Technical Assistance to Improve the Quality of Ground Water-Surface Water Interactions
CWA section 319 (h) FY 1993
Nonpoint Source Pollution Program Task#400
Oklahoma Conservation Commission Task #48

April 19, 2001

ACKNOWLEDGMENTS

The Water Quality Division of the Oklahoma Conservation Commission prepared this report in association with the help from various cooperators. Cooperators included the West Caddo Conservation District, OSU Cooperative Extension Service, Environmental Protection Agency (Houston) Lab, Natural Resources Conservation Service, Oklahoma Department of Environmental Quality Laboratory, Oklahoma State Department of Agriculture Forestry Services, and Oklahoma State Department of Agriculture Plant Industries. The Water Quality Staff participated as follows:

Scott Stoodley- Current Water Quality Programs Director;

John Hassel- Former Water Quality Program Director;

Jim Leach- Project management and data management;

Phil Moershel- Quality Assurance and report review;

Shanon Haraughty- Technical Support and report review;

Kendra Eddleman- Project management and data management;

Dan Butler- Coordinates all monitoring activities and oversees monitoring personnel activities;

Brooks Trammel- Biological data collection, habitat assessment, water sample collection, and fish enumeration;

Wes Shockley- Biological data collection, habitat assessment, water sample collection, fish identification and enumeration;

Derek Johnson- Biological data collection, GIS cartography, physical/chemical data collection and drafting the final report;

Chris Hise- Biological collection, habitat assessment, water sample collection, and data analysis.

List of Tables, Figures, and Maps

1.0 INTRODUCTION:

In several areas of western Oklahoma groundwater resources are very shallow and are responsible for maintaining significant base flow levels in streams even during the very dry summer months. In most cases this is through discharge at or below stream surface level; however, in many areas discernable seeps several feet above stream level can be identified.

Because of the topography, climate, tillable soils, and the availability of shallow ground water supplies (<40 inches below the soil surface), these areas are also intensively farmed with correspondingly high levels of fertilizer and pesticide applications. The table below displays the landuses within the Lake Creek Watershed.

A demonstration project conducted through the Oklahoma Conservation Commission and Cooperative Extension Service has shown that in some fields fertilizer use is excessive and has contaminated shallow ground water. Ambient monitoring by the United States Geological Survey has identified areas with very high (> 50 mg/L) levels of nitrate in groundwater.

Taken together, this information suggests that there is a significant interaction between ground and surface water with groundwater discharges resulting in loading of Nonpoint Source (NPS) pollutants, some of which are toxic. The study conducted by the Cooperative Extension Service indicates that soil
testing is relatively uncommon in terms of the decision-making process for fertilizer application. In a test plot they found that soil nitrogen was adequate to support several years of cotton farming without further supplements. This indicates that there is an information gap between landowners and those who could provide information concerning proper application rates of fertilizer and pesticides.

1.1 Project Overview:

The overall water quality objective of these activities is the improvement of the quality of ground and surface water through educational efforts, behavioral changes of landowners and land users, and of the implementation of Best Management Practices. The project also looked at characterizing the interactions between surface and ground water in areas of intensive agriculture. This involved both qualitative and quantitative components. This program will also serve as a basis for other similar projects located across the state and information gained during its operation will be transferred to other areas through State nonpoint source agencies, the Cooperative Extension Service, and the Natural Resource Conservation Service.

1.2 Background:

Because of the topography, climate, tillable soils, and the availability of shallow groundwater supplies (<40 inches below the soil surface), these areas are intensively farmed with correspondingly high levels of fertilizer and pesticide application. Upland soils are composed of the Pond Creek-Cobb Association, the Grant Pond Creek Lucian Association, and the Dougtherty Eufaula Association. These are mostly deep to moderately deep, loamy to sandy soils which range in slope from level to steep. Soils in the watershed are subject to severe water erosion on steeply sloped areas. In areas with slopes of 3-12% grade, management is required which reduces the choice of plants possible to grow and requires the installation of practices to reduce soil erosion. These steeply sloped or rolling areas with these soil associations are typically listed as a class III or higher by the soil survey indicating they have severe to very severe limitations caused by erosion potential. Floodplain soils of the study area are mostly composed of Post-Gracemont-Pulaski Association. These are deep level to nearly level floodplain soils that are sandy and loamy. Port and Pulaski are well drained and moderately to rapidly permeable while Gracemont soils are characterized by a moderately rapid permeability, poor drainage, and a water table <40 inches below the soil surface. Typically the bottomland vegetation was composed of hardwoods with many marshes and wetlands. Upland areas were originally vegetated by a mosaic of tall grass prairie and cross-timbers. The majority of the current land usage consists of agriculture. Wheat, peanuts, alfalfa, and other row crops are produced in the watershed. These crops are produced on both irrigated and non-irrigated lands.

A demonstration project currently being conducted through the Oklahoma Conservation Commission and Cooperative Extension Service has shown that in some fields fertilizer use is excessive and has contaminated shallow ground water. Ambient monitoring by the United States Geological Survey has identified areas with very high (> 50 mg/L) levels of nitrate in ground water. A study by the Oklahoma Conservation commission identified several streams in these areas where toxicity was measured during base flow conditions. This indicates discharge of toxic substances from ground water, although the nature of these compounds has not been determined.

1.2.1. Previous Lake Creek Project

A study by the Oklahoma Conservation Commission (FY 1988 205(j) Task 500) identified several streams in these areas where toxicity was measured during base flow conditions. This indicates discharge of toxic substances from groundwater, although the nature of these compounds was not determined. The project focused on three key objectives; 1) to determine the levels of pesticides, 2) determine the degree of toxicity, and 3) document the degree of impairment of the biological community in Lake Creek and surrounding streams due to the chemical quality of the water. These objectives were completed through biological collections (both macroinvertebrates and fish), habitat analysis, bioassays, and water quality characterization of surface waters.

The 1988 study sampled 5 sites on Lake Creek, 1 site on Cobb Creek, 1 site on Fivemile Creek and 1 site on Willow Creek. The biological collection protocol for the 1988 collections varied from the 1998 protocol. In 1988, fish collection consisted of a 30-minute seining while in 1998 collection time was equal to the amount of time to collect 400 meters or 30 times the stream width (whichever is greater). In this case 400 meters were collected and assessed. Use of a backpack shocker was also incorporated into the 1998 study. The 1998 protocol not only increased the collecting time but also assured that a wide range of habitats were collected. This is not guaranteed with seining for only a short period of time. Due to the inconsistencies in collection protocol, the biological collections from 1988 and 1998 were not compared. The 1988 bioassessments, generally followed the Rapid Bioassesment Protocols as contained in EPA Publication 444/4-89-01. Invertebrates were collected from three one-meter sections of habitat at each site by vigorously agitating root habitat into a standard dip net. The three collections were then composited into a single sample, which was then processed as described in the rapid bioasssesment protocols. Again habitat variables were measured in accordance with RBP published in the EPA publication 444/4-89-01.

Bioassays samples were taken from Lake Creek and a seven-day Ceriodaphnia dubia and reproduction/seven day Fathead Minnow Embryo-Larval Tests were run (EPA/600/4-85/013 and EPA/600/4-85/014, respectively). All of the Lake Creek sites showed some varying degree of lethality, reproductive inhibition, and/or growth inhibition with the exception of site 3. Results from these bioassays showed significant C. dubia reproduction and growth inhibition, and Fathead Minnows with growth effects during May through June with a couple of sites (Lake Creek sites 2 and 4) in late April. Site 3 was only tested from late August to mid October and no toxicity effects were found. Sites 2 and 4 were found to have lethal effects on Fathead minnows and reproductive effect on Ceriodaphnia. Site 2 had Fathead minnow lethality 4 times with Ceriodaphnia reproduction twice. Fathead minnow lethality occurred at site 4 on three occasions and Ceriodaphnia growth was inhibited in water collected during June.

OCC staff collected water chemistry. In-situ parameters included pH, dissolved oxygen, conductivity, alkalinity, turbidity, discharge, and temperature. Laboratory analysis included chloride, sulfate, nitrate, nitrite, ammonia, Kjeldahl-N (TKN), ortho phosphorus, and total phosphorus. Selected pesticides were chosen for analysis based on use within the watershed. This information was acquired through meetings with the local Conservation Districts, USDA Personnel and the Oklahoma Cooperative Extension Service personnel. A total of 27 pesticides were analyzed during this project.

1.2.2. Results of 1988 Study

The water quality at the Lake Creek sites showed no major problems. Levels of phosphorus and nitrogen were acceptable for that region of the state. However, some high values were recorded for phosphorus (0.49 mg/l). High temperature readings were noted at the sites but are typical of a stream with little to no riparian zones. Pesticides were found in the water column of Lake Creek during this project. Two pesticides were found in significant quantities; atrazine, and alachlor.

A total of 49 bioassays were performed with the water from six sites. Eighteen of the samples produced a statistically significant effect on at least one of the organism. Eleven samples demonstrated effects on fish only, three samples affected Ceriodaphnia only, and four samples affected both organisms.

2.0 MATERIAL AND METHODS

2.0 Introduction

Due to the amount of variable work completed during this project, the materials and methods section will be seperated into sections. The materials and methods are described in this section of the report. The chapter is broken down into two categories; 1) field materials and methodology and 2) laboratory materials and methods

2.1 Field Materials and Methods

The procedures used in the collection of surface water, seep, and biological samples followed methods outlined in the Standard Operating Procedures (SOP's) developed and maintained by the Oklahoma Conservation Commission, Water Quality Division (OCC, 1996). Prior to each sampling event an entry was made in a field notebook. At each site, all activities were recorded as well as any general or specific comments and/or field observations. Field sheets were filled out for each sampling event, and each sampling episode. The Sampling Episode Sheet contains all the information for each site sampled during a single day. Quality Assurance/Quality Control information, sites visited, and general comments are recorded on this sheet. The Sample Collection Sheets contain the information on each individual site evaluated and/or sampled. Observations and measurements are recorded on this sheet and include stream information, site activities, site conditions, physical/chemical data, periphyton data, observed landuse, and stream site observations.

2.1.1a. Base Flow Surface Water Collection

Water quality samples for basic nutrients and inorganic parameters were collected in 1-quart high-density polyethylene (HDPE) plastic bottles with polyethylene lids and foam liners. Care was taken when sampling to rinse each sampling container a minimum of three times and sample upstream from an area disturbed by the sampler. At surface water quality monitoring sites, 2-quart samples were taken for various laboratory analyses. Each bottle was then labeled with the location, time, date, and preservation method in indelible ink. The following table lists parameters, preservatives, and holding times for each type of sample.

Table 1: Parameters, preservatives, and holding times

Parameter	*Container*	*Preservative*	*Holding Time*
Dissolved Oxygen	*in-situ*	none	-
Specific Conductance	*in-situ*	none	-
pH	*in-situ*	none	-
Temperature	*in-situ*	none	-
Alkalinity	plastic	ice	24 hours

Turbidity	plastic	ice	24 hours
Total Kjeldahl Nitrogen	plastic	H_2SO_4 within 24 hours/ ice	7 days
Nitrate	plastic	H_2SO_4 within 24 hours/ ice	7 days
Total Phosphorus	plastic	H_2SO_4 within 24 hours/ ice	28 days
TSS	plastic	ice	4 days
Sulfate	plastic	ice	28 days
Chloride	plastic	ice	7 days
Hardness	plastic	ice	7 days
Metals	plastic	Ultrapure HNO_3	
Pesticides	acid washed glass teflon lids containers will be provided by the State environmental laboratory	Cool to 4 C	7 days
Benthic macro invertebrates	-	Ethyl Alcohol	-
Fish	-	10% Formalin Solution	-
Instantaneous stream flow	*in situ*	-	-
Seepage flow	*ins situ*	-	-

Sampling procedures can be found in Oklahoma Conservation Commission Standard Operating Procedures (*OCC SOP #10*). In-situ measurements were made for the parameters pH, dissolved oxygen, specific conductivity, water temperature, alkalinity, turbidity, and instantaneous discharge. Specific procedures for collection of these parameters are found in OCC SOP # 1,7, 9, 12, 13, and 37. Of the two samples collected, one sample was preserved with concentrated sulfuric acid and the other was placed immediately on ice (refer to table1 for specific parameters and preservation methods). Samples were delivered to the laboratory on the day of collection.

Metal samples were taken with a separate HDPE quart container; again all SOP protocols were followed for the collection of metals (*SOP #10, revision 1*). Metal samples were immediately placed on ice and delivered to the laboratory for acidification and analysis.

All samples were delivered with a chain of custody. Each custody form was completed prior to delivery. Location information, container quantities, parameters to be measured, and applicable comments were included with the custody forms.

Pesticide samples were collected using acid washed glass containers with Teflon lids provided by the state environmental laboratory. Particular care was taken not to contaminate the pesticide containers and sample. The immunoassay samples were collected in new, clean, glass organic sample vials. The containers were double rinsed with ambient water before collection. Sites were chosen before the sampling event that allowed for collection from midstream in flowing water.

All field analytical protocols are described in the OCC SOP document. Laboratory procedures can be obtained from the City-County Health Department of Oklahoma City (CCHDOC) Program Plan. Reporting of any field analytical procedures and the implementation of corrective action for failed analytical procedures was the responsibility of the Monitoring Coordinator (Dan Butler). Failure in laboratory analytical procedures was the responsibility of CCHDOC Laboratory Director (Tom Stricker).

2.1.1.b. Seep Water Sampling

Seeps were monitored for their physical/chemical properties as well as nutrients, metals, and pesticides. Physical/chemical monitoring included the parameters conductivity, alkalinity, pH, and discharge. Measurements were taken at the point were the seep exited from the ground above the elevation of the stream. The day before the monitoring was to be completed, a basin was dug with a clean spade. Generally this basin was large enough to hold approximately four liters of seep water. This allowed enough volume and depth for sample collection. The basins were dug to pool the water with a short retention time. Therefore, the seep was constantly flowing and the samples were not taken from a pool of water exposed for long periods of time. When samples were collected, pesticides were sampled before nutrients and metals to avoid any potential contamination from the other HDPE containers and/or sampling disturbance. Pesticides were collected with solvent rinsed analytically clean glass containers. Physical/chemical parameters were measured at the basin were the sample collection occurred. Discharge was measured using the weighted beaker and stopwatch method. This allowed an estimate of unit of volume per unit of time (reported as ml/min). Samples were taken with a two quart HDPE sample containers rinsed a minimum of three times with ambient water. Care was taken to not disturb sediments and/or re-suspend material that could result in sampler bias. A separate quart container was used to collect a sample for metal analysis. Each bottle was labeled accordingly. Preservative (Sulfuric Acid) was added to one quart, the other put directly on ice. The metal sample was put on ice and acidified at City County Health Department the same day. All pesticide vials were placed on ice in a separate pre-cleaned cooler. All samples were delivered to the City County Health Department the same day they were collected. Pesticide samples were analyzed within 24 hours at the Oklahoma Conservation Commission Water Quality Laboratory by Chris Hise (Water Quality Specialist II).

Pesticides were analyzed using SDI’s Enzyme Linked Immunosorbent Assays (ELISA's). These kits were used to quantify the concentration of pesticides in the Lake Creek water column and seep water. These tests work by combining selective antibodies with sensitive enzymes to produce analytical systems to detect very low concentrations of chemicals.

2.1.1.c. High Flow Surface Water Sampling

During elevated flow periods when water levels were much too high for wading, samples were taken from a bridge using a US-DH76 depth integrated sampler. This sampler is slightly modified for using as an attachment for a flow sensor. Procedures for high flow sampling can be found in OCC SOP (*OCC SOP #2, revision 2*). Depth and width integrated samples are composited into a splitter churn and dispensed into the appropriate pre-labeled containers. The samples were preserved as appropriate for regular base flow samples.

2.1.1d. Biological Monitoring

Biological monitoring is an integral part of a water quality program. Chemical sampling data may show what is happening at that specific point in time and over a long duration of sampling decisions may be made from this type of data. However, biological sampling looks at both long-term and short-term affects of water quality and habitat quality. This information coupled with chemical data is a powerful tool for water quality analysis.

Biological sampling followed EPA rapid bioassessment protocols (RBP) (*EPA, 1989*) as modified by OCC. Collection protocols can be found in OCC's SOP (*OCC SOP #29, 30, 31, 35, 36, and 39*).

Macroinvertebrate Collections

Macroinvertebrate collections were completed to assess the physical and chemical water quality of Lake Creek and reference sites. To represent an accurate picture of the communities within a stream section, three types of habitats are collected, if present (rocky riffles, streamside vegetation, and woody debris). These habitats generally offer stability and refuge for aquatic invertebrates to live, feed, and reproduce. When one or more habitat is not available throughout the reach of interest, the other is used. Invertebrate sampling is done at base flow conditions, when the community has had no major stream events that may naturally scour the habitat and/or lower their numbers. Lake Creek has a very low frequency of rocky riffles and what riffles that exist are usually hardpan clay and not considered a true rocky riffle. No riffle samples were collected at Lake Creek during the project. The majority of the reaches did have streamside vegetation and woody debris. These parameters were used in the final scoring process.

Eight community attributes are used to score the condition of the benthic invertebrate community. These attributes are discussed individually below. Points received for each metric are summed to score a stream, and the total score is then compared to the total score of the reference condition in order to classify the stream.

<u>Number of Taxa</u> refers to the total number of taxonomically different types of animals in the sample. As is the case with the fish, this number rises with increasing water or habitat quality.

<u>The Modified Hilsenhoff Biotic Index</u> is a measure of the invertebrate community's tolerance to organic pollution. It ranges between 0 and 10 with 0 being the most pollution sensitive. The index used in the RBP Manual is based on the pollution tolerance of invertebrates from the upper Midwest. The Index used here is calculated the same way, but uses tolerance values of North Carolina invertebrates.

<u>% Shredders</u> refers to the percentage of the sample composed of invertebrates that shred the remains of plants in order to glean the bacterial and fungal films off their surfaces. Because

many toxicants selectively bind to organic material, these animals are especially good indicators of low levels of toxicants. This metric will often detect very low concentrations of pollutants that don't affect the other metrics as noticeably. This group is based on the method of feeding and is independent of taxonomic order.

The EPT Index is the number of different taxa from the orders Ephemeroptera, Plecoptera, and Trichoptera, the mayflies, stoneflies, and caddisflies respectively. With few exceptions, these insects are more sensitive to pollution than any other groups. As a stream deteriorates in quality, members of this group will be the first to disappear. This is a robust metric that allows discrimination between all but the worst of streams.

% EPT is a measure of how many individuals in the sample are members of the EPT group. This metric helps to separate high quality streams from those of moderately high quality. The highest quality streams will have many individuals of many different taxa of EPT. As conditions deteriorate, animals will begin to die or to drift downstream. At this point, the community will still have many taxa of EPT, but there will be fewer individuals.

% Chironomids refers to the percentage of the collection composed of members of the Dipteran family Chironomidae or midges. Many members of this family are pollution tolerant, and they can build up to high numbers as animals that prey on them begin to disappear due to the effects of pollution.

% Dominant Taxa is the percentage of the collection composed of the most common taxa. As more and more species are excluded by increasing pollution, the remaining ones can build up to larger numbers due to the unused resources left by the excluded animals. This metric helps to separate the high quality from the moderate quality streams.

The Shannon-Weaver Species Diversity Index measures the evenness of the species distribution. It increases as more and more taxa are found in the collection and as individual taxa become less dominant. This metric increases with increasing biotic quality.

Rocky Riffles Collections

A riffle is described as a "sudden downward change in stream level of the streambed as such that the surface of the water is disrupted by waves" (*OCC SOP #29, revision 1*). Collection and assessment methods are geared toward flowing water. Lotic invertebrates typically need stable substrate to live, feed, and reproduce. Samples collected for this project were sent to the CCHDOC for enumeration and identification to genus level by a professional taxonomist, when applicable.

Streamside Vegetation Collections

Streamside vegetation habitats include any streamside vegetation that offers fine structure for invertebrates to dwell upon or within (*OCC SOP #30, revision 1*). This habitat can be fine root masses of grasses, sedges, or trees. Collection methods and analysis are geared towards communities that live in flowing environments. Collections must be made on substrates submerged long enough to be colonized by bacteria, fungus, and algae. Freshly submerged roots at elevated flow are unacceptable habitat to collect from. Samples collected for this project were sent to the CCHDOC for enumeration and identification to genus level when applicable.

Woody Debris

Suitable substrates for woody debris include wood with or without bark that has been in the stream long enough to develop a natural community of bacteria, fungus, algae, and invertebrates. The woody debris must also have enough flow for filtering animals to feed on suspended material and be exposed to the range of water quality changes within the stream. Collection protocol is described in OCC SOP (*OCC SOP #31, revision 1*).

Fish Collections

Fish collection protocol is discussed in OCC SOP (*OCC SOP 35, revision 2*). The collection procedure follows a modified version of the EPA Rapid Bioassesment Protocol V (*EPA, 1989*). Fish collection generally involves the use of two methods, seining, and electroshocking. Together, these methods produce a representative collection of the fish community. Collections are typically 400 meters in length. The OCC uses a Coffelt CPS backpack shocker powered by a 300-ma 120 volts generator. Seines range in size and depth. It is up to the crew leader collecting the site to determine the appropriate length and depth of net to use. All fish that are not field identified are placed in a 1-gallon polyethylene jar with a 10% formalin solution. The formalin solution "pickles" or preserves the fish for final identification by a professional taxonomist. All fish that are field identified are inspected, photographed, noted, and released.

The Index of Biotic Integrity (IBI) is taken from EPA Rapid Bioassessment Protocols for Use in Streams and Rivers (EPA, 1989). It is similar to the habitat suitability score in that it measures several different attributes of the fish community, assigns points to each attribute, and then sums the points to arrive at a score. The IBI score indicates the quality of the fish community.

<u>Total Number of Fish Species</u> decreases with decreasing water or habitat quality.

<u>Number of Sunfish Species</u> decreases with decreasing pool quality and with decreasing cover. Sunfish also require a fairly stable substrate on which to spawn, so their long-term success is also tied to conditions that affect the amount of sediment that enters and leaves the stream.

Proportion of individuals as Green Sunfish, Red Shiners, <u>Gambusia affinis</u> and <u>Black Bullheads or Percent Tolerant Individuals</u> is a characteristic that allows moderate quality streams to be separated from low quality streams. These are all opportunistic, tolerant fish that dominate communities that have lost their competitors due to loss of habitat or water quality.

