0	8943	0	0	0
Oct	0.0	0.0	0.0	8943	0	0	0
Nov	0.0	0.0	0.0	8943	0	0	0
Dec	0.0	0.0	0.0	8943	0	0	0

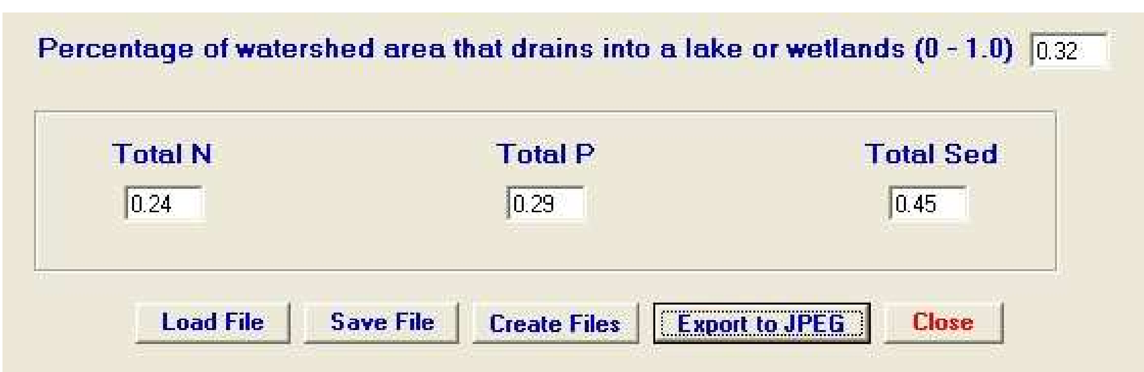
Groundwater (mg/L)		Tile Drainage (mg/L)			Per capita tank effluent		Growing season N/P uptake		Sediment	
N (mg/L)	P (mg/L)	N		Sed	N (g/d)	P (g/d)	N (g/d)	P (g/d)	N (mg/Kg)	P (mg/Kg)
0.29	0.09	15	0.1	50	12	2.5	1.6	0.4	3000.0	800.0

Load File | Save File | Export to JPEG | Close

Nutrient file

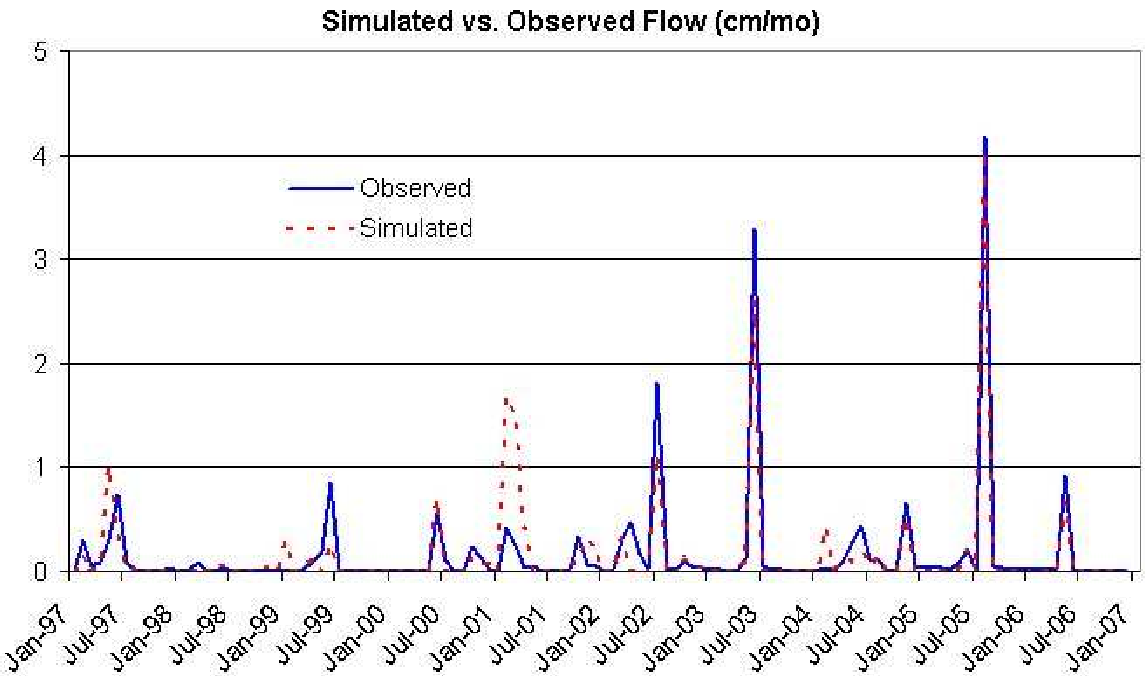


Animal file



Retention file

California Creek (TX)



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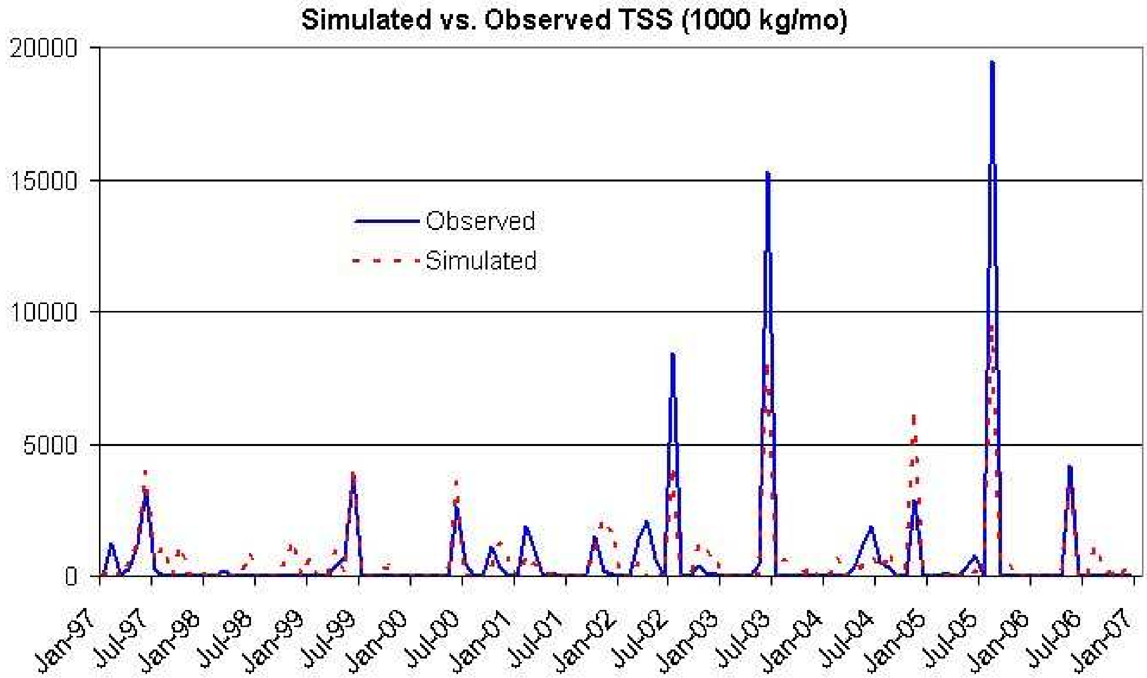

Simulated vs. Observed TSS (1000 kg/mo)
20000
15000
10000
5000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
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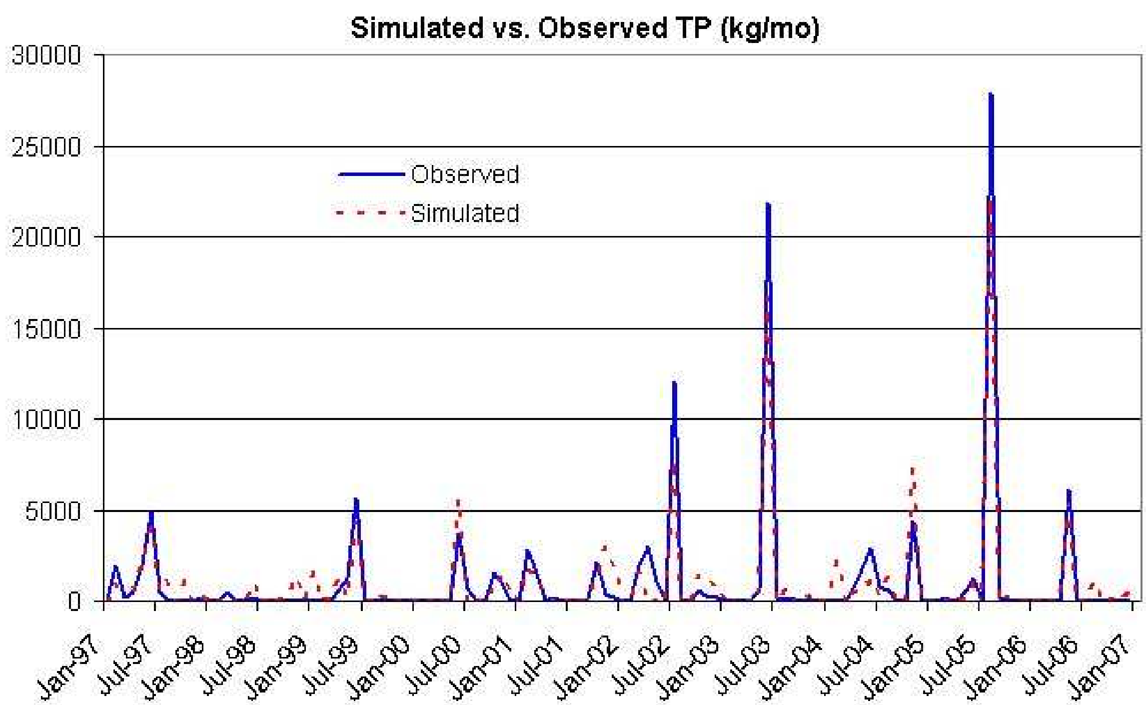
Jan-06
Jul-06
Jan-07



Simulated vs. Observed TP (kg/mo)
30000
25000
20000
15000
10000
5000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

Carrizozo Creek (NM)

Rural LU	Area (ha)	CN	K	LS	C	P
Forest	18468	80	0.32	1.104	0.001	0.66
Wetland	75	80	0.32	0.233	0.01	0.1
Quarry	2	89	0.32	0.246	0.1	0.1
Turf_Grass	32060	71	0.311	0.326	0.03	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.55	9.7	0	0.268	0	0
Feb	0.6	10.6	0	0.268	0	0
Mar	0.63	11.8	0	0.268	0	0
Apr	0.78	13.1	1	0.34	0	0
May	0.85	14.1	1	0.34	0	0
Jun	0.9	14.5	1	0.34	0	0
Jul	0.93	14.3	1	0.34	0	0
Aug	0.95	13.4	1	0.34	0	0
Sep	0.95	12.2	1	0.34	0	0
Oct	0.98	10.9	1	0.268	0	0
Nov	0.83	9.9	0	0.268	0	0
Dec	0.75	9.5	0	0.268	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.071	Seepage Coefficient	0
Unsat Avail Wat (cm)	15.8498	Tile Drain Ratio	0.5	Sediment A Factor	8.6226E-05
		Tile Drain Density	0		

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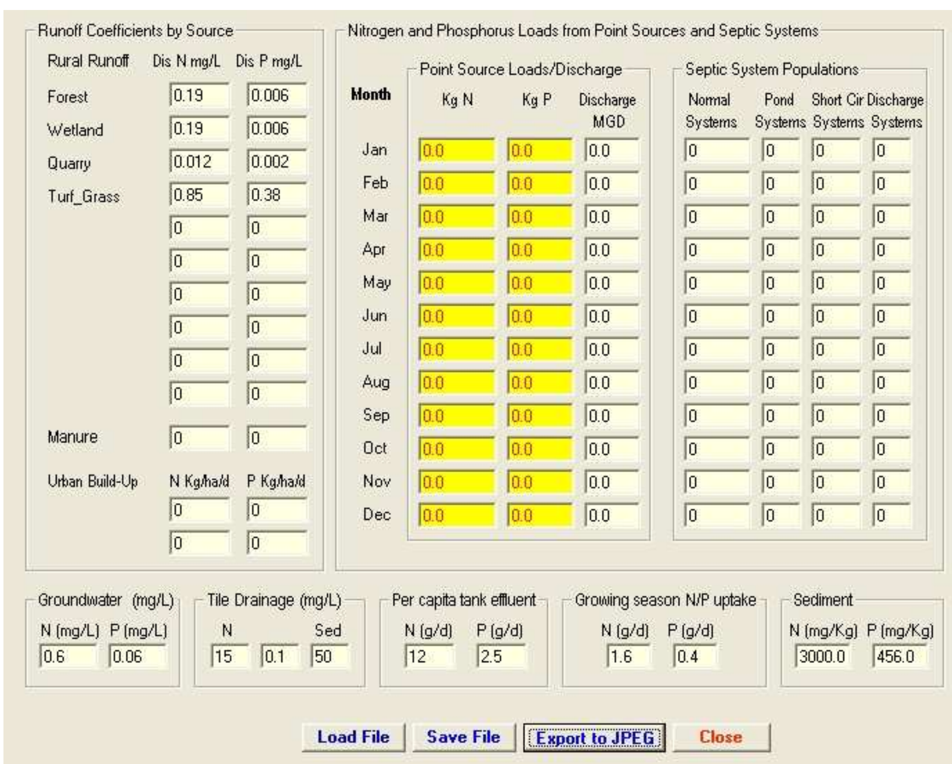
Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	0.85	0.38
	0	0
	0	0
	0	0
	0	0
	0	0
	0	0
Manure	0	0
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
	0	0
	0	0

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	0	0	0	0
Feb	0.0	0.0	0.0	0	0	0	0
Mar	0.0	0.0	0.0	0	0	0	0
Apr	0.0	0.0	0.0	0	0	0	0
May	0.0	0.0	0.0	0	0	0	0
Jun	0.0	0.0	0.0	0	0	0	0
Jul	0.0	0.0	0.0	0	0	0	0
Aug	0.0	0.0	0.0	0	0	0	0
Sep	0.0	0.0	0.0	0	0	0	0
Oct	0.0	0.0	0.0	0	0	0	0
Nov	0.0	0.0	0.0	0	0	0	0
Dec	0.0	0.0	0.0	0	0	0	0

Groundwater (mg/L) N (mg/L)	P (mg/L)	Tile Drainage (mg/L) N	P	Sed	Per capita tank effluent N (g/d)	P (g/d)	Growing season N/P uptake N (g/d)	P (g/d)	Sediment N (mg/Kg)	P (mg/Kg)
0.6	0.06	15	0.1	50	12	2.5	1.6	0.4	3000.0	456.0

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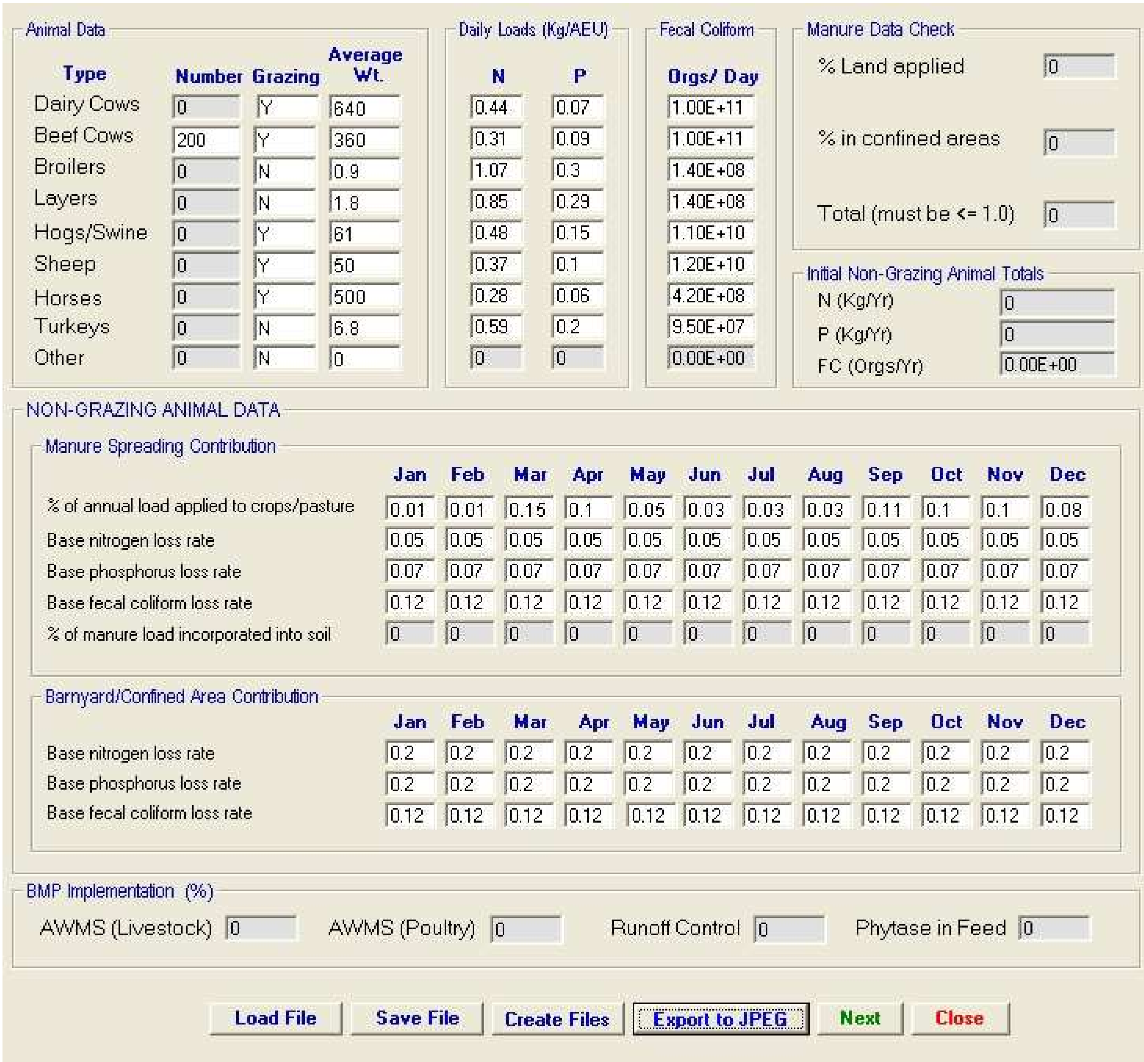
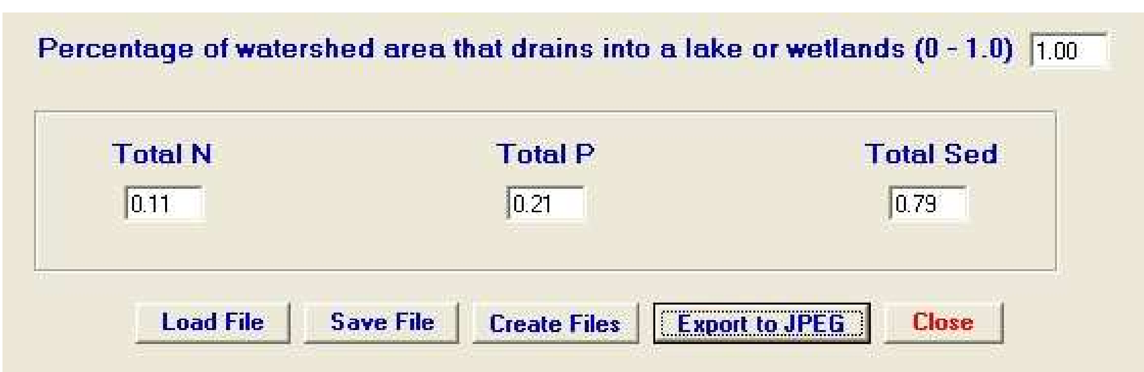
Nutrient file

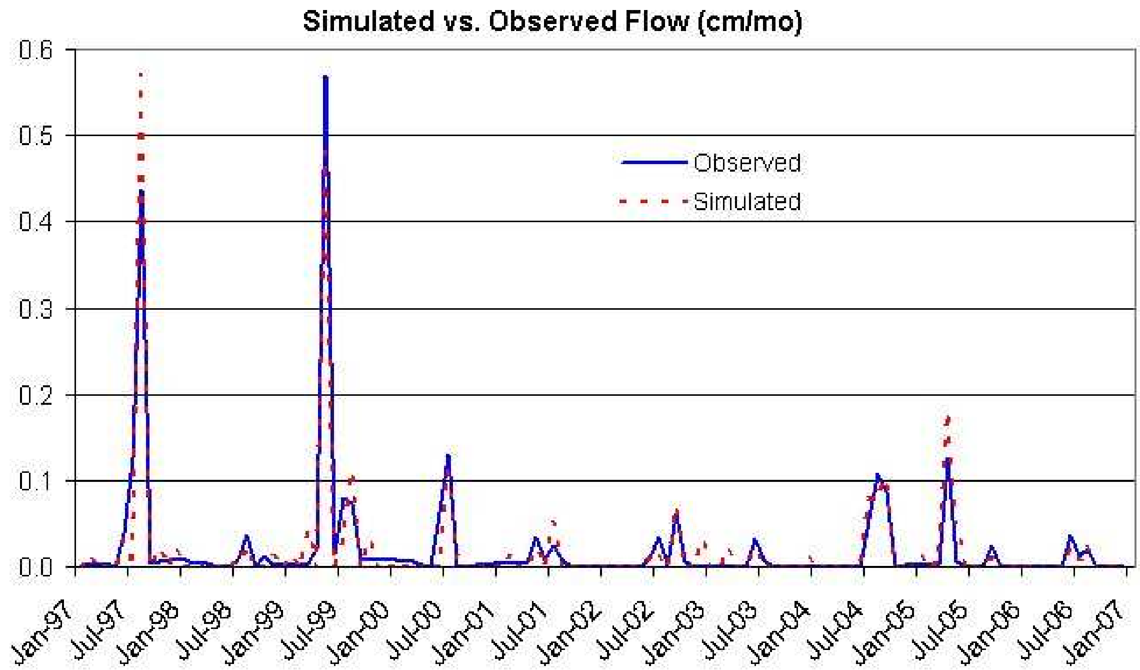


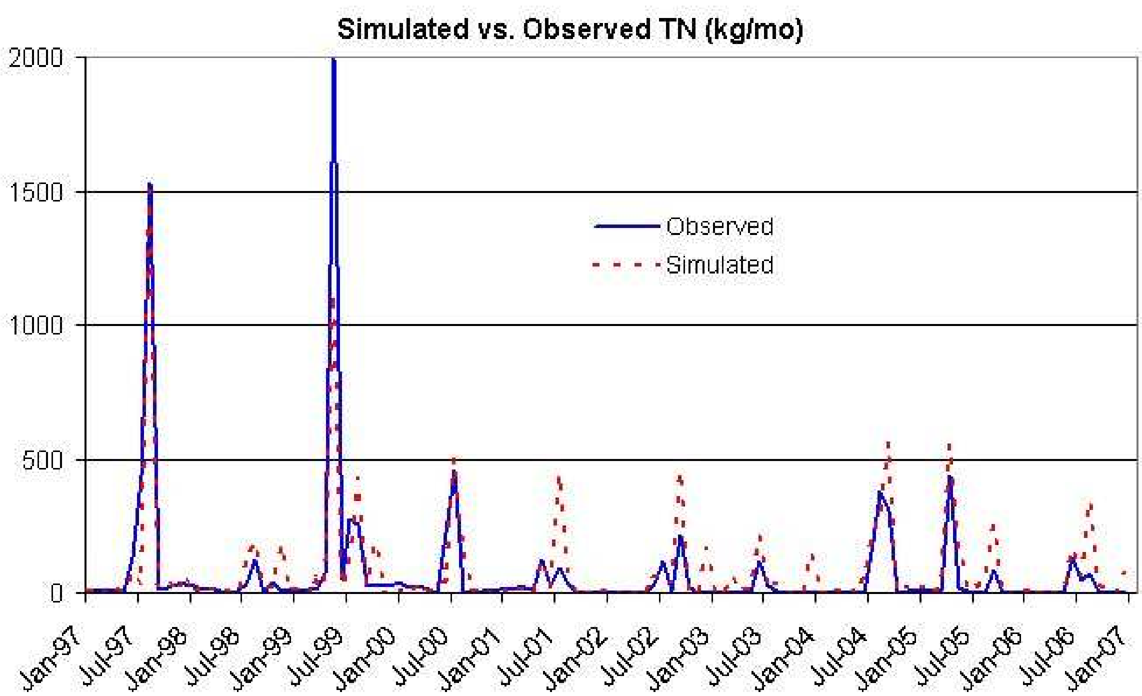
Animal file

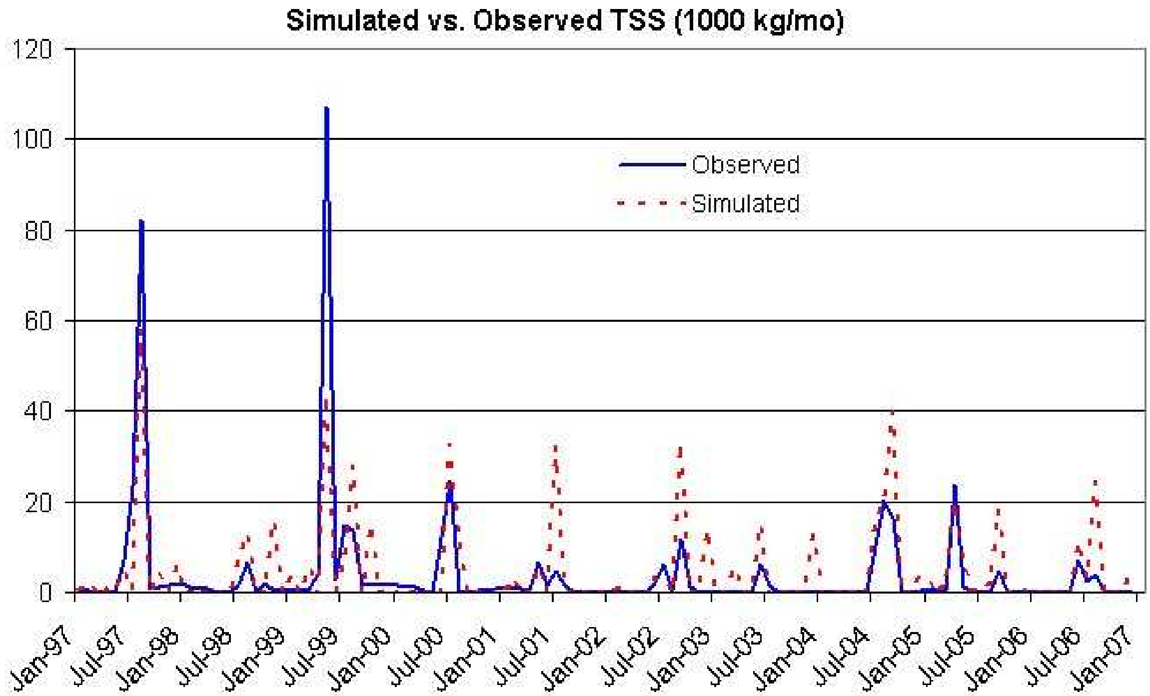


Retention file

Carrizozo Creek (NM)






Simulated vs. Observed TSS (1000 kg/mo)
120
100
80
60
40
20
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
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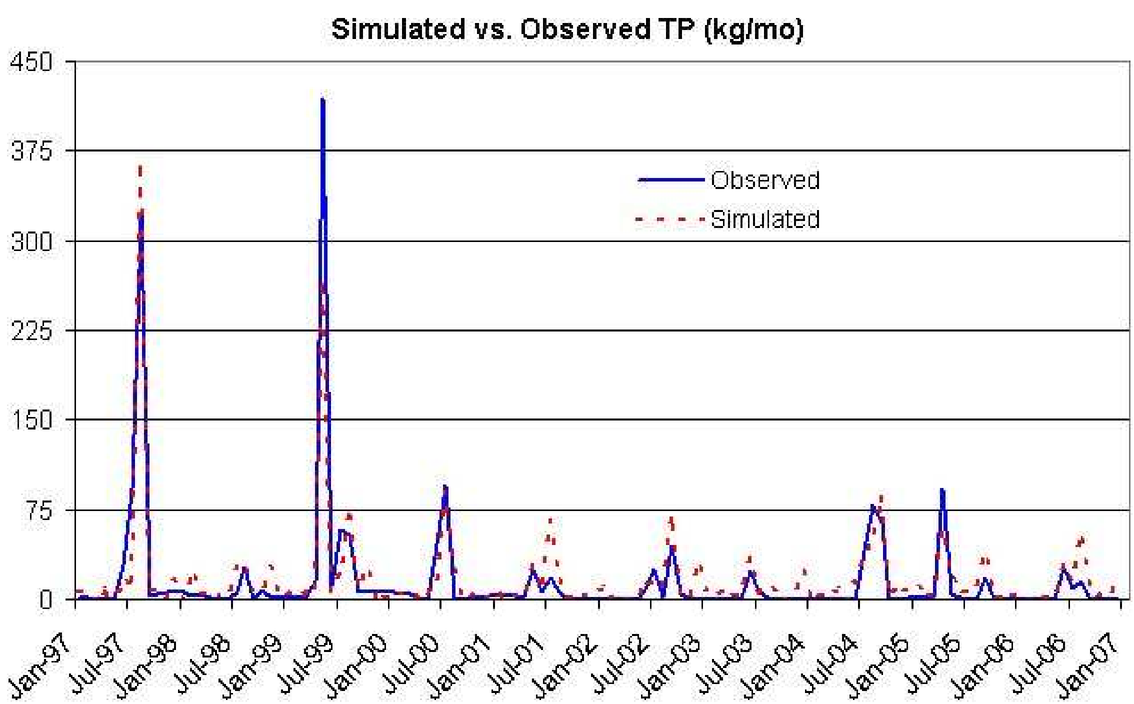
Jan-06
Jul-06
Jan-07


Simulated vs. Observed TP (kg/mo)
450
375
300
225
150
75
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

East Cache Creek (OK)

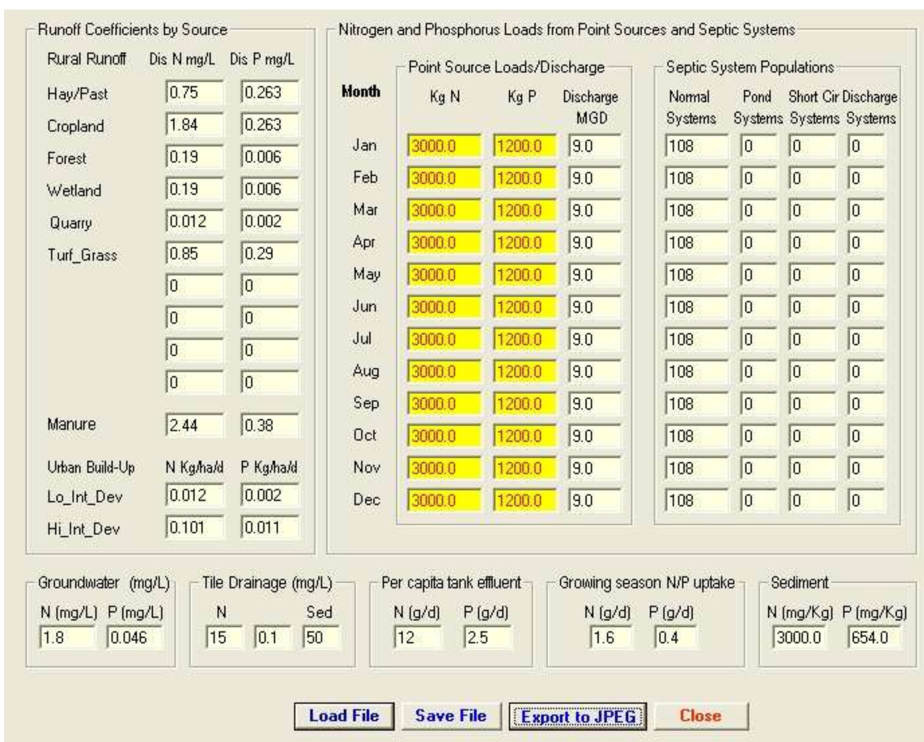
Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	228	75	0.335	0.246	0.06	0.45
Cropland	41017	82	0.35	0.239	0.2	0.45
Forest	14289	73	0.338	0.371	0.004	0.52
Wetland	20	87	0.326	2.396	0.01	0.1
Quarry	335	89	0.32	0.352	0.8	0.1
Turf_Grass	110842	71	0.353	0.358	0.06	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	4439	83	0.389	0.269	0.08	0.2
Hi_Int_Dev	3300	93	0.394	0.275	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.72	9.8	0	0.2	0	0
Feb	0.8	10.6	0	0.2	0	0
Mar	0.84	11.8	0	0.2	0	0
Apr	1.16	13	1	0.3	0	0
May	1.36	14	1	0.3	0	0
Jun	1.48	14.4	1	0.3	0	0
Jul	1.52	14.2	1	0.3	0	0
Aug	1.56	13.4	1	0.3	0	0
Sep	1.6	12.2	1	0.3	0	0
Oct	1.6	11	1	0.2	0	0
Nov	1.28	10	0	0.2	0	0
Dec	1.12	9.6	0	0.2	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.07
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.048	Seepage Coefficient	0
Unsat Avail Wat (cm)	10.0435	Tile Drain Ratio	0.5	Sediment A Factor	3.8770E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	0.75	0.263
Cropland	1.84	0.263
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	0.85	0.29
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

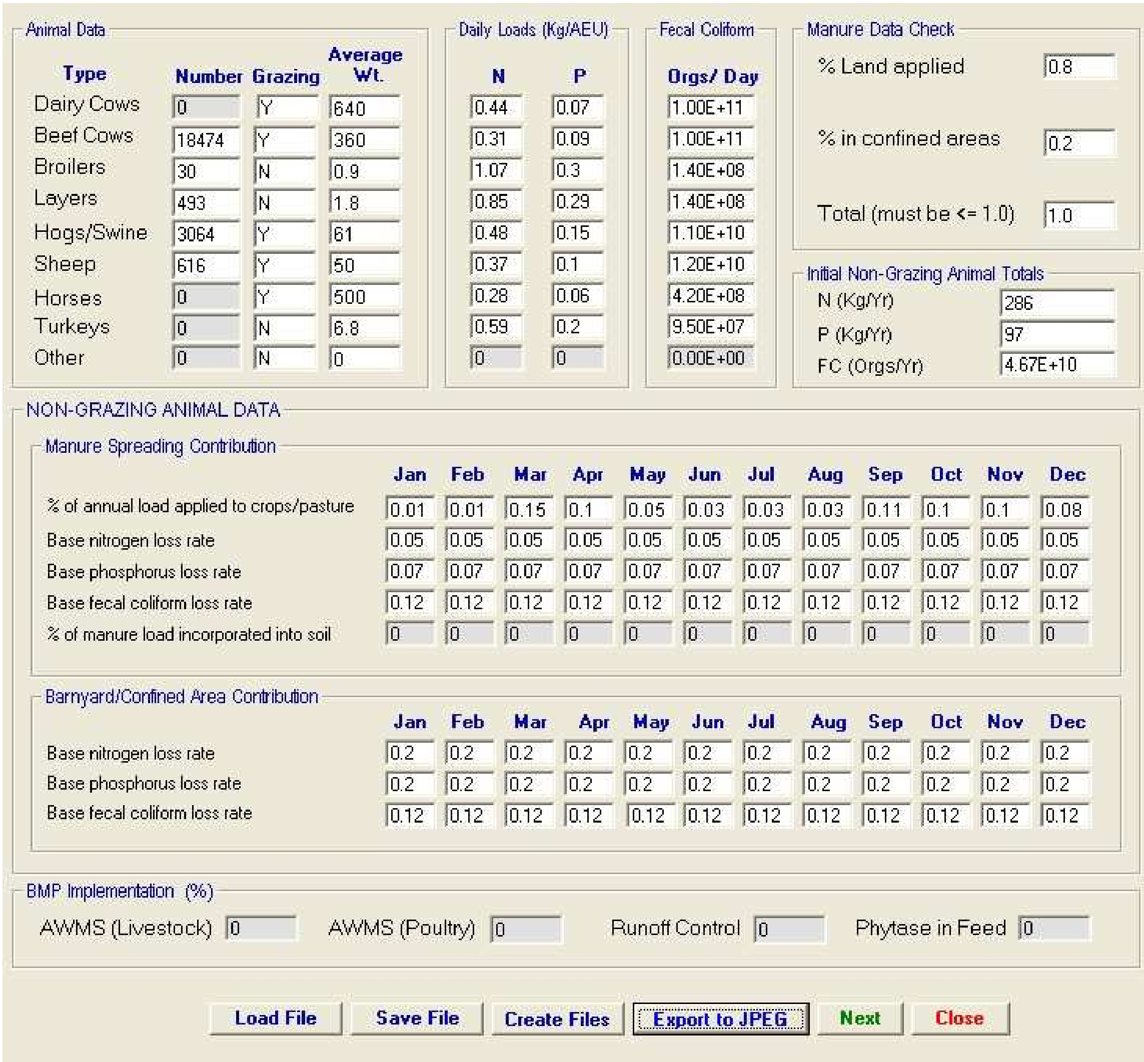
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	3000.0	1200.0	9.0	108	0	0	0
Feb	3000.0	1200.0	9.0	108	0	0	0
Mar	3000.0	1200.0	9.0	108	0	0	0
Apr	3000.0	1200.0	9.0	108	0	0	0
May	3000.0	1200.0	9.0	108	0	0	0
Jun	3000.0	1200.0	9.0	108	0	0	0
Jul	3000.0	1200.0	9.0	108	0	0	0
Aug	3000.0	1200.0	9.0	108	0	0	0
Sep	3000.0	1200.0	9.0	108	0	0	0
Oct	3000.0	1200.0	9.0	108	0	0	0
Nov	3000.0	1200.0	9.0	108	0	0	0
Dec	3000.0	1200.0	9.0	108	0	0	0

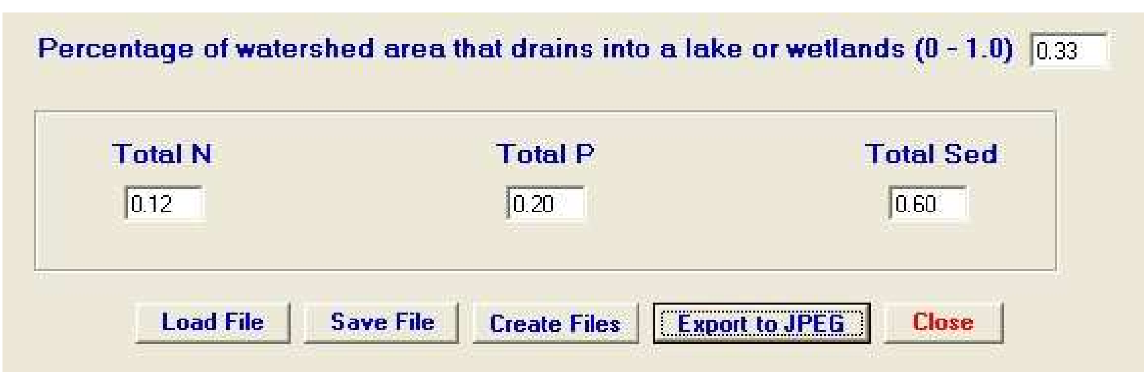
Groundwater (mg/L): N (mg/L)	P (mg/L)	Tile Drainage (mg/L): N		Sed	Per capita tank effluent: N (g/d)	P (g/d)	Growing season N/P uptake: N (g/d)	P (g/d)	Sediment: N (mg/Kg)	P (mg/Kg)
1.8	0.046	15	0.1	50	12	2.5	1.6	0.4	3000.0	654.0

