Clean Water Act Section 319(h) Nonpoint Source Pollution Control Program Project

Best Management Practice (BMP) verification using observed water quality data and watershed planning for implementation of BMPs

Quality Assurance Project Plan (Project # 04-18)

Texas State Soil and Water Conservation Board

prepared by

Texas A&M AgriLife

Texas Water Resources Institute

Texas A&M University Spatial Sciences Laboratory

Blackland Research and Extension Center

Effective Period: September 2005 to August 2009

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

Kevin Wagner, TWRI Quality Assurance Officer

klwagner@ag.tamu.edu

-or-

Dr. Raghavan Srinivasan, Professor and Director, Spatial Sciences Laboratory

Texas A&M University

1500 Research Parkway, Suite B220

2120 TAMU

College Station, TX 77843-2120

Section A1 Approval Sheet

Quality Assurance Project Plan for *Best Management Practice (BMP) verification using observed water quality data and watershed planning for implementation of BMPs.*

United States Environmental Protection Agency (USEPA), Region VI

Name: Donna Miller
Title: USEPA Chief; State/Tribal Programs Section

Signature:___________________________________Date:______________

Name: Ellen Caldwell

Title: USEPA Texas Nonpoint Source Project Manager

Signature:___________________________________Date:______________

Texas State Soil and Water Conservation Board (TSSWCB)

Name: Pamela Casebolt
Title: TSSWCB Project Manager

Signature:___________________________________Date:_____________

Name: Donna Long
Title: TSSWCB Quality Assurance Officer

Signature:___________________________________Date:_____________

Texas A&M AgriLife, Texas Water Resources Institute (TWRI)

Name: Kevin Wagner
Title: TWRI Quality Assurance Officer (QAO)

Signature:___________________________________Date:_____________

Texas A&M University (TAMU)—Spatial Sciences Lab (SSL)

Name: Raghavan Srinivasan
Title: Spatial Sciences Lab Director; Project Manager

Signature:__________________________________Date:_____________

Texas AgriLife Research, Blackland Research and Extension Center (BREC)

Name: Santhi Chinnasamy
Title: Associate Research Scientist; Co-investigator

Signature:__________________________________Date:_____________

Section A2: Table of Contents

Section: Title **Page**

List of Tables

List of Figures

List of Acronyms and Abbreviations

APEX	agricultural policy/environmental eXtender
BMP	best management practices
BREC	Blackland Research and Extension Center
CAR	corrective action report
CBMS	computer based mapping system
CWA	Clean Water Act
DEM	digital elevation model
DQO	data quality objectives
EPA	Environmental Protection Agency
EPIC	erosion productivity impact calculator
GIS	geographic information system
GPS	global positioning system
HUMUS	hydrologic modeling of the United States project
NEXRAD	next generation weather radar
NAWQA	National Water Quality Assessment
NLCD	national land cover data set
NPS	nonpoint source
NRCS	Natural Resources Conservation Service
QA	quality assurance
QAPP	quality assurance project plan
Research	Texas AgriLife Research
SAS	Statistical Analysis System
SOP	standard operating procedures
SSL	Spatial Sciences Laboratory
SSURGO	soil survey geographic
SWAT	surface water assessment tool
TCEQ	Texas Commission on Environmental Quality
TMDL	total maximum daily load
TPDES	Texas pollutant discharge elimination system
TRWD	Tarrant Regional Water District
TSSWCB	Texas State Soil and Water Conservation Board
TWRI	Texas Water Resources Institute
SWCD	Soil and Water Conservation District
USDA-ARS	United States Department of Agriculture-Agricultural Research Service
USDA-NRCS	United States Department of Agriculture-Natural Resources Conservation Service
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

Section A3: Distribution List

Organizations, and individuals within, which will receive copies of the approved QAPP and any subsequent revisions include:

- United States Environmental Protection Agency, Region VI

  Name: Donna Miller
  Title: USEPA Chief; State/Tribal Programs Section

  Name: Ellen Caldwell
  Title: USEPA Texas Nonpoint Source Project Manager

- Texas State Soil and Water Conservation Board (TSSWCB)

  Name: Pamela Casebolt
  Title: TSSWCB Project Manager

  Name: Donna Long
  Title: TSSWCB Quality Assurance Officer

- Texas A&M AgriLife, Texas Water Resources Institute

  Name: Kevin Wagner
  Title: TWRI Quality Assurance Officer

- Texas A&M University—Spatial Sciences Lab

  Name: Raghavan Srinivasan
  Title: Spatial Sciences Lab Director

- Texas AgriLife Research, Blackland Research and Extension Center (BREC)

  Name: Santhi Chinnasamy
  Title: Associate Research Scientist

Section A4: Project/Task Organization

The following is a list of individuals and organizations participating in the project with their specific roles and responsibilities:

USEPA – United States Environmental Protection Agency (USEPA), Region VI, Dallas, Texas. Provides project overview at the Federal level.

Ellen Caldwell, USEPA Texas Nonpoint Source Project Manager

Responsible for overall performance and direction of the project at the Federal level. Ensures that the project assists in achieving the goals of the federal Clean Water Act (CWA). Reviews and approves the quality assurance project plan (QAPP), project progress, and deliverables.

TSSWCB –Texas State Soil and Water Conservation Board, Temple, Texas. Provides project overview at the State level.

