# Quality Assurance Project Plan

**EPA Contract #EP-C-06-029**

**Work Assignments #3-36 and 4-36**

# Water Quality Modeling and TMDL Development for the Illinois River Watershed

Prepared for:
USEPA Office of Science and Technology, Washington DC
and EPA Region 6, Dallas, TX

Prepared by:

AQUA TERRA Consultants
2685 Marine Way, Suite 1314
Mountain View, CA 94043

Revision 0 – August 25, 2010

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| ______________________ | __________ | ______________________ | __________ |
| Quang Nguyen<br>Work Assignment Manager<br>EPA/Region 6 | Date | John Imhoff<br>Quality Assurance Officer<br>AQUA TERRA Consultants | Date |
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| Curry Jones<br>Approving Quality Assurance Official<br>EPA/Region 6 | Date | Claudia Hosch<br>Branch Chief (NPDES Permits & TMDLs) EPA/Region 6 | Date |
| ______________________ | __________ | ______________________ | __________ |
| Anthony Donigian, Jr.<br>Work Assignment Leader<br>AQUA TERRA Consultants | Date | Robert Shippen<br>Quality Assurance Coordinator<br>EPA/OST/SHPD | Date |
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| Quang Nguyen<br>Work Assignment Manager<br>EPA/Region 6 | Date | John Imhoff<br>Quality Assurance Officer<br>AQUA TERRA Consultants | 8/25/10<br>Date |
| Curry Jones<br>Approving Quality Assurance Official<br>EPA/Region 6 | Date | Claudia Hosch<br>Branch Chief (NPDES Permits & TMDLs) EPA/Region 6 | Date |
| Anthony Donigian, Jr.<br>Work Assignment Leader<br>AQUA TERRA Consultants | 9/7/10<br>Date | Robert Shippen<br>Quality Assurance Coordinator<br>EPA/OST/SHPD | Date |
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| Anthony Donigian, Jr.<br>Work Assignment Leader<br>AQUA TERRA Consultants | Date | Robert Shippen<br>Quality Assurance Coordinator<br>EPA/OST/SHPD | 9-8-10<br>Date |
| Tangela Cooper<br>Project Officer<br>EPA/OST/SHPD | 9/8/10<br>Date | | |

This quality assurance project plan (QAPP) has been prepared according to the guidance provided in EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5, 2001) to ensure that environmental and related data collected, compiled, and/or generated for this project are complete, accurate, and provide the type, quantity, and quality required for their intended use. The QAPP is consistent with EPA Guidance for Quality Assurance Plans for Modeling (EPA QA/G-5M, 2002); EPA Manual 5360 A1 (EPA, 2000); and EPA Order 5360.1 A2 (EPA, 2000). AQUA TERRA Consultants and its subcontractors will conduct work in conformance with the quality assurance program described in the Quality Management Plan for the contract and with the procedures detailed in this QAPP.

This QAPP is one of the contractor requirements and is used to communicate to all interested parties the QA/QC procedures that will be followed to ensure that the quality objectives for the Illinois River watershed modeling project are achieved throughout this multi-year project. The QAPP is a commitment by AQUA TERRA Consultants that must be approved by EPA Region 6 and EPA Headquarters. EPA's intention is to develop a scientifically robust model of the Illinois River watershed, upon which regulatory and non-regulatory decisions can be confidently based. To ensure that the model will be as representative of the watershed as possible, EPA has and will continue to both solicit and encourage active participation from State partners and stakeholders in the development of this modeling project. Besides the QAPP, future project deliverables will be shared with both States and stakeholders for technical peer review and comment. Throughout this process, EPA will continue to inform and engage States and stakeholders about project developments by conducting informational meetings to update and to solicit inputs useful for refining and improving the watershed model.

## Contents

Attachments: Work Assignment 3-36 Work Plan
Work Assignment 4-36 Work Plan

**Foreword:** The information contained in this QAPP is presented in the order, and includes the heading topics, suggested by EPA's "Guidance for Quality Assurance Project Plans for Modeling (EPA QA/G-5M). For the sake of completeness all major headings from this guidance document have been included. Specifying the quality procedures needed to support certain project activities (i.e., heading topics) depends on efforts, decisions and deliverables that will developed as part of the project work. The need to provide additional information for such topics by means of an addendum to this QAPP is noted.

## 1. Distribution List

| Name and Title | Organization and Contact Information |
|---|---|
| Quang Nguyen<br>*Work Assignment Manager* | U.S. EPA, Region 6<br>1445 Ross Avenue, Suite 1200 6WQ-PT<br>Dallas, TX 75202-2733<br>nguyen.quang@epa.gov<br>214-665-7238 (voice)<br>214-665-2191 (fax) |
| Tangela Cooper<br>*Project Officer* | U.S. EPA, Office of Water<br>1200 Pennsylvania Ave. 4305T<br>Washington, DC 20460<br>cooper.tangela@epa.gov<br>202-566-0392 (voice)<br>202-566-0409 (fax) |
| Robert Shippen<br>*Quality Assurance Coordinator* | U.S. EPA, Office of Water<br>1200 Pennsylvania Ave. 4305T<br>Washington, DC 20460<br>shippen.robert@epa.gov<br>202-566-0391 (voice)<br>202-566-0409 (fax) |
| Claudia Hosch<br>*Branch Chief (NPDES Permits and TMDLs)*<br>*EPA Region 6* | U.S. EPA, Region 6<br>1445 Ross Avenue, Suite 1200 6WQ-PT<br>Dallas, TX 75202-2733<br>hosch.claudia@epa.gov<br>214-665-6464 (voice)<br>214-665-2191 (fax) |
| Anthony Donigian, Jr.<br>*Work Assignment Leader &*<br>*Project Manager* | AQUA TERRA Consultants<br>2685 Marine Way, Suite 1314<br>Mountain View, CA 94043-1115<br>donigian@aquaterra.com<br>650-962-1864 (voice)<br>650-962-0706 (fax) |
| John Imhoff<br>*Quality Assurance Officer* | AQUA TERRA Consultants<br>735 Main Street, P.O. Box 323<br>Ouray, CO 81427<br>jcimhoff@aquaterra.com<br>970-325-4283 (voice)<br>970-325-4328 (fax) |
| Curry Jones<br>*Approving Quality Assurance Official*<br>*EPA Region 6* | U.S. EPA, Region 6<br>1445 Ross Avenue, Suite 1200 6WQ-PT<br>Dallas, TX 75202-2733<br>jones.curry@epa.gov<br>214-665-6793 (voice)<br>214-665-2191 (fax) |

## 2. Project Organization

The key individuals for ensuring that the work assignment meets all QA and QC objectives are Quang Nguyen, Curry Jones, Robert Shippen, and Marion Kelly from the EPA and Anthony Donigian, Jr., Brian Bicknell and John Imhoff from AQUA TERRA Consultants.

### 2.1 U.S. EPA QA/QC Responsibilities

**Quang Nguyen** will provide the overall work assignment oversight as the Work Assignment Manager (WAM). He will be responsible for the review and final approval of all deliverables. Mr. Nguyen's responsibilities include reviewing and approving the WA work plan and QAPP, and reviewing and approving all contractor deliverables.

**Curry Jones** is the Approving Quality Assurance Official at Region 6. His responsibilities include reviewing and approving the QAPP and ensuring that the QA/QC practices and requirements specific to Region 6 are achieved. He will do this via communication with Robert Shippen and Marion Kelly.

**Robert Shippen** is EPA OST's Quality Assurance Coordinator for the work assignment. His responsibilities include reviewing and approving the QAPP.

### 2.2 AQUA TERRA Consultants QA/QC Responsibilities

**Anthony Donigian, Jr.** is the Work Assignment Leader for AQUA TERRA, responsible for directing and coordinating technical work and interaction with the EPA WAM. He will also track the budget, prepare monthly progress reports and perform administrative functions.

**Brian Bicknell** is the Deputy Project Officer for AQUA TERRA. In this capacity he will serve as the Technical Monitor for the work assignment.

**John Imhoff** is the Quality Assurance Officer for AQUA TERRA. Mr. Imhoff is the individual responsible for maintaining AQUA TERRA's official Quality Management Plan. He will also be responsible for overseeing all QA/QC activities that AQUA TERRA performs for this project.

One or more subcontractors who have expertise related to specific watershed and receiving water models will be added to the Work Assignment Team contingent on decisions that will be made as part of the project effort. Figure 1 shows the work assignment organizational chart and indicates the dual communication lines between subcontractors and the appropriate technical and QA points of contact at AQUA TERRA. The appropriate subcontractors will be determined during the process of developing the Model Simulation Plan (see Section 4.3). When the Simulation Plan is complete the QAPP will be revised, and Figure 1 and supporting text in this section will be updated to identify the specific individual(s) responsible for subcontractor QA/QC.