Load File | Save File | Export to JPEG | Close

Nutrient file

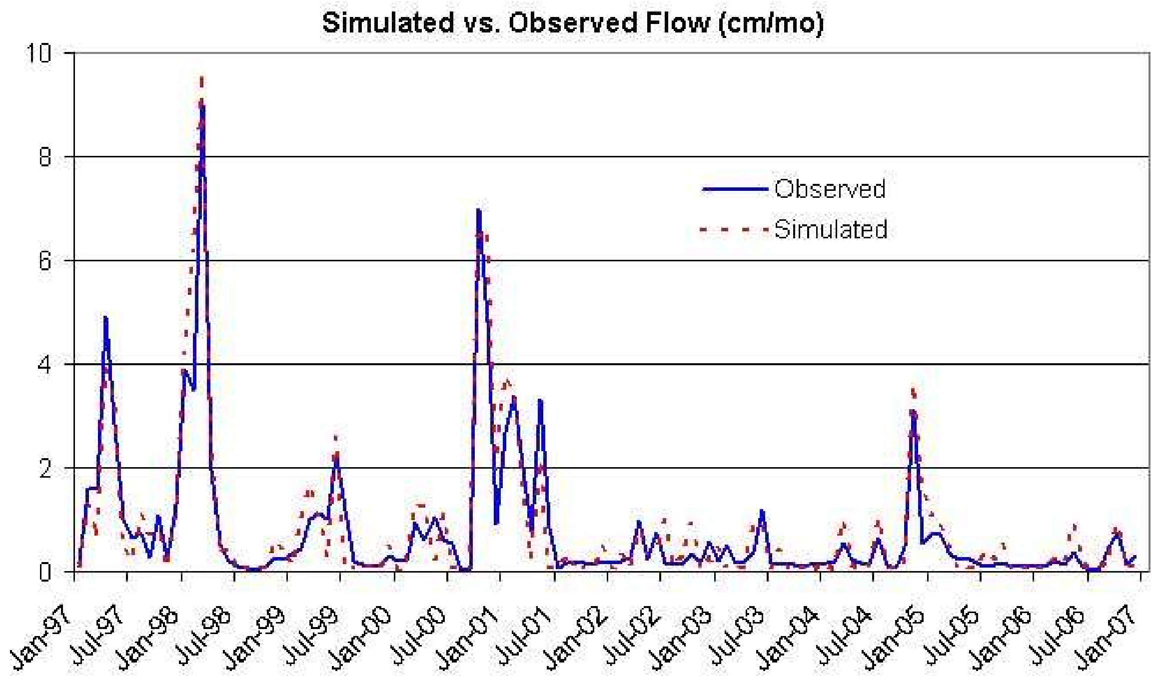


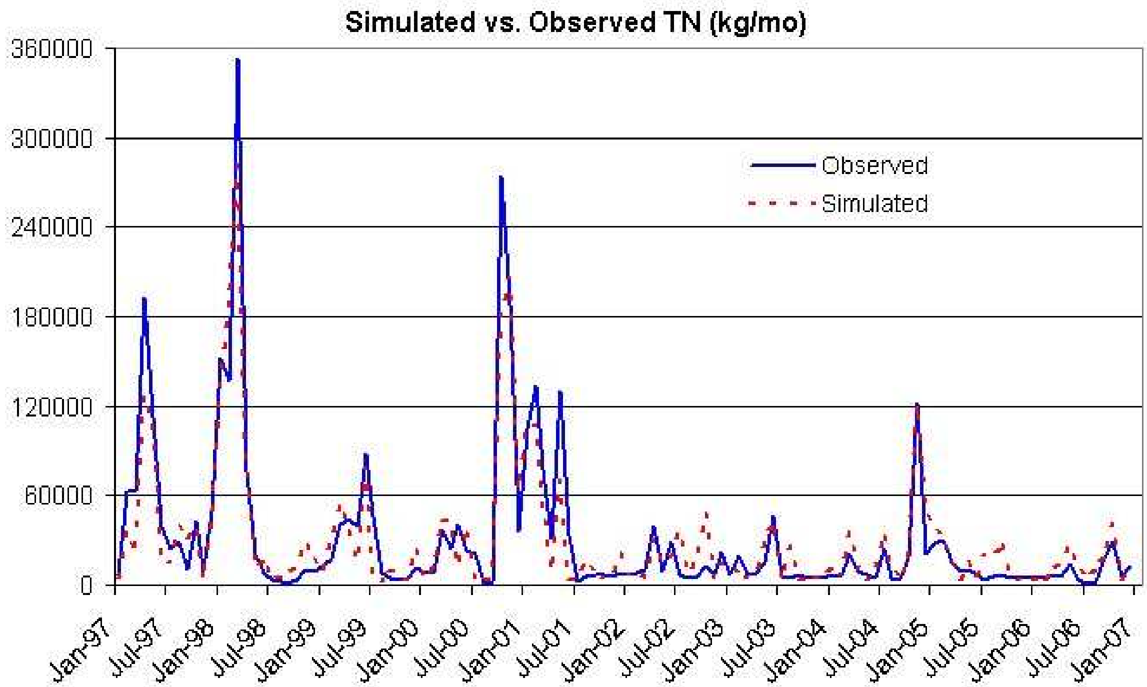
Animal file

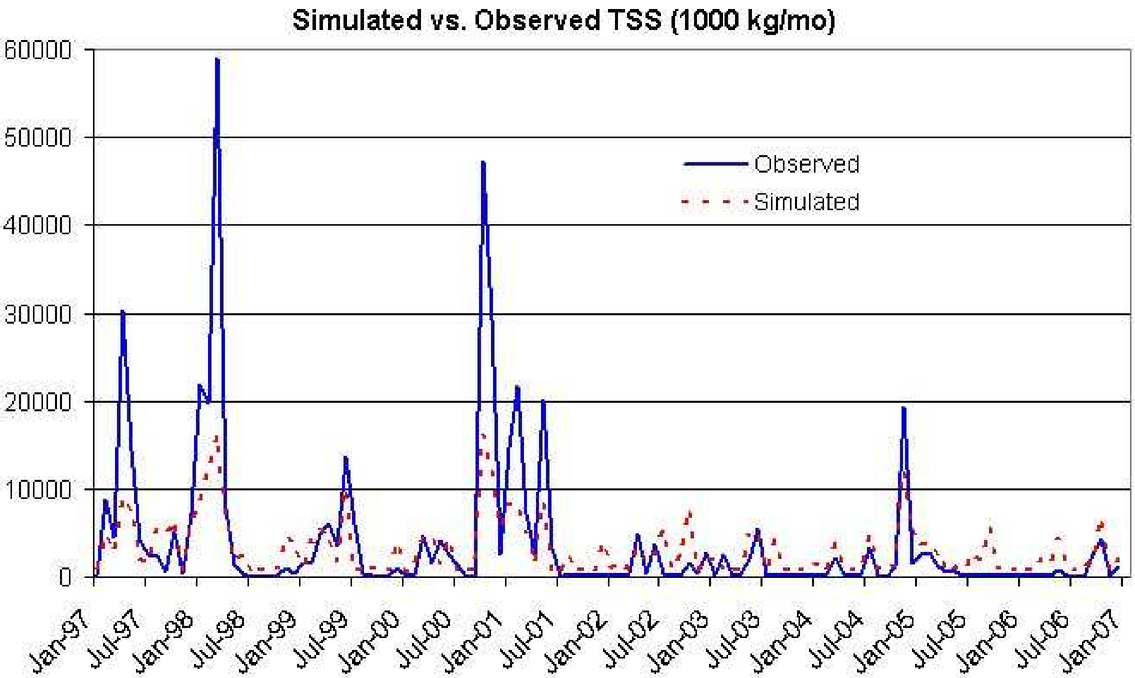


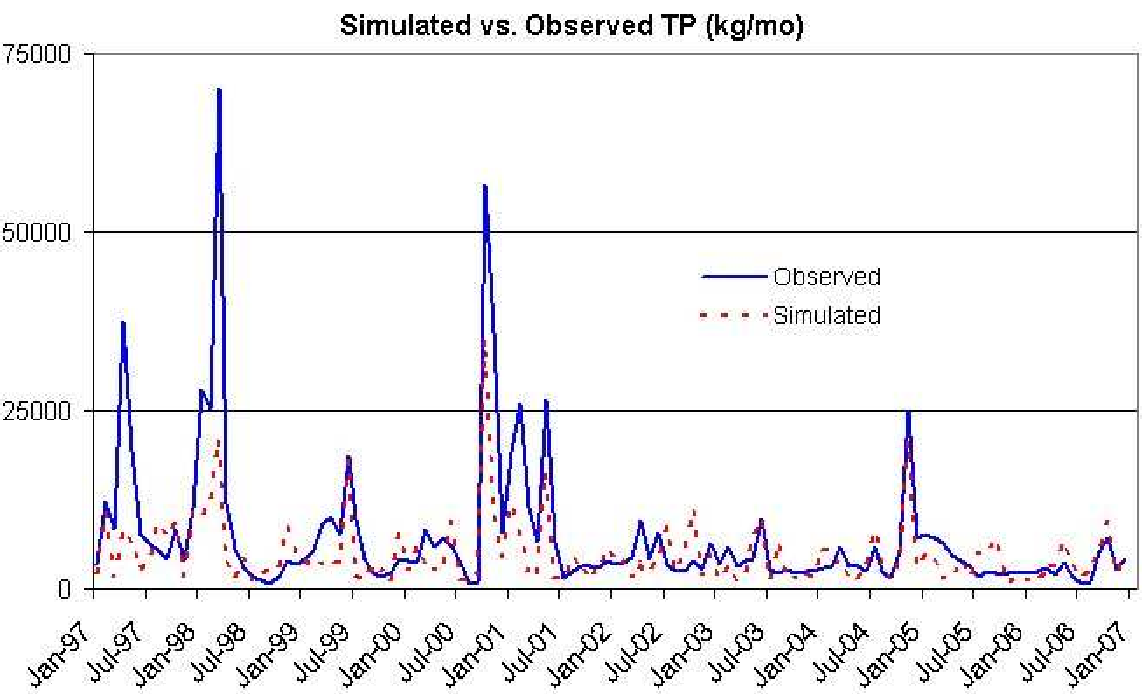
Retention file

East Cache Creek (OK)

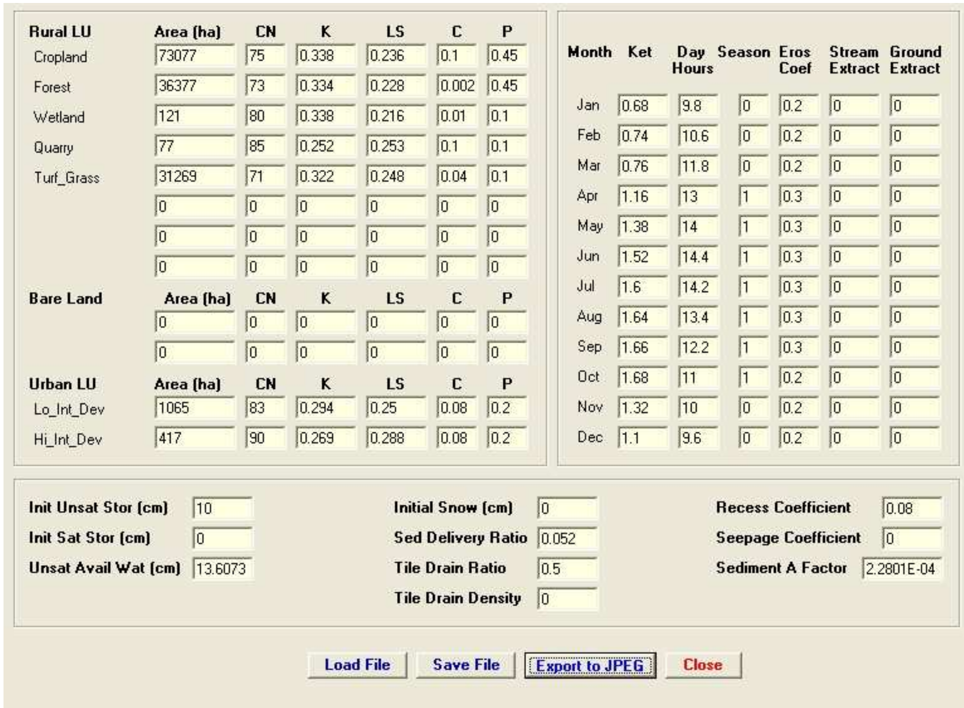





Simulated vs. Observed TSS (1000 kg/mo)
60000
50000
40000
30000
20000
10000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07


Simulated vs. Observed TP (kg/mo)
75000
50000
25000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

Elk Creek (OK)



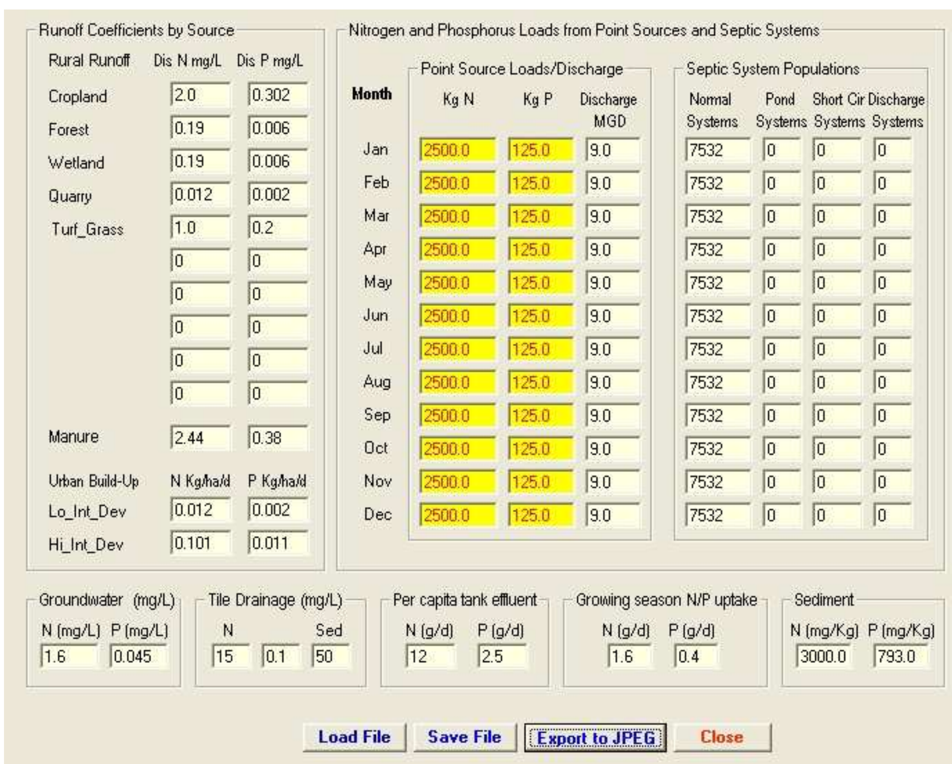
Rural LU	Area (ha)	CN	K	LS	C	P
Cropland	73077	75	0.338	0.236	0.1	0.45
Forest	36377	73	0.334	0.228	0.002	0.45
Wetland	121	80	0.338	0.216	0.01	0.1
Quarry	77	85	0.252	0.253	0.1	0.1
Turf_Grass	31269	71	0.322	0.248	0.04	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	1065	83	0.294	0.25	0.08	0.2
Hi_Int_Dev	417	90	0.269	0.288	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.68	9.8	0	0.2	0	0
Feb	0.74	10.6	0	0.2	0	0
Mar	0.76	11.8	0	0.2	0	0
Apr	1.16	13	1	0.3	0	0
May	1.38	14	1	0.3	0	0
Jun	1.52	14.4	1	0.3	0	0
Jul	1.6	14.2	1	0.3	0	0
Aug	1.64	13.4	1	0.3	0	0
Sep	1.66	12.2	1	0.3	0	0
Oct	1.68	11	1	0.2	0	0
Nov	1.32	10	0	0.2	0	0
Dec	1.1	9.6	0	0.2	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.08
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.052	Seepage Coefficient	0
Unsat Avail Wat (cm)	13.6073	Tile Drain Ratio	0.5	Sediment A Factor	2.2801E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Cropland	2.0	0.302
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	1.0	0.2
	0	0
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

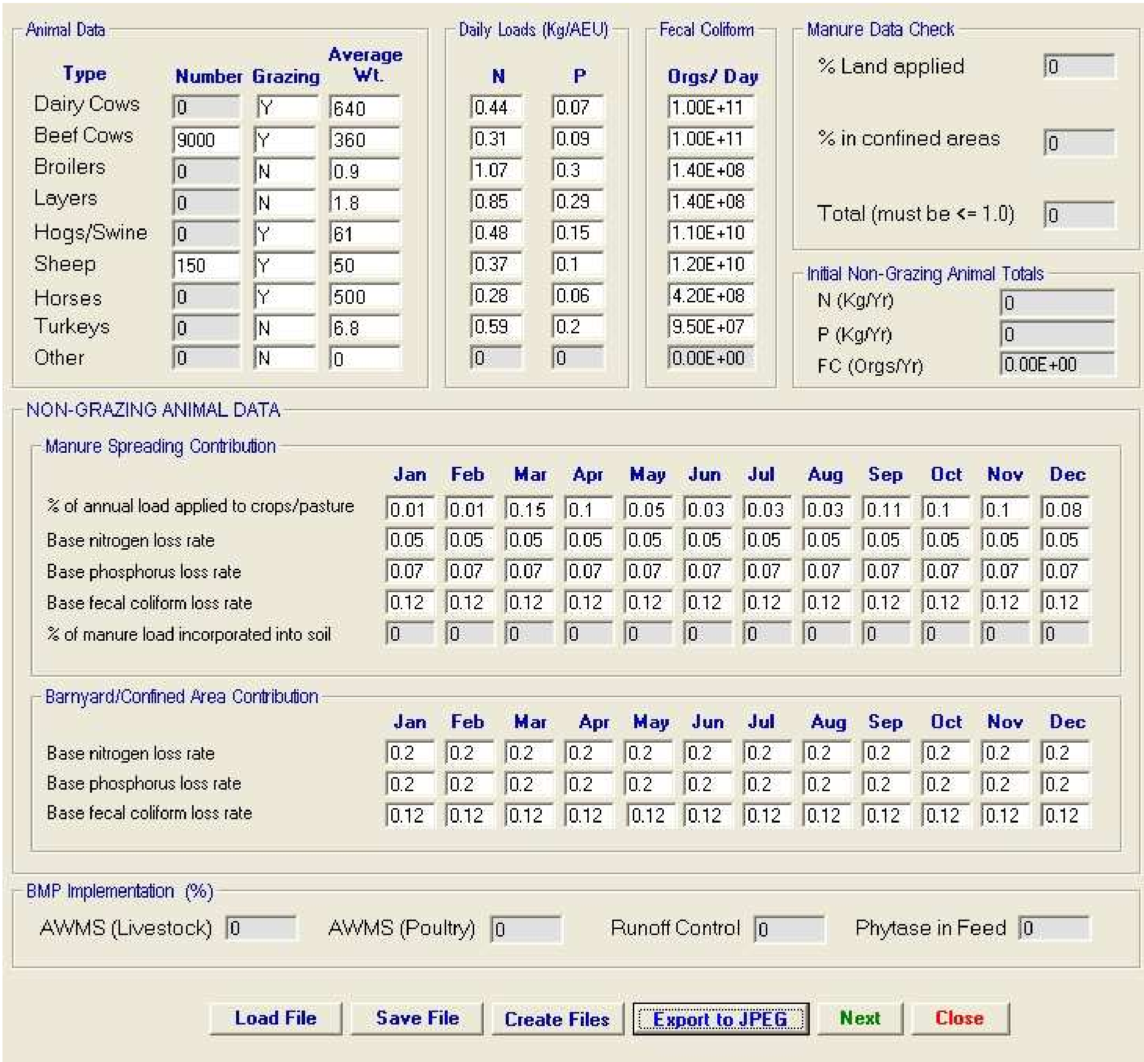
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	2500.0	125.0	9.0	7532	0	0	0
Feb	2500.0	125.0	9.0	7532	0	0	0
Mar	2500.0	125.0	9.0	7532	0	0	0
Apr	2500.0	125.0	9.0	7532	0	0	0
May	2500.0	125.0	9.0	7532	0	0	0
Jun	2500.0	125.0	9.0	7532	0	0	0
Jul	2500.0	125.0	9.0	7532	0	0	0
Aug	2500.0	125.0	9.0	7532	0	0	0
Sep	2500.0	125.0	9.0	7532	0	0	0
Oct	2500.0	125.0	9.0	7532	0	0	0
Nov	2500.0	125.0	9.0	7532	0	0	0
Dec	2500.0	125.0	9.0	7532	0	0	0

Groundwater (mg/L) N (mg/L)	P (mg/L)	Tile Drainage (mg/L) N	P	Sed	Per capita tank effluent N (g/d)	P (g/d)	Growing season N/P uptake N (g/d)	P (g/d)	Sediment N (mg/Kg)	P (mg/Kg)
1.6	0.045	15	0.1	50	12	2.5	1.6	0.4	3000.0	793.0

Load File | Save File | Export to JPEG | Close

Nutrient file



Animal Data

Type	Number	Grazing	Average Wt.
Dairy Cows	0	Y	640
Beef Cows	9000	Y	360
Broilers	0	N	0.9
Layers	0	N	1.8
Hogs/Swine	0	Y	61
Sheep	150	Y	50
Horses	0	Y	500
Turkeys	0	N	6.8
Other	0	N	0

Daily Loads (Kg/AEU) / Fecal Coliform

N	P	Orgs/ Day
0.44	0.07	1.00E+11
0.31	0.09	1.00E+11
1.07	0.3	1.40E+08
0.85	0.29	1.40E+08
0.48	0.15	1.10E+10
0.37	0.1	1.20E+10
0.28	0.06	4.20E+08
0.59	0.2	9.50E+07
0	0	0.00E+00

Manure Data Check

% Land applied 0

% in confined areas 0

Total (must be <= 1.0) 0

Initial Non-Grazing Animal Totals

N (Kg/Yr) 0

P (Kg/Yr) 0

FC (Orgs/Yr) 0.00E+00

NON-GRAZING ANIMAL DATA

Manure Spreading Contribution

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
% of annual load applied to crops/pasture	0.01	0.01	0.15	0.1	0.05	0.03	0.03	0.03	0.11	0.1	0.1	0.08
Base nitrogen loss rate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Base phosphorus loss rate	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Base fecal coliform loss rate	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
% of manure load incorporated into soil	0	0	0	0	0	0	0	0	0	0	0	0

Barnyard/Confined Area Contribution

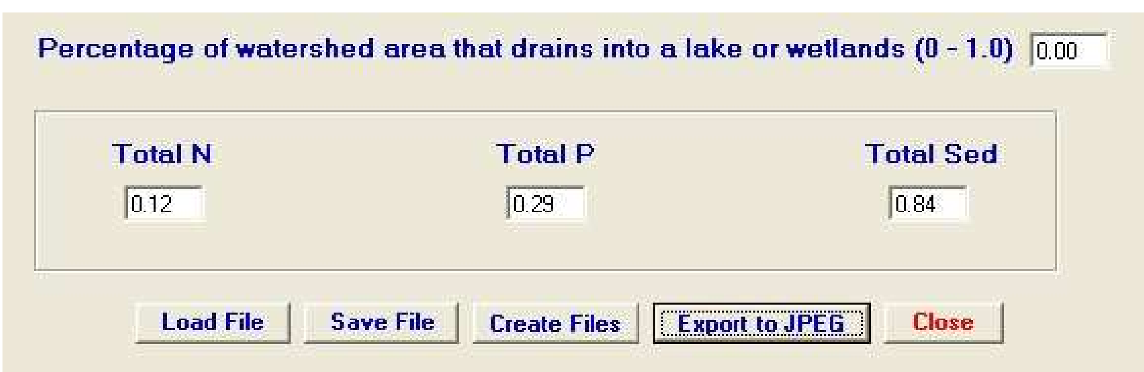
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Base nitrogen loss rate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Base phosphorus loss rate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Base fecal coliform loss rate	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

BMP Implementation (%)

AWMS (Livestock) 0 AWMS (Poultry) 0 Runoff Control 0 Phytase in Feed 0

Load File | Save File | Create Files | Export to JPEG | Next | Close

Animal file



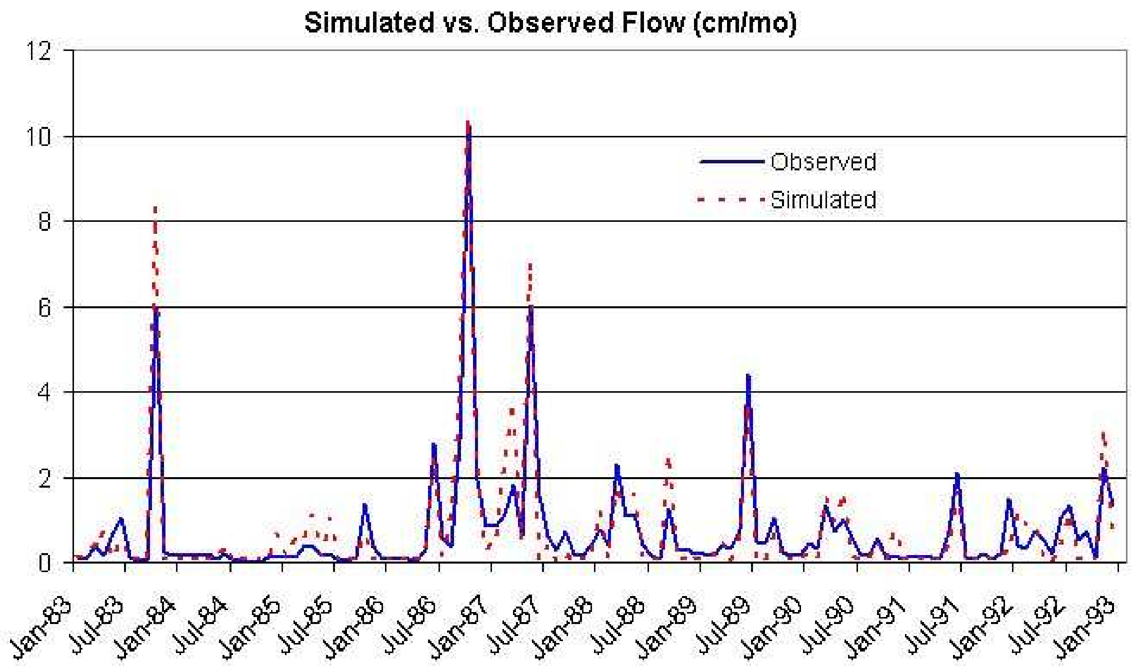
Percentage of watershed area that drains into a lake or wetlands (0 - 1.0) 0.00

Total N	Total P	Total Sed
0.12	0.29	0.84

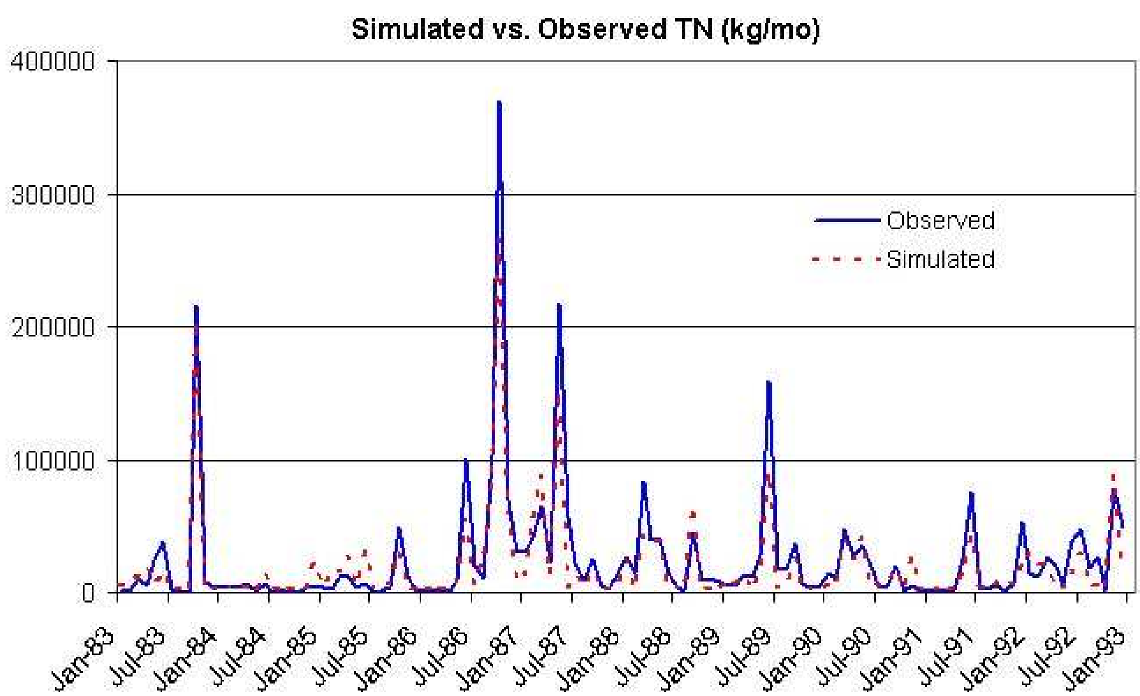
Load File | Save File | Create Files | Export to JPEG | Close

Retention file

Elk Creek (OK)

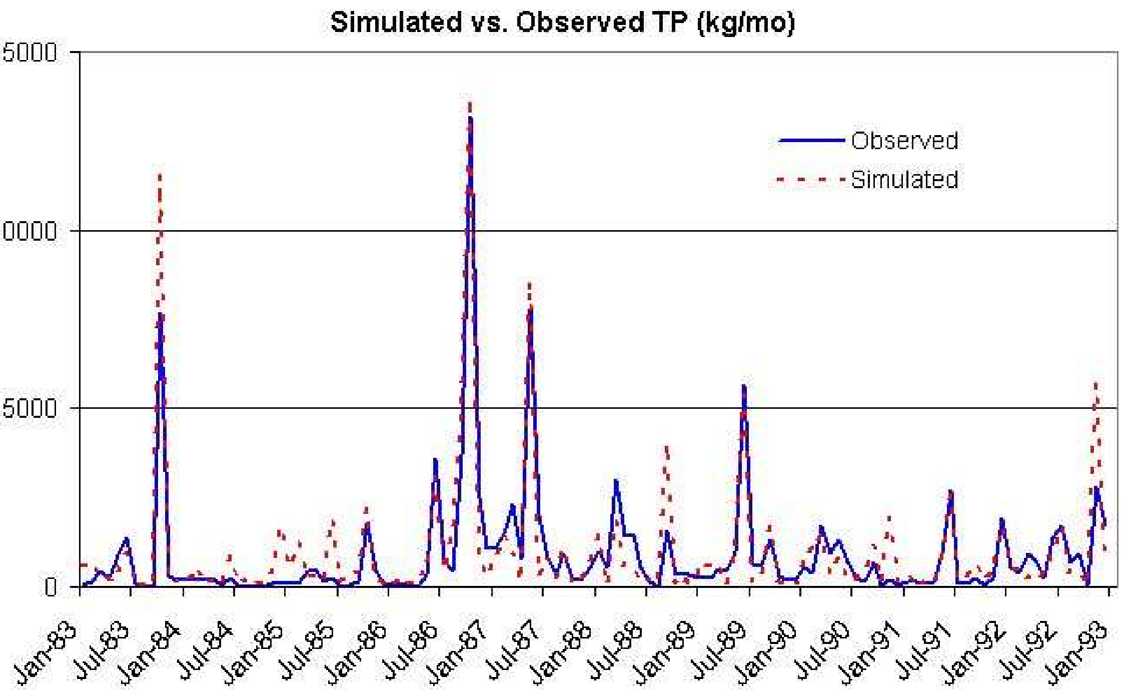


Simulated vs. Observed Flow (cm/mo)
12
10
8
6
4
2
0
Observed
Simulated
Jan-83
Jul-83
Jan-84
Jul-84
Jan-85
Jul-85
Jan-86
Jul-86
Jan-87
Jul-87
Jan-88
Jul-88
Jan-89
Jul-89
Jan-90
Jul-90
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93



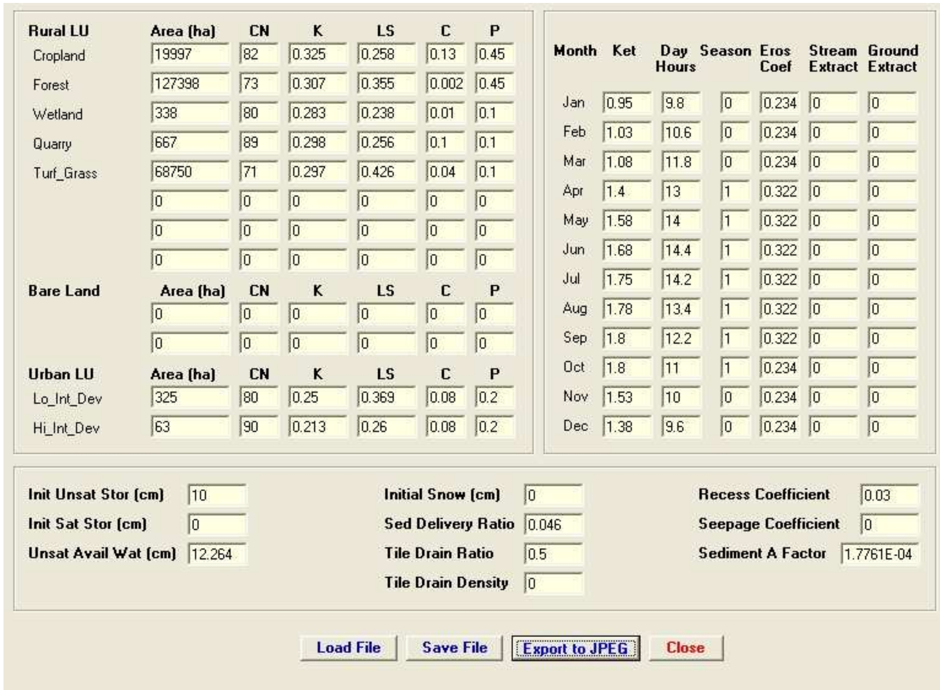
Simulated vs. Observed TN (kg/mo)
400000
300000
200000
100000
0
Observed
Simulated
Jan-83
Jul-83
Jan-84
Jul-84
Jan-85
Jul-85
Jan-86
Jul-86
Jan-87
Jul-87
Jan-88
Jul-88
Jan-89
Jul-89
Jan-90
Jul-90
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93

No TSS data



Simulated vs. Observed TP (kg/mo)
45000
30000
15000
0
Observed
Simulated
Jan-83
Jul-83
Jan-84
Jul-84
Jan-85
Jul-85
Jan-86
Jul-86
Jan-87
Jul-87
Jan-88
Jul-88
Jan-89
Jul-89
Jan-90
Jul-90
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93

Elm Fork/North Fork River (OK and TX)



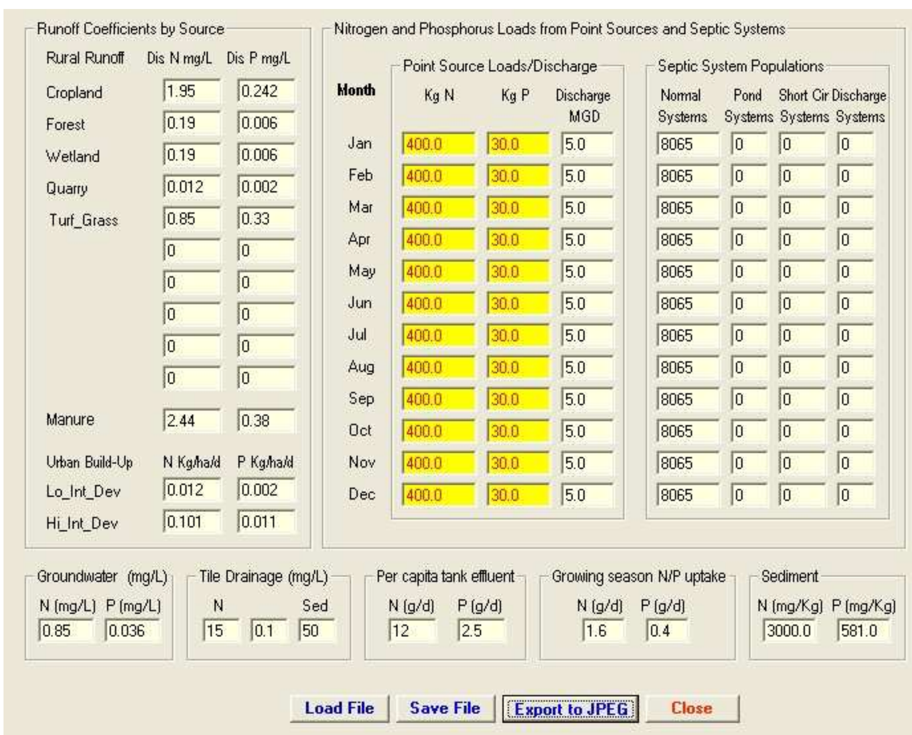
Rural LU	Area (ha)	CN	K	LS	C	P
Cropland	19997	82	0.325	0.258	0.13	0.45
Forest	127398	73	0.307	0.355	0.002	0.45
Wetland	338	80	0.283	0.238	0.01	0.1
Quarry	667	89	0.298	0.256	0.1	0.1
Turf_Grass	68750	71	0.297	0.426	0.04	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	325	80	0.25	0.369	0.08	0.2
Hi_Int_Dev	63	90	0.213	0.26	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.95	9.8	0	0.234	0	0
Feb	1.03	10.6	0	0.234	0	0
Mar	1.08	11.8	0	0.234	0	0
Apr	1.4	13	1	0.322	0	0
May	1.58	14	1	0.322	0	0
Jun	1.68	14.4	1	0.322	0	0
Jul	1.75	14.2	1	0.322	0	0
Aug	1.78	13.4	1	0.322	0	0
Sep	1.8	12.2	1	0.322	0	0
Oct	1.8	11	1	0.234	0	0
Nov	1.53	10	0	0.234	0	0
Dec	1.38	9.6	0	0.234	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.03
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.046	Seepage Coefficient	0
Unsat Avail Wat (cm)	12.264	Tile Drain Ratio	0.5	Sediment A Factor	1.7761E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Cropland	1.95	0.242
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	0.85	0.33
	0	0
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	N Kg/ha/d	P Kg/ha/d
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

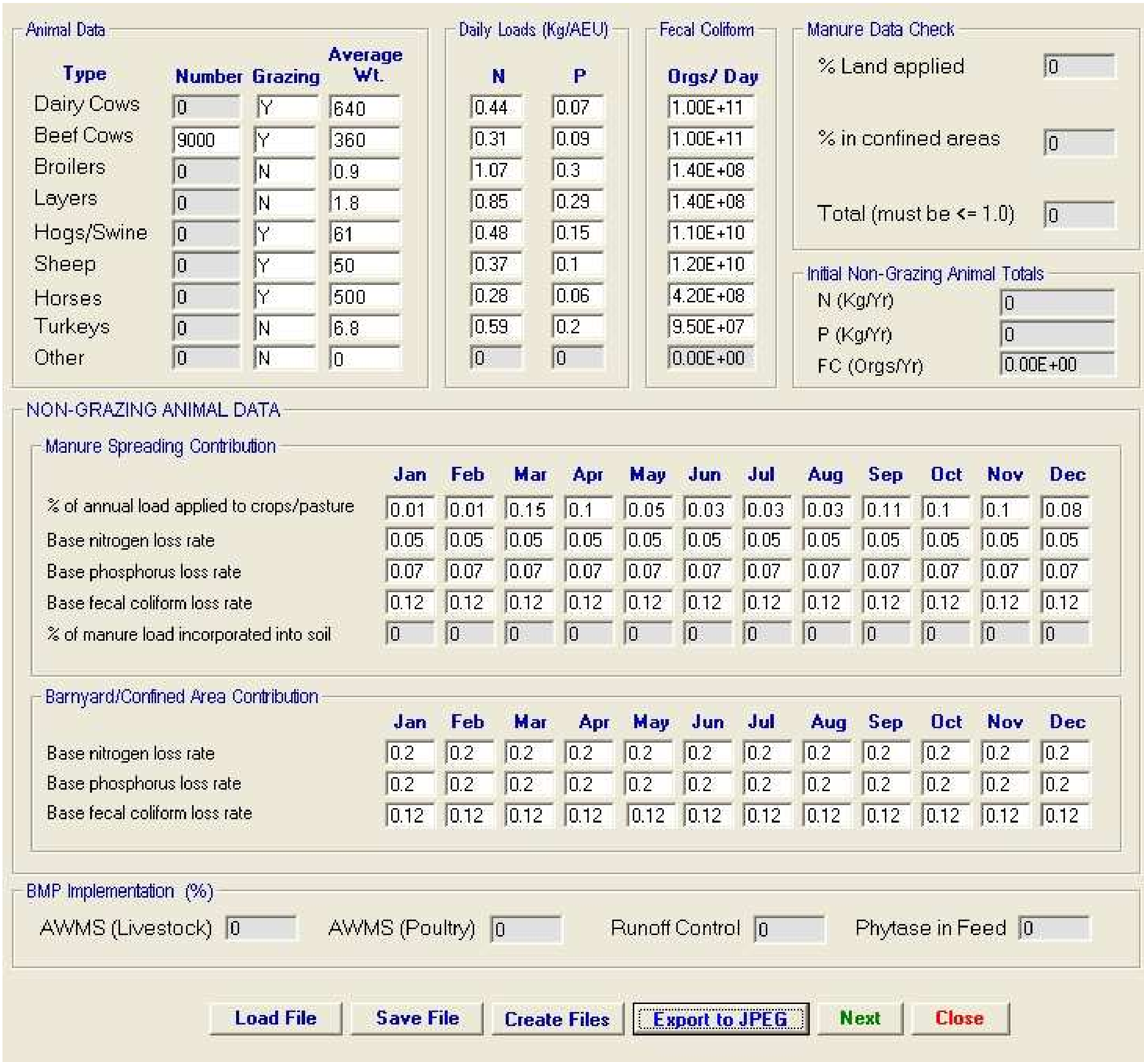
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	400.0	30.0	5.0	8065	0	0	0
Feb	400.0	30.0	5.0	8065	0	0	0
Mar	400.0	30.0	5.0	8065	0	0	0
Apr	400.0	30.0	5.0	8065	0	0	0
May	400.0	30.0	5.0	8065	0	0	0
Jun	400.0	30.0	5.0	8065	0	0	0
Jul	400.0	30.0	5.0	8065	0	0	0
Aug	400.0	30.0	5.0	8065	0	0	0
Sep	400.0	30.0	5.0	8065	0	0	0
Oct	400.0	30.0	5.0	8065	0	0	0
Nov	400.0	30.0	5.0	8065	0	0	0
Dec	400.0	30.0	5.0	8065	0	0	0