Pamela Casebolt, TSSWCB Project Manager

Responsible for ensuring that the project delivers data of known quality, quantity, and type on schedule to achieve project objectives. Tracks and reviews deliverables to ensure that tasks in the work plan are completed as specified. Reviews and approves QAPP and any amendments or revisions and ensures distribution of approved/revised QAPPs to TSSWCB and USEPA participants.

Donna Long; TSSWCB Quality Assurance Officer

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

TWRI – Texas A&M AgriLife, Texas Water Resources Institute (TWRI), College Station, Texas. Responsible for development of data quality objectives (DQOs) and a quality assurance project plan (QAPP). Will assist with development and facilitation of the project through quarterly meetings.

Kevin Wagner, Quality Assurance Officer

Responsible for determining that the Quality Assurance Project Plan (QAPP) meets the requirements for planning, quality control, and quality assessment. Conducts audits of field and laboratory systems and procedures. Responsible for maintaining the official, approved QAPP, as well as conducting Quality Assurance audits in conjunction with TSSWCB and EPA personnel.

SSL - Spatial Sciences Lab (SSL), Texas A&M University, College Station, Texas. Responsible for modeling activities associated with SWAT.

Raghavan Srinivasan, Spatial Sciences Laboratory Director; Project Manager

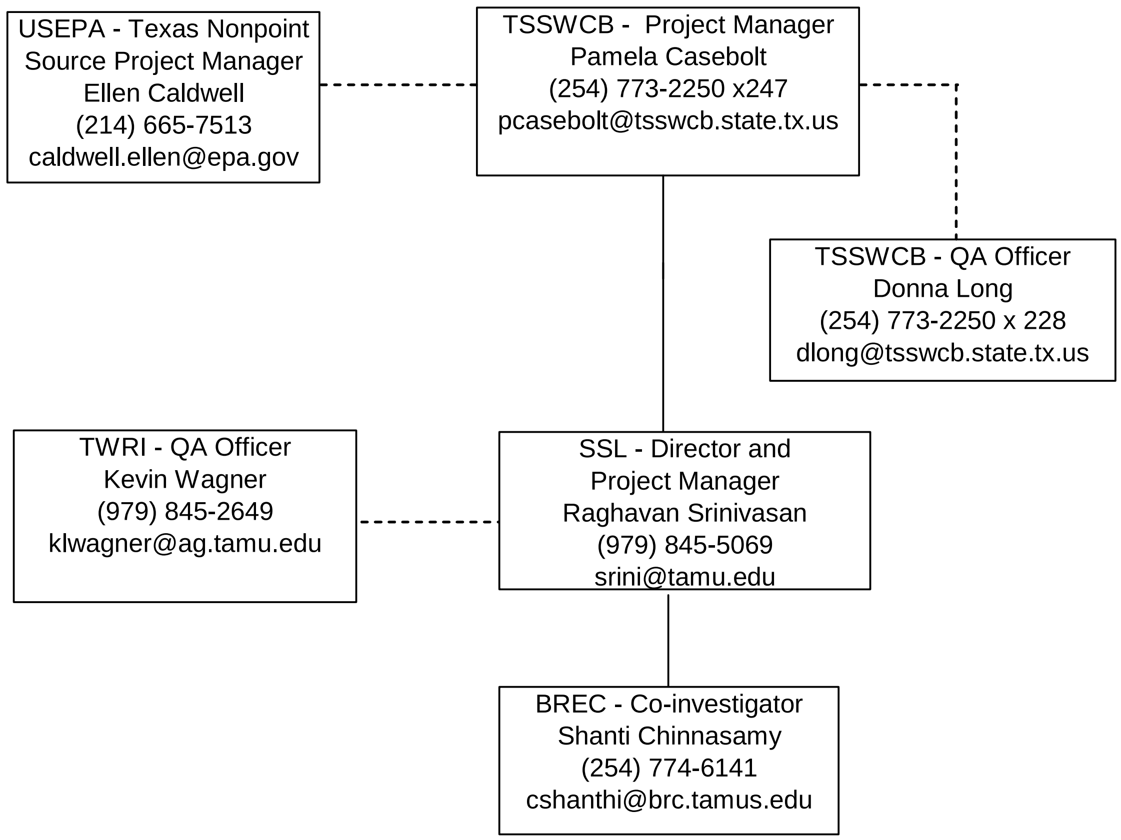
Responsible for overall operations of the environmental modeling program at TAMU. Responsible for oversight of all laboratory operations and ensuring that all quality assurance-quality control requirements are met. Enforces corrective action, as required. Responsible for supporting water quality modeling using SWAT and coordination of watershed data, water quality data and BMP information and reporting tasks for the project. Responsible for coordination of quarterly reports and the final project report.

BREC - Blackland Research and Extension Center (BREC), Texas AgriLife Research, Temple, Texas. Responsible for BMP modeling using APEX/EPIC models.

Santhi Chinnasamy, Co-investigator

Responsible for modeling of the BMPs using EPIC/APEX/SWAT models, data anlaysis and reporting tasks for the project with other project staff.

Figure A4-1. Project Organization Chart
Dashed lines indicate communication only



Section A5: Problem Definition/Background

Richland-Chambers Reservoir is the largest among the four major water supply reservoirs maintained by the Tarrant Regional Water District (TRWD) that supplies water to a major portion of the 1.5 million people in North-Central Texas. Segment 0814 – Chambers Creek is listed under category “5c” in the 2002 303(d) list for water quality impairment due to depressed dissolved oxygen and partially supporting aquatic life use. Segment 0836 – Richland-Chambers Reservoir is listed under category “5c” in the 2002 303(d) list for water quality impairment due to high pH and partially supporting general use. In the draft 2004 303(d) list, nutrient enrichment and algal growth due to excess nitrate and nitrite are listed as concerns at the Richland-Chambers Reservoir in addition to the high pH. Hence these segments have been identified as areas of concern in the Richland-Chambers watershed. These segments are listed as category 5c with rank D indicating that additional data and information will be collected before a TMDL is scheduled.

