Modeling Efforts for the Brady Creek Watershed Protection Plan
Quality Assurance Project Plan

Upper Colorado River Authority
512 Orient
San Angelo, Texas 76903

and as Subcontractor

Texas Institute of Applied Environmental Research
Tarleton State University
Box T-0410
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Funding Source:

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Prepared in cooperation with the Texas Commission on Environmental Quality
and the U.S. Environmental Protection Agency
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Effective Period: One year from date of final approval

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

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A1 APPROVAL PAGE

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Field Operations Support Division

Stephen Stubbs 7.11.11
Stephen Stubbs, TCEQ QA Manager Date

7/5/11
Kyle Girten, QA Specialist Date
Quality Assurance Team

Water Quality Planning Division

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Monica Harris, Section Manager Date
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6/22/2011
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Anju Chalise 6/22/2011
Anju Chalise, QA Specialist Date
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Lauren Bilbe 6/22/11
Lauren Bilbe Date
Project Manager, Nonpoint Source Program

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Upper Colorado River Authority (UCRA)

Chuck Brown, Project Manager	6/21/11 Date	Fred Teagarden, QA Officer	6-21-11 Date

Texas Institute for Applied Environmental Research (TIAER)

Ali Saleh, Associate Director	6/20/11 Date	Nancy Easterling, TIAER QAO	06/20/11 Date
Tae Jin Kim, Lead Modeler and Project Data Manager	06/20/11 Date		

The UCRA will secure written documentation from additional project participants (e.g., subcontractors, laboratories) stating the organization's awareness of and commitment to requirements contained in this quality assurance project plan and any amendments or revisions of this plan. The UCRA will maintain this documentation as part of the project's quality assurance records. This documentation will be available for review. (See sample letter in Attachment 1 of this document.)

Copies of this documentation will also be submitted as deliverables to the TCEQ NPS Project Manager within 30 days of final TCEQ approval of the QAPP. (See sample letter in Attachment 1 of this document.)

A2 TABLE OF CONTENTS

A3 DISTRIBUTION LIST

The TCEQ QA Specialist will provide original versions of this project plan and any amendments or revisions of this plan to the TCEQ Project Manager and the Upper Colorado River Authority (UCRA) Project Manager. The TCEQ Project Manager will provide copies to the EPA Project Officer within two weeks of approval. The TCEQ Project Manager will document receipt of the plan and maintain this documentation as part of the project's quality assurance records. This documentation will be available for review.

U.S. Environmental Protection Agency Region 6
State/Tribal Section
1445 Ross Avenue, Suite # 1200
Dallas, TX 75202-2733

Leslie Rauscher, Project Officer
(214) 665-2773

The UCRA will provide copies of this project plan and any amendments or revisions of this plan to each project participant defined in the list below. The UCRA will document receipt of the plan by each participant and maintain this documentation as part of the project's quality assurance records. This documentation will be available for review.

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List of Acronyms

ARS	Agricultural Research Service
BLSM	Brady Lake Spreadsheet Model
BMP	Best Management Practice
BRC	Blackland Research Center
CAR	Corrective Action Report
CAP	Corrective Action Plan
COC	Chain of Custody
CREM	Council of Regulatory Environmental Modeling
CWA	Clean Water Act
EPA	Environmental Protection Agency
DEM	Digital elevation model
DMR	Discharge monitoring report
GIS	Geographic Information System
ICIS	Integrated Compliance Information System
LCRA	Lower Colorado River Authority
NCDC	National Climatic Data Center
NHD	National Hydrography Dataset
NLCD	National Land Cover Data
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
P8-UCM	P8 – Urban Catchment Model
PM	Project Manager
QA	Quality Assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QAS	Quality Assurance Specialist
QMP	Quality Management Plan
QPR	Quarterly Progress Report
QUAL2K	Not an acronym – one-dimensional water quality model
RPD	Relative Percent Difference
SSURGO	Soil Survey Geographic
STATSGO	State Soil Geographic
SWAT	Soil and Water Assessment Tool

SWMM	Storm Water Management Model
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TDS	Total dissolved solids
TIAER	Texas Institute for Applied Environmental Research
TKN	Total Kjeldahl nitrogen
total-N	Total nitrogen
TNRIS	Texas Natural Resources Information System
total-P	Total phosphorus
TPWD	Texas Parks and Wildlife Department
TSWQS	Texas Surface Water Quality Standards
TSS	Total suspended solids
UCRA	Upper Colorado River Authority
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WPP	Watershed Protection Plan

A4 PROJECT/TASK ORGANIZATION

TCEQ

Field Operations Support Division

Kyle Girten
Lead QA Specialist
Assists the TCEQ Project Manager in QA related issues. Serves on planning team for NPS projects. Participates in the planning, development, approval, implementation, and maintenance of the QAPP. Determines conformance with program quality system requirements. Coordinates or performs audits, as deemed necessary and using a wide variety of assessment guidelines and tools. Concurs with proposed corrective actions and verifications. Monitors corrective action. Provides technical expertise and/or consultation on quality services. Provides a point of contact at the TCEQ to resolve QA issues. Recommends to TCEQ management that work be stopped in order to safe guard project and programmatic objectives, worker safety, public health, or environmental protection.

Water Quality Planning Division

Kerry Niemann, Team Leader
NPS Program
Responsible for management and oversight of the TCEQ NPS Program. Oversees the development of QA guidance for the NPS program to be sure it is within pertinent frameworks of the TCEQ. Monitors the effectiveness of the program quality system. Reviews and approves all NPS projects, internal QA audits, corrective actions, reports, work plans, and contracts. Enforces corrective action, as required. Ensures NPS personnel are fully trained and adequately staffed.

Lauren Bilbe
TCEQ NPS Project Manager
Maintains a thorough knowledge of work activities, commitments, deliverables, and time frames associated with projects. Develops lines of communication and working relationships between the contractor, the TCEQ, and the 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. Serves on planning team for NPS projects. Participates in the development, approval, implementation, and maintenance of the QAPP. Assists the TCEQ QAS in technical review of the QAPP. Responsible for verifying that the QAPP is followed by the contractor. Notifies the TCEQ QAS of particular circumstances which may adversely affect the quality of data derived from the collection and analysis of samples. Enforces corrective action.

Anju Chalise
TCEQ NPS Project Quality Assurance Specialist
Assists Lead QAS with NPS QA management. Serves as liaison between NPS management and Agency QA management. Responsible for NPS guidance development related to program quality assurance. Serves on planning team for NPS projects. Participates in the development, approval, implementation, and maintenance of the QAPP.

Upper Colorado River Authority

Chuck Brown
UCRA Project Manager
Responsible for coordinating the modeling effort with other aspects of the overall Brady Creek Watershed Protection Plan. 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 the TCEQ.

Texas Institute for Applied Environmental Research

Ali Saleh
TIAER Project Manager
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 the TCEQ and UCRA. Responsible for verifying the QAPP is followed and the project is producing results of known and acceptable quality. Complies with corrective action requirements.

Nancy Easterling
TIAER QAO
Responsible for verifying the QAPP is followed and the project is producing data of known and acceptable quality. Responsible for coordinating development and implementation of the QA program. Responsible for maintaining TIAER QAPPs. Responsible for maintaining records of QAPP distribution within TIAER, including appendices and amendments. Responsible for maintaining written records of TIAER sub-tier commitment to requirements specified in this QAPP. Responsible for identifying and receiving project quality assurance records. Responsible for coordinating with the TCEQ QAS to resolve QA- related issues. Notifies the TIAER Project Manager of particular circumstances that may adversely affect the quality of data. Coordinates the research and review of technical QA material and data related to model inputs and analytical techniques. Develops, facilitates, and conducts modeling activity audits.

Tae Jin Kim
TIAER Lead Modeler and Project Data Manager
The Lead Modeler is responsible for the operation of all computer models and associated documentation of model operation. Responsible for accuracy of input data to models. Performs operation of the models to ensure valid results are being predicted. Responsible for formulating model input to reflect the scenarios and situations to be emulated by each model.

The Project Data Manager is responsible for acquisition and verification of data, documentation of data sources, ensuring the accuracy of data, and for the transfer of data to the TCEQ. Responsible for maintaining project quality assurance records. Oversees data management for the study. Performs data quality assurances prior to transfer of data to UCRA. Responsible for transferring data to the UCRA in an acceptable format. Ensures data are submitted according to workplan specifications. Provides the point of contact for the TCEQ Data Manager to resolve issues related to the data.

U.S. EPA Region 6

Leslie Rauscher
EPA Project Officer
Responsible for managing the CWA Section 319 funded grant on the behalf of EPA. Assists the TCEQ 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 workplans, draft deliverables, and works with the State 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.

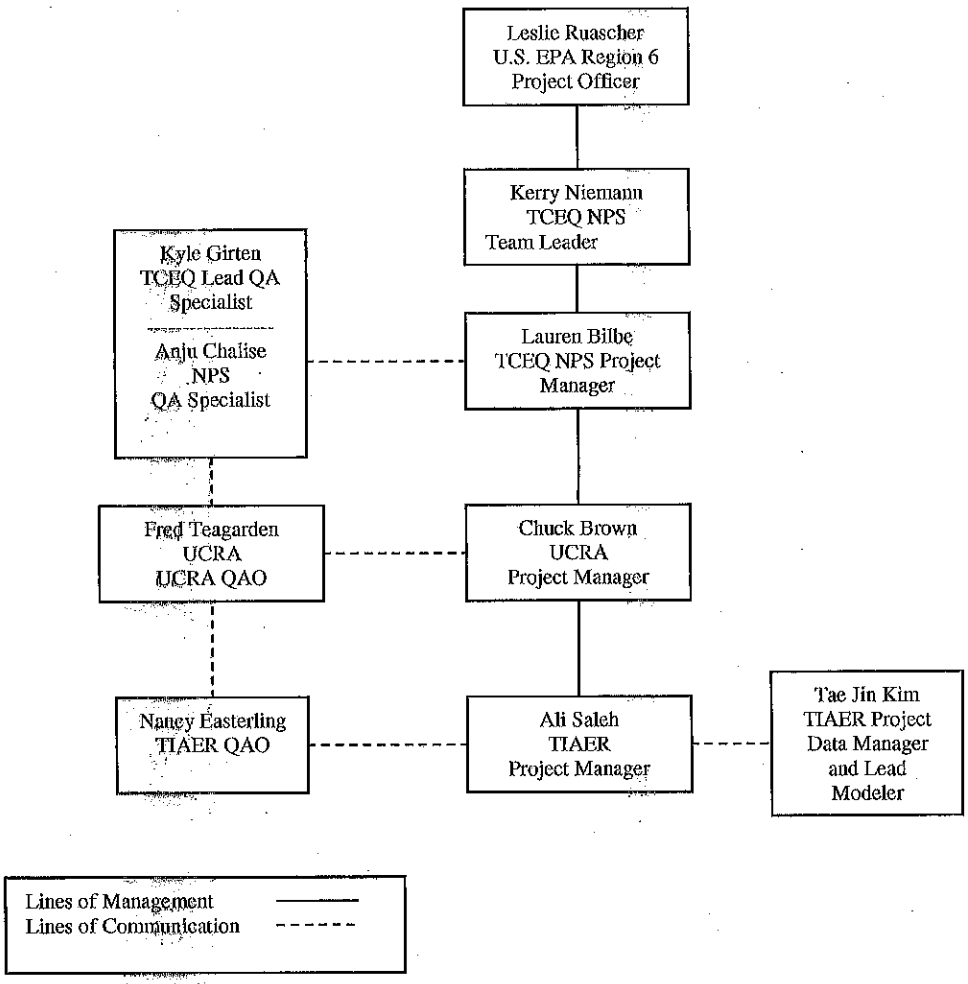


Figure A4.1. Organization Chart - Lines of Communication

A5 PROBLEM DEFINITION/BACKGROUND

Water quality in Brady Creek through the city of Brady has continued to degrade since the construction of Brady Lake. Brady Creek has been identified as impaired on the Texas 303(d) list since 2004 for not supporting its designated aquatic life due to low dissolved oxygen. The absence of scouring stream flows and perennial flows has resulted in the stream functioning primarily as a series of storm water ponds with intermittent stream flows. As a result, it often displays the characteristics of a eutrophic stream with prolific algae blooms, odors, and a generally unpleasant appearance. There is also a history of fish kills that have been investigated by the Texas Parks and Wildlife Department (TPWD) and the Texas Commission on Environmental Quality (TCEQ). Reported investigations conclude that the fish kills were the result of nonpoint source (NPS) urban runoff. (See Appendix A for a map of Brady Creek watershed).

In partnership with the city of Brady and the LCRA, the UCRA applied for and received funding for two (2) NPS abatement projects (Phase I & II). Phase I included the completion of a Master Plan for the downtown portion of Brady Creek and a demonstration Best Management Practice (BMP). Phase II included demonstration BMPs and a preliminary Watershed Characterization plan, based primarily on developing a WPP for the entire Brady Creek watershed.

Within the sampling phase of the present project, the design intent is to assess the ambient water quality at five locations within the Brady Creek watershed as well as both rural and urban storm water quality. The ambient water quality sites are identical to those utilized in the phase 1 watershed characterization project previously completed. The **urban** storm water sites were selected to (1) sample areas of the city not previously monitored and (2) resample sub-basins with suspected heavy impact on Brady Creek water quality. An additional urban storm water site has been selected on Brady Creek below the City of Brady to quantify total loadings from the City of Brady. This site is routinely monitored quarterly by TCEQ Region 8 staff and historical ambient data are available. The **rural** storm water sites selected are the three ambient sites above Brady Lake.

