Oklahoma Conservation Commission/
Water Quality Programs

FY 1994 319(h) - Task 600
GIS Water Quality Targeting

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1. Introduction

The Oklahoma Conservation Commission is continually seeking ways to strengthen its conservation and nonpoint source (NPS) pollution programs. With limited availability of financial resources new tools must be utilized to target spending to critical areas. Geographic Information Systems (GIS) was identified as an important tool for these targeting efforts. However, the Commission's GIS capabilities were limited due to lack of raw computer power, data storage space, workspace, and available GIS data layers. The objective of this grant was to upgrade the Commission's GIS system and capabilities to provide spatial analysis support to the Water Quality program and its various projects. The success of the project is demonstrated by the Commission's GIS capabilities in targeting management efforts to priority nonpoint source pollution areas.

2. Project Tasks

2.1. Purchase of Equipment

The initial plan for upgrading the GIS equipment was to network two X-terminal servers (nodes) to the Sun Sparcstation 2 as the X client (host). (For the X Windows systems the X server is the software that controls the user's display on the network node and the client is the application program which resides on the host.) After further review, it was decided that greater capability could be gained by substituting the second X-terminal with the existing Sparcstation 2 (to act as another workstation) and purchasing a more powerful computer to act as the host. It was also more economical to keep the Sparc2 intact than to reconfigure it and purchase the additional X-terminal.

Ultimately the Commission expanded from a single Sparcstation 2 with 1.4 gb of storage to a Sparcstation 20 with 5.2 gb of storage and networked it to a SparcClassic X terminal. With the Sparc 20 server on an ethernet network additional X terminals were created on the network using PC based X terminal software on networked PCs. A dedicated connection to the Internet was also obtained to both retrieve and offer GIS data. An additional seven port SCSI board was added to the system to allow future equipment expansion.

Initially, the GIS division utilized GRASS (Geographic Resource Analysis Support System - a public domain GIS software produced by the Army Corps. of Engineers) as the only GIS software. However the limited capability of GRASS, being raster based, and the increasingly limited availability of data in GRASS format caused the Commission to assess other GIS software. ESRI's ARC/INFO was selected due to its wide spread use in state universities and government agencies as well as the availability of data layers in ARC format. Currently, the Commission uses GRASS along with ESRI's ARC/INFO and ARCVIEW 3.0 as their GIS software. The plan is to use ARC/INFO exclusively. Informix is used to create and manage relational databases for use in the GIS system.

2.2. Gathering of data for input into the system

The production of GIS data layers can consume large portions of GIS project funds. Available data layers are continuously being sought in state and national archives for the state of Oklahoma to minimize the need to construct layers. A connection to the internet is very important for searching for available data layers as well as coordinating with other GIS users to produce coverages, and for making data layers available to others. In the short duration of this project the following statewide coverages have been obtained:

- NRCS 200 Meter Resolution Landuse
- NRCS 200 Meter Resolution Soils
- EPA 1: 5000000 Streams (Reach file 1) from USGS DLG
- EPA 1: 1000000 Streams (Reach file 3) from USGS DLG
- Ecoregions
- Geology
- 1990 Census population block group boundaries/ STF3A
- School Districts
- State Senate Boundaries
- State House Boundaries
- County Boundaries
- State Boundaries
- USGS Stream Gauge Stations
- National Dams Inventory 8 Digit Hydrologic Basins
- 11 Digit Hydrologic Basins
- STATSGO Soil Map (NRCS)
- NRCS MLRA boundaries
- Highway Network
- County Road Network
- Confined Animal Feeding Operations (CAFOS) Locations
- Citizen Pollution Complaint Locations
- 1:100000 DEM's Statewide
- 1:100000 DLG's (USGS)
- National Resource Inventory (NRI) by NRCS
- EPA TRI (Toxic Release Inventories)
- 1:100K USGS Map Boundaries
- 105 Congressional Districts
- 1:24K USGS Map Boundaries
- Agriculture Census (with zip code boundary coverage)
- Climate divisions
- EOSAT Rows and Paths
- Evaporation
- GNIS 1
- Hypsography (USGS DLG)
- Indexed Oklahoma WBID- Lakes

- OK Cons. Dist. Bndry
- 1: 100K DLG Public Land Survey
- Rainfall isopleths
- Runoff isopleths
- USGS Land use/ Land code (late 1970's)

The GIS division is in the process of obtaining the following coverages statewide:

- Digital Ortho Photography

The use of GIS analysis of various project areas has resulted in project level coverages for some areas including:

- Detailed landuse (field assessment with aerial photos)
- Stream habitat assessments
- Soil sampling
- Confined animal operations inventories
- Conservation plan inventories
- Well Locations

Additional coverages are currently being developed or obtained:

- Locations of all available point source data (esp. permitted wastewater discharges statewide)
- GIS support for whole basin primer (planning and assistance)
- Linking 303(d) list to Reach File 3
- 319 Assessment
- Link Water Quality relational database to Arc/Info GIS system

3. Demonstration of GIS Capabilities

The GIS system has found an increased role in project support. It is likely that GIS will be used to some degree in all Water Quality projects. GIS is being used extensively in a continuing project in the Spavinaw Creek watershed above Lake Eucha. Attached as an appendix to this report is the final report of the first stage of work in the watershed. Phosphorus loading to Lake Eucha prompted an investigation of the watershed above the lake for both point and non-point sources. The watershed, which is partly in both Oklahoma and Arkansas, has seen an explosion in confined animal feeding operations over the past few years. An inventory of those feeding operations was conducted on the ground in the watershed.