The expected outcomes of the study include a verification of the effectiveness of BMPs installed on Mills Creek; development of a methodology/modeling approach for making quantitative assessments of the effectiveness of BMPs in reducing non-point source pollution; and an identification of areas of nonpoint source pollution concern in this watershed.

The detailed information provided by this study will be beneficial to State Water Quality Agencies such as Texas State Soil and Water Conservation Board (TSSWCB) and Texas Commission on Environmental Quality (TCEQ) by providing a modeling approach and an assessment of the effectiveness of BMPs that can be used in other watersheds and an identification of areas within the Richland-Chambers watershed still needing treatment.

Section A6: Project/Task Description

The goals of the project are to verify the effectiveness of BMPs installed on a portion (Mill Creek) of the Richland-Chambers reservoir watershed to provide supporting information for BMP implementation within the entire Richland-Chambers reservoir watershed (Figure A6-1). The specific objectives are 1) Verify the effectiveness of BMPs implemented by analyzing observed water quality data, 2) Develop a methodology/modeling approach to make quantitative assessment of the effectiveness of BMPs in reducing non-point source pollution (NPS), and 3) Spatial and temporal analysis of the impacts of BMPs on water quality.

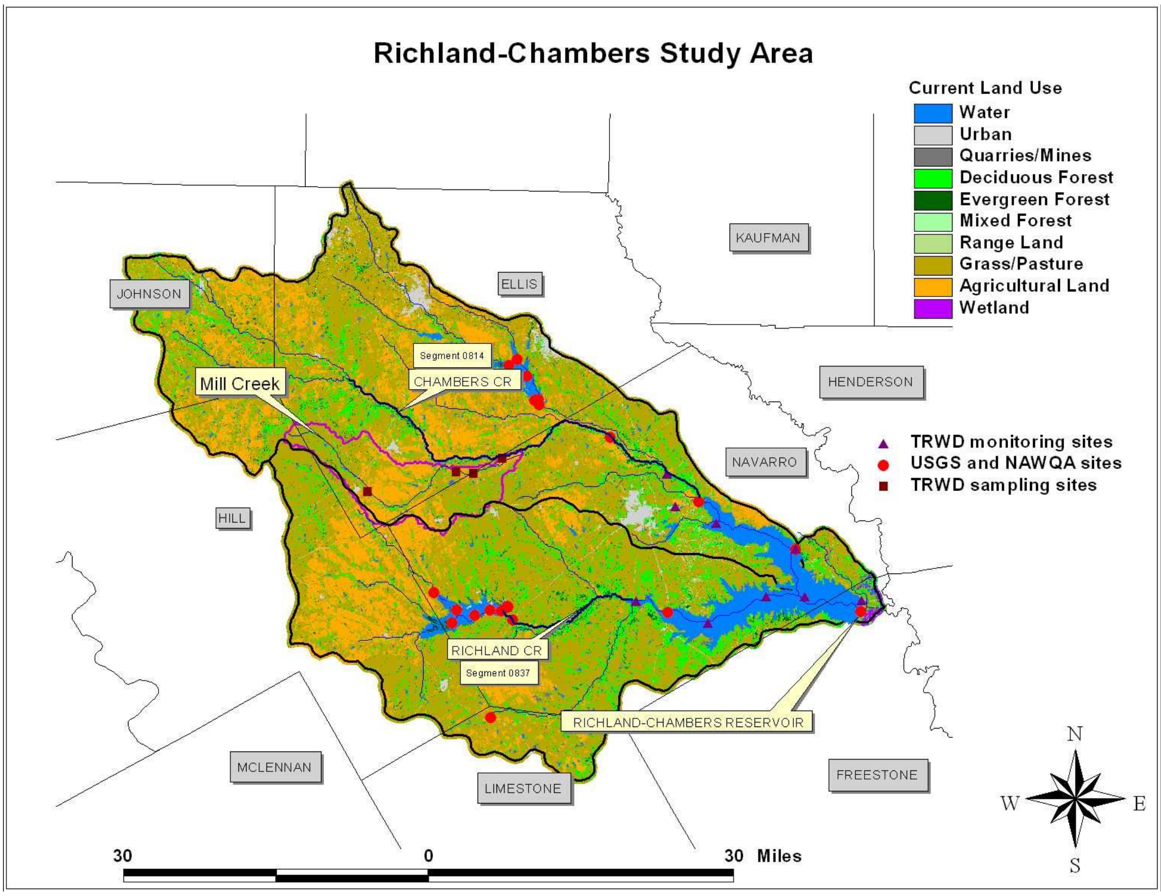


Figure A6-1. Richland-Chambers Reservoir Watershed

Richland-Chambers watershed is 515,690 ha in size and is located in North Central Texas approximately 40 miles south of the city of Dallas in Trinity River Basin. Pasture is the dominant landuse (57%) followed by agricultural cropland (20%) and forest land (13%). During the 1960's and 1970's, the Natural Resources Conservation Service (NRCS) identified Chambers Creek as one of the tributaries producing the greatest amount of sediment at the Richland-Chambers Reservoir.

