Table 26. Estimated Nutrients Produced by Poultry in Subwatersheds of the Illinois River.

			Broiler				Layer			
			lbs/yr		lbs/mi²/yr		lbs/yr		lbs/mi²/yr	
Subwatershed	**GIS label**	**Size (mi²)**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**
Smith Hollow	48	12.62	22000	6800	1743.22	538.81	8250	2550	653.71	202.05
Snake & Cato Creek	49	11.42	0	0	0.00	0.00	0	0	0.00	0.00
South Briggs Hollow	50	7.59	22000	6800	2899.38	896.17	0	0	0.00	0.00
South Proctor Creek	51	14.63	0	0	0.00	0.00	0	0	0.00	0.00
Steeley Hollow	52	18.59	0	0	0.00	0.00	0	0	0.00	0.00
Tahlequah & Kill Hollow & Rock Br	53	8.29	198000	61200	23879.44	7380.92	0	0	0.00	0.00
Tailhot Creek	54	18.56	0	0	0.00	0.00	0	0	0.00	0.00
Tate Parrish Branch	55	16.68	22000	6800	1318.74	407.61	45100	13940	2703.41	835.60
Telamay H. & Dog Hollow	56	12.37	0	0	0.00	0.00	0	0	0.00	0.00
Terrapin Creek	57	17.44	0	0	0.00	0.00	0	0	0.00	0.00
Tyner Creek	58	42.67	627000	193800	14692.72	4541.39	0	0	0.00	0.00
Walltrip Branch	59	9.96	24750	7650	2484.66	767.98	0	0	0.00	0.00
Welling Creek	60	4.98	0	0	0.00	0.00	0	0	0.00	0.00
West Branch	61	7.77	57750	17850	7435.09	2298.12	38500	11900	4956.73	1532.08
Total Watershed	T	821.69	4276250	1321750	5204.21	1608.57	490600	151640	597.06	184.55

Table 27. Nutrient Production by Turkeys in Subwatersheds of the Illinois River Basin.

			Turkey				Pullet			
			lbs/yr		lbs/mi²/yr		lbs/yr		lbs/mi²/yr	
Subwatershed	**GIS label**	**Size (mi²)**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**
Ballard Creek	1	25.19	0	0	0.00	0.00	0	0	0.00	0.00
Battle Branch	2	9.33	159000	60000	17040.53	6430.39	0	0	0.00	0.00
Beaver Creek	3	14.51	0	0	0.00	0.00	0	0	0.00	0.00
Bidding Creek	4	17.46	79500	30000	4554.00	1718.49	0	0	0.00	0.00
Blackfox & Winset Hollow	5	22.92	79500	30000	3468.12	1308.73	0	0	0.00	0.00
Blue Spring Branch	6	5.28	0	0	0.00	0.00	0	0	0.00	0.00
Burnt Cabin Creek	7	12.32	0	0	0.00	0.00	0	0	0.00	0.00
Calunchety Hollow	8	6.95	0	0	0.00	0.00	0	0	0.00	0.00
Cedar Hollow & Tully Hollow	9	11.12	0	0	0.00	0.00	0	0	0.00	0.00
Crazy Creek	10	9.41	0	0	0.00	0.00	0	0	0.00	0.00
Dennison Creek	11	7.89	0	0	0.00	0.00	0	0	0.00	0.00
Dripping Spring Branch	12	11.35	0	0	0.00	0.00	0	0	0.00	0.00
Dripping Springs Hollow	13	11.76	0	0	0.00	0.00	0	0	0.00	0.00
Dry Creek & Bolin Hollow	14	27.48	0	0	0.00	0.00	0	0	0.00	0.00
Elk Creek	15	21.67	0	0	0.00	0.00	0	0	0.00	0.00
England Hollow Creek	16	9.46	0	0	0.00	0.00	55000	17000	5816.25	1797.75
Evansville Creek	17	48.52	0	0	0.00	0.00	0	0	0.00	0.00
Fagan Creek	18	3.72	0	0	0.00	0.00	0	0	0.00	0.00
Fall Branch	19	8.62	0	0	0.00	0.00	0	0	0.00	0.00
Falls Branch	20	10.93	119250	45000	10910.26	4117.08	0	0	0.00	0.00
Field Hollow	21	6.64	0	0	0.00	0.00	0	0	0.00	0.00
Five Mile Hollow	22	11.23	0	0	0.00	0.00	0	0	0.00	0.00
Goat Mountain	23	12.60	0	0	0.00	0.00	0	0	0.00	0.00
Green Creek	24	15.60	0	0	0.00	0.00	0	0	0.00	0.00
Hazelnut Hollow	25	4.52	0	0	0.00	0.00	0	0	0.00	0.00
Illinois River Echota Bend Laterals	26	6.92	0	0	0.00	0.00	0	0	0.00	0.00
Kirk Springs & Sawmill Hollow	27	9.13	0	0	0.00	0.00	0	0	0.00	0.00
Linder Bend & Sawmill Hollow	28	8.46	0	0	0.00	0.00	0	0	0.00	0.00
Luna Branch	29	14.83	0	0	0.00	0.00	0	0	0.00	0.00
Mining Camp Hollow (North)	30	6.91	0	0	0.00	0.00	0	0	0.00	0.00
Mining Camp Hollow (South)	31	7.87	0	0	0.00	0.00	0	0	0.00	0.00
Mollyfield & Peavine Creeks	32	12.03	198750	75000	16515.65	6232.32	0	0	0.00	0.00
Mulberry Hollow	33	15.96	0	0	0.00	0.00	0	0	0.00	0.00
Negro Jake Hollow	34	16.98	119250	45000	7023.95	2650.55	0	0	0.00	0.00
North Briggs Hollow	35	2.11	0	0	0.00	0.00	0	0	0.00	0.00
Park Hill Branch	36	19.14	0	0	0.00	0.00	0	0	0.00	0.00
Peacheater Creek	37	25.34	0	0	0.00	0.00	0	0	0.00	0.00
Peavine Branch	38	16.14	0	0	0.00	0.00	0	0	0.00	0.00
Pettit Creek	39	15.51	0	0	0.00	0.00	0	0	0.00	0.00
Pine Hollow	40	5.12	0	0	0.00	0.00	0	0	0.00	0.00
Proctor Mountain Creek	41	10.03	0	0	0.00	0.00	0	0	0.00	0.00
Pumpkin Hollow	42	18.66	0	0	0.00	0.00	0	0	0.00	0.00
Ross Branch & Tahlequah Creek	43	18.35	0	0	0.00	0.00	0	0	0.00	0.00
Sager Creek	44	8.24	0	0	0.00	0.00	0	0	0.00	0.00
Scraper Hollow Creek	45	9.33	0	0	0.00	0.00	0	0	0.00	0.00
Shell Branch	46	17.58	79500	30000	4521.42	1706.20	0	0	0.00	0.00
Sizemore Creek	47	6.99	0	0	0.00	0.00	0	0	0.00	0.00

Table 27. Nutrient Production by Turkeys in Subwatersheds of the Illinois River Basin.

			Turkey				Pullet			
			lbs/yr		lbs/mi²/yr		lbs/yr		lbs/mi²/yr	
Subwatershed	**GIS label**	**Size (mi²)**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**
Smith Hollow	48	12.62	0	0	0.00	0.00	0	0	0.00	0.00
Snake & Cato Creek	49	11.42	0	0	0.00	0.00	0	0	0.00	0.00
South Briggs Hollow	50	7.59	238500	90000	31431.89	11861.09	0	0	0.00	0.00
South Proctor Creek	51	14.63	0	0	0.00	0.00	0	0	0.00	0.00
Steeley Hollow	52	18.59	0	0	0.00	0.00	0	0	0.00	0.00
Tahlequah & Kill Hollow & Rock Br	53	8.29	0	0	0.00	0.00	0	0	0.00	0.00
Tailhot Creek	54	18.56	0	0	0.00	0.00	0	0	0.00	0.00
Tate Parrish Branch	55	16.68	0	0	0.00	0.00	0	0	0.00	0.00
Telamay H. & Dog Hollow	56	12.37	0	0	0.00	0.00	0	0	0.00	0.00
Terrapin Creek	57	17.44	0	0	0.00	0.00	0	0	0.00	0.00
Tyner Creek	58	42.67	0	0	0.00	0.00	0	0	0.00	0.00
Walltrip Branch	59	9.96	0	0	0.00	0.00	0	0	0.00	0.00
Welling Creek	60	4.98	0	0	0.00	0.00	0	0	0.00	0.00
West Branch	61	7.77	0	0	0.00	0.00	0	0	0.00	0.00
Total Watershed	T	821.69	1073250	405000	1306.15	492.89	55000	17000	66.94	20.69

Table 28. Nutrient Production from Cattle in Subwatersheds of the Illinois River Basin.

			Dairy				Beef Cattle			
			lbs/yr		lbs/mi²/yr		lbs/yr		lbs/mi²/yr	
Subwatershed	**GIS label**	**Size (mi²)**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**
Ballard Creek	1	25.19	33852	26208	1344.07	1040.57	283920	85176	11272.87	3381.86
Battle Branch	2	9.33	32723.6	25334.4	3507.09	2715.17	43680	13104	4681.32	1404.40
Beaver Creek	3	14.51	0	0	0.00	0.00	97188	29156.4	6698.69	2009.61
Bidding Creek	4	17.46	10155.6	7862.4	581.74	450.38	97188	29156.4	5567.22	1670.17
Blackfox & Winset Hollow	5	22.92	0	0	0.00	0.00	174720	52416	7622.02	2286.61
Blue Spring Branch	6	5.28	0	0	0.00	0.00	60060	18018	11368.14	3410.44
Burnt Cabin Creek	7	12.32	0	0	0.00	0.00	16380	4914	1329.48	398.85
Calunchety Hollow	8	6.95	7898.8	6115.2	1136.90	880.18	32760	9828	4715.25	1414.57
Cedar Hollow & Tully Hollow	9	11.12	0	0	0.00	0.00	86268	25880.4	7757.29	2327.19
Crazy Creek	10	9.41	11284	8736	1199.62	928.74	54600	16380	5804.60	1741.38
Dennison Creek	11	7.89	4513.6	3494.4	571.93	442.79	91728	27518.4	11623.18	3486.96
Dripping Spring Branch	12	11.35	14669.2	11356.8	1292.15	1000.38	131040	39312	11542.81	3462.84
Dripping Springs Hollow	13	11.76	0	0	0.00	0.00	43680	13104	3713.84	1114.15
Dry Creek & Bolin Hollow	14	27.48	0	0	0.00	0.00	72072	21621.6	2622.98	786.89
Elk Creek	15	21.67	0	0	0.00	0.00	5460	1638	252.00	75.60
England Hollow Creek	16	9.46	13540.8	10483.2	1431.94	1108.60	109200	32760	11547.90	3464.37
Evansville Creek	17	48.52	6770.4	5241.6	139.53	108.02	327600	98280	6751.26	2025.38
Fagan Creek	18	3.72	0	0	0.00	0.00	22932	6879.6	6162.39	1848.72
Fall Branch	19	8.62	12412.4	9609.6	1440.37	1115.13	66612	19983.6	7729.87	2318.96
Falls Branch	20	10.93	6770.4	5241.6	619.43	479.56	98280	29484	8991.70	2697.51
Field Hollow	21	6.64	0	0	0.00	0.00	54600	16380	8222.92	2466.88
Five Mile Hollow	22	11.23	0	0	0.00	0.00	32760	9828	2918.12	875.44
Goat Mountain	23	12.60	0	0	0.00	0.00	84084	25225.2	6672.42	2001.73
Green Creek	24	15.60	5642	4368	361.59	279.94	174720	52416	11197.67	3359.30
Hazelnut Hollow	25	4.52	0	0	0.00	0.00	43680	13104	9654.27	2896.28
Illinois River Echota Bend Laterals	26	6.92	0	0	0.00	0.00	0	0	0.00	0.00
Kirk Springs & Sawmill Hollow	27	9.13	0	0	0.00	0.00	70980	21294	7773.70	2332.11
Linder Bend & Sawmill Hollow	28	8.46	0	0	0.00	0.00	16380	4914	1936.35	580.91
Luna Branch	29	14.83	0	0	0.00	0.00	98280	29484	6626.44	1987.93
Mining Camp Hollow (North)	30	6.91	0	0	0.00	0.00	79716	23914.8	11539.44	3461.83
Mining Camp Hollow (South)	31	7.87	0	0	0.00	0.00	90636	27190.8	11514.50	3454.35
Mollyfield & Peavine Creeks	32	12.03	0	0	0.00	0.00	92820	27846	7713.12	2313.94
Mulberry Hollow	33	15.96	0	0	0.00	0.00	185640	55692	11631.71	3489.51
Negro Jake Hollow	34	16.98	5642	4368	332.32	257.28	196560	58968	11577.59	3473.28
North Briggs Hollow	35	2.11	0	0	0.00	0.00	69888	20966.4	33057.55	9917.27
Park Hill Branch	36	19.14	4513.6	3494.4	235.80	182.55	27300	8190	1426.20	427.86
Peacheater Creek	37	25.34	42879.2	33196.8	1692.33	1310.19	294840	88452	11636.57	3490.97
Peavine Branch	38	16.14	9027.2	6988.8	559.24	432.96	185640	55692	11500.51	3450.15
Pettit Creek	39	15.51	0	0	0.00	0.00	32760	9828	2112.12	633.64
Pine Hollow	40	5.12	0	0	0.00	0.00	10920	3276	2132.90	639.87
Proctor Mountain Creek	41	10.03	0	0	0.00	0.00	87360	26208	8707.69	2612.31
Pumpkin Hollow	42	18.66	0	0	0.00	0.00	141960	42588	7606.47	2281.94
Ross Branch & Tahlequah Creek	43	18.35	0	0	0.00	0.00	16380	4914	892.82	267.85
Sager Creek	44	8.24	15797.6	12230.4	1918.06	1484.95	32760	9828	3977.54	1193.26
Scraper Hollow Creek	45	9.33	0	0	0.00	0.00	129948	38984.4	13927.28	4178.18
Shell Branch	46	17.58	17490.2	13540.8	994.72	770.11	196560	58968	11179.01	3353.70
Sizemore Creek	47	6.99	0	0	0.00	0.00	24024	7207.2	3436.65	1031.00

