# IMPLEMENTATION OF A STREAM/RIVER PROBABILISTIC SAMPLING NETWORK FOR THE STATE OF OKLAHOMA

State of Oklahoma
U.S. Environmental Protection Agency Region 6
FY05 Regional Environmental Monitoring and Assessment Program REMAP
Research Plan

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## Table of Contents

## List of Tables



## List of Figures

## Project Description

Several agencies conduct water quality monitoring in the State of Oklahoma. These agencies meet complementary monitoring objectives that support the management of Oklahoma's surface waters. The two primary components of the statewide monitoring program include (a) the Beneficial Use Monitoring Program, a long-term, fixed-station water quality monitoring network, and (b) the Small-Watershed Rotating Basin Monitoring Program, targeting water quality and ecological conditions in waters flowing from 11-digit hydrologic units. The state recently completed a water quality monitoring strategy that describes their existing programs in detail and the monitoring objectives that cannot be met with existing resources. These objectives include the ability to make statistically valid inferences about environmental conditions throughout the state, based on a probabilistic selection of sites. Meeting this objective will improve the ability to make condition estimates required in section 305(b) of the Clean Water Act. This requirement includes a description of the quality of all lotic waters, and the extent that all waters provide for the protection and propagation of aquatic life.

In 2001, the State requested assistance with the design of a probabilistic approach to stream and river site selection from the U.S. Environmental Protection Agency, Office of Research and Development (ORD), National Health and Environmental Effects Research Laboratory (NHEERL). The study design was completed, but Oklahoma agencies remained unable to initiate further planning and implementation because of a lack of resources. The purpose of the Regional Environmental Monitoring and Assessment Program (REMAP) program proposal is to secure funding and ongoing technical assistance from ORD to initiate the study.

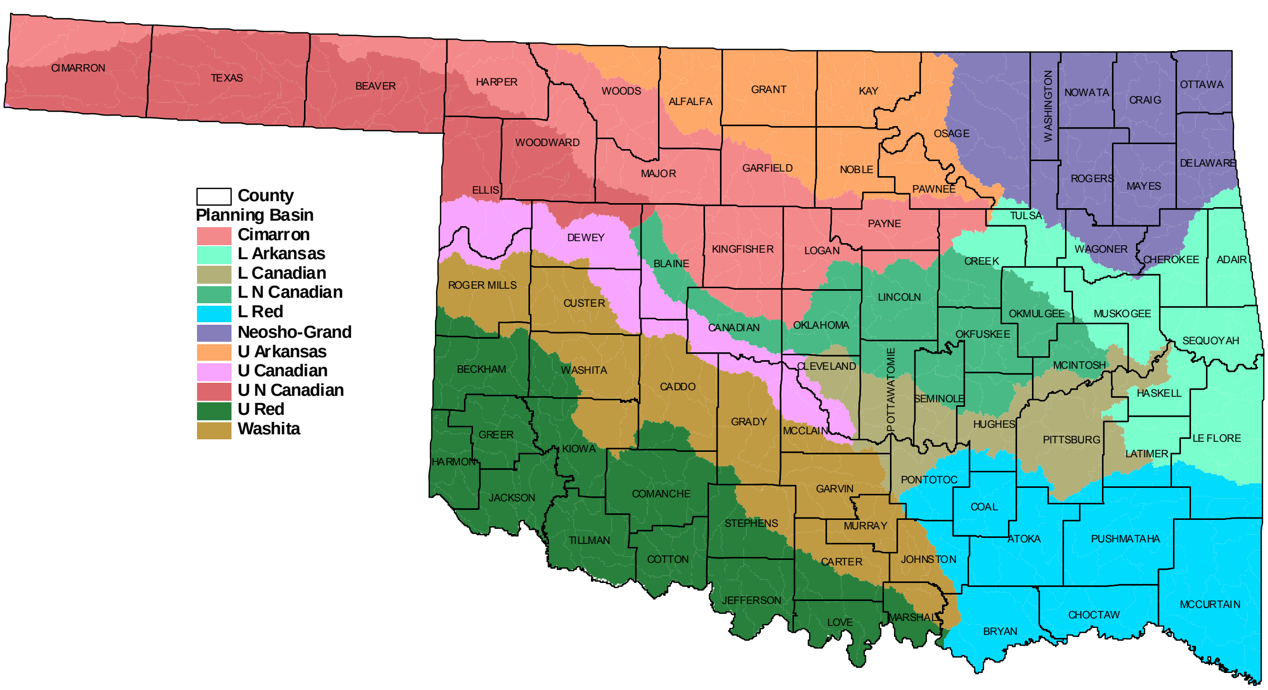


**Figure 1.** State of Oklahoma Planning Basins

Oklahoma's probabilistic survey will be completed over a five-year period (2005-2009) with approximately 42 sites sampled annually (210 total). The design is stratified to allow statewide estimates (15 stations per year) as well as estimates within planning basins (27 stations per year). To date, three sources of funding have been identified to complete the initial three years of the study (126 stations). Study year one includes the Lower Red River planning basin (Figure 1) and is underway. It is funded by a regional 104(b)(3) grant (30 sites) and state dollars (12 sites). Upon approval of this proposal, study years two and three will be funded by a combination of REMAP (74 sites) and state monies (10 sites). These years will include intensive sampling in the Grand River, Upper North Canadian River, Upper Canadian River, Upper Arkansas River, Lower Canadian River, and Cimarron River planning basins (Figure 1). Additional funding is being pursued to complete study years four and five.

All selected sites will be visited once or twice during a mid spring to late summer index period and sampled only under base flow conditions. A suite of physical, chemical, and biological variables will be collected. The biological collections will include a sampling of the macroinvertebrate, fish, periphyton/algae, and microbiological communities. Water quality samples will be collected to determine concentrations of various nutrients, cations, anions, turbidity and toxicants. General water quality variables (i.e., dissolved oxygen, temperature, pH, specific conductance, etc.) will be measured *in situ*. An assessment of physical habitat and a measurement of instantaneous discharge will be made. Taxonomic and chemical analysis will be contracted to qualified laboratories.

## Project Objectives

1. To determine the overall health of Oklahoma's streams and rivers through a statistically valid approach.

   At the end of the project period, there will be one hundred twenty-six (126) sites available for inclusion in data analyses. When study years four and five are completed, much more precise estimates may be possible. All planning basins will be sampled at the higher resolution scale, and the statewide estimate will include at least seventy-five (75) sites.

2. To assist the development and validation of statewide biocriteria and nutrient criteria.

   The study will yield biological, chemical, and physical data for across a gradient of environmental conditions, supporting evaluation of relationships between these indicators. This will help to calibrate the existing biocriteria ranges and established reference condition. Nutrient criteria development will be assisted in several ways. Periphyton data may assist in development of nutrient criteria. Baseflow nutrient data will help to verify regional averages when associated with data from other programs.

3. To provide an additional data layer for determining localized monitoring needs and developing short- and long-term monitoring goals.

   The data will allow for the assessment of the water quality standards for Fish & Wildlife Propagation beneficial use for additional waters in the state, some of which were previously unassessed. Observations suggesting impaired biological integrity at individual sites will identify a need for follow-up studies in local areas. Additionally, if regional numbers are not within state criteria, the area may be designated a "hot-spot" for a particular water quality issue and resources allocated.

4. To evaluate the feasibility of using land use and land cover data to predict biological integrity and target monitoring efforts.

   The delineation of watersheds upstream from each site and calculation of landscape metrics for each watershed will yield variables to be used in the development of predictive models for indicators of biological integrity.

## Technical Approach

### *Overview*

The target population for the survey design includes all perennial streams and rivers within Oklahoma, excluding atypical systems with highly unique characteristics and fauna; specifically, oxbow and wetland dominated systems, and navigational channels and lock-dominated systems. The sampling design, described below, yields an ordered listing of sites that must be evaluated for accessibility, landowner access, and verification that the site is representative of the target population. The next site in the list will be used to replace sites that are rejected for any reason. Three stages of planning will be carried out prior to data collection. The initial stage of planning will be reconnaissance to determine station accessibility, best available routes, and landowner permission to enter their property. Once stations are determined to be accessible, secondary recon will be necessary to assess any special considerations including hazards, time of travel, etc. The final planning stage will be the preparation of a sampling plan for each station.

All selected sites will be visited once during a late spring to late summer index period in which fish assemblage will be determined and comprehensive suite of physical habitat measurements will be made. In addition, an *in-situ* water quality collection will be made including measurements for water temperature, dissolved oxygen, pH, specific conductance, and turbidity. All selected sites will be visited again during an index period from July 1$^{st}$ through August 30$^{th}$ in which a comprehensive collection of water quality chemistry and microbiology, a collection for benthic macroinvertebrates, short form physical habitat measurements, and a collection of benthic periphyton will be made. All collections will be made under base flow conditions. The data will be assessed using existing protocols for making standards attainment decisions (OWRB 1987), and by multivariate analyses to examine relationships between the indicators and landscape metrics.

The study will be temporally limited by biological index periods. The index period for the fish assemblage in Oklahoma is May 15$^{th}$ through September 15$^{th}$. This period may be extended to October 1$^{st}$ if stream has not risen above summer seasonal base flow. The index habitat period for the macroinvertebrate assemblage in Oklahoma is July 1$^{st}$ through August 30$^{th}$. However, macroinvertebrate collections will be completed in as short a time period as possible beginning July 1$^{st}$. Because an independent habitat form is utilized for macroinvertebrate sampling, collections may be done separately from fish collections.