The primary industry and potential non-point pollution source in the Lake Eucha watershed is confined animal production sites. The Commission conducted a confined animal inventory. The inventory identified houses in operation, the type of animal confined, houses not in production and houses which were no longer standing. Digitizing these sites and sub-dividing the watershed into smaller watersheds allowed analysis using the GIS system. Using estimates of the nutrient production from each type of animal in the watershed, obtained from the Oklahoma State University Cooperative Extension Service, estimates of the annual nutrient production in each subwatershed could be made. From this data additional analyses were possible to show critical sub-watersheds in the area feeding Lake Eucha.

Work in the Lake Eucha watershed continues with the GIS system to model the watershed using spatial data. This modeling will give estimates of the contributions of nutrients to Lake Eucha from the various point and non-point pollution sources. In addition through modeling, goals for the reduction of nutrient loading to Lake Eucha can be set and the most cost-effective implementation of BMP's in the watershed can be determined. This work demonstrates the current and expanding use of and capability of the Commission's GIS system.

4. Planned use of GIS Capabilities

The Water Quality Programs of the Oklahoma Conservation Commission plans to use the GIS system for project support in the following areas:

- Support for monitoring site selection
- Identification of potential pollutant sources
- Display of Water Quality data spatially
- Modeling (TMDL)
- Targeting of areas within watersheds for the most effective implementation of BMP's
- Development/ enhancement of a statewide watershed prioritization model
- Tracking pollution complaints
- Coordination of GIS activities with state and federal agencies for sharing and cooperative development of GIS data layers
- Storage and display of spatial data on potential NPS pollution sources in project watersheds
- Project management
- 319 Assessment

Other potential uses and needs will surface as our GIS capability and use expands.

5. Project Budget

The total budget for this project was $66,667. This included $40,000 federal dollars and a $26,667 match from the state. The financial resource was allocated as outlined in the following report.

Total Project Outlays as of Report Date	
Personnel	$12,759.00
Equipment	$34,456.26
Travel	$862.32
Supplies and Operating Expense	$10,970.19
Consultants / Subcontracts	$7,000.00
Indirect Costs	$618.95
Total	**$66,666.72**

6. Conclusion

The capabilities of a GIS system are only as good as the spatial data available to it. Currently the Water Quality Division has concentrated on collecting spatial data available from others and inputting and sharing its own spatial data to expand the capability of the GIS system. Once the necessary data layers have been collected the Commission's Water Quality Division will use GIS as a versatile tool to support its various projects. GIS will be used for such things as pre-project planning, watershed prioritization, project management, identification of non-point pollution sources, watershed characterization, targeting for BMP implementation, and storage of spatial data. Ultimately, GIS will become a critical part of the non-point source pollution program by increasing the effectiveness of the Water Quality Division in natural resource conservation.

Appendix

This appendix contains the final report of the confined animal inventory in the Lake Eucha watershed conducted by the Oklahoma Conservation Commission, Water Quality Division in the summer of 1996. Along with the report is a map which displays the locations, type, and size of confined animal operations identified in the watershed.

Oklahoma Conservation Commission
Water Quality Division

Confined Animal Inventory:
Lake Eucha Watershed

Final Report
August, 1996

This is a brief report containing an inventory of confined poultry and hogs in the watershed of Lake Eucha. A large amount of related material, such as lake and stream water quality, estimates of annual nutrient loadings to the lake, watershed land uses, soils and geology, and much more not discussed here, are contained within the Phase I Clean Lakes Diagnostic and Feasibility of Lake Eucha which will be published in September of 1996. It will be forwarded to the City of Tulsa at the time of publication.

Three separate methods were considered for this inventory. The first and most inexpensive involves mapping of animal houses from 8 inch to the mile Natural Resource Conservation Service aerial photos. While the houses are easily visible on these photos, it is impossible to distinguish active from inactive ones. Also, none of the photos are up to date. The ones covering Oklahoma were shot in 1991 and the ones covering Arkansas were shot in the early 1980's. This method was rejected early on in the course of the project.

The second method considered was a flyover of the watershed with a global positioning system unit getting locational information along with the number and size of the houses. This method was rejected because it offered no way to distinguish active from inactive houses and would have resulted in a large overestimation of animal production in the watershed.

The method chosen was direct mapping based on a site visit and usually a discussion with the grower. This method allows differentiation of active from empty houses and additionally allows recording of the name of the producer and the company they grow for. Using existing aerial Photos and USGS 7.5" topographic maps as a starting point, all roads were driven. Houses are all marked at the driveway or entrance from the nearest public road by easily visible signs so that the company feed and animal transporting truck drivers can find them. Using these signs, we verified previously mapped houses, and mapped those which didn't appear on any of the NRCS or USGS maps.

Table 1 lists all the growers in the watershed by name, location, number and type of animals produced, and the company they are produced for.

Table 2 lists the subwatersheds of Spavinaw Creek from Lake Eucha dam to the headwaters. The GIS number column refers to the identification number of each subwatershed on the map. Areas not draining to major tributaries or draining directly to Spavinaw creek are delineated and referred to as Spavinaw laterals. They are designated either North or South depending on their position relative to Spavinaw Creek, and are located along Spavinaw Creek by the occurrence of major tributaries which

form their East - West boundaries. The size column lists the size of each mapping unit in square miles. Sites indicates the number of animal producers. One site can have any number of houses. Houses refers to the actual number of buildings used to raise animals in. The column labeled animals refers to the actual number of chickens, turkeys or hogs for a particular watershed or subwatershed.