Table 28. Nutrient Production from Cattle in Subwatersheds of the Illinois River Basin.

			Dairy				Beef Cattle			
			lbs/yr		lbs/mi²/yr		lbs/yr		lbs/mi²/yr	
Subwatershed	**GIS label**	**Size (mi²)**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**
Smith Hollow	48	12.62	11848.2	9172.8	938.82	726.83	141960	42588	11248.51	3374.55
Snake & Cato Creek	49	11.42	0	0	0.00	0.00	16380	4914	1434.15	430.24
South Briggs Hollow	50	7.59	0	0	0.00	0.00	58968	17690.4	7771.39	2331.42
South Proctor Creek	51	14.63	0	0	0.00	0.00	98280	29484	6719.27	2015.78
Steeley Hollow	52	18.59	0	0	0.00	0.00	141960	42588	7634.65	2290.39
Tahlequah & Kill Hollow & Rock Br	53	8.29	0	0	0.00	0.00	64428	19328.4	7770.23	2331.07
Tailhot Creek	54	18.56	0	0	0.00	0.00	136500	40950	7355.87	2206.76
Tate Parrish Branch	55	16.68	4513.6	3494.4	270.56	209.46	49140	14742	2945.58	883.67
Telamay H. & Dog Hollow	56	12.37	0	0	0.00	0.00	96096	28828.8	7769.54	2330.86
Terrapin Creek	57	17.44	0	0	0.00	0.00	5460	1638	313.11	93.93
Tyner Creek	58	42.67	29902.6	23150.4	700.72	542.49	327600	98280	7676.77	2303.03
Walltrip Branch	59	9.96	0	0	0.00	0.00	138684	41605.2	13922.51	4176.75
Welling Creek	60	4.98	0	0	0.00	0.00	57876	17362.8	11614.47	3484.34
West Branch	61	7.77	0		0.00	0.00	89544	26863.2	11528.45	3458.54
Total Watershed	T	821.69	301847	233688	367.35	284.40	5809440	1742832	7070.10	2121.03

Table 29. Nutrient Production by Hogs in Subwatersheds of the Illinois River Basin.

			Hog			
			Pounds per year		lbs/mi²/yr	
Subwatershed	**GIS label**	**Size (mi²)**	**N**	**P**	**N**	**P**
Ballard Creek	1	25.19	0	0	0.00	0.00
Battle Branch	2	9.33	0	0	0.00	0.00
Beaver Creek	3	14.51	0	0	0.00	0.00
Bidding Creek	4	17.46	0	0	0.00	0.00
Blackfox & Winset Hollow	5	22.92	0	0	0.00	0.00
Blue Spring Branch	6	5.28	0	0	0.00	0.00
Burnt Cabin Creek	7	12.32	0	0	0.00	0.00
Calunchety Hollow	8	6.95	0	0	0.00	0.00
Cedar Hollow & Tully Hollow	9	11.12	0	0	0.00	0.00
Crazy Creek	10	9.41	0	0	0.00	0.00
Dennison Creek	11	7.89	0	0	0.00	0.00
Dripping Spring Branch	12	11.35	0	0	0.00	0.00
Dripping Springs Hollow	13	11.76	0	0	0.00	0.00
Dry Creek & Bolin Hollow	14	27.48	0	0	0.00	0.00
Elk Creek	15	21.67	0	0	0.00	0.00
England Hollow Creek	16	9.46	0	0	0.00	0.00
Evansville Creek	17	48.52	0	0	0.00	0.00
Fagan Creek	18	3.72	23000	7600	6180.66	2042.31
Fall Branch	19	8.62	0	0	0.00	0.00
Falls Branch	20	10.93	0	0	0.00	0.00
Field Hollow	21	6.64	0	0	0.00	0.00
Five Mile Hollow	22	11.23	0	0	0.00	0.00
Goat Mountain	23	12.60	0	0	0.00	0.00
Green Creek	24	15.60	0	0	0.00	0.00
Hazelnut Hollow	25	4.52	0	0	0.00	0.00
Illinois River Echota Bend Laterals	26	6.92	0	0	0.00	0.00
Kirk Springs & Sawmill Hollow	27	9.13	0	0	0.00	0.00
Linder Bend & Sawmill Hollow	28	8.46	0	0	0.00	0.00
Luna Branch	29	14.83	0	0	0.00	0.00
Mining Camp Hollow (North)	30	6.91	0	0	0.00	0.00
Mining Camp Hollow (South)	31	7.87	0	0	0.00	0.00
Mollyfield & Peavine Creeks	32	12.03	0	0	0.00	0.00
Mulberry Hollow	33	15.96	0	0	0.00	0.00
Negro Jake Hollow	34	16.98	0	0	0.00	0.00
North Briggs Hollow	35	2.11	0	0	0.00	0.00
Park Hill Branch	36	19.14	0	0	0.00	0.00
Peacheater Creek	37	25.34	0	0	0.00	0.00
Peavine Branch	38	16.14	0	0	0.00	0.00
Pettit Creek	39	15.51	0	0	0.00	0.00
Pine Hollow	40	5.12	0	0	0.00	0.00
Proctor Mountain Creek	41	10.03	0	0	0.00	0.00
Pumpkin Hollow	42	18.66	0	0	0.00	0.00
Ross Branch & Tahlequah Creek	43	18.35	0	0	0.00	0.00
Sager Creek	44	8.24	0	0	0.00	0.00
Scraper Hollow Creek	45	9.33	0	0	0.00	0.00
Shell Branch	46	17.58	0	0	0.00	0.00
Sizemore Creek	47	6.99	0	0	0.00	0.00

Table 29. Nutrient Production by Hogs in Subwatersheds of the Illinois River Basin.

			Hog			
			Pounds per year		lbs/mi²/yr	
Subwatershed	**GIS label**	**Size (mi²)**	**N**	**P**	**N**	**P**
Smith Hollow	48	12.62	0	0	0.00	0.00
Snake & Cato Creek	49	11.42	0	0	0.00	0.00
South Briggs Hollow	50	7.59	0	0	0.00	0.00
South Proctor Creek	51	14.63	0	0	0.00	0.00
Steeley Hollow	52	18.59	0	0	0.00	0.00
Tahlequah & Kill Hollow & Rock Br	53	8.29	1226666.7	405333.33	147939.99	48884.52
Tailhot Creek	54	18.56	0	0	0.00	0.00
Tate Parrish Branch	55	16.68	0	0	0.00	0.00
Telamay H. & Dog Hollow	56	12.37	0	0	0.00	0.00
Terrapin Creek	57	17.44	0	0	0.00	0.00
Tyner Creek	58	42.67	0	0	0.00	0.00
Walltrip Branch	59	9.96	0	0	0.00	0.00
Welling Creek	60	4.98	0	0	0.00	0.00
West Branch	61	7.77	0	0	0.00	0.00
Total Watershed	T	821.69	1249666.7	412933.33	1520.85	502.54

Based on these numbers, an estimated total of 13,256,000 lbs. of nitrogen and 4,284,800 lbs of phosphorus will be excreted by confined animals in the Oklahoma portion of the Illinois River Basin each year. In Oklahoma, chickens produce 36% and 34%, turkeys produce 9% and 10%, dairy cattle produce 2% and 5%, hogs produce 9% and 10%, and beef cattle produce 44% and 41%, respectively of the nitrogen and phosphorus excreted in the watershed. These numbers reflect a large increase over the previous measurement taken in 1987 and given recent trends it should be expected that current animal populations have increased substantially over these figures.

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 estimated total number of chickens in the Oklahoma portion of the watershed would increase from 8,667,000 to 16,362,200.

If all houses capable of production were being used, it is estimated that a total of 17,502,000 lbs. of Nitrogen and 5,597,240 lbs. of phosphorus would be produced in the Oklahoma portion of the watershed per year.

In the past, much of the attention concerning nutrient sources in the Illinois River Watershed has focused on the poultry industry, and indeed this industry is a significant primary source of many of the nutrients available to the river and lake. However, the cattle industry is also

a significant source of nutrients. Although some of the nutrients secreted by cattle originally came from the poultry industry (via pasture fertilized with poultry litter), certainly not all nutrients cattle secrete originated in chicken feed and/or litter. In addition, cattle process nutrients (some of which were originally from the poultry industry) in grass into a more readily available form to algae, compounding the problem. Given direct access to water, cattle frequent the riparian areas, as on hot days, these areas provide the most shade. Thus, the cattle act almost as a point source, depositing nutrients directly in the stream. Due to the magnitude of the potential source of nutrients from cattle, efforts to reduce nutrient transport to the streams should focus not only on the poultry industry, but also on the cattle industry.

In addition, grazing land is at a premium in the watershed. As a result, pastures are frequently overgrazed during part, if not all of the year. The result is not only poor forage crops, but a significant reduction in the ability of the pasture vegetation to trap and utilize the animal waste applied to it (either by livestock or the landowner). In addition, root systems are curbed and surface vegetation is sparser so the land is more prone to erosion. Although certain grazing areas in the watershed are properly maintained, a significant number are exploited with corresponding affects on water quality.

It is very important to note that the above 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 the Illinois River. 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.

Phosphorus, 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. However, recent studies indicate that phosphorus mobility in soil is greater than once believed; Phosphorus has been shown to move through the soil layers into the groundwater and runoff from Phosphorus-rich soils contains significant concentrations. One troublesome thing about Phosphorus 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 phosphorus settles out of the liquid phase. The lagoon will eventually be pumped out and the phosphorus 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 Lake Tenkiller, it is apparent that a significant portion of them do and that they are having an impact. This is demonstrated by the steady increase in total nitrogen and phosphorus concentrations seen at the monitoring sites in the watershed over the last twenty years (OWRB 1995). It's also manifested in the lake as steadily increasing chlorophyll values (OWRB 1995). 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 1997. 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 phosphorus 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 chickens in the watershed is equal to 538,300 humans in terms of nitrogen excreted, and 1,605,000 humans in terms of phosphorus excreted. Averaging these two numbers and dividing by the number of square miles in the watershed, we arrive at a human density equivalent of 1,304 humans per square mile or 2 humans per acre. This is in addition to the humans that actually live there and the waste produced is not subject to the same treatment as that of humans, i.e. it generally does not pass through a treatment plant or septic system.

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 was demonstrated by the fact that

Lake Tenkiller is still in fairly good shape. There is still much room for improvement and trends indicate that the lake will continue to decline at an increasingly rapid rate if something is not done to decrease the nutrient load it receives. 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 Tenkiller and the Illinois River 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.

