Adaptation of the AVGWLF Watershed Model for Use in Texas and Surrounding States: Phase I (Project 07-3)

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Nonpoint Source Pollution Control Program Project
In cooperation with
Texas State Soil and Water Conservation Board
and
U.S. Environmental Protection Agency

Effective Period: Upon EPA Approval through January 2010
(with annual updates required)

Questions concerning this quality assurance project plan should be directed to:

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A1 APPROVAL PAGE

Quality Assurance Project Plan for project titled: Adaptation of the AVGWLF Model for Use in Texas and Surrounding States; Phase I.

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Table 1. Acronyms and Abbreviations

AVGWLF	ArcView Generalized Watershed Loading Function
BMP	Best Management Practice
DP	Dissolved Phosphorus
GWLF	Generalized Watershed Loading Function
MRLC	Multi-Resource Land Characterization
NEIWPCC	New England Interstate Water Pollution Control Commission
NASS	National Agricultural Statistics Service
NAWQA	National Water-Quality Assessment
NH_3	Ammonia
NLCD	National Land Cover Data
NO_2	Nitrite
NO_3	Nitrate
NOAA	National Oceanic & Atmospheric Administration
NPS	Nonpoint Source
NRCS	Natural Resource Conservation Service
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
STATSGO	State Soil Geographic
SSURGO	Soil Survey Geographic
TAC	Technical Advisory Committee
TDS	Total Dissolved Solids
TKN	Total Kjehldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TS	Total Solids
TSS	Total Suspended Solids
TSSWCB	Texas State Soil and Water Conservation Board
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

A3 Distribution List

US Environmental Protection Agency; Region V1
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The PSIEE will provide copies of the project plan and any amendments or appendices of this plan to each person on this list. The PSIEE will document distribution of the plan and any amendments and appendices, maintain this documentation as part of the project's quality assurance records, and will be available for review.

A4 Project/Task Organization

Texas State Soil and Water Conservation Board, (TSSWCB)

Mitch Conine
TSSWCB Project Manager

Maintains a thorough knowledge of work activities, commitments, deliverables, and time frames associated with project. Develops lines of communication and working relationships between PSIEE, TSSWCB, and EPA. Tracks deliverables to ensure that tasks are completed as specified in the contract. Responsible for ensuring that the project deliverables are submitted on time and are of acceptable quality and quantity to achieve project objectives. Participates in the development, approval, implementation, and maintenance of the QAPP. Assists the TSSWCB QAO in technical review of the QAPP. Responsible for verifying that the QAPP is followed by the PSIEE. Notifies the TSSWCB QAO of particular circumstances that may adversely affect the quality of data derived from the collection and analysis of samples. Enforces corrective action.

Texas State Soil and Water Conservation Board

Donna Long,
TSSWCB Quality Assurance Officer

Reviews and approves QAPP and any amendments or revisions. Ensures distribution of approved and/or revised QAPPs to TSSWCB and EPA participants. Responsible for verifying that the QAPP is followed by project participants. Determines that the project meets the requirements for planning, quality assurance (QA), quality control (QC), and reporting under the CWA Section 319 program. Monitors implementation of corrective actions. Coordinates or conducts audits of field and laboratory systems and procedures.

Pennsylvania State University

Barry M. Evans, Ph.D.
PSIEE Project Leader

Responsible for ensuring tasks and other requirements in the contract are executed on time and are of acceptable quality. Monitors and assesses the quality of work. Coordinates attendance at conference calls, training, meetings, and related project activities with TSSWCB. Responsible for writing and maintaining the QAPP. Responsible for maintaining records of QAPP distribution, including appendices and amendments. Responsible for coordinating with the TSSWCB QAO to resolve QA-related issues. Notifies the TSSWCB project manager of particular circumstances that may adversely affect the quality of model calibration and validation as well as the preparation of documentation related to data compilation and model testing. Enforces corrective action. Responsible for developing and providing TSSWCB with project final report.

Environmental Protection Agency

Ellen Caldwell
EPA Project Officer

Responsible for managing the CWA Section 319 funded grant on the behalf of EPA. Assists the TSSWCB in approving projects that are consistent with the management goals designated under the State's NPS management plan and meet federal guidance. Coordinates the review of project work plans, QAPPs, draft deliverables, and works with the TSSWCB in making these items approvable. Meets with the State at least semi-annually to evaluate the progress of each project and when conditions permit, participate in a site visit on the project. Fosters communication within EPA by updating management and others, both verbally and in writing, on the progress of the State's program and on other issues as they arise. Assists the regional NPS coordinator in tracking a State's annual progress in its management of the NPS program. Assists in grant close-out procedures ensuring all deliverables have been satisfied prior to closing a grant.

A5 Project Definition/Background

Introduction

Nonpoint source pollution (NPS) is considered a primary threat to the quality of waters in the country. 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. Using 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.

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; particularly those associated with non-point sources of sediment and nutrients. Under this current effort, the Texas State Soil and Water Conservation Board (TSSWCB), in collaboration with the Penn State Institutes of Energy and the Environment (PSIEE), will develop 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.

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 GIS package that is used to parameterize input data for the GWLF 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 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 accurately estimate nutrient and sediment loading for every watershed in the state, including those for which there were minimum water quality data 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 at 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 highly-desirable model for development and calibration in other regions of the country.

Objectives

For this project, TSSWCB is collaborating with Penn State to calibrate and adapt the AVGWLF model for use in EPA Region VI, which includes 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 will be calibrated and validated using representative watersheds throughout EPA Region VI. The calibration and validation of this model will provide the states in this region with a tool to estimate load reduction and TMDLs more consistently for the entire region.

The project 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.

A6 Project/Task Description

In this project, TSSWCB will work with Dr. Barry Evans at Penn State to calibrate and validate AVGWLF. AVGWLF model development for the region will be guided by a technical advisory committee (TAC) to be organized immediately after QAPP approval. The TAC will be made up of representatives from each state 319 program and from EPA Region VI, along with Mitch Conine at TSSWCB and Dr. Evans at Penn State. The project is comprised of four primary tasks: 1) preparation of a Quality Assurance Project Plan; 2) selection of the calibration watersheds; 3) compilation and preparation of the model input data; and 4) calibration/validation of the model for selected areas in EPA Region VI.

QAPP Development

The QAPP will be prepared and submitted to EPA for approval in accordance with EPA requirements. The QAPP must be fully approved before any data compilation and/or generation activities begin. TSSWCB and Penn State are responsible for developing and submitting the QAPP

Watershed Selection

As part of this project, model calibration and verification will be conducted in selected areas of Region VI. Due to limited funding, this work will be carried out in three specific eco-regions that traverse EPA Region VI (see Figure 1). These eco-regions include the Southwest Tablelands, Central Great Plains, and South Central Plains. In the original project plan, it was anticipated that AVGWLF would be tested at 8 different sites (four calibration and four verification) within 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 water quality data (particularly in the drier westernmost regions), the number of study sites has been 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 2). An attempt was made to select test watersheds that range in size from approximately 20 to 400 square miles. Due to lack of data again, however, the watershed sizes of the watersheds selected range in size from about 50 to 1200 square miles in size. These watersheds were selected on the basis of size, characteristics, quality of available data, and location. (See Section A7 for details on calibration watershed criteria).