Sites not standing are sites which appear on USGS 1:24000 topographic maps but are no longer there. Sites not in production are houses which are standing and could be used for production but were empty at the time of the site visit. Potential houses in production, potential animals, and potential animal density all refer to the total number of animals that would exist if all empty houses were put into production along with those already producing. For ease of calculation, all empty houses are assumed to be chicken houses.

Table 3 lists the estimated nutrients (Nitrogen and Phosphorous) excreted by all of the confined animals in each watershed or subwatershed. Estimates are derived from numbers provided by Doug Hamilton of OSU Cooperative Extension in Stillwater. A synopsis of these numbers follows.

Broilers/20,000 birds

5 flocks / year at 50 days / flock
Average weight of bird = 2 pounds
Nitrogen production = 1.10 lbs. /1000 lbs. live weight / day
Phosphorous production = 0.34 lbs. / 1000 lbs. live weight / day
Nitrogen excreted by 20,000 bird house / year =11,000 lbs.
Phosphorous excreted by 20,000 bird house / year = 3,400 lbs.

Turkeys / 20,000 birds

Occupied 300 days / year
average weight = 11.75 lbs.
Nitrogen production = 0.74 lbs. / 1000 lbs. live weight / day
Phosphorous production = 0.28 lbs. / 1000 lbs. live weight / day
Nitrogen excreted / 20,000 bird operation / year = 53,000 lbs.
Phosphorous excreted / 20,000 bird operation / year = 20,000 lbs.

Hogs / 600 sow unit

Nitrogen excreted / 600 sow unit / year =23,000 lbs.
Phosphorous excreted / 600 sow unit / year = 7600 lbs.

An estimated total of 8,259,600 lbs. of Nitrogen and 2,585,540 lbs. of Phosphorous will be excreted by confined animals in the watershed this year. Of this total, 33% of each nutrient will be produced in Oklahoma with the remainder coming from Benton County, Arkansas. In Oklahoma, chickens produce 82.8% and 81.8% of the total Nitrogen and Phosphorous respectively with the remainder being produced by hogs. While the majority of the nutrients and poultry are produced in Arkansas,

70% of the hogs produced in the watershed are grown in Oklahoma accounting for the rather large percentage of the Oklahoma total which is derived from hogs. There are no turkeys grown in the Oklahoma portion of the Eucha watershed. In Arkansas, chickens produce 91.5% and 90.3% of the total Nitrogen and Phosphorous respectively, with the remainder being split fairly evenly between hogs and turkeys.

A large number of the houses not in production will never be used because of outdated equipment and facilities. Nonetheless, many of them are currently being used for production but did not have birds in them at the time of the visit due to a variety of reasons. If all of the empty houses were put into production of chickens, the total number of chickens in the watershed would increase from 13,302,000 to 25,095,700 with 76.1 % of the increase occurring in Arkansas and the remainder in Oklahoma.

If all houses capable of production were being used, it is estimated that a total of 10, 1 84,600 lbs. of Nitrogen and 3,180,540 lbs. of Phosphorous would be produced in the entire watershed per year. Arkansas would produce 68.6% of both nutrients under this scenario.

It is very important to note that this is an estimate of the total amount of nutrients excreted by confined animals in the watershed and that under normal conditions, only a small fraction of the total would ever reach the water. Only in an extreme worst-case scenario would all of these nutrients end up in Spavinaw Creek. Typically, about 40% of the total Nitrogen in poultry litter is lost to the atmosphere during storage, so that unless the grower took the litter straight from the house to the field throughout the entire year the amount of Nitrogen introduced to the environment would be quite a bit less than the amount excreted. Likewise, a large portion of the remaining Nitrogen is lost to the atmosphere after application, and living plants take up much of the rest leaving only a fraction of the original to become a potential water pollutant. Phosphorous, although not volatile in any naturally occurring form, often binds tightly to soil particles. Only a fraction of the original will be available in a water-soluble form that is likely to wash into surface water. One troublesome thing about Phosphorous is that it occurs in poultry waste in greater amounts than plants need in relation to the Nitrogen present. This means that it tends to accumulate on and near the soil surface and will eventually become a water pollutant wherever poultry waste is used as a fertilizer year after year.

Other factors that influence the amount of nutrients reaching water include the timing of application in relationship to rainfall and plant growth cycles. Litter applied right before a heavy rain or in the winter when grass isn't growing is far more likely to reach water than is litter applied when grass is actively growing and rainfall is absent or slow. Also, the amount of nutrients produced is a function of the number of flocks raised per year. Our calculations assume that growers are running their houses at maximum capacity, but this is often not the case. Many growers will only raise three or four flocks a year rather than five, which is the maximum possible. Finally, in almost all cases, hog and laying hen waste is put into a lagoon or detention pond where much of the Nitrogen is lost to the atmosphere, and a majority of the Phosphorous settles out of the liquid phase. The lagoon will

eventually be pumped out and the Phosphorous in the sludge will be land applied, but by that time an unknown amount will be in a non-soluble form not available to plants and algae.