In order to determine pollutant loads from unimpaired portions of the watershed, to determine more precise pollutant loadings from the impaired urban watershed within the city of Brady, and to evaluate depressed dissolved oxygen along Brady Creek within the city of Brady, the Texas Institute for Applied Environmental Research (TIAER) as a subcontractor to UCRA will develop and apply appropriate computer models. SWAT modeling will be developed for the Brady Lake watershed. SWMM modeling will be used to evaluate urban pollutant loadings within urban areas of the city of Brady and QUAL2K will be applied to evaluate possible control measures that may reduce occurrences of depressed oxygen in the urban portion of Brady Creek. Finally, a simple mass balance model for dissolved solids will be developed for Brady Lake (hereafter referred to as the Brady Lake Spreadsheet Model or BLSM). Inputs from existing data collected from the aforementioned projects, as well as newly acquired water quality data, will be used to evaluate environmental issues in the Brady Creek watershed and to address needs for estimating loading reductions. The purpose of this project is to develop and complete a watershed planning process for Brady Creek. The additional monitoring and modeling efforts are necessary for a greater assurance that the implementation of the WPP will achieve the goal to meet stream standards, along with maintaining/improving water quality in the greater watershed.

The UCRA will complete a WPP for Brady Creek (Segments 1416A, B and C). The primary goal of the WPP is to restore water quality to meet stream standards. The WPP will meet the nine required elements established by the EPA. Under this project, the UCRA will:

- Refine the Brady Creek Watershed Characterization by:
  - Conducting additional water quality monitoring and modeling.
  - Further identifying and quantifying pollutant loading sources.
- Utilize the Brady Creek Master Plan by:
  - Prioritizing BMPs identified in the Master Plan for the City of Brady.
- Identify additional BMPs for the greater watershed.
- Estimate costs and load reductions to be achieved through BMP implementation.
- Create a schedule for implementation with measurable milestones and methods of determining whether milestones have been met.
- Involve stakeholders throughout the process.

The goal of the completed Brady Creek WPP, a plan for the entire Brady Creek watershed, is to give basin stakeholders a strategy that will result in the maintenance and restoration of water quality conditions consistent with the State of Texas Surface Water Quality Standards for the designated uses of the stream or water body. Basin-wide water quality goals include the maintenance of appropriate levels of dissolved oxygen, prevention of eutrophic conditions due to elevated nutrient loads, prevention of erosion and sediment deposition within the stream and, where possible, maximize stream base flows to restore or enhance aquatic utilization.

This QAPP pertains to those unique tasks and goals associated with the development and application of computer models associated with completion of the Brady Creek WPP. The goals of the modeling activities covered by this QAPP are the following:

- Assist in the characterization of causes and sources of pollution and estimation of pollutant loads.
- Assist in the selection of BMPs.
- Estimate the load reductions obtained from BMP implementation in the City of Brady.
- Estimate the benefits of brush control on water quality in the Brady Creek watershed.
- Evaluate sediment control functionality of aging flood-retardation dams in the upper watershed.
- Evaluate the effects evaporation and inflows on rising dissolved solids content of Brady Lake.

A6 PROJECT/TASK DESCRIPTION

Watershed planning is an iterative and adaptive process. A successful WPP begins with adequate planning and a clear and consistent message of what is required. Development of the project Scope of Work was based on the understanding and interpretation of 1) *the Nonpoint Source Program and Grants Guidelines for States and Territories* promulgated by the United States Environmental Protection Agency (EPA) in 2003 (hereafter referred to as the 2003 Guidelines), and 2) the *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*, finalized by EPA in 2008 (hereafter referred to as the EPA Handbook). The Scope of Work structure is designed to ensure the project is consistent with and satisfies the EPA's nine elements fundamental to a successful watershed-based plan.

A summary of the WPP project work tasks is as follows:
(1) Project Administration; (2) Build Partnerships; (3) Element A: Watershed Characterization – Phase 2: Data Collection and Analysis; (4) Element A: Watershed Characterization- Phase 3: Identification of Causes and Sources of Pollution and Estimation of Pollutant Loads; (5) Element B: Estimate of Pollutant Load Reductions Expected from Management Measures; (6) Element C: Description of Management Measures; (7) Element D: Estimate of Technical and Financial Assistance Needed; (8) Element E: Information and Education; (9) Element F: Schedule for Implementation of Management Measures; (10) Element G: Description of Interim, Measurable Milestones; (11) Element H: Criteria to Determine if Load Reductions are Achieved; (12) Element I: Monitoring Component to Evaluate Effectiveness; (13) Completion of the WPP.

This QAPP covers the modeling activities within the following tasks:

- Task3: Element A: Watershed Characterization – Phase 2: Data Collection and Analysis;
- Task 4: Element A: Watershed Characterization- Phase 3: Identification of Causes and Sources of Pollution and Estimation of Pollutant Loads;
- Task 5: Element B: Estimate of Pollutant Load Reductions Expected from Management Measures; and
- Task 6: Element C: Description of Management Measures.

These tasks of the overall project work plan are provided in Appendix B.

Overview of Applications of Models

As listed immediately above, the four models selected for the project (i.e., SWAT, SWMM, QUAL2K, and Brady Lake Spreadsheet Model) will be used to characterize various issues within the basin to provide information regarding the following elements of the WPP: Element A: Watershed Characterization - Identification of Causes and Sources of Pollution and Estimation of Pollutant Loads and Element B: Estimate of Pollutant Load Reductions Expected from Management Measures.

The SWAT model will be set up to represent the majority of the Brady Creek watershed with an emphasis on the upper portion of the watershed, especially the Brady Lake drainage area. Sediment control provided by 35 aging flood-retardation structures in the Brady Lake watershed plus water quality benefits associated with brush control are the issues to be addressed with SWAT based on previously expressed stakeholder concerns. Further, SWAT will be used to provide the inflows to Brady Lake for the Brady Lake Spreadsheet Model.

The SWMM model will be used to estimate volume and water quality of urban runoff within the City of Brady and to predict load reductions from various urban best management practices (BMPs) including, but not limited to, wet ponds and dry ponds. This modeling effort will also be used to assist in location and sizing of urban BMPs that address the depressed dissolved oxygen and elevated nutrient levels along this portion of the stream. The modeling effort will assess existing and post-BMP pollutant loadings to Brady Creek from relevant portions of the City of Brady for the purpose of evaluating effectiveness of BMPs and load reductions.

The QUAL2K model will be used to evaluate depressed dissolved oxygen in Brady Creek within the city of Brady. This modeling effort will be used to assist in evaluating the benefits of recirculating flow and/or pumping wastewater treatment plant effluent above the area of depressed dissolved oxygen to increase flow in that portion of Brady Creek. The model will also be used with SWMM to estimate water quality benefits to the urban portion of Brady Creek from reductions in urban pollutant loadings.

The BLSM will be a simple conservative substance, mass balance model based on an Excel spreadsheet. Increasing dissolved solids content has been experienced within Brady Lake over the years since its construction in 1963. Natural dissolved solids runoff is thought to be contributing to this issue, but the lake also rarely spills and as such concentration of dissolved solids through evaporation is considered as an additional mechanism resulting in increased concentrations within the reservoir. This simple spreadsheet model will allow the importance of evaporation and hydrology (e.g., infrequency of reservoir releases) to be assessed as a factor in the increasing dissolved solids concentrations. SWAT and BLSM will operate as a modeling system with SWAT providing the required lake inflow data for BLSM.

Model Descriptions

Soil and Water Assessment Tool (SWAT)

SWAT is a physically-based watershed and landscape simulation model developed by the USDA-ARS (Arnold et al., 1998). Major components of the model include hydrology, weather, erosion, soil, temperature, crop growth, nutrients, pesticides and agricultural management. SWAT also has the ability to predict changes in sediment, nutrients (such as organic and inorganic nitrogen and organic and soluble phosphorus), pesticides, dissolved oxygen, bacteria and algae loadings from different management conditions in large un-gauged basins. SWAT operates on a daily time step and can be used for long-term simulations. The model output is available in daily, monthly and annual time scales. SWAT has been successfully applied to model water quality issues including sediments, nutrients and pesticides in watersheds (Arnold et al., 1999).

Storm Water Management Model (SWMM)

SWMM was developed by the EPA and is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas (Huber and Dickinson, 1988; Rossman, 2009). As described in the user's manual (Rossman, 2009), SWMM consists of runoff, transport and tracking components. The runoff component operates on a collection of sub-catchment areas that receive precipitation and generates runoff and pollutant loads. The transport component takes this runoff through a drainage system network of pipes, channels, storage/treatment devices, pumps, and regulators. Then SWMM tracks the quantity and quality of runoff generated within each sub-catchment, and the flow rate, flow depth, and quality of water in each pipe and channel. Thus SWMM has capabilities of simulating the generation and transport of runoff flows, estimating the production of pollutant loads associated with this runoff, and predicting changes in water quantity and quality as a result of management decisions and storage/treatment devices (e.g., wet and dry ponds).

It should be noted that for the urban environment modeling, P8-UCM was originally going to be applied, but since development of the work plan, SWMM is now the model favored for representing the urban environment. SWMM was selected over P8-UCM because it is a more complete, physically based model. Further the project team is engaged in an unrelated project applying SWMM in the San Angelo, TX area, which is in close proximity to the City of Brady, and that experience will readily carry over to the present project.

QUAL2K

QUAL2K was developed for EPA by Dr. Steve Chapra, Tufts University. In Chapra *et al.* (2008) the model is described as follows. QUAL2K provides for the prediction of water quality in river and stream systems by representing the channel in a one-dimensional, longitudinal manner with the assumption of vertical and lateral complete mixing. The model allows branching tributaries, provides non-uniform, steady flow hydraulics, and water quality variables are simulated on a diel time scale. An Excel workbook serves as the interface for QUAL2K. Model execution, input and output are all implemented from within Excel. Visual Basic for Applications (VBA) serves as Excel's macro language for implementing all interface functions, and numerical calculations are implemented in FORTRAN 90.

Brady Lake Spreadsheet Model (BLSM)

A simple mass-balance spreadsheet model will be developed for this project to estimate the importance of evaporation in Brady Lake on the increasing dissolved solids concentrations experienced in the lake over the years. Existing, off-the-shelf reservoir models (e.g., CE-QUAL-W2) that take into account evaporation, heat budget, and reservoir geomorphology are very complex with large input data requirements and high demands for accurate calibration and validation, which is much more intensive in resource requirements than needed for this project. For this reason the decision was made to develop a simple mass balance model (BLSM) for this project. BLSM will be developed within an Excel spreadsheet platform specifically for this project. As a simple hydrologic and conservative substance model, the processes included in BLSM will include a water balance and a conservative constituent (preferably total dissolved solids or TDS) balance without any kinetic rates required. The water balance will be based on be estimated inflows to Brady Lake, lake evaporation, direct rainfall on the reservoir, releases and spills from the dam, shallow groundwater interactions, and water use by the City of Brady and any other users of water from the lake. The water balance equation to be solved will be represented as follows:

$$\frac{dV}{dt} = Q_{in} + Q_{out} + PA_s + EA_s + G - W$$

Where V = lake volume, t = time (monthly or weekly time step), Q_{in} = inflows (predicted by SWAT), Q_{out} = spills and releases, P = direct precipitation on the lake, E = lake evaporation, A_s = lake surface area, G = lake seepage to shallow groundwater, and W = withdrawals (City of Brady water use). Using bathymetric data for Brady Lake, V and A_s will be determined as a function of lake water level.

Similarly, the mass balance equation for TDS as a conservative substance will be represented as follows:

$$\frac{dVS}{dt} = Q_{in}S_{in} + Q_{out}S + PA_sS_P + EA_sS_E + GS_G - WS$$

Where S = lake TDS concentration, S_{in} = inflow TDS concentration estimated from monitoring data, Q_{out} = spills and releases, S_P = TDS in precipitation (assumed to approach zero), S_E = TDS concentration removed with lake evaporation (assumed to be zero), S_G = TDS of lake seepage to shallow groundwater.

A simple finite-difference approximation will be used to solve the water and mass balance equations. The model output will be lake water level, volume, surface area, spills, and TDS (likely estimated from specific conductance) or chlorides concentration depending upon data availability.

Verification of Models

Because each selected model is addressing a different water quality concern expressed by stakeholders or as reflected in recent Texas Section 305(b) Reports, the models will not in general be applied as a system, except that SWAT output will be used with the BLSM to provide the inflow to Brady Lake and SWMM will be used with QUAL2K in evaluating depressed dissolved oxygen, and further the required simulation time periods for each application will vary. Each model will undergo one or more verification processes to help ensure proper model function within the Brady Creek watershed. The particular verification processes or processes selected for each model will be largely determined by the amount of data available for comparison to model predictions. For each model the verification process will consist of two distinct steps: model calibration (Section B7) and model validation

(Section D2). During the calibration step input parameters to each model will be adjusted to provide an acceptable level of comparison to observed data using both qualitative and quantitative measures. Only a portion of the total set of observed data will be used in the calibration step with the remainder set aside for the separate validation step. For the validation step, input parameters adjusted during the calibration process are left at their calibration values and model predictions are compared against the observed data set aside for this purpose. For calibration, qualitative and quantitative measures will be used to evaluate acceptability of performance for each model.