The disposal of wastes produced by these facilities provides a serious management dilemma for landowners as the amount of animal wastes produced exceeds the amount of land available for waste application. In addition, wastes are produced and must be disposed of year-round, despite the problems associated with application during the non-growing season. In addition, the soils in the watershed are becoming phosphorus-saturated. Additional applications of litter result merely in higher concentration of nutrients in runoff, rather than increased forage growth. Research has shown that runoff of nutrients from areas where these wastes are applied has the potential to contain high levels of nutrients (Agricultural Research Service, Bulletin T-169).

a. POTENTIAL SOLUTIONS

1. Development and adoption of a basin-wide animal waste management strategy

2. Development of individual waste management plans

3. Reduction in animal numbers

4. Removal of waste from the watershed

Discussion of Potential Solutions

1. Although waste management has been addressed towards individual landowners in some watersheds, a basin wide approach has not been developed. Management of wastes on this scale will be necessary if solutions such as transferring wastes out of the basin are to be considered. A waste management strategy would involve identification of the waste carrying capacity of land in the basin as well as plans for the fate of additional wastes produced in the future. The Oklahoma Registered Poultry Feeding Operations Act went into effect July 1, 1997 which requires registration of new poultry feeding operations, utilization of best management practices (soil testing, litter application on a soil phosphorus basis, etc.), development of animal waste management plans, and other specific provisions to protect water resources. Another measure put in effect in July 1997 was the

Oklahoma Poultry Waste Transfer Act which encourages the transfer of poultry waste out of environmentally-sensitive watersheds, and the Poultry Waste Applicators Certification Act which requires applicators of poultry waste to be certified by the State Department of Agriculture. Also included was a provision requiring integrators to contract with Oklahoma State University through the Cooperative Extension Service for an educational training program for both poultry feeding operations and poultry waste applicators.

2. Implementation work completed in the Battle Branch watershed showed that management of wastes was largely based upon the need for disposal. In other words the driving force behind waste disposal was the need to get the waste out of feeding facilities with little consideration being given to proper application rates. Application rates were determined by the amount of waste produced divided by the acres available for disposal, rather than by the amount of nutrients in the soil or the ability of plants to utilize those nutrients. Individual waste management plans determine proper application rates through soil testing and land availability and identify those areas which are suitable or unsuitable for waste disposal. Included in this plan should be establishment of buffer strips and/or protection of riparian areas which are free from application of poultry waste and/or cattle access. The water quality problems and threats produced by improper management of poultry waste have become severe enough that regulatory action has been taken. Litter must now be applied based on soil phosphorus levels, rather than the size of the litter pile and the area of the field. Growers must have animal waste management plans on file. Measures are underway to transport excess litter outside of sensitive watersheds like the Illinois River to areas with phosphorus-poor soil. In addition, the OCC has committed over 2 million dollars towards implementation of BMPs and monitoring the success of BMPs in the Illinois Watershed between FY 1999 and 2004. Included in the project is an education component aimed at reducing nonpoint source pollution from all sources (urban, agricultural, etc) in the watershed. Many of the BMPs will focus on reducing the impacts of animal production operations on the watershed. The project will be overseen by a Watershed Advisory Group (WAG), made up of local leaders. The WAG will decide which BMP practices should be supported with cost-share funds and where the project should be targeted in the watershed. Likely BMPs which will be written into farm and waste management plans include measures to protect riparian areas and streambanks (fencing, planting, off-site watering, alternate shade sources), measures to reduce overland runoff (buffer strips, pasture maintenance, fencing, correct fertilizer application rates), and various other measures to reduce the impacts of animal production operations. Funds will be administered through local conservation districts.

3. The most obvious solution to reducing the waste produced in the basin is to reduce the number of animals. During the development of individual waste management plans, the carrying capacity of individual operations could be determined. This

would be based upon the amount of waste produced and the acres available for disposal. It is likely that this approach would be unpopular as in many cases it would be determined that too many animals were being produced. The solution to the problem will have to be economically feasible for the producer and also allow the poultry industry to meet the public's demand for poultry products.

4. Assuming that the amount of waste being produced exceeds the number of acres on which it can be applied, the basic problem is obvious. As part of a basin wide waste management strategy, a plan to transfer wastes out of the watershed is under development. These wastes would be a welcome resource in many areas. Waste volume could be significantly reduced through composting which could be accomplished at a central facility. The cost of waste transfer is the primary limiting factor; however, when the cost of this option is weighed against a reduction in animal production or increasing the efficiency of municipal WWTFs, it approaches feasibility.

b. RESPONSIBLE ENTITIES

The Oklahoma State Department of Agriculture is responsible for programs which deal with animal production. Cost-share programs directed at agriculture based nonpoint source pollution are conducted through the Oklahoma Conservation Commission and the Natural Resources Conservation Service.

c. STATE GOALS

The state has completed the first project designed to demonstrate the effectiveness of BMP implementation in reducing nonpoint source pollution in rural areas of the Illinois River Basin. Additional implementation projects are being directed at two high priority sub-basins in the Baron Fork watershed, Peacheater and Tyner Creeks. A Section 319 National Monitoring Project is underway in the two watersheds, aimed at developing and implementing the most effective best management practices to protect water quality in the basin. Implementation will begin in March of 1999. The long term state goal is to transfer the information and techniques learned in these projects to the entire Illinois River Basin. This will begin with the high priority watersheds and move downwards; however, some watersheds may not require implementation of BMPs. This will be funded through an FY99 Section 319 project aimed at improving and protecting water quality in the Illinois River Basin. The project will provide cost-share assistance to landowners for installation of BMPs to reduce nonpoint source pollution in the watershed. Many of these BMPs will focus in reducing the impacts of animal production operations. The initial step in this process will be the development of a Conservation Plan of Operation for all producers within the river basin, beginning in priority areas. Significant cost-share funds are available to implement BMPs throughout the

watershed. These BMPs will target litter management, riparian development and protection, and streambank erosion.

An additional goal of the state is to ensure that all relevant rules and regulations which apply to animal operations, particularly those which apply to waste management, are applied in a fair and consistent manner. This specifically refers to rules and regulations concerning Confined Animal Feeding Operations (CAFOs) and to land application of poultry litter.

d. COSTS

If it is assumed that the Battle Branch watershed was typical, it can be estimated that BMP implementation in the Oklahoma portion of the Illinois River Basin would cost upwards of 10 million dollars.

The economic costs of reducing animal numbers is not possible to predict until projected reductions can be calculated.

4. ON-SITE WASTE DISPOSAL

The on-site disposal of domestic liquid waste in Oklahoma is accomplished primarily through the use of septic tanks and lateral lines. These systems provide an adequate means of preventing contact with human waste; however, in some cases they do not provide for adequate protection of environmental resources. This can occur when groundwater resources are shallow or when the geology allows for rapid infiltration rates. Information surveys conducted in several parts of the state have shown that many of the poorer residences have inadequate or completely lack septic systems. Many people also fail to properly maintain the systems they have to ensure optimal operation. In Oklahoma's 319 Assessment Report, on-site sewage disposal is listed as one on the major sources of nonpoint source pollution in Oklahoma.

In rural areas of Oklahoma, most residences rely on septic tanks. When residences are not on public sewage collection systems it can be assumed that on-site sewage disposal is taking place. For the three main counties in the Illinois River Basin, the use of on-site sewage disposal is listed in **Table 30** (U.S. Census Bureau Structural, Plumbing, and Equipment Characteristics: 1990).

Table 30. On-Site Waste Disposal in Adair, Cherokee, and Delaware Counties.

County	Population	Housing Units	On-Site Disposal(%)	On-Site Disposal(#)
Adair	18,421	7124	70.9	5051
Delaware	34,049	16808	80.2	13480
Cherokee	28,070	15935	62.2	9112
Total	**39,867**			**27643**

Based upon the combination of 1990 county population figures and data from the SCS Agricultural Waste Management Field Handbook (1992) it can be calculated that rural residents dispose of the waste amounts through on-site systems as listed in **Table 31**.

Table 31. Characteristics of Waste Disposed of in On-Site Systems.

County	Waste (dry tons)	Nitrogen (lbs.)	Phosphorus (lbs.)
Adair	1174	141942	14194
Delaware	2019	244636	24522
Cherokee	1898	230031	23094
Total	5091	616609	61810

Four factors should be considered when assessing these data:

1) The numbers represent entire county figures, although only a portion of each county is within the Illinois River watershed. In this regard these numbers should be regarded as liberal estimates.

2) Work in the Battle Branch watershed indicated that only about 25% of on-site waste disposal systems met state requirements. Examples of disposal inadequacies include lack of or insufficient lateral lines, lack of or insufficient septic tanks, direct disposal of grey water into streams, ditches, or land surfaces, and improperly located septic tanks and lateral fields.

3) The soils of most of these counties consist of chert rubble which has a very high percolation rate. With this characteristic, contamination of shallow ground water, and subsequently surface water, is likely.

4) The Oklahoma Department of Environmental Quality (ODEQ) completed a study of potential impact of septic systems in the Illinois River Watershed in 1997. Results

of the study suggested little potential threat to the Illinois River from improperly constructed and/or maintained septic systems. Reasons for this conclusion included small wastewater volumes, facilities located significant distances from the river and its tributaries, and low nutrient concentrations. It should be noted that the ODEQ study focused on non-residential septic systems, including residential systems only when there were multiple dwellings using the same system, a significant number of dwellings were concentrated in the same area, or if the system was utilized as part of a commercial activity. Thus, individual septic systems were largely ignored. These individual septic systems are more likely to be the suspect systems as they are more likely to be poorly constructed or maintained than large or commercial systems.

a. POTENTIAL SOLUTIONS

1. Connecting houses to WWTFs.

2 Installation of proper on-site waste disposal.

Discussion of Potential Solutions

1. Installation of interceptor lines for transferring domestic wastes to municipal WWTFs would be very expensive to implement. Given the number of residences which would have to be reached, their scattered locations, and the distance from treatment plants, this not appear to be a feasible solution. Benefits of this option include increasing the potential for economic development but a negative consequence would be increasing the load on WWTFs.

2. Given the experience in the Battle Branch watershed, it is likely that as many as 75% of on-site waste disposal systems are inadequately constructed or located. Bringing these systems up to standard would involve considerable expense to landowners; however, the experience in the Battle Branch watershed demonstrated that most landowners will voluntarily cooperate in upgrading their systems if cost-share funds are available. Probably the most feasible way to facilitate this installation is through an overall water quality improvement cost-share program administered through local conservation districts. Another important component is an education program to inform people about the importance of proper tank installation and maintenance. This will be provided both by the Oklahoma Scenic Rivers Education Program and the Cherokee County Conservation District Education Programs.

b. RESPONSIBLE ENTITIES

Oklahoma Department of Environmental Quality

Oklahoma Conservation Commission is generally responsible for cost-share programs

c. STATE GOALS

A complete inventory of on-site waste disposal systems and their status is desirable in order to assess the impacts of this practice. This inventory might be limited to high priority watersheds to reduce the manpower costs of this action. The state goal is to have all on-site waste disposal systems installed according to state standards. New systems are required to be inspected by a sanitarian and installed according to state standards; however, older systems may be "grandfathered" to fall under the rules which existed when they were installed. In many cases, these systems were installed before there were state rules. In cases where clear violations occur, such as the direct disposal of grey or black water onto the ground surface, these systems should be required to be brought into compliance.

d. COSTS

Current manpower levels are inadequate to accomplish complete inventories. If it assumed that six systems can be evaluated per man-day then it would take 4607 man days to inspect all systems in the three county area. Assuming a cost of $120 per man-day, the cost of this action would be $552,840.

If 75% of on-site waste disposal systems are inadequate as estimated, then approximately 20,000 new systems will need to be installed in the three county area. Cost of installation in average residence varies between $1500 and $2500 but for the purpose of discussion a figure of $2,000 per residence will be used. Using these two estimates it can be calculated that the cost of re-fitting houses in need within the three county area would be approximately 40 million dollars.

5. GRAVEL MINING

In-stream and near stream mining of gravel poses a threat to water quality through the exposure of bed load material and stream banks to erosion. Removal of material from the riverbed can cause more erosion upstream, as the river struggles to naturalize itself and fill in the void left by excavated material. In addition, gravel mining destroys wildlife habitat and has negative aesthetic effects.