Even though most of the nutrients excreted may not reach the lake, it is apparent that a significant portion of them do. This is demonstrated by the steady increase in total Nitrogen and Phosphorous concentrations seen at the monitoring site at the Arkansas Department of Pollution Control and Ecology at Arkansas Hwy. 43 over the last twenty years. It's also manifested in the lake as steadily increasing chlorophyll values. The decrease in water quality matches an increase in poultry production that can be estimated by comparing the number of animal houses on the USGS 7.5" topo maps that were mapped in the early 70's to those that appear on the photorevisions of the early 80's and those that appear on our map of 1996. It is easy to see that water quality has decreased as the confined animal industry has increased.

Chickens, pigs, turkeys, and humans all excrete Nitrogen and Phosphorus at different ratios and concentrations. That means that while one person equals 23 broilers in terms of the pounds of waste excreted, they equal 11 broilers in terms of Nitrogen excreted, and only 3.7 broilers in terms of Phosphorous excreted. Of course poultry aren't present in any given house all year. A normal flock of broilers takes 50 days to mature, and five flocks per year are normally grown, so those numbers should all be multiplied by the inverse of the fraction of the year they are actually present which is 365/250 or 1.46. This changes the above numbers to 33.6, 16.1, and 5.4 respectively. Similar calculations can be performed for other animals. The total number of confined animals in the watershed is equal to 1,275,000 humans in terms of Nitrogen excreted, and 3,778,000 humans in terms of Phosphorous excreted. Averaging these two numbers and dividing by the number of square miles in the watershed, we arrive at a human density equivalent of 7,121 humans per square mile or 11 humans per acre. This is in addition to the humans that actually live there.

Looking at the data in this way allows one to better understand the need to properly manage animal waste to prevent eutrophication and health hazards. The thought of this many people in the watershed without any waste treatment system would be startling to say the least, and the populace would want something done about the situation immediately. Many of the animal growers are on animal waste management plans, and most of those on a plan adhere to it to a greater or lesser degree. This is demonstrated by the fact that Lake Eucha is still in fairly good shape. There is still much room for improvement however. People disagree on just what constitutes an adequate plan, who must have an animal waste plan, and what level of compliance to the plan should be expected, and whether or not there should be enforcement or not. If the present day water quality of Lake Eucha is to be preserved or improved, it's imperative to begin work in the watershed to decrease the amount of nutrients reaching the stream and groundwater immediately.

TABLE 1: Lake Eucha Watershed Confined Animal Inventory Site Data

Label	Type	Houses/ Size (ft)	Est. Animals	Company	Label	Type	Houses/ Size (ft)	Est. Animals	Company
A8	Chicken	3\400	60000	Peterson	A113	Chicken	4\400	80000	Simmons
A11	Chicken	1\400,1\300	35000	Tyson	A120	Chicken	2\400	40000	Simmons
A13	Chicken	2\400	40000	Peterson	A122	Chicken	3\400, 1\300	60000	Simmons

A22	Chicken	4\400	80000	Peterson	A123	Chicken	2\300	30000	Peterson
A24	Chicken	4\300,1\400	80000	Peterson	A124	Chicken	3\400	60000	Hudson
A27	Chicken	2\400	40000	George's	A178	Chicken	2\400	40000	Peterson
A35	Turkey	1\400	20000	Cargill	A179	Chicken	2\400	40000	Tyson
A37	Chicken	4\400	80000	Cobb-Vantress	A181	Chicken	2\400	40000	Peterson
A38	Chicken	3\400	60000		A182	Chicken	2\400	40000	Peterson
A39	Chicken	3\400	60000		A183	Chicken	23\400	460000	Peterson
A41	Chicken	3\400	60000	Peterson	A185	Chicken	5\400	100000	Peterson
A43	Chicken	2\400	40000	Peterson	A186	Chicken	6\400	120000	Peterson
A44	Chicken	2\400	40000	Peterson	A187	Chicken	2\400	40000	Simmons
A45	Chicken	2\400	40000	Tyson	A188	Chicken	2\300	30000	Peterson
A47	Chicken	3\400	60000	Simmons	A189	Chicken	1\400	20000	Peterson
A48	Turkey	4\400	80000	Cargill	A190	Chicken	14\400	280000	Peterson
A51	Chicken	2\300	30000	Peterson	A191	Chicken		232000	Peterson
A56	Chicken	2\400	40000	Cobb-Vantress	A192	Chicken	13\400	260000	Peterson
A57	Chicken	2\400	40000	Cobb-Vantress	A194	Chicken	3\400	60000	Peterson
A62	Hog	1\400	300	Peterson	A195	Chicken	4\400	80000	Peterson
A65	Chicken	4\400	80000	Peterson	A196	Chicken	6\400	120000	Peterson
A68	Chicken	3\400	60000	Simmons	Al 97	Chicken	2\400	40000	Peterson
A69	Chicken	4\400	80000	Simmons	A198	Chicken	1\300	15000	Peterson
A70	Chicken	2\400	40000	Peterson	A199	Chicken	2\300	30000	Peterson
A73	Chicken	3\400	60000	Peterson	A200	Chicken	2\400	40000	Peterson
A77	Chicken	2\400	40000	Peterson	A201	Chicken	3\400	60000	Peterson
A78	Hog		600	Tyson	A202	Chicken	3\400	60000	Peterson
A79	Chicken	4\400	80000	Tyson	A203	Chicken	2\400	40000	Peterson
A80	Chicken	4\400	80000		A204	Chicken	2\400	40000	Peterson
A81	Chicken	2\400	40000	Peterson	A205	Chicken	2\400	40000	Peterson

