Data Review and Analysis for Water Quality Modeling and TMDL Development for the Illinois River Watershed

FINAL REPORT

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EXECUTIVE SUMMARY

The Illinois River is a multi-jurisdictional tributary of the Arkansas River, approximately 160 miles long, in the states of Arkansas and Oklahoma. The objective of this study is to develop a scientifically robust and defensible watershed model to determine reductions in phosphorus loads needed to meet water quality standards in both states, Arkansas and Oklahoma. This watershed model will serve as a tool for sound technical decisions on appropriate point and nonpoint source controls to meet those standards. Ultimately, the intent is development of a tool that can lead to scientifically sound TMDLs and a basin-wide water quality restoration plan.

A tremendous amount of data, reports, and information has been provided to EPA Region 6 for use in this study as a result of initial data requests and acquisition efforts, and subsequent responses from the State and federal agencies and other stakeholders. This includes both time-variable (e.g. meteorologic data, stream flow, water quality, point sources) and GIS data (e.g., land use, topography, hydrography), along with an extensive array of reports and studies performed on or within the Illinois River Watershed. In addition, this information has also provided citations for other supplemental reports and studies identified through online searches and investigations.

The purpose of this report is to describe and document the extent and results of these data gathering efforts, compare this accumulated data and information to the data requirements for watershed and waterbody modeling in the IRW, and thereby identify any critical data gaps, or deficiencies, which might impact, or ultimately inhibit, water quality model development for the IRW. In addition, this report allows the designated State Points-of-Contact (POCs), other state and federal agencies, and other stakeholders to assess and evaluate whether any relevant data and information has not been identified and is still outstanding.

As a compilation and synthesis of the available data, this report provides the foundation for the development of the Simulation Plan (AQUA TERRA Consultants, 2011), which was recently released as a draft for review and comment by stakeholders and the public. The Simulation Plan provides an overview of the model selection effort and the selected models – both watershed and waterbody models – and includes details of the model application effort, including the calibration and validation time periods, constituents to be simulated, model scales and resolution, model performance targets, and an initial investigation of scenarios to be investigated as part of the TMDL development procedure. Thus, this data report should be viewed as a companion and supporting document to the Simulation Plan. Note that additional data needs may be identified as we continue to review and analyze the compendium of reports and data that have been provided to date.

At the time of the Draft Data Report (August 2010b), a number of deficiencies were identified for spatially characterizing selected conditions within the IRW. At that time, the deficiencies included the following:

a. NRCS hydrologic soil groups (HSG)
b. More recent land use/cover data
c. Locations of known karst formations
d. Animal Populations and Distribution
e. Fertilizer and Manure Applications
f. Soil Nutrient Concentrations

Items a and b have been resolved with the development of a HSG map, and the release of the 2006 NLCD data layer, as discussed herein. We believe we have all the available data and information on karst conditions (Item c) and have developed a path forward for their consideration in the modeling effort (see the Simulation Plan. Items d, e, and f remain as issues currently being investigated, as discussed in the Simulation Plan. Both ODAFF and ANRC have provided data and information related to these items, in various forms. ODAFF has provided GIS data for many of these data needs, and both agencies have provided a considerable amount of data in tabular form, and on a county basis. In a number of the reports received, we have noted spatial displays of different animal groups, fertilizer/manure applications, and soil nutrients throughout the watershed, but have not been able to locate corresponding GIS coverages. We are continuing to investigate a number of sources, in concert with the agencies noted above, as the modeling effort moves forward.

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SECTION 1.0

INTRODUCTION

1.1 BACKGROUND AND STUDY OBJECTIVES

The Illinois River is a multi-jurisdictional tributary of the Arkansas River, approximately 160 miles long, in the states of Arkansas and Oklahoma. The objective of this study is to develop a scientifically robust and defensible watershed model to determine reductions in phosphorus loads needed to meet water quality standards in both states, Arkansas and Oklahoma. This watershed model will serve as a tool for sound technical decisions on appropriate point and nonpoint source controls to meet those standards. Ultimately, the intent is development of a tool that can lead to scientifically sound TMDLs and a basin-wide water quality restoration plan.

The U.S. Environmental Protection Agency's (EPA's) Region 6 is funding this project through numerous Work Assignments titled -- Water Quality Modeling and TMDL Development for the Illinois River Watershed -- under EPA's BASINS Contract (# EP-C-06-029) with AQUA TERRA Consultants, Mountain View, California. Additional resources have been provided through a direct contract with EPA Region 6 (PO# EP-11-000023). AQUA TERRA conducts 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 the Quality Assurance Project Plan (QAPP) developed for this effort (AQUA TERRA Consultants, 2010a).

The Illinois River begins in the Ozark Mountains in the northwest corner of Arkansas, and flows for 50 miles west into northeastern Oklahoma (See Figure 1.1). 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. A portion of the Arkansas section of the Illinois River is designated as an Ecologically Sensitive Waterway (e.g. presence of Neosho Mucket, a freshwater mussel) and is a perennial fishery supporting a diverse community of indigenous fish including smallmouth bass. 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 (See Figure 1.2).

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. On 4 February 2010, EPA organized meetings in Fort Smith AR with the core state and federal agencies participating in the study, and with local stakeholder groups. These meetings provided an overview of the project and its objectives, and further elaborated on the data needs included in the FR Call for Data. Following

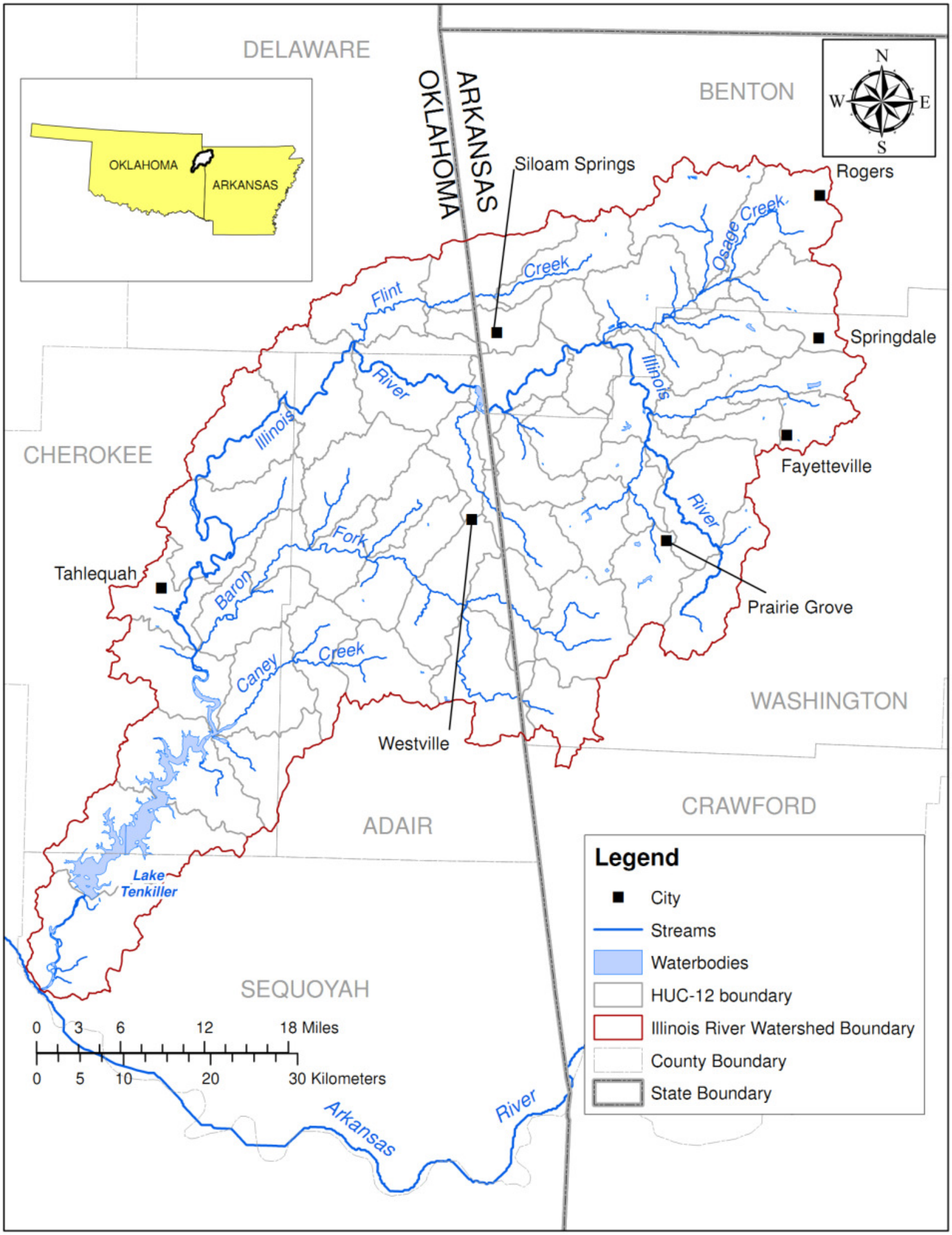


Figure 1.1 Illinois River Watershed Location Map

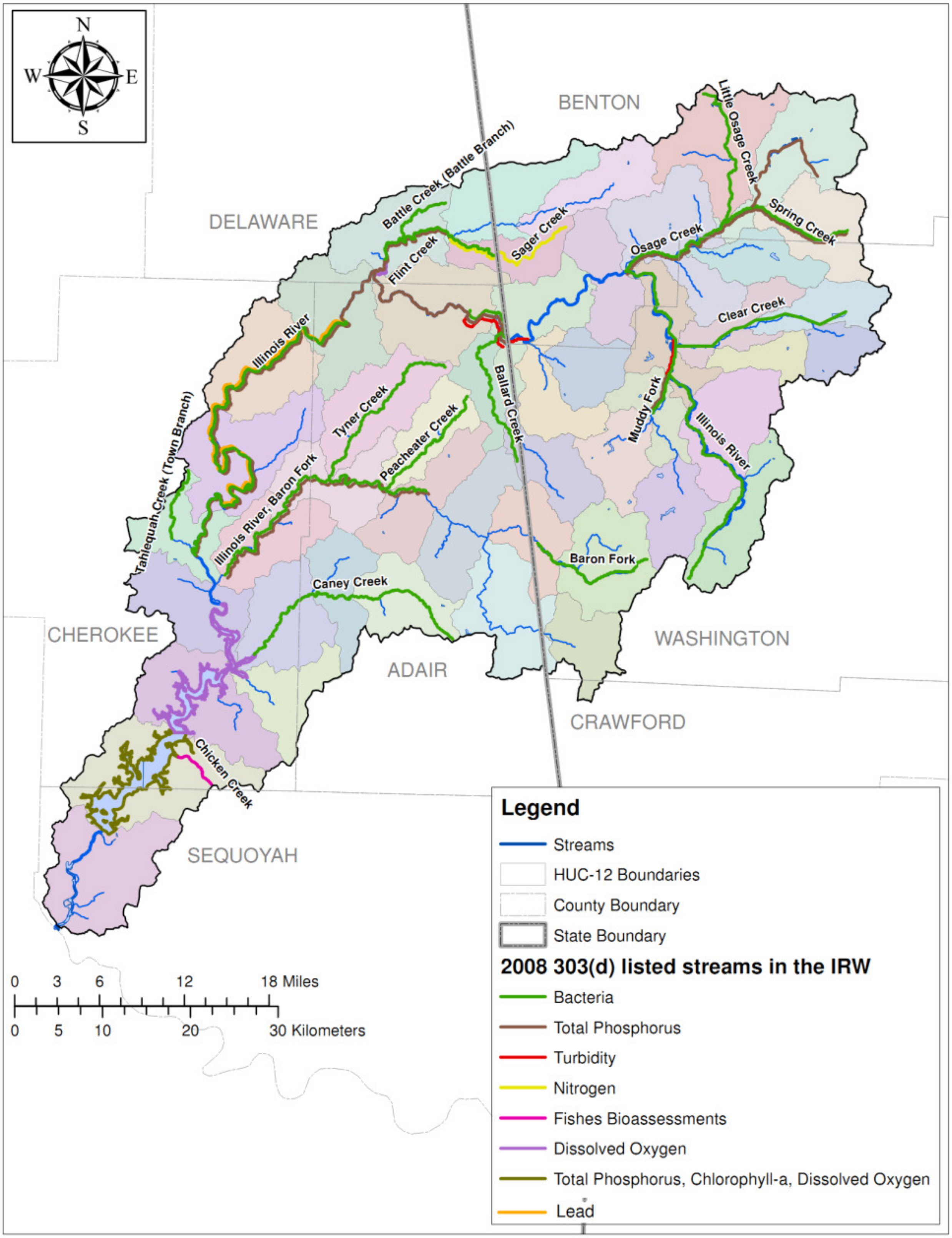


Figure 1.2 Section 303(d) Listed Impaired Segments within the Illinois River Watershed

the Ft Smith meeting and the FR Notice, a wide range of groups and agencies at all levels – federal, state, local, university – have been supportive of the of the effort by providing reports, documents, references, and data for use in the study.

In addition, individuals in each lead State agency – OK Department of Environmental Quality and AR Department of Environmental Quality – were identified and designated as the primary Point of Contact (POC) within each State.

A tremendous amount of data, reports, and information has been provided to EPA Region 6 for use in this study as a result of these initial data requests and acquisition efforts. This includes both time-variable (e.g. meteorologic data, stream flow, water quality, point sources) and GIS data (e.g., land use, topography, hydrography), along with an extensive array of reports and studies performed on or within the Illinois River Watershed. In addition, this information has also provided citations for other supplemental reports and studies identified through online searches and investigations.

The purpose of this report is to describe and document the extent and results of these data gathering efforts, compare this accumulated data and information to the data requirements for watershed and waterbody modeling in the IRW, and thereby identify any critical data gaps, or deficiencies, which might impact, or ultimately inhibit, water quality model development for the IRW. In addition, this report allows the State POCs, other state and federal agencies, and other stakeholders to assess and evaluate whether any relevant data and information has not been identified and is still outstanding.

As a compilation and synthesis of the available data, this report provides the foundation for the next step in this modeling study, development of the Simulation Plan. The recently completed Draft Simulation Plan (AQUA TERRA Consultants, 2011) provides an overview of the model selection effort and the selected models – both watershed and waterbody models – and provides details of the model application effort, including the calibration and validation time periods, constituents to be simulated, model scales and resolution, model performance targets, and an initial discussion of potential scenarios to be investigated as part of the TMDL development procedure. Thus, this data report should be viewed as a companion and supporting document to the Draft Simulation Plan, submitted in August 2011.

1.2 PRIOR MODELING STUDIES

The initial step in any modeling and/or data assessment effort is to review prior modeling studies that may identify and compile relevant data on the IRW and Lake Tenkiller, since all modeling efforts essentially use the same general types and categories of watershed and waterbody data. This section discusses the major prior modeling efforts on the IRW and Lake Tenkiller with a focus on the data used for model setup and calibration, along with the most current data needed to accurately reflect current watershed conditions.

Over the recent past, the IRW has been the focus of modeling efforts by Donigian et al., (2009), Storm et al., (2006 and 2009), and others, which focused on the entire IRW. 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 simulation covered a 20-year period from 1984 through 2003, but available water quality data (at that time) limited the TN calibration to the period 1990-1996 and the TP calibration from 1999-2003, with downstream stations primarily in OK. Additional USGS data are now available through at least 2004 (Tortorelli and Pickup, 2006), and more recently through 2007 by Andrews (Andrews at al., 2009) to support extended model calibration efforts in both OK and AR under the current study. In addition, Brian Haggard, Arkansas Water Resources Center (AWRC), has indicated that the most recent load data is available through 2009 (B. Haggard, personal communication, 28 July 2010). In this HSPF/AQUATOX effort, the AQUATOX calibrations were limited to 1992-1993 using Clean Lakes Program data from Oklahoma State University (1996).

The watershed modeling effort by Storm et al. (2006) used the USDA SWAT model to represent the IRW, including specific consideration of the poultry litter applied to pasture areas, and subsequent runoff to the river system. That effort used relatively simple instream algorithms to approximate the complex instream fate and transport interactions of dissolved and particulate phosphorus. SWAT model runs were performed for the period of 1980 through 2006, including both calibration and validation; water quality calibration for TP (and dissolved P) was performed for 1990 through 2006. The OK DEQ provided to EPA and AQUA TERRA the most recent modeling report submitted by Dr. Storm, along with the model input and data files, including GIS files used in this SWAT model setup, as these may provide valuable spatial data coverages for this effort.

More recently Saraswat et al., (2010) and White (2009) have published modeling efforts using the SWAT model applied to the AR portion of the IRW. The Saraswat effort focused on the 12-Digit HUC (Hydrologic Unit Code) spatial level within the IRW, and addressed issues of impaired stream segments for the Illinois River and selected tributaries within AR. White's study appears to be a refinement of the previous study by Storm et al (2009), with greater detail on the AR side. Both efforts were primarily directed to monthly comparisons of observed and simulated loads and concentrations, but include a comprehensive assessment of phosphorus sources and potential impacts of conservation efforts and management practices.

There have been at least two studies of Lake Tenkiller using the US EPA HSPF watershed model for loadings and the US EPA EFDC model for hydrodynamics and water quality simulation of the lake. These include an initial study performed in support of TMDL development by EPA Region 6 and OK DEQ (US EPA and OK DEQ, 2001), with Tetra Tech contracted to perform the modeling, and a subsequent revision and refinement of that effort performed by Dynamic Solutions LLC (Craig, 2006) with AQUA TERRA Consultants (Donigian et al., 2005) subcontracted to upgrade the HSPF model of the IRW. Water quality calibrations were performed with available Clean Lakes Program data for 1992 and 1993, the same period as the subsequent AQUATOX application noted above. Thus, initial model setups for both EFDC and AQUATOX are available, along with the supporting calibration data, as candidate starting points for the current modeling effort of Lake Tenkiller.

The above mentioned studies appear to be the primary modeling efforts that have covered major portions of the IRW, and include simulation of both flow and water quality, and thus provide the best opportunities for acquisition of data relevant to our current study. There have been a few other smaller scale modeling studies covering selected subbasins (e.g. Ajami et al., 2004; Safari and Smedt, 2008) but many are hydrology only efforts and lack attention to water quality issues.

The modeling studies by Saraswat et al (2010) and White (2009) were also part of development efforts for watershed management planning for the IRW on both sides of the state line. Near the end of 2010, a draft watershed management plan (WMP) was published by the Illinois River

Watershed Partnership (IRWP) Watershed Management Plan (IRWP, 2010). This WMP presents a watershed management strategy with the goal to "improve water quality in the Illinois River and its tributaries so that all waters meet their designated uses both now and in the future." Although this document focuses on the AR portion of the IRW, a comparable effort has been ongoing for the OK portion by the Oklahoma Conservation Commission (OCC), who recently finalized their draft plan (OCC, 2010). Both of these plans have been very helpful in our efforts to identify previous studies, available data, water quality issues of concern, and potential remediation and restoration alternatives within their respective portions of the IRW.

1.3 DATA IDENTIFICATION, ACQUISITION, AND INVESTIGATION EFFORTS

Table 1.1 lists the typical types of data required for watershed and waterbody modeling efforts. These categories include precipitation and meteorologic data, land characteristics (e.g. topography, land use, soils, climate variability), hydrography and waterbody characteristics, monitoring data, and other supporting information (e.g. prior studies, source identification).

All data and information accumulated as part of the prior modeling efforts with the EPA HSPF model (discussed above) were obtained, in addition to the SWAT model files and data provided by OK DEQ. The EPA BASINS system was used to download all available timeseries and GIS data relevant to modeling the IRW, along with direct use of other data gathering agency web sites (e.g. USGS, NWS) as needed.

As noted above, 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. Following the 4 February 2010 project coordination and stakeholders meeting in Fort Smith, AR, a number of agencies were forthcoming with an extensive array of data and reports. Table 1.2 lists the agencies and organizations, along with individual contacts, who provided the information, primarily through email submittals, but also some hard copy and other electronic forms of transmission. In addition, Appendix D provides a compilation of the agencies, contacts, types of data and reports supplied, dates received and selected file names for the information provided by each agency. This information was further supplemented by directed online searches and by leads (or actual data) provided by the designated POCs for both States, Oklahoma and Arkansas. Note that a number of contributing agencies, may not be listed in Table 1.2 as their documents, reports and data may have been provided by the listed agencies. However, their contributions are noted and equally appreciated.

Appendix A includes a list of all reports received and obtained by AQUA TERRA during this information and data gathering effort. Not all of these documents have been fully reviewed and analyzed in detail for possible data and information relevant to the study; this is an intensive and time-consuming effort that continues at the current time. This report is a snapshot of what has been identified and obtained to date.

All data have been stored on AQUA TERRA computers, with daily backups, in file directories identified by the agency/source that provided the information, in order to keep track of how the information was obtained.

1.4 THIS REPORT

This report is an identification, summary and partial compilation of the data and information received through the various data gathering efforts described above, and serves as the deliverable for the data task and data gap analysis of the project. Since both time-variable data and spatial data coverages are needed for developing a comprehensive watershed and water

Table 1.1 Data Requirements for Typical Watershed Model Applications*

1. Precipitation and meteorologic data (for simulation period)
    a. Precipitation, Daily and hourly (or 15-minute values for small watersheds)
    b. Daily pan evaporation
    c. Daily maximum and minimum air temperature *(needed for water temp and snow only)*
    d. Total daily wind movement *(needed for water temp and snow only)*
    e. Total daily solar radiation *(needed for water temp and snow only)*
    f. Daily dewpoint temperature *(needed for water temp and snow only)*
    g. Average daily cloud cover *(needed for water temp and snow only)*

2. Watershed land use/land cover characteristics (preferably as GIS layers)
    a. Topographic map/data of watershed and subwatersheds, and/or DEM coverage
    b. Land use/cropping delineation and acreages (as GIS layer)
    c. Soils delineation and characteristics (GIS soils coverage of soil texture and/or SCS Hydrologic Soil Groups)
    d. Isohyetal map of mean annual rainfall (GIS layer preferred)

3. Hydrography and channel characterization
    a. Channel lengths, slopes, cross-sections and geometry, or DEM of channel and overbank areas
    b. Channel bed composition (e.g. particle dist., nutrients, pesticides)
    c. Diversions, point sources, channelized segments, etc.
    d. Tributary area (and land use distribution) for each channel reach (or available from GIS land use layers)
    e. Waterbody/reservoir bathymetry (or stage-volume-surface area relationships), stage-discharge relationships, operational procedures, and spillway characteristics

4. Monitoring program observations
    a. Flow rates during all monitored storm events
    b. Flow volume/rate totals for storm/daily, monthly, annual (both storm and baseflows)
    c. Snow depths (for areas with significant snow accumulation)
    d. Sediment concentrations and mass losses in runoff
    e. Chemical/constituent concentrations and mass losses in runoff
    f. Soil concentrations of constituent/nutrient forms, if available
    g. Estimated/actual constituent concentrations in precipitation
    h. Particle size distributions (sand, silt, clay fractions) of soils, eroded sediments, and channel bed sediments

5. Other useful information
    a. Description/quantification of any other contaminant sources (e.g. point sources, feedlots) or other relevant information (e.g. ponds, dams, marshes)
    b. Technical reports or articles which analyze and/or summarize the monitoring data
    c. Soils characterization information for estimating model parameters
    d. Previous watershed inventory, assessment, or modeling studies

* -- *Not all application sites will have all listed data items available, so extensions from other nearby sites, and/or regional or national level data may be used to estimate site values, as a last resort.*

quality model of the IRW, this report covers our efforts searching for, identifying, and obtaining both types of data and information. Section 2 covers the time-variable data and information applicable to the IRW and Tenkiller Reservoir, including all existing flow and water quality data from AR and OK, point source discharges, nonpoint source contributions, and any other data specifically useful for water quality model application. Section 3 discusses the GIS coverages that were obtained, cataloged and displayed. Data and information specific to Lake Tenkiller are discussed in Section 4.

The compiled data have been assessed and any initial data gaps critical to model development have been identified and are discussed in each section. As noted above, this report serves to document the results of our data gathering efforts and our currently perceived critical data gaps. It also provides an opportunity for the Study Team members and stakeholders to review the data accumulated and assess whether there exists other additional data and information we are not aware of, or not discussed herein, that should be included in the study effort. Thus, it provides a check on whether these efforts have been effective and complete in identifying all available data and information to support the IRW water quality model development effort.

Table 1.2 Agencies/Groups Providing Data and Reports

Agency/Source	Contact (s) Name	Contact info
Arkansas DEQ - Water Planning	John Bailey Mary Barnett	BAILEY@adeq.state.ar.us, BARNETT@adeq.state.ar.us
Arkansas Natural Resources Commission	Patrick Fisk Ed Swaim	Patrick.Fisk@arkansas.gov, Edward.Swaim@arkansas.gov
Arkansas Water Resources Center	Brian E. Haggard Marty Matlock	haggard@uark.edu mmatlock@uark.edu
City of Tahlequah/Public Works Authority	Ben Berry David Morrison	stormwater@cityoftahlequah.com genman@cityoftahlequah.com
Oklahoma Conservation Commission	Greg Kloxin	greg.kloxin@conservation.ok.gov
Oklahoma Dept of Agriculture, Food, and Forestry	Quang Pham	Quang.Pham@oda.state.ok.us
Oklahoma DEQ	Mark Derichsweiler Andrew Fang	mark.derichsweiler@deq.ok.gov, Andrew.Fang@deq.state.ok.us,
Oklahoma DEQ-Water Quality	Steve Webb	steve.webb@deq.ok.gov
Oklahoma Scenic Rivers Commission	Ed Fite	ed.fite@oklahomascenicrivers.net
Oklahoma Water Resources Board	Paul Koenig Bill Cauthron Julie Chambers	PDKOENIG@owrb.ok.gov WLCAUTHRON@owrb.ok.gov jmchambers@owrb.ok.gov
Rogers Water Utility	Paul Burns	paulburns@rwu.org
Tyson Foods	Robert George Carol Ross	Robert.George@tyson.com, Carol.Ross@tyson.com,
United Keetowah Band	Brandi Ross	bross@unitedkeetowahband.org
University of Arkansas	Marty Matlock	mmatlock@uark.edu
USGS, Arkansas Water Science Center	Reed Green	wrgreen@usgs.gov
USGS, Oklahoma District	Robert L. Blazs	rlblazs@usgs.gov

SECTION 2.0

TIME-SERIES DATA NEEDS AND AVAILABILITY

Simulation of hydrology and water quality within the IRW requires the following types of time series data:

1. Precipitation
2. Potential evapotranspiration
3. Other meteorologic data (e.g. air temperature, wind, solar radiation, dewpoint, cloud cover)
4. Streamflow
5. Water quality observations
6. Other data (e.g. points sources, diversions, withdrawals, atmospheric deposition)

This section discusses the availability of these time series data, plus additional data such as water supply withdrawals and point sources, that define the inflow, outflow, and quality of water in the watershed.

2.1 PRECIPITATION

For hydrology calibration of the IRW, all watershed models require precipitation timeseries that are complete records (*i.e.*, no missing data) at a daily or shorter timestep, depending on the selected model, and with adequate spatial coverage and density across the model domain. Precipitation is the critical forcing function for all watershed models as it drives the hydrologic cycle and provides the foundation for transport mechanisms, both flow and sediment, that move pollutants from the land to the waterbody where their impacts are imposed.

For this study, long-term precipitation data have been obtained from the following primary sources:

a. Prior modeling efforts with BASINS/HSPF and SWAT
b. Online databases (e.g., NOAA, USGS) accessed through the BASINS download data capability
c. OK Mesonet data network (provided by ODEQ)
d. Daily NEXRAD data (provided for AR by Drs Matlock and Saraswat at the University of Arkansas (Personal communication, 1 January 2011)
e. BASINS data extended through 12/31/09 (from an ongoing BASINS data project)

The last two precipitation data items (listed above) were obtained since the publication of the Draft Data Report in August 2010. Figure 2.1 shows the precipitation stations and corresponding model segments used in the BASINS/HSPF/AQUATOX application to the IRW. Seven stations were used and assigned to the corresponding color-coded areas (as shown in Figure 2.1); this means that the precipitation recorded at the station was applied to the identified land area as part of the hydrologic modeling with HSPF. As noted earlier, the model runs were performed for the time period of 1984 through 2003, so the precipitation and additional meteorologic data were available for that time period; the data for currently active sites have been obtained through 2006, and have subsequently been extended further through 2009, as discussed in the Simulation Plan.