The verification process for hydrologic (streamflow) predictions from SWAT benefits from a long-term hydrologic record at a US Geological Survey (USGS) streamflow gage. Because of the extent of this data set, the SWAT hydrologic validation process can be divided into calibration and validation steps each comprised of two separate, non-overlapping time periods, each multiple years in duration. The verification streamflow data are available at the USGS gage on Brady Creek at Brady, Texas (08145000). Depending upon availability of reliable rainfall records for model input, portions of these time periods will preferably be prior to completion of the dam for Brady Reservoir in 1963, which intercepts almost all streamflow originating upstream of the dam and preventing that flow from reaching the gage location. (Note: The USGS 0814500 streamflow records begin June 1, 1938 and contain a multi-year gap between October 1986 and May 2001.)

The verification process for total suspended solids (TSS), total phosphorus (total-P), and total nitrogen (total-N) predictions from SWAT will use the limited data that has been collected in the upper portion of the watershed in 2008 and that will be collected under the current WPP project. The limited amount of data will likely preclude separating the data into calibration and validation periods.

SWMM verification will benefit from storm data for four events collected at four urban sites in the City of Brady within the period of October 2002 and February 2004 and additional urban runoff data being collected as an additional task to the WPP project. The goal is to use the previously collected data and the data currently being collected as separate calibration and validation data sets. Relevant parameters in the SWMM verification data sets include streamflow, total Kjeldahl nitrogen, nitrite/nitrate nitrogen, and total phosphorus.

BLSM will first be developed and confirmed to computationally conserve mass before being calibrated and verified to separate time periods for data sets collected since the completion of the Brady Lake dam in 1963. Historical water quality data and water elevation data will be used in this validation process.

Upon completion of the verification process, documentation for each model will explain

1) the selection of years used for model verification;
2) the model parameter values;
3) the methods for processing data;
4) evaluation of verification results; and
5) other modeling assumptions and considerations.

Application of Models

The validated SWAT model will be used to evaluate stakeholder concerns regarding implications of brush encroachment on streamflow and the impact of streamflows on water quality, e.g., water quality of Brady Lake, sediment control afforded by flood retardation reservoirs, and specific agricultural land management practices. The SWAT model applications will be performed for a multi-year historical period of weather data that includes drought, normal, and high rainfall periods with the model outputs of focus being streamflow and total suspended sediments. The model will be operated under various scenarios that include as one set of simulations the watershed with and without the 35 flood retardation reservoirs above Brady Lake and as a second set of simulations of the watershed with brush encroachment as it presently exists, with reduced encroachment, and with increased encroachment. As needed, based on stakeholder concerns, a baseline condition representing present practices will be compared through SWAT simulations to alternative scenarios representing agricultural management practices such as nutrient and livestock management.

The validated SWMM model will be used to evaluate load reductions from urban BMPs implemented within the City of Brady. In contrast to the multi-year simulations performed with SWAT, SWMM will be applied to evaluate BMP performance for individual storm events and sequences of storm events over a simulated period of a few to several months of historical rainfall. SWMM outputs needed for the evaluations include stormwater flows, suspended sediment, total nitrogen, and total phosphorus.

The validated QUAL2K model will be used to evaluate effects of various control measures on reducing the occurrences of depressed dissolved oxygen in the urban portion of Brady Creek within the city of Brady. One control measure to be considered using QUAL2K will be increased streamflow through recirculating flow and/or pumping wastewater treatment plant effluent above the area of depressed dissolved oxygen. The model will also be used with SWMM to estimate water quality benefits to the urban portion of Brady Creek from control measures that reduce urban stormwater pollutant loadings. This later application will entail professional judgment in evaluating changes in instream sediment oxygen demand resulting from reduced stormwater loadings.

Finally, BLSM will evaluate the implications of evaporation and inflows on dissolved solids content of Brady Lake. The duration of the simulation will be multiple past decades ideally representing the time from dam completion to the recent past depending upon availability of required data to operate the model. Both SWAT and BLSM will need to be operated for the selected period. The main output from BLSM needed for the evaluation is TDS, although reservoir volume and surface area are additional outputs of importance. In the unlikely circumstance that there are more measured chloride data than TDS data, BLSM will be revised to predict chloride concentrations instead of TDS concentrations as the conservative substance of concern.

A7 QUALITY OBJECTIVES FOR MODEL INPUTS/OUTPUTS

Quality objectives for model inputs

Data used in the modeling procedures for this project were generally collected in accordance with approved quality assurance measures guiding the data collection programs of the state's Clean Rivers Program (CRP), TCEQ, Texas Water Development Board (TWDB), U.S. Department of Agriculture (USDA), National Weather Service (NWS), and USGS. Future data collection supported by CWA §319(h) funds through TCEQ and as part of separate tasks of this overall WPP project will be incorporated into the modeling process as the data become available. The separate water quality monitoring portion of the project will be conducted by UCRA and all the data will be collected under a separate QAPP.

Data will be sought primarily from professional sources, collected and compiled by observers trained in the discipline. Water quality and streamflow data, for example, will be obtained from agencies such as the TCEQ, USGS, and UCRA under approved QAPPs wherein the samples are collected and measurements made by trained professionals and analyzed by experienced chemists.

Additional data sources are expected to be minor and may include literature sources based upon case studies outside the basin, local experts or other within-basin sources. Stakeholder advice will also be sought regarding sources and quality of locally available data that may be of value to the project, especially from those individuals knowledgeable in specific areas concerning the various modeling efforts.

Quality objectives for model outputs

Model developers will strive to achieve the highest quality of fit possible between model predictions and observed data during calibration (Section B7) and validation (Section D2). For this application of models, committing the model results to pre-determined numerical criteria is inadvisable because it emphasizes numerical accuracy rather than model usefulness. Overly stringent criteria can cause the rejection of satisfactory models, while loose criteria can cause the acceptance of useless and even inaccurate models. USEPA's Council of Regulatory Environmental Modeling (CREM) recommends that models be evaluated on the basis of their appropriateness in informing policy decisions (USEPA 2008). To obtain the decision purposes of the models, the models will be applied to evaluate causative factors in observed trends (e.g., increasing dissolved solids in Brady Lake) and reductions through comparisons of model prediction of baseline/existing conditions and future conditions with various control measures (e.g., urban BMPs with SWMM, level of brush control implementation with SWAT, increased streamflow with QUAL2K). Model applications and decision purposes for this project involve relative comparisons that can be provided by models meeting less stringent calibration and validation fits than applications involving comparisons to actual values, such as numeric criteria established to protect assumed or designated uses. Section C1 provides discussion of model assessment and response.

Both quantitative and qualitative concepts will be used to corroborate model performance to the degree deemed appropriate for the needs of model application. Local stakeholder input will be garnered to determine if performance of the models passes the reality test of being acceptable to stakeholders. Areas where model performance does not meet calibration criteria (see B7 – Model Calibration) will be documented after resources are expended attempting to rectify problem areas.

Qualitative Corroboration
Qualitative corroboration involves expert judgment or best professional judgment reviewing the models performance based upon what would be expected to happen. Expert knowledge can establish model reliability through consensus and consistency (EPA 2009). One example is using a stakeholders' group of knowledgeable people familiar with the water body being modeled to assist in determining reliability of each model, and another is reliability based on the professional judgment and expertise of the UCRA and TIAER staff engaged in this project. Both examples will be employed for qualitative corroboration on this project. If there is agreement that the methods and model output are consistent with what relevant experts and professionals would expect to occur, the model could be deemed reliable.

Quantitative Methods
Quantitative methods involve comparing model predictions to observed data. There are many ways in which this can be performed. The first method is by graphical analysis. By inspection one could conclude the model is well parameterized and constrained by the available observational data. Temporal and spatial plots of model outputs will be evaluated for reasonableness when compared to observed data. Another quantitative method is statistical comparison of model predictions versus the observed data. Statistical methods allow for determining model bias or a direct comparison of how well the model is predicting the variability in the data. The statistical methods employed for verification of each model are provided in Section B7 (Model Calibration).

A8 SPECIAL TRAINING/CERTIFICATION

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

A9 DOCUMENTS AND RECORDS

All TIAER modeling records, including modeler's notebooks and electronic files, will be archived by TIAER for at least five years after completion of the project. 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), sources of historical data, sources of new theory, calibration and sensitivity analyses results, and documentation of adjustments to parameter values due to calibration. Electronic data on the project computers 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 a relatively short amount of time, typically less than one day. Data generated on the day of the failure may be lost, but can be reproduced from raw data in most cases.

Table A9.1 Document and Records

Document/Record	Location	Retention	Form
QAPPs, amendments, and appendices	TIAER/UCRA	5 years	Paper/Electronic
QAPP distribution documentation	TIAER/UCRA	5 years	Paper/Electronic
Model User's Manual or Guide (including application-specific versions)	TIAER	5 years	Paper
Assessment reports for acquired data	TIAER	5 years	Paper/Electronic
Raw data files	TIAER	5 years	Paper/Electronic
Model input files	TIAER	5 years	Electronic
Model output files	TIAER	5 years	Electronic
Code Verification Reports	TIAER	5 years	Paper
Calibration Report	TIAER	5 years	Paper
Model Assessment Reports	TIAER	5 years	Paper
Progress report/CAR/final report/data	TIAER/UCRA	3 years	Paper/Electronic
Model code and executable	TIAER	5 years	Electronic
Validation log book	TIAER	5 years	Paper

Quarterly progress reports 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. A final technical report on modeling analysis will be developed and will summarize outcomes. Outcomes will be submitted to the established stakeholder group, incorporated into the Brady Creek WPP and utilized in future management implementation.

Corrective Action Reports (CARs) will be utilized when necessary. CARs will be maintained in an accessible location for reference at TIAER. Copies of completed CARs written for excursions that may negatively affect the quality of data will be disseminated to the UCRA PM and QAO. CARs documenting any changes or variations from the QAPP or any excursions that may impact the quality of the data or output will be made known to pertinent project personnel within 30 days of confirmation of the problem and documented in updates or amendments to the QAPP, as necessary.

B1 SAMPLING PROCESS DESIGN (EXPERIMENTAL DESIGN)

Not relevant.

B2 SAMPLING METHODS

Not relevant. No new sampling will occur through the project tasks covered by this QAPP.

B3 SAMPLE HANDLING AND CUSTODY

Not relevant. No new sampling will occur through the project tasks covered by this QAPP.

B4 ANALYTICAL METHODS

Not relevant. No new sampling will occur through the project tasks covered by this QAPP.

B5 QUALITY CONTROL

Not relevant. No new sampling will occur through the project tasks covered by this QAPP.

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE

Not relevant. No new sampling will occur through the project tasks covered by this QAPP.

B7 MODEL CALIBRATION

Model calibration is the process where the model input parameters are adjusted until the simulated data from the model match with observed data. Model inputs and parameters will be adjusted to match the measured and simulated flow, sediment, and nutrients at key locations in the watershed and in the lake. During the calibration process, all model parameters will be adjusted within literature recommended ranges. Model calibration is an iterative procedure that is achieved using a combination of best professional judgment and quantitative comparison with a subset of the observed data.

To evaluate model performance and the variability of results, sensitivity and uncertainty analyses will also be carried out for each model. During the calibration process the sensitivity or responsiveness of the model predictions to various assumptions and rate constants specified will be evaluated. The set up of the models will likely include parameters based on literature recommendations and best professional judgment, and estimates in the absence of data. Specific areas to address with sensitivity and uncertainty analyses include boundary conditions, watershed loads, as well as process rate parameters. Fundamental parameters will be varied by increasing and decreasing by a factor of two or an order of magnitude, and the resulting predictions compared to understand whether a factor has a discernible effect on circulation or water quality predictions. Uncertainty can arise from a number of sources that range from errors in the input data used to calibrate the model, to imprecise estimates for key parameters, to variations in how certain processes are parameterized in the model domain. Regardless of the underlying cause it is good practice to evaluate these uncertainties and reduce them if possible. The final report will identify the parameters that are varied and will document parameters that have greatest uncertainty and strongly influence the results.

Calibration of mathematical models will be conducted as outlined below to maximize correspondence between model predictions and field observations. If steps outlined below do not bring predicted values within calibration criteria, the UCRA PM and TIAER PM will work with TCEQ, EPA and stakeholders to arrive at an agreeable compromise. (Relevant calibration criteria are discussed below under the subsection for each model.)

Model parameters will be adjusted to minimize differences between measured and simulated flow and water quality trends at key locations. All model parameters will be adjusted within reasonable ranges recommended in published literature. Time series plots and standard statistical measures will be used to evaluate the performance of models during calibration and validation. Calibration is done systematically, first for flow and then for water quality parameters (Santhi et al., 2001).

In the instance that calibration criteria for each model 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.

SWAT

The implementation of the SWAT model will require data from other agencies, including historical data on topography, soils, rainfall (and other meteorological parameters), land use, land management practices, existing flood retardation structures, human infrastructure, and vegetation (Table B7.1).