Label	Type	Houses/ Size (ft)	Est. Animals	Company	Label	Type	Houses/ Size (ft)	Est. Animals	Company
A82	Chicken	4\400	80000	Peterson	A206	Chicken	2\400	40000	Peterson
A83	Chicken	2\400	40000	Tyson	A207	Chicken	4\400	80000	Peterson
A84	Chicken	3\400	60000	Simmons	A208	Chicken	4\400	80000	Peterson
A85	Chicken	2\400	40000	Tyson	A213	Chicken	3\400	60000	Peterson
A86	Chicken	2\400	40000	Tyson	A220	Chicken	3\400	60000	Peterson
A87	Chicken	1\400	20000	Tyson	A229	Chicken	1\400	20000	Peterson

A88	Chicken	2\400	40000	Tyson	A233	Chicken	4\400	80000	Peterson
A89	Chicken	1\400	20000	Tyson	A234	Chicken	2\400	40000	Peterson
A90	Chicken	6\400	120000	Simmons	A235	Chicken	4\400	80000	Peterson
A91	Chicken	7\400	140000	Peterson	A236	Chicken	3\300	45000	Peterson
A92	Chicken	2\400	40000	Peterson	A239	Chicken	1\300, 1\400	35000	Peterson
A93	Hog		3000	Tyson	A240	Chicken	2\300, 1\400	50000	Peterson
A95	Chicken	5\400	100000	Peterson	A243	Chicken	1\300	15000	Peterson
A96	Hog		1500	Tyson	A244	Chicken	2\400	40000	Peterson
A97	Chicken	3\400	60000	Peterson	A245	Chicken	4\400	80000	Peterson
A98	Chicken	3\400	60000	Peterson	A246	Chicken	4\400	80000	Peterson
A99	Chicken	5\400	100000	Peterson	A247	Chicken	4\400	80000	Peterson
A100	Chicken	3\400	60000	Tyson	A249	Chicken	2\400	40000	Peterson
A101	Chicken	4\300	45000	Peterson	A252	Chicken	2\400	40000	Peterson
A104	Chicken	4\400	80000	Tyson	A257	Chicken	3\400	60000	Peterson
A105	Chicken	2\400	40000	Peterson	A262	Chicken	3\400	60000	Hudson
A107	Chicken	4\400	80000	Peterson	A263	Chicken	2\400	40000	Peterson
Al 08	Chicken	1\400	20000	Simmons	A264	Chicken	2\400	40000	Peterson
A109	Chicken	2\400	40000	Simmons	A265	Chicken	1\400	20000	Peterson
A111	Chicken	3\400	60000	Tyson	A268	Chicken	4\400	80000	Peterson
A112	Chicken	2\300	30000	Peterson	A269	Chicken	3\400	60000	Peterson
A273	Chicken	3\400	60000	Peterson	O37	Chicken	2\300	30000	Tyson
A283	Chicken	1\400	20000	Hudson	O42	Chicken	4\400	80000	Peterson
A284	Chicken	6\300	90000	Hudson	O46	Chicken		16000	Simmons
A285	Chicken	3\400	60000	Peterson	O47	Chicken	10\400	200000	'Tyson
A286	Chicken	4\400	80000	Hudson	O49	Chicken	1\400	20000	Peterson
A287	Chicken	3\400	60000	Tyson	O51	Chicken	10\400	200000	Tyson
A297	Chicken	3\400	60000	Tyson	O55	Chicken	4\400	80000	Peterson

Label	Type	Houses/ Size (ft)	Est. Animals	Company	Label	Type	Houses/ Size (ft)	Est. Animals	Company
A298	Chicken	3\400	60000	Peterson	O56	Chicken	2\300	30000	Peterson
A301	Chicken	4\400	80000	Hudson	O58	Chicken	2\400	40000	Peterson
A315	Chicken	6\300	90000	Peterson	O59	Chicken	2\400	40000	Peterson
A316	Chicken	2\300	30000	Tyson	O60	Chicken	2\400	40000	Simmons
A317	Chicken	2\400	40000	Peterson	O63	Chicken	3\400	60000	Peterson
A318	Chicken	2\400	40000	Peterson	O64	Chicken	1\400, 1\300	20000	Tyson