Figure 2.2 shows the complete set of precipitation stations obtained through the BASINS data download facility, along with the specific stations used in the SWAT modeling effort by Storm et al., (2009) and those available from OK Mesonet. Table 2.1 tabulates all the available

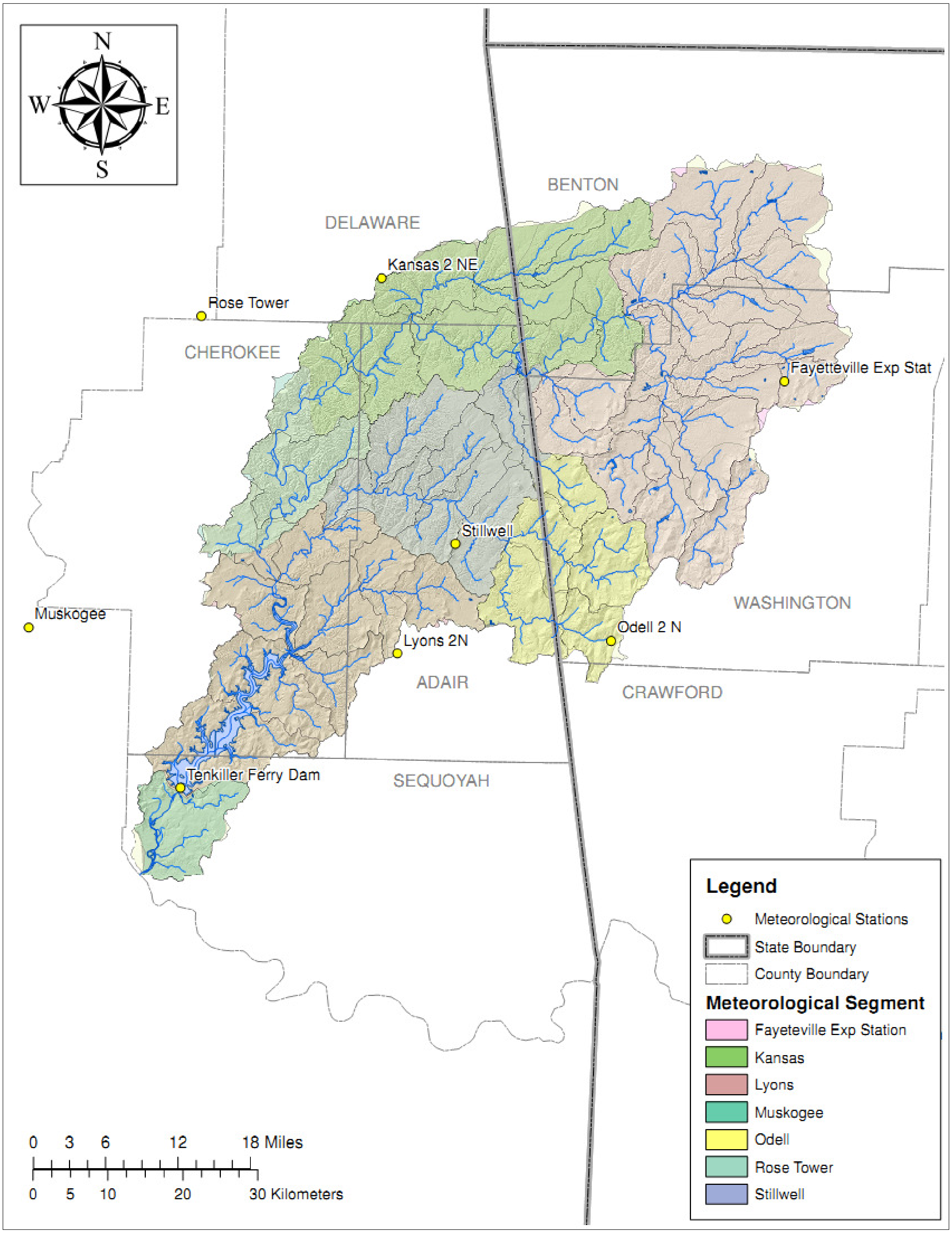


Figure 2.1 Precipitation Stations and Segments from HSPF/AQUATOX report

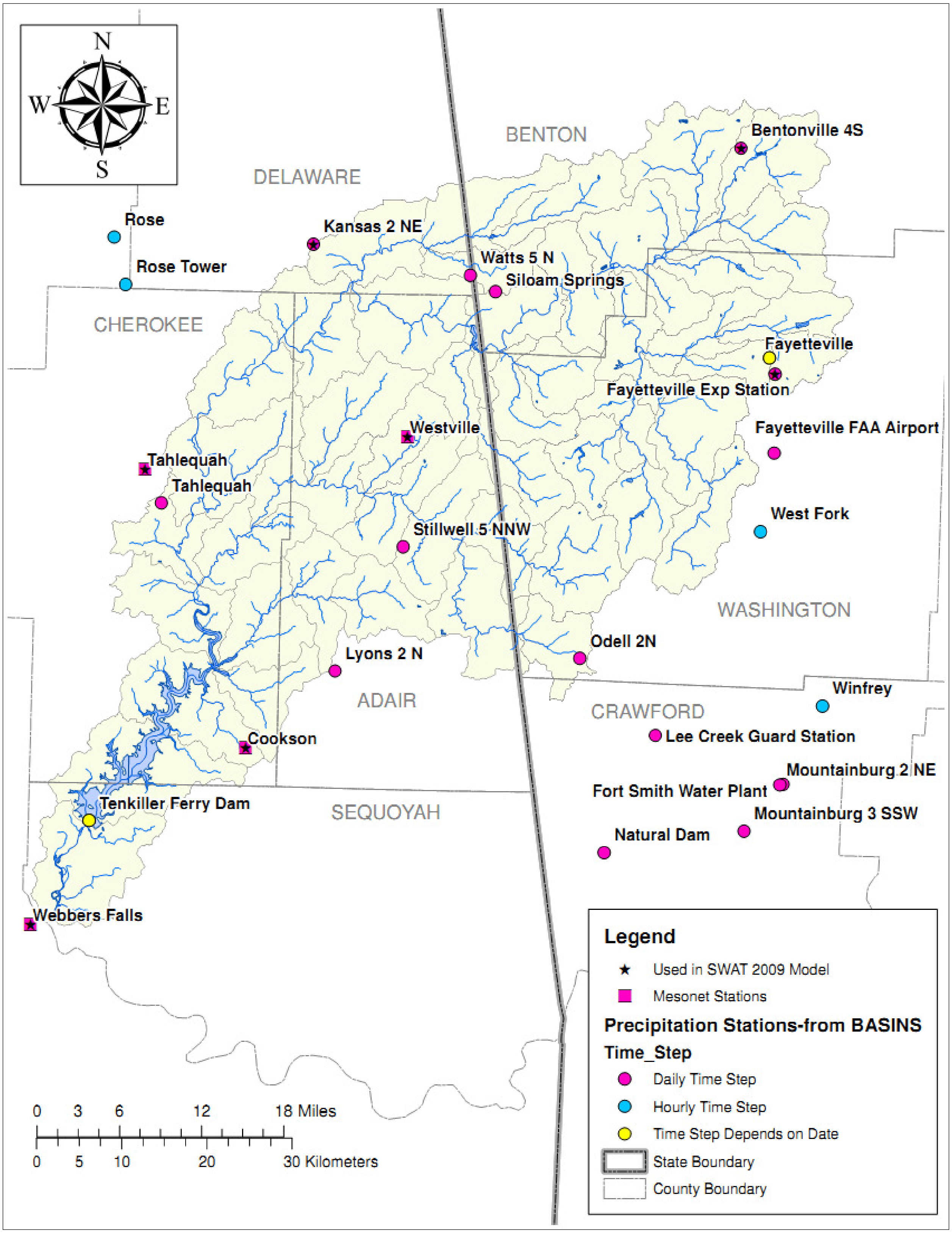


Figure 2.2 Precipitation Stations in/near the Illinois River Watershed

Table 2.1 Precipitation Stations in/near the Illinois River Watershed

Site Name	Site Number	Source	Start	End	Av Annual Precip (in)
Bentonville 4S	AR030586	BASINS daily	12/31/1947	2/28/2007	46.79
Cookson	31	Mesonet 5-min	1/1/1994	present	
Fayetteville	AR032442	BASINS daily	12/31/1947	12/31/1960	46.17
Fayetteville FAA Airport	AR032443	BASINS daily	6/30/1949	1/31/1982	47.22
Fayetteville Exp Sta*	AR032444	BASINS hourly	4/1/1966	3/31/2006	46.17
Fayetteville Exp Sta*	AR032444	BASINS daily	12/14/1926	8/31/2003	46.17
Fort Smith Water Plant	AR032578	BASINS daily	12/31/1947	8/31/1985	50.61
Lee Creek Guard Station	AR034116	BASINS daily	12/31/1947	12/31/1962	50.36
Mountainburg 2NE	AR035018	BASINS daily	8/31/1985	12/31/2009	50.61
Mountainburg 3 SSW	AR035056	BASINS daily	12/31/1947	9/30/1954	49.33
Natural Dam	AR035160	BASINS daily	12/31/1962	12/31/2009	49.39
Odell 2 N*	AR035354	BASINS daily	12/31/1947	12/31/2009	51.56
Siloam Springs	AR036624	BASINS daily	12/31/1947	12/31/1987	46.96
West Fork	AR037694	BASINS hourly	5/1/1948	4/30/1966	50.43
Winfrey	AR037936	BASINS hourly	5/1/1948	8/31/1956	51.83
Kansas 2 NE*	OK344672	BASINS daily	3/31/1959	12/31/2009	48.23
Lyons 2 N*	OK345437	BASINS daily	12/31/1947	12/31/2003	47.75
Rose	OK347732	BASINS hourly	2/1/1951	1/31/1974	45.97
Rose Tower*	OK347739	BASINS hourly	1/1/1974	12/31/2003	46.79
Stillwell 5 NNW*	OK348506	BASINS daily	9/30/1948	12/31/2003	49.11
Tahlequah*	OK348677	BASINS daily	12/31/1947	12/31/2006	47.64
Tahlequah	92	Mesonet 5-min	1/1/1994	present	
Tenkiller Ferry Dam*	OK348769	BASINS hourly	4/1/1949	1/31/1999	46.33
Tenkiller Ferry Dam*	OK348769	BASINS daily	3/31/1949	6/30/1979	46.33
Watts 5 N	OK349382	BASINS daily	12/31/1947	8/31/1954	47.01
Webbers Falls	103, 132	Mesonet 5-min	1/1/1994	5/26/2010	
Westville	104	Mesonet 5-min	1/1/1994	5/26/2010	

*This station was previously used in the HSPF/AQUATOX report

precipitation stations, and identifies the Mesonet sites and the specific stations used by SWAT. Mesonet stations provide 5-minute accumulative precipitation on a daily basis and can be converted to 5-minute time interval precipitation data (needed by HSPF), and they appear to fill in some areas with sparse gage coverage in the southern and western portions of the IRW. The Mesonet stations also provide extensive meteorologic data, discussed below.

The study was fortunate to obtain daily precipitation data from Drs Matlock and Saraswat at the University of Arkansas for 28 'pseudo' gage sites located at the approximate centroid of the HUC12 subwatersheds on the AR side of the IRW. This daily data set was developed as a combination of three NWS stations (Bentonville, Fayetteville, and Gravette) for the period 1981-93, and NWS NEXRAD (Next Generation Weather Radar) data for the period 1994-2008 (Saraswat et al, 2010). This NEXRAD dataset, and its use in the modeling, is discussed in more detail in the Simulation Plan.

Based on the previous HSPF and SWAT modeling efforts, the NEXRAD data, and the precipitation stations identified in Table 2.1, Figure 2.1 and Figure 2.2, the coverage of daily stations appears sufficient for coverage of the IRW, especially with the addition of the Mesonet stations on the OK side, and the NEXRAD data on the AR side. Also, long-term hourly stations are available at about 9 sites across the watershed, to assist in the disaggregation of the daily station values to hourly intervals.

2.1.1 Snow Data

Snow depth and 'snow on ground' data is used to calibrate the snow accumulation and melt processes when they are activated on a specific watershed. These same data are also used in conjunction with mean and maximum winter air temperatures to assess whether or not to activate the snow simulation capability within the watershed model. Snow data for selected sites within the IRW from the Southern Regional Climate Center in Baton Rouge, LA (http://www.srcc.lsu.edu/) was reviewed. For the Fayetteville region, mean temperatures during the winter generally range from the mid-thirties to the mid-forties (degrees F);mean annual total snowfall is in the range of 6 to 12 inches, at most, and rarely exceeds a few inches in any event. Such minor amounts usually melt within a few days at most, and will normally have little impact on storm runoff and the hydrologic regime of the IRW.

As discussed in the Simulation Plan, we do not plan to activate the snow simulation on the IRW, at least for our initial hydrology calibration runs, based on the lack of persistent snow cover, as demonstrated in the data we received and based on reviewer comments on our Draft Data Report. If model results indicate problems with matching storm events during winter periods, we may consider if activating the snow modules will improve the simulations.

2.2 EVAPOTRANSPIRATION AND OTHER METEOROLOGICAL DATA

Watershed models require evaporation data as a companion to precipitation to drive the water balance calculations inherent in the hydrologic algorithms contained in these types of models. In addition, other meteorologic time series are also often required in temperate climates where snow accumulation and melt are a significant component of the hydrologic cycle and water balance. These same time series, such as air temperature, solar radiation, dewpoint temperature, wind, and cloud cover, are often required if soil and/or water temperatures are simulated. Water temperature is subsequently used to adjust rate coefficients in most water quality processes, and other time series are used in selected calculations, like solar radiation affecting algal growth.

Both HSPF and SWAT have similar weather data requirements (with some slight differences), so the availability of weather data is expected to be adequate for model application. HSPF generally uses measured pan evaporation to derive an estimate of lake evaporation, which is considered equal to the potential evapotranspiration (PET) required by model algorithms, i.e., PET = (pan evap) X (pan coefficient). The actual simulated evapotranspiration is computed by the program based on the model algorithms that calculate dynamic soil moisture conditions, ET parameters, and the input PET data. Where pan evaporation is not available, potential evapotranspiration (PET) can be computed from minimum and maximum daily air temperatures using the Hamon formula (Hamon, 1961). This method was used to compute the PET data included in BASINS database of available meteorologic time series. The Hamon method generates daily potential evapotranspiration (inches) using air temperature (F or C), a monthly variable coefficient, the number of daylight hours (computed from latitude), and absolute humidity (computed from air temperature). Like HSPF, SWAT can use observed pan data or computed PET data, and a number of methods for calculating PET are available in SWAT's weather generator, and within BASINS.

The primary source of evapotranspiration and the other meteorologic data was the BASINS database of thousands of stations across the US; the download capability within BASINS allows users to identify their selected watersheds and then access all the data available, including meteorologic data. Figure 2.3 shows the available meteorologic stations in and near the IRW available through BASINS; it also shows the nearest OK Mesonet stations. The OK Mesonet is an automated network of hundreds of remote meteorologic stations across OK instrumented to monitor and measure soil and meteorologic conditions. As shown in Figure 2.3, there are five Mesonet stations within or near the IRW. Table 2.2 lists the meteorologic stations found through BASINS along with the Mesonet sites.

The nearest pan evaporation station to the IRW is the Blue Mountain Dam NWS site approximately 30 miles southeast of the watershed. This site was used as the only evaporation data station for the HSPF/AQUATOX study; since PET generally demonstrates little spatial variability in this climate region, compared to rainfall variability, the distance was not considered excessive. The SWAT model application used calculated PET from five NWS sites, plus two Mesonet sites. Table 2.2 shows 14 sites with BASINS computed evapotranspiration data providing sufficient coverage for the IRW. Also, the stations available for the remaining weather data, combined with the Mesonet sites, appears to provide a similar level of coverage.

The final selection of meteorologic data sites to be used in the modeling is described in the Simulation Plan. However, based on the data identified in Figure 2.3 and Table 2.2, there appears to be adequate coverage across the IRW so that meteorologic data is not expected to be a limitation on the modeling effort.

2.3 STREAMFLOW

Flow data is needed for both calibration and validation of the watershed model to ensure it is reproducing the hydrologic behavior of the IRW, and providing proper boundary inflows into Lake Tenkiller, along with its transport of sediment and water quality constituents. The BASINS download capability provided the means to access all the USGS flow (and water quality) data for sites in the watershed. Figure 2.4 shows the locations of the USGS gaging sites within the watershed, and Table 2.3 lists their names, USGS ID numbers, periods of record, tributary areas, and elevations for selected sites.

The USGS sites designated with red circles (●) are those used for model calibration and/or validation in the previous HSPF and SWAT model applications discussed above. The simulation plan addresses the issue of selection of calibration/validation sites in both states. There appears to be adequate periods of record for three to five calibration sites within each state, if project resources support this level of calibration effort.

At this time, we are not aware of any continuous flow data collected for significant time periods by other agencies that might supplement the sites listed in Table 2.3. If such data exist, we would request that it be supplied to EPA for use in this effort.

Data and information on Lake Tenkiller is discussed separately in Section 4.

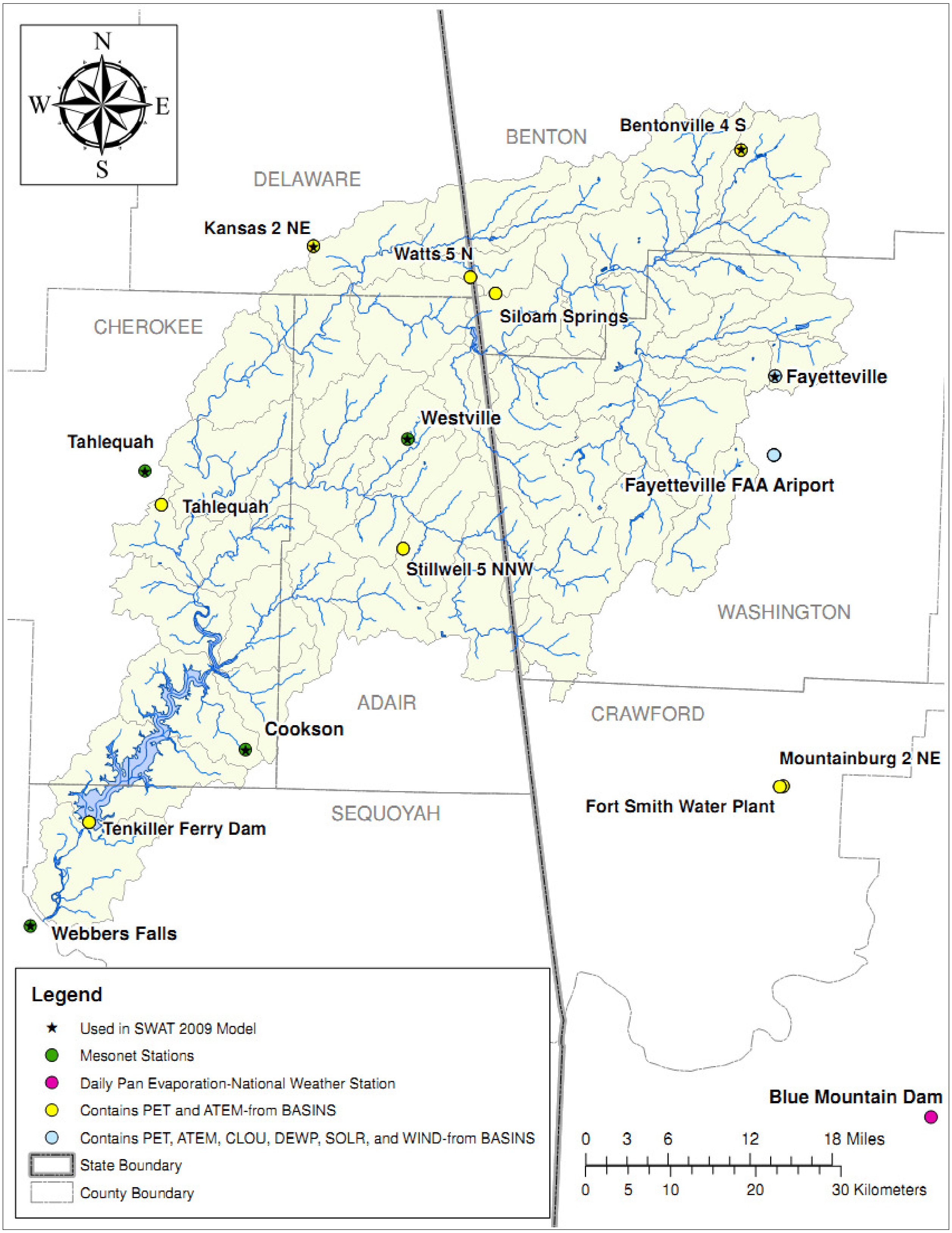


Figure 2.3 Other Meteorological Stations in/near the Illinois River Watershed

Table 2.2 Meteorological Stations in/near the Illinois River Watershed

Site Name	Site Number	Source	Data Type	Start	End
Bentonville (AWOS)	AR723444	BASINS	ATEM, PET, WIND, SOLR, DEWP, CLOUD	1/1/1995	12/31/2009
Bentonville 4S	AR030586	BASINS	ATEM, PET	1/1/1948	2/28/2007
Blue Mountain Dam		previous study	ATEM, PET	1/1/1984	9/30/2004
Cookson	31	Mesonet	ATEM, BP, SOLR, WIND	1/1/1994	present
Fayetteville Exp Sta	AR032444	BASINS	ATEM, PET	8/26/1921	8/31/2003
Fayetteville FAA Airport	AR032443	BASINS	WIND, SOLR, DEWP, CLOUD	12/31/1994	12/31/2009
Kansas 2 NE	OK344672	BASINS	ATEM, PET	4/1/1959	1/1/2010
Muskogee	OK346130	BASINS	ATEM, PET	1/1/1948	12/31/2009
Rogers	AR723449	BASINS	ATEM, PET, WIND, SOLR, DEWP, CLOUD	1/1/1995	12/31/2009
Siloam Springs (AWOS)	AR723443	BASINS	ATEM, PET, WIND, SOLR, DEWP, CLOUD	1/1/1995	12/31/2009
Stilwell 5 NNW	OK348506	BASINS	ATEM, PET	1/1/1960	4/30/2003
Tahlequah	OK348677	BASINS	ATEM, PET	1/1/1948	12/31/2006
Tahlequah	92	Mesonet	ATEM, BP, SOLR, WIND	1/1/1994	present
Webbers Falls	103, 132	Mesonet	ATEM, BP, SOLR, WIND	1/1/1994	present
Webbers Falls Dam	OK349450	BASINS	ATEM, PET, WIND, SOLR, DEWP, CLOUD	1/1/1970	12/31/2009
Westville	104	Mesonet	ATEM, BP, SOLR, WIND	1/1/1994	present

Table 2.3 USGS Stream Gages Containing Flow Data

Location	Gage Station	Flow Data		Tributary Area (mi²)	Elevation (ft)
Illinois River near Tahlequah, OK	07196500	10/1/1935	present	959.0	664
Baron Fork at Eldon, OK	07197000	10/1/1948	present	307.0	701
Baron Fork at Dutch Mills, AR	07196900	4/1/1958	present	40.6	986
Illinois River near Watts, OK	07195500	10/1/1955	present	635.0	894
Illinois River near Viney Grove, AR	07194760	9/5/1985	10/16/1986	80.7	1051
Illinois River at Savoy, AR	07194800	6/21/1979	present	167.0	1019
Niokaska Creek at Township St at Fayetteville, AR	07194809	9/19/1996	present	1.2	1482
Osage Creek near Elm Springs, AR	07195000	10/1/1950	present	130.0	1052
Illinois River at Hwy. 16 near Siloam Springs AR	07195400	6/21/1979	2/7/2011	509.0	1170
Illinois River South of Siloam Springs, AR	07195430	7/14/1995	present	575.0	909
Flint Creek at Springtown, AR	07195800	7/1/1961	present	14.2	1173
Flint Creek near West Siloam Springs, OK	07195855	10/1/1979	present	59.8	954
Sager Creek near West Siloam Springs, OK	07195865	9/12/1996	present	18.9	960
Flint Creek near Kansas, OK	07196000	10/1/1955	present	110.0	855
Peacheater Creek at Christie, OK	07196973	9/1/1992	9/16/2004	25.0	802
Caney Creek near Barber, OK	07197360	10/1/1997	present	89.6	638
Illinois River near Gore, OK	07198000	3/25/1924	present	1626.0	468

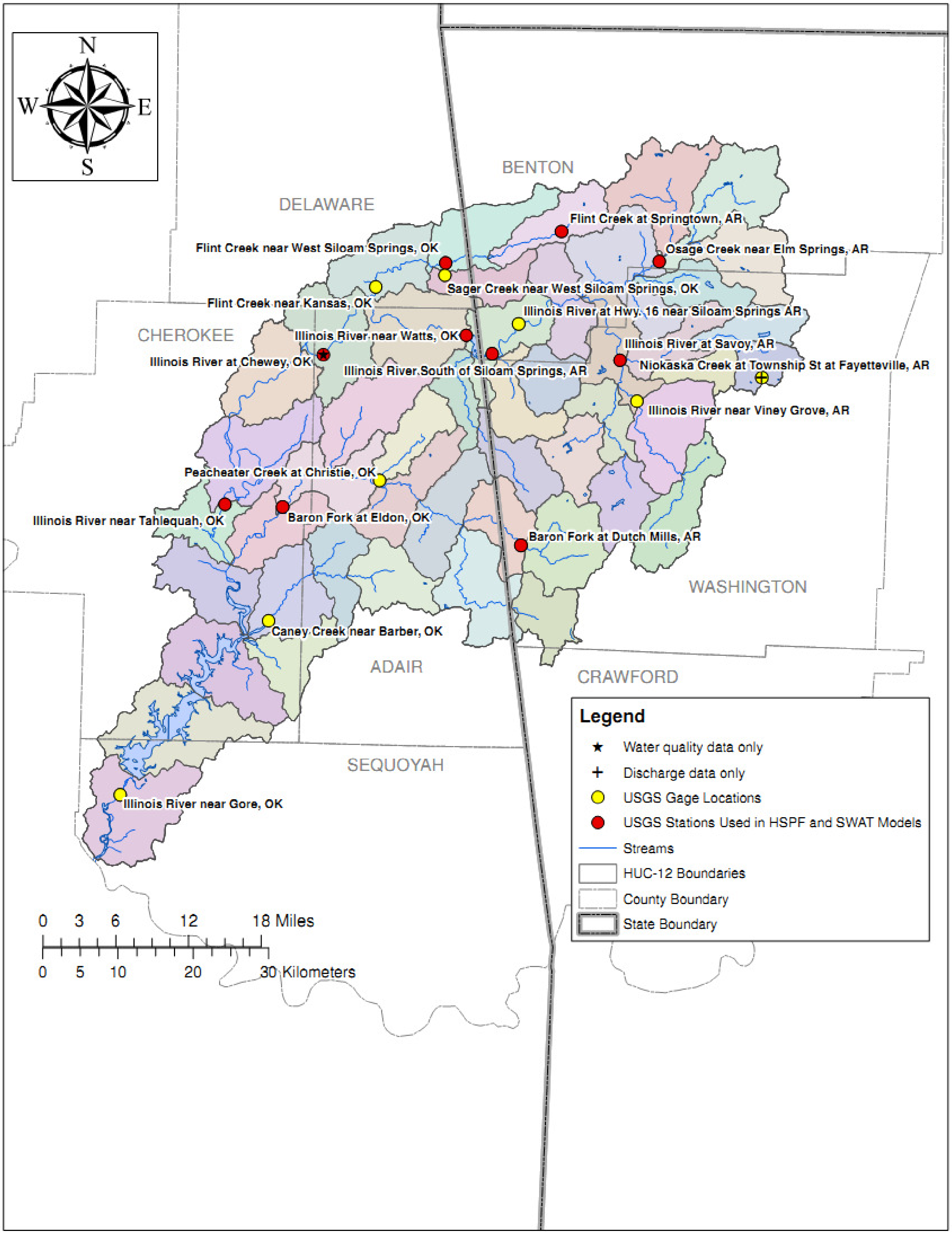


Figure 2.4 USGS Stream Gage Locations in the IRW

2.4 WATER QUALITY DATA

Water quality data is used primarily for model calibration and validation, but also to help quantify source contributions and boundary conditions, such as for point sources, selected agricultural sources, and atmospheric deposition. A number of agencies contributed a wide variety water quality related data to be used in this effort. The specific constituents to be modeled in this study is defined as part of the Simulation Plan. However, the following list shows the conventional constituents that are modeled when nutrients are the focus of a modeling effort; it includes flow and TSS as the basic transport mechanisms for moving the nutrients:
.