<u>Proportion of Individuals as Omnivores</u> increases as stream quality decreases. Omnivores are well suited to prosper in streams that are unstable. This prosperity comes at the expense of fish whose diet is more restrictive.

Proportion of Individuals as Insectivorous Cyprinids increases as the quality and quantity of the invertebrate food base increases. These are the dominant minnows in North American Streams but are replaced by either omnivorous or herbivorous minnows as the quality of the food base deteriorates. Often, as the density of aquatic invertebrates decreases, the standing crop of algae increases. This is because the aquatic invertebrates are the largest group of primary consumers. Fish that can switch their diet to algae or fish that eat only algae will replace fish that can't adapt to the new conditions.

Proportion of Individuals as Top Carnivores decreases as the quality of the stream decreases. Many top carnivores are popular sports fish, so their absence doesn't necessarily mean life in the stream is stressful in and of itself. If angling pressure can be ruled out as a cause of low predator numbers, their scarcity is a good indicator and integrator of the sum total of life in the stream since they sit at the top of the food web.

The individual scores of these eight metrics are summed to get the IBI score. The IBI score is a score indicating the quality of the fish community, but says nothing about whether any deficiencies are due to degraded water quality or to degraded habitat.

Electroshocking

Electroshocking is typically used for collecting from habitat that a seine is unable to collect from such as large logjams, dense tree roots, undercut banks, and rocky banks. Shocking efficiency is most effective around 250-600 micro-seimens. Sampling distance is typically for 400 meters or 30 times the stream width, whichever is greater. All fish that cannot be readily field identified are preserved with 10% formalin in labeled. A professional taxonomist completes the final identification.

Seining

Seining is used for collecting fish in more open water were snags and other debris are not extensive. However in some areas of very high conductivity, seining may be the only option. In these cases the crew leader must decide when habitat have been sufficiently collected. For an in depth discussion of seining, refer to OCC SOP (*OCC SOP #35, revision 2*).

Bioassay (Toxicity Sampling)

An aquatic toxicity test is a procedure in which the responses of aquatic organisms are used to detect or measure the presence or effect of one or more substances, wastes, or environmental factors, alone or in combination (*Standard Methods, 1992*). OCC utililized the Fathead Minnow *Pimphales promelas* and the Cladoceran, *Ceriodaphnia dubia* as test organisms. Both sediment and water column samples were collected. Sediment was taken from a pool at least 0.5 meter in depth. A stainless steal scoop was used to gather the top three to four centimeters of sediment from the bottom of the pool. The gathered quantities were then placed into a solvent rinsed, analytically clean wide mouth glass container with a Teflon lined lid. Pool water column samples were taken in compliance with OCC SOP (*OCC SOP #10, revision 1*). All of the samples, both water column and sediment were then placed on ice and shipped overnight to the laboratory. Water column samples were collected from pools at least 0.5 meter in depth and followed methods described in OCC SOP (*OCC SOP 10, revision 1*).

With these samples, OCC utilized seven day survival and reproduction tests using *C. dubia* and a seven day embryo/larval test using *P. promelus* to test for toxicity in Lake Creek. The sediment and water column samples were analyzed for the following parameters; pH, hardness, alkalinity, conductivity, total ammonia, total chlorine, and salinity.

2.1.1e. Habitat Assessment

The habitat assessment was designed to incorporate habitat quality in relation to support of biological communities in and around the stream. OCC's habitat assessment adheres to a modified version of the EPA RBP (*EPA, 1989*). The assessment is based on particular parameters grouped into three principal categories (*EPA 1989*). Three primary categories are scored; micro scale habitat, macro scale habitat, and riparian/bank structure. Micro scale habitat includes substrate makeup, stable cover, canopy, and flow. Macro scale assesses the channel morphology, sediment depositions, and other parameters. The third category looks at the riparian zone quality, width, and general makeup (trees, shrubs, vines, and grasses) as well as bank features. Bank erosion, and streamside vegetative cover and are incorporated into this section. Quantitative weighting is given to each of these sections in relation to their biological significance. Scores are computed and assigned as an evaluation of that in-stream section and riparian zone. Habitat assessments are usually completed for a reach that is 400-meters long or 30 times its stream width, whichever is greater, with measurements or a scoring for each parameter every 20 meters. Further information on habitat assessment can be found in OCC SOP (*OCC SOP #39, revision 7*).

2.2 Laboratory Materials and Methods

Because of poorly definable action levels and decision criteria, water quality analysis methods and associated detection limits will be based on precedent and available technology. Detection limits for nutrients will allow least impaired waters as well as determining levels of impairment. Precision and accuracy of all data must, of course, be as true as possible. As a general rule, precision and accuracy must be within + or - 10 % except for parameters approaching detection limits, where practical considerations require a wider range of acceptable precision and accuracy. The precision and accuracy criteria presented in CCHDOC Laboratory Quality Assurance Plan are suitable for this study. CCHDOC insures data quality through the use of analysis control charts for precision and accuracy following Section 1020 of *Standard Methods* (*Standard Methods 1992*). With these charts, warning limits of + or - 2 standard deviations are established and control limits of + or - 3 standard deviations. General acceptance limits for field duplicates and spikes are based on Table 1020:I of *Standard Methods* (*Standard Methods, 1992*). Method detection limits and acceptable limits for field duplicates and spikes for the water quality parameters to be analyzed are shown in the following table.

Table 2: Parameters, precision, recovery, and method detections.

		Acceptable limits			
Parameter/Method From Standard Methods (1992)	***Meter/ laboratory***	***Precision of low level field duplicates***	***Precision of high level field duplicates***	***Recovery of known additions in the field***	***Method Detection level****
Dissolved Oxygen/ Method 4500G	YSI model 57	90-110%	90-110%		0.1 mg/l
Specific Conductance/ Method 2510B	YSI	90-110%	90-110%		1.0 microseimen
pH/ Method 4500H-B	Orion	90-110%	90-110%		0.01 S.U.
Temperature	YSI model 57	90-110%	90-110%		-5 C
Alkalinity/ Method 2320-B	Hach digital titrator		90-110%		15 mg/l
Turbidity/ Method 2130B	Hach 2100P		90-110%		0.01 NTU
Total Kjeldahl Nitrogen/ Method 4500-N-C	CCHDOC	75-125%	90-110%	80-120%	.1 mg/l
Nitrate/nitrite/ Method 4500-NO3-D	CCHDOC	75-125%	90-110%	80-120%	0.1 mg/l
Total Phosphorus/ Method 4500-P-B-E	CCHDOC	75-125%	90-110%	80-120%	.005 mg/l
TSS/ Method 2540-O	CCHDOC	75-125%	90-110%	80-120%	1.0 mg/l
Sulfate/Method 4500-SO4-E	CCHDOC	75-125%	90-110%	80-120%	1.0 mg/l
Chloride/ Method 4500-C	CCHDOC	75-125%	90-110%	80-120%	0.50 mg/l
Hardness/ Method 2340-C	CCHDOC	90-110%	90-110%	80-120%	0.5 mg/l

2.3. Analytical Methods

Analytical methods utilized during this project are described in this section.

2.3.1. Methods of Water Quality Analysis

Water quality samples were analyzed within appropriate holding times as described in Table 3 (*EPA, 1983b*). Procedures followed OCC SOP (*OCC SOP # 7, 9, 12, 13, 14*). Further discussion can be found in OCC SOP. Specific readings taken in the field include pH, dissolved oxygen, specific conductance, turbidity, alkalinity, and discharge. The meters were calibrated and/or checked for accuracy prior to each sampling event. Each meter is calibrated and evaluated quarterly at our quarterly calibration day. All problems associated with the meters were documented and brought to the attention of the Monitoring Coordinator and the Quality Assurance Officer. Further action is taken from there and suspect data was flagged.

Table 3: Parameters, preservation, and holding times.

Parameter	Preservation	Holding Times
Conductance	cool, 4^o C	28 days
Hardness	HNO_3 to pH <2	6 months
Dissolved Oxygen	None	*in situ*
pH	None	*in situ*
Total Suspended Solid	cool, 4^o C	7 days
Total Dissolved Solids	cool, 4^o C	7 days
Temperature	None	*in situ*
Turbidity	cool, 4^o C	48 hours
Total Metals	HNO_3 to pH <2	6 months
Dissolved Metals	filtered on site, HNO_3 to pH <2	6 months
Acidity	cool, 4^o C	14 days
Alkalinity	cool, 4^o C	14 days
Chloride	None	28 days
Sulfate	cool, 4^o C	28 days
Nitrate	cool, 4^o C	48 hours
Ammonia	cool, 4^o C, H_2SO_4 to pH <2	28 days
Total Kjeldahl	cool, 4^o C, H_2SO_4 to pH <2	28 days
Total Phosphorous	cool, 4^o C, H_2SO_4 to pH <2	28 days
Ortho-Phosphorous	cool, 4^o C	48 hours

Temperature

Water was measured in situ using a YSI Model 30 Conductivity Meter. Temperature measurements are calibrated quarterly. Further information for temperature collection can be found in OCC SOP (*OCC SOP #7, revision 0*).

Dissolved Oxygen

Dissolved oxygen was measured in situ utilizing a YSI Model 55. The meter was calibrated in situ for atmospheric partial pressures prior to any measurement readings. Further discussion about dissolved oxygen measurements can be found in OCC SOP (*OCC SOP #9, revision 1*) and the manufacture's manual.

Hydrogen Activity (pH)

Hydrogen activity was measured using a Cole Parmer Model 59002 portable pH meter and later replaced with YSI Model 60. Prior to measurement readings, the meter was calibrated according to OCC SOP (*OCC SOP 14, revision 1*) and the manufacturer's manual. Calibration buffer standards 4, 7, and 10 were used to acquire a 2-point calibration, when possible.

Conductivity

Electrical conductivity was measured *in situ* using a YSI Model 30 portable conductivity meter. Measurement protocol is outlined in OCC SOP (*OCC SOP #1, revision 1*). Quarterly calibration checks were performed against Oakton standard solutions of 84 and 1413 µS (high and low ranges).

Alkalinity

Field alkalinity measurements were made using a Hach Digital Titration Kit as outlined in OCC SOP (*OCC SOP #13, revision 0*). Equipment was visually and mechanically checked at each quarterly calibration day. Precision was checked at each quarterly calibration day.

Turbidity

Turbidity was measured in situ using a Hach Model 2100A Turbidity meter following OCC SOP protocols (*OCC SOP #12, revision 0*). The meter's calibration is checked prior to and after each sampling run. Each meter is also recalibrated and checked at each quarterly calibration day.

Flow Measurement

Flow was measured in situ using a Marsh McBirney 2000 Flo-Mate digital flow meter with a 10-foot sensor lead. Measurement procedures are outlined in OCC SOP *(OCC SOP # 37, revision 2*). The meter was calibrated prior to each sampling trip and at each quarterly meter calibration day.

2.3.2. Laboratory Analytical Methods

Water samples were collected and delivered to the OCCHDOC for parameters that could not be measured in-situ. These parameters and their holding times are listed in Table 3. Laboratory methods and quality assurance (i.e.- precision, recovery, and method detection limits) are displayed in table 2. A basic description of each analyzed parameters follows.

Hardness

Polyvalent metallic cations are the cause of water hardness. In fresh water environments, the major cause is due to calcium and magnesium although iron, strontium, and manganese can contribute to hardness under elevated conditions. In order to standardize reporting, hardness is reported as mg/L as calcium carbonate ($CaCO_3$). Using a standard format, water can be classified as being soft, moderately hard, hard, or very hard. See Table 2. Although there is uncertainty associated with the effect that hardness has on the aquatic environment, there is an overall benefit associated with increased hardness. The debate is focused around the chemical mechanisms involved with the positive water quality effects. For instance, is the toxicity of various metals reduced due to the formation of metal complexes or is the effect associated with one of the principal cations contributing to hardness (*EPA, 1986*). However, it has been shown that the toxicity of metals in water containing carbonate hardness is greatly reduced (*EPA, 1986*).

Table 4: Classification of water by hardness content (*EPA, 1986*).

HARDNESS CLASSIFICATION	
mg/L $CaCO_3$	**Classification**
0 - 75	Soft
75 - 150	Moderately hard
150 - 300	Hard
300 - above	Very hard

Nitrogen, Nitrate

Nitrate is of concern primarily because of eutrophication and because of drinking water concerns. The toxic effect of nitrate on warm water fish species does not become a concern until levels approach 90 mg/L (Knepp and Arkin, 1973).

Nitrogen, Nitrite

Nitrite is of concern because it is toxic to warm water fish species and because it has some effects on human health with respect to drinking water. Nitrite levels at or below 5 mg/L should adequate protect most species of warm water fish (*McCoy, 1972*).

Nitrogen, Organic (TKN)

According to Standard Methods (APHA *et al*, 1989), organic nitrogen is defined as organically bound nitrogen in the trinegative oxidation state. This definition does not include all organic nitrogen forms, but most forms such as proteins, peptides, and numerous other organic compounds comprise organic nitrogen. When organic nitrogen and ammonia are determined together the term Total Kjeldahl nitrogen (TKN) is used to indicate the combination. For this study, ammonia and organic nitrogen are reported together as TKN.

Phosphorous, Total

Phosphorous in the phosphate form is a macronutrient essential to plant growth. In most surface waters, phosphorous is the nutrient that limits the growth of algae. In natural waters, phosphorous occurs almost solely as phosphate, which is classified into orthophosphates and organically bound phosphates. Of these two forms, over 90% of the phosphorous in fresh water is found in the organic phosphate state. In terms of lake loading, phosphorous is often used as the primary measure of determining whether algae blooms will occur. Although the level that causes problems varies from lake to lake and depends upon the size of the streams and rivers that feed it, values above 0.020 to 0.050 mg/L are usually considered as excessive (*Lynch, 1992*). According to the EPA (*1986*), total phosphorous should not exceed 0.050 mg/L in flowing streams that enter water bodies (measured at the point of entry) or 0.025 mg/L in lakes or reservoirs. Flowing waters that do not discharge to water bodies can have 0.100 mg/L without eutrophication problems (*Mackenthun, 1973*). At this time, numerical criteria for phosphorous do not exist for Oklahoma, although narrative guidelines are included in Oklahoma's Water Quality Standards.

Phosphorous, Orthophosphate

Orthophosphate refers to the inorganic, soluble form of phosphate. Generally, orthophosphate is readily available to algae. Measurement of orthophosphate is as an indication of the oxygen demand that will be imposed on a water body and is also an indication of human pollution.

Total Suspended Solids

Organic and inorganic particulate matter physically entrained in the water is considered to be suspended solids. Suspended solids include sediments as well as detritus and planktonic organisms. Suspended solids are important because of aesthetics effects and also due to the adverse affects associated with fish. A study conducted by the European Inland Fisheries Advisory Commission (*EIFAC, 1965*) identified the following affects:

1. increased mortality and/or reduced growth rates;
2. prevention of successful development of fish eggs and larvae;
3. modification of natural movement and migration habits; and
4. reduction in the abundance of food available to fish species.

Suspended solids that settle out of suspension also adversely affect macroinvertebrates. Several studies have identified instances where invertebrate populations were significantly reduced. (Gammon, 1970, EIFAC, 1965, and Tebo, 1955).

Metals

Heavy metal toxicity has been widely investigated in numerous environmental settings. With the onset of the industrial revolution, concentrations of metals in the environment have increased exponentially. An understanding of heavy metal toxicity is difficult to fully appreciate because of the complicating factors that influence toxicity. For instance, pH, hardness, synergism between metals, organism sensitivity, and other physical-chemical-biological interactions can all profoundly influence toxicity. In that regard, it is beyond the scope of this section to discuss all of these aspects. Kelly, (1988) has compiled a lengthy discussion of numerous studies which address toxicity.

Despite the complexity, it is possible to make some general assumptions based on Kelly's review. For instance, of the four metals discussed—lead (Pb), nickel (Ni), copper (Cu), and zinc (Zn)-Cu was most toxic to faunal species. Concentrations of 0.01 mg/L Cu and above were particularly toxic to various invertebrate species, while Zn, Pb, and Ni toxicity was reported at higher concentrations (0.1 mg/L and greater). Similarly, fish species were more sensitive to Cu toxicity (~0.01 mg/L) than Pb, Zn, or Ni. Various fish species experienced toxicity at 0.1 mg/L for Pb and Zn, but few reports of Ni toxicity were observed below 10 mg/L—almost 100 times higher than the toxic Cu concentration.

Pesticides

Agriculture predominates much of Oklahoma’s land usage. To control insect, fungal, parasitic and other pest problems, pesticides are widely utilized in many watersheds. The term pesticides encompasses the full compliment of fungicides, herbicides, biocides, etc. The scope of this section is not to discuss all potential effects of pesticides. The pesticides selected for collection and analysis by the OCC where determined through compiling information on a previous study in the Lake Creek watershed (OCC FY 1988 205(j) Task 500), other studies in nearby watersheds, surveying the local conservation districts, and surveying the Oklahoma Cooperative Extension Service. Emphasis was placed on those substances which have been shown to be environmentally mobile, and which have been identified in other studies (i.e. triazine herbicides).

2.4. Quality Assurance/Quality Control

Water sampling quality assurance/quality control (QAQC) consisted of collecting blank, duplicate, and replicate samples.

- **FIELD BLANK**: Refers to a sample of de-ionized water (analyte-free). The blank is collected, preserved, documented, and transported under the same conditions as the samples. Blank samples are utilized to determine sampler bias.

- **SPLIT/DUPLICATE**: A split or duplicate sample refers to a grab sample that is either mixed in a splitter-churn (split) or two samples are prepared by dividing a larger sample. In either case, the two samples are supposed to be as close to identical as possible. Duplicate samples are used to determine precision.

- **REPLICATE**: A replicate is one or more grab samples taken in different locations (width or length) or at different times. These samples are designed to estimate the spatial and/or temporal in-stream variation.

All QAQC requirements for this project can be found in the Quality Assurance Project Plan. The OCC SOP document also describes the methods for the preparation of field blank, duplicates, and replicate sample as well as the rate at which these QA checks are submitted to the laboratory with regular samples (*OCC SOP #4, revision 1*). These sample QA methods were designed in accordance with EPA requirements. All quality control for Immunoassays follow the manufacturer's recommendations.

Quality control of field parameters were achieved through regular calibration of the field meters and the quarterly calibration checks of all meters in use by the OCC. Quality control of flow measurements was achieved by second measurement at one site per sampling event or every ten flow measurements per sampling event. Quality control of habitat assessment was achieved through strict adherence to the habitat assessment SOP and deployment of trained investigators (*OCC SOP #39 revision 7*). Quality control of fish and benthic collections will be achieved through careful application of methods as described in the SOP's and documentation of any deviation from the prescribed methods (*OCC SOP #29, 30, 31, 35, 36, and #43*). A replicate benthic invertebrate sample will be taken at one site for each sampling event.

For surface water collection activities 8 blanks, 6 replicates, and 5 duplicates were delivered and analyzed at the laboratory. All data found to be out of acceptable limits with the parameters set forth in table 2 (*Taken directly or impart from Standard Methods table 1020:I, 1989)* of this document will not be used in the final analysis. Tables displaying the QAQC acceptable limit results can be found and discussed under the results section of this report.

3.0. Project Activities

3.1. Introduction

The work conducted through this grant was centered in the Lake Creek/Ft. Cobb watershed. Dense agricultural activities, shallow ground water and coarse, fragile soils characterize the watershed. The watershed is approximately 69.1 square miles (44,212 acres) and drains to the Ft. Cobb Reservoir. Ft. Cobb Reservoir is listed as a private and public water supply and is the primary drinking water source for the City of Chickasha
. In 1998, OWRB data showed the Lake was hypereutrophic and in 1999, eutrophic. Fort Cobb Reservoir and six stream segments in its watershed are listed on the 1998 303(d) list as being impaired by nutrients, pesticides, siltation, suspended solids, and unknown toxicity.

Poor to non-existent riparian zones typify the stream. The surrounding watershed consists of dense agriculture, primarily farming. Crops raised in the watershed include peanuts, wheat, alfalfa, and other small grains. Other observed landuses in the area include CAFO's, urban areas, forestland, pasture land, and a hog operation (see map 2). The soils are coarse, fragile, and highly erodable allowing surface water to percolate into the shallow ground water. Due to the shallow groundwater (Rush Springs Aquifer), which is easily tapped, and intensive agriculture, the watershed is highly irrigated.

Table 5: Landuse in the Lake Creek Drainage Basin

Landuse In the Lake Creek Watershed by Percentage			
LANDUSE	**COUNT**	**Acreage Summary**	**Percentage**
CAFO	3	11.8540	0.03%
Alfalfa	1	20.5270	0.05%
Brush	15	1022.3150	2.31%
Corn	1	53.3030	0.12%
Cotton	8	457.3560	1.03%
Forest	10	784.1960	1.77%
Hay/small grains	26	1452.3710	3.28%
No data	91	12672.7480	28.66%
Pasture	137	11657.7340	26.37%
Peanuts	98	6872.2880	15.54%
Truck/vegetable crop	11	554.4040	1.25%
Urban	2	146.6250	0.33%
Wetland	1	41.2450	0.09%
Wheat	133	8465.9600	19.15%
Total		**44212.9260**	

The following table was compiled from information in the 319 Assessment report and lists the waterbodies and the contaminants responsible for their, use impairment:

Table 6: 319 Assessment Report (1992)

WATERBODY	CONTAMINANT	EPA CAUSE CODE
Cobb Creek Including Ft. Cobb Lake and watershed	Pesticides nutrients siltation	02 09 11
Washita River	Pesticides nutrients siltation	02 09 11

The objective of the physical/chemical measurements was to detect the pesticides which enter the stream through both stream bank seepage and rainfall run-off. No data existed concerning the variability of the concentrations of pesticides in the seepage water. It was anticipated that due to high shallow ground water flow rates, variable rainfall occurrence generally of short duration and high rates, and unknown fertilizer and pesticide application times and rates, that the quantity and quality of the seepage water may be highly variable. Therefore, the variability of the seepage water weekly, monthly, seasonally, and annually was determined. It was likely that the high variability would limit the use of the data for representation of the average stream condition for an extended period of time beyond the sampling period. Improvements in the quality of water discharged from stream side seeps likely cannot be quantitatively determined, based on the expected variability, without intense long term sampling for which resources are not available. However, any reductions in fertilizer and/or pesticides would result in long-term improvements in both surface and ground water quality, which would be measured through improvements in the health of the biological community.