Table B7.1 – SWAT model input data sets

SWAT Inputs	Units	Source *
Soils data (SSURGO) coverage	No units	F
Land Use/Land Cover (NLCD) coverage	No units	F
Digital Elevation Model (USGS-NHD) coverage	m (elevation)	F
Weather data (precip., temp) (NCDC)	inches, °C, etc.	F
Stream flow and reservoir data (USGS)	Varies	F
Water quality data (TCEQ-SWQM; UCRA)	Varies	F
WWTP location and permit limit data (TCEQ) coverage	No units	F
Small flood retardation reservoirs physical data (USDA)	Varies	F
Brady Lake physical data (City of Brady)	Varies	F
Land management Information	No units	F

* F –based on field measurement or actual site-specific data; L – literature value

Calibration of SWAT will consist of long-term comparisons of model predictions to daily streamflow records from USGS gage 08145000 (Brady Creek at Brady, TX) and short-term comparisons to streamflow, TSS, total P, and total N data obtained by UCRA during their watershed characterization studies in 2008 and during this WPP project. To the extent that multiple measurements or observations for input parameters are available, such multiple measurements are used for comparison to model predictions. Using multiple measurement sets enables assessment of the total variability of the model predictions into (1) within-station variability in site conditions as exhibited in the input measurements and (2) variability and uncertainty associated with how well the model fits the data (i.e., lack-of-fit).

For the SWAT watershed setting, model calibration is defined as how well the model is able to reproduce current observed flow rates and TSS, total P, and total N (e.g., trends and average values), as measured from field surveys and stored in the TCEQ SWQMIS monitoring database and with UCRA, and available USGS data. The performance criteria are based on the premise that the intrinsic accuracy of the data measurements dictates to some degree the expected accuracy of the model. The following calibration criteria have been established for this project as acceptable SWAT calibration outputs:

- Annual averages of daily flows will be calibrated so that predicted values agree with measured values within 20%.
- Flow water balance *(relationship between surface and subsurface flows as defined by base flow filter)* will be calibrated so that predicted annual values also agree with measured values within 30%.
- TSS, total P, and total N concentrations (depending on available observed data) will be calibrated so that the mean of predicted values falls within two standard deviations of the mean of the observed concentrations that occurred within the selected calibration period.

The desired final calibration is a set of investigated input parameters that meets each enumerated criterion. If more than one set of input parameters meets all criteria, best professional judgment will be used to select the optimal set of parameters, and the rationale for determining the selected set of parameters will be included in the Modeling Documentation Report (see Section C2). In the event that each criterion cannot be met, all data will be checked for deficiencies, pertinent model algorithms will be reviewed, and the model will be re-calibrated after corrections of deficiencies. While these quantitative measures will guide assessment of model performance, final determination of acceptability of model output will be according to qualitative corroboration (see Section A7) in accordance with the decision purposes of the model for this project.

Anticipated SWAT model parameters that will be adjusted in the iterative process of calibration are provided in Table B7.2. These parameters and any others determined once the calibration process is underway will only be adjusted within the ranges provided in the SWAT user's manual (Neitsch et al., 2004) and in Thomann and Mueller (1987). The model will be validated against data for another time period without adjusting any parameters (Section D2).

Table B7.2 – Selected SWAT model parameters and common range of parameters

SWAT Model Parameters	Common range of values	Units	Source
Curve number (CN2)	25 - 98	No units	L
Soil evaporation factor (ESCO)	0.0-1.0	No units	L
Threshold depth of water in shallow aquifer for percolation to occur (GWQMN)	0.0-300	mm H_2O	L
Mannings n for overland flow (OV_N)	0.010-0.60	No units	L
Cover or management factor (C FACTOR)	0.003 – 0.45	No units	L
Surface runoff lag coefficient (SURLG)	1-12	No Units	L
Linear parameter for calculating sediment (SPCON)	0.0001-0.01	No Units	L
Uptake distribution parameter (UBN)	1-20	No Units	L
Phosphorus percolation coefficient (PPERCO)	10-17.5	$10m^3/Mg$	L
Phosphorus soil partitioning coefficient (PHOSKD)	100-175	m^3/Mg	L
Nitrogen percolation coefficient (NPERCO)	0.2-0.6	No units	L

* F –based on field measurement or actual site-specific data; L – literature value

SWMM

As with SWAT, the implementation of the SWMM model will require data from other agencies, including historical data on topography, soils, rainfall (and other meteorological parameters), land use, human infrastructure, and vegetation (Table B7.3).

Table B7.3 – SWMM model input data sets

SWMM Inputs	Units	Source
Soils data (SSURGO) coverage	No units	F
Land Use/Land Cover (NLCD) coverage	No units	F
Digital Elevation Model (USGS-NHD) coverage	m (elevation)	F
Weather data (precip, temp) (NCDC)	inches, °C, etc.	F
Stream flow and reservoir data (USGS)	Varies	F
Storm-event flow and water quality data (UCRA)	Varies	F
Land management information	No units	F

* F –based on field measurement or actual site-specific data; L – literature value

Calibration of SWMM will consist of short-term comparisons to flows and water quality data obtained by UCRA during four urban storm water events at four sites collected within the period of October 2002 through February 2004. To the extent that multiple measurements or observations for input parameters are available, such multiple measurements are used for comparison to model predictions. Using multiple measurement sets enables assessment of the total variability of the model predictions into (1) within-station variability in site conditions as exhibited in the input measurements and (2) variability and uncertainty associated with how well the model fits the data (i.e., lack-of-fit).

For the urban storm water setting, SWMM calibration is defined as how well the model is able to reproduce current observed flow rates and water quality (e.g., trends and peak values), as measured from the storm events monitored by UCRA. The performance criteria are based on the premise that the intrinsic accuracy of the data measurements dictates to some degree the expected accuracy of the model. Because of the very high natural variability in storm event runoff and water quality, differences between model predictions and observed data are anticipated to be large. Therefore, numeric criteria of model acceptance are not strictly stipulated for SWMM, but are rather provided to guide the calibration process. Acceptable calibration will be based on qualitative evaluations of the professional team engaged in the model application and stakeholder satisfaction with the predictions. The following criteria have been established for this project to guide the calibration process:

- Stormwater volume for individual events will be calibrated so that predicted values agree with measured values within 40%.
- Peak stormwater flow for individual events will be calibrated so that predicted values agree with measured values within 30%.
- TSS, total phosphorus, and total nitrogen concentrations will be calibrated so that the mean of predicted values fall within two standard deviations of the mean of the observed concentrations for all calibration storm events.

The desired final calibration is a set of investigated input parameters that meets each enumerated criterion. If more than one set of input parameters meets all criteria, best professional judgment will be used to select the optimal set of parameters, and the rationale for determining the selected set of parameters will be included in the Modeling Documentation Report (see Section C2). In the event that each criterion cannot be met, all data will be checked for deficiencies, pertinent model algorithms will be reviewed, and the model will be re-calibrated after corrections of deficiencies. While these quantitative measures will guide assessment of model performance, final determination of acceptability of model output will be according to qualitative corroboration (see Section A7) in accordance with the decision purposed of the model for this project.

Anticipated SWMM model parameters that will be adjusted in the iterative process of calibration are provided in Table B7.4. These parameters and any others determined once the calibration process is underway will only be adjusted within the range provided in the SWMM user's manual (Rossman, 2009) and in Thomann and Mueller (1987). The model will be validated against data for another time period without adjusting any parameters (Section D2).

Table B7.4 – Selected SWMM model parameters and common range of parameters

SWMM Model Parameters	Common range of values	Units	Source
NRCS Saturated hydraulics conductivity	0.00-≥ 0.45	In/hr	L
SCS Curve Number	25-98	No Units	L
Depression Storage			
Impervious surfaces	0.05-0.10	Inches	L
Lawns	0.10-0.20	Inches	L
Pasture	0.20	Inches	L
Forest Litter	0.30	Inches	L
Manning's n			
Overland Flow	0.011-0.80	No Units	L
Closed Conduits	0.011-0.026	No Units	L
Open Channel	0.011-0.40	No Units	L

* F –based on field measurement or actual site-specific data; L – literature value

QUAL2K

The QUAL2K model will require data from other agencies, including historical data on meteorological parameters (e.g., air temperature, wind speed, cloud cover, dew point), channel cross-section, channel distances, and headwater conditions (e.g., streamflow and water quality) (Table B7.5).

Table B7.5 – QUAL2K model input data sets

QUAL2K Inputs	Units	Source
Stream segmentation, stream distances (from USGS-NHD)	km	F
Weather data (temp, cloud cover, dew point temperature, wind speed) (NCDC)	°C, mph, etc.	F
Headwater streamflow (USGS and TCEQ SWQMIS)	cms	F
Headwater water quality data (nutrients, chlorophyll-a, dissolved oxygen, misc. parameters) (TCEQ SWQMIS)	mg/L or µg/L	F

* F –based on field measurement or actual site-specific data; L – literature value

Calibration of QUAL2K will consist of comparison of model predictions to 24-hour dissolved oxygen data (minimum and average concentrations) and related water quality data (e.g., nutrients) collected by either the Upper Colorado River Authority or the Lower Colorado River Authority. During the period of August 2002 through March 2007 seven 24-hour multiprobe deployments occurred at station 17005 on Brady Creek with associated water quality data collection. Each 24-hour survey event will be evaluated to determine completeness of associated water quality parameters (e.g., chlorophyll-a and nutrient forms) and approximately ½ of the survey events will be used for calibration purposes (possibly 3 or 4 events) and the remaining events reserved for model validation. To the extent that multiple measurements or observations for input parameters are available, such multiple measurements are used for comparison to model predictions. Using multiple measurement sets enables assessment of the total variability of the model predictions regarding variability and uncertainty associated with how well the model fits the data (i.e., lack-of-fit).

QUAL2K calibration is defined as how well the model is able to reproduce current observed water quality (e.g., minimum and average dissolved oxygen values), as measured during the 24-hour multiprobe deployments. The performance criteria are based on the premise that the intrinsic accuracy of the data measurements dictates to some degree the expected accuracy of the model. Because of natural spatial and temporal variability in dissolved oxygen, differences between model predictions and observed data are anticipated to be large. Therefore, numeric criteria of model acceptance are not strictly stipulated for QUAL2K, but are rather provided to guide the calibration process. Acceptable calibration will be based on qualitative evaluations of the professional team engaged in the model application and stakeholder satisfaction with the predictions. The following criteria have been established for this project to guide the calibration process:

- Minimum 24-hour dissolved oxygen concentrations will be calibrated so that predicted values agree with measured values within the smaller of 2 mg/L or two standard deviations of the mean of the observed concentrations across all calibration events.
- Average 24-hour dissolved oxygen concentrations will be calibrated so that predicted values agree with measured values within the smaller 1.5 mg/L or two standard deviations of the mean of the observed concentrations across all calibration events.
- Nutrient forms (e.g., total phosphorus and ammonia) and chlorophyll-a concentrations will be calibrated so that the mean of predicted values fall within two standard deviations of the mean of the observed concentrations across all calibration events.

The desired final calibration is a set of investigated input parameters that meets each enumerated criterion. If more than one set of input parameters meets all criteria, best professional judgment will be used to select the optimal set of parameters, and the rationale for determining the selected set of parameters will be included in the Modeling Documentation Report (see Section C2). In the event that each criterion cannot be met, all data will be checked for deficiencies, pertinent model algorithms will be reviewed, and the model will be re-calibrated after corrections of deficiencies. While these quantitative measures will guide assessment of model performance, final determination of acceptability of model output will be according to qualitative corroboration (see Section A7) in accordance with the decision purposed of the model for this project.

Anticipated QUAL2K model parameters that will be adjusted in the iterative process of calibration are provided in Table B7.6. These parameters and any others determined once the calibration process is underway will only be adjusted within the range provided in the QUAL2K documentation (Chapra et al., 2008), Bowie et al. (1985), TNRCC (1995), and Thomann and Mueller (1987). The model will be validated against data for other 24-hour survey time periods without adjusting any parameters (Section D2).

Table B7.6 – Selected QUAL2K model parameters and common range of parameters

QUAL2K Model Parameters	Common range of values (at 20°C)	Units	Source
Sediment oxygen demand	0.0 – 5.0	g $O_2/m^2/d$	L
Biochemical oxygen demand decay rate	0.05 – 0.30	d^{-1}	L
Ammonia nitrification rate	0.0 – 0.5	d^{-1}	L
Organic N hydrolysis rate	0.0-0.3	d^{-1}	L
Organic N settling rate	0.01 - 0.20	m/d	L
Organic P hydrolysis rate	0.0 – 0.3	d^{-1}	L
Organic P settling rate	0.01 – 0.20	m/d	L
Organic P hydrolysis rate	0.0 – 0.03	d^{-1}	L
Phytoplankton max. growth rate	0.5-3.0	d^{-1}	L
Phytoplankton respiration rate	0.05 – 0.5	d^{-1}	L
Phytoplankton death rate	0.05 – 0.5	d^{-1}	L
Phytoplankton settling rate	0.1 – 3.0	m/d	L
Bottom algae max. growth rate	20 – 100	Mg $A/m^2/d$	L
Bottom algae respiration rate	0.05 – 0.5	d^{-1}	L
Bottom algae excretion rate	0.05 – 0.5	d^{-1}	L
Bottom algae death rate	0.05 – 0.5	d^{-1}	L
Dissolution rate	0.0 – 0.5	d^{-1}	L
Reaeration rate	0.05 - 100	d^{-1}	Texas Equa.