1. Flow/discharge
2. TSS
3. water temperature
4. DO
5. BOD ultimate, or total BOD
6. NO3/NO2, combined
7. NH3/NH4
8. Total N
9. PO4
10. Total P
11. Phytoplankton as Chl a

For most modeling efforts of moderate to large watersheds, the USGS is the primary source of both flow and water quality data. In the IRW, the USGS works collaboratively with both the OK DEQ and AWRC for flow and water quality data collection efforts. Data was obtained from both the USGS NWIS system through direct downloading, along with files provided by the state agencies. Table 2.4 lists the USGS flow gages that also include water quality data, along with their period of record, and Table 2.5 provides a compilation of the number of data points and their period of record for each relevant water quality constituent, at each water quality gage.

Another source of water quality data is the US EPA STORET system; the system is divided into data collected and input prior to 1999 (known as Legacy STORET) and those that were collected post 1999 (known as Modern STORET). In Figure 2.5, STORET data sites are shown within the IRW, differentiating the pre – and post –1999 stations. Table 2.6 provides a tabulation of the number of samples for various nutrient forms and TSS collected at various STORET sites from the Modern STORET (post 1999); it provides an indication of the amount of data possibly available for this effort. A summary of stations and organizations contributing water quality data to the Modern STORET database is presented in Appendix E. This summary of availability of data from Modern STORET was taken from EPA's "Surf Your Watershed" for the Illinois River catalog unit (HUC= 11110103). ADEQ has questioned whether all available data was covered by these numbers (in Table 2.6) (J. Bailey, personal communication, 13 September 2010); this is being further investigated as a precursor to the water quality calibration effort.

From EPA's Legacy STORET database, water quality data was extracted for the period from 1970 through 1999. Water quality parameters related to carbon, nitrogen, phosphorus, algae, oxygen depletion, water clarity, suspended solids and bacteria were extracted for the Illinois River Catalog Unit (HUC=11110103). Data records were extracted separately for Arkansas and Oklahoma since the Legacy STORET database is organized by state and county. Within the Arkansas portion of the catalog unit, data was extracted for Benton, Crawford and Washington counties. In Oklahoma, data was extracted for Adair, Cherokee, Delaware, Muskogee and

Sequoyah counties. Water quality records were extracted by Parameter Code (e.g., P=00011 and P=00010) and combined, where appropriate, into a common water quality constituent, e.g., water temperature as Deg-C. A summary of the total number of records extracted for the Oklahoma counties and Arkansas counties is presented in Tables 2.7 and Table 2.8, respectively. An annual inventory, year-by-year, from 1970 through 1999 was also extracted for the OK and AR counties within the IRW, to identify the time periods with the greatest frequency of data values. These Legacy pre-1999 data are currently being further investigated.

Table 2.4 USGS Stream Gages with Water Quality Data in the IRW

Location	Gage Station #	Period of Record		Tributary Area (mi²)	Elevation (ft)
Illinois River near Tahlequah, OK	07196500	8/23/1955	12/15/2009	959	664
Baron Fork at Eldon, OK	07197000	5/7/1958	12/14/2009	307	701
Baron Fork at Dutch Mills, AR	07196900	3/17/1959	8/25/2009	40.6	986
Illinois River near Watts, OK	07195500	9/12/1955	10/26/2009	635	893
Illinois River near Viney Grove, AR	07194760	9/6/1978	7/19/2007	80.7	1051
Illinois River at Savoy, AR	07194800	9/11/1968	8/25/2009	167	1019
Osage Creek near Elm Springs, AR	07195000	9/10/1951	8/25/2009	130	1052
Illinois River at Hwy. 16 near Siloam Springs AR	07195400	9/8/1978	9/20/1994	509	1170
Illinois River South of Siloam Springs, AR	07195430	10/3/1972	8/25/2009	575	909
Flint Creek at Springtown, AR	07195800	10/15/1975	7/1/1996	14.2	1173
Flint Creek near West Siloam Springs, OK	07195855	7/11/1979	8/28/1996	59.8	954
Sager Creek near West Siloam Springs, OK	07195865	5/24/1991	10/21/2009	18.9	960
Flint Creek near Kansas, OK	07196000	9/7/1955	10/26/2009	110	855
Peacheater Creek at Christie, OK	07196973	8/6/1991	5/16/1995	25.0	802
Caney Creek near Barber, OK	07197360	8/25/1997	10/27/2009	89.6	638
Illinois River at Chewey, OK	07196090	7/16/1996	10/27/2009	825	820
Illinois River near Gore, OK	07198000	4/12/1940	8/16/1995	1626	468

As a supplement to the USGS water quality data, the AR Water Resources Center provided a series of annual reports, along with spreadsheets of loading calculations, for four sites within the AR portion of the IRW (B. Haggard, personal communication, 25 May 2010). Daily loads are available for the IR at Highway 59 (USGS gage #07195430), Ballard Creek, Moore's Creek, and Osage Creek, and for various time periods from 1999 to 2008; 2009 data have recently been provided and the daily loads have been calculated (see Nelson et al., 2006 as an example annual report). ADEQ also provided the most recent 305(b) report with state-wide data available for use in this effort (ADEQ, 2009)

The Oklahoma Water Resources Board (OWRB) maintains an archive of water quality data for Oklahoma. OWRB conducts Oklahoma's Beneficial Use Monitoring Program (BUMP), which has collected data on Lake Tenkiller quarterly every few years, and the lake watershed has been sampled 8-10 times yearly since the year 2000. Data collected under BUMP is published in annual reports, and is discussed further in Section 4.2. OWRB also provided a recent study report that describes and include data from a probabilistic monitoring program that sampled 51 randomly selected sites during 2007-2009 (OWRB, 2010). The study was designed to address stream health and habitat issues, and includes physical, chemical, and biological data for both the water column and the steam bed.

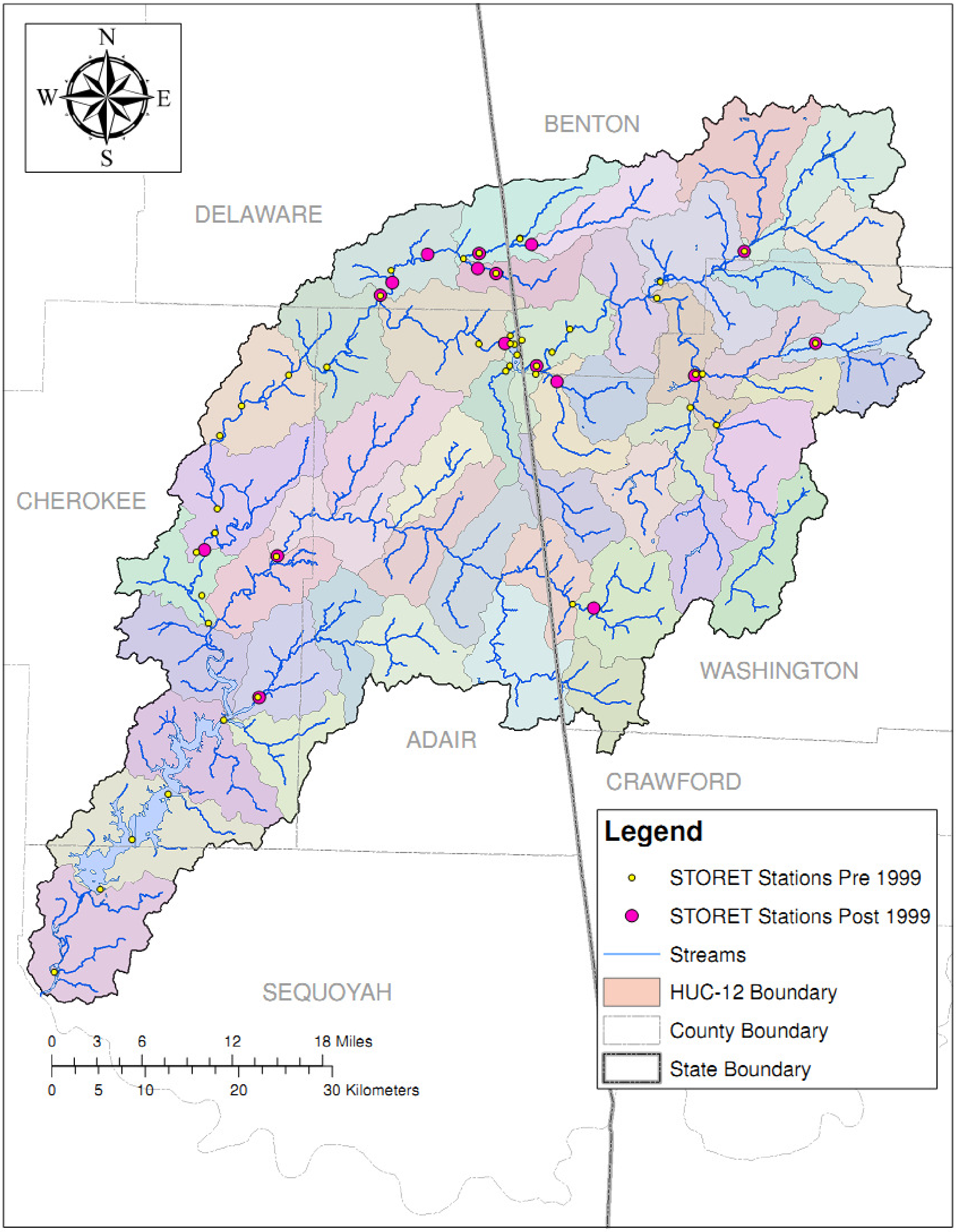


Figure 2.5 STORET Sampling Station Locations

Table 2.5 USGS Water Quality Stations and Available Data

		10	60	300	301	400	600	605	608	610	613	618	623	625	631	650	660	665	671	680	681	31625	31633	31673	32211	50468	50569	70331	70953	80154	80155	
	Station Name	Temperature, water, degrees Celsius	Discharge, cubic feet per second	Dissolved oxygen, water, unfiltered, milligrams per liter	Dissolved oxygen, water, unfiltered, percent of saturation	pH, water, unfiltered, field, standard units	Total nitrogen, water, unfiltered, milligrams per liter	Organic nitrogen, water, unfiltered, milligrams per liter	Ammonia, water, filtered, milligrams per liter as nitrogen	Ammonia, water, unfiltered, milligrams per liter as nitrogen	Nitrite, water, filtered, milligrams per liter as nitrogen	Nitrate, water, filtered, milligrams per liter as nitrogen	Ammonia plus organic nitrogen, water, filtered, milligrams per liter as nitrogen	Ammonia plus organic nitrogen, water, unfiltered, milligrams per liter as nitrogen	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen	Phosphate, water, unfiltered, milligrams per liter	Orthophosphate, water, filtered, milligrams per liter	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	Orthophosphate, water, filtered, milligrams per liter as phosphorus	Organic carbon, water, unfiltered, milligrams per liter	Organic carbon, water, filtered, milligrams per liter	Fecal coliform, M-FC MF (0.7 micron) method, water, colonies per 100 milliliters	Escherichia coli, m-TEC MF method, water, colonies per 100 milliliters	Fecal streptococci, KF streptococcus MF method, water, colonies per 100 milliliters	Chlorophyll a, phytoplankton, spectrophotometric acid method, micrograms per liter	Escherichia coli, Defined Substrate Technology, water, most probable number per 100 milliliters	Total coliform, Defined Substrate Technology, water, most probable number per 100 milliliters	Suspended sediment, sieve diameter, percent smaller than 0.0625 millimeters	Chlorophyll a, phytoplankton, chromatographic-fluorometric method, micrograms per liter	Suspended sediment concentration, milligrams per liter	Suspended sediment discharge, tons per day	Totals
7196500	Illinois River near Tahlequah, OK	580*	42	503	502	550	199	97	214	20	214	161	31	247	214	15	213	257	214	65	30	112	78	111	42	30	30	158	10	286	284	4929
		11/6/1959**	11/6/1959	12/16/1975	12/16/1975	11/6/1959	11/12/1975	11/16/1989	11/16/1989	7/24/1978	11/16/1989	11/20/1959	4/29/1993	10/20/1976	11/16/1989	9/30/1990	11/16/1989	12/16/1975	11/16/1989	10/17/1977	4/29/1993	4/29/1993	5/16/1994	4/29/1993	7/16/1996	10/10/2007	10/10/2007	4/29/1993	12/7/2005	8/23/1955	8/23/1955	
		10/27/2009***	5/16/1995	10/27/2009	10/27/2009	10/27/2009	9/23/2009	9/23/2009	9/23/2009	12/8/1992	9/23/2009	9/23/2009	8/24/1995	9/23/2009	9/23/2009	12/8/1992	9/23/2009	9/23/2009	9/23/2009	6/24/2009	8/24/1995	2/12/2007	7/15/2003	2/12/2007	6/10/2003	10/27/2009	10/27/2009	8/20/2009	6/7/2007	8/20/2009	6/24/2009	
7197000	Baron Fork at Eldon, OK	571	58	502	476	570	168	70	184	9	184	146	20	218	184	7	177	227	184	61	3	81	63	81	42	31	31	131		133	129	4741
		5/7/1958	10/7/1958	12/16/1975	12/16/1975	5/7/1958	11/12/1975	11/20/1991	7/30/1991	7/30/1991	7/30/1991	5/7/1958	4/28/1993	10/20/1976	7/30/1991	11/20/1991	11/20/1991	12/16/1975	7/30/1991	10/17/1977	5/17/1994	5/17/1994	5/17/1994	5/17/1994	7/16/1996	10/4/2007	10/4/2007	5/17/1994		5/17/1994	5/17/1994	
		10/27/2009	9/14/1976	10/27/2009	10/27/2009	10/27/2009	10/9/2009	6/24/2009	10/9/2009	12/7/1992	10/9/2009	10/9/2009	7/27/1995	10/9/2009	10/9/2009	12/7/1992	10/9/2009	10/9/2009	10/9/2009	6/24/2009	5/15/1995	7/15/2003	7/15/2003	7/15/2003	6/10/2003	10/27/2009	10/27/2009	8/27/2009		8/27/2009	6/24/2009	
7196900	Baron Fork at Dutch Mills, AR	421	18	361	234	382	79	52	79	195	79	64		97	78	137	64	300	79	60		85	84	61				82		82	79	3252
		3/14/1960	3/14/1960	10/3/1972	10/3/1972	3/17/1959	8/7/1985	8/7/1985	6/28/1995	4/5/1977	6/28/1995	3/17/1959		8/7/1985	6/28/1995	10/7/1980	6/28/1995	10/17/1972	6/28/1995	10/25/1988		6/28/1995	1/5/1993	6/28/1995				6/28/1995		6/28/1995	6/28/1995	
		8/25/2009	3/2/1993	8/25/2009	8/25/2009	8/25/2009	8/25/2009	8/25/2009	8/25/2009	9/20/1994	8/25/2009	8/25/2009		8/25/2009	8/25/2009	9/20/1994	8/25/2009	8/25/2009	8/25/2009	9/20/1994		8/25/2009	8/25/2008	6/20/2005				8/25/2009		8/25/2009	8/25/2009	
7195500	Illinois River near Watts, OK	555	95	437	420	573	214	143	196	25	196	222	18	230	196	66	194	280	196	64		81	60	78	42	29	29	133		134	131	5037
		5/27/1959	9/12/1955	7/30/1969	10/13/1970	9/12/1955	11/12/1975	7/24/1978	11/16/1989	7/24/1978	11/16/1989	10/16/1957	6/30/1993	11/17/1976	11/16/1989	7/30/1969	11/16/1989	7/30/1969	11/16/1989	10/17/1977		9/8/1978	7/23/1996	7/23/1996	7/23/1996	10/4/2007	10/4/2007	11/19/1991		3/4/1965	3/4/1965	
		10/26/2009	9/14/1976	10/26/2009	10/26/2009	10/26/2009	8/20/2009	8/20/2009	8/20/2009	12/9/1992	8/20/2009	8/20/2009	7/31/1995	8/20/2009	8/20/2009	12/9/1992	8/20/2009	8/20/2009	8/20/2009	6/15/2009		7/14/2003	7/14/2003	7/14/2003	6/10/2003	10/26/2009	10/26/2009	8/20/2009		8/20/2009	6/15/2009	
7194760	Illinois River near Viney Grove, AR	43		43	43	16	13	9	12	4	12	11		13	12	4	11	16	12			16	12					12	12	12	6	344
		9/6/1978		9/6/1978	9/6/1978	9/6/1978	8/25/1981	7/25/1979	8/31/2005	9/6/1978	8/31/2005	8/31/2005		8/25/1981	8/31/2005	9/6/1978	8/31/2005	9/6/1978	8/31/2005			9/6/1978	8/31/2005					8/31/2005	8/25/1981	8/31/2005	3/7/2006	
		7/19/2007		7/19/2007	7/19/2007	7/19/2007	7/19/2007	7/19/2007	7/19/2007	8/25/1981	7/19/2007	7/19/2007		7/19/2007	7/19/2007	8/25/1981	7/19/2007	7/19/2007	7/19/2007			7/19/2007	7/19/2007					7/19/2007	7/19/2007	7/19/2007	7/19/2007	
7194800	Illinois River at Savoy, AR	393	1	372	239	347	89	67	82	204	83	61		102	83	140	71	308	83	63		93	89	61				87	16	87	85	3306
		4/24/1974	9/11/1968	4/24/1974	4/24/1974	9/11/1968	8/26/1981	9/6/1978	6/29/1995	5/3/1977	6/29/1995	9/11/1968		8/26/1981	6/29/1995	9/6/1978	6/29/1995	4/24/1974	6/29/1995	10/25/1988		9/6/1978	1/5/1993	6/29/1995				6/29/1995	8/31/2005	6/29/1995	6/29/1995	
		8/25/2009		8/25/2009	8/25/2009	8/25/2009	8/25/2009	8/25/2009	8/25/2009	9/20/1994	8/25/2009	8/25/2009		8/25/2009	8/25/2009	9/20/1994	8/25/2009	8/25/2009	8/25/2009	9/20/1994		8/25/2009	8/18/2008	6/22/2005				8/25/2009	7/19/2007	8/25/2009	8/25/2009	
7195000	Osage Creek near Elm Springs, AR	381	17	364	230	356	94	62	79	202	79	69		100	79	150	78	307	79	67		89	85	61				82	1	82	81	3274
		2/3/1953	9/10/1951	4/9/1974	4/9/1974	9/10/1951	8/26/1980	9/7/1978	6/29/1995	4/19/1977	6/29/1995	9/10/1951		8/26/1980	6/29/1995	11/28/1978	6/29/1995	4/9/1974	6/29/1995	8/26/1980		9/7/1978	1/5/1993	6/29/1995				6/29/1995	8/25/1981	6/29/1995	6/29/1995	
		8/25/2009	4/1/1975	8/25/2009	8/25/2009	8/25/2009	8/25/2009	3/23/2009	8/25/2009	9/20/1994	8/25/2009	8/25/2009		8/25/2009	8/25/2009	9/20/1994	8/25/2009	8/25/2009	8/25/2009	9/20/1994		8/25/2009	8/18/2008	6/22/2005				8/25/2009		8/25/2009	8/25/2009	
7195400	Illinois River at Hwy. 16 near Siloam Springs AR	144	5	135	9	132	15	16		130				19		120		123		63		4	5						1			921
		9/8/1978	11/5/1985	9/8/1978	9/8/1978	9/8/1978	8/26/1981	9/8/1978		9/8/1978				8/26/1981		9/8/1978		9/8/1978		10/25/1988		9/8/1978	1/5/1993						8/26/1981			
		9/20/1994	10/22/1991	9/20/1994	9/5/1981	9/20/1994	9/2/1986	9/2/1986		9/20/1994				9/2/1986		9/20/1994		9/20/1994		9/20/1994		8/26/1981	9/21/1993									
7195430	Illinois River South of Siloam Springs, AR	277	121	277	275	256	98	65	115	56	114	59		116	115	15	115	204	115			116	108	86				111				2814
		10/3/1972	10/3/1972	10/3/1972	10/3/1972	10/3/1972	8/26/1981	9/7/1978	6/29/1995	4/5/1977	6/29/1995	6/29/1995		8/26/1981	6/29/1995	9/7/1978	6/29/1995	10/17/1972	6/29/1995			9/7/1978	6/29/1995	6/29/1995				6/29/1995				
		8/25/2009	9/22/1981	8/25/2009	8/25/2009	8/25/2009	8/25/2009	12/12/2007	8/25/2009	9/22/1981	8/25/2009	8/25/2009		8/25/2009	8/25/2009	9/22/1981	8/25/2009	8/25/2009	8/25/2009			8/25/2009	8/25/2008	6/22/2005				8/25/2009				
7195800	Flint Creek at Springtown, AR	38		3	2	3	3				3		3	2	3		3	2	3		3	2	2	2				2		2	2	83
		10/15/1975		10/25/1994	10/25/1994	10/25/1994	10/25/1994				10/25/1994		10/25/1994	7/18/1995	10/25/1994		10/25/1994	7/18/1995	10/25/1994		10/25/1994	10/25/1994	10/25/1994	10/25/1994				10/25/1994		10/25/1994	10/25/1994	
		7/1/1996		7/1/1996	7/18/1995	7/1/1996	7/1/1996				7/1/1996		7/1/1996	7/1/1996	7/1/1996		7/1/1996	7/1/1996	7/1/1996		7/1/1996	7/18/1995	7/18/1995	7/18/1995				7/18/1995		7/18/1995	7/18/1995	
7195855	Flint Creek near West Siloam Springs, OK	51		49	18	47	1	1	2	31	2	2		2	2	18	2	32	2	28		8	13	8				8		8	8	343
		7/11/1979		10/22/1991	6/29/1995	10/22/1991	8/3/1995	8/3/1995	6/29/1995	10/22/1991	6/29/1995	6/29/1995		6/29/1995	6/29/1995	10/22/1991	6/29/1995	10/22/1991	6/29/1995	10/22/1991		6/29/1995	1/5/1993	6/29/1995				6/29/1995		6/29/1995	6/29/1995	
		8/28/1996		8/28/1996	8/28/1996	8/28/1996			8/3/1995	9/20/1994	8/3/1995	8/3/1995		8/3/1995	8/3/1995	9/20/1994	8/3/1995	8/3/1995	8/3/1995	9/20/1994		8/28/1996	8/28/1996	8/28/1996				8/28/1996		8/28/1996	8/28/1996	
7195865	Sager Creek near West Siloam	254		252	249	254	115	68	117	9	117	66	17	124	117	8	115	122	115			60	42	60	42			74		74	73	2544
		8/6/1991		8/6/1991	10/6/1992	8/6/1991	5/24/1991	5/24/1991	10/6/1992	5/24/1991	10/6/1992	12/8/1992	6/30/1993	5/24/1991	10/6/1992	5/24/1991	10/6/1992	5/24/1991	10/6/1992			7/18/1996	7/18/1996	7/18/1996	7/18/1996			7/18/1996		7/18/1996	7/18/1996	
		10/21/2009		10/21/2009	10/21/2009	10/21/2009	8/20/2009	8/20/2009	8/20/2009	12/8/1992	8/20/2009	8/20/2009	7/31/1995	8/20/2009	8/20/2009	12/8/1992	8/20/2009	8/20/2009	8/20/2009			6/9/2003	6/9/2003	6/9/2003	6/9/2003			8/20/2009		8/20/2009	4/20/2009	
7196000	Flint Creek near Kansas, OK	511	67	465	463	540	166	81	174	11	174	130	16	208	174	7	174	215	174	58		77	59	77	42	29	29	127		127	124	4499
		10/7/1959	9/7/1955	11/12/1975	11/12/1975	9/7/1955	11/12/1975	7/25/1991	7/25/1991	7/24/1978	7/25/1991	10/7/1959	6/30/1993	11/17/1976	7/25/1991	7/25/1991	7/25/1991	12/16/1975	7/25/1991	10/17/1977		7/18/1996	7/18/1996	7/18/1996	7/18/1996	10/1/2007	10/1/2007	11/19/1991		11/19/1991	7/18/1996	
		10/26/2009	9/14/1976	10/26/2009	10/26/2009	10/26/2009	10/9/2009	10/9/2009	10/9/2009	12/8/1992	10/9/2009	10/9/2009	7/31/1995	10/9/2009	10/9/2009	12/8/1992	10/9/2009	10/9/2009	10/9/2009	6/1/2009		7/14/2003	7/14/2003	7/14/2003	6/9/2003	10/26/2009	10/26/2009	8/20/2009		8/20/2009	6/1/2009	
7196973	Peacheater Creek at Christie, OK	22		21	9	21	2		6	17	6	2	3	25	10	14	10	25	10		3	3	3	3				1		2	2	220
		8/6/1991		8/6/1991	10/13/1992	8/6/1991	8/6/1991		10/13/1992	8/6/1991	10/13/1992	12/7/1992	5/17/1994	8/6/1991	10/13/1992	8/6/1991	10/13/1992	8/6/1991	10/13/1992		5/17/1994	5/17/1994	5/17/1994	5/17/1994				5/17/1994		5/17/1994	5/17/1994	
		5/16/1995		5/16/1995	5/16/1995	5/16/1995	9/14/1993		5/16/1995	12/7/1992	5/16/1995	2/22/1993	5/16/1995	5/16/1995	5/16/1995	12/7/1992	5/16/1995	5/16/1995	5/16/1995		5/16/1995	5/16/1995	5/16/1995	5/16/1995						5/16/1995	5/16/1995	
7197360	Caney Creek near Barber, OK	198		198	198	198	83	36	101		101	54		102	101		98	101	101	43		57	56	56		25	25	46		46	41	2065
		8/25/1997		8/25/1997	8/25/1997	8/25/1997	4/22/1998	4/22/1998	8/25/1997		8/25/1997	12/15/1997		8/25/1997	8/25/1997		8/25/1997	8/25/1997	8/25/1997	7/11/2005		8/25/1997	8/25/1997	8/25/1997		10/4/2007	10/4/2007	2/24/2001		2/24/2001	2/24/2001	
		10/27/2009		10/27/2009	10/27/2009	10/27/2009	9/10/2009	4/21/2009	9/10/2009		9/10/2009	9/10/2009		9/10/2009	9/10/2009		9/10/2009	9/10/2009	9/10/2009	6/8/2009		6/13/2006	6/10/2002	6/10/2002		10/27/2009	10/27/2009	8/27/2009		8/27/2009	6/8/2009	
7198000	Illinois River near Gore, OK	515	367	259	243	606	50	19	33	14	53	305	15	59	79	82	23	69	32	9										40	40	2912
		10/1/1947	10/1/1947	11/12/1975	11/12/1975	10/1/1947	11/12/1975	12/14/1976	8/8/1979	3/8/1990	7/17/1973	10/1/1947	2/9/1993	10/14/1976	7/17/1973	10/1/1964	10/12/1989	12/16/1974	10/12/1989	10/18/1977										4/12/1940	4/12/1940	
		8/16/1995	9/15/1976	8/16/1995	8/16/1995	8/16/1995	5/10/1995	5/10/1995	6/21/1995	12/16/1992	6/21/1995	6/21/1995	6/21/1995	6/21/1995	6/21/1995	12/16/1992	6/21/1995	6/21/1995	6/21/1995	9/6/1978										2/14/1950	2/14/1950	
7196090	Illinois River at Chewey, OK	418		418	414	417	137	73	151		151	111		151	151		151	151	151	51		77	40	76		29	29	113		113	112	3685
		7/17/1996		7/17/1996	7/17/1996	7/17/1996	3/25/1997	3/18/1998	7/17/1996		7/17/1996	7/17/1996		7/17/1996	7/17/1996		7/17/1996	7/17/1996	7/17/1996	5/23/2005		7/17/1996	7/1/1999	7/17/1996		10/4/2007	10/4/2007	7/1/1999		7/1/1999	7/1/1999	
		10/27/2009		10/27/2009	8/26/2009	10/27/2009	8/26/2009	4/13/2009	8/26/2009		8/26/2009	8/26/2009		8/26/2009	8/26/2009		8/26/2009	8/26/2009	8/26/2009	6/11/2009		8/9/2006	7/14/2003	7/14/2003		10/27/2009	10/27/2009	8/26/2009		8/26/2009	6/11/2009	
																																0
Totals		5372	791	4659	4024	5268	1526	859	1545	927	1568	1463	123	1815	1598	783	1499	2739	1550	632	39	961	799	821	210	173	173	1167	40	1228	1197	

*Number of data available for given location
**Start date for given location
***End date for given location

Table 2.6 Modern STORET Stations with Nutrient and TSS Data in the IRW (post 1999)