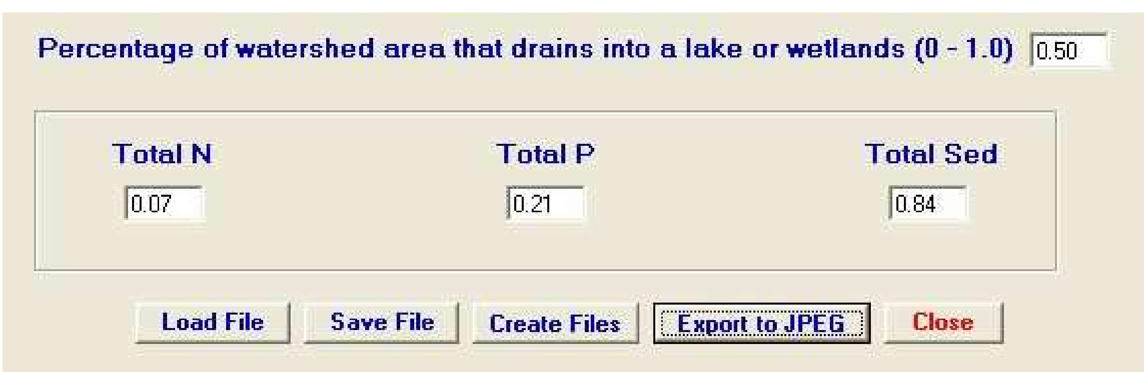
Groundwater (mg/L): N (mg/L)	P (mg/L)	Tile Drainage (mg/L): N	P	Sed	Per capita tank effluent: N (g/d)	P (g/d)	Growing season N/P uptake: N (g/d)	P (g/d)	Sediment: N (mg/Kg)	P (mg/Kg)
0.85	0.036	15	0.1	50	12	2.5	1.6	0.4	3000.0	581.0

Load File | Save File | Export to JPEG | Close

Nutrient file

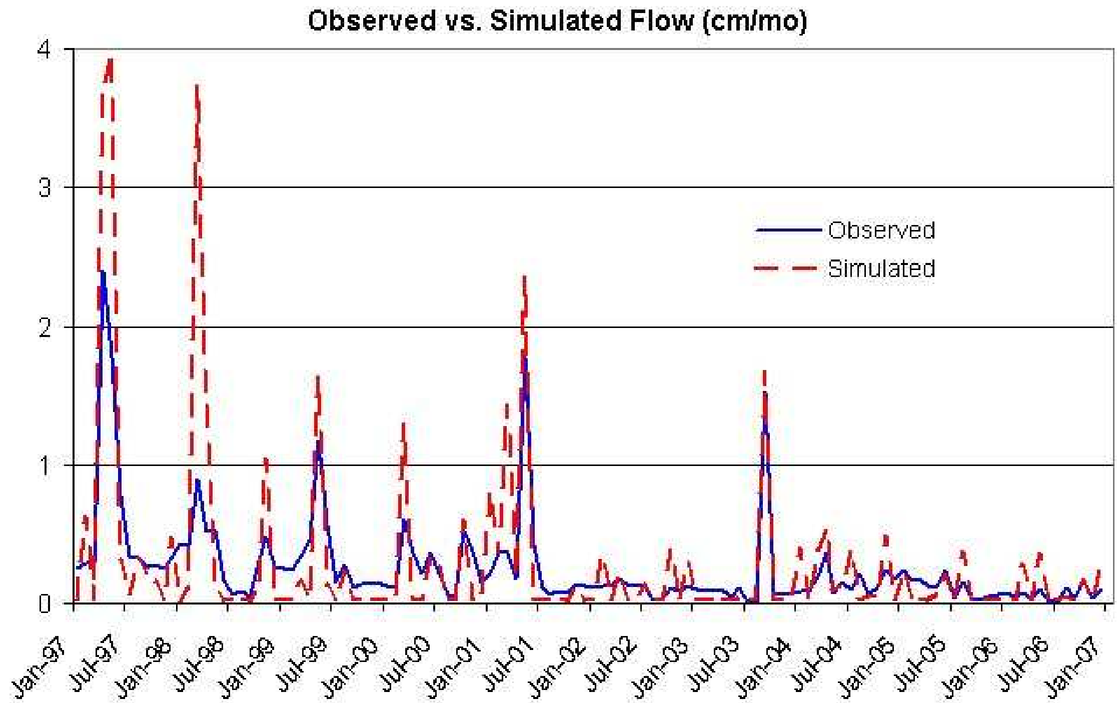


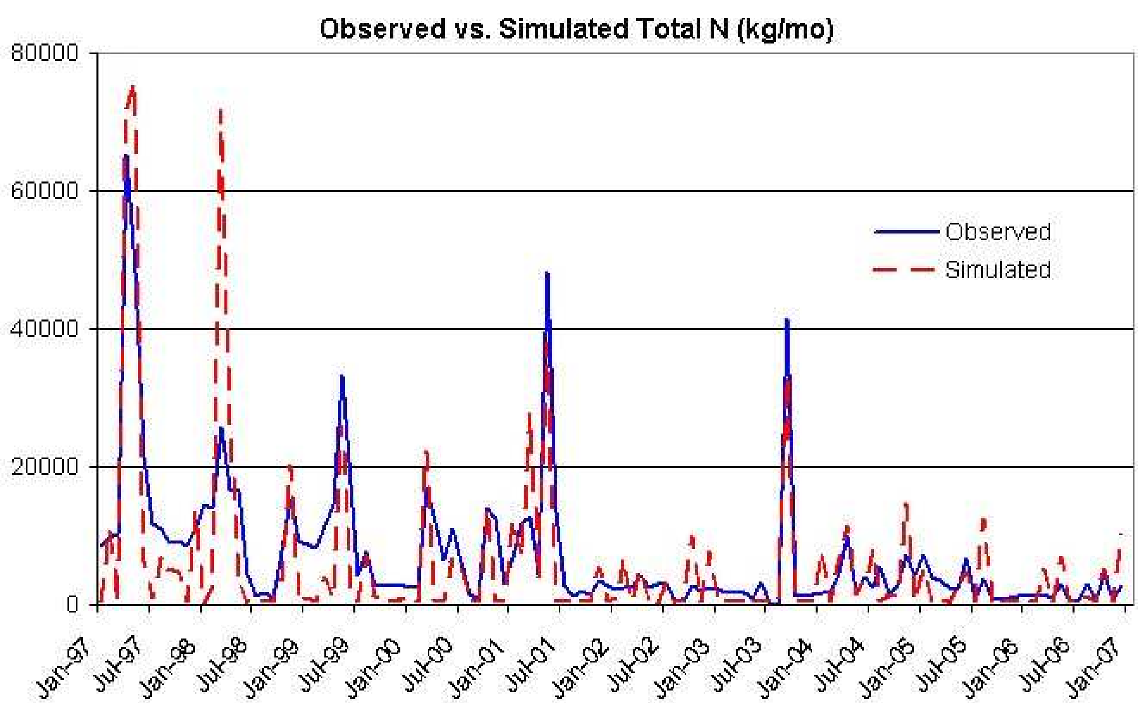
Animal file

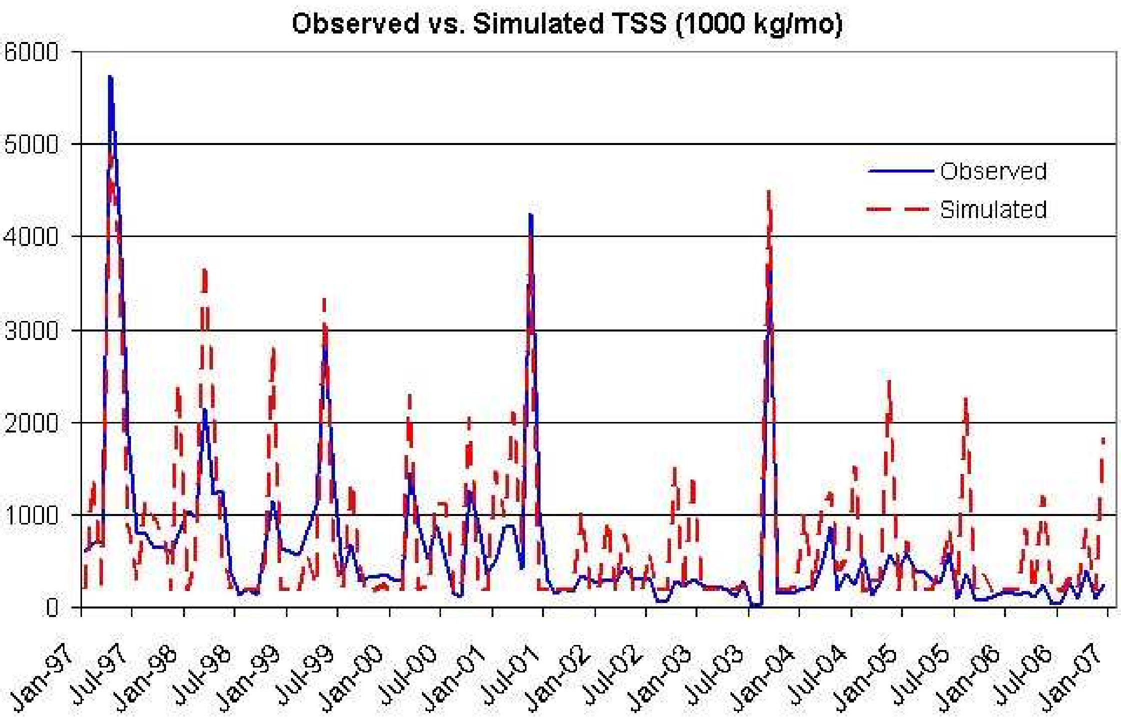


Retention file

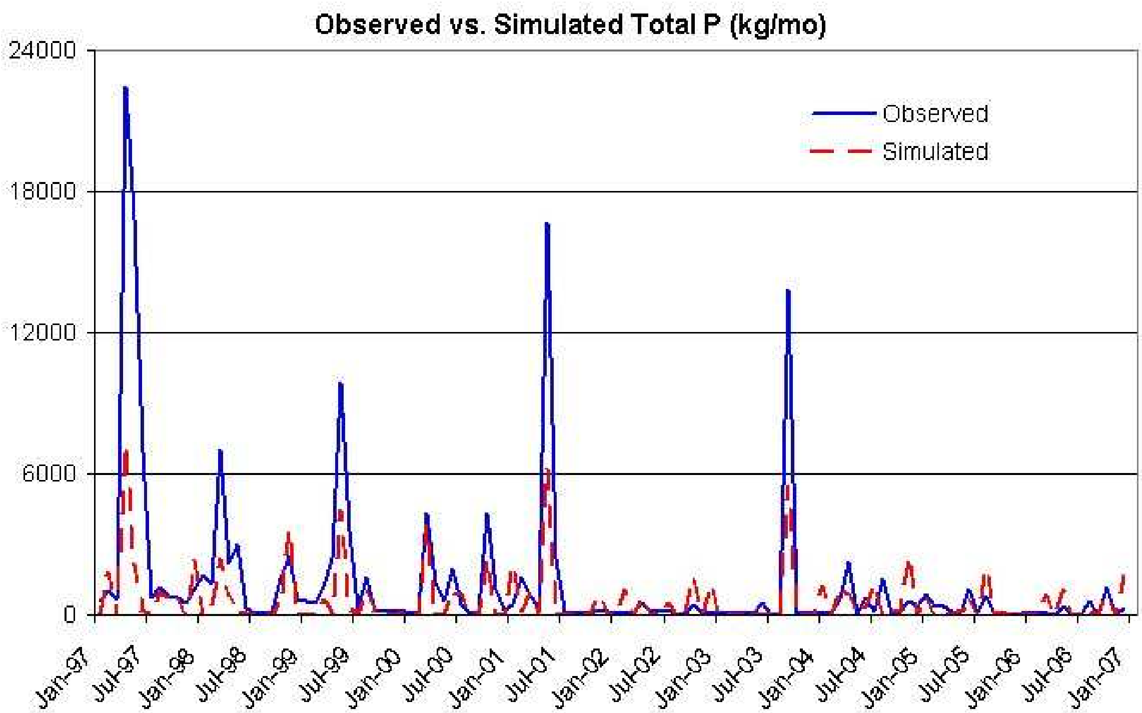
Elm Fork/North Fork River (OK and TX)







Observed vs. Simulated TSS (1000 kg/mo)
6000
5000
4000
3000
2000
1000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07



Observed vs. Simulated Total P (kg/mo)
24000
18000
12000
6000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

Frazier Creek (TX)

Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	914	63	0.26	1.37	0.03	0.45
Cropland	39	75	0.26	0.623	0.12	0.45
Forest	9701	60	0.26	1.581	0.015	0.45
Wetland	1051	80	0.262	1.022	0.01	0.1
Turf_Grass	371	58	0.26	1.704	0.04	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	118	80	0.26	2.247	0.08	0.2
Hi_Int_Dev	18	90	0.26	1.143	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	1.07	10	0	0.11	0	0
Feb	1.16	10.8	0	0.11	0	0
Mar	1.2	11.8	0	0.11	0	0
Apr	1.45	12.9	1	0.11	0	0
May	1.58	13.8	1	0.11	0	0
Jun	1.67	14.2	1	0.11	0	0
Jul	1.72	14	1	0.11	0	0
Aug	1.75	13.2	1	0.11	0	0
Sep	1.77	12.2	1	0.11	0	0
Oct	1.77	11.1	1	0.11	0	0
Nov	1.57	10.2	0	0.11	0	0
Dec	1.45	9.8	0	0.11	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.03
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.108	Seepage Coefficient	0
Unsat Avail Wat (cm)	11.0466	Tile Drain Ratio	0.5	Sediment A Factor	2.8000E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file

Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	0.75	0.179
Cropland	1.84	0.179
Forest	0.19	0.006
Wetland	0.19	0.006
Turf_Grass	0.75	0.29
	0	0
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

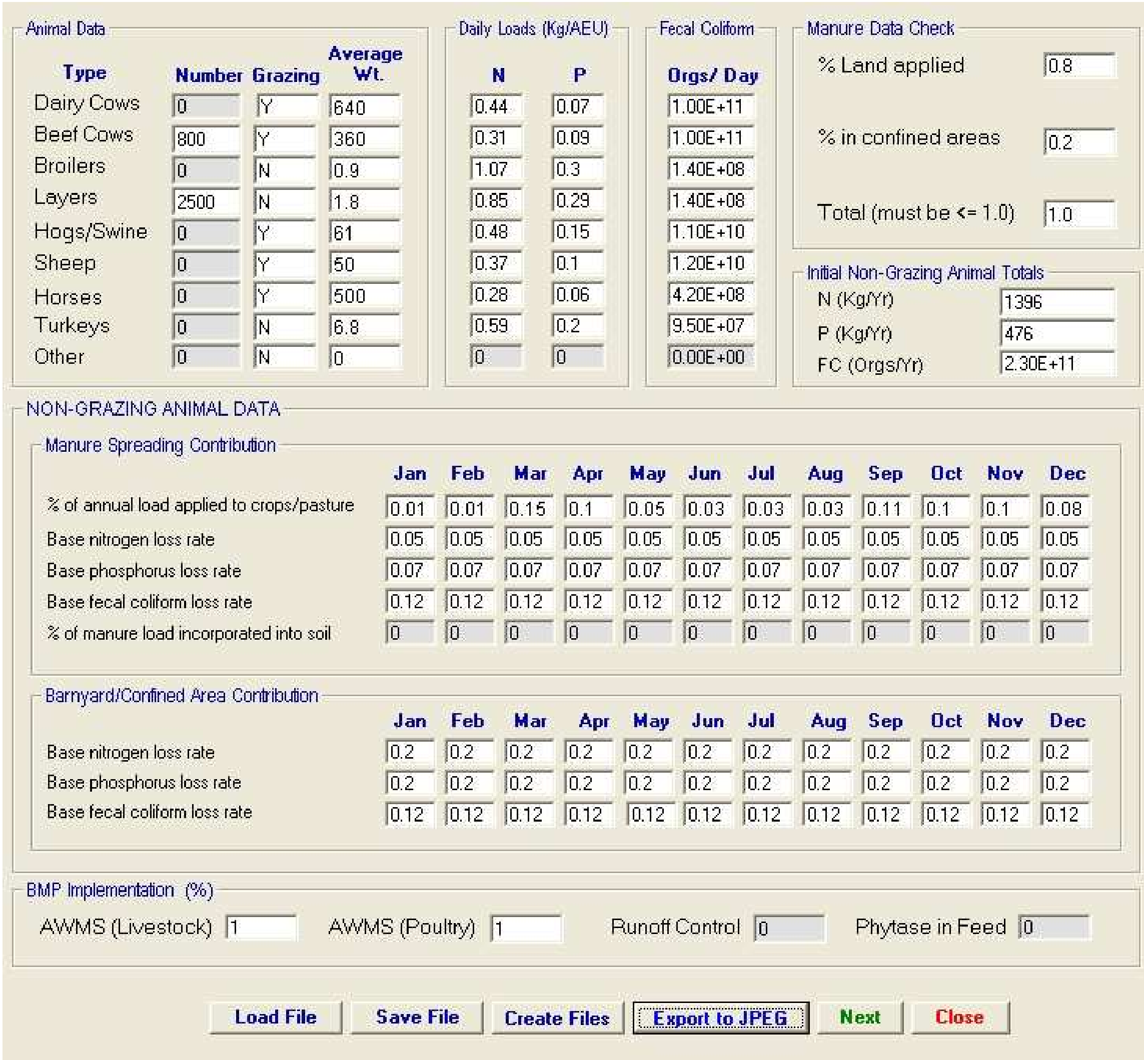
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	1487	0	0	0
Feb	0.0	0.0	0.0	1487	0	0	0
Mar	0.0	0.0	0.0	1487	0	0	0
Apr	0.0	0.0	0.0	1487	0	0	0
May	0.0	0.0	0.0	1487	0	0	0
Jun	0.0	0.0	0.0	1487	0	0	0
Jul	0.0	0.0	0.0	1487	0	0	0
Aug	0.0	0.0	0.0	1487	0	0	0
Sep	0.0	0.0	0.0	1487	0	0	0
Oct	0.0	0.0	0.0	1487	0	0	0
Nov	0.0	0.0	0.0	1487	0	0	0
Dec	0.0	0.0	0.0	1487	0	0	0

Groundwater (mg/L)		Tile Drainage (mg/L)			Per capita tank effluent		Growing season N/P uptake		Sediment	
N (mg/L)	P (mg/L)	N		Sed	N (g/d)	P (g/d)	N (g/d)	P (g/d)	N (mg/Kg)	P (mg/Kg)
0.26	0.05	15	0.1	50	12	2.5	1.6	0.4	3000.0	355.0

Load File | Save File | Export to JPEG | Close

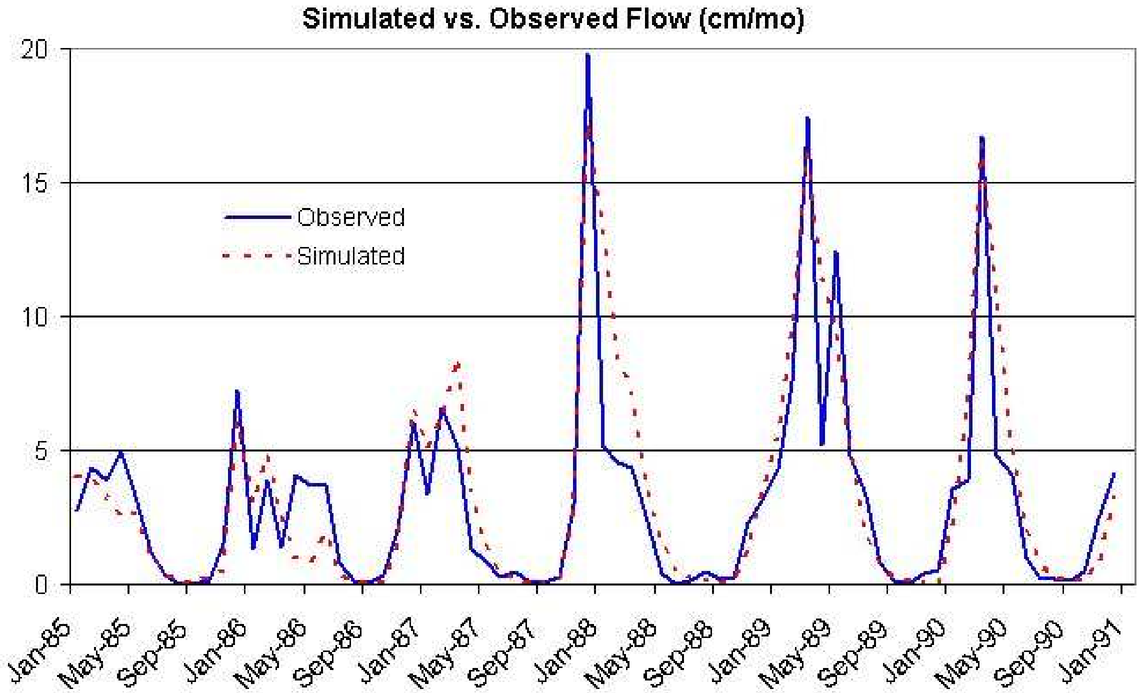
Nutrient file

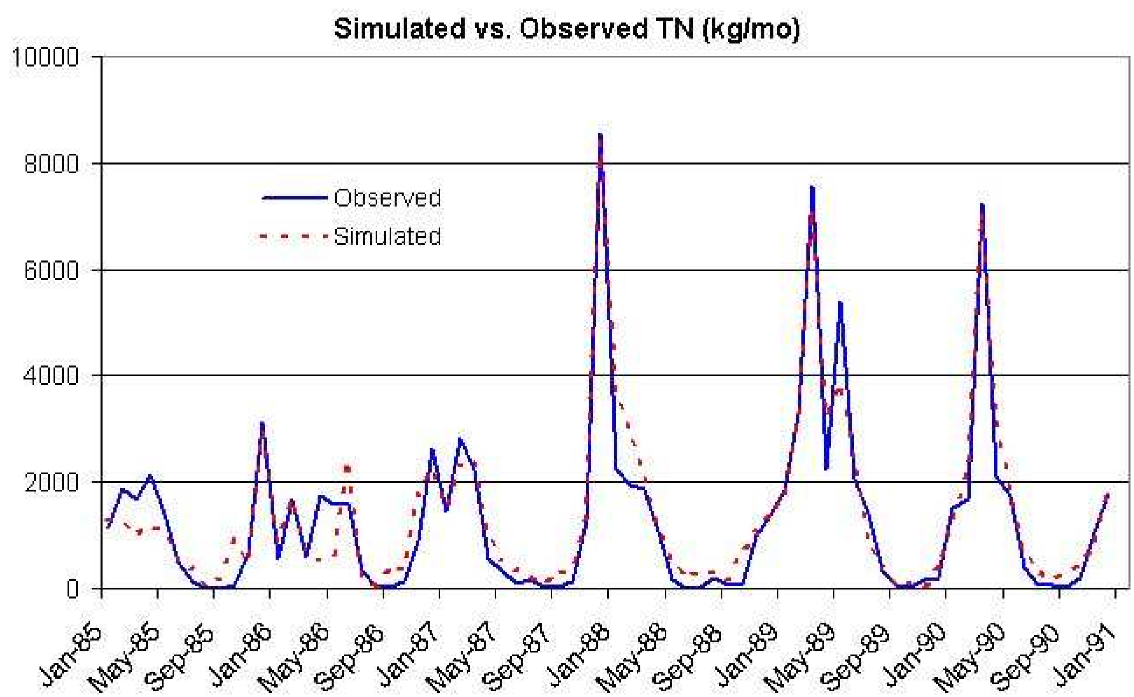


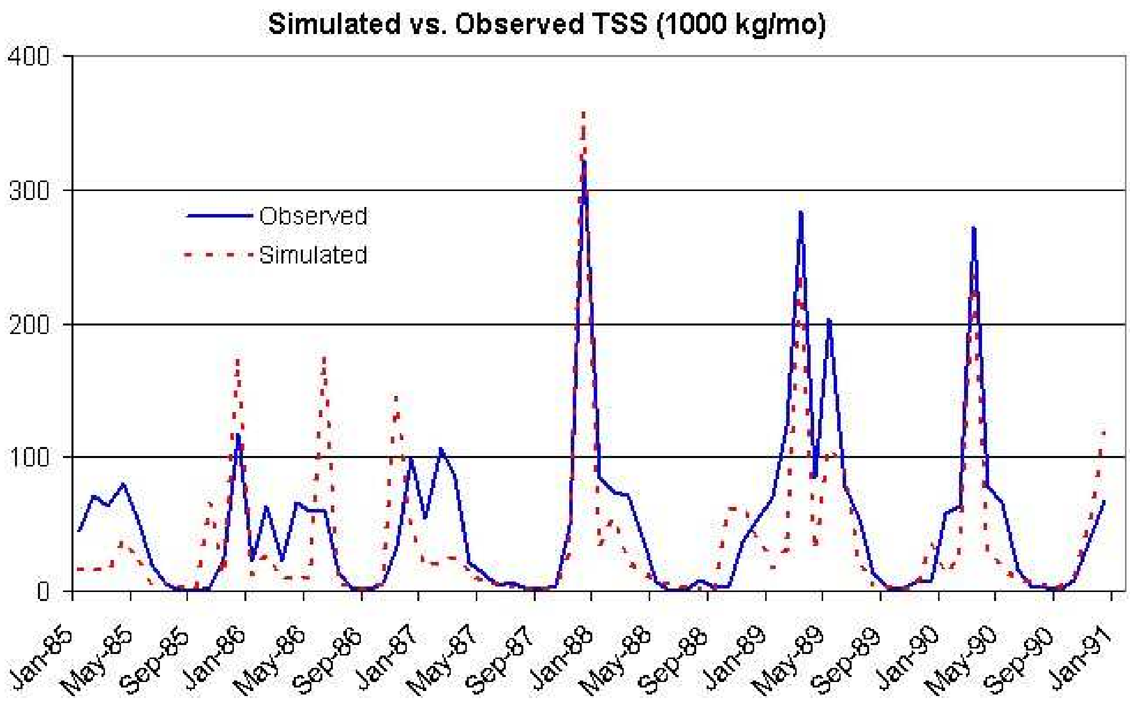
Animal file

Retention file

Frazier Creek (TX)






Simulated vs. Observed TSS (1000 kg/mo)
400
300
200
100
0
Observed
Simulated
Jan-85
May-85
Sep-85
Jan-86
May-86
Sep-86
Jan-87
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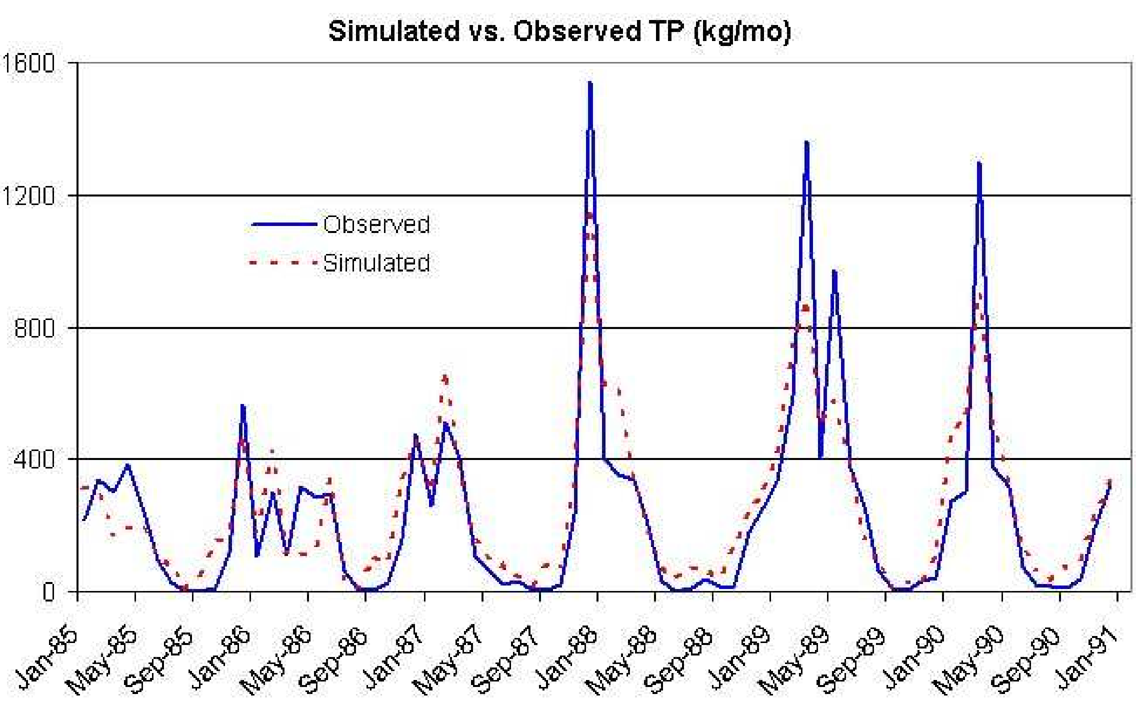
May-90
Sep-90
Jan-91


Simulated vs. Observed TP (kg/mo)
1600
1200
800
400
0
Observed
Simulated
Jan-85
May-85
Sep-85
Jan-86
May-86
Sep-86
Jan-87
May-87
Sep-87
Jan-88
May-88
Sep-88
Jan-89
May-89
Sep-89
Jan-90
May-90
Sep-90
Jan-91

Gallinas River (NM)

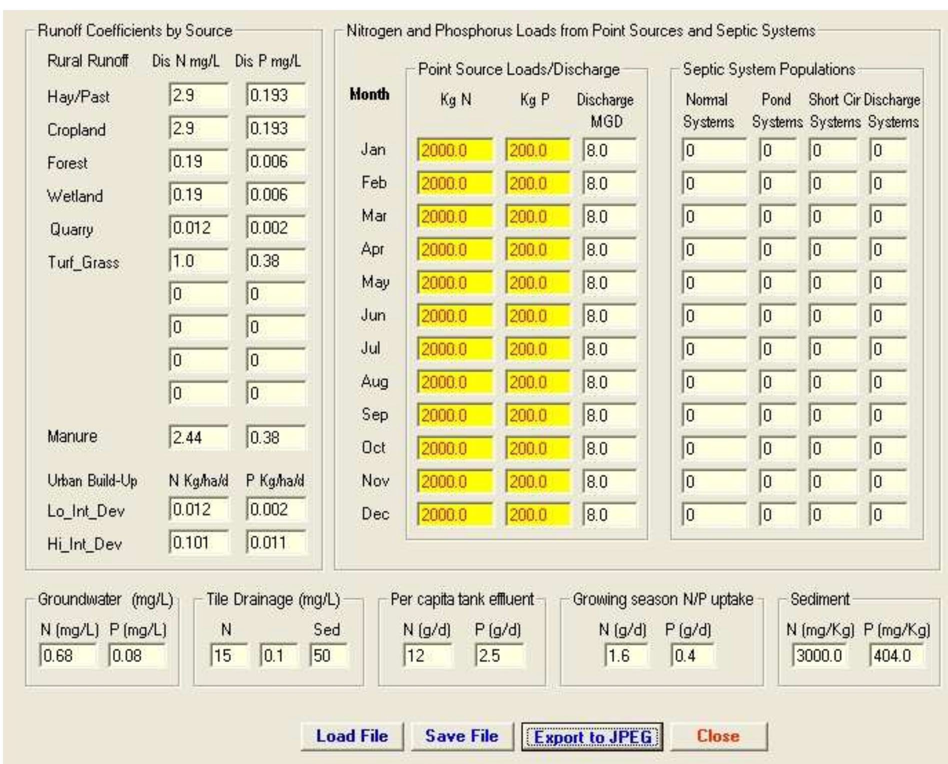
Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	272	75	0.351	0.388	0.03	0.45
Cropland	92	82	0.357	0.244	0.15	0.45
Forest	38486	73	0.318	2.19	0.002	0.74
Wetland	1162	87	0.382	0.307	0.01	0.1
Quarry	97	89	0.388	1.511	0.1	0.1
Turf_Grass	38580	71	0.372	0.401	0.04	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	648	83	0.399	0.332	0.08	0.2
Hi_Int_Dev	321	93	0.4	0.301	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.51	9.7	0	0.152	0	0
Feb	0.56	10.6	0	0.152	0	0
Mar	0.58	11.8	0	0.152	0	0
Apr	0.7	13.1	1	0.198	0	0
May	0.78	14.1	1	0.198	0	0
Jun	0.83	14.5	1	0.198	0	0
Jul	0.86	14.3	1	0.198	0	0
Aug	0.86	13.4	1	0.198	0	0
Sep	0.88	12.2	1	0.198	0	0
Oct	0.88	10.9	1	0.152	0	0
Nov	0.77	9.9	0	0.152	0	0
Dec	0.7	9.5	0	0.152	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.08
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.061	Seepage Coefficient	0
Unsat Avail Wat (cm)	5.02051	Tile Drain Ratio	0.5	Sediment A Factor	2.4467E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	2.9	0.193
Cropland	2.9	0.193
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	1.0	0.38
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge			Septic System Populations			
	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	2000.0	200.0	8.0	0	0	0	0
Feb	2000.0	200.0	8.0	0	0	0	0
Mar	2000.0	200.0	8.0	0	0	0	0
Apr	2000.0	200.0	8.0	0	0	0	0
May	2000.0	200.0	8.0	0	0	0	0
Jun	2000.0	200.0	8.0	0	0	0	0
Jul	2000.0	200.0	8.0	0	0	0	0
Aug	2000.0	200.0	8.0	0	0	0	0
Sep	2000.0	200.0	8.0	0	0	0	0
Oct	2000.0	200.0	8.0	0	0	0	0
Nov	2000.0	200.0	8.0	0	0	0	0
Dec	2000.0	200.0	8.0	0	0	0	0

Groundwater (mg/L)		Tile Drainage (mg/L)			Per capita tank effluent		Growing season N/P uptake		Sediment	
N (mg/L)	P (mg/L)	N		Sed	N (g/d)	P (g/d)	N (g/d)	P (g/d)	N (mg/Kg)	P (mg/Kg)
0.68	0.08	15	0.1	50	12	2.5	1.6	0.4	3000.0	404.0

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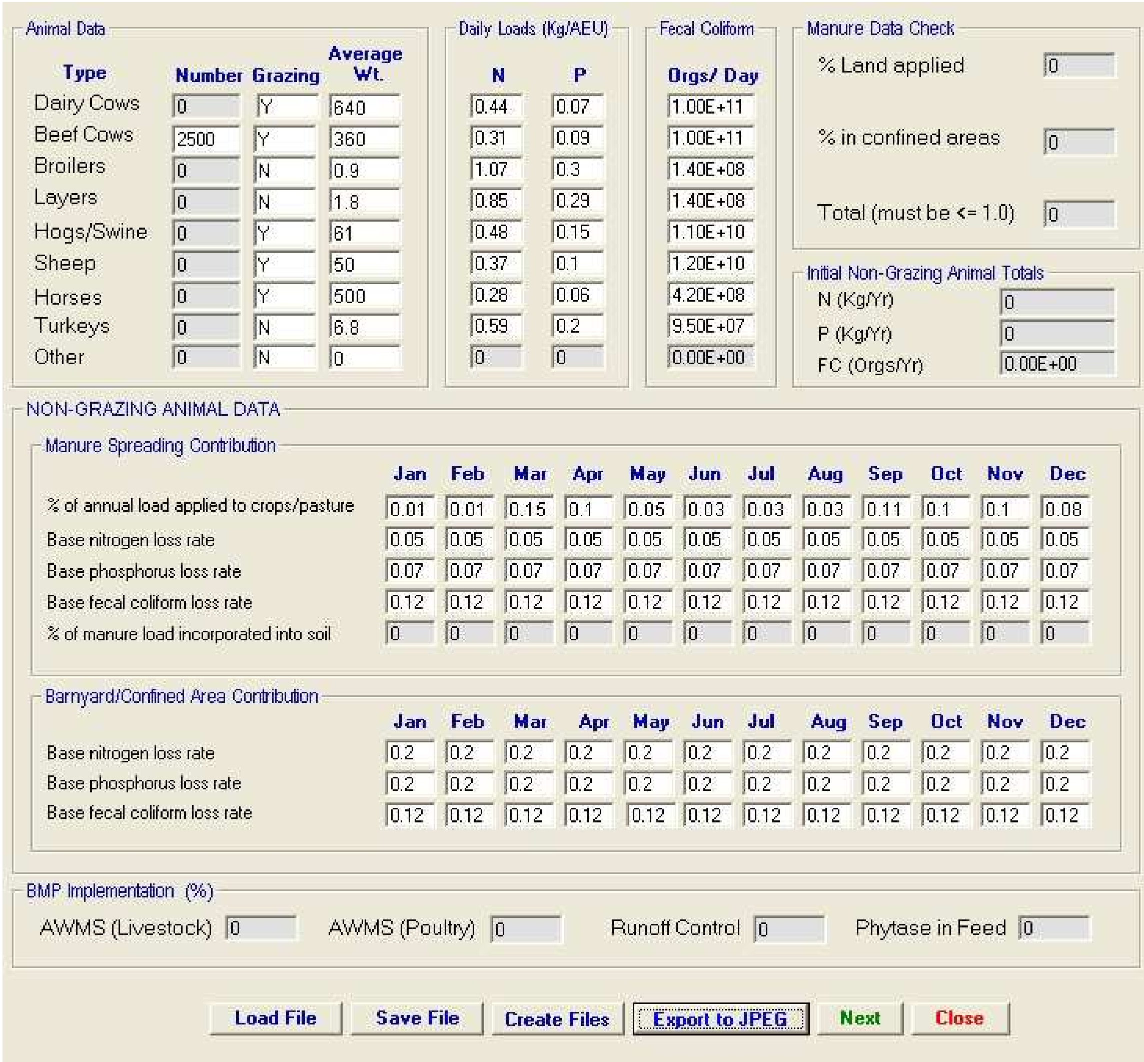
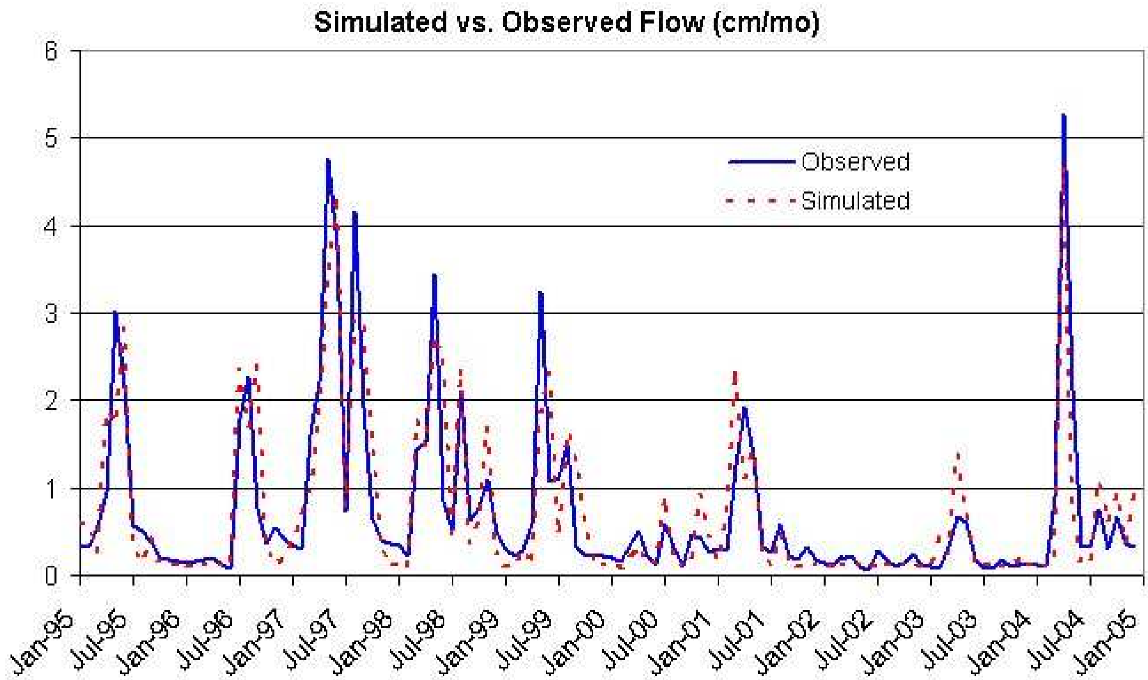
Nutrient file