There are currently six active operations in the basin within Oklahoma. Also, of concern, are several small un-licensed operations on river tributaries.

Name	Location	County
Addielee Sand and Gravel	Baron Fork	Adair
T&M Sand and Gravel	Illinois River	Sequoyah
Wade's Backhoe & Gravel	Illinois River	Cherokee
Tri-B Nursery, Inc.	Illinois River	Cherokee
Greenleaf Nursery Company	Illinois River	Cherokee
Phillip Rayls	Illinois River	Cherokee

a. POTENTIAL SOLUTIONS

1. Setting effluent limits
2. Banning mining
3. Site Restoration

Discussion of Potential Solutions

1. Effluent limits could be placed on mining operators to insure that the water leaving operations does not cause water quality problems. This would require monitoring by the operators and mine inspectors as well as a process to enforce permit values. Given the small number of operations this would not appear to place a significant burden on mine inspectors; however, adequate monitoring might fall outside of the technical and financial capabilities of mine operators. This effort might provide some water quality benefits, but would likely have little impact on habitat degradation. Habitat degradation is one of the most severe impacts of near or in-stream gravel mining.

2. In-stream and/or near stream mining could be totally banned. This might cause a significant financial loss to mine operators if alternative locations were not available.

3. Near stream mining often involves the destruction of the vegetation which stabilizes sediment and prevents streambank erosion. Restoration of these sites through re-shaping and re-vegetation would help to prevent further erosion. These processes might be beyond the technical capabilities of mine operators as they would require some level of site engineering. However, technical expertise is available through the NRCS and OCC to accomplish this task.

b. RESPONSIBLE ENTITIES

The Oklahoma Department of Mines has jurisdiction over mining activities in Oklahoma. In this capacity they are responsible for issuing permits to gravel mining operations. Permits include restrictions on the location and type of mining including provisions to protect stream quality.

In the event that gravel mining operations were required to have discharge permits, they would be subject to enforcement by the Department of Environmental Quality (DEQ). DEQ has jurisdiction over all aspects of NPDES permitting.

The Oklahoma Scenic Rivers Commission (OSRC) has jurisdiction over activities in scenic rivers. Since much of the Illinois River, Baron Fork, and Flint Creek are designated as scenic rivers, OSRC would appear to have controlling influence over these operations.

c. STATE GOALS

The goal of the state in regard to gravel mining in the Illinois River Basin is to develop a strategy which will minimize their effects on river quality. This strategy will be developed through a joint effort of the Oklahoma Department of Mines and the Oklahoma Scenic Rivers Commission.

d. COSTS

There is currently no model available which can predict the cost of improving or eliminating the effects of gravel mining in the river or its tributaries.

6. STREAMBANK EROSION

Streambank erosion poses a major threat to Oklahoma's waterbodies. Eroded materials increase turbidity, fill in valuable aquatic habitat, and are often rich in nutrients. This erosion is primarily the result of poorly managed riparian areas both through clearing of native vegetation and overuse by livestock. It has long been recognized that the banks of the Illinois River were significantly eroding in certain places. However, the consequences of bank erosion of smaller tributaries have only recently become apparent. Many local landowners are complaining that their creeks are "drying up". Landowners often blame the problem on increased water usage upstream such as poultry houses or irrigation. However, these activities cannot account for the apparent decrease in water levels in the streams. In fact, water flowing through the streams has not decreased, as the flows on the mainstem are not decreasing over time. The cause of the decreased upstream stream depth is that eroded streambanks and hillsides are actually filling in pools with gravel,

causing the stream to be dominated by subsurface flow. The water is still there, it is just no longer on the surface. The consequences of such change are drastic, not only for headwater fisheries, but also for larger order streams and Lake Tenkiller. The bedload in the Illinois River and its tributaries continues to increase and local scuba divers are noting the effects of this bedload as it fills in the upper reaches of Lake Tenkiller. An additional concern are the nutrients contained in this eroded material. Eroded sediment adds yet another nutrient addition to an already nutrient-overloaded system.

The magnitude of the problem is not well understood and documentation of the problem is still in its early stages. In 1997, the OCC and OSU Biosystems and Agricultural Engineering conducted a study of the major eroding banks on the Upper Illinois River, a 63 mile stretch from Lake Frances to Lake Tenkiller. Details of this study are presented earlier in this report. Conclusions of the study indicate that bank erosion is indeed a significant problem in the basin.

a. POTENTIAL SOLUTIONS

1. Establish riparian corridors, let the river stabilize itself

2. Site restoration of eroding banks

3. Do nothing

Discussion of Potential Solutions

1. Establishing a protected riparian corridor along the river and its tributaries would, over time, help stabilize the river. In addition, a protected riparian zone would filter effects of upland land use practices before they reached the streams and river as well as providing valuable habitat for wildlife species. Implementation would require landowner agreement to discontinue practices in the riparian zone, including cattle grazing, clearing, litter spreading, etc. Thus, implementation would require incentives to guarantee landowner cooperation. Implementation would also require fencing, development of alternate watering facilities, and perhaps relocation of structures or septic systems on some of the smaller streams. To institute a basin-wide riparian corridor could be a very expensive undertaking and it is likely to meet with significant opposition from landowners. A protected riparian corridor might also negatively impact gravel mining operations and canoe operators. Finally, the time frame for stabilization is unknown. Certain areas may stabilize within a year, while others may remain unstable decades later. It may be that anthropogenic influences have been too strong in certain areas for the river to correct itself. It is also possible that inability to protect the entire riparian corridor or all of the significant areas of the corridor will compromise the function of the corridor. An

upstream disturbance may still impact downstream areas with stable, protected riparian areas and even compromise their stability. Education programs, like those run by the OSRC and the Cherokee County Conservation District, are important to inform landowners and other watershed users about the importance of maintaining a proper riparian area.

2. Actual restoration activities in eroding areas has already been implemented by the OCC at one site on the Illinois River (Echota Bend) and is scheduled to be implemented at another (Hanging Rock). Echota Bend is located on the Illinois River northeast of Tahlequah, Oklahoma about one mile north of U.S. Highway 62 in the northwest quarter of Section 24, Township 17 North, Range 22 East, Cherokee County. Echota Bend was an unstable bend of the Illinois River characterized by a 15 to 20 foot high eroding bank. Aerial photography indicated that the bank migrated approximately 500 feet down valley between 1938 and 1990. The banks continued to erode at a rate of approximately 10 feet a year since that time. It has been roughly estimated that approximately 200,000 yd^3 of material has been lost from this site since 1938 (OCC 1997). **Figure 13** displays an aerial view of Echota Bend prior to restoration work in May 1997. **Figure 14** displays an aerial view of Echota Bend following the restoration work. The restoration method uses natural materials to reconfigure the channel and follow the natural tendency of the river, based on stable configurations of the river in other locations. Rock veins and rootwads were used to send the force of high flows to the center of the channel, rather than the outside bank. Vegetation in the form of trees and grasses was planted in the riparian area to help stabilize the banks. The initial effort to stabilize the channel was compromised by high flow events in late winter of 1998. The fault was repaired in February, 1998 by installing more rock veins and using larger rocks. The resulting bank has held through at least two bankfull storm events and is well established with vegetation.

The type of restoration work completed at Echota Bend, using Rosgen methods, is typically much less expensive than more traditional bank stabilization techniques, such as rip rap or gabions. In addition, this method results in fewer downstream blowouts, because the energy of the flow is dissipated by the root wads and rock veins, rather than sent somewhere downstream. Implementation of Rosgen type restoration at the major eroding sites (approximately 20 river miles) along the Illinois River would cost an estimated 3.5 million dollars, based on cost/ft of restoring the Echota Bend site. Rip rap or more traditional methods would cost an estimated 12 million dollars.

Figure 13. Aerial View of Echota Bend Prior to Restoration.

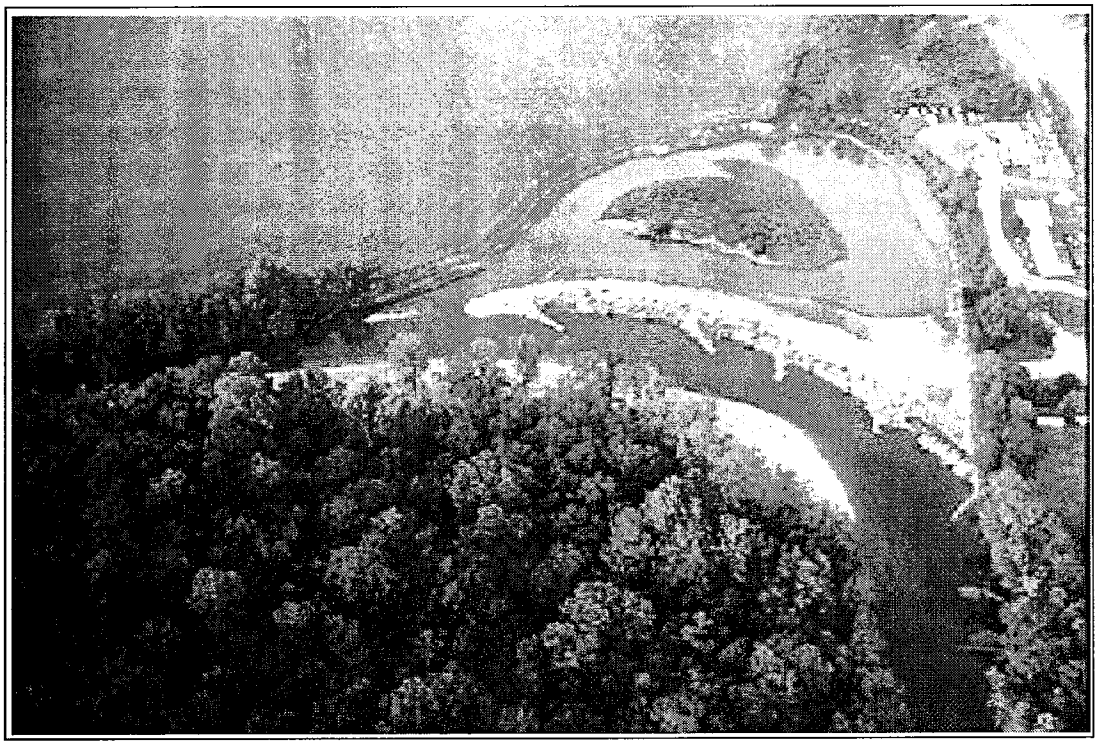

Figure 14. Aerial View of Echota Bend Following Restoration.

3. The option of doing nothing could have a wide range of consequences. The river banks alone lost an estimated 62 million cubic feet of material between 1979 and 1991. Current erosion rates vary between -0.03 ft - 26.5 ft, averaging 4.5 feet over a ten month study period. In addition, the channel is changing courses, at some points moving as much as 220 feet within the space of ten months (Harmel 1997). The river is assuming more characteristics of a wide braided channel with unstable banks and shifting courses, rather than its original meandering channel with stable banks and courses. If nothing is done to correct the problems causing the erosion, this shift may continue. Or, if left alone, the river may correct itself. However, the types of disturbances which have led to the current erosion rates are likely to continue and may even increase in frequency and magnitude, thus the river is unlikely to be left alone to correct itself. The Baron Fork once sustained a canoe float industry but has become too shallow to canoe. This decrease in depth is due to sedimentation not change in water tables. The Illinois River could suffer a similar fate without intervention. However, long before the river became unnavigatable, the biological community would be severely impacted, as would Lake Tenkiller. Although streambank erosion adds a tremendous volume of gravel bedload to the streams and river, which will eventually be carried to Lake Tenkiller, it also adds silt and nutrients which are carried more quickly to the lake. These can dramatically speed up the eutrophication process. Failure to curb streambank erosion will likely have irreparable consequences to the river and Lake Tenkiller.

b. RESPONSIBLE ENTITIES

The U.S. Army Corp of Engineers (USACE) has jurisdiction over channel altering activities such as instream dredging or streambank stabilization in Oklahoma. In this capacity they are responsible for issuing permits for these types of activities. Also necessary for this type of activity is Oklahoma Water Quality (401) certification issued by the Department of Environmental Quality (ODEQ).

The Oklahoma Scenic Rivers Commission (OSRC) has jurisdiction over activities in scenic rivers. Since much of the Illinois River, Baron Fork, and Flint Creek are designated as scenic rivers, OSRC would appear to have controlling influence over these operations.