The Quality Assurance Project Plan addressed 8 key questions in the watershed:

- What is the level of impairment to the aquatic community?
- Is toxicity within the stream still a problem?
- What is the nature of the toxicity?
- What is the source of the toxic pollutant? e.g. ground water, irrigation return, overland flow, pesticide dumping, wash water, discarded containers, or natural sources?
- What are the nutrient contributions to the stream from ground water?
- What impairments to the aquatic community are contributable to habitat degradation?
- What reduction in pollutant loads or improvements to water quality can be attributed to education and demonstration program in the watershed?
- What changes in the aquatic community can be documented after the demonstration /education program?

3.2. Surface Water Site Selection

Five sites in the Lake Creek watershed and two sites outside of the watershed were identified and selected as sites to monitor for both chemical and biological monitoring. Criteria for these selections included: 1) perennial flow; 2) the stream morphology at the site is characteristic of the average conditions for the stream; 3) the potential pollution source is predominantly represented in the watershed between the above and below sites; 4) and that samples, both base flow and high flow, can be easily collected.

Table 7: Site descriptions for the Lake Creek project

Site	WB #	Latitude	Longitude	Legal	County
Lake Creek #1	OK310830-06-0040G	35 15 30.42	98 31 54	NB12,9N,13W	Caddo
Lake Creek #2	OK310830-06-0040K	35 18 16.62	98 31 36.24	NB36,10N,13W	Caddo
Lake Creek # 3	OK310830-06-0040M	35 20 1.2	98 31 36.24	NW/NE24,10N,13W	Caddo
Lake Creek # 4	OK310830-06-0040N	35 21 45.78	98 30 56.82	NB7,10N,12W	Caddo
Lake Creek # 5	OK310830-06-0040Q	35 24 21.9	98 31 14.52	NB25,11N,13W	Caddo
Oak Creek	OK310830-02-0090G	34 50 25	97 48 28	NE31,8N,15W	Washita
East Roaring Creek	OK310810-02-0180P	35 07 44	98 48 41	NW11,4N,6W	Grady

Lake Creek Site 1

Site 1 was located near the terminus of the creek, yet above the backwaters of Ft. Cobb Lake. The site was downstream and adjacent to heavily farmed areas. Numerous seeps were located at and upstream of this site. Just above and below this site has the most intact riparian zone throughout the entire reach of the system.

Lake Creek Site 2

Site 2 was located approximately 6 miles upstream of confluence with Ft. Cobb Lake (2 miles N. of site #1). Landuse is similar to Lake Creek Site 1 (dense farming, and moderate cattle activity) with the exception of an intact riparian zone. This site had very poor/nonexistent riparian zone. Lake Creek Site 2 was the station where all sediment and water column toxicity samples where taken. Again this stretch was typified by extremely poor riparian zone and aquatic habitat.

Lake Creek Site 3

Lake Creek site 3 was located on an ephemeral lateral unnamed tributary of Lake Creek approximately seven miles upstream of the confluence with Ft. Cobb Reservoir. The site was downstream of intensive agriculture. The site lacks the majority of its riparian zone and again is typified by poor habitat (primarily sedimentation).

Lake Creek Site 4

Lake Creek site 4 was located in the upstream portion of the watershed. This site and the upstream watershed are less intensely farmed yet still had substantial tilled land. The majority of the upstream land was pasture.

Lake Creek Site 5

Lake Creek site 5 was located approximately fourteen miles upstream. It was the uppermost site in the study and was located in the headwaters of Lake Creek. The stream channel was deeply entrenched at this site. Again the riparian zone was highly damaged if intact at all.

3.3. Seep Water Quality Monitoring Sites

Twenty-seven seeps were monitored along the main branch of Lake Creek. Streamside seeps were monitored for the same parameters as surface waters with the exception of TSS. Ideally, streamside seeps were selected to represent two characteristic types: 1) a seep directly down the hydraulic gradient (which generally follows the terrain) from an area of intense farming; and 2) a seep directly down the hydraulic gradient from an area of no farming but with similar soil and slope characteristics as the farmed areas. Seep sites were also selected based on ease of access and size (relative flow) of the seep. The largest seep in an area was selected with preference for those away from the stream where bank storage and piping may be a factor.

The seeps that were monitored fell into general areas at or near Lake Creek surface water-sampling sites and thus are associated with these sites (see table 5 below). This table is simply displayed to give readers an idea of where the seeps are in regards to surface water quality sites.

Table 8: Seep Name and Associated Lake Creek Sites

Seep Name	Number of Sites	Associated Site
A-F	6	Lake Creek #1
G-K	5	Lake Creek #2
L-Q	6	Lake Creek #3
R-V	5	Lake Creek #4
W-AA	5	Lake Creek#5

3.4. Biological Reference Sites

A reference site typically represents conditions which are minimally disturbed. Originally two biological reference sites were chosen in neighboring watersheds. However, macroinvertebrate collections and fish collection at Oak Creek indicated that the stream has degraded significantly since the last biological collections were made at this site. Oak Creek also went intermittent with pools becoming extremely shallow throughout the reach for the entire summer of 1999. Lake Creek had perennial flow during the project period. Oak Creek was deemed as not an acceptable biological reference site and is not used in the final biological analysis. East Roaring Creek in Grady County was used as a biological reference site. During 1984, biological collections were made in the Central Great Plains Ecoregion. More reference sites were needed to complete the fish analysis. Eleven sites were chosen to use as reference sites from these previous collections.

3.4.1. Central Great Plains Biological Reference Sites

These sites were selected to further strengthen the fish reference site information for the Lake Creek project. These sites are representative of streams with sandy substrates in western Oklahoma. Recent information was used that distinguished rocky bottomed stream biological communities from sandy bottomed stream communities (Howe, 2001). The following are the sites selected from the Central Great Plains monitoring sites.

Table 9: Central Great Plains Biological (Fish) Reference Sites

Stream Name	Legal	County	IBI	Habitat
Sand Cr.	S 18, 22N 7W	Garfield	26	74
East Bitter Cr.	N 32, 8N 5W	Grady	30	125
Lone Cr.	N 26, 17N 18W	Dewey	30	108
Trail Cr.	S 7, 17N 15W	Dewey	26	89
Bear Cr.	NE SW 17, 14N 13W	Custer	28	119
Station Cr.	S 18, 6N 23W	Greer	24	85
Little Beaver Cr.	S 19, 1N 8W	Stephens	24	89
Trail Cr.	S 2, 9N 20W	Washita	24	84
Unnamed tributary to the Canadian R. (Hanging Fence)	W 3, 12N 11W	Caddo	30	104

3.4.2. Original Lake Creek Reference Sites

Oak Creek, Caddo County

Oak Creek is located out of the project watershed but still within an area of similar biological conditions. Oak Creek is a tributary of the Washita River approximately nineteen miles west and five miles south of Ft. Cobb Lake. The Oklahoma Water Resources Board identified Oak Creek as a positive reference site from past data collection activities. The sites conditions (biological, watershed, chemical, physical) all meet the criteria to use as a positive reference site. The Oklahoma Conservation Commission identified and utilized Oak Creek as a reference site during the 1988 Lake Creek Study (*FY1988 205(j) Task 500*). Unfortunately, Oak Creek has degraded biologically since the last survey and is not used as a reference site in this report.

East Roaring Creek, Caddo County

East Roaring Creek is located outside of the project watershed but is still in an area of similar biological conditions. This site was used as a biological reference site. The conditions (biological, watershed, chemical, physical) all meet the criteria to use as a positive reference site. The Oklahoma Conservation Commission identified East Roaring Creek as a reference site while surveying for reference conditions in the western half of the state.

3.5. Site Activities

3.5.1. Surface Water Sampling

3.5.1a Surface Water Physical/Chemical Sampling Frequency

Physical/chemical monitoring was ongoing from August 1998 through November 1999 at all Lake Creek sites. Monthly readings were taken from mid August ‘98 through early January ‘99 and bimonthly readings, early February ‘99 through mid October ‘99. High flow readings were taken at Lake Creek sites 1, 2, and 4. Measurements included basic in-situ monitoring of water temperature, specific conductance, pH, dissolved oxygen, alkalinity, turbidity, and flow. Sample collections were made for sulfate, chloride, TSS, and total hardness and analyzed at the OCCHDOC. Stream site observations were also made at each site monitored. These observations include any pertinent information regarding localized sources of pollution (i.e. cattle in the stream during sampling event), cow flops in the streambed and upper floodplain, and ambient conditions (wind, air temp, stream shading, etc.).

3.5.1b Surface Water Nutrient Sampling

Nutrients were measured from August ‘98 through November ‘99. Total phosphorus, Nitrate, TKN, and at times Ortho phosphorus were analyzed.

Sampling Frequency

- Lake Creek Site 1 was sampled sixteen times for nutrients. Of those sixteen sampling events, two were at elevated flow conditions.
- Lake Creek Site 2 was sampled once for nutrients. All samples were taken at base flow conditions.
- Lake Creek Site 3 was not sampled for nutrients.
- Lake Creek site 4 was sampled fifteen times for nutrients. All samples were taken at base flow conditions.
- Lake Creek site 5 was sampled once for nutrients. All samples were taken at base flow conditions.

3.5.1c Surface Water Metal Sampling

Thirteen different (see table) metals were analyzed from August 13, 1998 through August 30, 1999. Emphasis was placed on monitoring for those metals that are commonly associated with agriculture (copper and arsenic).

Sampling Frequency

- Lake Creek Site 1 was sampled seven times for metals. Two of those events, April 25 and June 21, 1999, were at elevated flow conditions.
- Lake Creek site 2 was sampled once for metals. This sampling event was at base flow.
- Lake Creek site 3 was not sampled for metals.
- Lake Creek site 4 was sampled a total of six times for metals. All sampling events were at base flow levels.
- Lake Creek sit 5 was sampled one time for metals at base flow conditions.

Table 10: Monitored Parameters

Parameters Measured			
In-Situ	**Physical Chemical**	**Metals**	**Pesticides**
Dissolved Oxygen	Chloride	Antimony	Alachlor
pH	Sulfate	Arsenic	Aldicarb
Conductivity	Total Hardness	Berylium	Atrazine
Water Temperature	TSS	Cadmium	Captan
Turbidity	Total Phosphorus	Chromium	Carbofuran
Alkalinity	Total Ortho Phosphorus	Copper	Chlorothalonil
Flow (ft/sec)	Nitrate	Lead	Chlorpyrifos
	TKN	Mercury	Cyanazine
		Nickel	Metolachlor
		Selenium	Metribuzin
		Silver	Paraquat
		Thallium	Picloram
		Zinc	Triclopyr

3.5.1d Surface Water Pesticide Sampling

Thirteen pesticides were analyzed from Lake Creek water collections (see table). Pesticide sampling occurred from August 27, 1998 through October 22, 1999. The objective of sampling for pesticides was to detect the pesticides entering the stream through bank seepage and rainfall runoff events. Pesticide sampling will address concerns about the variability and concentrations of pesticides in surface water and seep water discharge. We will also address the concerns of toxicity due to these compounds within the surface waters of Lake Creek. Pesticides were sampled monthly from late August '98 to mid March '99, bimonthly from early April '99 to late August 99', and monthly during September and October 1999. The sampling frequency reflects the times when there is a high probability of occurrence within the water column and seep water discharge.

Surface Water Pesticide Sampling Frequency

- Lake Creek site 1 was sampled twenty-four times for pesticides. Of these twenty-four, two sampling events, April 26, 1999 and June 22, 1999, were at elevated flow conditions.
- Lake Creek site 2 was sampling twenty-two times for pesticides. All samples were collected at base flow conditions.
- Lake Creek site 4 was sampled twenty-four times for pesticides. Of these twenty-four samples, two sampling events (April 26, 1999 and June 22, 1999) were at elevated flow conditions.
- Lake Creek site 5 was sampled twenty-two times for pesticides. All samples were collected under base flow conditions.

3.5.2. Seep Water Quality Sampling

Twenty-seven seeps were located and sampled during the project duration. Many of these seeps were sampled once. When a seep was sampled, a legal and GPS point was given to each sampling point. The sites have been grouped according to their location on the main branch of Lake Creek. These sites may or may not be the same seeps sampled previously. This was due to the shifting nature of the stream and seep locations. Before each sampling event, field reconnaissance was necessary to insure that a seep was located in that general area and/or had not stopped flowing. However, all seeps down gradient from the same land usage of that associated site and should therefore represent the nature of the site, as much as possible. Seeps were sampled for the parameters; specific conductance, alkalinity, pH, ortho phosphorus, nitrate, selected pesticides, metals, and discharge.

3.5.2a Seep Physical/Chemical Sampling Frequency

Physical/chemical monitoring consisted of sampling seeps for pH, alkalinity, conductivity, and discharge (ml/min.). Sampling measurements were taken during any routine sample collection of inorganic and/or organic parameters.

3.5.2b Seep Water Nutrients Sampling Frequency

Seep nutrients were sampled from December of 1998 through October 1999. Parameters included Ortho Phosphorus and Nitrate Nitrogen. Below is a breakdown of the sampling frequency by associated site.

- Lake Creek site 1 (seeps A-F) seeps were sampled a total of 46 times.
- Lake Creek site 2 (seeps G-K) seeps were sampled a total of fourteen times.
- Lake Creek site 3 (seeps L-Q) seeps were sampled a total of 33 times.
- Lake Creek site 4 (seeps R-V) seeps were sampled a total of twenty-three times.
- Lake Creek site 5 (seeps W-AA) seeps were sampled a total of seven times.

3.5.2c Seep Water Metals Sampling Frequency

Three seeps were monitored one time each for metals. Seep E (June 13, 1999) and seep S (December 15, 1998). No other seeps were monitored for metals during the duration of this project.

3.5.2d. Seep Water Pesticide Sampling Frequency

- Six seeps were sampled at Lake Creek site 1 (seeps A-F) with a total of 46 samples taken at these seeps. Seep A was sampled the least (twice) and seep F was sampled the highest amount of times (twelve times).
- Five seeps were sampled at Lake Creek site 2 (seeps G-K) with a total eighteen samples taken at these seeps.
- Six seeps were sampled at Lake Creek site 3 (seeps L-Q) with a total of 35 samples taken at these seeps.
- Five seeps were sampled at Lake Creek site 4 (seeps R-V) with a total of twenty-three samples taken at these seeps.
- Five seeps were sampled at Lake Creek site 5 (seeps W-AA) with a total of eight samples taken at these seeps.

3.5.3. Biological Monitoring and Habitat Monitoring

Biological collections were made for fish and macroinvertebrates. Water column and pool bottom soil samples were also collected to perform Bioassays. These samples were collected for thirteen months. Fish collections were completed one time for each monitoring site. During the fish collection, a habitat assessment was also completed. Macroinvertebrates were collected twice during each year of the project representing both a winter and summer collection.

3.5.3a. Fish Collection Dates

Fish were collected once for each site during the project duration. As mentioned in the previous text, habitat assessments are completed at the time of the fish collection. All of the Lake Creek sites were collected in the summer of 1998.

Table 11: Fish Collection Dates and Collection Type(s)

Site Name	Date	Seine	Shock
Lake Creek Site 1	8/19/1998	X	X
Lake Creek Site 2	8/20/1998	X	X
Lake Creek Site 3	Not Collected	-	-
Lake Creek Site 4	8/20/1998	X	X
Lake Creek Site 5	8/21/1998		X

3.5.3b. Macroinvertebrate Collection Dates

Benthic macroinvertebrates were collected from each site three times during the project duration. At each site, field personnel attempted to collect three different habitat types; riffle, woody debris, and streamside vegetation (*OCC SOP #29, 30, 31*). The collections were made in

September 1998 (summer collection), February 1999 (winter collection), and August 1999 (summer collection).

3.5.3c. Bioassay Collection Dates

All of the bioassay water column and pool bottom soil samples were collected from Lake Creek site 2 with the exception of the collection made during April 1998. This collection was made at Lake Creek Site 6, which was a site located just upstream (within biological reach) from Lake Creek site 2, and later dropped from the sampling locations. A total of 12 samples, both water column and sediment, were sampled from Lake Creek. Samples were taken from April 1998-September 1999. One sample was destroyed in route to the laboratory.

Table 12: Bioassay Collection Dates

Bioassay Sample Collection Dates	
Site Name	Date of Bioassay Sample Collection
Lake Creek 6	4/19/1998
Lake Creek 2	5/13/1998
Lake Creek 2	6/11/1998
*	July
Lake Creek 2	8/26/1998
Lake Creek 2	9/15/1998
Lake Creek 2	10/19/1998
Lake Creek 2	11/9/1998
Lake Creek 2	1/11/1999
Lake Creek 2	3/10/1999
Lake Creek 2	7/19/1999
Lake Creek 2	8/16/1999
Lake Creek 2	9/13/1999

- Site collected but destroyed in route.

4.0. Results

Data was tabulated and assessed utilizing basic descriptive statistics and nonparametric statistics were applicable. Distinctions were made between high flow and base flow utilizing periphyton lines and other instream characteristics of base flow. High flow observations were analyzed separately from base flow data due to its composition differences. For example, turbidity, TSS, and nutrients would simply not be in equal proportions during base flow conditions compared to high flow conditions. The same was completed for streamside seeps. Observations and comments were both recorded with other numeric data and were used as indicators for potential problems within the watershed. Chemical sampling quality assurance data was reviewed prior to utilizing this information. Biological data was worked up in accordance to guidance set forth in the EPA RBP (*EPA, 1989*). Biological data was reviewed for completeness before it was used in analysis.

4.1. Quality Assurance/Quality Control Results

The results of duplicate analysis are displayed in table 12. One parameter, TSS, did not fall within acceptable limits on January 11, 1999 (highlighted in the table below). On that sampling date, TSS measured in the sample was 412 mg/l and the duplicate was measured at 309 mg/l. When calculated as the difference of the percentage of the mean, it was 85.7%. An acceptable limit for this parameter (high level precision) is 90-110% (table 2). The samples collected for TSS on this day were not used in the final analysis.

Table 13: Duplicate Quality Assurance

Duplicate Quality Assurance										
Site	WBID	Date	Type	Chloride % of Mean	Sulfate % of Mean	Total Hardness % of Mean	TSS % of Mean	Total Phosphorus % of Mean	Nitrate % of Mean	TKN % of Mean
Lake Creek Site 5	OK310830-06-0040Q	13-Aug-98	Duplicate	100.0	100.9	102.1	100.0	97.1	99.0	105.4
Lake Creek Site 5	OK310830-06-0040Q	13-Aug-98	Sample							
Lake Creek Site 4	OK310830-06-0040N	15-Sep-98	Duplicate	100.0	98.1	100.0	98.1	100.0	94.7	100.8
Lake Creek Site 4	OK310830-06-0040N	15-Sep-98	Sample							
Lake Creek Site 1	OK310830-06-0040G		Sample							
Lake Creek Site 4	OK310830-06-0040N	11-Jan-99	Duplicate	100.0	101.4	99.8	85.7	97.0	100.5	100.9
Lake Creek Site 4	OK310830-06-0040N	11-Jan-99	Sample							
Lake Creek Site 1	OK310830-06-0040G	20-Apr-99	Duplicate	100.0	99.6	99.3	99.4	104.7	101.2	105.0
Lake Creek Site 1	OK310830-06-0040G	20-Apr-99	Sample							
Lake Creek Site 4	OK310830-06-0040N	20-Jul-99	Duplicate	100.0	98.9	101.8	107.4	100.0	99.6	95.7
Lake Creek Site 4	OK310830-06-0040N	20-Jul-99	Sample							

Six replicate samples were taken at three sites, Lake Creek Site 2, Site 4, and Site 5. Replicate samples were analyzed in the same manner in which duplicate samples were analyzed with the exception of comparing the sample parameter concentrations with the replicate concentrations and not the mean concentration of both the sample and the replicate. A high degree of variability significantly lower readings were recorded for the parameters chloride and sulfate. Variable readings that were significantly higher in concentrations than the sample were recorded for the parameters total hardness and to a lesser frequency but higher magnitude nitrate and TKN. Again replicate samples are designed to show potential instream variability and do not reflect the quality of the samples or samplers. A possible reason for this variability is that during the summer months, Lake Creek's base flow is maintained by groundwater inflow from the seeps that are along the length of the stream. These seeps, even seeps those that are very close to one another are often highly variable in their chemical constituents. During the summer when flow is maintained by these seeps, specific zones of varying water quality may occur. During the winter and spring months when base flow levels are typically higher than during the summer, replicate samples are much closer to sample concentrations. In future investigations, summer low flow water collections should be collection using depth and width integrated sampling techniques.

Table 14: Replicate Quality Assurance

Site	WBID	Date	Type	Chloride % of sample	Sulfate % of sample	Total Hardness % of sample	TSS % of sample	Total Phosphorus % of sample	Total Ortho Phosphorus % of sample	Nitrate % of sample	TKN % of sample
Lake Creek Site 5	OK310830-06-0040Q	13-Aug-98	Replicate	28.0	20.1	217.4	48275.9			75.9	282.4
Lake Creek Site 5	OK310830-06-0040Q	13-Aug-98	Sample								
Lake Creek Site 4	OK310830-06-0040N	15-Sep-98	Replicate	32.7	11.3	248.1	80000.0			303.0	66.7
Lake Creek Site 4	OK310830-06-0040N	15-Sep-98	Sample								
Lake Creek Site 1	OK310830-06-0040G	13-Oct-98	Replicate	62.1	97.3	101.0	81.0	111.7		99.5	114.3
Lake Creek Site 1	OK310830-06-0040G	13-Oct-98	Sample								
Lake Creek Site 1	OK310830-06-0040G	09-Feb-99	Replicate	100.0	100.6	99.2	91.9	100.0		101.9	98.2
Lake Creek Site 1	OK310830-06-0040G	09-Feb-99	Sample								
Lake Creek Site 4	OK310830-06-0040N	20-May-99	Replicate	91.7	111.1	101.5	127.8	111.1		102.1	87.7

Lake Creek Site 4	OK310830-06-0040N	20-May-99	Sample								
Lake Creek Site 4	OK310830-06-0040N	09-Nov-99	Replicate	118.2	71.4	99.2	98.8	97.3		100.0	112.5
Lake Creek Site 4	OK310830-06-0040N	09-Nov-99	Sample								

4.2. Surface Water Stream Site Observations

At each site sampled, a Site Collection Sheet accompanied other associated data. These sheets gathered valuable qualitative data on stream site observations and landuse activities. The following tables break down this information by percent occurrence in relation to the total observations made at each site. Actual observations used in calculations (for parameters unsightly appearance and foam/scum) were made at base flow. This data was omitted to avoid biasing turbidity and froth from high flow events. Each site observation was recorded by walking 400 meters of the upstream or downstream of the sampling point.