The study will be hydrologically limited by a variety of conditions. Sites may be inaccessible due to ephemeral conditions caused by drought or unseasonably heavy rainfall. To avoid bias, biological sampling will be done during base flow time periods, because fish collections may be biased due to gear (seines and dipnets) inefficiency in higher flows. Macroinvertebrate samples may be biased because substrate is depopulated during higher flows. Therefore, sites will not be visited for data collection within 10 days after a return to base flow.

***Statistical Design***

An unequal probability random tessellation stratified (RTS) survey design (Stevens 1997, Stevens and Olsen 2004) was used to select stream sample sites across the state. The sample design is weighted by Strahler stream order categories to achieve an approximately equal expected sample size across stream order categories 1st, 2nd, 3rd, and 4th+ to ensure that larger order streams are represented. Both wadeable and non-wadeable waterbodies are included in the design. The site selection process included an "oversample" to provide alternate sites for those that do not fit the target population, or where access is prohibited by landowners. The original 2001 balanced sampling design was modified to a spatially stratified design to support estimates of conditions at the statewide scale within the three-year project period, and to support estimates at the scale of selected planning basins (or combinations of basins).

Oklahoma's probabilistic survey will be completed over a five-year period (study years 2005-2009) with approximately 42 sites sampled annually. The design is stratified to allow statewide estimates as well as estimates within planning basins. During study year one through three, at least fifteen (15) sites will be visited at the statewide scale each year, yielding a sample size of at least forty-five (45) sites. In addition, twenty-seven (27) sites will be visited within seven specific planning basins (Table 1) that have been selected for more intense sampling. This yields an additional eighty-one (81) sites during the initial three years of the study. Because of the differing size or geographic area covered by each basin, the number of sites targeted within each planning basin ranges from five to twenty-seven sites (Table 1). At the end of the project period, there will be one hundred twenty-six (126) sites available for inclusion in data analyses. When study years four and five are completed, much more precise estimates may be possible. All planning basins will be sampled at the higher resolution scale, and the statewide estimate will include at least seventy-five (75) sites.

**Table 1.** Numbers of sites within selected basins.

| STUDY YEAR (SY) | PLANNING BASIN | SITES |
|---|---|---|
| SY-2005 (1) | Lower Red River | 27 |
| | Statewide Stations | 15 |
| SY-2006 (2) | Grand-Neosho River | 15 |
| | Upper North Canadian River | 5 |
| | Upper Canadian River | 7 |
| | Statewide Stations | 15 |
| SY-2007 (3) | Upper Arkansas River | 10 |
| | Lower Canadian River | 6 |
| | Cimarron River | 11 |
| | Statewide Stations | 15 |
| SY-2006-2004 | Total Stations | 126 |

***Landscape Component***

The landscape component of the study is intended to explore the extent to which existing land use and land cover data can be interpreted and used to predict biological integrity. This information may then assist water quality managers in determining the feasibility of targeting monitoring resources. Findings from a growing number of studies support the general statement that increasing human land use typically results in water quality degradation, physical habitat alterations, and/or modified hydrologic regimes. It remains difficult to make specific quantitative statements about the extent that different land uses may affect biological integrity, because studies have been conducted over a wide range of geographic areas using many different response indicators. The potential magnitude of disturbance appears to depend on whether the effects of the land uses include increased storm water runoff, increased pollutant concentrations in storm water runoff, increased pollutant concentrations in near-surface groundwater, direct wastewater discharges to streams, destruction of riparian zones resulting in physical habitat modifications, hydrologic modifications, barriers to migration, or varying combinations of all of the above (Harding *et al.* 1998;Richards *et al.* 1996;Sponseller *et al.* 2001;Tong and Chen 2002). Land uses within riparian areas, in addition to the greater watershed, may result in more extensive instream physical habitat modifications (Diamond *et al.* 2002;Diamond and Serveiss 2001).

Teels and Danielson (2001) successfully formulated a human disturbance index by applying quantitative thresholds for the extent of urban area, cropland, and pastureland throughout entire watersheds, and allotted scores for watersheds based on the land use with the greatest potential for disturbance, in addition to information about fish barriers and visual habitat assessments. The resulting index values correlated well with several commonly used measures of fish community integrity (Teels 2003). The land use thresholds associated with lower scores for individual sites generally agree with the findings in several studies where investigators quantified the extent of individual land use types associated with a change in environmental quality (Diamond, Bressler, and Serveiss 2002; 1999;Wang *et al.* 2001).

Oklahoma will delineate watersheds above selected sites within the study area, using digital elevation models, then use an ArcView extension, developed by EPA's Office of Research and Development, to calculate landscape metrics (Ebert *et al.* 2001;Harrison *et al.* 2000) from land use and land cover data (U.S. Geological Survey 2000) for each watershed. The extension, named Analytical Tools Interface for Landscape Assessments (ATtILA), includes four types of indicators -- landscape characteristics, human stresses, riparian characteristics, and physical attributes. We will attempt to identify correlations between these variables and measures of biological integrity, and develop predictive models. A subset of the sites and corresponding watersheds will be set aside for testing and validation of the models.

Previous studies have generated somewhat conflicting results about whether different indicators of biological integrity were more closely related to conditions within entire watersheds versus riparian areas. We will assess both by examining land uses and land cover within a 30m riparian zone (the limit of resolution for existing land use data).

The U.S. Geological Survey has completed an assessment of the accuracy of land use and cover maps to be used for this project, available at http://landcover.usgs.gov/accuracy/. Eighty to 100 randomly selected sites within each land cover class were selected for validation by comparison of mapped and photo-interpreted land cover classes. Their findings suggest the level of accuracy is adequate for continental and regional applications. The USGS recommended using higher-level aggregations for smaller scale studies to minimize the potential for classification errors. They also cautioned against using data for highly localized studies at a scale of watersheds of only tens of square miles. We will limit our use of the ATtILA metrics to those representing the higher-level aggregations of data, as suggested.

The documentation and records supporting this component of the study will include electronic files, calculated landscape metric outputs from ATtILA, and a hardcopy data report that includes calculated index values. Landscape metric names documented in the ATtILA user's manual (Harrison *et. al.* 2000) will be used as field names in electronic data files.

### *Sampling Procedures and Protocols*

Parameters will be measured to determine chemical, physical, bacteriological, biological, and habitat properties of each site. Chemical and physical analysis will consist of measurements of turbidity, pH, dissolved oxygen (DO), alkalinity, specific conductivity, water temperature, instantaneous discharge, nitrate ($NO_3$) plus nitrite ($NO_2$), orthophosphate ($PO_4$), total phosphorous (TP), total Kjeldahl nitrogen (TKN), ammonia ($NH_3$), chloride (Cl), sulfate ($SO_4$), total dissolved solids (TDS), total suspended solids (TSS), total hardness, metals included in the OWQS, and sestonic and benthic chlorophyll-a. Bacteriological monitoring will consist of monitoring for fecal coliforms, *Enterococcus* and *Escherichia coli*. Biological monitoring will consist of a collection of fish and benthic macroinvertebrates. To measure habitat, an assessment will accompany each fish and macroinvertebrate collection. In addition, observations of periphyton/algae, odor, excessive bottom deposits, surface scum, oil/grease, and foam will be recorded.

Field sampling and analysis methods for all types of samples are described by APHA (1995), EPA (1977, 1979b), Welch (1948), Lind (1979), Wetzel and Likens (1979), OWRB Standard Operating Procedures (SOPs), USGS manuals for "Field Water-Quality Methods for Surface Water", and OWRB Technical Report 99-3 (1999). Much of the equipment used in sampling is described in the individual method SOPs which are available at the OWRB website.

Equipment SOPs:

1. Measurement of Hardness and Alkalinity
2. Measurement of Turbidity
3. Use of Floats to Determine Stream Discharge
4. Recording of Physical/Chemical Parameters Using a Multi-Parameter Instrument
5. Cleaning of Glassware and Sampling Equipment

Methods SOPs:

1. Collection of Water Quality Samples
2. Measurement of Stream Discharge
3. Collection of Sestonic and Benthic Chlorophyll-a Samples
4. Collection of Fish
5. Collection of Fish in Non-wadeable Prairie Rivers
6. Collection of Benthic Macroinvertebrates
7. Collection of Habitat Information
8. Forms

The methods and meters required to perform field water quality and quantity analyses are listed in Table 2. Field methods are described in short below.

1. Multi-parameter instrument direct measurements—Includes measurements for dissolved oxygen (mg/l), specific conductance (µSiemens/cm), water temperature (°C), oxidation-reduction potential (Redox) (mv), and pH (standard units). One reading is taken at the area of fastest and deepest at approximately the middle of the water column.

2. Multi-parameter instrument indirect measurements—Includes measurements for % Dissolved oxygen saturation (based on temperature and dissolved oxygen), salinity (ppm; based on specific conductance), total dissolved solids (TDS; based on specific conductance and temperature). One reading is taken at the area of fastest and deepest water at approximately the middle of the water column.

3. Nephelometric Turbidity (ntu) sample is taken from the water quality sample. Measurement is made using a Hach 2100P turbidometer.

4. Total Alkalinity sample is taken from the water quality sample. Measurement is made using a HACH® Total Alkalinity Kit.