The Oklahoma Conservation Commission has devoted significant resources towards training an engineer to implement these practices and towards implementation of streambank restoration methods. In addition, as the agency responsible for monitoring and reducing sources of nonpoint source pollution, the OCC should be involved in efforts to reduce streambank erosion.

c. STATE GOALS

The goal of the state in regard to streambank erosion in the Illinois River Basin is to develop a strategy which will minimize its effects on river quality. This strategy will be developed through a joint effort of the Oklahoma Scenic Rivers Commission, the OCC, the ODEQ, and the USACE.

7. OTHER NONPOINT SOURCES

A number of other nonpoint sources exist in the watershed which are not detailed in this report or this plan. The reason for these ommissions are either insufficient ability to make estimates of the significance of these sources or known lack of significance considering the other nonpoint sources identified in this document. These other sources include but are not limited to wildlife, natural background loading due to geology and natural vegetation of the basin, illegal dumping, county road erosion, and smaller livestock facilities such as people who keep a few head or horses or cattle.

The potential impact from wildlife is not known. It is extremely difficult to estimate the negative impacts from such mobile animals. We cannot prove that wildlife in the basin do not contribute a significant load to the river. This seems unlikely though because due to the relative homogeneity of the basin (mostly forested, rather than half forested and half marshland) the wildlife should be fairly evenly spread throughout out the watershed. Thus their impacts should be fairly even throughout the watershed. However, not all streams appear to be negatively affected by nutrients; several streams where land use intensities are low (and thus, you might suspect wildlife are even more concentrated) appear to be in very good condition with good water quality and healthy aquatic communities. Thus, wildlife do not appear to have a negative impact on those streams. However, it is possible that wildlife negatively impact water quality somewhere in the watershed and that these impacts may be magnified by the implementation of practices to control other sources of pollution.

Natural background loading due to native vegetation and the geology of the basin is not believed to be a significant contributor to the pollution in the basin. This belief is based on the fact that the subwatersheds where land use intensity is lowest (and thus the loading is mostly from natural sources) have good water quality and healthy aquatic communities. If background loading were significant, these communities might show some impact and water quality data would indicate some impairment.

Runoff from unpaved and paved roads and the bridges necessary for those roads may contribute significant loads to the system. Although this has not specifically

been suspected as a problem by water quality professionals or residents in the area, it has been shown to impact streams in other areas. This is not likely to be a watershed-wide problem but may need to be addressed on a case-by-case basis at a later date.

Small animal operations and other low intensity land uses may also contribute to the problem. Again though, correlations between land use and water quality data indicate that watersheds where landuses are primarily low intensity have significantly better water quality than watersheds where land use is more intensive.

Although all of these other sources currently seem to be insignificant in the total scheme of things, reduction in the impacts from other sources may magnify the effects of these sources. Thus, it may be necessary to revisit and better define the magnitude of these sources once steps have been taken to reduce the impacts of other sources. In addition, education programs like those run by the OSRC and Cherokee County Conservation District are critical to reducing all type of nonpoint source pollution. Their goal is to cause people to understand how pollutants reach the water, what types of effect they can have, and things people can do to reduce the impacts of pollution. Those education programs may be a significant tool towards reducing other, minor sources.

C. COMBINED SOURCES

1. URBAN RUNOFF

Urban runoff combines the effects of both point sources and nonpoint sources in that at times it contains pollution from both point sources (in the form of overflows and system breaks) and nonpoint sources in the form of runoff from urban areas. The effects of stormwater runoff from urban areas within the basin is unknown. The primary pollutants from small urban areas are solids, oil and grease, and nutrients. In large urban areas, these contributions can be significant; however, given the small size of urban areas in the basin within Oklahoma, it is probably relatively small. Tahlequah and Stilwell are the two major urban areas and contain 10,400 and 2,660 citizens, respectively (1990 census).

a. POTENTIAL SOLUTIONS

1. Bringing all municipalities into urban stormwater permitting process.

2. Education programs to reduce pollutants in urban runoff.

<u>Discussion of Potential Solutions</u>

1. If municipalities participate in the urban stormwater permitting process, then the attainment of certain standards will be required. This could involve the construction of retention or detention lagoons or other practices which could ameliorate the effects of urban runoff. Tahlequah is the only municipality which is currently large enough to fall under federal guidelines.

2. Education programs to inform citizens about the dangers of nonpoint source pollution, including urban runoff, are in place and active at both the Oklahoma Scenic Rivers Commission (OSRC) and the Cherokee County Conservation District (CCCD). The OSRC has 84 programs schedule between 19 Jan 99 and 29 Apr 99 which will reach approximately 3,000 students. Also planned are events at local fairs and newspaper articles for education purposes. The CCCD Illinois Jones Program is long-standing and aimed mainly at educating children and their parents about nonpoint source pollution and offering solutions to the problem. The CCCD also educates general audiences on means to prevent nonpoint source pollution through fairs, festivals, programs aimed at ag-producers, one-on-one meetings and phone information services and various other means. The Oklahoma Conservation Commission's Statewide Blue Thumb Program is available to assist in these education efforts.

b. RESPONSIBLE ENTITIES

The Oklahoma Department of Environmental Quality is responsible for stormwater permitting. Municipalities or other entities which fall under stormwater regulations can also be listed as responsible parties.

The Oklahoma Scenic Rivers Commission, Conservation Districts, and Oklahoma Conservation Commission's Statewide Blue Thumb Program are responsible for providing education programs to reduce urban nonpoint source pollution.

c. STATE GOALS

The current state strategy to address urban nonpoint source issues is to follow the federal guidance under which the stormwater program is operated.

d. COSTS

Implementation of stormwater regulations could entail considerable costs to municipalities; however, those costs cannot be determined at this point.

2. NURSERIES

Two major nurseries are located along the Illinois river and one on the shores of Lake Tenkiller. Irrigation tail waters of the two largest nurseries have been shown to contribute significant quantities of nutrients to the basin. Following implementation of Best Management Practices resulting from cooperative agreements between the nurseries and the Oklahoma State Department of Agriculture, one nursery on the river was shown to contribute as much as 0.3% of the yearly NO3-N load and 0.19 % of the yearly total phosphorus load in the river. The nursery on the shore of Lake Tenkiller was shown to contribute 1.95% of the total NO3-N content each year. The total phosphorus contribution is 1.13 % (OSDA 1992). These loadings are based on estimated irrigation return flows. Storm runoff from the nurseries was not monitored.

a. POTENTIAL SOLUTIONS

1. Setting effluent limits
2. Additional BMP implementation
3. Total retention
4. Site pre-approval
5. No Action
6. CAFO model

Discussion of Potential Solutions

1. In 1990 voluntary compliance agreements were established between each nursery and the Oklahoma State Department of Agriculture. Agreement effluent limits were set where input would not increase the nitrate concentration in the river by more than 0.1 mg/l NO_3-N or total phosphorus by more than 0.01 mg/l. This involved an average NO_3-N limit of 18.5 ppm and a total phosphorus limit of 1.0 ppm in the tailwater of each nursery. Pesticide limits were set to meet water quality standards, but also called for suspending the use of any pesticide that was detected in tailwater samples until methods of its use could be studied. More stringent limits may be required to meet load allocations as result of a TMDL for nutrients within the basin.

2. The Illinois River Irrigation Tailwater Project was initiated in 1989 following concern about impacts of irrigation tailwater leaving nurseries along the Illinois River. The project was designed to limit the release of nutrients and pesticides from the

nurseries. The project involved sampling irrigation tailwater at Blue Valley Nursery, Greenleaf Nursery, Midwestern Nursery, and Park Hill Nursery for nitrate-nitrogen (NO_3-N), total phosphorus (TP), and pesticide residues. Samples were taken monthly between May 1989 and December 1992. The 1992 Curtis Report summarized water quality results and recommended continued monitoring of nursery tailwaters. Sampling continued and is presently ongoing. Annual results of the project are available in the OSDA Curtis Reports.

The 1992 OSDA "Curtis Report" outlined 16 sediment control BMPs and 9 cultural and physical control BMPs which had been, or were in process of being implemented. The sediment controls included:

- access road location, construction, and maintenance
- grass and brush management to improve plant cover and reduce erosion
- drainage way design to slow water speed, allowing solids precipitation
- alternate uses of irrigation tailwater to minimize volume of discharge
- contour arrangement- group crops to maximize water infiltration & retention
- use of silt or settling basins to give time for solids precipitation and pesticide degradation
- use of rough or porous surfacing materials to encourage water retention and infiltration
- heavy use area protection suing hard surfacing and/or containment to minimize stormwater contributions.
- use of piped or lined drainage structures to reduce drainage ditch contributions to effluents
- irrigation water management- determining & controlling rate & amount of irrigations to minimize soil erosion & runoff
- use of mulch in planting and drainage area to reduce evaporation and increase filtration of suspended solids
- minimize soil disturbances- reduce number of tills and road grading.
- precision land forming- reshaping surface to planned plateaus from continuous slopes
- trickle irrigation- apply small quantities of water to individual plants
- use of underwater outlets to control bank erosion of tailwaters to streams

The cultural and physical control BMPs included:

- mechanical or biological control of pests
- improve pest scouting techniques to encourage use of pesticides based upon economic threshold determinations
- schedule irrigation based on plant needs to minimize water, fertilizer, and pesticide runoff
- lower pesticide and fertilizer application rates where feasible

- use of slow-release encapsulated pesticide and fertilizers
- substitute effective pesticides with lower solubilities
- use of resistant varieties to reduce pesticide usage
- use of chemicals with no environmental impact to encourage precipitation of dissolved or suspended particles in the tailwaters
- evaluation of storage and mixing facilities to minimize possibility of accidental discharges or spills

Results of nursery tailwater monitoring from the 1992 Curtis Report are seen in **Table 32**. Although average NO_3-N concentrations generally decreased over time, maximum NO_3-N values and average and maximum Total P values did not decrease over time. However, Blue Valley Nursery maintained NO_3-N and Total P tailwater concentrations below the compliance agreement. Greenleaf Nursery's NO_3-N yearly average concentration was below the compliance agreement average for 1991 and 1992. Greenleaf exceeded the compliance agreement maximum on three dates at three tailwater sites, once in 1991 at site IT-6, and twice in 1992 at site IT-3a and IT-12. Although Greenleaf's yearly average total P concentrations increased from 0.387 ppm in 1989 to 0.701 ppm in 1992, the compliance agreement average concentration of 1.0 ppm was not exceeded. Midwestern Nursery exceeded compliance agreement maximum NO_3-N concentrations twice in 1991, at sites IT-25 and IT-27, and once in 1992 at site IT-25. The yearly average total P concentrations increased between 1989 and 1992. The 1992 yearly average total p concentration was above the compliance agreement of 1.0 ppm. The compliance agreement maximum was exceeded twice in 1991 at sites IT-23 and IT-26, one in 1992 at site IT-25, and four times in 1992 at site IT-27.

Table 33 contains annual nutrient loadings to the Illinois River/Lake Tenkiller from nursery tailwaters. Although loadings from nursery tailwaters comprise only a small percentage of the total annual load to the Illinois River and Lake Tenkiller (less than two percent), the loading represents a sizeable mass of nutrients contributed to the system.

Table 32. Yearly Average and Maximum NO_3-N and Total -P Concentrations (ppm) for Nursery Tailwater Sampling Sites (1989-1992).

Site	NO_3-N ppm				Total P ppm			
	1989	1990	1991	1992	1989	1990	1991	1992
IT-30d		2.11	2.38	3.62		0.46	0.6	0.36
BVmax		11.14	5.93	8.41		0.72	0.88	0.60
IT-2	30.22	32.91	12.05	8.58	1.63	1.10	1.86	1.13
IT-3a	18.08	14.44	18.31	15.65	0.37	0.55	0.65	0.46
IT-6	44.75	21.45	24.94	14.48	0.43	0.47	0.60	0.44
IT-12	26.25	41.60	19.68	16.68	0.63	0.53	0.78	1.18
GLmax	71.3	144.9	51.62	52.48	2.30	4.40	4.70	2.90
IT-23	12.05	9.92	6.97	6.75	0.94	0.44	0.82	0.2
IT-25	29.61	21.08	15.60	10.71	1.83	0.51	0.43	0.93
IT-26	4.17	8.02	8.05	13.25	2.12	1.23	1.93	2.0
IT-27	12.76	12.27	7.67	9.02	1.83	0.82	0.61	1.54
MWmax	58.9	56.22	25.6	45.45	5.4	2.40	4.10	4.40
IT-18	1.16	1.42	1.19	0.81	0.61	0.20	0.45	0.52
IT-19b	0.48	2.14	2.06	0.24	0.71	0.89	0.96	1.74
PHmax	6.04	7.51	7.07	5.28	1.10	0.46	1.28	1.80

BV: Blue Valley Nursery, GL: Greenleaf Nursery, MW: Midwestern Nursery, PH: Park Hill Nursery.