Intensive surface water monitoring survey of segment 0814 by the Texas Department of Water Resources during 1977, 1983 and 1989 identified depressed levels of dissolved oxygen at the stream especially during the low flow conditions. In October 1993 a three year intensive data collection program was initiated under the National Water-Quality Assessment (NAWQA) program at the Richland-Chambers stream segments and reservoir. The study identified nutrient loading from non-point sources especially fertilizer from croplands and animal manure from cattle ranching as a major water quality issue. The study also identified Mill Creek and Big Onion Creek (Tributaries of segment 0814 – Chambers Creek) as the major contributors of nutrient load to the stream and the reservoir.

TRWD took a leading role in coordinating the development of a partnership of several stakeholders to implement a program aimed at reducing pollutant loads in the Richland-Chambers Reservoir. Development of this partnership enabled the application of $5 million in funding from the NRCS to implement Best Management Practices aimed at the reduction of sediments and nutrients from the Mill Creek watershed. Additionally, the District has provided funding to assist in partially satisfying the local match requirements associated with using the federal funds. As a result of this program, a number of BMPs have been implemented within the watershed starting in 1996. There are about 177 structural and 87 nonstructural (agronomic) BMPs implemented in the Mills Creek watershed.

TRWD has established four fixed sampling stations to gather water quality data and evaluate the effectiveness of the BMPs since 1996. Several water quality parameters were observed at the four fixed sampling stations in Mill Creek Watershed. The water quality parameters monitored include total suspended solids, total phosphorus, organic phosphorus, ammonia, total Kjeldahl nitrogen, organic nitrogen, nitrate nitrogen, nitrite nitrogen, chlorophyll-a, dissolved oxygen, and carbonaceous Biological Oxygen Demand. In addition to this, several USGS stations have collected water quality data on nutrients and sediments at the streams in the Richland-Chambers watershed from 1960's to 1980's prior to the construction of the Richland-Chambers reservoir in 1987. Since 1989 till the present day, TRWD has been periodically (monthly and quarterly) monitoring the water quality for nutrients and sediments at Richland and Chambers Creek as well as at various locations within the reservoir.

BMPs and conservation practices are designed and implemented to reduce nutrient and sediment loading from the agricultural watersheds. But only few studies have been able to verify the effectiveness of BMPs implemented. The BMPs installed at the Mill Creek watershed, the water quality data collected by TRWD at four locations within Mill Creek and the historical water quality data from USGS and TRWD provide an unique opportunity to verify the effectiveness of various BMPs implemented in this watershed and the changes in water quality in pre-BMP (without BMPs) and post-BMP (with BMPs) conditions. The major aspects of this study are to verify the effectiveness of installed BMPs in the Mill Creek watershed within the Richland-Chambers reservoir study area using observed water quality data and transfer the BMP data from the Mill Creek test site to other parts of the watershed primarily within the impaired segment of Chambers Creek (Segment 0814) to provide information on appropriate areas for BMP implementation in a cost effective way.

Additionally, TSSWCB has implemented BMPs in other parts of the Richland-Chambers watershed through separate 319(h) projects. The NRCS-Water Resources Assessment Team (NRCS-WRAT) is involved in assessing the benefits of these BMPs in reducing the herbicide (atrazine) loading. The 319(h) project BMPs will be included in this project for the assessment of sediment and nutrient reductions.

A watershed based modeling approach (with spatial/geographic information system capability) allows for considering the variations in weather, soils, land use and management practices in the watershed, and evaluating the impacts of conservation practices in terms of % pollution load reductions of nonpoint sources at different locations in the watershed. It is also possible to evaluate whether the existing management practices implemented are enough to meet the designated water uses/standards or not and also to identify what additional practices are needed to achieve the water quality standards. In studies funded by TSSWCB, Santhi et al. (2003) and Santhi and Srinivasan (2004) have applied a watershed modeling approach in the Big Cypress Creek Watershed and West Fork Watershed in Texas, for estimating the % load reduction due to implementation of BMPs. The present study with good observed water quality data will aid in verifying the effectiveness of implemented BMPs and aid in transferring the knowledge from test site (Mill Creek) to other parts of the watershed (Chambers Creek segment 0814) to examine their impacts on water quality improvement and provide supporting information for BMP implementation.

Project tasks include the following:
1) Watershed data collection,
2) Analysis of observed water quality data,
3) Modeling of the BMPs at field and watershed scales,
4) Representation of the pre- and post- BMPs conditions in the modeling approach,
5) Model calibration and validation with observed data,
6) Evaluation of the impacts of BMPs on water quality, and
7) Spatial and temporal analysis of the impacts of BMPs

Subtasks are outlined in Table A6-1 along with a listing of the responsible agency or agencies and an activity schedule.