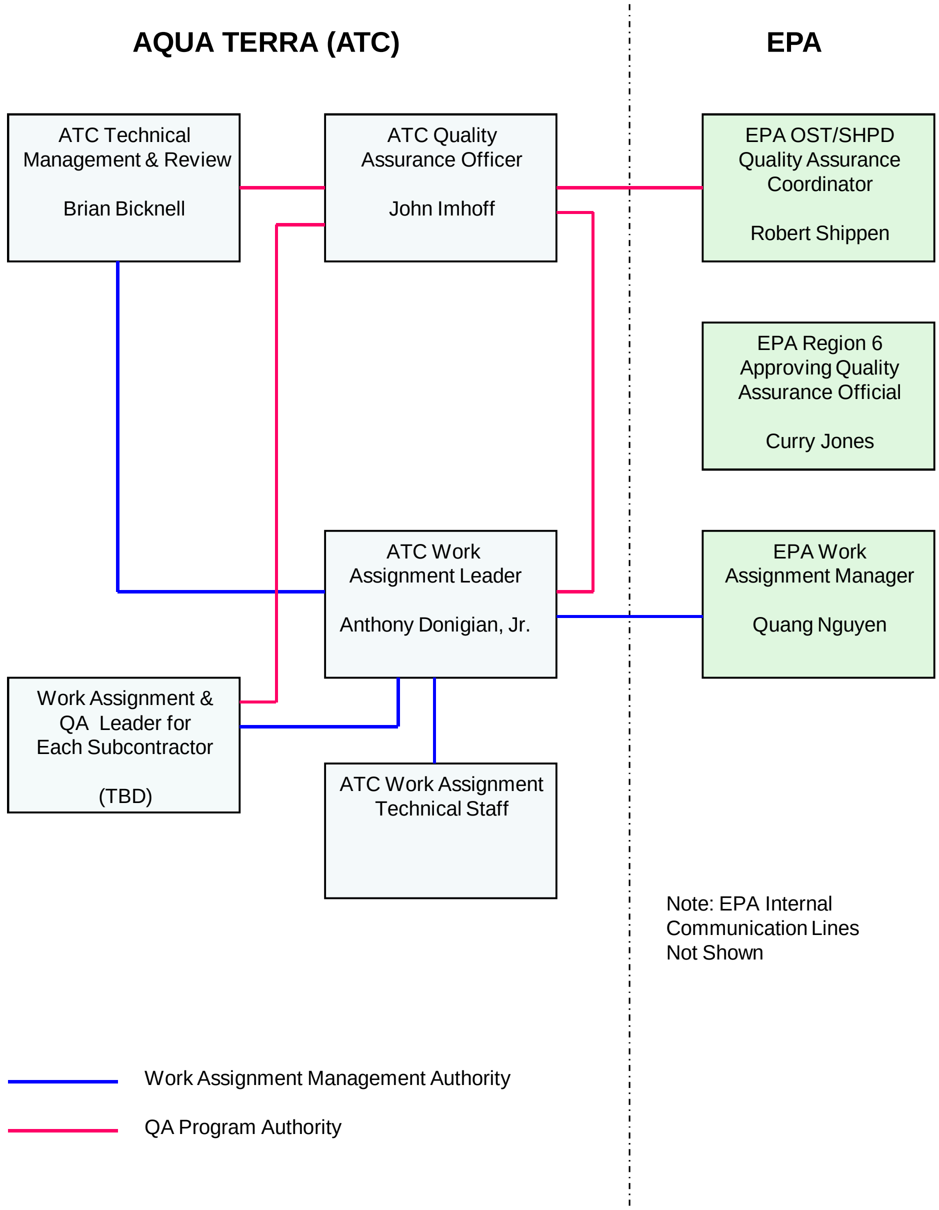


**Figure 1. Work Assignment Organizational Chart**

## 3. Problem Definition/Background

This Quality Assurance Project Plan (QAPP) has been prepared to address quality assurance issues related to tasks in **EPA Contract #EP-C-06-029, Work Assignments #3-36 and 4-36: Water Quality Modeling and TMDL Development for the Illinois River Watershed**. U.S.

Environmental Protection Agency's (EPA's) Region 6 is funding this project through a Work Assignment under EPA's BASINS contract (# EP-C-06-029) with AQUA TERRA Consultants, Mountain View, California. AQUA TERRA will conduct work for this project in conformance with the Quality Assurance (QA) program described in the BASINS Quality Management Plan (QMP) and with the procedures detailed in this QAPP. For additional details on AQUA TERRA's organizational quality assurance program refer to the Quality Management Plan (QMP) for AQUA TERRA's BASINS contract (AQUA TERRA Consultants, 2002).

The Illinois River is a multi-jurisdictional tributary of the Arkansas River, approximately 160 miles long, in the states of Arkansas and Oklahoma. The Illinois River begins in the Ozark Mountains in the northwest corner of Arkansas, and flows for 50 miles west into northeastern Oklahoma. The Arkansas portion of the Illinois River Watershed is characterized by fast growing urban areas and intensive agricultural animal production. It includes Benton, Washington and Crawford Counties and according to the US Census Bureau, the population of Benton and Washington Counties increased by 45% between 1990 and 2000. Arkansas ranked second in the nation in broiler production in 1998. Benton and Washington Counties ranked first and second respectively in the state. Other livestock production such as turkey, cattle and hogs are also all significant in this area. Upon entering Oklahoma, the river flows southwest and then south through the mountains of eastern Oklahoma for 65 miles, until it enters the reservoir Tenkiller Ferry Lake, also known as Lake Tenkiller. The upper section of the Illinois River in Oklahoma is a designated scenic river and home to many native species of bass with spring runs of white bass. The lower section, below Tenkiller dam flows for 10 miles to the Arkansas River, and is a designated year-round trout stream, stocked with rainbow and brown trout.

Several segments of the Illinois River are currently on the State of Oklahoma's 303(d) list for Total Phosphorus (TP), while the mainstem Illinois River in Arkansas is not listed for TP. However, several tributaries to the Illinois River in Arkansas (e.g. Osage Creek, Muddy Fork, and Spring Creek) are designated as Phosphorus-impaired and included in the State's Clean Water Act 303(d) list.

## 4.0 Project Description and Schedule

The objective of Contract No. EP-C-06-029, Work Assignment 3-36 is to develop a watershed model to determine reductions in phosphorus loads needed to improve the water quality in the Illinois River watershed. This watershed model will serve as a tool for sound technical decisions on appropriate point and nonpoint source controls to meet this objective. Ultimately, the intent is development of a tool that can lead to scientifically sound TMDLs and a basin-wide water quality restoration plan.

Tasks 1 and 2 of this work assignment entail the development of a Work Plan and the development of this Quality Assurance Project Plan (QAPP), respectively. Major activities that must be addressed in the QAPP include data compilation and assessment (Task 3); development of a GIS database of land uses and other relevant geo-spatial data (Task 4); and water quality model development (Task 5). Each activity has inherent QA/QC requirements and requires management and QA/QC oversight by qualified personnel, and consequently each is discussed in a separate section below.

This QAPP describes QA/QC issues and procedures for work currently planned to be performed through 31 March 2010, but selected tasks are likely to extend past this date into a second work Option Year. The key deliverables resulting for Task 3 through 5 will be a Draft Simulation Plan, and a Draft Model Calibration Status Report, including discussion of model scenarios. (All deliverables are identified in Section 17.) It is clear from the extensive work required in this WA, along with necessary coordination and review with EPA and other stakeholders that the entire project will extend past 31 March 2010. On or before that date AQUA TERRA will submit a status report to EPA on the extent of model setup and calibration that has been accomplished, along with identification of the expected remaining tasks and issues to be addressed. When EPA has defined the scope for completion, the QAPP will need to be expanded to address any additional tasks that are established.

### 4.1 Data Compilation and Assessment

The following discussion introduces the data compilation and assessment task, the first task of the modeling project. Previous modeling studies are noted, and the general need and mechanisms for supplemental data collection and reporting are described. Fuller elaboration of the types of data that will be used to develop the model and the data acquisition procedures are provided in Section 9.

For this task, the data compilation effort will start with two previous modeling efforts by Donigian et al., (2009) and Storm et al., (2006). Under WA 2-11 of EPA Contract EP-C-06-029, AQUA TERRA and Eco Modeling completed an integrated-linked watershed and ecosystem modeling effort of the Illinois River and Tenkiller Reservoir, using the US EPA HSPF watershed model and AQUATOX ecosystem model (Donigian et al., 2009). This effort was directed to nutrient criteria development and was based on a relatively limited period of available data. The watershed effort used TP data primarily collected by the USGS prior to 2001. Additional USGS data are now available through 2004 (Tortorelli and Pickup, 2006) to support extended model calibration efforts under the current WA. Figure 2 shows the primary USGS station locations within the watershed.

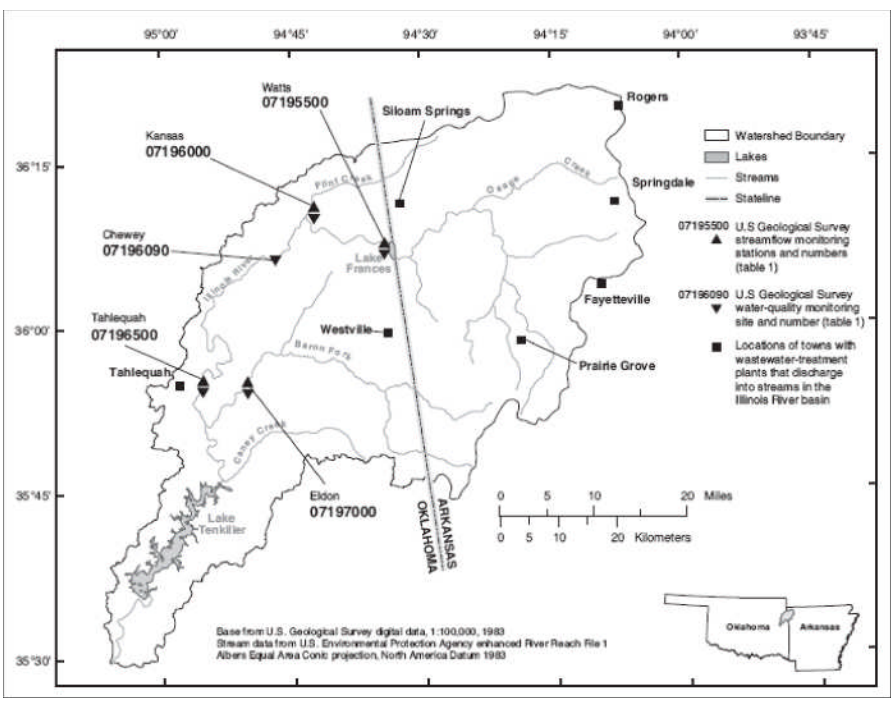


**Figure 2. Location of the Illinois River and USGS Monitoring Stations in Arkansas and Oklahoma**

In addition, a watershed modeling effort by Storm et al. (2006) used the USDA SWAT model to represent the Illinois River watershed, including specific consideration of the poultry litter applied to pasture areas, and subsequent runoff to the river system (Storm et al., 2006). That effort used relatively simple instream algorithms to approximate the complex instream fate and transport interactions of dissolved and particulate phosphorus. Contact has already been initiated with Dr. Dan Storm who is currently obtaining permission to release to AQUA TERRA his most recent modeling report submitted to the OK DEQ. We will also seek to obtain Dr. Storm's SWAT data files, including GIS files used in his SWAT model setup, as these may provide valuable spatial data coverages.

Both of these modeling efforts, along with the USGS data collection efforts and any other data uncovered as part of this WA, provide the starting point for developing the watershed and water quality model needed for addressing the water quality issues in the Illinois River.

At the onset of the current study we are aware of historical water quality data on Tenkiller Ferry Reservoir available from several sources, including an EPA National Eutrophication Survey report (U.S. Environmental Protection Agency 1977), a USACE study (Nolen et al. 1989), and a "Clean Lakes" study, conducted in 1992-1993 (Oklahoma State University 1996). The Clean Lakes data were used to calibrate the AQUATOX ecosystem model in the nutrient criteria exercise noted above (Donigian et al. 2009).