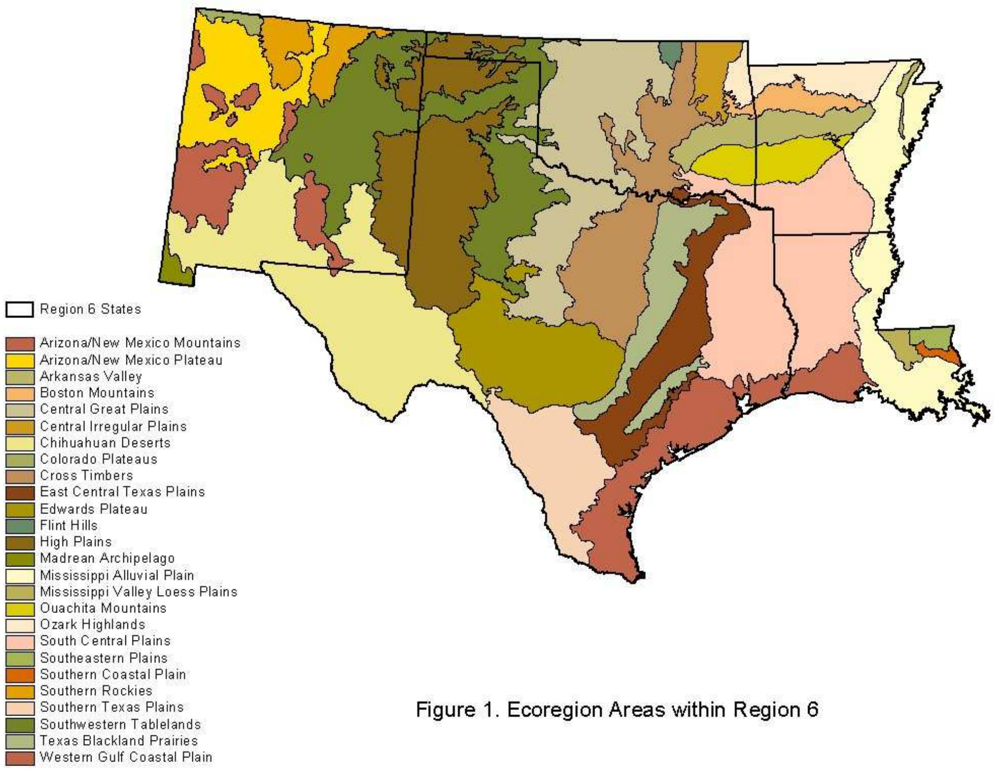

Figure 1. Ecoregion Areas within Region 6

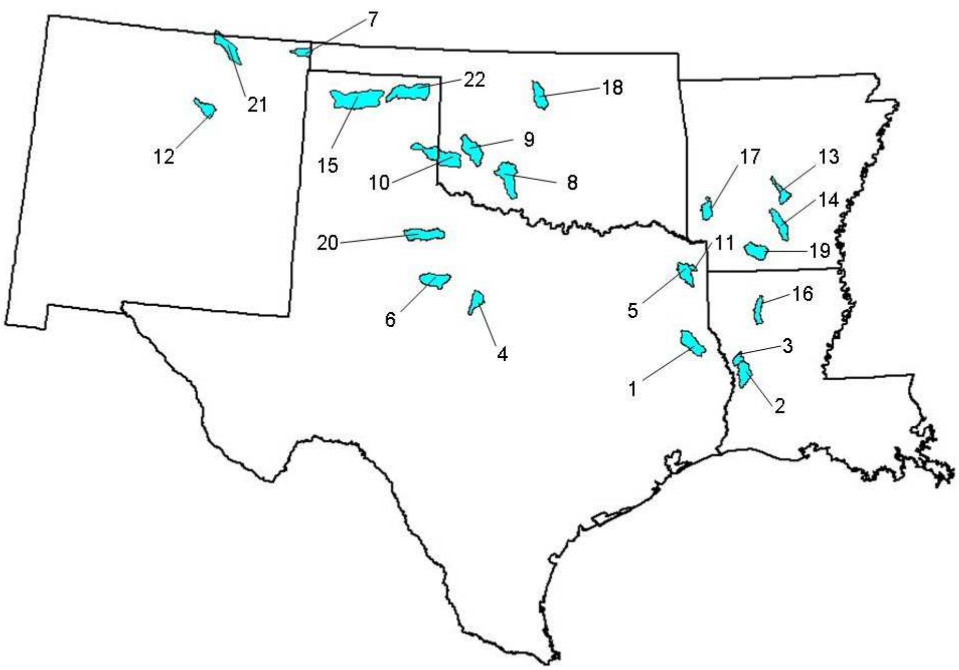

Figure 2. Location of watershed test sites.

Table 2. 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	Galinas River	293	NM
13	OUA116	7363300	Hurricane Creek	255	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

Model Input Data

Penn State, TSSWCB and the TAC will work closely together to compile input data for the region and the selected test watersheds. Critical watershed-related data such as hydrology, land cover, soils, topography, weather, and pollutant discharges will comprise the core input for the model. Penn State will be primarily responsible for working with the TAC to locate necessary data for use in the model. Specific data inputs for any given watershed may include:

- weather data (average temperature and precipitation), a minimum of 2 weather stations per watershed is desired;
- mean monthly and/or annual nutrient loads and flows from point source discharges;
- information about water extractions;
- information on tile drainage systems;
- information on unpaved roads;
- septic system usage;
- animal density;
- soils information;

- land use;
- elevation data (100m resolution);
- groundwater nitrogen (based on background nitrogen estimates)
- physiographic province;
- soil phosphorus levels;
- 5+ years of consistent water quality and stream discharge data.

Dr. Evans at Penn State will be primarily responsible for ensuring that input data is formatted properly for subsequent use in the model.

Calibration and Validation

Once the input data sets are completed, Dr. Evans at Penn State will calibrate and validate the model's algorithms and verify model output (estimated nutrient and sediment loading) for the test watersheds using observed data sets constructed from historic water quality and flow data.

Project Plan Milestones

The schedule for completion of the project is as follows:

2008

April-May	Project commences. QAPP developed and submitted
August-September	TAC organized. Initial meeting held to discuss input data needs and calibration/verification watershed selection.
September-October	TAC teleconferences to discuss and select calibration/verification watersheds.
August	Begin compilation of input data for model. Penn State to work with TAC to collect necessary data.
November	Complete compilation of input data for model. Begin model calibration and verification with Dr. Evans.
December	TAC Teleconference to provide project update and discuss status of model calibration/verification.