- At Lake Creek Site 1, 29 Site Collection Sheets were filed. Of these 29 sheets, 60 separate stream observations were recorded.

- At Lake Creek Site 2, 35 Site Collection Sheets were filed for this site. Of these sheets, 54 stream observations were recorded.

- At Lake Creek Site 3, fifteen Site Collection sheets were filed for this site. Of these sheets, 33 stream site observations were recorded.

- At Lake Creek Site 4, 28 Site Collection Sheets were filed for this site. Of those sheets, 47 stream site observations were recorded.

- At Lake Creek Site 5, twenty-four Site Collections Sheets were filed for this site. Of those sheets, 65 stream site observations were recorded.

As stated in the Oklahoma Water Quality Standards (OWQS) 785:45-519 (Aesthetics section) water will be free of floating material, suspended substances, color, turbidity, odors, tastes, and materials that form objection deposits. The tables above were calculated as a percent of the total number of observations on sheets that were filed for each site. The table below displays the total number of each observation made for each category as a percentage of the total site visits. The siltation and entrenchment categories were omitted. These categories will be constant through the sampling period of two years. It would not be expected that siltation and/or entrenchment would change during such a short sampling period.

Table 15: Percent of Site Observations that Indicate Aesthetics Impacts

Percent of Site Visits that Observations indicate Aesthetics Impacts Over a 2 Year Period														
Site Name	Clean	Fish Kill	Manure in Stream	Unsightly Appearance	Foam/Scum	Floating Debris	Trash	Significant Algae	Dead Animals in Stream	Flow Alteration	Habitat Alteration	Oily Film/Grease	Offensive Odor	Other
Lake Creek Site 1				7	62	59	41	21						
Lake Creek Site 2			29	26	37	26	6	14	3	3				
Lake Creek Site 3			13	7	60	47	26	33						
Lake Creek Site 4			11	7	29	32	46	7	4			4		
Lake Creek Site 5	4		58	17	54	41	17	25				4		

As supported by the percentages in the tables above, significant negative observations were recorded for each of the Lake Creek sampling locations. For example, at Lake Creek Site 2, foam and scum were recorded during 37% of all of the sampling visits. Unsightly appearance, floating debris, trash, and significant algae were recoded for 26%, 26%, 6% and 14% respectively.

4.3. Surface Water Monitoring Results

Lake Creek Site 1

Dissolved oxygen ranged from 6.26-14.63 mg/l at Lake Creek site 1 with median concentration of 8.73 mg/l. pH readings ranged within 7.65-8.51. Conductivity ranged between 387-672 μs/cm. At base flow conditions, turbidity ranged from 4.38 NTUs to a maximum of 82.0 NTUs. Water temperature ranged from a minimum of 0.7°Celsius- 27.5°Celsius. High flow condition turbidity was measured at 2000 NTU. Median flow was 2.8 ft/sec. The water is considered hard to very hard due to natural depositions of gypsum throughout the watershed. Total hardness ranged from 210-300. TSS ranged from 5.50 mg/l – 90.00 mg/l with a median concentration of 21.75 mg/l. The median chloride concentration was 15.00 mg/l. Sulfate concentration ranged from 33.00 to a maximum of 49.50 mg/l.

Total phosphorus ranged from a minimum of 0.05 mg/l to a maximum of 0.16 mg/l. Ortho phosphorus was measured one time during the study at this site at 0.46 mg/l. Nitrate concentrations ranged from 0.25-1.81 mg/l. The median nitrate concentration was 1.04 mg/l. TKN values ranged between 0.32 mg/l and 0.77 mg/l, with a median concentration of 0.52 mg/l.

No water quality standards violations for the parameters pH, dissolved oxygen, turbidity, metals, pesticides, chloride, or sulfate were reported during the sampling at Lake Creek site 1.

Lake Creek Site 2

Dissolved oxygen ranged from a minimum concentration of 7.2 mg/L to 14.8 mg/l with a median concentration of 9.67 mg/l. pH readings ranged between 7.70-8.28. Conductivity ranged between 380-696 μs/cm. At base flow conditions; turbidity at the clearest was 5.86 NTUs. The maximum turbidity recorded was 99.00 NTUs. The median Turbidity was 18.65 NTUs. Water temperature ranged from 2.5° Celsius – 25.9° Celsius.

Only one base flow sampling event (on August 13, 1998) occurred at this site for the parameters: chloride, sulfate, total hardness, TSS, total phosphorus, nitrate, and Kieldahl nitrogen (TKN).

No standards violations were reported for the parameters pH, dissolved oxygen, and pesticides. Turbidity was partially supporting at Lake Creek site 2 (4 of 32 baseflow samples or 13% exceeded 50 NTU). Nutrients, chloride, sulfate, and metals were not sampled at this site.

Lake Creek Site 3

Dissolved oxygen ranged from a minimum concentration of 7.31 mg/l to a maximum concentration of 14.87 mg/l. The median dissolved oxygen concentration was 9.25 mg/l. All pH readings were within 7.35-8.20. Conductivity ranged from 525-828 μs/cm. At base flow conditions, turbidity ranged from a minimum of 2.63 NTUs to a maximum of 15.70 NTUs. Water temperature ranged from a minimum of 4.2°Celsius–29.4°Celsius. Flow was measured at each sampling event. No high flow events were sampled during the duration of the project at this site. This site was intermittent during the summer months. The maximum flow was 0.30 CFS.

One high flow event was sampled at this site. During this event, turbidity was measured at 420 NTUs.

No standards violations were reported for pH, dissolved oxygen, turbidity, pesticides, and metals. Samples were not analyzed at this site for the following parameters: chloride, sulfate, total hardness, TSS, total phosphorus, total ortho phosphorus, nitrate, and Kieldahl nitrogen (TKN). Nutrients were not analyzed frequently enough to verify standards compliance, however, significant algae was noted during 33% of the sampling events.

Lake Creek Site 4

Dissolved oxygen ranged from a minimum concentration of 6.93 mg/l to a maximum concentration of 12.35 mg/l. The median oxygen concentration was 9.30 mg/l throughout the sampling period. All pH readings were between 7.65-8.35. Conductivity ranged from 435µs/cm to 653µs/cm. At base flow conditions, turbidity ranged from 16.80 NTUs to a maximum of 101.00 NTUs. The median turbidity value was 38.70 NTUs. Water temperature ranged from a minimum of 5.50°Celsius to a maximum of 34.5°Celsius. Flow was measured during each sampling event. Two high flow events were sampled. In April and June of 1999, two high flow events were sampled. The flow measured during these events was 106.2 CFS and 32.9 CFS. The minimum flow measured was 0.90 CFS and the maximum flow (at base flow levels) was measured at 4.50 CFS. The median flow for all measured base flow events was 2.20 CFS.

The median alkalinity was 247.0 mg/L CaCO3. Chloride ranged between 6.5 and 12 mg/l. Sulfate ranged from 20.9 mg/l to 47.20 mg/l. Total hardness ranged from 192 mg/l to 300 mg/l with a median of 242 mg/l. The water at this site is considered hard water when compared with the table on page 15. TSS has a minimum value of 20.4 mg/l and a maximum value of 412 mg/l. The median value of TSS was 106.0 mg/l.
Total phosphorus ranged from 0.095 mg/l to a maximum of 0.023 mg/l. The median value for total phosphorus was 0.144 mg/l. Ortho phosphorus was measured twice during the sampling period, on June 13, 1999 and October 19, 1999. The ortho-phosphorus values of these samples were 0.219 and 0.59 respectively. Nitrate values ranged between 1.28 mg/l and 3.30 mg/l. The median value of nitrate during the project duration was 2.00 mg/l. TKN concentrations ranged from a minimum of 0.43 mg/l to a maximum of 32.00 mg/l.

No standards violations were reported for pH, dissolved oxygen, metals, pesticides, chloride, and sulfate. Site 4 was partially supporting for turbidity. Based on the guidelines set by USAP, the occurrence of excessive algae, shallow depths, nutrient concentrations, and elevated oxygen saturations suggest that the site was nutrient threatened.

Lake Creek Site 5

Dissolved oxygen concentrations ranged from 8.10 mg/l to a maximum concentration of 13.05 mg/l. The median concentration of dissolved oxygen was 10.27 mg/l. All pH readings were between 7.20-8.19. Conductivity ranged from 507µs/cm to 683µs/cm. No high flow measurements were taken at this site during the project sampling period. At base flow conditions, turbidity ranged from 11.70 NTUs to a maximum of 113 NTUs. The median turbidity at this site was 38.90 NTUs. The minimum flow was measured at 0.119 CFS and the maximum flow was measured at 1.58 CFS. The median flow was 0.64 CFS.

Only one base flow sampling event (on August 13, 1998) occurred at this site for the parameters: chloride, sulfate, total hardness, TSS, total phosphorus, nitrate, and Kieldahl nitrogen (TKN).

No standards violations were recorded for pH, dissolved oxygen, metals, and pesticides. The site was not evaluated for nutrients, chloride, and sulfate. Site 5 is not supporting its beneficial use based on turbidity violations (9 of 32 samples exceeded criteria).

4.4. Seep Water Quality

Twenty-seven seeps were monitored in the Lake Creek Watershed. The table below (table 19) displays the seeps and data collected for pesticides. The number of detections and the percent detections are displayed at the bottom of the table. Oklahoma Water Quality Standards mandate the groundwater should not contain detectable quantities of pesticides; therefore detections and percent detections represent water quality standards violations.

Seeps were violating standards due to detectable pesticide concentrations as much as 32% of the time. The most frequently detected pesticides included Aldicarb, Atrazine, and Alachlor. Pesticides were detected in seeps sampled throughout the year.

Nitrate concentrations were above allowable levels for drinking water in two of the 27 seeps. Nitrate was detected in all samples collected with concentrations ranging from 0.003 mg/l – 63.2 mg/l. The median concentration was 0.25 mg/l, well below the drinking water standard of 10 mg/l.

Concentrations of orthophosphate were generally low, ranging from 0.001 – 0.51 mg/l, with a median value of 0.01 mg/l. Orthophosphate concentrations were generally at background levels in all but four of the seeps.

Seeps A, C, D, F, M, O, and V may be near or influenced by sources of nutrients based on concentrations of nitrate and orthophosphate detected that were above the concentration detected in other seeps or nearby wells. Further investigation of the landuse adjacent to these seeps may suggest reasons for elevated nutrient concentrations detected at these sites.

Conductivities, pH, and alkalinities of the seep samples were indicative of water that has been in contact with the aquifer long enough to become mineralized. In other words, these concentrations were not indicative of “new” water from precipitation, but rather waters that had moved through the aquifer and soil and rock layers. However, the relatively high concentrations of nutrients in some seeps, coupled with the prevalence of pesticides in seep samples, suggests a strong interaction between surface activities and ground water.

Table 16: Pesticides Samples From the Lake Creek Seeps that Concentrations Were Above Detection Limits

Site name	Date	2,4-D (ppb)	Alachlor (ppb)	Aldicarb (ppb)	Atrazine (ppb)	Captan (ppb)	Carbofuran (ppb)	Chlorothalonil (ppb)	Metolachlor (ppb)	Paraquat (ppt)	Triclopyr (ppb)
Detection Limit		0.7	0.05	0.25	0.05	0.01/0.08	0.06	0.07	0.05/0.10	50.0	0.03
A	12/16/98		0.1		0.1			0.1			
B	12/16/98		0.1		0.1			0.1			
B	02/10/99						0.12				
B	03/17/99								0.07		
B	04/06/99			1.46							
B	04/20/99			0.73							
B	10/08/99			0.63							
C	05/21/99			0.67							
C	07/08/99		0.33								
D	12/16/98		0.1		0.1			0.1			
D	04/20/99			1.04							
E	12/16/98		0.1		0.1			0.1			
E	04/20/99			0.55							
E	05/21/99			0.5							
E	06/02/99						0.15				
E	06/14/99			0.84							
F	10/01/98			0.46			0.27			50.89	
F	06/14/99			0.51							
F	07/21/99		0.11								
F	08/31/99		0.21								
H	04/06/99			0.29							
H	04/20/99			0.46							
H	05/21/99			0.55							
H	06/14/99			1.14							
J	05/07/99			0.37							
J	05/07/99			0.37							

K	04/06/99				0.34						
K	04/06/99				0.34						
L	12/16/98		0.1		0.1			0.1			
L	04/20/99		0.13	1.53							
L	05/21/99			0.79							
L	08/03/99								0.11		
L	08/31/99		0.12								
M	04/20/99		0.13	0.47							
M	05/21/99			0.71							
M	06/14/99			0.64							
M	10/08/99			1.09							
O	08/03/99							0.15	0.11		0.05
O	08/31/99						0.065	1.57			0.14
R	04/06/99						0.2				
R	04/20/99		0.09	0.43					0.35		
R	05/07/99				0.07						
S	12/16/98		0.1		0.1		0.24	0.1			
S	04/20/99			0.41							
S	05/21/99			0.63							
S	06/14/99			0.54							
U	04/20/99			0.54							
U	05/07/99					0.03			0.71		
V	04/06/99						0.07				
V	04/20/99		0.11								
V	05/07/99				0.07		0.13				
V	05/21/99			0.68	0.12						
V	06/14/99			0.54							
V	07/21/99	22.94	0.06					0.08			0.37
W	04/20/99		0.36	0.45							0.06
W	05/07/99				0.8						
X	05/07/99			0.62							
X	05/21/99			0.72							

X	06/14/99			0.58				0.17			
Y	12/16/98		0.1		0.1			0.1			
Z	12/16/98		0.1		0.1			0.1			
ZZ	12/16/98		0.1		0.1			0.1			
# of detections		1	19	33	15	1	8	13	5	1	4
% detections		1.5%	19.6%	31.7%	12.2%	2.4%	6.4%	11.4%	4.2%	9.1%	3.6%

4.5. Biological

4.5.1. Fish Collection Results

OCC collected fish at Lake Creek Site 1, Site 2, Site 4, and Site 5. At those four sites 3,363 total fish comprising of 15 different species were collected (see below).

Common Carp	*Cyprinus carpio*
Red Shiner	*Notropis lutrensis*
Sand Shiner	*Notropis stramineus*
Fathead Minnow	*Pimephales promelas*
Bullhead Minnow	*Pimephales vigilax*
Yellow Bullhead	*Ictalurus natalis*
Black Bullhead	*Ictalurus melas*
Channel Catfish	*Ictalurus punctatus*
Plains Killfish	*Gambusia dicksmoker*
Mosquito Fish	*Gambusia affinis*
River Carpsucker	*Carpiodes carpio*
Green Sunfish	*Lepomis cyanellus*
Bluegill Sunfish	*Lepomis macrochirus*
Longear Sunfish	*Lepomis megalotis*
Largemouth Bass	*Micropterus salmoides*

As described in the previous sections, fish were analyzed utilizing protocols from EPA RBP III (*EPA,1989*). Total species, number of Centrarchedea species, number of sensitive benthic species, percent tolerant individuals, percent omnivores, percent insectivore Cyprinidae, percent top carnivores, and total number of fish collected are the eight metrics utilized to describe and quantify the fish community in Lake Creek. The following tables are the collections from the Lake Creek sites 1-5.

Table 17: Fish Collected at Lake Creek Sites 1, 2, 4, and 5

Lake Creek #1	OK310830-06-0040G	08/19/98
Common Name	Collected Seine	Collected Shocker
Red shiner	319	330
Common carp	1	5
Sand shiner	7	39
Fathead minnow	4	21
Bullhead minnow	4	22
Black bullhead		6
Yellow bullhead	1	84
Channel catfish		13
Mosquitofish	69	107
Green sunfish		18
Bluegill		5
Longear sunfish	1	19
Largemouth bass	3	12

Lake Creek #2	OK310830-06-0040K	08/20/98
Common Name	Collected Seine	Collected Shocker
Red shiner	153	220
Common carp	2	31
Sand shiner	3	2
Fathead minnow		2
Bullhead minnow	2	11
River carpsucker		1
Black bullhead		3
Yellow bullhead		8
Channel catfish	40	24
Plains killifish	6	3
Mosquitofish	118	295
Green sunfish	2	30
Longear sunfish		1
Largemouth bass		1

Lake Creek #4	OK310830-06-0040N	08/20/98
Common Name	Collected Seine	Collected Shocker
Red shiner	230	168
Sand shiner	12	21
Fathead minnow	27	89
Bullhead minnow	2	17
Yellow bullhead	1	3
Plains killifish	21	5
Mosquitofish	6	19
Green sunfish		1

Lake Creek #5	OK310830-06-0040Q	08/21/98
Vern Name	Collected Seine	Collected Shocker
Red shiner		118
Sand shiner		3
Fathead minnow		7
Bullhead minnow		15
Yellow bullhead		1
Mosquitofish		548
Green sunfish		1

Thirteen species and 1,090 fish were collected from Lake Creek Site 1. Lake Creek Site 2 had 958 fish collected comprising of 14 species. Lake Creek site 4 had a total fish collection of 622 with eight species and Lake Creek site 5, 693 total collected comprising of 7 species.

The Lake Creek fish collections were scored against the selected pooled reference. This score is based on the percentage of the site compared to the pooled reference score. However, some metrics are scored as a percentage of the collected population rather than the pooled reference score. Each percentage is given a numerical score and tallied. These tallied IBI scores are then compared against a modified Index Score Interpretation (*EPA, 1989*). The modification is simply to adjust for the reduction in the amount of metrics used to evaluate the fish community.

Table 18: Level of Fish Community Impairment.

Site	*IBI*	*Status*
Lake Creek 1	17	Poor
Lake Creek 2	13	**Very Poor**
Lake Creek 3		Not Collected
Lake Creek 4	9	**Very Poor**
Lake Creek 5	11	**Very Poor**
Pooled Reference	28	Reference

Using reference sites, a "best fit" line was drawn using total IBI and habitat scores. Habitat is the independent variable and the IBI is the dependent variable. A "best fit" or regression line is drawn using the data from the reference scores. This regression line relates habitat scores to the IBI scores. This enables the determination of the degradation of the biological (fish) community in relation to the degradation of the habitat within the stream in question.

Analysis of the fish collected from Lake Creek show the fish communities are in poor condition at Site 1 and very poor at sites 2, 4, and 5. All of the sites were assessed for 400 meters during the fish collections. Fish communities depend on the different types of habitat within a waterbody. When habitats become unstable or degraded by natural or anthropogenic effects, the species composition of the stream may change. Certain species may prevail while others will simply dwindle in numbers or disappear completely from the reach. The measurement of the habitat variables is critical in determination of whether the biological communities are degraded due to habitat destruction or water quality problems.

The most stable habitat was measured at Site 2 (39.2 points) and the poorest habitat was measured at Site 1 (28.8 points). At all of the sites, a high degree of siltation was recorded and the majority of the streams reaches consisted of shallow sandy runs. The average depths ranged from 0.05 -0.2 meters. The deepest point measured within all of the assessed reaches was 0.3 meters. Extremely poor riparian zones with little stable cover typify the reach. The majority of the stable cover for fish and macroinvertebrates consist of emergent aquatic vegetation and terrestrial vegetation over hanging into the stream. Bank vegetation consist of primarily grasses, however, at Site 1 mixtures of grasses, shrubs, and trees were recorded. Unstable point bars, scouring features, and poorly vegetated banks were recorded throughout all of the reaches.

Table 19: Lake Creek Habitat Scores

Site	**99' Habitat Score**
Lake Creek 1	46.6
Lake Creek 2	47.7
Lake Creek 3	Not Assessed
Lake Creek 4	46.5
Lake Creek 5	37.6
East Roaring Creek	64.1
Captain Creek	46.7

When compared with the data gathered during the 1988 study conducted by the OCC, the habitats within the reaches in Lake Creek tend to show a high degree of deterioration. The habitat protocol was similar but not exactly the same as the habitat protocol in 1998. However, side-by-side comparisons of the habitat assessments from 1988 and 1999 show the magnitude of the change in relation to the habitat scores.

Table 20: Comparison of 1998 Habitat Scores to the 1988 Habitat Scores

Site	99' Habitat Score	88' Habitat Score
Lake Creek 1	46.68	101
Lake Creek 2	47.7	88
Lake Creek 3		83
Lake Creek 4	46.5	103
Lake Creek 5	37.6	84

- Lake Creek Site 1 consisted of 5% stable cover for fish and aquatic macroinvertebrates. The average depth was 0.1 meter in depth, the minimum and maximum depth in the section were 0.05 meters and 0.3 meters, respectively. The reach consisted of 100% sandy, shifty run. The substrate in all of the sections was composed of 95% sand and 5% particulate organic matter (POM). Depositional and scouring features were recorded for 100% of the reach. The average canopy cover was 5%. This riparian zone was the highest quality of all riparian zones assessed in the Lake Creek watershed. The average riparian zone width was 33 meters wide and judged to be in good to excellent condition. No observations of cattle or cattle degradation were observed within the reach.

- Lake Creek Site 2 consisted of 5% stable cover. The minimum recorded depth was 0.05 meters. The maximum-recorded depth was 0.2 meters, with an average depth of 0.15 meters. The reach consisted of 90% shallow, sandy runs. The remaining 10% consisted of a hardpan clay riffle and a shallow pool. Sand was the primary substrate (90%) with a small portion of silt (5%), POM (3%), and hardpan clay (2%) making up the remaining percentage. Depositional and scouring features were observed for 100% of the reach. The average canopy cover was 5%. The riparian zone was an average width of 4.5 meters wide. The riparian zone was judged to be in poor to very poor condition. The primary makeup of the riparian zone was 80% grass. Cattle trampling was recorded for 44% of the reach. Twenty-four cow flops were counted one meter upstream and downstream of each transect.

- Lake Creek Site 3 was not assessed for this reach.

- Lake Creek Site 4 consisted of 3% stable cover for fish and aquatic macroinvertebrates. The minimum recorded depth was 0.05 meters. The maximum-recorded depth was 0.3 meters and the average depth for the entire reach was 0.15 meters. The reach consisted of 100% shallow, shifty, sandy runs. Ninty-two percent of the substrate consisted of sand with the remaining 8% consisted of POM and to a lesser extent silt. Depositional and scouring observations were made for 75% of the reach. The canopy covered 4% of the entire reach. The riparian zone was an average width of four meters wide and judged to be in poor to very poor in condition. The primary makeup of the riparian zone was grasses (75%) and shrubs (25%). Cattle trampling was recorded one meter upstream and one meter downstream of each transect. An average of 49% of each transect was trampled. Fourteen cow flops were counted within the assessed reach.