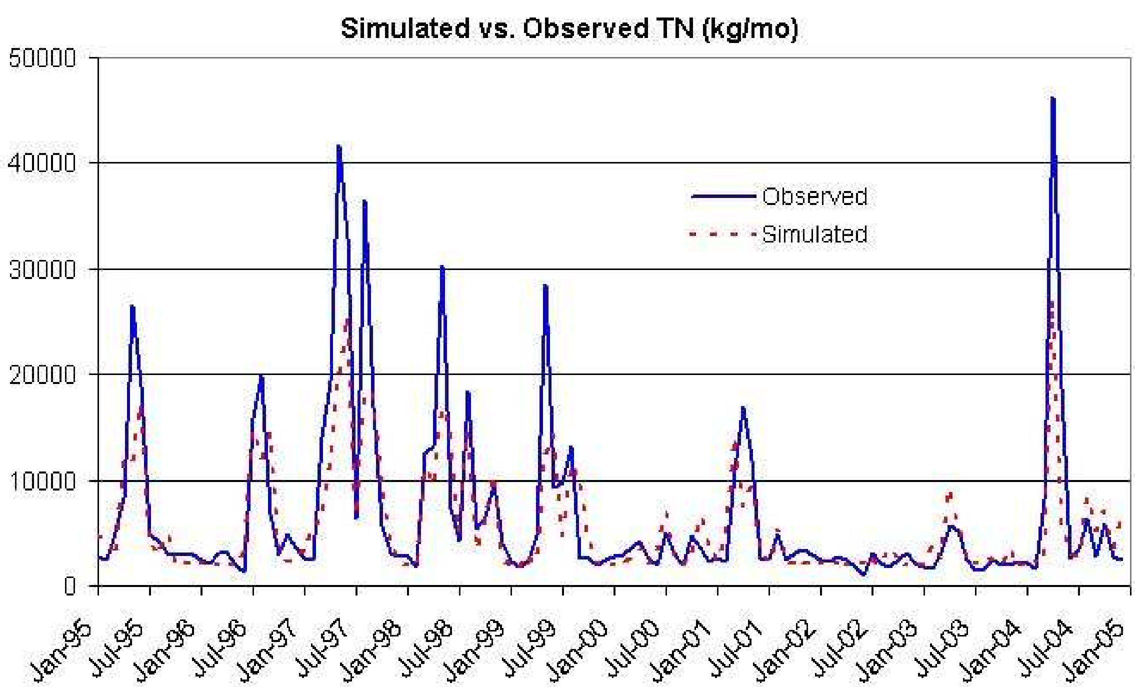


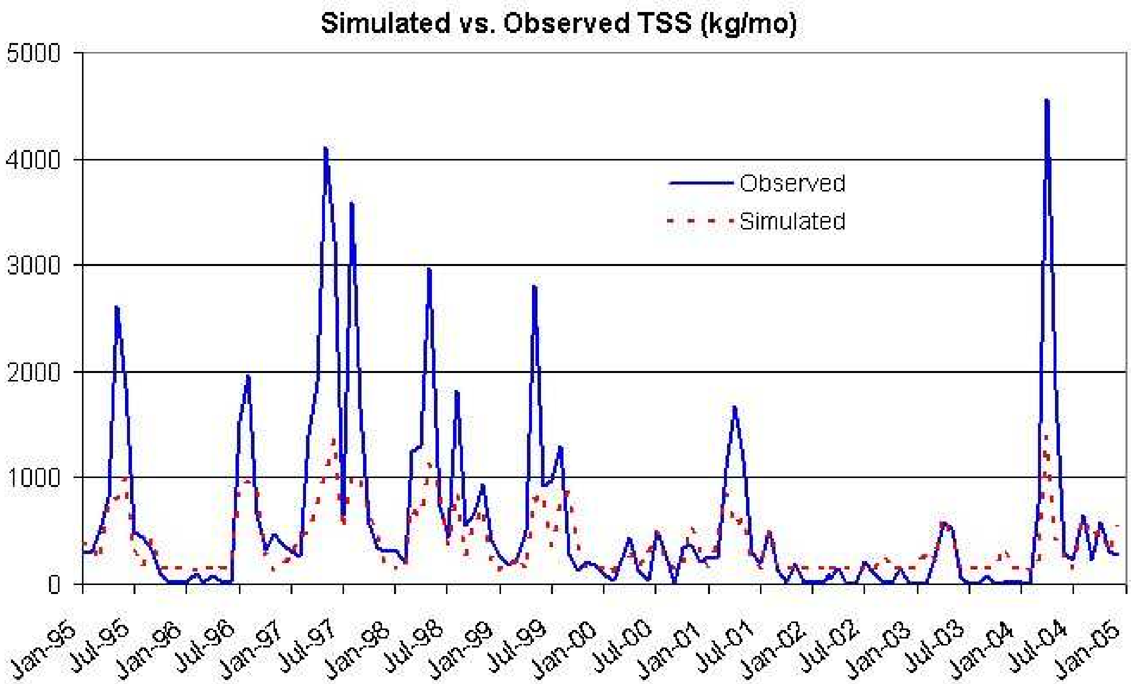
Animal file

Retention file

Gallinas River (NM)






Simulated vs. Observed TSS (kg/mo)
5000
4000
3000
2000
1000
0
Observed
Simulated
Jan-95
Jul-95
Jan-96
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Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
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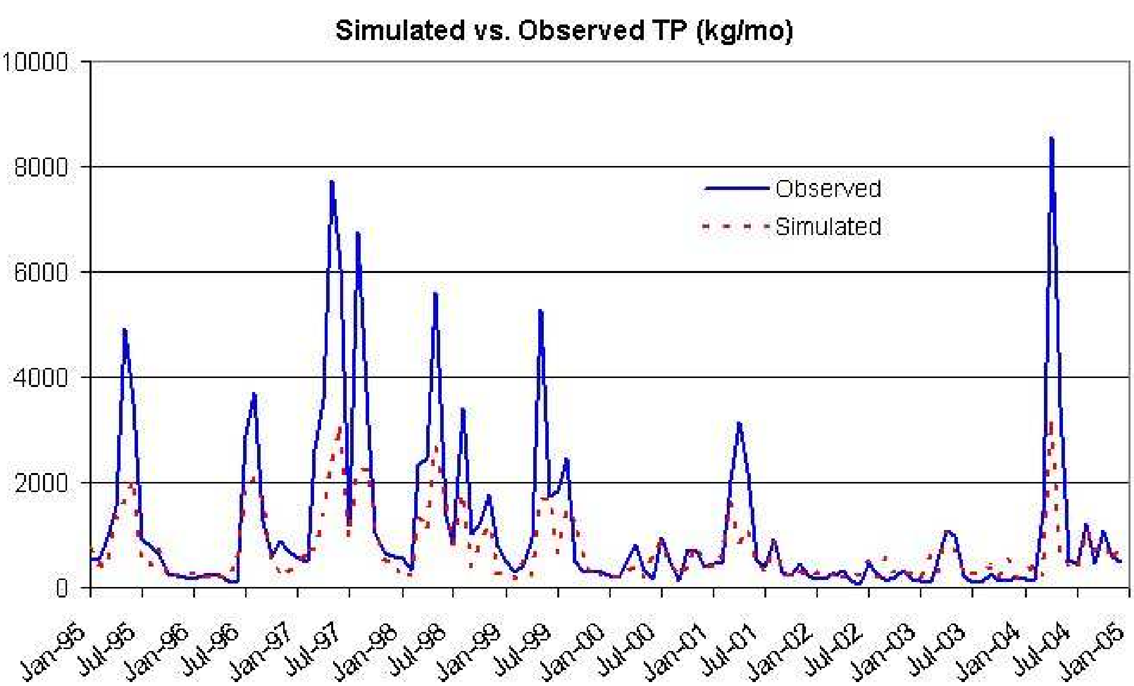
Jan-04
Jul-04
Jan-05


Simulated vs. Observed TP (kg/mo)
10000
8000
6000
4000
2000
0
Observed
Simulated
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05

Hurricane Creek (AR)

Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	3827	75	0.328	0.279	0.03	0.45
Cropland	229	82	0.303	0.384	0.42	0.45
Forest	35774	73	0.323	0.28	0.05	0.45
Wetland	6254	90	0.328	0.248	0.01	0.1
Quarry	47	89	0.313	0.24	0.8	0.1
Turf_Grass	1821	71	0.326	0.314	0.08	0.2
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	2268	83	0.32	0.31	0.08	0.2
Hi_Int_Dev	379	93	0.309	0.325	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.82	9.9	0	0.118	0	0
Feb	0.88	10.7	0	0.118	0	0
Mar	0.91	11.8	0	0.118	0	0
Apr	1.08	13	1	0.204	0	0
May	1.16	13.9	1	0.204	0	0
Jun	1.22	14.4	1	0.204	0	0
Jul	1.26	14.1	1	0.204	0	0
Aug	1.27	13.3	1	0.204	0	0
Sep	1.28	12.2	1	0.204	0	0
Oct	1.28	11	1	0.118	0	0
Nov	1.15	10.1	0	0.118	0	0
Dec	1.08	9.6	0	0.118	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.07	Seepage Coefficient	0
Unsat Avail Wat (cm)	15.0628	Tile Drain Ratio	0.5	Sediment A Factor	4.2016E-04
		Tile Drain Density	0		

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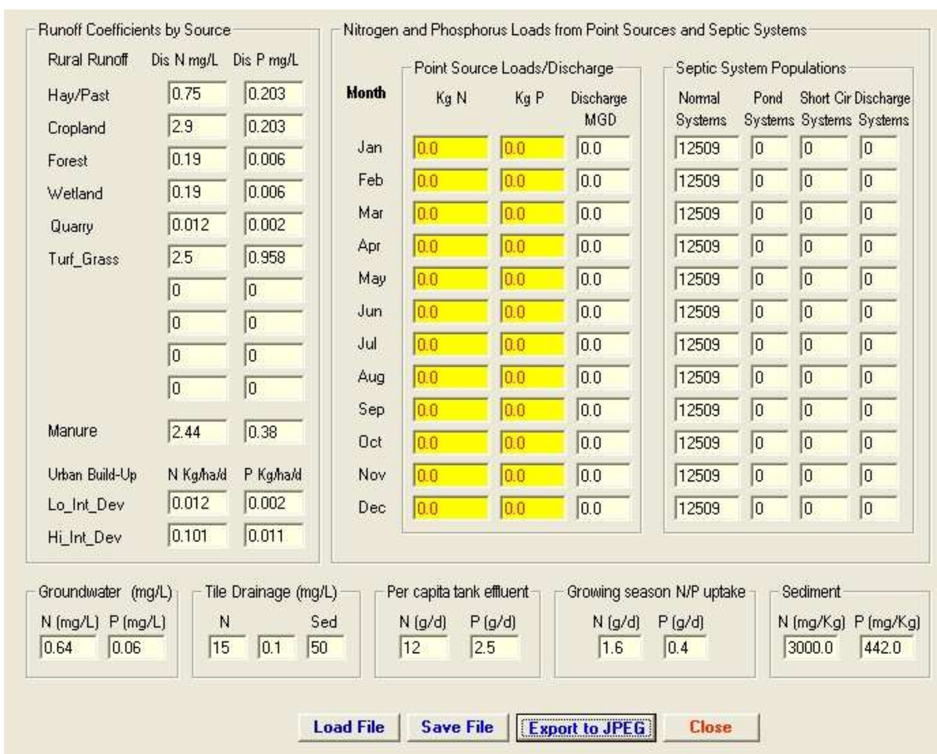
Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	0.75	0.203
Cropland	2.9	0.203
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	2.5	0.958
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	12509	0	0	0
Feb	0.0	0.0	0.0	12509	0	0	0
Mar	0.0	0.0	0.0	12509	0	0	0
Apr	0.0	0.0	0.0	12509	0	0	0
May	0.0	0.0	0.0	12509	0	0	0
Jun	0.0	0.0	0.0	12509	0	0	0
Jul	0.0	0.0	0.0	12509	0	0	0
Aug	0.0	0.0	0.0	12509	0	0	0
Sep	0.0	0.0	0.0	12509	0	0	0
Oct	0.0	0.0	0.0	12509	0	0	0
Nov	0.0	0.0	0.0	12509	0	0	0
Dec	0.0	0.0	0.0	12509	0	0	0

Groundwater (mg/L): N (mg/L)	P (mg/L)	Tile Drainage (mg/L): N	P	Sed	Per capita tank effluent: N (g/d)	P (g/d)	Growing season N/P uptake: N (g/d)	P (g/d)	Sediment: N (mg/Kg)	P (mg/Kg)
0.64	0.06	15	0.1	50	12	2.5	1.6	0.4	3000.0	442.0

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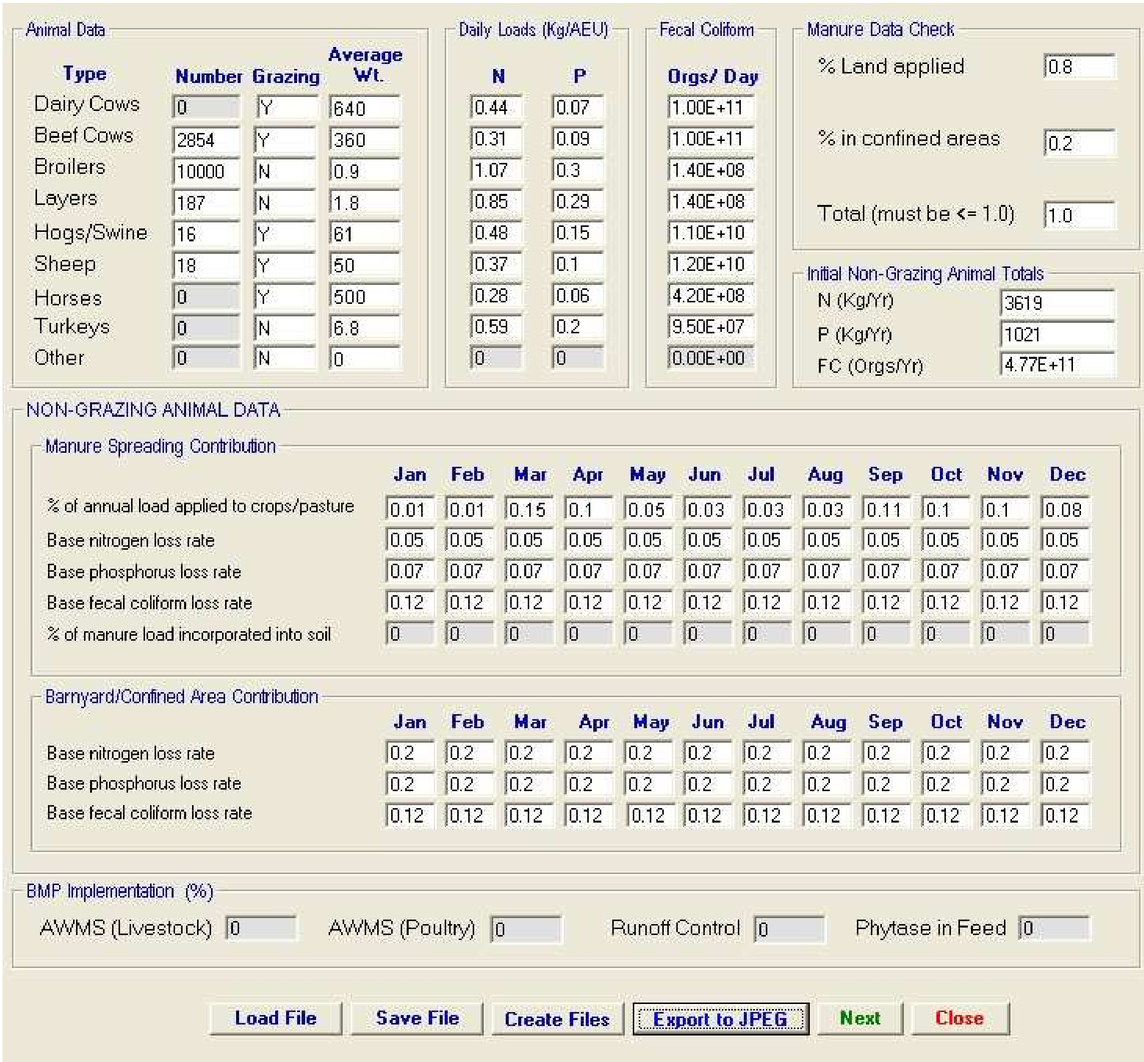
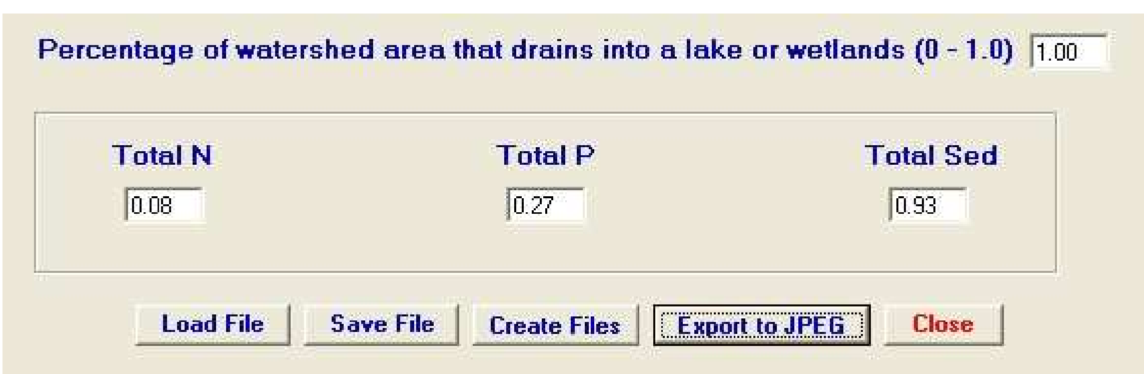
Nutrient file

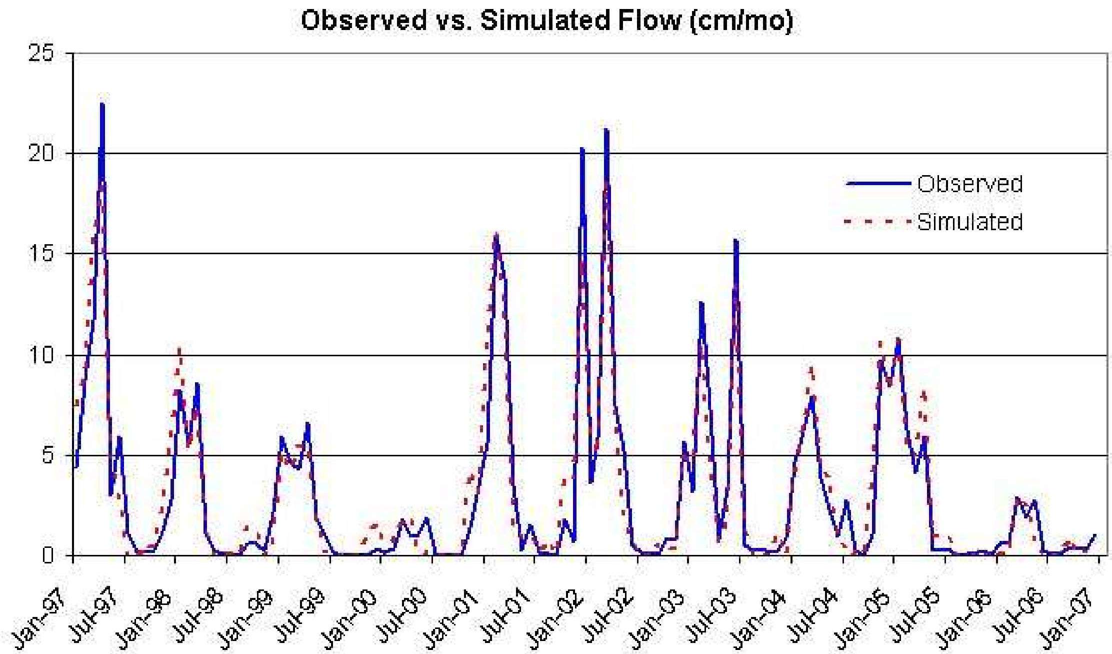


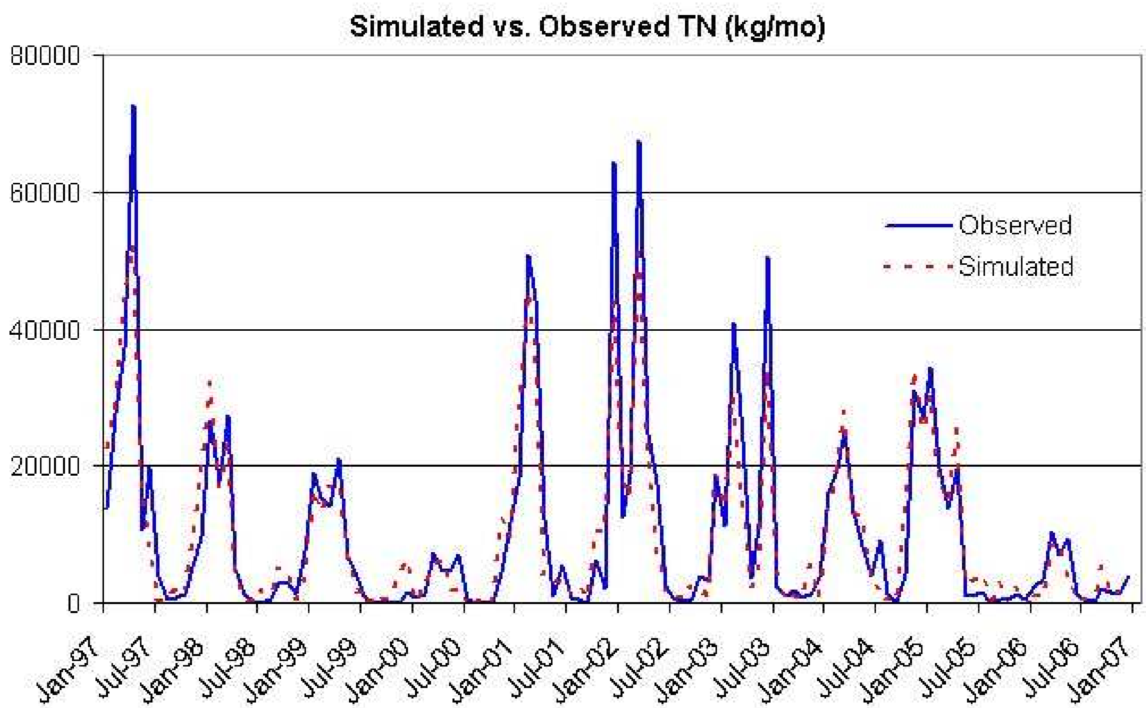
Animal file

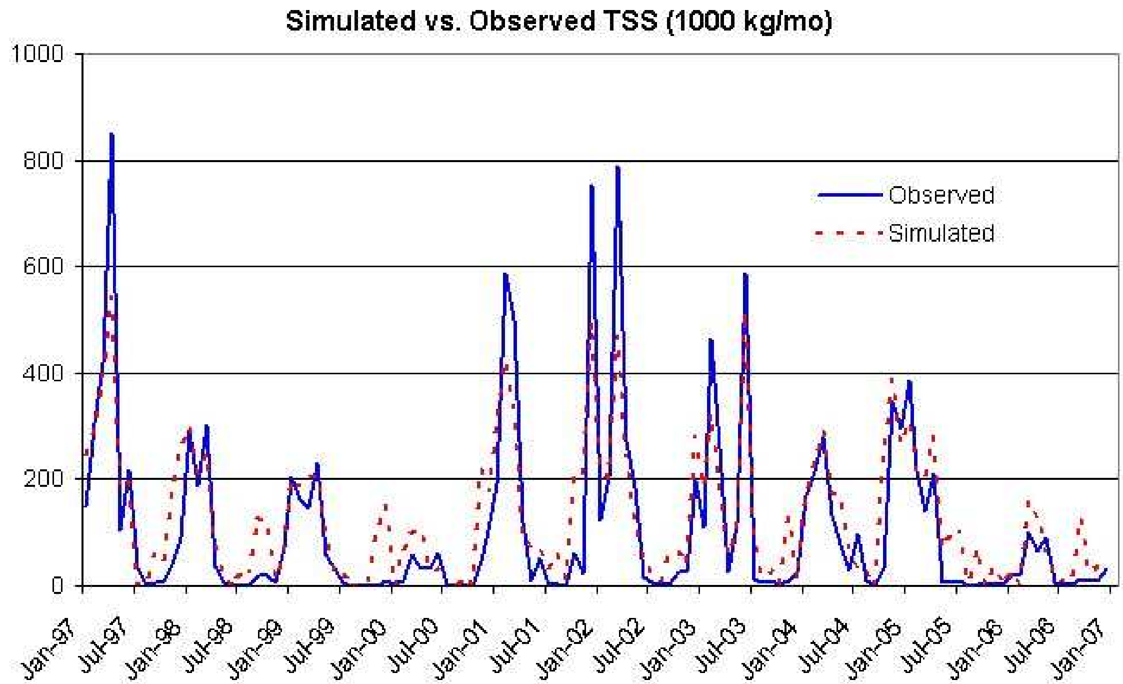


Retention file

Hurricane Creek (AR)






Simulated vs. Observed TSS (1000 kg/mo)
1000
800
600
400
200
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
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Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
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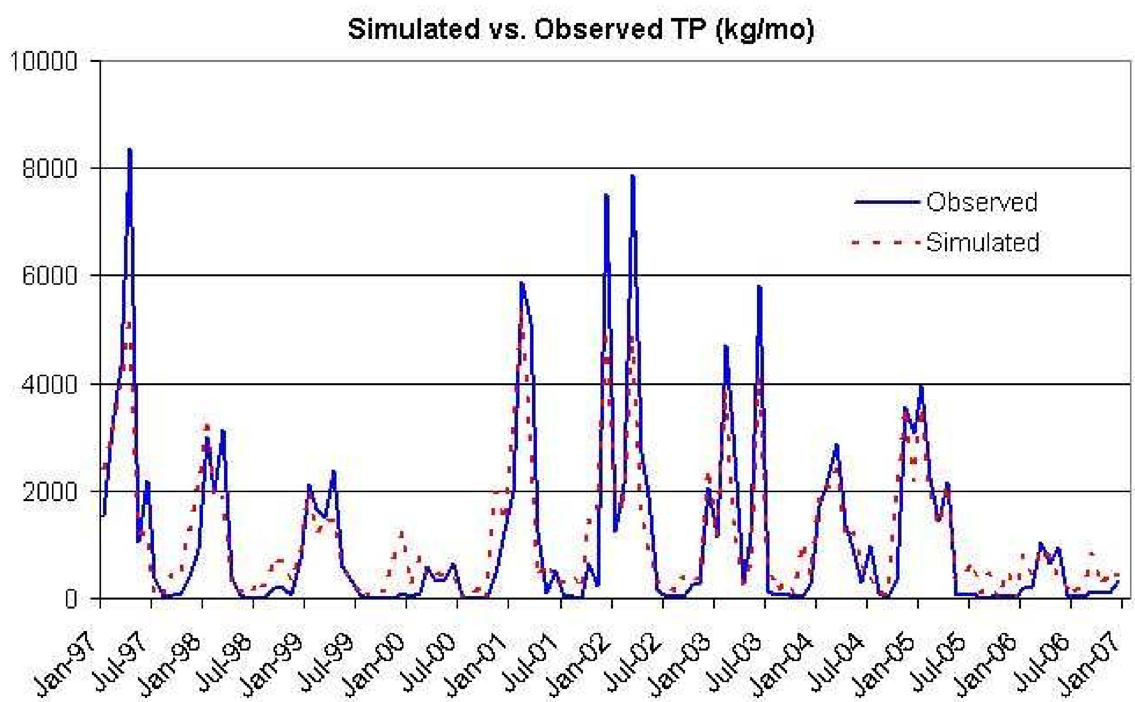
Jan-06
Jul-06
Jan-07


Simulated vs. Observed TP (kg/mo)
10000
8000
6000
4000
2000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

Moro Creek (AR)

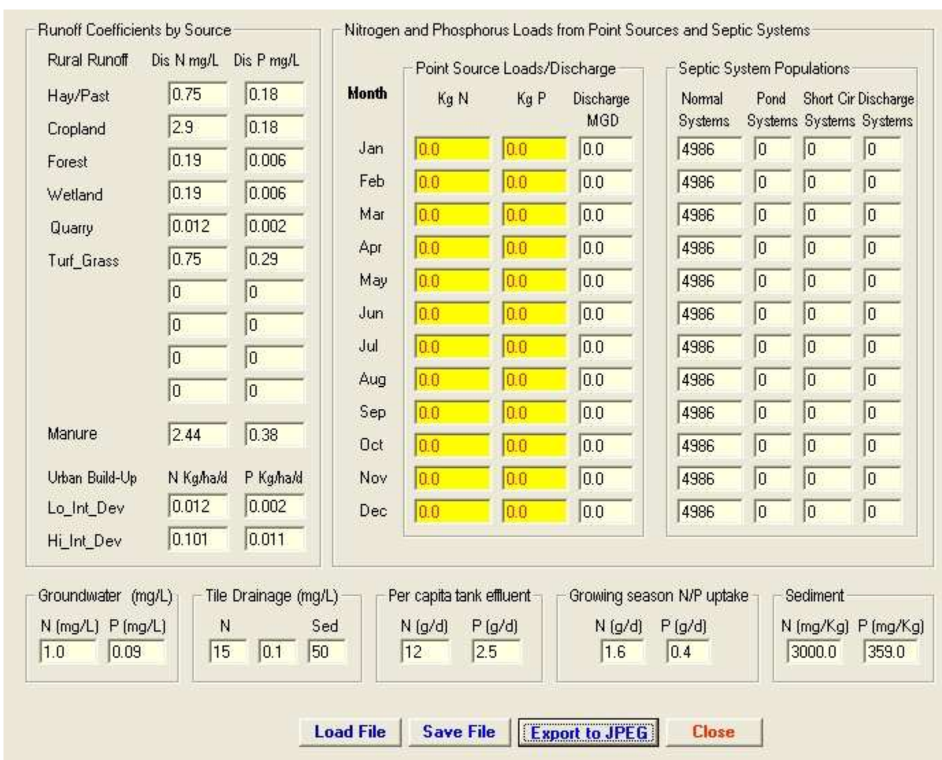
Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	1169	75	0.327	0.276	0.03	0.45
Cropland	46	85	0.372	0.288	0.42	0.45
Forest	76867	80	0.337	0.271	0.1	0.45
Wetland	16317	90	0.333	0.228	0.01	0.1
Quarry	13	91	0.376	0.223	0.8	0.1
Turf_Grass	1353	78	0.34	0.298	0.04	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	3538	84	0.34	0.296	0.08	0.2
Hi_Int_Dev	227	94	0.347	0.327	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.9	9.9	0	0.11	0	0
Feb	0.96	10.7	0	0.11	0	0
Mar	1.01	11.8	0	0.11	0	0
Apr	1.18	13	1	0.2	0	0
May	1.29	13.9	1	0.2	0	0
Jun	1.35	14.4	1	0.2	0	0
Jul	1.38	14.1	1	0.2	0	0
Aug	1.4	13.3	1	0.2	0	0
Sep	1.42	12.2	1	0.2	0	0
Oct	1.42	11	1	0.11	0	0
Nov	1.27	10.1	0	0.11	0	0
Dec	1.18	9.6	0	0.11	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.058	Seepage Coefficient	0
Unsat Avail Wat (cm)	16.2052	Tile Drain Ratio	0.5	Sediment A Factor	1.3165E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	0.75	0.18
Cropland	2.9	0.18
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	0.75	0.29
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

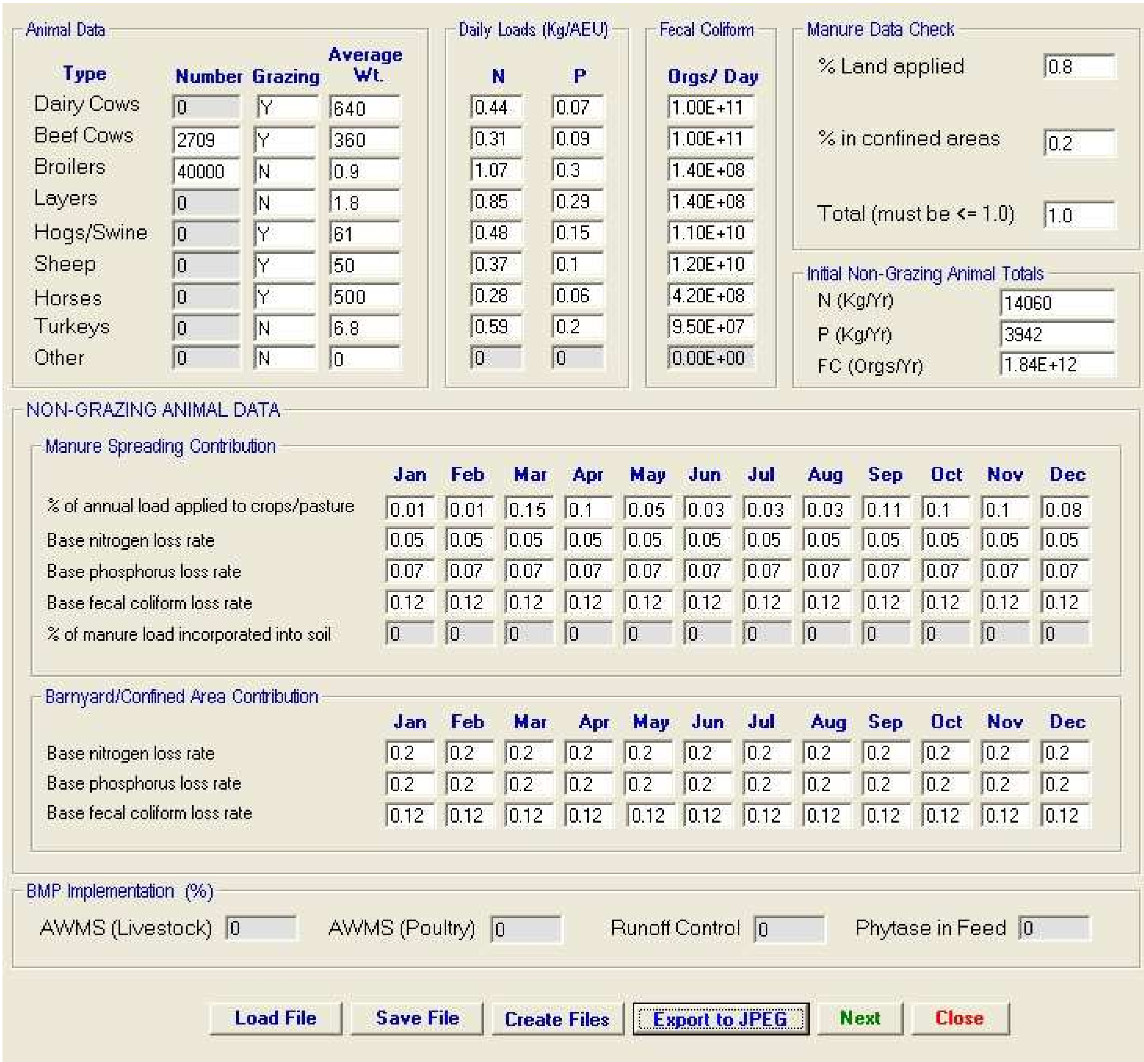
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	4986	0	0	0
Feb	0.0	0.0	0.0	4986	0	0	0
Mar	0.0	0.0	0.0	4986	0	0	0
Apr	0.0	0.0	0.0	4986	0	0	0
May	0.0	0.0	0.0	4986	0	0	0
Jun	0.0	0.0	0.0	4986	0	0	0
Jul	0.0	0.0	0.0	4986	0	0	0
Aug	0.0	0.0	0.0	4986	0	0	0
Sep	0.0	0.0	0.0	4986	0	0	0
Oct	0.0	0.0	0.0	4986	0	0	0
Nov	0.0	0.0	0.0	4986	0	0	0
Dec	0.0	0.0	0.0	4986	0	0	0

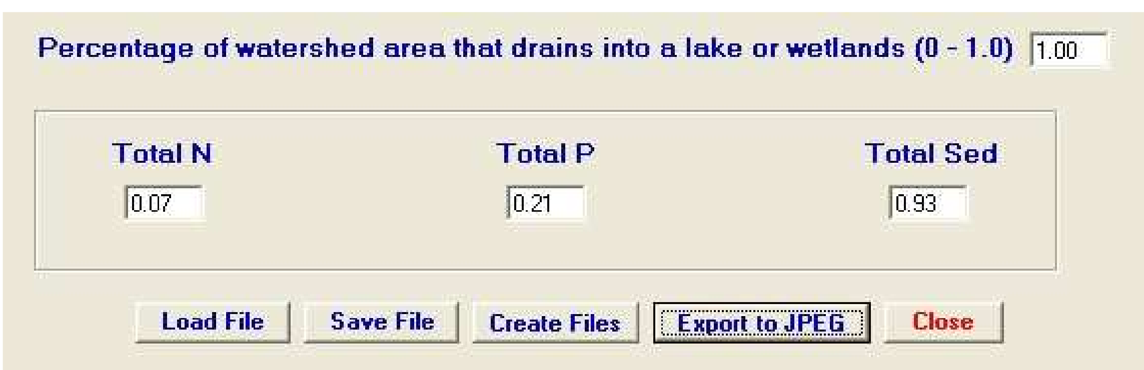
Groundwater (mg/L): N (mg/L)	P (mg/L)	Tile Drainage (mg/L): N	P	Sed	Per capita tank effluent: N (g/d)	P (g/d)	Growing season N/P uptake: N (g/d)	P (g/d)	Sediment: N (mg/Kg)	P (mg/Kg)
1.0	0.09	15	0.1	50	12	2.5	1.6	0.4	3000.0	359.0