* F –based on field measurement or actual site-specific data; L – literature value; Texas Equation is the reaeration equation developed for Texas and used by TCEQ and its predecessor agencies in dissolved oxygen modeling.

BLSM

The Brady Lake Spreadsheet Model (BLSM) will be developed within an Excel spreadsheet platform. While requiring less input data than SWAT and SWMM, the implementation of the BLSM model will require data from other agencies, including historical data on physical characteristics of Brady Lake (e.g., water level – storage relationship), evaporation, rainfall (and other meteorological parameters), and water usage (Table B7.7).

Table B7.7 – BLSM model input data sets

BLSM Inputs	Units	Source
Brady Lake physical data (City of Brady)	Varies	F
Water usage & water rights (City of Brady & TCEQ)	ac-ft	F
Evaporation data (TWDB)	m (elevation)	F
Weather data (precipitation) (NCDC)	inches, °C, etc.	F
Stream flow & reservoir data (USGS & SWAT model)	Varies	F, M
Water quality data (TCEQ SWQMIS & UCRA)	Varies	F

* F –based on field measurement or actual site-specific data; L – literature value; M – predicted from SWAT

Calibration of BLSM will consist of long-term comparisons to reservoir water-level data obtained by USGS on a daily basis and TDS (or chlorides) data obtained from TCEQ SWQMIS. Based on density of TDS data, the calibration period will most likely span the first 10 to 20 years of operation of the reservoir with data for more recent years reserved for model validation. If there are more chlorides data than TDS, which is not anticipated, then chlorides will be used as the preferred measure of dissolved solids in Brady Lake.

Model calibration is defined as how well the model is able to reproduce fluctuation in reservoir water level and changes in TDS over the 10- to 20-year calibration period. The performance criteria are based on the premise that the intrinsic accuracy of the data measurements dictates to some degree the expected accuracy of the model. The following calibration criteria have been established for this project as acceptable model calibration inputs and outputs, respectively:

- Annual change in reservoir volume will be calibrated so that predicted values agree with measured values within 20%.
- TDS (or chlorides) concentrations will be calibrated so that the mean of predicted values agrees with the mean of measured values within 30% and the range in predicted values and measured values agrees within 30%. (Mean and standard deviation of measured values calculated using data within the calibration period.)

The desired final calibration is a set of investigated input parameters that meets each enumerated criterion. If more than one set of input parameters meets all criteria, best professional judgment will be used to select the optimal set of parameters, and the rationale for determining the selected set of parameters will be included in the Modeling Documentation Report (see Section C2). In the event that each criterion cannot be met, all data will be checked for deficiencies, pertinent model algorithms will be reviewed, and the model will be re-calibrated after corrections of deficiencies. While these quantitative measures will guide assessment of model performance, final determination of acceptability of model output will be according to qualitative corroboration (see Section A7) in accordance with the decision purposed of the model for this project.

BLSM model parameters that will be adjusted in the iterative process of calibration are provided in Table B7.8. These parameters will only be adjusted within the range provided in Table B7.8. The model will be validated against data for another time period without adjusting any parameters (Section D2).

Table B7.8 – Selected BLSM model parameters and common range of parameters

BLSM Model Parameters	Common range of values	Units	Source
Global multiplier to inflows (Qadj)	0.5 - 2.0	No units	L
Multiplier to gross evaporation data (Eadj)	0.8 - 1.1	No units	L
Seepage through bottom sediments (SEEP)	0.0 - 0.02	ft/day	L
Adjust inflow TDS concentration (TDSadj)	0.8 - 1.2	No units	L

* L – literature value

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Not relevant.

B9 NON-DIRECT MEASUREMENTS

The datasets listed in the Table B9.1 will be used to create the databases, input data, and validation data sets for the analytical tools to be constructed and applied on the WPP. No additional validation of these datasets will be performed because they are either from state- and national-level recognized and accepted sources or have already been validated before their inclusion into the respective databases of origin database. The table provides the data type, the data source, and the intended use and relevance to construction of the project's analytical tools and their application.

It is anticipated that for some continuous-time data needed for the project, gaps could exist in the data. Typically, for streamflow data the USGS will use appropriate estimation procedures to fill-in data gaps and note the data accordingly. However, the possibility also exists for data gaps with weather data and these data typically are not filled in. The following procedure will be used to estimate data to fill-in data gaps. For gaps in the data of four hours or less, estimates will be made using linear interpolation. Gaps longer than four hours will be filled-in by comparing all continuous segments of the same data set and selecting the one which most closely matches the values and slopes at the beginning and ending points of the gap so that a subset of actual continuous data can be spliced in most seamlessly.

Because the data needs for the model required for this project can be extensive, it is likely that various data limitations will occur regarding information needed for developing the models, for model input, and for model validation. Data limitations will be addressed in a hierarchical manner. The necessary data will first be sought from sources within the Brady Creek watershed. If multi-sources of needed data are available, for example geographic information system land use and land cover data for different time periods, then typically the preference will be to use the data most representative of the conditions to be simulated by the model. If watershed specific data are not available or are insufficient, similar data from adjacent watersheds may be appropriate in some instances. An example of appropriate data from adjacent watersheds would be weather data from stations nearby, but outside of the watershed.

Because most historical data is of known and acceptable quality and were collected and analyzed in a manner comparable and consistent with needs for this project, no limitations will be placed on their use, except where known deviations have occurred.

Table B9-1 Non-Direct (Acquired) Data Required for Development and Application of Analytical Tools

Data Type	Data Source	Applicable Date or Other Attributes	Use/Relevance
Routine ambient water quality data: TSS, nutrients, specific conductance, TDS, chlorides (Cl)	TCEQ, collected by TCEQ and UCRA, TCEQ website in SWQMIS. [Moderate data volume.]	Full historical data range (1970s – present)	Validation of SWAT and BLSM models
Storm water event flow and water quality data (TSS, nutrients)	UCRA, collected by UCRA; available from UCRA. [Moderate data volume]	2002 – present	Validation of SWAT and SWMM models
Digital elevation models (DEM) 10-m resolution; GIS data	USEPA-BASINS website preferred; webGIS and GeoCommunity websites as alternatives. [Large data volume.]	N/A	Segmentation delineation and elevation data for SWAT and SWMM
Land use and land cover; GIS data	NLCD website [Large data volume]	USGS 2001 National Land Cover Database	Input data to SWAT and SWMM
Soils data; GIS data (Soil Survey Geographic –SSURGO)	NRCS website; SURGO databases [Large data volume]	SSURGO is the most detailed soil maps developed by NRCS	Input data to SWAT and SWMM
Daily weather data (rainfall, min. and max. air temperature)	EPA-BASINS website; NCDC and NWS websites on NOAA. [Large data volume.]	1960s to present	Input data to SWAT and SWMM
Daily streamflow for Brady Creek and elevation and storage data for Brady Lake	USGS web site. [Large data volume.]	Streamflow: 6/1938 – present Reservoir: 5/1963 – present	Validation of SWAT and BLSM
Municipal & Industrial WWTP data (monthly discharged flow)	TCEQ Information Resources Division data and USEPA ECHO website (EPA ICIS-NPDES). [Small data volume. Discharge monitoring report (DMR) provided by permit holders.]	Limited DMR data available from EPA website; more complete records from TCEQ); preferred data range 1960s to present	SWAT model input; provides historical discharge quantity
Water rights information and data (monthly water withdrawals from Brady Lake by City of Brady)	TCEQ Water Rights Team databases; some available on-line and City of Brady. [Small data volume anticipated.]	Period of available record is needed.	Validation of SWAT and BLSM
Gross lake evaporation (monthly values by 1° quadrangles)	TWDB [small data volume]	1960s to present	Input data to BLSM
Land management (typical agricultural practices)	NRCS local field representatives	N/A	Input data to SWAT and SWMM
Miscellaneous geographic data (roads, streams, boundaries, etc.) [Required for physical presentation of maps in reports, largely not needed for modeling.]	TNRIS; North Carolina State Univ. Libraries geospatial data services website; U.S. Census Bureau website; Montana State University Geographic Locater website. [Large data volume.]	N/A	Input data to SWAT, SWMM, and BLSM

B10 DATA MANAGEMENT

Responsibility for data management during the course of the project is assigned to the prime contractor, TIAER.

All data files used as model input for this project will be stored in a secured, password-protected directory. Only authorized project participants, i.e., the TIAER PM and TIAER Project Data Manager (DM), will be able to store and manipulate the files in the project directory. The types of project data files are described in the Migration/Transfer/Conversion section.

Information about the data files and types of data contained in each will be clearly documented to provide identification and traceability for all modeling inputs. The TIAER PM will be responsible for ensuring that all data files used for the project are included in the directory and that those files used as model input for the final modeling results are clearly distinguished from initial or intermediate versions of the dataset.

Data management procedures for all types and sources of data including raw data files from acquired (non-direct) data; model input data files; and model output files from calibration, verification, and allocation scenarios are described in this section.

Migration/Transfer/Conversion

The TIAER DM will transfer electronic data files to the project directory, which is located on the TIAER Intranet, from the Internet.

The various types of data to be downloaded from the Internet are included in Table B9.1. Databases on the Internet are stored in a variety of formats. Some data or files required for the project can be downloaded from the Internet into text or Excel files, where they can be manipulated to create text files or other types of data files that can be used directly by models. For Internet-downloaded data or files too large to be directly used by models, TIAER staff will write programs in Visual Basic, VBA, or FORTRAN to transform the data into the format required by models.

Ensuring Data Quality

The simplest and most straightforward means of maintaining high-quality data is to thoroughly train all individuals involved in data collection and data management procedures in appropriate data qualification protocols and data management procedures. If all project data users are familiar with protocol and use identical procedures, potential problems will be averted.

Internet data will be downloaded from authorized organizations or websites when they are needed for modeling activities. It is not uncommon that some Internet-downloaded data, e.g., weather data, do contain gaps. Missing or empty data values (i.e., gaps) can occur, and these data gaps will be filled in as discussed in Section B9 Non-Direct Measurements.

Geographic Information System (GIS) DEM data will be checked for integrity in such areas as projection, sinks, tears and holes.

The TIAER DM will carefully verify Internet-downloaded data and document any potential errors discovered during modeling activities. For example, if precipitation data downloaded from an authorized organization indicates a possible shifting of date of recorded rainfall due to the time that observations are recorded, the data will be compared to other sources, e.g., local weather data centers to assure data quality. Any necessary corrections will be made to the data and noted in the project data log.

Electronic Codebook and Data Logs

As part of the QA procedures for this project, the TIAER DM will maintain an electronic codebook listing data management decisions, procedures, and operations, which ensures consistency and traceability for the data across time and changing staff.

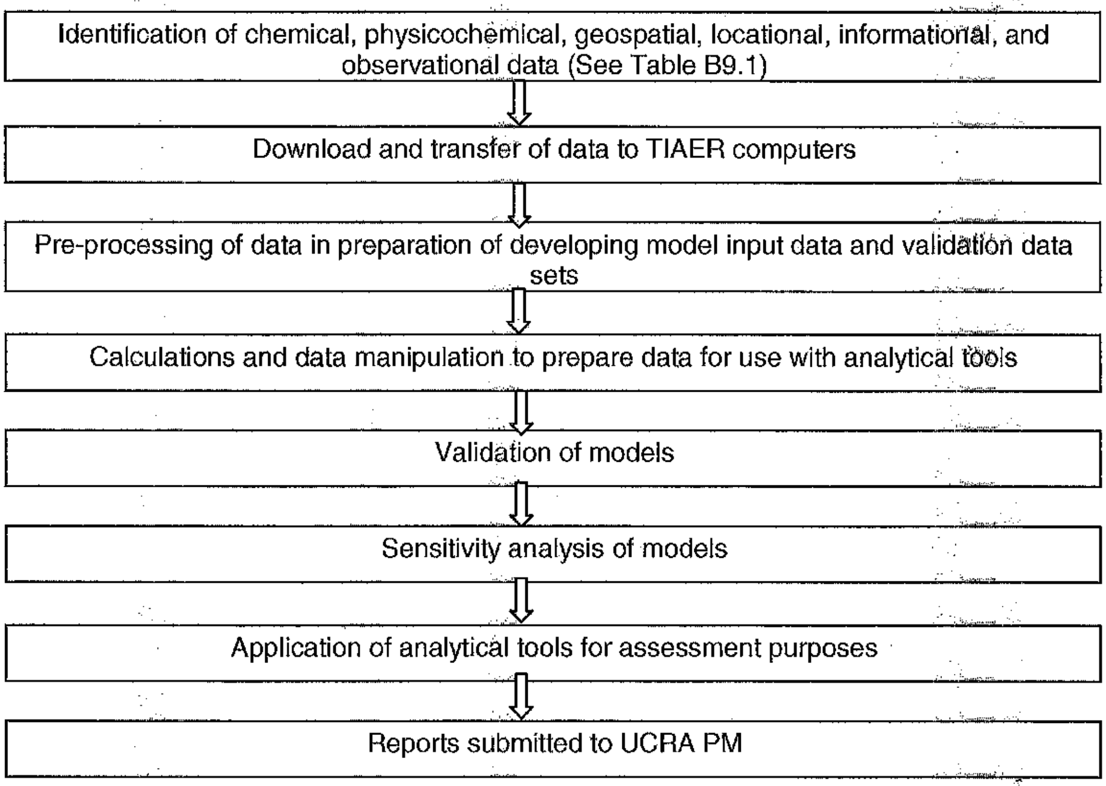
As an essential part of the database codebook, the TIAER PM will create a log that describes each key step in data management procedures and includes Internet-downloaded data entry and QA checks of Internet-downloaded data. Any changes to the data are documented in the codebook.