- Lake Creek Site 5 consisted of 4% stable cover for fish and aquatic macrinvertebrates. The minimum and maximum-recorded depth were 0.05 meters and 0.1 meters, respectively. The average depth was 0.10 meters. The reach consisted of 100% shallow, sandy runs. Seventy percent of the substrate consisted of sand with the remaining 30% consisting of POM and to lesser extent silt. Depositional and scouring was observed in 65% of the reach. The canopy covered approximately 1% of the entire reach. There was no observed riparian zone within this surveyed reach. The primary bank vegetation consisted of 100% grasses. Thirty percent of each transect had trampling within one meter upstream and one meter downstream of that transect. Approximately three cow flops were counted during the survey.

4.5.2. Macroinvertebrate Collection Results

As previously mentioned, the OCC collected macroinvertebrates from the Lake Creek sites. Samples were collected in the summer 1998, winter 1999, and summer 1999. The “EPA RBP for Use In Streams and Rivers” was used as guidance (EPA, 1989). The OCC utilized eight metrics to analyze the aquatic macroinvertebrates collected from Lake Creek. Biological condition scoring criteria for the metrics EPT/Total (Density), Shredders, and Shannon-Weiver were modified to better represent Southwestern Oklahoma streams (OCC). The OCC used Taxa Richness, a Modified IBI (using North Carolina tolerance indices), EPT/Total, Shredders, EPT/EPT + Chironomidae, EPT Taxa, Dominants to Total, and the Shannon-Weiver indices to describe the benthos macroinvertebrate community in Lake Creek.

Table 21: Modified Biological Condition Scoring Criteria

Metrics	***6***	***4***	***2***	***0***
Taxa Richness**	>80	60-80	40-60	<40
Modified Hilsenhoff Biotic Index* (***)	>85	70-85	50-70	<50
Modified IBI* (**)	>85	70-85	50-70	<50
Ratio of Scrapers and Filterers				
EPT/Total (Density)***	>30	30 & >20	<=20 & >10	<=10
Shredders***	>10	<=10 & >5	<=5 & >1	>=1
EPT/EPT + Chironomidae**	>75	50-75	25-50	<25
EPT Taxa (Index)**	>90	80-90	70-80	<70
Dominants to Total**	<20	20-30	30-40	>40
Shannon-Weiver***	>=3.5	<3.5&>=2.5	<2.5&>=1.5	<1.5

***Modified IBI Using North Carolina Tolerance Values**
****RBP for Use in Streams and Rivers, 1989**
*****Modified by OCC**

- Taxa Richness- is scored as a ratio of the study site to the reference site x 100 (EPA, 1989).
- Modified HBI- is a ratio of the reference site to the study site x 100 (EPA, 1989).
- EPT/Total (density)- scored as a percent of contribution (EPA, 1989).
- Shredders- scored as a percent of contribution (EPA, 1989).
- EPT/EPT + Chironomidae- is scored as a ratio of the study site to the reference site x100 (EPA, 1989).
- EPT Taxa (Index)- is scored as a ration of the study site to the reference site x100 (EPA, 1989).
- Dominants to Total- is scored as a percent contribution (EPA, 1989).
- Shannon-Weiver- scored directly with numerical guidance in the EPA RBP (EPA, 1989).

East Roaring Creek and Captain Creek were used as macroinvertebrate reference sites. The reference sites are deemed “high quality” sites that are representative of streams in fairly pristine condition. The reference sites are scored utilizing the same metrics as the sites being analyzed. Taxa richness, modified HBI, EPT/EPT + Chironomidae, and EPT Taxa (index) were scored as a percentage of the reference site and/or as a ratio of the study site. The metrics EPT/Total, Shredders, and Dominants to Total were scored as a percent contribution to that population. The Shannon-Weiver was scored directly to the numerical guidance set forth in the RBP (EPA, 1989). These reference scores were pooled for each collection. For example, each specific collection such as wood was compared directly to the scores for woody debris collected during that specific sampling period to the reference stream woody collection. Each study site was then compared as a percentage of the pooled reference score. The tables below display the results of the macroinvertebrate analysis.

Table 22: Macroinvertebrate Community Status

2/17/1999 (Winter)		Vegetation	
Stream Name	**Vegetation Score**	**Vegetation % of Reference**	**Status**
Lake Creek 1	10	35.7%	Moderately Impaired
Lake Creek 2	16	57.1%	Slightly Impaired
Lake Creek 3	-	-	Not Collected
Lake Creek 4	20	71.4%	Slightly Impaired
Lake Creek 5	18	64.3%	Slightly Impaired
Pooled Reference	28	-	Pooled Reference
9/1/1998 (Summer)		**Vegetation**	
Lake Creek 1	36	113.0%	Nonimpaired
Lake Creek 2	30	94.0%	Nonimpaired
Lake Creek 3	-	-	Not Collected
Lake Creek 4	26	81.3%	Slightly Impaired
Lake Creek 5	20	62.5%	Slightly Impaired
Pooled Reference	32	-	Pooled Reference
8/30/1999 (Summer)		**Vegetation**	
Lake Creek 1	-	-	No reference
Lake Creek 2	-	-	No reference
Lake Creek 3	-	-	No reference
Lake Creek 4	-	-	No reference
Lake Creek 5	-	-	No reference
Pooled Reference	-	-	Pooled Reference

2/17/1999 (Winter)		Wood	
Stream Name	**Wood**	**Wood % of Reference**	**Status**
Lake Creek 1	22	76%	Slightly Impaired
Lake Creek 2	20	69%	Slightly Impaired
Lake Creek 3	8	28%	Moderately Impaired
Lake Creek 4	36	124%	Nonimpaired
Lake Creek 5	18	62%	Slightly Impaired
Pooled Reference	29	-	Pooled Reference
9/1/1998 (Summer)		**Wood**	
Lake Creek 1	-	-	
Lake Creek 2	12	38%	Moderately Impaired
Lake Creek 3	-	-	
Lake Creek 4	-	-	
Lake Creek 5	-	-	
Pooled Reference	32	-	Pooled Reference

8/30/1999 (Summer)		Wood	
Lake Creek 1	16	47%	Moderately Impaired
Lake Creek 2	-	-	
Lake Creek 3	-	-	
Lake Creek 4	-	-	
Lake Creek 5	-	-	
Pooled Reference	34	-	Pooled Reference

During the sampling period there were significant collections that could not be used for analysis due to either not being collected or the reference sites lacked the specific habitat for comparison. The OCC weights the riffle and vegetation habitats much more than woody habitat collections. Woody habitat collections tend to be more variable and thus do not give as reliable of data as the other two habitat type collections. Unfortunately, riffle habitats do no exist in the reaches surveyed in Lake Creek and therefore could not be used for comparison. The data from the summer of 1999 was not used in the final analysis due to incomplete data for comparison. Vegetation samples during that period were not collected from the reference site. Woody debris from that same time period was not collected from the Lake Creek sites with the exception of one site (Lake Creek Site 1). No determination of the macroinvertebrate community will be determined during that summer. During the summer of 1998, collections were made from the streamside vegetation habitats and one collection from woody debris habitat (Lake Creek Site 2). Sufficient data is available for determination of the health of the biological community. The collection during the winter of 1999 is the most complete data set available and was used in final determination of the status of the macroinvertebrate community during the winter months.

The macroinvertebrate data during the summer of 1998 show varying levels of impairment. Lake Creek sites 1 and 2 were nonimpaired in relation to the reference sites. However, the woody debris collection from the summer of 1998 was moderately impaired. This again may be do to the variability of the woody debris. Site 3 was not collected due to lack of adequate flow during the collection period. Site 4 and 5 were both slightly impaired when compared with the reference sites.

During the winter of 1999, all vegetation collections were classified as slightly impaired and moderately impaired. Site 3 was not collected due to inadequate vegetative habitat during the collection period. Site 1 was classified as moderately impaired. Sites 2, 4, and 5 were classified as slightly impaired when compared against the reference sites. The woody debris collections during the winter of 1999 again showed varying degrees of impairment. Sites 1, 2, and 5 were all slightly impaired and site 3 was moderately impaired. Lake Creek site 4 was classified as nonimpaired.

The macroinvertebrate communities in Lake Creek show a range of impairments from a nonimpaired to moderately impaired status during the sampling period. However, the majority of the collections show some degree of impairment.

4.5.3. Bioassay Analysis

As mentioned in the previous sections, OCC collected water column and sediment samples for bioassays. The Cyprinid Pimphales promelas and the Cladoceran, Ceriodaphnia dubia, were used as test organisms. The tables below display the results of the tests. Further discussion of the results of these tests can be found in the discussions section of this report.

Table 23: Bioassays Results

Sediment

		Ceriodaphnia dubia			***Pimphales promelas***		
Site Name	Date	Control	Site	**Conclusion**	Control	Site	**Conclusion**
Lake Creek 6	4/19/1998	0	0	No significant effect	0	3	No significant effect
Lake Creek 2	5/13/1998	0	0	No significant effect	0	0	No significant effect
Lake Creek 2	6/11/1998	0	0	No significant effect	3	10	No significant effect
*	July	*	*	-	*	*	-
Lake Creek 2	8/26/1998	0	0	No significant effect	3	7	No significant effect
Lake Creek 2	9/15/1998	0	0	No significant effect	3	7	No significant effect
Lake Creek 2	10/19/1998	0	10	No significant effect	3	7	No significant effect
Lake Creek 2	11/9/1998	0	0	No significant effect	0	0	No significant effect
Lake Creek 2	1/11/1999	0	0	No significant effect	0	3	No significant effect
Lake Creek 2	3/10/1999	0	0	No significant effect	3	13	No significant effect
Lake Creek 2	7/19/1999	0	0	No significant effect	0	0	No significant effect
Lake Creek 2	8/16/1999	0	0	No significant effect	0	0	No significant effect
Lake Creek 2	9/13/1999	0	0	No significant effect	3	0	No significant effect

***Samples destroyed in route to the laboratory.**

Water							
		Ceriodaphnia dubia			***Pimphales promelas***		
Site Name	Date	Control	Site	**Conclusion**	Control	Site	**Conclusion**
Lake Creek 6	4/19/1998	0	0	No significant effect	3	7	No significant effect
Lake Creek 2	5/13/1998	0	0	No significant effect	0	3	No significant effect
Lake Creek 2	6/11/1998	0	0	No significant effect	3	0	No significant effect
-	July	*	*	-	*	*	-
Lake Creek 2	8/26/1998	0	0	No significant effect	3	0	No significant effect
Lake Creek 2	9/15/1998	0	0	No significant effect	3	0	No significant effect
Lake Creek 2	10/19/1998	0	0	No significant effect	3	0	No significant effect
Lake Creek 2	11/9/1998	0	0	No significant effect	3	0	No significant effect
Lake Creek 2	1/11/1999	0	10	No significant effect	0	3	No significant effect
Lake Creek 2	3/10/1999	0	0	No significant effect	0	7	No significant effect
Lake Creek 2	7/19/1999	0	0	No significant effect	0	3	No significant effect
Lake Creek 2	8/16/1999	0	0	No significant effect	0	7	No significant effect
Lake Creek 2	9/13/1999	0	0	No significant effect	3	0	No significant effect

***Samples destroyed in route to the laboratory.**

As mentioned in the previous sections, water column and sediment samples were collected, tested, and used as a medium for bioassays. These samples were tested for the following parameters pH, hardness, alkalinity, conductivity, total ammonia, total chlorine, and salinity. High ammonia concentrations were noted from the bioassays water column and sediment analysis. To determine whether ammonia concentrations in Lake Creek were at levels toxic to aquatic life, the OCC looked at temperature, pH, and total ammonia concentrations. These parameters were analyzed to extrapolate the %-unionized portion of the total ammonia concentrations. These concentrations along with pH, and temperature are displayed in the following table. The bioassays were not affected by the unionized portions of the total ammonia because the laboratory neutralized the unionized ammonia.

Table 24: Total Ammonia and Unionized Ammonia Concentrations

Site	Date	Type	Temp	pH	Total Ammonia	% Un-ionized Ammonia
Lake Cr.	4/19/1998	Bioassay/Sediment	25	7	19.2	0.108569762

Control	4/19/1998	Bioassay/Sediment	25	7.8	0.1	0.00346386
Control	4/19/1998	Bioassay/Sediment	25	7.9	0.1	0.004321979
Control	4/19/1998	Bioassay/Water	25	7.8	0.1	0.00346386
Control	4/19/1998	Bioassay/Water	25	7.9	0.1	0.004321979
Lake Cr.	4/19/1998	Bioassay/Water	25	8.3	0.2	0.020380882
Lake Cr.	5/13/1998	Bioassay/Sediment	25	7.6	3	0.066415437
Control	5/13/1998	Bioassay/Sediment	25	7.7	0.1	0.002771184
Control	5/13/1998	Bioassay/Sediment	25	8	0.1	0.005380833
Control	5/13/1998	Bioassay/Water	25	7.7	0.1	0.002771184
Control	5/13/1998	Bioassay/Water	25	8	0.1	0.005380833
Lake Cr.	5/13/1998	Bioassay/Water	25	8.4	0.2	0.024998412
Control	6/11/1998	Bioassay/Sediment	25	6.9	0.1	0.00044969
Lake Cr.	6/11/1998	Bioassay/Sediment	25	7.2	13.2	0.11790917
Control	6/11/1998	Bioassay/Water	25	6.9	0.1	0.00044969
Lake Cr.	6/11/1998	Bioassay/Water	25	8.3	0.6	0.061142647
Lake Cr.	8/26/1998	Bioassay/Sediment	25	7.1	4.32	0.030708316
Control	8/26/1998	Bioassay/Sediment	25	8.4	0.1	0.012499206
Control	8/26/1998	Bioassay/Sediment	25	8.4	0.1	0.012499206
Control	8/26/1998	Bioassay/Water	25	8.4	0.1	0.012499206
Lake Cr.	8/26/1998	Bioassay/Water	-	-	-	-
Lake Cr.	8/26/1998	Bioassay/Water	25	-	-	-
Lake Cr.	9/15/1998	Bioassay/Sediment	25	7.5	0.5	0.008832828
Lake Cr.	9/15/1998	Bioassay/Sediment	25	7.5	0.5	0.008832828
Control	9/15/1998	Bioassay/Sediment	25	8.2	0.1	0.00826784
Control	9/15/1998	Bioassay/Sediment	25	8.4	0.1	0.012499206
Control	9/15/1998	Bioassay/Sediment	25	8.5	0.1	0.015242273
Control	9/15/1998	Bioassay/Water	25	8.2	0.1	0.00826784
Control	9/15/1998	Bioassay/Water	25	8.4	0.1	0.012499206
Lake Cr.	9/15/1998	Bioassay/Water	25	8.5	0.4	0.060969091
Lake Cr.	10/19/1998	Bioassay/Sediment	25	7.5	3.2	0.056530097
Control	10/19/1998	Bioassay/Sediment	25	8.2	0.1	0.00826784
Control	10/19/1998	Bioassay/Sediment	25	8.5	0.1	0.015242273
Lake Cr.	10/19/1998	Bioassay/Water	25	7.5	3.2	0.056530097
Control	10/19/1998	Bioassay/Water	25	8.2	0.1	0.00826784
Lake Cr.	10/19/1998	Bioassay/Water	25	8.3	0.3	0.030571323
Control	10/19/1998	Bioassay/Water	25	8.5	0.1	0.015242273
Lake Cr.	11/9/1998	Bioassay/Sediment	25	7.5	0.5	0.008832828
Control	11/9/1998	Bioassay/Sediment	25	8.2	0.1	0.00826784
Control	11/9/1998	Bioassay/Sediment	25	8.5	0.1	0.015242273
Lake Cr.	11/9/1998	Bioassay/Water	25	7.5	0.5	0.008832828

Control	11/9/1998	Bioassay/Water	25	8.2	0.1	0.00826784
Lake Cr.	11/9/1998	Bioassay/Water	25	8.3	0.4	0.040761765
Control	11/9/1998	Bioassay/Water	25	8.5	0.1	0.015242273
Lake Cr.	1/11/1999	Bioassay/Sediment	25	7.7	2.4	0.066508424
Lake Cr.	1/11/1999	Bioassay/Sediment	25	7.7	24	0.665084245
Control	1/11/1999	Bioassay/Sediment	25	8.3	0.1	0.010190441
Control	1/11/1999	Bioassay/Sediment	25	8.4	0.1	0.012499206
Lake Cr.	1/11/1999	Bioassay/Water	25	8.2	0.4	0.033071359
Control	1/11/1999	Bioassay/Water	25	8.3	0.1	0.010190441
Control	1/11/1999	Bioassay/Water	25	8.4	0.1	0.012499206
Lake Cr.	2/8/1999	Bioassay/Sediment	25	7.8	3	0.103915805
Control	2/8/1999	Bioassay/Sediment	25	8.3	0.1	0.010190441
Control	2/8/1999	Bioassay/Sediment	25	8.6	0.1	0.018460327
Control	2/8/1999	Bioassay/Water	25	8.3	0.1	0.010190441
Lake Cr.	2/8/1999	Bioassay/Water	25	8.5	0.5	0.076211363
Control	2/8/1999	Bioassay/Water	25	8.6	0.1	0.018460327
Lake Cr.	3/10/1999	Bioassay/Sediment	25	7.9	14.4	0.622364913
Control	3/10/1999	Bioassay/Sediment	25	8.3	0.1	0.010190441
Control	3/10/1999	Bioassay/Sediment	25	8.5	0.1	0.015242273
Lake Cr.	3/10/1999	Bioassay/Water	25	8.2	0.7	0.057874877
Control	3/10/1999	Bioassay/Water	25	8.3	0.1	0.010190441
Control	3/10/1999	Bioassay/Water	25	8.5	0.1	0.015242273
Lake Cr.	7/19/1999	Bioassay/Sediment	25	8	1.9	0.102235834
Control	7/19/1999	Bioassay/Sediment	25	8.5	0.1	0.015242273
Control	7/19/1999	Bioassay/Water	25	8.3	0.1	0.010190441
Lake Cr.	7/19/1999	Bioassay/Water	25	8.3	0.2	0.020380882
Control	7/19/1999	Bioassay/Water	25	8.5	0.1	0.015242273
Lake Cr.	8/16/1999	Bioassay/Sediment	25	7.6	0.1	0.002213848
Lake Cr.	8/16/1999	Bioassay/Sediment	25	7.6	0.8	0.017710783
Control	8/16/1999	Bioassay/Sediment	25	8.3	0.1	0.010190441
Control	8/16/1999	Bioassay/Sediment	25	8.5	0.1	0.015242273
Lake Cr.	8/16/1999	Bioassay/Water	25	8.2	0.7	0.057874877
Control	8/16/1999	Bioassay/Water	25	8.3	0.1	0.010190441
Control	8/16/1999	Bioassay/Water	25	8.5	0.1	0.015242273
Lake Cr.	9/13/1999	Bioassay/Sediment	25	7.7	-	-
Lake Cr.	9/13/1999	Bioassay/Sediment	25	7.7	5.4	0.149643955
Control	9/13/1999	Bioassay/Sediment	25	8.2	0.1	0.00826784
Control	9/13/1999	Bioassay/Sediment	25	8.6	0.1	0.018460327
Control	9/13/1999	Bioassay/Water	25	8.2	0.1	0.00826784
Lake Cr.	9/13/1999	Bioassay/Water	25	8.2	0.8	0.066142717

Control	9/13/1999	Bioassay/Water	25	8.6	0.1	0.018460327
Lake Cr.	9/15/2009	Bioassay/Sediment	25	7.2	5.3	0.047342318

Nonionized ammonia is considerably more toxic than ionized ammonia. This is primarily due to the unionized or non-charged (neutral) particles being able to cross epithelial layers into the bodies of certain animals much more readily than the ionic form of ammonia. In order to determine whether the ammonia concentrations might be toxic, the concentrations of unionized ammonia were determined. A screening level of 0.05 mg/l unionized ammonia was used to indicate whether toxic levels existed in the Lake Creek watershed.

The table below displays the dates and the sample types that exceeded 0.05 mg/l unionized ammonia. A total of 34 tests were run on the Lake Creek samples (not including quality control samples). From the sediment samples, ten samples had levels of unionized ammonia that could be toxic to the aquatic life living in the interstitial zone between the water column and the substrate. From the water column samples, seven samples exceeded 0.05 mg/l unionized ammonia concentrations. Again, at these levels unionized ammonia could be toxic to aquatic life in the Lake Creek system.