Load File | Save File | Export to JPEG | Close

Nutrient file

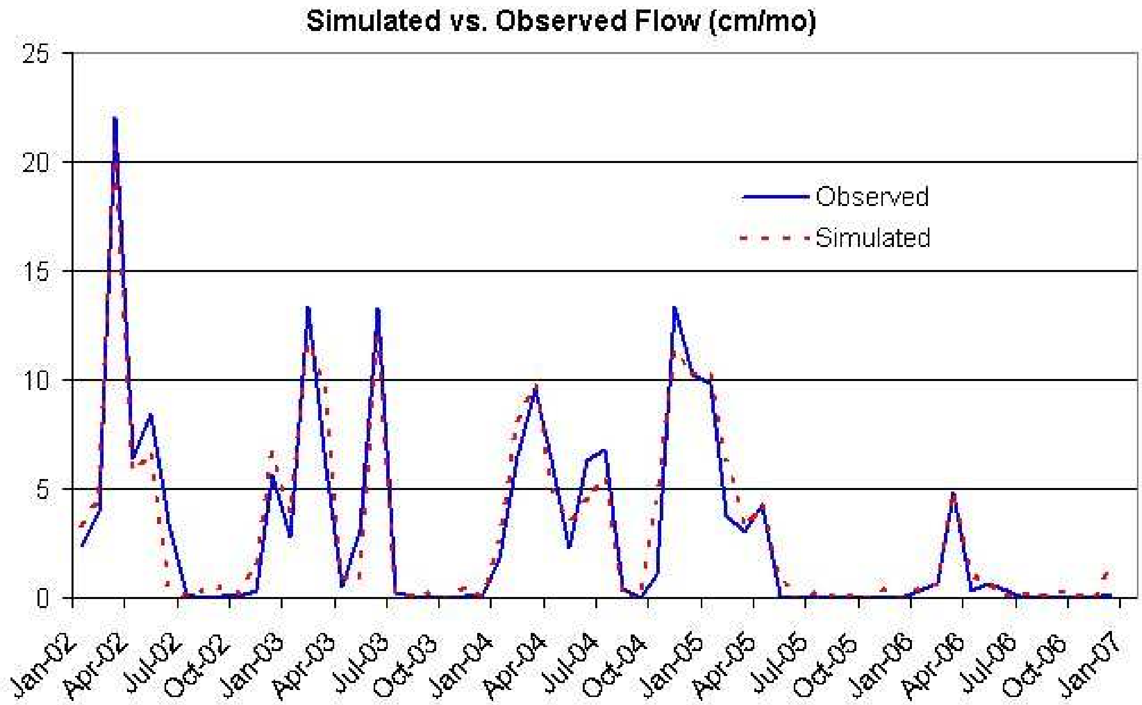


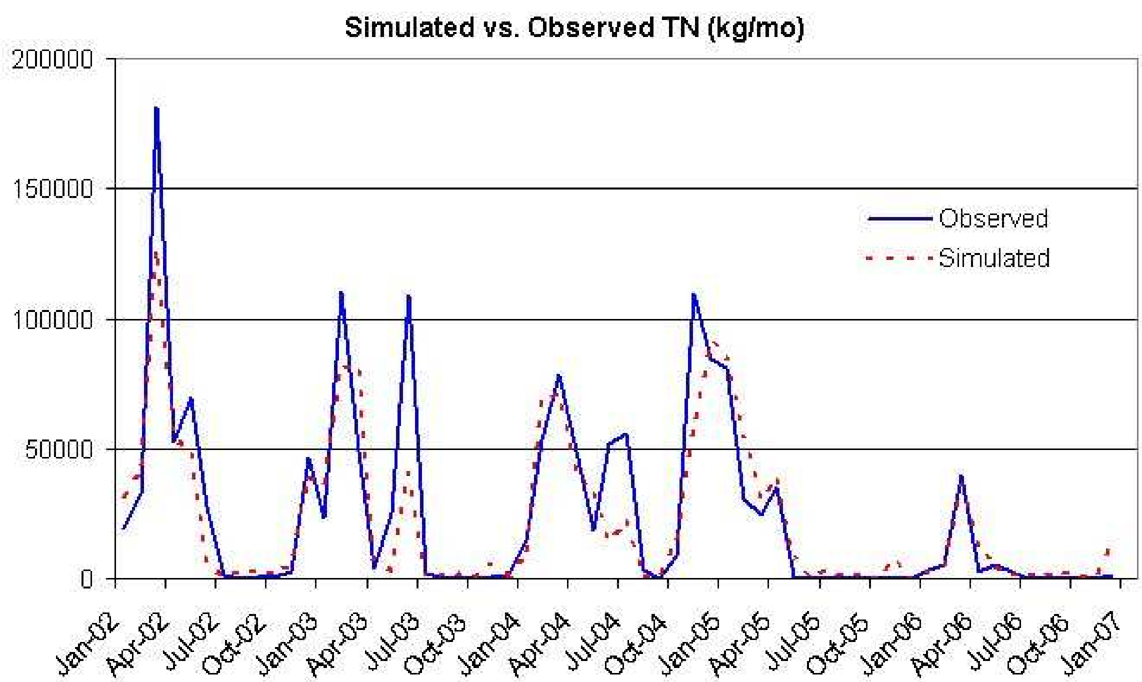
Animal file

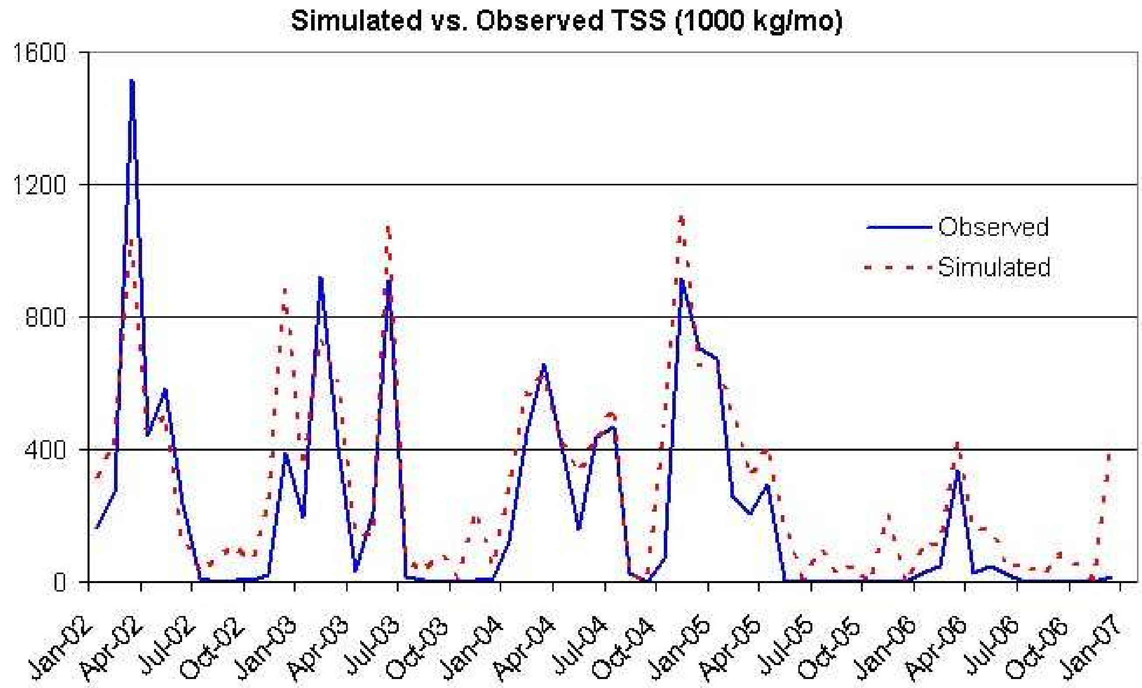


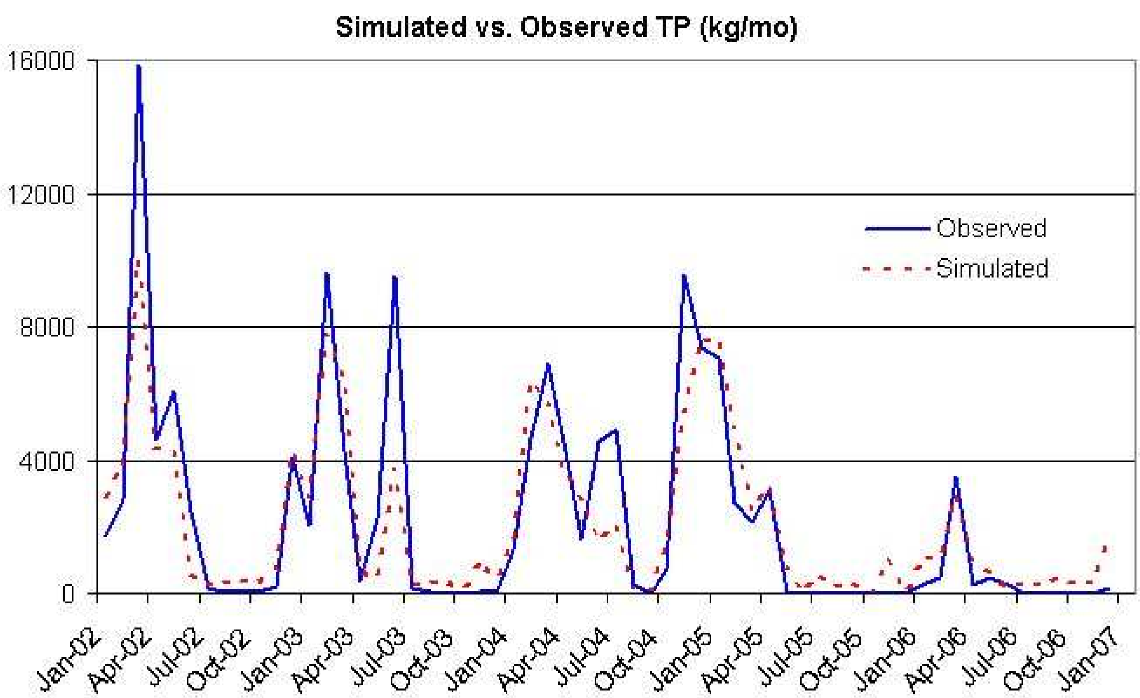
Retention file

Moro Creek (AR)






Simulated vs. Observed TSS (1000 kg/mo)
1600
1200
800
400
0
Observed
Simulated
Jan-02
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07


Simulated vs. Observed TP (kg/mo)
16000
12000
8000
4000
0
Observed
Simulated
Jan-02
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07

Palo Duro Creek (TX)

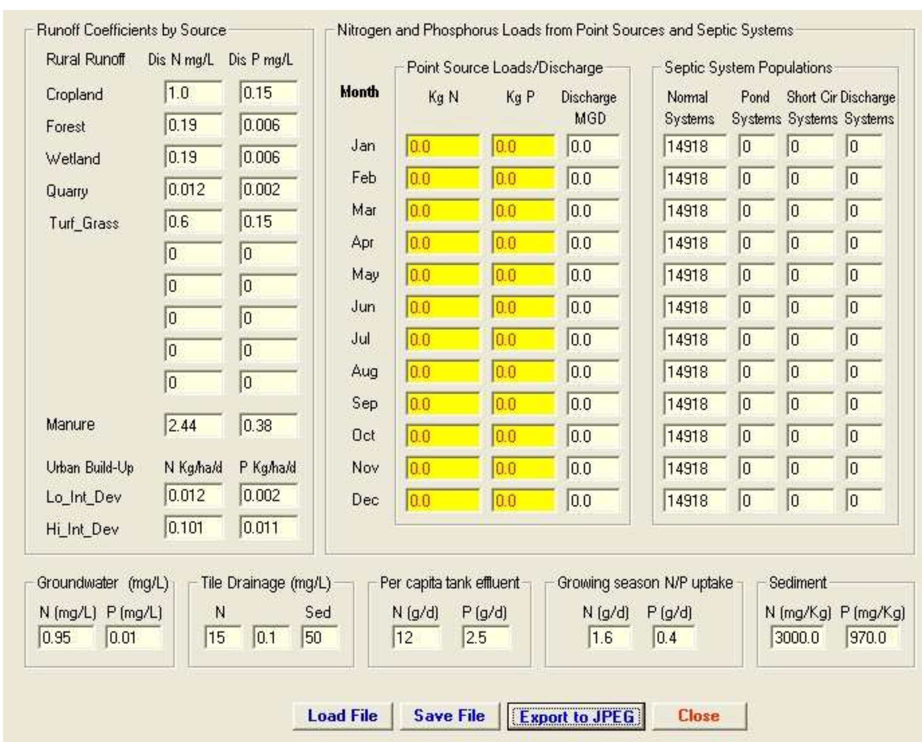
Rural LU	Area (ha)	CN	K	LS	C	P
Cropland	178365	75	0.314	0.27	0.01	0.1
Forest	14619	60	0.31	0.289	0.002	0.45
Wetland	84	80	0.327	0.262	0.01	0.1
Quarry	85	76	0.316	0.357	0.1	0.1
Turf_Grass	109967	58	0.311	0.262	0.01	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	1703	80	0.31	0.275	0.08	0.2
Hi_Int_Dev	375	90	0.308	0.288	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.9	9.8	0	0.299	0	0
Feb	0.98	10.6	0	0.299	0	0
Mar	1.01	11.8	0	0.299	0	0
Apr	1.69	13	1	0.34	0	0
May	2.1	14	1	0.34	0	0
Jun	2.33	14.4	1	0.34	0	0
Jul	2.48	14.2	1	0.34	0	0
Aug	2.55	13.4	1	0.34	0	0
Sep	2.59	12.2	1	0.34	0	0
Oct	2.63	11	1	0.299	0	0
Nov	1.95	10	0	0.299	0	0
Dec	1.58	9.6	0	0.299	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.1
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.041	Seepage Coefficient	0
Unsat Avail Wat (cm)	15.9664	Tile Drain Ratio	0.5	Sediment A Factor	0.0000E+00
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Cropland	1.0	0.15
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	0.6	0.15
	0	0
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	N Kg/ha/d	P Kg/ha/d
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

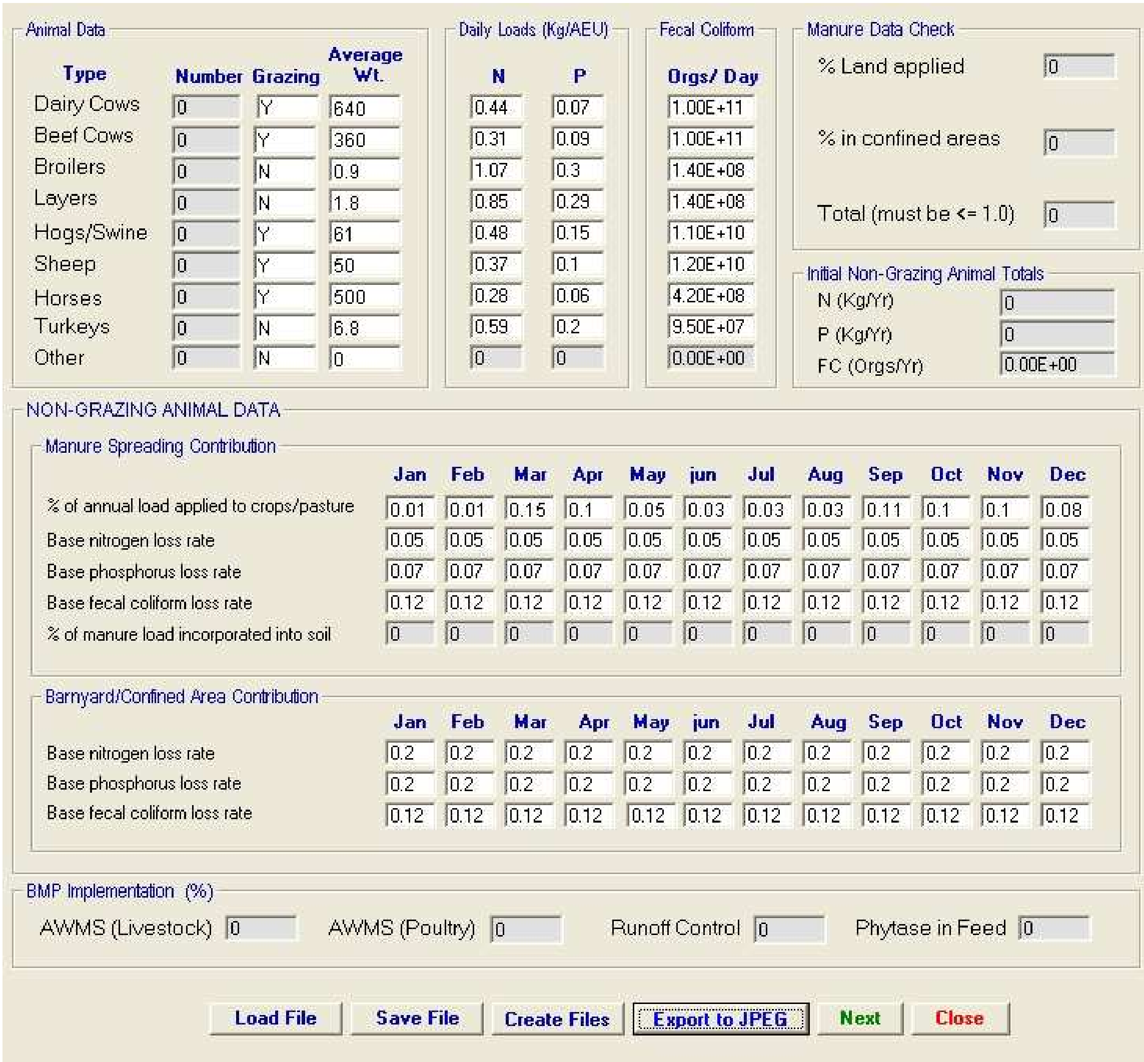
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	14918	0	0	0
Feb	0.0	0.0	0.0	14918	0	0	0
Mar	0.0	0.0	0.0	14918	0	0	0
Apr	0.0	0.0	0.0	14918	0	0	0
May	0.0	0.0	0.0	14918	0	0	0
Jun	0.0	0.0	0.0	14918	0	0	0
Jul	0.0	0.0	0.0	14918	0	0	0
Aug	0.0	0.0	0.0	14918	0	0	0
Sep	0.0	0.0	0.0	14918	0	0	0
Oct	0.0	0.0	0.0	14918	0	0	0
Nov	0.0	0.0	0.0	14918	0	0	0
Dec	0.0	0.0	0.0	14918	0	0	0

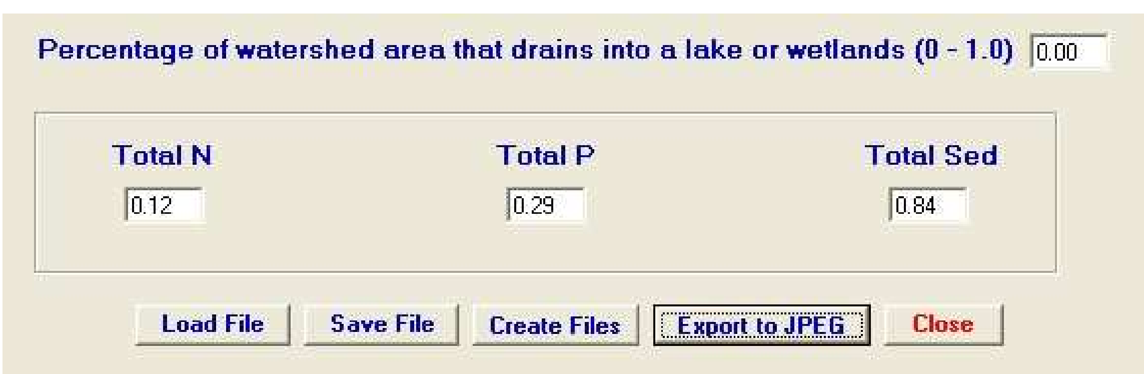
Groundwater (mg/L): N (mg/L)	P (mg/L)	Tile Drainage (mg/L): N	P	Sed	Per capita tank effluent: N (g/d)	P (g/d)	Growing season N/P uptake: N (g/d)	P (g/d)	Sediment: N (mg/Kg)	P (mg/Kg)
0.95	0.01	15	0.1	50	12	2.5	1.6	0.4	3000.0	970.0

Load File | Save File | Export to JPEG | Close

Nutrient file

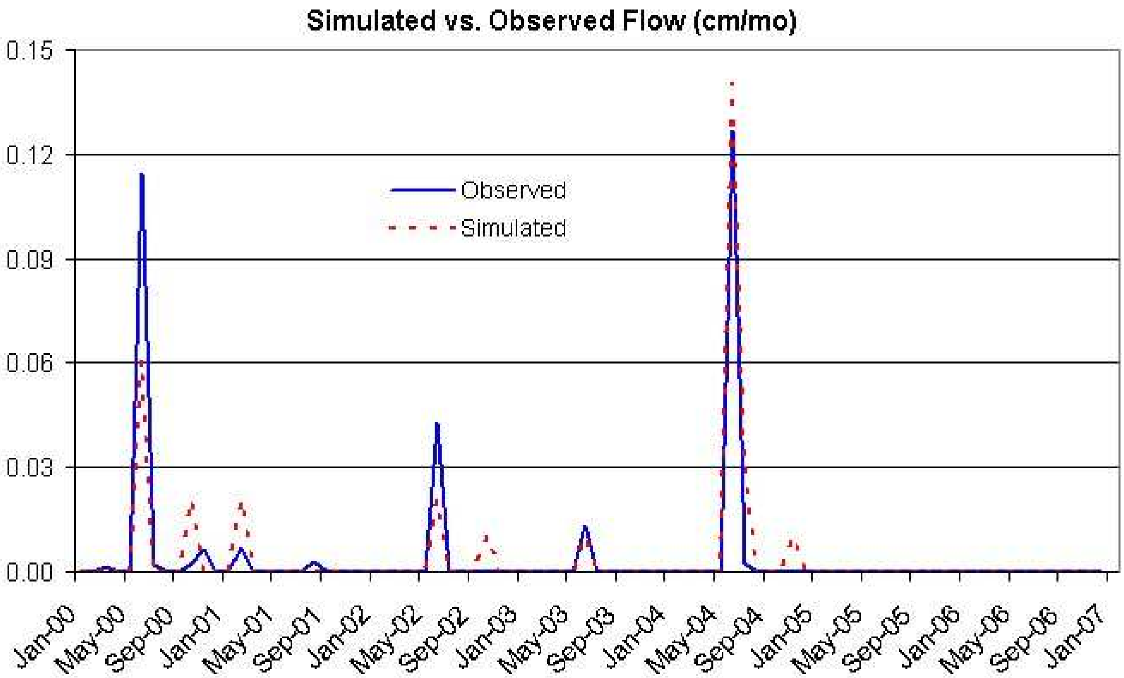


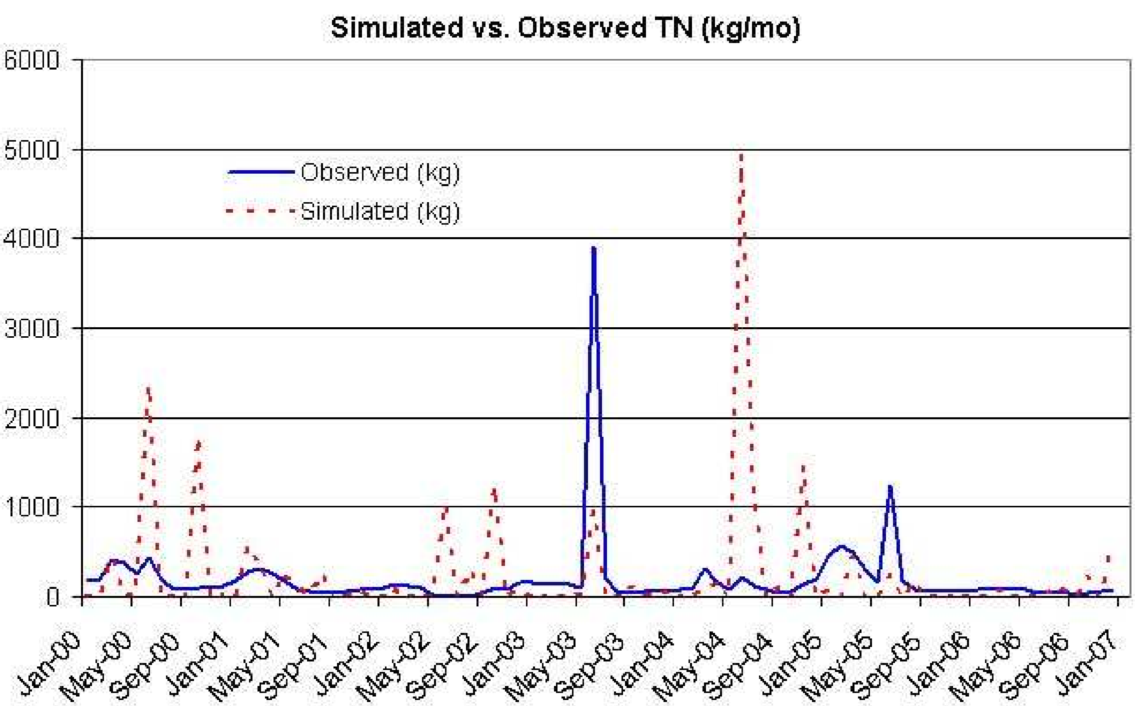
Animal file

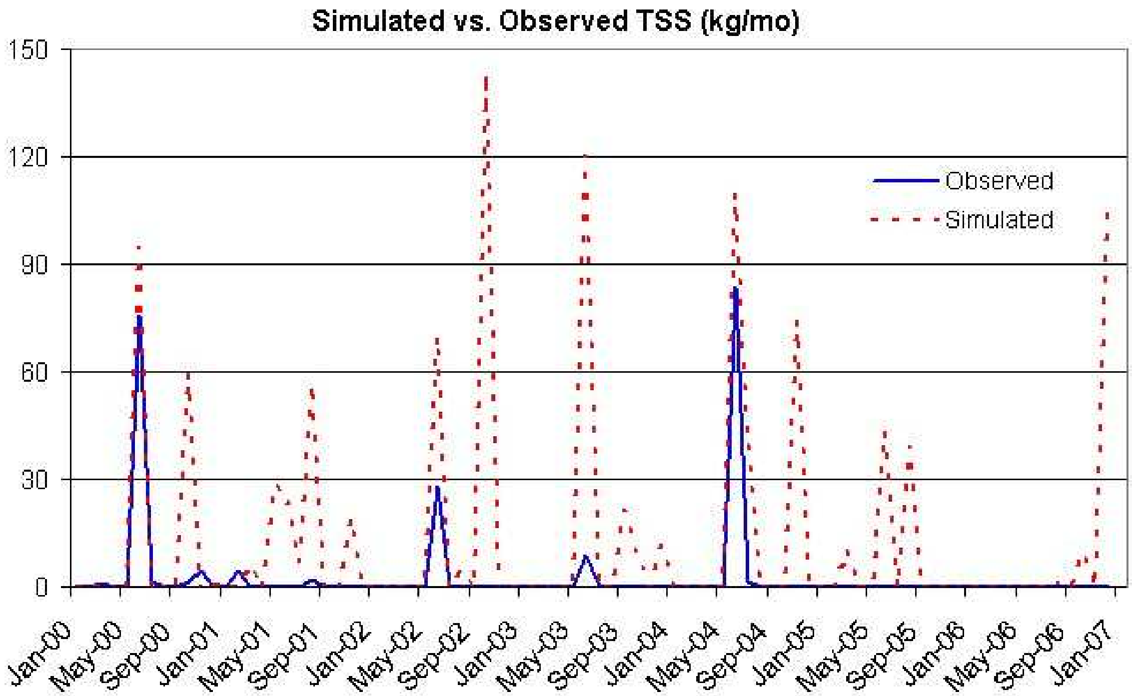


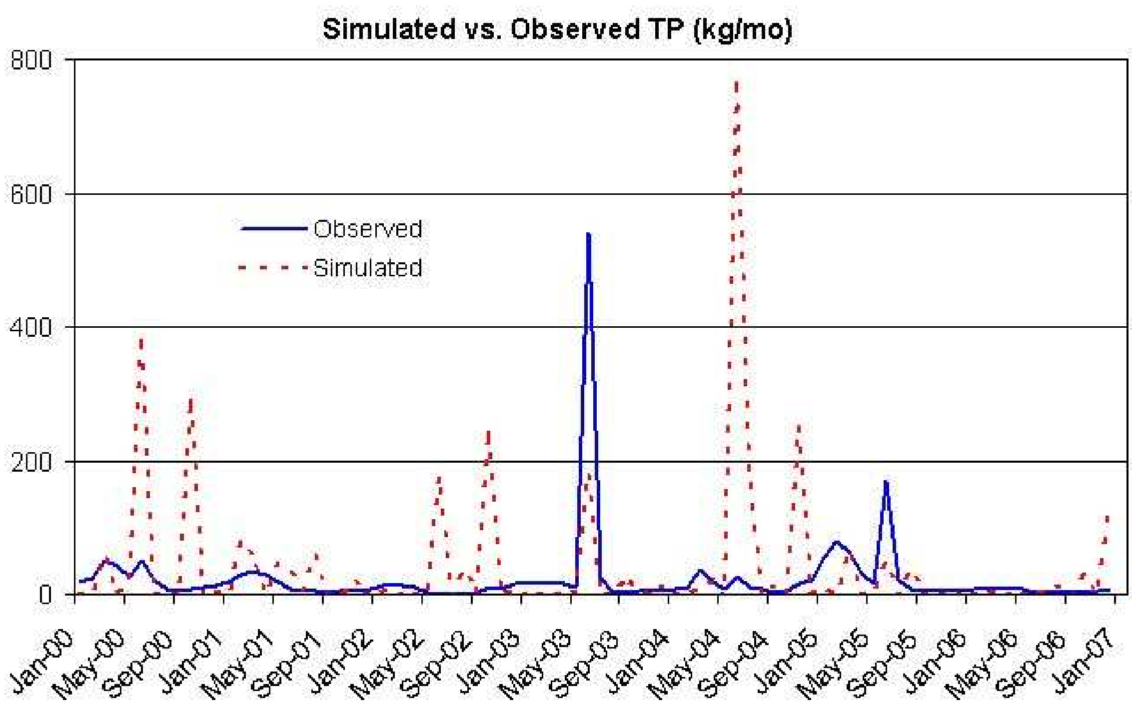
Retention file

Palo Duro Creek (TX)






Simulated vs. Observed TSS (kg/mo)
150
120
90
60
30
0
Observed
Simulated
Jan-00
May-00
Sep-00
Jan-01
May-01
Sep-01
Jan-02
May-02
Sep-02
Jan-03
May-03
Sep-03
Jan-04
May-04
Sep-04
Jan-05
May-05
Sep-05
Jan-06
May-06
Sep-06
Jan-07


Simulated vs. Observed TP (kg/mo)
800
600
400
200
0
Observed
Simulated
Jan-00
May-00
Sep-00
Jan-01
May-01
Sep-01
Jan-02
May-02
Sep-02
Jan-03
May-03
Sep-03
Jan-04
May-04
Sep-04
Jan-05
May-05
Sep-05
Jan-06
May-06
Sep-06
Jan-07

Saline Bayou (LA)

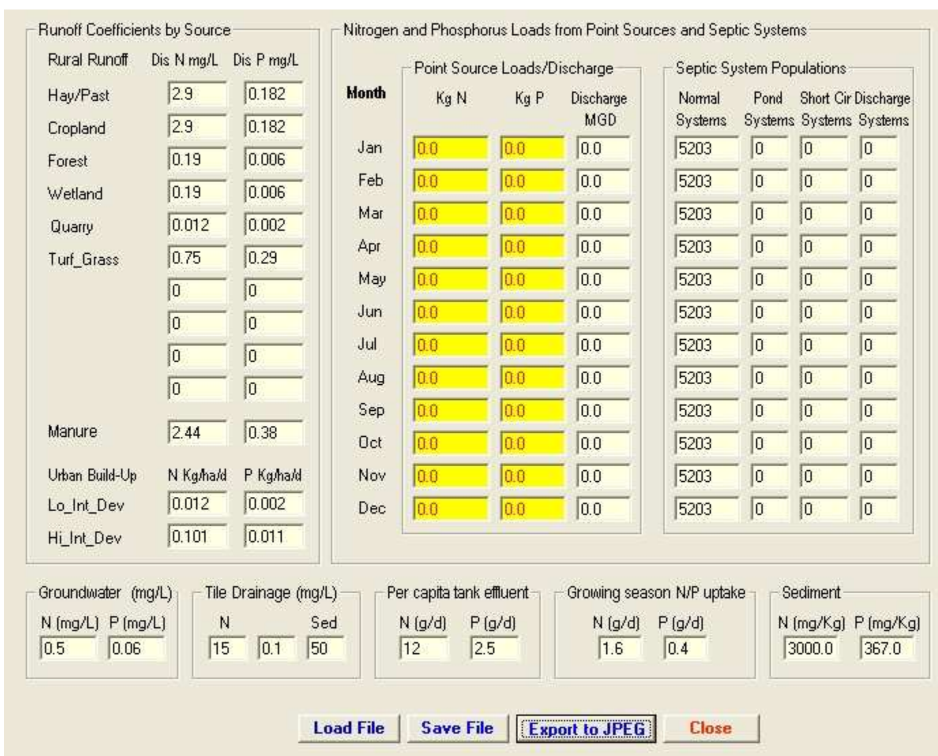
Rural LU	Area (ha)	CN	K	LS	C	P
Hay/Past	1287	75	0.282	0.339	0.03	0.45
Cropland	104	82	0.285	0.345	0.15	0.45
Forest	53027	73	0.288	0.4	0.05	0.45
Wetland	6796	90	0.295	0.253	0.01	0.1
Quarry	6	89	0.287	0.243	0.1	0.1
Turf_Grass	2413	71	0.285	0.398	0.04	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	1150	83	0.285	0.351	0.08	0.2
Hi_Int_Dev	88	93	0.282	0.331	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	1.06	10	0	0.11	0	0
Feb	1.14	10.8	0	0.2	0	0
Mar	1.4	11.8	1	0.2	0	0
Apr	1.55	12.9	1	0.2	0	0
May	1.63	13.8	1	0.2	0	0
Jun	1.68	14.2	1	0.2	0	0
Jul	1.72	14	1	0.2	0	0
Aug	1.73	13.2	1	0.2	0	0
Sep	1.75	12.2	1	0.2	0	0
Oct	1.75	11.1	1	0.2	0	0
Nov	1.75	10.2	1	0.11	0	0
Dec	1.55	9.8	0	0.11	0	0

Init Unsat Stor (cm)	10	**Initial Snow (cm)**	0	**Recess Coefficient**	0.06
Init Sat Stor (cm)	0	**Sed Delivery Ratio**	0.065	**Seepage Coefficient**	0
Unsat Avail Wat (cm)	13.8233	**Tile Drain Ratio**	0.5	**Sediment A Factor**	2.5078E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Hay/Past	2.9	0.182
Cropland	2.9	0.182
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	0.75	0.29
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	N Kg/ha/d	P Kg/ha/d
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

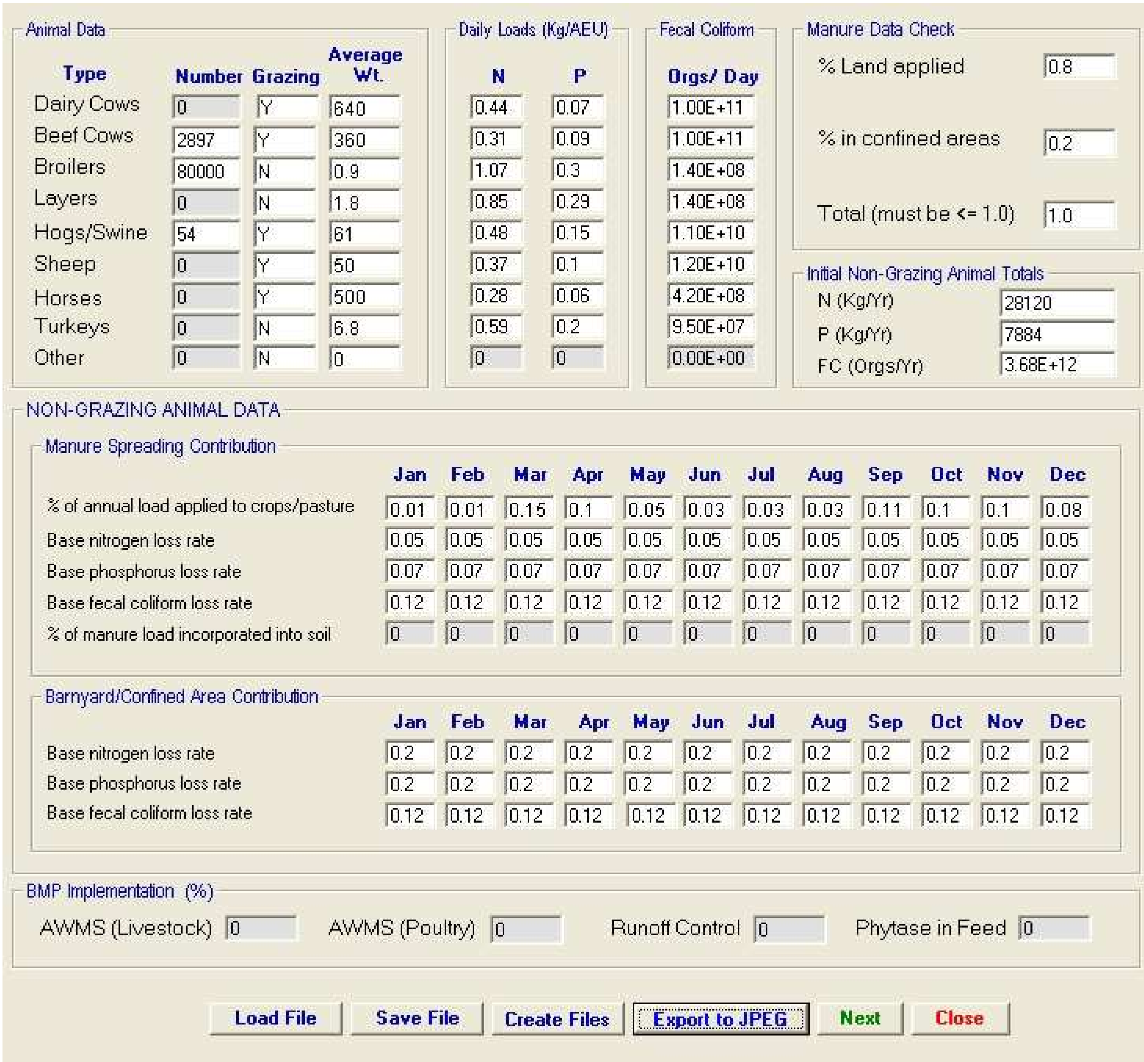
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge			Septic System Populations			
	Kg N	Kg P	Discharge MGD	Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	5203	0	0	0
Feb	0.0	0.0	0.0	5203	0	0	0
Mar	0.0	0.0	0.0	5203	0	0	0
Apr	0.0	0.0	0.0	5203	0	0	0
May	0.0	0.0	0.0	5203	0	0	0
Jun	0.0	0.0	0.0	5203	0	0	0
Jul	0.0	0.0	0.0	5203	0	0	0
Aug	0.0	0.0	0.0	5203	0	0	0
Sep	0.0	0.0	0.0	5203	0	0	0
Oct	0.0	0.0	0.0	5203	0	0	0
Nov	0.0	0.0	0.0	5203	0	0	0
Dec	0.0	0.0	0.0	5203	0	0	0

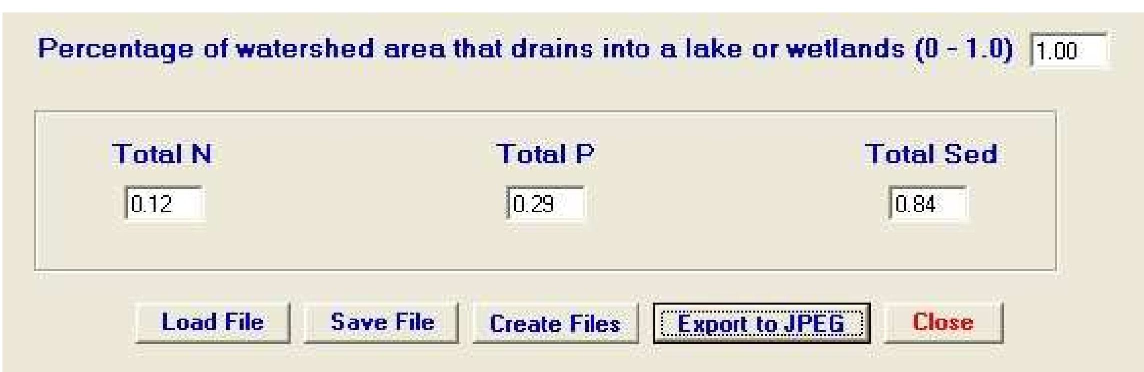
Groundwater (mg/L)		Tile Drainage (mg/L)			Per capita tank effluent		Growing season N/P uptake		Sediment	
N (mg/L)	P (mg/L)	N		Sed	N (g/d)	P (g/d)	N (g/d)	P (g/d)	N (mg/Kg)	P (mg/Kg)
0.5	0.06	15	0.1	50	12	2.5	1.6	0.4	3000.0	367.0

Load File | Save File | Export to JPEG | Close

Nutrient file

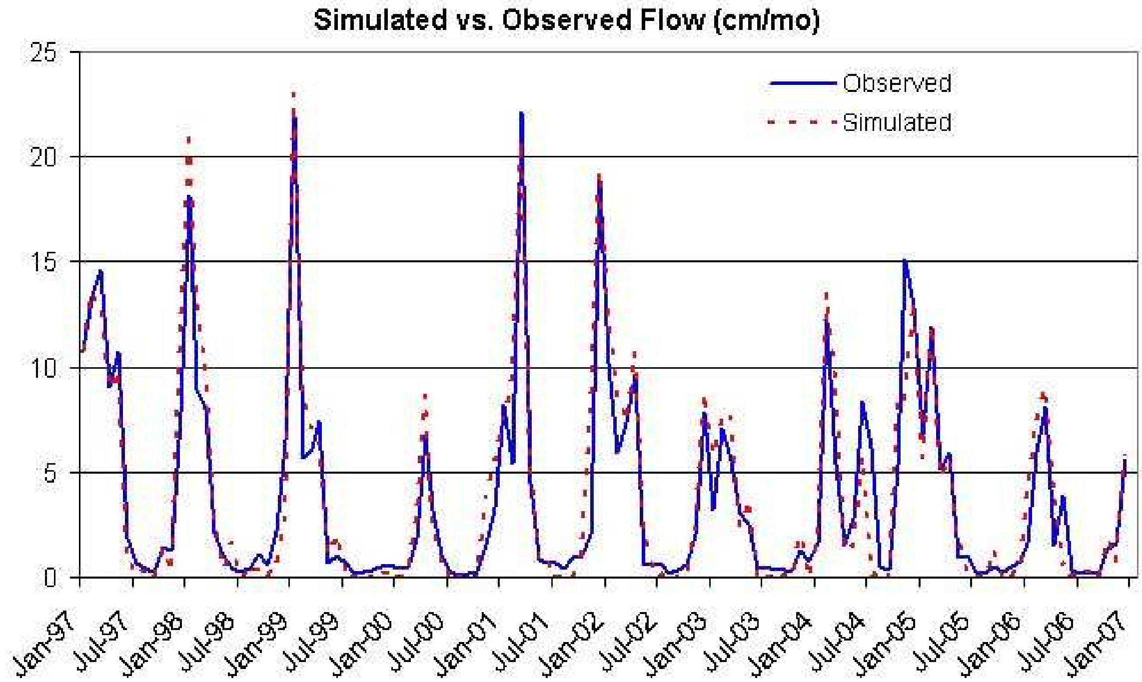


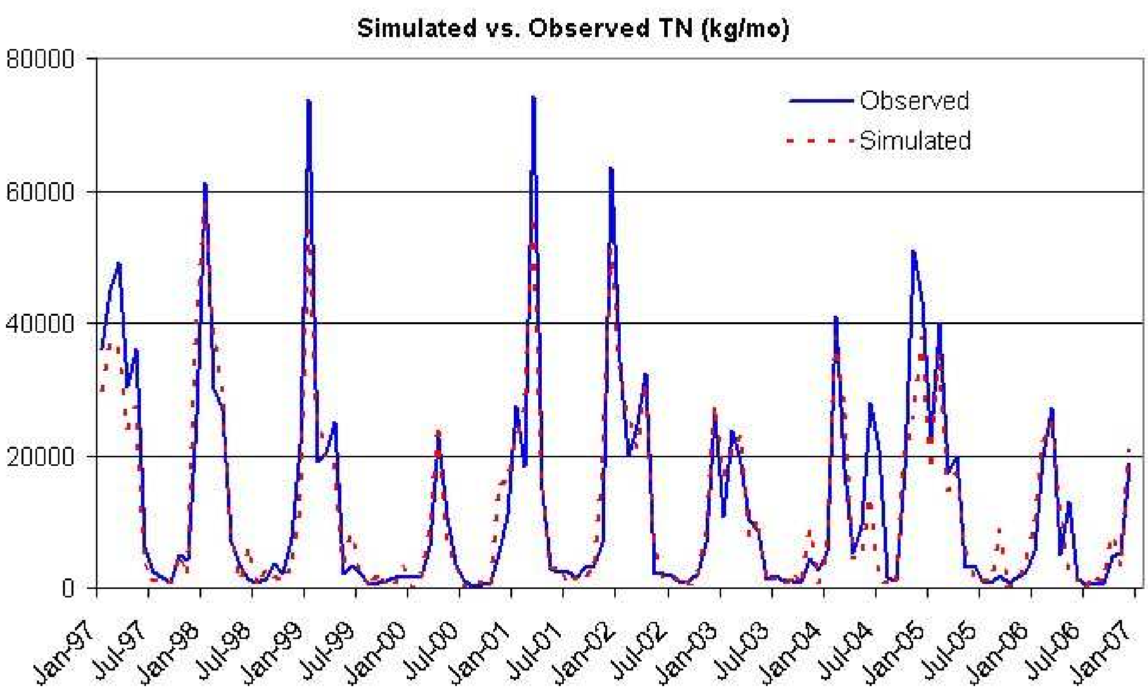
Animal file



Retention file

Saline Bayou (LA)