Table 33. Annual Nutrient Loads from Nursery Tailwaters.

	Greenleaf		Midwestern	
	NO_3-N	TP	NO_3-N	TP
1989 Annual load (lbs. per year)	231.36	3.20	46.22	5.92
1990 Annual load (lbs. per year)				2.54
1991 Annual load (lbs. per year)				3.03
1992 Annual load (lbs. per year)	105.55	5.79	25.45	3.69
1992 % of 1992 Total load to Lake/River	1.95	1.13	0.30	0.19

In 1994, Plant Industry and Consumer Services (PICS) negotiated with each of the nurseries a new compliance agreement which set limits for nutrients. The compliance agreement limits are seen in **Table 34**. The agreement stated individual sample maximum values may be no more than fifty percent above the compliance agreements yearly average on two consecutive samples.

Table 34. Compliance Agreement Nutrient Limits.

	1993	1994	1995	1996
Yearly Average NO_3-N	18.5 ppm	15.5 ppm	14.5 ppm	10.0 ppm
Individual Sample Maximum NO_3-N	27.0 ppm	23.25 ppm	21.75 ppm	15.00 ppm
Yearly Average Total-P	1.0 ppm	1.0 ppm	1.0 ppm	1.0 ppm
Individual Sample Maximum Total-P	2.0 ppm	1.5 ppm	1.5 ppm	1.5 ppm
Pesticides	suspend use of any detected	suspend use of any detected	suspend use of any detected	suspend use of any detected

Nursery tailwaters continue to be monitored by PICS as a result of the compliance agreement (**Table 35**). Blue Valley Nursery was dropped from the project in 1996 as a result of no activity at the nursery. Nitrate-nitrogen and total phosphorus were under compliance agreement maximum values at Blue Valley Nursery in 1993, 1994, and 1995.

Yearly average NO_3-N concentrations and overall yearly average total phosphorus concentrations (0.74 ppm) were below compliance levels in 1993 at Greenleaf Nursery. However, one tailwater site, IT-2, had a yearly average (1.09 ppm) greater than the compliance agreement. Nitrate-nitrogen concentrations were lower at three tailwater sites in 1994, however one site, IT-2, reported a concentration (29.5 ppm) in excess of the compliance maximum in August. IT-2 also reported a yearly average total phosphorus concentration of 1.37 ppm which was over the compliance agreement concentration. Other tailwater sites at Greenleaf Nursery were below compliance agreement maximums in 1994. Nitrate-nitrogen and total phosphorus concentrations above compliance agreement maximum concentrations were also reported for IT-2 in 1995, with two excessive value for NO_3-N in July and September and two consecutive violations for total phosphorus in June. The runoff from IT-2 is in the process of being diverted to a retention facility for reuse on the nursery. Concentrations of NO_3-N and total phosphorus were below compliance agreement levels at other sites in 1995. 1996 yearly average NO_3-N concentrations exceeded compliance agreement levels at IT-6.

Three consecutive samples exceeded the compliance agreement maximum at site IT-6. These violations were believed to be due to the movement of dirt during construction of the retention basins in addition to use of a new fertilizer and correcting a fertilizer deficiency

problem. No tailwater sites at Greenleaf nursery exceeded compliance agreement levels

Table 35. Yearly Average and Maximum NO_3-N and Total -P Concentrations (ppm) for Nursery Tailwater Sampling Sites (1993-1996).

Site	NO_3-N ppm				Total P ppm			
	1993	1994	1995	1996	1993	1994	1995	1996
IT-30a	1.84	1.60	1.53	NA	0.15	0.14	0.17	NA
IT-30b	0.13			NA	0.06			NA
IT-30c	1.27	1.11	0.61	NA	0.08	0.95	0.24	NA
IT-30d	2.79	2.28	3.33	NA	0.33	0.35	0.37	NA
IT-31			1.74	NA			0.14	NA
IT-32			1.80	NA			0.13	NA
BVmax	3.26	9.68	6.62	NA	0.46	0.80	0.80	NA
IT-1	1.11	1.10	0.81	1.18	0.11	0.16	0.09	0.12
IT-1b			0.97	1.01			0.08	0.11
IT-2	6.24	10.53	10.13	8.65	1.09	1.37	1.29	0.8
IT-3a	11.85	6.97	6.56	9.01	0.61	0.43	0.68	0.51
IT-6	9.30	8.57	4.27	13.12	0.06	0.44	0.51	0.41
IT-11	0.42	0.15	0.44	0.62	0.03	0.07	0.05	0.03
IT-12	12.09				0.66			
GLmax	27.45	29.46	39.2	33.47	1.65	2.6	2.5	1.18
IT-23	2.79	2.71	3.19	3.98	0.44	0.26	0.51	0.41
IT-24			1.5	1.47			0.12	0.24
IT-25	2.54	2.80	3.46	3.58	0.62	0.47	0.63	0.67
IT-26a	2.23	2.34	2.29	2.50	0.06	0.11	0.07	0.06
IT-27	3.29	2.86	3.83	5.58	0.81	0.52	0.77	0.71
IT-28	1.87	1.82	1.26	1.64	0.13	0.10	0.15	0.15
IT-29			1.41	1.38			0.13	0.16
MWmax	58.9	56.22	25.6	45.45	5.4	2.40	4.10	4.40
IT-15			1.31	0.98			0.47	0.27
IT-16a	1.52	1.49	1.45	1.62	0.13	0.12	0.12	0.08
IT-16b			1.08	1.79			0.11	0.11
IT-16c			0.64	0.71			0.09	0.14
IT-18	2.32	1.01			0.36	0.57		
IT-18a			1.02	0.65			0.22	0.16
IT-19a	4.63	4.18	2.88	2.04	0.07	0.05	0.06	0.04
IT-19b	0.94	1.36	0.49	0.69	1.37	1.04	0.40	0.35
PH max	5.56	5.55	4.3	3.67	1.9	3.4	0:76	0.88

BV: Blue Valley Nursery, GL: Greenleaf Nursery, MW: Midwestern Nursery, PH: Park Hill Nursery, NA: Not Active.

for total phosphorus in 1996.

Park Hill nursery tailwater sites were well below compliance agreement concentrations of NO_3-N in 1993, 1994, 1995, and 1996. Yearly average total phosphorus concentrations were above the agreement at site 19-b but below at the other 3 sites in 1993 and 1994. Yearly average total phosphorus concentrations were below the agreement at all sites in 1995 and 1996.

3. Total retention

Total retention is the most desirable control for waste water from all sources. The Greenleaf nursery has constructed facilities to capture, treat, and recirculate their runoff. Thus, the system now operates as a total retention structure and Greenleaf no longer discharges to Lake Tenkiller. Although some runoff likely still occurs during storm events, the magnitude is greatly decreased as is the annual loading of nutrients, pesticides, and sediments from the nursery.

4. Site pre-approval

Additional nurseries should be situated away from the river and lake to minimize impacts to water quality and to maintain integrity of riparian areas. Sites should be located to allow implementation of BMPS, terracing and diversion of runoff and construction of retention lagoons.

5. No Action

Current controls may already be sufficient to control pollution from this source.

6. Following the strategies employed to control pollution from confined animal facilities, runoff from nurseries should be bermed and channeled into a limited number of permitable "point source" discharge points for issuance of an NPDES permit. This action would have to be done at the state level because of the specific prescriptions against this in the Clean water Act at the federal level.

b. RESPONSIBLE ENTITIES

The OSDA is designated as the state agency with authority to establish Best Management Practices or other measures to control those potential pollutants of agricultural origin.

A specific exemption for the agricultural nonpoint category of "Agricultural Return Flows " from NPDES permitting is outlined in CWA, section 402(k)(1).

c. COSTS

Implementation of load allocations could entail considerable costs to nurseries; however, those costs cannot be determined at this point.

EFFECTIVENESS OF NONPOINT SOURCE NUTRIENT CONTROL PROGRAMS

Control of nonpoint source pollution on a complete watershed basis has been completed on only one watershed in the Illinois River Basin. This was Oklahoma's first 319(h) demonstration project and was completed over a three year period. Initial analysis of water quality data indicate that this project was successful in reducing nutrient loading to surface waters. Given the relatively consistent patterns of land use with the Illinois River Basin as whole, transfer of the information gathered from this project should be easily accomplished; however, success will be closely tied to the availability of cost-share funds for land use improvements.

The total cost of BMP implementation on this watershed was approximately $100,000. This includes technical assistance, landowner contact, and BMP implementation. The cost for BMP implementation was $50,000. The Battle Branch watershed covers 5970 acres; therefore, it can be calculated that the cost of remediation was $16.75 per acre. If it is assumed that land uses in the Battle Branch watershed represent typical or average conditions across the Illinois River Basin, the basin wide cost for remediation is:

$16.75 x 576,000 acres = $9,648,000

It should be obvious that this figure only loosely estimates the funds that will be required for BMP implementation in the Illinois River Basin considering the assumptions on which it was based. Despite the shortcomings of this estimate it should be useful in discussions of the relative costs of nutrient control programs in point versus nonpoint source programs. It should also be noted that some of this cost has already been spent in the monitoring and implementation activities that have already occurred in the watershed. It is possible that less than the $10 million estimate will be necessary to implement practices since we already have water quality data. However, a survey of all the county District Conservationists requesting estimated needs for BMP implementation (and this figure includes only funding for implementation and technical assistance) estimated approximately $7 million necessary for implementation across the basin. When costs for monitoring to assess the effectiveness (in some cases, both "before and "after" monitoring may be necessary, rather than just "after") and education are added, the $10 million dollars may be accurate.

A. Battle Branch Demonstration Project

Oklahoma's first Section 319h project was completed during FY 93. The Battle Branch watershed was identified as one of Oklahoma's highest priority watersheds in the 1991 watershed prioritization efforts. This project can be viewed as a successful endeavor by several different measures. Although the original meaning of the term 'demonstration project' may have been BMP-oriented, that is, the projects were intended to demonstrate

the efficacy of BMPs in reducing NPS pollution, this project has 'demonstrated' other important factors as well. It was demonstrated in this project that the implementation of BMPs reduced levels of nutrients in Battle Branch; however, equally important to the ability of BMPs to reduced pollution is the level of voluntary public participation. This project 'demonstrated' that public interest was high as 84% of landowners participated in the project. The importance of project administration cannot be overlooked as this project involved the coordination of efforts between local, state, and federal agencies, landowners, and contractors. The fact that this project was a success 'demonstrates' that the administrative mechanism through EPA and OCC is adequate to ensure that 319h projects are properly administered and carried out. It was also 'demonstrated' that project successes could be transferred to other areas as witnessed by the inclusion of the entire Flint Creek watershed as a SCS Hydrologic Unit Area and the start of an implementation project in the Peacheater Creek watershed.

Table 36 lists of the final totals for BMP implementation:

Table 36. BMPs Installed in Battle Branch Watershed.

Number of "Conservation Plan of Operation"	16
Total Acres under "Conservation Plan of Operation"	1424
Waste Management Plans	9
Rural Wastewater Systems (Septic Tanks)	10
Dairy Lagoons	3
Waste Utilization Management Operations (acres)	774
Pasture and Hayland Operations (acres)	592
Poultry Composters	6
Forest Land Management (acres)	32
Tree Planting (acres)	172
Waste Storage Structures	4
Soil Testing	129

Data Analysis:

Battle Branch was monitored regularly between early 1986 and mid-1987, and was monitored monthly between January of 1990 and August of 1994. The monitoring during these periods has consisted of the collection of both runoff event and base flow samples. Runoff event samples have been collected by means of an automated sampler which is

triggered by a float switch in the stream, while base flow samples consist of monthly grab samples. Thirty-five base flow samples and fourteen runoff event samples had been collected through July, 1992.