2009

January	TAC Teleconference to provide project update and discuss status of model calibration/verification.
February	Complete beta version of the adapted AVGWLF model.
March	The draft model report is completed.
April	Draft model report is distributed to TAC members.
May	TAC Meeting to review and test beta model and discuss draft model report.
June	Comments form TAC on draft model report to TSSWCB/Penn State.
	TAC teleconference, if necessary, to discuss draft model report comments.
	Submit compiled comments on draft model report to Dr. Evans.
July	Adapted AVGWLF model and final model report complete.
July	AVGWLF Model Overview Workshop for member states.

A7 Quality Objectives and Criteria for Model Inputs/Outputs

Watershed Selection Criteria

Early in the project, the TAC will hold several conference calls for the purpose of identifying potential test watersheds in three eco-regions distributed across all five states in EPA Region VI. From these discussions, it is expected that twenty-four (24) such sites will be selected for subsequent model calibration and verification purposes, with four() calibration and four() verification sites in each eco-region. An attempt will be made to select watersheds that collectively represent a wide range of landscape characteristics found across the region. In the selection process, focus will be placed on watersheds that best meet the criteria listed below. In some cases, watersheds that do not meet certain criteria may be chosen because they have special characteristics that make them worthwhile candidates. In such cases, deviations from the criteria will be acknowledged as likely causes of deviations from expected results. The criteria are as follows:

- Watershed size should range from about 50 to 1200 square miles. Larger watersheds may provide less accurate nutrient estimates since the model does not account for in-stream N or P attenuation. Very small watersheds, however, typically aren't diverse enough to provide the model with sufficient input variation. To capture regional variability, the calibration watersheds should vary in size.

- Watersheds should have at least one monitoring station, and a minimum of 5 years of consecutive water quality and flow data. Watersheds with year-round data are preferred; however, it is possible to work with a watershed that only has seasonal data. Watersheds should contain at least one USGS (or other long-term, continuous) flow gage that provides estimates of mean daily flow. Daily flow data will better reflect the variability of the weather data.

- Watersheds should have in-stream water quality data on total nitrogen, total phosphorus, and sediment (preferably total suspended solids) concentration. Watersheds that lack data for nitrogen, phosphorus or sediments will not necessarily be discounted since the model can be run to simulate each pollutant independently. At least 5 years of data should be available to reflect year-to-year variability in weather.

- In-stream concentration data should have corresponding data on instantaneous flow (measured at time of sample collection). If such data are not available, it may be possible to estimate flow based on daily flow data from a nearby stream gage. As with in-steam concentration data, flow data at the outlet are needed. At least 5 years of data should be collected to reflect variability in weather.

- Watersheds with significant point source inputs are acceptable as long as they are not dominated by such inputs.

- Watersheds should have a variety of characteristics that are of regional interest since a primary objective of model testing is to reflect diverse landscapes across the region.

- Watersheds with few best management practices (BMPs) should be selected in order to simplify the watershed simulation process. If watersheds with a high degree of BMP implementation are selected, an attempt should be made to accurately quantify the extent of implementation.

- The most recent watershed data should be utilized for any test watershed that has experienced significant changes over the past 10 years.

Input Map Data Criteria

All digital map (GIS) data acquired for model testing purposes must conform to QA/QC procedures established by the source agency (e.g., states, EPA, USGS, etc.). If necessary, the data will be converted (by Penn State) to a common geographic projection to facilitate data processing within AVGWLF.

Model Limitations

The primary purpose of AVGWLF is to estimate nutrient (total N and total P) and sediment loads that may be delivered via a given landscape area (typically a watershed) to a nearby body of water (e.g., stream, lake, bay, etc.). The core simulation model used within AVGWLF (i.e., GWLF) is not an in-stream model and therefore does not account for in-stream attenuation and sedimentation. As watershed size increases, these processes typically become more important. Consequently, it is advised that the model ***not*** be used in very large watersheds where measured loads at the outlet (i.e., “delivered” loads) may be substantially less than “generated” loads, thereby complicating the model calibration process.

A8 Special Training Requirements/Certification

All personnel involved in model calibration, verification, and development have received the appropriate education and training required to adequately perform their duties. In fact, this work is being done by the individuals responsible for the original development of the AVGWLF modeling system. No special certifications are required.

A9 Documentation and Records

All records, including modeler's notebooks and electronic files, will be archived at PSIEE and at Pennsylvania State University for at least five years. These records will document model testing, calibration, and evaluation and will include record of code verification (hand-calculation checks, comparison to other models), source of historical data, and source of new theory, calibration and sensitivity analyses results, and documentation of adjustments to parameter values due to calibration. Electronic data on the desktop and network server relevant to this project will be backed up daily to an external disk drive. In the event of a catastrophic systems failure, the drive can be used to restore the data in less than one day's time. Data generated on the day of the failure may be lost, but can be reproduced from raw data in most cases.

Quarterly Reports

Quarterly progress reports disseminated to the individuals listed in Section A3 will note activities conducted in connection with the water quality modeling project, potential problems, and any variations or supplements to the QAPP. Potential problems and any variations or supplements to QAPP procedures noted in the quarterly progress report will be made known to pertinent project personnel and included in an update or amendment to the QAPP.

Corrective Action Reports (CARs)

Corrective Action Reports (CAR) will be utilized as necessary (Appendix A). CARs will be maintained for reference in an accessible location by PSIEE and disseminated to the individuals listed in section A3. CARs resulting in any changes or variations from the QAPP will be made known to pertinent project personnel and documented in updates or amendments to the QAPP.

QAPP Revisions and Amendments

Until the work described is completed, this QAPP shall be revised as necessary and reissued annually on the anniversary date, or revised and reissued within 120 days of significant changes, whichever is sooner. The last approved versions of QAPPs shall remain in effect until revised versions have been fully approved; the revision must be submitted to the TSSWCB for approval before the last approved version has expired. If the entire QAPP is current, valid, and accurately reflects the project goals and the organization's policy, the annual re-issuance may be done by a certification that the plan is current. This can be accomplished by submitting a cover letter stating the status of the QAPP and a copy of new, signed approval pages for the QAPP.

Amendments to the QAPP may be necessary to reflect changes in project organization, tasks, schedules, objectives and methods; address deficiencies and nonconformances; improve operational efficiency; and/or accommodate unique or unanticipated circumstances. Requests for amendments are directed from the PSIEE Project Lead to the TSSWCB Project Manager in writing. The changes are effective immediately upon approval by the TSSWCB Project Manager and Quality Assurance Officer, or their designees, and the EPA Project Officer. Amendments to the QAPP and the reasons for the changes will be documented, and copies of the approved

QAPP amendment form will be distributed to all individuals on the QAPP distribution list by the PSIEE Project Lead or their designee. Amendments shall be reviewed, approved, and incorporated into a revised QAPP during the annual revision process.