A320	Chicken	3\600	120000	Cargill	O65	Chicken	3\400	60000	Peterson
A322	Chicken	3\400	60000	George's	O66	Chicken	1\400	20000	Simmons
A329	Chicken	3\400	60000	Peterson	O67	Chicken	3\400	60000	Peterson
A368	Chicken	2\400, 2\300	70000	Peterson	O68	Chicken	3\300	45000	Peterson
A369	Chicken	3\400	60000	Peterson	O70	Chicken	2\400	40000	Peterson
A371	Chicken	2\300	30000	George's	O71	Chicken	2\300	30000	Peterson
A372	Chicken	4\300	60000	Peterson	O73	Chicken	4\300	60000	Hudson
A373	Chicken	3\400	60000	Peterson	O74	Chicken	3\400	60000	Hudson
A375	Chicken	4\400	80000	Peterson	O75	Chicken	4\300	60000	Peterson
A377	Chicken	2\400	40000	Peterson	O76	Chicken	10\400	200000	Tyson
A378	Chicken	3\400	60000	Cargill	O77	Chicken		15000	Tyson
A379	Chicken	2\400	40000	Peterson	O78	Chicken	4\400	80000	Peterson
A380	Chicken	2\400	40000	Peterson	O79	Chicken	4\400	80000	George's
A381	Chicken	2\400	40000	Cargill	O82	Chicken	2\300	30000	Peterson
A409	Chicken	9\400	180000	Tyson	O85	Chicken	2\400	40000	Peterson
A456	Chicken	10\400	200000	Peterson	O86	Chicken	4\400	80000	Peterson
A457	Chicken	1\400	20000	Peterson	O91	Chicken	2\400	40000	Peterson
A458	Chicken	4\400	80000	Peterson	O94	Chicken	2\400	40000	Peterson
A459	Chicken	2\400	40000	Peterson	O95	Chicken	3\400	60000	Simmons
A514	Chicken	2\400	40000	Peterson	O96	Chicken	2\400	40000	Simmons
A515	Chicken	3\300	45000	Peterson	O98	Chicken	2\400	40000	Peterson
A517	Chicken	2\300	30000	Peterson	O102	Chicken	3\400	60000	Peterson
A585	Chicken	2\400	40000	Peterson	O106	Chicken	1\400	20000	Hudson
O3	Chicken	2\400	40000	Peterson	O107	Chicken	2\400	40000	Peterson
O4	Chicken	2\400	40000	Peterson	O109	Chicken	1\400	20000	Simmons
O5	Hog		1500	Tyson	O111	Chicken	2\400	40000	Peterson
O6	Chicken	3\400	60000	Peterson	O112	Chicken	4\400	80000	Peterson

Label	Type	Houses/ Size (ft)	Est. Animals	Company	Label	Type	Houses/ Size (ft)	Est. Animals	Company
O7	Chicken	2\400	40000	Peterson	O113	Chicken	3\400	60000	Peterson
O8	Chicken	5\400	100000	Hudson	O114	Chicken	10\400	200000	Tyson
O10	Chicken	3\400	60000	George's	O116	Chicken	2\400	40000	Hudson
O13	Chicken	1\400	20000	Peterson	O117	Chicken	2\400	40000	Peterson
O15	Chicken	4\400	80000	George's	O118	Chicken	4\400	32000	Hudson
O16	Hog		4800	Tyson	O119	Chicken	2\400	40000	Hudson

O20	Chicken	2\400	40000	Hudson
O22	Chicken	2\400	40000	Simmons
O23	Chicken	3\400	60000	Hudson
O24	Chicken	2\400	40000	Tyson
O25	Chicken	4\400	80000	Peterson
O29	Chicken	3\300, 1\400	45000	Simmons
O30	Chicken	2\400	40000	Hudson
O32	Chicken	2\400	20000	Simmons
O34	Hog		6000	Tyson
O120	Chicken	4\400	32000	Cobb-Vantress
O121	Chicken	1\400	20000	Simmons
O122	Chicken	2\300	30000	Simmons
O125	Chicken	10\400	200000	Tyson
O126	Chicken	4\400	80000	Simmons
O127	Chicken	4\400	80000	Peterson
O128	Chicken	3\400	60000	Peterson
O129	Chicken	1\400	20000	Peterson