	Location	NH3	TKN	NO2 + NO3	Org N	Total P	PO4-P	TSS	
Station ID		Count	Count	Count	Count	Count	Count	Count	Total
121700030010-01	Illinois River	72	78	6	24		76	30	286
121700030350-01	Illinois River	79	85	5	15		70	20	274
121700040010-01	Caney Creek	52	56	5	6		56	12	187
121700050010-01	Barren Fork River	112	117	15	14		107	20	385
121700060010-01	Flint Creek	64	68	5	16		68	21	242
121700060080-01	Sager Creek	98	106	10	14		106	19	353
ARK0004A	Flint Creek	42	29	42		38	42	84	277
ARK0005	Sager Creek	42	26	42		38	42	84	274
ARK0006	Illinois River	41	26	41		37	41	82	268
ARK0007A	Baron Fork	43	33	43		40	43	86	288
ARK0010C	Clear Creek	70	52	70		64	70	140	466
ARK0040	Illinois River	43	30	43		40	43	86	285
ARK0041	Osage Creek	49	33	49		44	49	98	322
ARK0141	Cincinnati Circle	42	25	42		39	42	84	274
FC1	Flint Creek		22				34		56
FC3	Flint Creek		22				33		55
FC5	Flint Creek		22				34		56
Totals		849	830	418	89	340	956	866	

station also in pre 1999 Data

Table 2.7 Summary Inventory of Legacy STORET Records for Oklahoma 11110103

```
LEGACYSTORET_WTEMP.CSV     N_OBS=  1280 WATER_TEMPERATURE
LEGACYSTORET_SALINITY.CSV  N_OBS=  2104 SALINITY
LEGACYSTORET_OXYGEN.CSV    N_OBS=  1214 DISSOLVED-OXYGEN
LEGACYSTORET_OXYGEN_SAT.C  N_OBS=  1199 OXYGEN_SATURATION_PERCENT
LEGACYSTORET_TSS.CSV       N_OBS=  1582 TOTAL_SUSPENDED_SOLIDS [TSS=POM+PIM=VSS+
LEGACYSTORET_POM.CSV       N_OBS=   219 PARTIC_ORG_MATTER_[VOLATILE (VSS)]
LEGACYSTORET_PIM.CSV       N_OBS=   197 PARTIC_INORG_MATTER_[NON-VOLATILE (NVSS)
LEGACYSTORET_TOC.CSV       N_OBS=   594 TOTAL-ORGANIC-CARBON (TOC=POC+DOC)
LEGACYSTORET_ALK.CSV       N_OBS=   537 ALKALINITY AS CACO3
LEGACYSTORET_PH.CSV        N_OBS=  1184 PH as PH UNITS
LEGACYSTORET_TPO4.CSV      N_OBS=     6 TOTAL-ORTHO_PHOSPHATE (TPO4 = DISS + PAR
LEGACYSTORET_DIP.CSV       N_OBS=    12 DISSOLVED-INORG-PHOSPHORUS
LEGACYSTORET_TP.CSV        N_OBS=  1734 TOTAL-PHOSPHORUS (TP=(POP+DOP)+TPO4
LEGACYSTORET_TON.CSV       N_OBS=    10 TOTAL-ORGANIC-NITROGEN(TON=PON+DON)
LEGACYSTORET_TKN.CSV       N_OBS=  1331 TOTAL-KJELDHAL-NITROGEN(TKN=TON+NH3-N)
LEGACYSTORET_NH3.CSV       N_OBS=   796 AMMONIA-NITROGEN(NH3-N)
LEGACYSTORET_NO2.CSV       N_OBS=    72 NITRITE-NITROGEN(NO2-N)
LEGACYSTORET_NO3.CSV       N_OBS=   159 NITRATE-NITROGEN(NO3-N)
LEGACYSTORET_NO2NO3.CSV    N_OBS=  1433 NITRITE-N+NITRATE-N(NO2-N + NO3-N)
LEGACYSTORET_TN.CSV        N_OBS=   845 TOTAL-NITROGEN(TN=PON + DON + NH3 + NO2
LEGACYSTORET_FEC_COLI.CSV  N_OBS=   429 FECAL-COLIFORM-BACTERIA
LEGACYSTORET_FEC_STREP.CS  N_OBS=   120 FECAL_STREPTOCOCCI-BACTERIA
LEGACYSTORET_BOD5.CSV      N_OBS=   809 BOD5[5-DAY BOD](CARBONACEOUS+NITROGENOUS
LEGACYSTORET_SECCHI.CSV    N_OBS=   218 SECCHI DEPTH
LEGACYSTORET_TURBIDITY_J.  N_OBS=  1238 TURBIDITY AS JTU
LEGACYSTORET_TURBIDITY_N.  N_OBS=   612 TURBIDITY AS NTU
LEGACYSTORET_COLOR.CSV     N_OBS=   139 COLOR AS PLATINUM COLOR UNITS
LEGACYSTORET_CHLA_UNCORR.  N_OBS=   206 CHLOROPHYLL_A[UNCORRECTED]
LEGACYSTORET_CHLA_UNK.CSV  N_OBS=   145 CHLOROPHYLL_A[UNKNOWN IF CORRECTED]
```

Table 2.8 Summary Inventory of Legacy STORET Records for Arkansas 11110103

```
LEGACYSTORET_WTEMP.CSV     N_OBS=  1141 WATER_TEMPERATURE
LEGACYSTORET_SALINITY.CSV  N_OBS=   735 SALINITY
LEGACYSTORET_OXYGEN.CSV    N_OBS=   587 DISSOLVED-OXYGEN
LEGACYSTORET_OXYGEN_SAT.C  N_OBS=   569 OXYGEN_SATURATION_PERCENT
LEGACYSTORET_TSS.CSV       N_OBS=   582 TOTAL_SUSPENDED_SOLIDS [TSS=POM+PIM=VSS+
LEGACYSTORET_POM.CSV       N_OBS=   123 PARTIC_ORG_MATTER_[VOLATILE (VSS)]
LEGACYSTORET_PIM.CSV       N_OBS=   106 PARTIC_INORG_MATTER_[NON-VOLATILE (NVSS)
LEGACYSTORET_TOC.CSV       N_OBS=   462 TOTAL-ORGANIC-CARBON (TOC=POC+DOC)
LEGACYSTORET_ALK.CSV       N_OBS=   189 ALKALINITY AS CACO3
LEGACYSTORET_PH.CSV        N_OBS=   862 PH as PH UNITS
LEGACYSTORET_TP.CSV        N_OBS=   533 TOTAL-PHOSPHORUS (TP=(POP+DOP)+TPO4
LEGACYSTORET_TKN.CSV       N_OBS=   270 TOTAL-KJELDHAL-NITROGEN(TKN=TON+NH3-N)
LEGACYSTORET_NH3.CSV       N_OBS=   553 AMMONIA-NITROGEN(NH3-N)
LEGACYSTORET_NO2.CSV       N_OBS=    18 NITRITE-NITROGEN(NO2-N)
LEGACYSTORET_NO3.CSV       N_OBS=    17 NITRATE-NITROGEN(NO3-N)
LEGACYSTORET_NO2NO3.CSV    N_OBS=   533 NITRITE-N+NITRATE-N(NO2-N + NO3-N)
LEGACYSTORET_TN.CSV        N_OBS=    42 TOTAL-NITROGEN(TN=PON + DON + NH3 + NO2
LEGACYSTORET_FEC_COLI.CSV  N_OBS=   463 FECAL-COLIFORM-BACTERIA
LEGACYSTORET_FEC_STREP.CS  N_OBS=    14 FECAL_STREPTOCOCCI-BACTERIA
LEGACYSTORET_BOD5.CSV      N_OBS=   467 BOD5[5-DAY BOD](CARBONACEOUS+NITROGENOUS
LEGACYSTORET_SECCHI.CSV    N_OBS=   308 SECCHI DEPTH
LEGACYSTORET_TURBIDITY_J.  N_OBS=    42 TURBIDITY AS JTU
LEGACYSTORET_TURBIDITY_N.  N_OBS=   515 TURBIDITY AS NTU
LEGACYSTORET_COLOR.CSV     N_OBS=    43 COLOR AS PLATINUM COLOR UNITS
LEGACYSTORET_CHLA_UNCORR.  N_OBS=    21 CHLOROPHYLL_A[UNCORRECTED]
LEGACYSTORET_CHLA_UNK.CSV  N_OBS=    68 CHLOROPHYLL_A[UNKNOWN IF CORRECTED]
```

The University of Arkansas has collected and provided water quality data for Osage and Spring Creeks for the period 2007-2010. According to Matlock, these data represent the most comprehensive analyses of water quality in the upper basin in ten years. In addition, the City of Rodgers has an ongoing NPS monitoring program, and this data is available through ADEQ.

As part of the ongoing litigation between the OK Office of the Attorney General (OAG) and AR Poultry Producers, extensive sampling and analyses were performed between 2005 and 2010. As part of this case, the engineering firm Camp, Dresser, & Mckee (CDM) worked with the USGS to collect a variety of samples from different media, and analyze them for various water quality constituents, including sediment (TSS), and various forms of both nitrogen and phosphorus. The OAG provided the resulting database to EPA and AQUA TERRA for use in this effort, through the ODEQ (A. Fang, personal communication, 19 May 2010). The OAG indicated that the following data types were available:

- Stream water quality data for the Illinois, Flint Creek, Baron Fork and many of their tributaries
- Water quality data for Lake Tenkiller, reference lakes and some smaller reservoirs in the IRW
- Poultry waste sample results
- Spring water quality data
- Pasture soil and edge of field water sample results
- Algae and benthic macroinvertebrate sample results
- Waste Water Treatment Plant discharge sample results
- Sample results for development of the poultry waste biomarker
- Lake Tenkiller sediment core sample results and age dating
- Disinfection Byproduct sample results for precursors and in finished water

Table 2.9 summarizes the types of data, number of locations within the IRW, the time period, and the number of samples related to sediment, nitrogen, and phosphorus available in the CDM database. Figure 2.6 shows the location distribution of these data collection sites across the IRW. AQUA TERRA is still in the process of reviewing and interpreting these data for their use in this effort, along with an extensive list of documents and expert reports associated with the court case. The data is accompanied by a Quality Assurance Project Plan (QAPP) documenting the data collection QA/QC procedures implemented in this data collection effort.

Table 2.9 Summary of IR CDM Database Provided by OK Attorney General's Office

Locations	Number of Locations	Sediment	Phosphorus	Nitrogen	Approximate Time Period
Edge Of Field	**68**		45	77	2005-2007
Tenkiller and other Lakes	**22**	4	492	473	2005-2008
Tenkiller Lake Sediment	**5**	12	89	100	2005-2006
Poultry Litter Sample	**4**		4	4	2006
Reach	**221**	1	1069	445	2005-2008
Springs	**35**		40	48	2005-2007
USGS Gage	**7**		237	183	2005-2010
Water Treatment Plant	**2**				2006
Litter Application Locations	**54**	51	171	116	2006

In support of the defendant's side in the above-mentioned court case, Tyson Foods has provided extensive documentation on water quality issues and phosphorus sources within the IRW (Robert George, Tyson Foods, numerous personal communications, February-March 2010). In addition to background information on poultry litter and litter management, many of the documents are expert reports developed as part of the court case, including critical reviews of the QA/QC procedures used in the data collection by CDM (above). These expert reports, along with those provided by the OAG's office, amount to more than 5,500 pages of technical reviews and analyses for both sides of the litigation, and describe detailed assessments of the supporting data and water quality issues within the IRW. Since portions of this database were challenged during the litigation, we plan to use only data from this database that provides unique and significant value to the modeling effort either during the model setup phase or as part of the model calibration effort. When such data is identified, it will be reviewed along with its accompanying Quality Assurance Project Plan (QAPP) documenting the data collection QA/QC procedures implemented in the data collection effort, to ensure that the data meets EPA's QA/QC standards. In addition, we will review the QA/QC concerns identified during the litigation to assess their potential impact on our use of the data. The results of these analyses will be reported and documented in the model calibration report.

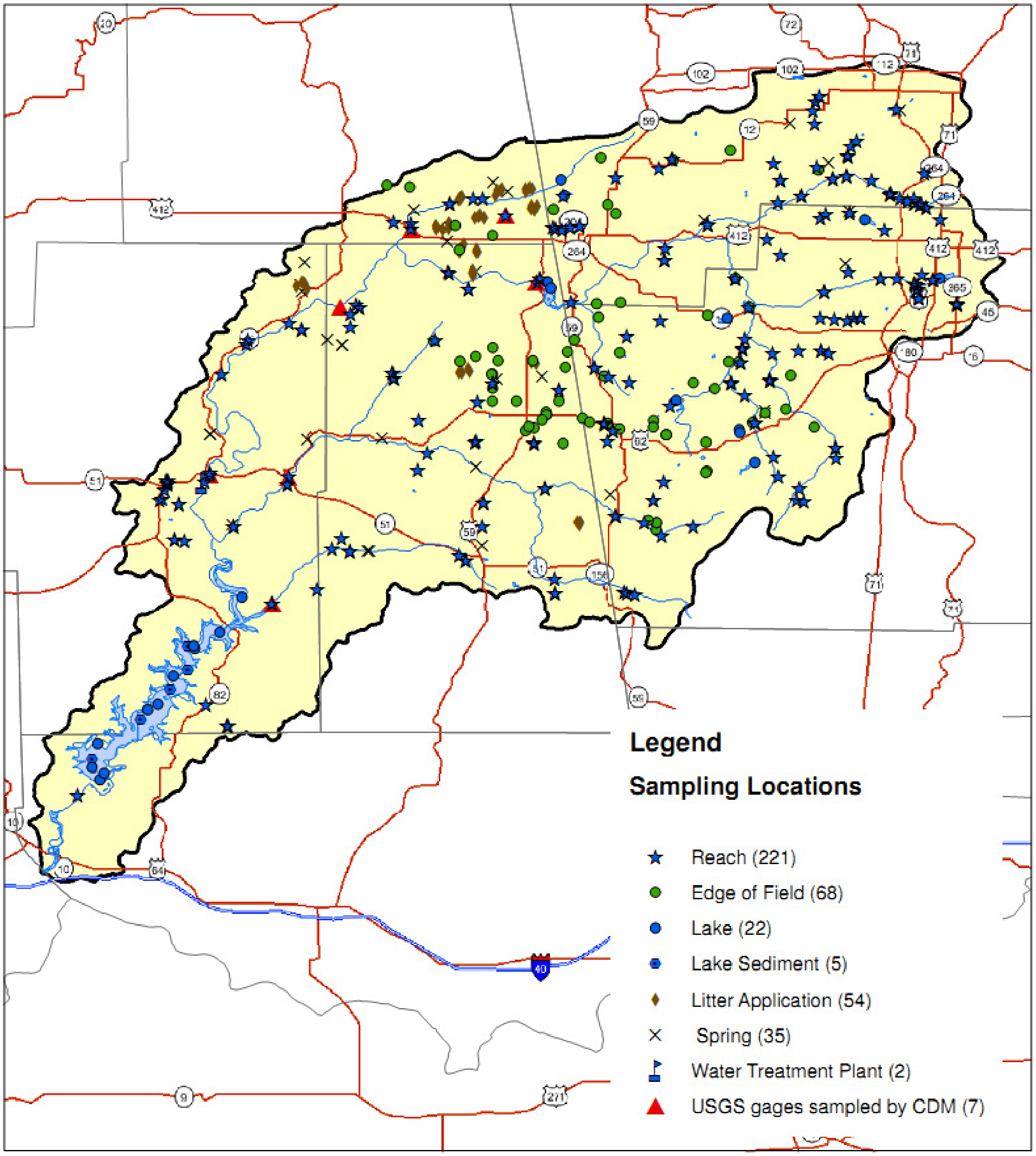


Figure 2.6 Sample Locations and Types Provided by the OK Office of Attorney General

2.5 POINT SOURCES

Data on point sources discharges have been compiled from a number of different sources of information. Figure 2.7 shows the locations of point source dischargers included in the prior modeling efforts with both BASINS/HSPF and SWAT. Clearly the two modeling efforts focused on the major dischargers, and ignored the contributions from the numerous minor, and smaller ones. However, some screening of all the EPA designated sources will need to be done to confirm that the major point sources have been included for use in the proposed modeling.

For each effluent discharger, a timeseries of flows and loads will need to be developed for each constituent included in the modeling. Although the BASINS/HSPF application represented the point sources as mean annual loads, the SWAT model obtained and used monthly values to allow for seasonal variations. In addition, ODEQ developed and provided spreadsheets of monthly loads for the OK dischargers at the time of the BASINS/HSPF effort (A. Fang, personal communication, approximately January 2008). These were based on data from NPDES Discharge Monitoring Reports (DMR) and various assumptions on organic fractions of the TN and TP. These data-derived estimates cover the period from 1990 through 2007, and ODEQ has updated these values through 2009 for the current effort (A. Fang, personal communication, 3 March 2011). ADEQ has also provided updated data to develop the needed timeseries data for the AR dischargers.

The City of Tahlequah provided hard copy reports of their effluent discharge data as recorded in the NPDES DMRs, along with other water quality data from Tahlequah Creek (D. Morrison, Tahlequah Public Works Authority, personal communication, March 30, 2010). These reports will be used to confirm the final discharge loadings developed for that facility.

Development of the final point source loadings data for use in the model will require working with State representatives, and with EPA, and their ICIS database, to screen the permitted point sources for selection of the major ones to include in the model, and then possibly working with site-specific data to develop the loading files from available information for each source. As noted above, both ODEQ and ADEQ have provided updated discharge data for their respective dischargers. In addition, the assumptions inherent in this effort (e.g. organic fractions, interpolation methods, etc.) are currently being developed to establish consistency in the final discharge values. Where a specific water quality constituent is not available from the records for a wastewater facility, as a last resort effluent concentrations can be estimated based on either a default concentration or a ratio of other related constituents (e.g, TOC/TSS, where TSS available from the NPDES effluent records can be used to estimate the missing constituent (e.g., TOC)). Effluent data, derived, in part, from a national inventory of wastewater NPDES records (Tetra Tech, 1999), has been used to develop a table of typical effluent concentrations (see Table 2.10) for the different levels of municipal wastewater treatment (e.g., secondary, advanced waste treatment) (Stoddard et al., 2002; Tetra Tech and Stoddard, 2000). The values in Table 2.10 can be used to estimate missing effluent constituents, if needed. Both ODEQ and ADEQ will be contacted for any additional local data that can assist in this effort, to avoid a need to use nationally-based estimates for this study. Although point source data is not a current data deficiency, it is a task that needs to be performed with accepted procedures in order to accurately represent point source contributions within the modeling effort.

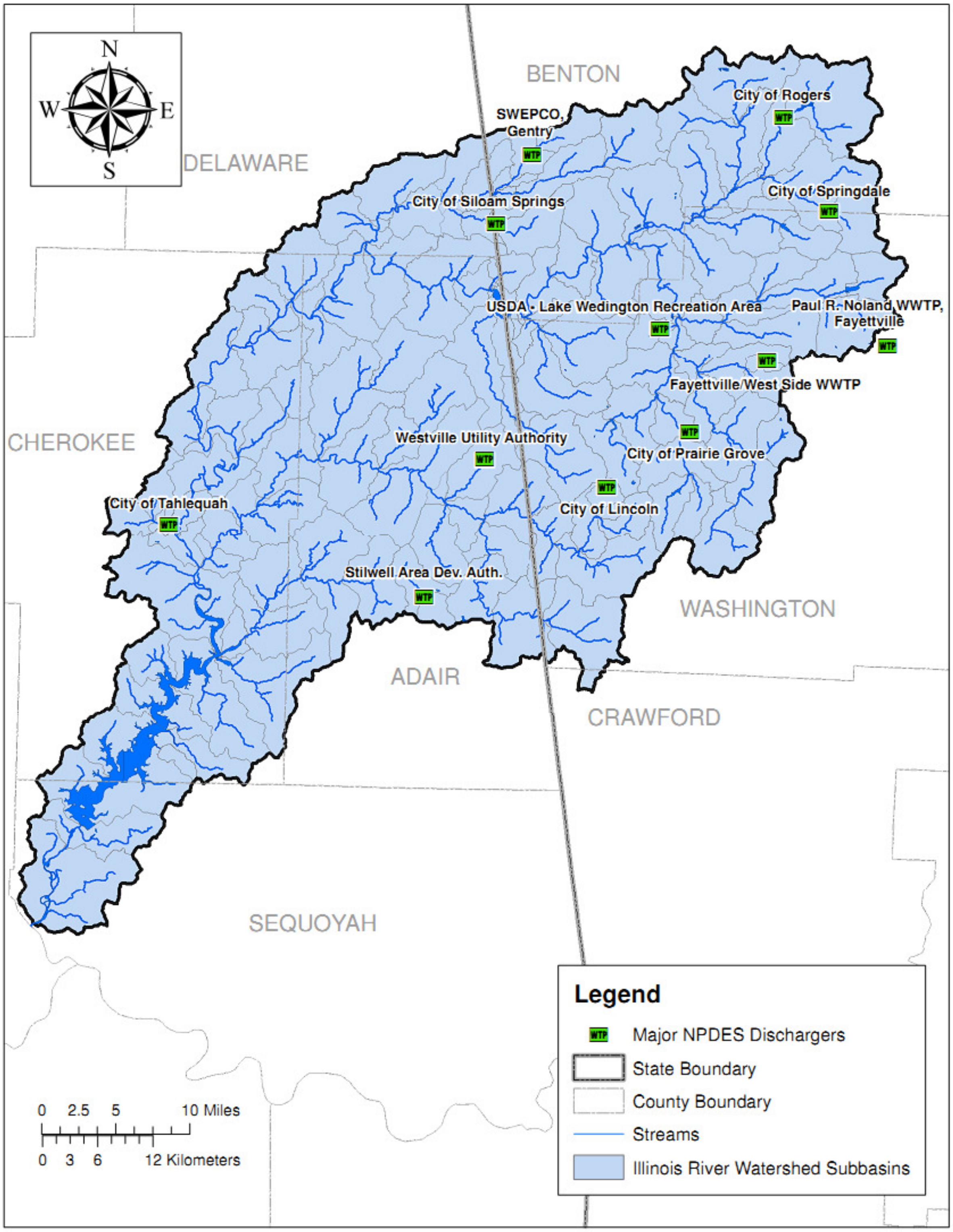


Figure 2.7 Locations of Point Sources Within the IRW

Table 2.10 Effluent Characteristics for POTWs (Tetra Tech and Stoddard, 2000)

Parameter (mg/L)	(Influent) Raw	Primary	Advanced Primary	Secondary	Advanced Secondary	Advanced Wastewater Treatment
BOD_5						
Mean	205.0	143.5	102.5	16.4	6.2	4.1
% Removal	0	30	50	92	97	98
Reference/Notes	*a, j*	*b*	*c*	*a*	*a, d*	*a, d*
$CBOD_u/CBOD_5$						
Mean	1.2	1.6	1.6	2.84	2.84	3.0
Reference/Notes	*e*	*f*	*f*	*f*	*f*	*f*
TSS (mg/L)						
Mean	215	107.5	64.5	17.2	6.5	4.3
% Removal	0	50	70	92	97	98
Reference/Notes	*a, j*	*b*	*c*	*a*	*a,d*	*a,d*
NH_3-N (mg-N/L)						
Mean	18.0	14.4	14.4	12.2	3.4	2.0
% Removal	0	20	20	32	81	89
Reference/Notes	*a*	*b*	*b*	*a*	*a,d*	*a,d*
TKN (mg-N/L)						
Mean	30.0	23.4	23.4	16.5	12.9	3.6
% Removal	0	22	22	45	57	88
Reference/Notes	*a*	*b*	*b*	*a*	*a,d*	*a,d*
Total N (mg-N/L)						
Mean	30.0	23.4	23.4	18.3	18.4	14.4
% Removal	0	22	22	39	39	52
Reference/Notes	*g*	*h*	*h*	*a*	*a,d*	*a,d*
Total P (mg-P/L)						
Mean	6	5.2	5.2	2.5	0.4	0.4
% Removal	0	13	13	58	94	94
Reference/Notes	*a*	*b*	*b*	*a*	*a,d*	*a,d*
DO (mg/L)						
Mean	4.1	4.3	4.3	6.6	6.6	7.1
Reference/Notes	*i*	*j*	*j*	*j*	*j*	*j*
Total Organic Carbon (mg/L)						
Mean	148.6	107.5	76.8	21.8	8.2	5.8
% Removal	0	28	48	85	94	96
Reference/Notes	*g*	*b, k*	*k*	*b,k*	*k*	*k*

References/Notes

a. AMSA, 1997. Influent concentration, percent removal, and TKN:TN, NH_3:TKN, and PO_4:TP ratios for secondary, advanced secondary, and advanced wastewater treatment. ***b.*** Gunnerson et al., 1982. ***c.*** NRC, 1993. Percent removal for advanced primary with "low dose chemical addition." ***d.*** MWCOG, 1989. Percent removal and TKN:TN, NH_3:TKN, and PO_4:TP ratios for advanced secondary, and advanced wastewater treatment. ***e.*** Thomann and Mueller, 1987. ***f.*** Leo et al., 1984. ***g.*** Metcalf and Eddy, 1991. TKN:TN, NH_3:TKN, and PO_4:TP ratios of influent concentration for "medium" strength wastewater, raw TOC influent concentration based on BOD_5, $CBOD_u$:BOD_5, oxygen:carbon, and ratios of C:DW. ***h.*** ICPRB, 1991. TKN:TN, NH_3:TKN, and PO_4:TP ratios of effluent concentration for primary, advanced primary, and secondary treatment. ***i.*** Assume 50 percent saturation at 25 °C and 50 mg/L chlorides at sea level. ***j.*** Tetra Tech, 1999. Mean effluent oxygen concentrations based on PCS database for primary, secondary, and advanced treatment. Mean influent concentrations for BOD_5 (207 mg/L) and TSS (209 mg/L) from CWNS database consistent with influent data from AMSA (1997). ***k.*** Effluent TOC concentration computed from effluent BOD_5, $CBOD_u$:BOD_5, oxygen:carbon ratio and assumption that 80 percent of organic carbon is accounted for by BOD_5 measurement. Removal efficiencies computed for primary and secondary treatment are consistent with data from Gunnerson et al., 1982.

2.6 ATMOSPHERIC DEPOSITION

Atmospheric deposition of nutrients is commonly included in watershed modeling efforts that focus on nutrient issues, like the current study. Atmospheric deposition data were obtained online through the National Atmospheric Deposition Program (NAPD) (http://nadp.sws.uiuc.edu/) and the Clean Air Status and Trends Network (CASTNet) (http://java.epa.gov/castnet/). Sites in the NADP precipitation chemistry network began operations in 1978 with the goal of providing data on the amounts, trends, and geographic distributions of acids, nutrients, and base cations in precipitation. The network grew rapidly in the early 1980s funded by the National Acid Precipitation Assessment Program (NAPAP), established in 1981 to improve understanding of the causes and effects of acidic precipitation. Reflecting the federal NAPAP role in the NADP, the network name was changed to NADP National Trends Network (NTN). The NTN network currently has 250 sites.

CASTNet began collecting measurements in 1991 with the incorporation of 50 sites from the National Dry Deposition Network, which had been in operation since 1987. CASTNET provides long-term monitoring of air quality in rural areas to determine trends in regional atmospheric nitrogen, sulfur, and ozone concentrations and deposition fluxes of sulfur and nitrogen pollutants in order to evaluate the effectiveness of national and regional air pollution control programs. CASTNet operates more than 80 regional sites throughout the contiguous United States, Alaska, and Canada. Sites are located in areas where urban influences are minimal. The primary sponsors of CASTNET are the Environmental Protection Agency and the National Park Service.

The data available from NADP/NTN are wet deposition of NH4 and NO3 in the form of precipitation-weighted concentrations (mg-N/L) on a monthly basis from 1980-2009. There are two active stations near the watershed: one is in Fayetteville, AR, and the other is in McClain County, OK. Two inactive stations in Oklahoma at Lake Eucha and Stilwell have data only for a limited period (2000-2003). There are no phosphorus data available.

The CASTNet data available for the watershed are weekly, quarterly, seasonal, and annual dry deposition fluxes of NH4, HNO3, and NO3- for 10/88-12/09. There are some missing periods, one of which is approximately one year long. The units are kg/ha as the species; therefore, the data will be converted to N for use in the model. The stations near the watershed are Cherokee Nation in Adair County, OK and Caddo Valley in Clark County, AR. The Caddo Valley station is near an NADP station, but not the Fayetteville station.

Recent contact with NADP (R. Larson, personal communication, 9/21/2011) has discovered that orthophosphate data is routinely collected, but not published, because it is used as an indicator of sample contamination, and values are rarely above detection levels. However, the available data for AR and OK has been requested.

Finally, a review comment by Dr. M. Matlock indicates that the Cherokee Nation Environmental Protection Department maintains atmospheric monitoring stations throughout the region and may provide the most relevant data for characterizing atmospheric deposition (Matlock, 2010). We have received data directly from the Cherokee Nation, and it appears to be the same as the CASTNet site noted above. We are in the process of confirming that, and it also appears to lack any phosphorus deposition data. The Simulation Plan addresses this issue of atmospheric deposition of phosphorus and its representation in the modeling.