Data collected to support these efforts will be supplemented by further directed searches and by leads (or actual data) provided by the designated Points of Contact (POCs) for the States of Oklahoma and Arkansas. On 19 January 2010 a Call for Data was published in the Federal Register requesting that data relevant to this project be submitted before 3 March 2010. By that time, the State POCs will send the EPA WAM a list of data/sources available to support this work assignment. The EPA WAM and Region 6 TMDL Section Chief will synthesize an integrated list of the available data and provide it to the Work Assignment Team as a starting point for acquiring supplemental data. Both time-variable (e.g. point sources) and GIS data (Task 4) will be identified and acquired.

For Task 3, we will compile all existing time-variable data and information applicable to the Illinois River and Tenkiller Reservoir, including all existing flow and water quality data from AR and OK, point source discharges, nonpoint source contributions, and specifically data useful for water quality model application. The compiled data will be assessed and any data gaps critical to model development will be identified. Following the QAPP submittal and receipt of the above mentioned list of data from the EPA WAMl AQUA TERRA will complete and submit a Data Gaps Analysis Report, identifying any critical data gaps which might impact water quality model development. Beforehand, we will coordinate with the EPA WAM regarding the form/format for submission of the data, which might be in Microsoft Word, Excel, a combination of these, or other suitable format. Critical data gaps (if any) will be discussed with the EPA WAM for resolution and/or development of corrective actions.

### 4.2 Development of a GIS Database of Land Uses and Other Relevant Geospatial Data

As for Task 3, the GIS data compilation performed in this task will start with the earlier watershed modeling efforts. Unfortunately, only a limited number of GIS coverages were available for the prior HSPF application (Donigian et al., 2009), but we have ready access to the GIS data layers that were used in that effort. In an analogous fashion, we expect to obtain the GIS coverages used by Storm et al., (2006) in their SWAT applications.

In addition, the US EPA BASINS system has an extensive GIS database for all data layers – soils, hydrography, landuse, topography, -- needed for watershed model applications. The data layers are mostly at national scales but provide complete coverage of the entire US and will include relevant data for this assessment. We will supplement this with additional direct contacts resulting from the lists of data/sources that are provided to the EPA WAM by the POCs for Arkansas and Oklahoma. As requested in the WA Request, we will georeference all point source dischargers to provide a GIS coverage of their locations, if such coverage is not readily available.

Within 15 days following completion of Task 3, we will provide a Preliminary Version GIS database for the Illinois River Watershed. This will likely be in ArcGIS format (i.e. shape files), which is the most commonly used GIS data format, but we can also provide a MapWindow format which is an open-source GIS system used by BASINS 4.0. These preliminary shape files will be shared with the State agencies to allow each State to perform QA/QC checks on the preliminary GIS analysis. Each State will be allowed two weeks to review the compiled GIS files. Any comments received will be reviewed and the need for revisions will be determined. We will coordinate with the EPA WAM for a decision on the format for submission. Following comments by the EPA WAM, we will provide the Final Version GIS within 15 calendar days. The only caveat to this might be if we are still awaiting data layers that have been requested from the States, and delayed. We will keep the EPA WAM apprised if this situation occurs.

## 4.3 Water Quality Model Development

This task encompasses both watershed and reservoir model development, includes both the flow quantity and water quality capabilities in both models, and linkage of the models so that the watershed model provides flow and loading of constituents to the reservoir model. Each of these components will be discussed in turn below.

**Watershed Model Development:** As noted above, the prior modeling efforts by Donigian et al (2009) using the HSPF model (Bicknell et al., 2003) and Storm et al., (2006) using the SWAT model (Neitsch et al. 2002), provide a strong foundation for the watershed modeling component of this effort. Both models are recognized as among the best available for performing comprehensive watershed modeling (Shoemaker et al., 1997; Fitzpatrick et al., 2001; Shoemaker et al., 2005). However, each of these models and their applications to the Illinois River Watershed has particular strengths and weaknesses that need to be investigated as part of the development to select which one will be recommended for use in this effort. Thus a focused model evaluation and selection task will be performed as a basis for the model selection. Some of the issues that will be investigated are as follows:

- Although HSPF has extensive capabilities to represent agriculture-dominated watersheds, the prior Illinois River application was constrained by resources and its original development effort (by OK DEQ and their contractors) to only model three constitutents – Total Nitrogen (TN), Total Phosphorus (TP), and BOD5. Sediment was not included in that modeling and it is a major transport mechanism for phosphorus.
- The SWAT model application also did not model sediment fate/transport in the river system, but it provides a more detailed representation of the poultry litter sources of phosphorus and their application to pasture areas.
- The instream TP fate/transport model used in the Storm et al., (2006) study was developed for that effort, and is a relatively simple representation of riverine processes for TP. It uses transfer coefficients between the bed and the water column for TP without direct modeling of sediment scour/deposition processes.

- HSPF provides a moderately complex sediment transport capability and allows direct modeling of sediment-contaminant interactions, partitioning of dissolved and particulate inorganic phosphorus, transfer between the bed and water column, and uptake/cycling of phosphorus by algae and DO/BOD processes. SWAT also includes an instream capability, but it does not appear to allow scour of nutrients from the channel bed (J. Butcher, Tetra Tech, personal communication, 8 October 2009).
- HSPF is generally recognized as providing a better hydrologic model than SWAT using hourly (or less) precipitation, for more accurate storm event simulations, and an energy-balance approach to snow accumulation and melt processes. Storm et al (2006) specifically note that SWAT "...... could not be adequately calibrated for daily flow."

Professional judgment, as well as prior use in the Illinois River Watershed, supports the use of one of these two models for the current study. The Work Assignment Team is familiar with both HSPF and SWAT model capabilities, and hence the most important elements of the tightly-bounded model selection effort performed for this work assignment will be (1) further evaluation of the previous applications of the two models to the Illinois River Watershed and (2) consideration of the specific modeling needs required for developing scientifically sound watershed analyses. .

**Reservoir Model Development:** Lake Tenkiller has previously been modeled using two different reservoir models, AQUATOX and EFDC. Both models are recognized as reliable tools for performing comprehensive receiving water quality modeling (Imhoff and Yager, 1999; Fitzpatrick et al., 2001; Imhoff et al., 2003; Imhoff et al., 2004). Similar to the situation that has been discussed above for the watershed models, each of these reservoir models and their applications to Lake Tenkiller has particular strengths and weaknesses that need to be investigated as part of the model recommended for use in this effort.

The AQUATOX model has been most recently applied to the reservoir for nutrient criteria development using a modeling scheme that divided the reservoir into five longitudinal segments (Figure 3). Developed with funding from the US EPA and successfully peer-reviewed by two panels, AQUATOX has a myriad of potential applications to water management issues and programs, including water quality criteria and standards, Total Maximum Daily Loads, and ecological risk assessments of aquatic systems. AQUATOX can be used to predict ecological responses to proposed management alternatives. The model is an integral part of the BASINS system. Release 3, which was issued by EPA in September (USEPA 2009), includes the Di Toro sediment diagenesis submodel; this enhancement is important in modeling a reservoir such as Tenkiller with nutrient-enriched sediments.

As noted above, AQUATOX was applied successfully in modeling water quality in Tenkiller for a prior period (Donigian et al. 2009). However, two aspects of that calibration could be improved: the representation of blue-green algae and turbidity. If AQUATOX is selected for use in this work assignment, these areas will receive attention as part of Task 5 using the earlier calibration data. Once the new watershed calibration is available it will be used to generate loadings that, along with reservoir water quality data, will permit the setup and preliminary calibration of AQUATOX for simulating current and anticipated conditions.

The US EPA EFDC model (Hamrick 1992, Hamrick 2007) has also been applied to Lake Tenkiller and to other lakes in Oklahoma sponsored by the OK DEQ. In fact, EFDC was the first model applied to Lake Tenkiller and its hydrodynamic simulation of the flow field was used

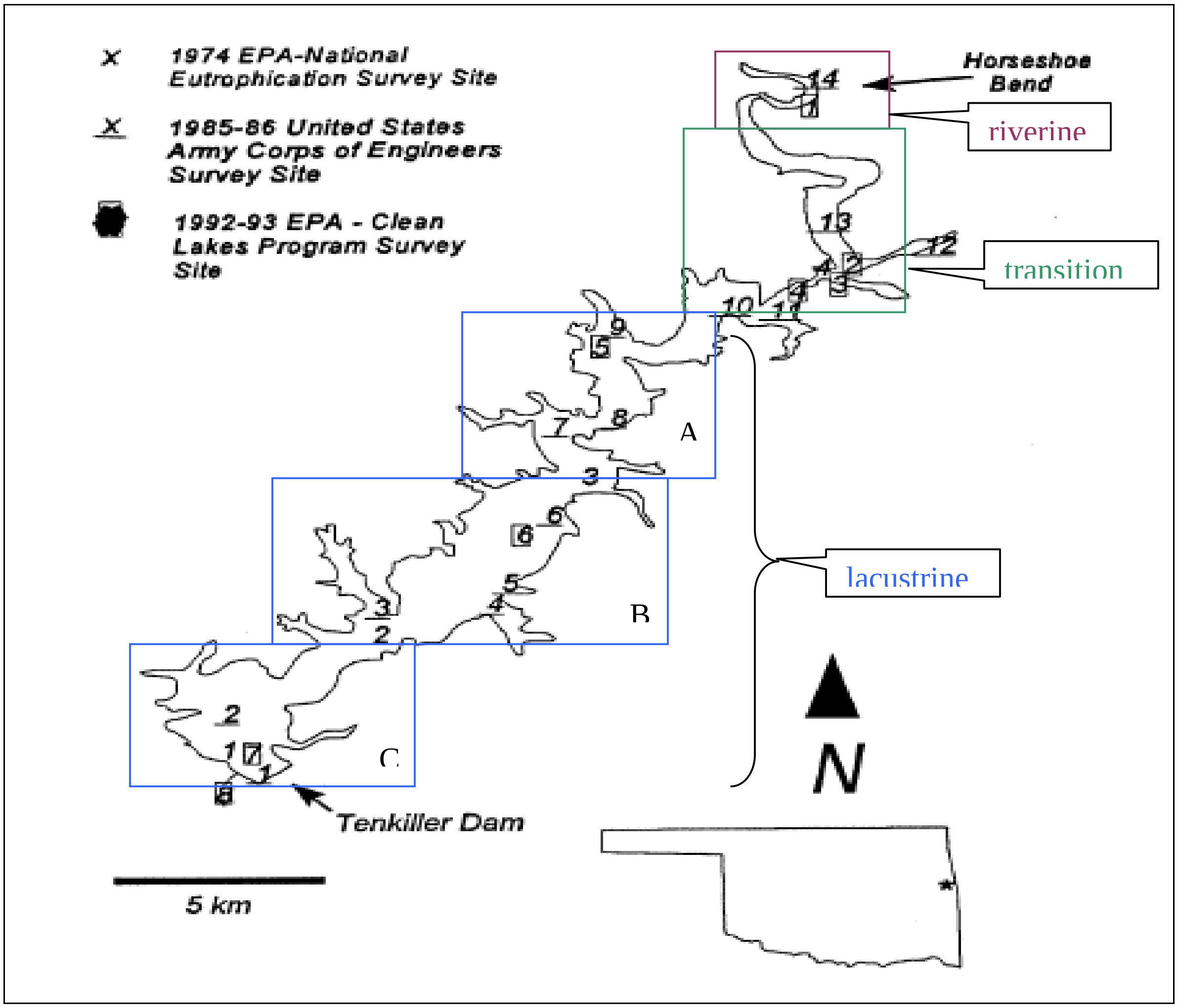


**Figure 3. Longitudinal segments and sampling stations on Tenkiller Ferry Lake, Oklahoma. Base map from (Oklahoma State University 1996).**