Table 25: Sediment and Water Column Concentrations Exceeding 0.05 mg/l Unionized Ammonia

Sediment Exceeding 0.05 mg/l NH4				Water Column Exceeding 0.05 mg/l NH4		
Lake Cr.	4/19/1998	Sediment		Lake Cr.	6/11/1998	Water Column
Lake Cr.	5/13/1998	Sediment		Lake Cr.	9/15/1998	Water Column
Lake Cr.	6/11/1998	Sediment		Lake Cr.	10/19/1998	Water Column
Lake Cr.	10/19/1998	Sediment		Lake Cr.	2/8/1999	Water Column
Lake Cr.	1/11/1999	Sediment		Lake Cr.	3/10/1999	Water Column
Lake Cr.	2/8/1999	Sediment		Lake Cr.	8/16/1999	Water Column
Lake Cr.	3/10/1999	Sediment		Lake Cr.	9/13/1999	Water Column
Lake Cr.	7/19/1999	Sediment				
Lake Cr.	9/13/1999	Sediment				
Lake Cr.	9/13/1999	Sediment				

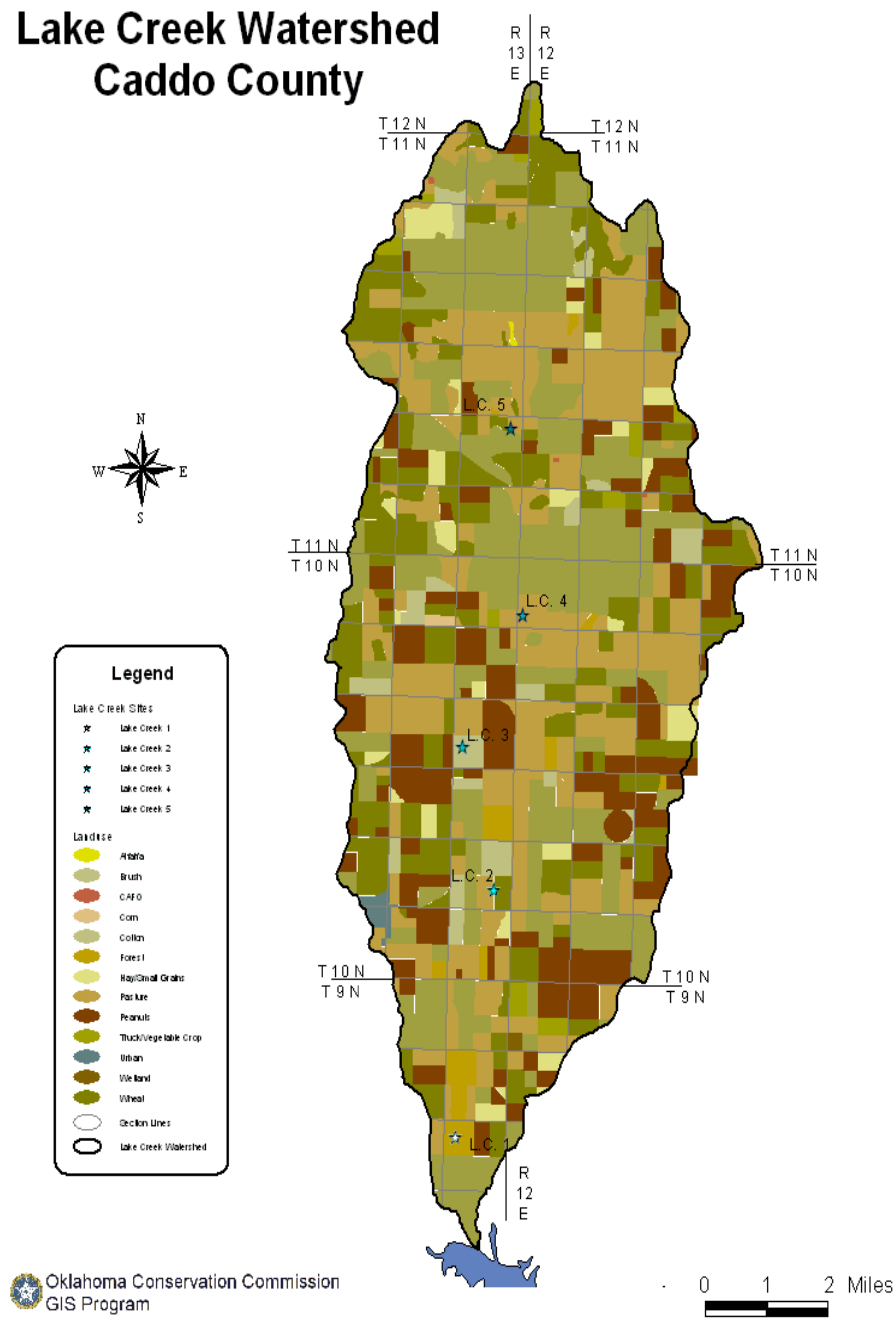
5.0. Implementation:

The Best Management Practices within the Lake Creek watershed were implemented through the West Caddo County Conservation District. A list of landowners was obtained from the conservation district for the watershed and surrounding area. Efforts were made to isolate the critical areas in the watershed with soils and other data sources that would enable BMP installation to be the most effective. Landowners were notified of potential cost share incentives through ads published in the local newspapers, personal communication, and two public meetings. Numerous one on one meetings were held with landowners to convince them of the importance of sound conservation planning. Below are three maps that were used in isolating areas that would best "target" sensitive soils, riparian areas, and landuse types deemed vulnerable. Areas that were identified include specific soils that have a high rate of percolation, a close proximity to the stream, and the landuse practices that fall within these specific soils.

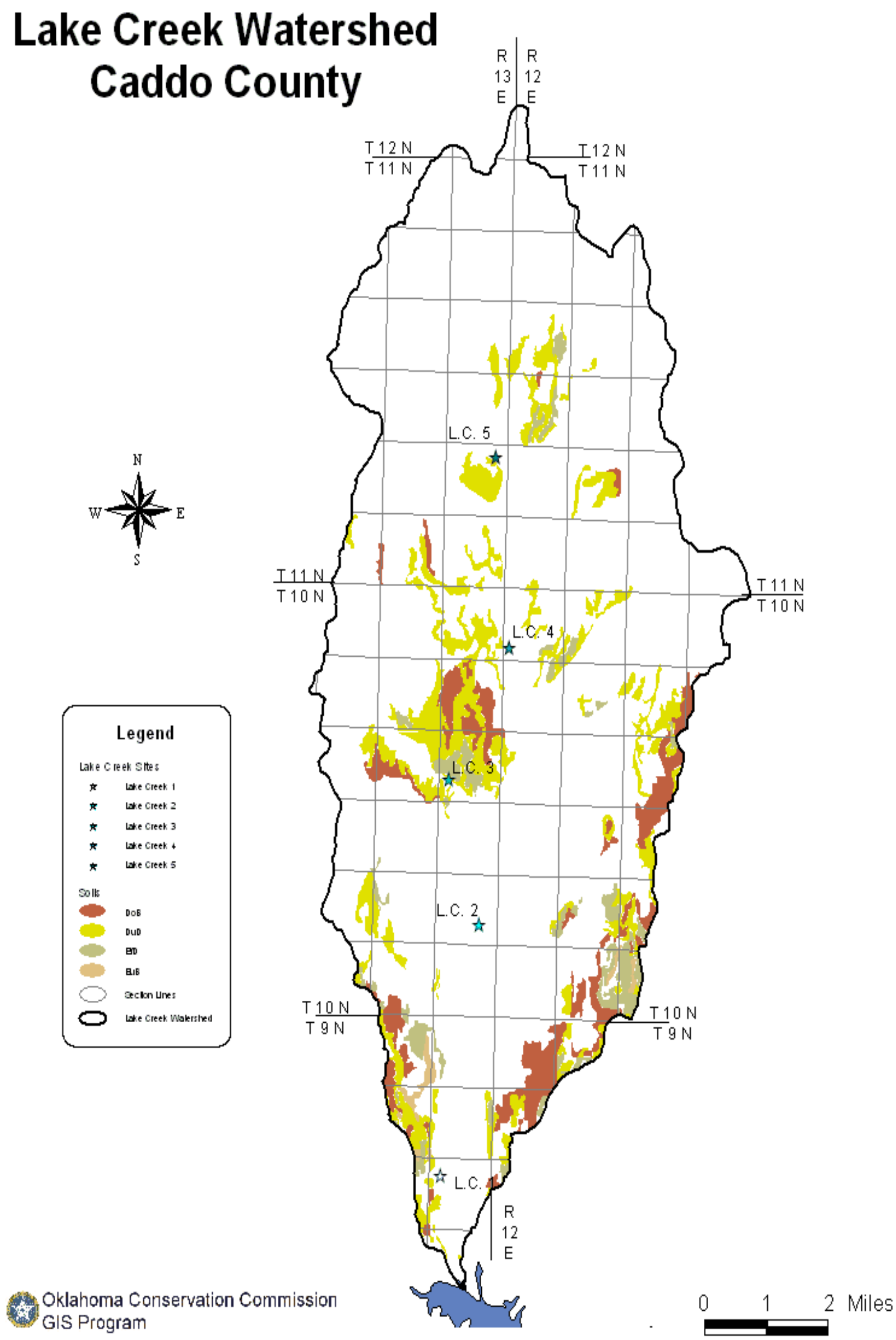
Cooperative agreements were signed with landowners that pertained to both management practices such as differed grazing and "on ground" implementation of BMP's. Practices included riparian zone fencing, critical area planting, riparian zone re-vegetation, construction of off-stream watering, drop structures, diversion terraces, deferred and rotational grazing. Map 1 below contains the landuses in the Lake Creek watershed. Map 2 displays the selected soils targeted by the OCC. Map 3 displays demonstration areas and implementation types in the Lake Creek watershed**.** Best management Practices were installed on thirteen different landowners' properties. A partnership was established with the West Caddo Conservation District, Master Conservancy District and the County Commissioner to implement the BMPs.

Table 26: Best Management Practices Installed in the Lake Creek Watershed

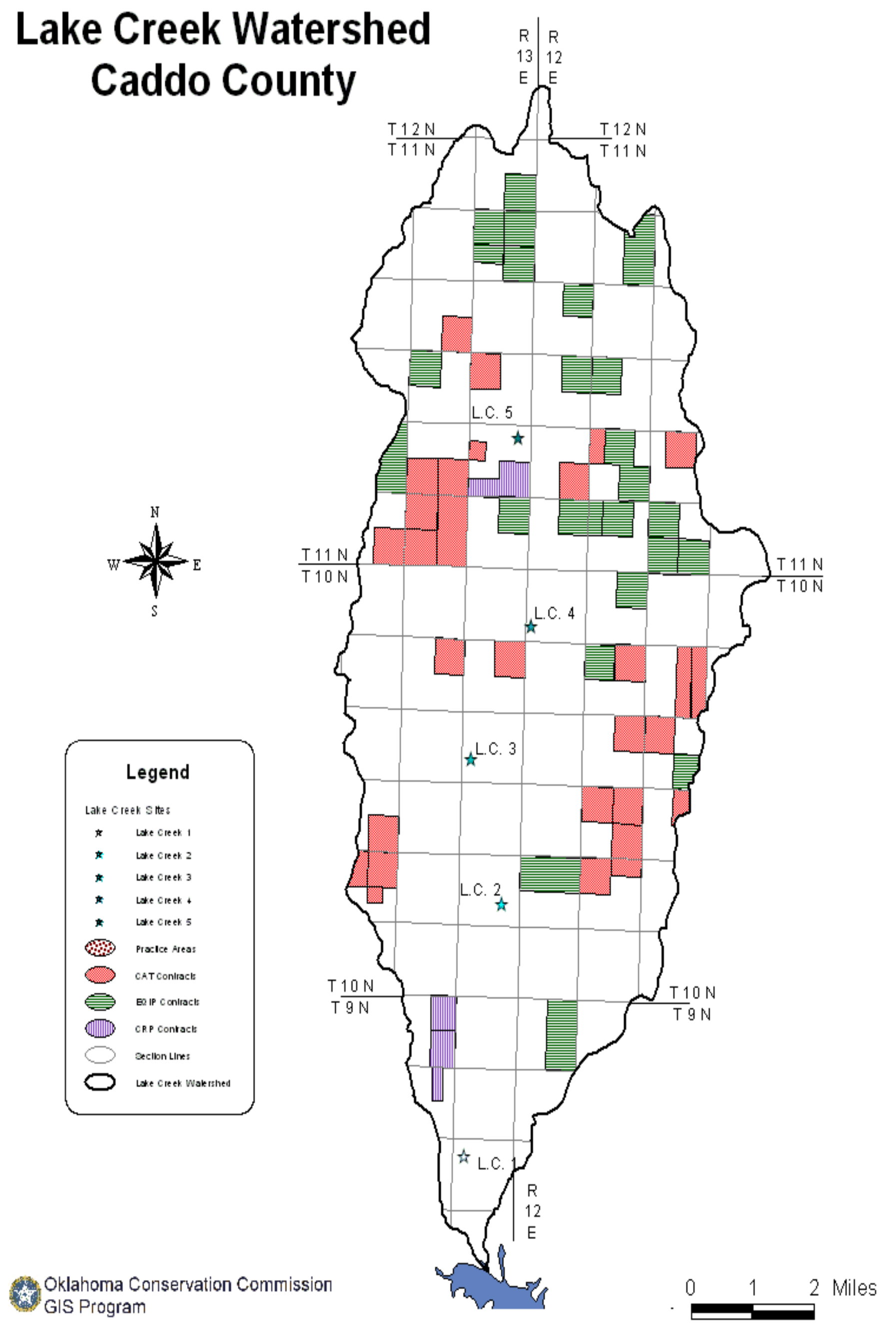
Practice	Amounts	Costs
4-wire fencing	19975 ft	$18,000
Pond excavation	3 ponds	$1,400
Grade stabilization structures	2	$11,700
Diversion terrace	1	$1,100
Deferred grazing	3 fields (52 acres)	No Cost
Rotational grazing	2 farms (368 acres)	No Cost
Critical area planting	1 acre	No Cost



Map1- Landuse in the Lake Creek Watershed



Map 2- Selected Soils Targeted by the OCC



Map 3- Demonstration and Implementation Types in the Lake Creek Watershed

5.1 Educational Efforts

The Oklahoma Cooperative Extension Service (OCES) completed the educational components of this project. Information regarding the educational aspects of this project can be found in the OCES "Technical Assistance to Improve the Quality of Ground Water-Surface Water Interactions Task III: Educational Component" final report. This report attached as Appendix 1.

The report details the activities of the OCES from 1998 – 1999 in support of the FY 1994 CWA 319(h) Nonpoint Source Pollution Program Task 400 grant entitled "Improving the Quality of Ground and Surface Water in the Lake Creek Watershed." The OCC administered the grant. The key personnel at OSU leading these activities included:

Project Director -- Michael D. Smolen, OCES Water Quality Programs Coordinator

Project Manager – J. Wes Lee, OCES Southwest Area Water Quality/IPM Specialist (currently OCES Educator, Agriculture for Murray County)

5.1.1 Introduction

The Lake and Cobb Creek watersheds are in one of the most intensive agricultural farming areas of the state. Over half of the state's peanuts are grown in or near these two watersheds, along with wheat, alfalfa and many other row crops. Due to the high dollar value, much of the farmland has been continuously planted to peanuts for several years. The landscape is riddled with irrigation wells tapping the relatively shallow Rush Springs Aquifer. Most of the farmland in the watershed is irrigated. The soils are very coarse and fragile, allowing for high infiltration rates and excessive erosion.

The watershed has had several water quality monitoring projects conducted in the past. One of the projects, FY1988 205(j)(5), Task 500, indicated numerous nonpoint source water quality concerns in the Lake Creek watershed. Principal concerns included low dissolved oxygen at low flow levels due to excessive nutrient enrichment, pesticide levels detrimental to algae and toxic to certain animals, and declining stream habitat caused by high erosion/siltation levels. These studies concluded that the primary causes for these problems were pesticide and nutrient runoff, soil erosion due to uninformed farming practices, and destabilization of riparian areas.

This educational project was developed to address the environmental issues identified in the previous monitoring projects. Most of the demonstration efforts of this project focused on crop production issues and included best management practices for tillage, pest management and soil fertility. Demonstration plots were located in producers' fields and at the Ft. Cobb Research Station, located directly adjacent to Fort Cobb Lake. Other demonstrations showed appropriate vegetation management and cattle exclusion devices on riparian areas.

The educational effort of the project targeted both adult and youth audiences. Workshops promoted the protection of riparian areas, the Rush Springs Aquifer, home drinking waters, and

Fort Cobb Lake. The educational projects were divided into 8 different "tasks". The tasks, the educational efforts conducted, and the results follow.

5.1.1a. Project-Area

The targeted area for this project included land in the Lake Creek and/or Cobb Creek watersheds in Caddo County. These two watersheds comprise the major drainage basin for Fort Cobb Lake. The watersheds are located over the Rush Springs Aquifer, one of Oklahoma's most widely used aquifers for irrigation purposes. Fort Cobb Lake is one of Southwestern Oklahoma's most popular recreation areas. Activities at the lake include fishing, camping, boating and swimming. It is also the sole source of drinking water for the Grady County town of Chickasha, population 16,000.

5.1.1b. Project-Objectives

The overall water quality objective of these activities was the improvement of the quality of ground and surface water through educational efforts, behavioral changes of landowners and land users, and of the implementation of Best Management Practices. The project also characterized the interactions between surface and ground water in areas of intensive agriculture. This involved both qualitative and quantitative components. This program will serve as a basis for other similar projects located across the state and information gained during its operation will be transferred to other areas through state Nonpoint Source agencies, the Cooperative Extension Service and the Natural Resource Conservation Service.

5.1.1c. Objectives for the Demonstration/Education Component

This project was a water quality education and "Best Management Practice" (BMP) demonstration project for Caddo County clientele located in and around the Lake Creek, Cobb Creek watershed area. The overall objectives were to increase the awareness of water quality issues and concerns and reduce pollutant loads that affect the Lake and Cobb Creek watersheds and ultimately Fort Cobb Lake. The primary focus was on demonstrating the water quality benefits of integrated pest management for peanuts, alfalfa and other row crops and of proper riparian area management. The project included educational efforts directed towards agricultural producers, homeowners, and youth.

The bulk of the field demonstration projects focused toward crop production including BMPs for tillage, pest management, and soil fertility. Demonstration plots were located in producers' fields or at the Fort Cobb Research Station, located directly adjacent to Fort Cobb Lake. Plots illustrated research-based BMPs for crop production to reduce nutrient, pesticide, and sediment loading to Lake Creek and Fort Cobb Lake.
Riparian area demonstration and education projects promoted adoption of riparian management and protection. Demonstration areas exhibited appropriate vegetation management and cattle exclusion devices.

Information gathered during two previous studies suggests that there is a significant interaction between ground and surface water with ground water discharges resulting in loading of NPS pollutants, some of which are toxic. There seems to be an absence of information for landowners on how land uses can adversely affect ground and surface water. An educational effort was directed toward the implementation of a farm management program for use in areas of shallow ground water where land uses directly affect ground water, and subsequently, surface water quality. This program can be used in conjunction with the development of conservation plans for landowners. A major focus of this program was the dissemination of information regarding potential cost savings for landowners through reduction of fertilizer and other chemical usage. This should provide the basis for establishing landowner interest and participation. We anticipate the long-term water quality benefits/changes resulting from these educational activities will at least minimize if not eliminate the impact of pesticides and nutrients in the system. Most of the time when implementing a project, public awareness will increase, affecting water quality benefits. We feel that these educational activities will help perpetuate the awareness factor and the improvements in water quality.

5.1.1d. Project Tasks

The goals of the project were divided into eight different tasks. A copy of the work plan delineating the tasks is provided as Appendix A. A listing of the eight tasks with a discussion of the education/demonstration activities undertaken to accomplish them follows.

Task 1. Educate 35 agricultural producers and residents, located in and around the Lake and Cobb Creek watersheds, on the water quality benefits of maintaining effective riparian areas and how they should be properly protected.

This project included both a field demonstration and a classroom educational component. The demonstration site was established on April 5, 1999. The site consisted of a 1/2 mile of creek where virtually no trees existed. A severe drought during the summer of 1998 left the area heavily overgrazed and exposed the sandy soils to high levels of erodibility. The riparian area of the creek was fenced along the sides but cattle were allowed free access to the creek. To demonstrate effective management of a riparian zone an electric fence was installed that divided the 1/2 mile creek into two 1/4 mile sections (see attachment #1). In one half of the plot, from the electric fence south, cattle were excluded from grazing and 4000 bare root trees were planted on the eroding creek banks. On the advice of the State Forest Service the following number and species of trees were planted:

- 750 Shumard Oak
- 750 Burr Oak
- 100 Black Walnut
- 300 Bald Cypress
- 2100 Black Locust

The oaks and walnuts were planted in a 10' x 6' grid along the top of the creek channel. Three rows of trees were planted on each side. These native trees were selected because of there long term potential for stabilizing the soil and to provide food and cover for wildlife. Cypress and locust trees were planted in a random pattern within the creek channel. These fast growing, self-populating trees should provide soil erosion benefits in a short period of time. Trees were planted under ideal conditions and received adequate rainfall for the first three months. The initial survival rate of the hardwood trees along the top of the creek channel was estimated to be 75%. Trees within the channel initially had a much better rate of survival at around 95%.

The newly planted trees faced little or no rain during July and August 1999. Signs of stress were quick to appear, the drought being compounded by the limited root systems and the deep sandy soils. A severe infestation of grasshoppers was also present during these summer months. In addition, the heavy overgrazing of the area in 1998 enabled weeds to become established in 1999 and "choke out" some of the slower growing trees. As a result, tree survival was reduced to an estimated 25% for the hardwoods and 80% for the softwoods by the end of the summer. However, if these survivors grow to maturity, this population should still meet the desired goals of the project.

Nine photo points were established to help determine the effectiveness of the riparian protection program. A description of the photo points can be seen in attachment #2. The "before" photos were taken on 3/23/99, within two weeks of the planting date. "After" photos were taken on 9/8/99. These digital photos are included with the enclosed disk. The increase in vegetation due to livestock exclusion is clearly evident in the photos (Appendix 1). The black locusts performed extremely well, as indicated in the photos, and should have a large enough root system by next summer to assist in soil stabilization. Seedlings of various other tree species, including willow, cottonwood, and red cedar, have also appeared in the creek channel since the cattle were excluded.

The site was toured on May 5, 1999 in conjunction with the riparian educational program. The Caddo County Natural Resource Conservation Service and the local conservation district were included in the design and implementation of the demonstration and will continue to monitor the site.

Establishing an effective riparian demonstration site is a long-term effort. The effects of mismanagement on an area cannot be completely "undone" in one year. The goal of this short-term demonstration has been accomplished. However, the long- term effects of a properly managed riparian zone should provide an excellent educational opportunity for years to come.

Riparian Education Meeting

On May 5, 1999, twenty-five participants attended an all-day workshop at the Caddo Electric Cooperative in Binger, OK. This meeting was part of the FY1993 319 Task 300 project “Technical Assistance for the Establishment and Maintenance of Riparian Corridors.” OCES and NRCS staff organized and presented a program on the importance and function of riparian areas and also discussed management options that benefit these areas. Speakers from these two agencies as well as OCC and ODA-Forestry Division presented information on these topics during a morning classroom session.

During the afternoon, workshop participants toured nearby sites of riparian interest. Discussion at the various sites centered upon the dynamics of stream flow and the resultant changes in the stream channel. The Lake Creek riparian demonstration area provided a first-hand look at some of the methods available to landowners to combat the degradation of riparian areas on their holdings.

Results of the pre- and post-testing of the workshop attendees indicated fewer incorrect answers on questions concerning riparian characteristics. Attendees learned that woody plants hold soil better than grasses, creek straightening does not reduce flooding, "S"-shaped channels are the most efficient, recreational leases can be more profitable than traditional cropping, bridges cause erosion, riparian vegetation helps regulate dissolved oxygen, and invasive species reduce biodiversity. However, when questioned on management-specific information, the improvements in the scores were less well defined. These findings were echoed in the comments provided by attendees on the workshop evaluation forms. Many attendees requested more information on management-specific issues and solutions to problems. More demonstration sites, such as the one installed in the Lake Creek watershed, that provide concrete examples of problem solving would help move riparian awareness from knowledge to application.

Task 2. Educate 25 crop producers in the watershed area to reduce pesticide use by using appropriate pest infestation thresholds and integrated pest management techniques.