SECTION 3.0

GEOGRAPHIC INFORMATION SYSTEMS (GIS) DATA NEEDS AND AVAILABILITY

Whenever any watershed model is set up and applied to a watershed, the entire study area must undergo a process sometimes referred to as 'segmentation'. The purpose of watershed segmentation is to divide the study area into individual land and channel segments, or pieces, that are assumed to demonstrate relatively homogenous hydrologic/hydraulic and water quality behavior. This segmentation provides the basis for assigning similar or identical input and/or parameter values or functions to where they can be applied logically to all portions of a land area or channel length contained within a model segment. Since most watershed models differentiate between land and channel portions of a watershed, and each is modeled separately, each undergoes a segmentation process to produce separate land and channel segments that are linked together to represent the entire watershed area.

Watershed segmentation is based on individual spatial characteristics of the watershed, including topography, drainage patterns, land uses and distribution, meteorologic variability, and soils conditions. The process is essentially an iterative procedure of overlaying these data layers and identifying portions of the watershed with similar groupings of these characteristics. The results of the land segmentation process are a series of model segments, sometimes call hydrologic response units (HRUs) that demonstrate similar hydrologic and water quality behavior. Over the past few decades, geographic information systems (GIS), and associated software tools, have become critical tools for watershed segmentation. Combined with advances in computing power, they have allowed the development of automated capabilities to efficiently perform the data-overlay process.

GIS data, or coverages, are used to spatially quantify the characteristics of the watershed landscape to develop the model input that informs the model as to how the watershed characteristics change across the study area. GIS data used in the segmentation process that affect the hydrologic and water quality response of a watershed are: topography and elevation, hydrography/drainage patterns, land use and land cover, soils information, and other various types of spatial data.

The primary sources for GIS data obtained for the IRW were those accessed through the use of the BASINS data download capability, and from the SWAT 2009 modeling files provided by OK DEQ. Through the BASINS interface a wide range of GIS data layers were downloaded and displayed. BASINS accesses GIS data from a variety of sources such as The National Land Cover Data, National Hydrography Dataset, and the U.S.G.S. seamless data server (http://seamless.usgs.gov/). Other sources include the earlier HSPF modeling efforts, Geospatial One-Stop (http://gos2.geodata.gov/wps/portal/gos), and contacts with the ODEQ and ADEQ. Geospatial One-Stop is an e-government initiative sponsored by the Federal Office of Management and Budget (OMB) to make it easier, faster, and less expensive for all levels of government and the public to access geospatial information

Appendix B is a catalog of the various GIS data coverages that were downloaded and are currently available for this study of the IRW. Below we discuss the major categories of GIS data, display some sample coverages to be used in the model development effort, and identify some gaps in the GIS data that should be further investigated.

3.1 TOPOGRAPHY AND ELEVATION

GIS layers of topography are important in setting up HSPF because they provide elevation and slope values for the project area, and are needed for characterizing the landscape and the land areas of the watershed. These elevation values are usually used to delineate subbasins, determine average elevations for each model subbasin, or to compute average slopes for model subbasins and land uses within a subbasin. A very detailed topographic layer can also be useful for determining stream cross-sections. Several GIS layers of topography are available for this study.

The National Elevation Dataset (NED) available through BASINS 4.0 Includes both a 30-meter and a 10-meter Digital Elevation Model (DEM) grid, with vertical units in centimeters. The 10-meter layer has been converted to feet and is shown in Figure 3.1. The 10-meter resolution DEM is used for slope calculations in the model for better accuracy and spatial resolution.

3.2 HYDROGRAPHY/DRAINAGE PATTERNS

Hydrography includes GIS layers of stream segments, at various levels of detail, as well as subbasins or drainage boundaries, and waterbodies. Several layers of hydrographic data are available for use in the Illinois River Watershed modeling effort. A set of coverages that is commonly used in watershed modeling is the NHDPlus dataset. NHDPlus is an integrated suite of geospatial data sets that incorporates many of the best features of the National Hydrography Dataset (NHD), the National Elevation Dataset (NED), the National Land Cover Dataset (NLDC), and the Watershed Boundary Dataset (WBD).

The NHDPlus dataset includes elevation, flow accumulation, and flow direction grids. These grids can be used to automate the subbasin delineation process for reaches with high topographic variation, e.g., mountainous regions of the watershed. The grids have undergone significant processing to ensure that drainage patterns are consistent with the 1:100,000 scale NHD and WBD using the "New England Method" (Dewald, 2006). These grids are the most hydrologically accurate 30 meter DEMs available to the water resources community. As noted above, a 10-meter DEM has also been acquired for portions of the Illinois River Watershed and will be used as a modeling resource as appropriate. Recently, NHD has been incorporated into a geodatabase implementation known as NHDinGEO (http://nhd.usgs.gov/data.html). Although this tool allows some additional flexibility and efficiency in working within a GIS environment, it has not been integrated within the BASINS system and it doesn't include the catchment detail or the additional attributes noted above that are useful in model setup tasks. Figure 3.2 shows the available stream hydrography coverage with the 1st order streams shown in light blue, and the 2nd through 6th order streams in dark blue.

3.2.1 Channel Characteristics

Although not a strict GIS type data layer, channel characteristics are needed to help define routing and stage-discharge behavior, bed composition for sediment, carbon, and nutrients, and bed/water column interactions related to temperature, benthic oxygen demand, nutrient fluxes, and benthic algal mass. Since they need to be defined spatially throughout the stream system, they will require location information through GIS data coverages.

Previous modeling efforts are one source of channel data. However, documentation appears to be lacking in terms of what specific data and assumptions were used to define the stream reach

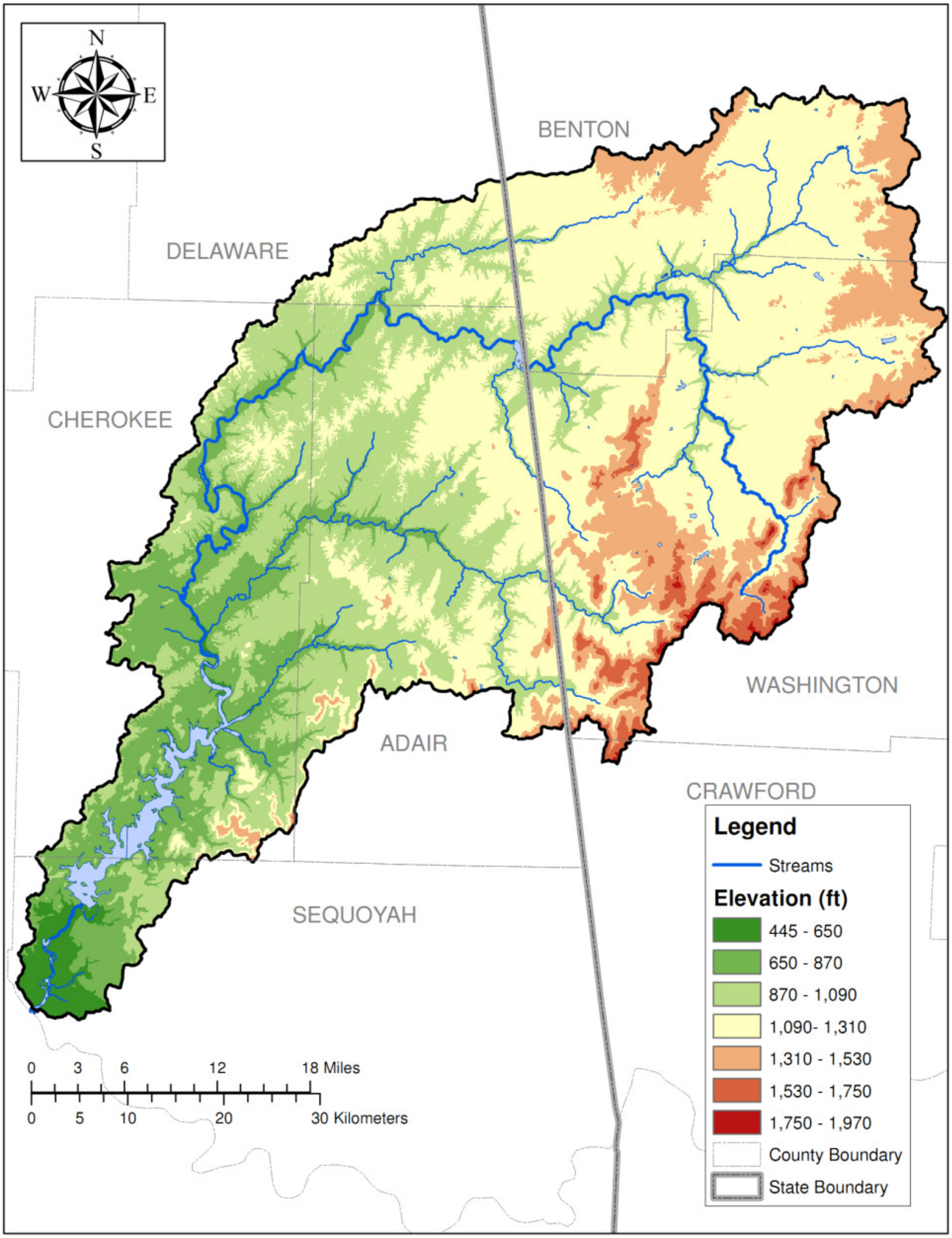


Figure 3.1 Elevations Derived From a 10-Meter DEM of the IRW

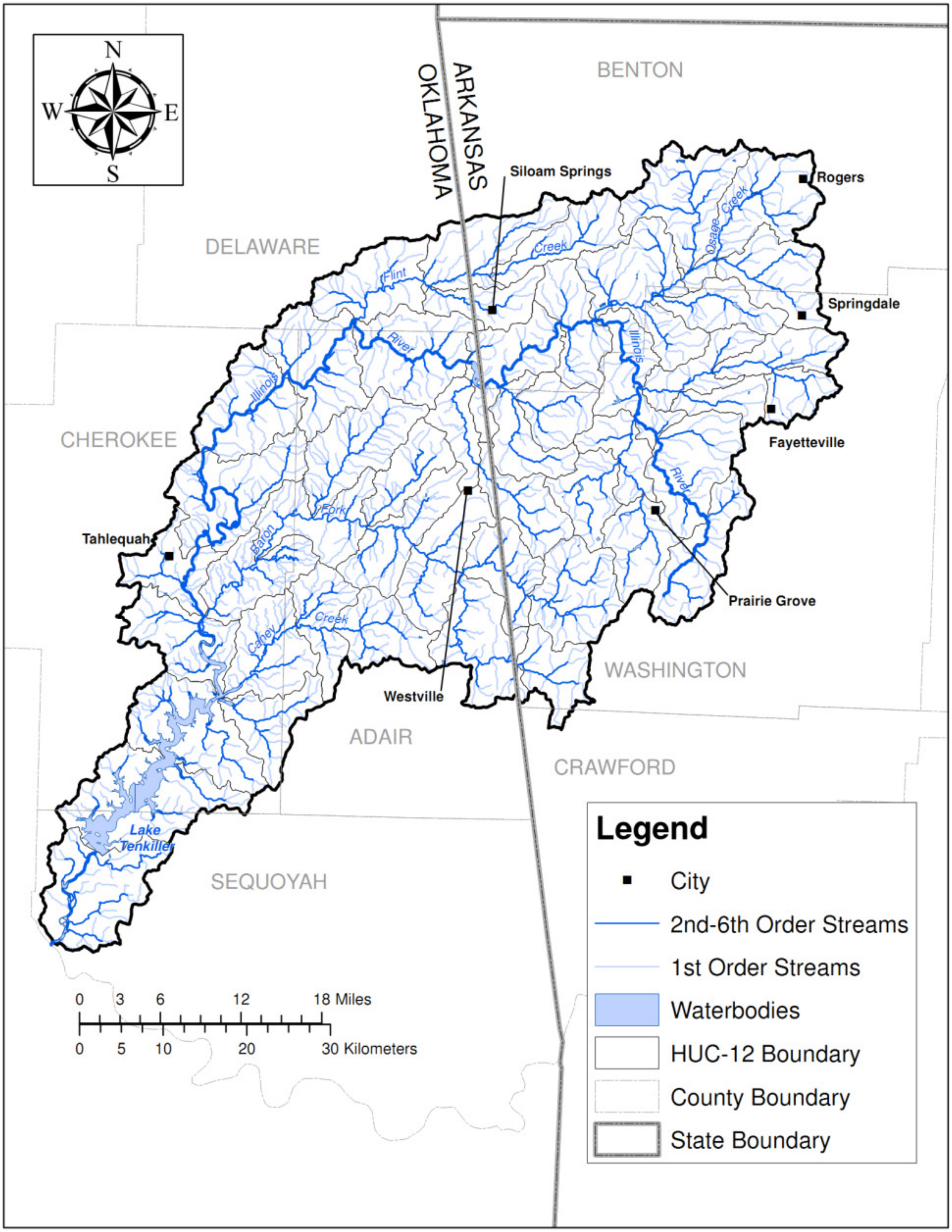


Figure 3.2 Stream Hydrography Coverage for the IRW from NHDPlus

physical characteristics spatially. For example, the prior BASINS/HSPF model includes FTABLES (Function Tables) for each stream reach which specifies the volume, surface area, and discharge as a function of depth. These FTABLES are often developed from channel cross-section data, plus slope and length values, for each stream reach. However, the specific cross-section information and other characteristics are not included with the earlier project files. All USGS gage sites usually have such data available and will be accessed for the corresponding stream reaches; that still leaves many portions of the stream system without physical measurements.

Alternatively, this information can be developed from existing flood insurance studies with models used for calculating flood inundation levels (e.g. HEC-RAS). Lacking detail physical data, geomorphological relationships between drainage area and channel width and depth values are sometimes used, but they are very approximate and can lead to misleading stage-discharge relationships. Thus, actual cross section data at various points in the stream system is preferred.

Stream bed characteristics are needed for setup of the instream sediment transport modeling, and for representing the bed/water column interactions for nutrients. Bed storages for sediment, including particle size distributions, and for nutrients provide the basis for both starting conditions and the potential magnitude of bed contributions to the water column. Citations and data provided by M. Derichsweiler (personal communication, email dated 18 February 2010) included information on pebble counts for Battle Branch and Baron Fork (dated 1998), and the a paper by Harmel et al., (1999) identifies median bed particle diameters (D_{50}) for 36 sites along the Illinois River mainstem, as part of study on bank erosion and riparian vegetation impacts. Data collected for OCC (2007) as part of a stream habitat survey includes bed materials composition analyses at approximately 25 sites in the watershed, particularly Tyner and Peachtree Creek areas. As part of the court case, Grip (2008, 2009) performed aerial photography and analyses to study and define meander conditions and patterns for the Illinois river mainstem, and to estimate bank erosion contributions to the sediment load entering Lake Tenkiller. His data include hundreds of cross section measurements, with channel bottom, bank, and floodplain elevations that may be helpful for channel characterization.

Following submission of the Draft Data Report, additional channel data were provided from the following sources:

1. The USGS provided multiple cross-section and rating curve data for sites in OK (J. Wellman and S. Scott, personal communications, multiple emails in June 2011) and in AR (W. Baldwin and K. Martin, personal communication, multiple emails in June 2011).
2. Dr. Marty Matlock provided multiple cross-sections and bed sediment particle size distributions for multiple sites in Osage and Spring Creeks in AR (M. Matlock, personal communication, flash drive, September 2010), collected as part of the water quality and ecological assessment on those creeks by (McGoodwin, Williams, and Yates, 2009).
3. Robert George of Tyson Foods, Inc. provided electronic files of cross-section data from the Grip Study (noted above) for hundreds of sites along the mainstem of the Illinois River (R. George, personal communication, August 25, 2011).

Details on the use of these data for FTABLE development is discussed in the Simulation Plan.

Haggard and Soerens (2006) discuss bed phosphorus releases from a small breached impoundment, the former Lake Frances, near the OK/AR state line. They present some bed information and phosphorus release estimates that will be useful on any attempt to include these processes in the modeling. Sediment bed data for phosphorus is also reported for selected Ozark catchments (Haggard et al., 2007). Sediment flux data for phosphorus under aerobic and anaerobic conditions is available from investigations in Lake Eucha (Haggard et al., 2005). Sen et al. (2007) have reported sediment phosphorus release rates from Beaver Reservoir in northwest Arkansas. A review of sediment phosphorus release and the interaction with bottom water dissolved oxygen in lakes by Hupfer and Lewandowski (2008) could provide important insight for the calibration and validation of the sediment flux component of the lake model.

3.3 LAND USE

When the Draft Data Report was first published, in August 2010, the most recent land use layer (designated land cover) available was the NLCD 2001 land use. In early 2011, the 2006 NLCD was released and provided the consistent coverage covering both States, and applicable to a relatively recent time period. A 1992 NLCD coverage is also available. Depending on the specific time periods selected for model calibration and validation, the corresponding NLCD coverage will be chosen to provide the land use data for the model. For example, if the best data available for model calibration includes data between the year 2000 and through 2008 or 2009, then land use data for 2005 through 2007 would be most appropriate for representing the land conditions during this period. Table 3.1 shows the land use areas and distributions for the 1992, 2001, and 2006 NLCD coverages for the IRW, and Figure 3.3 shows their spatial distribution for the 2001 and 2006 data. The Simulation Plan discusses the use of this data in the modeling effort.

Table 3.1 Distribution of NLCD Land Use for 1992, 2001, and 2006 in the IRW

	1992		2001-v2		2006	
Description	Area (Sq. Mi.)	% Land Use	Area (Sq. Mi.)	% Land Use	Area (Sq. Mi.)	% Land Use
Deciduous Forest	555.98	33.63	684.66	41.40	679.64	41.11
Evergreen Forest	33.96	2.05	19.79	1.20	19.62	1.19
Mixed Forest	114.88	6.95	8.14	0.49	8.09	0.49
Pasture/Hay	769.13	46.52	693.31	41.92	679.15	41.08
Grassland/Herbaceous	0.21	0.01	56.38	3.41	60.05	3.63
Shrub/Scrub	13.56	0.82	7.69	0.46	8.27	0.50
Barren land (rock/sand/clay)	3.30	0.20	1.86	0.11	3.20	0.19
Developed, Open Space	7.50	0.45	92.85	5.61	97.99	5.93
Developed, Low Intensity	28.66	1.73	35.66	2.16	39.93	2.41
Developed, Medium Intensity	13.69	0.83	12.23	0.74	15.22	0.92
Developed, High Intensity	12.34	0.75	4.76	0.29	5.73	0.35
Woody Wetlands	5.04	0.31	9.75	0.59	9.73	0.59
Emergent Herbaceous Wetlands	1.63	0.10	0.12	0.01	0.12	0.01
Cultivated Crops	61.14	3.70	2.55	0.15	2.45	0.15
Open Water	32.34	1.96	24.13	1.46	24.15	1.46
Total	1653.35	100.00	1653.87	100.00	1653.35	100.00

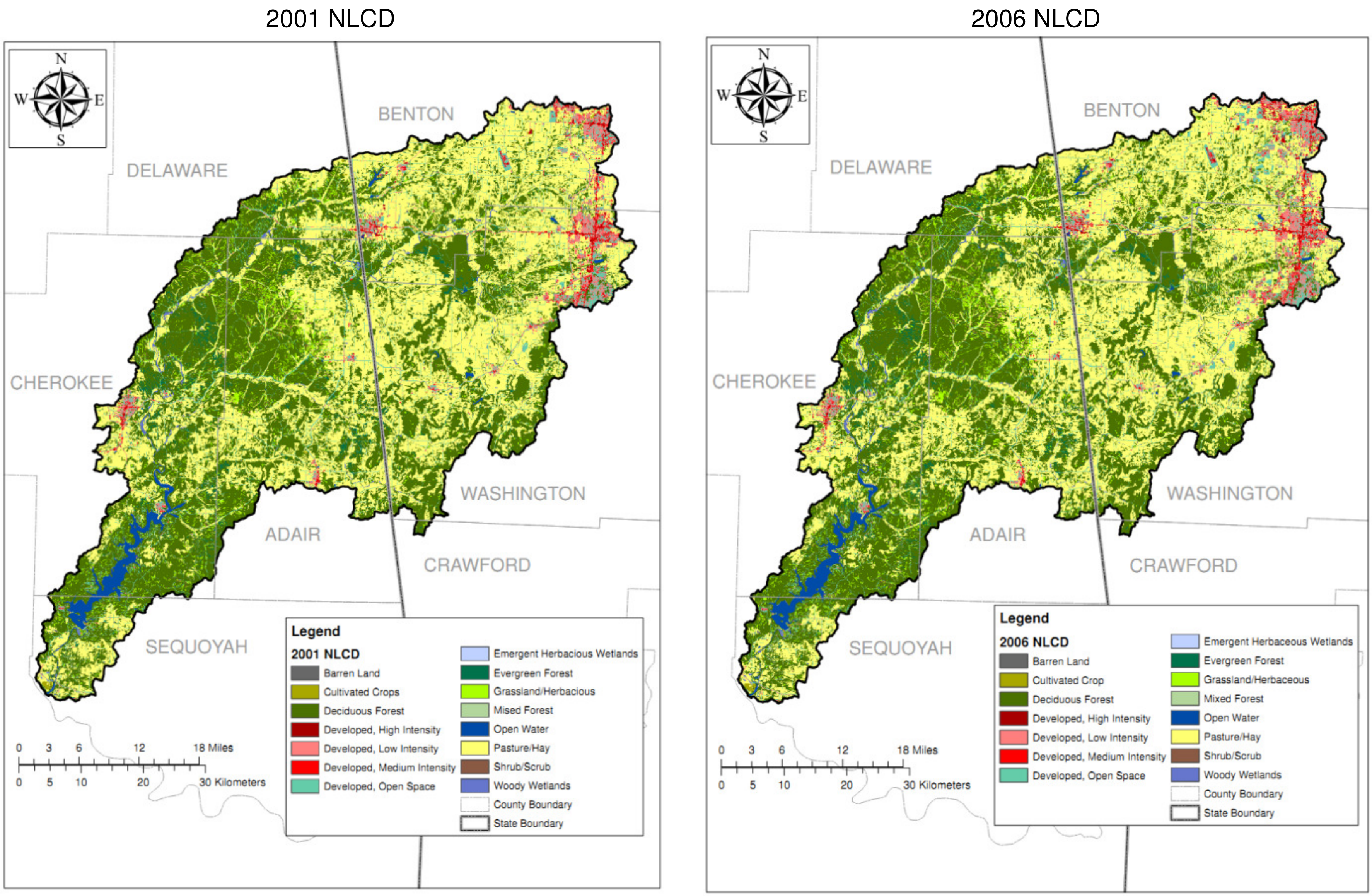


Figure 3.3 National Land Cover Data (NLCD) for 2001 and 2006 for the IRW

As part of the data effort, the EPA identified the USDA-NASS Cropland Data Layer as a potential source of recent land use data. The Cropland Data Layer (obtained from http://datagateway.nrcs.usda.gov/GDGHome.aspx) is a raster, geo-referenced, categorized land cover data layer produced using satellite imagery. The purpose of the Cropland Data Layer Program is to use satellite imagery on an annual basis to (1) provide supplemental acreage estimates for each state's major commodities and (2) produce digital, crop-specific, categorized geo-referenced output products. The imagery was collected between the dates of 03/01/1997 and the present. The approximate scale is 1:100,000 with a ground resolution of 56 meters by 56 meters for the AWiFS (advanced wide field sensor) data. The data layer is aggregated to a possible 85 standardized categories for display purposes, with the emphasis being agricultural land cover. Most data layers average about 10 to 20 categories out of the 85 possible categories. The years that are available for the IRW are 2006, 2007, 2008, and 2009; thus they provide a coverage that is consistent with recent data available for calibration . For the Arkansas portion of the basin, the 2003 cropland shapefile that shows the land cultivated, water, or non-agricultural is also available. To use these layers in the modeling, they can be converted to a shapefile and clipped to the IRW as the coverage is only downloadable for the entire state.

The University of Arkansas Center for Advanced Spatial Technology (CAST) maintains a high resolution land use database for Arkansas. The data are available in multiple geospatial formats. The data available for the IRW was obtained for a number of years from 2003 to 2009, and is available as needed for the modeling effort.

The ODEQ directed us to digital orthophotography coverages that are available for 2003 (1-meter resolution), 2004 (2-meter), 2005 (2-meter), 2006 (2-meter), and 2008 (1-meter) for the entire state of Oklahoma by county (A. Fang, ODEQ, personal communication, 13 July 2010). These data were downloaded from State of Oklahoma's website: (http://okmaps.onenet.net/digital_ortho.htm). These photographs combine the image characteristics of a photograph with the geometric qualities of a map. Unlike a standard aerial photograph, relief displacement in orthophotos has been removed so that ground features are displayed in their true ground position. This allows for the direct measurement of distance, areas, angles, and positions. Also, an orthophoto displays features that may be omitted or generalized on maps. They can be used to verify and update land cover changes in the watershed over the years for small areas or with the help of digital photo/GIS processing software, for larger areas.

In summary, the above data have been reviewed and analyzed in our search to develop a consistent land use coverage for the entire IRW for both calibration and validation time periods. The Simulation Plan describes the results of this investigation and the specific data selected for use in the modeling effort.

3.4 SOILS DATA

The USDA/NRCS DataGateway site was also used to download SSURGO (Soil Survey Spatial and Tabular Data) soils data for the IRW. SSURGO depicts information about the kinds and distribution of soils on the landscape. This dataset is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. This dataset consists of georeferenced digital map data, computerized tabular attribute data, and associated metadata. The soil map units are linked to attributes in the Soil Survey Tabular database, which gives the proportionate extent of the component soils and their properties within the area of interest. In order to use these data, the shapefiles and tabular data were downloaded, were read into an Access database template available online (http://soildatamart.nrcs.usda.gov/Templates.aspx), and the tables of interest were linked to the shapefile. The properties of this shapefile that are of interest in this study are: soil description, slope gradient, water table depth, flooding frequency, available water storage, hydrologic group, and hydric group. A table describing all attributes in the shapefile is included in the GIS Database in Appendix C. The spatial data on the SCS Hydrologic Soil Groups (HSG) were used to generate a mapping of these HSG A, B, C, and D values by subwatershed as a basis for model parameterization; the resulting map is shown in Figure 3.4.

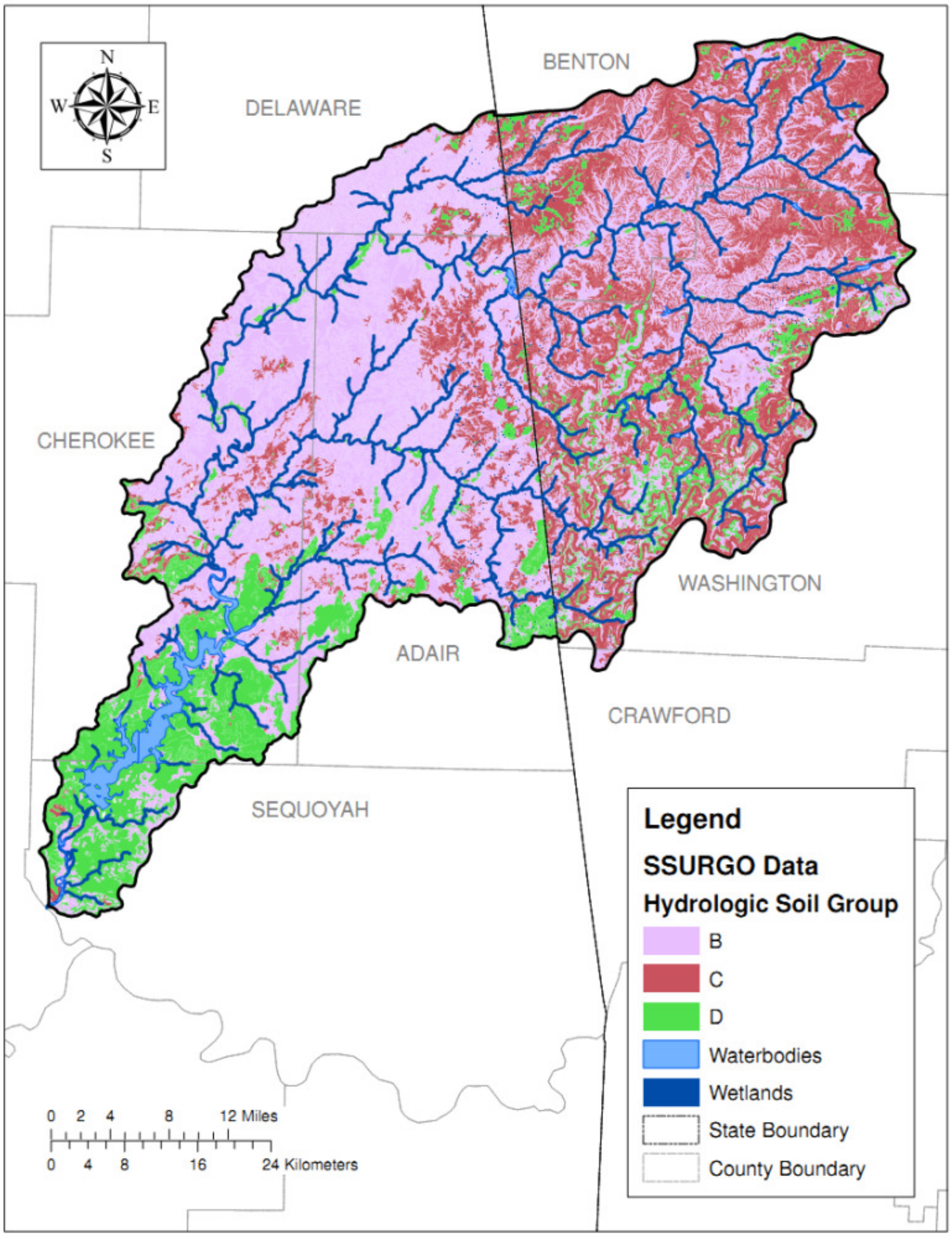


Figure 3.4 Distribution of NRCS Hydrologic Soil Groups for the IRW

3.5 STATION AND SAMPLE LOCATIONS

GIS data is also frequently used to identify and display locations of gaging stations, sample sites, and various other gage sites. In discussing the timeseries data in Section 2, GIS coverages were used to display these locations to demonstrate and assess their distribution across the landscape of the IRW. This was done for precipitation, meteorologic data, flow and water quality sampling sites, etc. Appendix B shows the various coverages available to identify and display these locations.