directly in the subsequent AQUATOX effort described above. EFDC is widely accepted and has been used in many approved TMDLs, including applications in Region 6. Applications of EFDC are more labor-intensive than those using AQUATOX, but several significant advantages are enabled:

- By using a three-dimensional grid to simulate water temperature and density, dynamic simulation of thermal stratification is enabled.
- By specifying a detailed grid cell network, considerable spatial resolution can be achieved, and individual lake sampling points can be accommodated.
- EFDC utilizes short computational time steps that enable simulation of dynamic, short-term lake responses to flow and loading changes due to nonpoint source storm-driven contributions.

An investigation and confirmation of the relative advantages of AQUATOX and EFDC is warranted as part of the model section effort to ensure that the most appropriate reservoir model is selected and applied. When the reservoir model has been selected, all procedures, assumptions and limitations in the model calibration and application will be clearly documented in the draft report. It is anticipated that most of the calibration and application of the receiving water model will occur during 2010 and early 2011.

**Model Linkage:** Since both the HSPF and SWAT models allow a direct linkage to AQUATOX through the BASINS system, and HSPF has been linked to EFDC in the earlier Tenkiller study, model linkage is not expected to be an issue, nor a major distinguishing characteristic in the model selection process. That is, model linkage needs to be addressed as a component of the model development plan but linkage procedures are well developed for these models. Model linkage details will be established and reported as an element of a subsequent deliverable of this work assignment, the Model Simulation Plan.

**Simulation Plan and Model Application:** As the initial effort in Task 5, we will develop a Simulation Plan, incorporating the available data from Task 3 and 4, discussing the model selection process and recommended models, and describing **how** the recommended models will be applied to the Illinois River and Lake Tenkiller. AQUA TERRA typically develops a Simulation Plan for all watershed modeling efforts, and this practice is highlighted in the BASINS/HSPF training workshops as a critical element of the model application process. The Simulation Plan provides a roadmap and a communication tool for both the EPA WAM and stakeholders as it describes the study objectives, the available data, water quality and land uses, calibration/validation procedures and targets, and potential scenarios for assessment.

A Draft Simulation Plan will be submitted to Region 6 as requested in the WA Request. Each State will be allowed two weeks to review the Draft Simulation Plan. Comments received from Region 6 and form the States will be reviewed and the need for revisions will be determined. We will coordinate with the EPA WAM for a decision on the format for submission. Following technical review and approval of the Plan by EPA, we will proceed to develop the watershed and reservoir models and their linkage for the Illinois River Watershed and Lake Tenkiller. We will thoroughly document model development, data development (derived from Task 3 and 5), and calibration/validation activities, as requested in the WA Request. All calculations, new coding, model setup, and assumptions and limitations will be clearly documented. Following the model calibration and validation, and in consultation with the EPA WAM, we will develop various point and nonpoint source scenarios to meet applicable water quality criteria.

### 4.4 Project Schedule

Table 1 provides a tentative list of the *major* project milestones and completion dates.

**Table1**. Project milestones and completion dates

| Project Milestone | Date for Completion |
|---|---|
| Kick off Meeting | Nov 20, 2009 |
| Federal Register Notice | Jan 19, 2010 |
| Final Illinois River Project QAPP | August 2010 |
| Final WQ Model Selection and Simulation Plan | October 2010 |
| Water Quality Modeling Completed | February 2011 |
| Publish Notice TMDL | August 2011 |
| TMDL Establishment | December 2011 |

## 5. Quality Objectives and Criteria for Model Inputs/Outputs

The Quality Assurance/Quality Control (QA/QC) goals for this work assignment are:

- Objectivity—all work should be based on a methodology and utilize a set of evaluation criteria that can be explicitly stated and applied.
- Thoroughness—all elements of the study should be carried out and documented in a thorough manner.
- Consistency—all work should be performed and documented in a consistent manner.
- Transparency—the documentation will make it clear the sources of the data used), the assumptions used in the modeling, and the results obtained.

USEPA (2000, 2002) emphasizes a systematic planning process to determine the type and quality of output needed from modeling projects. This begins with a Modeling Needs and Requirements Analysis, which includes the following components:

- Assess the need(s) of the modeling project
- Define the purpose and objectives of the model and the model output specifications
- Define the quality objectives to be associated with model outputs

The first item (needs assessment) is covered in EPA's Work Assignment Request. In essence, simulation models are needed to develop a scientifically robust and defensible watershed model to assess potential changes in phosphorus loads needed to improve the water quality in the Illinois River watershed. The existing watershed simulation models HSPF and SWAT and reservoir simulation models AQUATOX and EFDC are believed to be sufficient to this purpose, and creation of new models (i.e., model code) is not required.

EPA recognizes the value of performing holistic modeling of the Illinois River Watershed that includes consideration of Tenkiller Lake. Hence, the need exists for a linked modeling system that includes a reservoir simulation model. The quality objectives for the model(s) follow directly from the purposes and objectives. In general, the modeling effort needs to be designed to achieve an appropriate level of accuracy and certainty in answering the principal study question. This process takes into account the following elements:

- The accuracy and precision needed for the models to predict a given quantity at the application site of interest to satisfy study questions
- The appropriate criteria for making a determination of whether the models are accurate and precise enough on the basis of past general experience combined with site-specific knowledge and completeness of the conceptual models
- How the appropriate criteria would be used to determine whether model outputs achieve the needed quality

## 6. Special Training Requirements/Certification

AQUA TERRA's President is responsible for ensuring that all staff receive initial and periodic refresher training on the company's quality system and specialized quality-related training, as appropriate. (Note: Such training is provided by a Quality Assurance Officer with the appropriate technical specialties.) The President maintains documentation of staff training, as well as files on all personnel which contain any relevant qualifications, certifications, accreditations, and licenses.

All AQUA TERRA employees receive basic quality assurance training. The AQUA TERRA QMP is made available for employees to review. The awareness training includes a review of any changes that may have occurred in the AQUA TERRA QMP Plan.

The Work Assignment Leader (WAL) will be responsible for identifying the specific skills needed on this work assignment and for assigning staff with appropriate training, skills, and certifications. If special additional training requirements are identified, the WAL will be responsible for arranging for that training to take place prior to the start of the relevant task. (Currently, we do not anticipate the need for staff training in order to perform this work assignment, subject to the outcome of the model selection effort.)

This work assignment will be performed by staff having a strong technical background and extensive experience in environmental science, engineering and modeling. The Work Assignment Team will include experts for the models that are selected (see Section 4.3) for performing the Illinois River Basin modeling, most likely from among two watershed models (HSPF and SWAT) and two receiving water models (AQUATOX and EFDC). The staff devoted to this work assignment will be experienced in the issues and requirements involved in performing water quality modeling to support TMDL development.

## 7. Documentation and Records

A **document** is any written or pictorial information describing, defining, specifying, reporting, or certifying activities, requirements, procedures, or results. A **record** is a document that furnishes objective evidence of the items or activities and that has been verified and authenticated as technically complete and correct. Records may include photographs, drawings, magnetic tape, and other data-recording material. Generally speaking, *documents* comprise efforts that are complete and organized to describe the results of a significant element of the project effort, whereas *records* are more specific and limited data elements that often lack contextual explanation. Recognizing this distinction, products considered to be records will be archived at AQUA TERRA Consultants unless specifically requested by EPA Region 6. Products considered to be documents will be delivered to EPA Region 6 to be included in EPA's project archive.

The AQUA TERRA Work Assignment Leader, Tony Donigian, will be responsible for ensuring that all work assignment-related documents and records are managed in accordance with the procedures described below and elaborated upon in the contract QMP. Work assignment-specific documents or records will be clearly identified by:

- Title
- Author or responsible person
- Date
- Report or document number (if applicable)
- Work Assignment-related information (i.e., contract number, work assignment number, task or sub-task number, if applicable, and work assignment code)

Documents and records that will be collected and archived for the Illinois River modeling study include, but are not limited to:

Documents

- Work plan
- Project quality plans (e.g., the QAPP)
- Significant interim drafts and all review drafts and final drafts of all established deliverables (see Section 17 of this QAPP)
- Internal working papers, e.g. technical memos, spreadsheet analyses, GIS documents
- Peer review documents (if developed)

Records

- Interview notes
- Working notes and calculations
- Assessment results and findings
- Calibration data
- Data usability results
- Field notes
- Other records required for statutory or contract-specific compliance

All documents will be subject to review by the AQUA TERRA WAL to ensure their conformance with technical requirements and quality system requirements. Documents will be released to EPA Region 6 following authorization by the WAL and, when required, the QAO. The WAL shall ensure that records are developed, authenticated, and maintained to reflect the achievement of quality goals. Through adoption of these document-specific quality control procedures, AQUA TERRA intends to ensure that records and documents reflect completed work, in keeping with specifications of Section 3.6 of EPA QA/R-2.

Throughout the course of the work assignment, the work assignment-specific indexing and filing system will meet the following minimum performance specifications:

- All documents and records will be physically or electronically retrievable.
- Primary copies of all physical documents and records will be stored in filing cabinets or other appropriate storage space on AQUA TERRA's premises. Any backup copies of physical documents and records will be stored separately.
- Any documents subject to confidential business information (CBI) restrictions will be stored in strict accordance with AQUA TERRA's CBI plan.