To accomplish the goals of this task, four educational meetings were conducted. Three of the meetings were designed for peanut producers in the Lake Creek Watershed. At the first meeting on March 25, 1999, material was presented to producers, industry personnel, and crop consultants in a classroom setting (See attached brochure). The 16 in attendance were taught how to effectively scout for peanut insects, weeds and diseases. Material was also presented on proper use of the "Peanut Leafspot Model".

Two in field "peanut turn row" meetings were at the Fort Cobb Research Station on June 16 and September 8, 1999 (see appendix #3). Eight (8) producers participated in the first meeting and the second had 12 in attendance. Identification and management of early season and late season pests were discussed. The groups also toured several demonstrations sites such as the leafspot model plots (see task 4 below), peanut herbicide trails, and disease management plots at the station.

An integrated pest management clinic for alfalfa production was held on March 9, 1999, in Chickasha (see attached brochure). Twenty (20) alfalfa producers from Caddo, Grady, and McClain Counties learned techniques for proper weed and insect scouting, determining pest thresholds, interpreting soil test reports in a classroom setting before being transported to the South Central Research Station for hands-on scouting activities.

Evaluations from the alfalfa clinic participants indicated the educational efforts were successful. Attendees particularly liked having the complete pest management program discussed at one meeting. Responses are included as Appendix 4. It is anticipated that this program will be continued in the future.

Task 3. Convert 15 peanut fields in and around the Lake/Cobb Creek watershed to a Ro-till reduced tillage plan.

The original plan of this task to purchase or lease a reduced tillage implement and convert 15 fields to a reduced tillage plan had to be modified. These machines are no longer in production, and an operable used "Ro-Till" machine for purchase or long-term lease could not be located. The North Caddo Conservation District served as an advisory board to modify the task. They suggested the practice be demonstrated at the Caddo Research Station, and located a suitable machine available for a two-day lease to implement the demonstration.

The demonstration consisted of four 8 row X 150 ft plots. Spanish peanuts were planted on normal planting dates (late May) in two of the plots. Plot 1 was planted in conventional clean tilled soil. In plot 2, the soil bed was prepared using a reduced tillage method that left small grain stubble from the previous crop in the row middles. Fertility, fungicides, irrigation and management were kept identical between the two plots. These plots were used to compare the yield potential of reduced till versus clean till. In the remaining two plots "sacrifice" peanuts were planted the first week of August. Tillage was the same as in the first two plots with plot 3 being clean till and plot 4, reduced tillage. Identical management after planting was also used for these two plots.

On September 21, 1999, all peanut producers in the state were invited to attend a tour of the plots at the Caddo Research Station. Approximately 70 producers, agency personnel, consultants, and industry representatives attended the tour. The rainfall simulator was set up to cover a 50-ft circle in plots 3 and 4. Rainfall at the rate of 2.5 inches per hour was applied to the plots. Runoff was channeled and collected in glass jars to view sediment loads. In the clean till area the soil surface "sealed" off and runoff began almost immediately. In the plot with residue on the surface, water infiltration rates were better and runoff was delayed significantly. The sediment load was also lower in the runoff of the reduced till plot. Based on discussions held with participants following the demonstration, the tour was considered a success.

Task 4. Demonstrate and distribute "The Peanut Leafspot Advisory" directly to 25 producers, CO-OPs, or producer gathering points (i.e. local coffee/donut shops) bi-weekly from June 1 through harvest.

The peanut leafspot advisory is a modeling program designed to better manage fungicide applications on peanuts. The model is developed from weather information gathered daily by the Oklahoma MESONET system. To implement this task the data was collected from two MESONET sites, Ft. Cobb and Hinton, OK. This information was organized into a calendar-based format (see appendix #5), and faxed twice-weekly throughout the growing season to fifteen (15) gathering points for peanut producers, including peanut buying points, extension offices, Co-op's, and a local radio station. These locations were asked to post the calendars in easily viewed locations. The fax program was conducted in both 1998 and 1999.

To complement the fax program, a demonstration site was established at the Fort Cobb Research Station. Spanish peanuts were planted in 4 plots on May 25, 1999. Each plot consisted of 8 rows of peanuts that were 120 feet long. In each plot a different leafspot management strategy was demonstrated as described below.

Plot 1 = AUPNUT Model. This model developed by the Alabama CES utilizes rainfall or irrigation events to trigger a leafspot fungicide application.
Plot 2 = Traditional 14-Day Program. A fungicide application was made 30 days after planting and every 14-calendar days thereafter. This is the schedule most often used in the project area.
Plot 3 = Check Area. Peanuts were sprayed 30 days after planting and no additional applications were made.
Plot 4 = MESONET Leafspot Advisory. Peanuts were sprayed according to infection hours determined from weather information gathered daily from automated weather towers in the area.

The fungicide Tilt+Bravo® was used for all required applications. There were three applications made to plot 1, five applications to plot 2, one application to plot 3, and two applications were made to plot 4. Very few leafspot lesions could be found anywhere in the demonstration area. Due to this below-average leafspot disease year, no significant differences between the plots were observed. The plots were viewed during the IPM program tour conducted as part of Task 2 and participants in the reduced tillage demonstration tour of Task 3 were also allowed to informally tour the plot.

Task 5. Have at least 5 low-pressure ground sprayers used for pest control in and around the watershed properly calibrated.

The sprayer calibration project was not accomplished. Most of the spraying in the Lake Creek watershed is done commercially with a large percentage being accomplished by air. Peanuts are the primary crop in the area to which pesticides are applied. After peanuts "lap" in mid-summer, it becomes difficult to spray by ground rig because of the damage done by driving on the vines. This task was not attempted until too late in the year for sprayer calibration to be worthwhile. No funds were expended for this task.

Task 6. Demonstrate appropriate nitrogen fertility management for small grains grown in or around the Lake/Cobb Creek watershed.

A wheat fertility demonstration site was established in the watershed on October 20,1998. The deep sands, low organic matter and low nitrogen (N) carryover rate of the selected site were characteristic of the area. A soil test at the beginning of the project produced the following results:

PH = 6.1 Surface NO_3-N = 2 P = 69

Buffer = 7.1 Subsoil NO_3-N = 8 K = 259

A plot map (Appendix 6) illustrates the design for this demonstration. A 5-ft "Gandy" drop spreader was used to apply 34-0-0 fertilizer at six different rates to different sections of the plot. These six treatments were:

- 200 Lbs. of actual N fall applied.
- 100 Lbs. of actual N fall applied.
- 50 Lbs. of actual N fall applied.
- 50 Lbs. of actual N fall applied, plus 50 Lbs. of actual N spring applied.
- 100 Lbs. of actual N fall applied, plus 100 Lbs. of actual N spring applied.
- Control with no N applied.

An electric fence was installed around the plot to prevent cattle grazing on the site. A wheat herbicide demonstration was established adjacent to the fertility demonstration to ensure adequate material for a field day to demonstrate the results (see plot plan).

In February 1999, the plots were toured by a group of eight Extension Agriculture Educators. The effects of the N-fertilizer and herbicides were quite apparent. In the spring however, the site became overgrown with hairy vetch and cereal rye. The infestation was so severe the fertility plots could not be distinguished and cattle were returned to the area. Consequently, the formal producer tour scheduled for May was cancelled. The plots were in a highly traveled area with appropriate signage and the location was advertised in various newsletters. Local producers did view the plots on an informal basis.

Task 7. Educate 150 homeowners with water wells in and around the watershed about wellhead protection techniques and water quality standards.

The objective of this task was accomplished by utilizing materials from the “Oklahoma Farm and Ranch*A*Syst” and the “Oklahoma Home*A*Syst” programs. Three educational meetings were held in or near the Lake Creek watershed. Participants were presented information on proper septic tank management, water well construction, wellhead delineation, and EPA primary and secondary drinking water standards. A water test screening, consisting of nitrate, TDS, and pH was conducted for all participants who brought samples to the meetings. Bacteriological testing at the state laboratory was offered for all meeting participants free of charge.

The first meeting was held on 8/11/98 at the Eakly High School cafeteria. There were 35 in attendance with 53 water samples analyzed. Two days later (8/13/99) the second meeting was held at the Fort Cobb Vo-Tech auditorium. At this meeting, 30 participants brought in 32 water samples. The results of individual water test screenings were confidential. However, summary information was obtained and indicated that 24 of the 85 samples (28%) exceeded the secondary drinking water standard of 500 ppm of TDS. The highest TDS obtained was 1551 ppm. A shockingly high percentage of the samples exceeded the primary drinking water standard of 10 ppm nitrates. Fifty-five (55) of the 85 samples tested, or 65%, were above the standard. The highest nitrate recorded was 63.8 ppm. These tests were considered a screening tool and a

follow-up analysis by a certified laboratory was encouraged. The margin of error of the screening was estimated to be within ±3%.
Participants were also offered the opportunity for a bacteriological analysis at a state certified lab free of charge. The samples were collected by the homeowners in approved containers and taken directly to the lab by OSU personnel. Of the 45 samples analyzed, 22 (49%) indicated a positive bacteria count. This high percentage is in line with previous statewide averages. It is estimated that approximately half of the samples tested positive due to contamination by the collector.

The third educational meeting was held at the fairgrounds in Anadarko on 3/19/99. The meeting was held in conjunction with an environmental fair held by the Caddo County Family and Consumer Science Club. There were approximately 50 people in attendance at the meeting but only 12 brought water samples. Difficulties with the testing equipment were encountered at the meeting and samples had to be taken to Stillwater for analysis. Results were mailed directly to the participants and no summary information was obtained.

To evaluate the effectiveness of the educational meetings, 50% of the participants were randomly selected and surveyed. The survey instrument was designed to document increased knowledge in the area of water quality and specific measures taken to protect the quality of their personal drinking water supplies. Approximately 45% of those selected chose to complete and return the survey. The survey instrument along with the summarized results can be seen in Appendix 7. The education efforts appeared to be successful as participants indicated that several corrective actions were taken to prevent contamination of their drinking water supplies.

Task 8. Increase awareness of 4-H youth living in and around the watershed about existing water quality and environmental concerns.

<u>Environmental Camp</u>

A one-day water quality/environmental camp was held in the park at Fort Cobb Lake on 6/23/98. There were 35 4-H youth in attendance, along with several teenage and adult sponsors. The event was held under the direction of Andrea Coffey, Extension 4-H Educator for Caddo County. The students consisted of 23 females and 12 males; 31 Caucasian and 4 Native Americans; and the average age was 11 years old. The participants were divided into small groups and directed to six different educational "stations" in an outdoor classroom style. The six stations included:

1. Ecology of fresh water fish - Several large aquariums from Langston University were filled with various species of fish seined from Fort Cobb Lake. Instructors discussed fish habitat, classification, and the effects of pollution.

2. Managing landscapes to prevent soil erosion - An "enviroscape" sponsored by the Caddo County Soil Conservation Service illustrated how changes in land practices and management affect soil erosion rate.

3. The Oklahoma Omniplex Earth Bus - A converted school bus contained several hands-on demonstrations involving topics such as water conservation, predator/prey relationships, and solar energy.

4. Understanding insect life - An OSU area entomologist with several insect displays introduced students to the interactions of insects with humans. Topics included beneficial vs. harmful insects, where insects are found, and eating habits of insects.

5. Project WET - The Oklahoma Conservation Commission conducted activities that gave students first-hand knowledge on how important water is to life on earth.

6. Oklahoma wildlife - Oklahoma Dept. of Wildlife personnel discussed wildlife native to the Fort Cobb Lake watershed and the importance of wildlife habitat preservation.

In the afternoon, all students were assembled together for an exciting presentation on reptiles. The instructor emphasized the important roles that all species play in the environment. Students learned how to distinguish between poisonous and non-poisonous snakes, what constitutes a reptile's diet, and how reptiles help balance an ecosystem.

Identical pre- and post-tests administered prior to the classroom sessions and at the end of the day were used to evaluate the effectiveness of the educational efforts. A sample of the survey instrument used is included in Appendix 8. Individual scores can be seen in Appendix 9. The average score of the pre-test was 47. However, the post-test average was only 50. The students indicated verbally that the teaching efforts were successful, but the increases in test scores were much smaller than expected. Review of the pre/post test instrument suggests it may have been too difficult for the age group. The activity was considered an overall success and may be continued in future years.

Lifestyles of the Wet and Wild

"Lifestyles of the Wet and Wild" is a series of hands on water quality activities developed by OSU for youth of all ages. It consists of a curriculum and corresponding materials housed in an "education trunk". A one-day training session to familiarize youth educators with this new material was conducted on April 29, 1999. Registration for this event was limited to 25 and was open to educators working in the Fort Cobb watershed area. Participants included 4-H educators, volunteers, and youth educators from other state agencies. A complete agenda for the program is included in Appendix 10. Participation was excellent and responses from the participants indicated the material would be useful in their training activities.

The "Wet and Wild" resource trunk was taken to the 1st Annual Apache Tribal Environmental Camp held on June 17, 1999, at Fort Cobb. At this event, 30 Native American youth were educated on riparian areas, stream assessment, and microscopic aquatic life. The event was successful and is to be continued in future years. For a more complete listing of the educational events held at the camp see the attached brochure.

Task 10. Prepare a final report summarizing work done within this project including accomplishments.

6.0. Discussion

The Oklahoma Water Resources Board identified Lake Creek in the Ft. Cobb Watershed as a warm water aquatic community. Designated beneficial uses include 1) fish and wildlife propagation, 2) agriculture, 3) industrial and municipal process and cooling water, 4) recreation (primary body contact), and 5) aesthetics. Lake Creek was also identified as a Sensitive Public Water Supply. The monitoring allowed OCC to assess beneficial use support for Fish and Wildlife Propagation and Aesthetics beneficial uses.

6.1. Biological Community

6.1.1 Fish Community

The macroinvertebrate and fish communities in Lake Creek displayed varying degrees of impact. The fish communities at all of the sites were impaired to some degree. Lake Creek Site 1 was classified as moderately impaired while the other sites (sites 2, 4, and 5) were classified as slightly impaired. State Standards (*785:45-5-12*) state that "aquatic life designated Fish and Wildlife Propagation shall not exhibit degraded conditions". The Lake Creek sites all exhibited impairment in the fish community when compared to reference sites.

Table 27: Fish Community Status

Site	***IBI***	***Status***
Lake Creek 1	17	Poor
Lake Creek 2	13	**Very Poor**
Lake Creek 3		Not Collected
Lake Creek 4	9	**Very Poor**
Lake Creek 5	11	**Very Poor**
Pooled Reference	28	Reference

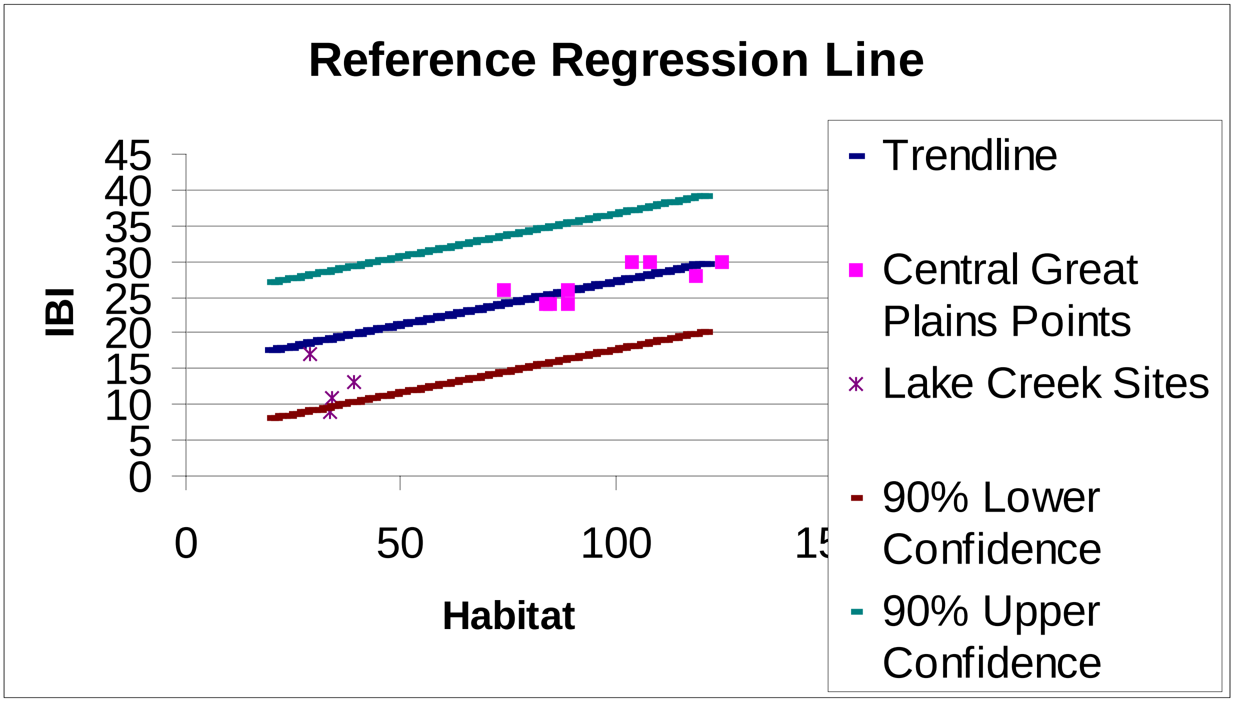
Lake Creek Site 1 was classified as poor, which is defined as: top carnivores and many expected species are absent or rare; omnivores and tolerant species are dominant (*EPA, 1989*). Lake Creek sites 2, 4, and 5 were classified as very poor, which is defined as: few species and individuals present with tolerant individuals present, and diseased fish frequent (*EPA, 1989*).

When compared with the reference site fish collections, the Lake Creek site fish collections are not meeting it designated fish and wildlife beneficial use.

To relate the IBI score to water quality, habitat availability must be accounted for. IBI scores must be interpreted within the context of the potential of the habitat of any given stream to support its fish community. Another way of putting this is to say that some streams have suitable habitat for a robust fish community and other streams don't. No matter how clean the water, a stream with limited habitat will never be able to support the robust fish community found in a stream with clean water and excellent habitat.

With this in mind, the OCC analyzed the relationship of IBI scores to habitat from the Central Great Plains Reference sites and the original Lake Creek reference sites. Oak Creek was not used in the analysis. Below is the relationship between the habitat scores and the regression line drawn using the Central Great Plains Reference sites and original Lake Creek reference sites.

Figure 1: Habitat/Fish IBI Regression Line



Based on this analysis, three of the Lake Creek sites, Lake Creek sites 1, 2, and 5 fell within the 90% confidence intervals. Site 4 fell just below the 90% confidence interval, which suggests that this site's biological community may be affected by water quality degradation. The sites within the 90% confidence interval yet below the fitted line, drawn using the reference sites, suggest that water quality and habitat degradation may be affecting these sites. Lake Creek site 1 fell just under the fitted line, which suggests that the biology is responding appropriately to poor habitat conditions.

6.1.2. The Macroinvertebrate Community

Streamside vegetation was relied upon to make the final determination about the status of the macroinvertebrate community. In the absence of streamside vegetation samples woody debris samples were utilized in the final determination.

The macroinvertebrate communities showed varying degrees of impacts from nonimpaired to severely impaired status. During the summer of 1998, sites 1 and sites 2 were classified as nonimpaired and sites 4 and 5 slightly impaired. Sites 4 and 5 were not supporting the fish and wildlife propagation beneficial use support. In the winter of 1998/1999 all of the streamside vegetation samples were classified as slightly impaired to moderately impaired. Sites 2, 4, and 5 were classified as slightly impaired and Site 1 was moderately impaired. Site 3 was not collected for these parameters. According to the streamside vegetation samples, the Lake Creek sites are not meeting the fish and wildlife propagation beneficial use. The woody debris collections from the same collection period support these results. Sites 1, 2, and 5 were classified as slightly impaired. Site 3 was classified as moderately impaired. Site 4 was classified as nonimpaired.

The summer of 1999 samples were not analyzed due to lack of sufficient reference data and adequate sample from the Lake Creek sites.

Based on turbidity readings exceeding state water quality standards, Lake Creek is partially supporting the Fish and Wildlife Propagation beneficial use. However, the biological collections indicate that Lake Creek is not supporting its Fish and Wildlife Propagation beneficial use determination.

Lake Creek biological communities are impaired by a number of stressors; both water quality and physical in nature. The habitat at all of the Lake Creek sites is severely damaged. Habitat concerns include lack of canopy, siltation, unstable beds, lack of stable cover, poor/nonexistent riparian zones, dense cattle activities along and in the stream, and extremely shallow depths. Some of the water quality impacts include algal blooms, low levels of pesticides in the water column, possible toxic concentrations of unionized ammonia, and high turbidity levels.

6.1.3. Bioassay

As displayed in table 22, no statistically significant effects were recorded from the water and sediment collections made from Lake Creek site 2. This is somewhat misleading due to the concentration of unionized ammonia concentrations found in both the water column and sediment samples. Before the bioassays were initiated, the laboratory converted the unionized ammonia into the much less toxic ionized ammonia. If levels of unionized ammonia levels were left in the samples, toxicity probably would have occurred. The bioassays were not measuring toxicity from unionized ammonia and pH, but measuring the other potential toxics within the stream. From this perspective, no toxicity was found at any of the Lake Creek sites.

6.2. Water Quality

6.2.1 Surface Water

The overall water quality in regards to state standards had no violations for dissolved oxygen, pH, pesticides, chloride, sulfate, and metals. Turbidity was partially supporting due to 19 of 112 (17%) samples exceeded criteria for turbidity. Analysis in which there are no numerical criteria but were evaluated with acceptable approaches included unionized ammonia and other nutrients. The unionized ammonia found in Lake Creek was found to be at concentrations significant enough to be toxic to some fish and aquatic insects. This parameter is difficult to determine as toxic due to the varying sensitivities of different organisms as well as exposure duration to the chemical.

Based on the guidelines set by USAP, the occurrence of excessive algae, shallow depths, nutrient concentrations, and elevated oxygen saturations suggest that Lake Creek site 5 is nutrient threatened. Determination of use support relative to nutrients is more difficult to assess. Twenty eight percent of the phosphorus samples collected exceeded the guidance established in the USAP to suggest nutrient threatened streams. However, the average base flow turbidity was 30 NTU and USAP assumes that at turbidities above 20 NTU, algae become light limited. Unfortunately, periphyton chlorophyll a concentrations were not collected and only qualitative estimations of periphyton productivity are available. Site observation records suggest that a significant alga was observed in twenty-one of 131 samples or eighteen percent of the time observations were recorded. Dissolved oxygen super saturation ranged as high as 169%, although the lowest observed saturation was 74%. These high saturation values, coupled with the frequency of significant algae observations and the shallow water depth at all sites suggests that Lake Creek is likely threatened by nutrients despite the higher average turbidities.