5. Total Hardness sample is taken from the water quality sample. Measurement is made using a HACH® Total Hardness Kit.

6. Instantaneous Discharge is measured by taking a composite of readings using mechanical velocity (pygmy or Price AA) or electromagnetic meters. Floats may be used when point discharges are below the method detection limit of instruments.

**Table 2.** Parameters, Methods, Meters, and Method Detection Levels for Each Field Measured Parameter

| PARAMETER | METHOD | METER/KIT | METHOD DETECTION LEVEL |
|---|---|---|---|
| Dissolved Oxygen | 4500-G | Hydrolab Series 4 or 4a | 0.1 ppm |
| Specific Conductance | 2510-B | Hydrolab Series 4 or 4a | 1.0 uS |
| pH | 4500 H-B | Hydrolab Series 4 or 4a | 1.0 standard unit |
| Temperature* | | Hydrolab Series 4 or 4a | -5.0˚C |
| Total Dissolved Solids | Calculation based on specific conductance and water temperature. | Hydrolab Series 4 or 4a | 1 ppm |
| Total Hardness | | Hach Test Kit | 1.0 ppm |
| Total Alkalinity | 2320-B | Hach Test Kit | 1.0 ppm |
| Nephelometric Turbidity | 2130-B | Hach 2100P | 0.1 NTU |
| Instantaneous Discharge | Electromagnetic | Marsh McBirney | 0.1 cfs |
| Instantaneous Discharge | Mechanical | Pygmy Meter | 0.031 cfs |
| Instantaneous Discharge | Mechanical | Price Type AA | 0.031 cfs |

Samples presented for chemical analysis require certain containers, preservatives, and holding times. Containers and preservatives are outlined in detail in the narrative below. In addition, containers, preservatives, and holding times are outlined for each parameter and presented in Table 3.

Field samples collected for laboratory analysis of inorganics and metals will be labeled at the time of collection. Labeled information will include project code, stream name, collection date, and preservative used. All information except collection date is contained on a printed label attached one day before sample collection. Collection date is recorded with a waterproof marker. Each sample will consist of up to four narrow-mouthed, 1-L polyethylene bottles. One bottle is preserved with sulfuric acid (labeled "$H_2SO_4$") to reduce the sample pH to 2.0 units with subsequent storage on ice at 4°C. A second bottle is preserved with ice (labeled "ICE") to 4°C. A third bottle may be collected for metals analysis. The bottle is preserved with nitric acid (labeled "$HNO_3$") with subsequent storage to 4°C. A fourth bottle may be collected for metals analysis when average reach hardness is below 150 ppm. When average reach hardness below 150 ppm exists, hardness dependent metals criteria for cadmium, copper, lead, and silver become extremely low, and to analyze samples with low enough reporting limits to meet the low criteria, the analytical laboratory uses a different method. This bottle is preserved the same as the other metals bottle. All metals samples are preserved on ice in the field and the analytical lab upon sample delivery adds nitric acid.

Field samples collected for laboratory microbiological analysis will be labeled at the time of collection. Labeled information will include project code, stream name, collection date, collection time, and preservative used. All information except collection date and time is contained on a printed label attached one day before sample collection. Collection date and time is recorded with a waterproof marker. Each sample will consist of two sealable, 100-mL polyethylene bottles. Both bottles are double bagged in plastic ziplock baggies and preserved with ice (labeled "ICE") to 4°C. One bottle is used for analysis of fecal coliforms and *E. coli*, and the second bottle is used for the analysis of *Enterococci*.

Field samples collected for fish and macroinvertebrate analyses will be labeled at the time of collection. Labeled information will include project code, stream name, collection date, collection time, habitat sampled (macroinvertebrate), and gear used. All information is recorded with a waterproof marker directly on the lid and bottle. In addition, a label with all necessary information will be completed in pencil or indelible ink on a rite-in-rain paper and added to each jar. Separated by type of gear used (seine or electrofisher), fish samples will be placed in 1-gallon wide mouth polyethylene bottles and fixed with 10% formalin. Specimens may be further preserved in ethanol. Separated by habitat sampled (riffle, streamside vegetation, or woody debris), benthic macroinvertebrate samples will be placed in 1-quart wide mouth polyethylene bottles and preserved with 95% ethanol.

**Table 3.** Containers, preservation methods and holding times for water quality samples collected for laboratory analysis.

| PARAMETER | CONTAINER | PRESERVATIVE | HOLDING TIME |
|---|---|---|---|
| Total Alkalinity | Polyethylene | Ice, 4 °C | 24 hours |
| Ammonia Nitrogen | Polyethylene | Ice, 4 °C, acid ($H_2SO_4$) to pH < 2 | 7 days |
| Nitrate Nitrogen | Polyethylene | Ice, 4 °C | 48 hours |

| PARAMETER | CONTAINER | PRESERVATIVE | HOLDING TIME |
|---|---|---|---|
| Nitrite Nitrogen | Polyethylene | Ice, 4 °C | 48 hours |
| Nitrate + Nitrite Nitrogen | Polyethylene | Ice, 4 °C, acid ($H_2SO_4$) to pH < 2 | 28 days |
| Kjeldahl Nitrogen | Polyethylene | Ice, 4 °C, acid ($H_2SO_4$) to pH < 2 | 7 days |
| Total Nitrogen | Polyethylene | Ice, 4 °C, acid ($H_2SO_4$) to pH < 2 | 48 hours |
| Total Phosphorus | Polyethylene | Ice, 4 °C, acid ($H_2SO_4$) to pH < 2 | 28 days |
| Orthophosphate | Polyethylene | Ice, 4 °C | 48 hours |
| Nephelometric Turbidity | Polyethylene | Ice, 4 °C | 24 hours |
| Chlorophyll-a | Polyethylene | Ice, 4 °C, dark | 24 hours to filtration, 30 days filter processing |
| Total Hardness | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Phenolphthalein Alkalinity | Polyethylene | Ice, 4 °C | 24 hours |
| Sulfate | Polyethylene | Ice, 4 °C | 28 days |
| Chloride | Polyethylene | None required | 28 days |
| Total Suspended Solids | Polyethylene | Ice, 4 °C | 7 days |
| Total Dissolved Solids | Polyethylene | Ice, 4 °C | 7 days |
| Arsenic | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Cadmium | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Zinc | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Chromium (Total) | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Copper | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Lead | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Mercury | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 28 days |
| Nickel | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Selenium | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Silver | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Thallium | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Calcium | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Iron | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Magnesium | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Potassium | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Sodium | Polyethylene | Ice, 4 °C, acid ($HNO_3$) to pH < 2 | 6 months |
| Enterococci | Polyethylene | Ice, to < 10 °C | 24 hours |
| Fecal & Total Coliform | Polyethylene | Ice, to < 10 °C | 24 hours |
| Benthic Macroinvertebrate | Polyethylene | Ethanol | Indefinite w/ proper preservation |
| Fish | Polyethylene | Formalin (fixative); Ethanol (preservative) | Indefinite w/ proper preservation |

### *Sample Tracking and Custody Procedures*

A sample handling and custody program has been established to document sample handling procedures and transfer of sample custody from field to laboratory personnel. Documentation of sample handling and transfer from field collection to delivery of data results to the investigator(s) is essential in the quality assurance and control process. All records are duplicated to prevent loss in case one set is misplaced or destroyed. Example field notes for all measurement listed above are included with the OWRB QMP (QTRACK No. 03-275) and in the Forms SOP.

OWRB personnel fill out a Sample Analysis Request Form and a Chain of Custody Form (See examples in the OWRB QMP and Forms SOP) prior to sample submittal to the laboratory. The Sample Analysis Request Form includes information identifying each sample by sampler name, station name, station ID, date, time collected, and parameters to be analyzed. A space is left on the form for the receiving laboratory to record the laboratory tracking number. The Chain of Custody Form records the sampling personnel, station name, number of bottles per sample, and the date and time of sample collection. Upon sample arrival at the laboratory, laboratory personnel officially receive the collected samples from OWRB personnel. The laboratory assigns an identification number to each sample and writes the assigned number on the Sample Analysis Request form. The time and date the samples are received is recorded on the Chain of Custody form. The designated laboratory representative receiving sample custody signs the Chain of Custody form as does the OWRB personnel relinquishing sample custody. A space is provided on both forms to allow for any comments to be recorded by either OWRB personnel or laboratory receiving personnel. Upon completion of both forms, a photocopy is made with the laboratory retaining one document and the OWRB receiving the other document.

Final laboratory results will be reported to the OWRB Project Manager and Database Manager in both a hardcopy format and in a database format for direct upload to the Water Quality Database. Hardcopy sheets are placed in the project notebook after internal review. Each report contains information identifying the Project Manager, sample number, sample date, and results of the analyses. Space is reserved at the bottom of the laboratory results sheet for comments by the collector and/or analyst. Once the OWRB receives sample analyses, the official chain of custody “cycle” has been completed. Staff with the OWRB work closely with contract laboratory personnel to ensure that all procedures are correctly followed and data is delivered to the Project Manager in a timely manner. Once data is received it is reviewed for completeness and accuracy by field staff with further review conducted by the Water Quality Programs Division Database Manager. Any problems identified will be resolved as quickly as possible with cooperation between the Database Manager and the contract laboratory. If problems cannot be resolved between the Database Manager and the laboratory, then the project coordinator will work with the contract laboratory with the involvement of the OWRB QA Officer as required. If problems still cannot be resolved, the OWRB QA Officer and the Water Quality Programs Division Chief will work with the contract laboratory to resolve the issue.