User's Guide

A User's Guide (Evans et al., 2008) for AVGWLF is presently available and will be modified as needed for the adapted version of AVGWLF. At its discretion, TSSWCB may seek review and comment from the TAC on draft deliverables. TSSWCB, the TAC and EPA will be provided with a copy of all documentation compiled during the course of the project.

Final Report

The final project report will be produced electronically and as a hard copy and all files used to produce the final report will be saved electronically by PSIEE for at least five years.

B1 Sampling Process Design (Experimental Design)

Not relevant.

B2 Sampling Methods

Not relevant.

B3 Sample Handling and Custody

Not relevant.

B4 Analytical Methods

Not relevant.

B5 Quality Control

Not relevant.

B6 Instrument/Equipment Testing, Inspection and Maintenance

Not relevant.

B7 Instrument/Equipment Calibration and Frequency

As described in previous sections, the initial focus of this project will be to develop the various input data sets used by AVGWLF to derive model input parameters. Subsequent to this activity, watershed simulations will be performed for each of the test watersheds located in the three eco-regions. Initial model calibrations will be performed on half of these watersheds for a 5-10 year period depending on the availability and period of record of historic stream data. During this step, adjustments will be iteratively made in various model parameters until a "best fit" is achieved between simulated and observed stream flow, and sediment and nutrient loads. In recognition of the fact that various AVGWLF routines are based on default values and algorithms originally developed in Pennsylvania, some effort will be expended during the calibration process to fine-tune selected default values and algorithms used to better reflect conditions in the three eco-regions selected in EPA Region VI. Based on previous experience, it is anticipated that the parameters and routines to be adjusted during calibration will primarily include those that affect stream flow, nutrient and sediment loads due to upland erosion, sediment loads from stream bank erosion, and background concentration of nitrogen and phosphorus in groundwater. During the calibration process, an attempt will be made to adjust these parameter values (or algorithms used to estimate these values) in a way that will achieve an overall "best fit" between the simulated and observed nutrient loads in all of the test watersheds.

Based on the calibration results, revisions will be made to various AVGWLF routines to alter the manner in which model input parameters are automatically estimated. To check the reliability of these revised routines, follow-up verification runs will be made on the remaining watersheds for the same time period. In this case, observed flows and loads in the verification watersheds will be compared against "un-calibrated" results. As described earlier, Penn State will be responsible for all model calibration and verification activities under the guidance of TSSWCB and the TAC.

To assess the correlation, or "goodness-of-fit", between observed and predicted values for both calibration and verification watersheds, two different statistical measures will be 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 often tend to be lower than R^2 for the same sets of data being evaluated.

During the calibration process, the model will be adjusted to achieve the best possible R^2 and Nash-Sutcliffe values. In using these statistical measures, there are no established minimum values that can be used to determine that the model has been calibrated successfully. Practically speaking, however, the higher the value, the better the calibration.

For this project, the mean monthly, seasonal and annual results for both calibration and verification watersheds will be reported in tables such as that shown in Table 3, and the median values for each period will be calculated. In the calibration report prepared as part of the project, descriptive information and commentary will be provided to aid model users in interpreting model results.

Table 3. Example table from New England study containing summary statistics for monthly results in the calibration watersheds.

Watershed	**Flow (R^2)**	**Sed (R^2)**	**N (R^2)**	**P (R^2)**	**Flow (NS)**	**Sed (NS)**	**N (NS)**	**P (NS)**
Ashuelot River	0.78	0.23	NA	0.54	0.78	0.20	NA	0.53
Broad Brook	0.74	0.32	0.66	0.62	0.74	0.00	0.66	0.55
Farmington River (U)	0.76	0.67	0.69	0.44	0.75	0.65	0.68	0.09
Lamprey River	0.82	0.66	0.67	0.77	0.80	0.66	0.57	0.77
Little Otter Creek	0.80	0.48	0.84	0.70	0.78	0.23	0.83	0.70
Poultney River	0.79	0.39	0.70	0.52	0.74	0.04	0.69	0.46
Saco River	0.83	0.43	0.78	0.46	0.83	0.43	0.78	0.39
Sheepscot River	0.85	NA	NA	0.65	0.83	NA	NA	0.63
Squannacook River	0.82	0.39	0.84	0.66	0.82	0.22	0.81	0.57
Sudbury River	0.71	0.61	0.68	0.44	0.71	0.58	0.65	0.39
West Branch	0.91	0.64	0.87	0.85	0.91	0.57	0.84	0.77
Mean	0.80	0.48	0.75	0.60	0.79	0.36	0.72	0.53

Note: “R^2” refers to the Pearson coefficient and “NS” refers to the Nash-Sutcliffe coefficient.

B8 Inspection/Acceptance of Supplies and Consumables

Not relevant.

B9 Non-Direct Measurements (Data Acquisition Requirements)

To support the modeling effort, map and non-map data will be acquired from a variety of qualified sources, including federal and state agencies, universities, and watershed groups. Input data for the region will include: hydrology, land cover, soils, topography, weather, pollutant discharges, and other critical watershed-related characteristics that will serve as core input for the model.

Specific data sets for any given watershed may include:

- weather data (average temperature and precipitation), a minimum of 2 weather stations per watershed is ideal;
- mean monthly and/or annual discharges (both nutrient concentrations and discharge flow volumes) from point sources;
- information about water extractions;
- tile drainage systems;
- information on unpaved roads;
- septic system usage;
- animal density;
- soils information;
- land use;
- elevation data;
- groundwater nitrogen (based on background nitrogen estimates)
- physiographic province;
- soil phosphorus levels;
- 5-10 years of consecutive water quality and stream flow data (for deriving observed flows and loads for calibration and verification watersheds).

Weather data – The weather data will likely be obtained from the National Oceanic and Atmospheric Administration (NOAA) (www.ncdc.noaa.gov/oa/climate/climatedata.html) web site. The data, however, may be acquired from EarthInfo (a company based in Colorado) because they package data on a CD that has an easy-to-use interface for extracting data by location.

Nitrogen, Phosphorus, and Sediment Loads – 5-10 years of stream flow and water quality data will be needed to derive observed data sets for the calibration and verification watersheds. Obtaining total nitrogen data may require obtaining constituent load data, such as for TKN, NO_2, NO_3, and NH_3. Much of the nutrient data will be obtained from USEPA and/or USGS (via STORET), although some will come from other sources, including state agencies. Sediment data may be available from several sources, including USGS, US EPA, state agencies, as well as watershed groups. In all cases, data will only be used from source agencies that have established quality assurance procedures.

For the following categories of input data, data will be used when available. All data will follow quality assurance standards established by the source agency.

Water Extraction Information – Data on quantities of water extracted for various uses (e.g., irrigation, potable water, industrial use, etc.) will be used where available if it is believed that such usage will have an impact on simulated flows and loads within a given watershed.

Tile Drainage – Information on the location/extent of agricultural tile drainage will be used where available if it is believed that the extent of use within a given watershed will have an effect on simulated nutrient loads. If available, it is likely that this information will come from the Natural Resource Conservation Service (NRCS).

