Second Errata for: Nutrient Pollution of Streams in the Illinois River Watershed, Oklahoma: Effects on Water Quality, Aesthetics, and Biodiversity

Expert Report of Dr. R. Jan Stevenson

For

State of Oklahoma

In

Case No. 05-CU-329-GKF-SAJ

State of Oklahoma v. Tyson Foods, et al.

(In the United States District Court for the Northern District of Oklahoma)

Dr. R. Jan Stevenson
Professor of Zoology
Aquatic Ecologist

September 26, 2008

Exhibit G

The following changes are the result of changes in Dr. Engel's model results (Engel Errata, September 4, 2008) and a few typographical errors that were found during the review. Some of the analysis and conclusion in Section 5 of my Report rely on Dr. Engel's modeling results. Page and line references are to my August 5, 2008 Errata.

Section 5.2.1, first full paragraph, line 2, change from "0.100 and 0.120 mg TP/L" to "0.090 and 0.100 mg TP/L" due to Engel model change.

Section 5.2.1, first full paragraph, line 6, change "0.120 mg TP/L" to "0.020 mg TP/L" due to typographic error.

Section 5.2.1, third full paragraph, line 4, change "the early 1970s" to "the mid-1980s" due to Engel model change.

Section 5.2.2, Finding (paragraph 2), line 1, change "Thirteen" to "Twelve" due to Engel model change.

Section 5.2.2, Finding (paragraph 2), line 3, change "35 percent fewer" to "42 percent fewer" due to Engel model change.

Section 5.2.2, Finding (paragraph 2), line 3, change "48 percent difference" to "54 percent difference" due to Engel model change.

Section 5.2.2, paragraph 3, line 4, change "44-51" to "55-60" due to Engel model change.

Section 5.2.2 paragraph 3, line 4, change "under litter" to "under no litter" due to typographical error.

Section 5.2.2, paragraph 3, line 6, change "118 and 126%" to "83 and 80%" due to Engel model change.

Section 5.2.2, paragraph 3, line 9, change "3-4%" to "2-3%" due to Engel model change.

Section 5.2.2, paragraph 3, line 10, change "(-44 percent)" to "(-55 percent)" due to Engel model change.

Section 5.2.2, paragraph 3, line 11, change "(-50 and -51 percent)" to "(-59 and -60 percent)" due to Engel model change.

Section 5.2.2, paragraph 4, line 2, change "36 percent increase to a 35 percent decrease" to "31 percent increase to a 44 percent decrease" due to Engel model change.

Section 5.2.2, paragraph 4, line 5, change "83" to "78" due to Engel model change.

Section 5.2.2, paragraph 5, line 2, delete "with buffer" due to typographical error.

Section 5.2.2, paragraph 5, line 4, change "48" to "41" due to Engel model change.

Section 5.2.2, paragraph 5, line 6, change "56" to "46" due to Engel model change.

Section 5.2.2, paragraph 5, line 7, change "26" to "23" due to Engel model change.

Section 5.2. Table 5.3 should be renumbered as Table 5.2.

Section 6 (Summary and Opinions), paragraph 11, line 4, change "Eleven" to "Twelve" to conform the Report's Summary to the Errata.

Section 6, paragraph 11, line 6, change "as many as 19" to "37" to conform the Report's Summary to the Errata.

Section 6, paragraph 11, line 7, change "only 15" to "24" to conform the Report's Summary to the Errata.

Section 6, paragraph 11, line 7, add "if litter application is halted" to the end of the sentence that on that line to conform the Report's Summary to the Errata.

Section 6, paragraph 11, line 8, insert "these" before "management practices."

Section 6, paragraph 11, line 8, change "an 11" to "a 12" to conform the Report's Summary to the Errata.

Section 6, paragraph 11, line 9, change "19" to "37" to conform the Report's Summary to the Errata.

Section 6, paragraph 11, line 9, change "30" to "49" to conform the Report's Summary to the Errata.

Replace Tables 5.1 and 5.3 with the Tables 5.1 and 5.2, respectively, at the end of the errata. The percent change for each scenario and the predicted TP concentrations in the 96 representative watersheds in 2057 under different management scenarios were revised in these tables. In addition the column labeled rank was removed from Table 5.1 because it was a column used in sorting during data analysis and not intended to be printed in the report.