### *Analytical Procedures*

All analytical methods to be used are described in American Public Health Association Standard Methods: 19th Edition (1995) or EPA publications (1977, 1979b) and are described in detail in the individual SOPs. Analytical procedures for each field and laboratory water quality are also referenced in Tables 4 and 5. Details on the internal operations of the analytical laboratory in regards to data entry, laboratory tracking procedures, and sample custody (sample handling, storage, and disbursement) are documented in the ODEQ Quality Management Plan (QTRACK No. 00-182).

*Internal Quality Control*

The OWRB uses principle investigators, defined as team leaders, to conduct all studies. This designation may be made upon the leader of a multi-person or single person team. Principle investigators for this project are required to have degrees and/or experience with biological or other applicable sciences. In addition, training is required for all SOPs dealing with water quality and quantity collections and measurements as well as habitat assessments and biological collections. In-house training will be conducted for the use of all meters and digital titrators used for water quality or quantity measurements. Investigators must be familiar with OWRB SOP document and all training will follow the methods outlined in that document. Extra training will be provided when new SOPs are developed. Training of field crews will be done through dry run exercises in the laboratory to familiarize field crews with sample collection, sample preservation, instrument operation, calibration, and maintenance. In addition, when new personnel are hired or new methods developed, qualified staff will train on sample collection, measurement, and field analysis methods through side-by-side field trips. These trips will familiarize staff with SOP requirements. When training is considered adequate, a field audit conducted by a qualified staff member will conduct a formal QA check with field staff for adherence to SOPs.

All data will be checked to ensure that certain data quality objectives (DQO) are met. These DQOs include representativeness, completeness, precision, and accuracy. The data are representative as a result of the study design and sampling methods. The design entails sampling across broad spatial scales in a way that ensures that selected sites are representative of the target population. Sampling methods are commonly used and accepted methods and are described thoroughly in the OWRB's SOPs. To ensure the precision and accuracy of measurements, all data are checked through a series through replication or duplication of sampling effort at a percentage of the total sites. Precision refers to internal method consistency, measured by the degree of agreement among individual measurements of the same characteristic under similar conditions. Consistency of sampling and sample processing and striving for repeatability of measurements increases the precision of estimates and reduces measurement error (Platts et al. 1983). Accuracy and precision of field measurements will be assessed through instrument calibration and post calibration, and comparison with known standards. The Oklahoma Department of Environmental Quality (ODEQ) lab ensures data quality of laboratory samples through the use of analysis of control charts for precision and accuracy following Section 1020 of Standard Methods (1992). General acceptance limits for field duplicates are based on Table 1020:I of the Standard Methods (1992). Taxonomic laboratories ensure precision and accuracy through repeat identification and the use of taxonomic keys. Acceptable precision and accuracy for water quality parameters and biological assessments are more explicitly defined below. Data that are collected in a representative manner and meet the requirements of precision and accuracy are considered complete. To maintain the integrity of the design, at least 95% of the target number of sites must be designated as complete.

The OWRB and OCC regularly calibrate all instruments. Instrument calibrations are maintained in logbooks for each instrument. All multi-parameter instruments will be calibrated prior to every field-sampling event. Furthermore, instruments will be calibrated in the field when certain conditions apply. These include but are not limited to: 1) measured data is outside a previously calibrated range (e.g., pH is calibrated to a range of 7 and 10 and the current measurement or historical data is 6.8 standard units), 2) a parameter used in calibration (e.g., barometric pressure in the calibration of dissolved oxygen) has changed significantly, or 3) needed maintenance is performed (e.g., the changing of a dissolved oxygen sensor membrane).

Specific calibration procedures are outlined in the Multi-Parameter Instrument SOP. Turbidometer calibration procedures are outlined in the Turbidity Measurement SOP. Primary calibration for each turbidometer instrument will occur as recommended by the manufacturer. Secondary calibration of the HACH® instrument using secondary standards with known values will occur prior to sample analysis. Velocity meter calibration procedures are outlined in the Measurement of Discharge SOP. Calibration occurs before each measurement and weekly when sampling trips are completed. Acceptable precision and accuracy of field instrumentation is provided in Table 4.

**Table 4.** Summary of field measured water quality variables and their associated range of values for precision and accuracy.

| PARAMETER | METHOD | METER / LAB | RANGE OF VALUES | PRECISION | CALIBRATED ACCURACY |
|---|---|---|---|---|---|
| Dissolved Oxygen | 4500-G | Multiparameter Instrument | 0 to 20 ppm | 0.01 ppm | ± 2% of reading |
| Specific Conductance | 2510-B | Multiparameter Instrument | 0 to 150 mSiemens/cm | 0.1% of reading | ± 0.5% of reading |
| pH | 4500 H-B | Multiparameter Instrument | 0 su to 14 su | 0.01 su | ± 0.2 su |
| Temperature* | | Multiparameter Instrument | -5˚C to 45˚C | 0.02˚C | ± 0.2˚C |
| Total Hardness | 130.1 | Hach Test Kit | 10 – 4000 | 1-5 mg/L | HACH Digital Titration Test |
| Total Alkalinity | 2320-B | Hach Test Kit | 10 – 4000 | 1-5 mg/L | HACH Digital Titration Test |
| Nephelometric Turbidity | 2130-B | Hach 2100P | 0 to 999 NTU | 0.01 NTU | ± 2% of reading |
| Instantaneous Discharge | Electromagnetic | Marsh McBirney | | | |
| Instantaneous Discharge | Mechanical | Pygmy Meter | | | |
| Instantaneous Discharge | Mechanical | Price Type AA | | | |

A series of blanks, duplicates, and replicates will be submitted with each sampling event. In addition, a blank for field DI water and cleaning methods will be conducted weekly. Methods for preparing field blanks, field duplicate samples, and replicate samples are described in the various OWRB SOP documents. Field measured total alkalinity, total hardness, and turbidity samples will be controlled through this process. The QC of laboratory parameters will be achieved through regular submittal of duplicate and replicate samples as well as various types of blank samples. Laboratory quality control sample results will be tracked by constructing a tabular summary by date for each quality control method blank, duplicate, and replicate. For blank samples above the stated detection limit, the potential percent contribution of the blank value to environmental samples will be calculated. Samples that have a potential percent contribution of greater than 5% will be considered questionable. Duplicate and replicate samples will be presented in a table with calculations for the difference between the values. These variances will then be compared to acceptable limits for precision and accuracy outlined in Table 5 of this document. When samples are outside the acceptable interval, data will be considered questionable. When using data for assessment of beneficial use impairment, the interval will be placed around the reported value to determine if an incorrect decision of support or impairment may occur from erroneous data. Furthermore, when data is questionable, reported values will be presented with the associated interval of the duplicate or replicate data.

**Table 5**. Acceptable limits for duplicate and replicate samples (method detection limits noted).

| PARAMETER | METHOD | METER/ KIT | ACCEPTABLE PRECISION FOR LOW LEVEL FIELD DUPLICATES AND REPLICATES | ACCEPTABLE PRECISION FOR HIGH LEVEL FIELD DUPLICATES AND REPLICATES | METHOD DETECTION LEVEL* |
|---|---|---|---|---|---|
| Alkalinity | 2320-B | Hach Kit | 75-125% | 90-110% | 10-25 mg/L |
| Hardness | 130.1 | Hach Kit | 75-125% | 90-110% | 10-25 mg/L |
| Nephelometric Turbidity | 2130-B | Hach 2100P | 75-125% | 90-110% | 0.01 NTU |
| Ammonia | 4500 | ODEQ | 75-125% | 90-110% | 0.015 mg/L |
| Total Kjeldahl Nitrogen | 4500-N-C | ODEQ | 75-125% | 90-110% | 0.01 mg/L |
| Nitrate / Nitrite | 4500-NO3-D | ODEQ | 75-125% | 90-110% | 0.5 mg/L |
| Ortho Phosphorus | 4500 P E | ODEQ | 75-125% | 90-110% | 0.005mg/l |
| Total Phosphorous | 4500-P-B-E | ODEQ | 75-125% | 90-110% | 0.005 mg/L |
| Total Suspended Solids | 160.2 | ODEQ | 75-125% | 90-110% | 1 mg/l |
| Total Dissolved Solids | 160.1 | ODEQ | 75-125% | 90-110% | 1 mg/l |
| Metals | 200.7 | ODEQ | 75-125% | 90-110% | 5 µg/L |
| Sulfate | 4500-SO4-E | ODEQ | 75-125% | 90-110% | 0.1 mg/L |
| Chloride | 4500-C | ODEQ | 75-125% | 90-110% | 0.5 mg/L |
| Fecal Coliform | 9222D | ODEQ | 50-150% | 75-125% | 10 cfu/mL |
| E. Coli | 9223 | ODEQ | 50-150% | 75-125% | 10 cfu/mL |
| Enterococcus | 9230C | ODEQ | 50-150% | 75-125% | 10 cfu/mL |
| Chlorophyll-a | 10200H | ODEQ | 25-175% | 50-150% | 0.1 mg/m3 |

*Method detection limits reported by ODEQ Environmental Laboratory using Method 1030E from Standard Methods (APHA, AWWA, WPCF 1992).

Quality control of flow measurements will be achieved by conducting a replicate measurement at 10% of all sites. Side by side measurements will also be taken on a yearly basis. Mechanical meters will be calibrated (spin test), cleaned, and oiled at the beginning of each day and the end of each measurement. Electromagnetic meters will be calibrated (zero flow test) at the beginning of each day and cleaned at the end of each measurement.

