IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF OKLAHOMA

STATE OF OKLAHOMA,	)	
	)	
Plaintiff,	)	
	)	
v.	)	**Case No. 05-cv-329-GKF(PJC)**
	)	
TYSON FOODS, INC., et al.,	)	
	)	
Defendants.	)	

DECLARATION OF BERNARD ENGEL, Ph.D.

I, Bernard Engel, Ph.D., hereby declare as follows:

1. I hold a B.S. and M.S. in Agricultural and Biological Engineering from the University of Illinois and a Ph.D. in Agricultural Engineering from Purdue University. I am a registered Professional Engineer (PE) in the State of Indiana. Since 1988, I have been a faculty member in the Purdue University Department of Agricultural and Biological Engineering. I am currently Department Head and Professor within this program. My research, teaching and outreach expertise are in environmental engineering and the application of information systems technologies to environmental problems. I have extensive experience in developing and applying computer models, databases, and geographic information systems to a range of environmental issues. In this regard, I have developed hydrologic/water quality models and decision support systems that are widely used by consultants and local, state and federal agencies. My work has allowed me to obtain extensive experience in applying models and information technologies to assess nutrient and pesticide movement in surface waters of watersheds and into watershed groundwater. I have published more than 100 articles on related topics in peer reviewed scientific journals.

2. I have been retained by the Oklahoma Attorney General to evaluate the generation and land application of poultry waste within the Illinois River Watershed ("IRW"). In addition, I have been asked to evaluate the movement of this waste and its constituents into streams, rivers, and groundwaters within the IRW and into Lake Tenkiller.

3. On May 22, 2008, I submitted an Expert Report to the Defendants in the above-captioned litigation. Included in the Expert Report are my findings and opinions regarding poultry waste and phosphorus (P) generation in the IRW.

Exhibit 55

4. The following statements and opinions in this Declaration are taken verbatim from my May 22, 2008 Expert Report, pp. 12-17.

5. Annual poultry waste generated in the Illinois River Basin was calculated using several sources of data. ***The analyses indicate each of the defendants' poultry operations within the Illinois River Watershed (IRW) produces a substantial amount of poultry waste and phosphorus. Calculated poultry waste produced within the IRW range between 354,000 and more than 500,000 tons annually. Phosphorus content of the poultry waste ranges from 8.7 million to nearly 10 million pounds annually.***

6. *Poultry Production Data from Integrators*

The 2001-2006 poultry production data for the Illinois River Basin provided by the integrators (Table 3.1) was used to calculate poultry waste and phosphorus (P) production. Not all integrators provided production data by type of poultry. Therefore, it was necessary to estimate the number of poultry by type for Tyson and Simmons. This was done by using the number of houses of each type of poultry by integrator created by Dr. Fisher (Fisher, 2008) and the average poultry production by type per house from the Arkansas Soil and Water Conservation Commission to estimate the proportion of poultry type for Tyson and Simmons. The Cobb data were combined with Tyson data.

Poultry waste production was calculated using waste values from the USDA Agricultural Waste Management Field Handbook, Ch.4 - Ag Waste Characteristics. The average weights of poultry by type were obtained from the Arkansas Soil and Water Conservation Commission data.

Table 3.1. Poultry Production in the Illinois River Basin Provided by Defendants' Discovery Responses

Defendant	2001	2002	2003	2004	2005	2006
Cal-Maine	1,135,998	879,281	633,656	403,739	200,000	0
Cargill	3,058,603	3,032,295	3,381,331	3,545,084	3,381,451	2,305,422
Cobb	1,189,358	1,279,798	1,237,193	1,250,237	1,243,562	1,244,481
George's	19,972,941	20,082,206	21,312,971	23,535,964	26,524,368	27,479,391
Peterson	13,277,715	14,454,936	14,897,458	20,981,977	18,166,724	16,887,638
Simmons	15,400,000	17,600,000	18,600,000	25,400,000	31,600,000	27,400,000
Tyson	87,027,895	88,142,559	90,098,641	95,023,680	89,719,497	88,639,337
TOTAL	**140,870,901**	**145,267,093**	**149,255,914**	**170,140,681**	**170,835,602**	**163,956,269**