The following shows the Report text with the above changes made.

5.2 Results and Discussion

5.2.1 Historic Conditions

Finding: Historic TP concentrations, as late as 1950, would not have supported the frequent nuisance accumulations of FGA observed today.

Historic P conditions in the Illinois River at Tahlequah during the spring and summer increased from a predicted concentration of less than 0.030 mg TP/L to between 0.090 and 0.100 mg TP/L in 1999 (Dr. Bernard Engel's Expert Witness Report). Summer P concentrations were predicted to be slightly lower than spring P concentrations. Predicted changes in P concentrations in the Baron Fork during the spring were less, ranging from less than 0.010 mg TP/L in 1950 to about 0.020 mg TP/L in 1999. Results from the Caney Creek were not used because of dry periods during summer conditions.

The increases in nutrient concentrations in the Illinois River at Tahlequah indicate that nutrients were low enough that extensive FGA cover would have been rare in 1950. The risk of nuisance FGA cover that would alter aesthetics and habitat for biodiversity increased greatly from 1950 to 1999. Oklahoma State phosphorus criterion for aesthetics use was predicted to be exceeded by the late 1950s in the Illinois River at Tahlequah. The probability of extensive FGA is great when TP concentrations are as high as 0.100 mg/L (Stevenson et al. 2006). Aesthetics problems would not have been as great in the Baron Fork. However, local problems within the Baron Fork watershed were likely where P loading was sufficient to increase P concentrations in small streams, but not in the main branch of the Baron Fork where P would become diluted and processed biologically.

The increases in nutrient concentrations in the Illinois River at Tahlequah and the Baron Fork indicate that nutrients were low enough that little risk to fish species composition from nutrient pollution existed in 1950. However, in the Illinois River, the increase in P concentrations exceeded the benchmark for fish effects, 0.060 mg TP/L, during the mid-1980s.

Based on summer 2006 sampling of 96 3rd order subwatersheds in the IRW, 47 percent exceeded the fish benchmark for injury; and assuming that TP concentrations were at least as high during the spring as summer, aesthetics of 83 percent of streams were injured with TP concentrations higher than the 0.027 mg TP/L benchmark (Tables 5.1 and 5.2). Seventy-four percent of the 3rd order subwatersheds would have exceeded the 0.037 mg TP/L criterion set by the State Oklahoma (OWRB 2005).

5.2.2 Future Scenarios

Land use was characterized in 332 of the 336 3rd order subwatersheds of the IRW. The median poultry house density in watersheds was 1.375 houses/mi^2, with a minimum of 0, maximum of 7.095, and 25th and 75th quartiles of 0.267 and 3.717 houses/mi^2 (Figure 5.1). The median of urban land use was 4.67 percent of subwatersheds, with a minimum of 0.375, maximum of 88.847, and 25th and 75th quartiles of 3.142 and 7.59 percent. The median of percent agricultural land use was 44.4 percent of watersheds, with a minimum of 0, a maximum of 88.0, and 25th and

75th quartiles of 23.5 and 59.6 percent. In summary, most of the 3rd order subwatersheds had less than 10 percent urban land use and low poultry house densities. The land use characteristics of the subset of 96 3rd order subwatersheds that had measured TP concentrations during summer 2006 were similar to the land use characteristics of the full set of 332 3rd order subwatersheds of the IRW. It is my opinion that the estimates of subwatershed percentages injured in the subset 96 3rd order subwatersheds are representative of the injuries of stream miles throughout the IRW stream and river network, based on similarity of the land use characteristics of the 96 3rd order subwatersheds and the 332 3rd order subwatersheds plus other considerations of temporal and spatial variation in TP and nutrient effects on stream and river ecosystems.

Finding: Twelve percent more streams in the IRW would be injured in 50 years if growth of the industry continues as modeled. However, if litter application were halted and stream buffers were established, as many as 42 percent fewer streams would be injured. This represents a 54 percent difference in the number of watersheds injured in 50 years depending upon future management practices.