3.6 OTHER DATA TYPES AND SOURCES

For the Illinois River Watershed, comprehensive watershed modeling also requires a wide range of disparate data, especially related to potential pollutant sources and their locations throughout the watershed. For this effort, the focus is on nutrients, primarily phosphorus, and sources for phosphorus include, among others, point sources from wastewater treatment plants, industrial discharges, urban stormwater, wildlife populations, commercial/rowcrop agriculture, cattle contributions and impacts, septic tanks, dirt/gravel roads, and biosolids applications, as well as possible contributions from poultry industry, as evidenced by the hundreds of poultry houses located throughout the watershed.

A GIS data layer containing the poultry house locations and status was provided by ODEQ, as part of the SWAT model files, and is shown in Figure 3.5. This figure shows the status of the various houses – active, inactive, abandoned, etc. – and once the data is reviewed and analyzed, it may be included as part of the data used to characterize and quantify the phosphorus contributions from poultry litter applications. The SWAT modeling by Storm et al (2009) used this type of information in their study. In addition, another GIS data layer of poultry houses was provided by Tyson (R. George, personal communication, email dated 27 September 2010) developed as part of the court case. These two layers will be reviewed and compared if they are used in developing our approach to representing poultry litter contributions, as discussed further in the Simulation Plan.

In addition to poultry house status and location information, a number of reports and studies have been provided that address the issue of phosphorus contributions from the poultry industry to water quality in the IRW. These include the following:

1. An IR Basin-Wide pollution inventory by Storm et al (1996).
2. Bird populations, poultry feeding operations, and litter management practice information provided by ODAFF and ANRC.
3. Procedures for estimating runoff from litter applications in modeling efforts by Storm et al (2009), White (2009), and Saraswat (2010).
4. Expert reports on poultry litter practices and impacts representing both the plaintiffs (provide by OAG) and defendants (provide by Tyson Foods) in the current court case.

Also, comprehensive modeling needs to consider ALL potential sources of phosphorus in order to accurately represent the relative contributions and impacts of any single source. A number of expert reports developed in association with the ongoing court case address the issues of phosphorus contributions (and mass balances) from various sources; these documents present the perspectives of both sides of the court case, from both the plaintiffs (e.g. Smith et al., (2008), Johnson (2008), Engel (2008) and the defendants (e.g. Connolly (2009), Clay (2008), Jarman(2008)). Our review of this information is ongoing, with the objective of developing methods to consider all significant sources of phosphorus within the IRW, accurately include their contributions within the model structure for this study, and thereby develop a realistic representation of how these sources impact water quality within the IRW in both AR and OK. The Simulation Plan provides an update of our ongoing efforts to develop appropriate procedures for phosphorus accounting within the selected modeling framework.

3.6.1 Karst Formations and Locations

A number of documents have indicated the existence of, and potential impacts of, karst formations on the hydrology and water quality within the IRW, and selected stakeholders have raised the issue regarding how these conditions will be represented within the modeling framework. Modeling of karst conditions and impacts is a relatively new endeavor, and a capability that is not often included in current operational watershed models. However, the capability and flexibility to represent karst conditions was included as a criterion in the model selection task. The challenge here is twofold: first, to identify where karst formations exist, and then to determine appropriate model parameter adjustments to approximate their impacts.

As noted above, the first step is to identify where karst formations exist within the IRW. We were able to locate maps like the one shown in Figure 3.5 for Washington County, AR, at the following web site: http://www.nwarpc.org/pdf/GIS-Imagery/KASM_WASHINGTON_CO.pdf. A corresponding map exists for Benton County, AR; however we have not been able to locate any comparable information or data, at a similar scale and resolution, for the OK portion of the IRW. The red areas (lines) in Figure 3.5 indicate regions where the presence of karst formations are 'extremely high', versus the green areas where karst is extremely low. Although, these maps are not really 'data', per se -- they were developed by overlays of information on depth to groundwater, recharge, soils, topography, vadose zone characteristics, and faults/fracture zones (essentially a correlation model) – they do provide some indication of where in the IRW watershed evidence of karst impacts may be exerted. The Simulation Plan further discusses our use of this data and information to consider karst conditions within the modeling framework.

3.7 REMAINING DATA DEFICIENCIES FOR GIS COVERAGES

Appendix B provides a catalog of the various GIS coverages that have been obtained for use in this modeling effort. This catalog has been significantly expanded since the Draft Data Report, due to additional contributions from stakeholders, and it represents an extensive inventory of GIS data in support of the IRW TMDL modeling effort. At the time of the Draft Report, a number of deficiencies were identified for spatially characterizing selected conditions within the IRW. At that time, the deficiencies included the following:

a. NRCS hydrologic soil groups (HSG)
b. More recent land use/cover data
c. Locations of known karst formations
d. Animal Populations and Distribution
e. Fertilizer and Manure Applications
f. Soil Nutrient Concentrations

Items a and b have been resolved with the development of the HSG map (Figure 3.4) and the release of the 2006 NLCD data layer, as discussed above. We believe we have all the available data and information on karst conditions (Item c) and have developed a path forward for their consideration in the modeling effort (see the Simulation Plan). Items d, e, and f remain as issues currently being investigated, as discussed in the Simulation Plan. Both ODAFF and ANRC have provided data and information related to these items, in various forms. ODAFF has provided data for many of these data needs, and both agencies have provided a considerable amount of data in tabular form, and on a county basis. In a number of the reports received, we have noted spatial displays of different animal groups, fertilizer/manure applications, and soil nutrients throughout the watershed, but have not been able to locate corresponding GIS coverages. We are continuing to investigate a number of sources, in concert with the agencies noted above, as the modeling effort moves forward.

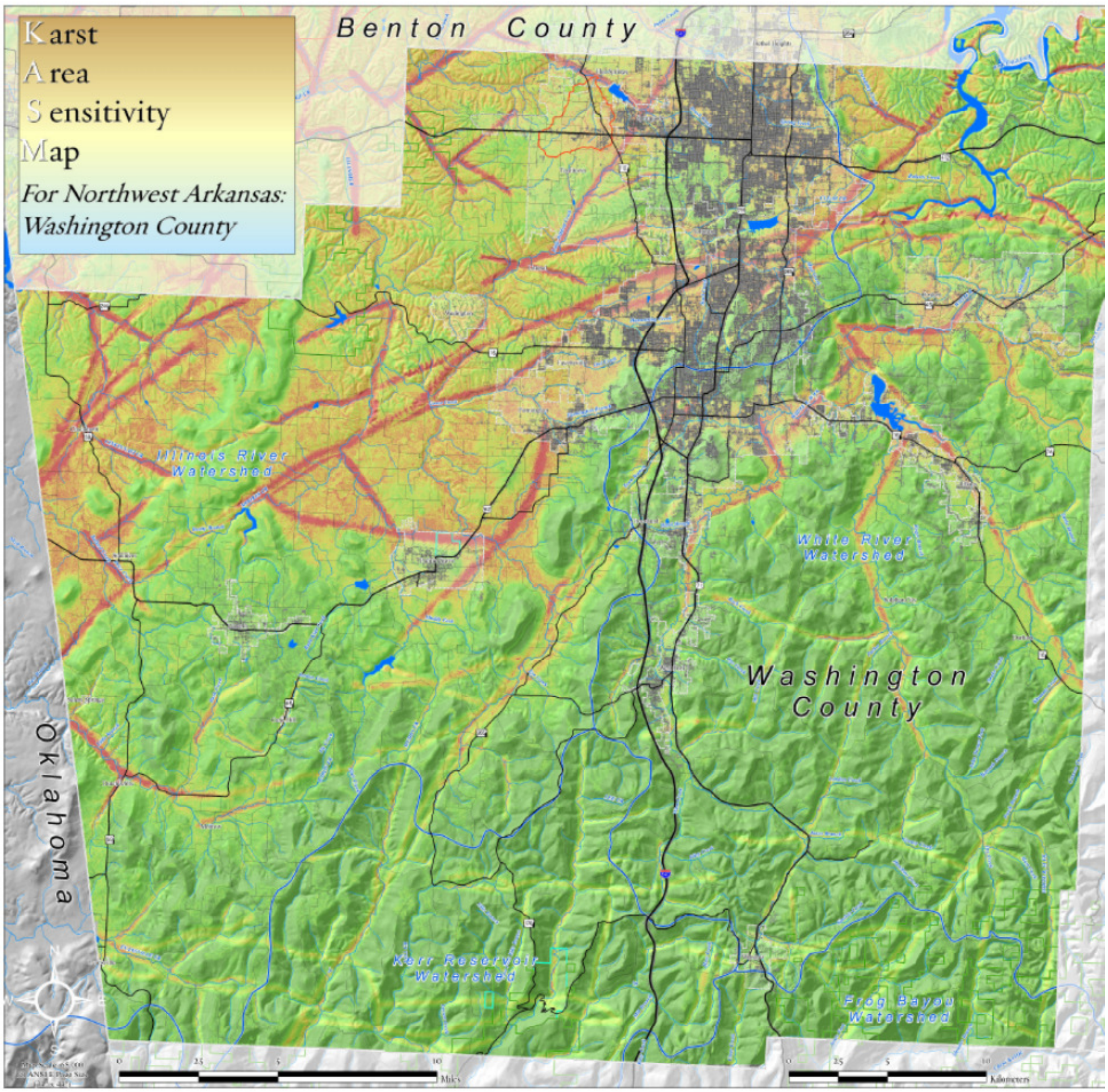


Figure 3.5 Karst Area Sensitivity Map for NW AR, Washington County (TNC, 2007)

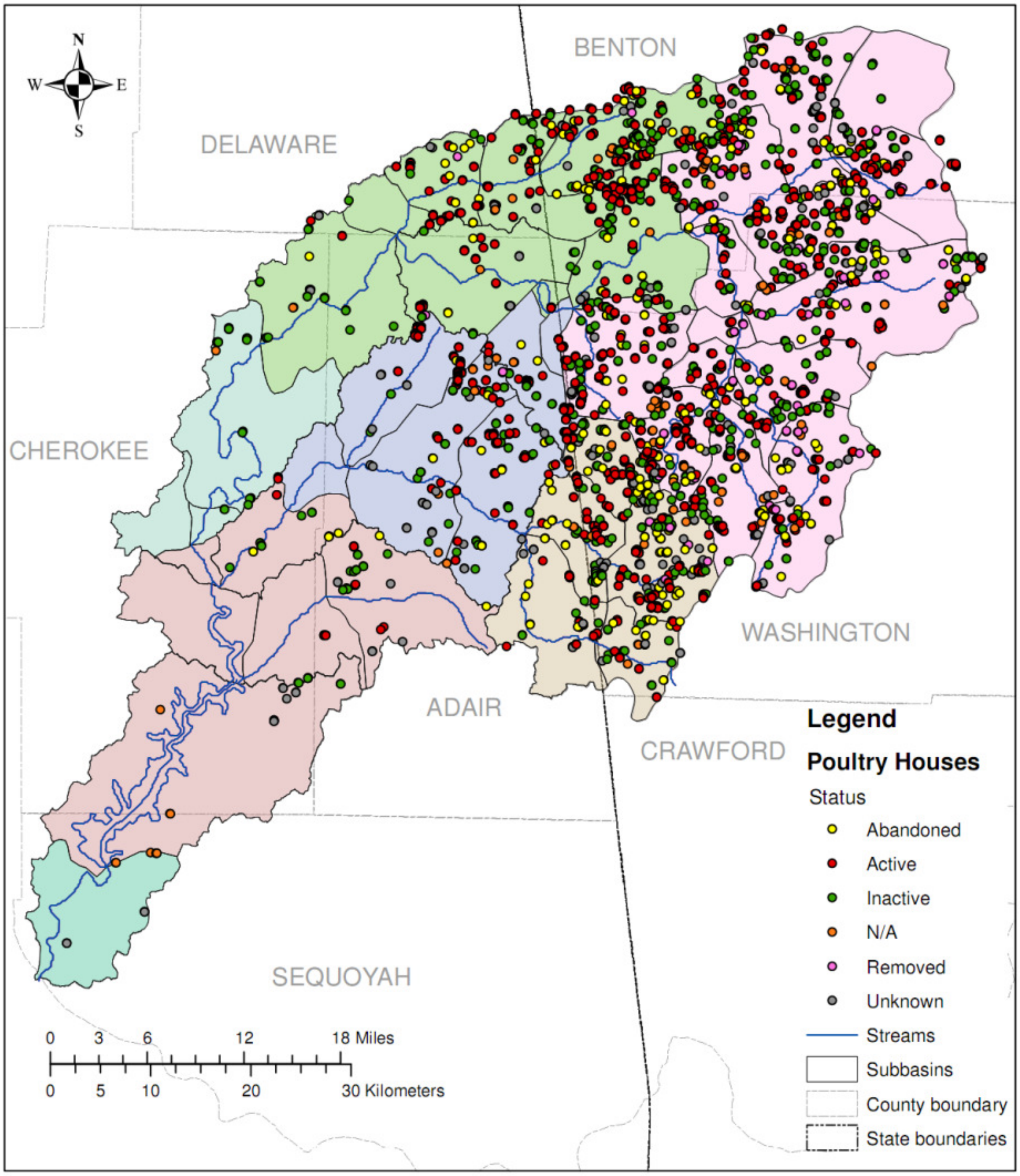


Figure 3.4 Locations of Poultry Houses and Their Status in the IRW (Storm et al, 2009)

SECTION 4.0

DATA NEEDS AND AVAILABILITY FOR LAKE TENKILLER

This section is an initial review of data available for modeling of Lake Tenkiller, and was prepared for the August 2010 Draft Data Report. Preliminary data reviews were performed by Dr. Richard Park of Eco Modeling, as an extension of his application of the AQUATOX model performed as part of the integrated BASINS/HSPF/AQUATOX (Donigian et al., 2009) effort noted in Section 1, and by Dr. Andrew Stoddard of Dynamic Solutions LLC. Dynamic Solutions applied the EFDC model to Lake Tenkiller for ODEQ in support of earlier TMDL development efforts (Craig, 2006).

Since the selection of EFDC as the model to be used for Lake Tenkiller, a more detailed analysis and discussion of the available data is included as part of the Simulation Plan (AQUA TERRA Consultants, 2011). We have retained this section since it was included in the Draft Report.

4.1 PRELIMINARY DATA COVERAGE FOR TENKILLER FERRY LAKE BY ECO MODELING

Ninety-five files (listed Appendix C) were obtained and examined in order to determine the data coverage for the lake from 1992 to the present. The year 1992 was taken as the starting date because prior modeling, using HSPF (Donigian et al. 2005, Donigian et al. 2009), EFDC (Craig 2006), and AQUATOX (Donigian et al. 2009), covered the period of 1992 and 1993 for the lake simulations. The coverage was enumerated according to the number of longitudinal lake segments that were represented in the AQUATOX model (Figure 4.1). Almost all data cover both epilimnion and hypolimnion segments, with the exception of the riverine reach, which is well mixed. Although additional site data were available for 1992-93 in the Transition segment, later Corps of Engineers and Oklahoma Water Resources Board (OWRB) sites match the AQUATOX segmentation reasonably well. However, beginning in 2001, another OWRB site (#7) was added in the **downstream** portion of Lacustrine B segment; for this reason it may be desirable to split Lacustrine B into two segments, if the AQUATOX model is selected for this effort. Thus, With the exception of Station 7, the COE and OWRB sampling sites correspond and are well represented by the AQUATOX segmentation.

In this search, no data were identified for the period after 2006, and no biotic data after 2005 (except fish)[1]. In general, data coverage is suitable for calibrating the AQUATOX model to simulate water quality in the lake from 1992 to 2005. However, there are significant gaps in data for 1994, 1995, and 1997 (Table 4.2). Unless additional data are forthcoming, any lake model applied will have to proceed through those time periods without water quality data to support the simulations. This is not seen as a serious impediment because loadings will come from simulations obtained from a linked watershed model, and daily data on reservoir volume and water releases for power and flood control are available from the Corps of Engineers and can be used to simulate continuous flow among compartments in AQUATOX. In addition to obtaining more recent water quality data, it would be very desirable to have data on organic carbon content in the sediments for each of the lake segments; minimal sediment data are available in the “Clean Lakes” report (Oklahoma State University, 1996).

[1] Dr. Park did not have access to, nor was he aware of, the CDM database noted and discussed in Section 2.4, which includes additional water quality data for Lake Tenkiller.

The data are judged sufficient to support model calibrations of spatially varying nutrients, dissolved oxygen, chlorophyll *a*, biomass of key algal groups, and fish. Furthermore, the data can support simulations of *Cylindrospermopsis*, an invasive cyanobacterium characterized by rampant growth and production of a dangerous cyanotoxin, that first appeared in the lake in 2001; this cyanobacterium has been successfully simulated by AQUATOX in Florida lakes.

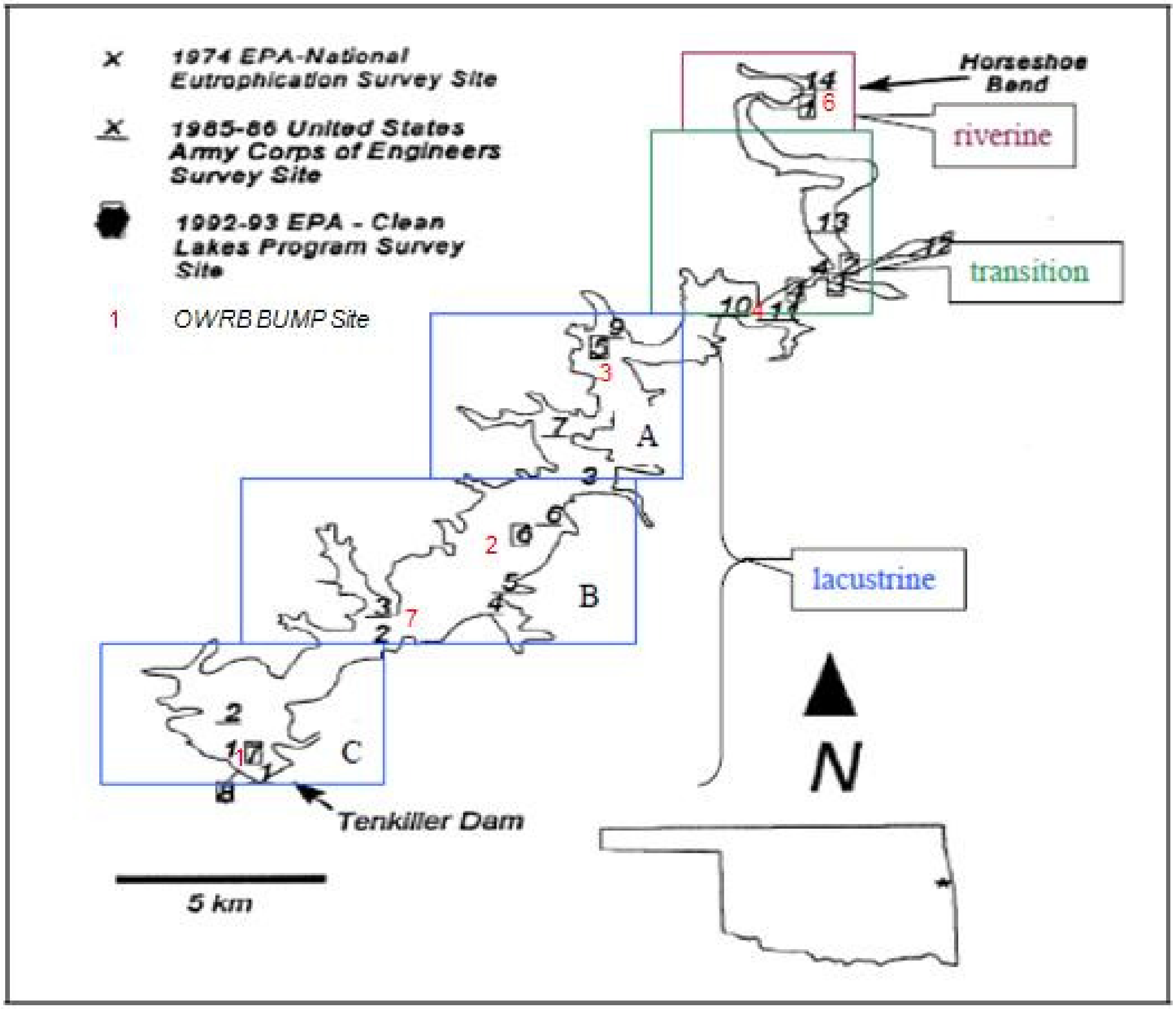


Figure 4.1 Longitudinal AQUATOX segments and sampling stations on Tenkiller Ferry Lake, Oklahoma. Base map from Oklahoma State University (1996).

Table 4.2 Summary of known data coverage for Tenkiller Ferry Lake; numbers indicate number of longitudinal segments with given data.

		Depth Profiles											
Year	Water Balance*	Temp	Turbidity	Secchi	DO	pH	TN	TP	Chl a	Algal spp	*Cylindro.*	Zooplk	Fish
1992		5	5	5	5	5	5	5	4	3			
1993		5	5	5	5	5	5	5	4	3		3	3
1994	X												X
1995	X												
1996	X	5	5	5	5	5	5	5	5				X
1997	X												X
1998	X	T	T	T	T	T	T	T	T				
1999	X	5	5	5	5	5	5	5	5				X
2000	X	5	T	5	5	T	5	5	T				
2001	X	5	5	5	5	5	5	5	5	5	5	4	X
2002	X	5	5	5	5	5	5	5	5	5	5		X
2003	X	5	5	5	5	5	5	5	5	5	5		X
2004	X	5	5	5	5	5	5	5	5	5	5		
2005	X	5	5	5	5	5	5	5	5	5	5		X
2006	X	5	5	5	5		5	5					X

* daily volume, power & flood control releases starting in Nov 1994

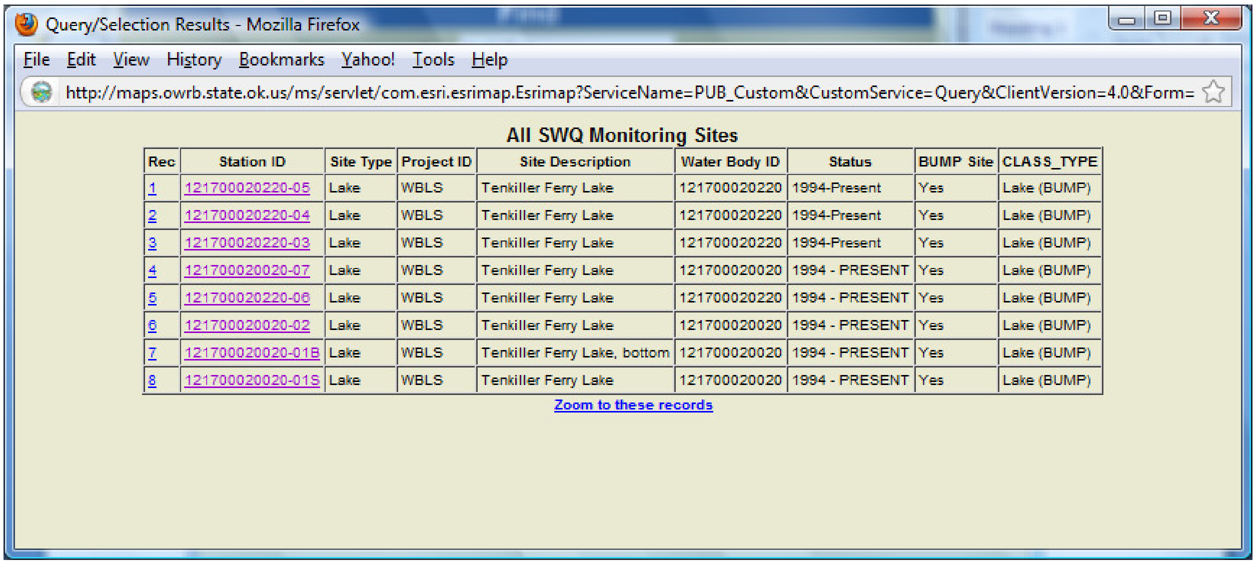
X whole reservoir

T Transition segment only

4.2 PRELIMINARY DATA REVIEW BY DYNAMIC SOLUTIONS, LLC

As noted above, the Oklahoma Water Resources Board (OWRB) maintains an archive of water quality data for Oklahoma. OWRB conducts Oklahoma's Beneficial Use Monitoring Program (BUMP), which has collected data on Lake Tenkiller quarterly every few years, and the lake watershed has been sampled 8-10 times yearly since the year 2000. The OWRB database was queried for the availability of data for Lake Tenkiller and selected streams in the IRW (HUC=11110103). The URL for access to the OWRB database is http://maps.owrb.state.ok.us/ms/ws/wqbycounty.php.

The OWRB database organizes water quality data using four categories: (1) Field; (2) Inorganic; (3) Metals; and (4) Biological. Field records are water temperature, DO, etc. Inorganic records are nutrients, TSS, etc. Metals are total arsenic, copper, etc. Biological is bacteria, algae and periphyton records. Data files were downloaded for Lake Tenkiller to obtain an inventory of data availability based on years of record for each station associated with the waterbody. Figure 4.2 is a screen shot of the data availability, stations, and periods of record; spreadsheet files were downloaded for the four data groups for all the stations identified for Lake Tenkiller. There may be some potential duplication of records between the OWRB database and the data obtained from the USGS NWIS database; this is currently being investigated.


Query/Selection Results - Mozilla Firefox
File Edit View History Bookmarks Yahoo! Tools Help
http://maps.owrb.state.ok.us/ms/servlet/com.esri.esrimap.Esrimap?ServiceName=PUB_Custom&CustomService=Query&ClientVersion=4.0&Form=

All SWQ Monitoring Sites

Rec	Station ID	Site Type	Project ID	Site Description	Water Body ID	Status	BUMP Site	CLASS_TYPE
1	121700020220-05	Lake	WBLS	Tenkiller Ferry Lake	121700020220	1994-Present	Yes	Lake (BUMP)
2	121700020220-04	Lake	WBLS	Tenkiller Ferry Lake	121700020220	1994-Present	Yes	Lake (BUMP)
3	121700020220-03	Lake	WBLS	Tenkiller Ferry Lake	121700020220	1994-Present	Yes	Lake (BUMP)
4	121700020020-07	Lake	WBLS	Tenkiller Ferry Lake	121700020020	1994 - PRESENT	Yes	Lake (BUMP)
5	121700020220-06	Lake	WBLS	Tenkiller Ferry Lake	121700020220	1994 - PRESENT	Yes	Lake (BUMP)
6	121700020020-02	Lake	WBLS	Tenkiller Ferry Lake	121700020020	1994 - PRESENT	Yes	Lake (BUMP)
7	121700020020-01B	Lake	WBLS	Tenkiller Ferry Lake, bottom	121700020020	1994 - PRESENT	Yes	Lake (BUMP)
8	121700020020-01S	Lake	WBLS	Tenkiller Ferry Lake	121700020020	1994 - PRESENT	Yes	Lake (BUMP)

Zoom to these records

Figure 4.2 Stations and period of record available for Lake Tenkiller From OWRB

4.3 CLOSURE

As noted above, a more extensive data identification and review has been performed since the Draft Data Report and since the selection of the EFDC model as the model to be used for Lake Tenkiller. This review identified additional water quality data for the time period of 2001 through 2007, including some data with vertical profiles in the lake, appropriate for model calibration; these data are discussed further in the Simulation Plan. The CDM database, discussed in Section 2.4, also includes data for this most recent period and may help to meet this need; it is continuing to be further investigated.