The intent of sampling was to characterize pre-implementation conditions and to monitor water quality improvements as they occurred. BMP implementation is described in **Table 36**; however, it is difficult to accurately draw a line where implementation was complete and to base water quality assessments on changes which occur after this point in time. There are several reasons which can explain the difficulty in identifying a point in time which to separate pre- from post- implementation: 1) actual implementation was spread out over more than one year between early 1991 and mid-1992, 2) some BMPs have a much more direct and rapid effect on water quality than others; therefore, the precise times that these were installed would be known and it is unlikely that installation of these practices was within a short time span, 3) many land use improvements were made through landowner contacts (prior to the actual date of 'official' BMP implementation) and do not constitute identifiable or quantifiable management practices as they are not necessarily included in the Conservation Plan of Operation and, 4) flushing of contaminated shallow ground water may take a considerable period; therefore, benefits may not be noticeable until some time in the future.

After consideration of all of these factors a cut-off date between pre- and post-implementation of August 1, 1991 was chosen. The represents more or less the mid-point between the beginning of landowner contacts and the completion of BMP implementation. A summary of the data can be seen in **Table 37**.

Table 37. Baseflow versus Runoff Event in Battle Branch (mean values in mg/L).

Pre-Implementation							
Nitrate		Kjeldahl		T. Phosphorus		o-phosphate	
BF	RE	BF	RE	BF	RE	BF	RE
1.98	2.33	1.62	0.73	0.053	0.062	0.067	0.406
Post-Implementation							
Nitrate		Kjeldahl		T. Phosphorus		o-phosphate	
BF	RE	BF	RE	BF	RE	BF	RE
2.20	4.40	0.22	0.20	0.031	0.040	0.024	0.035

(BF = Baseflow; RE = Runoff Event)

NITRATE

Nitrate values do not show any appreciable trends over the course of sampling and there is considerable variation among results over relatively short periods. As seen in **Table 37**, there was a slight decrease in base flow samples (1.62 to 0.22 mg/L, respectively); however, this would not appear to be significant due to the relatively high standard deviation of results for both periods (1.21 and 0.91, respectively).

There was also little difference between pre-implementation base flow and runoff event nitrate values. This indicates that entry of organic matter into the stream from overland runoff was not an important issue. It also indicates that the majority of nitrogen is in the form of benthic algae and represents drifting cells and not allocthonous materials, such as animal litter.

Mean runoff event values increased from 2.33 to 4.40 between pre- and post-implementation. This would appear to be a significant increase; however, the post-implementation value is based on only two data points so some caution should be taken in making inferences concerning this increase. A casual look at the runoff event data indicates a trend towards increasing nitrate values in runoff samples and this phenomenon will be closely observed as additional samples are taken.

Total Kjeldahl Nitrogen (TKN)

There was considerable variation among TKN values under both runoff and baseflow conditions; however, post-implementation baseflow values have been low and fairly uniform (mean = 0.22 mg/L; SD = 0.11). This compares with pre-implementation values of mean = 1.62 mg/L; SD = 1.77. There would appear to be adequate data to suggest that baseflow TKN levels have been reduced.

TKN values during runoff events were lower than during baseflow conditions during both pre- and post- implementation. This indicates two conditions: 1) TKN is not entering the stream in runoff (TKN levels in the stream are actually being diluted by runoff water) and, 2) the major source of stream TKN is drifting benthic organic material. Post-implementation runoff values are lower than pre-implementation values; however, this is based on a very small number of data points and any actual differences are probably more attributable to reductions in groundwater than surface contributions.

Pre-implementation TKN values ranged as high as 8.77 mg/L while the maximum post-implementation value was 0.50 mg/L. With a baseflow mean value of 0.22 mg/L it may not be realistic to expect further reductions. If this value could be achieved in all creeks of the Illinois River Basin, it would represent a significant reduction in nitrogen loading to the Illinois River.

Phosphorus

Phosphorus analysis has been somewhat inconsistent during the period of the project. For the first period of the study, only ortho-phosphate was measured and during the second part of pre-implementation only total phosphorus was measured. These differences are due to different laboratory protocols and project emphasis. While this may present some problems in data analysis it does not preclude making some conclusions concerning changes in water quality.

Approximately 80% of the phosphorus present was in the ortho-phosphate form which indicates a readily available supply of phosphorus for algal growth. Ortho-phosphate decreased from a mean of 0.067 during pre-implementation baseflow conditions to 0.024 mg/L during post-implementation. Although there is no uniformly accepted level of ortho-phosphate which is considered to be deleterious, it is generally accepted that values greater than 0.050 mg/L can cause stream problems and values in excess of 0.020 mg/L can result in downstream loading problems. From this data it is apparent that a significant decrease has occurred; however, the stream and its receiving waters could benefit from further reductions.

Ortho-phosphate values during runoff events were very high during the early period of monitoring ranging from 0.030 to 0.96 mg/L with a mean of 0.41. These are very high values and represent environmentally significant runoff of nutrients from land surfaces. These values were reduced to 0.035 mg/L during post-implementation, and despite the small number of samples upon which this mean is based, it is apparent that a significant reduction in runoff contributions has occurred.

Mean total phosphorus values also decreased somewhat between pre- (0.053 mg/L) and post-implementation (0.031 mg/L) during baseflow conditions. This phenomenon also occurred during runoff event samples.

Although total phosphorus values are not available from the early monitoring period, conclusions can be drawn about them. With the extremely high ortho-phosphate values that were found, the total phosphorus values would of necessity been correspondingly higher. With this in mind, it is obvious that very significant reductions in phosphorus loading has occurred in this stream.

FUTURE PROGRAMS

These future programs, already planned, make up the final segment of the Illinois River Comprehensive Basin Management Plan. Following the implementation of these plans, and assessing the success of the practices implemented, it may be necessary to add a supplementary plan to address either newly realized concerns or problems that were not

adequately dealt with by these planned programs.

a. Total Maximum Daily Load (TMDL)

Given the variety and number of point and nonpoint sources and the economic impacts of remediation, it is essential that clean-up efforts be directed towards the most cost-effective and beneficial endeavors. The first step towards completing this process is the development and implementation of a TMDL.

The TMDL will determine the level at which nutrients can be discharged to the river without causing water quality violations. The entire process of watershed restoration will be predicated on the accurate determination of the carrying capacity of the watershed. In this regard, the effects of nutrient loading on Lake Tenkiller must also be considered. It is likely that the levels of loading which would protect Lake Tenkiller will be less than those which would protect the Illinois River.

After determination of the TMDL, the difficult task of allocating permissible waste loads to various discharges must be undertaken. This will be a difficult process as it will involve some expense to all parties involved. Given the high levels of nutrients which currently exist in the river, it is likely that the TMDL process will determine that a significant decrease will be required before water quality standards can be met. Research has suggested that the majority of the loading is due to nonpoint source pollution, although point sources still contribute significantly to the problem. Most of the point sources in Oklahoma have already undergone significant upgrades. Thus efforts should focus primarily on reducing nonpoint sources although consideration should still be given to upgrading point source treatment. Consideration must also be given to the proportion of loading from the various subwatersheds and the two states. Oklahoma and Arkansas should coordinate implementation of pollution reduction measures to maximize the benefits of individual state efforts. In conclusion, the pros and cons of reducing point versus nonpoint sources must be considered in light of feasibility, cost-effectiveness, maintainability, and long-term effectiveness.

b. TMDL Development

There are two inter-related issues which must be considered and addressed in the development of a TMDL for the Illinois River Basin: 1) the size of the Illinois River watershed complicates the development of a TMDL and, 2) cross border issues aggravate the issue as the two states have water quality goals and priorities which are not necessarily congruent.

The most appropriate solution to the first issue is to divide the Illinois River Basin into smaller sub-basins. This would not only serve to reduce the size of the area under consideration but would also solve some of the problems associated with the second

issue. In Oklahoma it would appear that separate TMDLs should be developed for the Baron Fork, Flint Creek, and the Illinois River. The problem with division into subbasins arises when it becomes necessary to explain to landowners why they are not eligible for cost-share assistance based on where they live in the basin. The rapport between conservation districts and local landowners is damaged when the district conservationist must turn down an application for cost-share assistance because the landowner lives in the Telemay and Dog Hollow watershed (priority 7- OCC priority list) but his brother in the Peacheater Creek watershed (priority 1- OCC priority list) receives assistance.

The Oklahoma Department of Environmental Quality is currently in the process of developing a TMDL for the Oklahoma portion of the river, incorporating the 40% phosphorus reduction recommended by the Lake Tenkiller Clean Lakes Study, to help the Illinois River meet its beneficial use criteria. Portions of the Illinois River and tributaries are currently listed on the Oklahoma 1998 303(d) list as being impaired by metals, nutrients, siltation, organic enrichment/dissolved oxygen depletion, and noxious aquatic plants. Sources of these problems are identified as nonpoint source, nonirrigated crop production, pasture land, rangeland, feedlots, animal holding/management facilities, highway construction, road construction, bridge construction, land development, on-site wastewater systems, dam construction, flow regulation/modification, and municipal sewage systems.

The second issue will involve considerable technical and political skill. USEPA Region VI attempted to address this issue through the establishment of a technical committee composed of state agency personnel from both states. The purpose of this committee is to establish water quality goals and a procedure for establishing the TMDL. This committee agreed to work towards a 40% reduction (based on the recommendations of the 1994 Clean Lakes Report) of the total phosphorus load to Lake Tenkiller. State and Federal Agencies in both states have agreed to work towards this goal.

Whatever approach is taken, it will be necessary to establish water quality goals in specific stream reaches. At a minimum, water quality goals must be established at the Oklahoma/Arkansas border and at the head of Lake Tenkiller. In Oklahoma it would be desirable for water quality goals to be established at the mouths of major river tributaries.

Due to the high levels of nutrients which are found at the border and at the head of Lake Tenkiller, it can be predicted that any TMDL will determine that significant reductions in nutrient loading must occur. The ultimate determination of the cost and feasibility of reduction, as well as the allocation of loads to various sources, will be a difficult process; however, this issue must be faced if an effective plan to manage river and downstream water quality is to be established.

C. Best Management Practice (BMP) Implementation Plan

Implementation of the TMDL in Oklahoma may require further point source controls as well as significant nonpoint source controls. One of the difficulties in reducing nonpoint source pollution is that most efforts at reduction must be made on a voluntary basis as few rules and regulations apply to nonpoint source pollution. However, Oklahoma has made an attempt to regulate nonpoint sources of pollution in sensitive watersheds. The 1998 poultry bill passed in the state of Oklahoma sets specific limits with regards to the application of poultry litter in sensitive watersheds such as the Illinois River. Soils and litter must be tested before litter can be applied and litter must be applied on a phosphorus basis by state certified litter applicators. In addition, poultry growers must attend water quality based training courses provided by the integrators in order to participate in the program. A program is also being developed to transport excess litter outside of the basin to areas where soil phosphorus supplementation is needed. These efforts will likely reduce the rate at which poultry litter is applied to the land and thus reduce the concentrations of nutrients in the stream.

In addition, the governor of Oklahoma set aside monies to be used on a cost-share basis to implement BMPs in the basin. These BMPs will likely focus on protection of riparian areas and streambank stabilization techniques. Federal Environmental Quality Incentives Program (EQIP) monies are also available in the watershed for implementation of BMPs. Federal monies have the advantage that they can be used in both Oklahoma and Arkansas, whereas state monies are state-specific. This advantage is critical in the Illinois basin where much of the headwaters are in Arkansas. More and more research indicates that BMPs must be implemented starting in the headwaters and then move downstream to be successful in improving water quality. The most cost-effective BMPs are those that reduce NPS pollution at its source. The political boundaries are still an issue, however, because Oklahoma and Arkansas draw their federal money from different pots as they are in different EPA Regions. Spending Oklahoma dollars in Arkansas is a hard sell, just as spending Arkansas dollars in Oklahoma would be a hard sell.

Fortunately, the poultry industry, in particular, has taken significant steps to curb the impact from their operations. All Tyson growers (thus, both in Oklahoma and Arkansas) must have their litter and soil tested prior to litter application. All Tyson growers must apply litter on an approved phosphorus-ratio basis, rather than on a nitrogen basis. All Tyson growers must attend mandatory water quality training courses. Failure to comply with these rules results in termination of the Tyson-Grower contract. Other poultry companies are likely to follow Tyson's lead and require these steps of their growers.