Table A6-1. Project Plan Milestones

TASK	PROJECT MILESTONES	AGENCY	START	END
1	Develop a Quality Assurance Project Plan	TWRI	Sept05	Mar06
2.1	Watershed data collection	SSL	Nov05	May06
2.2	Collect information on BMPs implemented	SSL	Nov05	May06
2.3	Analyze watershed data	BREC & SSL	Nov05	May06
3.1	Field scale modeling of the BMPs implemented in Mill Creek/ Richland-Chambers Watershed(BREC) and watershed modeling (SSL)	BREC & SSL	Mar06	Jan09
3.2	Representation of each BMP for pre and post – BMP conditions in the modeling approach	BREC	Mar06	May08
4.1	Model calibration and validation at field scale	BREC	Oct06	Sept08
4.2	Model calibration and validation at watershed scale	BREC & SSL	Oct06	Sept08
5	Evaluation of the impacts of BMPs on water quality at field scale and watershed scales	BREC & SSL	Oct07	May09
6	Spatial and temporal analysis of the impacts of BMPs	SSL & BREC	Oct07	May09
7.1	Submit quarterly progress reports and conduct quarterly meetings to track progress of project activities	SSL & BREC	Sept05	Aug09
7.2	Development of final report	SSL & BREC	June09	Aug09

Section A7: Quality Objectives and Criteria for Model Inputs / Outputs

The objectives of the water quality modeling for this project are as follows:

1) Verify the effectiveness of BMPs installed on Mill Creek using the EPA approved EPIC/APEX and SWAT models
2) Develop a methodology/modeling approach to make quantitative assessment of the effectiveness of BMPs in reducing non-point source pollution
3) Spatial and Temporal Analysis of the impacts of BMPs

The Richland Chambers watershed will be delineated into sub-watersheds using the SWAT-ARCVIEW GIS interface (Di Luzio et al., 2004). The map of the BMPs will be overlaid on the sub-watershed map to identify the BMP and non-BMP areas within each sub-watershed. The soil and land use associated for the BMP and non-BMP areas will be identified using the GIS interface. GIS data to be used are SSURGO (Soil Survey Geographic) and CBMS (Computer Based Mapping System) soils, USGS NLCD (National Land Cover Dataset) landuse, and the USGS 30-meter resolution digital elevation model (DEM). Measured precipitation and temperature will be collected from National Weather Service climate stations, for input to SWAT, from 1999 to present. Measured stream flow will be collected at USGS stream gage stations, and measured sediment will be obtained from reservoir owners/operators, or the Texas Water Development Board and will be conducted using current QAPPs under which these agencies adhere to. Current information on typical crops and management practices (e.g. tillage, atrazine application rate and timing) will be obtained from local NRCS and SWCD field offices. Existing cropland BMPs (e.g. terraces, waterways, buffers) will be determined from field office records. SWAT inputs will be adjusted to accurately represent existing conditions and management.

A farm-scale model Agricultural Policy/Environmental eXtender (APEX) (Williams et al., 2000) will be used to simulate the BMPs. Farm scale modeling is helpful in representing the farm management activities/BMPs in detail. The APEX model has the capability to simulate terraces, grassed waterways, different types of animal waste management practices, manure/nutrient management practices, prescribed grazing system, pasture management, stream crossing, farm ponds and water troughs. The outputs from this model will provide benefits at edge of the field and will be input into the watershed model, Soil and Water Assessment Tool (SWAT) (Neitsch et al., 2002). SWAT will provide benefits of the practices at sub-watershed and watershed levels after accounting for stream routing and losses.

Literature information available from field-scale evaluation studies on BMPs will be used to parameterize the hydrologic and nutrient components, namely flows, and sediment and nutrient loadings produced at field/farm level from the EPIC/APEX models. The parameters related to various BMPs will be validated depending on the observed water quality data available at the field level from the Mill Creek watershed.

The SWAT model will be calibrated for streamflow, sediment, and nutrients using the monitoring data available from USGS stream gauges, and historical water quality data collected by TRWD and USGS at the reservoir and various stream segments. Model parameters related to (sub) watershed/landscape processes will be adjusted to match the measured and simulated flow, sediment, and nutrient at key locations in each watershed as indicated in the study area. Then the model will be validated without adjusting any parameters.

Model calibration, in this setting, is defined as how well the model is able to reproduce current observed flow rates, sediments and nutrients (e.g., trends and peak values), as measured from multiple field surveys and stored in the TCEQ monitoring database, TRWD database, and USGS database. Multiple measurements for these parameters are used for verifying the models. Thus, the calibration procedure is able to divide the total variability of the model predictions into two sources:

1. Within-station variability in the input measurements.
2. Variability and uncertainty associated with how well the model fits the data (i.e., lack-of-fit).

The following criteria has been established for this project as acceptable model calibration inputs and outputs, respectively:

- Annual flow will be calibrated so that predicted values agree to measured values within 15-20%,
- Flow water balance *(relationship between surface and subsurface flows as defined by base flow filter)* will be calibrated so that predicted values also agree to measured values within 15%,
- Sediment *(where sedimentation survey or other data is available)* will be calibrated so that predicted values also agree to measured values within 20-25%,
- Nutrient concentrations (depending on the length of in-stream data is available) will be calibrated so that the mean of the predicted values falls within two standard deviations of the mean of the measured values.

In the instance that these calibration standards are not obtained, the following actions will be taken:

- Check data for deficiencies and correct any that are found,
- Check model algorithms for deficiencies and correct any that are found, and
- Re-calibrate the model after corrections of deficiencies.

If the standards are obtained, a corrective action report will be submitted to TSSWCB with the following quarterly report. If these steps do not bring predicted values within calibration standards, the Quality Assurance Officer will work with TSSWCB and EPA to arrive at an agreeable compromise.

The APEX/SWAT models will be used to simulate the effectiveness of BMPs in the Richland-Chambers watershed. Pre-BMP conditions (or without BMPs) representing conditions of the watershed prior to the implementation of BMPs, and post-BMP conditions (or with BMPs) representing the conditions of the watershed after implementation of the practices will be simulated to quantify the impacts of BMPs at different locations within the watershed. Changes in sediment and nutrient loadings between pre-BMP and post-BMP conditions provide information to assess the "long-term impacts" on water quality.