SECTION 5.0

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APPENDICES

A. Bibliography of Reports/Data Received on the IRW (Dated 08/02/2010)

B. Catalog of GIS Coverages for the IRW

C. List Of Files/Data Related to Tenkiller Ferry Lake

D. Data/Reports Provided by Each Contributing Agency

E. Modern STORET Watershed Station Summary: HUC 1110103

APPENDIX A

BIBLIOGRAPHY OF REPORTS/DATA RECEIVED ON THE IRW

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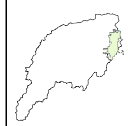
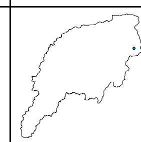
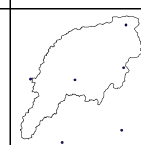
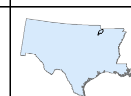
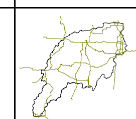
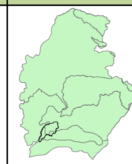
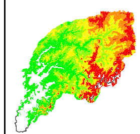
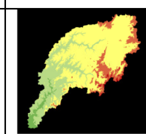
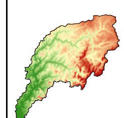
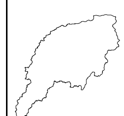
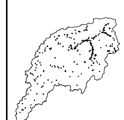
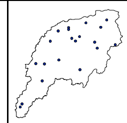
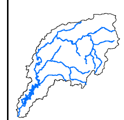
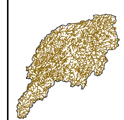
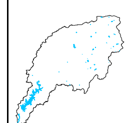
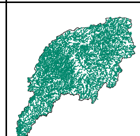
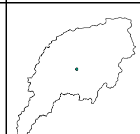
APPENDIX B

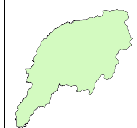
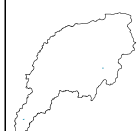
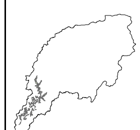
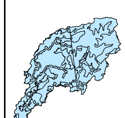
CATALOG OF GIS COVERAGES FOR THE IRW

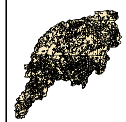
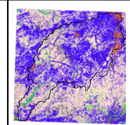
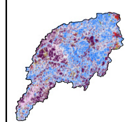
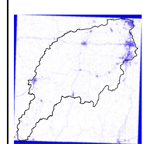
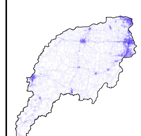
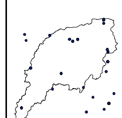
Note: The outline of the IRW shown below in the thumbnails is for display purposed only, and was derived for the HUC-8 boundary layer available though BASINS; whereas the GIS layers listed in the table have been recut to the more accurate HUC-12 boundary available from the Geospatial Data Gateway. (http://datagateway.nrcs.usda.gov/GDGHome.aspx)

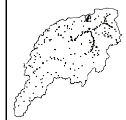
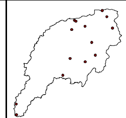
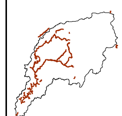
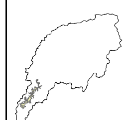
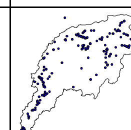
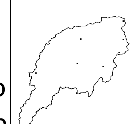
Folder\Type	Name	Description	Source	Thumbnail	Comments
BASINS\boundaries	urban	Urban area of Fayetteville/Springdale, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\boundaries	urban_nm	Urban area names , Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\boundaries	cntypt	County names, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\boundaries	epa_reg	EPA region boundaries, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\boundaries	fhards	Major Roads, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		

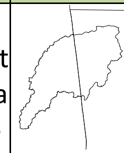
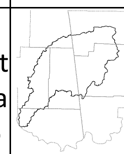
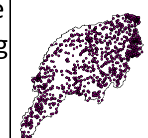
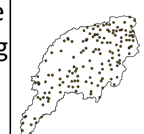
Folder\Type	Name	Description	Source	Thumbnail	Comments
BASINS\boundaries	ecoreg	Ecoregions, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\elevation	11110103	Shapefile of elevation in meters and feet, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		Not all data shown on thumbnail, as in white spaces, too much data to show
BASINS\elevation	elev_cm	Elevation in centimeters, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		Black section does not contain real value
BASINS\elevation\NED	ned_ft	National Elevation Dataset, 30m resolution, converted to feet, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		Originally in centimeters
BASINS\hydro	subbasin	Illinois River Watershed Subbasin, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		*This layer is displayed in all other thumbnails
BASINS\hydro	NWIS_Stations_discharge	NWIS discharge locations, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		This layer has been cut to only include points within the IRW

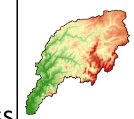
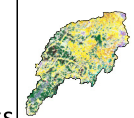
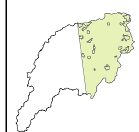
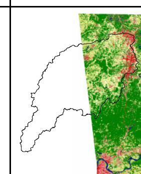
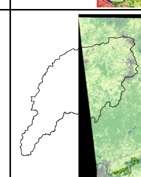
Folder\Type	Name	Description	Source	Thumbnail	Comments
BASINS\hydro	streamgageevent	USGS gage station locations, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\hydro	rf1	Major Streams in the IRW, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\hydro	nhdflowline	Major and minor stream in the IRW, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\hydro	nhdwaterbody	Waterbodies (lakes etc) in the IRW	BASINS		This layer was cut to the IRW
BASINS\hydro	11110103	National Hydrography dataset 11110103, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		Shows all streams, hard to see in thumbnail
BASINS\hydro	catpt	Cataloging Unit Code, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		

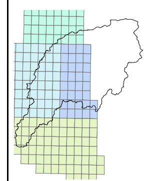
Folder\Type	Name	Description	Source	Thumbnail	Comments
BASINS\hydro	acc	Accounting unit boundaries, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\hydro	cat	Cataloging unit boundaries, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		While this layer is close to the "subbasin" layer downloaded from BASINS, it is not identical
BASINS\hydro	catchment	Catchment basins, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		Small catchment areas hard to see in thumbnail
BASINS\hydro	nhdline	Dams in the IRW, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\hydro	nhdarea	Areas surrounding Tenkiller lake, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\landuse	statsgo	NCRS State Soil codes, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		This layer was cut to the IRW

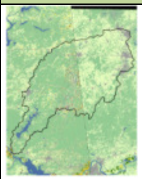
Folder\Type	Name	Description	Source	Thumbnail	Comments
BASINS\landuse	l_ftsmar_ tulsok	Landuse of the IRW cropland, forest etc, shapefile, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		l_ftsmar and l_tulsok were joined then cut to the IRW
BASINS\Landuse\NLCD	nlcd_landcover_2001	NLCD landcover, raster (tif), resolution: 30m, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		Projection was defined in ArcMap after it was downloaded in BASINS in desired projection (for some reason, ArcGIS wouldn't project it)
BASINS\Landuse\NLCD	land2001	Clipped NLCD landcover, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		NLCD_landcover clipped to IRW
BASINS\landuse\NLCD\NLCD	nlcd_impervious_2001	NLCD 2001 imperiousness, raster, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\landuse\NLCD\NLCD	imp2001	NLCD 2001 imperiousness, raster, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		nlcd_impervious_2001 Cut to IRB
BASINS\meteorological	met	Meteorological station location, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		

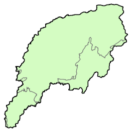
Folder\Type	Name	Description	Source	Thumbnail	Comments
BASINS\waterquality	NWIS_Stations_qw	NWIS water quality locations, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		This layer has been cut to only include points within the IRW
BASINS\waterquality	pcs3	Point source locations, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\waterquality	11110103_l	303(d) listed streams in the IRW, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		This layer is different than the 2008 layers given to us by OK DEQ and AR DEQ
BASINS\waterquality	11110103_a	303(d) listed lakes, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
BASINS\waterquality	11110103_lstoret	Legacy STORET Stations, Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	BASINS		
Downloaded\boundaries	City	Major Cities in the IRW, NAD_1983_UTM_Zone_15N	Geospatial one stop http://gos2.geodata.gov/wps/portal/gos		Original file contained all cities in the area, all cities that were not major cities in the IRW were removed.

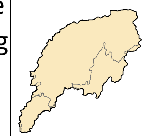
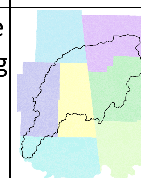
Folder\Type	Name	Description	Source	Thumbnail	Comments
Downloaded\boundaries	statesp020	State Boundaries Geographic Coordinate System: GCS_North_American_1983	National Atlas http://www.nationalatlas.gov/atlasftp.html?openChapters=chpbound#chpbound		This is the correct layer, the layer in the draft report was incorrect
Downloaded\boundaries	County_20	County Boundaries Geographic Coordinate System: GCS_North_American_1983	National Atlas http://www.nationalatlas.gov/atlasftp.html?openChapters=chpbound#chpbound		This file has only counties in the IRW extracted, This is the correct layer, the layer in the draft report was incorrect
Downloaded\boundaries\USDA_NRCS	geographic_names_nonpop	An extract that lists information about large physical and cultural features throughout the U.S. that are described in the Geographic Names Information System (GNIS) database. Geographic Coordinate System: GCS_North_American_1983	http://datagateway.nrcs.usda.gov/		This layer was originally downloaded by counties, it was combined and clipped to the IRW
Downloaded\boundaries\USDA_NRCS	geographic_names_pop	An extract that lists information about all cities, towns, housing subdivisions, and neighborhoods throughout the U.S. that are described in the Geographic Names Information System (GNIS) database. Geographic Coordinate System: GCS_North_American_1983	http://datagateway.nrcs.usda.gov/		This layer was originally downloaded by counties, it was combined and clipped to the IRW

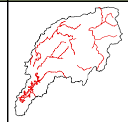
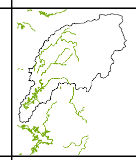
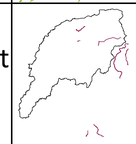
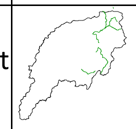
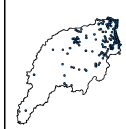
Folder\Type	Name	Description	Source	Thumbnail	Comments
Downloaded\elevation	DEM10m	Elevation raster, units in meters, 10m DEM	The National Map Seamless Server at http://seamless.usgs.gov/		Original projection for all tiles was GSC_North_American_1983, all tiles were reprojected into NAD_1983_UTM_Zone_15N, combined and cut to the basin.
Downloaded\landuse	land1992	NLCD 1992 landuse raster	The National Map Seamless Server at http://seamless.usgs.gov/		Original Projection was USA_Continuous_Albers_Equal_Area_Conic_USGS_version. It was reprojected into NAD_1983_UTM_Zone_15N, and cut to the basin.
Downloaded\landuse\EPAR6ftp	Strata_a_ar	Percent cultivated of land area Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	EPA's ftp site: scienceftp.epa.gov		Original Projected Coordinate System: WGS_1984_UTM_Zone_15N, Geographic Coordinate System: GCS_WGS_1984, this layer was reprojected and cut to the IRW
Downloaded\landuse\EPAR6ftp	IMAGE_LULC_FALL_CAST2006	2006 Landuse tif file Geographic Coordinate System: GCS_North_American_1983	EPA's ftp site: scienceftp.epa.gov		This layer needs to be cut to the IRW
Downloaded\landuse\EPAR6ftp	cdl_awifs_r_ar_2009_utm15.tif	2009 Landuse tif file WGS _1984_UTM_Zone_15N	EPA's ftp site: scienceftp.epa.gov		This layer needs to be cut to the IRW

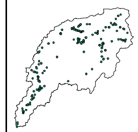
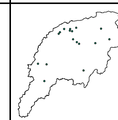
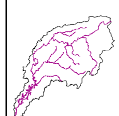
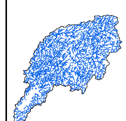
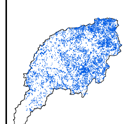
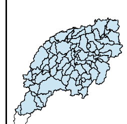
Folder\Type	Name	Description	Source	Thumbnail	Comments
Downloaded\landuse\okmaps\ 2003 (photos only) Adair Cherokee Delaware Sequoyah 2004* Adair Cherokee Delaware Sequoyah 2005 Adair Cherokee Delaware Sequoyah 2006 Adair Cherokee Delaware Sequoyah 2008 Adair Cherokee Delaware Sequoyah	Adair Cherokee Delaware Sequoyah (.shp and.sid for all counties) *2004 files named as naip_1-1_2n_s_okxxx_2004_1.sid	Aerial photography for the Oklahoma side of the basin, divided by counties. Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	ftp://ftp.okcc.state.ok.us/gis/County/	 	There is one .sid file and one shapefile per county per year for most years in the okmaps folder for a total of 36 layers. There is one thumbnail representation of the shapefile and another for the .sid files. The Thumbnail shown represents the year 2005 for all counties.

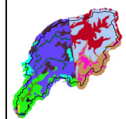
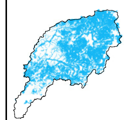
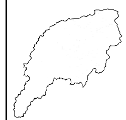
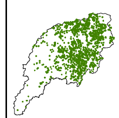
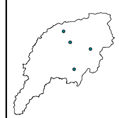
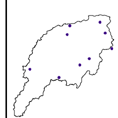
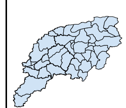
Folder\Type	Name	Description	Source	Thumbnail	Comments
Downloaded\landuse\USDA_NRCS	cdl_awifs_r_ar_2006 cdl_awifs_r_ar_2007 cdl_awifs_r_ar_2008 cdl_awifs_r_ar_2009_utm15 cdl_awifs_r_ok_2006 cdl_awifs_r_ok_2007 cdl_awifs_r_ok_2008 cdl_awifs_r_ok_2009_utm14 cdl_tm_r_ar_2003	Cropland Data The USDA-NASS Cropland Data Layer is a raster, geo-referenced, categorized land cover data layer produced using satellite imagery from the Thematic Mapper (TM) instrument on Landsat 5, Landsat7, or the Advanced Wide Field Sensor (AWiFS) on RESOURCESAT-1. The approximate scale is 1:100,000 with a ground resolution of 56 meters by 56 meters for the AWiFS data. The data layer is aggregated to a possible 85 standardized categories for display purposes, with the emphasis being agricultural land cover. Most data layers average about 10 to 20 categories out of the 85 possible categories. Geographic Coordinate System WGS_1984_UTM_Zone_14N (OK) WGS_1984_UTM_Zone_15N (AR)	http://datagateway.nrcs.usda.gov/		There are .jpg files that show the categories of each layer for each year included in the database (cdllegend). The displayed thumbnail shows the basin for the year 2006 (cdl_awifs_r_ar_2006 and cdl_awifs_r_ok_2006)

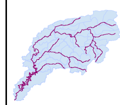
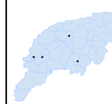
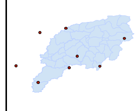
Folder\Type	Name	Description	Source	Thumbnail	Comments
Downloaded\landuse\USDA_NRCS	cra_a	A CRA map delineation is defined as a geographical area where resource concerns, problems, or treatment needs are similar. It is considered a subdivision of an existing Major Land Resource Area (MLRA) map delineation or polygon. Landscape conditions, soil, climate, human considerations, and other natural resource information are used to determine the geographic boundaries of a Common Resource Area. The database for the Digital General Soil Map of the U.S. (formerly STATSGO) is considered useful in subdividing the MLRA. The naming convention for is the MLRA symbol, followed by a dot and a numeric code (e.g., 102C.3 or 72.6). Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	http://datagateway.nrcs.usda.gov/		This was cropped to the IRW

Folder\Type	Name	Description	Source	Thumbnail	Comments
Downloaded\landuse\USDA_NRCS	mlra_a	Major land resource areas (MLRAs) are geographically associated land resource units (LRUs). Identification of these large areas is important in statewide agricultural planning and has value in interstate, regional, and national planning. Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	http://datagateway.nrcs.usda.gov/		This was cropped to the IRW
Downloaded\landuse\USDA_NRCS\SSURGO	soilmu_a_ok135_data soilmu_a_ok001_data soilmu_a_ok021_data soilmu_a_ok041_data soilmu_a_ar007_data soilmu_a_ar143_data soilmu_a_ar033_data	This dataset contains estimated and measured data on the physical and chemical soil properties, soil interpretations, and static and dynamic metadata. Most tabular data exist in the database as a range of soil properties, depicting the range for the soil survey area. In addition to low and high values for most data, a representative value is also included for these soil properties. Data are obtained from a combination of field observations, site descriptions and transects, and laboratory analyses. Projected Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	http://datagateway.nrcs.usda.gov/		Borders were removed from thumbnail to show counties as individual sections (musym) are not visible in the thumbnail. Layer did not have any data originally; tabular data was downloaded, entered into a database template, read into each layer and exported to get what is listed here. Document called "SSURGO_metadata.pdf" explains all column headings on page 70, Table Physical Name: muaggatt.

Folder\Type	Name	Description	Source	Thumbnail	Comments
Downloaded\waterquality	303d_2008_IRB	303(d) listed waters for the entire IRW.	See below		This is a combination of 2008_303d_Waterbodies, Final_ADEQ_2008_303d_List, and EPA_Added_Category_5_Segments, all layers were reprojected (of they weren't already) into NAD_1983_UTM_Zone_15N, combined and cut to the basin. The attributes table was modified to show what constituent the stream was on the list for (nitrogen etc) according to the 303(d) lists published by the states.
Downloaded\Waterquality\ 2008_303d_waterbodies_OK_Steve	2008_303d_Waterbodies	303(d) listed streams in OK	FTP site from Steve Webb at OK DEQ		Original Projected Coordinate System: Albers Oklahoma, Geographic Coordinate System: GCS_GRS_1980
Downloaded\waterquality\2008_303d_AR_Mary\	Final_ADEQ_2008_303d_List	303(d) listed streams in AR	Emailed from Mary Barnett at AR DEQ		Projected Coordinate System: NAD_1983_UTM_Zone_15N
Downloaded\waterquality\2008_303d_AR_Mary\	EPA_Added_Category_5_Segments	EPA-added 303(d) listed streams in AR	Emailed from Mary Barnett at AR DEQ		Projected Coordinate System: NAD_1983_UTM_Zone_15N
Downloaded\waterquality	Point_all	All point sources EPA, SWAT, and BASINS, Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	For the EPA sources ATC received a list from Quang Nguyen at EPA region 6		A list was created using EPA, SWAT and BASINS latitude and longitude data and then read into GIS. Therefore this layer is entirely created from coordinates.

Folder\Type	Name	Description	Source	Thumbnail	Comments
Downloaded\waterquality	STORETpre1999	STORET stations that contain any relevant data before the year 1999. Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	Downloaded from STORET online at http://iaspub.epa.gov/storpubl/legacy/proc_advanced_query		Stations were downloaded into an excel sheet and were then read into GIS. Some information was lost when read in, so the original spreadsheet named "STORETpre1999" was also provided. The "new column" contains primary IDs in both the GIS attribute table and in the excel sheet.
Downloaded\waterquality	STORETpost1999	STORET stations that contain a significant amount of relevant data after the year 1999. Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	Downloaded from STORET online http://iaspub.epa.gov/storpubl/DW_resultcriteria_geo		A list containing latitude, longitude and score (number of data points available) was created and read into GIS. Therefore this layer is entirely created from coordinates.
SWAT\hydro	newmajorstreams	Major streams in the IRW, undefined coordinate system,	SWAT 2009 GIS from ODEQ		
SWAT\hydro	streamspart2	Minor streams in the IRW, undefined coordinate system	SWAT 2009 GIS from ODEQ		
SWAT\hydro	ponds83	Ponds in the IRW, undefined coordinate system	SWAT 2009 GIS from ODEQ		
SWAT\hydro	swatwatersheds	Subbasins, undefined coordinate system	SWAT 2009 GIS from ODEQ		

Folder\Type	Name	Description	Source	Thumbnail	Comments
SWAT\landuse	statsgo	State soil raster, undefined coordinate system	SWAT 2009 GIS from ODEQ		
SWAT\landuse	pasturegrid	Pasture raster, undefined coordinate system	SWAT 2009 GIS from ODEQ		
SWAT\landuse	poultryhouse	Poultry house raster	SWAT 2009 GIS from ODEQ		This layer contains tiny dots which cannot be seen in the thumbnail
SWAT\misc	Poultry_houses_shp	Poultry houses in the IRW, Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	SWAT 2009 GIS from ODEQ		Poultry houses is misspelled, but none of the names have been changed from what was received from ODEQ
SWAT\waterquality	usgswqstations	Four USGS water quality stations, undefined coordinate system	SWAT 2009 GIS from ODEQ		
SWAT\waterquality	psources	Point Sources, undefined coordinate system	SWAT 2009 GIS from ODEQ		
Tenkiller_CD\hydro	subbasin	Subbasins from previous project, Geographic coordinate system: GCS_Assumed_Geographic_1	Subbasins from previous project, Geographic coordinate system: GCS_Assumed_Geographic_1		This will be shown on all Tenkiller_CD thumbnails

Folder\Type	Name	Description	Source	Thumbnail	Comments
Tenkiller_CD\hydro	hydro	Major streams, Geographic Coordinate System: GCS_Assumed_Geographic_1	Major streams, Geographic Coordinate System: GCS_Assumed_Geographic_1		
Tenkiller_CD\hydro	hydrGage	USGS gage stations, Geographic Coordinate System: GCS_Assumed_Geographic_1	USGS gage stations, Geographic Coordinate System: GCS_Assumed_Geographic_1		
Tenkiller_CD\Meteorological	metGage	Meteorological Gages, Geographic Coordinate System: GCS_Assumed_Geographic_1	Meteorological Gages, Geographic Coordinate System: GCS_Assumed_Geographic_1		
The following files have been received since September 2010					
Downloaded/waterquality	Cafo201008	The data is a point coverage of CAFO locations in the state of Oklahoma. Geographic Coordinate System: GCS_North_American_1983	Emailed from Quang Pham with OK Dept of Ag, Food, and Forestry		
Downloaded/waterquality	plt201004	The data is a point coverage of poultry operations in the state of Oklahoma. Geographic Coordinate System: GCS_North_American_1983	Emailed from Quang Pham with OK Dept of Ag, Food, and Forestry		

Folder\Type	Name	Description	Source	Thumbnail	Comments
Downloaded/hydro	wbdhu12_a_11110103	HUC-12 Boundaries Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	http://datagateway.nrcs.usda.gov/GDGHome.aspx		This is the layer that we are using for our HUC-8 boundary as well, all other layers have recently been cut to this layer instead the previous layer downloaded from BASINS
Downloaded/hydro	Individual_Sinkhole_Locations.shp	Sinkhole Location Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	Emailed from Quang Nguyen; files originally from ANRC		
Downloaded/hydro	Sinkhole_Areas	Sinkhole Areas Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	Emailed from Quang Nguyen; files originally from ANRC		
Downloaded/hydro	Chattanooga_shale	Chattanooga Shale Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	Emailed from Quang Nguyen; files originally from ANRC		
Downloaded/hydro	Karst_Area	Karst Areas Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	Emailed from Quang Nguyen; files originally from ANRC		
Downloaded/landuse	nlcd_2001v2	2001 NLCD Version 2	The National Map Seamless Server at http://seamless.usgs.gov/		Original Projection: USA_Contiguous_Albers_Equal_Area_Conic_USGS_version all tiles were reprojected into NAD_1983_UTM_Zone_15N, combined and cut to the basin.

Folder\Type	Name	Description	Source	Thumbnail	Comments
Downloaded/landuse	nlcd06_huc12	2006 Provisional NLCD	The National Map Seamless Server at http://seamless.usgs.gov/		Original Projection: USA_Contiguous_Albers_Equal_Area_Conic_USGS_version all tiles were reprojected into NAD_1983_UTM_Zone_15N, combined and cut to the basin.
Downloaded/landuse	Seamimp2001	2001 Impervious Areas Version 2	The National Map Seamless Server at http://seamless.usgs.gov/		Original Projection: USA_Contiguous_Albers_Equal_Area_Conic_USGS_version Reprojected to NAD_1983_UTM_Zone_15N, and cut to the basin.
Downloaded/landuse	Seamimp2006	2006 Impervious Areas	The National Map Seamless Server at http://seamless.usgs.gov/		Original Projection: USA_Contiguous_Albers_Equal_Area_Conic_USGS_version Reprojected to NAD_1983_UTM_Zone_15N, and cut to the basin.
Downloaded/landuse	TRANSP_ROADS_ALL_AHTD_line	Roads from Arkansas Highway and Transportation Department Coordinate System: NAD_1983_UTM_Zone_15N Geographic Coordinate System: GCS_North_American_1983	GeoStor at http://www.geostor.arkansas.gov/G6/Home.html		

APPENDIX C

LIST OF FILES/DATA RELATED TO TENKILLER FERRY LAKE

Directory of Tenkiller Ferry Lake Files Obtained by Dr. Richard Park, Eco Modeling

040506_5_clyde.pdf	cyanobacteria, including Tenkiller
040506_6_lynch.pdf	cyanobacteria toxin in OK
2002_303d_list.pdf	Appendix C 303d list for 2002
2003-2004 chla head of res.xls	chl a at Sta 6 for 2003-2004
2008_integrated_report_entire_documen...	Water Quality in OK 2008 report
ATT00370.eml (2.65 MB).msg	email from COE with data files 2001-2005 (see below)
Clean Lakes data.doc	link to OSU repository with 1992-93 data
Cylindro 0280892.pdf	article on *Cylindrospermopsis* T tolerance
Cylindro 20060028.pdf	occurrence of *Cylindrospermopsis* in Mich.
cylindro_balaton.pdf	occurrence of *Cylindrospermopsis* in Hungary
cylindro_queensland.pdf	occurrence of *Cylindrospermopsis* in Australia
Decision Support Model for Optimal Wa...	report on water allocation from Tenkiller
Dick's Ten File.xls	Hydrolab data around storm plume, 7/12/07
DS_PD_Tenkiller_Ferry_Lake.pdf	EFDC application to Tenkiller
email 9-26-06.txt	cover email for COE data
FinalCylindro%20Web.pdf	report on *Cylindrospermopsis* in Indiana
Gakstatter.pdf	1985 study by Jack Gakstatter, US EPA
IL R biota.pdf	periphyton and invertebrates in the river
ill_kings_appg.pdf	Ekka thesis on IL River
illinois-tahlequah 2005.pdf	BUMP stream report
illinois-watts 2005.pdf	BUMP stream report
IR FINAL Draft.pdf	draft for Horseshoe Bend & Caney Creek, '98-00 chl a
Lake Tenkiller 2002.xls	2002 chl a & chemistry
Lake Tenkiller.doc	paragraph by Paul Koenig on *Cylindrospermopsis* in OK
Limnology 1985-1986.pdf	COE report
Meo 7.pdf	IL River project
Monitoring DATA COE.xls	1986 chl a chemistry & TSI
MSC-336.pdf	Ark: IL River P 2002

new_nlws_tenkiller_tbird.pdf	OWRB nutrient designations
nitrogen_cylindrospermopsis.pdf	Hungarian study on *Cylindrospermopsis*
Obs algae.xls	1992-93 species data (from Clean Lakes report)
Optimal Allocation of Reservoir Water...Tenkiller as case study, 2009	
OSU document repository.doc	link to OSU repository with Clean Lakes data, also link to COE water release data, 11/1994 through 2009
OSU0000020.pdf	1982 fish survey, IL River
OSU0000521.pdf	pre-impoundment fish survey
OSU0000739.pdf	1979 National Eutrophication Survey, phytoplankton
OSU0000943.pdf	Gakstatter's report on IL River
OSU0003607.pdf	1989 algal study, IL River
OSU0004857.pdf	Clean Lakes data repository
OSU0006667.pdf	1987 Tenkiller fish survey
OSU0007095.pdf	1989 thesis on Fayetteville WWTP effluent
OSU0008198.pdf	Matlock thesis on periphyton growth
OSU0008243.pdf	Matlock dissertation on periphyton
OSU0010075.pdf	1975-6 water quality survey (poor scan)
p93_96.pdf	limiting factor for algae in Tenkiller, O Acad. Sci. abstract
partfour.pdf	ODEQ 2004 report
Phase I Tenkiller Rpt.PDF	1996 Clean Lakes report
RE Beach closure at Tenkiller.txt	2004 closure due to cyanobacteria bloom
README.dat	2006 COE file (goes with ATT00370.eml)
Revised Ten segments.docx	map showing segmentation of Tenkiller for AQUATOX
S2 Chlorophyll Averaging Period.doc…Colo. report on seasonal vs. annual averaging of chl a	
SB972report_2005update.pdf	restoration of OK scenic rivers
section4.pdf	2006 ODEQ water quality report
SOW TENKILLER for OWRB.doc	chemistry statement of work
Ten obs chl a detailed.xls	from Clean Lakes report 1992-93
TEN PHYTO 04-26-01_05-06-03.xls	COE data by spp.
TEN PHYTO 06-21-03 _09-20-04.xls	COE data by spp.
TEN ZOOP 2001.xls	COE zooplankton data
TENKILL wk3.xls	1996 Hydrolog
TENKILL.FM3	ditto (file extension)
TENKILL.WK3	ditto (original file)
Tenkiller 1979.pdf	1979 temperature & DO investigation