All downloaded data files will have a separate entry in the project data log. Metadata on each input dataset is recorded in an electronic project file. The metadata include website or Intranet address, date of download, TIAER staff responsible for download, directory and file name where downloaded data is stored, list of the variables (data fields) needed for modeling activities and their description when necessary, and how the data will be used for the project.

DATA MANAGEMENT PROCESS

A flow chart is provided below that traces the path of the data from acquisition to final use and storage.

Process Chart of Data Flow



Record Keeping and Data Storage

TIAER's general record-keeping and document control procedures are contained in the TIAER Quality Assurance Manual and this QAPP. For the modeling portion of this project, electronic files for the following will be kept for at least five years:

- Original data sets from the sources listed in Table B9.1.
- Metadata for main input datasets, including website address from which data are obtained, date of data download, initials of staff member responsible for download, general description and use of data, original provider of data, name and location of file in which the data are stored, name and location of file in which the data are manipulated (if appropriate).
- Plots, graphs, curves, and other representations used in decision-making aspects of the project.
- Documentation of all changes to the models used in production of the final modeling results.
- Documentation, where necessary, of accommodations taken to remediate lack of desired types of data for application of the model.
- Copy of each model code and its executable version as used to produce results for the project, including any changes to the original model used in production of the reported results.
- Final input data set files and modeling result files used in validation process.

- Final results of all sensitivity analyses.
- Files documenting the various types of graphical and statistical comparisons required for model validation and results of the final comparisons.
- Copies of all original results from applications of the model(s) that are used in project reports, with details of scenarios clearly described.

Data Handling

Data are transferred to TIAER computers for use with Microsoft applications, applications of analytical tools, and SAS programs. Data integrity is maintained by the implementation of password protection which controls access to directories in which project data are stored.

Backup/Disaster Recovery

As an electronic data protection strategy, TIAER utilizes Double Take software to mirror the Primary Aberdeen 1.2TB file server (raid 5 fault tolerant) that will be mirrored to a secondary Aberdeen Abernas211 file server (raid 5 fault tolerant). This provides instant fault recovery rollover capability in the event of hardware failure. TIAER also exercises complete backup of its Primary server to LTO-3 Quantum ValueLoader on a weekly basis, coupled with daily incremental backups. This provides a third level of fault tolerance in the event that both the primary and secondary server are disabled. TIAER will maintain all cyclic backup tapes for 26 weeks prior to reuse saving the 1st tape in the series indefinitely to preserve a historical snapshot. This will facilitate recovery of data lost due to human error. Backup tapes are stored in a secure area on the Tarleton University campus and are checked periodically to ensure viability. If necessary, disaster recovery can also be accomplished by manually re-entering the data.

Archives/Data Retention

Original data recorded on paper files and as electronic data are stored for at least five years. Data in electronic format are stored on tape drives. Complete electronic data sets are archived on tape backup and retained on the Tarleton State University campus in a fire-resistant storage area managed by the Tarleton ITS department.

Information Dissemination

TIAER will provide project updates to the UCRA PM in progress reports and the information will be made available at stakeholder meetings. Input data and model outputs resulting from the project described in this QAPP will be accessible to the general public.

HARDWARE/SOFTWARE CONFIGURATION

The types of TIAER computer equipment, hardware, and software to be used on the project are provided in Table B10.1.

Table B10-1 Listing of Project Hardware and Software

Equipment & software name	Type	Number	Specification	Use
Dell PC desktop Computers	Hardware	2	P4, CPU 3.2 GHz, 2 GB Ram, Windows XP professional 2002	Support modeling activities
AberNAS 1.5 TB Server	Hardware	1	P4 CPU 3.0GHz,1GB RAM Windows 2003 Server SP2	Primary Server, Veritas Backup Software, Double-Take Real-Time Replication Software
AberNAS 1.2 TB Server	Hardware	1	P4 CPU 3.0GHz,1GB RAM Windows 2003 Server SP2	Secondary Server, Veritas Backup Software, Double-Take Real-Time Replication Software
Quantum Autoloader	Hardware	1	LTO-3 Ultrium Backup Tape Unit	400GB/800GB Compressed Backup
ArcView 3.3	Software	1	Window interface	Create input data for DO model
ArcGIS 9.3 or higher	Software	1	Window interface	Create input data for DO model
SAS 8.2 or higher	software	1	Window interface and DOS interface	Analyze output data from models, and measurement data
Visual Fortran 6.0 or higher	software	1	User interface: Windows	Calibration and development of models
SWAT2005 or higher	software	1	Windows interface	Hydrology and water quality modeling
SWMM Version 5.0	software	1	Windows interface	Hydrology and water quality modeling
Microsoft Office Software (Excel, Word, PowerPoint)	software	2	Windows platform	Data preparation, report writing, presentations

C1 Assessments and Response Actions

Table C1.1 presents the types of assessments and response actions for 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	UCRA, TIAER	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
Technical Systems Audit	At the discretion of TCEQ	TCEQ 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 TCEQ QAO to address corrective actions

Model Validation and Results Assessment and Response

Methods for evaluating model outcomes are discussed in Section A7 (Quality Objectives for Model Inputs/Outputs) and Section B7 (Model Calibration).

As described in Section A, generally, and in Section B9, specifically, the analytical tools will be developed from observational data from many sources. A wide range of data is required to set up the models for this project. These data will be organized into various data files and databases to provide input data for each model. No additional validation of these datasets will be performed because they are either from state- and national-level recognized and accepted sources or have already been validated before their inclusion into their respective databases of origin.

As oversight and assessment measures, all input data to the models will be independently assessed for accuracy and completeness by an appropriately trained TIAER staff member. In response to any discrepancies and errors detected, the independent staff member will document necessary changes and corrections, report these to the TIAER Project Lead Modeler, and the Lead Modeler will make the necessary corrections.

All data and equations in Excel data spreadsheets used for preparing input data and in developing the BLSM that are newly created or calculated from other sources will be examined at least twice, with one examination by an independent, appropriately trained TIAER staff member. Any errors and discrepancies uncovered during the examinations will be reported by the reviewer to the lead modeler, who will perform any necessary corrections to data and equations. Where appropriate, simple diagnostic approaches (e.g., trend plots) will be applied to identify any problematic areas.

The validation process for each model will involve the TIAER Project Lead Modeler. The Lead Modeler will maintain a logbook for use in documenting input data refinements during the validation process. During the calibration step, the Lead Modeler will systematically adjust appropriate input parameters within the range of meaningful values based on observations made in the watershed, literature, and expert opinion and judgment for the purpose of achieving the optimal comparison of model output to the observational data. The qualitative and quantitative measures (as discussed and presented in Sections A7—Quality Objectives for Model Inputs/Outputs; B7—Model Calibration; and D2—Validation Method) will be the means of assessing progress in the validation process. After calibration is completed and prior to commencing the validation step, TIAER's PM will assess all adjusted input parameters to ensure that values stayed within acceptable ranges.

During the validation step, model predictions will be evaluated against observation data using the same graphical and statistical techniques as used during calibration. Based on this evaluation and the general targets and goals in Section B7—Model Calibration, the TIAER PM will assess whether the model is acceptably validated. If validation is acceptable, the model will be ready for application; otherwise the model will undergo a recalibration process requiring further input parameter adjustment, calibration to the original verification data sets, and verification to the original calibration data sets.

Model validation also involves qualitative corroboration that is based on best professional judgment of the project team and the acceptability of model output to knowledgeable stakeholders. As discussed in Sections B9 and D2, the quantitative corroboration to numeric criteria may fail and the model still be acceptable based on qualitative corroboration. If it appears that quantitative and qualitative model corroboration may both fail, the TIAER PM will contact the UCRA PM and QAO and inform them of the situation with the purpose of engaging the TCEQ PM is the appropriate course of action.

As the final task of the calibration step for each model and prior to the validation step, a sensitivity analysis of key input parameters will be performed to determine response of the predictions of the model as a means of quantifying the uncertainty associated with knowing the true value of input parameters (sometimes referred to as knowledge uncertainty). The key input parameters to be adjusted will most likely be those listed in Tables B7.2, B7.4, B7.6, and B7.8; however, additions or subtractions from these lists will be based on each model's performance during the calibration process. This sensitivity analysis will provide an indication of the importance of knowledge uncertainty associated with input parameters on model predicted output parameters (e.g., streamflow, TSS, storm water quality, TDS). Using experience gained in the calibration process, the TIAER PM and Lead Modeler will determine both the input parameters to be included in the sensitivity analysis and the variation of the parameter to be evaluated. Input parameters will be varied +/- 50 percent, unless experience obtained during the calibration process indicates to the contrary. Sensitivity analysis results will be presented in graphical mode in the task technical report.

Corrective Action

Corrective actions are 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. CARs will be filled out to document the problems and the remedial action taken. CARs will be transmitted to the UCRA PM and QAO for inclusion in the project QPR and for proper archiving. The UCRA QAO will also assist TIAER in resolving the issue at hand if TIAER cannot resolve the problem on its own. In the event that a feasible solution cannot be reached or calibration criteria cannot be achieved, the UCRA PM and TIAER PM will work with TCEQ to arrive at an agreeable compromise.

Corrective Action Process for Deficiencies

Deficiencies are any deviation from the QAPP, SWQM Procedures Manual, SOPs, or Data Management Reference Guide. Deficiencies may invalidate resulting model output and may require corrective action. Deficiencies are documented in logbooks, worksheets, etc. by TIAER staff. It is the responsibility of the TIAER Project Manager, in consultation with the TIAER QAO, to ensure that the actions and resolutions to the problems are documented and that records are maintained in accordance with this QAPP. In addition, these actions and resolutions will be conveyed to the NPS Project Manager both verbally and in writing in the project progress reports and by completion of a corrective action plan (CAP).

Corrective Action

CAPs should:

- Identify the problem, nonconformity, or undesirable situation
- Identify immediate remedial actions if possible
- Identify the underlying cause(s) of the problem
- Identify whether the problem is likely to recur, or occur in other areas
- Evaluate the need for Corrective Action
- Use problem-solving techniques to verify causes, determine solution, and develop an action plan
- Identify personnel responsible for action
- Establish timelines and provide a schedule
- Document the corrective action

Status of CAPs will be documented on the Corrective Action Status Table (See Appendix C) and included with Quarterly Progress Reports. In addition, significant conditions (i.e., situations which, if uncorrected, could have a serious effect on safety or on the validity or integrity of data) will be reported to the TCEQ immediately.

The TIAER Project Manager is responsible for implementing and tracking corrective actions. Corrective action plans will be documented on the Corrective Action Plan Form (See Appendix D) and submitted, when complete, to the TCEQ Project Manager. Records of audit findings and corrective actions are maintained by both the TCEQ and the TIAER QAO. Audit reports and corrective action documentation will be submitted to the TCEQ with the Quarterly Progress Report.

If audit findings and corrective actions cannot be resolved, then the authority and responsibility for terminating work are specified in the TCEQ QMP and in agreements in contracts between participating organizations.

Model Software Assessment and Response

Software requirements, software design, or code are examined to the extent practicable 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 or appropriately addressed. 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. Records of the reviews of software and code are included in the documentation of quality control activities.

SWAT

The watershed modeling task is intended to rely upon the SWAT2005 modeling code as published by ARS/BRC, and modifications to the code will not be made. The SWAT software that is used to compute model predictions is tested to assess 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, as part of the routine code generation by ARS/BRC. In the event that errors in the code are discovered through the routine model set-up and validation procedures of this project, these errors will be corrected to the degree feasible by TIAER staff and documented to UCRA, TCEQ and to the authors of SWAT at ARS/BRC. Code updates made available by ARS/BRC will be used to the extent practicable.

SWMM

The urban storm water modeling task is intended to rely upon the SWMM modeling code as published by EPA, and modifications to the code will not be made. In the event that errors in the code are discovered through the routine model set-up and validation procedures of this project, these errors will be documented to UCRA, TCEQ and to the authors of SWMM at EPA.

QUAL2K

The dissolved oxygen modeling task is intended to rely upon the QUAL2K modeling code as published by EPA, and modifications to the code will not be made. In the event that errors in the code are discovered through the routine model set-up and validation procedures of this project, these errors will be documented to UCRA, TCEQ and EPA.

BLSM

Checks will be made of the Excel computations and equations written by TIAER in developing BLSM to ensure that the computations produce accurate results, e.g., conserve both water and conservative substance mass, provide accurate solutions, and provide stable results under the expected range of conditions under which the model will be operated. These checks will follow the protocol established for all equations in Excel data spreadsheets in the third paragraph of this section (Section C1 Assessments and Response Actions).

C2 REPORTS TO MANAGEMENT

Reports to TCEQ Project Management

All reports detailed in this section are contract deliverables and are transferred to the TCEQ in accordance with contract requirements.

Reports from UCRA to TCEQ

Quarterly Progress Report - Summarizes TIAER's activities for each task; reports problems, delays, and corrective actions; and outlines the status of each task's deliverables. The TIAER PM will provide the necessary information to the UCRA PM for development of each progress report.