TABLE 2: Lake Eucha Confined Animal Inventory Summary of Results

SUBWATERSHED	GIS Label	Size (sq. mile)	Chicken Sites	Chicken Houses	Chicken Animals	Chicken Animal Density (per sq. mile)	Hog Sites	Hog Houses	Hog Animals	Hog Animal Density (per sq. mile)	Turkey Sites	Turkey Houses	Turkey Animals	Turkey Animal Density (per sq. mile)	Sites Not Standing	Sites Not In Production	Potential Houses In Production*	Potential Animals **	Potential Animal Density (per sq. mile)
Beaty Cr.	3	59.4	39	126	2,152,000	36,240	0				0				3	14	173	3,086,080	51,970
Brush Cr.	2	34.4	7	31	596,000	17,338	0				0				0	5	48	929,600	27,042
Cherokee Cr.	34	19.4	19	53	1,030,000	53,073	2	19	6,300	325	0				4	16	108	2,103,830	108,404
Cloud Cr.	32	24.9	4	10	190,000	7,619	0				0				0	8	37	723,760	29,026
Coon Cr.	29	15.4	22	62	1,225,000	79,740	2	3	900	59	0				3	18	124	2,426,860	157,974
Decatur Br.	24	11.2	17	61	1,185,000	105,382	0				0				0	18	121	2,385,960	212,184
Dry Cr.	31	28.7	2	8	160,000	5,576	0				0				0	0	8	160,000	5,576
Eucha and Spavinaw north laterals btwn Brush Cr and Beaty Cr.	22	1.2	0				0				0				0	0			
Eucha and Spavinaw south laterals btwn Dry Cr. and Cloud Cr.	27	2.9	0				0				0				0	0			
Eucha Laterals btwn Rattlesnake Cr. and Brush Cr.	19	2.2	0				0				0				0	0			
Eucha north laterals btwn Dam and Rattlesnake Cr.	17	5.3	0				0				0				0	0			
Eucha south laterals btwn Dam and Dry Cr.	21	11.7	0				0				0				0	0			
Hog Eye Cr.	18	6.9	3	18	312,000	45,446	0				0				0	2	26	445,440	64,882
Rattlesnake Cr.	11	9.0	1	4	80,000	8,905	0				0				0	0	4	80,000	8,905
South Prong	13	17.6	14	42	785,000	44,663	0				0				3	11	79	1,518,920	86,421
Spavinaw north laterals btwn Beaty Cr. and Hog Eye Cr.	26	5.2	3	9	180,000	34,880	0				0				1	0	9	180,000	34,880
Spavinaw north laterals btwn Hog Eye Cr. and Spring Branch	14	9.8	10	26	520,000	52,869	1	20	6,000	610	0				1	2	34	659,440	67,046
Spavinaw north laterals btwn Spring Branch and Un-named trib. at Gravette	5	7.2	5	13	260,000	36,135	0				0				2	9	43	860,480	119,591
Spavinaw north laterals btwn Un-named trib. at Nebo and head waters	6	13.1	12	38	780,000	59,749	0				0				1	14	85	1,714,080	131,301
Spavinaw north laterals btwn Un-named trib. at Gravette and Un-named trib. at Nebo	9	1.0	0				0				0				0	0			
Spavinaw south laterals btwn Cherokee Cr. and Coon Cr.	30	8.4	7	19	380,000	45,031	0				1	1	20,000	2,370	0	4	33	666,880	79,026
Spavinaw south laterals btwn Cloud Cr. and Cherokee Cr.	33	9.5	5	10	200,000	20,954	0				0				0	3	20	400,160	41,924
Spavinaw south laterals btwn Coon Cr. and Decatur Br.	23	1.1	0				0				1	4	80,000	74,652	0	0	1	80,000	74,652
Spavinaw south laterals btwn Decatur Br. and Wolf Cr.	15	8.2	14	37	725,000	88,607	2	15	4,500	550	0				0	12	79	1,530,140	187,009
Spavinaw south laterals btwn South Prong and head waters	10	16.2	7	26	510,000	31,509	0				0				0	19	89	1,777,680	109,829
Spavinaw south laterals btwn Wolf Cr. and South Prong	12	1.7	2	4	80,000	46,590	0				0				0	2	11	213,440	124,303
Spring Branch	4	6.3	4	13	260,000	41,427	0				0				1	6	33	660,320	105,211
Un-named trib. at Gravette	8	2.2	1	2	40,000	18,437	0				0				0	1	5	106,720	49,189
Un-named trib. at Nebo	7	2.7	3	10	170,000	63,693	0				0				0	4	23	436,880	163,426
Wolf Cr.	16	12.3	13	92	1,482,000	120,906	0				0				0	7	115	1,949,040	159,008
Total Spavinaw	-	354.8	214	714	13,302,000	37,492	7	57	17,700	50	2	5	100,000	282	19	175	1307	25,095,700	70,733
Total Oklahoma (Delaware County)	-	211.1	71	225	4,115,000	19,496	3	39	12,300	58	0	0	0	0	8	42	368	6,929,540	32,831
Total Arkansas (Benton County)	-	143.7	143	489	9,187,000	63,920	4	18	5,400	38	2	5	100,000	696	11	133	939	18,166,160	126,393

* Potential Houses In Production is calculated based on the average of 3.336 houses per active site in the Spavinaw watershed.