All documents and records will be listed and identified with respect to retention schedules. All documents in the first list above (e.g., work plans; QAPPs) are subject to an automatic disposition schedule that requires their retention for 10 years, unless a longer time is required by the particular contract under which they were created or is required for other purposes. Within one month of their creation, all other documents and records will be classified for retention/disposition.

Upon completion of this work assignment, a complete set of all the documents and records will be appropriately filed for long-term storage.

If any change(s) in this QAPP are required during the study, a memo will be sent to each person on the distribution list describing the change(s), following approval by the appropriate persons. The memos will be attached to the QAPP. QA/QC activities, including periodic inspections that are made by the QA/QC officer to ensure that required procedures are being followed, will be logged and described in the final report. Deviations from planned procedures will be documented and corrective measures implemented. The report will also include a description of the types of WA records that were maintained and the WA documents that were prepared.

## 8. Model Calibration

Model calibration is the process of adjusting model inputs within acceptable limits until the resulting predictions give good correlation with observed data. Commonly, calibration begins with the best estimates for model input based on measurements and subsequent data analysis. Results from initial simulations are then used to improve the concepts of the system or to modify the values of the model input parameters. The use of calibrated models, the scientific veracity of which is well defined, is of paramount importance to this project. Because the goal is to develop a watershed model to determine reductions in phosphorus loads needed to improve water quality in the Illinois River, model calibration and validation should strive to minimize differences between model predictions and observed measurement data. Hence, the availability of abundant observed data is an essential element of successful calibration.

Likewise, the experience and judgment of the modelers will be a significant factor in calibrating the model(s) accurately and efficiently. The AQUA TERRA Work Assignment Leader will direct the model calibration efforts, and will be assisted by competent modelers that have significant experience with the model(s) which they are applying. Modeling procedures and model results will be routinely reviewed by senior-level modelers at AQUA TERRA, and will be subjected to additional review by EPA Region 6. Results will also be made available to States and interested stakeholders.

Further, the model should meet pre-specified quantitative measures of accuracy to establish its acceptability in answering the principal study questions.

The model calibration process proceeds through both qualitative and quantitative analyses. Qualitative measures of calibration progress are commonly based on the following:

- Graphical time-series plots of observed and predicted data
- Graphical transect plots of observed and predicted data at a given time interval
- Scatter plots of observed versus predicted values in which the deviation of points from a 45 degree straight line gives a sense of fit
- Tabulation of measured and predicted values and their deviations

After initially configuring the modeling systems, the WA Team will perform model calibration and validation. The watershed models will be calibrated to the best available data, including literature values, and interpolated or extrapolated values using existing field data. If multiple data sets are available, an appropriate time period and corresponding data set will be chosen on the basis of factors characterizing the data set, such as corresponding weather conditions, amount of data, and temporal and spatial variability of data.

A model is considered calibrated when it reproduces data within an acceptable level of accuracy, as described in Section 8.1 and itemized for watershed models in Table 2 (quantitative measures). The target level of accuracy for this project will be that which corresponds in Table 2 to ‘Good’ results. Accuracy targets are highly dependent on the amount and quality of available data, and consequently the targets will be finalized after the Data Gaps Analysis Report has been produced.

A set of parameters used in a calibrated model might not accurately represent field values, and the calibrated parameters might not represent the system under a different set of boundary conditions or hydrologic stresses. Therefore, a model validation period helps establish greater confidence in the calibration and the predictive capabilities of the model. A site-specific model is considered validated if its accuracy and predictive capability have been proven to be within acceptable limits of error independently of the calibration data.

**Table 2.** General percent error calibration/validation targets for watershed models (applicable to monthly, annual, and cumulative values) (Donigian 2000).

| | % Difference Between Simulated and Recorded Values | | |
|---|---|---|---|
| | Very Good | Good | Fair |
| Hydrology/Flow | < 10 | 10 - 15 | 15 - 25 |
| Sediment | < 20 | 20 - 30 | 30 - 45 |
| Water Temperature | < 7 | 8 – 12 | 13 - 18 |
| Water Quality/Nutrients | < 15 | 15 - 25 | 25 - 35 |

The two candidate watershed models for use in this study are sufficiently similar that they can share the same set of calibration targets that are presented in Table 2. However, the two candidate reservoir models differ significantly in process emphasis, and accordingly they share a common set of calibration targets. Furthermore, establishing realistic calibration targets for one of the models (EFDC) depends on the dimensional characterization (i.e., 1-D, 2-D or 3-D) that is employed in the model setup. Detailed discussions of realistic calibration targets for EFDC have been developed in previous modeling QAPPs such as that prepared for the Housatonic River PCB study (Beach et al., 2000).

The calibration philosophy applied for AQUATOX differs somewhat from the three models described above in that it does not utilize calibration targets per se. The calibration goal is to obtain a set of parameters, consistent across model segments that are in agreement with literature and laboratory values and reproduce the observed biomass and nutrient concentrations. The strategy is first to calibrate the ecosystem model and then the fate model. The premise is that mechanistic ecosystem and bioaccumulation models are intended for application to changing conditions and therefore should be general. Recognizing that it is difficult to obtain site-specific data for all ecosystem components, calibration of AQUATOX focuses on realistic ecosystem dynamics based on general principles and confirmed by those data that can be collected.

In general, model validation is performed using a data set separate from the calibration data. If only a single time series is available, the series may be split into two subseries, one for calibration and another for validation. If the model parameters are changed during the validation, this exercise becomes a second calibration, and the first calibration needs to be repeated to account for any changes. Representative stations will be used to guide parameter adjustment to get an accurate representation of the conditions of the individual subwatersheds and streams. The calibration and validation process will be documented for inclusion in the technical reports.

### 8.1 Specified Performance and Acceptance Criteria

**Watershed Model (HSPF or SWAT)**

Calibration and validation will be achieved by considering qualitative *and* quantitative measures, involving both graphical comparisons and statistical tests. For flow simulations where continuous records are available, all these techniques will be employed, and the same comparisons will be performed, during both the calibration and validation phases. Comparisons of values for simulated and observed state variables will be performed for daily, monthly, and annual values, in addition to flow-frequency duration assessments. Statistical procedures will include error statistics, correlation and model-fit efficiency coefficients, and goodness-of-fit tests, as appropriate. Figure 4 provides value ranges for both correlation coefficients (R) and coefficient of determination ($R^2$) for assessing model performance for both daily and monthly flows. The figure shows the range of values that may be appropriate for judging how well the model is performing based on the daily and monthly simulation results. As shown, the ranges for daily values are lower to reflect the difficulties in exactly duplicating the timing of flows, given the uncertainties in the timing of model inputs, mainly precipitation.

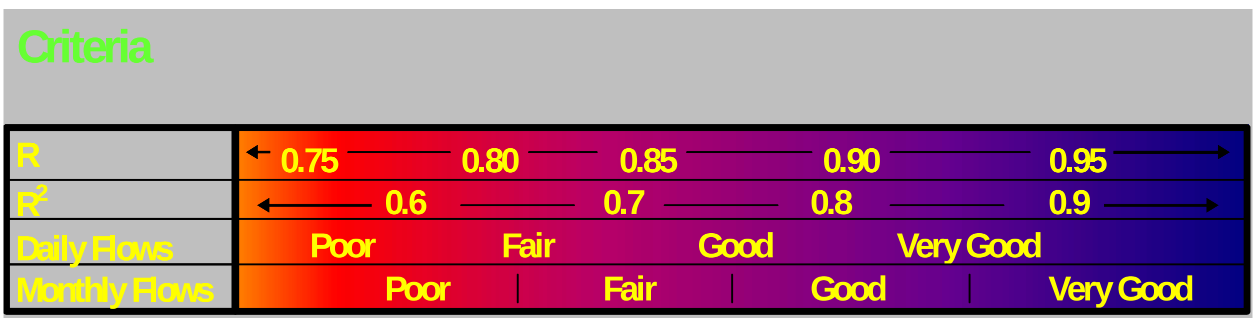


**Figure 4. R and $R^2$ value ranges for model performance (Donigian, 2002)**.

For water quality constituents, model performance will be based primarily on visual and graphical presentations as the frequency of observed data will likely be inadequate for accurate statistical measures.

Given the uncertain state-of-the-art in model performance criteria, the inherent errors in input and observed data, and the approximate nature of model formulations, **absolute** criteria for watershed model acceptance or rejection are not generally considered appropriate by most modeling professionals.

**EFDC**

The 2006 application of EFDC to Tenkiller Lake (Craig 2006) provides a customized weight-of evidence approach (Donigian, 2000; Donigian and Imhoff, 2009) to calibrating the model that is ideal for repeating and refining an EFDC application to support the current study. If EFDC is selected as the reservoir model for this work assignment, we will include the report authors (Dynamic Solutions, LLC) on our WA TEAM, and previously established performance and acceptance methods for EFDC will be utilized. The approach includes both (a) visual inspection of plots of model results compared to observed data sets (e.g., station time series or vertical profiles) and (b) analysis of model-data performance statistics. The "weight of evidence" approach recognizes that, as a numerical model approximation of a lake, perfect agreement between observed data and model results is not expected and is not specified as a performance criterion for model calibration. Model performance statistics are used, not as absolute criteria for acceptance of the lake model, but rather, as guidelines to supplement our visual inspection of model-data plots to determine appropriate endpoints for calibration of the lake model.

In evaluating the results obtained with the EFDC hydrodynamic model, a Relative RMS Error performance measure of $\pm 20\%$ is adopted for evaluation of the comparison of the model predicted results and observed measurements of water surface elevation of the lake. For the hydrographic state variables simulated with the EFDC hydrodynamic model, a Relative RMS Error performance measure of $\pm 50\%$ is adopted for evaluation of the comparison of the predicted results and observed measurements of salinity and water temperature. For the water quality state variables simulated with the EFDC water quality model, a Relative RMS Error performance measure of $\pm 20\%$ is adopted for dissolved oxygen; $\pm 50\%$ for nutrients and suspended solids; and $\pm 100\%$ for algal biomass for the evaluation of the comparison of the predicted results and observed water quality measurements for model calibration. These targets for hydrodynamic, sediment transport and water quality model performance are consistent with the range of model performance targets established for previous EFDC applications. Any model performance comparison of model results versus observed measurement yielding differences greater than the relative RMS errors listed above triggers a re-evaluation of all data used to construct the lake model to determine if (a) the input data is valid and needs to be revised or (b) the observed data sets are valid. If the input data requires revision, or if the observed data sets require modification, then the model input files and/or observed data files are revised, as needed, and the model re-run with the objective of achieving an acceptable comparison of model vs. observed data.