Section A8: Special Training Requirements/Certification

All personnel involved in model calibration, validation, and development will have the appropriate education and training required to adequately perform their duties. No special certifications are required.

Section A9: Documentation and Records

All records, including modeler's notebooks and electronic files, will be archived by SSL for at least five years. These records will document model testing, calibration, and evaluation and will include documentation of written rationale for selection of models, 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 Unix drive and the network server are backed up daily to a tape drive. In the event of a catastrophic systems failure, the tapes 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.

TWRI's QAO will produce an annual quality assurance/quality control report, which will be kept on file at TWRI with copies distributed to individuals listed in section A3. Any items or areas identified as potential problems and any variations or supplements to QAPP procedures noted in the quality assurance/quality control report will be made known to pertinent project personnel and included in an update or amendment to the QAPP.

Quarterly progress reports disseminated to the individuals listed in section A3 will note activities conducted in connection with the water quality modeling project, items or areas identified as potential problems, and any variations or supplements to the QAPP. The final report will include:

- GIS maps related to soil, land use, topography, and location of the various BMPs implementation sites in relation to 303(d)-listed segments of the watershed;
- Compilation of observed water quality data collected for various sites from different sources;
- Figures showing the time series of water quality data (sediment and nutrients);
- Any observed trends in water quality improvement due to BMP implementation and/or change in landuse;
- Documentation of the modeling procedures for various BMPs modeled, pre- and post-BMP farming conditions and model parameters adjusted along with procedures adopted for pre- and post-BMP conditions;
- Time series graphs showing the observed and simulated flows, sediment loading and nutrient loading for the calibration and validation periods as observed data available;
- Statistical measures such as means, standard deviation, coefficient of determination (R^2), and Nash-Suttcliffe simulation efficiency (Nash and Suttcliffe, 1970) to show the model's prediction with respect to observed data at several locations in the watershed;
- Results or the impacts of BMPs on water quality as percentage reductions in average annual sediment, total nitrogen (organic and mineral nitrogen) and total phosphorus (organic and mineral phosphorus) loadings at the farm level and at the watershed level; and

- A map identifying sediment and nutrient hotspots within the watershed, suggestions for alternative BMPs and the corresponding expected improvement in water quality in terms of percentage reductions in sediment and nutrients to the lake.

Corrective Action Reports CARs will be utilized when necessary (Appendix A). CARs will be maintained in an accessible location for reference at TWRI and will be 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.

Section B1: Sampling Process Design (Experimental Design)

Not relevant.

Section B2: Sampling Method Requirements

Not relevant.

Section B3: Sample Handling and Custody Requirements

Not relevant.

Section B4: Analytical Methods Requirements

Not relevant.

Section B5: Quality Control Requirements

Not relevant.

Section B6: Equipment Testing, Inspection, & Maintenance Requirements

Not relevant.

Section B7: Instrument Calibration and Frequency

Not relevant.

Section B8: Inspection/Acceptance Requirements for Supplies and Consumables

Not relevant.

Section B9: Data Acquisition Requirements (Non-direct Measurements)

The TRWD is a partner in the Clean Rivers Program for the state of Texas. As such, they collect data on a regular basis for routine water quality assessment as part of the state's mandate for CWA§305(b)--Water Quality Inventory Report. This data is also used by Texas for consideration of water bodies to be added to their list of impaired water body segments, as described in CWA§303(d).

All water quality data used in the modeling procedures for this project are collected in accordance with approved quality assurance measures under the state's Clean Rivers Program, Texas Commission on Environmental Quality, Texas Water Development Board, USDA, National Weather Service, or USGS.

GIS data to be used are SSURGO (Soil Survey Geographic) and CBMS (Computer Based Mapping System) soils, USGS NLCD (National Land Cover Dataset) landuse, and the USGS 30-meter resolution digital elevation model (DEM). Measured precipitation and temperature will be collected from National Weather Service climate stations, for input to SWAT. Quality assured stream flow measurements will be collected from USGS stream gage stations, and measured sediment will be obtained from TRWD or the Texas Water Development Board.

Within each watershed, current information on typical crops and management practices will be obtained from local NRCS and SWCD field offices (Limestone-Falls, Ellis-Prairie, McLennan County, Navarro, Hill County-Blackland and Johnson), the TSSWCB Dublin Regional Office and USDA Farm Service Agency. Existing BMPs (e.g. terraces, waterways, buffers) will be determined from field office records. EPIC/APEX and SWAT inputs will be adjusted to represent existing conditions and management.

Section B10: Data Management

Systems Design

The SSL as well as BREC uses laptop personal computers, desktop personal computers and Unix workstations. The computers run Windows operating system and Unix Solaris operating system. Databases include Microsoft® Excel, Microsoft® Access, and a SAS database management system run through a Unix Solaris operating system.