Engel's processed-based watershed models showed decreases in both spring and summer TP concentrations over the next 50 years in IRW streams under no litter and no litter plus buffer scenarios (Tables 5.1 & 5.2). Estimated decreases in TP concentrations ($\delta TP_{IRW,s\text{-}avg,j}$) ranged from 55-60% over the next 50 years under litter and no litter plus buffer scenarios during spring and summer periods. TP concentrations over the next 50 years in Engle's models were predicted to increase by 83 and 80% during spring and summer respectively, if poultry activity growth continues at the recent pace. TP concentrations under control scenarios in Engle's models were predicted to remain the same over the next 50 years; the calculated percent increase between 2-3% was within the interannual variability simulated by the model. The percent reduction in TP concentrations was successively higher for no litter (-55 percent) and the no litter plus buffer (-59 to -60 percent) scenarios. Discussion of reasons for differences in reductions of average seasonal TP concentrations among scenarios is beyond the scope of this report.

The predicted changes in proportion of IRW subwatersheds injured due to P pollution ranged from a 31 percent increase to a 44 percent decrease (Tables 5.1 & 5.2). The growth scenario increased the percent of watersheds injured for spring aesthetics, from 83 to 96 percent having TP concentrations greater than 0.027 mg TP/L. During the summer, the percent of watersheds with greater than 0.060 mg TP/L increased from 47 to 78 percent according to the growth scenario.

The management scenario which could produce the greatest improvement in TP concentrations over the next 50 years was the no litter plus buffer scenario, although the no litter with buffer scenario was similar (Tables 5.1 & 5.2). The no litter plus buffer scenario could cause a reduction in percent subwatersheds injured for spring aesthetics from 83 percent in 2007 to 42 percent in 2057. The no litter scenario could cause a reduction in percent subwatersheds injured for spring aesthetics from 83 percent in 2007 to 47 percent in 2057. The greatest percent reduction in summer injury for fish species composition was from 47 percent in 2007 to 26 percent in 2057 with the no litter plus buffer scenario.

Section 6. Summary and Opinions: Paragraph 11.

The 0.027 mg TP/L threshold observed in the IRW for FGA cover and the 0.060 mg TP/L benchmark were used to define injurious levels of TP and to evaluate changes in injury to IRW streams under different management scenarios. Historically, nutrient concentrations were low in the IRW and would not have caused these problems. Twelve percent more streams in the IRW would be injured in 50 years if growth of the industry continues as in the recent past. If litter application was halted, at the end of 50 years 37 percent fewer streams would be injured for aesthetics by FGA. After 50 years, 24 percent would recover from injury to fish species composition, if litter application is halted. Depending on these management practices, these models predict a 12 percent stream loss and a 37 percent stream gain that could result in a 49 percent difference in the number of Illinois River Watersheds that will be injured in 50 years.

Table 5.1. The expected average spring TP concentrations in the 96 representative watersheds in 2057 under different management scenarios. The TP concentrations during spring were assumed, conservatively, to be the same as during summer 2006. The percent change for each scenario is listed as well as the spring injury benchmark (0.027 mg TP/L). The numbers marked in bold are the site with lowest TP concentration that exceeded the spring injury benchmark.