**AQUATOX**

If AQUATOX is selected as the reservoir model for this work assignment, we will include the model authors (EcoModeling, Warren Pinnacle) on our WA Team. Performance assessment for AQUATOX also utilizes a weight-of-evidence approach featuring the following sequence of increasingly rigorous tests to evaluate performance and build confidence in the model results:

- Reasonable behavior as demonstrated by time plots of key variables—is the model behavior reasonable based on general experience with aquatic ecosystems? This is highly subjective, but it provides a minimal level of confidence in representation of the seasonal dynamics of the river ecosystem.
- Visual inspections of data points compared to model plots—do the observations and predictions exhibit a reasonable concordance of values?

- Do point observations fall within predicted model bounds obtained through uncertainty analysis? (AQUATOX uses an efficient Latin hypercube sampling procedure to analyze uncertainty in model application.)
- Do model curves fall within the error bands of observed data? For some data, time series “box and whisker” plots showing ± 1 standard deviation are available.
- Does the model produce results that are free of systematic bias? In addition to the graphical analyses, mean error and mean percent error statistics will be calculated.
- Do the model results and observed data have similar distributions? Relative error might be used to compare means and variances of the model results and field data. However, it is not clear that there are sufficient data for Tenkiller Lake for application of this robust statistic.

An addendum to this QAPP will be developed and provided to all QAPP signees after the watershed and reservoir models have been selected for this study. The addendum will provide a revised Section 8 that elaborates the QA/QC calibration/validation procedures specific to the watershed model (most likely HSPF or SWAT) and the reservoir model (most likely AQUATOX or EFDC) that will be applied. As a courtesy, both the addendum to the QAPP and the Model Simulation Plan will be made available to the States and other interested stakeholders for their review and comments. The Simulation Plan will also contain specifics related to the following:

1. Model orientation and dimensionality
2. Stream network representation
3. Lake segmentation
4. Representation scheme for point and nonpoint sources
5. Representation scheme for weather
6. Modeled endpoint metrics for flow and water quality constituents
7. Simulation time step(s)

### 8.2 Model Linkage

Since both the HSPF and SWAT models allow a direct linkage to AQUATOX through the USEPA BASINS system, and HSPF has been linked to EFDC in the earlier Tenkiller Lake study (and in other studies), tested and validated model linkages already exist. Consequently, model linkage needs to be addressed as a component of the Simulation Plan but linkage procedures are well developed for these models.

## 9. Data Acquisition Requirements

Data quality objectives (DQOs) are qualitative and quantitative statements that clarify the intended use of the data, define the type of data needed to support the decision, identify the conditions under which the data should be collected, and specify tolerable limits on the probability of making a decision error due to uncertainty in the data (if applicable). Data users develop DQOs to specify the data quality needed to support specific decisions.

The following DQO for streamflow is an example of one that will be adopted for this study:

> We will primarily use flow data identified with a 'Good' rating by the USGS, which corresponds to 95% of daily values being within 10%. If data of lesser quality is used, due to sparse coverage, data limitations, etc,, it will be identified and treated with greater caution.

Definition of explicit, achievable DQOs is dependent upon the abundance and types of relevant data. The work that will be performed in this study to produce the Data Gaps Analysis Report will enable refinement of the DQOs. DQOs for data types other than streamflow will be established and reported in an addendum to the QAPP and as an element of the Model Simulation Plan.

Data of known and documented quality are essential to the success of any water quality modeling study, which in turn generates data to use in establishing watershed management strategies. The Work Assignment Team will accomplish model setup, calibration, and validation for the work assignment governed by this QAPP using data available from other studies. The QA process for this work assignment consists of using appropriate data, data analysis procedures, modeling methodology and technology, administrative procedures, and auditing. To a large extent, the quality of a modeling study is determined by the expertise of the modeling and quality assessment teams. AQUA TERRA will address quality objectives and criteria for input/output data in the context of: (1) evaluating the quality of the data used and (2) assessing the results of the model application.

The quality of an environmental analysis program is achieved by means of three steps: (1) establishing scientific assessment quality objectives, (2) evaluating program design for whether the objectives can be met, and (3) establishing assessment and measurement quality objectives that can be used to evaluate the appropriateness of the methods used in the program. The quality of a data set is a measure of the types and amount of error associated with the data.

Sections 5.0 and 9.0 of this QAPP describe DQOs and criteria for model inputs and outputs for this WA, written in accordance with *EPA's Guidance for the Data Quality Objectives Process* (EPA QA/G-4) (USEPA 2000).

### 9.1 Review of Secondary Data

Secondary data will be used to test and verify the correctness and accuracy of the models. Secondary data are data collected by EPA for another purpose, or collected by an organization or organizations not under the direction of EPA, that are useful to support the development of the models. The Work Assignment Team will review available data for applicability to each model used in this WA. We will use secondary and third-party data collected through our in-house databases and data received from other sources, including data from EPA, USGS, USDA, NOAA, U.S. Census Bureau, States, universities and other local agencies.

The quality of a data set is a measure of the type and amount of error associated with the data. Sources of error are commonly grouped into two categories: sampling error and measurement error: These kinds of errors, as well as processing errors, can affect the accuracy and interpretation of results. For various reasons it is possible that not all secondary data evaluated for potential use in developing, calibrating and testing the models will be judged acceptable for uses to support this work assignment. The data acquisition procedures that will be followed for this WA include database review and management practices that will reduce sources of error and uncertainty in the use of the data. AQUA TERRA, in consultation with the EPA WAM, will determine the factors to be evaluated to assess whether the data provided by a secondary source are acceptable for use in developing, calibrating or testing the models for this work assignment. The Work Assignment Team will use the following general approach to evaluate the quality of secondary data to support the watershed modeling:

- Maintain a continuing dialog with the EPA WAM on technical data issues
- Establish appropriate data quality targets while recognizing the limits of the data
- Document and present the decisions and results

Currently, it is anticipated that most data used in the WA will have been collected or developed by a variety of sources commonly used for watershed model development. Often these data will be available in electronic format and will include *metadata* that will be valuable for assessing the QA/QC imposed on the data collection and processing. In cases where multiple sources of data are available, the Work Assignment Team will use the best available data with the highest quality. Data of unknown quality will be incorporated into the model only if approved by the EPA WAM, and the data's inclusion status will be documented. If there is no information available regarding the data, the data will either not be used or qualified with, "The quality of this specific secondary data set used in developing the watershed model could not be determined." The designated Points of Contact for the States of Arkansas and Oklahoma have agreed to participate in identifying and perhaps providing secondary data to support the Work Assignment. At the kickoff meeting on 20 November 2009 it was agreed that data provided by the States would be accompanied by QA/QC data describing its creation.

On 19 January 2010 a Call for Data was published in the Federal Register requesting that data relevant to this project be submitted before 3 March 2010. By that time, the State POCs will send the EPA WAM a list of data/sources available to support this work assignment. The EPA WAM and Region 6 TMDL Section Chief will synthesize an integrated list of the available data and provide it to the Work Assignment Team as a starting point for acquiring supplemental data. Both time-variable (e.g. point sources) and GIS data (Task 4) will be identified and acquired.

Data gaps will be identified (Section 4.1). Data of unknown quality will be considered data gaps, and will be identified as a component of the Data Gaps Analysis Report. The report will also summarize the type and source of all data sets that we have judged acceptable and useful for the water quality modeling effort(s).

The Work Assignment Team will retrieve secondary data from its in-house databases by downloading from high-quality federal data sources. Information from studies and surveys found to be of unacceptable quality will not be used to supplement model development. The Simulation Plan (see Section 4.3) will describe the data used for model development, the time period during which the data were collected, and the quality requirements of the data, as appropriate.

The data quality objectives for this work assignment will encompass aspects of both laboratory analytical results obtained as secondary data and database management to reduce sources of errors and uncertainty in the use of the data. Data commonly required for populating a database for use in calibrating watershed models are listed in Table 3. The data listed in the table are exemplary, and as such are not intended to be all-inclusive.

Whenever possible, the Work Assignment Team will download secondary data electronically from various sources to reduce the possibility of introducing errors during data entry. Secondary data will be organized into a standard model application database. The Work Assignment Team will use a screening process to scan through the database and flag data that are outside typical ranges for the site for a given parameter; the WA Team will not use values outside typical ranges to develop model calibration data sets or model kinetic parameters. For data that will be used in the models, the source of the data, the time period for which the data were collected, and an indication of how the data will be used will be included in the Data Gaps Analysis Report and the Model Simulation Plan. The Data Gaps Report will identify, inventory, and document (with attributes) the data received with respect to the originating source agencies, time periods, data types, and available QA/QC documentation. The Model Simulation Plan will further document the specific data planned for use in both model setup and calibration/validation efforts, since these aspects of the model application cannot be detailed until after model selection. As the modeling effort proceeds, project reporting will include identification of the data sources used in each step of the model application process, e.g., the GIS coverages used in model setup, the meteorologic data used to drive the model, the point source loading data used as model input, and the observed data used in model calibration and validation.

## 9.2 Data Sources Performance and Acceptance Criteria

Data to be used as input to the modeling effort will be judged acceptable for their intended use if they meet acceptance criteria. As described above, the WA Team, in consultation with the EPA WAM, will establish the factors that will be considered to determine whether the data provided in secondary sources are acceptable for use in developing, calibrating, or testing the models for this WA. Acceptance criteria that will be used for this WA will include data reasonableness, completeness, representativeness, and comparability.

- Data reasonableness: Data sets will be checked for reasonableness. For example, flow gaging data obtained form USGS have undergone quality review for reasonableness. This is not always the case for water quality data, and accordingly graphical methods will be used to evaluate potential anomalous entries that may represent data entry or analytical errors. In addition, all dates will be checked through queries to ensure that no mistyped dates and corresponding information are loaded into the models without clarification from the agency from which the data were collected.
- Data completeness: Data sets will be checked to determine if any data are missing. In any complex model study, it is inevitable that there will be some data gaps. These data gaps and the assumptions used in filling the gaps will be documented for inclusion in the technical reports.
- Data representativeness: Data sets will be checked for representativeness of geospatial data. Sampling station data will be checked through queries and mapping in an effort to avoid loading mistyped geospatial data (e.g., locations outside the watershed) and corresponding information into the models without clarification from the agency from which the data were collected. In addition, acceptance criteria will be collected from available QAPPs, sampling and analysis plans, standard operating procedures (SOPs), laboratory reports, and other correspondence for a given source of measurement data. The data assessment and quality guidelines associated with a given type of measurement will be developed from these sources and included in the Simulation Plan (see Section 5.3). The data will be reviewed and compared with the performance and acceptance criteria in this QAPP. Data not meeting the acceptance criteria requirements

will be rejected and their status documented, as deemed appropriate by the EPA WAM and the AQUA TERRA WAL.