Quality control of habitat assessment will be achieved through strict adherence to the habitat assessment SOP and deployment of trained investigators. Field investigators are field audited once each year to insure compliance to the SOPs developed and maintained by the OWRB. Field QA sessions will include a side-by-side measurement of all metrics with all personnel. Calculating a mean score for all team leaders creates a series of metric standards for the assessment. Team leaders and other staff are then compared to the mean and a percent difference is calculated for each metric. An acceptable percent difference is ½ of the scoring category range. Acceptable precision for habitat is referenced in Table 6.

Quality control for biological assessments will follow the suggestions in: *Revision to Rapid Bioassessment Protocols For Use in Streams and Rivers: Periphyton, Benthic, Macroinvertebrates, and Fish, EPA 841-D-97-002*. In addition, investigators are tested for identification abilities with a statewide assemblage of fish fauna before fish collections begin. These fish are comprised of species that are typically found in Oklahoma stream systems. The majority of the test specimens include fish with larger body sizes that are typically field identified and/or found in large numbers. Species of special concern such as the Arkansas River Shiner are also utilized during the testing procedure to insure endangered or threatened species may be correctly identified and released. A test score on critical species of 95% or better must be achieved before the investigator will be a field crew leader. Investigators that score under 95% will not collect without direct supervision of the crew leader.

Replicate habitat and biological collections will be made at approximately 10% of stations. Acceptable precision for biological revisits is given in Table 6. The sample will include application of all collection protocols at a nearby, similar reach on the same waterbody. The reach will not be randomly chosen. In addition, revisits will occur at approximately 10% of stations.

**Table 6**. Acceptable precision for biological assessments and habitat assessments.

| ACTIVITY | PARAMETER | PRECISION (RPD) FAULKNER 1994 |
|---|---|---|
| Fish collection: seine/electrofish | No. individuals<br>No. species | 50%<br>15% |
| Benthic macroinvertebrate collection | No. individuals<br>No. Taxa | 50%<br>15% |
| Habitat assessment | Habitat assessment score<br>Average depth<br>Average width<br>Percent cover | 15%<br>15%<br>15%<br>20% |

With the exception of hybrids, all fish will be identified to species level. Quality control of laboratory processing of fish collections will be achieved by the use of proper taxonomic techniques and regionally appropriate keys. An independent taxonomist will identify at least one in ten collections. Fish identified outside of their reported ranges will be forwarded to other taxonomists within the state for confirmation. These requirements will be outlined in the services contract with the qualified taxonomist. Data will be archived with the Oklahoma Museum of Natural History.

With the exception of Chironomids, all benthic macroinvertebrates will be identified to genus level. Quality control of laboratory processing of benthic macroinvertebrates will be accomplished by the use of proper taxonomic techniques and regionally appropriate keys. Additionally, a different taxonomist will re-identify one in ten samples. The laboratory will also maintain a library of all collections. Additional requirements will be outlined in the services contract with the qualified taxonomist.

### *Performance and Systems Audits*

Regular assessments and audits of all protocols will be performed. These reviews and appropriate responses are outlined in Table 7.

**Table 7**. Assessment and Response Actions

| ASSESSMENT | RESPONSE |
|---|---|
| Field Systems Audit:<br>Early in the sampling program and once each year, each field procedure will be compared with the written SOP for compliance. Field audits will include inspection of all equipment used and system performance. | Any inconsistency/deficiency between the SOP and the field audit will be reported to the Project Officer, Project Manager, and appropriate field personnel. Response to any inconsistency or deficiency will be the responsibility of the Project Officer and may include additional training, purchase of equipment, change in personnel, and/or revision of the SOP. Additional assessments may be recommended as required. Remedial actions will be reported to the QA Officer and Project Manager. |
| Data Management Review:<br>Data management protocol requires frequent communication between data management and the QA Officer. The data management system will be reviewed, in detail, quarterly for backup status and data completeness. | Data management and resolution of data entry problems are the responsibility of the QA officer and Project Manager. |
| Data Reporting & Interpretation Review:<br>Each report, prior to release, undergoes an internal review process of the technical writers, Project Officer, and Division Chief. | The technical writing staff will resolve comments and difference of data interpretation. |

The ODEQ currently operates the Oklahoma Laboratory Certification Program for laboratories performing analyses on samples collected in the State of Oklahoma. This program is designed to insure that chemical water analysis and biological data are reliable and accurate for scientific and legal purposes. To be certified, a laboratory is required to employ qualified personnel, possess adequate equipment and facilities, maintain adequate quality control, pass on-site inspection, and analyze accurately an appropriate set of reference samples provided by EPA. Reference samples are sent and certification must be renewed on an annual basis. Any laboratory that submits chemical or biological data to the ODEQ to fulfill waste disposal permit or research requirements, must be certified for the appropriate variables. The ODEQ laboratory is certified for all variables at the present time.

Evaluation of data quality will occur on a weekly basis as a result of instrument calibration and submission of quality control samples to the analytical laboratory. Instrument maintenance logbooks will be kept with the field instruments and therefore available for examination on an as needed basis. Management will be informed when calibration is not possible and corrective actions will be implemented. Replacement or repair of the affected part or parts will be performed if required. Management will also be informed on a monthly basis of the project status and project problems. Summary tables of quality control results are immediately available to management through the OWRB computer network system. Access to such information is limited to personnel in the Monitoring Section, the Water Quality Programs Division Chief, and the Division Administrative Assistant.

When it is determined that data received from the analytical laboratory is “incomplete”, through results of blank and/or replicate samples, management will be informed and any needed actions will subsequently be taken. Most reports made to management will be by the Project Manager, however, occasions may arise when the OWRB QA Officer will deal directly with management. The OWRB QA Officer will be notified when recurring problems with instruments or contract laboratories are compromising achievement of data quality objectives. If data quality objectives cannot be met due to laboratory or instrument errors, the Project Manager and OWRB QA Officer in concert will work with agency management to solve project QA problems and recommend corrective action procedures.

***Preventative Maintenance Schedules and Procedures***

The manufacturers provide procedures and a schedule for routine maintenance, inspection, and testing of each instrument. Other maintenance is required when calibration procedures, precision, and accuracy do not fall within acceptable limits. All maintenance, testing, and inspections are maintained in logbooks for each instrument. Maintenance of the thermometer probe, pH probe, specific conductance probe, and dissolved oxygen probe consists of cleaning, repair, and/or replacement of parts or reference solutions as required. Maintenance of dissolved oxygen, pH, thermometer, and specific conductance probes will occur on at least a monthly basis or more often as conditions warrant. Such maintenance is recorded in a logbook kept with each field-monitoring instrument. Maintenance of the HACH® Turbidometer 2100P consists of cleaning, repair, or replacement of parts as recommended by the manufacturer. Velocity meter maintenance, testing, and inspection procedures are outlined in the Measurement of Discharge SOP. These procedures occur before each measurement and weekly when sampling trips are completed.

Repairs to agency equipment or instruments will be made by OWRB or OCC personnel when possible and by the manufacturer when necessary. All of the parts listed below are currently available on the OWRB and OCC premises or in vehicles for use when necessary. Spare parts are maintained and monitored by the Project Manager. Project manager ensures that depletion does not occur through semi-annual inventories. A list of critical spare parts would include the following:

- Stock of dissolved oxygen membrane, O-rings, electrolyte solution
- Various spare probes for multi-parameter instruments
- Spare cables for all instruments
- Spare batteries for all applications
- Spare lamps and vials for turbidometer
- Spare glassware and plastic ware for all kits

- Spare plastic ware for depth-integrated samplers
- Spare filtering and tissue grinding kits for chlorophyll-a
- Spare parts for mechanical velocity meters
- Spare cabling attachments for sounding winches

Quality control of field-measured parameters consists of testing instrument readings against a known standard. This comparison between the field instrument and a known value will occur prior to each field trip. If an instrument or piece of equipment cannot meet calibration specifications, then the instrument will be repaired in-house until it can meet specifications. If the instrument cannot be repaired in-house then it will be shipped back to the manufacturer for repair and an analogous instrument will be utilized for data collection. The OWRB maintains several instruments for back-up purposes.

All supplies are inspected upon receipt for completeness and integrity. All reagents are checked for expiration dates and shelf life. Damaged, incomplete, and expired supplies will not be used and will be returned to the supplier. Supplies will be checked quarterly for expiration. If supplies are deemed expired, damaged, or contaminated, they will be disposed of in a proper manner and replaced immediately.

### *Data Management and Reporting*

Field observations and water quality data will be recorded in a standardized data format (Table 8) in field sheets, chains of custody, lab sheets, and record books as demonstrated in various OWRB SOPs. All field sheets used in-stream will be printed on waterproof paper. Hard copies of all data acquired will be maintained in a data notebook for each project for 10 years. The data manager will check field notes and lab sheets for completion before placing in the data notebook. Chains of custody will be checked by the data manager for signature and sample number before inclusion in the data notebook. In addition, data will be maintained in an electronic format as denoted in Table 8. All physical and chemical data used in analyses will be maintained in the OWRB Water Quality Database. Field data will be manually entered while most laboratory data will be transferred from the laboratory and uploaded automatically. Lab data will be checked for completeness and any data not uploaded automatically will be manually entered. All biological and habitat data will be manually entered into the OWRB Biological database.