The annual poultry waste and P produced by poultry based on poultry production data provided by the defendants are shown in Table 3.2 for the years 2001-2006. Phosphorus in the poultry waste shown in Table 3.2 is consistent with calculations obtained in performing a P mass balance for the Illinois River Watershed (as setout in Section 7 of this report and Appendix B). Waste ranges from nearly 420,000 tons in 2001 to more than 482,000 tons in 2004. Phosphorus in the poultry waste ranges from more than 8.7 million pounds in 2001 to nearly 10 million pounds in 2004.

Table 3.2. Poultry Waste and P Production within the IRW Based on Defendant Supplied Poultry Production Data

Year	Total Waste (tons)	Total P (lbs)
2001	420,555	8,732,752
2002	425,308	8,801,173
2003	440,920	9,176,463
2004	482,407	9,975,305
2005	476,649	9,819,383
2006	445,364	9,000,113

The annual poultry waste produced by integrator based on defendant supplied poultry production data is shown in Table 3.3. Each defendant produces a substantial amount of waste with Tyson producing approximately ½ of the waste.

Table 3.3. Poultry Waste by Defendant within the IRW Based on Defendant Supplied Poultry Production Data for 2001-2006

	Poultry Waste (tons)					
Year	**Cal-Maine**	**Cargill**	**Georges**	**Peterson**	**Simmons**	**Tyson+Cobb**
2001	18,626	45,086	69,510	27,970	40,247	219,116
2002	14,561	44,698	67,494	30,450	45,996	222,110
2003	10,821	49,843	73,401	31,382	48,610	226,862
2004	6,712	52,257	73,730	44,199	66,381	239,128
2005	3,135	49,845	76,879	38,269	82,585	225,936
2006	0	33,984	80,943	35,574	71,608	223,256

The annual P produced in poultry waste by integrator based on defendant supplied poultry production data is shown in Table 3.4. Each of the defendants' poultry operations produce a substantial amount of P in poultry waste with Tyson's producing approximately ½ of P in poultry waste.

Table 3.4. Phosphorus in Poultry Waste by Defendant within the IRW Based on Defendant Supplied Poultry Production Data for 2001-2006

	P in Poultry Waste (lbs)					
Year	**Cal-Maine**	**Cargill**	**Georges**	**Peterson**	**Simmons**	**Tyson+Cobb**
2001	396,398	1,484,311	1,452,470	543,414	768,007	4,088,152
2002	311,363	1,471,544	1,404,951	591,594	877,722	4,143,999
2003	233,511	1,640,927	1,532,054	609,705	927,592	4,232,673
2004	145,707	1,720,395	1,522,252	858,725	1,266,712	4,461,513
2005	71,837	1,640,986	1,571,747	743,505	1,575,910	4,215,398
2006	0	1,118,799	1,658,320	691,157	1,366,453	4,165,384

7. *USDA Agriculture Census Data*

In calculating poultry waste generated in the Illinois River Basin using the 2002 USDA Agriculture Census data, poultry were allocated to the basin using the proportion of pasture within counties to assign the proportion of poultry in the county to the basin. This approach calculated approximately 528,000 tons of poultry waste per year generated in the IRW.

Annual poultry waste generation was also calculated using 2002 USDA Agricultural Census data by allocating poultry to the basin proportional to the area of each county within the watershed. Calculated annual poultry waste in the IRW using this allocation approach is approximately 414,000 tons per year.

8. *Arkansas Soil and Water Conservation Commission Data*

The Arkansas Soil and Water Conservation Commission 2007 Poultry Registration data on poultry production in the Illinois River Basin were used to estimate poultry waste production in the basin. This data contained the type of poultry, weight, number, number of flocks, and number of houses. These data were provided for poultry operations that were within the basin within Benton and Washington counties. The average poultry production by type by house was computed from these data as was the average weight of poultry.