- Data comparability: Data sets will be checked with respect to variables of interest, commonality of units of measurement, and similarity in analytical and QA procedures. The WA Team will ensure additional comparability of data by similarity in geographic, seasonal, and sampling method characteristics.

**Table 3.** Secondary environmental data to be assembled for watershed and water quality modeling in the Illinois River Basin.

| Data type | Example measurement endpoint(s) or units |
|---|---|
| *Geographic or location information (typically in GIS format)* | |
| Hydrologic unit code (HUC) boundaries | shapefile map |
| Hydrography | shapefile map |
| Land use | shapefile map, acres |
| Topography | digital elevation model, meters |
| Population distributions | shapefile map, number |
| Soils (including soil characteristics) | shapefile map, hydrologic group, etc. |
| Water quality and biological monitoring statio | latitude and longitude, decimal degrees |
| Permitted point source discharge locations | latitude and longitude, decimal degrees |
| Dam locations | latitude and longitude, decimal degrees |
| *Flow* | |
| Historical record (daily) | cfs |
| Peak flows (daily maximum) | cfs |
| Storm hydrographs (hourly or less) | cfs |
| *Meteorological data* | |
| Rainfall | inches |
| Temperature | °C |
| Potential evapotranspiration | inches |
| Wind speed | miles per hour |
| Dew point | °C |
| Humidity | percent or grams per cubic meter |
| Cloud cover | percent |
| Solar radiation | watts per square meter |
| *Water quality (surface water, ground water)* | |
| Total suspended sediment (TSS) | mg/L |
| Nutrient concentrations | mg/L |
| Permit limits | flow, cfs and concentration, mg/L, µg/L |
| *Additional anecdotal information as appropriate* | |

## 10. Data Management

As indicated in Section 4.2, EPA's BASINS modeling system will be a significant source of data to support this project, regardless of the models that are selected for application. The BASINS modeling system contains a vast number of data types relevant to environmental characterization and analyses that are performed using BASINS' tools and models. Among these are:

- Hydrologic unit boundaries
- Major roads
- Populated place locations
- Urbanized areas
- State and county boundaries
- EPA regions
- Ecoregions Level III
- NAWQA study unit boundaries
- Clean Water Needs Survey
- STATSGO
- Managed Area Database
- Reach File Version 1
- Reach File Version 3
- National Hydrography Dataset
- Digital Elevation Model
- Land Use and Land Cover
- National Inventory of Dams
- Water Quality Monitoring Stations and Data Summaries
- Bacteria Monitoring Stations and Data Summary
- Water Quality Stations and Observation Data
- National Sediment Inventory Stations and Database
- Listing of Fish and Wildlife Advisories
- Weather Station Sites
- Gage Sites
- Drinking Water Supply Sites
- Watershed Data Stations and Database
- Classified Shellfish Areas
- Permit Compliance System Sites and Computed Annual Loadings
- Industrial Facilities Discharge Sites
- Toxic Release Inventory Sites and Pollutant Release Data
- Superfund National Priority List Sites
- Resource Conservation and Recovery Information System Sites
- Minerals Availability System/Mineral Industry Location System

### 10.1 Inherited QA for Source Data

Metadata is used to describe the pedigree of the source data. As spatial data is re-projected or otherwise updated, additions will be made to the metadata. Data created within BASINS will have metadata produced as part of the creation process.

### 10.2 Data Download

Given the vast number of data types and data sources relevant to the environmental characterization and analyses that will be performed for the Illinois River project using BASINS' tools and models, there will be a need to expand the data sets available for the project, and to update the values contained in already existing data sets. The primary mechanism for doing this is using electronic downloading. Quality assurance considerations involved in downloading are described below and include:

- Preventing errors
- Detecting errors
- Correcting errors

The BASINS system includes a tool, known as the BASINS Data Download tool, for downloading and extracting a set of databases that facilitate watershed analysis and modeling. Some of the data downloaded using this tool has been preprocessed for use in BASINS. These prepared data are known collectively as the BASINS data holdings. Other data that can be downloaded using the Data Download tool have not been preprocessed and are extracted directly from the agency responsible for collecting the data.

These national databases, hosted on an EPA web server, were compiled from a wide range of federal sources and selected for inclusion in BASINS based on relevance to environmental analysis. The data prepared for BASINS provide a starting point for the Illinois River analysis, but the modeling effort will also take advantage of additional data sets where locally derived data may be at a higher resolution, compiled more recently, or unique to the Illinois River Basin.

The BASINS databases are compiled into compressed files according to geographic location, according to the 8-digit Hydrologic Unit Codes (HUCs) established for the United States by the USGS. BASINS applications such as that for the Illinois River begin a project by specifying one or more HUCs of interest, and data for those HUCs are downloaded and extracted for the project.

The BASINS system also includes a tool for dynamically downloading data from an additional set of sources. In addition to downloading the BASINS data from the EPA web server, the Data Download tool provides links to the federal agencies where certain data types are hosted, as well as tools to download the data and convert it into forms usable by BASINS. Since data available on the web are not static, this tool will allow checking for more recent data and updating the Illinois River project data as appropriate.

When the Web Data Download tool is started, a window appears listing all of the available data types that the tool may add or update. The list of data types is determined at run-time, so this list may expand as new data-type components are created. The user chooses as many of the data types as desired, and the tool accesses the specified data through the World Wide Web and adds the data to the BASINS project.

Data types that are available for dynamic download include USGS flow data, the EPA Permit Compliance System (PCS) discharge data, the modernized EPA Storet system, the USGS water quality data, the National Hydrography Dataset, and the National Land Cover Database.

**Preventing Errors in Download**

The primary type of error that can occur during data download is an error connecting to the web server or in retrieving the data. The administrator of the EPA web server is responsible for maintaining the web server for the BASINS data holdings, and as such for this type of data the prevention of this type of problem is not within AQUA TERRA's domain. Changes to web addresses of the dynamic types of BASINS data can occur. To address these types of errors, in the event of a connection failure the data download tool connects to an alternate location to see if the requested address has been changed. In this way the request can be redirected, and while there may have been an error in the original connection, the user does not perceive of any problem.

**Detecting Errors in Download**

The primary means of detecting errors in downloaded data is provided through the protocols under which the world-wide-web operates. An incomplete file download is detected and an on-screen message is displayed alerting the user to an incomplete or failed download attempt. Since many of the data types are downloaded in a compressed (or zipped) format, an error during download would result in a file that cannot be uncompressed. If a downloaded file cannot be uncompressed the system is going to alert the user to that problem.
Data downloaded for the Illinois River project other than that supplied through the data download tool will be checked for accuracy by using other methods/tools provided by BASINS. The BASINS GIS and data display tools will assist in verifying that the data downloaded accurately represents the data intended.

**Correcting Errors in Download**

Errors in the web address for any dynamic BASINS data are corrected through an automated update checking system included as part of the core BASINS package. The update checking software runs the first time the BASINS software is started on any day, and if updates are available the user is prompted to download and install those updates. The most common type of update installed through this process is the correction of a web address. Once the download address has been corrected the user may re-download the data.

### 10.3 Data Manipulation

Two types of data will be integrated into BASINS to support the Illinois River project: GIS data and timeseries data. Both types of data change format as they are loaded into a project, and thus are subject to possible errors. New data types added to BASINS are also subject to these types of errors. Considerations involved in data manipulation are described below and include:

- Preventing errors
- Detecting errors
- Correcting errors

**Preventing Errors in Manipulation**

Errors in data manipulation are minimized through BASINS by automating the data manipulation processes. GIS data are projected automatically using a standard projection library. When a new type of GIS data is added to a project, BASINS automatically changes the projection of that data to match the projection of the project. When timeseries data are downloaded, they are imported into the standard BASINS database formats automatically. Having these processes occur automatically minimizes the mistakes that could occur during this process.

**Detecting Errors in Manipulation**

When a new dataset is processed for adding to BASINS, the data at the end of the process are checked versus the data at the beginning of the process to ensure accuracy. GIS and timeseries data are checked visually. If the new dataset is very large, the manipulation processes are automated by writing and testing software scripts. We will visually inspect all of the data for a selected sub-set of the dataset during testing of the software scripts. If that test succeeds the software is run as a 'production run' for manipulating the entire data set.

After the production run, we verify that the results exactly duplicate what was produced during software testing. Usually this verification is accomplished using comparison software such as 'Beyond Compare'. If that verification holds, we begin to visually cross-check a small portion of the data. Typically we would visually inspect all of the data for a second sub-set of the dataset during this phase as well, and then we visually cross-check a small portion of the manipulated data records, perhaps one per thousand, throughout the entire data set. If at any point in the process errors are found the entire process must be re-run. If re-run, at the end of that process the visual cross-check is performed again. When no errors are found the checking is ceased.

**Correcting Errors in Manipulation**

Since the manipulation processes are performed in an automated manner, using custom computer software scripts, the fixes are accomplished by fixing the automated conversion software. After the software has been corrected the entire visual check process is performed again.

### 10.4 Documentation of Data QA/QC Procedures and Activities

For dynamic datasets that are added at runtime by a BASINS user, the written documentation consists of the log file generated during the download process. The log file contains information such as where the data was downloaded from, the name of the new file where it is being stored, and any intermediate processing steps that may have been performed for that dataset.

When a very large new dataset is processed for adding to BASINS, the primary documentation of the procedure is the custom computer code that did the automated processing, with its integrated comments. That code serves as a written record showing exactly how that data were processed.

## 11. Hardware/Software Configuration

The requirement for this section of the QAPP is to provide information on the types of computer equipment, hardware, and software to be used on the project, including information on how they will be used (e.g., for conducting the specified data management procedures). The necessary hardware/software configurations for the Illinois River project cannot be specified until the models that will be applied in the project have been selected and the approach to applying them and linking them has been developed and described in the Simulation Plan. Accordingly, the specification of the configuration(s) that will be used in this project will be an element included in the Modeling QAPP addendum.