Watershed Protection Plan – TIAER will provide relevant information and sections of chapters to the UCRA PM that will comprise the WPP. TIAER's efforts on these sections will include development of the drafts and finalization of each section. The specific sections of the WPP in which TIAER will be engaged and the information to be provided by TIAER include:

- Draft and Final Watershed Characterization - Phase 3: Identification of Causes and Sources of Pollution and Estimation of Pollutant Loads Report: TIAER to provide model predictions on causes and sources of pollution and pollutant loadings from selected urban areas within the City of Brady plus evaluations of likely causes of increasing dissolved solids in Brady Lake, implications of brush encroachment and brush control on water quality above Brady Lake and the implications of aging flood retardation structures on sediment control above Brady Lake. This TIAER information generated with the computer models described in this QAPP will be reported in an integrated manner with other information generated from various aspects of this project including monitoring data and local stakeholder information.
- Draft and Final Element B: Estimate of Pollutant Load Reductions Expected from Management Measures Report: TIAER will provide model predictions regarding urban pollutant load reductions from the selected management measures, level of water quality

benefits from controlling brush encroachment, and, if necessary, an assessment of sediment reductions afforded by existing flood retardation structures.
- Draft and Final Element C: Management Measures Report: TIAER will provide information on the site specific management practices evaluated with the models.

Report from TIAER to UCRA
Modeling Documentation Report – TIAER will develop a report that summarizes and documents the calibration and verification of each model and technical information regarding application of the models in support of development of the Watershed Protection Plan. The report will also document the development of the BLSM including relevant equations representing the water balance and TDS balance. The reports will also provide information on the selection of years used for model verification, the model parameter values, the methods for processing data, evaluation of verification results, and other modeling assumptions and considerations used in the verification process for each model.

Contractor Evaluation - The Contractor participates in a Contractor Evaluation by the TCEQ annually for compliance with administrative and programmatic standards. Results of the evaluation are submitted to the TCEQ Financial Administration Division, Procurement and Contracts Section.

D1 DATA REVIEW, VERIFICATION, AND VALIDATION

All input data derived from data acquisition and used in development of the project's models will be checked for accuracy by staff with appropriate training. For these large data sets, data checks will consist of verification of a statistical sampling (e.g., 10 percent of relevant data) of the input data. Any errors in input data will be corrected at that time. No additional validation criteria are necessary for acquired data obtained for the project because they are either from state- and national-level recognized and accepted sources and have already been validated before their inclusion into their respective databases of origin.

All data obtained will be reviewed, validated, and verified against the data quality objects outlined in Section A7, "Quality Objectives for Model Inputs/Outputs." Only those data that support the intended uses and objectives will be considered acceptable for use.

The TIAER PM is responsible for ensuring that data and model outputs are properly reviewed, verified, and submitted in the required format for the project database, as required. The procedures for validation of model outputs are described in Section D2, below. Finally, the TIAER QAO is responsible for coordinating with the TIAER PM in the process of validating that downloaded data and model outputs used to make decisions in the project meet the quality objectives of the project and are suitable for including in project reports.

D2 VERIFICATION AND VALIDATION METHODS

SWAT

The watershed model, Soil Watershed Assessment Tool (SWAT) is built with state-of-the-art components in an attempt to simulate a wide range of watershed processes physically and realistically. Most of the model inputs are physically based (that is, based on readily available information or upon mechanistic relationships). SWAT is not a simple "one-parameter model" which can be implemented in a formal optimization procedure (as part of the calibration process) to fit any set of data. Instead, there are a number of input variables that are not well defined physically, including the runoff curve number (CN2) and the management and cover factor (C Factor) in the Universal Soil Loss Equation. While these model parameters may be adjusted within literature values so that the results are consistent with knowledge of watershed processes, there is no unique solution to the validation process because there are generally many more free parameters than sets of field data.

Validation of the SWAT model will be conducted for a different long-term record than used in the calibration process (as described earlier in the QAPP). The exact period will be determined after assessment of all required data sets to operate the model. 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. The same evaluation measures from the calibration process will be used for assessing the performance of the model during validation (Section B7). If evaluation measures do not indicate valid model results, the calibration process will be revisited until a best fit between simulated and observed data is obtained.

While quantitative measures will guide the assessment of the SWAT model, TIAER's final determination of model output will be according to qualitative corroboration of model predictions with observed data in accordance with the purposes of the model for this project.

SWMM

The calibrated SWMM model will be validated using storm water quantity and quality data being collected under another task of the WPP project within the City of Brady. 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. The same evaluation measures used in the calibration process will be used for assessing the performance of the model during validation. In the situation that the matching between simulated and observed data is not to the established criteria, the calibration process will be revisited until a best fit between simulated and observed data is obtained.

Both calibration and validation of the model will rely on a combination of quantitative statistics for goodness-of-fit and visual comparison of predicted and observed individual storm event data. This methodology is consistent with the standard of practice that has been established for similar modeling programs.

As with SWAT, while quantitative measures will guide the assessment of the SWMM model, the final determination of model output will be according to qualitative corroboration of model predictions with observed data in accordance with the decision purposes of the model for this project.

QUAL2K

The steady-state water quality model, QUAL2K, is built with state-of-the-art components in an attempt to simulate a wide range of natural instream water quality processes physically and realistically. Most of the model inputs are physically based (that is, based on readily available information or upon mechanistic relationships). QUAL2K is not a simple "one-parameter model" which can be implemented in a formal optimization procedure (as part of the calibration process) to fit any set of data. Instead, there are a number of input variables that are not well defined physically, including algal growth kinetics and sediment oxygen demand. While these model parameters may be adjusted within literature values so that the results are consistent with knowledge of instream processes, there is no unique solution to the validation process because there are generally many more free parameters than sets of field data.

Validation of the QUAL2K model will be conducted for different 24-hour surveys than used in the calibration process (as described earlier in the QAPP). The exact surveys will be determined after assessment of all required data sets to operate the model. 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. The same evaluation measures from the calibration process will be used for assessing the performance of the model during validation (Section B7). If evaluation measures do not indicate valid model results, the calibration process will be revisited until a best fit between simulated and observed data is obtained.

While quantitative measures will guide the assessment of the QUAL2K model, TIAER's final determination of model output will be according to qualitative corroboration of model predictions with observed data in accordance with the purposes of the model for this project.

BLSM

The calibrated BLSM model will be validated using recent USGS reservoir water level data and TCEQ SWQMIS TDS data for Brady Lake. 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. The same evaluation measures used in the calibration process will be used for assessing the performance of the model during validation. In the situation that 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.

Both calibration and validation of the model will rely on a combination of quantitative statistics for goodness-of-fit and visual comparison of predicted and observed time series of TDS and reservoir storage. This methodology is consistent with the standard of practice that has been established for similar modeling programs.

While quantitative measures will guide the assessment of the BLSM model, TIAER's final determination of model output will be according to qualitative corroboration of model predictions with observed data in accordance with the purposes of the model for this project.

D3 RECONCILIATION WITH USER REQUIREMENTS

The information derived from the modeling tasks of this project together with the results of monitoring efforts under separate WPP project tasks will be consolidated to provide the EPA, TCEQ, UCRA and local stakeholder groups with best-available information pertaining to watershed characteristics.

The modeling activities as a result of this project will be used to evaluate water quality issues in the Brady Creek watershed. At stakeholder meetings and other appropriate forums decided upon by UCRA, TIAER will provide UCRA and the interested parties of the Brady Creek Watershed Protection Plan with information pertaining to watershed characteristics, the prediction of urban pollution loadings, which will assist in identifying optimum placement of BMPs to prevent pollution loading to the urban portion of Brady Creek. Further, TIAER will provide information in the same forums on the role of evaporation on the increased salt levels in Brady Lake, issues related to erosion and sedimentation control in conjunction with the flood retardation structures in the upper watershed, and finally the implications of brush control in restoring baseflows in the upper watershed for water quality improvement. All this information, in turn, will enable their decision-making efforts as part of a comprehensive Watershed Protection Plan process.

The data and model outputs for the final production applications of each model will be reviewed to ensure they meet the requirements of intended use and quality objectives of Section A7 (Quality Objectives for Model Inputs/Outputs) as described in this QAPP. Corrective Action Reports will be initiated in cases where invalid or incorrect data have been detected. Data and outputs that have been reviewed, verified and validated will be summarized for their ability to meet the 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 use, will be included in the appropriate sections of the WPP.

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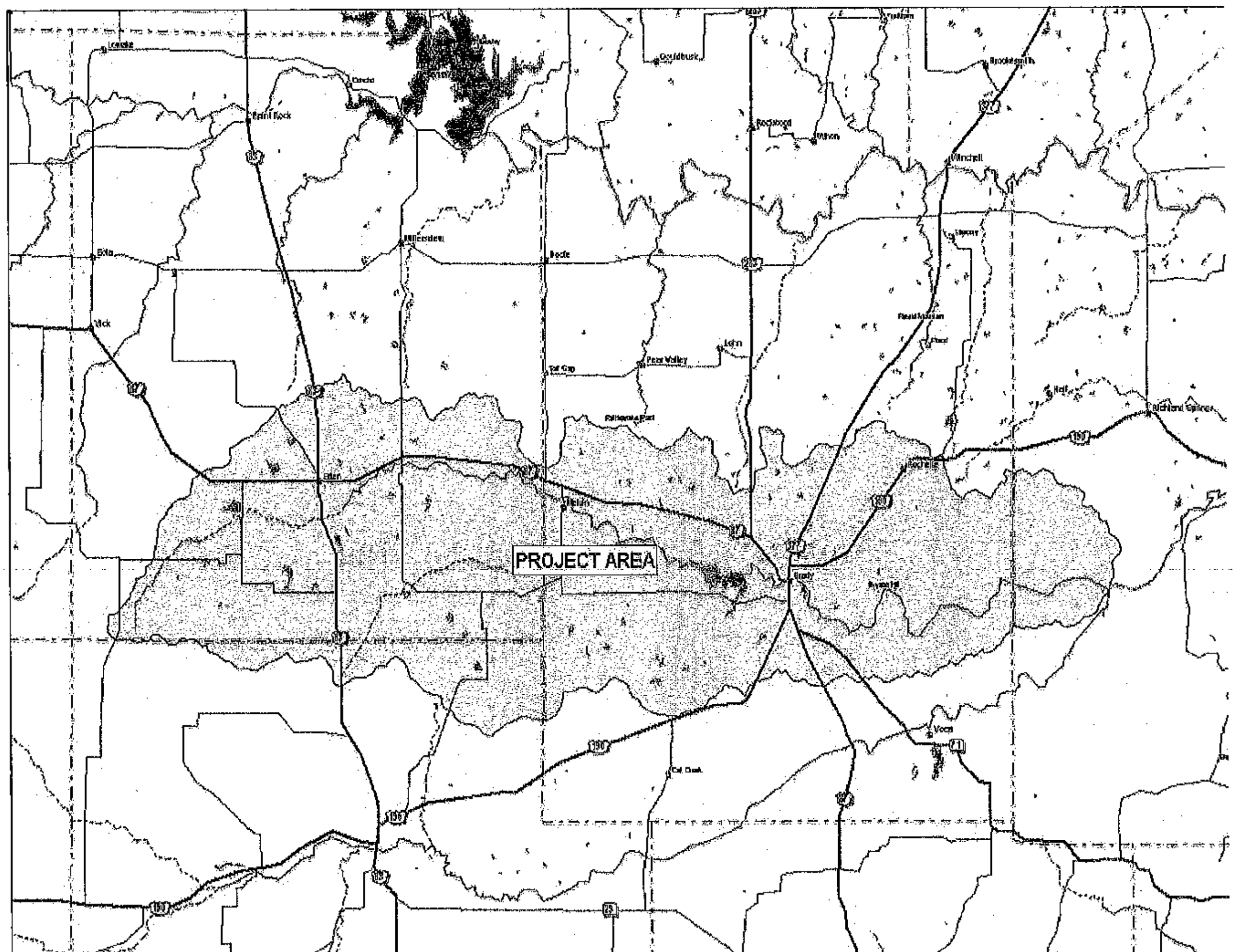
Appendix A. Area Location Map


PROJECT AREA

Appendix B. Work Plan
(Including Only Tasks In Which Modeling Activities Occur)