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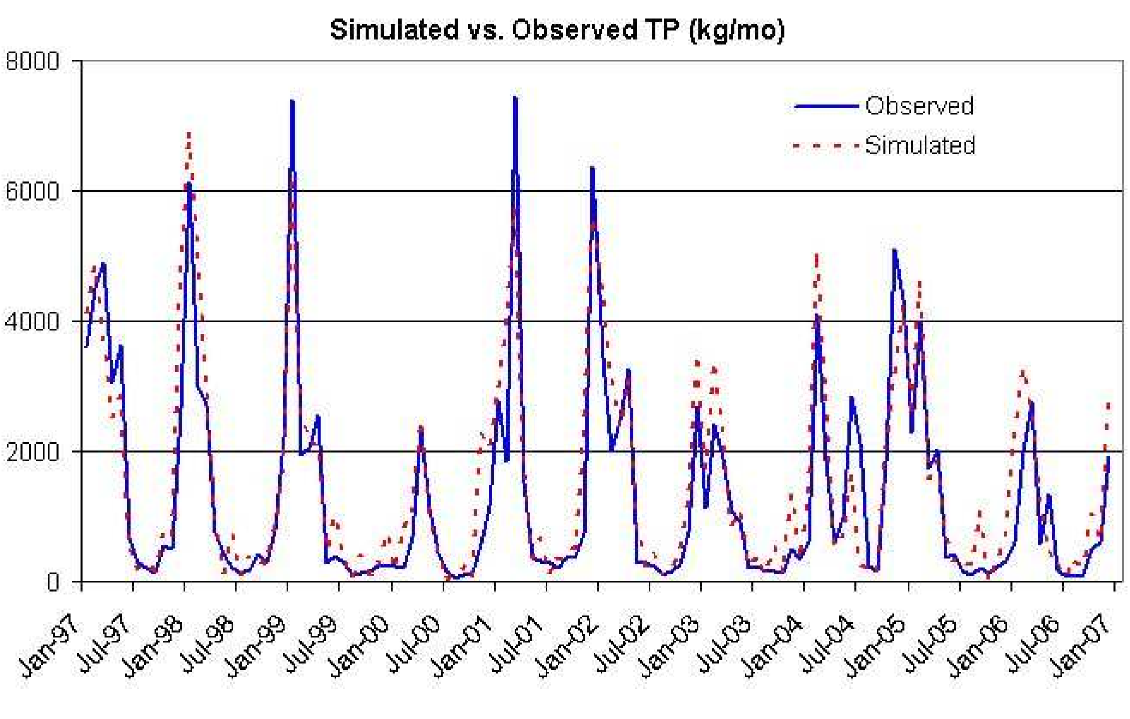
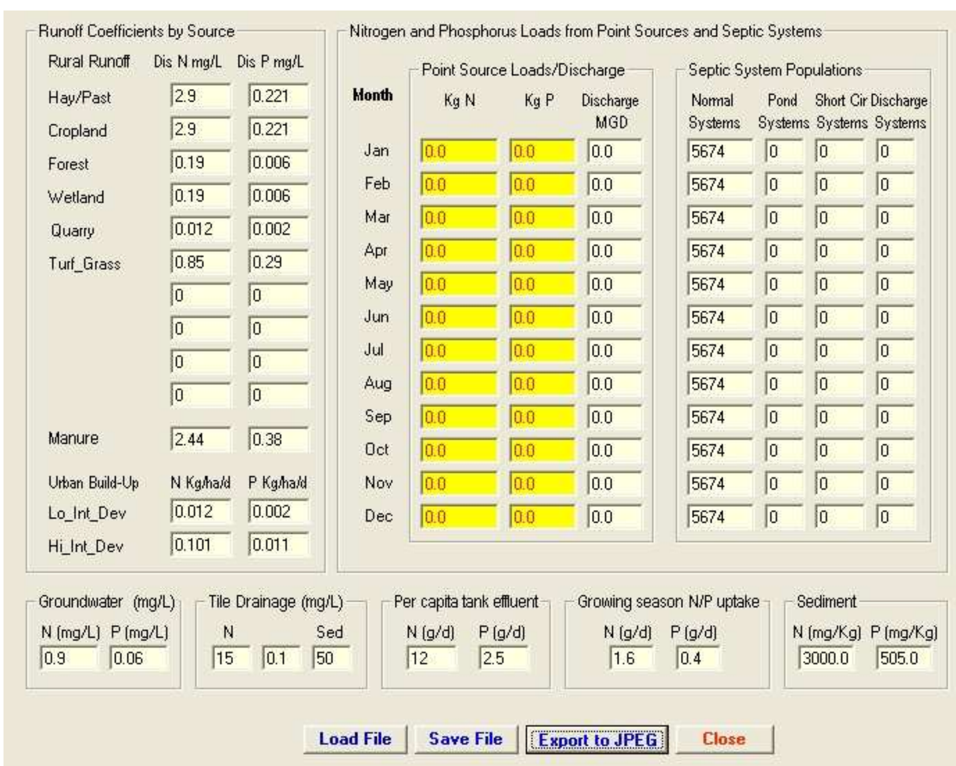


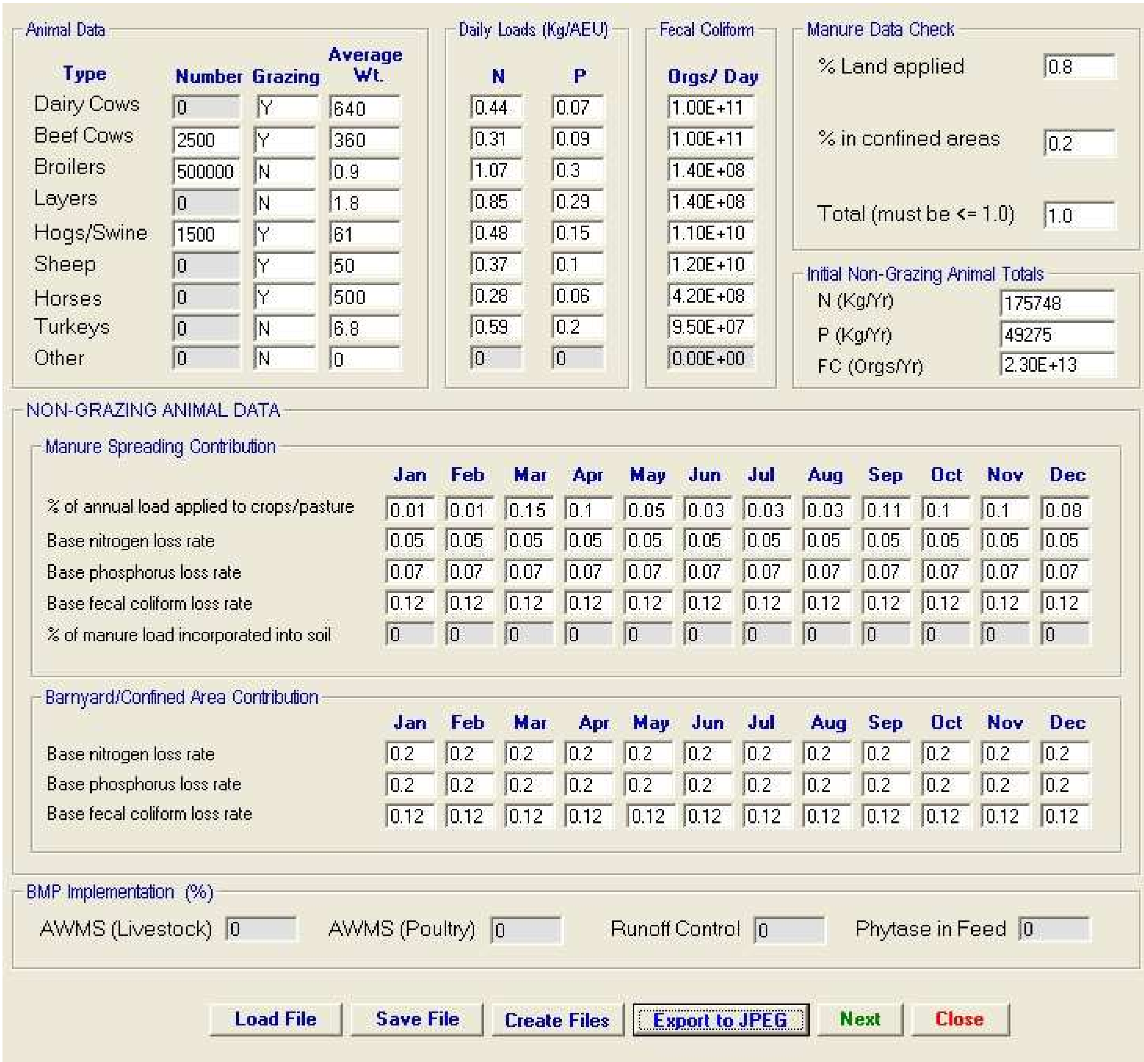
Simulated vs. Observed TP (kg/mo)
8000
6000
4000
2000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

Saline River (AR)

Transport file



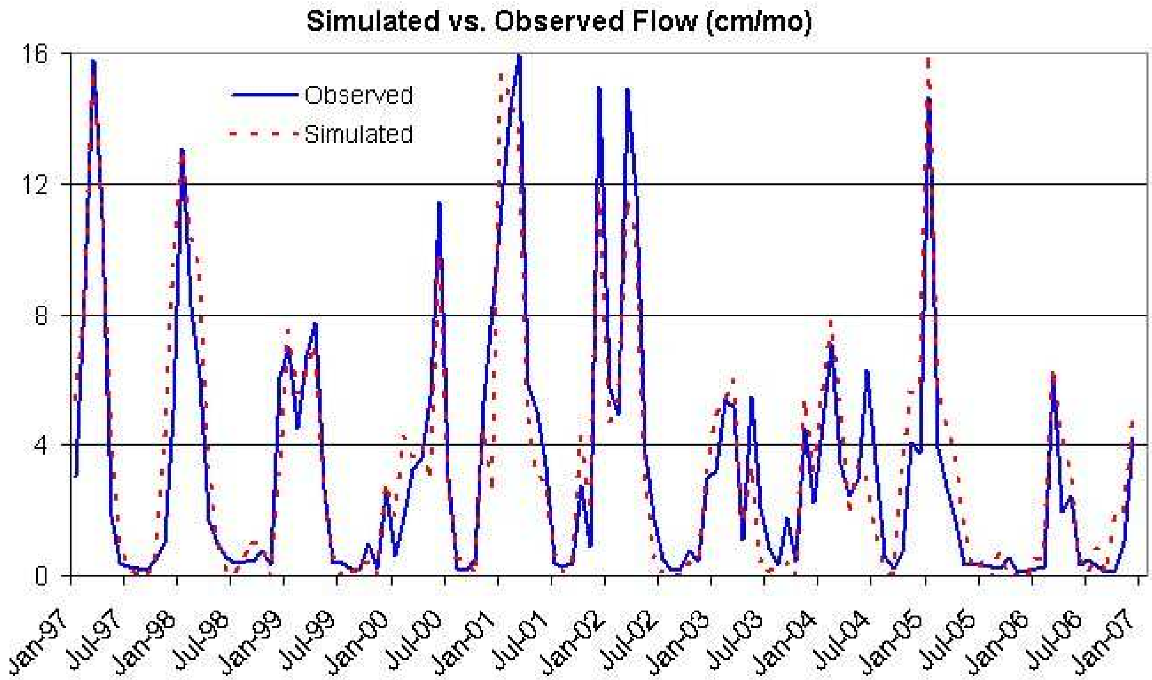
Nutrient file

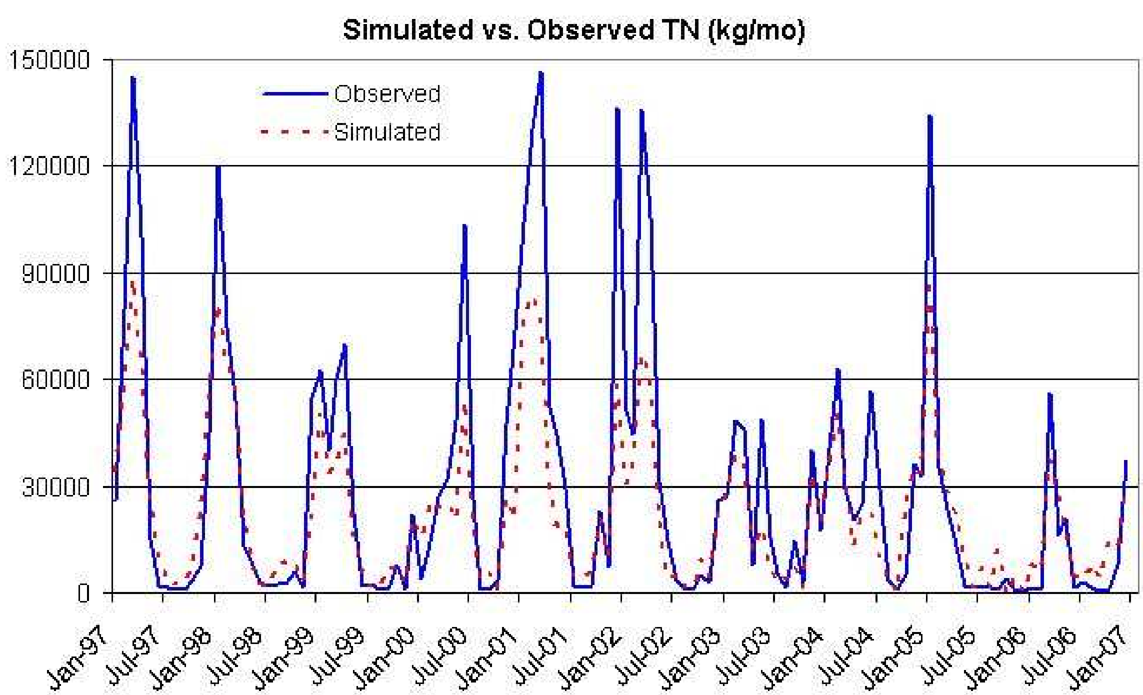


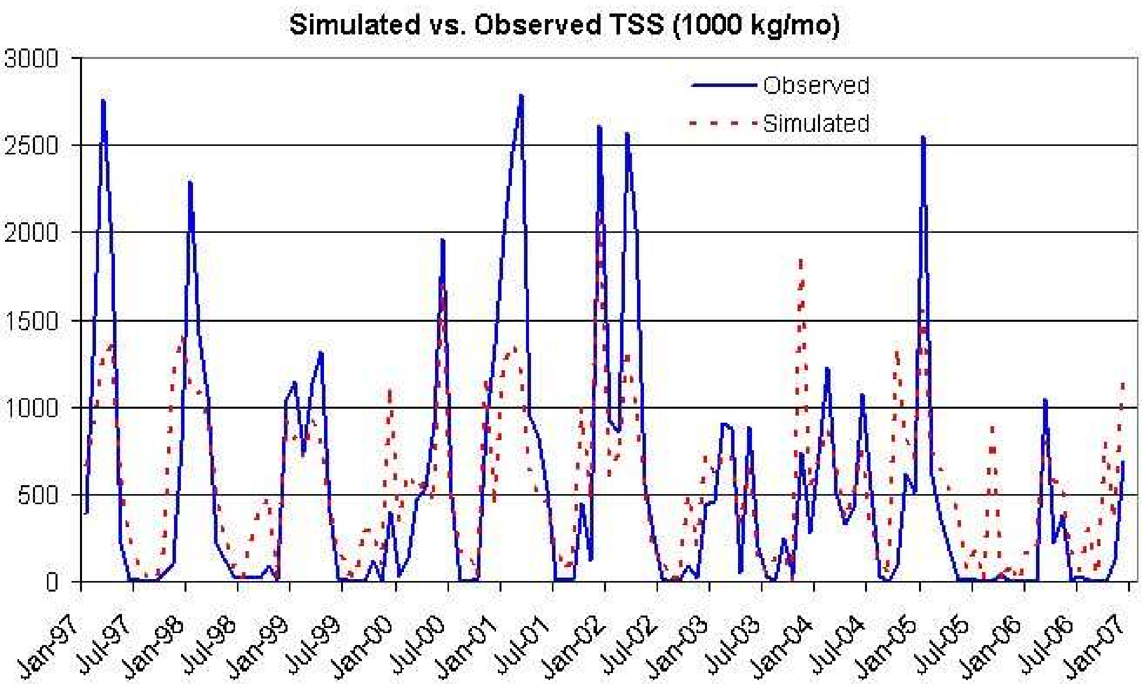
Animal file

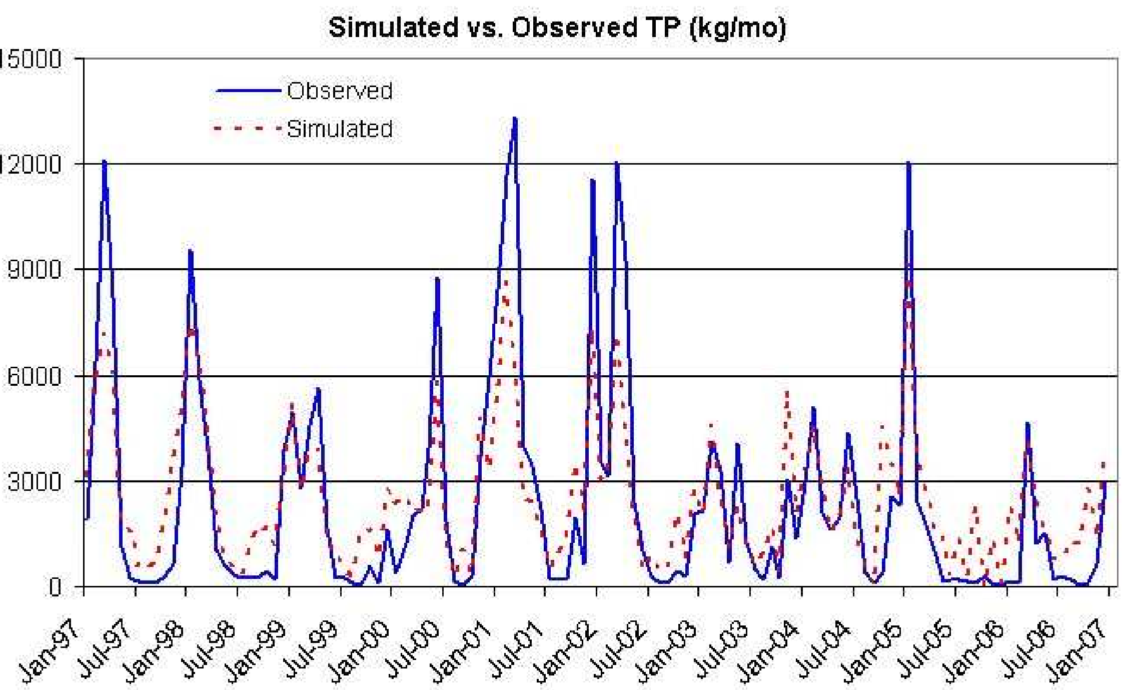
Retention file

Saline River (AR)



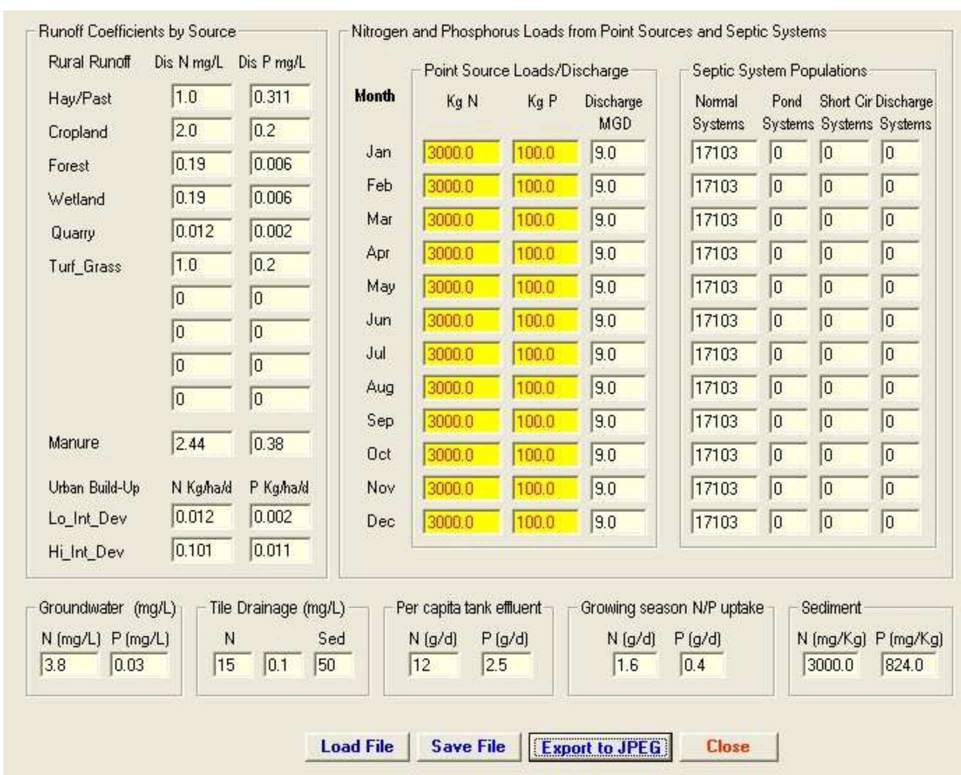



Simulated vs. Observed TSS (1000 kg/mo)
Observed
Simulated
3000
2500
2000
1500
1000
500
0
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

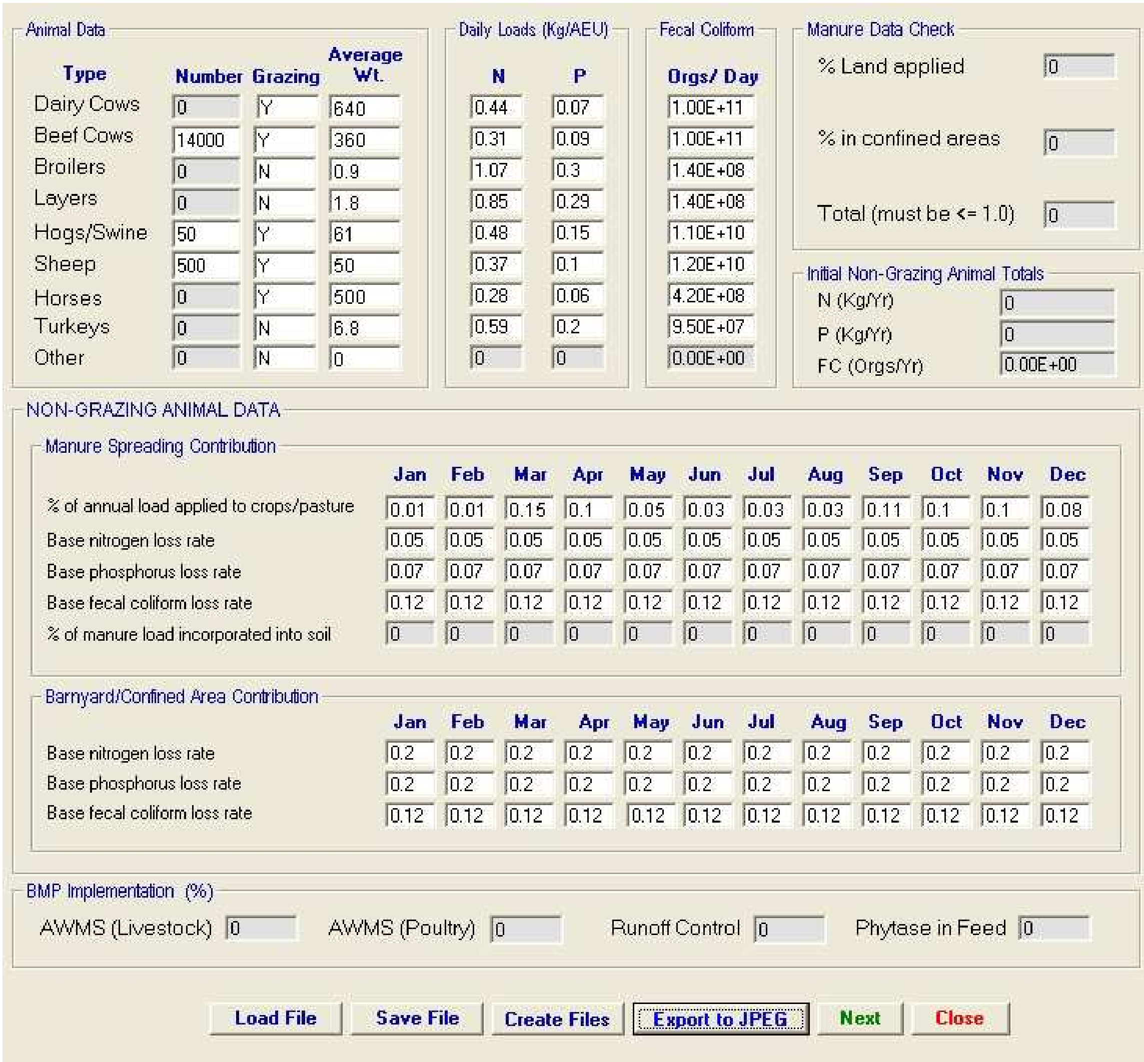

Simulated vs. Observed TP (kg/mo)
Observed
Simulated
15000
12000
9000
6000
3000
0
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

Skeleton Creek (OK)

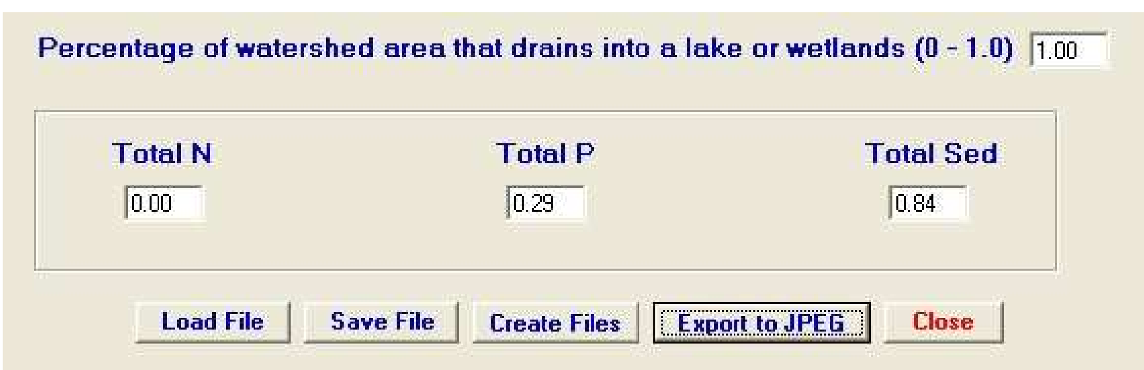
Transport file



Nutrient file

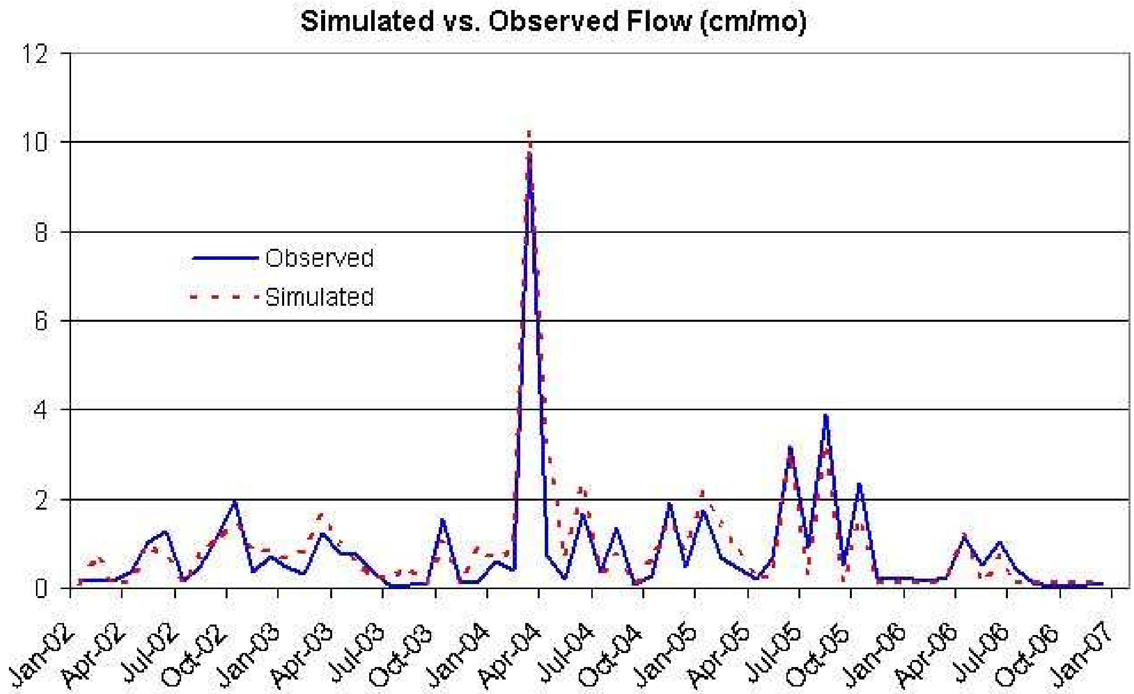


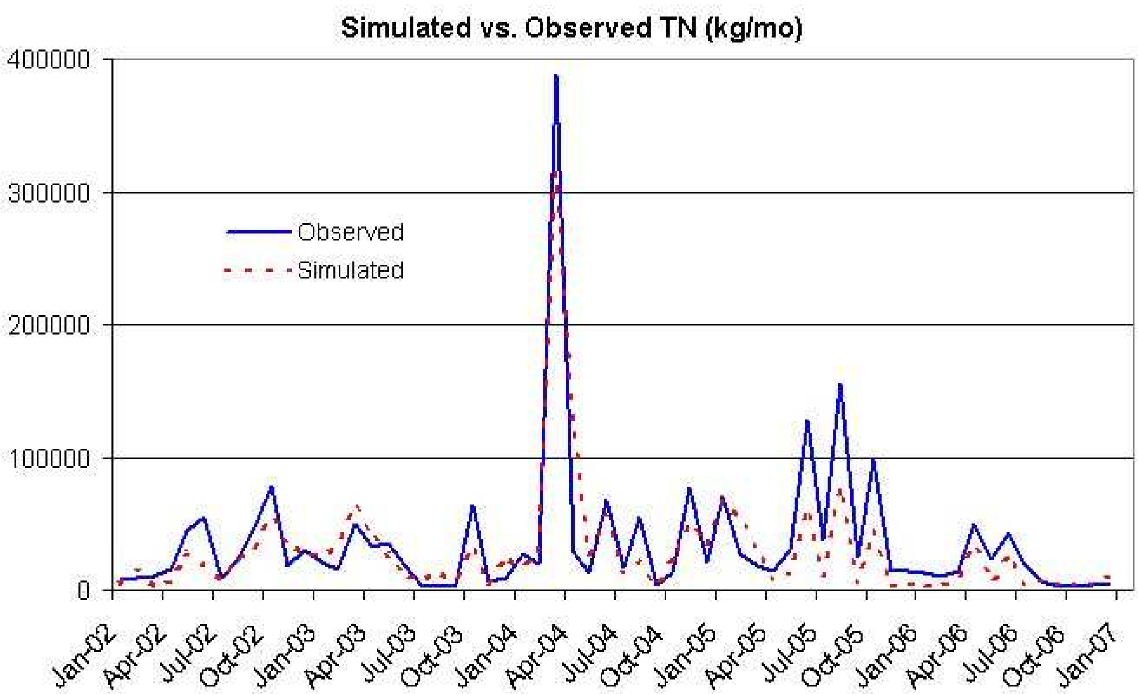
Animal file



Retention file

Skeleton Creek (OK)





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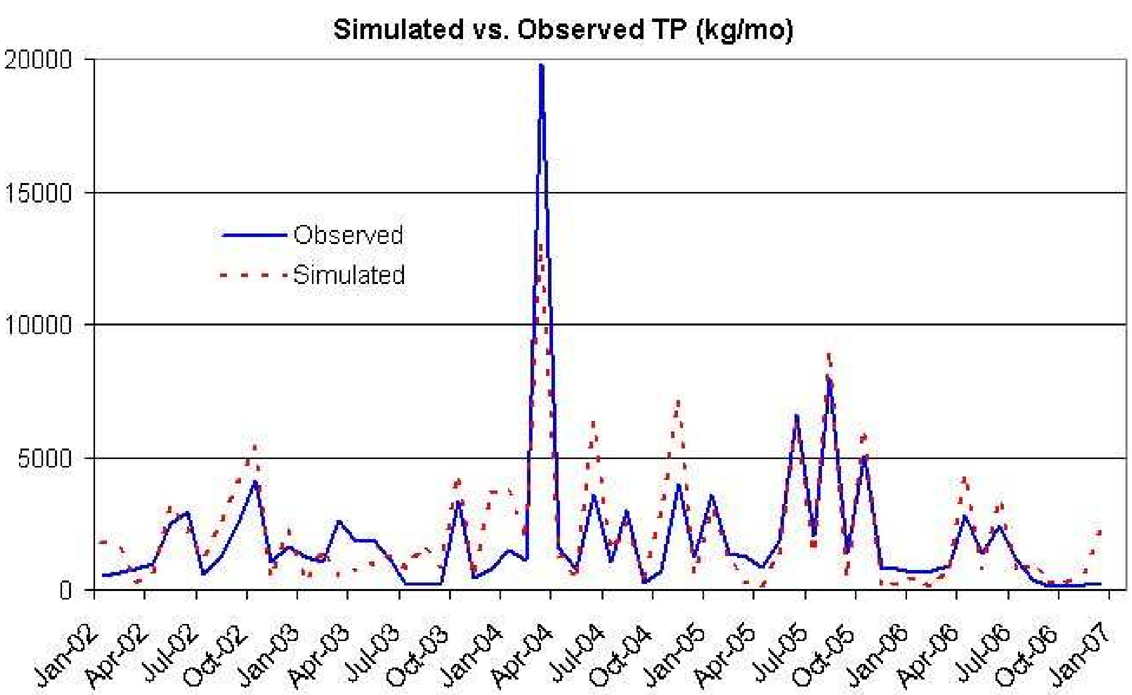
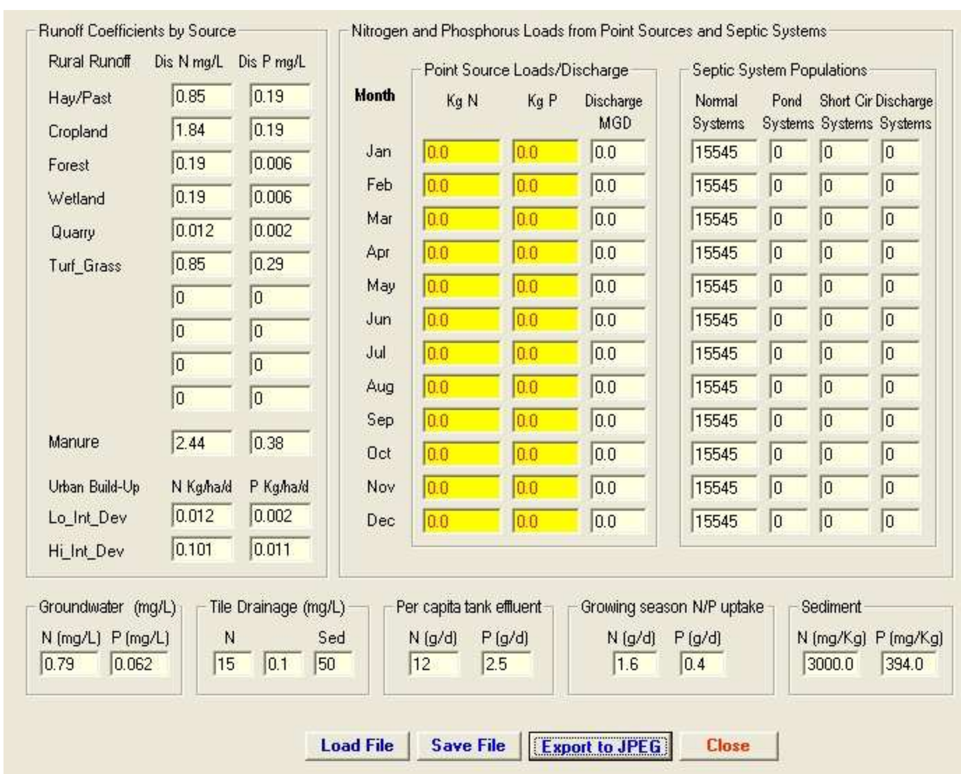


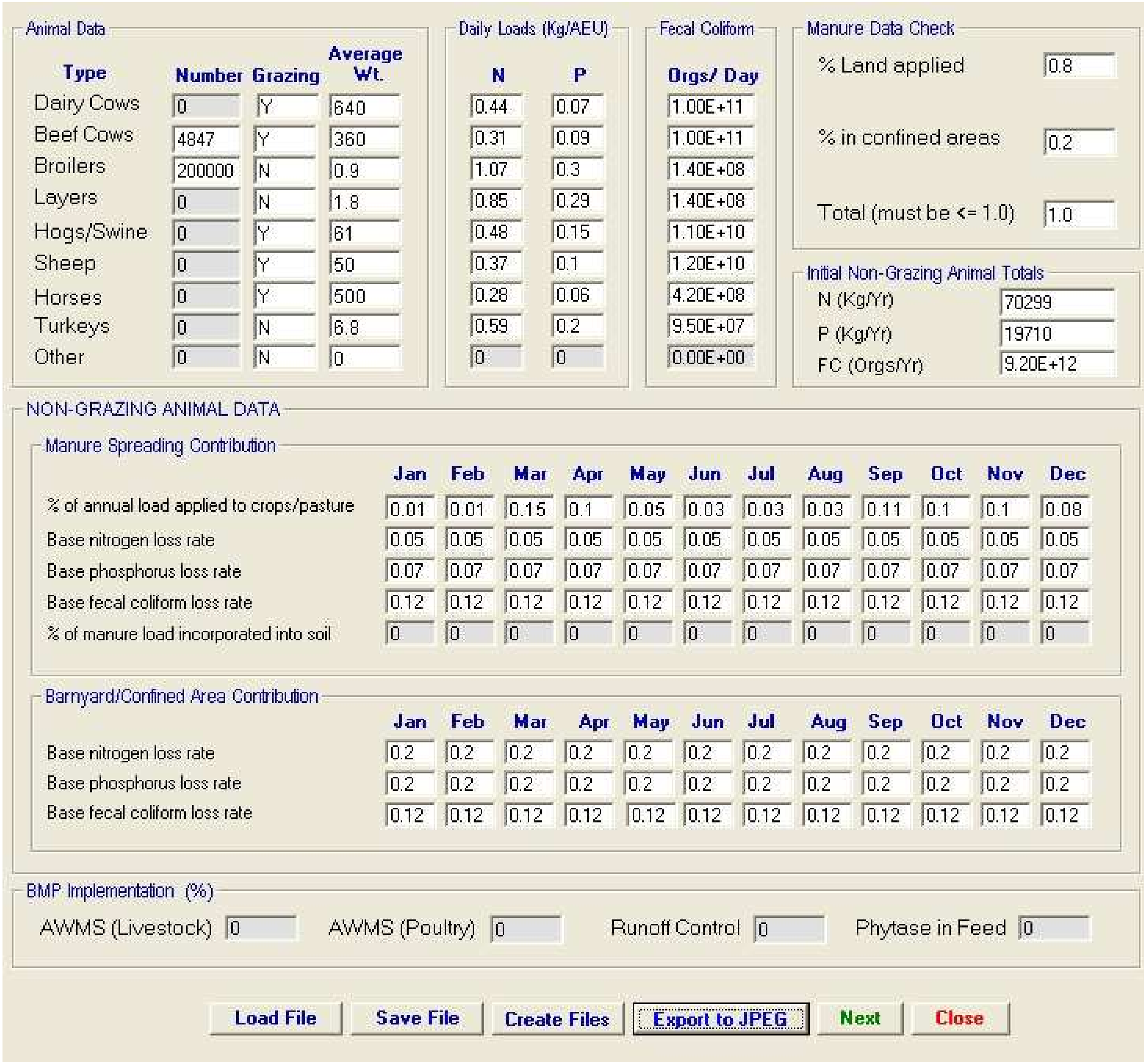
Simulated vs. Observed TP (kg/mo)
20000
15000
10000
5000
0
Observed
Simulated
Jan-02
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07