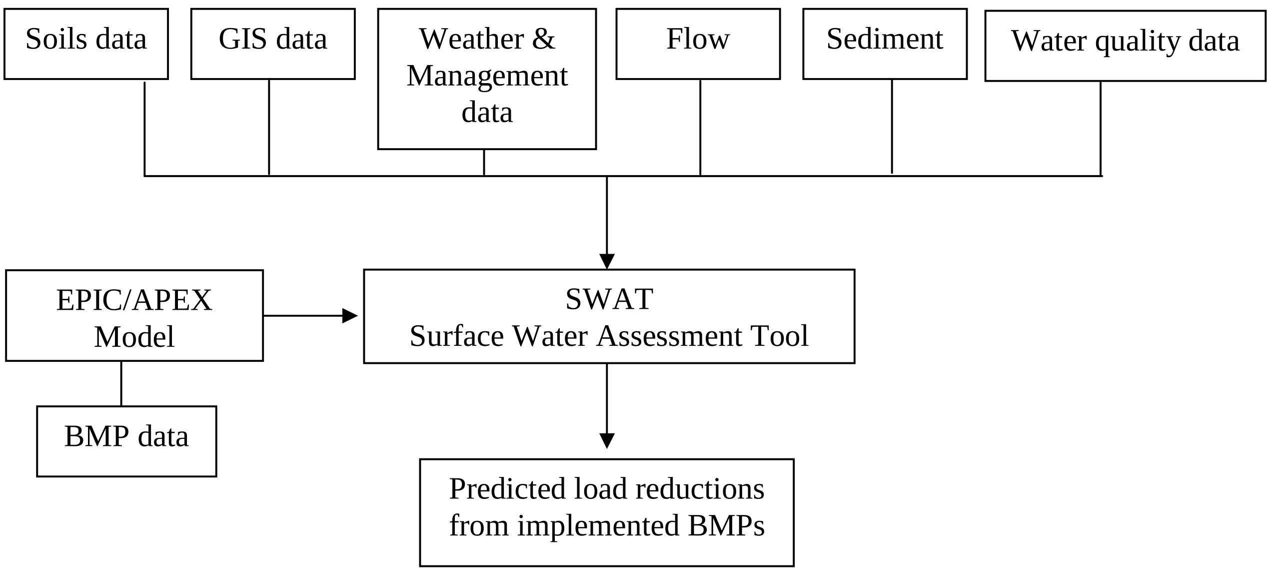
Backup and Disaster Recovery

The Unix drive and the personal computer drives are backed up on a daily/weekly basis to a tape drive. In the event of a catastrophic systems failure, the tapes 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 are stored for at least five years. Data in electronic format are stored on tape drives in a climate controlled, fire-resistant storage area on either the Texas A&M University campus or at the Blackland Research and Extension Center.

Figure B10-1. Information Dissemination Diagram



Section C1: Assessments and Response Actions

Table C1.1 presents the types of assessments and response actions for data collection activities applicable to the QAPP.

Table C1.1 Assessments and Response Actions

Assessment Activity	Approximate Schedule	Responsible Party(ies)	Scope	Response Requirements
Status Monitoring Oversight, etc.	Continuous	TCE, TWRI	Monitoring of the project status and records to ensure requirements are being fulfilled. Monitoring and review of performance and data quality	Report to project lead in Quarterly Report
Monitoring Systems Audit	Minimum of one during the course of this project.	TSSWCB QAO	The assessment will be tailored in accordance with objectives needed to assure compliance with the QAPP. Facility review and data management as they relate to the project	30 days to respond in writing to the TSSWCB QAO to address corrective actions

In addition to those listed above, the following assessment and response actions will be applied to modeling activities. 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 for Model Inputs/Outputs Data) and will follow-up with the various data sources on any concerns that may arise.

The model calibration procedure is discussed in Section D2 (Validation and Verification Methods), and criteria for acceptable outcomes are provided in Section A7 (Quality Objectives and Criteria for Model Inputs/Outputs).

Results will be reported to the project QA officer 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 Project Manager to assure that the correct files are read appropriately and the test is repeated to document compliance. 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 successful correction of identified problem. Corrective Action Reports (Appendix A) will be filled out to document the problems and the remedial action taken. Copies of Corrective action reports will be included with the TWRI's annual Quality Assurance report. The Quality Assurance report will discuss any problems encountered and solutions made. These QA reports are the responsibility of the Quality Assurance Officer and the Project Manager and will be disseminated to individuals listed in section A3. If the predicted value cannot be brought within calibration standards, the Quality Assurance Officer will work with TSSWCB and EPA to arrive at an agreeable compromise.

Software requirements, software design, or code are examined to detect faults, programming errors, violations of development 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 any specific 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.

Section C2: Reports to Management

Quarterly progress reports developed by the Project Manager will note activities conducted in connection with the 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 A). CARs will be maintained in an accessible location for reference at TWRI and disseminated to individuals listed in section A3. 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 successful correction of identified problem. Corrective Action Reports will be filled out to document the problems and the remedial action taken. Copies of Corrective action reports will be included with the TWRI's annual Quality Assurance report. The Quality Assurance report will discuss any problems encountered and solutions made. These QA reports are the responsibility of the Quality Assurance Officer and the Project Manager and will be disseminated to individuals listed in section A3.

Section D1: Data Review, Validation and Verification

All data obtained will be reviewed, validated, and verified against the data quality objects outlined in Section A7, “Quality Objectives and Criteria for Model Inputs / Outputs.” Only those data that are supported by appropriate quality control will be considered acceptable for use.

The procedures for verification and validation are described in Section D2, below. The TAMU Spatial Sciences Laboratory Project Manager is responsible for ensuring that data are properly reviewed, verified, and submitted in the required format for the project database. Finally, the TWRI QAO is responsible for validating that all data collected meet the data quality objectives of the project and are suitable for reporting.

Section D2: Validation and Verification Methods

Validation of the model will be done for a time period of no less than one year - depending on the observed data available. In the validation process, the model is operated with input parameters set during the calibration process without any change and the results are compared to the remaining observed data to evaluate the model prediction. Same evaluation measures will be used for assessing the performance of the model during validation. In case, the matching between simulated and observed data is not to the standard, the calibration process will be revisited until a best fit between simulated and observed data is obtained.