Tasks, Objectives and Schedules (Replicate or modify table as needed)						
Task 3:	Element A: Watershed Characterization – Phase 2: Data Collection and Analysis					
Costs:	Federal:	90,950.00	Non-Federal:	60,633.00	Total:	151,853.00
Objective:	This Objective meets a portion of Element A of the 2003 Guidelines. Guidance for developing this objective can be found in Chapters 6 and 7 of the EPA Handbook. To provide the baseline information for determination of amounts of existing non-point sources of pollution and existing point sources of pollution; to provide additional data for incorporation into a model, which will serve to determine the pollutant assimilative capacity of the water body, and to determine pollutant load reductions needed to achieve the goals of the WPP. UCRA will develop a SWAT model for the greater watershed and will apply the P8-UCM to estimate storm loadings from the urban areas of the City of Brady. The information collected will also form the baseline for future monitoring to determine if the pollutant load reduction goals are being met.					
Subtask 3.1:	Project objectives include the improvement in water quality of Brady Creek through the project area. The objective of project evaluation is the collection and utilization of water quality data and other hydrologic information pursuant to measurement of the effectiveness of constructed BMPs, water quality improvements in Brady Creek and preparation of the watershed characterization portion of a WPP. Quantitative and qualitative information regarding measurement data needed to measure BMP efficiency and instream water quality. The data collected for both objectives will be considered representative of the target population or phenomenon to be studied. The representativeness of the data is dependent on; 1) the sampling locations; 2) the flow regime during sample collection; 3) the number of years sampling is performed, and; 4) the sampling procedures. Site selection and sampling of pertinent media (i.e. water) and use of only approved analytical methods will assure that the measurement data represents the population being studied at the site. After the Quality Assurance Project Plan (QAPP) is approved, sampling events will be initiated. Plans are to monitor a minimum of 5 sites every other month for routine water chemistry to include flow, field, conventional parameters, and bacteria. In addition, 3 storm water runoff events will be monitored at the aforementioned sites. UCRA will also conduct 3 storm water monitoring events within the urbanized city of Brady. Areas targeted will be subwatersheds that either 1) have not been sampled in previous projects and 2) subwatersheds that are believed to contribute the highest loadings to Brady Creek.					
	Start Date:	January 1, 2010	Completion Date:	May 1, 2010		
Subtask 3.2:	The UCRA will conduct a data review to identify data gaps, and to determine the types of data needed to identify causes and sources of pollution. The acceptability of existing data will be reviewed by UCRA.					
	Start Date:	January 1, 2010	Completion Date:	June 1, 2012		
Subtask 3.3:	The UCRA will schedule Quality Assurance Project Plan (QAPP) planning meetings with the TCEQ Project Manager, Quality Assurance staff, technical staff, management, and contractors, to implement a systematic planning process, based on the elements of the TCEQ NPS QAPP Shell. The information developed during the planning meetings will be incorporated into a QAPP. A planning meeting may also be conducted to determine if any changes need to be made to an existing QAPP.					
	Start Date:	January 1, 2010	Completion Date:	May 1, 2010		
Subtask 3.4:	The UCRA will develop a QAPP for monitoring. The UCRA will schedule QAPP planning meetings with the TCEQ Project Manager, Quality Assurance staff, technical staff, management, and contractors to implement a systematic planning process based on the elements of the TCEQ NPS QAPP Shell. The information developed during the planning meetings will be incorporated into a QAPP. A planning meeting may also be conducted to determine if any changes need to be made to an existing QAPP.					
	Start Date:	January 1, 2010	Completion Date:	May 1, 2010		

Subtask 3.5:	The UCRA will develop a QAPP for modeling. The UCRA will develop and submit to the TCEQ a QAPP with project specific quality objectives and criteria for model inputs/outputs consistent with the *EPA Guidance for Quality Assurance Project Plans for modeling(EPA QA/G-5M)* format and the TCEQ TMDL QAPP Modeling Shell 120 days prior to the initiation of any modeling. The QAPP will be developed by the UCRA with review provided by the TCEQ Project Manager, Quality Assurance staff, technical staff, management, and contractors. The QAPP will be approved by the TCEQ.			
	Start Date:	January 1, 2010	Completion Date:	May 1, 2010
Subtask 3.6:	The UCRA will provide input annually throughout the project period to TCEQ 60 days prior to the end of the effective period of the QAPP, and will develop annual QAPP revisions 30 days prior to the end of the effective period of the QAPP.			
	Start Date:	January 1, 2010	Completion Date:	December 31, 2011
Subtask 3.7:	The UCRA will develop a monitoring program and conduct monitoring, as outlined in the QAPP, to achieve data quality objectives.			
	Start Date:	May 1, 2010	Completion Date:	February 29, 2012
Subtask 3.8:	The UCRA will incorporate relevant data into a model(s) selected by the UCRA with the approval of the TCEQ Project Manager and the Stakeholder Group, as outlined in the modeling QAPP, to achieve data quality objectives. Data sources used in the model, including literature values and other assumptions will be presented to the Stakeholder Group and feedback will be solicited by the UCRA. The model(s) will be, a) calibrated using available water quality data, b) utilized to assist in the determination of causes and sources of pollution and pollutant loadings, and c) applied to determine load reductions from various agricultural conservation practices and urban best management practices.			
	Start Date:	May 1, 2010	Completion Date:	February 29, 2012
Subtask 3.9:	The UCRA will review, verify, and validate water quality monitoring and modeling data before it is submitted to the TCEQ. Data will be submitted to TCEQ twice annually and at least 1 month prior to use, or prior to presenting to stakeholders.			
	Start Date:	August 1, 2010	Completion Date:	May 1, 2012
Subtask 3.10:	The UCRA will provide to the TCEQ and stakeholders a report that describes the results of sampling and modeling activities, and recommendations for future monitoring efforts.			
	Start Date:	August 15, 2010	Completion Date:	May 1, 2012
Deliverables	• Draft and Final Sampling Plan • Draft and Final QAPP • Draft and Final QAPP Annual Updates • Data Submittals • Draft and Final Watershed Characterization – Phase 2: Data Collection and Analysis Report			

Tasks, Objectives and Schedules (Replicate or modify table as needed)						
Task 4:	Element A: Watershed Characterization – Phase 3: Identification of Causes and Sources of Pollution and Estimation of Pollutant Loads					
Costs:	Federal:	7,658.00	Non-Federal:	5,105.00	Total:	12,763.00
Objective:	This Objective completes Element A of the 2003 Guidelines. Guidance for developing this objective can be found in Chapters 5, 6, 7, and 8 of the EPA Handbook. Identification of the causes and sources, or groups of similar sources, that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (a) of the 2003 Guidelines.					

Subtask 4.1:	The UCRA will further define watershed goals and refine numeric water quality targets for the pollutants or sources identified in Objective 5. The watershed goals and targets will be used to guide the identification and selection of management practices in Objective 6.			
	Start Date:	December 31, 2011	Completion Date:	June 1, 2012

Subtask 4.2:	The UCRA will analyze data to identify the causes and sources of water quality problems in the watershed. The analysis will:
	• Identify pollutant sources and causes of impairments or water quality concerns, including the following:
	  o Point sources
	  o NPSs
	  o Stakeholders' concerns and observations
	  o Effects on water quality and overall watershed functions
	• Compare available monitoring data to water quality standards, and to the current 303(d) list and 305(b) assessments.
	
	An evaluation will be done of the relative magnitude of sources, the location of sources, and the timing of source loading:
	• Major sources of pollution will be identified at a significant subcategory and subwatershed level
	• Minor sources of pollution may be identified by a general characterization
	
	The methods for analysis may include mapping, modeling, monitoring, field assessments, and stakeholder surveys.			

	Start Date:	December 31, 2011	Completion Date:	June 1, 2010
Subtask 4.3:	The UCRA will estimate pollutant loads for water quality parameters that: • Do not meet standards • Are identified as a concern in the Texas Water Quality Inventory 305(b) Report • May prohibit the water body from meeting designated uses In addition, pollutant loads may be also be estimated for water quality parameters identified by stakeholders as a concern. Pollutant loads will be calculated based on the relative magnitude of sources, the location of sources, and the timing of source loading. The loading analysis will be used in subsequent Objectives of this project to plan restoration and/or protection strategies, target load reduction efforts, and project future loads under new conditions.			
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010
Subtask 4.4:	The UCRA will provide maps of the watershed and subwatersheds that identify the major causes and sources of the water quality problems.			
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010
Subtask 4.5	UCRA will develop a report using data developed in this phase to identify causes and sources of pollution that need to be controlled. Pollutant load data and associated maps developed under this Objective will be included in the report. The document will also identify additional gaps in data, and methods to deal with these gaps will be recommended.			
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010
Deliverables	• Watershed maps that identify the causes and sources of water quality problems • Draft and Final Watershed Characterization - Phase 3: Identification of Causes and Sources of Pollution and Estimation of Pollutant Loads Report			

Tasks, Objectives and Schedules (Replicate or modify table as needed)						
Task 5:	Element B: Estimate of Pollutant Load Reductions Expected from Management Measures					
Costs:	Federal:	2,344.00	Non-Federal:	1,562.00	Total:	3,906.00

Objective:	This Objective meets Element B of the 2003 Guidelines. Guidance for developing this objective can be found in Chapters 8 and 9 of the EPA Handbook. To provide an estimate of the load reductions expected for the management measures described under Objective. Estimates should be provided at the same level as in Element A			
Subtask 5.1:	The UCRA will determine the load reductions that are needed to meet the watershed goals and water quality standards. Load reduction estimates will be calculated at key locations in the watershed in order to depict the major problem areas and sources, and to support efficient and targeted management. The load reductions should be calculated at the same spatial scale and level of detail as the causes and sources and pollutant loads identified in Objective 4. The load reductions identified should be sufficient to ensure that water quality standards and designated uses are met. If a Total Maximum Daily Load (TMDL) has been developed in this watershed, the WPP must be designed to achieve the waste load and load allocations identified in the TMDL. If TPDES permits have been issued or are anticipated, the WPP load reductions must achieve in the requirements of the permits.			
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010
Subtask 5.2:	The UCRA will provide a report describing the watershed goals, targets, and the necessary load reductions that are needed to meet the watershed goals.			
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010
Deliverables	• Draft and Final Element B: Estimate of Pollutant Load Reductions Expected from Management Measures Report			

Tasks, Objectives and Schedules (Replicate or modify table as needed)						
Task 6:	Element C: Description of Management Measures					
Costs:	Federal:	5,858.00	Non-Federal:	3,905.00	Total:	9,763.00
Objective:	This Objective meets Element C of the 2003 Guidelines. Guidance for developing this objective can be found in Chapters 10 and 11 of the EPA Handbook. Identify and describe the NPS management measures that will need to be implemented to achieve load reductions identified in Element B, and describe the critical areas where those measures will be needed to implement this plan. In addition, management measures may be identified to achieve other goals of the WPP.					
Subtask 6.1:	The UCRA will develop management objectives targeted at specific pollutants or sources to achieve the goals of the WPP. Management objectives will be determined with the input and approval of the Stakeholder Group.					
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010		
Subtask 6.2:	The UCRA will identify the programs, management strategies, and ordinances already being implemented in the watershed and determine the effectiveness of the measures in terms of achieving desired load reductions or meeting other management goals and objectives.					
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010		
Subtask 6.3:	The UCRA will select methodolog(ies) and/or model(s) that will be used to identify needed BMPs, to quantify load reductions achieved by each proposed BMP and to prioritize the suite of potential BMPs. Methods and/or models will be determined with the input and approval of the Stakeholder Group.					
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010		
Subtask 6.4:	Using the locations of pollutant sources identified in Element B, the UCRA will identify management practices that can be used to achieve the additional load reductions required. The critical areas and needed management measures will be determined with the input and approval of the Stakeholder Group.					
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010		

Subtask 6.5:	The UCRA will provide estimated pollutant load reductions expected for each management measure proposed. This will be accomplished by using published literature values and other available data, with the recognition of the natural variability of site specific BMPs and the difficulty in precisely predicting the performance of management measures over time. A report detailing this information will be provided to the Stakeholder Group and the TCEQ Project Manager.			
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010
Subtask 6.6	The UCRA will prioritize potential BMPs, with consideration of water quality benefits, costs, stakeholder support and other factors identified. This Task is related to and is dependent upon Objective 5. The prioritization of management measures will be conducted with the input and approval of the Stakeholder Group.			
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010
Subtask 6.7	The UCRA will develop Management Strategies and associated estimates of the total potential pollutant removal. Identify which combinations of management practices can meet the goals for load reductions and cost effectiveness.			
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010
Subtask 6.8	The UCRA will prepare a description and summary list of BMPs. Identify the specific need for each BMP and estimate load reductions that each BMP may provide. The suite of BMPs selected should reflect estimated load reductions needed to achieve water quality standards for the designated uses of the water body, and to achieve other goals of the WPP.			
	Start Date:	December 31, 2011	Completion Date:	June 1, 2010
Deliverables	• Draft and Final Element C: Management Measures Report			

Appendix C. Corrective Action Status Table

Corrective Action #	Date Issued	Description of Deficiency	Action Taken	Date Closed

Appendix D. Corrective Action Plan Form

Corrective Action Plan
Issued by:__________________ **Date Issued**__________________ **Report No.**______________________
Description of deficiency
Root Cause of deficiency
Programmatic Impact of deficiency
Does the seriousness of the deficiency require immediate reporting to the TCEQ? If so, when was it?
Corrective Action to address the deficiency and prevent its recurrence
Proposed Completion Date for Each Action
Individual(s) Responsible for Each Action
Method of Verification
Date Corrective Action Plan Closed?

ATTACHMENT 1
Example Letter to Document Adherence to the QAPP

TO: (name)
(organization)

FROM: (name)
(organization)

RE: Contractor Name, QAPP Title

Please sign and return this form by (date) to:

(address)

I acknowledge receipt of the "QAPP Title, Revision Date". I understand that the document describes quality assurance, quality control, data management and reporting, and other technical activities that must be implemented to ensure the results of work performed will satisfy stated performance criteria.

My signature on this document signifies that I have read and approved the document contents. Furthermore, I will ensure that all staff members participating in activities covered under this QAPP will be required to familiarize themselves with the document contents and adhere to the contents as well.

____

Signature Date

Copies of the signed forms should be sent by the Contractor to the TCEQ NPS Project Manager within 60 days of TCEQ approval of the QAPP.