**Table 8.** Documentation and Format of Data Collected

| DATA TYPE | PRIMARY REPORTING FORMAT | COMPUTER FORMAT | FINAL REPORTING FORMAT | FINAL DATA ARCHIVE |
|---|---|---|---|---|
| Water Quality Field Physical and Chemical Data | Water Quality Field Notes | OWRB Water Quality Database | Tables, graphs, etc. | STORET, OWRB Water Quality Database & Project Notebook |
| Instrument Calibration and Field QA Data | Instrument Book and Laboratory Sheets | OWRB Water Quality Database | QA Summary Report | OWRB Water Quality Database & Project Notebook |
| Water quality lab analysis | Lab Report Sheets and Electronic Transfers | OWRB Water Quality Database | Tables, graphs, etc. | STORET, OWRB Water Quality Database & Project Notebook |

| Data Type | Primary Reporting Format | Computer Format | Final Reporting Format | Final Data Archive |
|---|---|---|---|---|
| Water quality lab analysis - blanks, duplicates | Lab Report Sheets and Electronic Transfers | OWRB Water Quality Database | QA Summary Report | STORET, OWRB Water Quality Database & Project Notebook |
| Water quality lab analysis – fish flesh toxics | Lab Report Sheets and Electronic Transfers | OWRB Water Quality Database | Tables—will not be assessed in final report but will be forwarded to the ODEQ | STORET, OWRB Water Quality Database & Project Notebook |
| Habitat assessment | Standardized Field Sheets | OWRB Biological Database | Habitat metrics | OWRB Biological Database and Project Notebook |
| Fish collections | Standardized Fish Collection Sheets, Lab Data Sheets and Electronic Transfers | OWRB Biological Database | Tolerance & diversity indices; final report and list of species collected | OWRB Biological Database and Project Notebook; OK Museum of Natural History & EPA BIOS when appropriate |
| Benthic macro-invertebrate collections | Standardized Macroinvertebrate Collection Sheets and Lab Data Sheets and Electronic Transfers | OWRB Biological Database | Tolerance & diversity indices; list of species collected | OWRB Biological Database and Project Notebook; OK Museum of Natural History & EPA BIOS when appropriate |

Field observations, discharge, stage, total alkalinity, total hardness, nephelometric turbidity, multi-parameter data, and meteorological data will be recorded in the Water Quality Field Notes for each station. These forms are verified by the data manager for completeness and forwarded to data processing for entry into the Water Quality Database. After entry into the database, forms are transferred to a project notebook kept in the Division library.

Discharge measurement notes are completed for each measurement taken. These notes are transferred to an electronic format and saved to the OWRB network and compact disc. Hardcopies of the discharge measurement notes are maintained in the project notebook kept in the Division library. Discharge measurements collected via discharge computers are downloaded to the OWRB network and copied to compact disc. Hardcopies of these electronic notes are maintained in the project notebook kept in the Division library.

Biological and Habitat Notes are completed for each field collection. These notes are transferred to an electronic form in either Microsoft Excel® or the Water Quality Biological Database housed in Microsoft Access® format.

Upon completion of entry the resulting database will be double-checked for completeness and to confirm that parameter values are matched with the correct stations, depths, etc. Any result measured as the result of a sample taken according to the methods described in previous sections and meeting the acceptance criteria of this document will be assumed to be valid data until proven otherwise. For this reason, extreme values will not be treated as an "outlier" and excluded from data analysis.

To insure against loss of data, original laboratory data sheets and chains of custody will be filed in chronological order by month and kept in the project notebook upon receipt. Streams data will be stored electronically in the Water Quality Database, the Water Quality Biological Database, and in the OWRB network. All electronic transfers from analytical laboratories will be maintained on the OWRB network. In addition all electronic transfers and data stored in a non database format will be backed up to compact disc.

Primary storage of data will be on the OWRB computer network. A directory of these databases will be maintained for ease of retrieving data for specific projects. The primary data storage files will be backed-up on a weekly basis using *File Safe* software and are stored offsite. Personal computers used for data manipulation, reporting, etc. will be backed-up at this time also. Backups will be done prior to any repairs, moves, and/or procedures that may threaten data integrity. In addition, electronic transfers and data not stored in a database format will be backed up on compact disc. Maintenance of data and data networks will be the responsibility of the OWRB or its contractors as noted by the service contract.

Access to primary data storage is limited to personnel designated by Derek Smithee, Water Quality Programs Division Chief or the designated Project Manager. Anti-virus software is installed on all OWRB computers and anti-virus checks are routinely performed. A user-identification name or number and password are required before an individual can gain access to the agency network, which limits routine access to information by unauthorized personnel.

OWRB staff use various programs for routine data manipulation/graphical representation. Microsoft Excel® is commonly used for graphical representations and may be used for simple analysis such as descriptive statistics. Statistica, Minitab v.13, or WQStat Plus is used to perform statistical analyses.

***Data Reduction and Assessment***

Decisions about the relative health of each individual site will be based on the existing State of Oklahoma Use Support Assessment Protocols for biological assemblages. The protocols, adopted in Oklahoma Administrative Code (OAC) 785:46-15, (http://www.owrb.state.ok.us/util/rules/pdf_rul/Chap46.pdf) include fish index of biological integrity (IBI) scores for ecoregions throughout the state. In addition, state agencies frequently use a multi-metric index for evaluating macroinvertebrate health. Efforts are underway to refine these assessment methods, and the refinements will be incorporated into decision-making and reporting for this study.

Data for selected indicators will be summarized on a statewide basis, and at the scale of selected planning basins or combinations of basins, using cumulative distribution functions with confidence bounds, as described by Diaz-Ramos et al. (1996), with assistance from the EPA ORD Monitoring Design and Analysis Team. The indicators will include the fish and macroinvertebrate assemblage index values, described above, and other selected indicators of interest, such as the observed distribution of phosphorous concentrations and percent sand/silt in bed sediment. Data summaries for individual physical habitat attributes and water column chemistry variables will be limited to specific geographic areas to classify sites and account for naturally-occurring differences.

The relative risk for biological integrity associated with water column and physical habitat stressors will be determined by examining the strength of associations between indications of impairment of biological integrity and individual stressors, as described by Van Sickle (2004).

The approach requires setting thresholds for poor conditions associated with individual stressors, some of which exist in the form of numeric water quality standards criteria, and the indicators of biological integrity. Then, a two-way contingency table will be used to quantify the strength of the association. Individual stressors will then be ranked by the relative risk posed to biological integrity.

Predictive model(s) will be developed to evaluate the feasibility of using land use and land cover data within watersheds to target monitoring efforts toward waterbodies with a high probability of impaired biological integrity, generally following methods described in published literature (Diamond et al. 2002, Harding et al. 1998, Jordan and Vaas 2000, Richards et al, 1996, Sponseller et al. 2001, Teels and Danielson 2001, Wang et al 2001). First, data collected from individual sites will be split into two groups with one group to be used for development of models, and the other to be used for testing and model validation. Second, Pearson-product moment correlations and linear regression analyses will be applied to explore relationships between individual land use and land cover metrics, calculated at watershed and several riparian corridor scales, and indicators of biological integrity, in an attempt to identify the most meaningful predictor metrics. Data transformations will be applied to the variables, as necessary to produce approximate linear relationships (Helsel and Hirsch 1992). Third, the variables will be tested in multiple linear regression models for the ability to predict depauperate biological assemblages.

***Procedures for Assessing Precision, Accuracy, and Completeness of Data***

The Quality Assurance (QA) Officer will review the data for completeness and identify any problems or gross errors (i.e. violation of holding times). The Project Manager and the contract Laboratory Director will resolve problems with incomplete data and obvious reporting errors. Data where holding times have been violated will be flagged and discarded as appropriate. The QA officer in concert with the Project Manager will take action to resolve any problems leading to violation of holding times. Upon verification of data completeness, the Database Manager, or other designated staff, will enter the data into the appropriate electronic format. Flagged data will also be entered with an appropriate data quality code.

Quality assurance related blank, duplicate, and replicate sample data would be analyzed at this time. A hard copy of the quality assurance data will be given to the QA officer for review. The QA officer will flag data sets with unacceptable values. Data will be flagged as unacceptable according to criteria outlined in this QAPP and the OWRB Quality Management Plan. The Water Quality Division Database Manager or his designee will enter QA flags in the appropriate electronic storage venue.

The following procedures are intended to support the measurement and data quality objectives described above:

**Precision** in water sample collections will be assessed from duplicate analyses by relative percent difference (RPD) as follows:

$$RPD = \frac{(C_1 - C_2) \times 100}{C_1 - C_2}$$

Where $C_1$ = the larger of the two values and $C_2$ = the smaller of the two values. Precision in the statistical parameters to be estimated will be assessed by comparison of the width of confidence intervals with the stated data quality objective.

**Accuracy** in individual water samples will be determined from the difference between observed values and known standard reference media.

Data that fall within the limits of precision and accuracy stated in this document will be considered "complete". **Completeness** or percent of complete measurements (%C) will be assessed as follows:

$$\%C = \frac{v}{T} \times 100$$

Where $v$ = the number of measurements judged valid and entered into the data management system, and $T$ = the total number of planned measurements. Completeness will be assessed independently for each indicator or data type.