Oklahoma plans to implement BMPs which address the priority issues in priority areas. The Oklahoma Nonpoint Source Working Group, a group of federal, state, and nonprofit agencies with water quality concerns was asked to rank watersheds in the state of Oklahoma as priorities for future work. The Illinois River and Baron Fork watersheds were

ranked in the top five. The OCC plans to use this information to focus efforts in priority watersheds.

The OCC has allocated a significant portion of their FY1999 funds to address nonpoint source pollution problems in the Illinois River. Over 2 million dollars will be used to provide cost-share assistance to landowners to install BMPs in the watershed. The money will also be used to monitor water quality and other factors to verify the effects of these installations. The program will be administered by a Watershed Advisory Group (WAG), made up of local citizens and decision makers. The WAG will determine what types of BMPs will receive cost-share assistance and where the program should be concentrated.

The work will involve both implementation of BMPs and educational programs to reduce nonpoint source pollution in the Illinois River Basin. It is likely that many of the initial efforts in Oklahoma will focus in the Baron Fork watershed as it was identified as a priority, both by the Nonpoint Source Working Group, and by previous water quality studies. Water quality studies indicated that the Baron Fork was one of the most impacted streams in the system. Funds available at this time for implementation, although substantial, are likely not sufficient to implement necessary BMPs throughout the watershed. Thus initial §319 and state cost-share implementation funds will be targeted at areas where the need is greatest and the Baron Fork watershed contains the highest concentration of these in Oklahoma. Federal EQIP funds will be likely be targeted throughout the Illinois basin as will future §319 and state cost-share funds once implementation is complete in Baron Fork. Education efforts, however, will have a basin-wide focus. The OCC will continue to address water quality issues in the Illinois River Watershed through the implementation of BMPs as long as the Nonpoint Source Working Group identifies it as a priority watershed.

Corresponding to this effort, the Oklahoma Scenic Rivers Commission has focused on protection of the Illinois River. Beginning in 1993, the OSRC, the National Park Service, Oklahoma State University, and concerned local citizens began developing a plan to address the problems in the Illinois River corridor and set specific goals towards that end (OSRC 1998). The public felt that the river should be managed to emphasize naturalness and aesthetics. The group felt that attempts should be made to influence river users by education, such that their actions will protect and promote the health of the aquatic ecosystem. Should these efforts prove insufficient, rules and regulations should be designed to protect the environment. The effort organized three working teams to address specific issues related to the river. The teams identified the following goals (OSRC 1998):

Corridor Values

! Create constructive relationships with landowners by providing information and assistance regarding the full range of voluntary private land protection techniques.
! Minimize the impacts of development and construction within the Illinois River basin by encouraging local governments to adopt regulations to control development in

flood plain areas; monitor population and growth trends in the basin.

- Seek voluntary compliance with private landowners to establish and maintain a vegetated buffer of 60-100 feet along the river and its tributaries and to utilize existing cost-share programs and grant opportunities to enter cooperative agreements with riverfront property owners.
- Evaluate causes of streambank destabilization and determine the best possible actions for restoration by identifying and monitoring bank erosion and exploring opportunities to enter cooperative agreements with riverfront property owners.

Recreation Resources

- Provide a high quality recreation opportunity while protecting the river's outstanding resources and recognizing the needs of river outfitters and individual users. Place the highest priority on recreation opportunities requiring a quiet and high-quality natural ecosystem. Evaluate the authorized OSRC float areas and maintain ongoing research programs to track visitor patterns.
- Provide all visitors with the proper orientation to types of activities available, river safety information and expected behavior. Educate visitors on the outstanding natural, cultural, and historical values of the Illinois River basin.
- Encourage river users to respect the resources available to them through education and proper facility placement, thus reducing trespass on private lands. Develop a management plan for public access areas for day use and camping.

Water Quality

- Minimize alteration of stream habitat and sedimentation due to destabilization of stream beds; work with Arkansas to designate the Illinois River and its tributaries in that state as "outstanding resource waters."
- Reduce nutrient and pesticide loading into the basin from commercial nursery tailwater and pollutant loading into the river from urban runoff.
- Reduce nutrient pollution due to animal waste by requiring contracted producers to complete and implement approved conservation plans.
- Protect riparian areas from the impacts of livestock by educating livestock producers on negative consequences and promoting cost-incentive programs.
- Implement training and utilize volunteer labor to collect water quality data. Help with public education.

Implementation of measures to address these goals is a daunting effort and the OSRC plan recommends prioritizing issues and strategies to address each issue in order that limited funds available can be used in a the most cost-effective manner. Such a proposal seems to indicate that water quality issues be given highest priority, as other issues depend on the continued quality of the water. This suggests that measures must be put in place that will stop pollution at it source, that is to retain pollutants on the land surface,

riparian area, and stream bank rather than allowing them to enter the stream.

Whatever methods are implemented towards reaching goals defined by the public and concerned agencies, the OSRC plan stresses the importance of continued monitoring in the basin, both to determine the success and/or failure of implementation measures and to plan for the future of the resource. The plan recommends continued monitoring of land use, visual quality, cultural resources, vegetation and wildlife, recreational use - both of concerning the river user and physical impacts caused by river users, water quality, habitat quality, and fish species and abundance.

The OSRC plan also discussed issues which were perceived as having secondary importance compared to the main issues of corridor maintenance, recreational value, and water quality. Although these issues were considered secondary, they are nonetheless important and should be addressed when possible. These issues include:

- Visual Resources- the Oklahoma and National Wild and Scenic Rivers Act specifically identified scenery as an important resource which should be preserved and enhanced. Areas within the river corridor and viewshed should be managed to preserve visual qualities.
- River Setbacks- Agencies should work with landowners on a volunteer basis to develop adequate setbacks from the rivers edge. A 60-100 foot riparian buffer is generally considered minimum to screen most activities beyond that distance.
- Cultural Resources- State Agencies should work closely with Native American groups in identifying and protecting cultural resources located within the river corridor. Agencies should prepare and maintain an inventory of historical and archeological resources within the river corridor.
- Fire- Direct and indirect efforts towards fire suppression have led to a buildup of fuel load which increases the opportunities for wildfires to develop. Wildfire suppression actions should be coordinated with adjoining landowners, volunteer fire departments, and appropriate state agencies.
- Exotic Vegetation Management-To reduce the likelihood of exotic plant take-overs, agencies should work with landowners to clip and burn non-native plants. Any non-native plants introduced should be annuals, primarily grasses or other species that would provide temporary cover, but not persist over time.
- Wildlife- Maintenance of habitat diversity and wildlife viewing opportunities should be coordinated between state and federal agencies.
- Joint Oklahoma and Arkansas Management of the River- Management should consider needs of both states and should incorporate efforts by both states on the behalf of the watershed.
- Maintaining Water Quality- Agencies should take all action necessary to prevent further degradation of water quality, including regular water quality monitoring and stringent sewage and erosion controls. Efforts should also be maintained to promote adequate healthy aquatic habitat.

- Chemical Spills- Procedures should be formulated for handling hazardous material spills that might threaten resources within or near the river corridor.
- Floodplain Issues-The potential loss of life and monetary damage arising from a major flood has risen due to residential and commercial development within the floodplain. Floodplain zoning may be the best way to accommodate local development in accordance with the National Flood Insurance Act of 1968.
- Commercial Floatation Device Operators- The number of commercial operators on the river has grown from 5 in 1970 to 16 in 1993. To reduce the impact of river users, the OSRC recommends limiting the distribution of canoes aerially and temporally to reduce the impacts of recreation on any one area of the river.
- High Water- Floating during high water can be extremely dangerous. A management goal is to provide all users with sufficient information so they can make intelligent decisions about whether to float. No permit system to restrict use during high flows should be imposed at this time.
- Fishing- issues concerning conflict between anglers and nonanglers, angler trespassing, and limited resources should be addressed through appropriate education.
- Swimming and bathing- swimming should be permitted as long as state and local health standards are maintained. The use of soap, shampoo, detergents, and other cleaning agents while in the river is prohibited.
- Sightseeing- A scenic byway management plan to address the needs of sightseers, including pull-offs and parking area development should be developed.
- Motorized boating- Motorized boating which disturbs wildlife and solitude and may also cause safety problems should be discouraged along the river corridor.
- Camping and Day Use- Based on observations of crowding, resource degradation, and increasing maintenance requirements, there is a need for more intensive management of primitive camping areas operated by the OSRC. A system to enforce visitor carrying capacity and allocate use among user groups should be implemented when monitoring indicates environmental or social capabilities are being reached or that increased supervision is needed to properly utilize the river's physical capacity.
- User fees- Floaters who rent from commercial operators pay $1.00 per boat for a float permit. No fee is charged for camping at public access areas. It is suggested that the fee system continue.
- Human Waste and Litter Problems- Human waste and litter present obvious detriments to the corridors natural resources, aesthetics, and recreational opportunities. Vault toilets are being offered at reasonable intervals, but use is dependant upon conscientiousness of river users. A "pack it in - pack it out" philosophy should be encouraged among river users through signs and brochures. All canoes should be equipped with a litter bag. A current ban on use of glass and Styrofoam containers should be continued.
- Information and Education- the OSRC should emphasize the development of a coordinated public education program that utilizes signs, brochures, maps, and

other material to gain pubic understanding of rules, regulations, and activities which affect water quality.

- Interpretation- OSRC rangers performing routine work should be encouraged to maintain a high level of rapport with river users and in addition to law enforcement and resource monitoring responsibilities should assist in providing interpretive services to river corridor users.
- Access- Additional planning and development is needed to improve access and reduce potential impacts.
- Signing- Signs should be in the same format and located a predictable places. More of the various agency directed projects should be labeled with information identifying the agency responsible and education concerning the project, when appropriate.
- Land Acquisition and Easement Policy- the OSRC should seek acquisition of scenic or conservation easements on high priority tracts of land within the corridor based on the potential for future development, the potential for use by the public, the sensitivity of the land, and the opportunity for acquisition.

COST OF REMEDIATION

The estimated cost of remediation programs are summarized in this section. The accuracy of these estimates vary; however, for the purpose of discussion they are useful for comparing the costs of different approaches to controlling pollution within the Illinois River Basin. These values primarily represent the cost of implementation activities and do not take into account the positive or negative economic impacts of some potential solutions. In addition, this list does not include all of the potential solutions although it does address most of the major issues.

I.	Upgrading WWTFs	$5,300,000
II.	Recreation	$400,000
III.	Lake Frances	$500,000
IV.	Animal Production	$10,000,000
V.	On-Site Waste Disposal	$40,500,000
VI.	Gravel Mining	?
V.	Nurseries	?

The overall cost of remediating the problems in the Oklahoma portion of the Illinois River Watershed will be quite high. The OCC has allocated a significant portion of their FY1999

funds to address nonpoint source pollution problems in the Illinois River. Over 2 million dollars will be used to provide cost-share assistance to landowners to install BMPs in the watershed. The money will also be used to monitor water quality and other factors to verify the effects of these installations. The program will be administered by a Watershed Advisory Group (WAG), made up of local citizens and decision makers. The WAG will determine what types of BMPs will receive cost-share assistance and where the program should be concentrated. The plan will also be forwarded to members of the Nonpoint Source Working Group (a group, led by the OCC, made up of federal and state government agencies, nonprofit organizations, tribes, and agricultural producer organizations for the purpose of providing review of and direction to the State's Nonpoint Source Program) for review and comment.

Given the economic resources available, it may be impossible to fix all of the problems in the watershed. Thus, remediation efforts should focus in the most cost-effective manner. Thus, most of the future efforts should probably focus on reducing the impacts to the watershed from animal production operations. Much is already being done to reduce nutrient impacts to the watershed and substantial funds have been allocated towards reducing point and nonpoint source loading. Additional funds necessary to protect the water resources are difficult to estimate before the success of the currently planned activities can be determined.

It is impossible to know whether the planned activities referenced in this document will solve or curb the water quality problems in the river basin. Thus, the most appropriate course of action may be to continue to follow the phase program of implementation that is currently in place. Now that most of the point sources have been upgraded and a significant nonpoint source program is planned to focus on the main sources of water quality problems, it may be best to wait to determine the impact of these programs. Based on the success of these programs, it may or may not be necessary to revisit the basin with a second-phased approach to focus on areas such as Lake Frances, pit toilet facilities, use reduction provisions, or intensive streambank restoration measures.

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