Smackover Creek (AR)

Transport file



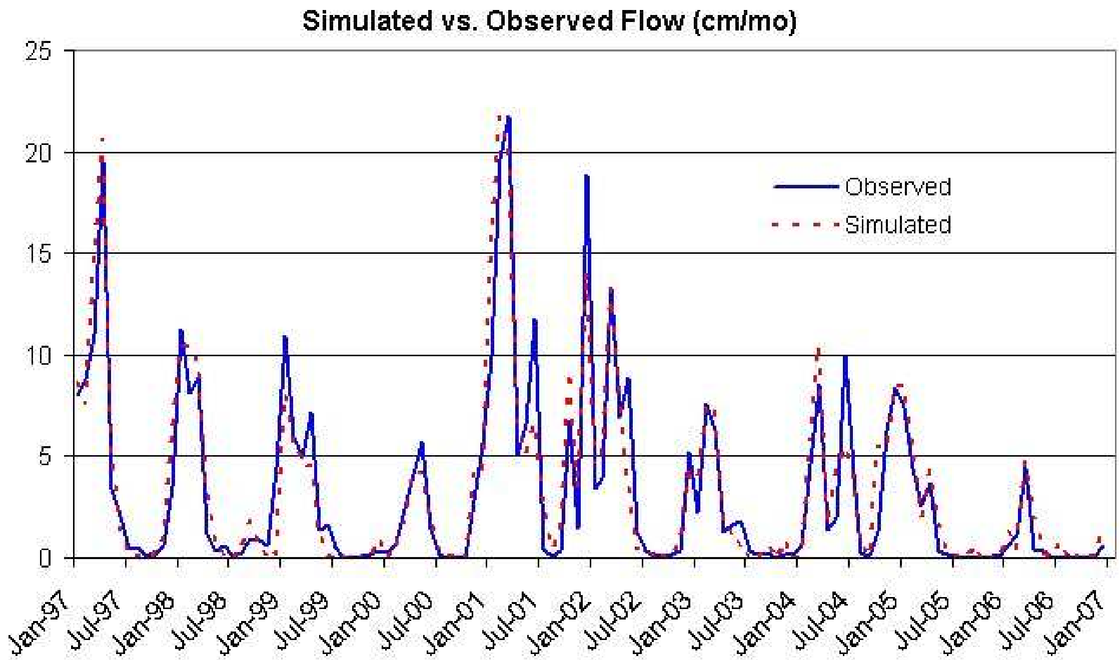
Nutrient file

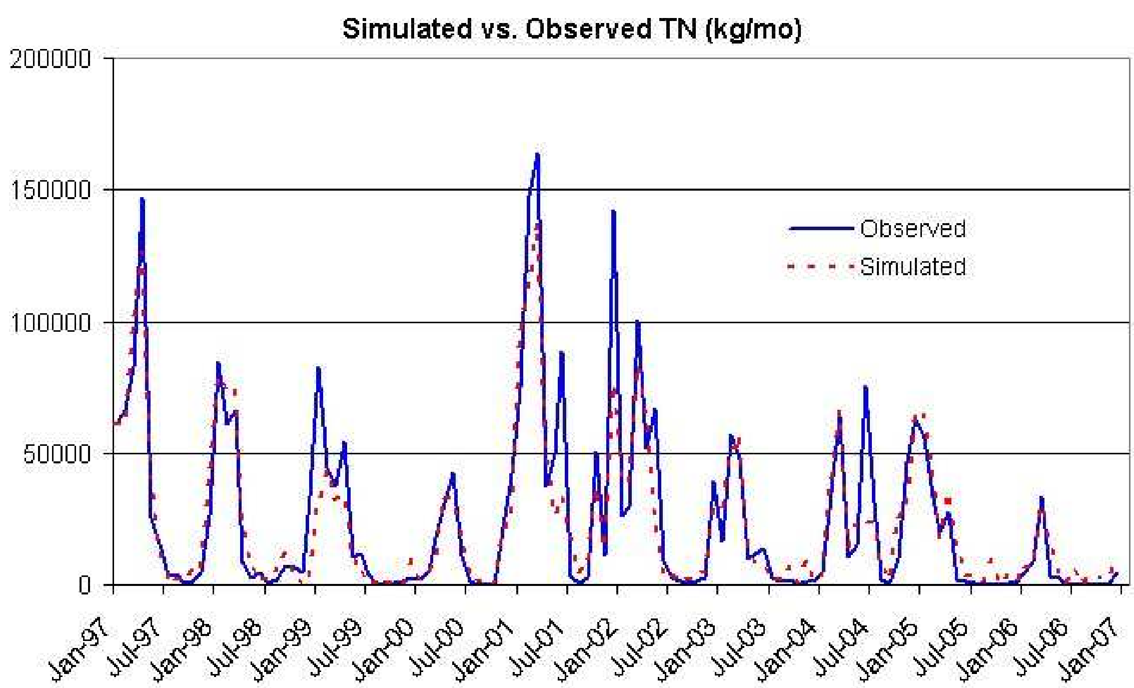


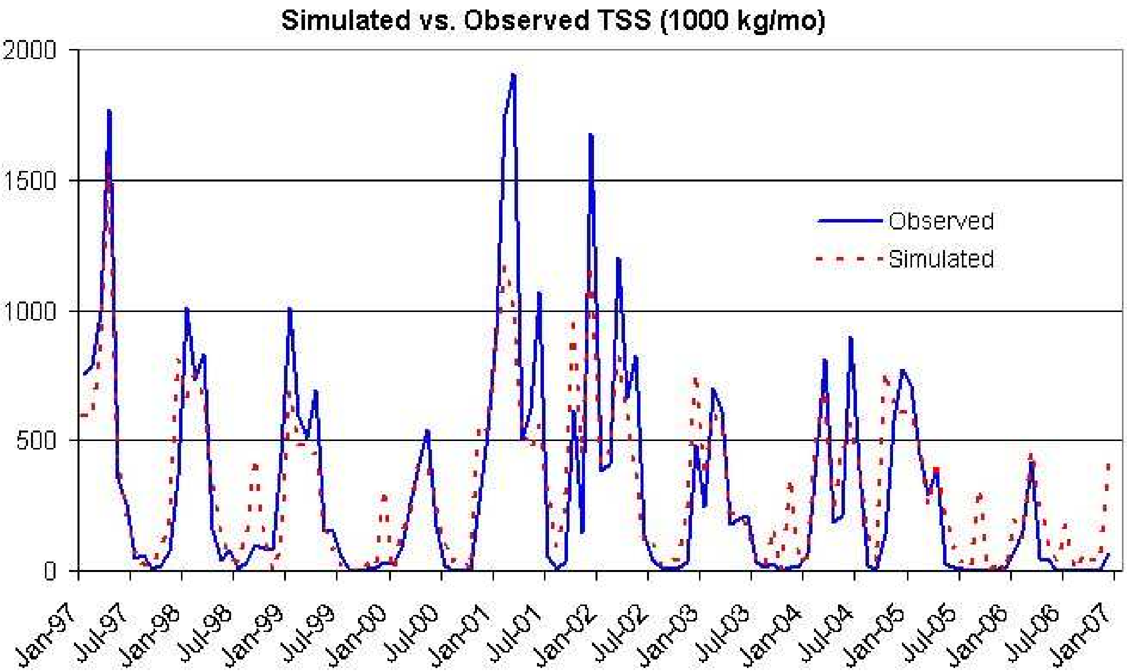
Animal file

Retention file

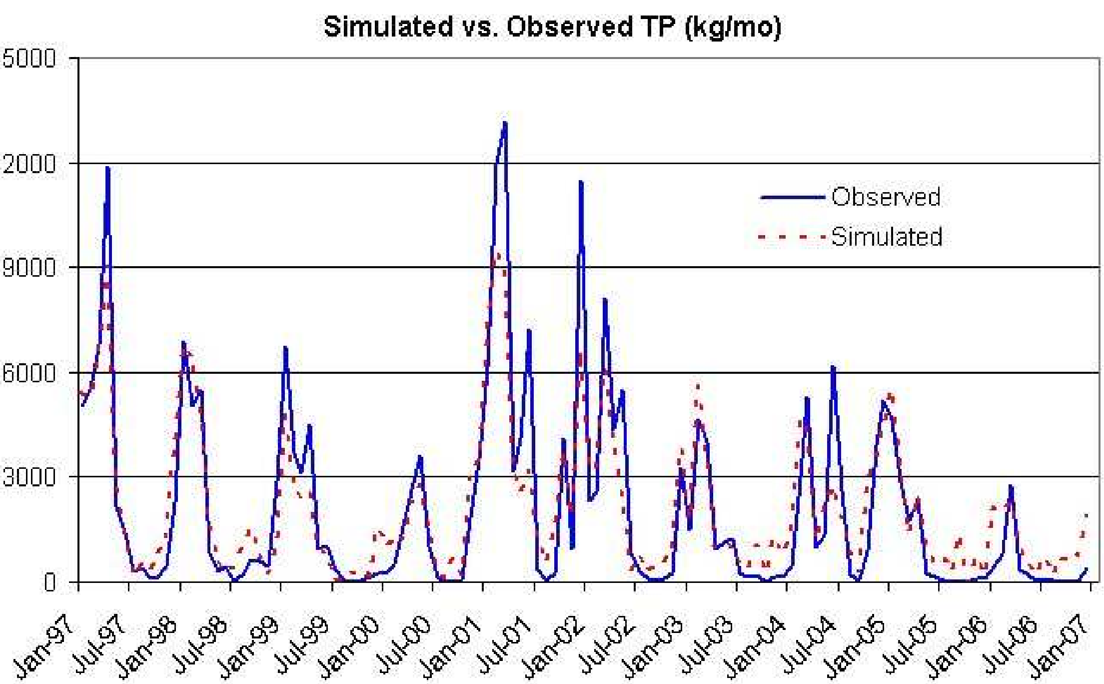
Smackover Creek (AR)





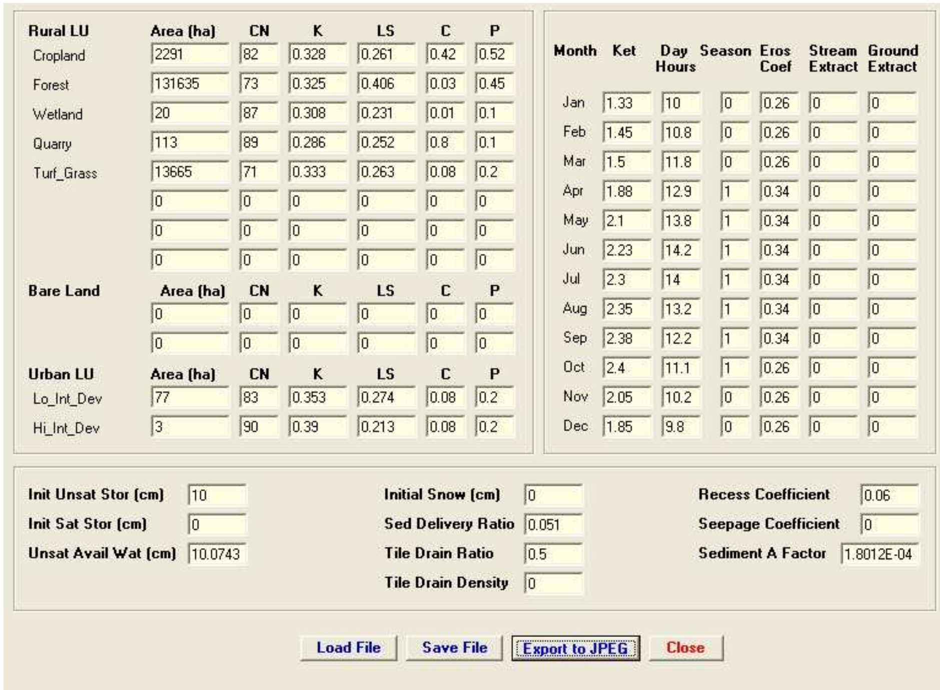


Simulated vs. Observed TSS (1000 kg/mo)
2000
1500
1000
500
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07



Simulated vs. Observed TP (kg/mo)
15000
12000
9000
6000
3000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

South Fork Wichita River (TX)



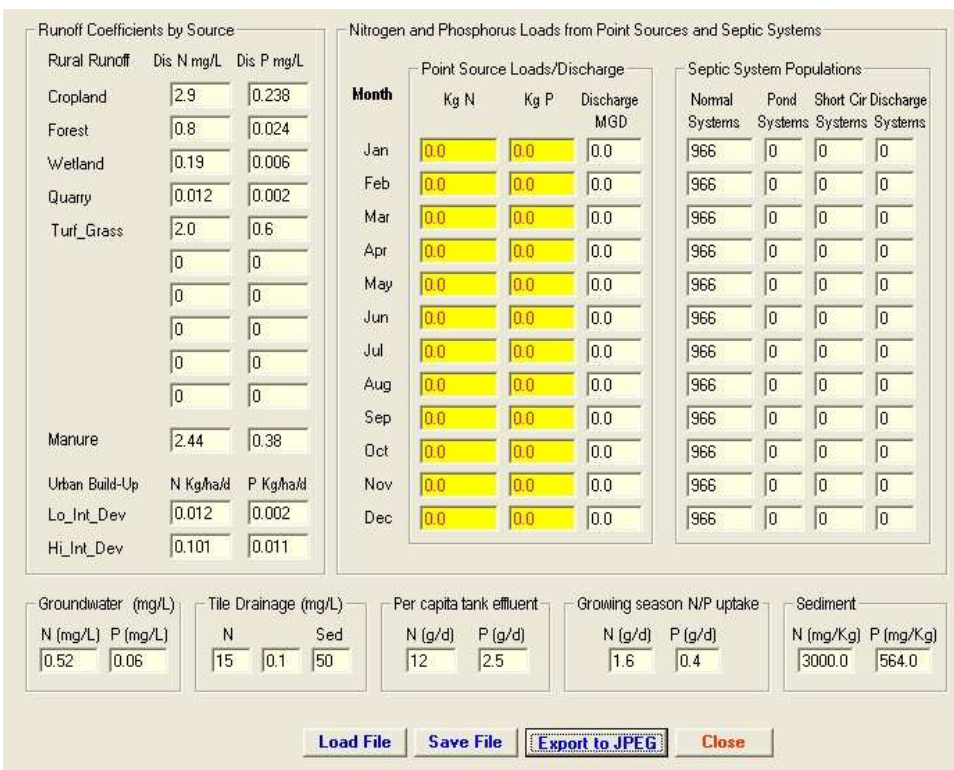
Rural LU	Area (ha)	CN	K	LS	C	P
Cropland	2291	82	0.328	0.261	0.42	0.52
Forest	131635	73	0.325	0.406	0.03	0.45
Wetland	20	87	0.308	0.231	0.01	0.1
Quarry	113	89	0.286	0.252	0.8	0.1
Turf_Grass	13665	71	0.333	0.263	0.08	0.2
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	77	83	0.353	0.274	0.08	0.2
Hi_Int_Dev	3	90	0.39	0.213	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	1.33	10	0	0.26	0	0
Feb	1.45	10.8	0	0.26	0	0
Mar	1.5	11.8	0	0.26	0	0
Apr	1.88	12.9	1	0.34	0	0
May	2.1	13.8	1	0.34	0	0
Jun	2.23	14.2	1	0.34	0	0
Jul	2.3	14	1	0.34	0	0
Aug	2.35	13.2	1	0.34	0	0
Sep	2.38	12.2	1	0.34	0	0
Oct	2.4	11.1	1	0.26	0	0
Nov	2.05	10.2	0	0.26	0	0
Dec	1.85	9.8	0	0.26	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.06
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.051	Seepage Coefficient	0
Unsat Avail Wat (cm)	10.0743	Tile Drain Ratio	0.5	Sediment A Factor	1.8012E-04
		Tile Drain Density	0		

Load File | Save File | Export to JPEG | Close

Transport file



Runoff Coefficients by Source

Rural Runoff	Dis N mg/L	Dis P mg/L
Cropland	2.9	0.238
Forest	0.8	0.024
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	2.0	0.6
	0	0
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	N Kg/ha/d	P Kg/ha/d
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

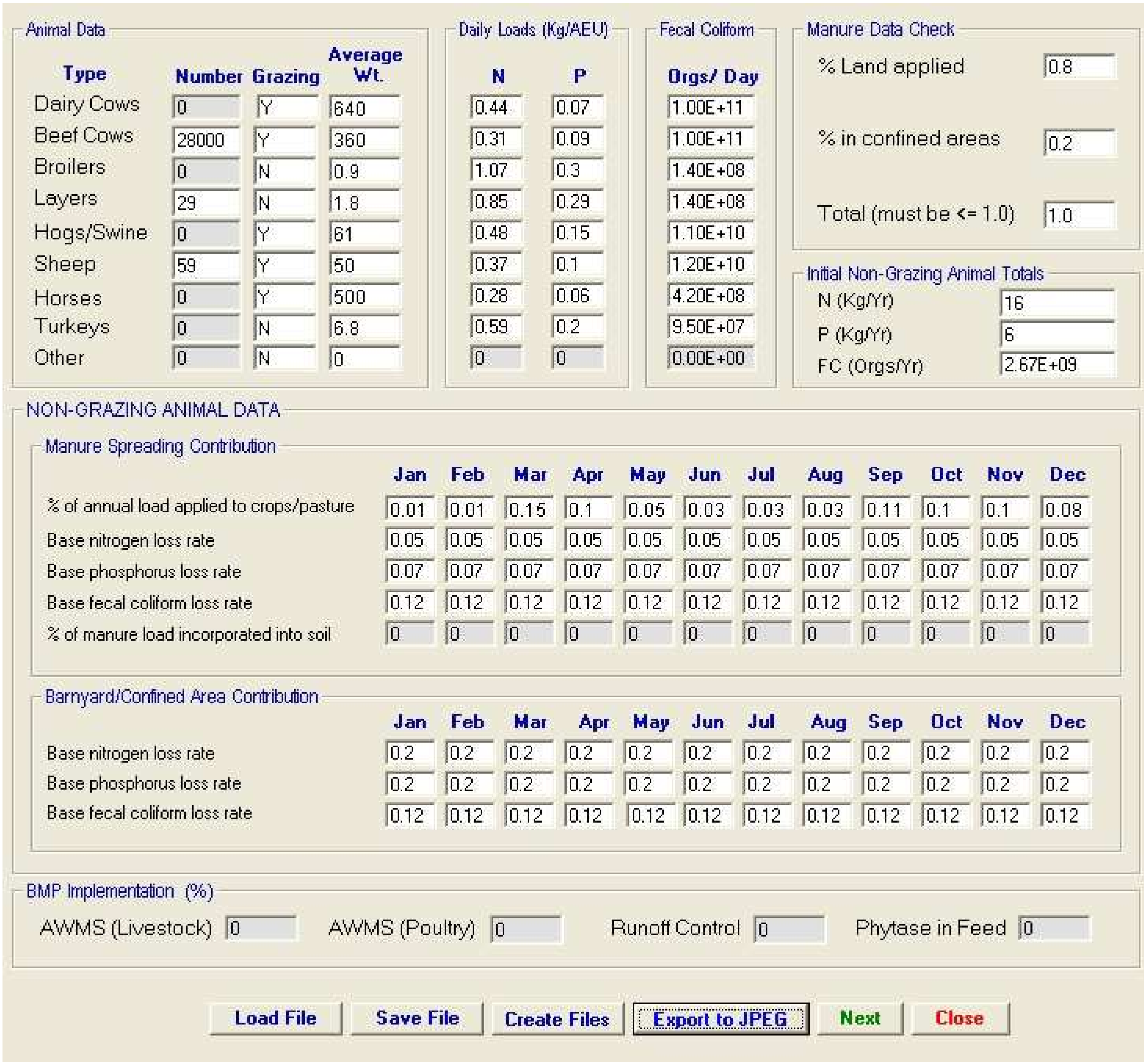
Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	966	0	0	0
Feb	0.0	0.0	0.0	966	0	0	0
Mar	0.0	0.0	0.0	966	0	0	0
Apr	0.0	0.0	0.0	966	0	0	0
May	0.0	0.0	0.0	966	0	0	0
Jun	0.0	0.0	0.0	966	0	0	0
Jul	0.0	0.0	0.0	966	0	0	0
Aug	0.0	0.0	0.0	966	0	0	0
Sep	0.0	0.0	0.0	966	0	0	0
Oct	0.0	0.0	0.0	966	0	0	0
Nov	0.0	0.0	0.0	966	0	0	0
Dec	0.0	0.0	0.0	966	0	0	0

Groundwater (mg/L) N (mg/L)	P (mg/L)	Tile Drainage (mg/L) N	P	Sed	Per capita tank effluent N (g/d)	P (g/d)	Growing season N/P uptake N (g/d)	P (g/d)	Sediment N (mg/Kg)	P (mg/Kg)
0.52	0.06	15	0.1	50	12	2.5	1.6	0.4	3000.0	564.0

Load File | Save File | Export to JPEG | Close

Nutrient file



Animal Data

Type	Number	Grazing	Average Wt.
Dairy Cows	0	Y	640
Beef Cows	28000	Y	360
Broilers	0	N	0.9
Layers	29	N	1.8
Hogs/Swine	0	Y	61
Sheep	59	Y	50
Horses	0	Y	500
Turkeys	0	N	6.8
Other	0	N	0

Daily Loads (Kg/AEU) / Fecal Coliform

Type	N	P	Orgs/ Day
Dairy Cows	0.44	0.07	1.00E+11
Beef Cows	0.31	0.09	1.00E+11
Broilers	1.07	0.3	1.40E+08
Layers	0.85	0.29	1.40E+08
Hogs/Swine	0.48	0.15	1.10E+10
Sheep	0.37	0.1	1.20E+10
Horses	0.28	0.06	4.20E+08
Turkeys	0.59	0.2	9.50E+07
Other	0	0	0.00E+00

Manure Data Check

% Land applied	0.8
% in confined areas	0.2
Total (must be <= 1.0)	1.0

Initial Non-Grazing Animal Totals

N (Kg/Yr)	16
P (Kg/Yr)	6
FC (Orgs/Yr)	2.67E+09

NON-GRAZING ANIMAL DATA

Manure Spreading Contribution

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
% of annual load applied to crops/pasture	0.01	0.01	0.15	0.1	0.05	0.03	0.03	0.03	0.11	0.1	0.1	0.08
Base nitrogen loss rate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Base phosphorus loss rate	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Base fecal coliform loss rate	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
% of manure load incorporated into soil	0	0	0	0	0	0	0	0	0	0	0	0

Barnyard/Confined Area Contribution

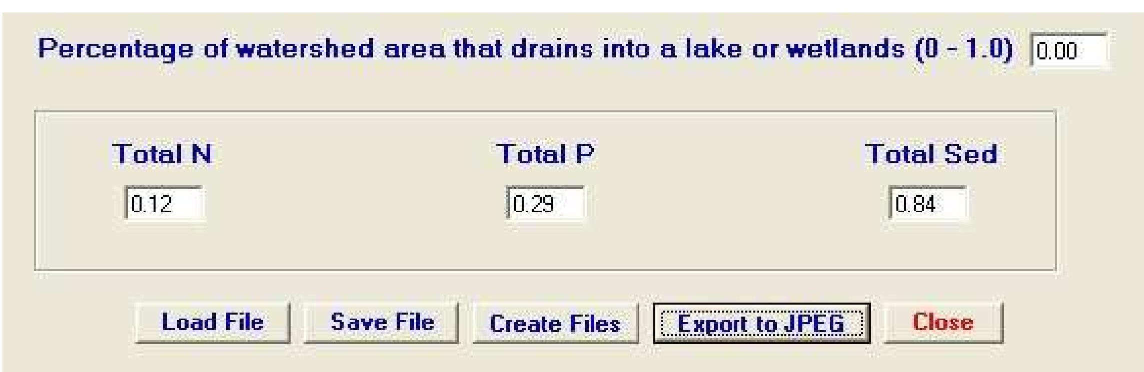
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Base nitrogen loss rate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Base phosphorus loss rate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Base fecal coliform loss rate	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

BMP Implementation (%)

AWMS (Livestock) 0 AWMS (Poultry) 0 Runoff Control 0 Phytase in Feed 0

Load File | Save File | Create Files | Export to JPEG | Next | Close

Animal file



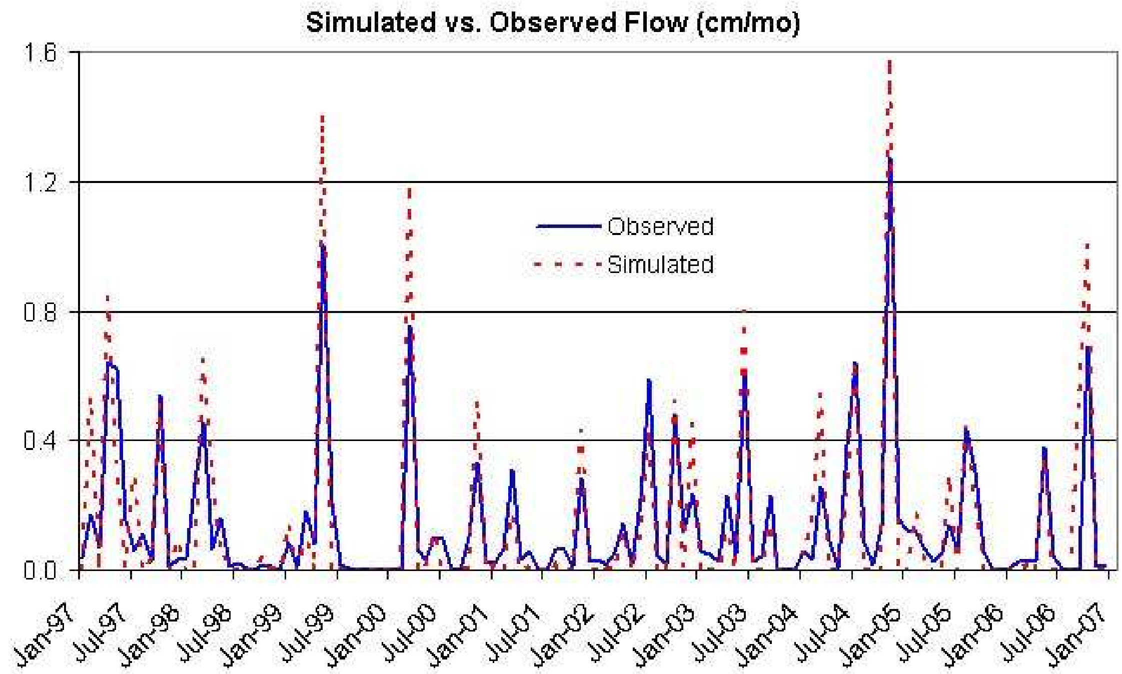
Percentage of watershed area that drains into a lake or wetlands (0 - 1.0) 0.00

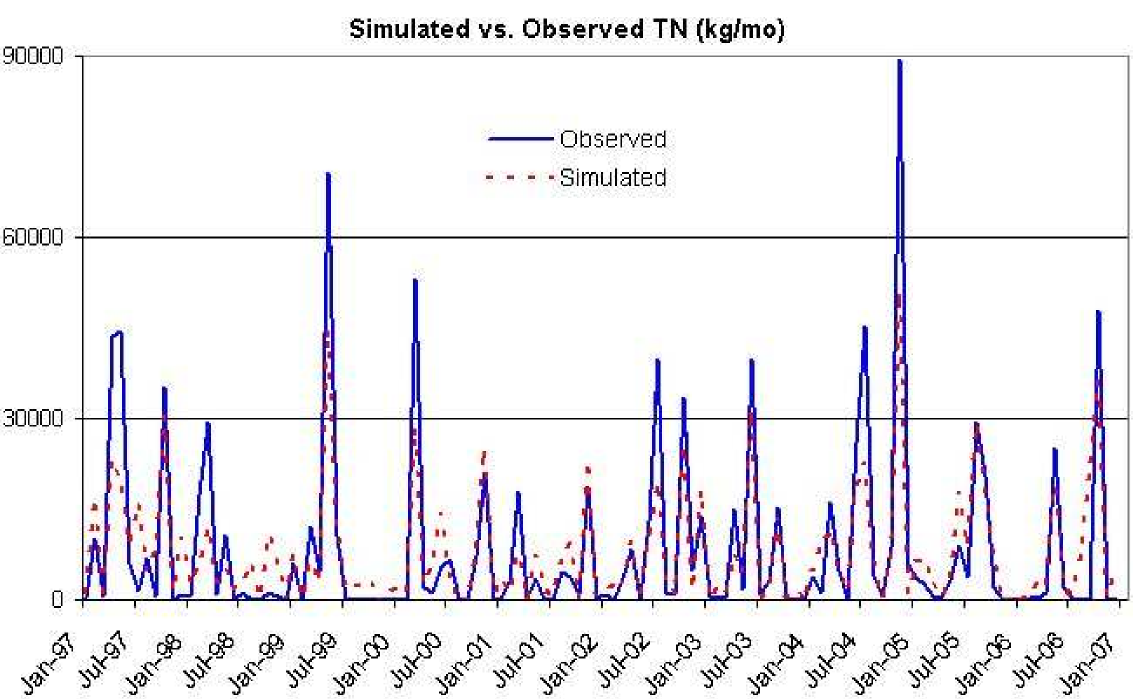
Total N	Total P	Total Sed
0.12	0.29	0.84

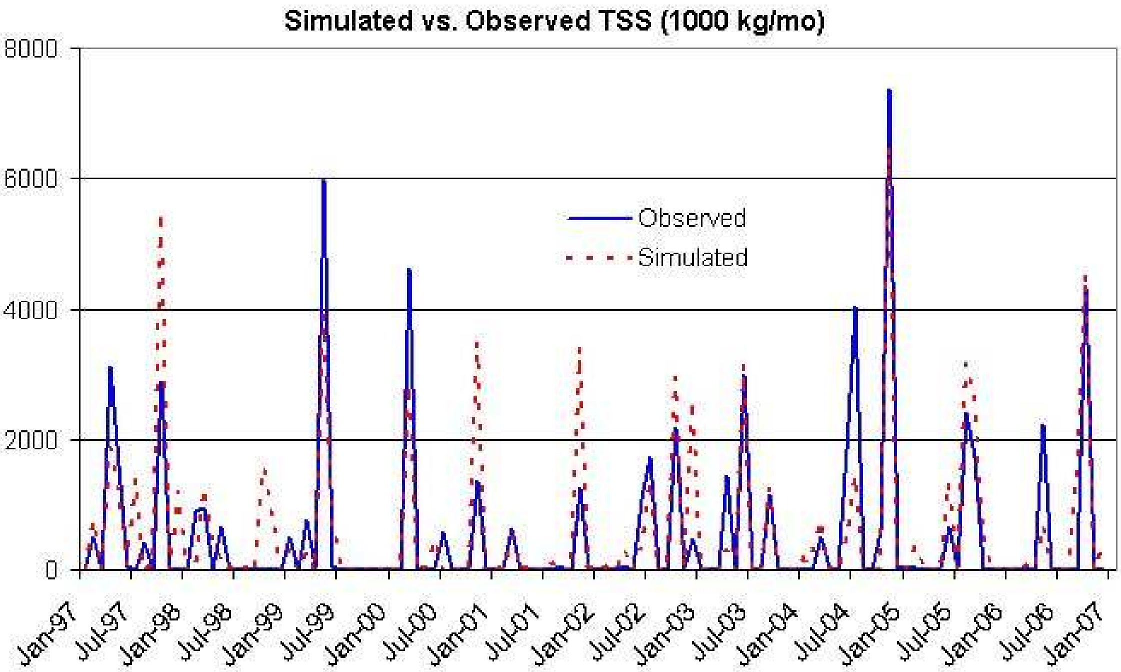
Load File | Save File | Create Files | Export to JPEG | Close

Retention file

South Fork Wichita River (TX)






Simulated vs. Observed TSS (1000 kg/mo)
8000
6000
4000
2000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
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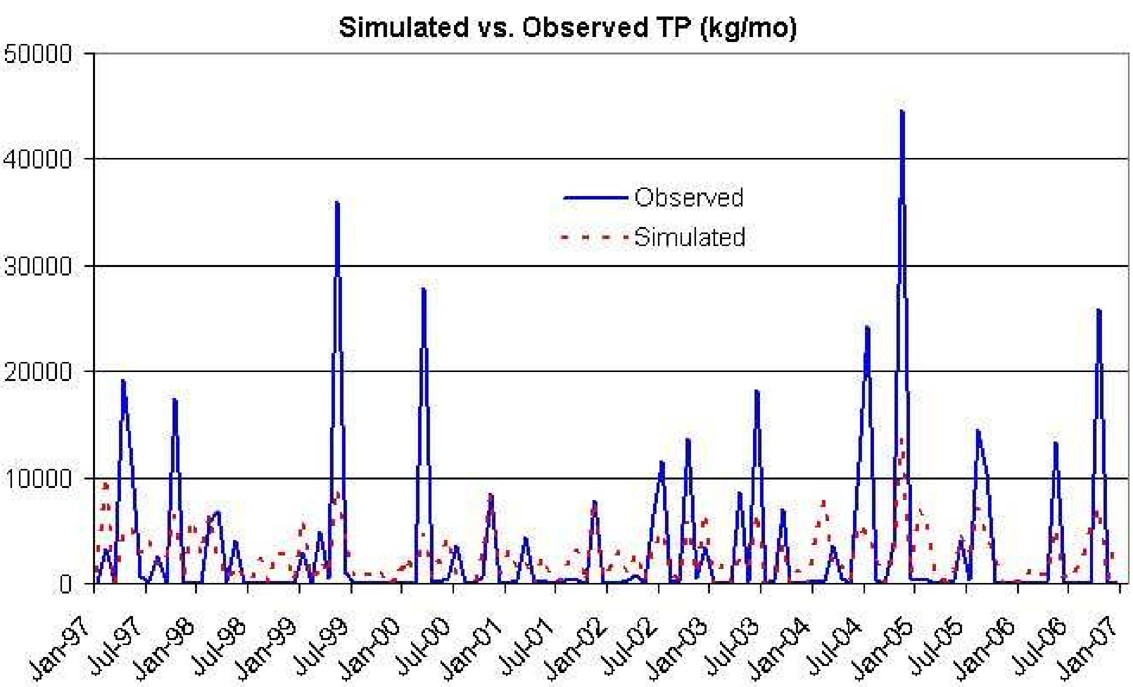
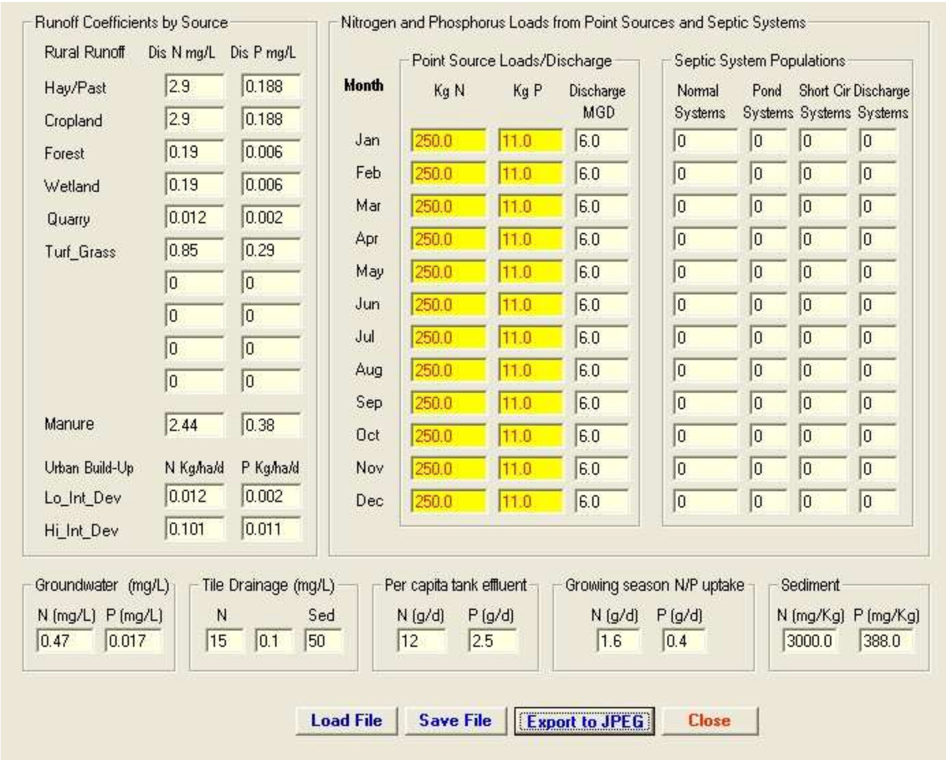
Jul-05
Jan-06
Jul-06
Jan-07

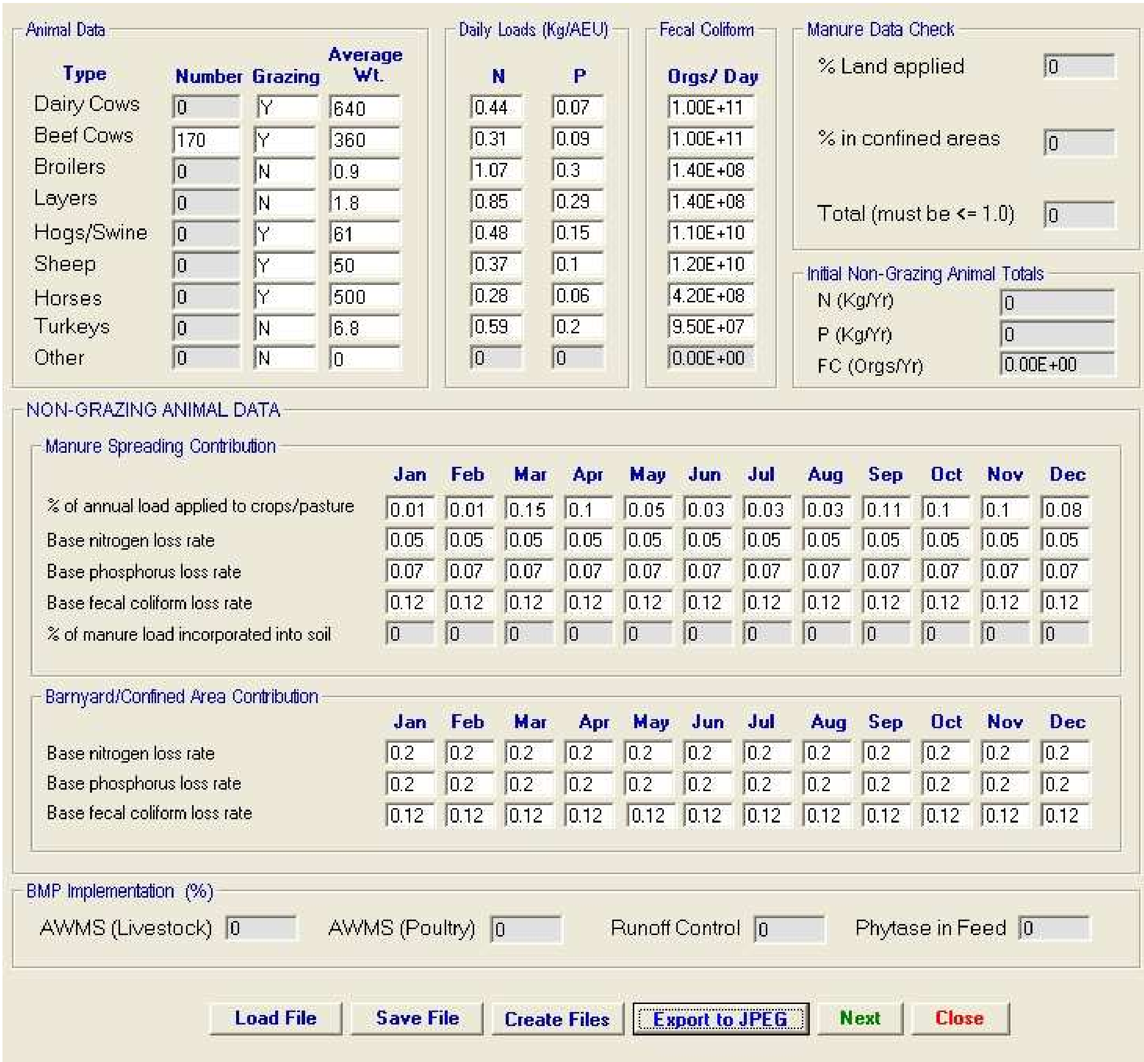

Simulated vs. Observed TP (kg/mo)
50000
40000
30000
20000
10000
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

Vermejo River (NM)