Pesticides were found in low concentrations in both the Lake Creek water column as well as the streamside seeps. State standards were not violated, however, this gives us insight to another stressor within the stream that may be contributing to the biological impairment discussed previously. In the table below, the percent occurrence of pesticides in both the surface water and the streamside seeps are displayed. The table also displays the maximum concentration detection throughout the sampling period. The conclusion drawn from this table is that pesticides, particularly, Alachlor and Aldicarb, were detected in the water column and in the streamside seeps. This also points out that the ground water is definitely being impacted by the surface activities in the drainage basin. Percent occurrence in the surface waters is an important perspective to look at. Many of these pesticides break down rapidly once they enter a body of water. For example, Captan, a fungicide that is nontoxic to humans but very toxic to fish, breaks down extremely fast in an aquatic environment (half-lives of 23-54 hours). Although the maximum concentration was measured at 0.01 parts per billion, OCC still found this rapidly degrading compound in 5.4% of the samples analyzed. The probability that higher concentrations would have been found if the sampling frequency was increased was high. The biota of the stream may not be impacted by concentrations of this individual pesticide. However the cumulative and synergistic effects of multiple detected pesticides within Lake Creek could have a substantial impact on the biota.

Table 28: Summary of Pesticides Detected From Lake Creek & Seeps

Using SDI RaPID Assay test kits

New	Surface water		Streamside seeps	
	% Occurrence	Max. Concentration (ppb)	% Occurrence	Max. Concentration (ppb)
2,4-D	2.22	0.71	1.49	22.94
Alachlor	12.20	0.26	11.46	0.36
Aldicarb	28.99	1.58	34.65	1.53
Atrazine	3.30	0.23	4.17	0.80
Captan	5.41	0.01	2.50	0.03
Carbofuran	9.09	0.27	8.20	0.27
Chlorothalonil	2.53	0.41	4.42	1.57

Chlorpyrifos	0.00	0.00	0.79	0.10
Cyanazine	15.38	0.40	0.00	0.00
Metolachlor	9.89	0.59	6.09	0.71
Metribuzin	5.88	0.04	0.00	0.00
Paraquat (ppt)	0.00	0.00	9.09	50.89
Picloram	14.29	2.08	0.00	0.00
Triclopyr	10.98	0.08	4.63	0.37

QA cutoff values (per Dan Butler 3/6/00):

Standard concentration	>160% or <60% of known value
% CV	Rejected if any two replicates have %CV >10
Blanks	Tests with blank "hits" are not rejected, but detections and values are noted

Table 28 is a summary of the pesticides monitored in Lake Creek. Information is displayed regarding the type (herbicide, insecticide, fungicide, etc.), toxicity class, aquatic toxicity (only for fish), and fate in an aquatic environment.

Table 29: Pesticide Information

Pesticide	Type	Toxicity Class	Aquatic Toxicity	Properties
2,4-D*	Herbicide	1,3 Slight to High	Variable	Rapid breakdown in water
Alachlor*	Herbicide	3-Slightly Toxic	Slightly Toxic	Rapid breakdown in water
Aldicarb*	Insecticide	1-Highly Toxic	Moderately	Moderate breakdown in water
Atrazine*	Herbicide	3-Slightly Toxic	Slightly Toxic	
Captan*	Fungicide	5-Practically nontoxic	Very toxic to fish	Extremely fast
Carbofuran*	Insecticide	1-Highly Toxic	Highly toxic to fish	Moderate breakdown in water
Chlorothalonil*	Fungicide	2-Moderately Toxic	Highly toxic to fish	Moderate breakdown in water
Chlorpyrifos*	Insecticide	2-Moderately Toxic	Highly toxic to fish	Rapid breakdown in water
Cyanazine*	Herbicide	2-Moderately Toxic	Moderately toxic	Highly persistent
Metolachlor*	Herbicide	3-Slightly Toxic	Moderately toxic	Highly persistent
Metribuzin*	Herbicide	3-Slightly Toxic	Slightly Toxic	Moderate breakdown in water
Paraquat**	Herbicide	1-Highly Toxic	Slight to moderate	Moderate breakdown in water
Picloram*	Herbicide	3-Slightly Toxic	Slight to moderate	Rapid to moderate
Triclopyr*	Herbicide	3-Slightly Toxic	Practically nontoxic	Rapid

6.2.2. Seep Water Quality

Terrace and alluvial deposits of groundwater in this basin have a level of nutrient vulnerability of very high, as designated in Oklahoma's Water Quality Standards. With respect to overall vulnerability, the major aquifer in the area, the Rush Springs aquifer is ranked as moderate, while the alluvium deposits of the basin are ranked as very high vulnerability.

There was limited data with respect to metals in the seeps, however, any concentrations above detection are notable. Not enough data to make determinations of use support.

Table 30: Seeps with Metals Concentration Higher Than Detection Limit.

Seep Name	WBID	Date	Antimony (ppb)	Arsenic (ppb)	Selenium (ppb)
Seep 123	OKTEMP-SM261	6/13/1999	29	16	< Detection
Seep 118	OKTEMP-SM256	6/13/1999	24	< Detection	< Detection
Cattail Seep	OKTEMP-SM138	6/13/1999	120	40	30

Oklahoma Water Quality Standards chapter 785:45-7-2(c) states that "if the concentration of any toxic substance listed pursuant to Section 307(a) of the Clean Water Act or any other pesticide in fresh groundwater is found above levels practically measured, it shall be deemed pollution and corrective action may be taken." Based on this determination, and the information presented in the table below, seeps in the Lake Creek Watershed violated water quality standards for pesticides. Pesticides concentrations higher than detectable limits were found for the pesticides; Alachlor, Atrazine, Captan, Carbofuran, Chlorothal, Metolachl, and Paraquat.

The table below (table 34) displays the seeps and data collected for pesticides. The number of detections and the percent detections are displayed at the bottom of the table. The number of detections and percent detections are values that violated the water quality state standards for pesticides in ground water.

Table 31: Seep Pesticide Concentration Greater Than Detection Limits

Site name	Date	2,4-D (ppb)	Alachlor (ppb)	Aldicarb (ppb)	Atrazine (ppb)	Captan (ppb)	Carbofuran (ppb)	Chlorothalonil (ppb)	Metolachlor (ppb)	Paraquat (ppt)	Triclopyr (ppb)
Detection Limit		0.7	0.05	0.25	0.05	0.01/0.08	0.06	0.07	0.05/0.10	50.0	0.03
A	12/16/98		0.1		0.1			0.1			
B	12/16/98		0.1		0.1			0.1			
B	02/10/99						0.12				
B	03/17/99								0.07		
B	04/06/99			1.46							
B	04/20/99			0.73							
B	10/08/99			0.63							
C	05/21/99			0.67							
C	07/08/99		0.33								
D	12/16/98		0.1		0.1			0.1			
D	04/20/99			1.04							
E	12/16/98		0.1		0.1			0.1			
E	04/20/99			0.55							
E	05/21/99			0.5							
E	06/02/99						0.15				
E	06/14/99			0.84							
F	10/01/98			0.46			0.27			50.89	
F	06/14/99			0.51							
F	07/21/99		0.11								
F	08/31/99		0.21								
H	04/06/99			0.29							
H	04/20/99			0.46							
H	05/21/99			0.55							
H	06/14/99			1.14							
J	05/07/99			0.37							
J	05/07/99			0.37							
K	04/06/99				0.34						

K	04/06/99				0.34						
L	12/16/98		0.1		0.1			0.1			
L	04/20/99		0.13	1.53							
L	05/21/99			0.79							
L	08/03/99								0.11		
L	08/31/99		0.12								
M	04/20/99		0.13	0.47							
M	05/21/99			0.71							
M	06/14/99			0.64							
M	10/08/99			1.09							
O	08/03/99							0.15	0.11		0.05
O	08/31/99						0.065	1.57			0.14
R	04/06/99						0.2				
R	04/20/99		0.09	0.43					0.35		
R	05/07/99				0.07						
S	12/16/98		0.1		0.1		0.24	0.1			
S	04/20/99			0.41							
S	05/21/99			0.63							
S	06/14/99			0.54							
U	04/20/99			0.54							
U	05/07/99					0.03			0.71		
V	04/06/99						0.07				
V	04/20/99		0.11								
V	05/07/99				0.07		0.13				
V	05/21/99			0.68	0.12						
V	06/14/99			0.54							
V	07/21/99	22.94	0.06					0.08			0.37
W	04/20/99		0.36	0.45							0.06
W	05/07/99				0.8						
X	05/07/99			0.62							
X	05/21/99			0.72							

X	06/14/99			0.58				0.17			
Y	12/16/98		0.1		0.1			0.1			
Z	12/16/98		0.1		0.1			0.1			
ZZ	12/16/98		0.1		0.1			0.1			
# of detections		1	19	33	15	1	8	13	5	1	4
% detections		1.5%	19.6%	31.7%	12.2%	2.4%	6.4%	11.4%	4.2%	9.1%	3.6%

Seeps were violating standards due to detectable pesticide concentrations as much as 32% of the time. The most frequently detected pesticides included Aldicarb, Atrazine, and Alachlor. Pesticides were detected in seeps sampled throughout the year.

Nitrate concentrations were above allowable levels for drinking water in two of the 27 seeps. Nitrate was detected in all samples collected with concentrations ranging from 0.003 mg/l – 63.2 mg/l. The median concentration was 0.25 mg/l, well below the drinking water standard of 10 mg/l.

Concentrations of orthophosphate were generally low, ranging from 0.001 – 0.51 mg/l, with a median value of 0.01 mg/l. Orthophosphate concentrations were generally at background levels in all but four of the seeps.

Seeps A, C, D, F, M, O, and V may be near or influenced by sources of nutrients based on concentrations of nitrate and orthophosphate detected that were above the concentration detected in other seeps. Further investigation of the landuse adjacent to these seeps may suggest reasons for elevated nutrient concentrations detected at these sites.

Conductivities, pH, and alkalinities of the seep samples were all indicative of water that has been in contact with the aquifer long enough to become mineralized. In other words, these concentrations were not indicative of “new” water from precipitation, but rather waters that had moved through the aquifer and soil and rock layers. However, the relatively high concentrations of nutrients in some seeps, coupled with the prevalence of pesticides in seep samples, suggests a strong interaction between surface activities and ground water.

7.0. Conclusion

The sites on Lake Creek indicate that the 303 (d) listing of this waterbody was appropriate. Water quality and biological investigations lead to the conclusion that Lake Creek is not supporting its fish and wildlife beneficial use. Bioassays indicated no toxicity in the surface water at any of the Lake Creek sites. However, concentrations of unionized ammonia were found in the water column and sediment samples that could be toxic. Further investigation of unionized ammonia needs to be incorporated into future projects in the area. This will be accomplished through the FY 2001 Ft. Cobb Watershed Project and the NPS Rotating Basin Monitoring Program.

Lake Creek may have some underlying water quality problems, but data suggests that the biology is being primarily impacted by habitat degradation. Lack of stable habitat, extremely poor depths, and lack of canopy/riparian zones are just a few of the many problems associated with the habitat degradations problems in Lake Creek. This is coupled with the potential unionized ammonia problem and detectable pesticide levels in the surface waters. These indicators lead to the conclusion that the biology is stressed by many factors and a single factor cannot be determined from this study.

Oklahoma Water Quality Standards chapter 785:45-7-2(c) states that “if the concentration of any toxic substance listed pursuant to Section 307(a) of the Clean Water Act or any other pesticide in fresh groundwater is found above levels practically measured, it shall be deemed pollution and corrective action may be taken.” The seeps monitored along Lake Creek were found to have levels of pesticides higher than detection limits. Metals were also found in concentrations higher than detection limits at three separate seeps. Although many of the pesticides have different breakdown properties in groundwater, it is safe to assume that there is significant interaction between the surface and shallow ground water. With the concentrations found in the seeps along Lake Creek, there are also concerns about the connection to the Rush Springs Aquifer.

Further monitoring needs to be incorporated into projects in the area to address concerns of nutrients, habitat degradation, and pesticides. Habitat assessments also identified high cattle activity and cow flop density. Future monitoring may also include assessment of bacteria levels in the surface waters of Lake Creek.

The educational component met the task set forth in the workplan.

An area along Lake Creek was selected for demonstration that had severely a severely damaged riparian zone. Approximately one quarter of this selected area was fence and the cattle were excluded. The Other quarter of the land was left “as is” and cattle were not excluded. Trees were planted in the fence area and used as a demonstration and control plot to educate landowners of the benefits of riparian zone management. Approximately 25 producers attended an “all day” riparian workshop.

Four educational meeting were conducted both in the field and in the classroom to demonstrate and explain pesticide use reduction through integrated pest management techniques. Three of the meetings were designed for peanut producers (16 producers attended). The other meeting covered integrated pest management techniques for alfalfa producers (20 producers attended).

An integrated pest management clinic for alfalfa production was held on March 9, 1999, in Chickasha (see attached brochure). Twenty (20) alfalfa producers from Caddo, Grady, and McClain Counties learned techniques for proper weed and insect scouting, determining pest thresholds, interpreting soil test reports in a classroom setting before being transported to the South Central Research Station for hands-on scouting activities.

Approximately 70 producers, agency personnel, consultants, and industry representatives attended a tour of test plots that were planted to demonstrate the effectiveness of a reduced tillage plan. During the demonstration, rainfall simulators were utilized to show the positive impacts of reduced tillage and sediment and water quantity runoff.

Data was collected from the Oklahoma MESONET, organized, and distributed to gathering points in the watershed. Test plots were also planted and maintained using different types of pesticides management techniques to demonstrate the effectiveness of proper conservative pesticide uses.

The proposed sprayer calibration component was not accomplished. Most of the spraying in the Lake Creek watershed is done commercially with a large percentage being accomplished by air. Peanuts are the primary crop in the area to which pesticides are applied. After peanuts "lap" in mid-summer, it becomes difficult to spray by ground rig because of the damage done by driving on the vines. This task was not attempted until too late in the year for sprayer calibration to be worthwhile. No funds were expended for this task.

Wheat plots were planted to demonstrate nitrogen fertility in the watershed. Four different plots were planted and different amounts of nitrogen were applied to the plots. The control plots had no nitrogen applied. Cattle were excluded from the plots. Originally, the plots were intended to demonstrate the different nitrogen rate application to producers. The plots were becoming established and demonstrating the intended results when eight Cooperative Extension Personnel where shown the results on a field day. However, the plots became infested with hairy vetch and cereal rye soon after and could not be used for further demonstration.

Three educational meetings were held in or near the Lake Creek watershed, utilizing materials from the “Oklahoma Farm and Ranch * A * Syst” and the “Oklahoma Home * A * Syst” programs. Participants were presented information on proper septic tank management, water well construction, wellhead delineation, and EPA primary and secondary drinking water standards. A water test screening, consisting of nitrate, TDS, and pH was conducted for all participants who brought samples to the meetings. Bacteriological testing at the state laboratory was offered for all meeting participants free of charge. Three meetings were held in Eakly, Ft. Cobb, and Anadarko. Approximately 115 people attended these meetings.

To increase the awareness of the 4-H youth living in and around the Lake Creek Watershed, two programs were utilized, Environmental Camp and Lifestyles of the Wet and Wild. The Environmental Camp consisted of a one-day camp, attended by approximately 35 youth. The youth were rotated through stations including ecology of fresh water fish, managing landscapes to prevent soil erosion, the Oklahoma Omniplex Earth Bus, understanding insect life, Project WET, and Oklahoma wildlife.

The “Lifestyles of the Wet and Wild” is a series of hands on water quality activities developed by OSU for youth of all ages. It consists of a curriculum and corresponding materials housed in an "education trunk". A one-day training session to familiarize youth educators with this new material was conducted on April 29, 1999. The “Wet and Wild” resource trunk was taken to the 1st Annual Apache Tribal Environmental Camp held on June 17, 1999, at Fort Cobb. At this event, 30 Native American youth were educated on riparian areas, stream assessment, and microscopic aquatic life. The event was successful and is to be continued in future years.

Seven Best Management Practices were installed in the Lake Creek Watershed. These included riparian zone fencing, pond construction, grade stabilization structures, diversion terraces, deferred grazing, rotational grazing, and critical area planting. These practices will benefit the stream. It is not reasonable to expect these practices to have an immediate impact on the water quality, biology, and habitat on Lake Creek. However, over time these practices will help to reduce erosion, maintain water sources (including sources other than Lake Creek), stabilize banks, and stabilize an unstable system. The efforts made within the Lake Creek watershed may also be used for future educational benefits. These benefits may include visual displays of the importance of riparian zone and their protective benefits to the stream banks, creating stable habitat, nutrient trapping, and reducing sediment entering the stream system. Future monitoring efforts in the watershed may be used in conjunction with these BMP’s to demonstrate these benefits to landowners within the watershed.

The Lake Creek Project paved the way for a larger Fort Cobb Reservoir Project to begin in 2001. The Fort Cobb Reservoir Project will focus on the information gained from the Lake Creek Project relative to the water quality and habitat problems and the practices that may or may not be successful at correcting those problems. The Fort Cobb Project, supplemented with monitoring from the State's NPS Rotating Basin Monitoring Program will continue to evaluate the success of this project in assessing and improving water quality in Lake Creek.

Budget Review

Task I. Prepare Quality Assurance Project Plan which includes the identification of sites to be monitored.
Resource Allocation:$ 2,500

Task II. Complete list of landowners and type of land use activities. Identify those that need revised conservation plans to address surface and ground water quality protection. Prepare land use maps, identifying potential vulnerable areas for ground and surface water contamination.
Resource Allocation: $ 45,000

Task III. The intent of this task is to provide information to a variety of groups through the news media, workshops, tours, newsletters, surveys and exiting conservation district and Commission programs.

Educate 35 agricultural producers and residents, located in and around the Lake and Cobb Creek watersheds, on the water quality benefits of maintaining effective riparian areas and how they should be properly protected.

Educate 25 crop producers in the watershed area to reduce pesticide use by using appropriate pest infestation thresholds and integrated pest management techniques.

Convert 15 peanut fields in and around the Lake/Cobb Creek watershed to a Ro-till reduced tillage plan.

Demonstrate and distribute “The Peanut Leafspot Advisory” directly to 25 producers, CO-OPs, or producer gathering points (ie. local coffee/donut shops) bi-weekly from June 1 through harvest.

Have at least 5 low-pressure ground sprayers used for pest control in and around the watershed properly calibrated.

Demonstrate appropriate nitrogen fertility management for small grains grown in or around the Lake Creek watershed.

Educate 150 homeowners with water wells in and around the watershed about wellhead protection techniques and water quality standards.

Increase awareness of 4-H youth living in and around the watershed about existing water quality and environmental concerns.

Hold periodic meetings with landowners and land users to discuss the information gathered and the results of the interpretation. Cover the findings gathered under the ground and surface water quality monitoring program.

One on one meeting with landowners to discuss the chemical application, timing, need for revised conservation plan of operation to address water quality concerns and answer questions pertaining to the project.

Results will be provided through the preparation of semi-annual and annual reports.
Resource Allocation:$166,298

Task IV. Monitoring and Evaluation Program. Results to be provided annually in the Commission's Annual Report of Activities. (July 1 of each year)
Resource Allocation: $154,943

Task V. Technical Transfer
Resource Allocation: $85,000

Task VI. Final Report (October 31, 1999)
Resource Allocation: $39,959

DURATION: Six years

RESOURCE SUPPORT:	**Federal**	**$280,441**
	State	**$186,961**
	Total	**$467,402**

Literature Cited

APHA et. Al., (1989), Standard Methods for the Examination of Water and Wastewater, 17th Edition, American Public Health Association, American Water Works Association, and Water Environment Federation, Washington, DC.

EPA 1983b EPA (1983b), "Methods for Chemical Analysis of Water and Wastes", Environmental Monitoring and Systems Laboratory, Cincinnati, Ohio.

EPA, (1986), Quality Criteria For Water 1986, EPA/440/5-86-001, U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC.

EPA, (1989), "Rapid Bioassessment Protocals for use in Streams and Rivers" EPA/440/4-89/001, United States Environmental Protection Agency, Washington DC.

European Inland Fisheries Advisory Commission (EIFAC), (1969), "Water Quality Criteria for European Freshwater Fish—Extreme pH Values and Inland Fisheries", prepared by EIFAC Working Party on Water Quality Criteria for European Freshwater Fish, Water Research 3:593.

Gammon, J.R., (1970), The Effect of Inorganic Sediment on Stream Biota, EPA Water Pollution Control Research Series 18050 DWC 12/70, US Governmet Printing Office, Washington D.C.

Kelly, M. (1988), Mining and the Freshwater Environment, Elsevier Applied Science, New York, New York.

Knepp, G.L. and G.F. Arkin, (1973), "Ammonia Toxicity Levels and Tolerance of Channel Catfish", The Progressive Fish-Culturist, 35:221.

OCC (1996), "Oklahoma Conservation Commission Standard Operating Procedures Document for the Collection and Analysis of Water Quality Samples", Oklahoma Conservation Commission, Water Quality Division, Oklahoma City, Oklahoma.

OWRB (1995), "Oklahoma Water Resources Board Water Quality Standards; As Amended Through July 27, 1995", Oklahoma Administrative Code (OAC), Title 785, Oklahoma Water Resources Board, Oklahoma City, Oklahoma.

Lynch, R., (1992), "Oklahoma Scenic Rivers Commission Report on Water Quality, Illinois River", Oklahoma Conservation Commission, Oklahoma City, Oklahoma.

Mackenthun, K.M., (1973), Toward a Cleaner Aquatic Environment, US Government Printing Office, Washington D.C.

McCoy, E.F., (1972), Role of Bacteria in the Nitrogen Cycle in Lakes, EPA, Water Pollution Control Research Series, EP 2.10:16010 HER 03/72, US Government Printing Office, Washington D.C.

Tebo, L.B., (1955), "Effects of siltation, Resulting from improper Logging, on the Bottom Fauna of a Small Trout Stream in the Southern Appalachians", The Progressive Fish-Culturist, 17:64.

Appendix 1: Technical Assistance to Improve the Quality of Ground Water – Surface Water Interactions (Task III: Educational Component) Final Report.

Appendix 2: Map showing the Lake Creek Monitoring Locations