EPIC/APEX and SWAT models proposed for this study are developed with an attempt to simulate the processes physically and realistically. Most of the model inputs are physically based (that is, based on readily available information). It is important to understand that either APEX or SWAT is not a 'parametric model' with a formal optimization procedure (as part of the calibration process) to fit any data. Instead, a few input variables that are not well defined physically such as runoff curve number and Universal Soil Loss Equation's cover and management factor or C factor may be adjusted to provide a better fit. Moreover, these model parameters are adjusted within literature recommended values so that the results are scientifically valid and defensible. In addition, statistical measures used for evaluating the model's predicted data using the observed data during calibration and validation help to maintain the quality of the model simulation processes and the model results reliable.

Calibration is the process where the model input parameters are adjusted until the simulated data from the model match with observed data. Model parameters related to watershed/landscape processes will be adjusted to match the measured and simulated flow, sediment, nutrients and pesticides at key locations in the watershed. During the calibration process, all model parameters will be adjusted within literature recommended ranges. Calibration will be done to represent normal, wet and dry years. Time series plots (between simulated and observed data) and statistical measures such as mean, standard deviation, coefficient of determination and Nash-Suttcliffe simulation efficiency (Nash and Suttcliffe, 1970) will be used to evaluate the prediction (performance) of the model during calibration. Coefficient of determination indicates the strength of relationship between the observed and simulated values. Nash-Suttcliffe simulation efficiency indicates how well the plot of observed versus simulated value fits the 1:1 line. If the values for these two measures are less than or very close to zero, the model prediction is considered 'unacceptable or poor'. If the values are one, then the model prediction is 'perfect'. Calibration is done systematically, first for flow, then for sediment and followed by organic and mineral nutrients (Santhi et al., 2001).

Literature information and observed water quality as available at field scale at Mill Creek will be used to validate the APEX model. Stream flow and monitoring data on sediment and nutrients along different locations of the watershed will be collected to calibrate and validate the SWAT model.

Model parameters related to subwatersheds and landscape processes will be adjusted to match measured and simulated flow and water quality trends at key locations in the watershed. All model parameters will be adjusted within ranges recommended in published literature. Then the model will be validated without adjusting any parameters. Depending on the monitoring data available, calibration and validation periods will be chosen. Time series plots and standard statistical measures will be used to evaluate the performance of models during calibration and validation.

Section D3: Reconciliation with Data Quality Objectives

Data generated by this project will be used primarily for planning purposes. By following the guidelines described in this QAPP, and through careful project design, the data collected in this project will be representative of the actual conditions and comparable to similar applications.

The final data will be reviewed to ensure that it meets the requirements as described in this QAPP. Corrective Action Reports will be initiated in cases where invalid or incorrect data have been detected. Data that have been reviewed, verified, and validated will be summarized for their ability to meet the data quality objectives of the project and the informational needs of water quality agency decision-makers. These summaries, along with a description of any limitations on data use, will be included in the final report.

The data and modeling framework developed by this project will be used to (1) evaluate the effectiveness of BMPs and (2) provide supporting planning information for implementation of BMPs. It will be incorporated to provide the TSSWCB, NRCS, SWCDs and local stakeholder groups with information pertaining to watershed characteristics and to the effectiveness of BMPs in reducing possible pollution problems. This, in turn, will enhance their decision-making efforts as part of a comprehensive watershed management strategy.

References

Di Luzio, M., Srinivasan, R., Arnold, J. G., 2004. A GIS-coupled hydrological model system for the watershed assessment of agricultural nonpoint and point sources of pollution. Transactions in Geographic Information System 8(1): 113-136

Nash, J. E., and J. V. Suttcliffe. 1970. River flow forecasting through conceptual models, Part I – discussion of principles. Journal of Hydrology 10(3), 282-290.

Neitsch, S. L., Arnold, J. G., Williams, J. R., Kiniry, J. R., King, K. W., 2002. Soil and Water Assessment Tool (Version 2000)- Model documentation. TR-191, Texas Water Research Institute.

Santhi, C., and R. Srinivasan, 2004. Mapping and Modeling of the Water Quality Management Plans Implemented in the West Fork Watershed of Trinity River. Blackland Research and Extension Center, Texas Agricultural Experiment Station, Texas A& M University System, Temple, TX. BRC Report No. 04-05.

Santhi, C., R. Srinivasan, J. G. Arnold, J. R. Williams. A Modeling Approach to Evaluate the Impacts of Water Quality Management Plans Implemented in the Big Cypress Creek Watershed. Second Conference on Watershed Management to Meet Emerging TMDL Environmental Regulations, Albuquerque, New Mexico, November 2003, pp: 384-394.

Santhi, C., Arnold, J. G., Williams, J. R., Dugas, W. A., Srinivasan, R., Hauck, L. M., 2001. Validation of the SWAT model on a large river basin with point and nonpoint sources. Journal of American Water Resources Association 37(5): 1169-1188.

Williams, J. R., Arnold, J. G., and Srinivasan, R, 2000. The APEX Model, Blackland Research and Extension Center, Texas Agricultural Experiment Station, Texas A& M University System, Temple, TX, BRC Report No. 00-06.

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:__________________________________

TWRI Quality Assurance Officer:_____________________________

TSSWCB Quality Assurance Officer:____________________________