Tenkiller All.xls	OWRB 2004-5 phyto. spp. & group biomass, graphs
Tenkiller Bac-T.xls	2004-6 coliform bacteria data
Tenkiller BUMP Rept.pdf	2005-6 Beneficial Use Monitoring Program report
Tenkiller Data Search.docx	Notes on data search with some URLs
Tenkiller Lake 2001.xls	COE chemistry & chl a
Tenkiller Lake 2002.xls	COE chemistry & chl a
Tenkiller Lake 2003.xls	COE chemistry & chl a
Tenkiller Lake 2004.xls	COE chemistry & chl a
Tenkiller Lake 2005.xls	COE chemistry & chl a
Tenkiller LAke Management Plan 2008.doc….excellent fish data, 1982-2006	
tenkiller usace.bmp	map of COE stations
Tenkiller%20Ferry 2002.pdf	BUMP report
tenkiller.jpg	map of COE stations
Tenkiller.pdf	BUMP report with map
Tenkiller.xls	Hydrolab and chl a, 1996-2006 compilation
tenkiller_ferry 2003.pdf	BUMP report
tenkiller_ferry 2004.pdf	BUMP report
tenkiller_ferry 2005.pdf	BUMP report
tenkiller_ferry.pdf	2006-7 BUMP report
tenkiller_water_watch_report.pdf	1997-2002 OWRB extensive report
Tenkiller-Secchi TN TP DO.xls	1996-2006 data, including Hydrolab for 1996
TenkillerTMDL.pdf	draft TMDL report, simulated 1985, created 2001
Tony Clyde (333 bytes).msg	null email message from COE, 2002
WQ-11110103.dbf	1983-94 STORET(?) data
WQ-11110103.xls	1983-94 STORET(?) data
WQ97-03-1.pdf	Illinois River biota, including periphyton
wri034168.pdf	USGS P loads for Illinois River, 1997-2001

Directory of Tenkiller Ferry Lake Files Obtained by Dr. A. Stoddard, DS LLC

Haggar&Soerens(2006_EE_28_3)LakeFrances.pdf

HaggardMooreDeLaune(2005_JEQ_34)LakeEucha.pdf

Hupfer&Lewandowski(p-release-sedimentbed-20090430).pdf

SenHaggard-etal(2007_WASP_179)BeaverReservoir.pdf

tt-stoddard(2000)-chap02.pdf

White_chaubey_ENSO.pdf

APPENDIX D

DATA/REPORTS PROVIDED BY EACH CONTRIBUTING AGENCY

Agency/Source	Contact Name	Contact info	Date Received	Method received	WQ	Discharge	GIS	Other	Comment	File Name
Arkansas DEQ-Water Planning	John Bailey	BAILEY@adeq.state.ar.us	3/24/2010	emailed links						400D8EBFd01.pdf
										7429B07Ad01.pdf
										A4872C16d01.pdf
	Mary Barnett	BARNETT@adeq.state.ar.us	2/3/2010	email			x		303(d) list	2008_4a_lakes
							x		303(d) list	2008_category_4a
							x		303(d) list	EPA Added Category 5 Segments
							x		303(d) list	Final ADEQ 2008 303d List
	Kim Fuller	FULLER@adeq.state.ar.us]	12/8/2010	emailed					originally from Duyen Tran at CH2M	Fayetteville West Side Effluent Results June 2008-Oct 2010.xls
Arkansas Natural Resources Commission	Patrick Fisk	Patrick.Fisk@arkansas.gov	7/7/2010	email						FOI request EPA Region 6-Scott Stein 2009 PFO.xls
	Tony Ramick	tony.ramick@arkansas.gov	11/19/2010	email						IRW_2010_May_ver1_saraswat.docx
										IRDAA_SWAT 01-14-11.pdf
	Earl Smith	Earl.Smith@arkansas.gov	8/6/2010	email						Litter Transport in Northwest Arkansas Summary.doc
	Ed Swaim	Edward.Swaim@arkansas.gov	5/27/2011	email					poultry registration and litter generated	IRW 12 digit HUCs.xlsm
			7/11/2011	email						FOI TMDL UPDATED by acres.xlsm
Arkansas Water Resources Center	Brian E. Haggard Marty Matlock	haggard@uark.edu mmatlock@uark.edu	1/27/2010	email	x	x			Water quality Sampling at Highway 59 Bridge	MSC_352.pdf
					x	x		stage	Ballard Creek Water Sampling	MSC_353.pdf
					x				Discusses PS from WWTP	Ekka2006_EE_26_4.pdf
						x			Estimate of Phosphorus loads	Haggard2003_AEA_19_2.pdf
					x	x			Nutrients and Algae	Chaubey2007_TRANS_ASABE_50_1.pdf
					x	x			P concentration at Border	Haggard2003_IWA.pdf
					x				Evaluates Sediment–aqueous Phase P Equilibrium	Haggard2004_TRANS_ASAE_47_4.pdf
					x				Municipalities P release	Haggard2005_TMDLconf.pdf
									Phosphorus and Sediments in Lake Francis	Haggard2006_EE_28_3.pdf
					x			landuse characterization	P release from Sediments	Haggard2007_JEQ_36_6.pdf
								rainfall intensity and runoff	Determine Runoff Mechanisms	Leh2008_Hydrologic_Processes.pdf
				previously	x				phosphorus and nitrogen concentrations	WRIR_01-4217.pdf
			5/25/2010	email	x					LoadsIR59(1997-2008)
			5/26/2010	email	x					Ballard(folder)

Agency/Source	Contact Name	Contact info	Date Received	Method received	WQ	Discharge	GIS	Other	Comment	File Name
					x					IllinoisMonthly(folder)
					x					IR59(folder)
					x					MooresCreek(folder)
					x					Osage(folder)
			8/2010?	conference						Haggard.2010.JEQ.V39.NovDec.pdf
			10/13/2010	email						09-1100 Kings River Monitoring Final Report (final).docx, 09-500 UWRB Monitoring Final Report (edited).docx, 09-600 UIRW Monitoring Final Report(edited)).docx
			1/5/2011	email						ILLINOIS_SWAT_REPORT_11.pdf
Cherokee Nation Environmental Programs	April Hathcoat	ahathcoat@cherokee.org	12/6/2010	link in email					deposition data	Cherokee_OK99_MDM
City of Tahlequah	Ben Berry	stormwater@cityoftahlequah.com	2/10/2010	email		x			contains temperature, depth, date, and flow	Flow data-TC-1 10-10-07 thru 7-9-09-1.xls
					x				10/27/2007-11/24/2009	Tahlequah Ck WQ data-to city-1.xls
								fish and taxa		Bioassessment data-1.pdf
	David Morrison	genman@cityoftahlequah.com	3/30/2010	mailed	x	x				Box contianing point source data
Dynamic Solutions	Andy Stoddard	astoddard@dsllc.com	7/20/2010							DS-Contribution-IllinoisR-DataReport(July20-2010).zip
			7/23/2010							TableDS-1-Part1.jpg, TableDS-1-Part2Footnotes.jpg, TableDS-1-Source-FromTT-stoddard(2000)-chap02.pdf
			7/27/2010							Chapter-2-text.doc, DSLLC-TKL-ATC-DataReview-July 20 2010(Draft#1Deliverable).docx, Table2-17.doc
Eco Modeling	Dick Park	dickpark@cableone.net	1/14/2010	links in email	x				stage volume	
			7/12/2011 original 7/30/2010	CD						Appendix C in data report
EPA Region 6	Quang Nguyen	Nguyen.Quang@epamail.epa.gov	7/7/2010	emailed						denise illinois consultation.pdf
										denise master large consultation.pdf
									animal locations	AR LWM Locations.xls
									OK poultry frams by county	4-12-10 PFO for EPA.xls
										4-12-10 CAFO for EPA.xls
			8/6/2010	emailed						The revised phosphorus index
			8/6/2010	emailed						Ark broilers by county.xls
			10/22/2010	emailed						WQ87-06-2 - Data Analysis.pdf
			1/10/2011	emailed						11 2 2010_IRWBP_revised.doc
			1/13/2011	emailed						Osage basin Wastewater District-Statement of Basis-edit2.doc
										Osage Basin AR0050024 Septic System Phosphorus reduction.wpd
										Osage Basin Sept Tank Survey.pdf
			9/8/2011	emailed						PltWasteApp_201109.zip
			3/22/2011	emailed				x	gis, originally provided by ANRC	Individual_Sinkhole_Locations.shp Sinkhole_Areas.shp Chattanooga_shale.shp, Karst_Area.shp (2x, but they look the same), Northern_Arkansas_sinkholes.jpg, Madison_sinkhole.jpg, Newton_CountySink.jpg, Northern_Arkansas_sinkholes.jpg, Searcy_sinkholes_2010.pdfWashington_sinkhole_2010.pdf, Sinkhole_Areas, Stone_County_Sinkhole10.pdf,

Agency/Source	Contact Name	Contact info	Date Received	Method received	WQ	Discharge	GIS	Other	Comment	File Name
	Angel Kosfiszer	Kosfiszer.Angel@epamail.epa.gov	7/8/2010	emailed						illinois study REPORT043.pdf
			7/12/2010	ftp site			x		2006 landuse tif	IMAGE_LULC_FALL_CAST2006.tif
										NPDES Nutrient Discharges.gdb (filder)
										Outfall Solids.mdb
	Curry Jones	jones.curry@epa.gov	3/25/2010	email					osage and spring creek report	Osage and Spring Creek Water Quality and Ecological Assessme.pdf
	Curry Jones	jones.curry@epa.gov	7/21/2010	emailed link						TenkillerPhase1.pdf
	Randall Rush	Randall.Rush@epamail.epa.gov	7/22/2010	email						IRWBP ver3 wp.pdf
										IRWBP FNL Comments 6-14-2010.doc
			11/17/2010	emailed						NPS Poultry Litter Projects Summary.doc
			2/21/2011							IRDAA_SWAT 01-14-11.pdf
	Angela Restivo	Angela.Restivo@epamail.epa.gov?	12/23/2010						provides some water quality information associated with karst features.	Monitoring Cavefish population and environmental quality in cave springs cave AR.pdf
									looks at vadose and upper karst interactions on the Arkansas side. This article also gives an example of a spring that feed into the Illinois River	sir2005-5160part4.pdf
									provides some information on recharge in the area.	ANHC1998Report.pdf
									provides research surrounding Cave Springs. It provides soils information for the area	Dixon_scan_article_ground_water_spatial_hydro_2004.pdf
									is true to it's name and looks at the Boone Groundwater Basin more from the Oklahoma side. It focuses on Lakes Eucha and Spavinaw , which are North of the Illinois River, but discusses characteristics of the area that includes the Illinois River watershed.	Hydrogeologic investigation report of the Boone Groundwater Basin.pdf
									llinois River Upland and In-stream Final Report	llinois_River_Report_ 6-28-2006.pdf
	Melinda McCoy	McCoy.Melinda@epamail.epa.gov	1/20/2011	email						Project 7 Rev sub 7-26-10.pdf, JanTAGMtg_Letter&Agenda.pdf
Oklahoma Conservation Commission	Stacey Day	Stacy.day@conservation.ok.gov	4/10/2011	email						
OK Dept of Ag, Food, and Forestry.	Quang Pham	Quang.Pham@oda.state.ok.us	2/17/2010	email				PFO list		PFOs_Ill_Rvr_20100209 List-2.pdf
								PFO map		PFOs_Ill_Rv_20100209 Map-1.pdf
								CAFO list		CAFO's_Ill Rvr_20100212 List-1.pdf
								CAFO map		CAFO_Ill_Rvr_20100212 Map-1.pdf
								waste application list		P_Waste App_Ill Rvr 7_07-6_08 List-2.rtf

Agency/Source	Contact Name	Contact info	Date Received	Method received	WQ	Discharge	GIS	Other	Comment	File Name
								waste application map		P_Waste App_Ill_Rvr 7_07-6_08 Map-1.pdf
										P_Waste Rpt_Cons_Com
			3/18/2010	email				waste application list		P_Waste App_Ill_River 7_08-6_09 List.pdf
								waste application map		P_Waste App_Ill_River 7_08-6_09 Map.pdf
			9/23/2010	email			x	gis	Active Licensed CAFO Operations Coverage	cafo201008.piz
							x	gis	The data is a point coverage of poultry operations in the state of Oklahoma.	plt201004.piz
									Poultry Waste Land Application	PltWasteApp.piz
Oklahoma DEQ	Mark Derichsweiler	mark.derichsweiler@deq.ok.gov	2/18/2010	email					Battle Branch Pebble	Battle Branch Pebble Count.xls
										BARONFRK.WB1
										Harmell.Haan.Dutnell.T.ASAE.1999.pdf
	Andrew Fang	Andrew.Fang@deq.ok.gov	1/19/2010	email from Tony				point source		TP-TN_loadings_update_1-15-08.xls
			5/11/2010	FTP site	x	x			reports for trial	reports_data_ODEQ (expert reports of Brown, Caneday, Cook and Welch, Engel, Fisher, Hardwood, Johnson, King, Lawrence, Olsen, Smith, Stevenson, Stratus, Taylor, Teaf, and Wells)
			5/19/2010	FTP site	x	x			access database	CDM.AG.db (folder)
			5/28/2010	FTP site					mesonet data	MesonetAndrew052910 (folder)
			6/2/2010	FTP site	x				Habitat information	OCCHabitatSurvey(folder)
			7/8/2010	FTP site (public) (http://okmaps.onenet.net/digital_ortho.htm)			x		Pictures of IRW that can be placed into GIS for Oklahoma for 2002, 2003. 2004, 2005, 2006, 2008	2002, 2003. 2004, 2005, 2006, 2008 (all folders)

Agency/Source	Contact Name	Contact info	Date Received	Method received	WQ	Discharge	GIS	Other	Comment	File Name
			9/14/2010	ftp (at ftp://204.62.18.178/)						infoforIRTMDLdatarequest_030110 OCLWA 2010 Symantec temp2490- 7.15.2010 Tbird WBP w changes.doc 2009 Annual Report compressed rev.pdf 2009.4.29 final report.doc 2010.1.14 2009 Annual Report in Publisher.pub 2010.4.30 Final Report.pdf 2010.7.06 Draft Stamper FR.doc 2010.7.8 Master SOP.doc 2010.8.9 HC Ltr Rpt & Septage Rpt.doc DCP_Operated_5_foot.dbf DCP_Operated_5_foot.prj DCP_Operated_5_foot.sbn DCP_Operated_5_foot.sbx DCP_Operated_5_foot.shp DCP_Operated_5_foot.shx HJTInstall.exe mbam-setup.exe Remaining_nwi_maps.zip Rotating Basin Watersheds.zip SUPERAntiSpyware.exe
			10/29/2010	email						PltWasteApp10_10.xxx
			11/23/2010	ftp site						ILLINOIS RIVER PROJECT.doc
			3/9/2011	ftp site					Stillwell WWTF scannes document	Stilwell 1-09 to12-10.pdf, Stilwell 1-06 to 12-08.pdf

Agency/Source	Contact Name	Contact info	Date Received	Method received	WQ	Discharge	GIS	Other	Comment	File Name
			3/3/2011	ftp://www.deq.state.ok.us/wqd/1/ToEPA/					Flow data and DMR reports	Flow data-TC-1 10-10-07 thru 7-9-09.xls table for Ben.xls Tahlequah Creek Data.xls WWTP DMR2001 DMR2002 DMR2003 DMR2004 DMR2005 DMR2006 DMR2007 DMR2008 DMR2009 DMR2010
			7/15/2011	email						P-sediment_SOD.zip: Dzialowski and Carter, Sediment Phosphorus Releas... Dzialowski and Carter, TMDL report.docx Final Alum Treatment Poster AEES 2011.pdf PVIABoardPresentationDEC2010.pdf Wister_AWRC.pdf
			7/15/2011	ftp://www.deq.state.ok.us/wqd/1/ToEPA/						Harmel.zip
ODEQ-Water Quality	Steve Webb	steve.webb@deq.ok.gov	2/3/2010	email			x		303(d) list	2008_303d_Waterbodies

Agency/Source	Contact Name	Contact info	Date Received	Method received	WQ	Discharge	GIS	Other	Comment	File Name
Oklahoma Water Resources Board	Paul Koenig Bill Cauthron Julie Chambers	PDKOENIG@owrb.ok.gov WLCAUTHRON@owrb.ok.gov JMCHAMBERS@owrb.ok.gov	1/15/2010	email						Lake Tenkiller.doc, RE Beach closure at Tenkiller, cylindro_balaton.pdf cylindro_balaton, cylindro_queensland, FinalCylindro%20Web, nitrogen_cylindrospermopsis, IR FINAL Draft, TenkillerTMDL, Tenkiller 1979, and data on Tenkiller Lake email 9-26-06.txt README TEN PHYTO 04-26-01_05-06-03.xls TEN PHYTO 06-21-03 _09-20-04.xls TEN ZOOP 2001.xls Tenkiller Lake 2001.xls Tenkiller Lake 2002.xls Tenkiller Lake 2003.xls Tenkiller Lake 2004-2.xls Tenkiller Lake 2005.xls Part 1.1.2 Tenkiller All.xls tenkiller.jpg Tenkiller.pdf Book2.xls Lake Tenkiller 2002.xls README.txt SOW TENKILLER for OWRB.doc TEN PHYTO 04-26-01_05-06-03.xls TEN PHYTO 06-21-03 _09-20-04.xls TEN ZOOP 2001.xls TENKILL.FM3 TENKILL.WK3 Tenkiller 2004.xls Tenkiller Bac-T.xls Tenkiller Lake 2001.xls Tenkiller Lake 2002.xls Tenkiller Lake 2003.xls Tenkiller Lake 2004.xls Tenkiller Lake 2005.xls Tenkiller Phytoplankton 04-26-01_05-06-03.xls tenkiller usace.bmp Tenkiller.xls Tenkiller-Secchi TN TP DO.xls
	Monty Porter	MAPORTER@owrb.ok.gov	10/14/2010							IRB TMDL Data Request.xlsx

Agency/Source	Contact Name	Contact info	Date Received	Method received	WQ	Discharge	GIS	Other	Comment	File Name
Rogers Water Utility	Paul Burns	paulburns@rwu.org	2/24/2010	CD	x	x				Cross Sections Dr Mark Nelson Papers Dr Nelson loading files ISCO Sampler Flow Module Data Major Reports Misc OC Blossom Way Reports Paul Burns loading calculation files USGS OC Elm Springs Flow Data USGS OC HW112 Bridge Flow Data Osage Creek Watershed Loading Summary 2008 update.xls Osage Creek Watershed Loading Summary 2008 update.xlsx READ ME for OSAGE CREEK - ROGERS WMP 2000 to 2007.docx READ ME for OSAGE CREEK - ROGERS WMP 2000 to 2007.pdf Rogers WS Grab Data Trends Yearly Averages 2004 to 2007 portrait.xls Rogers WS Grab Data Trends Yearly Averages 2004 to 2007 portrait.xlsx RPCF 2005 2006 2007 Daily and Weekly Results.xls RPCF ops32 data 2003 to 2009 daily effluent values 100108.xls USGS Gain Loss Study Osage & Prairie Creek WRIR03-4187.pdf Watershed Lab Data to 2008 100111.xls Watershed Lab Data to 2008 100111.xlsx
Siloam Springs (city of)	Tom Meyers	tmyers@siloamsprings.com	1/20/2011	email					point sources	2006TMDL data.xls, 2007 TMDL.xls, 2008 TMDL data.xls, 2009 TMDL Data.xls, 2010 TMDL Data.xls
Springdale Water Utilites	Jennifer Enos	jenos@springdalewater.com	12/23/2010							LetterRe. Request for Data121610.pdf, SWU WWTF Effluent data.xls
Tulsa Field Office	James J Wellman		9/22/2010	email					Karst	2006AR137B.pdf, 2006 tumbling creek cave.pdf
Tyson Foods	Carol Ross, Robert George	Carol.Ross@tyson.com, Robert.George@tyson.com	2/8/2010	FTP site	x	x			Document for Trial	Sullivan Report.pdf
					x	x			Document for Trial	Clay Report.pdf
									Document for Trial	Coale Report.pdf
					x	x			Document for Trial	Connolly Report.pdf
									Document for Trial	Grip 01 26 2009 Report.pdf
					x	x			Document for Trial	Grip 10 2008 Report.pdf
					x	x			Document for Trial	Jarman Report.pdf
					x	x			List of Facilities	ODEQ Bypass Reporting Database.pdf
					x	x			Sediment Yield	Stillwater Creek Watershed.pdf
					x	x			2006 SWAT modeling	Storm 2006 ODEQ.pdf
			7/20/2010	email					Document for Trial	Bierman_ExpertReport_012309.pdf
			9/30/2010	DVD						Information about Poultry Waste Management
	Robert George	Robert.George@tyson.com	8/25/2011	CD					Cross Section from Grip's expert report	Grip_cross (folder)
United Keetowah Band	Brandi Ross	bross@unitedkeetowahband.org	2/24/2010	CD	x	x			Data and reports on Tahlequah Town monitoring	Tahlequah Town Branch Database, FY07 104b3 (folder), FY10 104b3 (folder)

Agency/Source	Contact Name	Contact info	Date Received	Method received	WQ	Discharge	GIS	Other	Comment	File Name
University of Arkansas	Marty Matlock	mmatlock@uark.edu	6/23/2010	email						Data ~$ta Read Me Memo.docx Data Read Me Memo.docx Errata Memo.docx Biotics Diurnal In-Stream Parameters Habitat Data Canopy Cover.xlsx FLOW SUMMARY.xlsx Geomorphology Data.xlsx Periphyton Data.xlsx Water Chemistry Data.xlsx
	Andrew Sharpley	sharpley@uark.edu	11/12/2010	email						Watersheds and water quality UA Fact sheet FSA-9526 2008.pdf Arkansas P Index FSA-9531 2010.pdf, Grazing mgt & water quality - FSA-9530 2009.pdf, Nutrient Analysis of Poultry Litter - FSA-9529 2009.pdf, Outcomes of P based planning ESW - Sharpley ea FWG SWCS 2009.pdf
	Dharmendra Saraswat	dsaraswat@uaex.edu	1/1/2011	email						IRDAA_Precipitation.xlsx
										subwatersheds_pptstation.xlsx
USGS, Arkansas Water Science Center	Reed Green,	wrgreen@usgs.gov	2/8/2010	email	x					geometric mean comparison.pdf
										Phosphorus Concentrations, Loads, and Yields
										Clark, Mueller, and Mast, 2000.pdf
USGS, Oklahoma District	Robert L. Blazs	rlblazs@usgs.gov	2/8/2010	links in email	x	x			Phosphorus Concentrations, Loads, and Yields 1997-2001	Water-Resources Investigations Report 03-4168
					x	x			Summary of Surface-Water Quality Data 1970–2007	Scientific Investigations Report 2009–5182
					x	x			Phosphorus Concentrations, Loads, and Yields 2000–2004	Scientific Investigations Report 2006–5175
	James Wellman	jwellman@usgs.gov	6/2/2011	email						barber_rating chewey_rating eldon_rating Gore_rating kansas_rating sager_rating tahl_rating watt_rating barber.doc Baron_Fork.doc Chewey.doc Gore.doc kansas.doc Sager.doc Tahlequah.doc watts.doc
	Scott Strong	sstrong@usgs.gov	6/8/2011	email						Illinois_tribs_x-sect.xls

APPENDIX E

MODERN STORET WATERSHED STATION SUMMARY: 11110103

This page provides summary information for water quality data that are available within this watershed. You can access the water quality monitoring data by clicking on any of the 'Get Details' links. These data are generated from EPA's STORET database.
The data provided on this page were generated using *STORET Web Services*. For more information on how to incorporate these data into your application or web site, click here.

For this watershed, the following organizations have reported monitoring data:
ARDEQH2O_WQX - Arkansas Department of Environmental Quality
CHEROKEE - Cherokee Nation (Oklahoma)
NARSTEST - EPA National Aquatic Resources Survey
OKDEQ - Oklahoma Dept. of Environmental Quality
OKWRB - Oklahoma Water Resources Board

Organization ID: ARDEQH2O_WQX - Arkansas Department of Environmental Quality

Station ID	Station Name/Summary Information	Period of Record
ARK0007A	Baron Fork on County Road 21 near Dutch Mills (Get Details) 1646-Metal, 9-Microbiological, 609-Nutrient, 865-Other, 21-Pesticide, 1261-Physical,	11/03/1998-08/04/2009
ARK0007	Barren Fork at Dutch Mills, Arkansas (Get Details) 778-Metal, 36-Microbiological, 422-Nutrient, 381-Other, 6-PCB, 46-Pesticide, 984-Physical,	10/23/1990-09/19/2006
LARK012A	Bobb Kidd Lake - W. of Prairie Grove, midpoint of dam (Get Details) 50-Metal, 20-Nutrient, 20-Other, 36-Physical,	08/17/1994-08/23/1999
ARK0141	Cincinnati Creek near Cincinnati, Arkansas (Get Details) 1643-Metal, 9-Microbiological, 616-Nutrient, 870-Other, 21-Pesticide, 1274-Physical,	11/03/1998-08/25/2009
ARK0010C	Clear Creek at Hwy. 112 Bridge (Get Details) 2195-Metal, 18-Microbiological, 861-Nutrient, 1108-Other, 6-PCB, 67-Pesticide, 1800-Physical,	07/12/1994-08/04/2009
ARK0004A	Flint Cr NW of W Siloam Springs OK (Get Details) 2489-Metal, 45-Microbiological, 1068-Nutrient, 1290-Other, 6-PCB, 113-Pesticide, 2315-Physical,	09/25/1990-12/01/2009
ARK0040	Illinois River near Savoy, Arkansas (Get Details)	09/25/1990-08/25/2009

	2489-Metal, 45-Microbiological, 1080-Nutrient, 1297-Other, 6-PCB, 113-Pesticide, 2322-Physical,	
ARK0006A	Illinois River near Siloam Springs, Arkansas (Get Details) 763-Metal, 30-Microbiological, 420-Nutrient, 372-Other, 6-PCB, 92-Pesticide, 969-Physical,	09/25/1990-10/13/1998
ARK0006	Illinois River south of Siloam Springs, AR (Get Details) 1807-Metal, 13-Microbiological, 721-Nutrient, 987-Other, 6-PCB, 67-Pesticide, 1499-Physical,	01/28/1992-08/25/2009
LARK014A	Lake Elmdale - Southeast of Elm Springs AR. (Get Details) 50-Metal, 20-Nutrient, 20-Other, 36-Physical,	08/18/1994-08/24/1999
LARK015A	Lake Fayetteville - W. of spillway above boat docks. (Get Details) 50-Metal, 20-Nutrient, 20-Other, 36-Physical,	08/18/1994-08/24/1999
LARK018A	Lake Weddington - pt. on trans. parallel to dam. (Get Details) 50-Metal, 20-Nutrient, 20-Other, 36-Physical,	08/17/1994-08/23/1999
ARK0155	Osage Creek at Hwy. 264 Bridge (Get Details) 276-Metal, 16-Microbiological, 59-Nutrient, 95-Other, 119-Physical,	10/10/2005-06/19/2007
ARK0082	OSAGE CREEK AT LOGAN ARKANSAS (Get Details) 276-Metal, 65-Nutrient, 103-Other, 123-Physical,	08/18/2008-08/04/2009
ARK0041	Osage Creek near Elm Springs, Arkansas (Get Details) 2502-Metal, 44-Microbiological, 1082-Nutrient, 1303-Other, 6-PCB, 113-Pesticide, 2350-Physical,	09/25/1990-08/04/2009
ARK0005	Sager Cr near Siloam Springs AR (Get Details) 2496-Metal, 45-Microbiological, 1115-Nutrient, 1321-Other, 6-PCB, 113-Pesticide, 2451-Physical,	09/25/1990-08/25/2009
LARK009A	SWEPCO Lake - north of Siloam Springs, AR - midpoint of dam (Get Details) 50-Metal, 20-Nutrient, 20-Other, 36-Physical,	08/17/1994-08/23/1999