100-Percentile	Summer 2006 TP (mg/L)	Spring 2057 (0.027 mg TP/L benchmark)			
		Control	No Litter	No Litter & Buffer	Continued Growth
		2.75 %	-55.38 %	-60.18 %	82.57 %
100.00	0.006	0.006	0.003	0.002	0.011
98.96	0.009	0.009	0.004	0.003	0.016
97.92	0.009	0.009	0.004	0.003	0.016
96.87	0.010	0.010	0.004	0.004	0.018
95.83	0.017	0.017	0.008	0.007	**0.031**
94.79	0.018	0.018	0.008	0.007	0.032
93.75	0.018	0.018	0.008	0.007	0.033
92.71	0.018	0.019	0.008	0.007	0.033
91.67	0.021	0.022	0.009	0.008	0.038
90.62	0.021	0.022	0.009	0.008	0.038
89.58	0.021	0.022	0.009	0.008	0.038
88.54	0.022	0.023	0.010	0.009	0.040
87.50	0.023	0.023	0.010	0.009	0.041
86.46	0.025	0.025	0.011	0.010	0.045
85.42	0.025	0.025	0.011	0.010	0.045
84.37	0.025	0.025	0.011	0.010	0.045
83.33	**0.029**	**0.029**	0.013	0.011	0.052
82.29	0.029	0.030	0.013	0.012	0.053
81.25	0.030	0.031	0.013	0.012	0.055
80.21	0.030	0.031	0.014	0.012	0.055
79.17	0.033	0.034	0.015	0.013	0.060
78.12	0.035	0.036	0.016	0.014	0.064
77.08	0.036	0.037	0.016	0.014	0.065
76.04	0.037	0.038	0.016	0.015	0.067
75.00	0.037	0.038	0.017	0.015	0.068
73.96	0.038	0.039	0.017	0.015	0.069
72.92	0.038	0.039	0.017	0.015	0.070
71.87	0.039	0.040	0.017	0.015	0.070
70.83	0.039	0.040	0.017	0.016	0.071
69.79	0.040	0.041	0.018	0.016	0.073
68.75	0.040	0.041	0.018	0.016	0.073
67.71	0.040	0.041	0.018	0.016	0.074

100-Percentile	Summer 2006 TP (mg/L)	Spring 2057 (0.027 mg TP/L benchmark)			
		Control	No Litter	No Litter & Buffer	Continued Growth
		2.75 %	-55.38 %	-60.18 %	82.57 %
66.67	0.042	0.043	0.019	0.017	0.077
65.62	0.043	0.044	0.019	0.017	0.079
64.58	0.044	0.046	0.020	0.018	0.081
63.54	0.045	0.046	0.020	0.018	0.082
62.50	0.045	0.046	0.020	0.018	0.082
61.46	0.046	0.047	0.020	0.018	0.083
60.42	0.046	0.047	0.021	0.018	0.084
59.37	0.048	0.049	0.021	0.019	0.087
58.33	0.048	0.049	0.021	0.019	0.088
57.29	0.049	0.051	0.022	0.020	0.090
56.25	0.051	0.052	0.023	0.020	0.093
55.21	0.051	0.052	0.023	0.020	0.093
54.17	0.051	0.052	0.023	0.020	0.093
53.12	0.052	0.053	0.023	0.021	0.095
52.08	0.053	0.054	0.024	0.021	0.097
51.04	0.054	0.055	0.024	0.022	0.099
50.00	0.055	0.057	0.025	0.022	0.100
48.96	0.055	0.057	0.025	0.022	0.100
47.92	0.057	0.058	0.025	0.022	0.103
46.87	0.061	0.063	0.027	0.024	0.112
45.83	0.063	0.065	**0.028**	0.025	0.115
44.79	0.064	0.065	0.028	0.025	0.116
43.75	0.064	0.066	0.029	0.025	0.117
42.71	0.065	0.067	0.029	0.026	0.119
41.67	0.068	0.070	0.030	0.027	0.124
40.62	0.072	0.074	0.032	**0.029**	0.131
39.58	0.072	0.074	0.032	0.029	0.131
38.54	0.072	0.074	0.032	0.029	0.132
37.50	0.073	0.075	0.033	0.029	0.134
36.46	0.081	0.083	0.036	0.032	0.148
35.42	0.082	0.085	0.037	0.033	0.150
34.37	0.083	0.085	0.037	0.033	0.151
33.33	0.086	0.088	0.038	0.034	0.157
32.29	0.091	0.094	0.041	0.036	0.167
31.25	0.093	0.096	0.042	0.037	0.170