Septic System Usage – Information will be derived using a statewide census tract layer, which contains attribute data for the number of people served by septic systems as recorded in the U.S. census of 1990, the last time the census included this data. For modeling purposes, this number is estimated based on the proportion of one or more tracts that fall within a watershed. Data may also be obtained by obtaining sewer data from states, and assuming that residential areas without sewer access use septic systems.

Animal Density –County-level data are obtained from National Agricultural Statistics Service (NASS). NASS data are the official data of the USDA. Data also exists at the zip code level, although data are held for all zip code districts that have one to four farms. These data will conform to the USDA's quality assurance standards. Values are in units of AEU_Acres where 1 AEU = 1000 lbs of animal weight.
Data link: http://www.nass.usda.gov/census/

Soils Information – Soils data will be obtained from generalized statewide data layer called STATSGO. The source is the STATSGO soil mapping products developed by NRCS (Bliss and Reynold 1989). The data layer is typically compiled at a scale of 1:250,000. The map data are projected into an Albers Equal Area projection in meters.
Data link: ftp://ftp-fc.sc.egov.usda.gov/NCGC/products/statsgo/statsgo-user-guide.pdf

Physiographic Province – This map layer is essentially a "place-holder" for storing information on regional estimates of various model parameters such as rainfall intensity and groundwater recession rate that typically varies by landscape type. In this case, the landscape types will be represented by the "Level III" eco-region boundaries developed by the USEPA (see http://www.epa.gov/wed/pages/ecoregions/level_iii.htm). Also see Figure 1 given earlier for an example of this data layer.

Land Use – For this project, 2001-vintage multi-resource land characterization (MRLC) data will be used. This data will be obtained from the either the respective states in the region or directly from the federal government web site (see www.mrlc.gov). All MRLC data conforms to federal agency quality assurance standards.

Elevation Data – Data available as part of the National Elevation Dataset (www.ned.usgs.gov) will be used. All data available for the project area conform to USGS quality assurance standards.

Groundwater Nitrogen – This input map layer is typically created using spatial relationships between land use/cover and soil/rock type (surface geology) described in various National Water Quality Assessment (NAWQA) reports prepared by the U.S. Geological Survey (www.water.usgs.gov/nawqa). This process will involve an evaluation of land use/cover GIS data layers with available surface geology, physiography, and/or soils data layers. In the absence of suitable data for any given watershed, existing water quality data (specifically, low-flow nutrient concentration sample data) will be used to derive these grids.

Soil Phosphorus – This data layer is typically derived using information on land use/cover, soil texture and background concentrations of soil phosphate depicted in a national map available in the GWLF User's Manual (Haith et al., 1992).

Point Source Information – This data will likely come from National Permit Discharge Elimination System (NPDES) permits. Permitted, rather than actual, values of nitrogen and phosphorus concentrations may be used in some cases. Data may also come from the Permit Compliance System (PCS) inventory. Information regarding total nitrogen and total phosphorus levels are available by conducting a Water Discharge Permits query. These data are published by the EPA and conform to the agency's quality assurance standards. Actual observed data, when available, may also be used.

Streams Data – Data should be available from the National Hydrography Dataset. It is used to calculate stream density, which will in turn be used to derive slope length and estimate stream bank erosion.
Data link: http://nhdgeo.usgs.gov/metadata/nhd_local.htm

Flow Data – Stream flow data will primarily be available from either USGS or state agencies in the region. Five to ten years of data are typically needed to create suitable observed data sets for comparison with model output.
Data link: http://waterdata.usgs.gov/nwis/about

Quality Assurance/Quality Control

The success of this model testing project will largely depend on the quality of data collected for model input and the development of observed flow and water quality data sets. For this project, there will be no new data collection or base data development. Rather, the required data will be obtained from organizations that allow for a wide range of QA/QC standards. Consequently, the input data obtained for the model will be subject to the quality control standards of the federal and/or state agencies from which data are to be obtained.

B10 Data Management

Various data sets will be obtained from state agencies, typically through the state representatives on the Technical Advisory Committee. Additional data sets will be obtained from national agencies (e.g., weather data will be obtained from NOAA). Data may be obtained via direct web site downloads, by CD/DVD or email, whichever method is most convenient.

A copy of all datasets will be stored in the original form in which it was received. Whenever data are reformatted, the new files will be saved in a separate computer location to ensure that the original formats of the data are not lost. All emails regarding data information and transfer will also be saved. All data will be stored on a secure server at Penn State.

With the exception of data sets for each individual weather station, all final versions of datasets will be placed in a data directory. Within this directory, state-specific data will be kept in subdirectories for their respective states, and region-wide data will be kept in a regional subdirectory. Data for individual weather stations will be stored in a specific folder in the AVGWLF directory. Because of the large amount of data that will be collected to create the input for this model, a word document will be maintained that gives, for each dataset, the file name and a description, including any modifications made to the dataset.

Systems Design

PSIEE researchers working on this project use both laptop personal computers and desktop personal computers runningWindows operating systems. Software packages on these computers that will be used during the course of the project include Microsoft® Excel, Microsoft® Word, Microsoft® Access database, ArcView 3.3, and ArcGIS 9.2..

Backup and Disaster Recovery

All computers used during the course of this project will be backed up daily to external disk drives. In the event of a catastrophic systems failure, these drives can be used to restore the data in less than one day’s time. Data generated on the day of the failure may be lost, but can be reproduced from raw data in most cases.

Archives and Data Retention

Original data recorded on paper files will be stored for at least five years. Data in electronic format will be stored on CDs in a climate controlled room at PSIEE.

C1 Assessment and Response Actions

As described in Section B9 (Non-Direct Measurements), modeling staff will evaluate data to be used in calibration and as model input according to criteria discussed in Section A7. (Quality Objectives and Criteria) and will follow-up with the various data sources on any concerns that may arise.

The model calibration procedure is discussed in Section B7 (Instrument/Equipment Calibration and Frequency), and criteria for acceptable outcomes are provided in Section A7 (Quality Objectives and Criteria).

Results will be reported to the TSSWCB Project Manager and QAO in the format provided in Section A9. If agreement is not achieved between the calibration standards and the predictive values, corrective action will be taken by the PSIEE Project Lead to assure that the correct files are read appropriately and the test is repeated to document compliance. If the predicted value cannot be brought within calibration standards, the PSIEE Project Lead will work with the TSSWCB and EPA to arrive at an agreeable compromise.

Software requirements, software design, or code are examined to detect faults, programming errors, violations of developments standards, or other problems. All errors found are recorded at the time of inspection, with later verification that all errors found have been successfully corrected. Software used to compute model predictions are tested to assess its performance relative to specific response times, computer processing usage, run time, convergence to solution, stability of the solution algorithms, the absence of terminal failures, and other quantitative aspects of computer operation.