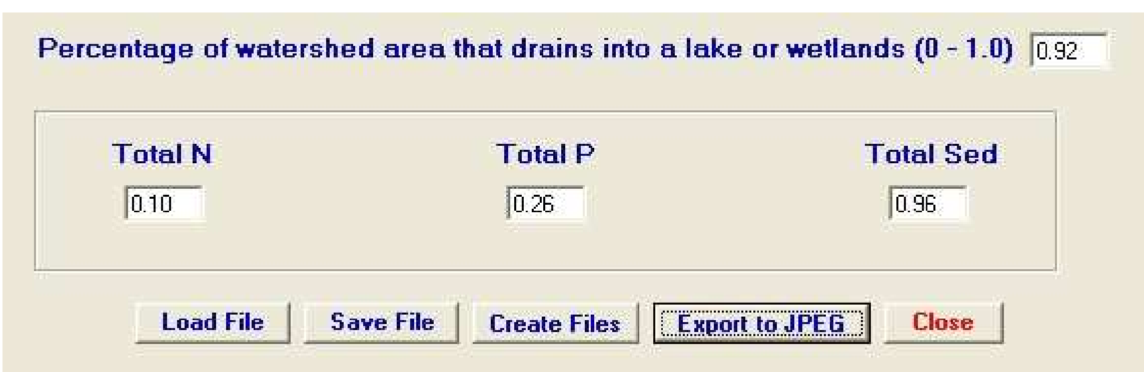
Transport file



Nutrient file

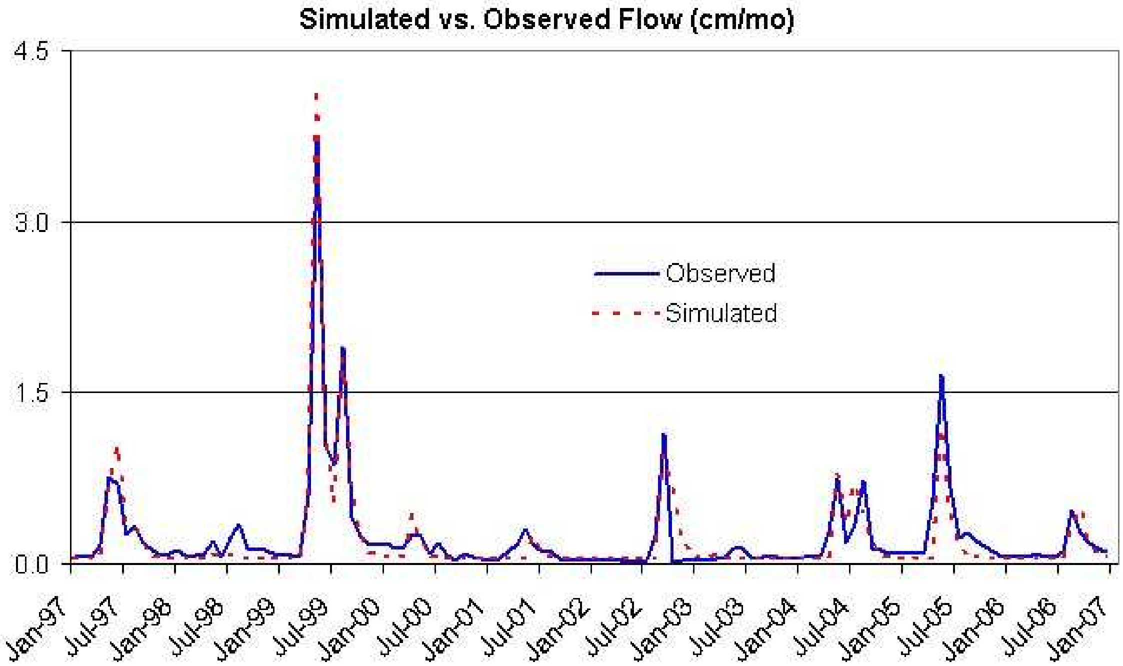


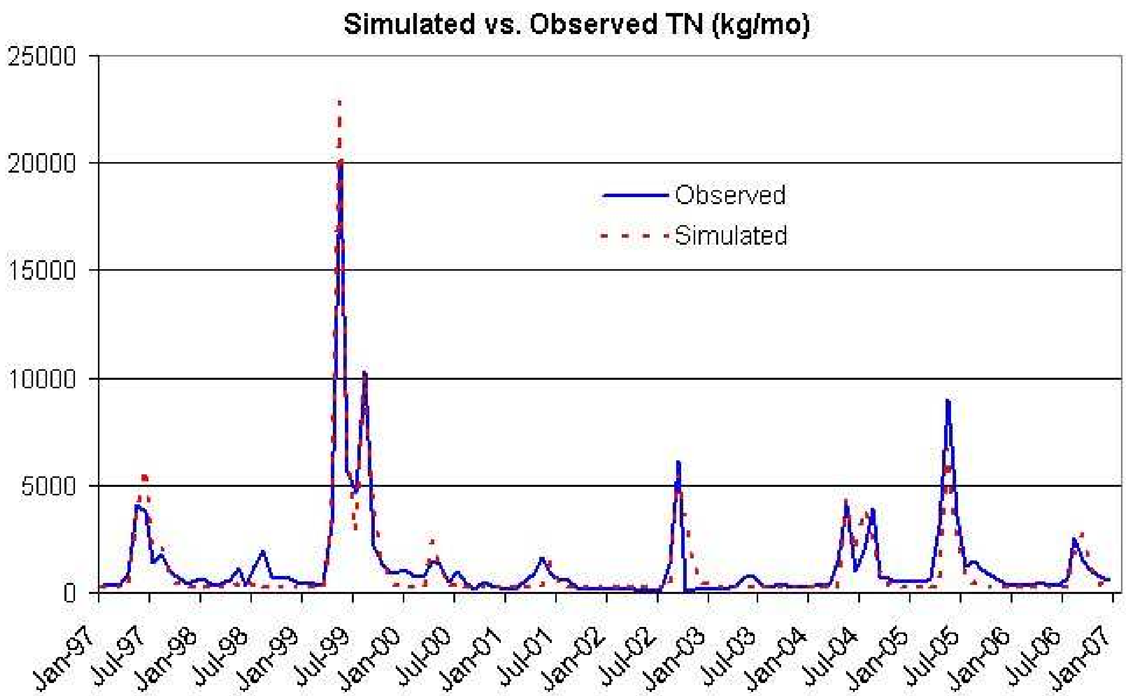
Animal file

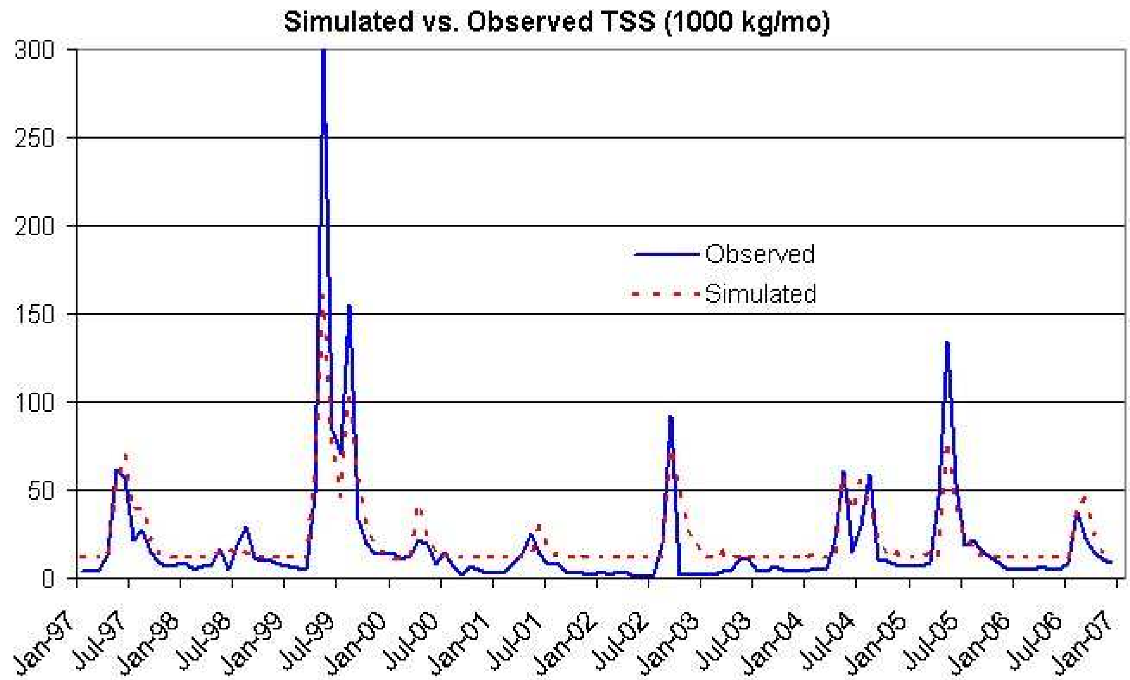


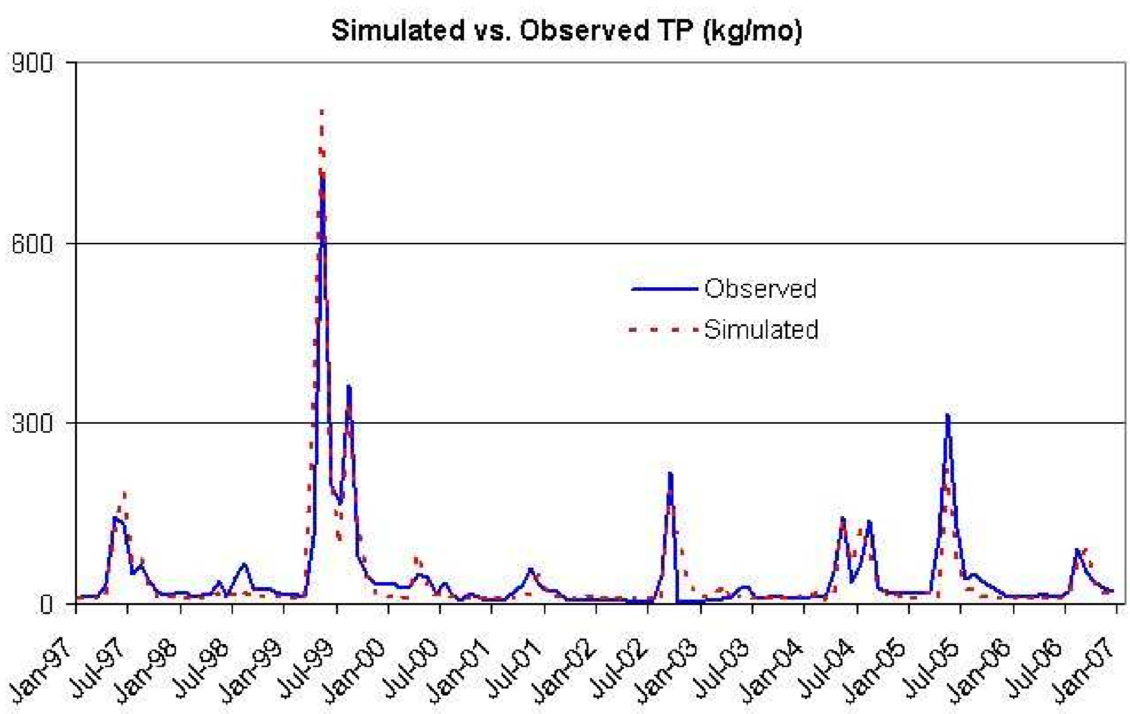
Retention file

Vermejo River (NM)






Simulated vs. Observed TSS (1000 kg/mo)
300
250
200
150
100
50
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07


Simulated vs. Observed TP (kg/mo)
900
600
300
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

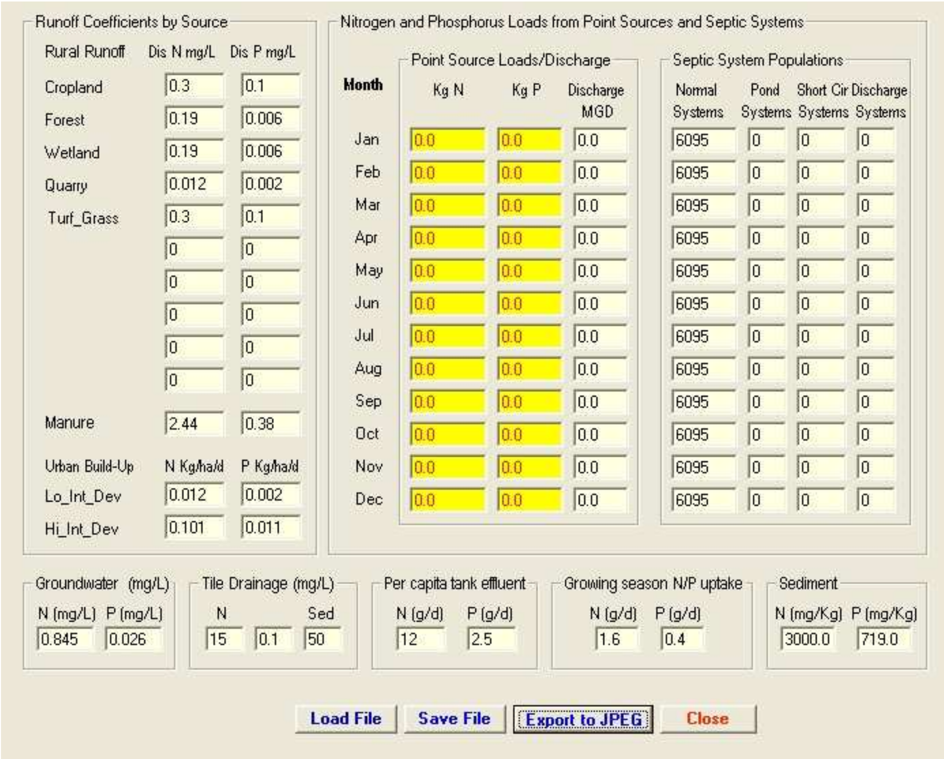
Wolf Creek (TX)

Rural LU	Area (ha)	CN	K	LS	C	P
Cropland	60922	82	0.318	0.262	0.01	0.52
Forest	24987	60	0.288	0.249	0.002	0.45
Wetland	1007	87	0.308	0.222	0.01	0.1
Quarry	182	85	0.268	0.418	0.1	0.1
Turf_Grass	116245	58	0.273	0.297	0.01	0.1
	0	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	0
Bare Land	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
	0	0	0	0	0	0
	0	0	0	0	0	0
Urban LU	**Area (ha)**	**CN**	**K**	**LS**	**C**	**P**
Lo_Int_Dev	341	83	0.302	0.256	0.08	0.2
Hi_Int_Dev	6	93	0.32	0.215	0.08	0.2

Month	Ket	Day Hours	Season	Eros Coef	Stream Extract	Ground Extract
Jan	0.77	9.8	0	0.277	0	0
Feb	0.85	10.6	0	0.277	0	0
Mar	0.89	11.8	0	0.277	0	0
Apr	1.36	13	1	0.34	0	0
May	1.62	14	1	0.34	0	0
Jun	1.79	14.4	1	0.34	0	0
Jul	1.87	14.2	1	0.34	0	0
Aug	1.91	13.4	1	0.34	0	0
Sep	1.96	12.2	1	0.34	0	0
Oct	1.96	11	1	0.277	0	0
Nov	1.53	10	0	0.277	0	0
Dec	1.28	9.6	0	0.277	0	0

Init Unsat Stor (cm)	10	Initial Snow (cm)	0	Recess Coefficient	0.08
Init Sat Stor (cm)	0	Sed Delivery Ratio	0.047	Seepage Coefficient	0
Unsat Avail Wat (cm)	14.6263	Tile Drain Ratio	0.5	Sediment A Factor	1.6175E-06
		Tile Drain Density	0		

Transport file



Runoff Coefficients by Source

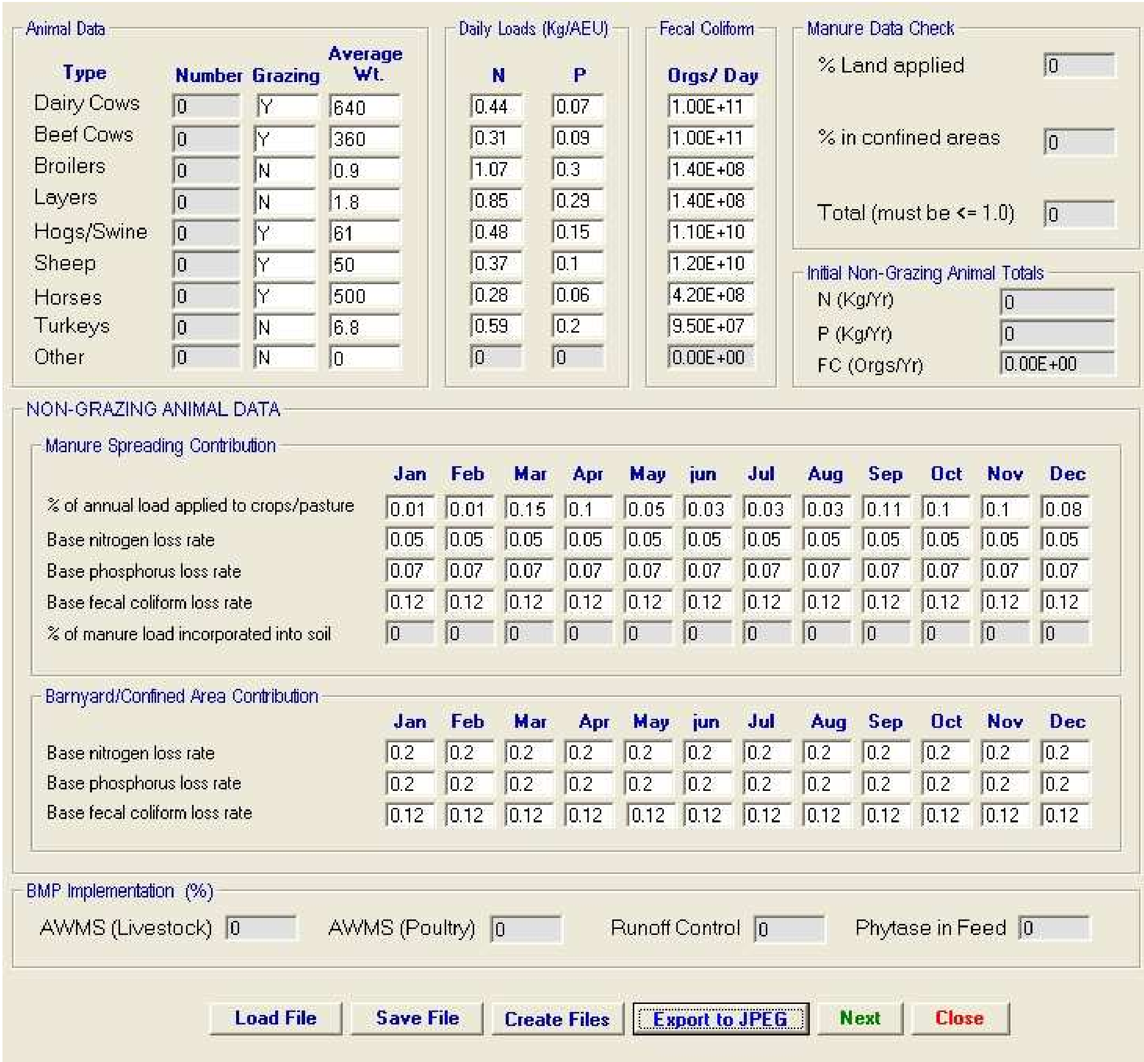
Rural Runoff	Dis N mg/L	Dis P mg/L
Cropland	0.3	0.1
Forest	0.19	0.006
Wetland	0.19	0.006
Quarry	0.012	0.002
Turf_Grass	0.3	0.1
	0	0
	0	0
	0	0
	0	0
	0	0
Manure	2.44	0.38
Urban Build-Up	**N Kg/ha/d**	**P Kg/ha/d**
Lo_Int_Dev	0.012	0.002
Hi_Int_Dev	0.101	0.011

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	Discharge MGD	Septic System Populations: Normal Systems	Pond Systems	Short Cir Systems	Discharge Systems
Jan	0.0	0.0	0.0	6095	0	0	0
Feb	0.0	0.0	0.0	6095	0	0	0
Mar	0.0	0.0	0.0	6095	0	0	0
Apr	0.0	0.0	0.0	6095	0	0	0
May	0.0	0.0	0.0	6095	0	0	0
Jun	0.0	0.0	0.0	6095	0	0	0
Jul	0.0	0.0	0.0	6095	0	0	0
Aug	0.0	0.0	0.0	6095	0	0	0
Sep	0.0	0.0	0.0	6095	0	0	0
Oct	0.0	0.0	0.0	6095	0	0	0
Nov	0.0	0.0	0.0	6095	0	0	0
Dec	0.0	0.0	0.0	6095	0	0	0

Groundwater (mg/L): N (mg/L)	P (mg/L)	Tile Drainage (mg/L): N	P	Sed	Per capita tank effluent: N (g/d)	P (g/d)	Growing season N/P uptake: N (g/d)	P (g/d)	Sediment: N (mg/Kg)	P (mg/Kg)
0.845	0.026	15	0.1	50	12	2.5	1.6	0.4	3000.0	719.0

Nutrient file


Animal Data

Type	Number	Grazing	Average Wt.
Dairy Cows	0	Y	640
Beef Cows	0	Y	360
Broilers	0	N	0.9
Layers	0	N	1.8
Hogs/Swine	0	Y	61
Sheep	0	Y	50
Horses	0	Y	500
Turkeys	0	N	6.8
Other	0	N	0

Type	Daily Loads (Kg/AEU) N	Daily Loads (Kg/AEU) P	Fecal Coliform Orgs/ Day
Dairy Cows	0.44	0.07	1.00E+11
Beef Cows	0.31	0.09	1.00E+11
Broilers	1.07	0.3	1.40E+08
Layers	0.85	0.29	1.40E+08
Hogs/Swine	0.48	0.15	1.10E+10
Sheep	0.37	0.1	1.20E+10
Horses	0.28	0.06	4.20E+08
Turkeys	0.59	0.2	9.50E+07
Other	0	0	0.00E+00

Manure Data Check

% Land applied 0

% in confined areas 0

Total (must be <= 1.0) 0

Initial Non-Grazing Animal Totals

N (Kg/Yr) 0

P (Kg/Yr) 0

FC (Orgs/Yr) 0.00E+00

NON-GRAZING ANIMAL DATA

Manure Spreading Contribution

	Jan	Feb	Mar	Apr	May	jun	Jul	Aug	Sep	Oct	Nov	Dec
% of annual load applied to crops/pasture	0.01	0.01	0.15	0.1	0.05	0.03	0.03	0.03	0.11	0.1	0.1	0.08
Base nitrogen loss rate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Base phosphorus loss rate	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Base fecal coliform loss rate	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
% of manure load incorporated into soil	0	0	0	0	0	0	0	0	0	0	0	0

Barnyard/Confined Area Contribution

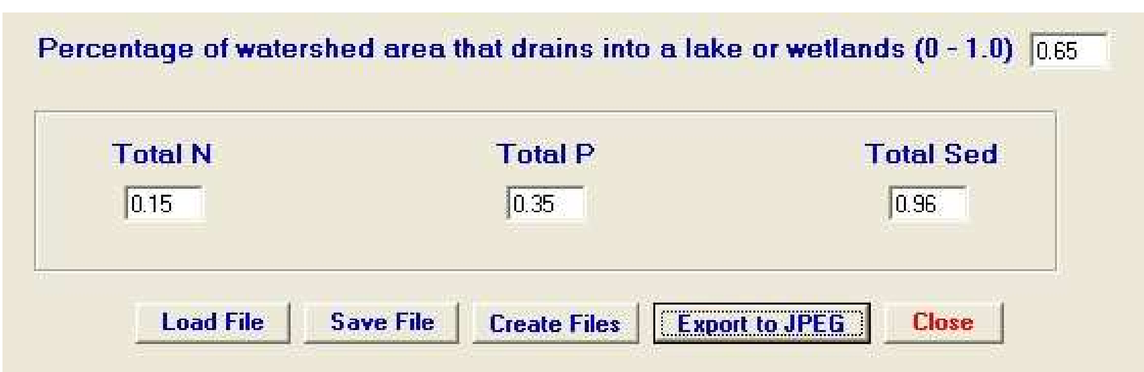
	Jan	Feb	Mar	Apr	May	jun	Jul	Aug	Sep	Oct	Nov	Dec
Base nitrogen loss rate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Base phosphorus loss rate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Base fecal coliform loss rate	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

BMP Implementation (%)

AWMS (Livestock) 0 AWMS (Poultry) 0 Runoff Control 0 Phytase in Feed 0

Load File | Save File | Create Files | Export to JPEG | Next | Close

Animal file

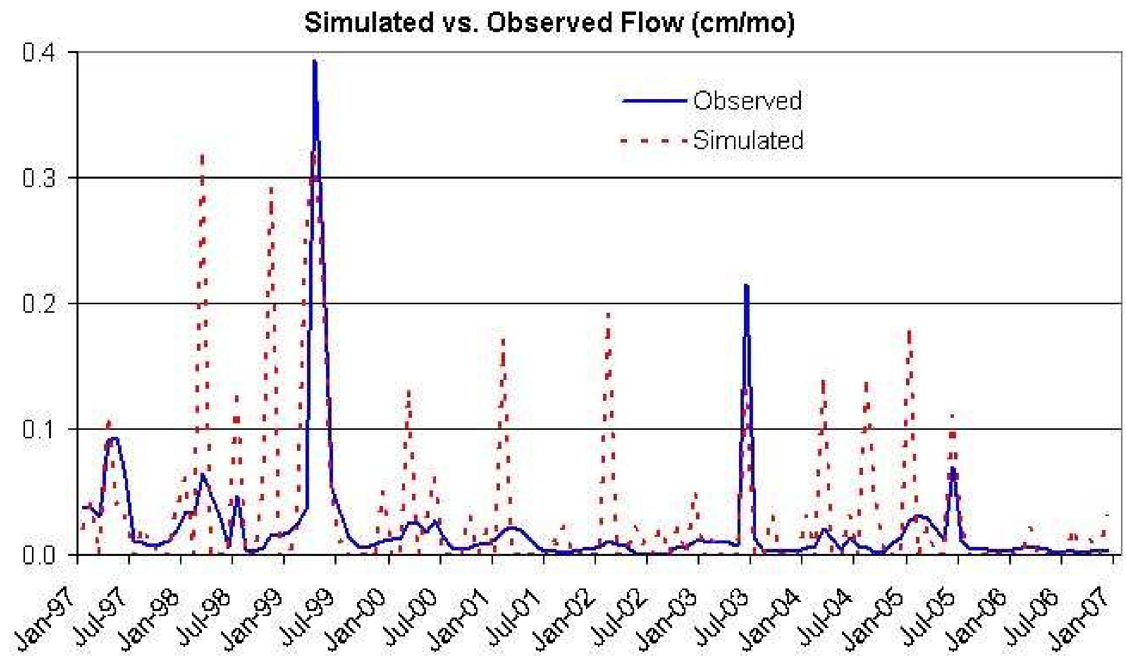

Percentage of watershed area that drains into a lake or wetlands (0 - 1.0) 0.65

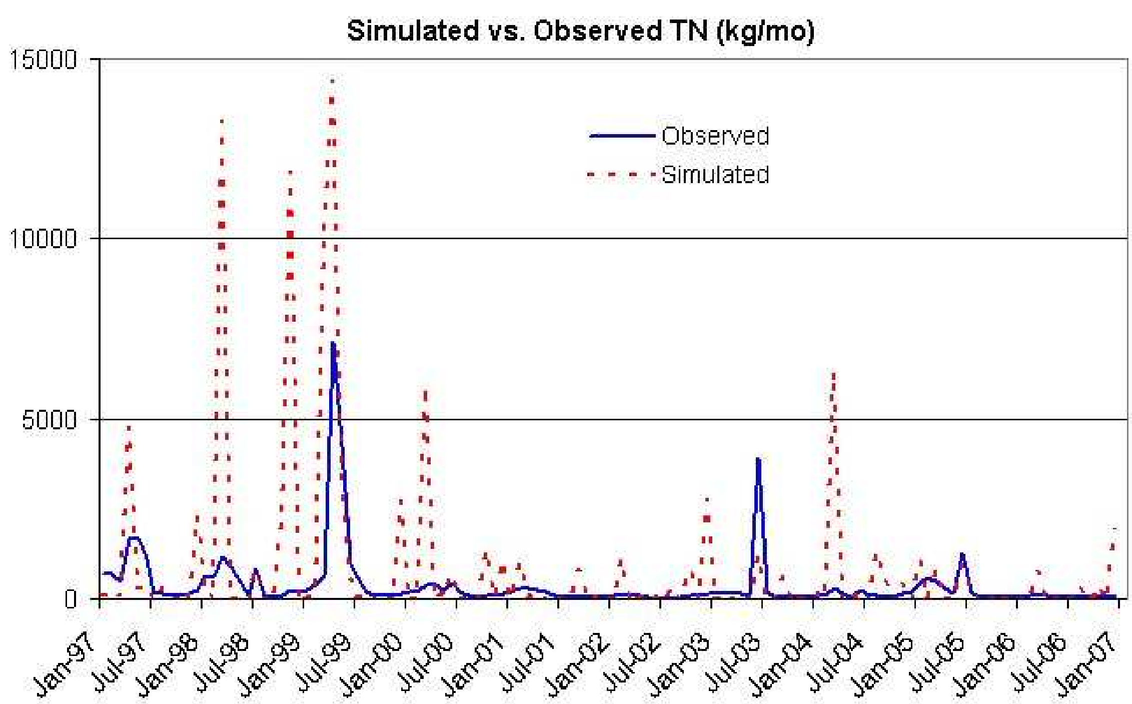
Total N	Total P	Total Sed
0.15	0.35	0.96

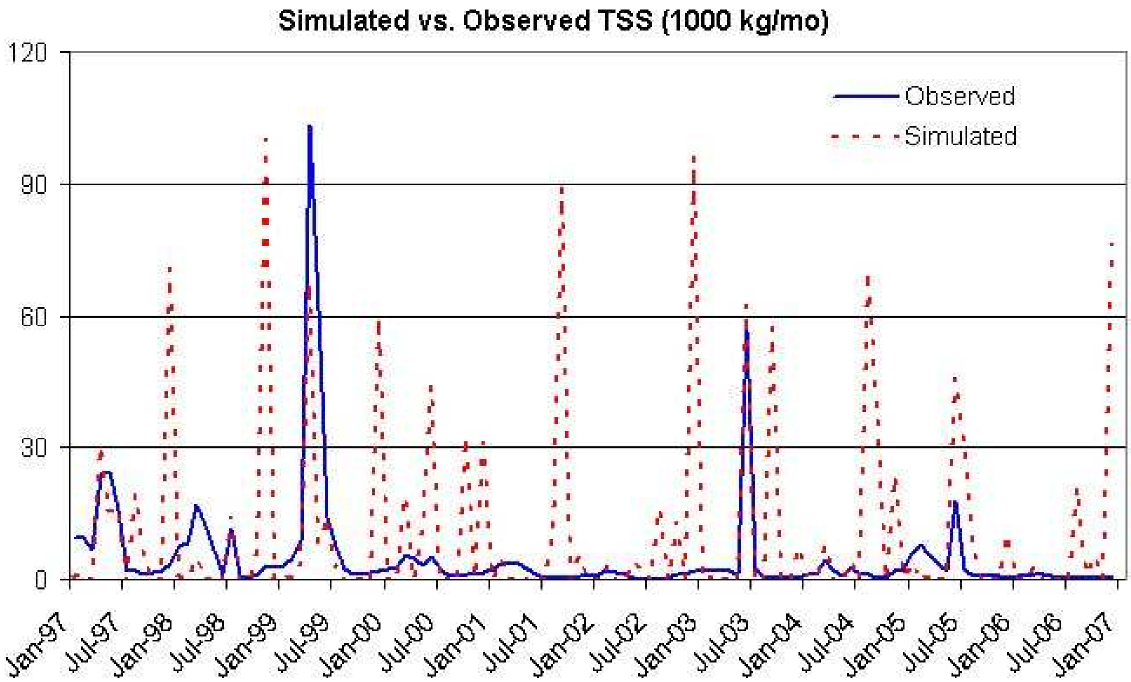
Load File | Save File | Create Files | Export to JPEG | Close

Retention file

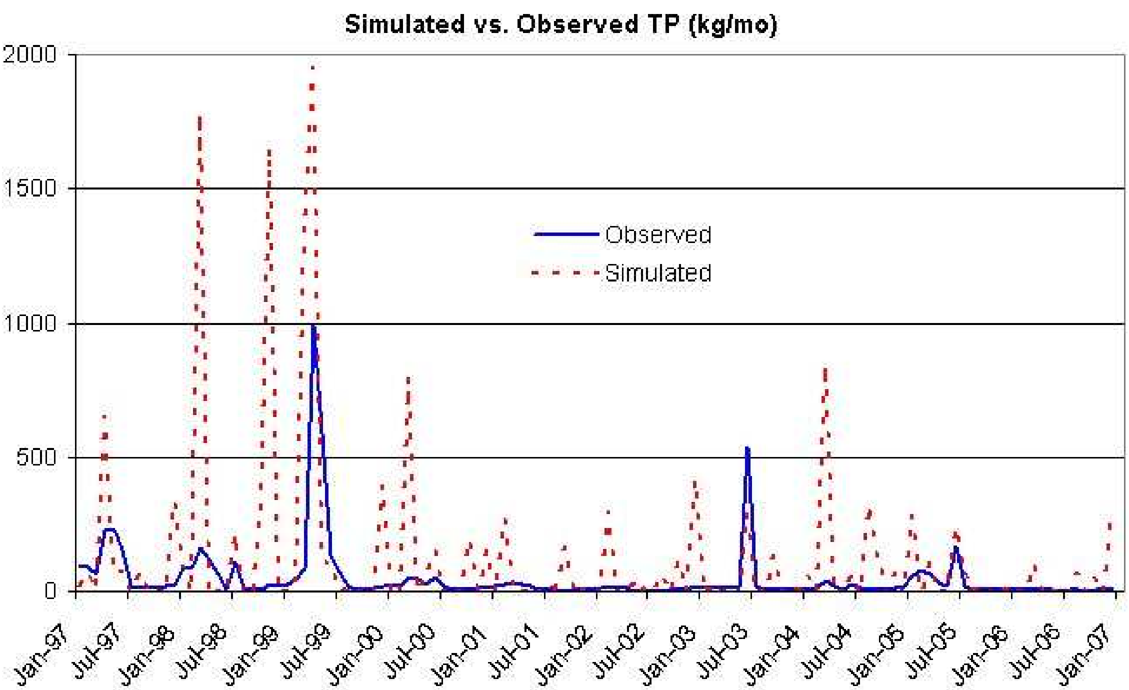
Wolf Creek (TX)







Simulated vs. Observed TSS (1000 kg/mo)
120
90
60
30
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07



Simulated vs. Observed TP (kg/mo)
2000
1500
1000
500
0
Observed
Simulated
Jan-97
Jul-97
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07

APPENDIX C

Description of Project-Related Data Sets on Data CD

1) Default Data Sets for Use in AVGWLF (in “AVGWLFData” folder)

Provided below are brief descriptions of the various data sets developed for use in this project. More detailed descriptions are given in Section 2.2 of the project report. To facilitate their use within **AVGWLF** for this project, the GIS data sets obtained from various sources were re-projected into a common geographic coordinate system. Specifically, an Albers metric coordinate system utilized by many federal agencies for national data sets was used. The projection information for this system is as follows:

PROJCS: NAD_1927_Albers
GEOGCS: GCS_North_American_1927
DATUM: D_North_American_1927
SPHEROID: Clarke_1866
PRIMEM: Greenwich",0.0
UNIT: Degree, 0.0174532925199433
PROJECTION: Albers
PARAMETER: "False_Easting", 0.0
PARAMETER: "False_Northing", 0.0
PARAMETER: "Central_Meridian", -96.0
PARAMETER: "Standard_Parallel_1", 29.5
PARAMETER: "Standard_Parallel_2", 45.5
PARAMETER: "Latitude_Of_Origin", 23.0
UNIT: "Meter", 1.0

A. ESRI-formatted grids

- **soilp:** Estimate of soil phosphorus concentration. Geographic coverage extends out to the limit of the “finalbasins” shapefile described below.
- **gwn:** estimate of sub-surface (shallow groundwater) nitrogen concentration. Geographic coverage extends out to the limit of the “finalbasins” shapefile described below.
- **demsub:** Estimate of surface elevation. Geographic coverage extends out to the limit of the “finalbasins” shapefile described below.
- **landcov:** Land use/cover categories. Geographic coverage extends out to the limit of the “finalbasins” shapefile described below.

B. ESRI-formatted shapefiles

- **ecoreg6.shp:** Boundary file showing geographic extent of EPA Region VI.
- **epa6soils.shp:** Soil polygons extracted from SSURGO data set. In this case, the geographic coverage extends out to the limits of the six states comprising EPA Region VI. However, detailed soil attribute information required for use with AVGWLF is not necessarily complete in all areas that extend beyond the boundaries of the “watershed” polygons used in the study (i.e., “finalbasins”).
- **epa6counties.shp:** Polygons based on counties in the region that contains information on county names, number of people on septic systems, farm animal populations, crop types, and various other types of information.
- **finalbasins.shp:** Polygons depicting the watershed boundaries used in the study.

- **weathersta.shp:** Point data depicting locations of weather stations for which historic data were compiled as described in a later section.

<u>Streams</u>

Contained in the “Streams” sub-folder are various shapefiles depicting the streams used in the study. Due to their size, they have been organized into separate files according to state as described below.

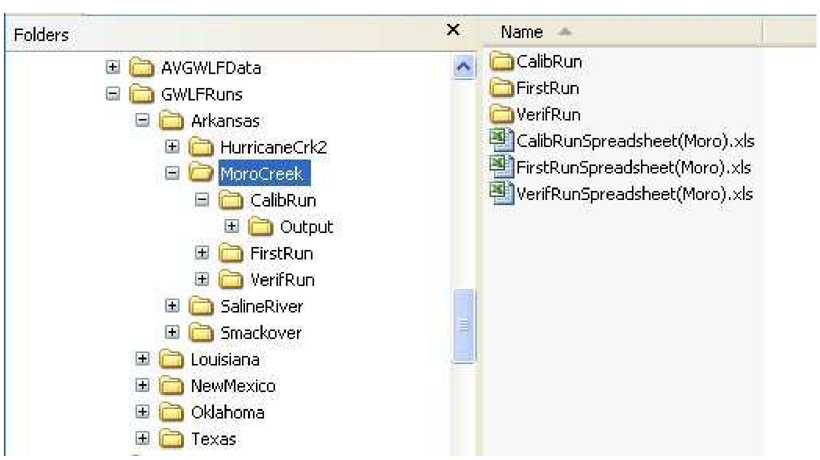
- **AR_streams.shp:** Stream segments in Arkansas (under “Arkansas” sub-folder).
- **lastreams.shp:** Stream segments in Louisiana (under “Louisiana” sub-folder).
- **nmstream.shp:** Stream segments in New Mexico (under “New Mexico” sub-folder).
- **okstreams.shp:** Stream segments in Oklahoma (under “Oklahoma” sub-folder).
- **elmforkstrms.shp:** Stream segments in the Elm Fork/North Fork watershed that includes portions of both Oklahoma and Texas (under the “Oklahoma” sub-folder).
- **txstreams_alb.shp:** Stream segments in Texas (under the “Texas” sub-folder).

C. Weather Data

Included in the “Weather” sub-folder are forty-two (42) files containing historic precipitation and temperature data. These are in a “*.csv” format, which is one of the “text” formats supported by Microsoft Excel.

2) Data Related to GWLF Model Runs

The “GWLFRuns” sub-folder contains input and output data sets associated with the numerous GWLF model runs completed as part of the project. These files are organized by both state and watershed. For example, the “Arkansas” sub-folders contains files for the Hurricane Creek, Moro Creek, Saline River, and Smackover Creek watersheds, with each having an associated sub-folder. Each of these sub-folders (“FirstRun”, “CalibRun”, and “VerifRun”) contain the input and out files associated with the initial, calibration, and verifications runs as described in Section 3 of the project report. Also included in each of the “watershed” sub-folders (e.g., Moro Creek) are three Excel files that provided comparisons of model runs for nutrients and sediment with historical observed data sets.



File locations for GWLF model run results.

3) Miscellaneous Data

A third folder called “MiscData” contains assorted miscellaneous data sets that were used during the course of the project. These data sets are included in three sub-folders (i.e., “FlowData”, “FLUXData”, and “WQData”) that pertain to the type of information contained in each. The “FlowData” sub-folder contains observed stream flow data obtained from the US Geological Survey (http://waterdata.usgs.gov/nwis/sw). These data are organized by state and by USGS gage location (i.e., watershed). The “FLUXData” folder contains “observed” sediment and/or nutrient load data that were derived using the FLUX program (see Section 3.2 of the report for additional detail on this process). Similar to flow data, these data are also organized by state and gage/watershed location. Lastly, the “WQData” folder contains stream water quality sample data pertaining to each watershed used in the study. These data are also organized by state and watershed. In some cases, the sample stations used are co-located with USGS gages, and in other case they are not. Not all data sets included in a given folder or sub-folder were necessarily used in the project . In all cases, both the raw data sets as well as Excel-formatted files are provided.