## Schedule, Milestones, Products and Final Reports

| | |
|---|---|
| Approved Workplan and Proposal | December 2004 |
| Planning for FY-2005 Sampling Period | September 2004-April 2005* |
| FY-2005 Sampling and Analysis | May 2005-September 2005* |
| Planning for FY-2006 Sampling Period | October 2005-April 2006 |
| FY-2006 Sampling and Analysis | May 2006-September 2006 |
| Planning for FY-2007 Sampling Period | October 2006-April 2007 |
| FY-2007 Sampling and Analysis | May 2007-September 2007 |
| Final Report | Spring 2008 |

** Schedule reflects ongoing work conducted under the regional 104(b)(3) grant.*

The final report will not be limited to sites funded under the REMAP grant but will include data from study years one through three. The report will include a description of the study, statewide estimates of conditions, estimates for selected planning basins (or combinations thereof), information about the relative risks associated with various stressors, and an examination of the feasibility of predicting biological integrity from land use and land cover data. The information will also be used in the State's Integrated Water Quality Assessment Report.

## Budget

| Proposed Budget for FY05-06 ORD REMAP Grant 74 sites | | | | |
|---|---|---|---|---|
| **Personnel** | | **Person Yrs.** | | **Expenditure** |
| 1 | Water Quality Division Chief | 0.02 | | $1,456 |
| 1 | Environmental Programs Manager III | 0.04 | | $2,344 |
| 1 | Environmental Programs Specialist IV | 0.10 | | $4,820 |
| 1 | Environmental Program Specialist III | 0.80 | | $33,680 |
| 1 | Environmental Program Specialist II | 1.00 | | $35,500 |
| 2 | Seasonal Employee(s) | 0.28 | | $11,648 |
| | Total Person Years = | 2.18 | Total Salary = | **$89,448** |
| **Benefits** | | | | |
| | 74.83% of Salaries for Indirect Costs | | | $66,934 |
| | 44.86% of salaries for Fringe Benefits | | | $34,901 |
| **Travel & Per Diem** | | | | |
| | Travel & Per Diem (Per State Travel Act) | | | $10,320 |
| **Sample Collection (Contractual)** | | | | |
| | OCC Contract for 1/2 of sites plus supplies | | | $40,000 |
| **Laboratory Analysis (Contractual)** | | | | |
| | Fish Identification | | | $12,450 |
| | Macroinvertebrate Identification | | | $23,400 |
| | Water Quality | | | $39,600 |
| **Supplies** | | | | |
| | Supplies | | | $2,779 |
| | Report Costs, Data Management & Printing Costs | | | $168 |
| | | | **TOTAL PROJECT COST =** | **$320,000** |

## State and Regional Matching Support

The efforts outlined in this workplan will be conducted using monies outlined above in the proposed budget as well as federal monies associated with an existing 104(b)(3) project and state monies. Yearly funding by source is provided in Table 9. The regional 104(b)(3) funding will be expended to support study year one. REMAP funding will support site visits during study years two and three and will be used in the analysis and reporting of data. Additional state funds will be expended during all three years of the study to for project management, data collection, and data reporting. EPA Region VI will also provide support for delineation of watersheds, calculation of landscape metrics, and limited assistance with data analyses. The EPA NHEER Laboratory in Corvallis, Oregon will provide assistance at several stages in the project. Scientists with the laboratory have already provided assistance with sample design and site selection. At the end of the study, scientists with the laboratory will also provide much needed assistance in the analyses and reporting of the data. This leveraging of all available state and federal monies will allow Oklahoma to do a much more comprehensive and robust probabilistic sampling regime than would otherwise be possible.

**Table 9.** Breakdown of yearly funding and activity funded.

| STUDY YEAR | FEDERAL 104(B)3 | REMAP | STATE |
|---|---|---|---|
| SY-2005 (1) | $130,118— recon and sampling of 30 sites; supplies and equipment | No Funding | $55,882—the state 5% match to the 104(b)3 ($6,849); recon and sampling of 12 sites; final reports |
| SY-2006 (2) | No Funding | $180,000—recon and sampling of all 42 sites; project and data management activities; supplies and equipment | $10,000—project and data management |
| SY-2007 (3) | No Funding | $140,000—recon and sampling of 32 sites; project and data management; portion of final report | $54,000—recon and sampling of 10 sites (Upper Arkansas Planning Basin); project and data management; portion of final report |
| 3 year Total ($570,000) | $130,118 | $320,000 | $119,882 |

## Personnel Qualifications, Project Management, Time Commitments, and Personnel Responsibilities

The Oklahoma Water Resources Board (OWRB) is the lead agency and will have final authority and responsibility for all project decisions and products and will have responsibility for all reconnaissance, analyzing, and reporting of data results as well as general project oversight. The OWRB will also be responsible for field collections at approximately 50% of the sites. The Oklahoma Conservation Commission (OCC) will be a partner in all activities of the project and be included in all decisions including reconnaissance, collection, analysis, and reporting protocols. The OCC will also review all QAPPs and reports before forwarding of the products to Oklahoma's Office of the Secretary of the Environment (OSE). The OCC will act as a contractor for field collections at approximately 50% of the sites. The Oklahoma Department of Environmental Quality (ODEQ) laboratories will perform laboratory analyses for water quality samples. The University of Oklahoma Museum of Natural History will be a contractor to identify fish. EcoAnalysts, of Moscow, Idaho, will be contracted to identify macroinvertebrates.

The Project Manager, Bill Cauthron, is responsible for data collection, data analysis, reporting of study results, and implementing quality assurance/quality control measures. The Project Manager is also responsible for reporting results of the OWRB quality assurance/quality control program. Monty Porter is responsible for data collection efforts and implementation of quality assurance/quality control measures for the streams sampling components of the project. Analysis and reporting of data collected is the joint responsibility of Mr. Porter and Mr. Cauthron. The Quality Assurance Manager for the OWRB, Jeff Everett, will be responsible for maintaining and distributing the approved QAPP and for reviewing the project as required to ensure proper quality assurance procedures are being implemented and followed. Derek Smithee is responsible for implementing and overseeing corrective action measures when data quality objectives are not being met and he is also responsible for general program oversight.

Principle investigators are defined as team leaders. This designation may be made upon the leader of a multi- or a one-person team. Principle investigators for these projects are required to have degrees and/or experience with biological or other applicable sciences. In addition, training is required for all SOPs dealing with water quality and quantity collections and measurements as well as habitat assessments and biological collections. In-house training will be conducted for the use of all meters and digital titrators used for water quality or quantity measurements. Investigators must be familiar with OWRB SOP document and all training will follow the methods outlined in that document. Extra training will be provided when new SOPs are developed. Training of field crews will be done through dry run exercises in the laboratory to familiarize field crews with sample collection, sample preservation, instrument operation, calibration, and maintenance. In addition, when new personnel are hired or new methods developed, qualified staff will train on sample collection, measurement, and field analysis methods through side-by-side field trips. These trips will familiarize staff with SOP requirements. When training is considered adequate, a field audit conducted by a qualified staff member will check field staff for adherence to SOPs. Currently, principle investigators for the OWRB include Mr. Porter and Jason Childress and will include Lance Phillips and Mr. Everett by the 2006 sample year. Current principle investigators for the OCC are Brooks Tramell, Wes Shockley, and Jason Ramming.

Personnel of the OWRB-Water Quality Programs Division-Monitoring/Assessment Section (OWRB-WQPD-MAS) will perform various tasks necessary to complete the project. The OWRB personnel involved and their qualifications and responsibilities are listed below.

Derek Smithee, Division Chief, OWRB-WQPD

Mr. Smithee is responsible for all operations of OWRB Water Quality Programs Division (WQPD). He is the final decision maker for all programs in the division. Mr. Smithee has a Bachelor of Science (BS) from Oklahoma State University (OSU) and a Master of Science (MS) from the University of Oklahoma (OU). He has over 20 years experience in the field of water quality management including experience with the OWRB and Oklahoma State Department of Health (OSDH).

Bill Cauthron, Section Head, OWRB-WQPD-MAS

Mr. Cauthron is the Project Manager. He is responsible for coordinating and expediting all projects and activities under the Monitoring and Assessment section including data collection, data analysis, reporting of study results, and implementing quality assurance/quality control measures. He is also responsible for implementation of all contracts under the section. Mr. Cauthron has a BS from East Central University (ECU) and a MS from OU. He has nearly 20 years experience in the field of water quality management.

Monty Porter, Streams and Rivers Monitoring Coordinator, OWRB-WQPD-MAS

Mr. Porter is the Assistant Project Manager. He is responsible for implementing all aspects of the project including communication with partners, establishment of data quality objectives, reconnaissance, data collection, data analysis, reporting of study results, and implementing quality assurance/quality control measures. He is also responsible for maintaining standard operating procedures for all field activities and the supervision, coordination, and training of the field investigative personnel. Mr. Porter also maintains a rigorous field schedule. He will be heavily involved in the field collection activities of this project as a team leader. Mr. Porter has a BS from the University of Central Oklahoma (UCO) and, in Summer 2005, will complete a MS in Biology from UCO. He has 8 years experience in the field of water quality management and over 5 years of previous research experience with OU and UCO.

Jeff Everett, Quality Assurance/Quality Control Officer and Field Collection Manager, OWRB-WQPD-MAS

Mr. Everett is the second in authority to the Division Chief on all matters concerning Quality Assurance/Quality Control including establishing of QA/QC and training procedures and implementation of remedial or corrective actions. He will be responsible for maintaining and distributing the approved QAPP and for reviewing the project as required to ensure proper quality assurance procedures are being implemented and followed. Mr. Everett manages and coordinates most field collection activities including collection of field data and samples and submission of samples to the laboratory. He also maintains a rigorous sampling schedule. He will be marginally involved as a team member in the field sampling activities of this project. Mr. Everett has a BS from Southwest Oklahoma State University (SWOSU). He has nearly 5 years experience in the field of water quality management and 5 years of previous water chemistry work with the Oklahoma Department of Agriculture Food and Forestry (ODAFF) and private laboratories.