Checks are made to ensure that the computer code for each module is computing module outputs accurately and within specified time constraints. The full model framework is tested as the ultimate level of integration testing to verify that all project-specific requirements have been implemented as intended. All testing performed on the original version of the module, or linked modules, is repeated to detect new “bugs” introduced by changes made in the code to correct a model.

C2 Reports to Management

The Project Officers for TSSWCB and Penn State shall coordinate, as necessary, to discuss progress of the model, including the collection and format of input data. All correspondence regarding the gathering of input data and model development shall be included in the quarterly reports to the TSSWCB. Quarterly progress reports will note activities conducted in connection with this water quality modeling project, items or areas identified as potential problems, and any variations or supplements to the QAPP.

Corrective action report forms will be utilized when necessary (Appendix B). CARs will be maintained in an accessible location for reference at PSIEE. CARs that result in any changes or variations from the QAPP will be made known to pertinent project personnel and documented in an update or amendment to the QAPP.

If the procedures and guidelines established in this QAPP are not successful, corrective action is required to ensure that conditions adverse to quality data are identified promptly and corrected as soon as possible. Corrective actions include identification of root causes of problems and document the problems and the remedial action taken. Copies of corrective action reports will be included with quarterly reports. The corrective action reports and quarterly reports will discuss any problems encountered and solutions made. These reports are the responsibility of the PSIEE Project Lead and are available for review upon request.

D1 Data Review, Verification and Validation

All acquired data will be reviewed and verified for integrity and continuity, reasonableness, and conformance to project requirements, and validated against the data quality objectives which are listed in Section A7. Only those data which are supported by appropriate quality control data and meet the data quality objectives defined for this project will be considered acceptable for use in testing and adapting the AVGWLF model. These objectives are subject to the best available quality control standards of the source agency and as approved by their respective state environmental agencies.

The procedures for verification and validation are described in Section D2, below. The PSIEE Project Lead and Co-Lead are responsible for ensuring that data are properly reviewed, verified, and submitted in the required format for the project database.

D2 Verification and Validation Methods

The AVGWLF model is a “watershed loading” model that estimates nutrient and sediment loads delivered to the outlet of a given watershed. Consequently, this may not be the most appropriate model for evaluating pollutant concentrations for specific stream segments within a watershed. In this case, an “in-stream” model such as QUAL2E or HSPF might be more appropriate. The AVGWLF model (in it’s current form) also does not account for in-stream losses and attenuation. Therefore, it is usually advised that assessments done with AVGWLF be limited to watersheds between 10-400 square miles in size to avoid significant over-estimation of pollutant loads.

A benefit of AVGWLF is that once the model has been calibrated, model users can “swap” coarser-scale data for finer-scale data. For example, if finer-scale soils information is available (e.g., SSURGO), that information could be inserted into the model in place of the coarser-scale soils information (i.e., STATSGO). Similarly, older land use/cover data can be replaced with more current information. AVGWLF also includes a tool called PRedICT which provides model users with the ability to evaluate different scenarios involving the implementation of various pollution mitigation strategies (e.g., agricultural and urban BMPs, stream protection, septic system upgrades, etc.).

The success of this project and the adaptation of AVGWLF for use in selected areas of EPA Region VI, will be assessed in two ways: 1) the results from the calibration and verification process, and 2) the ability of regional state agencies to utilize this tool in their NPS and TMDL programs. All input data for the model will undergo a review to ensure the quality of the data, as outlined in Section B7 (Instrument/Equipment Calibration and Frequency). Data that does not meet these standards will not be utilized in this model. This will insure that the model output will meet the necessary QA/QC standards for use in both the TMDL and NPS programs.

References

ASCE Task Committee on Definition of Criteria for Evaluation of Watershed Models of the Watershed Management Committee, Irrigation and Drainage Division, 1993. Criteria for Evaluation of Watershed models. Journal of Irrigation and Drainage Engineering, Vol. 199, No. 3.

Bliss, N.B. and W.U. Reybold, 1989. Small-scale Digital Soil Maps for Interpreting Natural Resources, Journal of Soil and Water Conservation, Vol. 44, pp. 30-34.

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Evans, B.M., D.W. Lehning, K.J. Corradini, G.W. Petersen, E. Nizeyimana, J.M. Hamlett, P.D. Robillard, and R.L. Day, 2002. A Comprehensive GIS-Based Modeling Approach for Predicting Nutrient Loads in Watersheds. J. Spatial Hydrology, Vol. 2, No. 2., (www.spatialhydrology.com).

Haith, D.A. and L.L. Shoemaker, 1987. Generalized Watershed Loading Functions for Stream Flow Nutrients. Water Resources Bulletin, 23(3), pp. 471-478.

Haith, D.R., R. Mandel, and R.S. Wu, 1992. GWLF: Generalized Watershed Loading Functions User's Manual, Vers. 2.0, Cornell University, Ithaca, NY.

Appendix A
Workplan

NONPOINT SOURCE SUMMARY PAGE
for the FY07 CWA, Section 319(h) Agricultural/Silvicultural Nonpoint Source Program
Project 07-3

1. Title of Project: Adaptation of AVGWLF watershed model for use in Texas: Phase I

2. Project Goals/Objectives: The purpose of this project is to test and modify the AVGWLF watershed model for use in selected areas of Texas and surrounding states.

3. Project Tasks: The primary tasks of this project are to: (1) Prepare a QAPP; (2) Identify and select test watersheds for model calibration and verification; (3) Develop required regional GIS and weather data sets; (4) Compile relevant stream flow and water quality data for testing purposes; (5) Complete calibration and verification of AVGWLF model in selected test areas; and (6) Prepare final report outlining work tasks and results.

4. Measures of Success: Development of a "regionalized" version of AVGWLF that can be used to support TMDL and watershed restoration activities in Texas and other states in EPA Region 6.

5. Project Type: Statewide (x); Watershed Implementation/Education ( ); Watershed Planning/Assessment (); Watershed Protection ( )

6. Status of Water Body: Project will cover selected ecoregions of Texas and surrounding states.

7. Project Location: Outcomes of this project will impact many stream segments and watersheds in Texas and surrounding states.

8. NPS Management Program Reference: State of Texas Agricultural/Silvicultural Nonpoint Source Management Program

9. NPS Assessment Report Status: Impaired ( ); Impacted ( ); Threatened ( ); TMDL ( ); Other (X).

10. Key Project Activities: Hire Staff ( ); Monitoring ( ); Regulatory Assistance ( ); Technical Assistance (X); Education ( ); Implementation ( ); Demonstration ( ); Other (X)

11. NPS Management Program Elements:

12. Project Costs: Federal ($122,623); Non-Federal Match ($0); Total Project ($122,623)

13. Project Management: Texas State Soil and Water Conservation Board (TSSWCB). Cooperating Entities: Penn State Institutes of Energy and the Environment (PSIEE)

14. Project Period: Two years (ending June 30, 2009) from the receipt of funding.

Adaptation of AVGWLF Watershed Model for use in Texas and Surrounding States: Phase I

WORKPLAN

Problem/Need Statement: 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; particularly those associated with nonpoint sources of sediment and nutrients. Under this current effort, the Texas State Soil and Water Conservation Board (TSSWCB), in collaboration with the Penn State Institutes of Energy and the Environment (PSIEE), proposes to develop a regional version of AVGWLF for 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.