The number of active poultry houses with known integrators within the Oklahoma portion of the basin was obtained from Dr. Fisher (Fisher, 2008). These houses had an assigned poultry type as well. Poultry numbers for the Oklahoma counties were computed using the average production numbers by type of poultry from the Arkansas Soil and Water Conservation Commission data.

The poultry waste values provided by the Arkansas Soil and Water Conservation Commission used equations that are unrealistic with regard to the amount of poultry waste produced per bird as removed from poultry houses. The equations used by the Arkansas Soil and Water Conservation Commission to compute poultry waste calculate the amount of waste excreted on a dry weight basis (amount of waste excreted with all water removed and without inclusion of bedding materials). Therefore, poultry waste production was calculated using waste values from the USDA Agricultural Waste Management Field Handbook, Ch.4 - Ag Waste Characteristics. The average weights of poultry by type were obtained from the Arkansas Soil and Water Conservation Commission data.

The calculated annual poultry waste production using this approach within the IRW is approximately 477,000 tons. The poultry house data prepared by Dr. Bert Fisher that identified integrator and type of poultry were used to calculate the proportion of each poultry type produced by each integrator (Fisher, 2008). Using this information and total

waste production for each type of poultry, the litter production within the IRW for each integrator was computed and is shown in Table 3.5.

Table 3.5. Calculated Annual Waste Production (tons) by Integrator Using Arkansas Soil and Water Conservation Commission Data and USDA Waste Characteristics Field Manual

Poultry Waste Production (tons/yr)

Type	Cal-Maine	Cargill	Georges	Peterson	Simmons	Tyson
Breeder	456	4,785	5,468	684	7,974	25,518
Broiler	0	1,018	56,006	38,950	58,552	148,162
Cornish	0	0	0	0	0	11,103
Turkey	0	52,073	0	0	0	0
Layer	12,362	0	11,411	6,657	0	6,657
Pullet	349	0	5,239	524	3,842	20,084
Total	13,167	57,876	78,125	46,814	70,368	211,523

The Arkansas Soil and Water Conservation Commission data show the following amounts of poultry waste generated within the Illinois River Watershed (Table 3.6). The poultry waste estimates by the Arkansas Soil and Water Conservation Commission use equations that greatly under predict poultry waste generation per bird as it would be removed from poultry houses. The equations used by the Arkansas Soil and Water Conservation Commission to compute poultry waste calculate the amount of waste excreted on a dry weight basis (amount of waste excreted with all water removed and without inclusion of bedding materials).

Table 3.6. Arkansas Soil and Water Conservation Commission (ASWCC) Estimate of Poultry Waste Generated in the Illinois River Watershed. Note the Equation Used by ANRC Underestimates Waste Production as Removed from Poultry Houses. Equation Estimates Waste Production on a Dry Weight Basis Without Bedding.

ASWCC Poultry Waste Generated in IRW (tons)

County	2004	2005	2006	2007
Benton	56,470	70,168	62,507	95,091
Washington	72,896	107,003	89,141	120,014

If the Arkansas Soil and Water Conservation Commission poultry waste estimate for 2007 (215,105 tons) is converted to waste as removed from poultry housing (includes some moisture and bedding material), the estimated poultry waste produced in Benton and Washington Counties is more than 376,000 tons. This is based on USDA Agricultural Waste Management Field Handbook, Ch.4 - Ag Waste Characteristics characterizations of poultry waste data (20 lbs dry weight per 1000 lbs broilers and 35 lbs as removed from housing including bedding per 1000 lbs broilers; to convert waste in Table 3.6 to as removed multiply values by 35/20 or 1.75).

9. *Poultry Waste Generated within the IRW Based on Poultry House Data*

Fisher (2008) calculated poultry waste generation within the IRW based on active poultry houses within the IRW, house sizes, type of poultry, integrator, and waste production data. Poultry houses within the IRW were identified from aerial photography and various data sources and observations were used to identify active houses (Fisher, 2008). The sizes of active houses were measured from aerial photography within a GIS. The integrator and type of poultry produced within each active house was identified from various records and observations (Fisher, 2008). The amount of waste produced per unit area of house by poultry type was calculated from data in animal waste management plans prepared under the supervision of the U. S District Court (N.D. Okl.) by the Eucha/Spavinaw Watershed Management Team. Additional details of the calculation are provided in Fisher (2008).