100-Percentile	Summer 2006 TP (mg/L)	Spring 2057 (0.027 mg TP/L benchmark)			
		Control	No Litter	No Litter & Buffer	Continued Growth
		2.75 %	-55.38 %	-60.18 %	82.57 %
30.21	0.102	0.105	0.045	0.041	0.186
29.17	0.103	0.106	0.046	0.041	0.188
28.12	0.116	0.119	0.052	0.046	0.212
27.08	0.117	0.120	0.052	0.047	0.214
26.04	0.128	0.132	0.057	0.051	0.234
25.00	0.141	0.144	0.063	0.056	0.257
23.96	0.142	0.146	0.063	0.057	0.260
22.92	0.154	0.159	0.069	0.061	0.282
21.87	0.157	0.161	0.070	0.062	0.286
20.83	0.170	0.174	0.076	0.068	0.310
19.79	0.187	0.192	0.083	0.074	0.341
18.75	0.187	0.192	0.084	0.075	0.342
17.71	0.189	0.194	0.084	0.075	0.345
16.67	0.190	0.195	0.085	0.076	0.347
15.62	0.191	0.196	0.085	0.076	0.348
14.58	0.236	0.243	0.105	0.094	0.432
13.54	0.255	0.262	0.114	0.101	0.465
12.50	0.260	0.267	0.116	0.103	0.474
11.46	0.283	0.291	0.126	0.113	0.516
10.41	0.350	0.360	0.156	0.139	0.639
9.37	0.383	0.393	0.171	0.152	0.698
8.33	0.437	0.449	0.195	0.174	0.798
7.29	0.446	0.458	0.199	0.178	0.814
6.25	0.475	0.488	0.212	0.189	0.867
5.21	0.557	0.572	0.249	0.222	1.017
4.16	0.592	0.608	0.264	0.236	1.081
3.12	0.597	0.614	0.267	0.238	1.091
2.08	1.428	1.468	0.637	0.569	2.608
1.04	4.111	4.223	1.834	1.637	7.504

Table 5.2. The expected summer average TP concentrations in the 96 representative watersheds in 2057 under different management scenarios. The percent change from summer 2006 for each scenario is listed as well as the summer injury benchmark (0.060 mg TP/L). The numbers marked in bold are the site with lowest TP concentration that exceeded the summer injury benchmark.

100-Percentile	Summer 2006 TP (mg/L)	Summer 2057 (0.060 mg TP/L)			
		Control	No Litter	No Litter & Buffer	Continued Growth
		2.45 %	-54.53 %	-59.01 %	79.95 %
100.00	0.006	0.006	0.003	0.002	0.011
98.96	0.009	0.009	0.004	0.004	0.016
97.92	0.009	0.009	0.004	0.004	0.016
96.87	0.010	0.010	0.005	0.004	0.018
95.83	0.017	0.017	0.008	0.007	0.030
94.79	0.018	0.018	0.008	0.007	0.032
93.75	0.018	0.018	0.008	0.007	0.032
92.71	0.018	0.019	0.008	0.007	0.033
91.67	0.021	0.022	0.010	0.009	0.038
90.62	0.021	0.022	0.010	0.009	0.038
89.58	0.021	0.022	0.010	0.009	0.038
88.54	0.022	0.023	0.010	0.009	0.040
87.50	0.023	0.023	0.010	0.009	0.041
86.46	0.025	0.025	0.011	0.010	0.044
85.42	0.025	0.025	0.011	0.010	0.044
84.37	0.025	0.025	0.011	0.010	0.045
83.33	0.029	0.029	0.013	0.012	0.051
82.29	0.029	0.030	0.013	0.012	0.052
81.25	0.030	0.031	0.014	0.012	0.054
80.21	0.030	0.031	0.014	0.012	0.054
79.17	0.033	0.034	0.015	0.014	0.059
78.12	0.035	0.036	0.016	0.014	**0.063**
77.08	0.036	0.037	0.016	0.015	0.064
76.04	0.037	0.038	0.017	0.015	0.066
75.00	0.037	0.038	0.017	0.015	0.067
73.96	0.038	0.039	0.017	0.015	0.068
72.92	0.038	0.039	0.017	0.016	0.069
71.87	0.039	0.039	0.018	0.016	0.069
70.83	0.039	0.040	0.018	0.016	0.070
69.79	0.040	0.041	0.018	0.016	0.072
68.75	0.040	0.041	0.018	0.016	0.072
67.71	0.040	0.041	0.018	0.017	0.072