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 and pathogen loading from various sources.

AVGWLF is essentially a customized interface developed by Penn State for the ArcView GIS package that is used to parameterize input data for the GWLF 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 *transport.dat* and *nutrient.dat* input files needed to execute the GWLF model. Also accessed through the interface are Excel files that contain temperature and precipitation information used to create the necessary *weather.dat* 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., 2006).

Evans, B.M., D.W. Lehning, K.J. Corradini, G.W. Petersen, E. Nizeyimana, J.M. Hamlett, P.D. Robillard, and R.L. Day, 2002. A Comprehensive GIS-Based Modeling Approach for Predicting Nutrient Loads in Watersheds. J. Spatial Hydrology, Vol. 2, No. 2., (www.spatialhydrology.com).

Evans, B.M., S.A. Sheeder, and K.J. Corradini, 2006. AVGWLF, Version 6.3: Users Guide. Penn State Institutes of Energy and the Environ., Penn State University, 82 pp.

Haith, D.A. and L.L. Shoemaker, 1987. Generalized Watershed Loading Functions for Stream Flow Nutrients. Water Resources Bulletin, 23(3), pp. 471-478.

General Project Description: As part of the proposed effort, PSIEE will develop the required data sets to support the use of AVGWLF for the area covered by EPA Region 6. Data development for the model will primarily be undertaken by PSIEE staff with limited input from GIS staff at TSSWCB, EPA and other cooperating state agencies. Within AVGWLF, both ArcView-compatible shape files and grids are manipulated for the purpose of estimating numerous model parameters. Up to 13 shape files and 4 grid files can be used by AVGWLF for the purpose of deriving required GWLF model input data. Table 1 provides a listing and brief description of all of the required and optional GIS layers used that will be compiled for the proposed project. To facilitate their use within this “regionalized” version of AVGWLF, the GIS data sets compiled for each state will be re-projected into a common geographic coordinate system; preferably one that is currently used by EPA Region 6.

Subsequent to data compilation, PSIEE will conduct model calibration and validation for Region 6. Due to limited funding, this work will only be conducted in selected areas of the region. To maximize the extent to which AVGWLF can be used, PSIEE proposes to test AVGWLF in three specific ecoregions that traverse EPA Region 6 (see Figure 1). These ecoregions include the Southwest Tablelands, Central Great Plains, and South Central Plains. Within each of these ecoregions, PSIEE proposes to test AVGWLF at 8 different sites (4 calibration and 4 validation) for a total of 24 test sites across all 5 states. During this phase, model algorithms will be tested and modified as needed to better represent conditions in each ecoregion.

Subsequent to model development and testing, a report will be prepared that summarizes work performed under the agreement. This report will include descriptions of the database development effort and model testing, statistical analyses, and an overview of any model limitations encountered and improvements that might be needed in the future.

Tasks, Objectives and Schedules:

Task 1: Develop a Quality Assurance Project Plan (QAPP).

Costs: $ 6,131 (Federal), $ 0 (Non-Federal Match), $ 6,131 (Total)

Objective/Summary: As required by EPA, a QAPP will be developed prior to beginning work on other technical activities related to the project. This document will be modeled on a similar QAPP developed as part of an earlier effort undertaken by PSIEE to adapt AVGWLF for use in New York and New England for the New England.

Deliverable

- Submit QAPP.

Delivery Date: Within 2 months after start date.

Table 1. AVGWLF Data requirements.

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

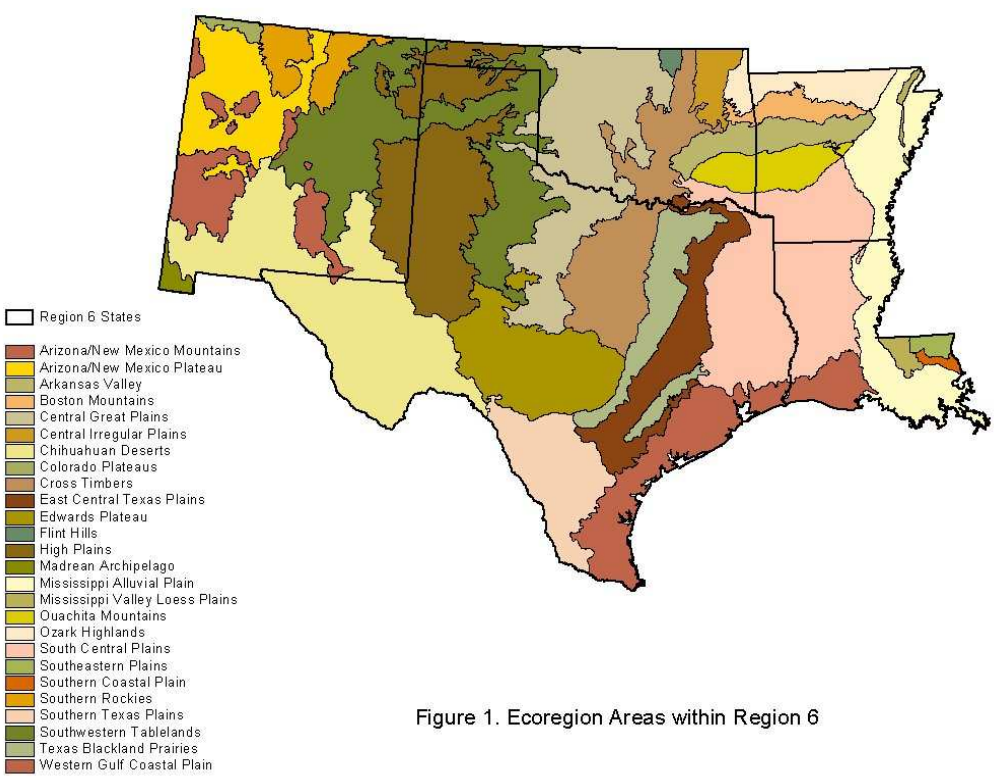

Figure 1. Ecoregion Areas within Region 6

Task 2: Identify and select test watersheds for model calibration and verification.

Costs: $ 14,662 (Federal), $ 0 (Non-Federal Match), $ 14,662 (Total)

Objective/Summary: A number of watersheds within three ecoregions spanning Texas and other surrounding states in EPA Region 6 will be evaluated for use as test sites for AVGWLF modeling. Within each of these ecoregions, PSIEE proposes to test AVGWLF at 8 different sites (4 calibration and 4 validation) for a total of 24 test sites across all 5 states. The final selection will be based on various watershed characteristics such as type of land use, degree of impact from point sources versus nonpoint sources, extent of stream impairment, availability of historical stream flow and water quality data, and other important factors.