Jason Childress, Water Quality Programs Specialist, OWRB-WQPD-MAS

Mr. Childress is a Team Leader for general monitoring activities and biological sampling. He is responsible for field supervision of monitoring activities, collection of field data and samples, reconnaissance and landowner permissions, submission of samples to the laboratory, equipment maintenance, and various related duties. He will be leading one of the teams responsible for field collections for this project. Mr. Childress has a BS from ECU and a MS in Fisheries from the University of Florida. He has worked for the OWRB since May 2004. He has over 5 years of experience in various research related activities.

Lance Phillips, Water Quality Programs Specialist, OWRB-WQPD-MAS

Mr. Phillips is a Team Leader for general monitoring activities and maintains a rigorous sampling schedule. He is responsible for field monitoring activities, collection of field data and samples, reconnaissance and landowner permissions, submission of samples to the laboratory, equipment maintenance, and various related duties. He will be involved as a team member in the field sampling activities of this project. He may be a team leader by 2006. Mr. Phillips has a BS from Northeastern State University. He has worked for the OWRB since January of 2004.

Vacant, Water Quality Programs Specialist, OWRB-WQPD-MAS

A full time equivalent position will be hired within the calendar year and will become a Team Leader for general monitoring activities. This person will maintain a rigorous sampling schedule. He/she will be responsible for field monitoring activities, collection of field data and samples, reconnaissance and landowner permissions, submission of samples to the laboratory, equipment maintenance, and various related duties. He/she will be involved as a team member in the field sampling activities of this project.

Vacant, Water Quality Programs Specialist, OWRB-WQPD-MAS

A full time equivalent position will be hired within the calendar year and may become a Team Leader for general monitoring activities. This person will maintain a rigorous sampling schedule. He/she will be responsible for field monitoring activities, collection of field data and samples, reconnaissance and landowner permissions, submission of samples to the laboratory, equipment maintenance, and various related duties. He/she will be involved as a team member in the field sampling activities of this project.

Personnel of the Oklahoma Conservation Commission (OCC), Water Quality Division will perform field and output review tasks necessary to complete this project. The OCC personnel involved and their responsibilities are listed below.

Lawrence R. Edmison, Program Director, OCC Water Quality Division

Responsible for all OCC Water Quality Division programs, the Program Director is the final decision making authority within the Water Quality Division.

Dan Butler, Assistant Director, OCC Water Quality Division

Second in command at OCC-WQD. Responsible for all field-sampling activities and has an integral part of all monitoring projects participates in establishing Data Quality Objectives. Responsible for administrative duties related to the Water Quality Division. He will be the OCC project manager for this project.

Jim Leach, Cost Share & Finance Director, OCC Water Quality Division

Responsible for coordinating and expediting management of OCC watershed projects, both within the OCC and with contracted agencies.

Brooks Tramell, Monitoring Coordinator/Water Quality Specialist, OCC Water Quality Division

Crew Leader- Responsible for field supervision of monitoring activities, collection of field data and samples, landuse and landowner surveys, submission of samples to the laboratory, equipment maintenance, and various related duties. He will be the OCC assistant project manager for this project and will be responsible for implementing sampling at OCC assigned sites.

Wes Shockley, Water Quality Specialist, OCC Water Quality Division

Crew Leader - Responsible for collection of field data and samples, landuse and landowner surveys, submission of samples to the laboratory, equipment maintenance, and various related duties. Also responsible for identification, enumeration, and cataloging of fish collections maintained by the OCC.

Leonard Moore, Water Quality Specialist, OCC Water Quality Division

Responsible for collection of field data and samples, landuse and landowner surveys, submission of samples to the laboratory, equipment maintenance, and various related duties.

Jason Ramming, Water Quality Specialist, OCC Water Quality Division

Crew Leader - Responsible for collection of field data and samples, landuse and landowner surveys, submission of samples to the laboratory, equipment maintenance, and various related duties.

Vacant, Water Quality Specialist, OCC Water Quality Division

Responsible for collection of field data and samples, landuse and landowner surveys, submission of samples to the laboratory, equipment maintenance, and various related duties.

Jerry Carr, Water Quality Specialist, OCC Water Quality Division

Responsible for collection of field data and samples, landuse and landowner surveys, submission of samples to the laboratory, equipment maintenance, and various related duties.

Judith Wilkins, Executive Secretary, OCC Water Quality Division
Division secretary, file manager, and data entry.

Margaret Blevins, Data Manager, OCC Water Quality Division
Initiates and handles correspondence relating to data management including: data handling, policies, and procedures. Produces documents of various levels of complexity including data summaries. Enters and retrieves water quality data using personal computer, and receives and reviews source documents; proofs previously entered data and makes routine corrections

Gayle Bartholomew, Environmental Projects Coordinator, OCC Water Quality Division
Responsible for the administration and management of WQ projects. Monitors, reviews and coordinates: grant outputs, agreements, and WQ cost-share implementation and demonstration projects. Coordinates and authorizes the purchasing of all water quality monitoring equipment and supplies under the supervision of the WQ Asst. Director and Commission Comptroller. Coordinates with WQ staff on the creation and administration of contracts and agreements with other Agencies, Universities, and non-governmental organizations.

Shanon Phillips, Senior Technical Writer/Quality Assurance Officer, OCC Water Quality Division
Lead technical writer, data analyst, and field investigator. Responsible for the drafting and review of the technical reports and other information from the Division. Also responsible for all Quality Assurance efforts implemented by the OCC.

Greg Kloxin, Environmental Manager, OCC Water Quality Division
Technical writer, data analyst, assistant QA officer, and field investigator. Under the direct supervision of lead technical writer.

Vacant, Technical Writer, OCC Water Quality Division
Technical writer, data analyst, assistant QA officer, and field investigator. Under the direct supervision of lead technical writer.

The ODEQ currently operates the Oklahoma Laboratory Certification Program for laboratories performing analyses on samples collected in the State of Oklahoma. This program is designed to insure that chemical water analysis and biological data are reliable and accurate for scientific and legal purposes. To be certified, a laboratory is required to employ qualified personnel, possess adequate equipment and facilities, maintain adequate quality control, pass on-site inspection, and analyze accurately an appropriate set of reference samples provided by EPA. Reference samples are sent and certification must be renewed on an annual basis. Any laboratory that submits chemical or biological data to the ODEQ to fulfill waste disposal permit or research requirements, must be certified for the appropriate variables. The ODEQ laboratory is certified for all variables at the present time.

EcoAnalysts, an independent environmental consulting firm located in Moscow, Idaho, will provide taxonomic analysis for benthic macroinvertebrates. Their area of expertise is the identification of freshwater aquatic organisms; macroinvertebrates, periphyton, plankton, and fish. In operation since 1995, they have become the largest private freshwater macroinvertebrate taxonomic laboratory in the Western United States. To date they have successfully completed more than 150 projects and have processed more than 11,000 macroinvertebrate, periphyton, plankton and fish samples. They have completed projects from Washington, Oregon, Idaho, California, Montana, Wyoming, New York, Maryland, New Hampshire, Arizona, New Mexico, Texas, North Dakota, Colorado, and Wisconsin. Clients include federal, state, county, city, and tribal agencies, as well as a wide variety of private entities.

The Sam Noble Oklahoma Museum of Natural History will provide taxonomic analysis for fish. Located at the University of Oklahoma in Norman, the museum has 12 collection divisions with more than 6,000,000 specimens and objects catalogued and in lots. Research collections form the foundations for education programs and exhibits of the museum as well as for both basic and applied research. Curators, students and others associated with the museum are active researchers, many recognized nationally and internationally for their work. The Division of Ichthyology houses the largest and most comprehensive collection of archived specimens of fishes for Oklahoma. The collection includes over 30,000 catalogued lots representing 34 families, primarily of North American freshwater fishes. Groups best represented are North American minnows (Cyprinidae), catfishes (Ictaluridae), darters (Percidae), sunfishes (Centrarchidae), and suckers (Catostomidae). The particular strength of the collection is in its holdings of extensive samples of fishes throughout the lower Great Plains, with emphasis on Oklahoma streams and reservoirs.

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| Lab. Supplies, Materials & Services - 3721 | | Sub-Total |
|---|---|---|
| 4 | Case(s) (6 jugs/case) 4-Liter Jugs of Ethanol | $208 |
| 5 | 20-Liter Jug of Formaldehyde | $325 |
| 1 | Cases (6 bottles/case) of pH Buffer | $91 |
| 1 | Chlorophyll-a Grinders, Filters & Hand Pumps | $675 |
| 5 | Reagents for Hardness Test Kits | $168 |
| 5 | Reagents for Alkalinity Test Kits | $177 |
| 1 | Case(s) (4 jugs/case) 4-Liter Jugs of Acetone | $80 |
| 1 | HACH Chemicals for Spectrophotometer | $135 |
| 1 | Nets, Seines, etc. for Biological Collections | $450 |
| 125 | Kevlar Tagline | $75 |
| 1 | Tagline Reels | $95 |
| 2 | Small Handheld GPS Unit(s) for Monitoring | $300 |
| | **TOTAL =** | **$2,779** |