100-Percentile	Summer 2006 TP (mg/L)	Summer 2057 (0.060 mg TP/L)			
		Control	No Litter	No Litter & Buffer	Continued Growth
		3.32 %	-43.98 %	-50.31 %	126.17 %
66.67	0.042	0.043	0.019	0.017	0.076
65.62	0.043	0.044	0.020	0.018	0.077
64.58	0.044	0.045	0.020	0.018	0.080
63.54	0.045	0.046	0.020	0.018	0.081
62.50	0.045	0.046	0.020	0.018	0.081
61.46	0.046	0.047	0.021	0.019	0.082
60.42	0.046	0.047	0.021	0.019	0.083
59.37	0.048	0.049	0.022	0.020	0.086
58.33	0.048	0.049	0.022	0.020	0.086
57.29	0.049	0.051	0.022	0.020	0.089
56.25	0.051	0.052	0.023	0.021	0.092
55.21	0.051	0.052	0.023	0.021	0.092
54.17	0.051	0.052	0.023	0.021	0.092
53.12	0.052	0.053	0.024	0.021	0.094
52.08	0.053	0.054	0.024	0.022	0.095
51.04	0.054	0.055	0.025	0.022	0.097
50.00	0.055	0.056	0.025	0.023	0.099
48.96	0.055	0.056	0.025	0.023	0.099
47.92	0.057	0.058	0.026	0.023	0.102
46.87	**0.061**	**0.063**	0.028	0.025	0.111
45.83	0.063	0.065	0.029	0.026	0.113
44.79	0.064	0.065	0.029	0.026	0.114
43.75	0.064	0.066	0.029	0.026	0.115
42.71	0.065	0.067	0.030	0.027	0.117
41.67	0.068	0.070	0.031	0.028	0.123
40.62	0.072	0.073	0.033	0.029	0.129
39.58	0.072	0.074	0.033	0.030	0.130
38.54	0.072	0.074	0.033	0.030	0.130
37.50	0.073	0.075	0.033	0.030	0.132
36.46	0.081	0.083	0.037	0.033	0.146
35.42	0.082	0.084	0.037	0.034	0.148
34.37	0.083	0.085	0.038	0.034	0.149
33.33	0.086	0.088	0.039	0.035	0.155
32.29	0.091	0.093	0.041	0.037	0.164
31.25	0.093	0.096	0.042	0.038	0.168

100-Percentile	Summer 2006 TP (mg/L)	Summer 2057 (0.060 mg TP/L)			
		Control	No Litter	No Litter & Buffer	Continued Growth
		3.32 %	-43.98 %	-50.31 %	126.17 %
30.21	0.102	0.104	0.046	0.042	0.183
29.17	0.103	0.106	0.047	0.042	0.185
28.12	0.116	0.119	0.053	0.048	0.209
27.08	0.117	0.120	0.053	0.048	0.211
26.04	0.128	0.131	0.058	0.052	0.230
25.00	0.141	0.144	0.064	0.058	0.253
23.96	0.142	0.146	0.065	0.058	0.256
22.92	0.154	0.158	0.070	0.063	0.278
21.87	0.157	0.160	0.071	0.064	0.282
20.83	0.170	0.174	0.077	0.070	0.305
19.79	0.187	0.191	0.085	0.077	0.336
18.75	0.187	0.192	0.085	0.077	0.337
17.71	0.189	0.194	0.086	0.077	0.340
16.67	0.190	0.195	0.086	0.078	0.342
15.62	0.191	0.195	0.087	0.078	0.343
14.58	0.236	0.242	0.107	0.097	0.425
13.54	0.255	0.261	0.116	0.104	0.458
12.50	0.260	0.266	0.118	0.106	0.467
11.46	0.283	0.290	0.129	0.116	0.509
10.41	0.350	0.359	0.159	0.144	0.630
9.37	0.383	0.392	0.174	0.157	0.688
8.33	0.437	0.448	0.199	0.179	0.787
7.29	0.446	0.457	0.203	0.183	0.802
6.25	0.475	0.487	0.216	0.195	0.855
5.21	0.557	0.571	0.253	0.228	1.002
4.16	0.592	0.606	0.269	0.243	1.065
3.12	0.597	0.612	0.272	0.245	1.075
2.08	1.428	1.463	0.650	0.586	2.570
1.04	4.111	4.211	1.869	1.685	7.397