Deliverable

- List of project test sites.

Delivery Date: Within 4 months after project start.

Task 3: Develop required regional GIS and weather data sets.

Costs: $ 18,393 (Federal), $ 0 (Non-Federal Match), $ 18,393 (Total)

Objective/Summary: The purpose of this task will be to compile the data sets necessary to drive the AVGWLF model. These data sets include both GIS data layers and historical weather data as described earlier in this document. With respect to compiling GIS data, emphasis will be placed on using existing data sets (e.g., land use/cover, soils, elevation) rather than creating new layers. Other new data sets (e.g., the background nitrogen in groundwater map and the soil phosphorus map) will be developed; however, these will primarily be developed using information contained in other previously-compiled data sets. Additionally, historical weather data for perhaps 20 to 30 weather stations distributed throughout the ecoregions evaluated will be compiled to provide the necessary precipitation and weather data to drive the watershed model. It is anticipated that approximately 10-15 years of weather data will be assembled for each station selected.

Deliverables

- GIS data sets as listed in Table 1 above.
- A weather database for approximately 20-30 weather stations.

Delivery Date: Within 8 months after project start.

Task 4: Compile relevant stream flow and water quality data for testing purposes.

Costs: $ 24,525 (Federal), $ 0 (Non-Federal Match), $ 24,525 (Total)

Objective/Summary: The purpose of this task will be to compile “observed” data sets that can be compared against simulated results produced by AVGWLF in each of the test watersheds. For each test watershed, data on both stream flow and water quality will be compiled. In the latter case, an attempt will be made to develop observed data sets for sediment, nitrogen and phosphorus loads. In some cases, depending on the availability of monitoring data, it may be possible to develop historic load information for only one or two of these pollutants.

Deliverables
- Data set of observed flows for each test watershed.
- Data sets of observed sediment and/or nutrient loads for each test watershed.

Delivery Date: Within 10 months after project start.

Task 5: Complete calibration and verification of AVGWLF model in selected test areas.

Costs: $ 49,049 (Federal), $ 0 (Non-Federal Match), $ 49,049 (Total)

Objective/Summary: This task comprises the bulk of the work to be accomplished in the proposed project. As described in previous sections, the initial focus of this project will be to develop the various input data sets used by AVGWLF to derive model input files. Subsequent to this activity, watershed simulations will be performed for each of the test watersheds located in the three ecoregions. Initial model calibrations will be performed on half of these watersheds for a 5-10 year period depending on the availability and period of record of historic stream data. During this step, adjustments will be iteratively made in various model parameters until a "best fit" is achieved between simulated and observed stream flow, and sediment and nutrient loads. Based on the calibration results, revisions will be made to various AVGWLF routines to alter the manner in which model input parameters are estimated. To check the reliability of these revised routines, follow-up verification runs will be made on the remaining watersheds for the same time period. Finally, statistical evaluations of the accuracy of flow and load predictions will be made.

Deliverables
- Data set of simulated flows for each test watershed.
- Data sets of simulated sediment and/or nutrient loads for each test watershed.

Delivery Date: Within 18 months after project start.

Task 6: Prepare final report outlining work tasks and results.

Costs: $ 9,863 (Federal), $ 0 (Non-Federal Match), $ 9,863 (Total)

Objective/Summary: The purpose of this task will be to prepare a final report that describes the activities and results associated with each work task completed as part of the proposed project.

Deliverable
- AVGWLF Model
- AVGWLF Model Training
- Final report.

Delivery Date: Within 24 months after project start.

Project Leader: Dr. Barry M. Evans, PSIEE
Co-project Leader: Dr. Brian A. Dempsey, PSIEE
Project Members: Mr. Kenneth J. Corradini, PSIEE

Mr. David W. Lehning, PSIEE
Mr. Scott A. Sheeder, PSIEE

Coordination, Roles, and Responsibilities: The Project Leaders and Members will be responsible for coordinating the project staff and for communication between the project, TSSWCB, Project Stakeholders and other appropriate individuals and agencies. Program development, modifications and delivery will be coordinated through TSSWCB and the Project Stakeholders.

Project Stakeholders:
Texas State Soil and Water Conservation Board
EPA Region 6

Public Outreach: N/A

Measures of Success and Performance: Success of this project will be measured by the ability of the adapted version of AVGWLF to simulate sediment and nutrient loads within the test watersheds that are similar to the observed loads for the same time periods, as well as by the ease of its' use by agency personnel in the region.

Project Lead
Name: Dr. Barry M. Evans PSIEE
Telephone: 814-865-3357
Organization: Pennsylvania State University

Project Costs: Federal ($122,623), Non-Federal Match ($0), Total Project ($122,623)

Project Period: Two years (ending June 30, 2009) from the receipt of funding.

OBJECT CLASS BUDGET
for the
Adaptation of AVGWLF Watershed Model for use in Texas and Surrounding States: Phase I

Object Class Category	Federal Funds	Non-Federal Match	Total Costs
Personnel	$86,103	$0	$86,103
Fringe Benefits	$22,214	$0	$22,214
Barry M. Evans			
Kenneth J. Corradini			
David W. Lehning			
Subtotal Personnel & Fringe	$108,317	$0	$108,317
Travel	$0	$0	$0
Equipment	$0	$0	$0
Supplies	$0	$0	$0
Contractual			
Construction			
Other	$3,158	$0	$3,158
Subtotal	$3,158	$0	$3,158
Total Direct Costs	$111,475	$0	$111,475
Indirect (15% Rate)	$11,148	$0	$11,148
Unrecovered IDC	$0	$0	$0
Total Project Costs	**$122,623**	**$0**	**$122,623**

BUDGET Justification
for the
Adaptation of AVGWLF Watershed Model for use in Texas and Surrounding States: Phase I

Personnel: (1) Research Associate and (2) Research Assistants

Fringe: Research Associate and Research Assistants are calculated at 26.6% of salary

Travel: Support for 2 multi-day trips by B. Evans (PSIEE) to Texas to meet with TSSWCB, EPA Region 6, and/or other project participants.

Equipment: N/A

Supplies: N/A

Other Direct: N/A

Indirect Costs: Per TSSWCB RFP for CWA, Section 319(h) Agricultural/Silvicultural Nonpoint Source Program, a maximum of 15% indirect costs will be reimbursed.

Appendix B
Corrective Action Report

Corrective Action Report
SOP-QA-001
CAR #:______________

Date:______________________ Area/Location:_______________________

Reported by:______________________ Activity:____________________________

State the nature of the problem, nonconformance or out-of-control situation:
____
____
____
____
____

Possible causes:
____
____
____

Recommended Corrective Actions:
____
____
____

CAR routed to:___________________________________

Received by:_____________________________________

Corrective Actions taken:
____
____
____
____

Has problem been corrected? YES NO

Immediate Supervisor:__________________________________

Program Manager:_____________________________________

Quality Assurance Officer:________________________________