** Sites not inproduction are assumed to be chicken CAFO's with the potential of 20,000 chickens per house.

TABLE 3: Lake Eucha Watershed Confined Animal Estimated Nutrient Production

			Chicken				Hog				Turkey				Total (Houses in Production)				Total (Full Production)			
			Pounds per year *		Pounds per sq mile per year		Pounds per year **		Pounds per sq mile per year		Pounds per year ***		Pounds per sq mile per year		Pounds per year		Pounds per sq mile per year		Pounds per year ****		Pounds per sq mile per year	
SUBWATERSHED	GIS Label	Size (sq. mile)	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus
Beaty Cr.	3	59.4	1,183,600	365,840	19,933	6,161	0	0	0	0	0	0	0	0	1,183,600	365,840	19,933	6,161	1,337,600	413,440	22,526	6,962
Brush Cr.	2	34.4	327,800	101,320	9,536	2,947	0	0	0	0	0	0	0	0	327,800	101,320	9,536	2,947	382,800	118,320	11,136	3,442
Cherokee Cr.	34	19.4	566,500	175,100	29,190	9,022	241,500	79,800	12,444	4,112	0	0	0	0	808,000	254,900	41,634	13,134	984,000	309,300	50,703	15,937
Cloud Cr.	32	24.9	104,500	32,300	4,191	1,295	0	0	0	0	0	0	0	0	104,500	32,300	4,191	1,295	192,500	59,500	7,720	2,386
Coon Cr.	29	15.4	673,750	208,250	43,857	13,556	34,500	11,400	2,246	742	0	0	0	0	708,250	219,650	46,103	14,298	906,250	280,850	58,991	18,282
Decatur Br.	24	11.2	651,750	201,450	57,960	17,915	0	0	0	0	0	0	0	0	651,750	201,450	57,960	17,915	849,750	262,650	75,568	23,357
Dry Cr.	31	28.7	88,000	27,200	3,067	948	0	0	0	0	0	0	0	0	88,000	27,200	3,067	948	88,000	27,200	3,067	948
Eucha and Spavinaw north laterals btwn Brush Cr and Beaty Cr.	22	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucha and Spavinaw south laterals btwn Dry Cr. and Cloud Cr.	27	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucha Laterals btwn Rattlesnake Cr. and Brush Cr.	19	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucha north laterals btwn Dam and Rattlesnake Cr.	17	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucha south laterals btwn Dam and Dry Cr.	21	11.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hog Eye Cr.	18	6.9	171,600	53,040	24,995	7,726	0	0	0	0	0	0	0	0	171,600	53,040	24,995	7,726	193,600	59,840	28,200	8,716
Rattlesnake Cr.	11	9.0	44,000	13,600	4,898	1,514	0	0	0	0	0	0	0	0	44,000	13,600	4,898	1,514	44,000	13,600	4,898	1,514
South Prong	13	17.6	431,750	133,450	24,565	7,593	0	0	0	0	0	0	0	0	431,750	133,450	24,565	7,593	552,750	170,850	31,449	9,721
Spavinaw north laterals btwn Beaty Cr. and Hog Eye Cr.	26	5.2	99,000	30,600	19,184	5,930	0	0	0	0	0	0	0	0	99,000	30,600	19,184	5,930	99,000	30,600	19,184	5,930
Spavinaw north laterals btwn Hog Eye Cr. and Spring Branch	14	9.8	286,000	88,400	29,078	8,988	230,000	76,000	23,384	7,737	0	0	0	0	516,000	164,400	52,462	16,715	538,000	171,200	54,699	17,406
Spavinaw north laterals btwn Spring Branch and Un-named trib. at Gravette	5	7.2	143,000	44,200	19,874	6,143	0	0	0	0	0	0	0	0	143,000	44,200	19,874	6,143	242,000	74,800	33,634	10,396
Spavinaw north laterals btwn Un-named trib. at Nebo and head waters	6	13.1	429,000	132,600	32,862	10,157	0	0	0	0	0	0	0	0	429,000	132,600	32,862	10,157	583,000	180,200	44,659	13,804
Spavinaw north laterals btwn Un-named trib. at Gravette and Un-named trib. at Nebo	9	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spavinaw south laterals btwn Cherokee Cr. and Coon Cr.	30	8.4	209,000	64,600	24,767	7,655	0	0	0	0	53,000	20,000	6,281	2,370	262,000	84,600	31,047	10,025	306,000	98,200	36,261	11,637
Spavinaw south laterals btwn Cloud Cr. and Cherokee Cr.	33	9.5	110,000	34,000	11,524	3,562	0	0	0	0	0	0	0	0	110,000	34,000	11,524	3,562	143,000	44,200	14,982	4,631
Spavinaw south laterals btwn Coon Cr. and Decatur Br.	23	1.1	0	0	0	0	0	0	0	0	212,000	80,000	197,827	74,652	212,000	80,000	197,827	74,652	212,000	80,000	197,827	74,652
Spavinaw south laterals btwn Decatur Br. and Wolf Cr.	15	8.2	398,750	123,250	48,734	15,063	172,500	57,000	21,083	6,966	0	0	0	0	571,250	180,250	69,816	22,030	703,250	221,050	85,949	27,016
Spavinaw south laterals btwn South Prong and head waters	10	16.2	280,500	86,700	17,330	5,356	0	0	0	0	0	0	0	0	280,500	86,700	17,330	5,356	489,500	151,300	30,242	9,348
Spavinaw south laterals btwn Wolf Cr. and South Prong	12	1.7	44,000	13,600	25,625	7,920	0	0	0	0	0	0	0	0	44,000	13,600	25,625	7,920	66,000	20,400	38,437	11,881
Spring Branch	4	6.3	143,000	44,200	22,785	7,043	0	0	0	0	0	0	0	0	143,000	44,200	22,785	7,043	209,000	64,600	33,301	10,293
Un-named trib. at Gravette	8	2.2	22,000	6,800	10,140	3,134	0	0	0	0	0	0	0	0	22,000	6,800	10,140	3,134	33,000	10,200	15,210	4,701
Un-named trib. at Nebo	7	2.7	93,500	28,900	34,976	10,811	0	0	0	0	0	0	0	0	93,500	28,900	34,976	10,811	137,500	42,500	51,435	15,898
Wolf Cr.	16	12.3	815,100	251,940	66,498	20,554	0	0	0	0	0	0	0	0	815,100	251,940	66,498	20,554	892,100	275,740	72,780	22,496
Total Spavinaw	-	354.8	7,316,100	2,261,340	585,568	180,994	678,500	224,200	89,156	19,547	265,000	100,000	204,108	77,022	8,259,600	2,585,540	848,832	277,563	10,184,600	3,180,540	1,022,857	331,352
Total Oklahoma (Delaware County)	-	211.1	2,263,250	699,550	10,723	3,314	471,500	155,800	2,234	738	0	0	0	0	2,734,750	855,350	12,957	4,052	3,196,750	988,150	15,146	4,729
Total Arkansas (Benton County)	-	143.7	5,052,850	1,561,790	35,156	10,866	207,000	68,400	1,440	476	265,000	100,000	1,844	696	5,524,850	1,730,190	38,440	12,038	6,987,850	2,182,390	48,619	15,184

* Estimated based on one 20,000 bird (chicken) house produces 11,000 lbs. nitrogen per and 3,400 lbs. phosphorus per year

** Estimated based on one 20,000 bird (turkey) house produces 53,000 lbs. nitrogen per and 20,000 lbs. phosphorus per year

*** Estimated based on one 600 sow unit produces 23,000 lbs. nitrogen per and 7,600 lbs. phosphorus per year

**** Estimated based the assumption that all houses not in production (Table 2) could be occupied by chickens during production.