## 12. Assessment and Oversight Actions

As described in Section 9, non-project-generated data will be used for model development and calibration. The DQOs were discussed in Section 5 of this document. Modelers will cross-check data for bias, outliers, normality, completeness, precision, accuracy, and other potential problems. Data generated outside the WA will be obtained primarily from quality-assured databases maintained by USEPA, USGS, and other entities. Additional data may be obtained from either published or non-published sources. The published data will have some degree or form of peer review. Typically, modelers examine these data as part of a data quality assessment. Unpublished databases are also examined in light of a data quality assessment. Data provided by EPA or other sources will be assumed to meet precision objectives established by those entities.

The QA program under which this work assignment will operate includes surveillance, with independent checks of the secondary data that will be used for modeling. (No field data collection is planned or expected in this WA.) The essential steps in the QA program are as follows:

- Identify and define the problem
- Assign responsibility for investigating the problem
- Investigate and determine the cause of the problem
- Assign and accept responsibility for implementing appropriate corrective action
- Establish the effectiveness of and implement the corrective action
- Verify that the corrective action has eliminated the problem

The model calibration procedure is discussed in Section 8. Model results will generally be checked by comparing results to those obtained by other models or by comparing them to hand calculations. Visualization of model results will help determine whether model simulations are realistic. Model calculations will be compared to field data. If adjustments to model parameters are made to obtain a fit to the data, the modelers will provided an explanation and justification that must agree with scientific knowledge and fit within reasonable ranges of process rates as found in the literature. Performing control calculations and post-simulation validation of predictions are also major components of the QA process.

Many of the possible technical problems can be solved on the spot by staff, for example, by modifying the technical approach or correcting errors or deficiencies in implementation of the approach. Immediate corrective actions are considered standard operating procedures, and they are noted in records for the WA. Problems that cannot be solved in this way require more formalized, long-term corrective action.

If quality problems that require attention are identified, AQUA TERRA will determine whether attaining acceptable quality requires either short- or long-term actions. If a failure in an analytical system occurs (e.g., performance requirements are not met), the WA Team technical modelers will be responsible for corrective action and will immediately inform the AQUA TERRA QAO, as appropriate. Subsequent steps taken will depend on the nature and significance of the problem.

The AQUA TERRA WAL has primary responsibility for monitoring the activities of this WA and identifying or confirming any quality problems. He will also bring these problems to the attention of the QAO, who will initiate the corrective action system described above, document the nature of the problem, and ensure that the recommended corrective action is carried out.

The EPA WAM and AQUA TERRA Technical Monitor and WAL will be notified of major corrective actions. Corrective actions can include the following:

- Re-emphasizing to staff the WA objectives, the limitations in scope and/or budget, the need to adhere to the agreed-upon schedule and procedures, and the need to document QA and QC activities
- Securing additional commitment of staff time to devote to the WA
- Retaining outside consultants to review problems in specialized technical areas
- Changing procedures

Performance audits are quantitative checks on different segments of WA activities; they are appropriate for data analysis, data-processing and modeling activities. The AQUA TERRA QAO is responsible for periodically implementing internal assessments during the data entry and analysis phases of the WA. As data entries, model codes, calculations, or other activities are checked, the AQUA TERRA QAO will sign and date a hard copy of the material, as appropriate, and provide this to the AQUA TERRA WAL for inclusion in the administrative record. Additional performance audits will consist of comparisons of model results with observed historical data.

Subject to the concurrence of the EPA WAM, the AQUA TERRA WAL may perform or oversee the following qualitative and quantitative assessments of model performance periodically to ensure that the model is performing the required task while meeting the quality objectives:

- Data acquisition assessments
- Model calibration studies
- Sensitivity analyses
- Uncertainty analyses
- Data quality assessments
- Model evaluations
- Internal peer reviews

Internal peer reviews, as needed, will be documented in the WA and QAPP files. Documentation will include the names, titles, and positions of the peer reviewers, their report findings, and the WA management's documented responses to their findings.

The AQUA TERRA WAL will perform surveillance activities throughout the duration of the WA to ensure that management and technical aspects are being properly implemented according to the schedule and quality requirements specified in this QAPP and the approved work plan. These surveillance activities will include assessing how WA milestones are achieved and documented; corrective actions implemented; budgets adhered to; peer reviews performed; data managed; and whether computers, software, and data are acquired in a timely manner.

System audits are qualitative reviews of WA activity to check that the overall quality program is functioning, and that the appropriate QC measures identified in the QAPP are being implemented. If requested by the EPA WAM, and additional funding is provided by EPA, the AQUA TERRA QAO or designee will conduct an internal system audit of the WA and report results to the EPA WAM and the AQUA TERRA WAL.

Critical to the implementation of any quality system is promoting and retaining an environment conducive to open and frank communication among members of the quality and technical staff. To that end, QA/QC responsibilities and authority are distributed throughout the various functional contribution teams comprised of work assignment technical staff as well as with the quality assurance staff. When disputes regarding quality system policies, procedures, or requirements arise which are not readily resolved at the lowest management level possible (closest to the issue), senior-level staff will be notified to ensure objectivity and to preserve the independence of the quality management organization in the resolution of those issues. This approach ensures that the needs of the Work Assignment Team are included in the consideration of the satisfaction and compliance with quality policy or requirements. Final authority to resolve disputes involving AQUA TERRA quality system issues lies with the Principal-in-Charge with the assistance of the Quality Assurance Officer. It should be noted that dispute resolution entails engagement of the Assessment and Response processes. Responses to disputes are based on corrective action investigation and findings and remedy options. Level of escalation and rate of recurrence dictate whether significant corrective actions should include modification of policies described in the BASINS QMP or work assignment-specific quality guidance (QAPP).

## 13. Reports to Management

In order to successfully perform this work assignment, there is a need for close and frequent communication between the individuals indicated in the work assignment organizational chart (Figure 1). This communication will be achieved by continually exercising the lines of communication that are indicated in that figure. As part of the standard reporting requirements of this EPA contract, AQUA TERRA will provide a written monthly progress report by the 15$^{th}$ of each month during the performance period of the work assignment. This report will include a progress report on each task and issues or problems that are encountered.

In addition to monthly written progress reports, we will communicate frequently via e-mail and fax to assure that all Work Assignment Team members are kept current. As needed, these verbal communications will be supplemented by development and distribution of technical memoranda presenting results of software tests, model performance evaluations, and other assessments such as output data quality assessments, significant quality assurance problems and recommended solutions. When deemed necessary, we will follow up electronic communications with phone calls in order to resolve remaining issues. An additional opportunity for communication and resolution of QA issues will be presented by the discussion and feedback occurring at each of the project breakpoints that are identified in Section 17.

## 14. Departures from Validation Criteria

Along with Section 15 (Validation Methods), this element of the QAPP describes the acceptance criteria presented in Section 5 (Quality Objectives and Criteria for Model Inputs/Outputs), which evaluate the model and its components based on its ability to produce results that can be used to achieve project objectives. For example, this element would state acceptance criteria associated with the degree to which each model output item has met its quality specifications. The possible types of discrepancies that may arise when the acceptance criteria and other QAPP specifications are not met in their entirety are also addressed, along with the effects that such discrepancies are likely to have on the outcome of the model development and application processes.

Section 5 notes that:

> Definition of explicit, achievable quality objectives and calibration and validation targets is dependent upon the abundance of relevant data, the selection of model(s) and the intended use of the model(s). The work that will be performed in this study to produce the Data Gaps Analysis Report and the Model Simulation Plan will enable refinement of these elements of the QAPP, and will be integrated into the QAPP as an addendum.

By necessity the evaluation of the models' ultimate success in meeting quality objectives and criteria cannot be achieved until a later stage of the project when the quality objectives and criteria have been established. A methodology for making this evaluation will be included in the Modeling QAPP addendum. The review process will be described for each component of the Illinois River Watershed model.

## 15. Validation Methods

The purpose of this element is to describe, in detail, the process for making a final assessment of whether model components and their outputs satisfy the requirements specified throughout the QAPP. The appropriate methods of evaluation will be determined by the quality objectives developed first in general terms in Section 5 (Quality Objectives and Criteria for Model Inputs/Outputs), and later in more detail in the Modeling QAPP addendum.

Evaluation of whether model components and their outputs are satisfying the DQOs will be an ongoing process during the model calibration and validation stage of the project. In-progress assessments of validation issues will be discussed between a team including both technical and QA representatives from EPA and AQUA TERRA. The authority for resolving validation issues will be the Approving Quality Assurance Official for EPA

Region 6 (see Section 1). The results of performing evaluations will be logged and integrated into the project documentation at the conclusion of the project.

Given the dependency of the topics and procedures addressed by this section on those described in Sections 5 and 14 above, Section 15 will be re-visited and expanded as an element of the Modeling QAPP addendum.

## 16. Reconciliation with User Requirements

The purpose this element is to outline and specify, if possible, methods for evaluating (relative to project requirements) the model outputs that the project generates. These methods include scientific evaluations of the model predictions to determine if they are of the right type, quantity, and quality to support their intended use. This element discusses the procedures in place to determine whether the final set of model results meets the requirements for the data quality assessment. This element should also discuss how departures from the underlying assumptions or output criteria associated with statistical procedures applied in the data quality assessment will be addressed, the possible effects of departures from assumptions or specified output criteria on the model results, and what potential modifications will need to be made to adjust for these departures. Finally, the discussion should specify model limitations that may impact the usability of the results.

By necessity an approach to evaluating whether model predictions are of the right type, quantity, and quality to support their intended use cannot be achieved until a later stage of the project when (1) the quality objectives and criteria have been established and (2) the models that will be applied have been selected. Accordingly, a methodology for making this evaluation will be included in the Modeling QAPP addendum. The results of the evaluation will be reported as an element of the project documentation at the conclusion of the project.

## 17. Project Breakpoints

The effort that has been defined for the initial period of this work assignment (26 October 2009 to 31 March 2010) features a series of well defined deliverables, each of which provides the EPA with opportunity to either approve products and decisions, or to request changes:

1. The Work Plan
2. This Quality Assurance Project Plan (QAPP)
3. Data Gaps Analysis Report
4. Preliminary Version GIS Database
5. Final Version GIS Database
6. Draft Simulation Plan
7. Model Development Status Report

By considering and responding to these products, EPA personnel will be an integral part of the Work Assignment, providing supplemental quality control.

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