Table 3.7 shows the amount of poultry waste produced by each integrator within the IRW based on the data and calculations overviewed above. Each of the defendants produces a significant amount of poultry waste within the IRW.

Table 3.7.
Poultry Waste Production (tons) Within the Illinois River Watershed Calculated from a Consideration of the Total Area of Active Poultry Houses Operated by a Known Defendant (from Fisher, 2008)

Defendant	Broiler	Breeder	Turkey	Pullet	Cornish	Hen	TOTAL	%
Cal-Maine		358		112		2,280	2,750	0.78%
Cargill		2,860	15,108				17,968	5.08%
Georges	49,813	5,911		2,489		1,888	60,101	16.98%
Peterson	35,063	491		277		1,311	37,143	10.49%
Simmons	58,724	5,757		1,818			66,299	18.73%
Tyson	129,421	18,593		7,735	9,874	1,521	167,144	47.22%
Willowbrook			2,597				2,597	0.73%
TOTAL	273,022	33,970	17,704	12,430	9,874	6,999	**354,000**	
	77.12%	9.60%	5.00%	3.51%	2.79%	1.98%		

10. *Literature Estimates of Poultry Waste and P in Poultry Waste in the IRW*

Reports and published journal papers have estimated poultry waste and P in poultry waste within the IRW. The estimates in these reports as described below are consistent with the analyses presented in the preceding sections.

Willett et al. (2006) estimated more than 361,000 tons of poultry waste was generated and applied within the IRW annually. They estimated this waste contained more than 9,000 tons of P. They recommended that poultry waste be exported from the watershed to address water quality issues in the IRW.

In reviewing the sources of nutrients, a 1989 Soil Conservation Service (USDA-SCS, 1989) inventory estimated more than 93,400,000 chickens and other poultry are produced in the basin each year, producing 366,000,000 kilograms (403,000 tons) of manure. Vieux and Moreda (2003) noted that the P generated by the poultry industry in the IRW is equivalent to a human population of 8 million people.

Smith et al. (1997) analyzed HUCs (watersheds) to identify the contributors of nutrients to streams and rivers. For the Illinois River Watershed, they found that livestock contributed 93.01 kg P per square km per year (out of a total of 118.29 kg P per square km per year), while point sources contributed 5.33 kg P per square km per year and fertilizer contributed 8.52 kg P per square km per year.

Nelson et al. (2002) found nearly 6,000,000 lbs of P annually were input into the Arkansas portion of the Illinois River Watershed (7,000,000 lbs if cattle are considered but Nelson et al. acknowledge that cattle are recycling P). Of the approximately 6,000,000 lbs of P, nearly 5,000,000 lbs of P were estimated to be from poultry litter application to pastures in the watershed.

The USDA SCS and FS (1992) estimated that poultry in the IRW generated twice as much manure as cattle in the IRW. They estimated poultry manure in the IRW contained 5 times as much P as cattle manure in the IRW.

11. *Summary of Poultry Waste Generation in the IRW*

Table 3.8 summarizes the poultry waste generation within the IRW by method and/or source. Poultry waste generated within the IRW ranges between 354,000 tons annually to more than 500,000 tons annually.

Table 3.8. Poultry Waste Generated in the Illinois River Watershed

Source	**IRW Poultry Waste (tons/yr)**
Dr. Fisher (Fisher, 2008)	354,000
Defendant supplied poultry and USDA waste coefficients (2001-2006)	421,000-482,000
USDA Census and USDA waste coefficients (2002)	414,000-528,000
Arkansas Soil and Water Conservation Commission Data, Dr. Fisher house data, USDA waste coefficient (2007)	477,000
USDA-SCS (1989)	403,000
Willett et al. (2006)	361,000

I declare under penalty of perjury, under the laws of the United States of America, that the foregoing is true and correct.

Executed on the 14th day of May, 2009.

Bernard Engel, Ph.D.